FINAL REPORT

WASH MODEL USER'S MANUAL

Prepared for
SFWMD

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1.1 PURPOSE OF THE DOCUMENT - RELATION TO THE OTHER WASH DOCUMENTS

The WaSh model is a coupled watershed water quality model (WaSh) originally developed with funding from the South Florida Water Management District (SFWMD) for simulating conditions in the St. Lucie Estuary (SLE) basins. WaSh is a time-dependent, coupled hydrologic and hydraulic simulation model. It includes representation of basic surface hydrology, groundwater flow, surface water flow, point sources and losses, and water quality fate and transport. It also includes many special features specifically required to simulate conditions in the SLE basins, such as irrigation demand and supply, high water table conditions, fully coupled groundwater and surface interactions, reservoirs and Stormwater Treatment Areas (STAs), and flow structures.

This **WaSh Model User's Manual** is one of three manuals comprising the full WaSh Model documentation. The three manuals are:

- The **WaSh Model User's Manual** which provides a detailed reference for each function and feature of the WaSh Model. It presents an introduction and overview of the model system, model capabilities and limitations, installation instructions, how to get started, detailed descriptions of each model component, data preparation, detailed model set-up, model parameters estimation, running the program, how to view model output and some discussion about analysis of model simulation runs.
- The **WaSh Model Application Guide** contains a tutorial that demonstrates various aspects of the WaSh model application. Each example consists of a problem statement, data requirements, detailed model set-up steps, displays of key input and output, and discussions of important modeling aspects. By going through these examples, a less experienced user will be able to conduct basic WaSh model application.
- The **WaSh Model Theory Documentation** describes the theory and data requirements for the hydrological simulation (including water quantity and water quality) performed by the WaSh. The mathematic model equations used in WaSh are presented along with the assumption used in their derivation. Methodology, algorithm, and numerical scheme, matrix solutions used in the WaSh are explained. The document provides model parameters reasonable range when applicable, and guidelines on model parameter estimation.

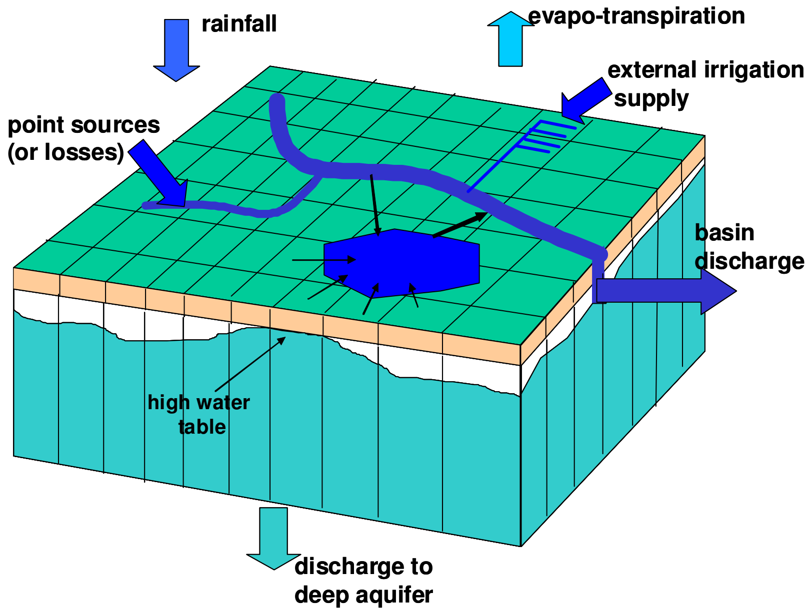
The **WaSh Model User's Manual** provides a reference for all features of the WaSh model, from installation through model configuration, execution and post processing. Key features of this user's manual are:

- Discussion of model assumptions/limitations
- Comprehensive list of all information needed prior to model setup
- The content and format of user provided input files
- Section by section description of model inputs and parameters with cross-reference to the Model Theory Documentation
- GUI screen shots showing how to access each model feature

- Content and format of simulation output files
- Post-processing options

1.2 BRIEF SUMMARY AND DESCRIPTION OF WASH

The WaSh model consists of four basic components: (1) a cell-based representation of surface hydrology, (2) a cell-based representation of subsurface hydrology (groundwater), (3) a reach network that represents streams, rivers, estuaries and canals, and (4) reservoirs and STAs. Each of these components is shown in Figure 1.1. In addition to providing a representation of surface hydrology, each cell can optionally store surface water in a system of tertiary canals. These canals receive direct surface runoff; convey water to the reach network, reservoirs and STAs; and interact with the groundwater (more information is provided in the runoff routing section).



1.1

The basin can be considered a bounded system with distinct sources and sinks. The sources and sinks, also identified in Figure 1.1, are:

1) Rainfall
2) Transpiration/Evaporation
3) Point sources or sinks
4) Percolation of a deep aquifer
5) External sources of irrigation water
6) Discharge from the basin

The first three items are user-specified input to the model, whereas the last three items are calculated internally by the WaSh model. External irrigation supplies are irrigation water that is supplied from outside the system, either from another basin or from the deep aquifer. The WaSh model calculates the external supply as the part of the irrigation demand that cannot be met with internally stored.

A functional schematic of the WaSh model components and how they interact is shown in Figure 1.2. This figure also serves as a summary level block diagram of the WaSh model computer program. The computations are divided into four groups:

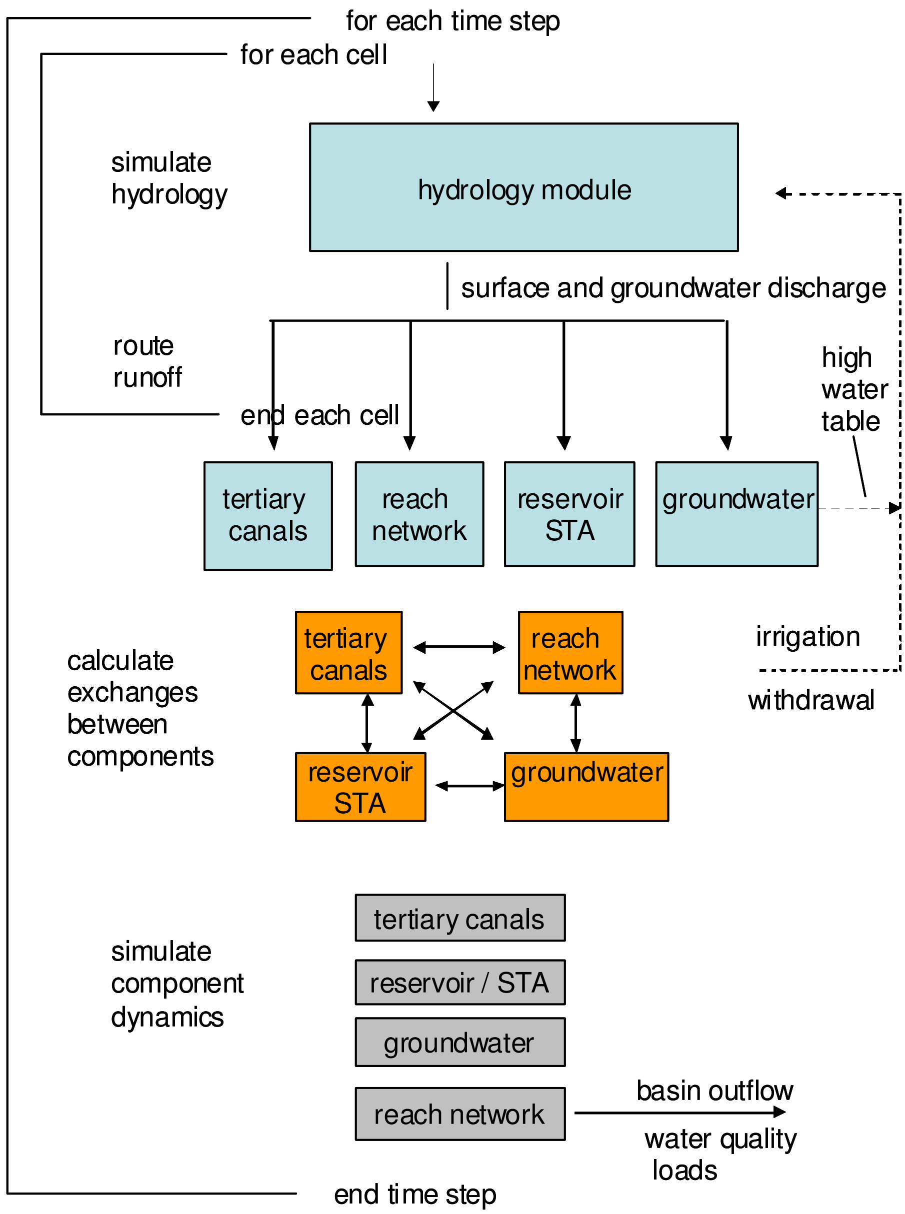
1) Hydrology calculations
2) Cell discharge routing
3) Component interactions
4) Individual component dynamics

For each time increment, the surface hydrology routine produces a surface and subsurface (percolation) discharge for each cell. The cell's percolated water is routed to the groundwater, and the surface discharge is routed to one of the receiving water bodies, i.e., either the tertiary canals, reach network, or reservoirs and STAs. The decision as to where each cell's surface discharge is routed depends on the basin geometry and on user-controlled setup of the WaSh model. The surface hydrology simulation is based on the HSPF algorithms (Bicknell et al., 1997; Johanson et al., 1981).

There is some coupling between the cell hydrology routines and the other components, due to possible high groundwater conditions or irrigation demand. The high groundwater module will reduce percolation when the groundwater rises into the surface moisture. When a cell's irrigation module is active, it will sense deficiencies in the moisture zones and calculate an irrigation demand to replenish the deficiency. The demand is allocated by the user to tertiary canals, the reach network and reservoirs, as well as to external sources. The demand is extracted from each component during the component simulation.

After the discharges are routed, the exchange of water between components is calculated. All four components can interact with each other, via groundwater-surface water exchanges, pumping, and gravity flow.

Once the fluxes between components are calculated, the response of each component is determined. The groundwater model consists of an unconfined aquifer, intended to represent the surficial water table. The reach network model is based on the one-dimensional shallow water wave equation, and includes branching and representation of structural control on flow and stages. The tertiary canals are represented in each cell as a storage potential, with flow controlled by user-specified parameters describing weir configurations and pumping operations. The reservoirs and STAs are also represented using a storage potential with six different flow control options for controlling flow into and out of the facilities.



1.2

The basic time period for generating model output is one day, with flows, loads and other fluxes provided as daily averages. However, certain processes are simulated using a smaller time step in order to properly resolve the system dynamics. The cell hydrology calculations are simulated with a one-hour time step. Surface water dynamics in the reach network, tertiary canals and reservoirs and STAs are completed on a half-hour time step, and the cell-to-cell groundwater flows are calculated with a daily time step. However, the groundwater exchanges with surface water (reservoirs, tertiary canals and the reach network) are calculated using a half-hour time step. Flux rates between components using different time steps are aggregated, as needed, in order preserve mass balance.

The water quality component of WaSh is based on the time-dependent scalar transport equations and is directly coupled to the flow model. There are two options for simulating water quality, the basic option (BWQ) and the advanced option (AWQ). The basic option consists of simulating the runoff and transport of five water quality constituents, Total Suspended Solids (TSS) and dissolved and particulate nitrogen and phosphorus. The constituent transport is based on mass conservation, but includes first-order decay and settling and re-entrainment of TSS and particulate fractions of nitrogen and phosphorus.

The AWQ option is based on the non-linear dissolved oxygen (DO) balance and eutrophication model as described in the WASP model documentation (Ambrose et al., 1988). There are eight constituents (state-variables): ammonia, nitrate, inorganic phosphorus, phytoplankton carbon, carbonaceous biochemical oxygen demand, dissolved oxygen, organic nitrogen, and organic phosphorus. The run-off and transport portion of the advanced water quality option is identical to that of the basic option. The primary difference occurs in the surface water bodies, for which the transformations between state-variables are also simulated in the AWQ option. Also, each reach in the reach network can be divided into an upper and lower section. Vertical diffusion between the upper and lower section can be simulated also, by specifying a diffusion rate. This capability was added to improve representation of conditions in which there are significant vertical variations in the water quality constituents.

The WaSh model also supports the implementation of numerous Best Managements Practices (BMPs) used to control the flow and water-quality characteristics of the basins. The BMPs are divided into two general categories, explicitly represented, and implicitly represented BMPs. Explicitly represented BMPs include structures that are included directly in the drainage system. These consist of detention and retention basins and certain irrigation practices. Implicitly represented BMPs include a wide variety of practices, ranging from filter strips to grazing practices, and are represented as modifications to model parameters controlling runoff quantity and quality.

The model is supported by a Graphical User Interface (GUI) that is developed as an ArcView extension. The GUI provides functions for configuring the model using "raw" data. Once a model is configured, the GUI provides the user with functions to modify the model, execute simulations and post process model outputs.

1.3 MODEL LIMITATIONS: PROPER AND IMPROPER APPLICATIONS

The WaSh model is intended to provide long term simulations of surface and subsurface hydrology, hydrodynamics and water quality. Since it is comprised of modules derived from or operate in a similar fashion to HSPF, MODFLOW, and WASP as well as a 1D hydrodynamic model, the typical limitations and applications of those models apply to WaSh model, as well. As with any model, there are specific limitations to the application of the model.

The WaSh model is intended for long term simulations and there are limitations on the minimum duration of a simulation. These limitations are imposed by the physical model algorithms, the numerical time step and the ability to prescribe initial conditions.

The model is typically used for multiple year simulations. However, it can be used for shorter duration, on the order of a week or month, depending on the intent of the simulation. Tests with the WaSh model indicate that a spin-up period of about 1 year is necessary to remove the effects of the initial conditions. The one-year time scale is driven by the soil moisture simulation and the groundwater simulation. However, if the surface hydrology and groundwater initial conditions are sufficient or these components are not important on a short time-scale then a shorter duration simulation can be considered.

The model was initially developed for conditions in Florida and therefore does not include any simulation of snow and ice effects. However, the model is otherwise a general purpose model and can be applied to any watershed if snow and ice are not an important controlling factor.

The simulation of reservoirs or STA does include a spatial representation of the water quality parameters across the reservoir or STA, but assumes that the water is well mixed vertically and laterally. However, if the reservoir exhibits vertically stratified conditions or there are highly variable conditions across the reservoir then caution should be used in using the WaSh model to simulate conditions in the reservoir or STA.

The WaSh model does provide the ability to represent vertically stratified conditions in the 1D hydrodynamic model, intended as an approximation for salt-wedge like conditions in estuaries. However, the salt-wedge dynamics and the density effect of salinity are not explicitly represented and the hydrodynamic simulation. The model uses a two-layer representation for water quality only and it splits the flow calculated in the 1D-hydrodynamic model evenly between the upper layer and the lower layer. The simulation of the water quality includes settling from the upper layer to the lower layer as well as mixing between the layers. Thus, the WaSh model should not be used to simulate any system in which the salt wedge dynamics and the associated flow patterns are critical to the fate and transport of water quality. Also, the 1D-hydrodynamic component implicitly assumes laterally well mixed conditions. Therefore, the WaSh model may not be the most appropriate model for use in wide estuaries exhibiting large variability in conditions.

2.1 OPERATING SYSTEM REQUIREMENTS

The WaSh Model is accessed and operated through a Graphical User's Interface (GUI) that functions within ArcMap 9.2 as a toolbar. ArcMap 9.2 must be installed prior to installation and operation of the WaSh Model.

Basic operating system requirement for ArcMap 9.2 are:

- CPU: 1.6 Ghz Pentium 4 or better
- Memory: 1 GB Minimum
- Disk Space: 1.2 GB Minimum
- Spatial Analyst is also required for certain features to function properly, such as the topographic processing using elevation raster files

The Wash GUI itself has the additional requirements of two MBs of disk space on the local hard drive. The Wash GUI extension will install and operate within ArcMap 9.1, but it has not been fully tested and is not supported

2.2 SELF-EXTRACTING EXECUTABLE

The WaSh Model GUI and Model Code are typically delivered in a zip file that contains two self-extracting files: Setup.exe and WASHGUI_SETUP.msi. To begin installation, run Setup.exe. This operation will verify that .NET 2.0 is installed on the PC. If .NET 2.0 has not been installed, the installation will be initiated for .NET 2.0 and the user will be instructed on the installation procedure. If the .NET 2.0 is currently installed, the installation of the Wash GUI will begin. The only user input required during the installation is the specification of the file for the model root directory. The default path in the Program Files directory is recommended, but any path can be specified.

After installation is complete, a folder named "SeedFolder" will reside in the WaSh GUI installation folder. The SeedFolder contains files vital to the operation of the Wash GUI. Files with the .lyr extension control how different features are displayed on the map. The WashGUI.config file contains several settings. The SeedTables.mdb file contains default values for many of the Wash Model parameters. It is recommended that you do not change these files names.

2.3 INITIALIZING WASH TOOLBAR

After installing the Wash GUI and opening an ArcMap session, the WaSh GUI toolbar should be visible and appear as:

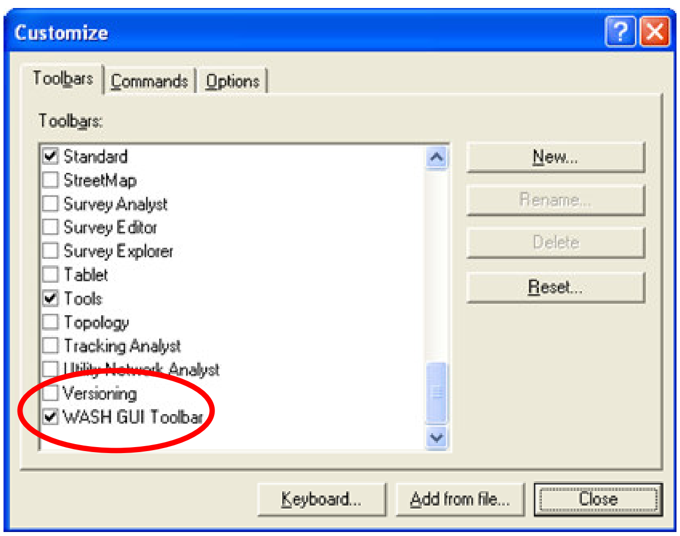
2.1

The toolbar can be removed from the center of the layout by adding it to the toolbars along the frame of the ArcMap screen.

If the Wash GUI toolbar is not visible, the list of available toolbars can be accessed by right clicking anywhere in the toolbar area. Activate the GUI toolbar by checking the associated box next to the "WASH GUI Toolbar" on the toolbar list.

2.2

If the WaSh GUI Toolbar is not on the list, then click "Customize..." and in the dialog that appears, click the "Add from file..." button. Then browse to the folder where WashGUI is installed and select "WashGUI.tlb". Once the correct path has been identified, make sure "WASH GUI Toolbar" is checked in the list. The Wash GUI Toolbar should now be visible in the ArcMap session.



2.3

The WaSh model requires various input data sets in order to configure and operate the model. The data are divided into two general categories: configuration data and forcing data. Configuration data consists of physical parameters that describe the system, such as topography and land use. Typically, the configuration data represents spatial variations and is considered time-invariant. Forcing data consists of input data which acts upon the physical system to alter flow and water quality. Typically, forcing data will be time varying and constant in space. However the spatially variable rainfall data may also be used with the WaSh Model. Some input data are required, and some are optional and dependent on the WaSh model modules being used in the simulations.

3.1 MODEL CONFIGURATION DATA

The physical characteristics of the basin are represented in the WaSh model on a uniform Cartesian grid. The spatial distribution of primary basins, secondary basins, land-use, soil type, topography, canals, rivers and streams, reservoirs and control structures are required to configure each basin model. The spatial distribution of attributes is obtained primarily in the form of GIS shapefiles, the contents of which are mapped onto each model grid cell using the WaSh GUI tools. The spatial data must all be in the same projection (i.e. state plane, local or UTM), with units of feet.

3.1.1 Required Data

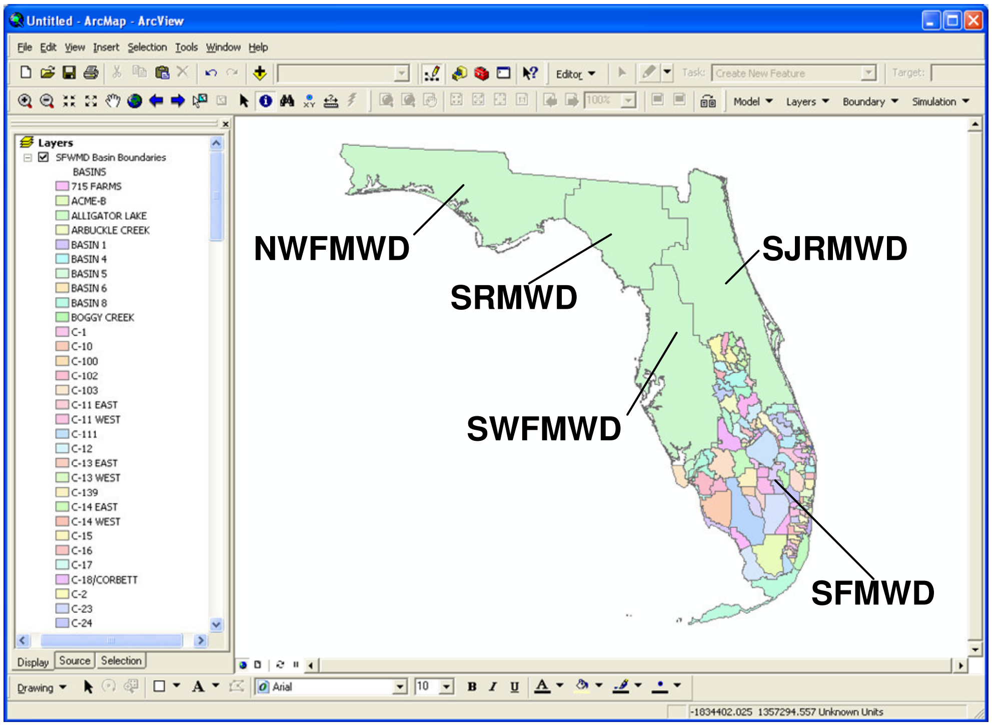
The basic model configuration requires six types of geospatial data, in the form of GIS shapefiles or coverages. GIS data necessary for configuration includes (1) basin or watershed boundaries with subbasin delineation, (2) landuse, (3) soils, (4) hydrology and (5) topography. The essential attributes of each data set are described below, using example GIS shapefiles from the SFWMD databases.

3.1.1.1 Model Domain: Watershed Boundary

Model domains are typically defined by a primary drainage basin, watershed boundary, or river catchment. Basin boundaries are often defined by topographic highs or ridges which delineate the opposing drainage directions. For modeling purposes, the domain can be defined based on the modeling needs. The basin can be as small as a mountain stream catchment or as large as a complete river system. In the WaSh model, a GIS polygon shapefile is needed to define the areal extent of the basin to be modeled.

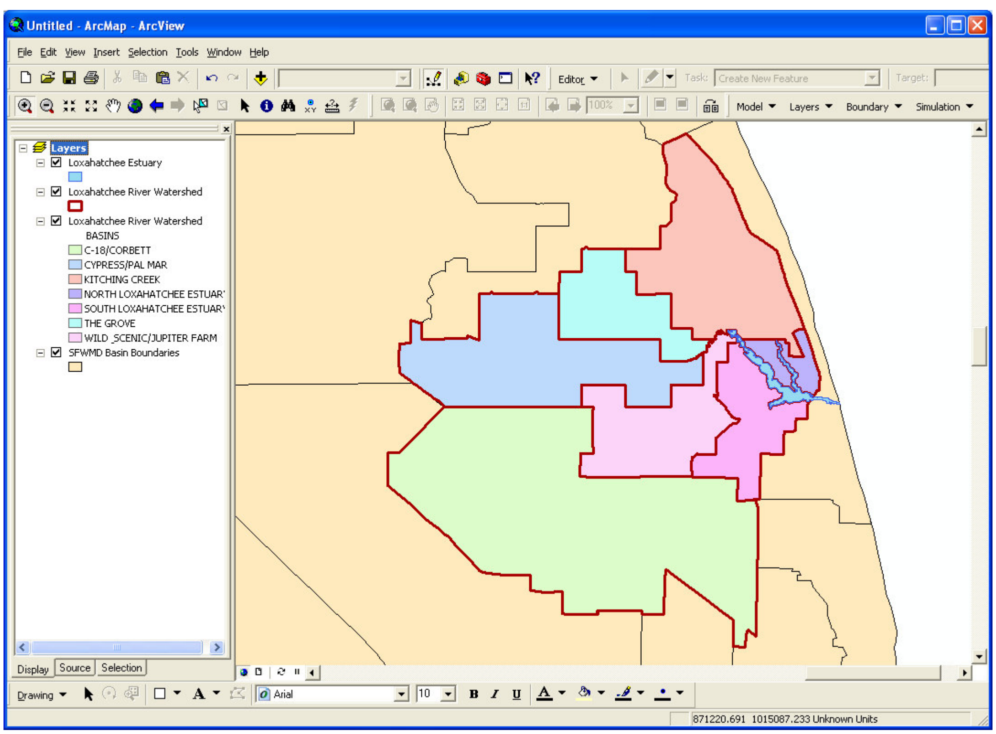
The State of Florida is divided into five Water managements districts based on general drainage systems within the state (green polygons): the North West Florida Water Management District (NWFWMD), the Suwannee River Water Management District (SRWMD), St. Johns River Water Management District (SJRWMD), Southwest Florida Water management District, and the South Florida Water Management District (SFWMD). (Figure 3.1)

The SFWMD is further divided into primary drainage basins, as noted in the multi-colored regions.



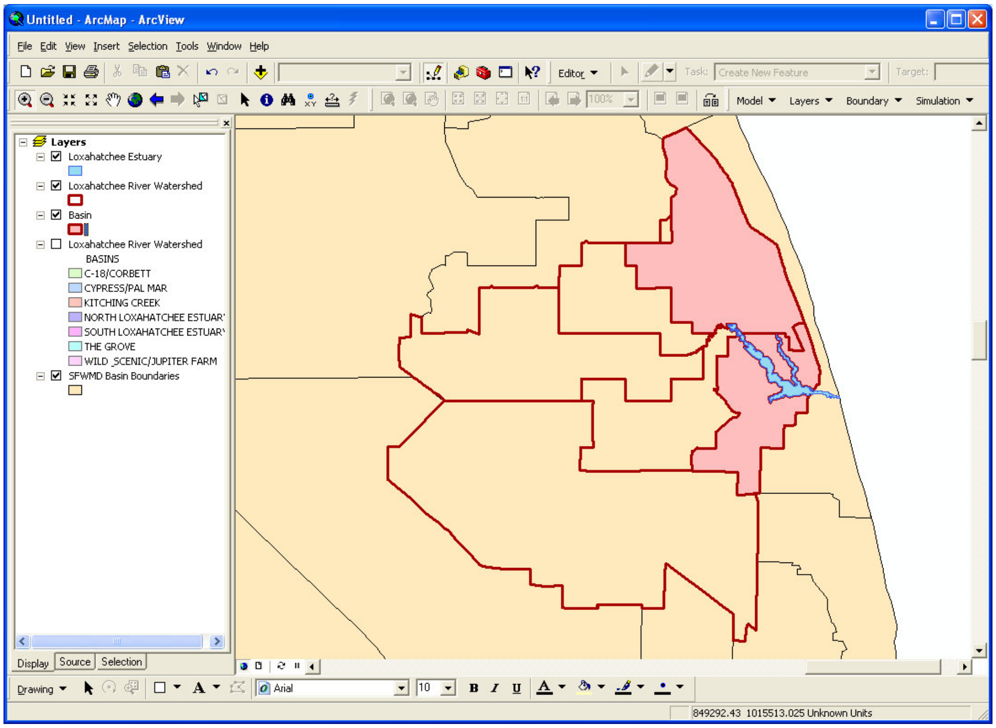
3.1

Drainage Basins can be grouped into watersheds, as noted in the following figure. The basins outlined in red all drain into Loxahatchee Estuary Watershed.



3.2

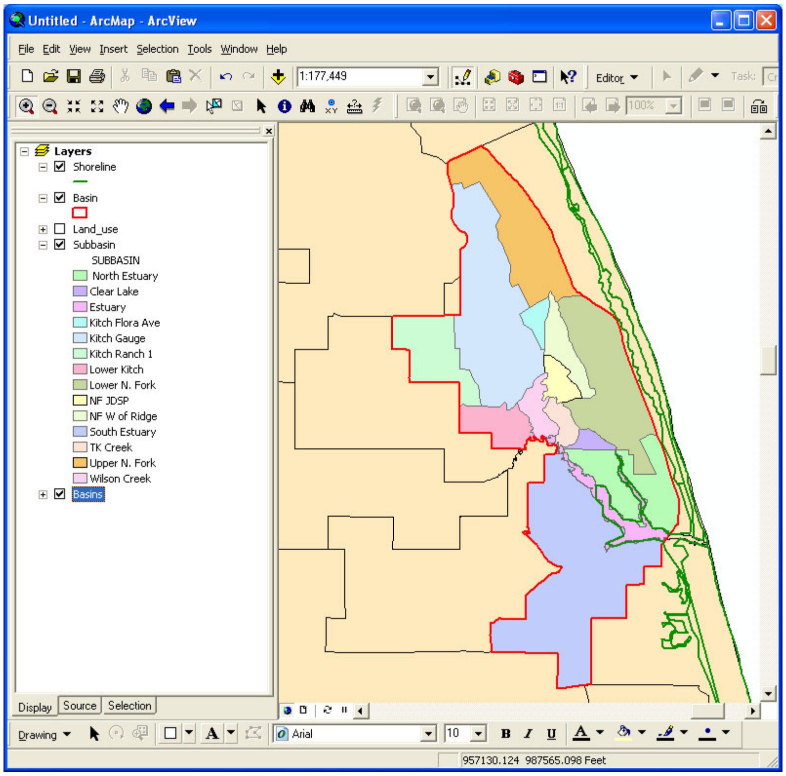
Three basins drain directly into the Loxahatchee Estuary. They have been combined to create one basin for use as an example in this manual. This merged basin is illustrated in the following figure. It is used to define the model grid domain.



3.3

3.1.1.2 Secondary Basins

The secondary basin boundary coverage is a polygon feature, which is typically used to help guide the specification of overland flow patterns in the model. During model generation, the secondary basins help to constrain the cell-to-cell surface flow paths, based on documented drainage patterns. Topographic resolution can often be too course, flat or subtle for the model to distinguish flow directions based on slope, especially in the coastal areas of South Florida. Therefore, the assistance of additional secondary boundaries aids in more accurate drainage representation in the model. Secondary basin coverages also tend to account for the subtle changes in drainage based on the introduction of buildings, roads, canals and stormwater systems, which alter the natural drainage patterns of an area. These anthropogenic systems are often unidentifiable in topographic coverages. An example of the secondary basin or sub-basin boundaries is shown in the following figure.



3.4

3.1.1.3 Land-use

Each grid cell requires a land use designation, which is the key parameter controlling the selection of model parameters affecting hydrology, irrigation practices and water quality runoff concentrations. The WaSh model was developed for use with Florida Land Use, Cover and Forms Classification System (FLUCCS) code designation, which include a four-level land use hierarchy. The level 1 FLUCCS codes are shown in the following table. Level 2 codes would include a non-zero value in the 100's place, and level three codes include a non-zero value in the 10's place.

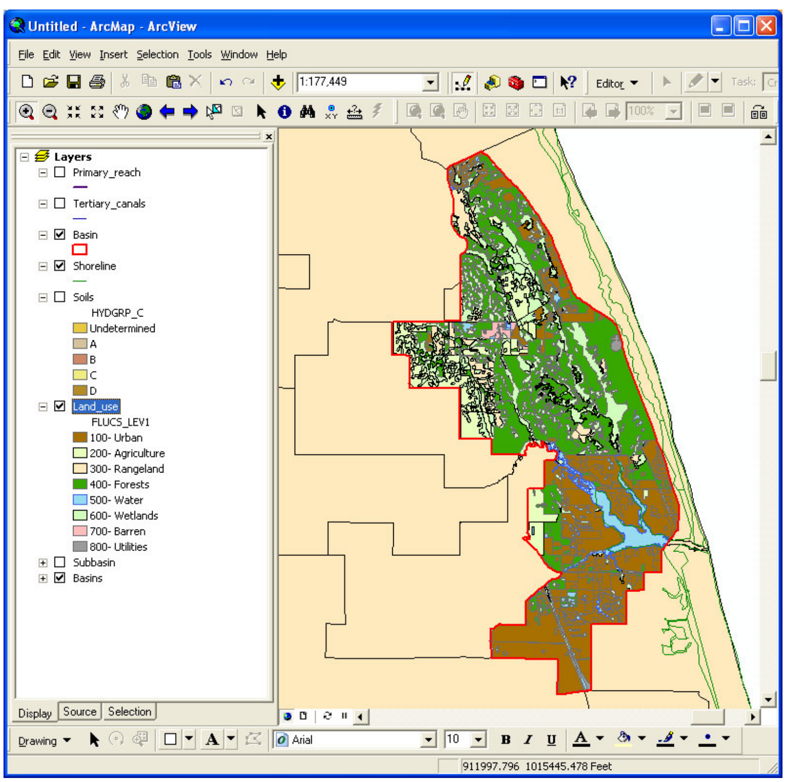
FLUCCS Level 1	FLUCCS Description
1000	Urban
2000	Agriculture
3000	Rangeland
4000	Forests
5000	Water
6000	Wetlands
7000	Barren Land
8000	Utilities

The attribute table associated with the land use polygon in the GIS shapefile must have the 4-digit land use code assigned for each land use polygon. The WaSh model can represent either level 1, 2 or 3 FLUCCS codes. The land use shapefile is required to have the FLUCCS level data for the desired FLUCCS code level.

Upon model generation, the WaSh model assigns to each grid cell the most dominant land-use within that cell. When dominant land-uses are assessed basin-wide, the smaller land-use polygon features can often be overlooked by the model and, therefore, under-represented in percentages of total lands use in each model basin. This typically happens, for instance, when wetlands in a basin consist of small patches distributed throughout a forested area or pasture land. The small patches never dominate the cell area and are therefore overlooked, resulting in an under-representation of the wetlands land-use in the model configuration. Thus, the percentage of each category of grid-generated land-use varies from the actual land-use coverage for the basin.

One method to eliminate this artifact of the grid discretization is to use smaller grid cells. However, this approach will require many more cells to represent the basin, and will lead to unreasonable simulation times. An alternate approach is to calculate the difference between modeled landuse and actual landuse, and then manually alter the land-use in individual cells so that the grid-based land-use designation preserves an accurate representation of current land-use within each basin.

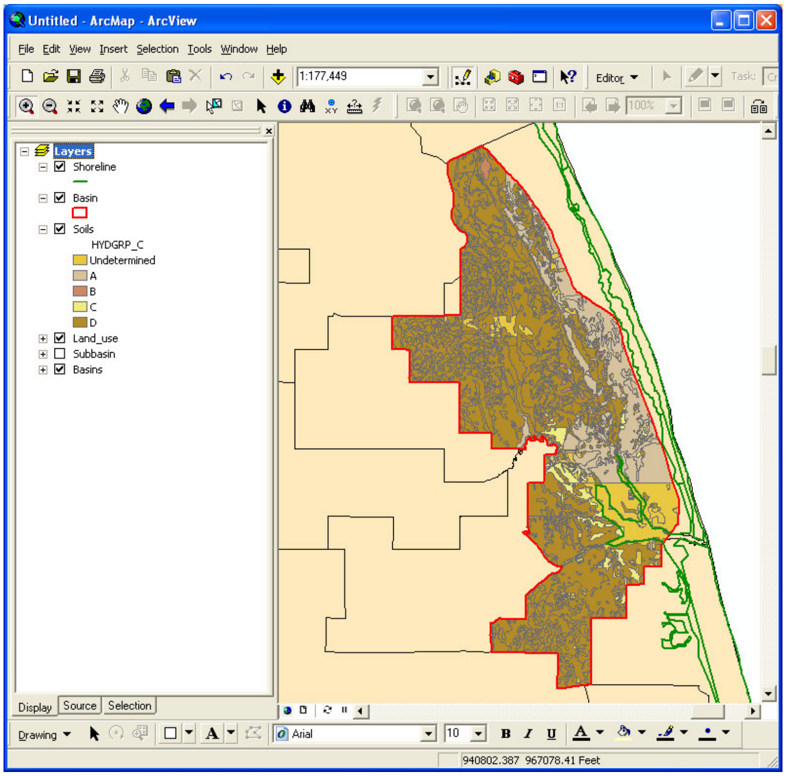
Polygon shapefile coverages for land use can discriminate between Levels 1, 2, 3 and 4 land uses. An example land use coverage is presented in the following figure.



3.5

3.1.1.4 Soils

Soil types are used in the model configuration along with land use to guide the selection of model parameters that affect the run-off and/or infiltration coefficients for each grid cell. Either the USGS hydro-group data or the SSURGO database can be used to specify the soils. In either case, the spatial distribution of the data needs to be contained in a polygon shapefile. An example of the USGS hydro-group soils coverage is presented in the following figure.

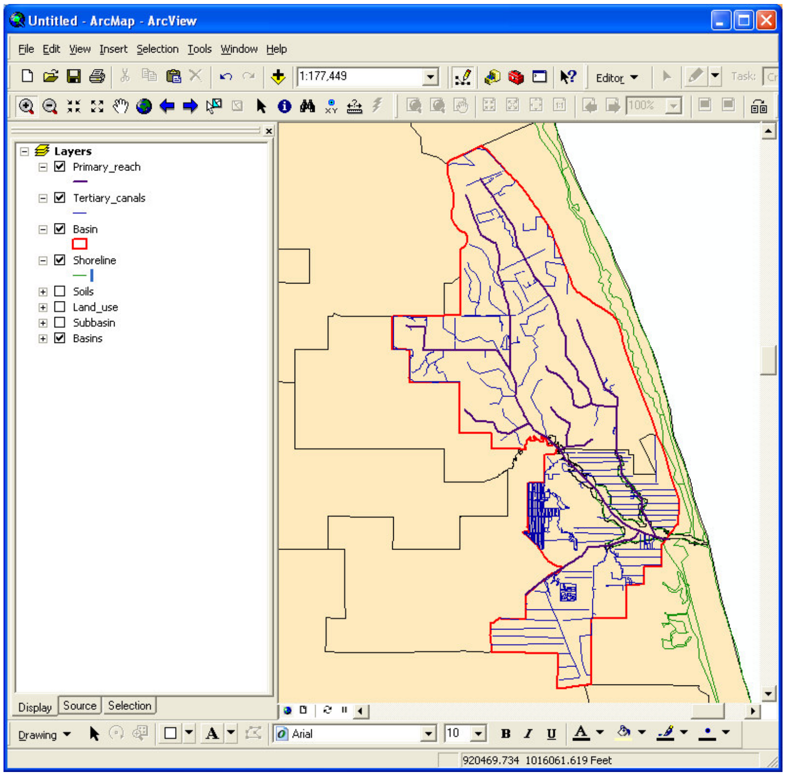


3.6

Each polygon in the soils shapefile must have one of the USGS hydro-group specification, A, B, C, D A/B, C/D associated with it. If the SSURGO data is used, then the shapefile must have a SSURGO soil type name designated for each polygon.

3.1.1.5 Surface Hydrology

Hydrology coverages are polyline features which include both natural and man-made drainage features. This coverage includes rivers, streams, and primary, secondary and tertiary canals. Two unique hydrology coverages are required for model configuration: tertiary canals and primary reach. The "tertiary canal" coverage is often an intense network of finger canals, small drainages, creeks, streams, and irrigation ditches. The tertiary canal system is mapped onto the grid cells with an attribute for total length of canals. An example hydrography coverage is presented in the following figure.



3.7

In the event that the user does not wish to model every hydrography polyline in the existing shapefile, an attribute field can be added to the shapefile and populated with a non-null value for each polyline that is to be modeled. Any polyline with a null value in the attribute field will be excluded from the configuration. This procedure eliminates the need to alter the original shapefile by deleting any existing hydrography. For example, if the user wishes to study the effects of changing landuse from agriculture to residential, the existing irrigation canals need to be removed from the system. By adding an attribute field and populating all cells with a "1" except for the irrigation canals in the area of interest, the tertiary canals will be removed from the system without deleting the polylines from the shapefile.

The bottom elevation, width and other drainage characteristics of the tertiary canals are not automatically assigned to each reach segment using polyline attributes in the shapefile. These attributes are added to each reach segment using the WaSh GUI edit menus. This procedure is described later in this manual (Section 6.4).

3.1.1.6 Primary Reach Network

The separate hydrology coverage for project canals, major rivers and large streams is used to develop the Primary Reach network, defining the main flow path through the system, culminating at the basin outfall. In order to accurately represent the flow characteristics within each reach, the canal or river dimensions must be entered in the model. Optimally, canal blueprints are used to calculate canal dimensions, but dimensions can be estimated from alternative mapping systems.

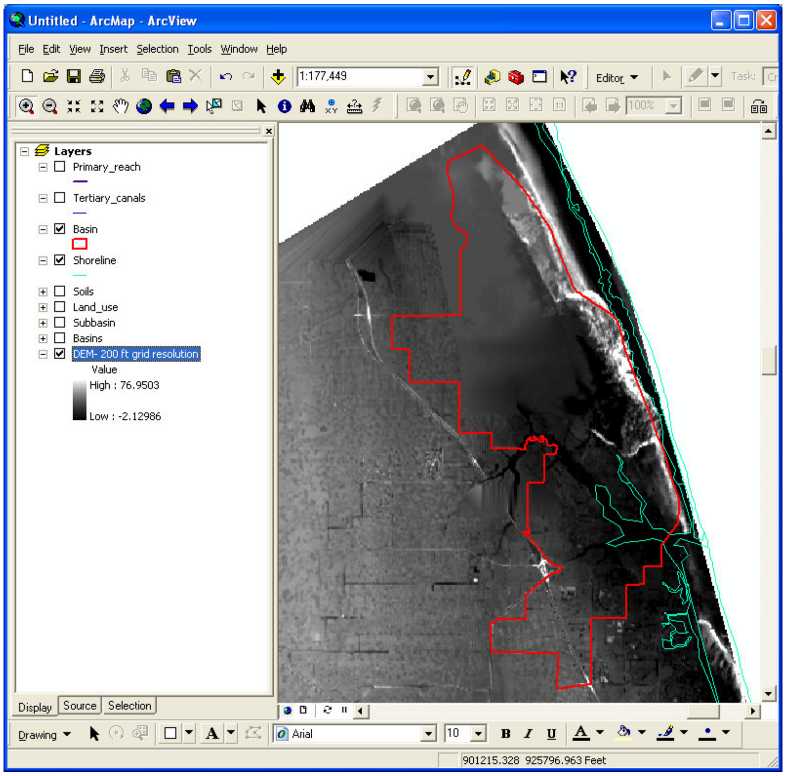
The WaSh model has the option to simulate the canal (or river) systems as a single layer or as a multiple layer. The single layer option is used for shallower channels, where vertical mixing is high and no stratification occurs. Most freshwater systems will require the single-layer model. The two-layer or multi-layer option was developed to improve the representation of deeper channels or in stratified systems in which vertical mixing is inhibited and distinct upper and lower layers develop. The two layer model is vital in estuarine systems, for example, where the freshwater/marine interface creates distinct, depth-dependent, water quality characteristics. Refer to the WaSh Model Theory Documentation for further discussion of single-layer and two-layer hydrodynamics

An example of a primary reach polyline coverage is presented in the previous figure (purple line over the tertiary canal coverage). The polyline shapefile used for the hydrology configuration can include lines for features other than the primary canals and rivers, but each line that is a primary river or canal must have a unique attribute that can be identified and used during the model configuration process. Thus polylines for the tertiary canals and the primary rivers and canals can reside in the same shapefile, but must have a distinct attribute field to allow the GUI to distinguish between them. In the attribute field for the primary canals, any non-null value identifies the polyline as part of the primary canal system. Also, each river or stream segment must be represented by a single line that roughly approximates the center of the waterway. In some cases, for wider waterways, there are two lines representing the banks of the river or canal. In these cases, the polyline coverage will need to be edited so that a single line represents the waterway prior to the coverage being used in the model configuration.

The bottom elevation and width of the river and canals are not automatically assigned to each reach segment using polyline attributes in the shapefile but are added to each reach segment using the WaSh GUI edit menus. This procedure is described later in this manual (Section 6.4).

3.1.1.7 Topography

A **digital elevation model** (**DEM**) is a digital representation of topography or bathymetry. A DEM can be represented as a raster (a grid of squares) or as a triangular irregular network (TIN). A three-dimensional DEM topography coverage can be generated in ArcMAP using a point shapefile with an elevation data attribute. Using the raster or the TIN, the model assigns to each cell the average elevation within that cell. Many DEM files are available online from USGS and others. An example of a DEM coverage is presented in the following figure.



3.8

3.1.2 Optional Data

Certain types of data are not required by the model in order for WaSh to operate, although the data may aid in the accurate representation of the natural system operations. Structures and Reservoirs are two such model inputs.

3.1.2.1 Structures

Flow structures can be added to the reach network representing the primary rivers and canals once the WaSh model configuration is completed. Weirs, gates, pumps and culverts can be represented. Multiple structures can be assigned at one location to represent complex structural controls on the flow and stage. A map or other data showing the location and type of each structure is useful to guide the model setup. A digital location map is not required for the model configuration since each structure is added to the configuration manually by selecting the location in the reach network using the WaSh GUI configuration tools.

3.1.2.2 Reservoirs

Water storage of a system is represented by reservoirs, dammed lakes, retention ponds and detention ponds. All of these components can be controlled in the Reservoir features. Reservoirs can be added to the WaSh model configuration using a polygon shapefile containing the footprint of each reservoir. Reservoirs can also be added manually to the model configuration by tracing the footprint on the WaSh model grid using the GUI tools. This option is available for easy setup of proposed reservoirs for the design may only be preliminary and polygon shapefiles are not available.

Other attributes of the reservoirs such as their lining characteristics, height and operational features are added in the WaSh GUI editing menus.

3.2 MODEL FORCING DATA

Model forcing data consists of input data which acts upon the physical system to alter flow and water quality outputs. Forcing data includes meteorological data such as rainfall, evapo-transpiration, radiation, temperature, point sources and boundary conditions. Some forcing data is required for a simulation, whereas some data is optional and depends on the water flow and water quality options used in the WaSh model configuration.

3.2.1 Required Data for Hydrology

Hydrology modeling in WaSh is dependent on accurate representation of rainfall and evapo-transpiration. These parameters directly affect the introduction and removal of water from the system.

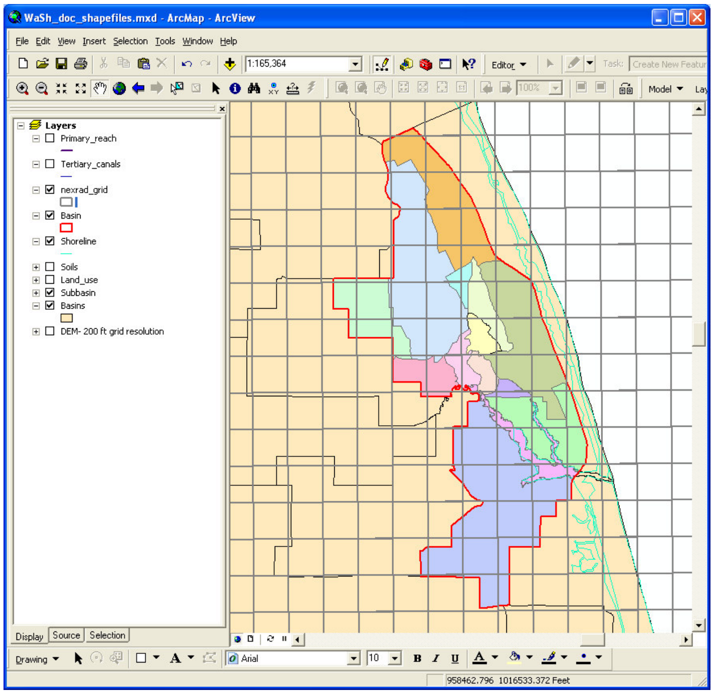
3.2.1.1 Rainfall

Two types of rainfall data can be used in the WaSh model: A combination of NexRad and GridIO data or gauge data. Time series data measured at a rain gage station can be used as the single rainfall input to the model. When using a single time series, it is assumed by the model that the rainfall is uniform throughout the basin. Rainfall data should be organized in a space or comma delimited text file (*.txt) format as hourly rainfall in inches per hour. The data should extend for the entire length of the model simulation. Data processing and interpolation may be needed to account for any missing data due to mechanical or organizational failures during the data collection process. A sample of rainfall time series input data is presented below. In the example, a rainfall event occurs between 10 AM and 2PM. All other times are recorded as zero.

Year	Month	Day	Hour	Rainfall (inches)
1968	9	24	8	0
1968	9	24	9	0
1968	9	24	10	0.002
1968	9	24	11	0.031
1968	9	24	12	0.058
1968	9	24	13	0.031
1968	9	24	14	0.002
1968	9	24	15	0
1968	9	24	16	0

The file contains a user defined single line header, (actual column names are not explicitly used by the model). The file contains one row for each day, with columns for year, month, day, hour and hourly rainfall in inches. The file can start with records prior to the simulation date as the WaSh model will scroll through the file until the simulation start date is reached.

Alternatively, the WaSh model can operate using NEXRAD/GridIO (2X2) rainfall data. NEXRAD Doppler Radar data is available in 2 by 2 km grid cells across the State of Florida. Data is available from 1996 to present. The NEXRAD grid is shown overlaying the basin in the following figure.



3.9

The GridIO (2X2) data covers a majority of the southern portion of Florida in a 2X2 grid and is available from 1965 to 2000. The grid for the GridIO data is similar to the NexRad grid.

Each cell in the rainfall databases is associated with a individual time series record of rainfall data. Each WaSh grid cell is attributed with the ID of the overlying NexRad cell and/or GridIO cell. The time series rainfall data for the overlying NEXRAD /GridIO cell is then used for rainfall for the WaSh grid cell. This creates a spatially varying rainfall input for the WaSh model. The use of NEXRAD/GridIO data is especially useful in areas like Florida, where the instantaneous spatial distribution of rainfall can vary significantly within a drainage basin.

The GUI will create two input files for the WaSh model. The first is a mapping file that lists the NEXRAD or GridIO pixel associated with each model grid cell. The second file contains the hourly time series data for each NEXRAD or GridIO pixcel that is used in the WaSh model. An example of a NEXRAD/GridIO rainfall time series file is presented below.

Year	Month	Day	Hour	Pixel1	Pixel2	Pixel3
1995	1	1	1	0	0	0
1995	1	1	2	0	0	0
1995	1	1	3	0.03	0.04	0.03
1995	1	1	4	0.17	0.19	0.16
1995	1	1	5	0.29	0.35	0.23

Year	Month	Day	Hour	Pixel1	Pixel2	Pixel3
1995	1	1	6	0.04	0.06	0.07
1995	1	1	7	0.06	0.06	0.05
1995	1	1	8	0	0	0
1995	1	1	9	0	0	0

The NEXRAD data covers the period from 1996 to present and new data is expected to be added each year as it becomes available. The GridIO data covers the period form 1965 through 2000. Thus there is an overlapping period form 2000 to 2005. Either data set can be used in the overlapping period.

The NEXRAD/GridIO database is only applicable for models developed to represent basins in the SFWMD boundaries. For other basins, the single time series input option can be used.

3.2.1.2 Evapotranspiration

Evapotranspiration (ET) data represent the potential evaporation from standing water bodies and soils and transpiration from plants. The WaSh model expects daily ET data based on the Penmon-Monteith approach. An example of an ET input file is presented below.

Year	Month	Day	ET (inches)
2005	1	1	0.0930
2005	1	2	0.0930
2005	1	3	0.0837
2005	1	4	0.0744
2005	1	5	0.0837
2005	1	6	0.0744
2005	1	7	0.0961
2005	1	8	0.0961
2005	1	9	0.0899

The file contains a user defined single line header, (actual column names are not explicitly used by the model). The file contains one row for each day, with tab or comma deliminated columns for year, month, day, hour and potential ET in inches. The file can start with records prior to the simulation date as the WaSh model will scroll through the file until the simulation start date is reached.

The potential ET from the input file is modified in the WaSh model by a land-use dependent coefficient to represent variations in leaf cover and soil conditions for each land use. These values are accessed via the WaSh GUI edit menus are described later in this manual.

3.2.2 Required Data for Water Quality

The basic water quality option does not require any additional model configuration or forcing data. However, when the advanced water quality module is used, two additional files specifying daily solar radiation and water temperature are required. The input data and file formats are described below.

3.2.2.1 Solar Radiation

The daily solar radiation is used in the advanced water quality module of the WaSh model to specify the phytoplankton growth rate. The daily rate is adjusted hourly in the simulation using a normalized (peak value of 1.0) half-sine function to specify the instantaneous amount of daylight (Section 9.2.3, **WaSh Model Theory Documentation**). The sunrise and sunset times for each day are set in the WaSh model GUI edit menus and are described later in this manual. An example of Solar Radiation input for the model is presented below.

Year	Month	Day	SolarRad (Langley's/day)
1993	1	1	0.093
1993	1	2	0.113
1993	1	3	0.068
1993	1	4	0.178
1993	1	5	0.174
1993	1	6	0.171
1993	1	7	0.083
1993	1	8	0.185
1993	1	9	0.185

The file contains a user defined single line header, (actual column names are not explicitly used by the model). The file contains one row for each day, with tab or comma deliminated columns for year, month, day, hour and solar radiation in langleys/day. The file can start with records prior to the simulation date as the WaSh model will scroll through the file until the simulation start date is reached.

3.2.2.2 Temperature

Time series of daily surface water temperature data is another parameter required for operation of the advanced water quality module of the WaSh model. The temperature affects the phytoplankton growth rate and various kinetic rates for nitrogen, phosphorus and CBOD (Section 9.2.3, **WaSh Model Theory Documentation**). Data should be used as input to the WaSh model in a times series of daily average of surface water temperatures in degrees C. An example of surface water temperature data is presented below.

Year	Month	Day	WaterTemp (deg_C)
1993	7	1	24.3

1993	7	2	24.6
1993	7	3	24.7
1993	7	4	24.8
1993	7	5	25.5
1993	7	6	24.7
1993	7	7	25.6
1993	7	8	25.9
1993	7	9	26.1

The file contains a user defined single line header, (actual column names are not explicitly used by the model). The file contains one row for each day, with tab or comma deliminated columns for year, month, day, hour and temperature in degrees Celsius. The file can start with records prior to the simulation date as the WaSh model will scroll through the file until the simulation start date is reached.

3.2.3 Optional Data

3.2.3.1 Grid Cell Point Source Data

Flow sources and sinks can be applied to any cell that has tertiary canals. The sources or sinks can be used to represent transfers of water into or out of the model domain or other industrial operations. The number of columns in the input file depends on the modules operational in the WaSh model. For a simulation without any water quality components, the time series point source input file is would appear as shown below:

Year	Month	Day	Flow (cfs)
2005	1	1	1070
2005	1	2	895
2005	1	3	562
2005	1	4	0
2005	1	5	0

The file contains a user defined single line header, (actual column names are not explicitly used by the model). The file contains one row for each day, with tab or comma deliminated columns for year, month, day, and daily inflow (positive value) or outflow (negative value). The file can start with records prior to the simulation date as the WaSh model will scroll through the file until the simulation start date is reached.

The daily flow is added to or removed from the tertiary canals at a uniform rate equal to the daily average flow in the input file. For sinks (outflow) the flow is removed form the cell's tertiary canal only if available. Thus it is possible that the entire outflow specified in a point source file may not be realized during a model simulation.

When the basic water quality module is invoked, the point source input file must also provide the concentration of each basic water quality constituent. An example of the proper input file is provided below:

Year	Month	Day	Flow (cfs)	TSS (mg/L)	P_N (mg/L)	P_P (mg/L)	S_N (mg/L)	S_P (mg/L)
2005	1	1	1070	8	0.162	0.034	0.051	0.036
2005	1	2	895	58	0.283	0.032	0.152	0.051
2005	1	3	562	15	0.223	0.07	0.079	0.045
2005	1	4	0	43	0.33	0.112	0.129	0.041
2005	1	5	0	12	0.23	0.103	0.119	0.035
2005	1	6	1225	16	0.356	0.109	0.083	0.073

In addition to the daily flow, the file must include in this order the concentrations in mg/L for total suspended solids, particulate nitrogen, particulate phosphorus, soluble nitrogen and soluble phosphorus. If these data are not provided, the WaSh model simulation will not start.

When the advanced water quality module is invoked, the point source input file must also provide the concentration of each advanced water quality constituent. An example of the proper input file is provided below:

Year	Month	Day	FLOW (cfs)	NH3-N (mg/L)	Nitr-N (mg/L)	IORG-P (mg/L)	Phyt-C (mg/m3)	CBOD (mg/L)	DissOx (mg/L)	ON-N (mg/L)	OP-P (mg/L)
1995	1	1	1.57E+02	1.60E-01	1.78E-01	6.61E-02	5.29E-01	2.65E+00	8.04E+00	2.91E+00	1.08E-01
1995	1	2	1.79E+02	1.92E-01	1.87E-01	6.74E-02	5.31E-01	2.55E+00	7.87E+00	2.87E+00	1.05E-01
1995	1	3	1.82E+02	2.18E-01	2.02E-01	6.87E-02	5.02E-01	2.43E+00	7.64E+00	2.82E+00	1.02E-01
1995	1	4	1.87E+02	2.32E-01	2.16E-01	6.91E-02	4.60E-01	2.26E+00	7.45E+00	2.75E+00	9.78E-02
1995	1	5	3.00E+02	2.36E-01	2.29E-01	6.86E-02	4.13E-01	2.05E+00	7.32E+00	2.66E+00	9.34E-02
1995	1	6	2.16E+02	2.30E-01	2.40E-01	6.71E-02	3.69E-01	1.83E+00	7.26E+00	2.55E+00	8.87E-02
1995	1	7	2.53E+02	2.21E-01	2.49E-01	6.53E-02	3.34E-01	1.64E+00	7.24E+00	2.45E+00	8.44E-02
1995	1	8	2.02E+02	2.09E-01	2.57E-01	6.32E-02	3.06E-01	1.48E+00	7.25E+00	2.35E+00	8.03E-02
1995	1	9	1.87E+02	1.96E-01	2.63E-01	6.12E-02	2.80E-01	1.34E+00	7.28E+00	2.26E+00	7.66E-02

In addition to the daily flow, the file must include in this order the concentrations in mg/L for Ammonium (C_NH3-N), Nitrate (C_Nitr-N), Inorganic nitrogen (C_IORG-P), Phytoplankton Carbon Mass (C_Phyt-C), biologic oxygen demand (C_CBOD), dissolved oxygen (C_Diss_Ox), organic nitrogen (C_ON-N), and organic phosphorus (C_OP-P). If these data are not provided, the WaSh model simulation will not start.

3.2.3.2 Reach Point Source Data

The reach point source data time series inputs are identical to the cell input time series files except that they are linked to reach segments in the reach network. The daily flow is added to or removed from the reach segment at a uniform rate equal to the daily average flow in the input file. For sinks (outflow) the flow is removed from the canal segment only if available. Thus it is possible that the entire outflow specified in a point source file may not be obtained during a model simulation.

If the advanced water quality module is active, and the WaSh model is configured with reaches with two layers, then the water quality concentrations are assumed to flow into both layers.

3.2.3.3 Downstream Transport/Boundary Conditions

Downstream boundary condition data are required if the tide boundary conditions is used in the model configuration. If either water quality model is active, then one of the downstream boundary conditions also requires some input data.

For the tidal forced flow boundary condition, the hourly tide elevation is required. For each tide boundary, a specific file will be required. An example of the file format for the tide boundary condition is shown below:

Year	Month	Day	Hour	Tide_(ft)
1995	9	24	0	-0.195
1995	9	24	1	-0.438
1995	9	24	2	-0.51
1995	9	24	3	-0.51
1995	9	24	4	-0.355
1995	9	24	5	-0.108
1995	9	24	6	0.3
1995	9	24	7	0.643
1995	9	24	8	0.87

The file contains a user defined single line header, (actual column names are not explicitly used by the model). The file contains one row for each day, with tab or comma-delimited columns for year, month, day, hour and tide elevation in feet relative to the project datum. The file can start with records prior to the simulation date as the WaSh model will scroll through the file until the simulation start date is reached.

There are two downstream boundary conditions for the water quality constituents at tidally forced boundaries. The first is a scaling condition. In this approach the constituent concentrations of the flow when it is directed out of the model domain are tracked. When the flow direction reverses and flow is into the watershed, the outgoing concentrations are scaled using a user prescribed scale factor and the scaled constituent concentrations are used as the incoming flow concentrations. The second approach uses a user prescribed constituent concentrations every time the flow is directed into the model domain. For this second approach, a time series of downstream concentrations are required. The file requires a continuous daily average concentration for each constituent, but the values for a particular day are only used if the flow at the boundary is into the model domain. An example of the required input file for the basic and advanced water quality simulations are shown below. For the basic water quality simulation the format is:

Year	Month	Day	Flow (cfs)	TSS (mg/L)	P_N (mg/L)	P_P (mg/L)	S_N (mg/L)	S_P (mg/L)
2005	1	1	1070	8	0.162	0.034	0.051	0.036
2005	1	2	895	58	0.283	0.032	0.152	0.051
2005	1	3	562	15	0.223	0.07	0.079	0.045
2005	1	4	0	43	0.33	0.112	0.129	0.041
2005	1	5	0	12	0.23	0.103	0.119	0.035
2005	1	6	1225	16	0.356	0.109	0.083	0.073

And for the advanced water quality simulation the format is:

Year	Month	Day	FLOW (cfs)	NH3-N (mg/L)	Nitr-N (mg/L)	IORG-P (mg/L)	Phyt-C (mg/m3)	CBOD (mg/L)	DissOx (mg/L)	ON-N (mg/L)	OP-P (mg/L)
1995	1	1	1.57E+02	1.60E-01	1.78E-01	6.61E-02	5.29E-01	2.65E+00	8.04E+00	2.91E+00	1.08E-01
1995	1	2	1.79E+02	1.92E-01	1.87E-01	6.74E-02	5.31E-01	2.55E+00	7.87E+00	2.87E+00	1.05E-01
1995	1	3	1.82E+02	2.18E-01	2.02E-01	6.87E-02	5.02E-01	2.43E+00	7.64E+00	2.82E+00	1.02E-01
1995	1	4	1.87E+02	2.32E-01	2.16E-01	6.91E-02	4.60E-01	2.26E+00	7.45E+00	2.75E+00	9.78E-02
1995	1	5	3.00E+02	2.36E-01	2.29E-01	6.86E-02	4.13E-01	2.05E+00	7.32E+00	2.66E+00	9.34E-02
1995	1	6	2.16E+02	2.30E-01	2.40E-01	6.71E-02	3.69E-01	1.83E+00	7.26E+00	2.55E+00	8.87E-02
1995	1	7	2.53E+02	2.21E-01	2.49E-01	6.53E-02	3.34E-01	1.64E+00	7.24E+00	2.45E+00	8.44E-02
1995	1	8	2.02E+02	2.09E-01	2.57E-01	6.32E-02	3.06E-01	1.48E+00	7.25E+00	2.35E+00	8.03E-02
1995	1	9	1.87E+02	1.96E-01	2.63E-01	6.12E-02	2.80E-01	1.34E+00	7.28E+00	2.26E+00	7.66E-02

The file contains a user defined single line header, (actual column names are not explicitly used by the model). The file contains one row for each day, with tab or comma deliminated columns for year, month, day, and the daily average concentration for each constituent in mg/L. The file can start with records prior to the simulation date as the WaSh model will scroll through the file until the simulation start date is reached.

The WaSh model requires certain features to be configured before a simulation can be executed. Other features are optional, and can be added after the required features are completed. In this section, (4.2) features that are required in the model configuration are described. Optional features are described in section 4.2. Also, certain configuration steps and model features are dependent on the existence of other features. The dependence of one feature on another is discussed in this manual, and the WaSh GUI will typically not allow a feature to be added if the prerequisite configuration and features are not available.

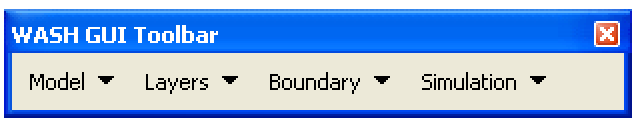
4.1 REQUIRED MODEL FEATURES

A new WaSh model can be created either by configuring a new model or editing an existing, already configured model. As a new model is being configured it is possible to save it without completing the configuration. An incomplete model configuration can be reloaded into the GUI and completed at any time.

The first time the GUI is used after the installation, the GUI will prompt the user for the location of GUI specific files. Once the path for each of the files is provided, they will not need to be set again unless the files are relocated by the user.

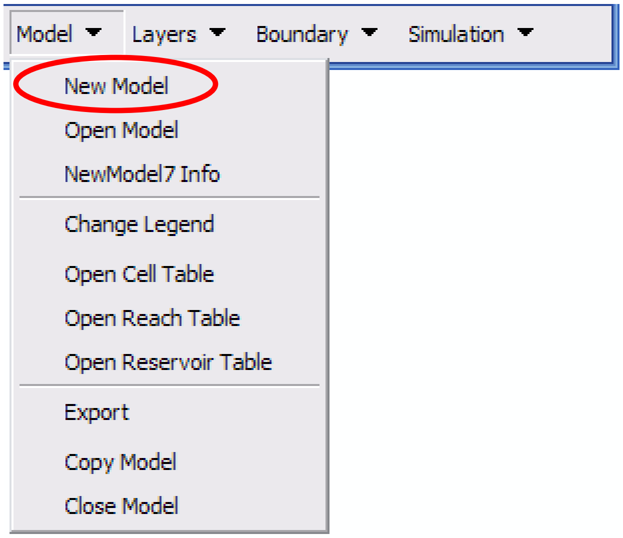
4.1.1 Creating New Model

The WaSh GUI tools needed to create a new model can be accessed through the WASH GUI Toolbar. Once the WaSh Model Toolbar has been activated under the View menu (see section 2.0), it should appear as:



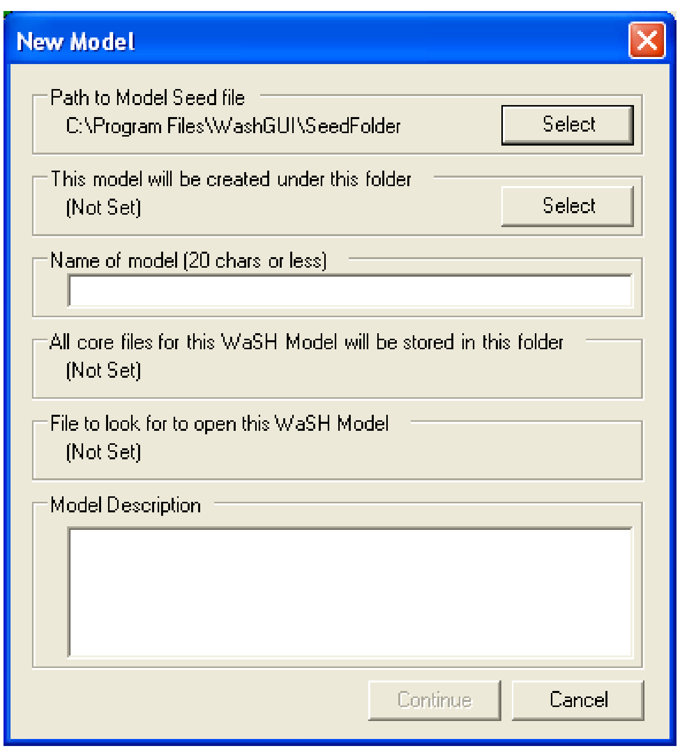
4.1

The Model menu allows the user to create a New Model, Open an existing model, change the symbology of the grid file based on configuration attributes, access the HSPF model inputs, and export data. Options will remain “grayed out” until the model development has progressed enough to warrant access of each model operation. For example, changes to the grid legend cannot be made until a grid has been created.



4.2

The model configuration tools can be accessed by selecting the New Model option from the Model menu. The following screen appears, prompting the user for the model seed file path and the model working directory. The seed file path is set once for the GUI whereas the model directory should be different for each model created. A name for the model can also be provided as well as a brief description.



4.3

The Seed folder is included in the self-extracting WaSh Model executable. The default installation of the WaSh model will place the Seed file in the C:Program Files\WashGUI folder. If an alternative path was chosen for the GUI installation, that same path will need to be designated as the location of the seed path. The Seed file can also reside in a folder other than in the Program files directory, as long as the path is indicated in the above screen during model creation.

The working directory for the new model will then need to be designated in the box labeled "This model will be created under this folder". A new model can be created in any directory, although models should be run on local drives (i.e. the C:\ drive), as opposed to network drives or external drives, in order to increase model simulation processing speeds.

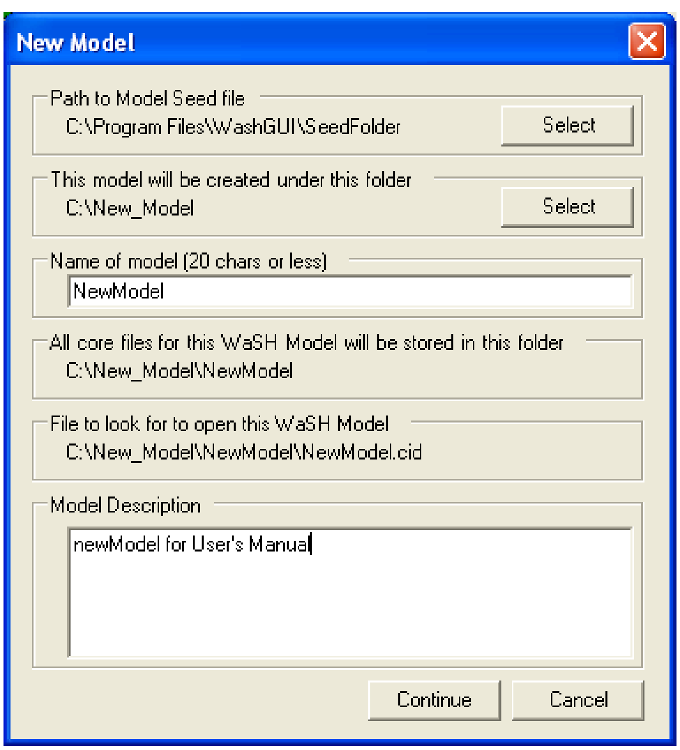
A model name must be selected. Shorter names are recommended for New Model generation, as the original name will act as the base name for potentially many generations of the same model with changes to the configuration or parameter values.

Note: ArcGIS will not recognize any pathways which contain spaces. Remove all spaces from the folder structure or replace with underscores and do not use a space in the Model Name.

The New Model window will then reiterate the model folder structure and indicate the files necessary for opening the new model, which will contain a .cid extension. If this file is accidentally moved or deleted, the model will fail to open. In any future GUI session, the model can be opened as an existing model by selecting the specified *.cid file (see section 4.1.2).

The user may also wish to enter a Model Description. The description may be up to 255 characters, and can help identify specific changes to the model that help distinguish identical model configurations with varying model inputs. Model description is optional, although its use is suggested, especially in sequential generations of models as it helps to define slight model modifications to the input parameters.

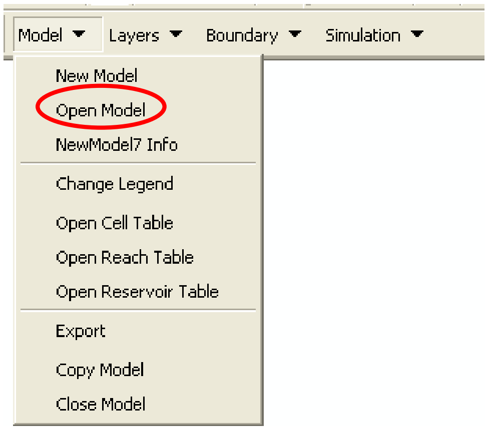
An example of a completed New Model menu is presented below.



4.4

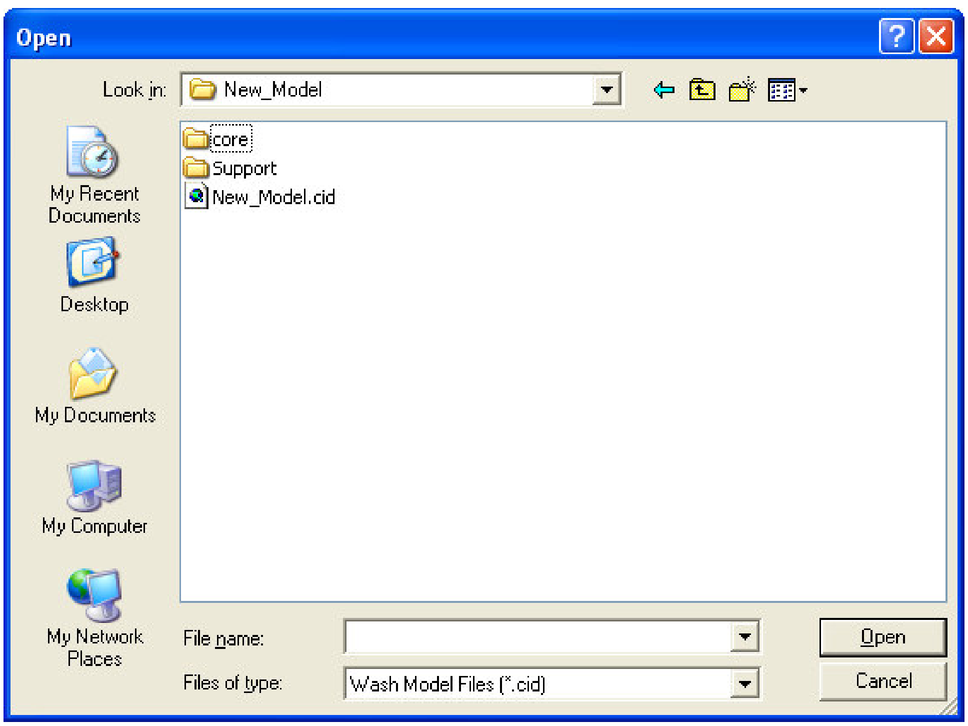
4.1.2 Opening an Existing Model

If a model has been completed or partially configured, it can be loaded into the WaSh GUI using the open Model menu option.



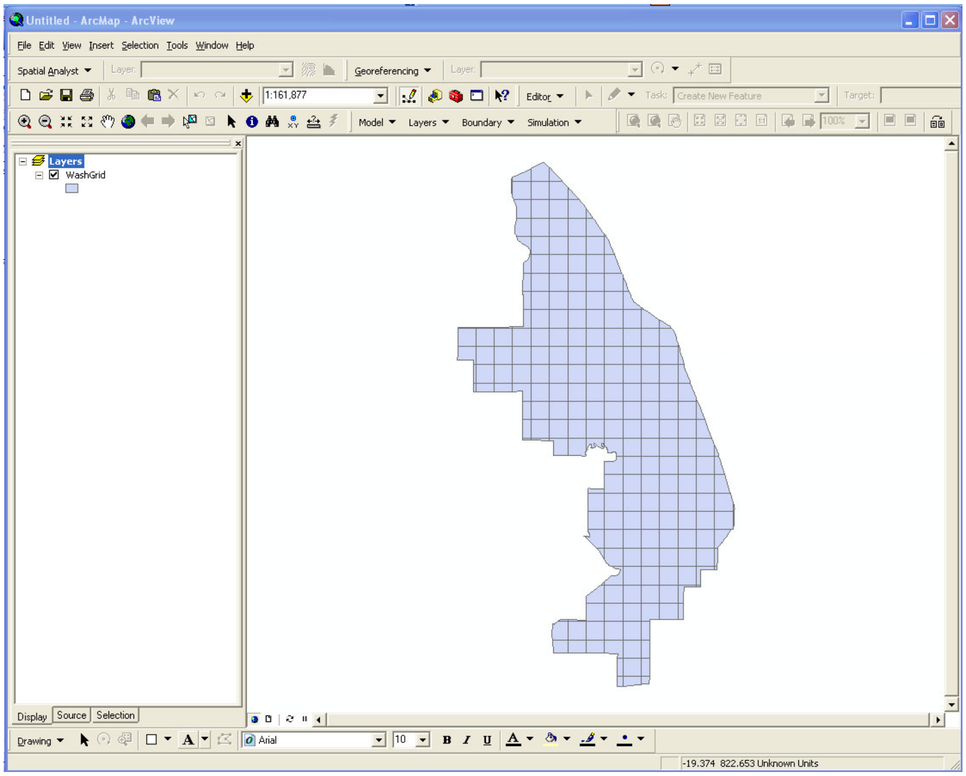
4.5

Choosing the "Open Model" function will open a file browsing menu, requesting the model file to be opened. The WaSh is searching for a file with the *.cid extension.



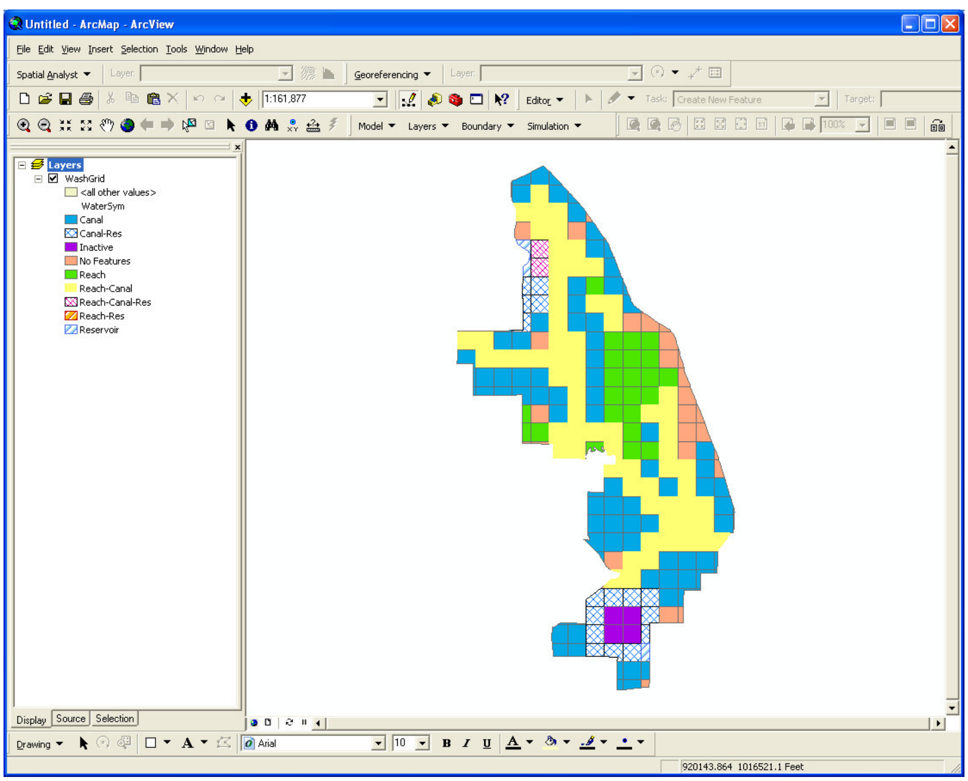
4.6

Choosing a model file and clicking the open button will open the requested model. The model configuration and forcing data will be permanently stored in the model folder, although the GUI may appear differently than it did when the model was last saved and closed. Upon reopening, the GUI will only show the model grid in a unique, default symbology.



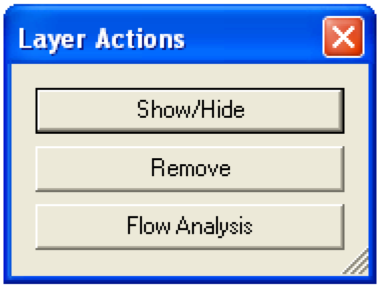
4.7

The Change Legend menu option can be used to convert the grid legend to a more useful representation. The “Water Symbols” legend is the standard for modeling operations, offering the most comprehensive detail for a WaSh hydrodynamic model.



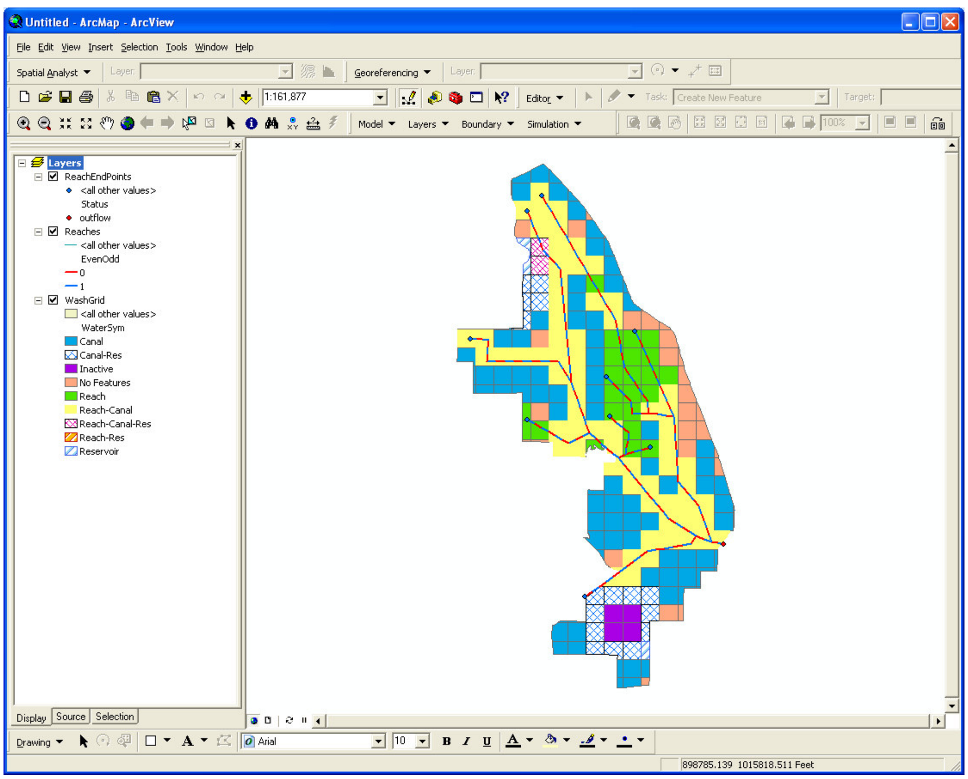
4.8

The view of the Primary Reach and reach endpoints will need to be refreshed separately, if the reach has previously been generated. Under the Layers Menu, the reach network option can be chosen and the following menu will appear. The Show/Hide option is a toggle switch that can be used to turn the layers on or off. The Remove option will delete the Primary reach and its associated endpoints. If this feature is employed, the primary reach will need to be added back into the model.



4.9

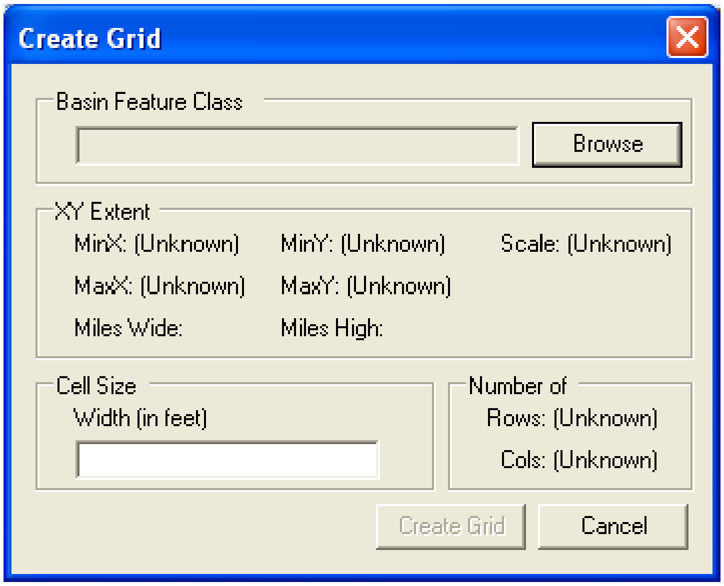
Once the Show/Hide button is selected, the model will appear as below.



4.10

4.1.3 Defining Grid Extents/ Grid Domain

The model grid generation is the first configuration operation for all new models. The WaSh GUI grid generation tool is accessed from the New Model menu by selecting the continue button at the bottom of the menu. When selected, the following menu appears:



4.11

The GUI will first define the vertical and lateral extent of the grid using the polygon representing the basin boundary. Click the "Browse" option to undicate the location of the basin boundary (i.e., primary basin or watershed boundary) shapefile. The basin shapefile should contain the following fields, which are listed with the field type. Additional fields are optional.

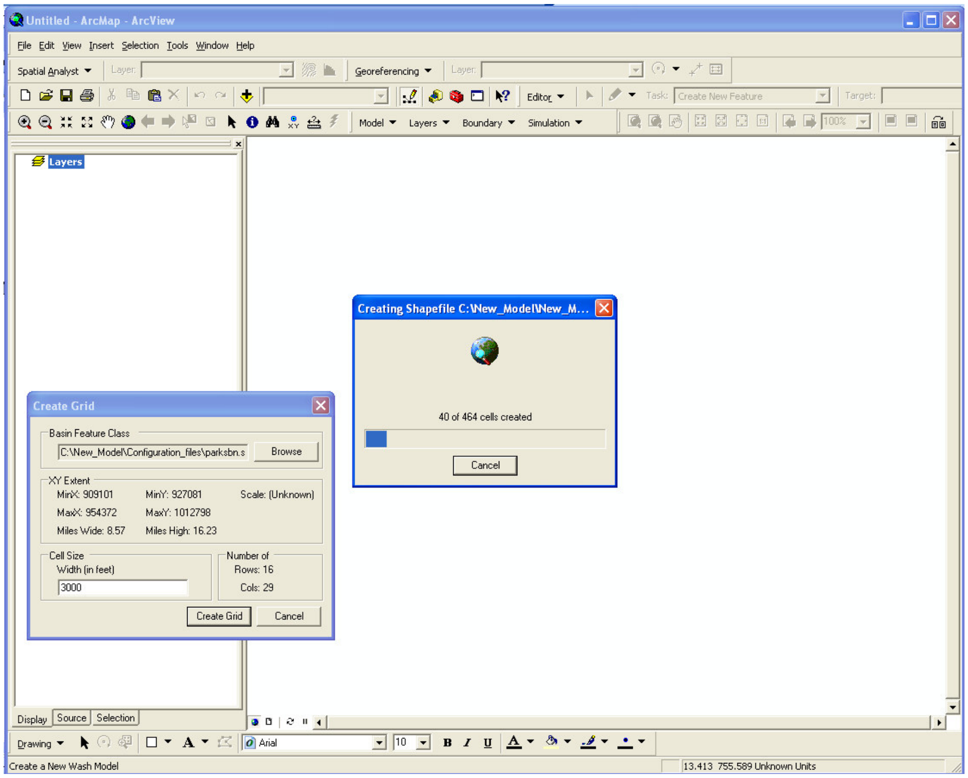
Field Name	Field Type
FID	Object_ID
Shape	Polygon
Area	Double
Basin	Text

The WaSh GUI will automatically calculate the geographic extent of the boundary. After the extents are calculated, they will be displayed in the "XY Extent" box on the screen.

Next, the grid cell size must be specified. Square cells are used in the model, and the cell size should be selected to provide sufficient representation of spatial variations in the watershed, while at the same time considering the effect of the total cell count on the simulation speed. Clearly this optimization requires some experience. However, as a guideline, a cell with 500 ft edge lengths to 2000 ft edge lengths are typically used. Also, it is typical to use about 2000 to 3000 cells to represent a 100,000 acre basin.

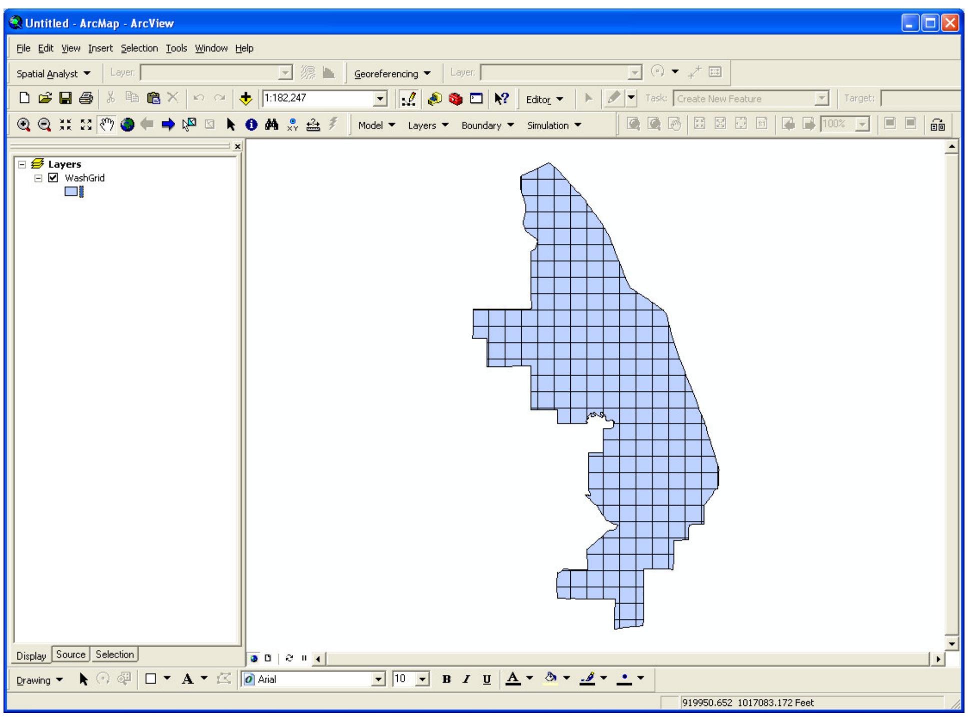
After entering a cell size, the number of rows and columns will automatically be populated, indicating the number of cells that comprise the grid. Different values can be entered into the Cell Size box until the desired number of rows and columns is obtained. Note that this cell count includes all cells in the rectangle defined by the grid extents. It is likely that some cells will not be used since they will lie outside the boundaries of the basin polygon.

When the final cell size is chosen, select the Create Grid feature. The Grid domain will then be generated. This operation may take several minutes. The screen will appear as:



4.12

When the grid is generated, it will look like the following.



4.13

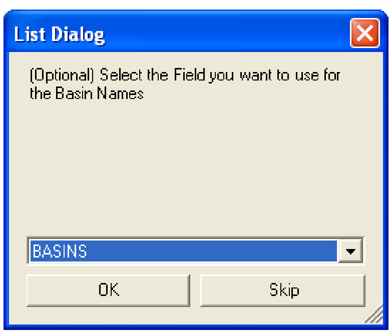
Once the grid is generated, each cell in the model grid can be assigned a basin and sub-basin ID. This ID is not used explicitly in the model simulation but does provides two important functions:

(1) it helps guide the user in specifying overland flow directions when the topography data is too coarse or the terrain is flat and (2) in post-processing it is often useful to average conditions over sub-basins. The basin ID is not used either, and is provided for informational purposed only.

In order to assign subbasin IDs to the model, a shapefile must be used for grid generation whose polygons are defined by the subbasin boundaries. An additional column in the shapefile containing the basin names will help to identify the basin names for each subbasin.The subbasin shapefile should contain the following fields, listed with the appropriate field type. The field names may vary, but the content is the important attribute. Any additional fields are optional.

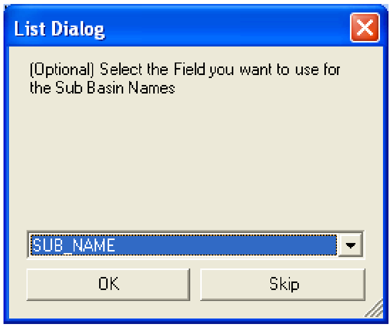
Field Name	Field Type
FID	Object_ID
Shape	Polygon
Area	Double
Basin	Text
Subbasin	Text

The GUI will provide a drop down menu with the field names in the shapefile and expect the user to select the field containing the Basin ID. The basin ID is not explicitly used in the model simulation and is only provided for informational purposes. This designation is optional and you may choose the "Skip" button to proceed without identifying the basin name field.



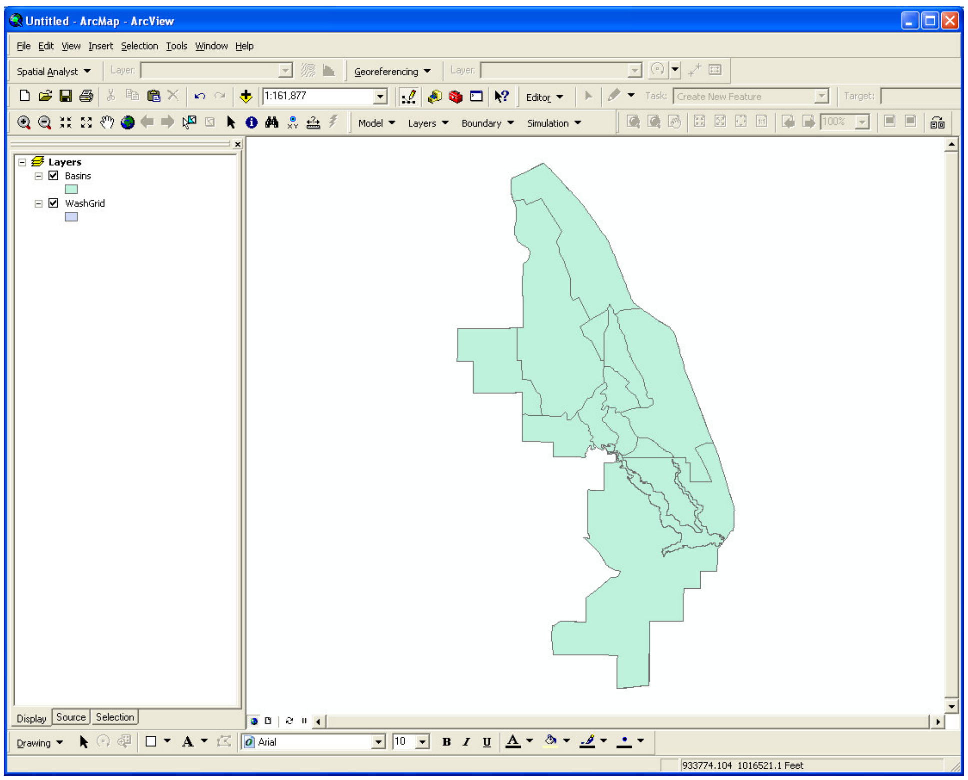
4.14

The same prompts are then provided for the sub-basin ID. Designation is also optional and the user may chose the "Skip" button to proceed without identifying the subbasin name field. If the user decides to provide the subbasin ID, then the field name will need to be selected from the drop down list.



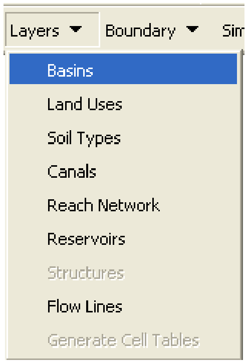
4.15

After the subbasins have been mapped unto the grid, the following screen will appear.



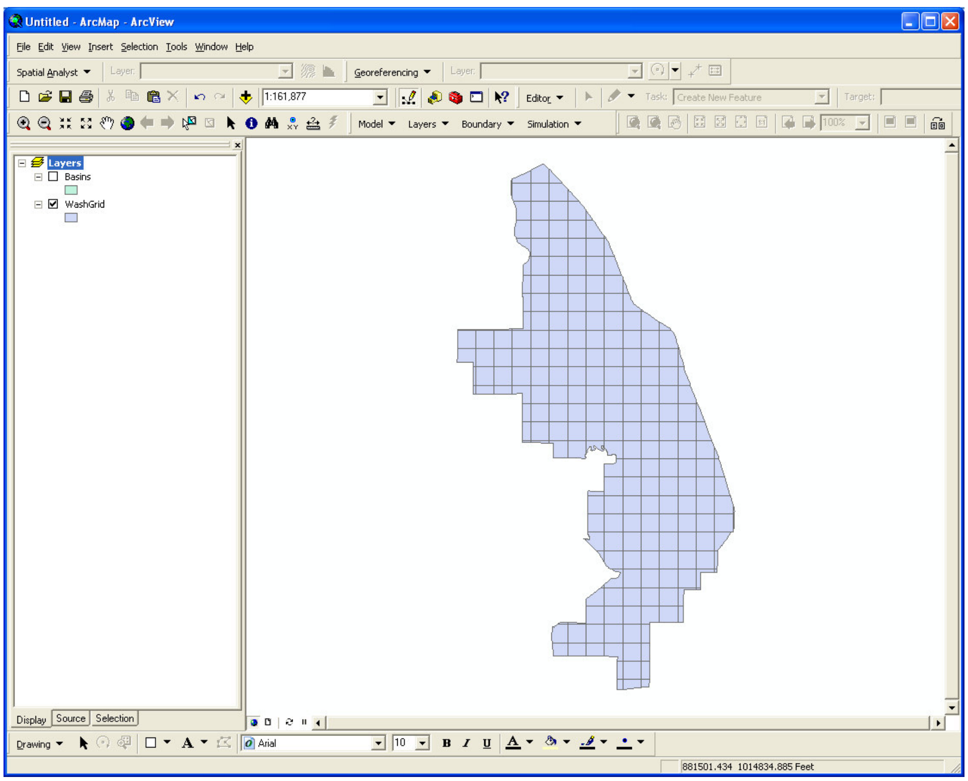
4.16

The basin or subbasin shapefile used in grid generation will be added to the map as the top layer. The layer can be removed from the Arc session by accessing the basins option under the Layers menu.



4.17

By selecting the “Basin” option, a toggle switch will remove the Basin layer from the screen and the screen will appear as in the following figure.



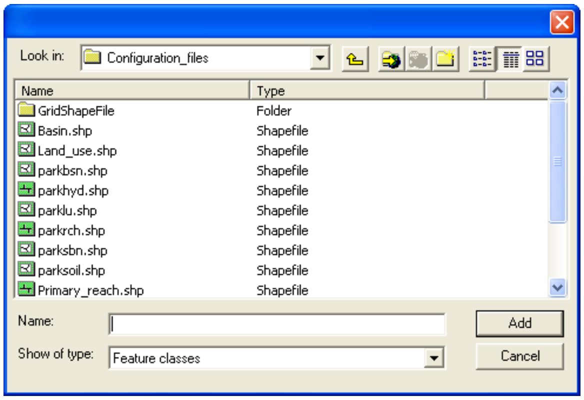
4.18

Once the grid is created it can be saved and accessed using the open model menu option. The remaining model configuration tools are accessible through the Layers menu option located in the WASH GUI Toolbar.

4.1.4 Assigning Land Use

Each active cell in the model requires the designation of land use. The land use is primarily used to select model parameter values for representing hydrologic and water quality processes in the model simulations. The tools needed to specify the cell land use are accessible from the Layers menu, by choosing the Land Use option.

Upon selection, a windows navigation screen appears prompting the user to identify the shapefile containing the land use data.



4.19

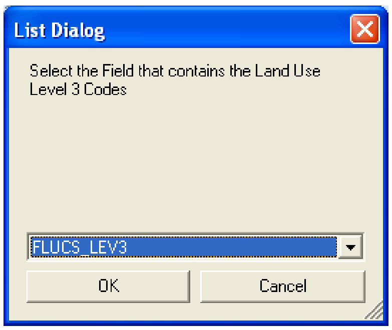
The selected land use shapefile should contain the following fields, listed with the appropriate field type. The field names may vary, but the content is the important attribute. Any additional fields are optional.

Field Name	Field Type
FID	Object_ID
Shape	Polygon
Area	Double
FLUCS_LEV1	Long
FLUCS_LEV2	Long
FLUCS_LEV3	Long
FLUCS1_DES	Text
FLUCS2_DES	Text
FLUCS3_DES	Text

For use in the WaSh model, land use can currently be assigned at Levels 1, 2 or 3. The choice for this option depends on the level of detail that the model is expected to resolve as well as the data that is available. Once the shapefile is identified, the user is prompted to indicate the level designation in the following screen. In this example, Level 3 has been chosen.

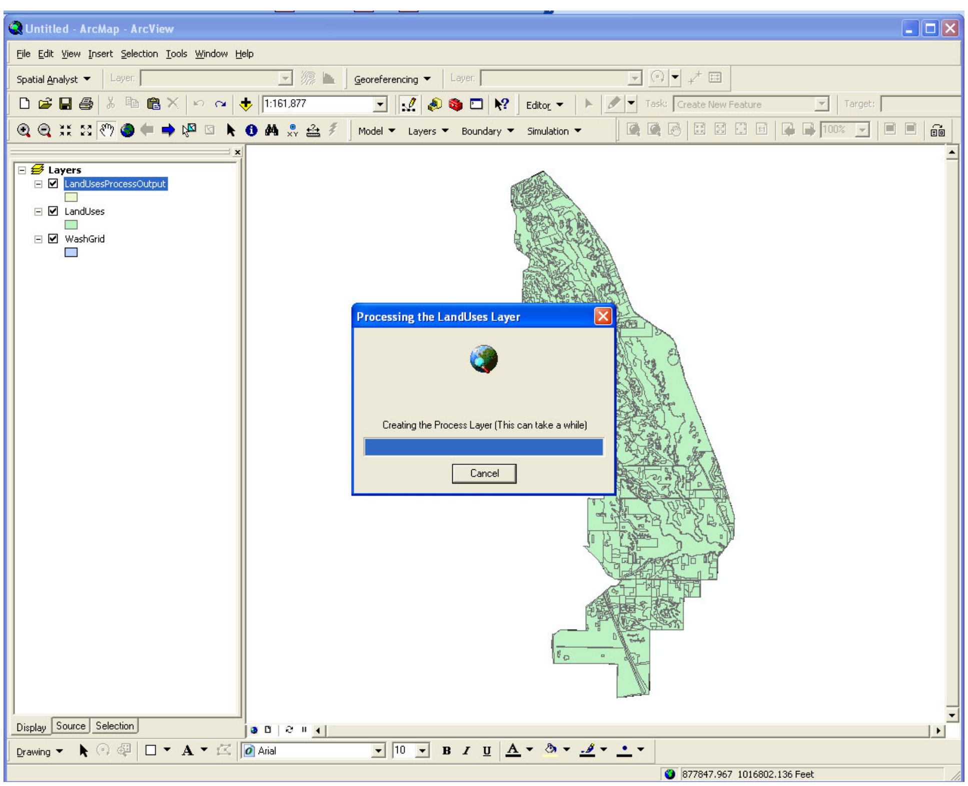
4.20

The selected Land Use level chosen above will then need to be referenced to the appropriate field in the land use coverage, in the following screen. The user selects form the list the appropriate field.



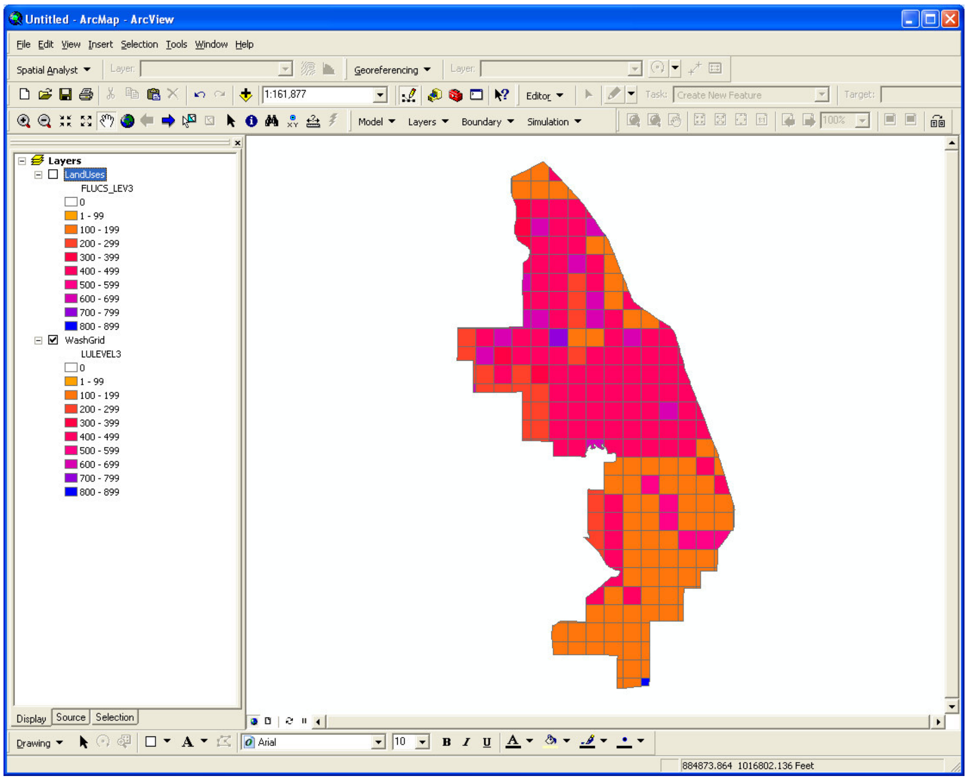
4.21

Clicking OK will begin the land use attribute mapping on to the grid cells. The following screen will appear during this process.



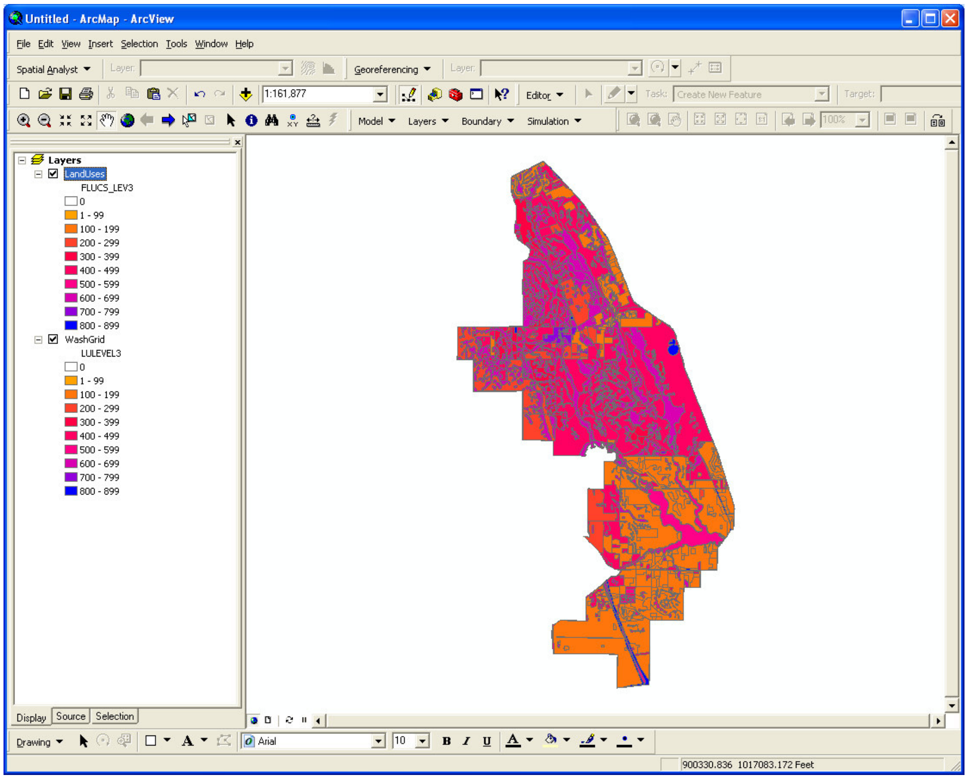
4.22

When the land use has been mapped onto the grid, the Legend Change option under the Model menu can be used to color-code the grid based on the Land Use. The default color legend colors the land use based on Level 1 land use codes. The color legend can be altered to represent a finer scale of discrimination.



4.23

In order to compare the land use representation based on the model grid to the GIS data, the color legend of the land use GIS shapefile has been matched to that of land use attribute of the Model grid.



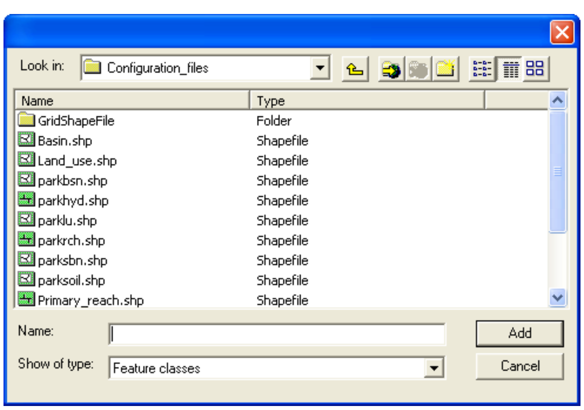
4.24

Land use attributes are assigned based on the dominate land use within each grid cell. The potential exists for the under-representation of smaller land use polygons. Manual changes to the land use can be made in the WaSh GUI editing menus and is described later in this manual.

4.1.5 Assigning Soil Type

Each active cell in the model requires the designation of soil type. The soil type is primarily used to select model parameter values for representing hydrologic and water quality processes in the model simulations. The tools needed to specify the soil type are accessible from the Layers menu, by choosing the Soil Type option.

Upon selection, a windows navigation menu will prompt the user to specify the path to the correct soils shapefile. Soils files are typically derived from generalized soils maps produced by the Department of Agriculture's Soil Conservation Service.



4.25

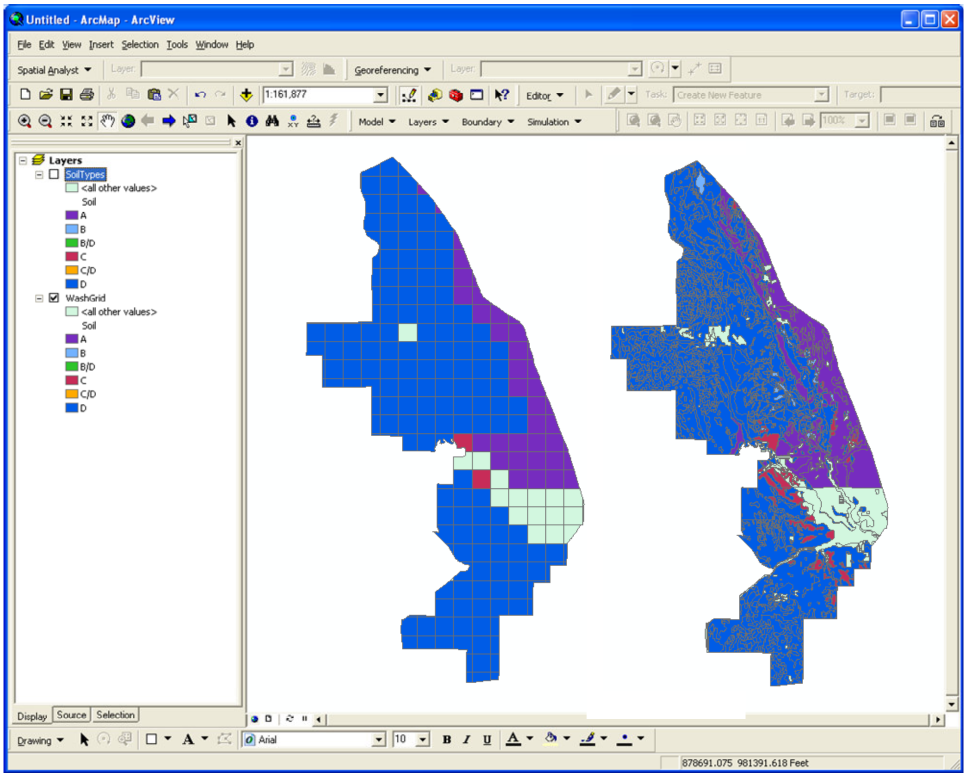
The selected soils shapefile should contain the following fields, listed with the appropriate field type. The field names may vary, but the content is the important attribute. Any additional fields are optional.

Field Name	Field Type
FID	Object_ID
Shape	Polygon
Area	Double
HYDGRP_C	Text

After choosing the soils file, WaSh will ask if you to define the field to use for soils type attribution.

4.26

Once the field is selected, the GUI will assign the soils type to each cell using the spatial data in the shapefile. The figure below is an example of the completed process (grid on left) as compared to the input soils file (grid on right).



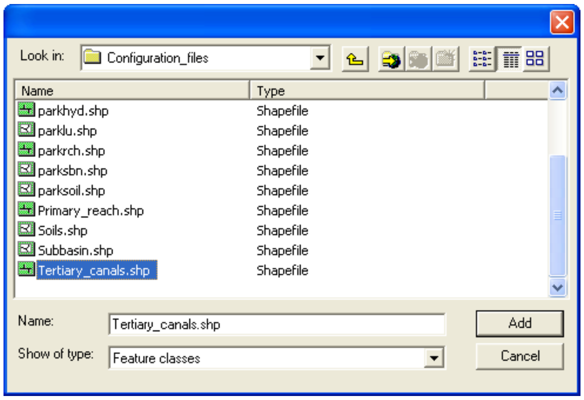
4.27

4.1.6 Delineating Surface Hydrography

Surface hydrography in the WaSh model is intended to represent rivers, estuaries, streams, creeks, primary, secondary and tertiary canals. In many coastal zones as well as in low lying or flat terrain, dense networks of small local canals have been constructed to help drain the land and/or irrigate cropland. These systems are designated as tertiary systems in the WaSh model. Often, it is not desirable to represent every single canal in these local systems because such an approach would lead to extremely large number of discrete model segments and consequently very long times for completing a simulation. However, it is still desirable to represent the basic storage and flow characteristics of these local tertiary canal systems. In the WaSh model, the surface hydrology can be divided into a tertiary system and a primary reach system. Each system is represented differently in the simulation. The primary reach system is represented using the 1D hydrodynamic simulation and is intended to represent the major rivers, streams, canals and other flow conduits. The tertiary canals are represented as a cell attribute as the total length of tertiary canal in the cell. Other cell attributes for the tertiary canals are also provided, such as the width, the bottom elevation, and the method by which the canals are operated (i.e. pumps or weirs). These parameters are accessed through the WaSh GUI edit menus and are described later in this manual.

4.1.6.1 Tertiary Canals

The mapping of tertiary canal properties onto the model grid is optional, but if they are mapped, they need to be mapped prior to the mapping of the primary reach. The WaSh GUI tools needed to map the tertiary canal lengths onto the model cells is accessible from the Layers menu by choosing tertiary canals option. The GUI will then provide a windows navigation screen prompting the user to identify the shapefile with the tertiary canal data.



4.28

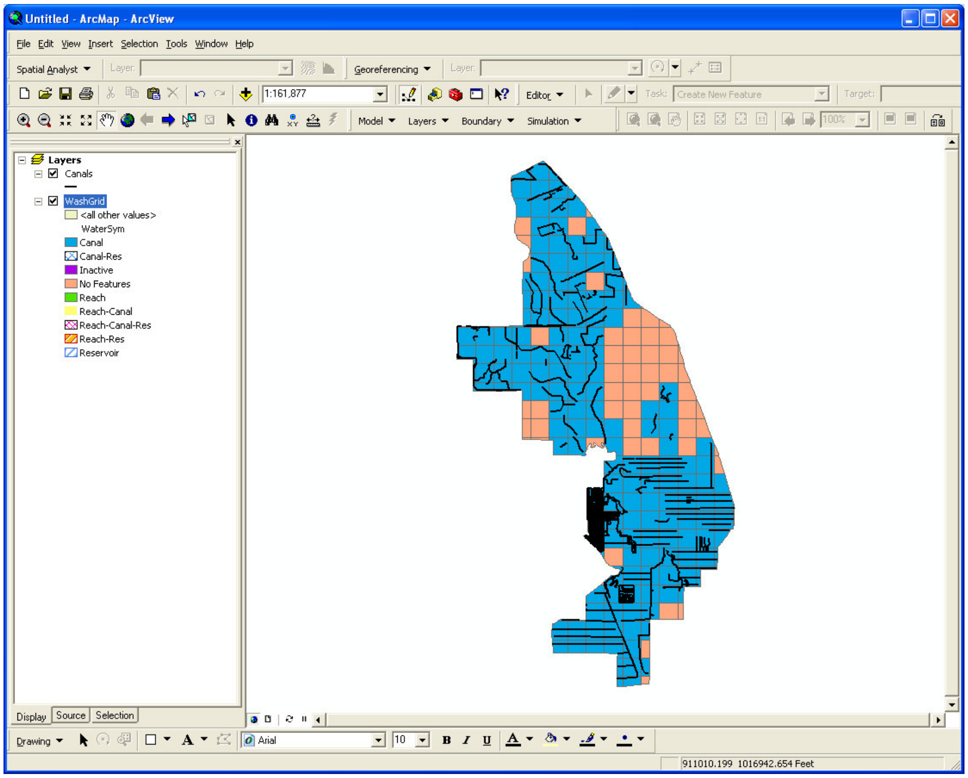
The selected tertiary canal shapefile should contain the following fields, listed with the appropriate field type. The field names may vary, but the content is the important attribute. Any additional fields are optional.

Field Name	Field Type
FID	Object_ID
Shape	Line
Length	Double
Name	Text

After the file is selected, the user has two options to identify the polylines in the shapefile that are to be mapped, and the options are shown in the figure below. If all of the polylines are to be used, the "Use Original" menu options should be selected. If an attribute field has been created in the shapefile to identify the tertiary canal polylines, then the user should select the field name from the drop down list. The GUI will only use the polylines with a non-null value in the selected attribute field.

4.29

Once the mapping approach is selected, the GUI will calculate the total length of all 'tertiary' polylines within the each cell. The cell will be labeled as a 'canal' cell and the canal length will be stored as a cell attribute. The following figure illustrates the results of the mapping process. The original tertiary canal hydrography polylines from the shapefile are shown in black. Each model cell that has been attributed with tertiary canals is color-coded to reflect the water feature legend. The hydrography coverage is included to indicate cells which are attributed as canal cells. All cells colored aqua include a polyline from the hydrography coverage. An inspection of the attribute table associated with the model grid would reveal non-zero lengths for the tertiary canal attribute.



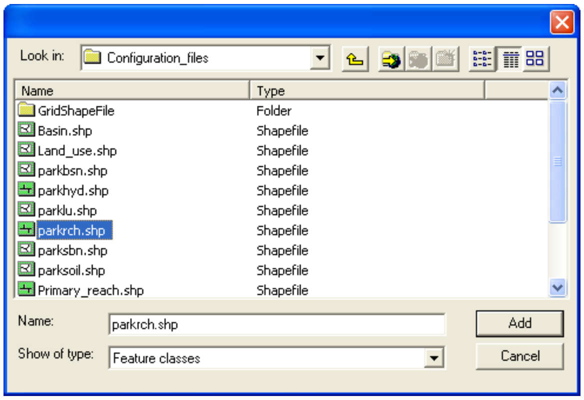
4.30

The designation of the cells as ‘canal’ cells that resulted from this mapping procedure is one of a number of cell designation used in the WaSh model. The specification of other cell designations and their role in the model simulation are described later in this manual.

4.1.6.2 Primary Reach

The Primary Reach Network is the digital representation of the primary reach system and should include the major drainage features of the basin. The Primary Reach Network typically represents major rivers, canals and estuaries. The digitized primary reach should be complete enough to identify the general basin flow without being so detailed that processing time is sacrificed. Likewise, the reach segment length is also an issue when configuring the model. Shorter reach lengths will generate more reach segments and more processing.

The WaSh GUI tools needed to create the primary reach network are accessible from the Layers menu by choosing reach network option. The GUI will then provide a windows navigation screen, prompting the user to identify the shapefile with the primary reach data.



4.31

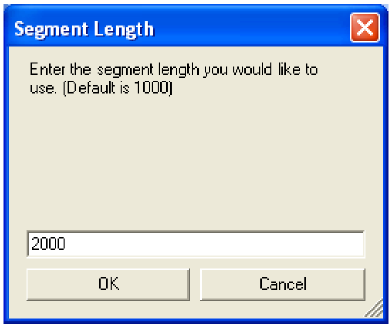
The selected Primary Reach shapefile should contain the following fields, listed with the appropriate field type. The field names may vary, but the content is the important attribute. Any additional fields are optional.

Field Name	Field Type
FID	Object_ID
Shape	Line
Length	Double
Name	Text

After the file is selected, the user has two options to identify the polylines in the shapefile that are to be used to construct the primary reach network and the options are shown in the figure below. If all of the polylines are to be used, the "Use Original" menu options should be selected. If an attribute field has been created in the shapefile to identify the tertiary canal polylines, then the user should select the field name from the drop down list. The GUI will only use the polylines with a non-null value in the selected attribute field.

4.32

Next, the reach segment length must be designated. A default value is provided, which is 1000 feet. However, the user has the options to change this value. Typically, the reach segment length should be about the same as the length of on the grid cell edge.

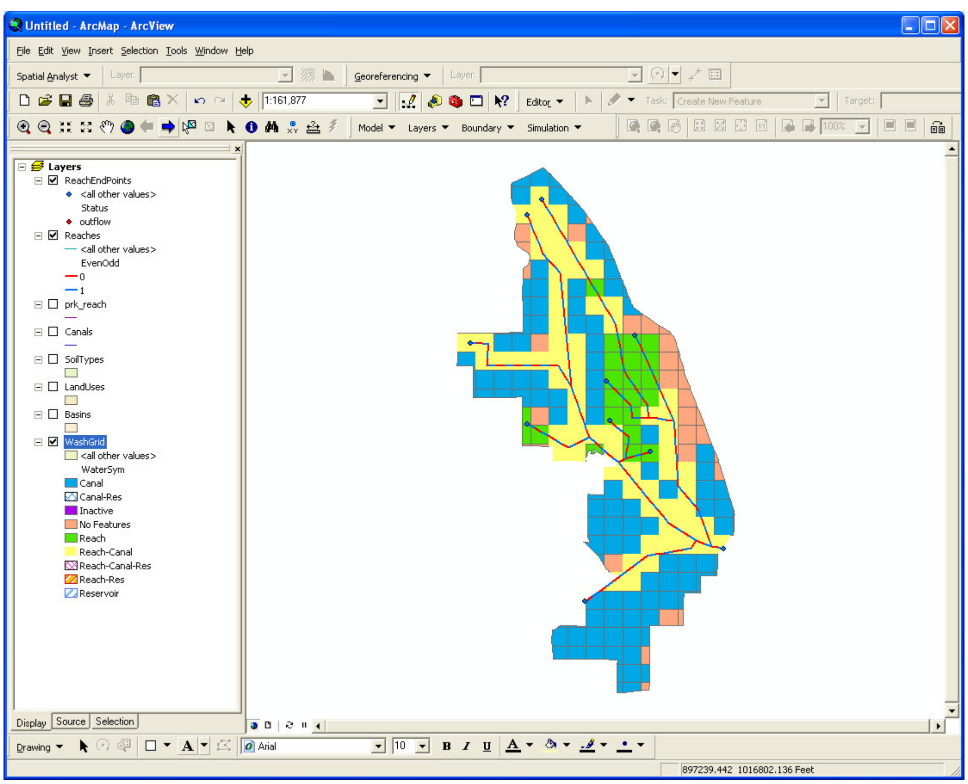


4.33

When done, the GUI will process the polyline data and generate the primary reach network. The WaSh model supports a fairly general configuration, with unlimited branching, confluences and end points within the network.

In addition to generating the reach segments and their connectivity, the GUI will also identify the cells that intersect each reach segment. Cells that directly intersect a reach are labeled as 'reach cells' and that attribute is stored in the grid file. This cell attribute is one of a number of cell designation used in the WaSh model. The attribute is used in the model to indicate how cell surface water and groundwater is exchanged with the reach network. The specification of other cell designations and their role in the model simulation are described later in this manual.

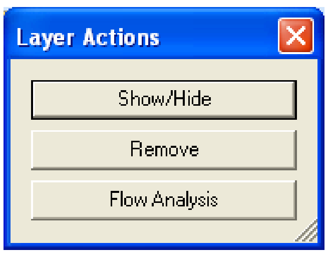
When the Primary Reach is attributed onto the WaSh model grid, the basin legend will then alter to appear as the figure below. Grid cells which contain segments of the primary reach are colored green, while cells containing both reach and canal segments are colored yellow. The primary reach is presented in alternating colors for help in identifying the endpoints of each reach segment. The endpoints or joints will be important later in model configuration, as structures and other features must be placed at reach segment joints.



4.34

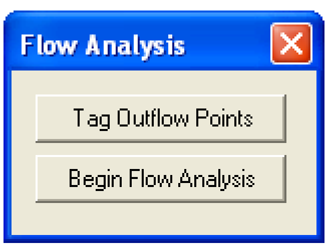
A last step in completing the reach network configuration is specification of the reach network endpoints. The WaSh GUI automatically identifies the end points of the entire network. These endpoints may represent upstream headwaters, upstream ends of canals or the downstream basin outfall(s). Multiple outfalls can be supported in the WaSh model.

The WaSh model needs to uniquely identify and order the segments in the reach network. This is done by selecting one of the end points and initiating the numbering or “flow analysis”. The selected endpoint will be segment 1, and the numbering will continue up the reach network until all reach segments are numbered. The segment ordering is not important for the user, but is a necessary attribute in the model configuration. The numbering process is initiated by first identifying the end points and the invoking the WaSh GUI tool that creates the numbering. The required tools can be accessed from the Primary Reach option in the Layers menu. The “Layer Actions” option is now available, since the reach network has been created. From the Layer Actions screen, the reach network view can be turned on or off, the reach can be removed entirely, or the user can choose to perform “Flow Analyis”.



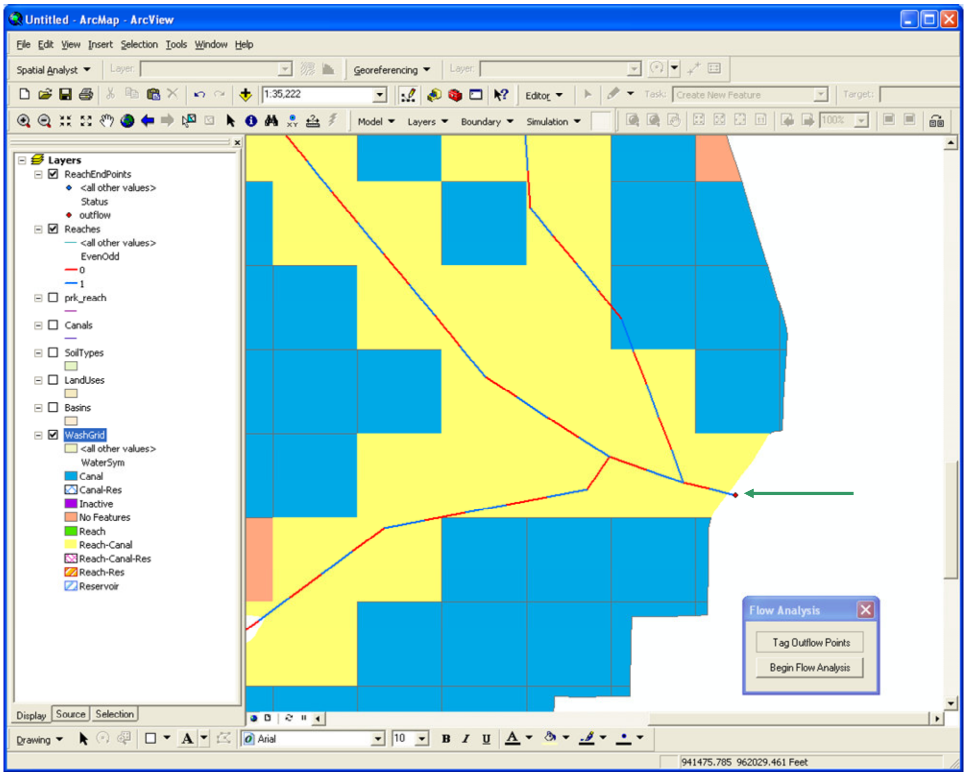
4.35

Choosing the Flow Analysis button directs the user to the following screen. The “Tag Outflow Points” option will allow the user to designate any endpoint in the reach network. When an endpoint has been selected, flow analysis can be initiated and all reach segments will be assigned an ID. Typically, the chosen point would be the basin outfall. However, when there are multiple endpoints, the user can arbitrarily choose any one of them to begin the numbering sequence.



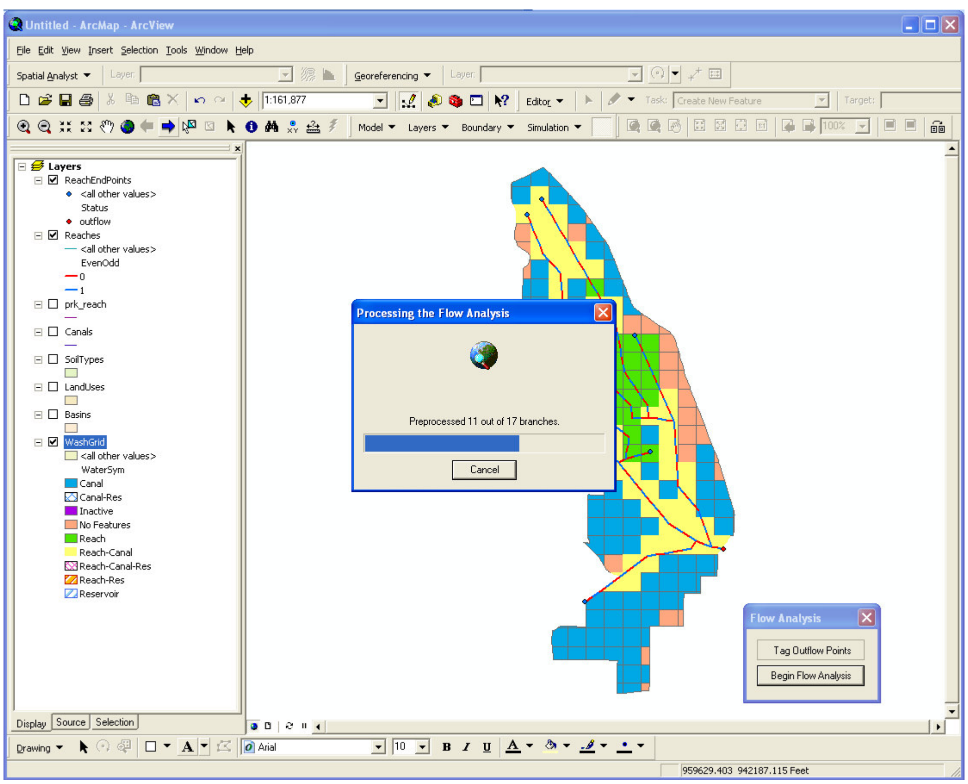
4.36

Once the end point is selected, the numbering process is invoked. In the following figure, the endpoint in the sample model turns from blue to red, indicating its identification as the starting point for the segment numbering.



4.37

Finally, a flow analysis must be performed to insure that the reach is stable, consistent and directing the flow in a logical manner in the model. By clicking the "Begin Flow Analysis" button, the model will process the analysis and the following screen will appear.



4.38

This process represents a QA/QC on the reach network segment numbering and will identify any problems and report them to the user.

Any flow control structures or flow boundary conditions associated with each reach network endpoint are specified in the structures menu or in the boundary conditions menu. If water quality simulations are specified, then water quality boundary conditions may also need to be specified. These options are discussed later in this manual.

4.1.7 Overland Flow Paths

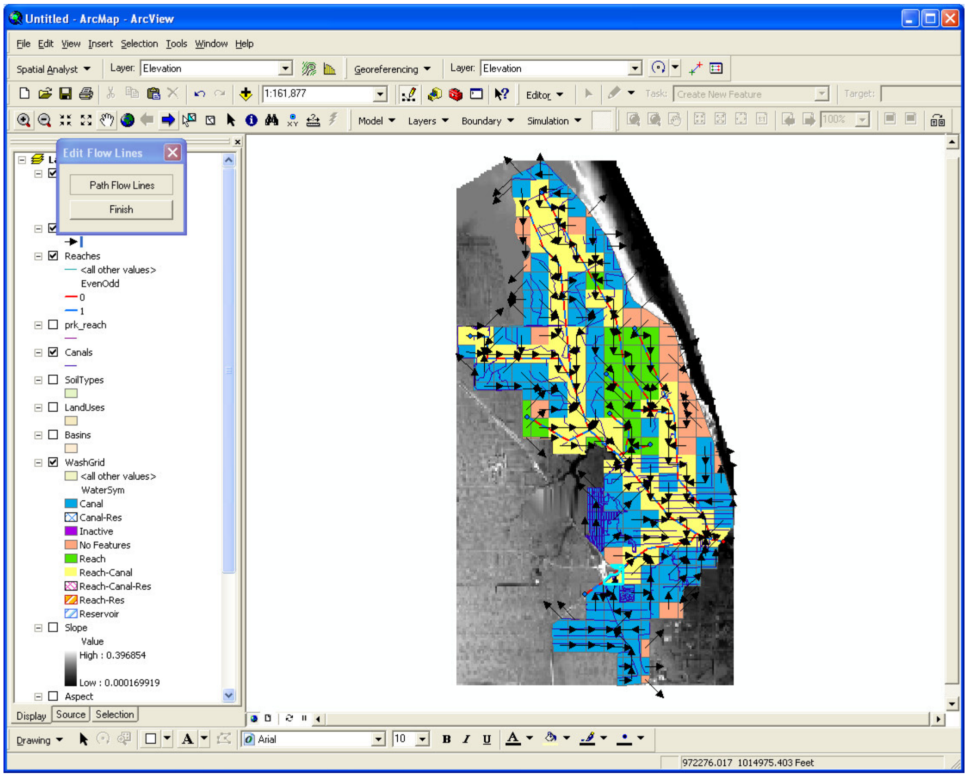
The WaSh model also represents the overland runoff by routing surface discharges from cell to cell. Overland flow is designated by cell-to-cell connections which guide the direction that runoff is routed. The flow continues from cell-to-cell until it reaches a surface water body, either cells with tertiary canals, a segment of the reach network or a reservoir. The WaSh GUI provides a tool that estimates the overland flow paths based on topographic gradients. This tool uses the topographic gradients to direct drainage of surface water to the neighboring down-gradient cell.

In many circumstances, the flow paths developed using the gradient approach do not provide accurate or even reasonable flow paths. This might occur on flat terrain or when the overland flow is obstructed by roads and other land features not represented in the DEM. The WaSh GUI provides a additional tool which allows the user to redirect the initial flow paths developed with the gradient tool. The manual tool can be used to adjust the flow routing to better represent the system.

4.1.7.1 Mapping Topography from a DEM

The WaSh GUI tool that sets the initial flow paths can be accessed from the Layers menu by choosing the “Flow Lines” option and indicate the digital elevation map or data to use for the model. The GUI will initiate any data conversions necessary and the calculate elevation, aspect and slope for each grid cell, based on the predominant DEM data within each cell. A flowline shapefile will be created. By changing the legend from simple line segments to arrows, the direction of flow can be illustrated as it is interpreted by the WaSh Model.

To change the legend of the Flow Lines, double-click on the line symbol in the legend. A Symbol Selector menu will appear. Choose the “Arrow at end” symbol by scrolling to the bottom of the default ESRI symbol line options. The following figures illustrates the flow lines shapefile, indicating the cell-to-cell flow pathing generated by the WaSh model.



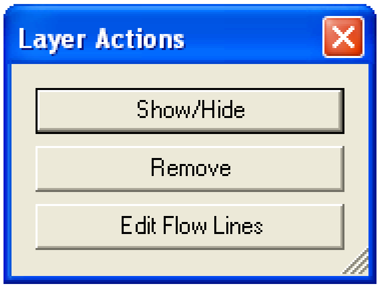
4.39

4.1.7.2 Redirecting Flow Paths

Note the cells at the edge of the model with arrows pointing out and away from the grid. Due to the flat terrain characteristics of this example and the intense canal network, the model can overlook certain hydrologic and anthropogenic features, resulting in the generation of inaccurate flow paths. With the secondary basin boundaries and hydrology coverage as guidelines, flow directions can be manually realigned using a WaSh GUI tool to provide an accurate representation of the actual overland drainage patterns.

Often the flow path is interrupted by boundary cells, which are only partially active within the grid domain. Border cells essentially contain “ridges” directing flow in opposite directions into different drainage basins. Therefore, when the majority of a grid cell is draining into another basin, the flow path will represent the path of dominant flow. In order to direct flow in the proper direction for the remaining, smaller section of the grid cell, the grid cell will require flow path editing. Additionally, canal networks, road construction and urban build-up can alter drainage, necessitating the need to redirect flow paths generated by the WaSh GUI gradient tool.

To edit flow lines and change the direction of drainage for a particular cell, choose the Flow Lines option from the Layers menu and click the Edit Flow Lines button.



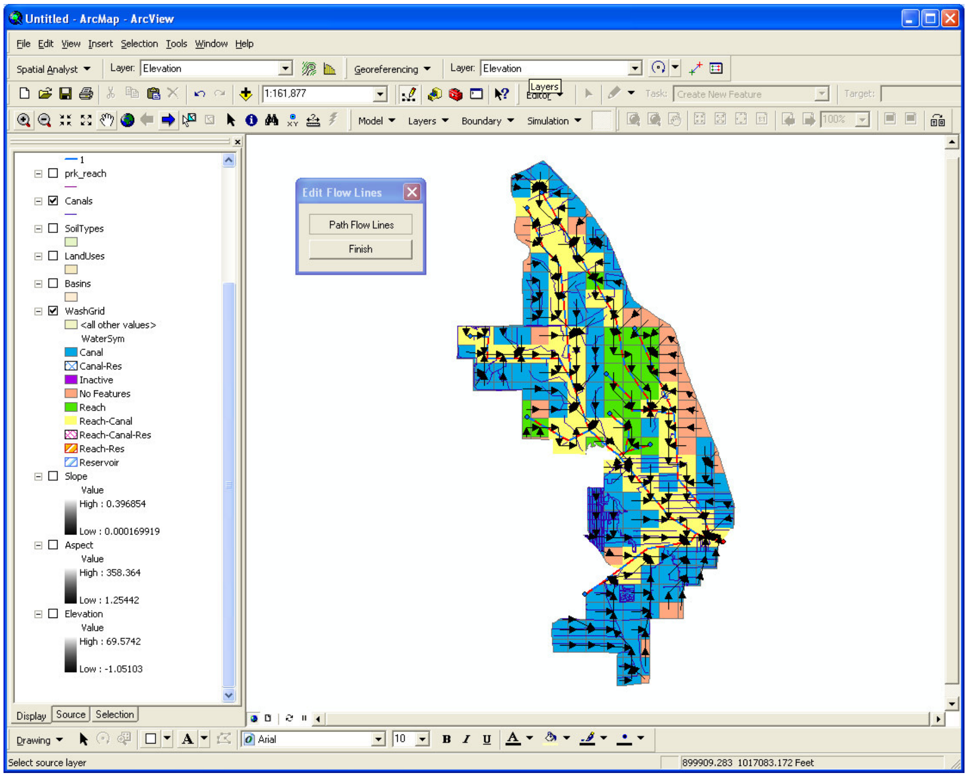
4.40

The following screen will then appear.

4.41

Clicking the "Path Flow Lines" button will activate the flow line editing tool. Start by clicking on a cell FROM which you want the flow to originate and then click on the cell TO which you wish the flow to go. Flow paths can be edited one line segment at a time or as a string. To edit a single cell, click on the original cell and then double click on the destination cell. The flow path arrow will be aligned in the chosen path when the operation is completed. To edit a string, single click from cell-to-cell in the chosen flow path. With each successive click the flow line arrow will orient with the chosen path. To end an edit path, double click in the destination cell. Activating the hydrology and primary reach shapefiles will assist in achieving flow paths as accurately as possible, especially in areas with a dense canal network.

When the basin flow paths are corrected, select the "Finish" button. The grid will look similar to the figure below. At this point, the flow lines shapefile may be turned off. The chosen flow paths have already been amended in the grid file.



4.42

4.2 OPTIONAL MODEL FEATURES

Several parameters are optional features in the WaSh model. These features can offer substantial refinement to a watershed model, although they are not essential to its operation. Such parameters include the addition of reservoirs and structures.

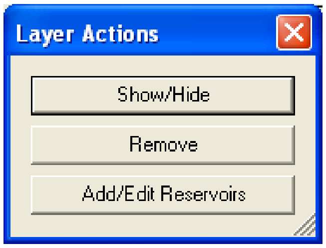
4.2.1 Reservoirs

Reservoirs represent the volume of water that remains in the hydrodynamic system as storage and it is essential to representing accurate water budgets. Reservoirs can exist as natural or man-made water bodies. Examples of reservoirs include lakes, ponds, storm water retention and detention ponds, utilities holding ponds, and even canals regulated by control structures.

Reservoirs can be introduced into the model via a shapefile defining the aerial extent or by digitizing them directly in the GUI. Obviously, importing a shapefile can greatly increase the accuracy of the potential volume of the reservoir, but directly digitizing a reservoir can be an effective method for anticipating the potential storage capacity for planned construction for which design specifications are not available.

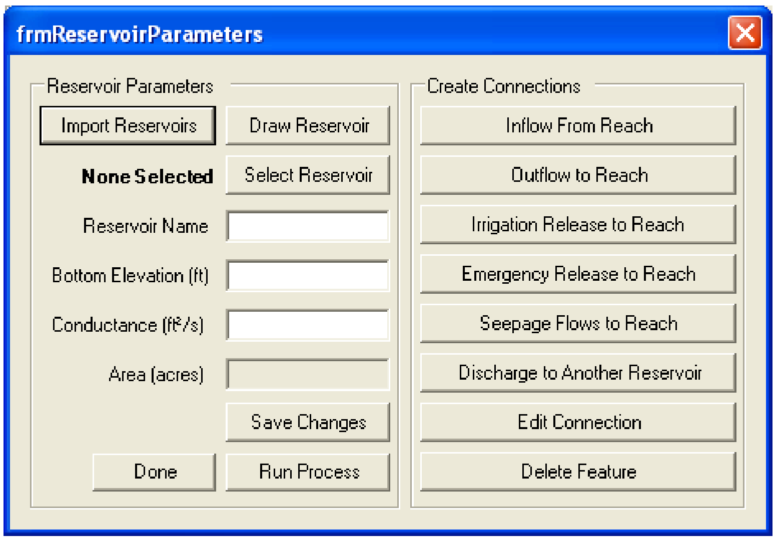
4.2.1.1 Adding a Reservoir Shapefile

From the Layers menu, the Reservoirs option can be chosen.



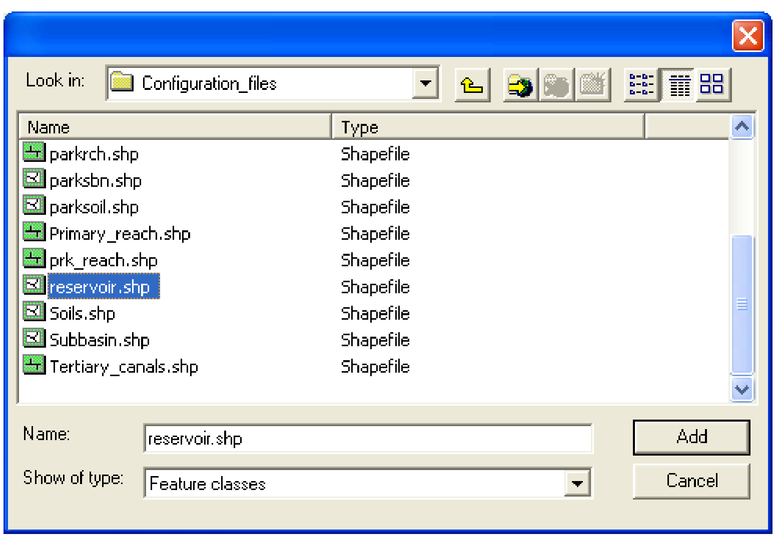
4.43

Choosing the Add/Edit Reservoirs option, and the following screen will appear.



4.44

To add a Reservoir using a polygon shapefile, click the "Import Reservoirs" button. The user may then browse and select the reservoir shapefile.

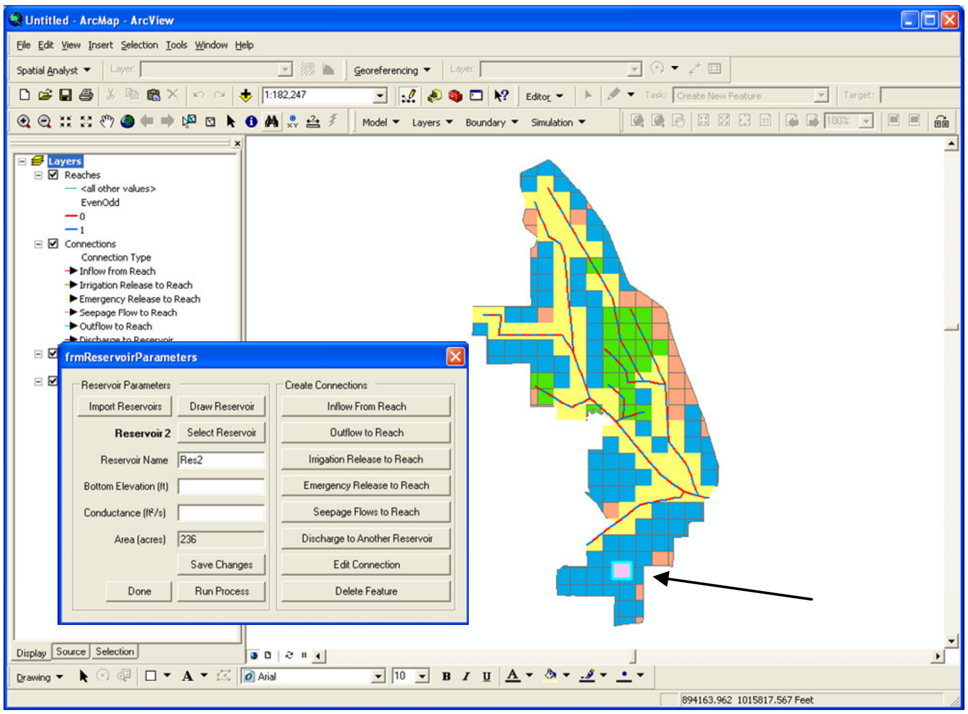


4.45

The selected reservoir shapefile should contain the following fields, listed with the appropriate field type. The field names may vary, but the content is the important attribute. Any additional fields are optional.

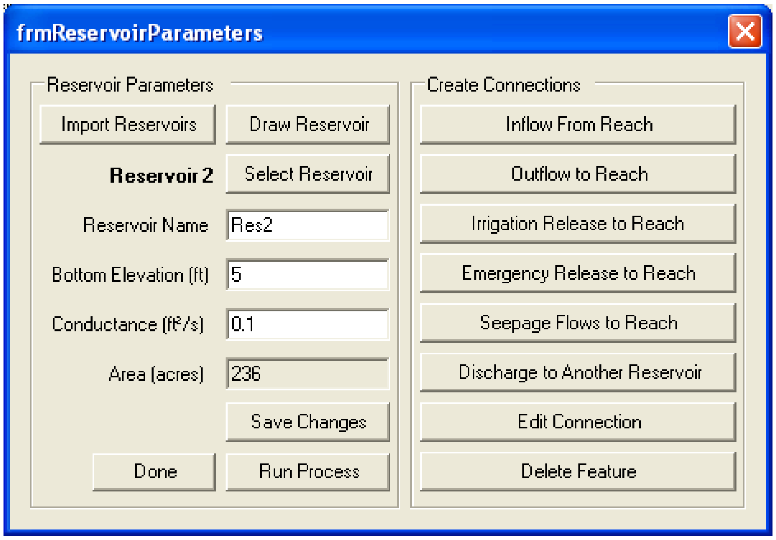
Field Name	Field Type
FID	Object_ID
Shape	Polygon
Area	Double
Name	Text

Each polygon contained within the shapefile will be visible in the model. Individual reservoirs may then be chosen and attributed by clicking the “Select Reservoir” button and selecting the reservoir polygon (black arrow in next figure).



4.46

The highlighted polygon will have the Acreage calculated and fields will be opened for edits, such as Reservoir name, bottom elevation, water elevation, and conductance.

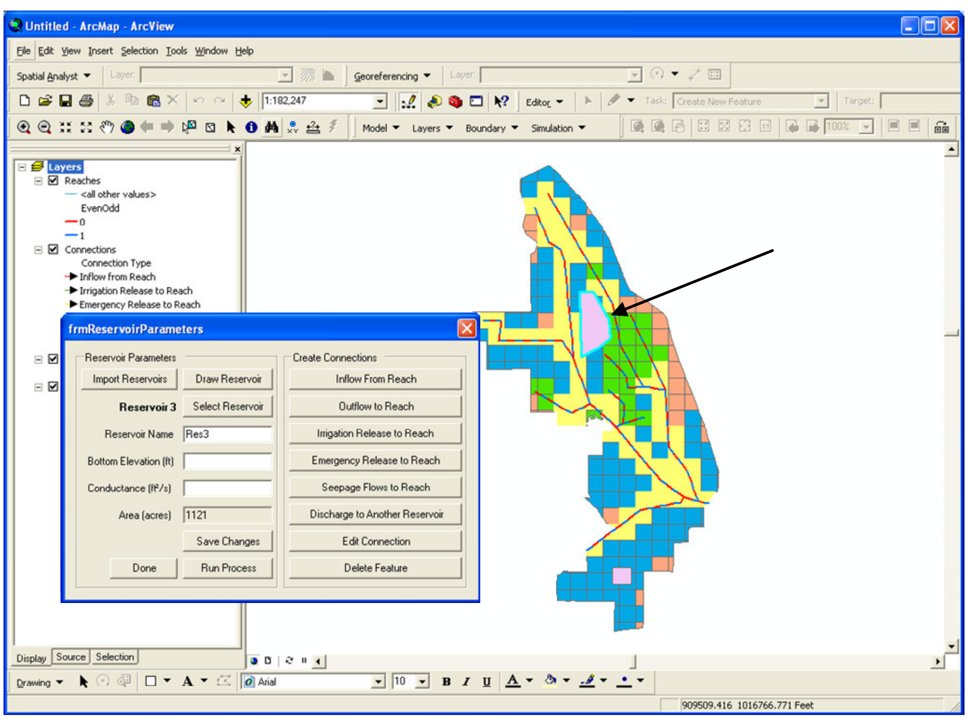


4.47

When the criteria are entered save changes and click the Done button. This will initialize the attribute changes to the grid file.

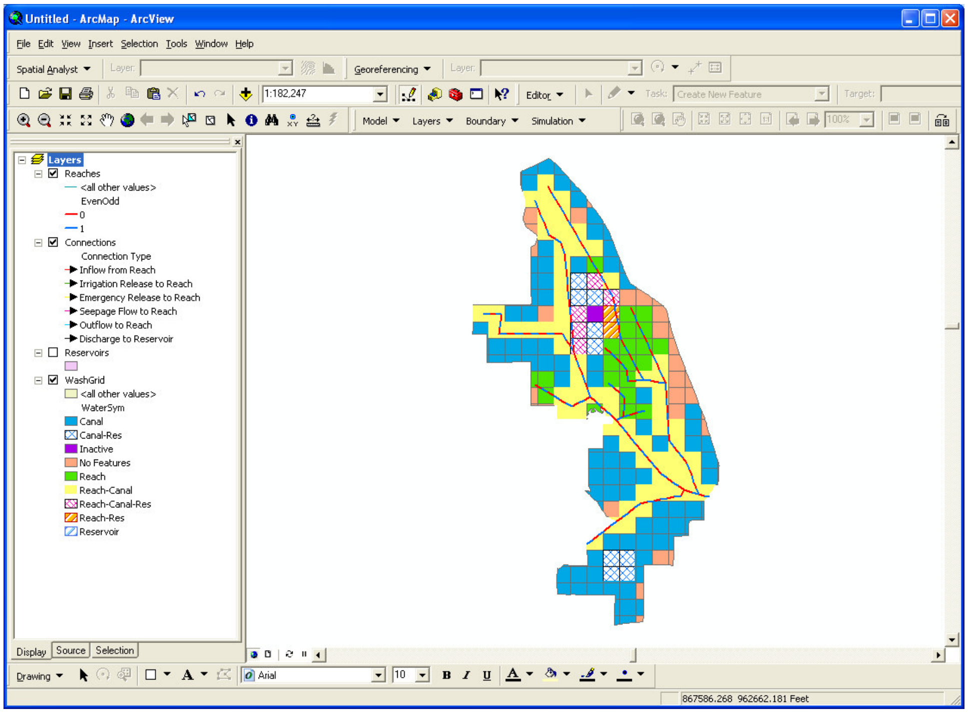
4.2.1.2 Digitizing a Reservoir

A reservoir can also be digitized into the model using the "Draw Reservoir" function. After clicking the "Draw Reservoir" button, use the cursor to draw the polygon outline of the desired reservoir. Double click to close the polygon. The new reservoir will be highlighted (black arrow) and ready to attribute with reservoir parameters.



4.48

After operations are completed, save changes and click the "Done" button, to process the water feature attribution of the grid file.



4.49

The water feature attributes will discriminate between cells that are strictly reservoir cells, those that contain reach and reservoir features, canal and reservoir features, and reach, canal and reservoir features.

4.2.1.3 Reservoir Attributes

Reservoir Attributes should be established after a reservoir is imported or digitized. Reservoir attributes include: Name, Bottom Elevation (ft), Water Elevation (ft), Conductance (ft2/s) and Acres. The reservoir acreage is automatically calculated when it is imported or digitized.

4.2.1.4 Reservoir Connections

After defining the dimensional parameters of the reservoir, connections can be made to and from the highlighted reservoir. Connections may include Inflow from the reach, Outflow to the reach, Irrigation release to the reach, Emergency release to the reach, seepage flows to the reach, and discharge to another reservoir. From this menu, connections can be edited and reservoir features can be deleted.

As an example, an inflow from the reach will be established for reservoir 1. By clicking the "Select Reservoir" button, highlighting the reservoir to edit, and selecting the "Inflow from Reach" option, the user will need to use the cursor to click on the segment of the reach from which flow will be diverted into the reservoir. The connection will be designated by an arrow from the reach into the center of the reservoir. Then, the following screen will appear. From this screen, the user can designate the percentage or portion of reach flow that will be directed from the reach and into the reservoir and also the critical flow rate.

4.50

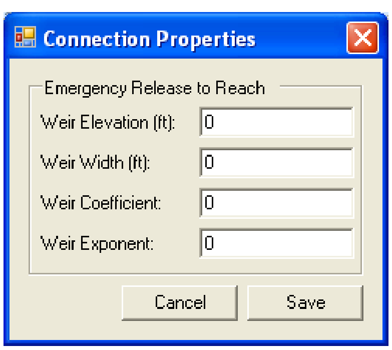
Outflow from the reservoir to the reach can also be mapped by clicking the “Outflow to Reach button. Using the cursor and selecting the reach segment to which reservoir flow will introduced back into the reach, the following menu will appear.

4.51

From this screen, the elevation, width, coefficient, and exponent for the weir controlling discharge from the reservoir can all be defined.

Alternative connections can be chosen to dictate the operational criteria for water release from a reservoir. The following operational criteria need to be added for each type of reservoir release connection:

emergency releases,

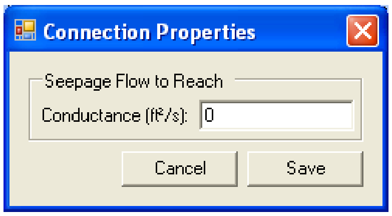


4.52

irrigational demands,

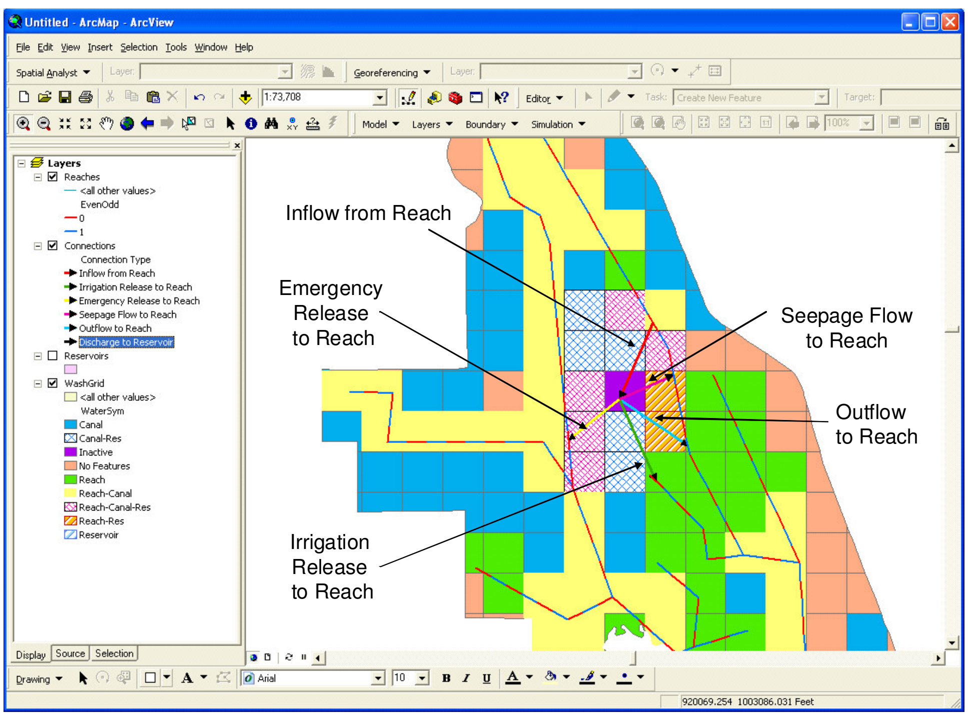
4.53

or seepage flow.



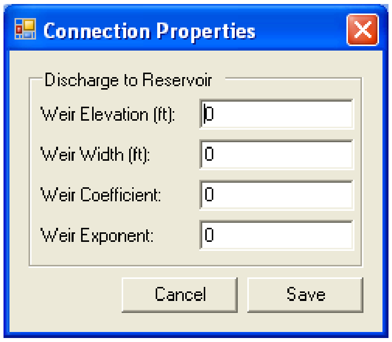
4.54

Examples of reservoir/reach connections are shown below.



4.55

Reservoirs can also be released into other reservoirs, based on the following criteria:



4.56

Reservoir connections can be edited to change operational criteria by choosing the "Edit Connection" option. Note that only the criteria can be changed with this command, but the type of release cannot be edited using this function. If the type of release needs reclassification from, for example, an Outflow to and Emergency release, the connection should be deleted with the "Delete Feature" option and the connection should be reestablished.

Governing equations for reservoir connections are listed in Section 7, WaSh Model Theory Documentation.

4.2.2 Structures

Structures consist of any feature that limits or restrict the flow from moving within the system, creating a storage element within the system, or from leaving the system as discharge. Structures can be added to any juncture along the reach network and at the network end points. Multiple structures can be applied at one juncture so that complex structural control on the flow can be represented.

4.2.2.1 Defining Structures

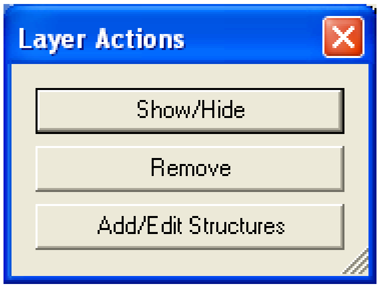
Structures that can be represented in the model are gates, culverts, weirs, or pumps. Below are descriptions of each type of structure and basic operational behaviors.

- Gate: rectangular structure opening at the bottom. Can set headwater and tailwater conditions for opening and closing and opening and closing rates
- Culvert: box or oval cross-section Can set length, bottom elevation, cross-sectional size and roughness
- Weir; sharp-crested feature. Can set width, crest elevation and weir coefficient. Crest elevation can vary monthly
- Pump: multi-directional pump. Can set pumping rate, headwater and tailwater conditions triggering starting and ceasing of pumping.

Defining equations for structure operation and model parameters are located in Section 6.4, WaSh Model Theory Documentation.

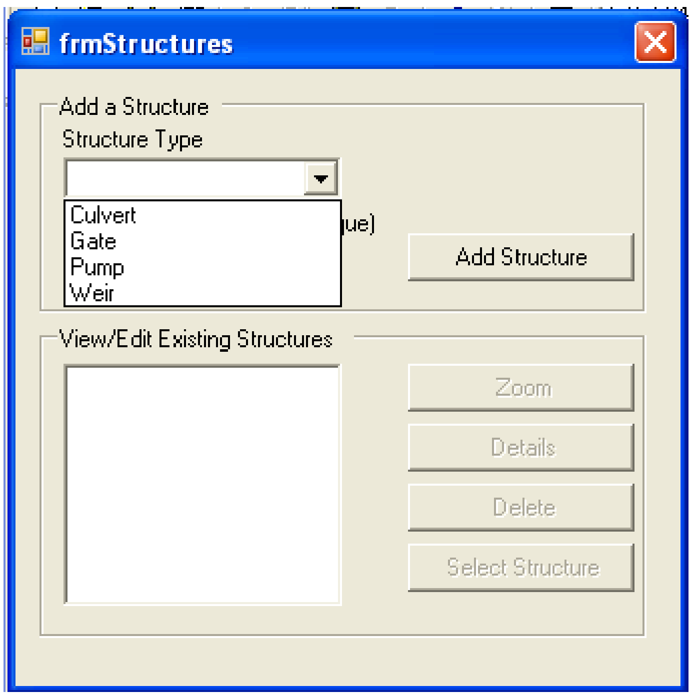
4.2.2.2 Location of Structures

To add a structure to a Wash Model, choose the Structures option under the Layers menu.



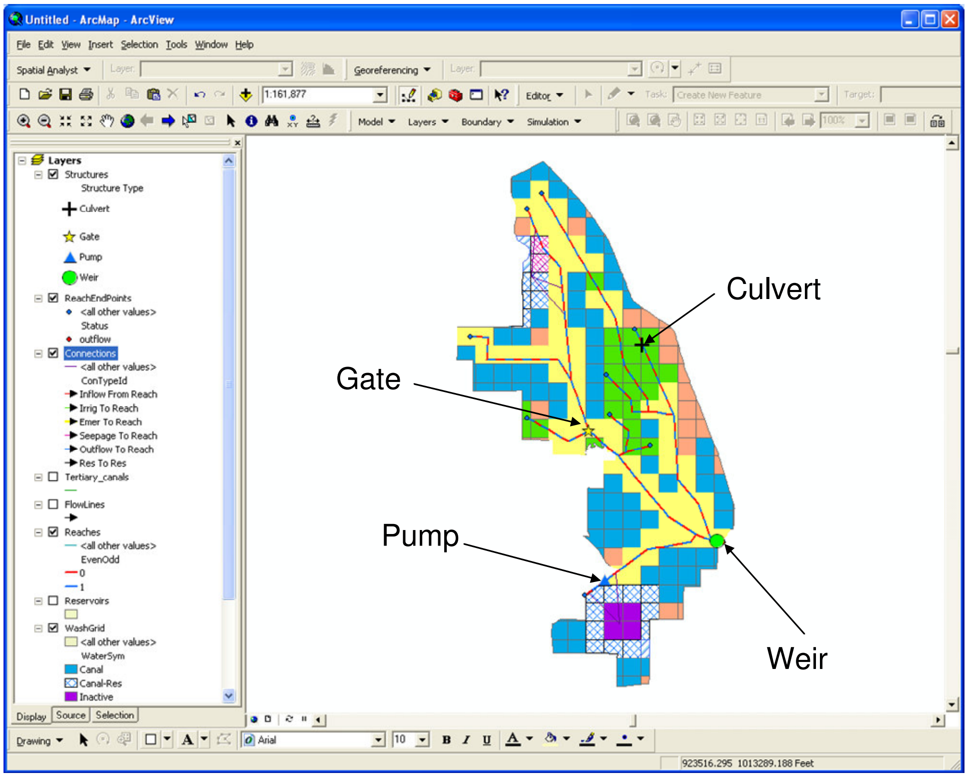
4.57

To add a structure, select the Add/Edit button.



4.58

A drop down menu will offer the four types of structures. Choose the appropriate structure type and then name the structure. (The name box is below the drop down menu shown above.) Using the Add Structure button, you will be able to use the cursor in the ArcMap session to locate the structure location on the model. Structures must be located at the junction between two reach segments. If the structure type is chosen and the given name of that structure does not immediately appear in the "View/Edit Existing Structures" box in the above screen, the reach junction was not located. Use the Arc zoom tool to enlarge the reach and follow the process again. When structures have been added they will appear similar to the following figure.



4.59

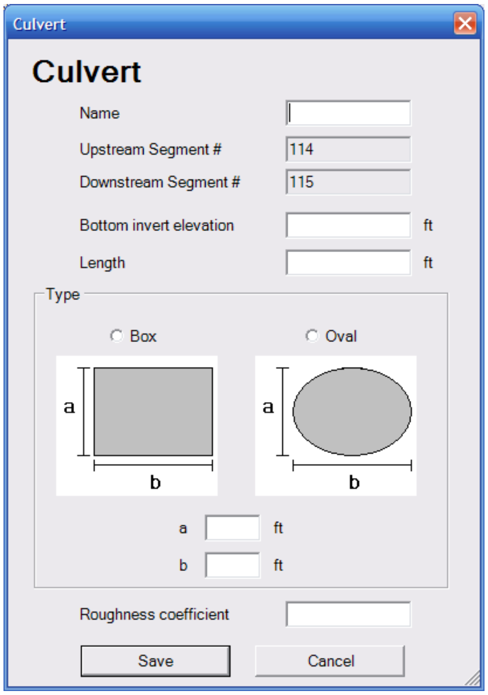
4.2.2.3 Attributing Structures

Each structure requires a specific set of parameters that characterize the structure dimensions and its operation. Once a structure is located on the reach network, the parameter values must be entered.

The following figure illustrates the various structures as they would appear in the model.

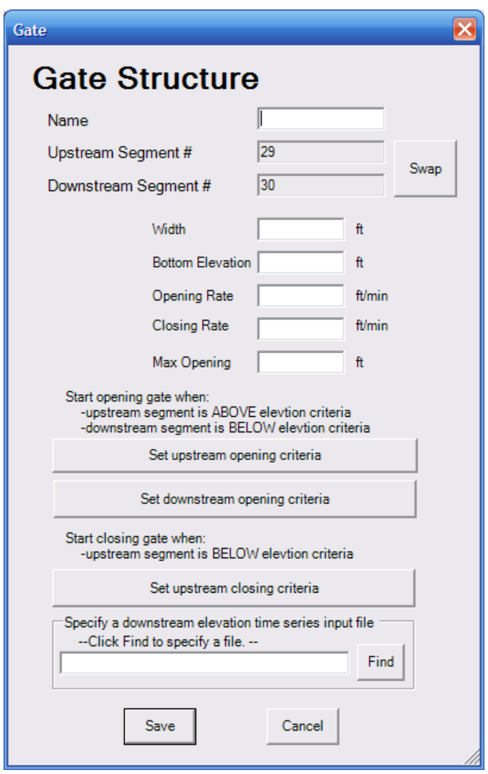
Below are listed the input parameters for each structure type.

CULVERT:



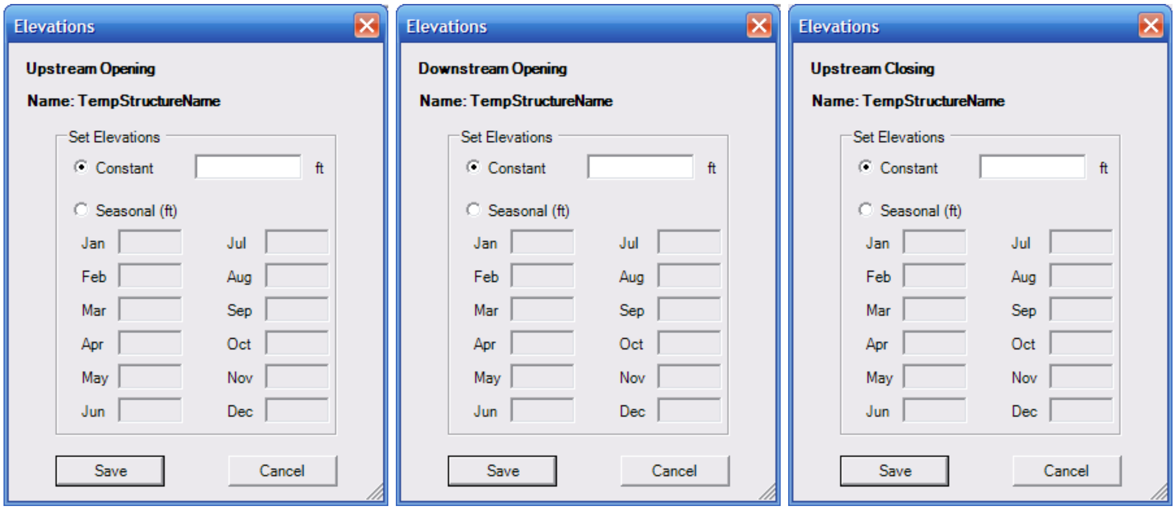
4.60

GATE:



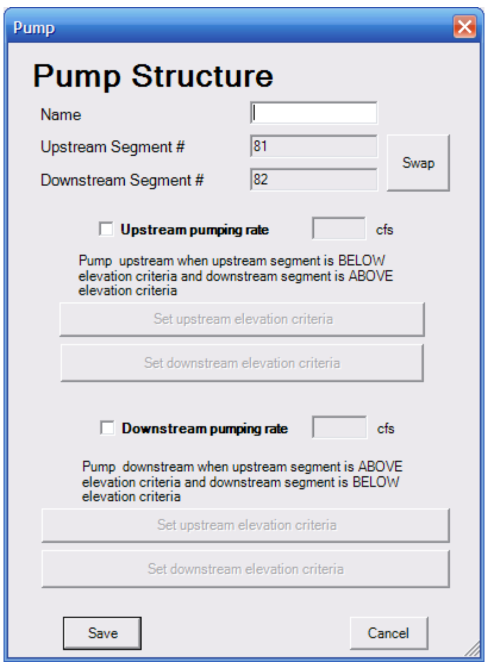
4.61

Selection of the opening or closing criteria buttons in the above screen will open the following screens for Gate Opening/Closing Criteria:



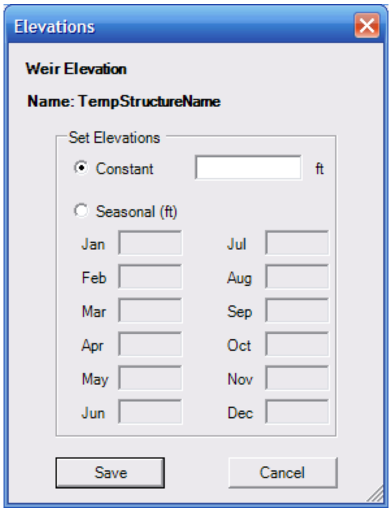
4.62

PUMP:



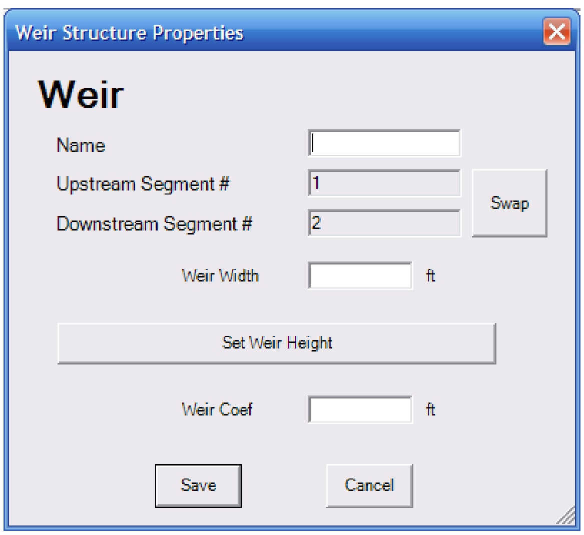
4.63

Pumping rates will need to be established for either upstream or downstream pumping options and elevation criteria need to be established as either constant or seasonally-variable for both upstream and downstream pumping options. An example of the elevation criteria screens is presented below.



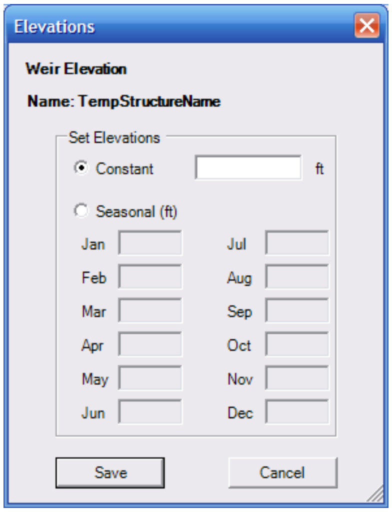
4.64

WEIR:



4.65

Weir height can be set as either a constant height or as seasonally-variable heights.



4.66

4.3 LEGEND CHANGES

The WaSh Grid shapefile can be color coded to illustrate a variety of attributes. The grid can color code the model domain, land use, soils types, and water feature types. The color coding is based on default *.lyr files provided with the Wash model. Using the Model menu in the toolbar, choose the change legend option. The pull-down menu will allow the user a choice of model legends based on physical attributes of the grid. The most commonly used legend will be the "Water Symbols" legend.

During the WaSh model configuration, various configuration tools provide values for the cell 'type' attribute. This attribute value represents the cell's interaction with other objects in the model, such as reaches and reservoirs and will control how exchanges between the cells and these other objects are controlled. The available cell attributes and their influence on the hydrology and hydrodynamic simulations are described in Table 4-1. The WaSh GUI provides a tool for mapping the cell-type attribute onto each cell.

Table 4-1. Water Routing Operations for Each Cell Type

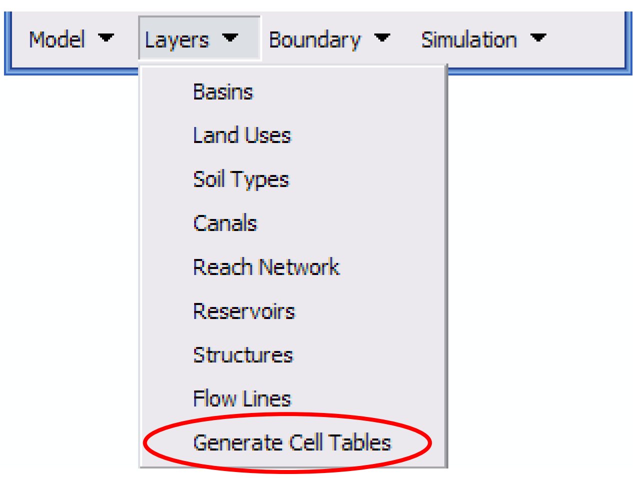
Cell-Type	Flow Routing Operations
Free	Infiltration is directed to cell groundwater Surface water is directed to a nearby cell's canals, reach or reservoir*
Canal	Infiltration is directed to cell groundwater Surface water is directed to cell canals Groundwater and canal surface water allowed to exchange
Free-Reach	Infiltration is directed to cell groundwater Surface water is directed to the cell's reach or nearby cell's canals Groundwater and reach surface water allowed to exchange
Canal-Reach	Infiltration is directed to cell groundwater Surface water is directed to cell canals Groundwater and be exchanged with canal surface water and with reach surface water Canal and reach surface water can be exchanged
Free-Reservoir	Infiltration is directed to cell groundwater Surface water is directed to the cell's reservoir or nearby cell's canals ** Groundwater and reservoir surface water allowed to exchange
Canal-	Infiltration is directed to cell groundwater

Cell-Type	Flow Routing Operations
Reservoir	Surface water is directed to cell canals Groundwater can be exchanged with canal surface water and with reservoir surface water
* a nearby canal cell or reach is determined by the flow network which is discussed in the next section ** the surface water does not necessarily have to drain to the coincident reach in a free-reach cell, for instance, in the case that a dike separates the reach from surface water runoff.	

4.4 GENERATING TABLES

After a model has been configured, parameter tables should be generated. The table generation process attributes every grid cell, reach segment, and reservoir cell with the default parameters unique to that element based on model configuration. Each parameter will be required for the WaSh model operation. It is recommended to perform this task immediately after model configuration, as the process may take several minutes, depending upon the model size and cell density. However, once the tables are created, any updates to the tables will occur instantaneously. The tables will be referenced whenever the model tables are exported or a model simulation is executed. If the tables have not been generated previously, the model will have to perform this task prior to the export or model execution.

To generate model tables, select the "Generate Tables" option under the Layers menu.

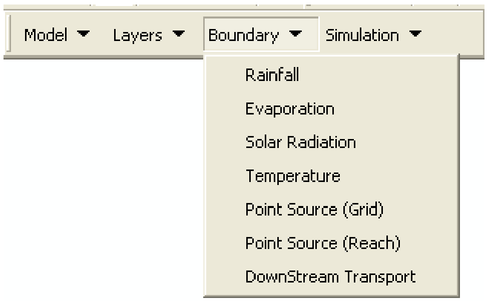


4.67

Tables will be created in the WashMoel.mdb file located in the core folder under the model folder. A progress bar will be shown during the table generation process.

At this point the model is considered to be "Configured". All of the physical attributes characterizing the system have been established in the grid cell file and in the reach network. The model now requires the introduction of Forcing Data.

The boundary pull-down menu in the WaSh Model toolbar allows the user to add model forcing data such as rainfall data, evapo-transpiration data, point source data, and Downstream Transport or Tidal Boundary Conditions data.



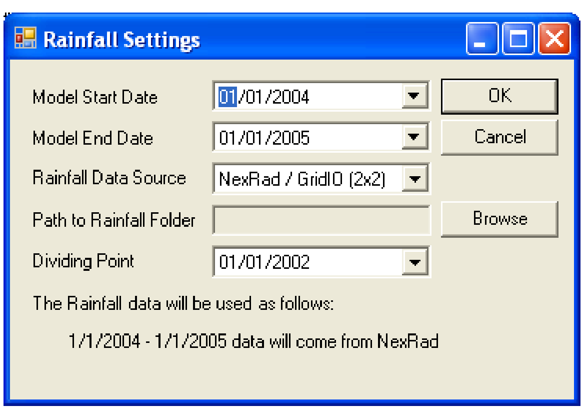
5.1

5.1 HYDROLOGIC FORCING DATA

As discussed in Section 3.0, hydrologic forcing data is required to drive the flow component of the model. This hydrologic data includes complete hourly time series data for rainfall and daily time series data for evapo-transpiration. Time series data must extend through the entire length of the simulation time period. In fact, the rainfall option of the model will be used to set the simulation time period.

5.1.1 Rainfall

From the Boundary conditions menu, selecting the rainfall option will open the following screen. The user will first indicate the model simulation period by selecting the model start and end dates.

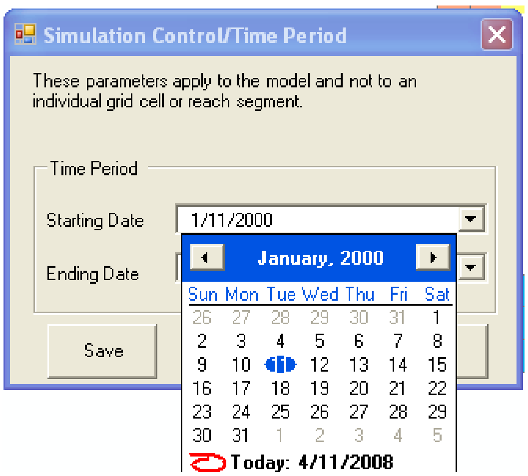


5.2

The time period of simulation is the duration of time over which the simulation should operate. For calibration purposes, this period should mirror the period of available data that will be used for calibration comparison. However, the period may extend beyond the calibration period if the model is to be used as a predictive tool.

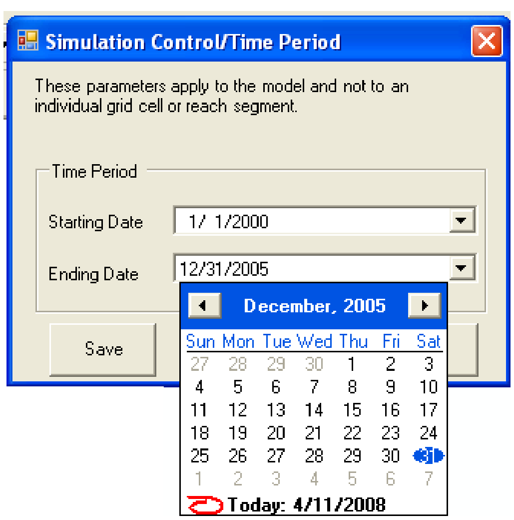
Dates can be entered manually or by selecting the date drop-down menus which opens a calendar for date selection. It is recommended that the year of simulation be entered by hand into the chosen date prior to opening the calendar window to expedite date choice. Otherwise, the user will need to scroll back by month until the preferred year and month is reached.

By accessing the start date calendar menu, The date appears as in the following figure.



5.3

After changing the Start date, the end date should be chosen.

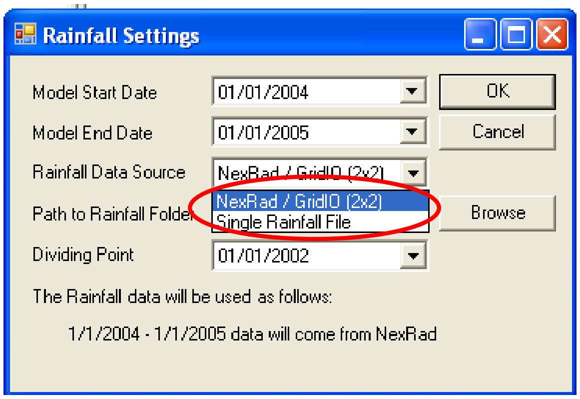


5.4

If there is uncertainty about the initial conditions which is usually the case, it is recommended that a "Spin-Up period" be used in order for the model to stabilize. A minimum of one year is recommended. Using the above dates as an example, if calibration data exists for calendar years 2001-2005, the model simulation is begun in 2000 to eliminate the effects of initial conditions in the simulation.

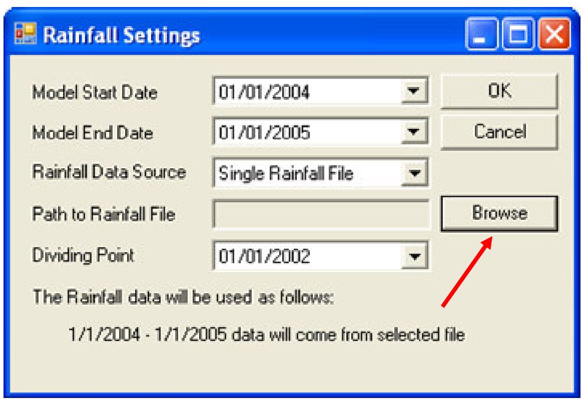
5.1.1.1 Single Point Gage Data

To use a single point rainfall time-series file, select the Single Rainfall File Option from the "Rainfall Data Source" menu. Clicking the "Find" button will open a file browse menu to indicate the specific text file containing the rainfall data to be used by the model. Text file format is indicated in Section 3.0.



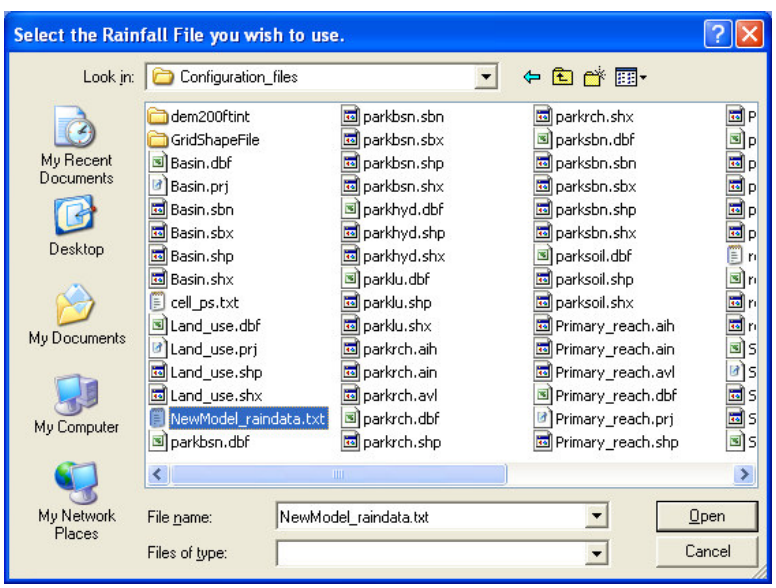
5.5

Use the Browse button to identify the rainfall input file.



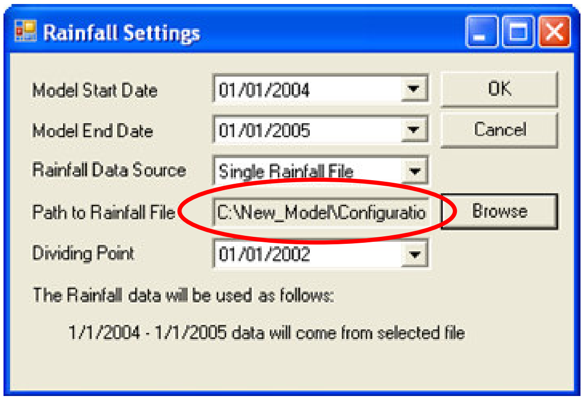
5.6

Using the windows screen, select the file and choose the "Open" button.



5.7

The last option on the rainfall screen is the "Dividing Point" menu. This option is not required when using time-series rainfall input.

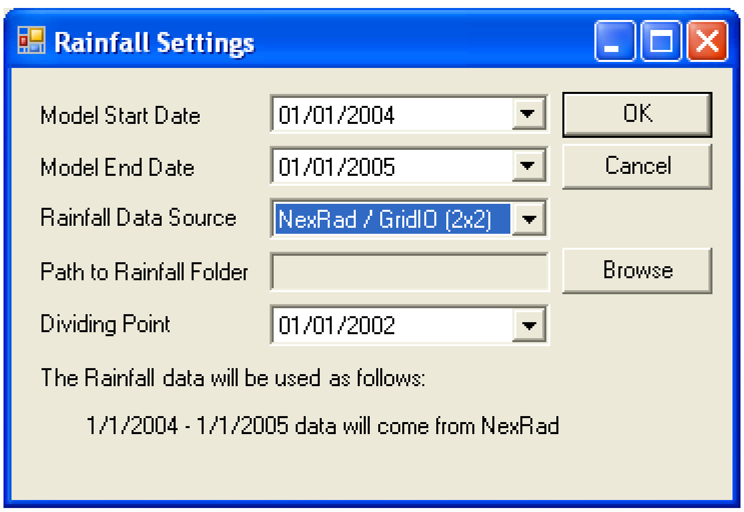


5.8

Selecting the "OK" button will close the screen and save the rainfall input file.

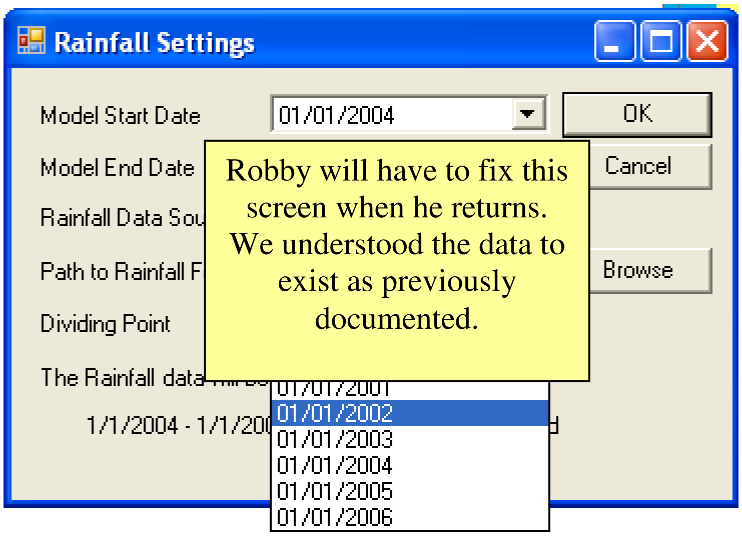
5.1.1.2 NexRad Data

If NEXRAD/GridIO data is to be used in the model, the "NexRad / GridIO (2x2)" option will be chosen from the Rainfall Data source menu.



5.9

Since the NexRad data is available from 1996- Present and the GridIO data is available from 1965 to 2000, there is an overlapping period between 1996 and 2000. If the simulation time period spans all or part of this overlapping period, the user must specify the date at which the model switches from using the GridIO data to using the NexRad data. This date is called the "Dividing Point" and it can occur on January 1st of any calendar year from 1996-2000.



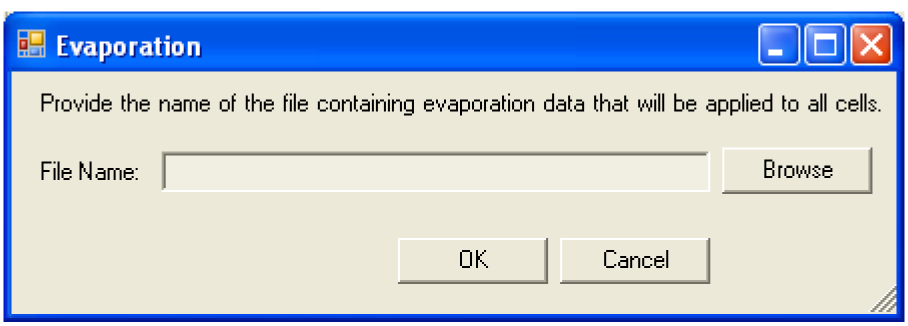
5.10

If the Dividing Point is before the Model Start Date, the NexRad data will be used entirely for the simulation. If the Dividing Point is after the Model End Date, the GridIO dataset will be used for the entire simulation. If the Dividing Point occurs during the simulation period, the model will switch from using the GridIO data to the NexRad data at the beginning of the specified year. Also, WaSh will use the GridIO rainfall data to fill NexRad data gaps.

Selecting the “OK” button will save the rainfall source information. The model will require processing time to extract the proper rainfall data

5.1.2 Evapotranspiration

Evapo-transpiration data can be added to the model by choosing the Evaporation option from the Boundary menu. Using the “Browse” button, the associated browse menu will initiate a search for the single time series ET file to be used by the model. The format and contents of the evapo-transpiration input file is described in Section 3.0

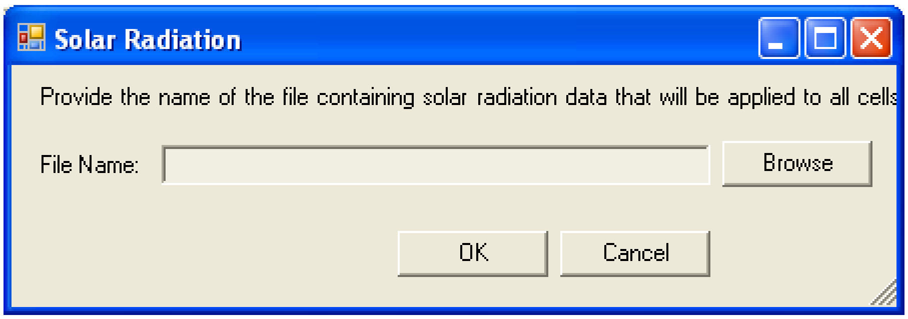


5.11

5.2 WATER QUALITY FORCING

5.2.1 Solar Radiation

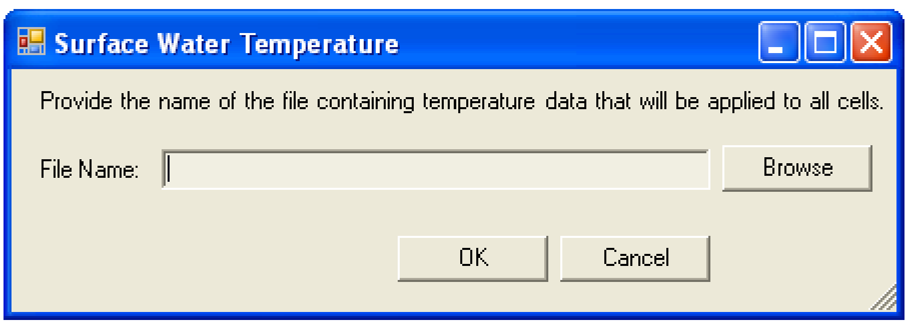
Solar Radiation data can be added to the model by choosing the Solar Radiation option from the Boundary menu. Using the “Browse” button, the associated browse menu will initiate a search for the single time series solar radiation file to be used by the model. The format and contents of the solar radiation input file is described in Section 3.0



5.12

5.2.2 Temperature

Water temperature data can be added to the model by choosing the Surface Water Temperature option from the Boundary menu. Using the “Browse” button, the associated browse menu will initiate a search for the single time series temperature file to be used by the model. The format and contents of the temperature input file is described in Section 3.0.



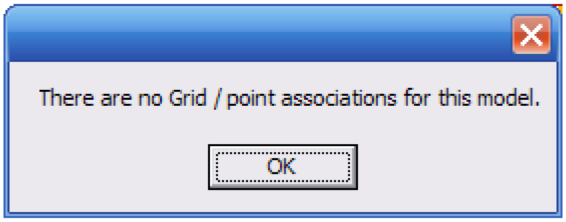
5.13

5.3 OPTIONAL FORCING DATA: POINT SOURCES

The use of point source data is optional in the model, but it may be an important component in the accuracy of modeling a system. Point sources can be grid cell point sources or reach point sources. They can be introduced into the model as either a simple flow element or as a flow element combined with a water quality element.

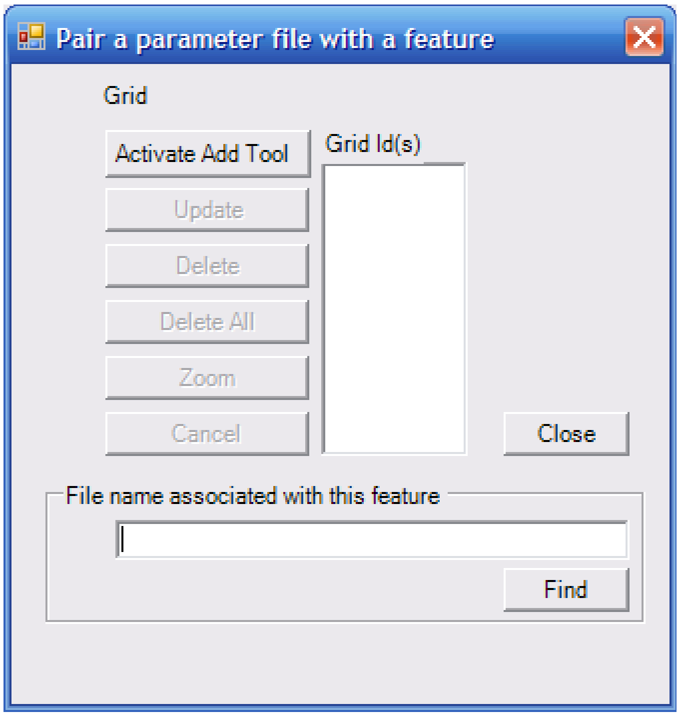
5.3.1 Grid Cell

Under the Boundary menu, choosing the Grid Point source option for the first time will cause the following screen to appear.



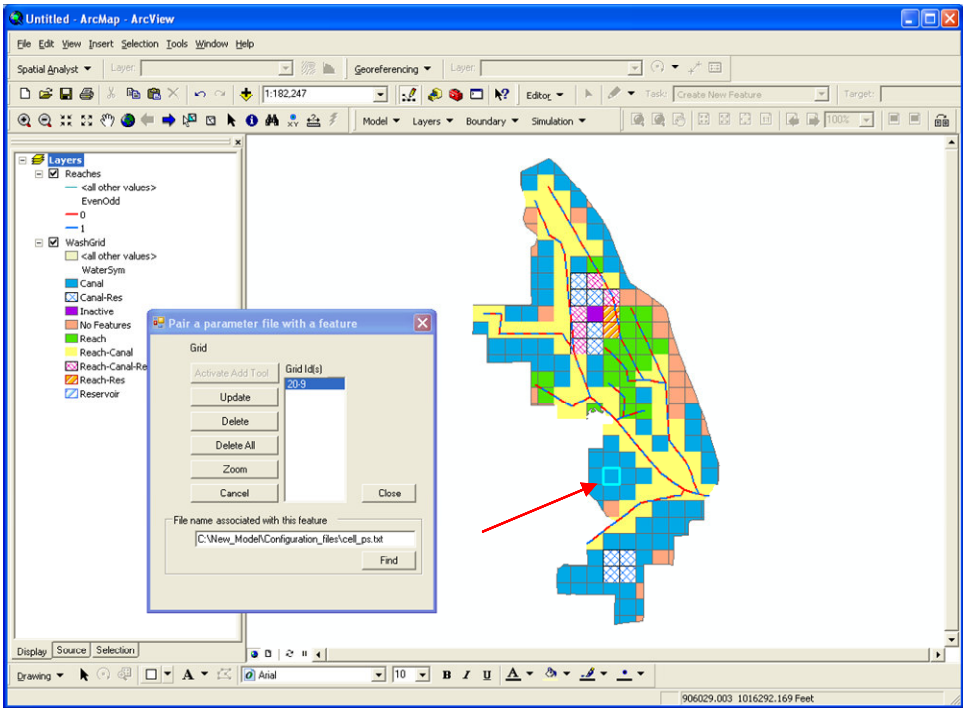
5.14

After clicking “OK”, a menu will appear which will allow the pairing of a point within the model with a time series file characterizing the introduction of additional flow and/or nutrients into the model system.



5.15

A file name for the associated input data must be indicated first, and then the user may “Activate the Add Tool” and choose the appropriate grid cell in the model. Then grid cell will become “highlighted” in the data view. Once the point source grid cell has been chosen and attributed with the correct file, all options in the above figure will become active.

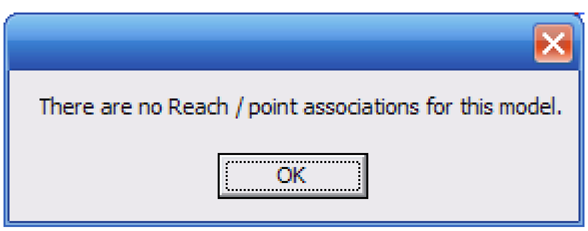


5.16

The user will then be allowed to delete, delete all, zoom and cancel operations. The update feature allows the user to swap time series files associated with previously designated point sources. Once a point source has been established, if the input time series file is altered and renamed, the grid ID can be highlighted, a new file can be chosen, and the Update button can be clicked, to allow the model to path to the new file.

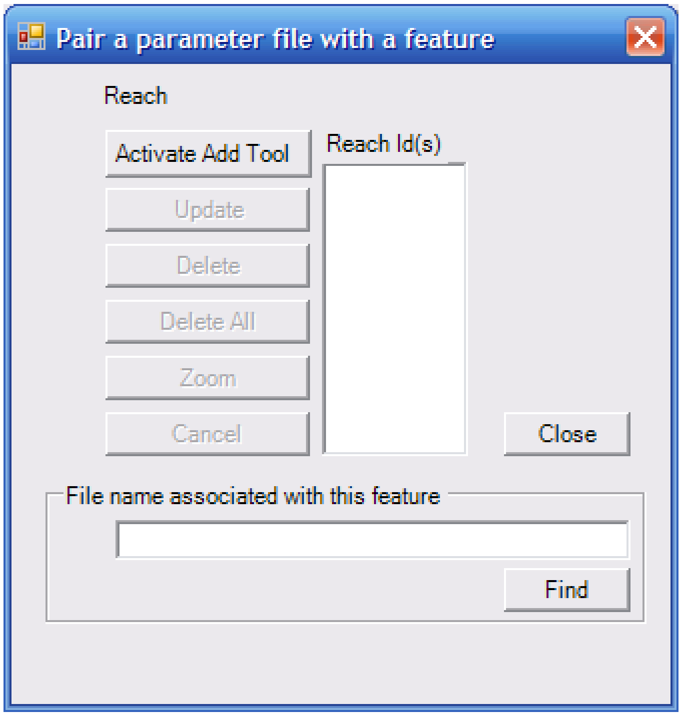
5.3.2 Reach Network

The Reach Network Point Source features work similarly to the Grid Cell Point Source attributes. Once the Reach option has been chosen from the Boundary menu for the first time, the screen will indicate that no Point Sources exist.



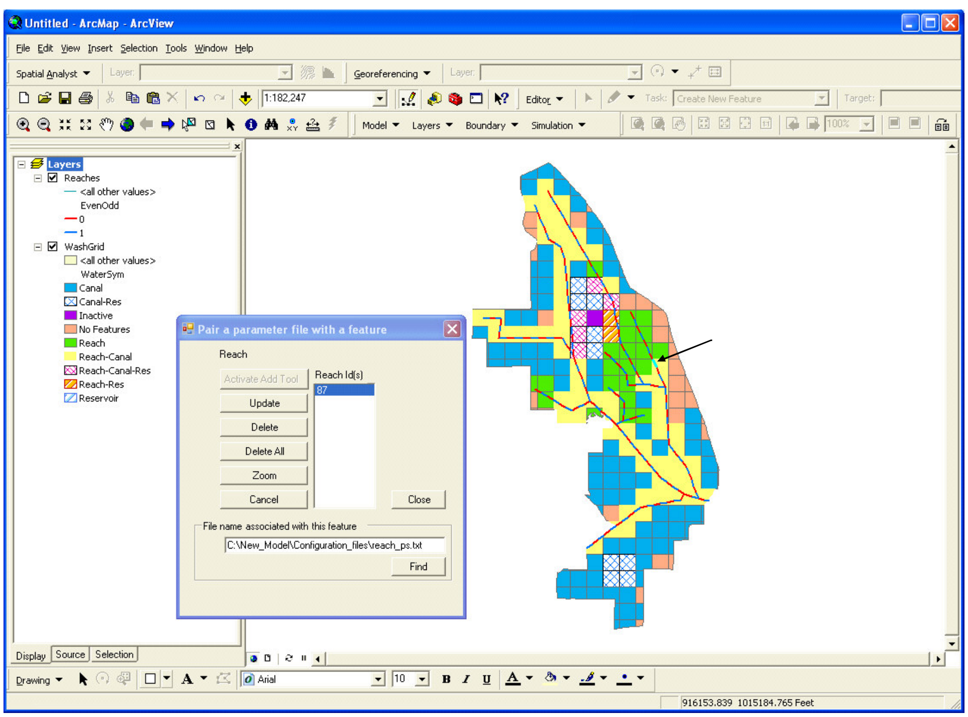
5.17

By clicking “OK”, a screen will appear allowing the addition of point source files.



5.18

A file name for the associated input data must be indicated first, and then the user may "Activate the Add Tool" and choose the appropriate reach segment in the model. The reach segment will become "highlighted" in the data view. Once the point source reach segment has been chosen and attributed with the correct file, all options in the above figure will become active.



5.19

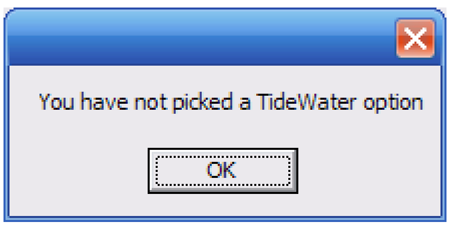
The user will then be allowed to delete, delete all, zoom and cancel operations. The update feature allows the user to swap time series files associated with previously designated point sources. Once a reach point source has been established, if the input time series file is altered and renamed, the reach ID can be highlighted, a new file can be chosen, and the Update button can be clicked, to allow the model to path to the new file.

5.3.3 Downstream Transport

The final option under the Boundary Menu is the Downstream Transport/ or the Tidal Boundary Conditions option. Before the boundary condition can be defined, the Transport option must be defined under the Simulation menu. Transport options include: None (Hydrology and Hydrodynamic only), Basic (Basic Water Quality), Advanced: Single Layer, and Advanced: Multiple Layers. This option must first be initiated by choosing the “Transport Option” from the “Simulation” menu on the toolbar. Refer to Section 9.2 for information regarding Transport Options.

5.3.3.1 None- Hydrology and Hydrodynamics Only

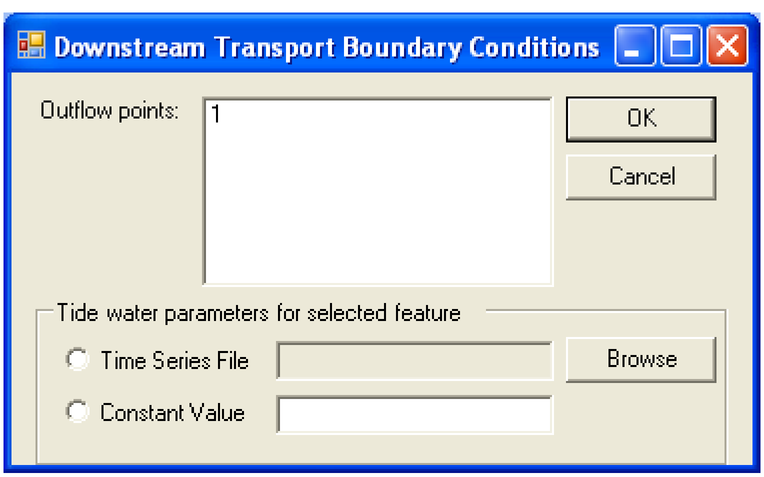
If the “None” option has been chosen for the Transport Option under the Simulation menu, then only flow and stage data will be simulated. The first time Tidal Boundary conditions option is chosen, the model will indicate that no Tide Water option has been established.



5.20

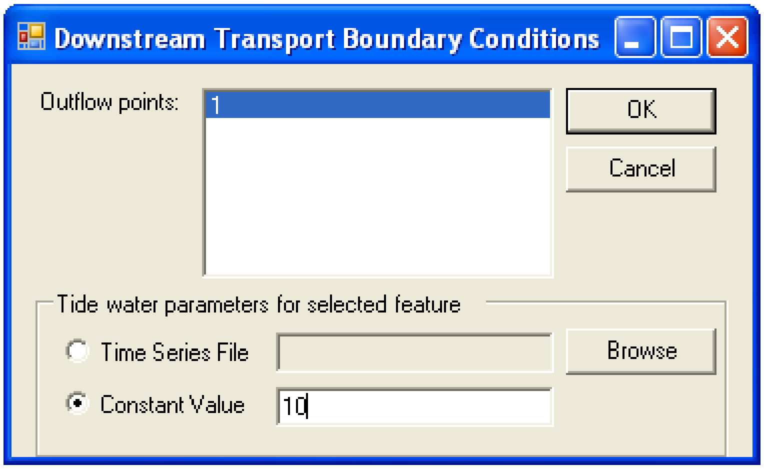
By clicking “OK”, the Downstream Transport Boundary Conditions screen will appear.

First, an outfall point must be chosen from all endpoints which were identified as outfall points during model configuration. Next, the tide water option must be selected. It must be indicated to the model if the tide is going to be set at a constant level or if a time series indicating a fluctuating tide boundary will be used.



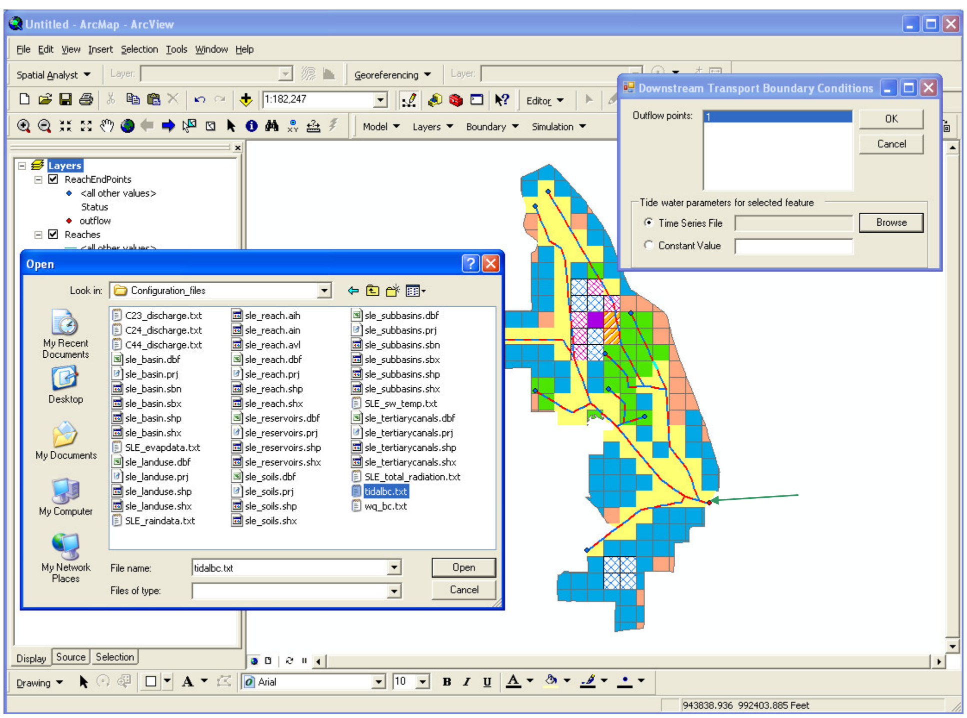
5.21

After highlighting the outfall point by selecting it from the list, the “Constant” option can be chosen and a tide elevation must be indicated. This option may be used, for example, when a control structure maintains a constant water elevation at the basin outfall.



5.22

If the basin outfall is to be designed to fluctuate with the natural ebb and flow of tide elevations, as in an estuary or uncontrolled system, then the time series option must be chosen and a filename for the boundary conditions time series must be indicated. This is typically the basin outfall or most downstream segment of the primary reach network.

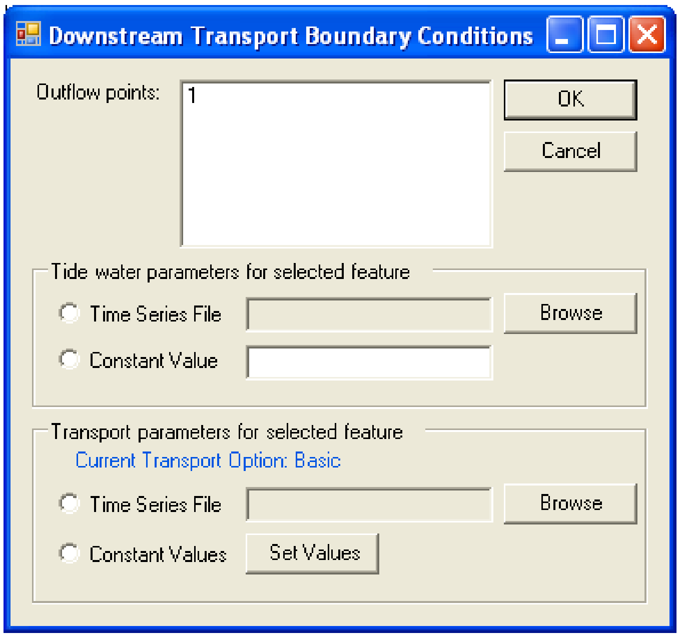


5.23

The input file format for the tide water boundary condition is defined in Section 3.2.3.3.

5.3.3.2 Basic Water Quality

If the Basic Water Quality transport option has been chosen, the model will simulate total nitrogen (dissolved and particulate), total phosphorus (dissolved and particulate) and total suspended sediment data. When the Downstream Transport option is chosen from the Boundary menu, the following screen will appear.

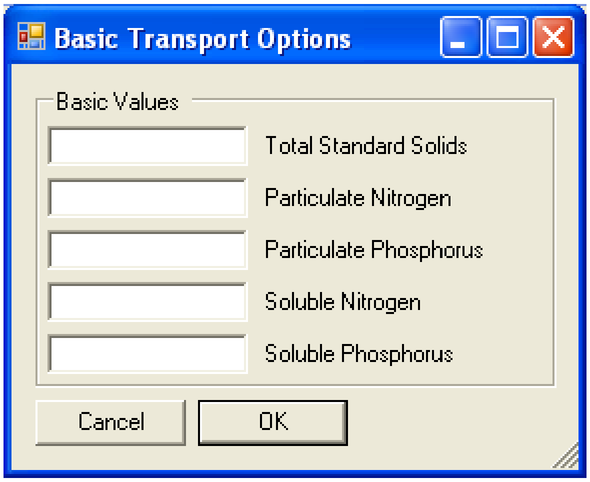


5.24

The basin outflow or tide water boundary point can be highlighted by selecting the appropriate outflow point from the box. A tide water parameter can be indicated by following the procedure indicated in the preceding section (Figures 5.17, 5.18).

For the water quality transport parameters, constant values or time series data can be used. The input file format for the tide water boundary condition is defined in Section 3.2.3.3. A comma-delimited, times-series text file can be supplied as input to the model.

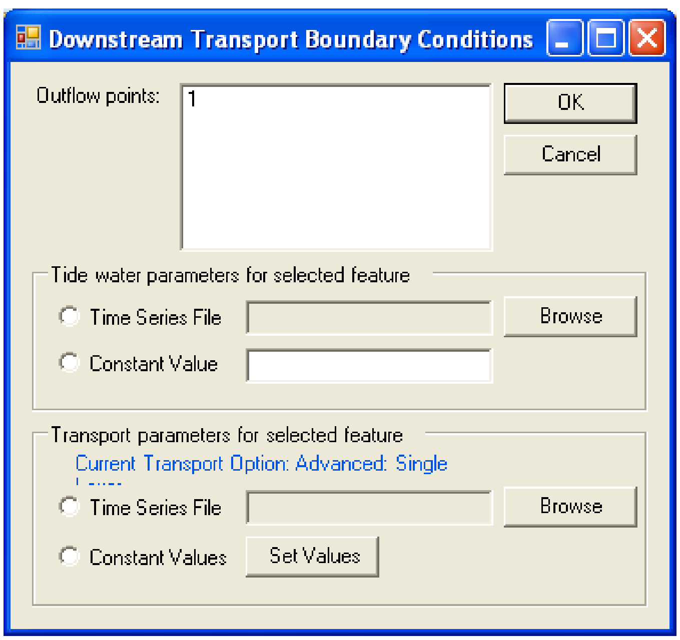
If constant values are to be used, select the “Constant Values” option and then select the “Set Values” button. At this point, individual constant values for each of the five water quality modeling parameters can be manually input.



5.25

5.3.3.3 Advanced: Single Layer

If the “Advanced: Single Layer” transport option has been chosen, the model will simulate ammonia, nitrate, organic nitrogen, orthophosphate, organic phosphate, dissolved oxygen, phytoplankton carbon mass, and CBOD. When the Downstream Transport option is chosen from the Boundary menu, the following screen will appear. Additional information regarding layers option for the reach can be found in Section 9.2.

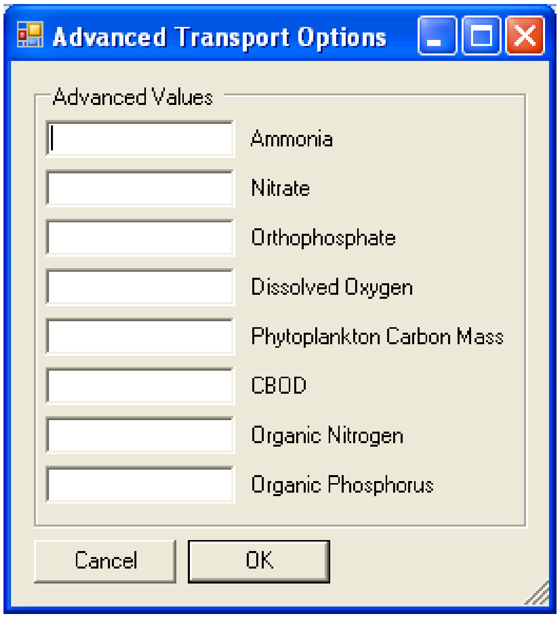


5.26

The basin outflow or tide water boundary point can be highlighted by selecting the appropriate point from the box. A tide water parameter can be indicated by following the procedure indicated in the preceding section (Figures 5.17, 5.18).

For the water quality transport parameters, constant values or time series data can be used. The input file format for the tide water boundary condition is defined in Section 3.2.3.3. A comma-delimited, times-series text file can be supplied as input to the model.

If constant values are to be used, select the "Constant Values" option and then select the "Set Values" button. At this point, individual constant values for each of the eight advanced water quality modeling parameters can be manually input.

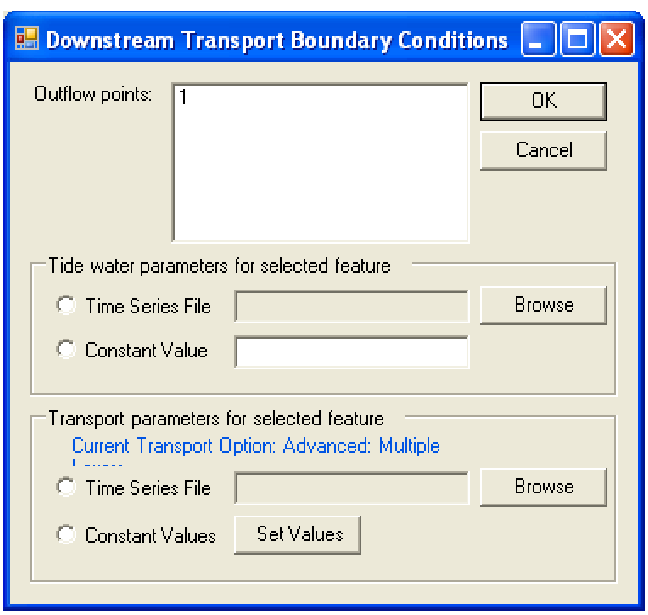


5.27

5.3.3.4 Advanced: Multiple Layers

. If the "Advanced: Multiple Layers" transport option has been chosen, the model will simulate ammonia, nitrate, organic nitrogen, orthophosphate, organic phosphate, dissolved oxygen, phytoplankton carbon mass, and CBOD for both an upper and lower layer in the reach. Additional information regarding multiple layers for the reach can be found in Section 9.2.

When the Downstream Transport option is chosen from the Boundary menu, the following screen will appear.

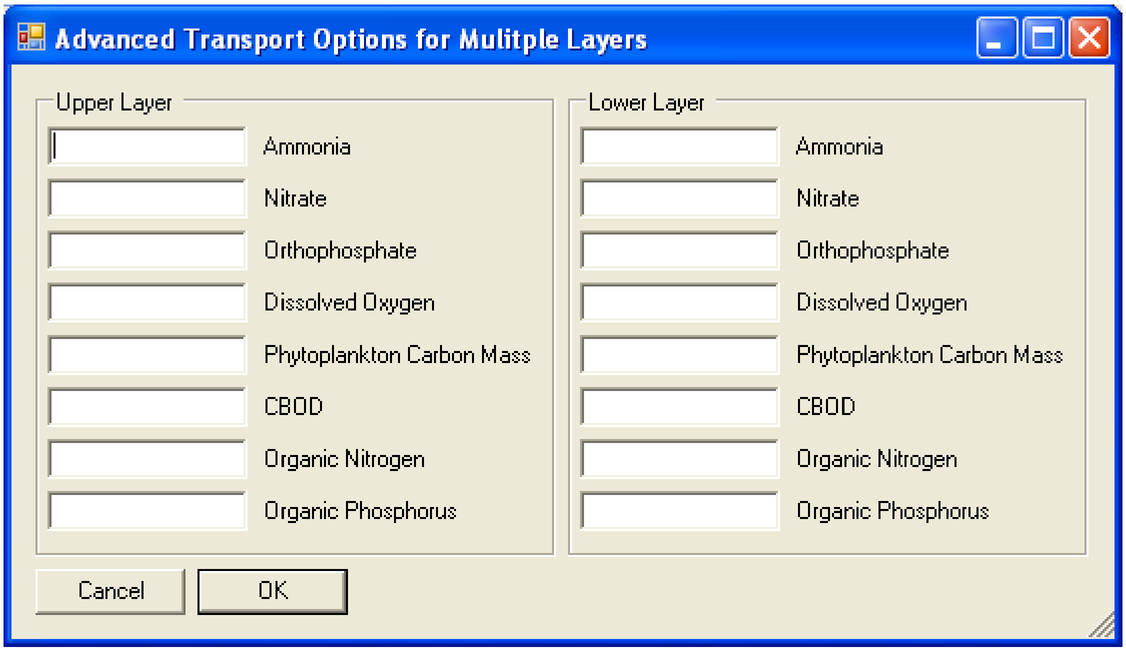


5.28

The basin outflow or tide water boundary point can be highlighted by selecting the appropriate point from the box. A tide water parameter can be indicated by following the procedure indicated in the preceding section (Figures 5.17, 5.18).

For the water quality transport parameters, constant values or time series data can be used. The input file format for the tide water boundary condition is defined in Section 3.2.3.3. A comma-delimited, times-series text file can be supplied as input to the model.

If constant values are to be used, select the "Constant Values" option and then select the "Set Values" button. At this point, individual constant values for each of the eight advanced water quality modeling parameters for upper and lower layers can be manually input.



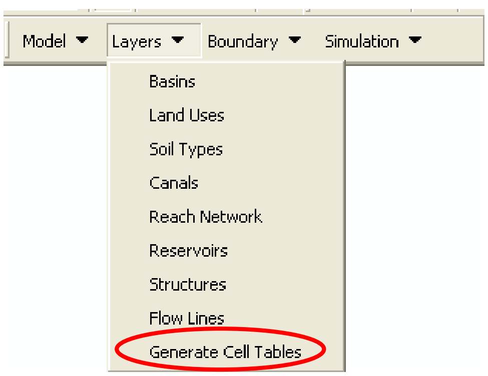
5.29

The model parameters for the cells can be divided into a number of hydrologic and water quality categories. The parameter values are set for each cell in the model grid. Some of the parameters control conditions within the cell while others control the interaction of the cell with other objects in the model domain (other cells and reach segments and reservoirs). The parameter values are accessible from the Model menu by selecting the “Open Model Table” option.

The user can select any of the categories to gain access to the parameter values. Initially, the parameters values are set with default values by the WaSh GUI during the model grid configuration. The user can modify the parameter values for and combination of cells in order to calibrate the model, conduct a sensitivity analysis or any other purpose. Editing can be done for special selections of cells, based on geographic location, or other attribute-based selections. The basic selection and editing procedures have been described in Section 6.4.

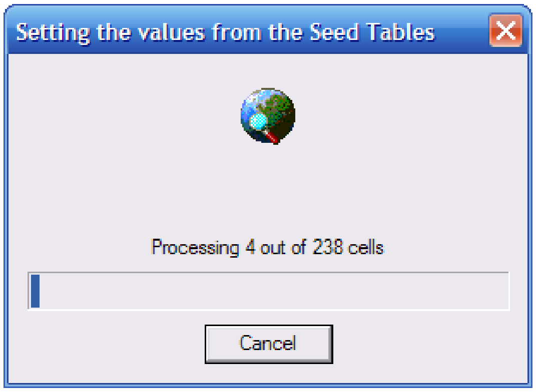
In the following sections, each model parameter is identified and described. The parameters are also cross-referenced to the associated equation in the WaSh Model Theory Documentation.

Each time that a new model is created and the Model tables are accessed for the first time, the GUI will take several minutes to generate the tables from configuration files located in the Seed Folder. The process can take several minutes, based on the size and resolution of the grid. The grid cell and reach tables can be generated using the “Generate Cell Tables” command, which resides in the Layers menu. The function is located in the Layers menu to prompt the user to generate tables immediately following model configuration.



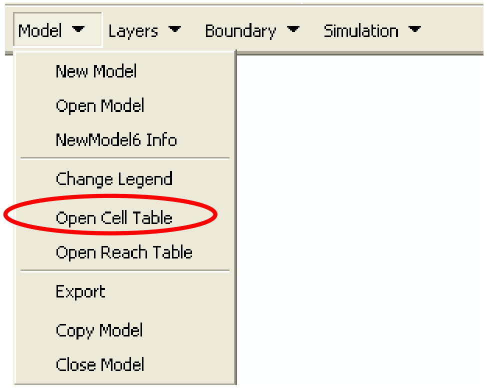
6.1

Once the tables have been created, successive opening of the tables will be virtually instantaneous. It is only the initial processing that takes time. The following screen will appear until processing is completed.



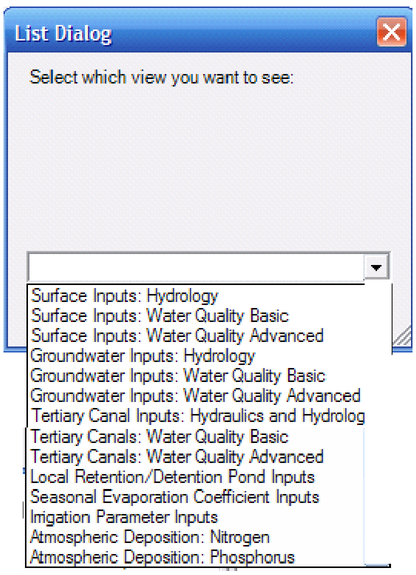
6.2

Upon table generation, all cell-based parameters associated with WaSh Model grid cells will be accessible in the Model menu through the Open Cell Table option.



6.3

The following parameter groups are available under the Model Table option.



6.4

For discussion purposes in this section, the tables are separated by their basic functions into "Hydrodynamics and Hydrology" functions, Basic Water Quality functions and Advanced Water Quality functions.

6.1 HYDRODYNAMICS AND HYDRAULICS

The following tables list each parameter name, along with the parameter symbol, the parameter unit, and, in some cases, a brief description. Section 6.4 will give a brief description of some methods used in table editing.

6.1.1 Surface Water

Hydrology and hydrodynamics parameters for Surface Water control any process directly related to the overland flow processes in the Wash model. Parameters can include variables in storage, interaction with the soil surface, meteorological components acting on the surface water, and infiltration.

Parameter[1]	Symbol	Units	Theory Manual Equation
Interception Storage Capacity	CEPSC	Inches	HSPF Documentation
Upper Zone Nominal Storage	UZSN	inches	1, 2
Manning's n	NSUR	none	HSPF Documentation
Interflow Coefficient	INTFW	none	HSPF Documentation
Interflow Recession Constant	IRC	day -1	HSPF Documentation
Lower Zone Evapotranspiration Potential	LZETP	inches	HSPF Documentation
Lower Zone Nominal Storage	LZSN	inches	1, 2
Infiltration Rate	INFILT	Inches/hour	HSPF Documentation
Infiltration Distribution	INFILD	none	HSPF Documentation
Length of Land Segment	LSUR	feet	HSPF Documentation
Slope of Land Surface	SLSUR	none	HSPF Documentation
Deep Fraction	DEEPFR	none	HSPF Documentation
Impervious Fraction	IFRAC	none	10
Impervious Retention Storage Capacity	IRETSC	none	HSPF Documentation
Impervious Roughness Coefficient	INSUR	none	HSPF Documentation
Runoff Option	RO-OPT	none	Section 3.1
Wetland Rating Curve Flow 1	Q1	Ft^3/day	Section 3.1
Wetland Rating Curve Flow 2	Q2	Ft^3/day	Section 3.1
Wetland Rating Curve Flow 3	Q3	Ft^3/day	Section 3.1
Wetland Rating Curve Flow 4	Q4	Ft^3/day	Section 3.1
Wetland Rating Curve Flow 5	Q5	Ft^3/day	Section 3.1
Wetland Rating Curve Height 1	D1	Ft^3/day	Section 3.1
Wetland Rating Curve Height 2	D2	Ft^3/day	Section 3.1
Wetland Rating Curve Height 3	D3	Ft^3/day	Section 3.1
Wetland Rating Curve Height 4	D4	Ft^3/day	Section 3.1
Wetland Rating Curve Height 5	D5	Ft^3/day	Section 3.1

[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.

6.1.2 Ground Water

The Ground water table for Hydrology and Hydrodynamics lists all parameters of the HSPF modeling equations which can affect the travel of water through soils.

Parameter[1]	Symbol	Units	Theory Manual Equation
Hydraulic Conductivity	HYDCON	ft/day	14, 17
Aquifer Base	AQFR_BASE	feet	14, 17
Ground Water Evapotranspiration	AGWETP	none	16
Porosity	POROSITY	none	14, 17
Small Drainage Features- Bottom Elevation	GW_HD	feet	11
Small Drainage Features- Conductance	GW_CD	feet/day	12
[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.			

6.1.3 Tertiary Canals

The Hydrology and Hydrodynamics table for Tertiary Canals identifies parameters and coefficients which dictate the drainage of surface water via the tertiary canal system. Canal Dimensions can be altered if design criteria are known or is anecdotal information exists regarding their dimensions.

Parameter[1]	Symbol	Units	Theory Manual Equation
Canal Length	CAN_LENGTH	feet	19
Canal Depth	CAN_DEPTH	feet	18
Canal Width	CAN_WIDTH	feet	19
Conductance	CAN_CONDUCTANCE	feet/day	57
Discharge Option	WEIR_OR_PUMP	integer	Section 7.3
Canal Pump Rate	CANPMPPARM	inches/day	Section 8
Upper Critical Pumping Elevation	PMP_UC	feet	Section 7.3
Lower Critical Pumping Elevation	PMP_LC	feet	Section 7.3
Weir Elevation	WEIR_ELEV	feet	61
Weir Width	WEIR_WIDTH	feet	61
Weir Coefficient	WEIR_COEFF	none	61
[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.			

6.1.4 Local Retention/Detention Pond

Local Retention and Detention Ponds can potentially remove large quantities of water from basin discharge, greatly altering the water budget for a region. The following table lists parameters for ponds which account for storage n the Hydrology and Hydrodynamics component of the WaSh model.

Parameter[1]	Symbol	Units	Theory Manual Equation
Pond Volume	Pnd_Vol	ft^3	100, 101
Recession Constant	Pnd_Rec	none	100, 101
Surface Area of Pond	Area	ft^2	102
Settling Speed – Particulate N	V_PN	ft/day	103
Settling Speed – Particulate P	V_PP	ft/day	103
Settling Speed – TSS	V_TSS	ft/day	103
Decay Rate Dissolved P	DEC_P	day^{-1}	103
Decay Rate Dissolved N	DEC_N	day^{-1}	103

[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.

6.1.5 Seasonal Evapotranspiration Coefficients

Although evapo-transpiration is entered in the model as a timeseries input file, the seasonal variability can be further refined by the Pan Coefficient values. Pan coefficient values are influenced by Pan evaporation calculations and they vary seasonally. Coefficients are higher in the hot, sunny summer months and lower in the cooler winter months.

Parameter[1]	Symbol	Units	Theory Manual Equation
Pan Coefficient- Jan	PAN_COEF1	none	Section 3.1
Pan Coefficient- Feb	PAN_COEF2	none	Section 3.1
Pan Coefficient- Mar	PAN_COEF3	none	Section 3.1
Pan Coefficient- Apr	PAN_COEF4	none	Section 3.1
Pan Coefficient- May	PAN_COEF5	none	Section 3.1
Pan Coefficient- Jun	PAN_COEF6	none	Section 3.1
Pan Coefficient- Jul	PAN_COEF7	none	Section 3.1
Pan Coefficient- Aug	PAN_COEF8	none	Section 3.1
Pan Coefficient- Sep	PAN_COEF9	none	Section 3.1
Pan Coefficient- Oct	PAN_COEF10	none	Section 3.1
Pan Coefficient- Nov	PAN_COEF11	none	Section 3.1
Pan Coefficient- Dec	PAN_COEF12	none	Section 3.1

[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.

6.1.6 Irrigation Parameters

Irrigation parameters can be greatly affected by soil types, land use, seasonal variations in meteorological parameters, crop type, and irrigation type. Accurate representation of these parameters in the model contribute to the accuracy of model simulation.

Parameter[1]	Symbol	Units	Theory Manual Equation
Irrigation Rate	IRATE	(in/in)	Section 3.1.1
Fraction of Irrigation Demand that is met	AZRI	(in/in)	8
Minimum Allowable Moisture	MinCap	%	7
Crop Root Depth	DR	inches	4
Source fraction from Canals	S_CANAL	%	Section 3.1.1
Source fraction from Shallow Aquifer	S_SH_AQ	%	Section 3.1.1
Source fraction from Deep Aquifer	S_EXT	%	Section 3.1.1
Application by Spraying	SPRAY	%	Section 3.1.1
Application to Surface Storage	SURF	%	Section 3.1.1
Application to Upper Soil Zone	UPPER_Z	%	Section 3.1.1
Application to Lower Soil Zone	LOWER_Z	%	Section 3.1.1
Application to Shallow Aquifer	SHALLOW	%	Section 3.1.1
Macro Pore Space	n_macro	none	4
Micro Pore Space	n_micro	none	1, 4

[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.

6.2 BASIC WATER QUALITY INPUTS

Basic Water quality addresses the components of the hydrologic and hydrodynamic model in addition to modeling total Nitrogen (TN), total Phosphorus (TP) and Total Suspended Solids (TSS). Individual speciation of TN and TP is not a function of the Basic Water Quality functions.

Surface water parameters in the Basic Water Quality module of WaSh are greatly affected by the seasonal signature of nutrient species TN and TP and also by TS. Especially in South Florida, summer heat brings an increase in rain, runoff, and nutrient cycling. Therefore, the WaSh model is designed to use seasonally varying parameters for TN, TP, and TSS. These values are referred to as Event Mean Concentrations, or EMC's. Theoretically, EMC data is derived from site-specific and rain-event specific water quality data produced when a runoff sample is collected directly after a rainfall event. The timing of the sampling event typically produces a measurement which is elevated above background levels. Additionally, EMC data is typically attributed to a specific land use, as different land uses can produce highly variable EMC values. In the absence of measured, site-specific EMC data, many authors publish land use specific EMC or nutrient runoff values. In Florida, the standard literature values are published by Harvey Harper, (1992, 1994, 2003).

6.2.1 Surface Water

In the Basic Water Quality table below, monthly EMC values can be added for surface water TN, TP, and TSS. The table also calls for the declaration of the fraction of TN and TP which are dissolved.

Parameter[1]	Symbol	Units	Theory Manual Equation
Concentration Coefficient 1	C1	inches	63a
Concentration Coefficient 2	C2	inches	63a
Monthly Total Nitrogen EMC Coeff.	BWQ_SW_TN_EMC_Mon[2]	mg/L	63b
Fraction of TN that is dissolved	BWQ_SW_N_Dissolved_Fraction	%	63b, c
Monthly Total Phosphorus EMC Coeff.	BWQ_SW_TP_EMC_Mon[2]	mg/L	63b
Fraction of TP that is dissolved	BWQ_SW_P_Dissolved_Fraction	%	63c
Monthly TSS EMC Coeff.	BWQ_SW_TSS_EMC_Mon[2]	mg/L	64

[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.

[2]. An individual parameter must be provided for each month.

6.2.2 Ground Water

In the Basic Water Quality table below, monthly EMC values for ground water can be added for TN, TP, and TSS. The table also calls for the declaration of the fraction of TN and TP which are dissolved.

Parameter[1]	Symbol	Units	Theory Manual Equation
Monthly Total Nitrogen EMC Coeff.	BWQ_GW_TN_EMC_Mon[2]	mg/L	63b
Fraction of TN that is dissolved	BWQ_GW_N_Dissolved_Frac	%	63b
Monthly Total Phosphorus EMC Coeff.	BWQ_GW_TP_EMC_Mon[2]	mg/L	63b
Fraction of TP that is dissolved	BWQ_GW_P_Dissolved_Frac	%	63b

[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.

[2]. An individual parameter must be provided for each month.

6.2.3 Tertiary Canals

Several parameters dictate the behavior of nutrients and TSS in tertiary canal system. Parameters include nutrient cycling coefficients and physical parameters influencing settling speeds.

Parameter[1]	Symbol	Units	Theory Manual Equation
Dissolved Nitrogen Decay	DN_DEC	day^{-1}	76 - 78
Dissolved Phosphorus Decay	DP_DEC	day^{-1}	76 - 78
Particulate Nitrogen Settling Speed	PN_SETTLING	ft/day	76 - 78
Particulate Phosphorus Settling Speed	PP_SETTLING	ft/day	76 - 78
Total Suspended Solids Production	TSSPROD	mg/day/ft	76 - 78
Total Suspended Solids Settling Speed	TSS_SETTLING	ft/day	76 - 78
[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.			

6.3 ADVANCED WATER QUALITY INPUTS

In the Advanced Water Quality Module in the WaSh Model, hydrologic and hydrodynamic components will be calculated, Dissolved Oxygen, Chemical Biologic Oxygen Demand (CBOD), and phytoplankton carbon mass.(C-Phyt), as well as the speciation of Nitrogen and Phosphorus.

Surface water parameters in the Advanced Water Quality module of WaSh are greatly affected by the seasonal signature of each nutrient species. Especially in South Florida, summer heat brings an increase in rain, runoff, and nutrient cycling. Therefore, the WaSh model is designed to use seasonally varying parameters for the individual nitrogen and phosphorus species listed above, DO, BOD and C-Phyt. These values are referred to as Event Mean Concentrations, or EMC's. Theoretically, EMC data is derived from site-specific and rain-event specific water quality data produced when a runoff sample is collected directly after a rainfall event. The timing of the sampling event typically produces a measurement which is elevated above background levels. Additionally, EMC data is typically attributed to a specific land use, as different land uses can produce highly variable EMC values. In the absence of measured, site-specific EMC data, many authors publish land use specific EMC or nutrient runoff values. In Florida, the standard literature values are published by Harvey Harper, (1992, 1994, 2003).

6.3.1 Surface Water

Surface Water components in Advance Water Quality module include TN, TP, DO, C-Phyt, and BOD. Also included, are the fractions of ammonia and nitrate in TN, the fraction of inorganic phosphorus in TP, and the Phytoplankton Seed value.

Parameter[1]	Symbol	Units	Theory Manual Equation
Monthly Total Nitrogen EMC Coeff.	AWQ_SW_TN_EMC_Mon[2]	mg/L	Section 9.2.1, Table 9.4
Fraction of TN that is Ammonia	AWQ_SW_Amm_Frac	none	Section 9.2.1, Table 9.4
Fraction of TN that is Nitrate	AWQ_SW_Nitrate_Frac	none	Section 9.2.1, Table 9.4
Monthly Total Phosphorus EMC Coeff.	AWQ_SW_TP_EMC_Mon[2]	mg/L	Section 9.2.1, Table 9.4
Fraction of TP that is inorganic	AWQ_SW_Inorganic_P_Frac	none	Section 9.2.1, Table 9.4
Monthly DO EMC Coeff.	AWQ_SW_DO_EMC_ Mon[2]	mg/L	Section 9.2.1, Table 9.4
Monthly Phytoplankton EMC Coeff.	AWQ_SW_PHYT_EMC_ Mon[2]	mg/L	Section 9.2.1, Table 9.4
Monthly BOD EMC Coeff.	AWQ_SW_BOD_EMC_ Mon[2]	mg/L	Section 9.2.1, Table 9.4
Phytoplankton Seed value	AWQ_SW Phyt_Seed	mg/L	Section 9.2.1, Table 9.4

[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table

[2]. An individual parameter must be provided for each month..

6.3.2 Ground Water

Groundwater components can either be simulated as fractions of surface water EMC values or as unique ground water EMC values. The Ground water components of the Advance Water Quality module include species of TN and TP, DO, C-Phyt, and BOD. Also included, are the fractions of ammonia and nitrate in TN, the fraction of inorganic phosphorus in TP, and the Phytoplankton Seed value.

Parameter[1]	Symbol	Units	Theory Manual Equation
Groundwater Input Option	GW_WQ_opt	Integer	Section 9.2.1, Table 9.5a, b
Fraction of Surface Water Organic Nitrogen	GW_ON_Frac	none	Section 9.2.1, Table 9.5a, b
Fraction of Surface Water Ammonia	GW_Amm_Frac	none	Section 9.2.1, Table 9.5a, b
Fraction of Surface Water Nitrate	GW_NItrate_Frac	none	Section 9.2.1, Table 9.5a, b

Parameter[1]	Symbol	Units	Theory Manual Equation
Fraction of Surface Water Organic Phosphorus	GW_OP_Frac	none	Section 9.2.1, Table 9.5a, b
Fraction of Surface OrthoPhosphate	GW_OrthoP_Frac	none	Section 9.2.1, Table 9.5a, b Section 9.2.1, Table 9.5a, b
Fraction of Surface Water Dissolved Oxygen	GW_DO_Frac	none	Section 9.2.1, Table 9 Section 9.2.1, Table 9.5a, b.5a, b
Fraction of Surface Water BOD	GW_BOD_Frac	none	Section 9.2.1, Table 9.5a, b
Fraction of Surface Water PhytoPlankton	GW_Phyt_Frac	none	Section 9.2.1, Table 9.5a, b
Monthly Ground Water Total Nitrogen EMC Coeff.	AWQ_GW_TN_EMC_Mon[2]	mg/L	Section 9.2.1, Table 9.5a, b
Fraction of Ground Water TN that is Ammonia	AWQ_GW_Amm_Frac	none	Section 9.2.1, Table 9.5a, b
Fraction of Ground Water TN that is Nitrate	AWQ_GW_Nitrate_Frac	none	Section 9.2.1, Table 9.5a, b
Monthly Ground Water Total Phosphorus EMC Coeff.	AWQ_GW_TP_EMC_Mon[2]	mg/L	Section 9.2.1, Table 9.5a, b
Fraction of Ground Water TP that is inorganic	AWQ_GW_Inorganic_P_Frac	none	Section 9.2.1, Table 9.5a, b
Monthly Ground Water DO EMC Coeff.	AWQ_GW_BOD_EMC_Mon[2]	mg/L	Section 9.2.1, Table 9.5a, b

[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.

[2]. An individual parameter must be provided for each month.

6.3.3 Atmospheric Deposition of Nitrogen and Phosphorus

The Atmospheric Deposition of Nitrogen and Phosphorus parameters for the Advanced Water Quality include wet and dry nitrate, ammonia, and inorganic phosphorus values.

Parameter[1]	Symbol	Units	Theory Manual Equation
N03 Wet Deposition-Mon[2]	N03_WETDEP1	mg/L	83
N03 Dry Deposition-Mon[2]	N03_DRYDEP1	$mg/m^2/yr$	84
Amm Wet Disposition-Mon[2]	AMM_WETDEP1	mg/L	83
Amm Dry Deposition-Mon[2]	AMM_DRYDEP1	$mg/m^2/yr$	84

[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.

Parameter[1]	Symbol	Units	Theory Manual Equation
[2]. An individual parameter must be provided for each month.			

Parameter[1]	Symbol	Units	Theory Manual Equation
IP Wet Deposition- Mon[2]	IP_WETDEP1	mg/L	83
IP Dry Deposition- Mon[2]	IP_DRYDEP1	mg/m^2/yr	84

[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.

[2]. An individual parameter must be provided for each month.

6.3.4 Tertiary Canals

Several parameters dictate the behavior of nutrients in tertiary canal system. Parameters include nutrient cycling coefficients, atmospheric parameters, photosynthetic coefficients, and physical parameters influencing settling speeds.

Parameter[1]	Symbol	Units	Theory Manual Equation
Extinction Coefficient (fixed)	KE1	ft^{-1}	88
Extinction Coefficient (variable)	KE2	ft^{-1} mg/ft^3	88
Fraction Daylight	FRAC_Daylight	none	87
Maximum Phytoplankton Growth Rate	GP	day^{-1}	86
Max Growth Temperature Coefficient	THETAGP	none	Section 9.2.3
Carbon-Chlorophyll Ratio	EC	none	Table 9.8
Light Intensity at Saturation	LIS	Langelys/day	87
Half-Saturation Nitrogen	KMN	mg-N/L	89
Half-Saturation Phosphorus	KMP	mg-P/L	89
Endogenous Respiration	K1R	day^{-1}	99
End. Resp. Temperature Coefficient	THETA1R	none	99
Phytoplankton Settling Velocity	VS4	ft/day	91
Phytoplankton Death Rate	KDP	day^{-1}	90
Endogenous Respiration	**K1R**	**day^{-1}**	99
Temperature Coefficient	**THETA1R**	none	99
Phytoplankton Nitrogen to Carbon Ratio	ANC	mg-N/mg-C	94, 95

Parameter[1]	Symbol	Units	Theory Manual Equation
Organic Nitrogen Mineralization Rate	K71	day^{-1}	94, 95
ON Min Rate Temperature Coefficient	THETA71	none	94, 95
Nitrification Rate	K12	day^{-1}	95, 96, 98, 99
Nitrification Rate Temp. Coefficient	THETA12	none	95, 96
Half-Saturation Constant- Oxygen	KNIT	mg O_2/L	95, 96
Denitrification Rate	K2D	day^{-1}	98
Den. Rate Temperature Coefficient	THETA2D	none	96
Michaelis Constant	KNO3	mg O_2/L	98
Fraction of Phytoplankton Released N going to ON	FON	none	94, 95
Organic Nitrogen Settling Velocity	VS3	ft/day	94
Phytoplankton Phosphorus to Carbon Ratio	APC	mg-P/mg-C	92, 93
Phosphate Mineralization Rate	K83	day^{-1}	92, 93
OP Min. Rate Temperature Coefficient	THETA83	none	92, 93
Half-Saturation Constant	KMPC	mg-C/L	92, 93
Fraction of Phytoplankton Released P going to OP	FOP	none	92, 93
Organic Phosphorus Settling Velocity	VS2	ft/day	92
CBOD-Oxygen to Carbon Ratio	AOC	mg-O_2/mg-C	98
BOD Settling Velocity	VS5	ft/day	98
Deoxygenation Rate	KD	day^{-1}	98, 99
Deoxy Rate Temperature Coefficient	THETAD	none	98, 99
Half-Saturation Constant- Oxygen	KBOD	mg-O_2/L	98,99
Sediment Oxygen Demand	SOD	$g/m^2/day$	99
SOD Temperature Coefficient	THETA2	none	99
Reaeration Rate	K2	day^{-1}	99

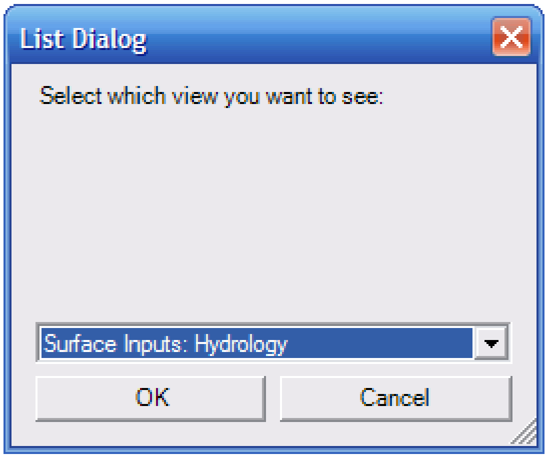
[1] Configuration cell data, such as Grid Cell ID, Cell Type, Land Use Levels…, resides in each table in the GUI. They have been omitted from the above table.

6.4 BASIC EDITING TABLE PROCEDURES

For detailed instruction in table editing techniques, refer to ESRI software documentation. This section is designed to address simple editing techniques used to edit table in the WaSh model.

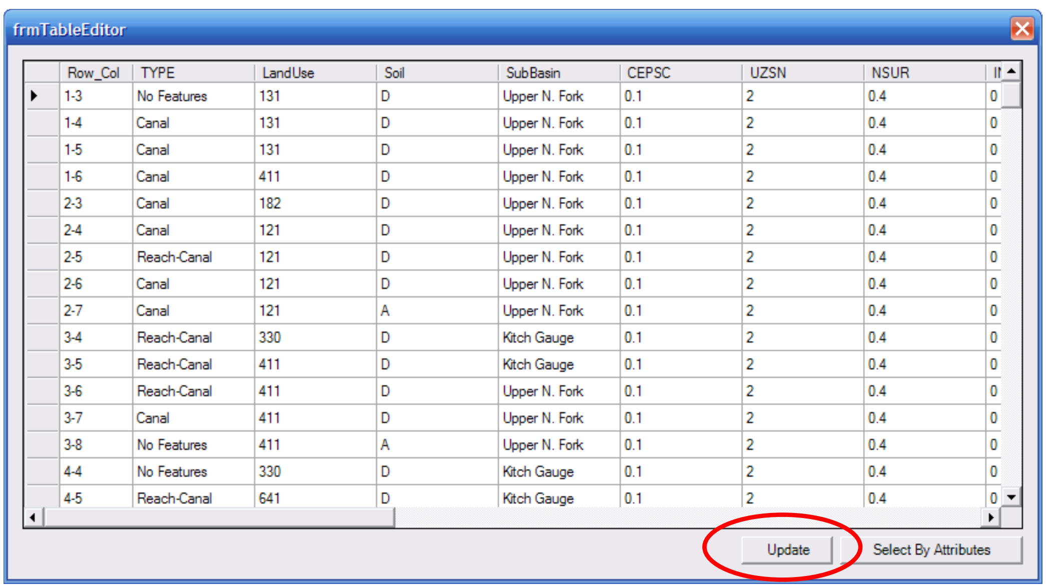
6.4.1 Global Parameter Changes

Changing parameters globally in a table begins with selecting and opening the table to be edited.



6.5

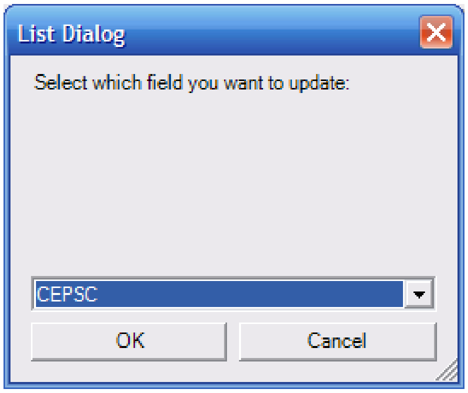
When opened, the table will display parameters as column headings, with rows identifying records based on grid cell ID's for Model tables or Reach Segments for Primary Reach tables. The table may not be totally visible but using the scroll bar at the bottom of the table will allow the user to view all parameters.



Row_Col	TYPE	LandUse	Soil	SubBasin	CEPSC	UZSN	NSUR	II
1-3	No Features	131	D	Upper N. Fork	0.1	2	0.4	0
1-4	Canal	131	D	Upper N. Fork	0.1	2	0.4	0
1-5	Canal	131	D	Upper N. Fork	0.1	2	0.4	0
1-6	Canal	411	D	Upper N. Fork	0.1	2	0.4	0
2-3	Canal	182	D	Upper N. Fork	0.1	2	0.4	0
2-4	Canal	121	D	Upper N. Fork	0.1	2	0.4	0
2-5	Reach-Canal	121	D	Upper N. Fork	0.1	2	0.4	0
2-6	Canal	121	D	Upper N. Fork	0.1	2	0.4	0
2-7	Canal	121	A	Upper N. Fork	0.1	2	0.4	0
3-4	Reach-Canal	330	D	Kitch Gauge	0.1	2	0.4	0
3-5	Reach-Canal	411	D	Kitch Gauge	0.1	2	0.4	0
3-6	Reach-Canal	411	D	Upper N. Fork	0.1	2	0.4	0
3-7	Canal	411	D	Upper N. Fork	0.1	2	0.4	0
3-8	No Features	411	A	Upper N. Fork	0.1	2	0.4	0
4-4	No Features	330	D	Kitch Gauge	0.1	2	0.4	0
4-5	Reach-Canal	641	D	Kitch Gauge	0.1	2	0.4	0

6.6

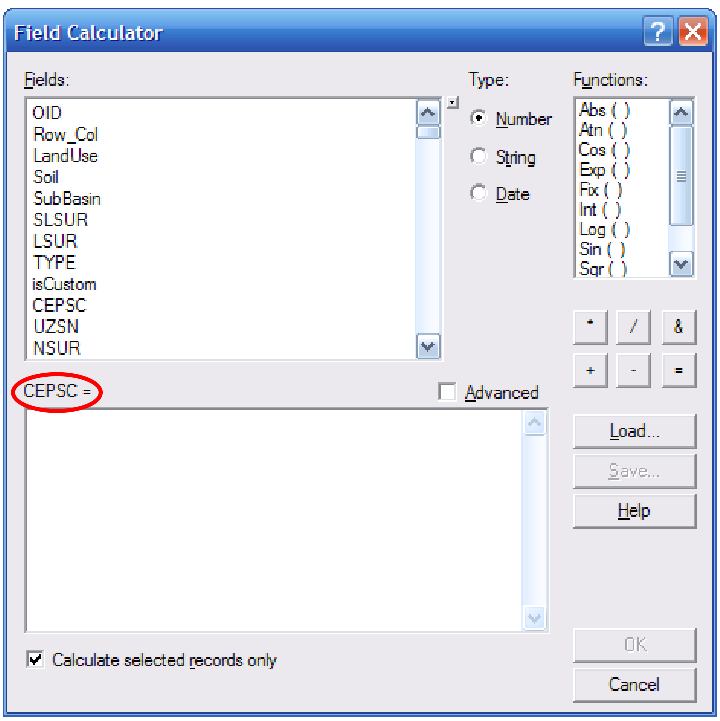
Choosing the Update button will open a field editing screen, allowing the user to choose individual parameters to be edited. The drop down menu in this screen will contain all parameters which may be edited.



6.7

Fields such as Row_Column, Water Feature Type, Land Use, Soil, Subbasin, etc. are physical attributes mapped onto the grid during the configuration procedure. These attributes may not be edited in these operations.

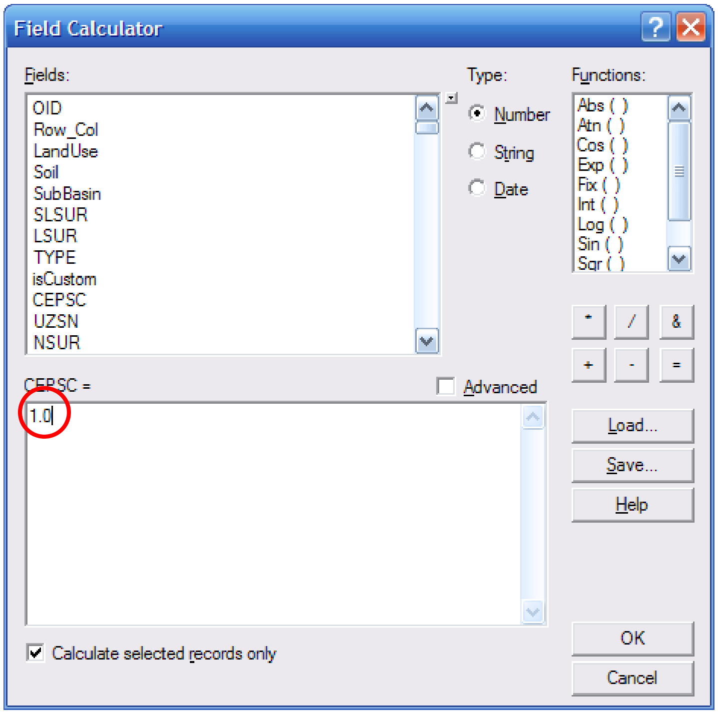
After choosing a parameter to edit, the ArcMap Field Calculator screen will appear. At this stage, only the attribute chosen in the previous screen may be edited. For this demonstration CEPSC is used.



6.8

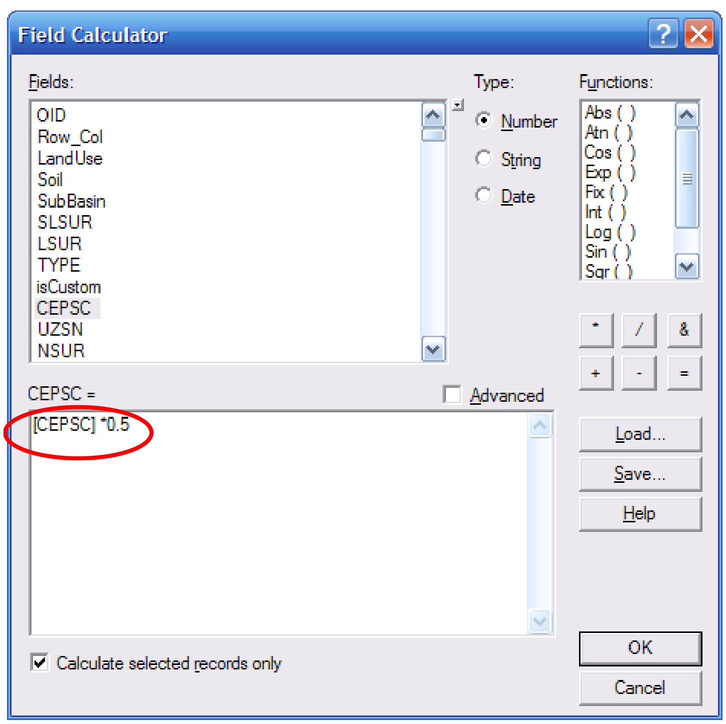
In the above screen, CEPSC may be edited by placing a value in the function box or by using an equation to calculate the parameter value.

CEPSC may be calculated as a single value for each record, by typing the desired value in the function box.



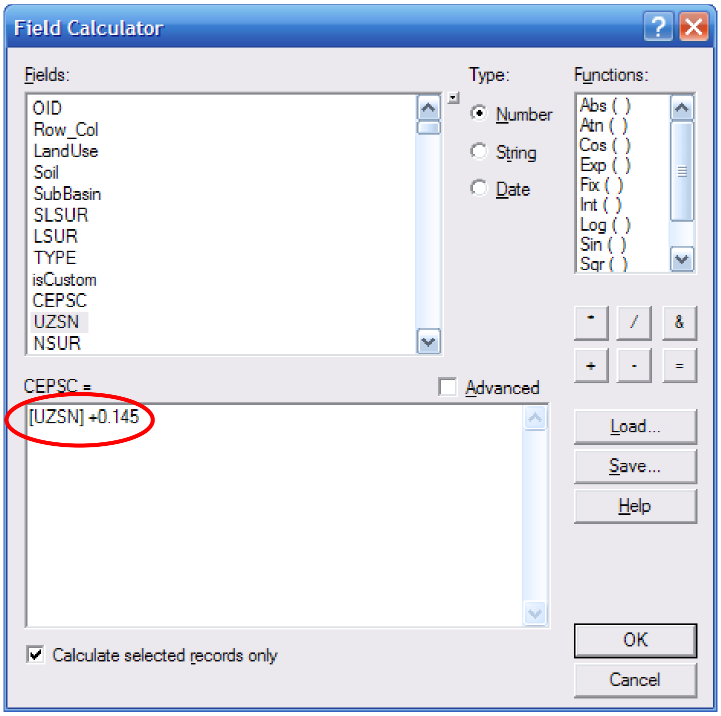
6.9

The parameter may also be calculated as a function of an existing value in the table. For example, if the CEPSC value needs to be reduced by 50%, an equation can be used in the operation box, which references the existing value.



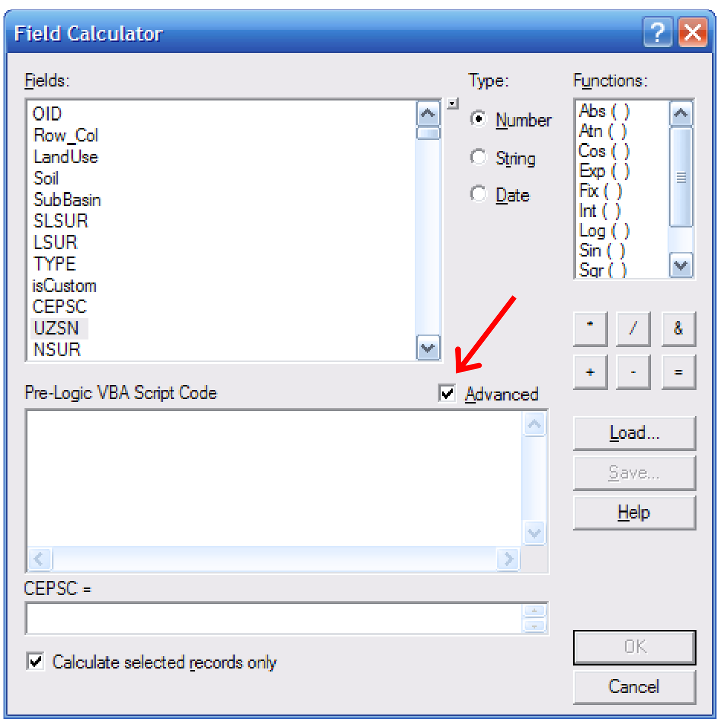
6.10

The value may also be calculated as a function of another field. For example, CEPSC can be calculated as the UZSN value plus a constant.



6.11

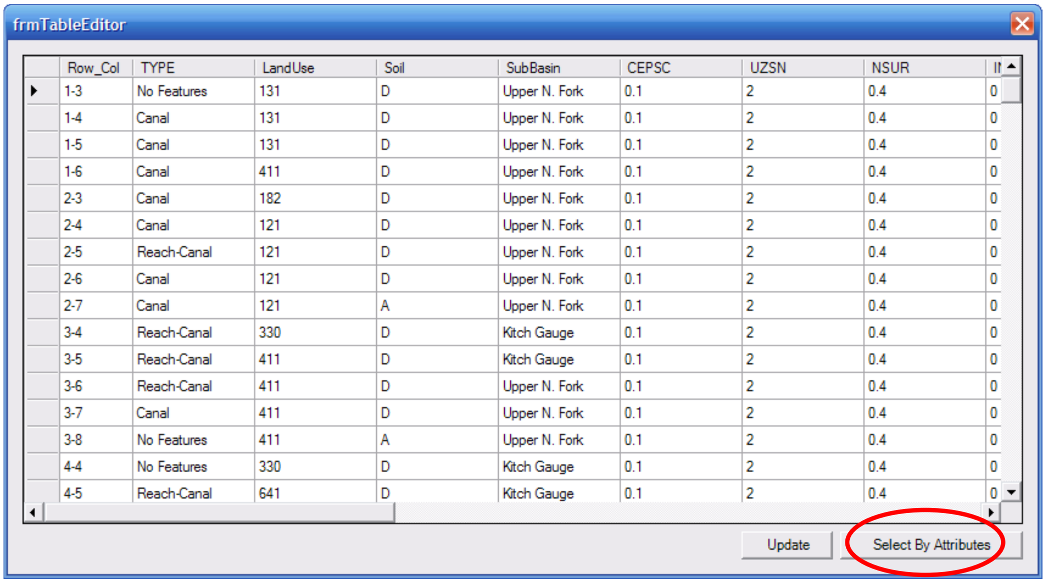
Editing operations can get significantly more advanced by choosing the advanced option and using Visual Basic operations. These operations will not be demonstrated in this text and they should rarely be necessary. For more complex coding edits, consult ESRI or Visual Basic documentation.



6.12

6.4.2 Editing by Attribute

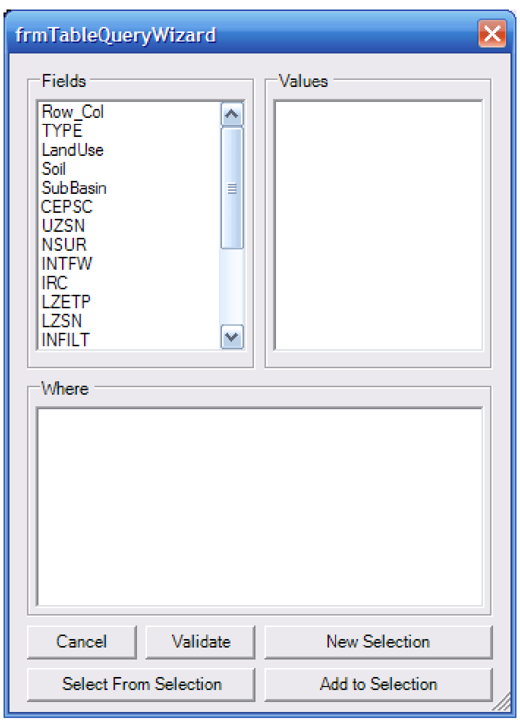
Often tables will require more refined editing, based on particular attributes of a record. The most common attribute editing is based on the Land Use category. This tool is especially valuable when editing EMC values, which are land use dependent. Choosing the "Select by Attribute" button on the parameter table will initiate selection by attributes.



Row_Col	TYPE	LandUse	Soil	SubBasin	CEPSC	UZSN	NSUR	II
1-3	No Features	131	D	Upper N. Fork	0.1	2	0.4	0
1-4	Canal	131	D	Upper N. Fork	0.1	2	0.4	0
1-5	Canal	131	D	Upper N. Fork	0.1	2	0.4	0
1-6	Canal	411	D	Upper N. Fork	0.1	2	0.4	0
2-3	Canal	182	D	Upper N. Fork	0.1	2	0.4	0
2-4	Canal	121	D	Upper N. Fork	0.1	2	0.4	0
2-5	Reach-Canal	121	D	Upper N. Fork	0.1	2	0.4	0
2-6	Canal	121	D	Upper N. Fork	0.1	2	0.4	0
2-7	Canal	121	A	Upper N. Fork	0.1	2	0.4	0
3-4	Reach-Canal	330	D	Kitch Gauge	0.1	2	0.4	0
3-5	Reach-Canal	411	D	Kitch Gauge	0.1	2	0.4	0
3-6	Reach-Canal	411	D	Upper N. Fork	0.1	2	0.4	0
3-7	Canal	411	D	Upper N. Fork	0.1	2	0.4	0
3-8	No Features	411	A	Upper N. Fork	0.1	2	0.4	0
4-4	No Features	330	D	Kitch Gauge	0.1	2	0.4	0
4-5	Reach-Canal	641	D	Kitch Gauge	0.1	2	0.4	0

6.13

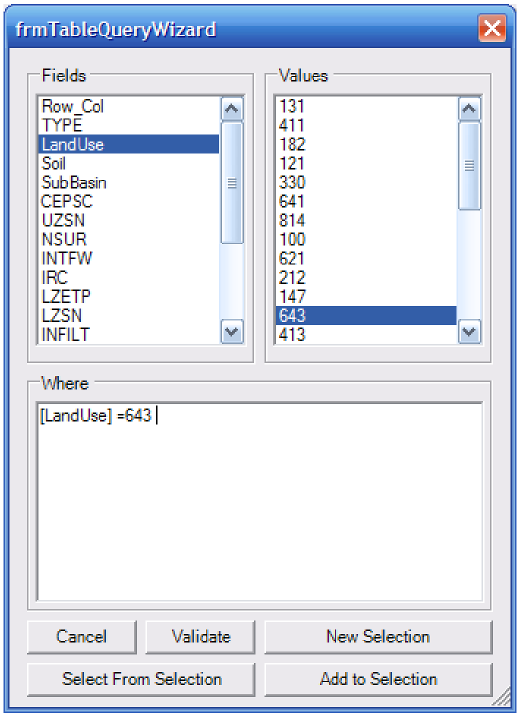
The Attribute selection screen appears below, containing a list of all field in the table.



6.14

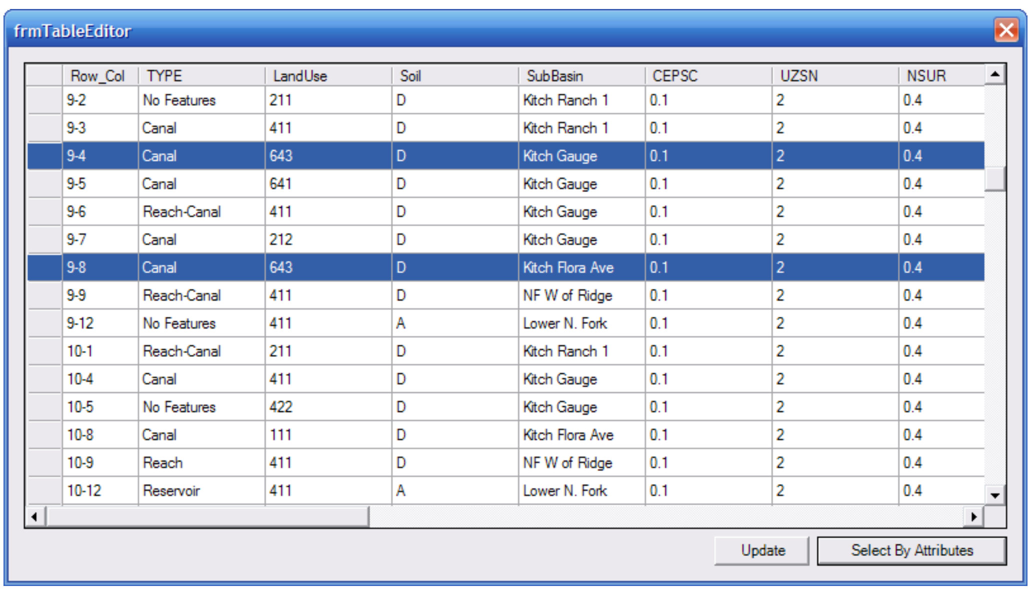
In the following screen, selection by land use will be used as the criteria. By double-clicking on landuse in the upper left box, the upper right box populates with all landuse categories present in the grid. Since the model was generated using FLUCCS level 3 values, all variations are present.

In order to select a single FLUCCS_3 code, simply add an equals and then double-click on the desired land use code.



6.15

Hitting the "New Selection" button will generate a search in which all chosen values are highlighted in the table.

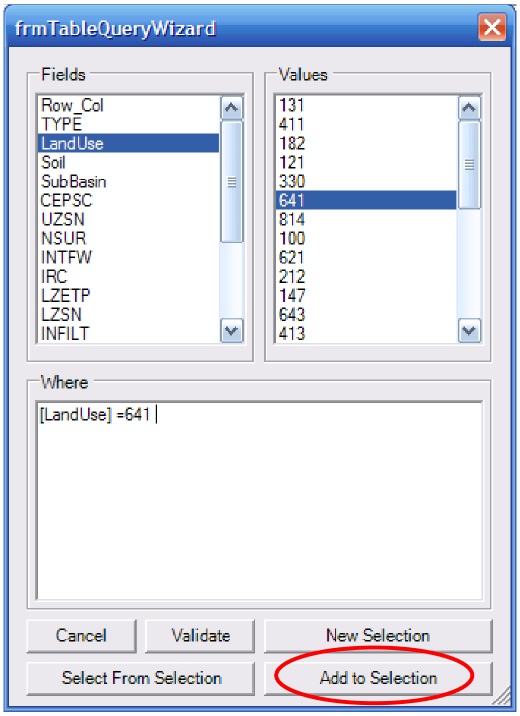

frmTableEditor

Row_Col	TYPE	LandUse	Soil	SubBasin	CEPSC	UZSN	NSUR
9-2	No Features	211	D	Kitch Ranch 1	0.1	2	0.4
9-3	Canal	411	D	Kitch Ranch 1	0.1	2	0.4
9-4	Canal	643	D	Kitch Gauge	0.1	2	0.4
9-5	Canal	641	D	Kitch Gauge	0.1	2	0.4
9-6	Reach-Canal	411	D	Kitch Gauge	0.1	2	0.4
9-7	Canal	212	D	Kitch Gauge	0.1	2	0.4
9-8	Canal	643	D	Kitch Flora Ave	0.1	2	0.4
9-9	Reach-Canal	411	D	NF W of Ridge	0.1	2	0.4
9-12	No Features	411	A	Lower N. Fork	0.1	2	0.4
10-1	Reach-Canal	211	D	Kitch Ranch 1	0.1	2	0.4
10-4	Canal	411	D	Kitch Gauge	0.1	2	0.4
10-5	No Features	422	D	Kitch Gauge	0.1	2	0.4
10-8	Canal	111	D	Kitch Flora Ave	0.1	2	0.4
10-9	Reach	411	D	NF W of Ridge	0.1	2	0.4
10-12	Reservoir	411	A	Lower N. Fork	0.1	2	0.4

Update
Select By Attributes

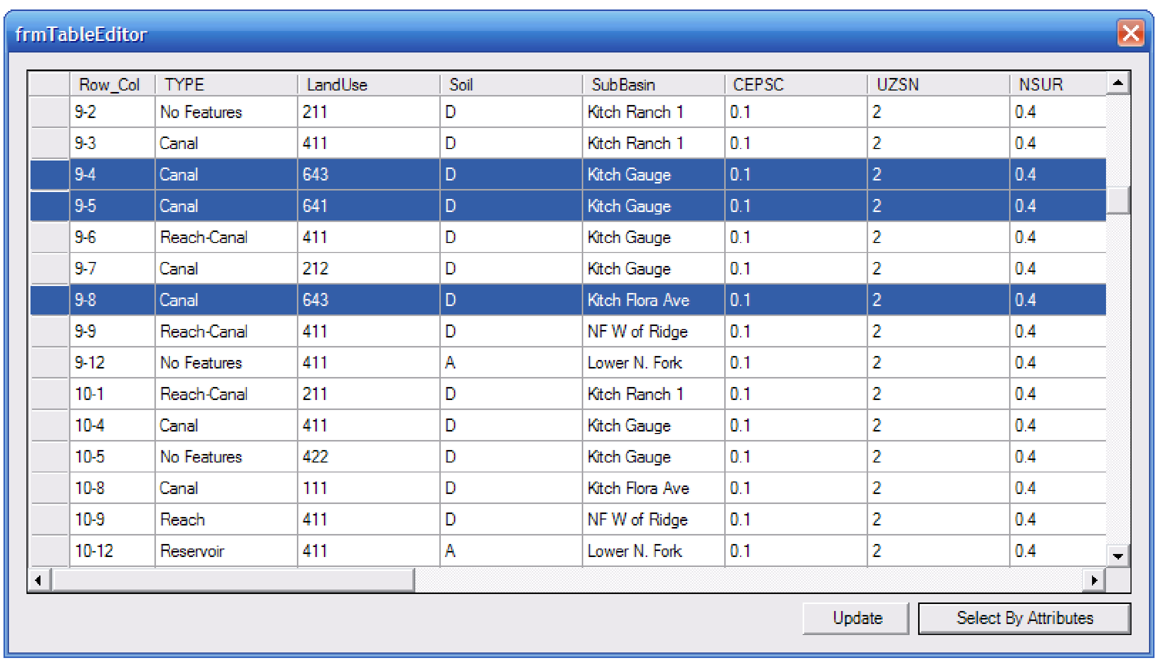
6.16

If additional parameter selections require the same edited values, subsequent land use categories can be added to the selection. Following the above outline procedure, identify the category to be selected and then use the "Add to Selection" option.



6.17

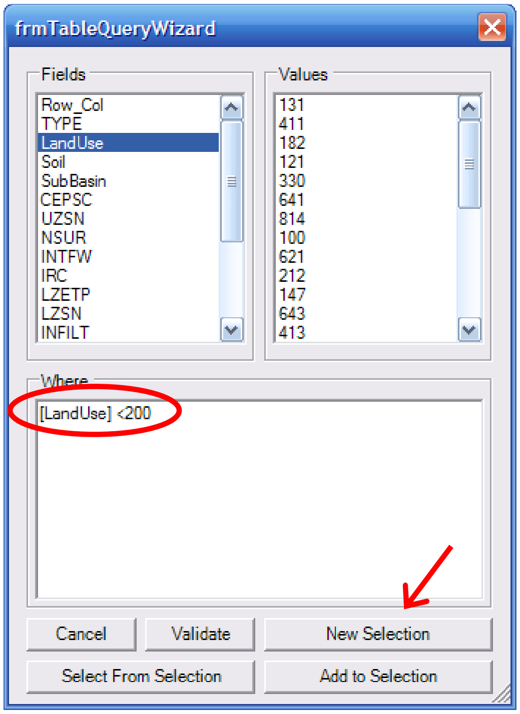
The Land use 641 will be highlighted in addition to the previously chosen 643.



Row_Col	TYPE	LandUse	Soil	SubBasin	CEPSC	UZSN	NSUR
9-2	No Features	211	D	Kitch Ranch 1	0.1	2	0.4
9-3	Canal	411	D	Kitch Ranch 1	0.1	2	0.4
9-4	Canal	643	D	Kitch Gauge	0.1	2	0.4
9-5	Canal	641	D	Kitch Gauge	0.1	2	0.4
9-6	Reach-Canal	411	D	Kitch Gauge	0.1	2	0.4
9-7	Canal	212	D	Kitch Gauge	0.1	2	0.4
9-8	Canal	643	D	Kitch Flora Ave	0.1	2	0.4
9-9	Reach-Canal	411	D	NF W of Ridge	0.1	2	0.4
9-12	No Features	411	A	Lower N. Fork	0.1	2	0.4
10-1	Reach-Canal	211	D	Kitch Ranch 1	0.1	2	0.4
10-4	Canal	411	D	Kitch Gauge	0.1	2	0.4
10-5	No Features	422	D	Kitch Gauge	0.1	2	0.4
10-8	Canal	111	D	Kitch Flora Ave	0.1	2	0.4
10-9	Reach	411	D	NF W of Ridge	0.1	2	0.4
10-12	Reservoir	411	A	Lower N. Fork	0.1	2	0.4

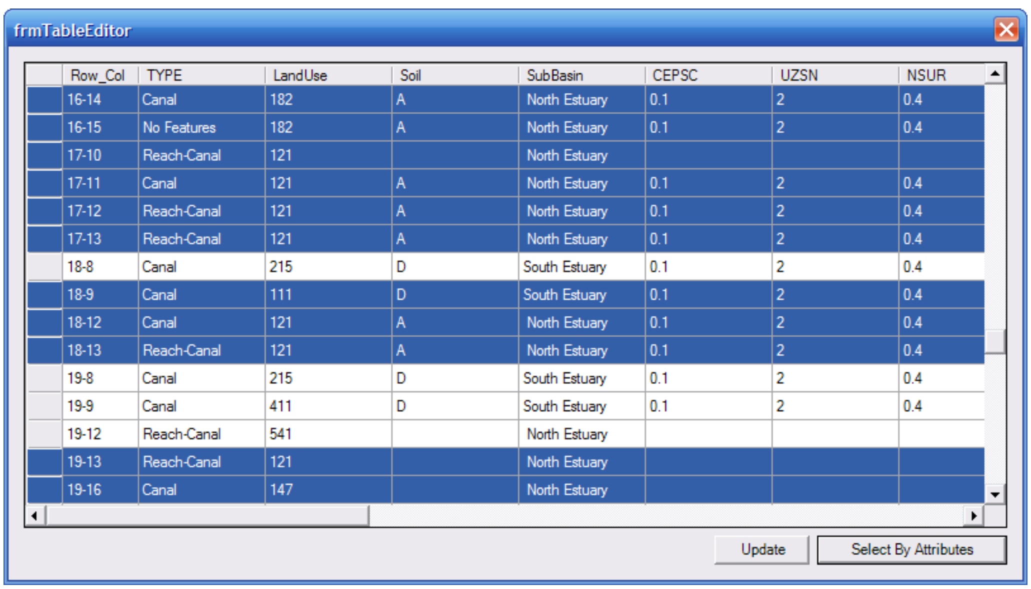
6.18

Often values will change on a more general scale and edits need to be made on a FLUCCS level 1 scale, for example. The selection can be generated for each successive FLUCCS level 3 code by adding the selection to the initial selection, or the process can be streamlined by selecting based on ranges of values. For example if all FLUCCS Level 1 codes are to be chosen for Urban, the select by attributes field will use the following equation and initiate a New Selection.



6.19

All FLUCCS Level 1 Urban cells have been highlighted and are ready for editing.

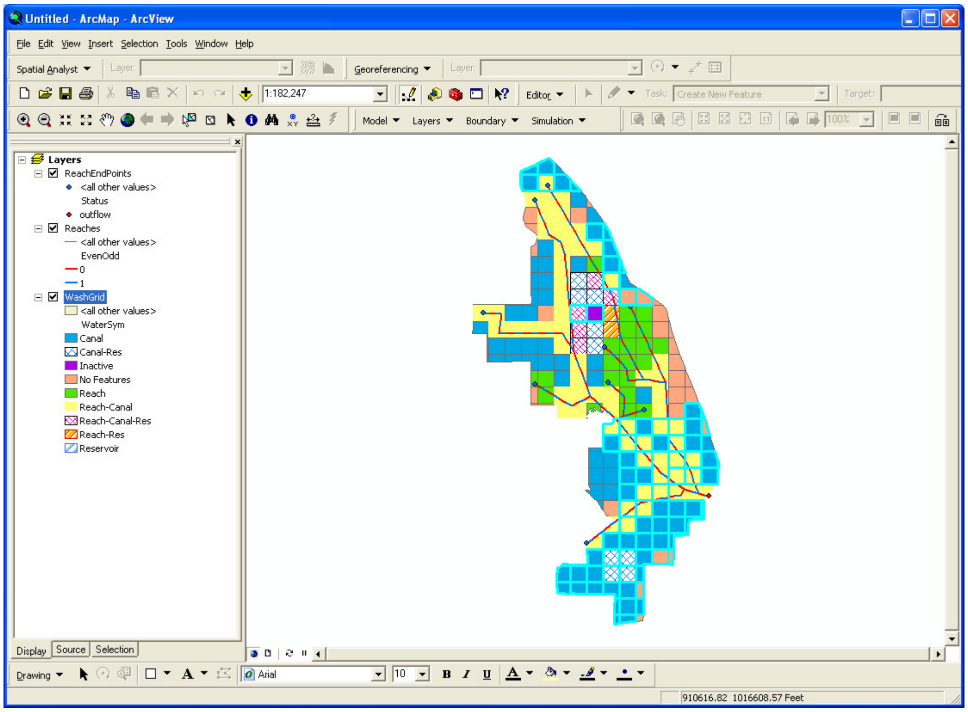

frmTableEditor

Row_Col	TYPE	LandUse	Soil	SubBasin	CEPSC	UZSN	NSUR
16-14	Canal	182	A	North Estuary	0.1	2	0.4
16-15	No Features	182	A	North Estuary	0.1	2	0.4
17-10	Reach-Canal	121		North Estuary			
17-11	Canal	121	A	North Estuary	0.1	2	0.4
17-12	Reach-Canal	121	A	North Estuary	0.1	2	0.4
17-13	Reach-Canal	121	A	North Estuary	0.1	2	0.4
18-8	Canal	215	D	South Estuary	0.1	2	0.4
18-9	Canal	111	D	South Estuary	0.1	2	0.4
18-12	Canal	121	A	North Estuary	0.1	2	0.4
18-13	Reach-Canal	121	A	North Estuary	0.1	2	0.4
19-8	Canal	215	D	South Estuary	0.1	2	0.4
19-9	Canal	411	D	South Estuary	0.1	2	0.4
19-12	Reach-Canal	541		North Estuary			
19-13	Reach-Canal	121		North Estuary			
19-16	Canal	147		North Estuary			

Update
Select By Attributes

6.20

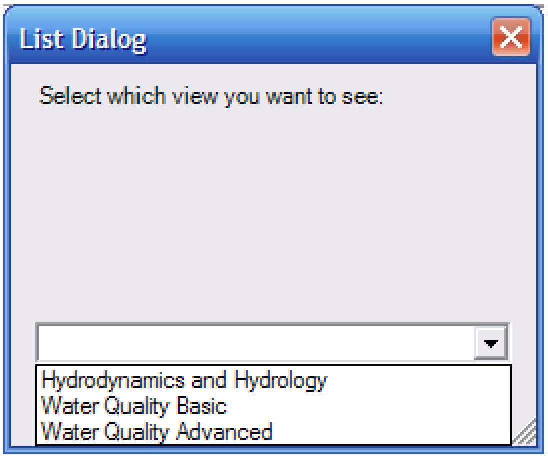
For reference, the selection can be verified in the data view. All grid cells chosen are now highlighted in the map.



6.21

Once the final selection is made, values may be edited as described in the previous section (6.4.1).

The model parameters for the reach segments can be divided in to hydrodynamics and hydrology, basic water quality and advanced water quality categories. The parameter values are set for each segment in the reach network. Some of the parameters control flow within the reach network while others control the interaction of the reach with other objects in the model domain (cells and reservoirs). The parameter values are accessible from the Model menu by selecting the Open Reach Table option.



7.1

The user can select any of the three parameter categories to gain access to the parameter values. Initially, the parameters values are set with default values by the WaSh GUI during the reach network configuration. The user can modify the parameter values for a combination of reach segments in order to calibrate the model, conduct a sensitivity analysis or any other purpose. Editing can be done for special selections of reach segments, based on geographic location, or other attribute-based selections. The basic selection and editing procedures have been described in Section 6.4 for cell parameters and those procedures apply here also.

In the following sections, each model parameter is identified and described. The parameters are also cross-referenced to the associated equation in the WaSh Model Theory Documentation.

7.1 HYDRODYNAMICS AND HYDRAULICS

The hydrodynamics and hydraulics component of the Primary Reach network addresses the dimensional aspects of the reach and water transport coefficients, Manning's n and conductance.

Parameter	Symbol	Units	Theory Manual Equation
Reach Segment	Rch_seg	integer	
Cell ID for connection	Cell_ID	integer	
Soil Type (from cell connection)	Hydro_grp	character	
Width	WIDTH	feet	21
Bottom Elevation	ELEVATION	feet	21
Mannings n	MANNINGS_N	none	22
Streambed Conductance	CONDUCTANCE	ft/day	59

7.2 WATER QUALITY: BASIC

Basic Water quality addresses the components of the hydrologic and hydrodynamic model in addition to modeling total Nitrogen (TN), total Phosphorus (TP) and Total Suspended Solids (TSS). Individual speciation of TN and TP is not a function of the Basic Water Quality functions.

The Basic Water Quality parameters for the Primary Reach Network are similar to the parameters discussed in section 6.2.4, which discusses Basic Water Quality in the Tertiary canal system.

Parameter	Symbol	Units	Theory Manual Equation
Reach Segment	Rch_seg	integer	-
Dissolved Nitrogen Decay	DN_DEC	day^{-1}	71
Dissolved Phosphorus Decay	DP_DEC	day^{-1}	71
Particulate Nitrogen Settling Speed	PN_SETTLING	ft/day	73
Particulate Phosphorus Settling Speed	PP_SETTLING	ft/day	73
Total Suspended Solids Production	TSSPROD	mg/day/ft	73
Total Suspended Solids Settling Speed	TSS_SETTLING	ft/day	73
Lateral Diffusion Coefficient	D_LATERAL	ft^2/sec	70
Critical Stress for Erosion	T_CRIT	Pa	73
Erosion Rate Coefficient	EROS	Inches/hr-Pa	73

7.3 WATER QUALITY: ADVANCED

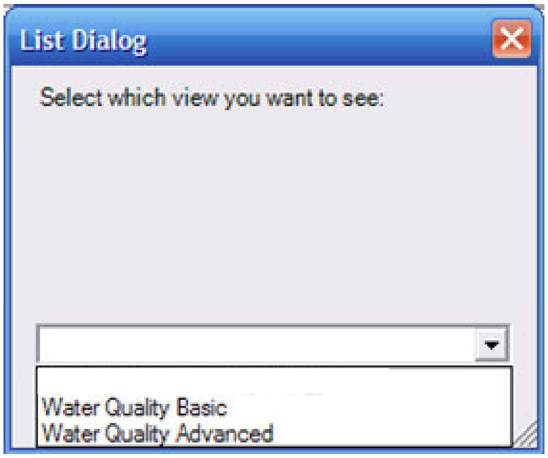
The majority of HSPF parameters are listed in the Advanced Water Quality module for the Primary Reach Network. Multi-layer operations are addressed for the first time, as well as all components of nutrient cycling and speciation dissemination. Components are similar to those previously discussed in section 6.3.4.

Parameter	Symbol	Units	Theory Manual Equation
Reach Segment	Rch_seg	none	-
Lateral Mixing Coefficient	D_Lateral	ft^2/sec	70
Number of Layers (1 or 2)	Num_Layers	integer	-
Vertical Mixing Coefficient	Mix_Vertical	ft^2/sec	82
Extinction Coefficient (fixed)	KE1	ft^{-1}	88
Extinction Coefficient (variable)	KE2	ft^{-1} mg/ft^3	88
Fraction Daylight	Frac_Daylight	none	87
Maximum Phytoplankton Growth Rate	GP	day^{-1}	85, 86, 93

Parameter	Symbol	Units	Theory Manual Equation
Max Growth Temperature Coefficient	THETAGP	none	Section 9.2.3
Carbon-Chlorophyll Ratio	EC	none	Table 9.8
Light Intensity at Saturation	LIS	Langelys/day	87
Half-Saturation Nitrogen	KMN	mg-N/L	89
Half-Saturation Phosphorus	KMP	mg-P/L	89
Endogenous Respiration	K1R	day^{-1}	99
End. Resp. Temperature Coefficient	THETA1R	none	99
Phytoplankton Settling Velocity	VS4	ft/day	91
Endogenous Respiration	**K1R**	**day^{-1}**	99
Temperature Coefficient	**THETA1R**	none	99
Phytoplankton Death Rate	KDP	day^{-1}	90
Phytoplankton Nitrogen to Carbon Ratio	ANC	mg-N/mg-C	94, 95
Organic Nitrogen Mineralization Rate	K71	day^{-1}	94, 95
ON Min Rate Temperature Coefficient	THETA71	none	94, 95
Nitrification Rate	K12	day^{-1}	95, 96, 98, 99
Nitrification Rate Temp. Coefficient	THETA12	none	95, 96, 99
Half-Saturation Constant- Oxygen	KNIT	mg O_2/L	95, 96
Denitrification Rate	K2D	day^{-1}	98
Den. Rate Temperature Coefficient	THETA2D	none	96
Michaelis Constant	KNO3	mg O_2/L	96, 98
Fraction of Phytoplankton Released N going to ON	FON	none	94, 95
Organic Nitrogen Settling Velocity	VS3	ft/day	94
Phytoplankton Phosphorus to Carbon Ratio	APC	mg-P/mg-C	92, 93
Phosphate Mineralization Rate	K83	day^{-1}	92, 93
OP Min. Rate Temperature Coefficient	THETA83	none	92, 93
Half-Saturation Constant	KMPC	mg-C/L	92, 93
Fraction of Phytoplankton Released P going to OP	FOP	none	92, 93
Organic Phosphorus Settling Velocity	VS2	ft/day	92
CBOD-Oxygen to Carbon Ratio	AOC	mg-O_2/mg-C	98
BOD Settling Velocity	VS5	ft/day	98

Parameter	Symbol	Units	Theory Manual Equation
Deoxygenation Rate	KD	day^{-1}	98, 99
Deoxy Rate Temperature Coefficient	THETAD	none	98, 99
Half-Saturation Constant- Oxygen	KBOD	$mg\text{-}O_2/L$	98, 99
Sediment Oxygen Demand	SOD	$g/m^2/day$	99
SOD Temperature Coefficient	THETA2	none	99
Reaeration Rate	K2	day^{-1}	99

The model parameters for the reservoir cells can be divided into basic water quality and advanced water quality categories. The parameter values are set for each cell in the reservoir network. The parameters control the interaction of the reservoir with other objects in the model domain (cells and reaches). The parameter values are accessible from the Model menu by selecting the Open Reservoir Table option.



8.1

The user can select any of the three parameter categories to gain access to the parameter values. Initially, the parameter values are set with default values by the WaSh GUI during the reservoir network configuration. The user can modify the parameter values for a combination of reservoir cells in order to calibrate the model, conduct a sensitivity analysis or any other purpose. Editing can be done for special selections of reservoir cells, based on geographic location, or other attribute-based selections. The basic selection and editing procedures have been described in Section 6.4 for cell parameters and those procedures apply here also.

In the following sections, each model parameter is identified and described. The parameters are also cross-referenced to the associated equation in the WaSh Model Theory Documentation.

8.1 WATER QUALITY: BASIC

Basic Water quality addresses the components of the hydrologic and hydrodynamic model in addition to modeling total Nitrogen (TN), total Phosphorus (TP) and Total Suspended Solids (TSS). Individual speciation of TN and TP is not a function of the Basic Water Quality functions.

The Basic Water Quality parameters for the Reservoir Network are similar to the parameters discussed in Section 6.2.4, which discusses Basic Water Quality in the Tertiary canal system.

Parameter	Symbol	Units	Theory Manual Equation
Reservoir ID	Res_ID	integer	
Dissolved Nitrogen Decay	DN_DEC	day^{-1}	71
Dissolved Phosphorus Decay	DP_DEC	day^{-1}	71
Particulate Nitrogen Settling Speed	PN_SETTLING	ft/day	73
Particulate Phosphorus Settling Speed	PP_SETTLING	ft/day	73

Parameter	Symbol	Units	Theory Manual Equation
Total Suspended Solids Production	TSSPROD	mg/day/ft	73
Total Suspended Solids Settling Speed	TSS_SETTLING	ft/day	73
Lateral Diffusion Coefficient	D_LATERAL	ft^2/sec	70
Critical Stress for Erosion	T_CRIT	Pa	73
Erosion Rate Coefficient	EROS	Inches/hr-Pa	73

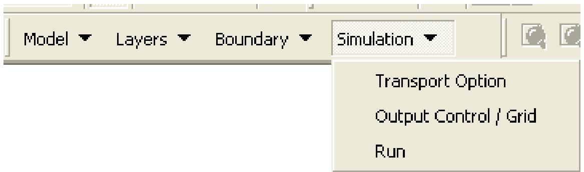
8.2 WATER QUALITY: ADVANCED

The majority of HSPF parameters are listed in the Advanced Water Quality module for the Reservoir Network. Multi-layer operations are addressed for the first time, as well as all components of nutrient cycling and speciation dissemination. Components are similar to those previously discussed in Section 6.3.4.

Parameter	Symbol	Units	Theory Manual Equation
Reach Segment	Rch_seg	none	-
Lateral Mixing Coefficient	D_Lateral	ft^2/sec	82
Number of Layers (1 or 2)	Num_Layers	integer	-
Vertical Mixing Coefficient	Mix_Vertical	ft^2/sec	82
Extinction Coefficient (fixed)	KE1	ft^{-1}	88
Extinction Coefficient (variable)	KE2	ft^{-1} mg/ft^3	88
Fraction Daylight	Frac_Daylight	none	87
Maximum Phytoplankton Growth Rate	GP	day^{-1}	85, 86, 93
Max Growth Temperature Coefficient	THETAGP	none	Section 9.2.3
Carbon-Chlorophyll Ratio	EC	none	Table 9.8
Light Intensity at Saturation	LIS	Langelys/day	87
Half-Saturation Nitrogen	KMN	mg-N/L	89
Half-Saturation Phosphorus	KMP	mg-P/L	89
Endogenous Respiration	K1R	day^{-1}	99
End. Resp. Temperature Coefficient	THETA1R	none	99
Phytoplankton Settling Velocity	VS4	ft/day	91
Endogenous Respiration	**K1R**	**day^{-1}**	99
Temperature Coefficient	**THETA1R**	none	99
Phytoplankton Death Rate	KDP	day^{-1}	90
Phytoplankton Nitrogen to Carbon Ratio	ANC	mg-N/mg-C	94, 95

Parameter	Symbol	Units	Theory Manual Equation
Organic Nitrogen Mineralization Rate	K71	day^{-1}	94, 95
ON Min Rate Temperature Coefficient	THETA71	none	94, 95
Nitrification Rate	K12	day^{-1}	95, 96, 98, 99
Nitrification Rate Temp. Coefficient	THETA12	none	95, 96, 99
Half-Saturation Constant- Oxygen	KNIT	mg O_2/L	95, 96
Denitrification Rate	K2D	day^{-1}	98
Den. Rate Temperature Coefficient	THETA2D	none	96
Michaelis Constant	KNO3	mg O_2/L	98
Fraction of Phytoplankton Released N going to ON	FON	none	94, 95
Organic Nitrogen Settling Velocity	VS3	ft/day	94
Phytoplankton Phosphorus to Carbon Ratio	APC	mg-P/mg-C	92, 93
Phosphate Mineralization Rate	K83	day^{-1}	92, 93
OP Min. Rate Temperature Coefficient	THETA83	none	92, 93
Half-Saturation Constant	KMPC	mg-C/L	92, 93
Fraction of Phytoplankton Released P going to OP	FOP	none	92, 93
Organic Phosphorus Settling Velocity	VS2	ft/day	92
CBOD-Oxygen to Carbon Ratio	AOC	mg-O_2/mg-C	98
BOD Settling Velocity	VS5	ft/day	98
Deoxygenation Rate	KD	day^{-1}	98, 99
Deoxy Rate Temperature Coefficient	THETAD	none	98, 99
Half-Saturation Constant- Oxygen	KBOD	mg-O_2/L	98, 99
Sediment Oxygen Demand	SOD	$g/m^2/day$	99
SOD Temperature Coefficient	THETA2	none	99
Reaeration Rate	K2	day^{-1}	99

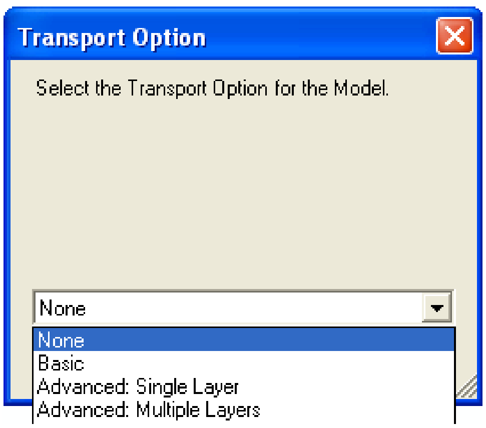
WaSh model can be launched after the configuration is complete. The basic simulation options are accessed under the "Simulation" menu.



9.1

9.1 TRANSPORT OPTION

The Transport Options menu allows for a choice of None, Basic, Advanced: Single Layer or Advanced: Multiple Layers water quality simulation.



9.2

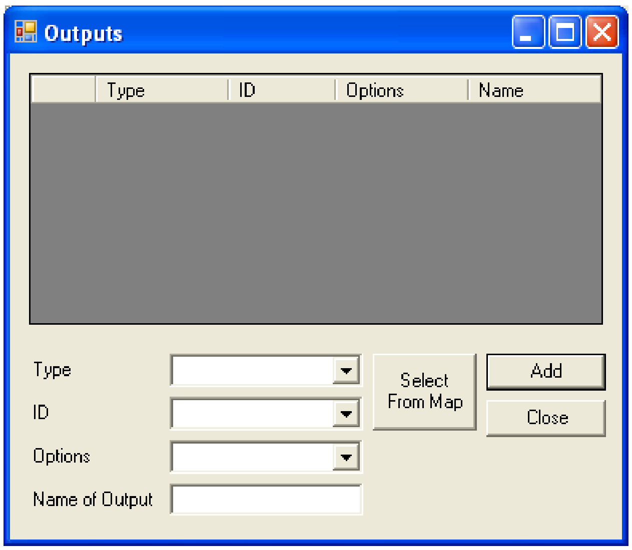
One of these options can be selected. The "None" option simulates Hydrology and Hydrodynamics only. Basic water quality will simulate hydrology and hydrodynamics along with dissolved and particulate Total Nitrogen, dissolved and particulate Total Phosphorus, and Total Suspended Sediments. Advanced water quality can simulates hydrology and hydrodynamics along with ammonia, nitrate, organic nitrogen, orthophosphate, organic phosphorus, CBOD, dissolved oxygen, and phytoplankton carbon mass. For models which contain large, deep reach systems, such as estuaries, the multiple layer switch can be employed. By using the multiple layer option, the reach can be divided vertically with an upper and lower section simulating separately. Vertical mixing coefficients allow for exchange between the two layers.

Note that the transport option for basic or advanced water quality must be selected here before the Downstream Transport Boundary Conditions menu options will be available for editing.

9.2 OUTPUT CONTROL

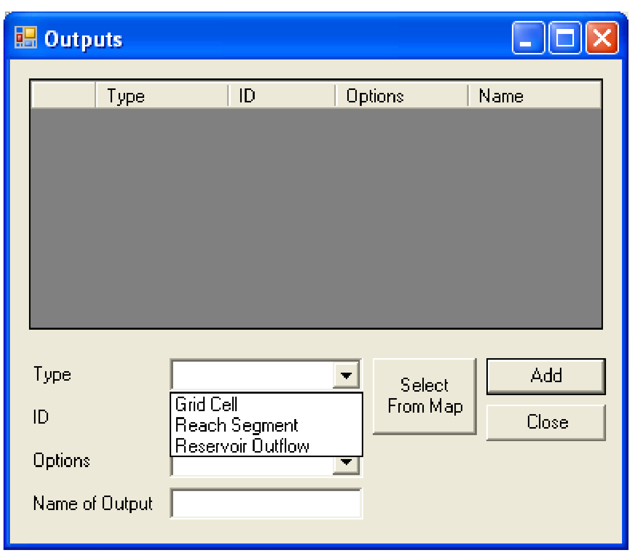
The grid cell Output control will instruct the model to generate an output file for the chosen grid cell, reach segment, or reservoir cell during the model simulation. The most common output file is the basin outfall associated with the Reach output control discussed in the next section. However, the user may wish to analyze model output for any grid cell or reservoir in the model. The output files can generate flow and stage data in the hydrology option, water quality data in the Transport option, or both in the Hydro/Transport option. Output will be generated in the time series tabular data in comma-delimited text format. For the water quality output data, the parameters listed will be based on the water quality option chosen: Basic v. Advanced. Note that each output location must have a unique ID for proper output and it is advied that output location names contain no spaces. The use of an underscore in place a of space will create a more stable format in ArcMap.

By selecting the “Output Control/Grid” option from the Simulation menu, the following screen will appear.



9.3

First, the type of output must be chosen. By opening the menu for Type, the following choices will appear.

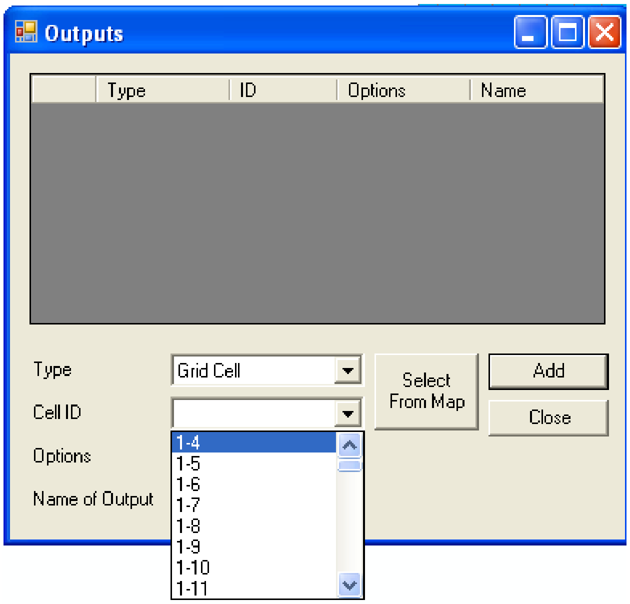


9.4

Output can be defined as a grid cell, reach segment, or as reservoir outflow.

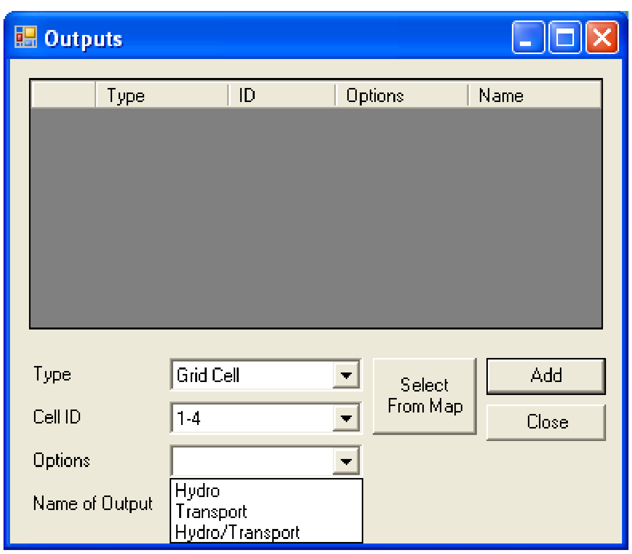
9.2.1 Output Control: Grid

By choosing the Grid Cell option, the Cell ID menu will populate with all available grid cell ID's.



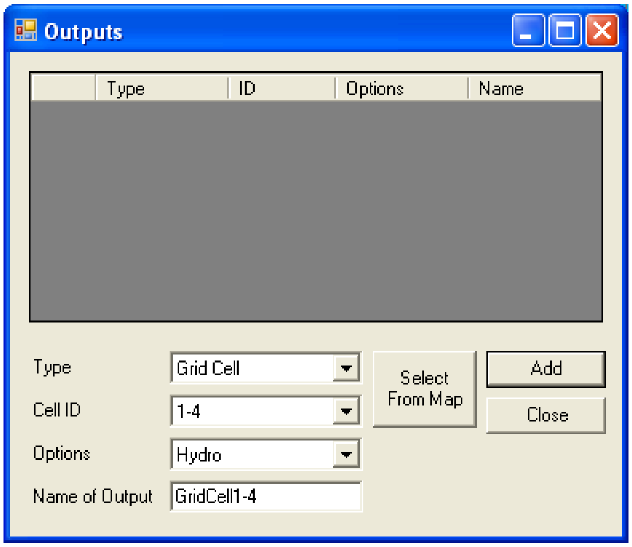
9.5

Cell ID's are comprised of the row and column numbers separated by a hyphen. When the desired Cell ID has been chosen, the options menu will allow the user to choose the type of Transport that will be output by the model. Output types include Hydro (Hydrology), Transport (Water Quality) and Hydro/Transport (Hydrology and Water Quality).



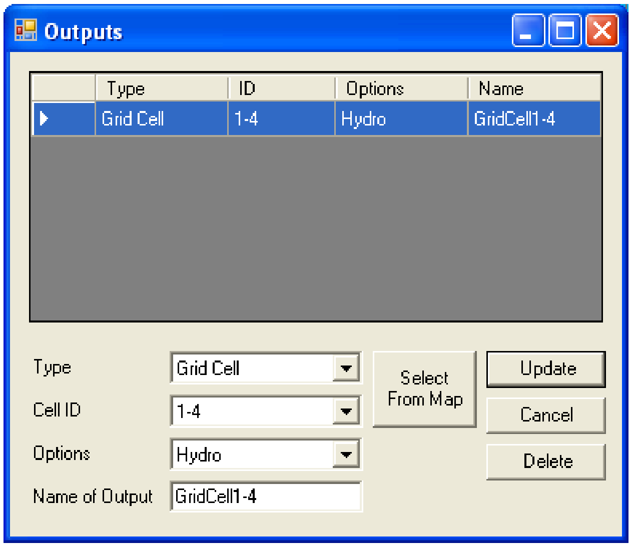
9.6

When the Transport option has been chosen, the output location will need to be named.



9.7

Selecting the "Add" button will save the output point and add it to the table at the top of the screen for future identification.

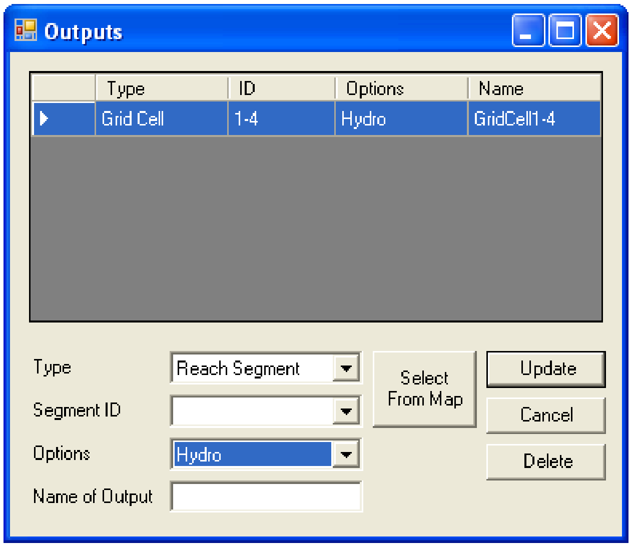


9.8

Selecting the "Cancel" button will remove the highlight from the previously selected output location and allow the user to add additional output points. In the event that the desired cell ID is not known, the "Select from Map" button can be used to

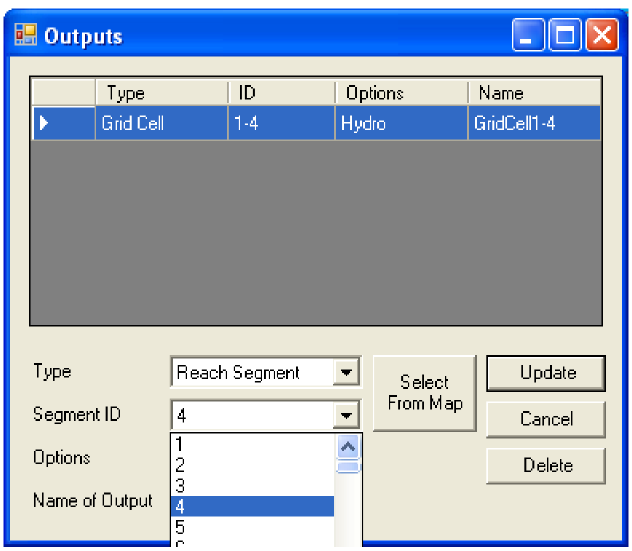
9.2.2 Output Control: Reach

Model output can be generated for individual reach segments.



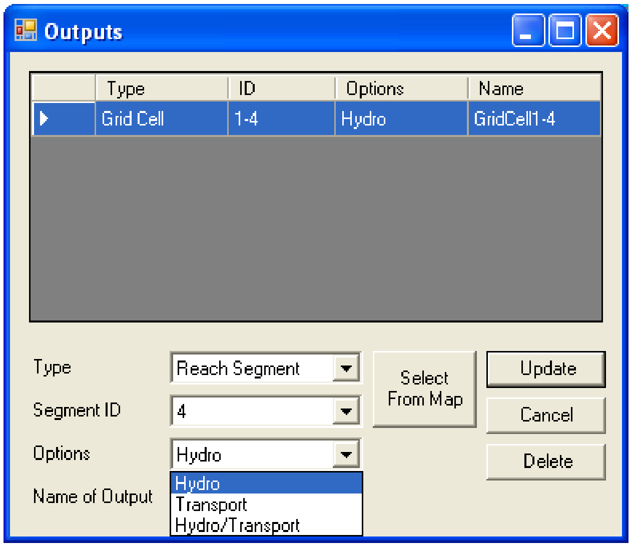
9.9

By selecting the "Reach Segment" output option from the Type menu, all available reach segment ID's will be available from the Segment ID list.



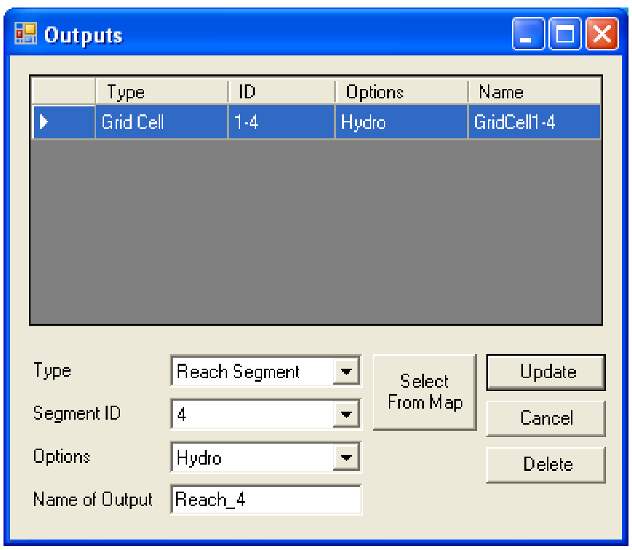
9.10

After selecting the desired reach segment, the Transport option must be identified, as in the previous section.



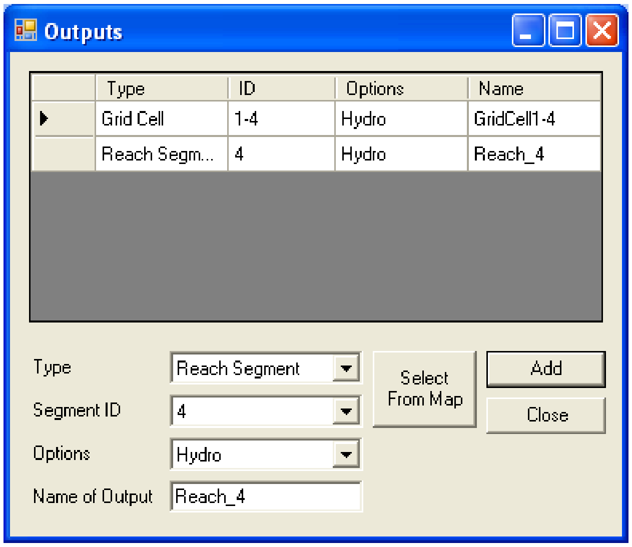
9.11

Next the reach output location will need to be named.



9.12

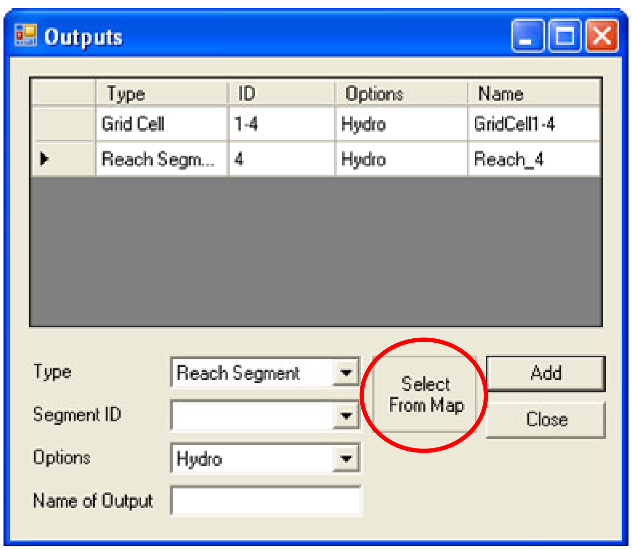
The “Update” button will add the reach output point to the Output table at the top of the screen.



9.13

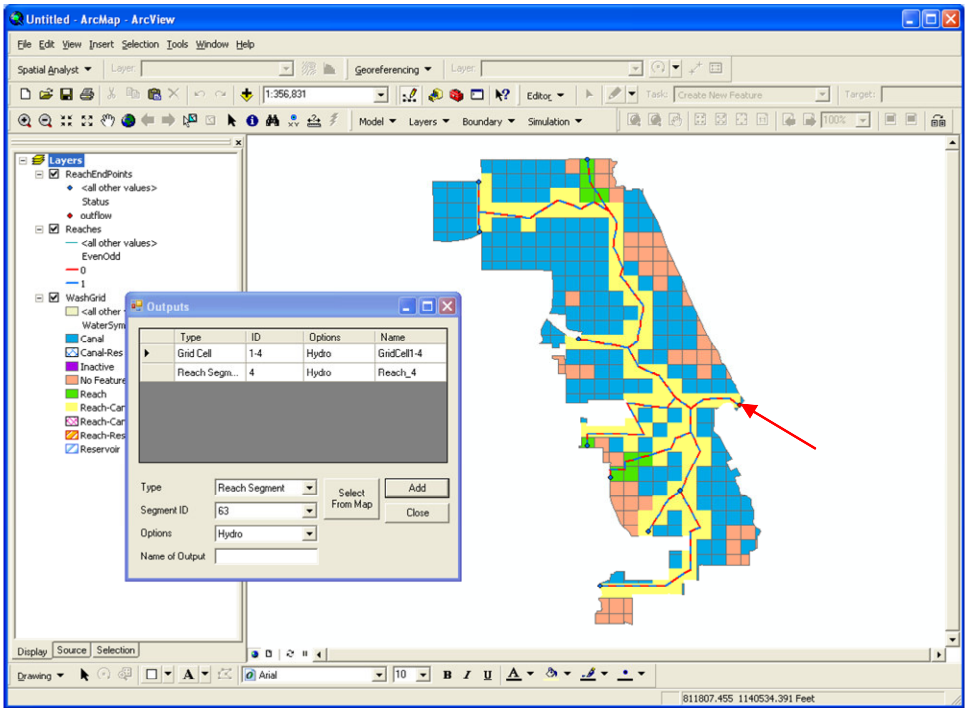
9.2.3 Output Control: BasinOutflow Point

For most models, the basin outfall will be the primary desired output. To access the basin outflow, use the Reach segment option under Type menu.



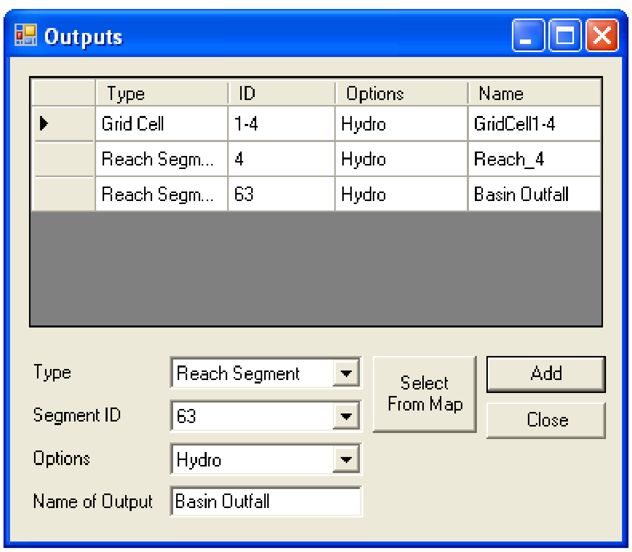
9.14

After selecting the "Reach Segment" option from the Type menu, the segment ID of the basin outfall can be chosen or the "Select from Map" option can be used to manually select the basin outfall. Using the cursor in the map, and clicking on the outfall endpoint, the appropriate reach segment will be identified in the Segmetn ID box..



9.15

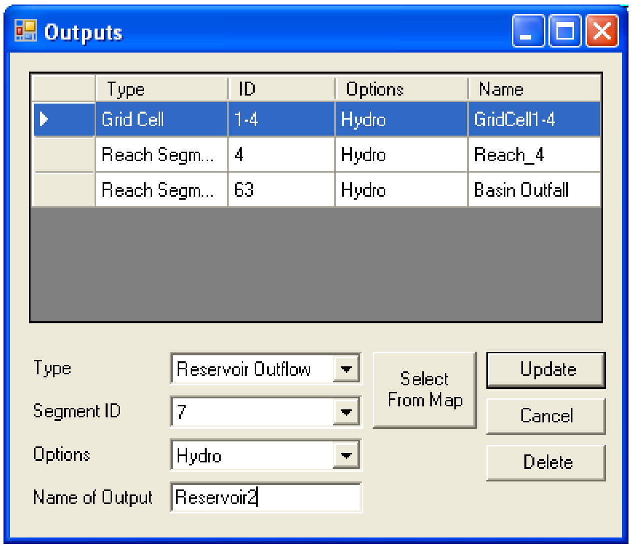
After selecting the transport option and naming the Output location, it will appear in the Output list.



9.16

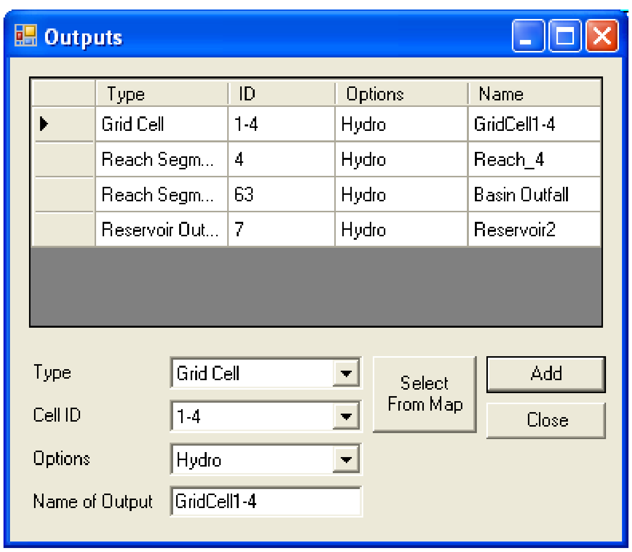
9.2.4 Output Control: Reservoir Outflow

As in the preceding sections, output files can be generated for each reservoir. Reservoir output does not distinguish between individual cells within the reservoir, however. Output is for the reservoir, as a whole. From the Output Control menu, select the Reservoir Output from the Type menu. All configured reservoirs will then be listed in the Reservoir ID field. Select the desired reservoir and the Transport option. After naming the reservoir output, the screen should appear as in the following figure.



9.17

Selecting the Update button will add the reservoir output to the output list and save it in the model.



9.18

Select the Close button to return to the model screen.

9.3 LAUNCHING A SIMULATION

The last option in the Simulation menu is the Run button. Once the model is configured, external forcing data has been added, all water quality and hydrologic parameters have been edited sufficiently, output points have been chosen and a simulation time step has been identified, the model is ready to launch. Select the Run button from the Simulation menu.

9.3.1 Input and Output Files

The first prompt menu will request the user to define the file path for the model input and output files. This file path will instruct the WaSh GUI on where to write the input files necessary for launching the Fortran executable. It will also create a subdirectory within the folder called "output" which will be the location of all model output files created by the Fortran program at the end on of a model simulation.

Each time the Run button is engaged, the user will be prompted to define a new path. The same path can be used in subsequent model runs. However, input and output files will be overwritten with each simulation execution. If the user wishes to edit the model and keep separate versions of the input files and the results, a different folder structure can be defined for each simulation. For instance, a model can be created and run with the output file defined as "Wash_v1". After the model parameters are edited, the model is run a second time with the output folder defined as "Wash_v2". If this option is used, it is important to note that only that last set of input and output files will match the model. All other data sets can be archived and used for analysis, but they will no longer match the model. The user must remember or record any changes made to the model with each version.

If each version of a model is to be preserved after a model simulation, the "Copy model" feature should be employed for each simulation. After a model is created and run, the model can be copied, edited and re-run. The output file path will need to be designated for each run, but it will reside in a newly copied model for each simulation.

9.3.2 Input File Names

When a model run is launched in the GUI, a set of input files will be generated for use in the fortran code. The list of files required for proper operation of the Fortran model are listed below.

```
WashGrid.csv
Reaches.csv
Structures_Culverts.csv
Structures_Gates.csv
Structures_Weirs.csv
Structures_Pumps.csv
FlowLines.csv
Reservoirs.csv
Connections.csv
ModelParams.csv
ReachCon.csv
ReachGrid.csv
ResGrid.csv
Transport.csv
CellData_1.csv
CellData_2.csv
PointSource_Grid.csv
```

```
PointSource_Reach.csv
OutputControl_Grid.csv
OutputControl_ReachSeg.csv
OutputControl_Reservoir.csv
Rainfall.csv
RFmap_index.csv
```

It is important the these file remain in the defined file path and that names not be edited prior to executing a model simulation. If files are missing or misnamed, the Fortran executable will not operate properly.

9.3.3 Model Execution

Upon launching a simulation, the ArcMap GUI will take a moment to compile all model parameters and export those parameters in predefined WaSh model input files. Any errors encountered during parameter compilation will be indicated in the ArcMap screen. When all files have been compiled properly, the WaSh executable will be launched by the GUI. A DOS window will open to display the progress of the model set-up. O If any errors occur, the DOS window will display error information. When the model is successfully launched, the DOS screen will count through the simulation process by daily timesteps until the model simulation time period is completed. At the end of the countdown, the Model Output will be written to a comma-delimited text file within the defined model output folder. If the model is interrupted during the simulation process, the output files will be incomplete.

Output will be generated in the time-series tabular data in comma-delimited text format for each output option selected.

10.1 REACH OUTPUT TABLES

A single file will be created for each reach segment identified. All reach segment output files will be created in the following format: *Rch_"ReachSegmentID".csv*. If the "Hydrology" option was chosen for output, time series data will be produced indicating the following parameters.

Column Header	Description	Units
Day	Date	mm/dd/yyyy
FLOW	Surface Water Discharge	cfs
STAGE	Surface water height	feet

If the Transport Option was chosen, output will contain the following parameters for the Basic Water Quality Option. A single file will be created for each reach segment identified.

Column Header	Description	Units
Day	Date	mm/dd/yyyy
FLOW	Surface Water Discharge	cfs
STAGE	Surface Water Height	feet
TSS	Total Suspended Solids	mg/L
Part_N	Particulate Total Nitrogen	mg/L
Sol_N	Soluble Total Nitrogen	mg/L
Part_P	Particulate Total Phosphorus	mg/L
Sol_P	Soluble Total Phosphorus	mg/L

If the Transport Option was chosen output will contain the following parameters for the Advanced Water Quality Option. A single file will be created for each reach segment identified.

Column Header	Description	Units
Day	Date	mm/dd/yyyy
FLOW	Surface Water Discharge	cfs
STAGE	Surface Water Height	feet
C_NH3-N	Ammonia, as N	mg/L
C_Nitr-N	Nitrate, as N	mg/L
C_IORG-P	Inorganic Phosphorus, as P	mg/L
C_Phyt-C	Phytoplankton Carbon Mass	mg/L
C_CBOD	Chemical Biologic Oxygen Demand	mg/L
C_DissOx	Dissolved Oxygen	mg/L
C_ON-N	Organic Nitrogen, as N	mg/L
C_OP-P	Organic Phosphorus, as P	mg/L

When the multi-layer option is chosen, model output will have two complete series of data for the upper and the lower layers in the model. Data series will appear as in the following table. A single file will be created for each reach segment identified.

Column Header	Layer	Description	Units
Day	n/a	Date	mm/dd/yyyy
FLOW	n/a	Surface Water Discharge	cfs
STAGE	n/a	Surface Water Height	feet
U_NH3-N	Upper	Ammonia, as N	mg/L
U_Nitr-N	Upper	Nitrate, as N	mg/L
U_IORG-P	Upper	Inorganic Phosphorus, as P	mg/L
U_Phyt-C	Upper	Phytoplankton Carbon Mass	mg/L
U_CBOD	Upper	Chemical Biologic Oxygen Demand	mg/L
U_DissOx	Upper	Dissolved Oxygen	mg/L
U_ON-N	Upper	Organic Nitrogen, as N	mg/L
U_OP-P	Upper	Organic Phosphorus, as P	mg/L
L_NH3-N	Lower	Ammonia, as N	mg/L
L_Nitr-N	Lower	Nitrate, as N	mg/L
L_IORG-P	Lower	Inorganic Phosphorus, as P	mg/L
L_Phyt-C	Lower	Phytoplankton Carbon Mass	mg/L
L_CBOD	Lower	Chemical Biologic Oxygen Demand	mg/L
L_DissOx	Lower	Dissolved Oxygen	mg/L
L_ON-N	Lower	Organic Nitrogen, as N	mg/L
L_OP-P	Lower	Organic Phosphorus, as P	mg/L

10.2 CELL HYDROLOGY

If the Transport Option was chosen output will contain the following parameters for the Basic Water Quality Option. A single file will be created for each grid cell identified. The output file will be named: ***Cell_“GridCellID”.****csv*.

Column Header	Description	Units
day	Calendar day	mm/dd/yyyy
rain	Daily rainfall	inches/day
irrigation	Applied irrigation	inches/day
evap	Daily evaporation (excluding evaporatoin from groundwater)	inches/day
Surf_inflow	Surface water inputs from other cells	inches/day
Surf_runoff	Surface discharge	inches/day

Column Header	Description	Units
percolation	Percolation to groundwater	inches/day
gwhgt	Groundwater elevation (at end of day)	feet (realtive to project datum)
gwhgt_high	Groundwater elevation (at end of day) If high water table exists, the elevation includes lzs, uzs, ifws and surs	feet (realtive to project datum)
surs	Surface storage (at end of day)	inches
lzs	Lower zone storage (at end of day)	inches
uzs	Upper zone storage (at end of day)	inches
ifws	Interflow storage (at end of day)	inches
elev	Land surface elevation	feet
area	Cell area	$feet^2$
L_TSS	Total Suspended Solids load	Metric Tons/day
L_PN	Particulate nitrogen load	Metric Tons/day
L_PP	Particulate phosphorus load	Metric Tons/day
L_SN	Soluble nitrogen load	Metric Tons/day
L_SP	Soluble phosphorus load	Metric Tons/day

*first row after header will have 00/00/00 date and the initial values for all storages (surs, etc.). All other values will be zero.

If the Transport Option was chosen output will contain the following parameters for the Advanced Water Quality Option. A single file will be created for each reach segment identified. The output file will be named ***Cell_"GridCellID".****csv*.

Column Header	Description	Units
day	Calendar day	mm/dd/yyyy
rain	Daily rainfall	inches/day
irrigation	Applied irrigation	inches/day
evap	Daily evaporation (excluding evaporatoin from groundwater)	inches/day
Surf_inflow	Surface water inputs from other cells	inches/day
Surf_runoff	Surface discharge	inches/day
percolation	Percolation to groundwater	inches/day
gwhgt	Groundwater elevation (at end of day)	feet (realtive to

Column Header	Description	Units
		project datum)
gwhgt_high	Groundwater elevation (at end of day) If high water table exists, the elevation includes lzs, uzs, ifws and surs	feet (realtive to project datum)
surs	Surface storage (at end of day)	inches
lzs	Lower zone storage (at end of day)	inches
uzs	Upper zone storage (at end of day)	inches
ifws	Interflow storage (at end of day)	inches
elev	Land surface elevation	feet
area	Cell area	$feet^2$
L_NH3-N	Ammonia load	Metric Tons/day
L_Nitr-N	Nitrate/Nitrite load	Metric Tons/day
L_IORG-P	Inorganic phosphorus load	Metric Tons/day
L_Phyt-C	Phytoplankton load	Metric Tons/day
L_CBOD	CBOD load	Metric Tons/day
L_DissOx	Dissolved oxygen load	Metric Tons/day
L_ON-N	Organic nitrogen load	Metric Tons/day
L_OP-P	Organic phosphorus load	Metric Tons/day

*first row after header will have 00/00/00 date and the initial values for all storages (surs, etc.). All other values will be zero.

10.3 GROUNDWATER HYDROLOGY

If the Transport Option was chosen, output will contain the following parameters for the Basic Water Quality Option. A single file will be created for the groundwater for each grid cell identified. The output file will be named: ***Cell_"GridCellID"_gw.****csv*.

Column Header	Description	Units
day	Calendar day	mm/dd/yyyy
hgt	Gw elevation	Feet (reltave to project datum)
percolation	Discharge from land to GW	cfs
evap	Groundwater evaporation	cfs
GW_fluxin	GW transport to cell from adjacent cells	cfs
GW_fluxout	GW tranport out of cell to adjacent cells	cfs
Src_can	Discharge from canals to GW	cfs
Disch_can	Discharge form GW to canals	cfs
Disch_ditch	Discharge to ditches	cfs

Column Header	Description	Units
GW_to_Irr	GW used for irrigation	cfs
Irr_to_GW	Irrigation added to GW	cfs
area	Cell area	$feet^2$
C_TSS	Total Suspended Solids concentration (at end of day)	mg/L
C_PN	Particulate nitrogen concentration (at end of day)	mg/L
C_PP	Particulate phosphorus concentration (at end of day)	mg/L
C_SN	Soluble nitrogen concentration (at end of day)	mg/L
C_SP	Soluble phosphorus concentration (at end of day)	mg/L

*first row after header will have 00/00/00 date and the initial values for all storages (hgt etc.). All other values will be zero.

If the Transport Option was chosen, output will contain the following parameters for the Advanced Water Quality Option. A single file will be created for the groundwater for each grid cell identified. The output file will be named: ***Cell_"GridCellID"_gw.****csv*

Column Header	Description	Units
day	Calendar day	mm/dd/yyyy
hgt	Gw elevation	Feet (relative to project datum)
percolation	Discharge from land to GW	cfs
evap	Groundwater evaporation	cfs
GW_fluxin	GW transport to cell from adjacent cells	cfs
GW_fluxout	GW tranport out of cell to adjacent cells	cfs
Src_can	Discharge from canals to GW	cfs
Disch_can	Discharge form GW to canals	cfs
Disch_ditch	Dsicharge to ditches	cfs
GW_to_Irr	GW used for irrigation	cfs
Irr_to_GW	Irrigation added to GW	cfs
area	Cell area	$feet^2$
C_NH3-N	Ammonia concentration (at end of day)	mg/L

Column Header	Description	Units
C_Nitr-N	Nitrate/Nitrite concentration (at end of day)	mg/L
C_IORG-P	Inorganic phosphorus concentration (at end of day)	mg/L
C_Phyt-C	Phytoplankton concentration (at end of day)	mg/L
C_CBOD	CBOD concentration (at end of day)	mg/L
C_DissOx	Dissolved oxygen concentration (at end of day)	mg/L
C_ON-N	Organic nitrogen concentration (at end of day)	mg/L
C_OP-P	Organic phosphorus concentration (at end of day)	mg/L

*first row after header will have 00/00/00 date and the initial values for all storages (hgt etc.). All other values will be zero.

10.4 CELL HYDROLOGY WITH IRRIGATION

If the Irrigation Option was chosen, output will contain the following parameters for the irrigation. A single file will be created for each grid cell identified. The output file will be named: ***Cell_"GridCellID"_irrigation.****csv*

Column Header	Description	Units
day	Calendar day	mm/dd/yy
irrigation	Applied irrigation	inches/day
IrrSrc_canal	Irrigation from canals	inches/day
IrrSrc_external	Irrigation from canals	inches/day
IrrSrc_gw	Irrigation from canals	inches/day
IrrApp_spray	Irrigation applied as spray	inches/day
IrrApp_Surf	Irrigation applied to surface water	inches/day
IrrApp_LZ	Irrigation applied to lower zone	inches/day
IrrApp_UZ	Irrigation applied to upper zone	inches/day
IrrApp_GW	Irrigation applied to groundwater	inches/day

10.5 CELL HYDROLOGY WITH TERTIARY CANALS

If the Transport Option was chosen, output will contain the following parameters for the Basic Water Quality Option. A single file will be created each grid cell identified with tertiary canals. The output file will be named ***Cell_"GridCellID"_canals.****csv*

Column Header	Description	Units
day	Calendar day	mm/dd/yy
SW_hgt	height of surface water in canal	Feet (relative to canal bottom)
SW_Inputs	Surface discharge into canal	cfs
GW_Inputs	Groundwater discharge into cell	cfs
Reach_inputs	Canal water source from reach network for to maintain irrigation water in canal	cfs
Disch_GW	Canal surface water discharged to GW	cfs
Disch_pump	Canal discharges to reaches using the pumping option	cfs
Disch_weir	Canal discharges to reaches using the wier option	cfs
Can_area	Surface area of canal	$feet^2$
Can_bot_elev	Botom elevation of the canal	feet (realtive to project datum)
Can_rain	Rainfall accumulation in the canal	cfs
Can_evap	Evaproation losses form canal	cfs
Can_irr	Canal discharges to cell for irrigation	
C_TSS	Total Suspended Solids concentration (at end of day)	mg/L
C_PN	Particulate nitrogen concentration (at end of day)	mg/L
C_PP	Particulate phosphorus concentration (at end of day)	mg/L
C_SN	Soluble nitrogen concentration (at end of day)	mg/L
C_SP	Soluble phosphorus concentration (at end of day)	mg/L
L_TSS	Total Suspended Solids load	mg/L
L_TSS	Particulate nitrogen load	Metric Tons/day
L_PN	Particulate phosphorus load	Metric Tons/day
L_PP	Soluble nitrogen load	Metric Tons/day
L_SN	Soluble phosphorus load	Metric Tons/day
L_SP	Total Suspended Solids load	Metric Tons/day

*first row after header will have 00/00/00 date and the initial values for all storages (Sw_hgt) All other values will be zero.

If the Transport Option was chosen, output will contain the following parameters for the Advanced Water Quality Option. A single file will be created each grid cell identified with tertiary canals. The output file will be named ***Cell_"GridCellID"_canals.****csv*

Column Header	Description	Units
day	Calendar day	mm/dd/yy
SW_hgt	height of surface water in canal	Feet (relative to canal bottom)
SW_Inputs	Surface discharge into canal	cfs
GW_Inputs	Groundwater discharge into cell	cfs
Reach_inputs	Canal water source from reach network for to maintain irrigation water in canal	cfs
Disch_GW	Canal surface water discharged to GW	cfs
Disch_pump	Canal discharges to reaches using the pumping option	cfs
Disch_weir	Canal discharges to reaches using the wier option	cfs
Can_area	Surface area of canal	$feet^2$
Can_bot_elev	Botom elevation of the canal	feet (realtive to project datum)
Can_rain	Rainfall accumulation in the canal	cfs
Can_evap	Evaproation losses form canal	cfs
Can_irr	Canal discharges to cell for irrigation	
C_NH3-N	Ammonia concentration (at end of day)	mg/L
C_Nitr-N	Nitrate/Nitrite concentration (at end of day)	mg/L
C_IORG-P	Inorganic phosphorus concentration (at end of day)	mg/L
C_Phyt-C	Phytoplankton concentration (at end of day)	mg/L
C_CBOD	CBOD concentration (at end of day)	mg/L
C_DissOx	Dissolved oxygen concentration (at end of day)	mg/L
C_ON-N	Organic nitrogen concentration (at end of day)	mg/L
C_OP-P	Organic phosphorus concentration (at end of day)	mg/L
L_NH3-N	Ammonia load	Metric Tons/day
L_Nitr-N	Nitrate/Nitrite load	Metric Tons/day
L_IORG-P	Inorganic phosphorus load	Metric Tons/day

Column Header	Description	Units
L_Phyt-C	Phytoplankton load	Metric Tons/day
L_CBOD	CBOD load	Metric Tons/day
L_DissOx	Dissolved oxygen load	Metric Tons/day
L_ON-N	Organic nitrogen load	Metric Tons/day
L_OP-P	Organic phosphorus load	Metric Tons/day

*first row after header will have 00/00/00 date and the initial values for all storages (Sw_hgt). All other values will be zero.