EPA/600/B-15/298

Quantitative Microbial Risk Assessment Tutorial

Land-applied Microbial Loadings within a 12-Digit HUC

Gene Whelan
Kurt Wolfe
Rajbir Parmar
Michael Galvin
Marirosa Molina
Richard Zepp
U.S. Environmental Protection Agency
Office of Research and Development
National Exposure Research Laboratory
Athens, GA

Keewook Kim
University of Idaho
Idaho National Laboratory
Center for Advanced Energy Studies
Idaho Falls, Idaho

Paul Duda
Mark Gray
AQUA TERRA Consultants, a Division of RESPEC, INC.
Decatur, GA 30030

11/20/15

Summary

This tutorial reviews screens, icons, and basic functions of the SDMProjectBuilder (SDMPB). It demonstrates how one chooses a 12-digit HUC for analysis, performs an assessment of land-applied microbes by simulating microbial fate and transport using HSPF, and analyzes and visualizes the results at multiple locations in the watershed using BASINS. It shows how to

- Initiate the execution of SDMPB.
- Navigate the SDMPB.
- Identify and label a 12-digit HUC.
- Develop the necessary input files to execute HSPF successfully.
- Develop the necessary input file to view results from the SDMPB and HSPF.
- Register the HSPF simulation with BASINS.
- Use HSPF to simulate SDMPB's problem statement.
- View simulation results for flows and microbial densities with BASINS.

Land-applied Microbial Loadings within a 12-Digit HUC

PURPOSE

Automate the data acquisition process for input data requirements of a confederation of models

OBJECTIVE

Preform an assessment of microbial fate and transport within a 12-digit HUC by capturing contextual data for the watershed model WinHSPF (a.k.a. HSPF) and pre-populate its input data files to account for

- Overland runoff;
- Snow accumulation/melt;
- Hourly simulations;
- NLDAS meteorological data;
- Land-applied microbial loadings; and
- Microbial fate and transport.

DEMONSTRATION

This tutorial reviews screens, icons, and basic functions of how one takes the output from the SDMProjectBuilder (SDMPB) and performs a microbial fate and transport analysis within a 12-digit Hydrologic Unit Code (HUC-12). A HUC-12 is a subwatershed between 16 and 63 mi^2. Application of the watershed model HSPF is demonstrated, as well as visualization of results at multiple locations in the watershed using BASINS. The application demonstrates how to

- Initiate the execution of SDMPB.
- Navigate the SDMPB.
- Identify and label a 12-digit HUC.
- Develop the necessary input files to execute HSPF successfully.
- Develop the necessary input file to view results from the SDMPB and HSPF.
- Register the HSPF simulation with BASINS.
- Use HSPF to simulate SDMPB's problem statement.
- View simulation results for flows and microbial densities with BASINS.

SOFTWARE ACCESS, RETRIEVAL, AND DOWNLOAD

Instructions for access, retrieval, and download of the SDMProjectBuilder, HSPF, and BASINS software products are provided by Whelan et al. (2015a). When installed, three shortcut icons should be on your desktop:

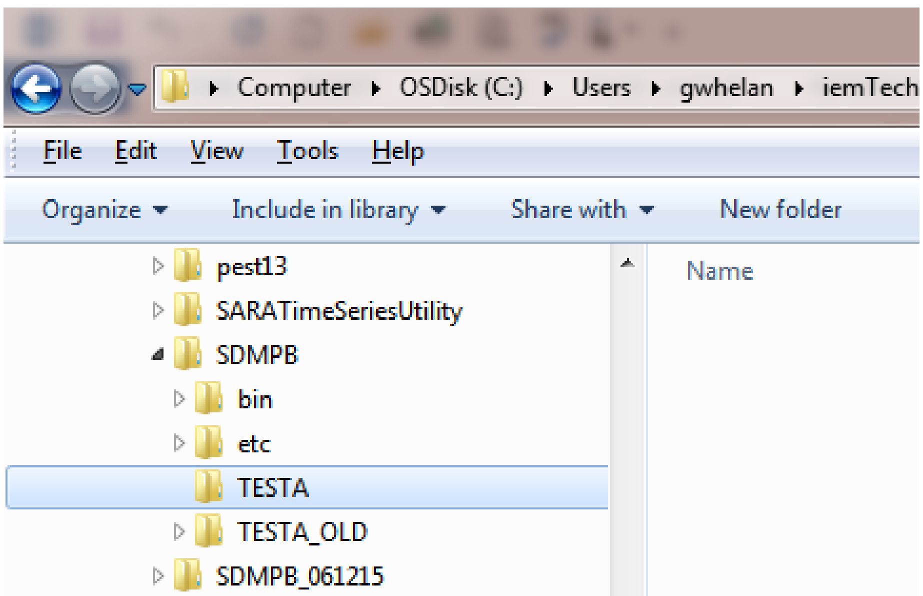
TUTORIAL – TABLE OF CONTENTS

NAVIGATING THE SDMPB AND IDENTIFYING THE HUC-8 OF INTEREST

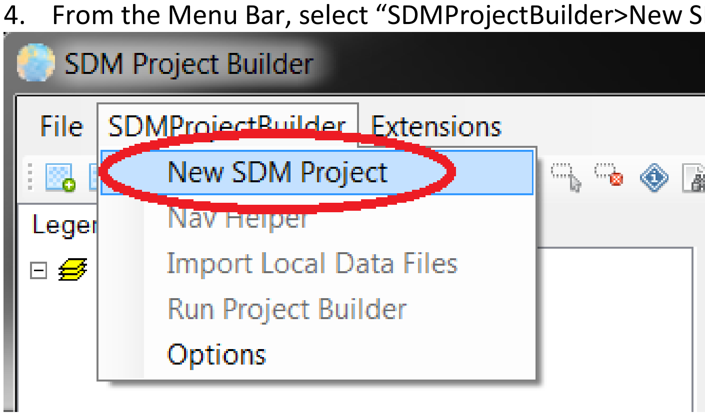
1. Execute the SDMProjectBuilder (SDMPB) by clicking on the shortcut icon displayed on the computer screen:

2. A detailed and more comprehensive tutorial describing the procedure for identifying an 8-digit HUC is provided in Whelan et al. (2015b). An abbreviated version follows.

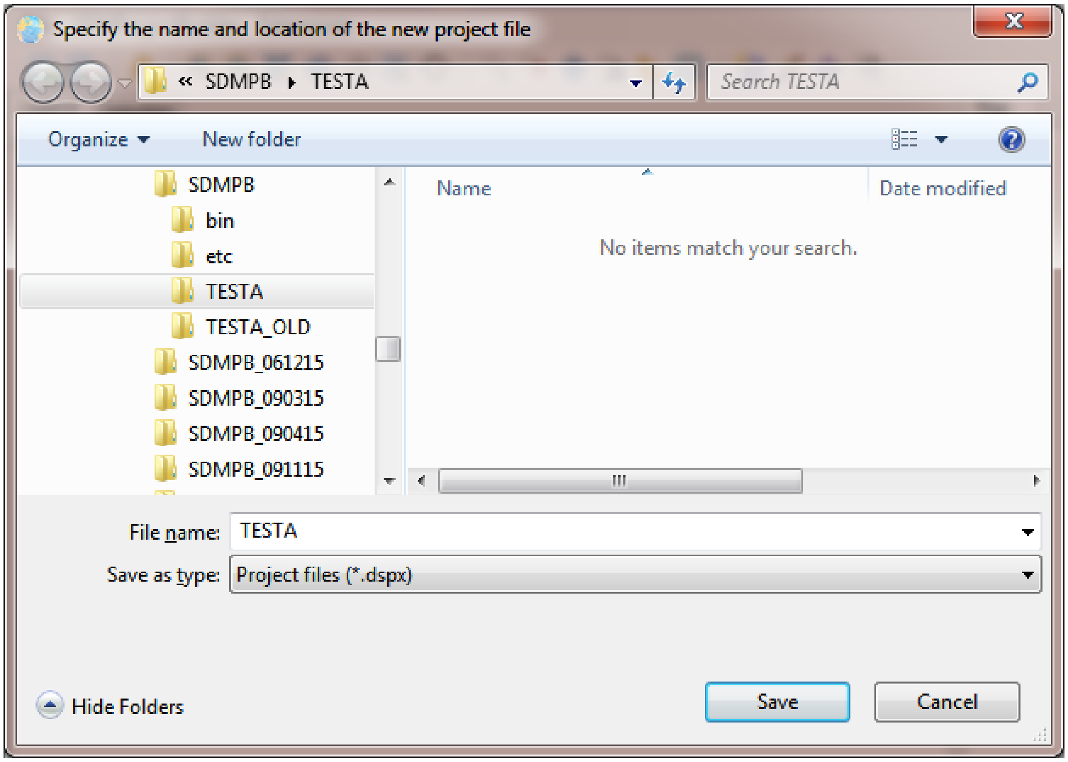
3. Create a folder where you have administrative rights. In the example below, “TESTA” was created. Click “Save”.



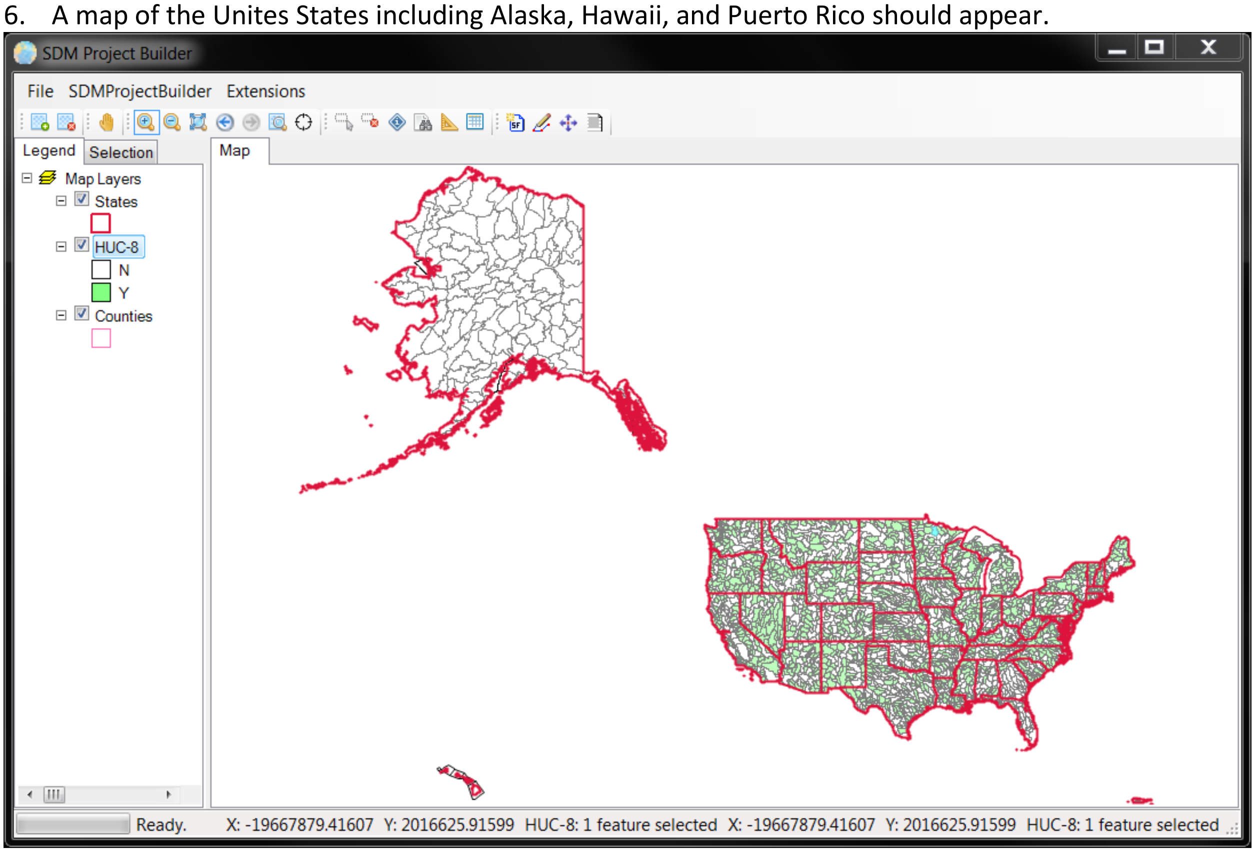
4. From the Menu Bar, select “SDMProjectBuilder>New SDM Project”.



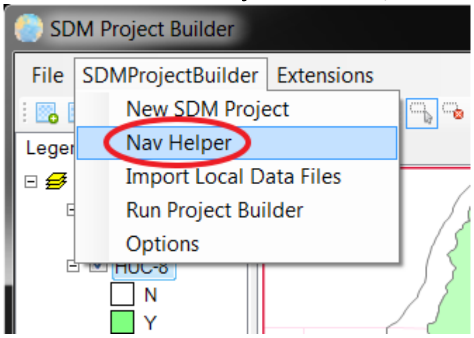
5. Create a new file named "TESTA" in the folder "TESTA". Click "Save".



6. A map of the Unites States including Alaska, Hawaii, and Puerto Rico should appear.

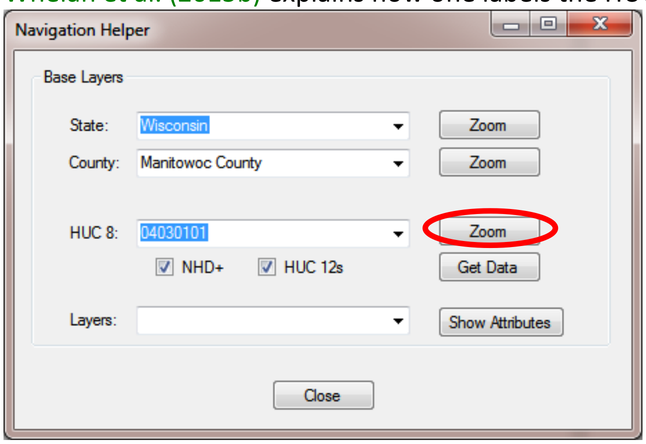


7. Under “SDMProjectBuilder”, select “Nav Helper”.

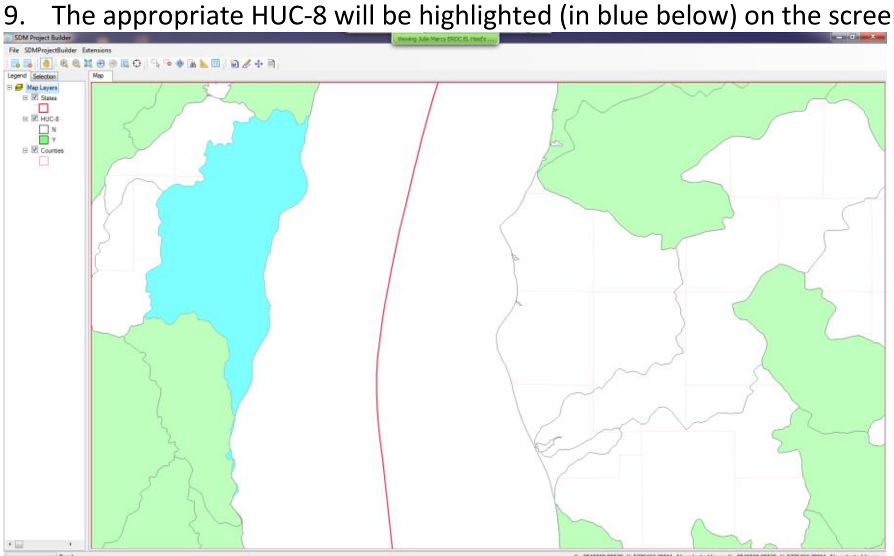


8. Whelan et al. (2015b) explains how a user can find a HUC-8 within the United States by zooming in on the State and County or directly inputting the HUC-8 identifying Catalog Unit (CU) code. In this case, catchments in the Manitowoc, Wisconsin County basin will be analyzed, within the HUC-8 04030101 near Manitowoc, Wisconsin. Do not close “Navigation Helper” until instructed.
   - Check the “NHD+” and “HUC-12” boxes
   - Type “04030101” as the “HUC 8”
   - Click “Zoom” to the right of “HUC 8”.

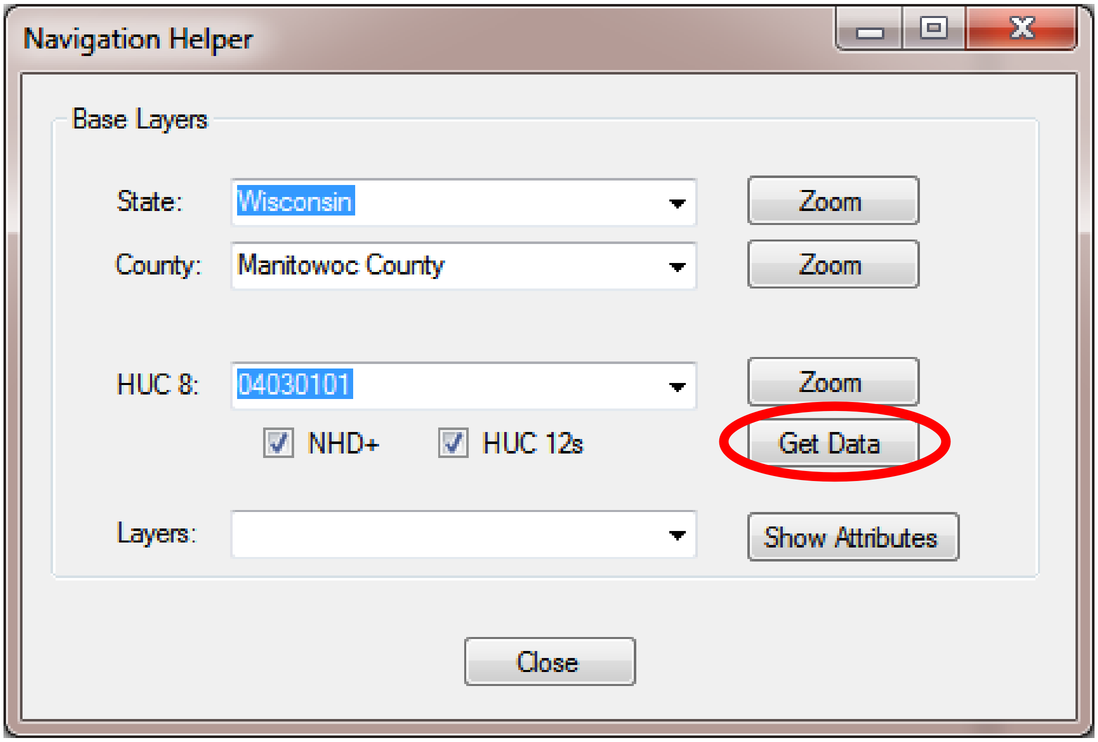
Whelan et al. (2015b) explains how one labels the HUC-8s with CU codes.



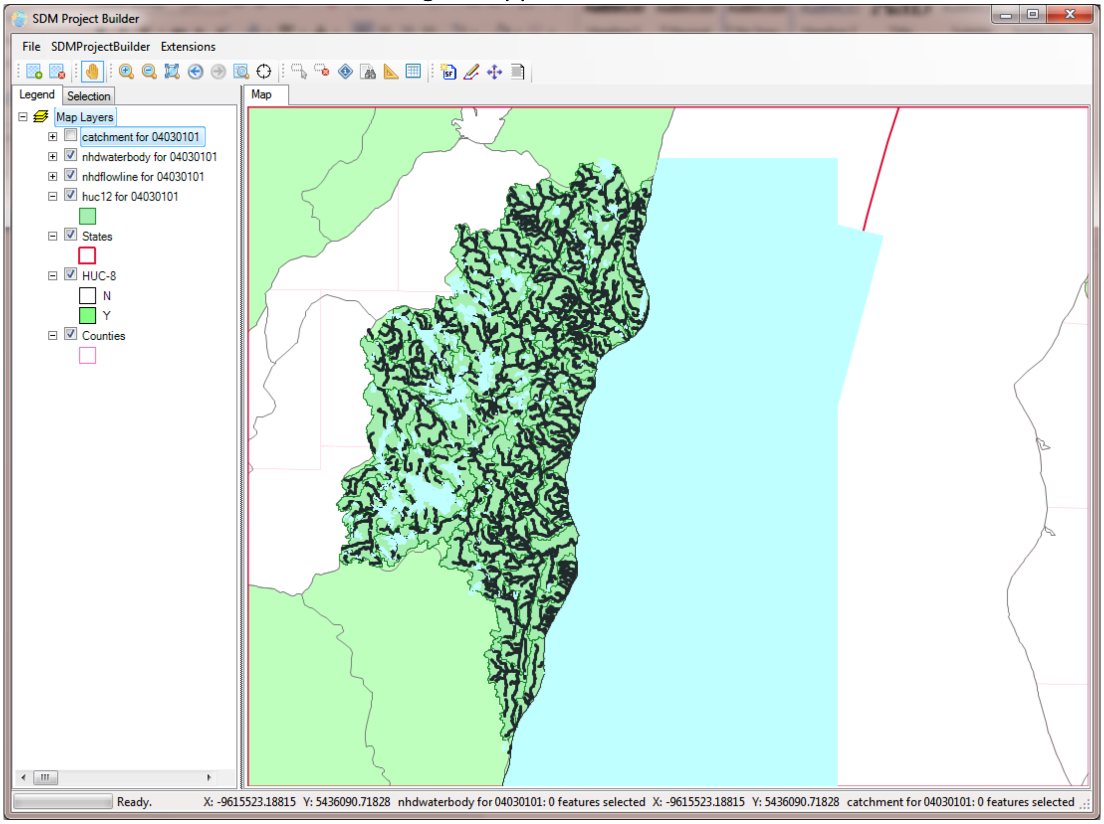
9. The appropriate HUC-8 will be highlighted (in blue below) on the screen:



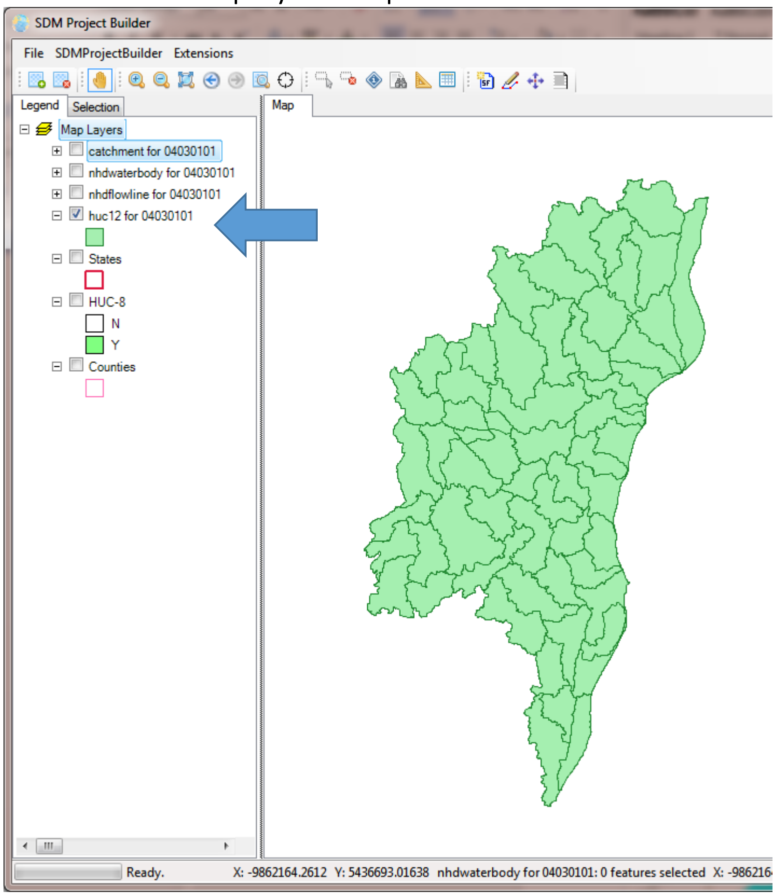
10. Click "Get Data".



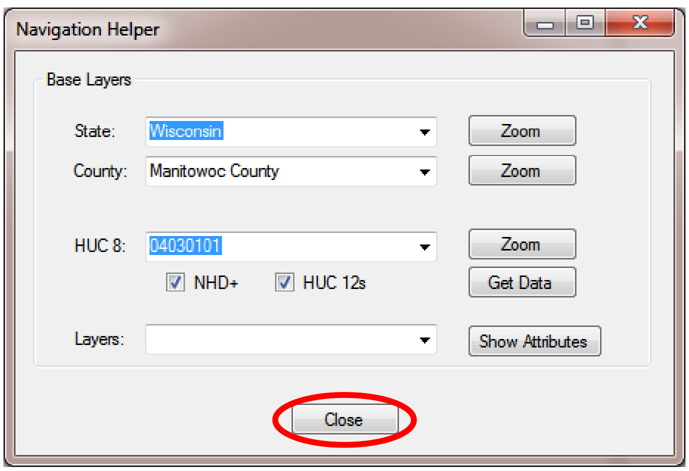
11. A screen similar to the following will appear.



12. Deselect all map layers except “huc 12 for 04030101”.



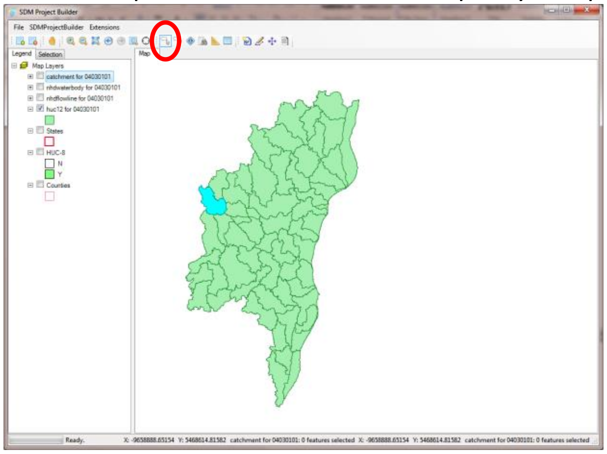
13. Choose “Close”.



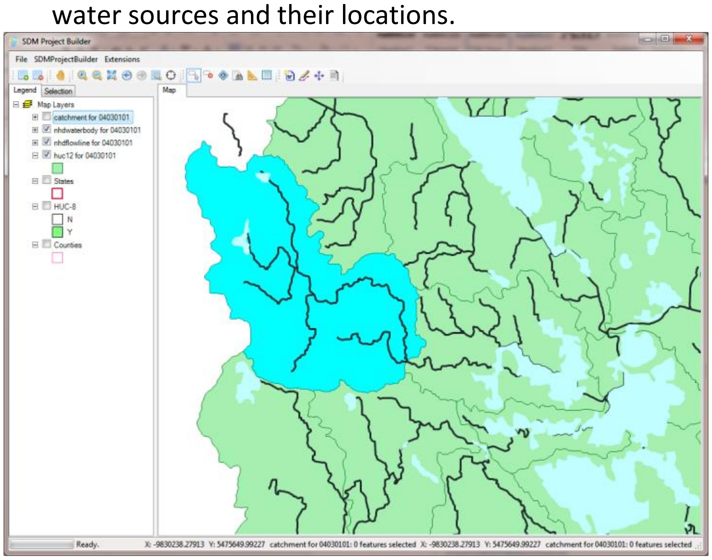
CHOOSE A 12-DIGIT HUC WITHIN A WATERSHED AND COLLECT ENVIRONMENTAL AND SOURCE-TERM DATA

Choose a HUC-12

14. Choose the “Select” button (red circle), then the appropriate HUC-12 (i.e., headwaters Killsnake River) as illustrated below. In this example, you are identifying a single HUC-12 (i.e., headwaters Killsnake River) in the Manitowoc Watershed, as highlighted in the figure below; highlight the single HUC-12 shown. The SDMPB allows the user to choose any HUC-12. Because it does not account for any upstream inflow to the HUC, it is advisable to choose only headwater HUCs when defining a single HUC-12. It should be noted that overland flow simulations are not a function of instream flow simulations, so these computations are not compromised if a non-headwater HUC is chosen. A future plan will allow the user to specify an upstream boundary condition to address this issue.



15. Using the Zoom In button , zoom to this area.
    Check the “nhdflowline” Map Layer. If it is not at the top of the listing, move it there to ensure it is the outermost projection, and it will appear on the map. To see where the ponded waters are located, check the Map Layer titled ”nhdwaterbody for 04030101”. This provides a full picture of water sources and their locations.



Identify and Modify Local Source-term Data

Descriptions of the local source-term data are described in Whelan et al. (2015c). There are 12 default files located in the “LocalData” directory, as illustrated below:

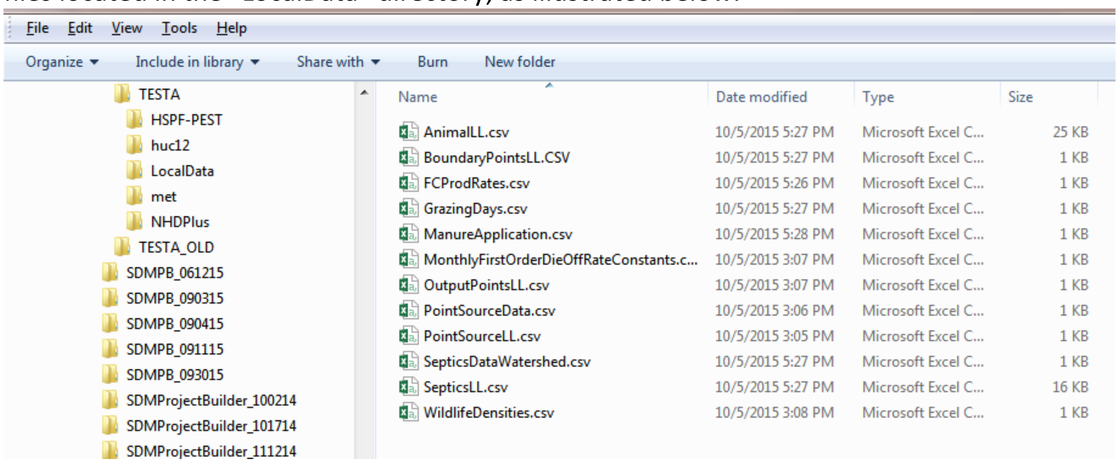


Table 1 summarizes the metadata associated with the parameters contained within each file, including definitions and units.

These files must be reviewed by the user to ensure they are applicable to the watershed of interest. For this example problem, the following modifications will be made:

- Domestic Animals and Wildlife
  - Farm locations with domestic animal numbers and types, their production rates along with production rates in built-up areas, number of animal grazing days, and fraction of animal-generated manure applied to the soil will remain unchanged, as documented in the AnimalLL.csv, FCProdRates.csv, GrazingDays.csv, and ManureApplication.csv example templates, respectively. The farm locations reflect actual farm locations within the Manitowoc Basin. No changes to any of these files are necessary.
  - Different first order die-off rates will be used for land-applied microbes, so modifications to the MonthlyFirstOrderDieOffRateConstants.csv example template are necessary.
  - Wildlife densities will be changed to reflect the actual number of deer in this area, so the WildlifeDensities.csv example template will be modified.
- Point Sources
  - There will be no point sources. Whelan et al (2015c) describe several ways to exclude point sources. The two default point source locations defined in PointSourceLL.csv just happen to randomly fall within our watershed. The user can do any of three things to remove the use or impacts of a point source: (1) change Latitude-Longitude coordinates to locations outside of the watershed, (2) reduce the point source loadings to *de minimus* levels in PointSourceData.csv, or (3) within HSPF, remove the point source from the simulation (see Whelan et al., 2015c). In this example, Latitude-Longitude pairs will be changed to a location outside of the watershed. Because only microbes are associated with this assessment, the reference to chemicals in PointSourceData.csv will be removed.

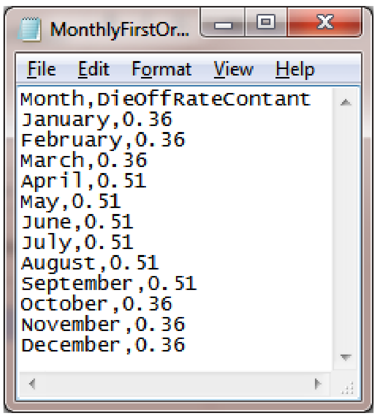
Table 1. Names of default support files and input types for which the user has access for modifications

FILE NAME	INPUT DATA AND DEFINITION	UNITS
Domestic Animals and Wildlife		
AnimalLL.csv	Domestic animal locations by Latitude and Longitude	Degree (by fraction)
	Domestic animal numbers by type and location	Number
FCProdRates.csv	Production or shedding rate of microbes from the domestic animal, which equals the multiple of the 1) Domestic animal shedding rate in mass of waste (wet weight) per time and 2) Microbial concentration based on mass of waste shed by the domestic animal	Counts/d/animal
	Typical microbial production or shedding rate per wildlife per area	Counts/d/ac
GrazingDays.csv	Number of grazing days per domestic animal per month	Number
	Fraction of the number of grazing days that Beef Cattle spend in a stream per month	fraction
ManureApplication.csv	Fraction of manure applied to soil each month per domestic animal	fraction
	Fraction of amount of manure shed by the domestic animal incorporated into soil	fraction
MonthlyFirstOrderDieOffRateConstants.csv	First-order microbial inactivation/die-off rate on the land surface per month	1/d
WildlifeDensities.csv	Typical number of wildlife per unit area by land use type	Number/mi^2
Point Sources		
PointSourceLL.csv	Point source locations by Latitude and Longitude	Degree (by fraction)
PointSourceData.csv	Annual-average flow for each point source	ft^3/s
	Annual-average microbial loading rate for each point source	Counts/yr
	Annual-average chemical loading rate for each point source	Lbs/yr
Septic Systems		
SepticsLL.csv	Septic system locations by Latitude and Longitude	Degree (by fraction)
SepticsDataWatershed.csv	Number of people per septic unit	Number
	Average fraction of septic systems that fail	fraction
	Average septic overcharge rate per person	gal/d/person
	Typical microbial density of septic overcharge reaching the stream	Counts/L
Intermediate Points		
BoundaryPoints.csv	Boundary point locations by Latitude and Longitude	Degree (by fraction)
OutputPoints.csv	Output point locations by Latitude and Longitude	Degree (by fraction)

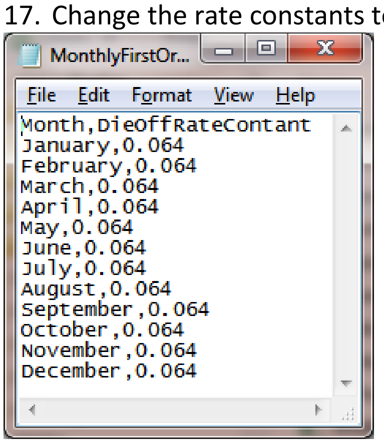
- Septic Systems
    - Septic locations and their metadata, represented by SepticsLL.csv and SepticsDataWatershed.csv, respectively, will remain unchanged and used as is, since these locations reflect actual locations within the Manitowoc Basin.
- Intermediate Points
    - The intermediate Latitude-Longitude locations listed in BoundaryPoints.csv and OutputPoints.csv randomly fall within the HUC-12 boundaries. Because they do not impact the simulations, their contents will remain unchanged.

MonthlyFirstOrderDieOffRateConstants.csv

16. Open MonthlyFirstOrderDieOffRateConstants.csv using TextPad, Notepad, WordPad, Excel, or other pertinent editor. Using WordPad, the original file includes die-off rate constants by month with units of d^{-1}:



17. Change the rate constants to 0.064 d^{-1}, so the file becomes:



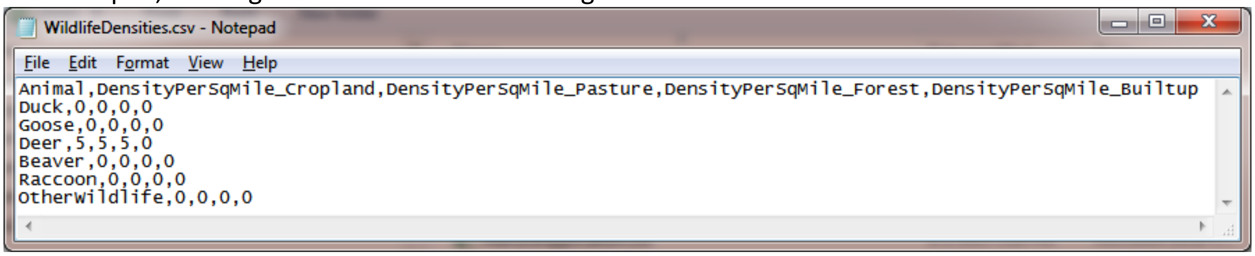
These reflect lower-end values by Martinez et al. (2013) (see Kim et al., 2015).

18. Save as a csv file and exit.

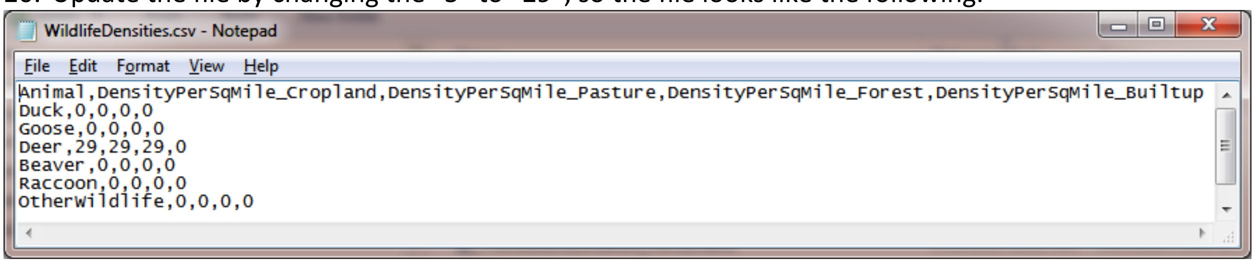
WildlifeDensities.csv

The wildlife densities associated with this region of Wisconsin tend to be dominated by deer, with typical fall and winter densities of 29 and 21 deer/mi^2, respectively (WDNR, 2015). 29 deer/mi^2 will be assumed to be associated with agricultural (pasture and cropland) and forest land types. No deer will be associated with Built areas. Because recreational activities with beaches typically occur during summer and fall, fall numbers will be used in this analysis.

19. Open WildlifeDensities.csv using TextPad, WordPad, Notepad, Excel, or other pertinent editor. Using Notepad, the original file includes the flowing locations:



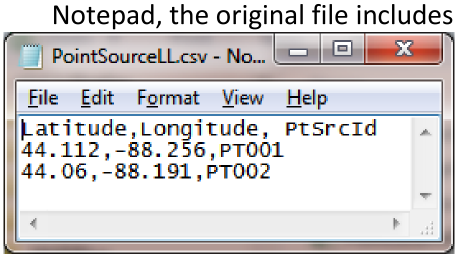
20. Update the file by changing the “5” to “29”, so the file looks like the following:



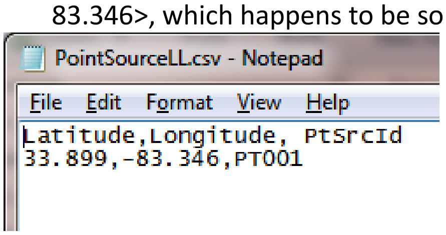
21. Save as a csv file, and exit.

PointSourceLL.csv and PointSourceData.csv

22. Open PointSourceLL.csv using Notepad, TextPad, WordPad, Excel, or other pertinent editor. Using Notepad, the original file includes the flowing point source locations PT001 and PT002:

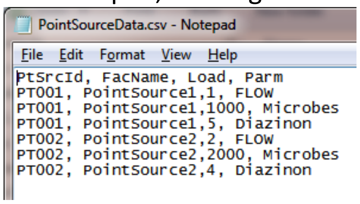


23. Remove the second Latitude-Longitude pair, and change the coordinates for PT001 to <33.899, -83.346>, which happens to be somewhere in Georgia.

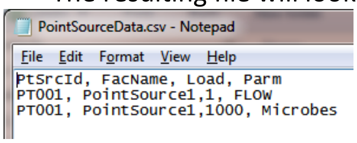


24. Save as a csv file, and exit.

25. Open PointSourceData.csv using Notepad, TextPad, WordPad, Excel, or other pertinent editor. Using Notepad, the original file includes the flowing point source locations PT001 and PT002:



26. Remove the three lines referencing PT002 and the line referencing the Diazinon loading for PT001. The resulting file will look like the following:



27. Save as a csv file, and exit.

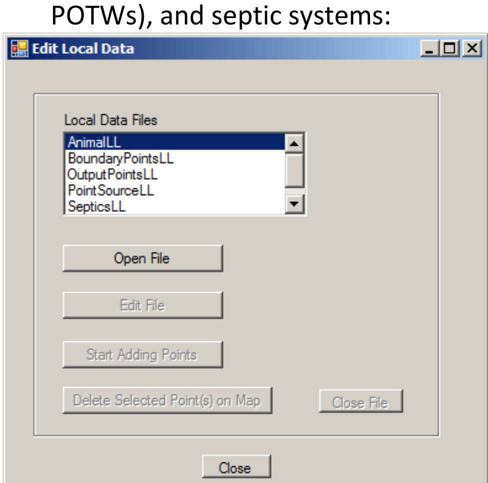
Ensure that all revised files replaced the original files contained in the “LocalData” folder under the working directory.

Import Local Data Files

After replacing the files in the “LocalData” folder within the working folder, these data can be registered with the SDMProjecBuilder (SDMPB).

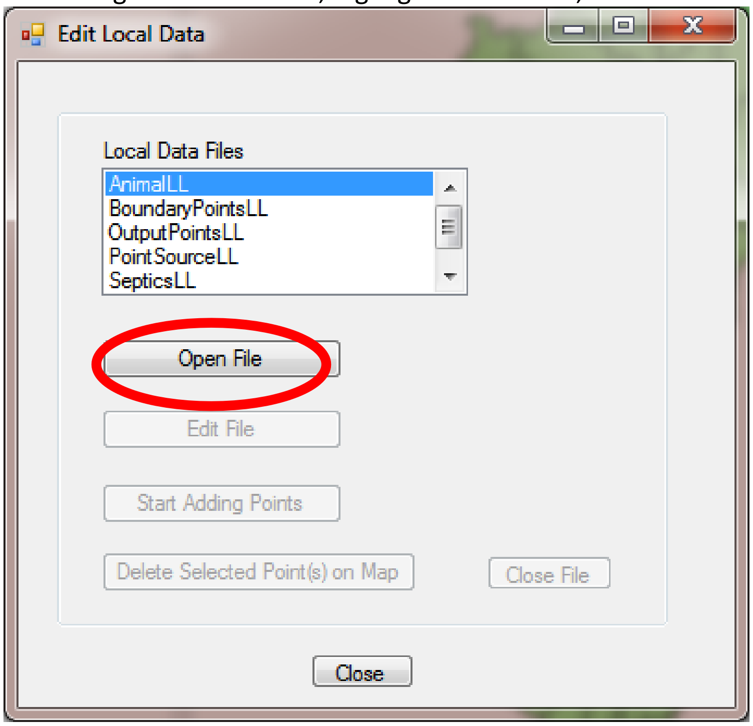
28. From the Menu Bar, choose “SDMProjectBuilder”, then “Import Local Data Files”.

A screen will appear to allow the user to import 12 “Local Data Files,” of which the five files listed in the screen below identify specific Latitude-Longitude locations for locations of domestic animals (e.g., farms), intermediate points (i.e., boundary conditions, output points), point sources (e.g., POTWs), and septic systems:

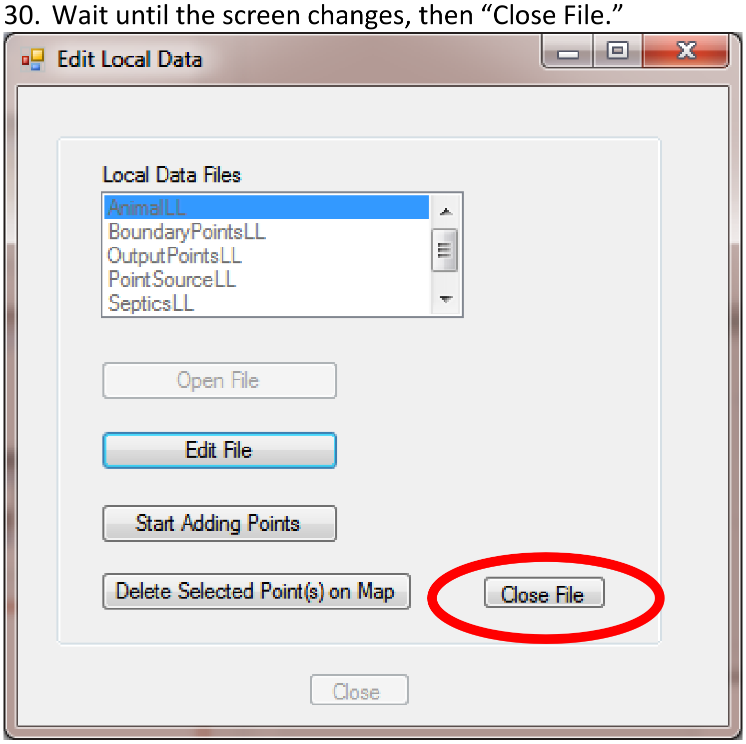


We will register, as map layers, the following Local Data Files: animal locations (AnimalLL) and Septic locations (SepticsLL) which happen to be the same (i.e., farms use septic systems).

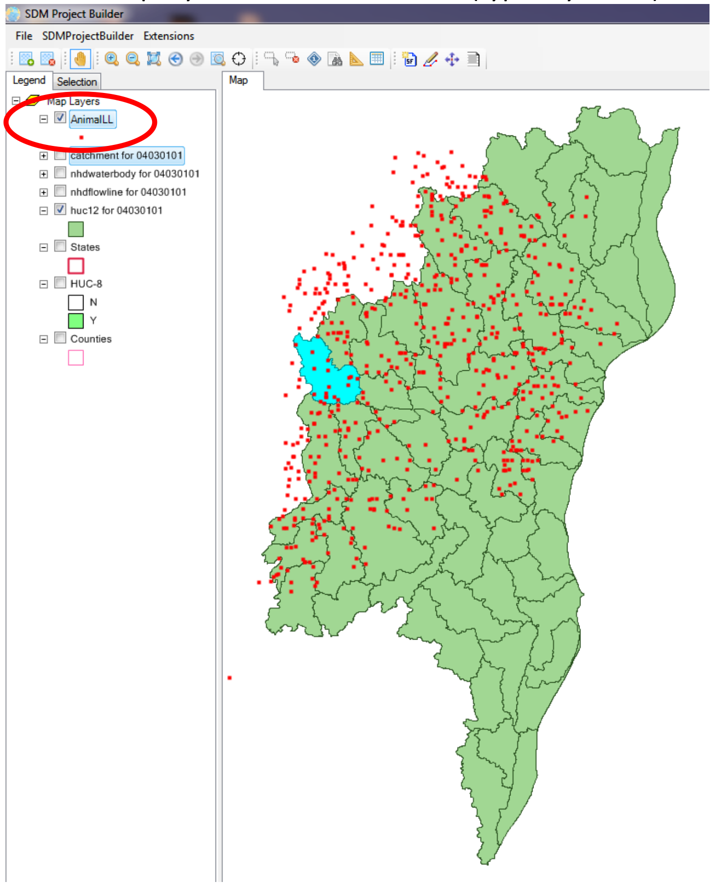
29. To register “AnimalLL”, highlight “AnimalLL”, and choose “Open File”.



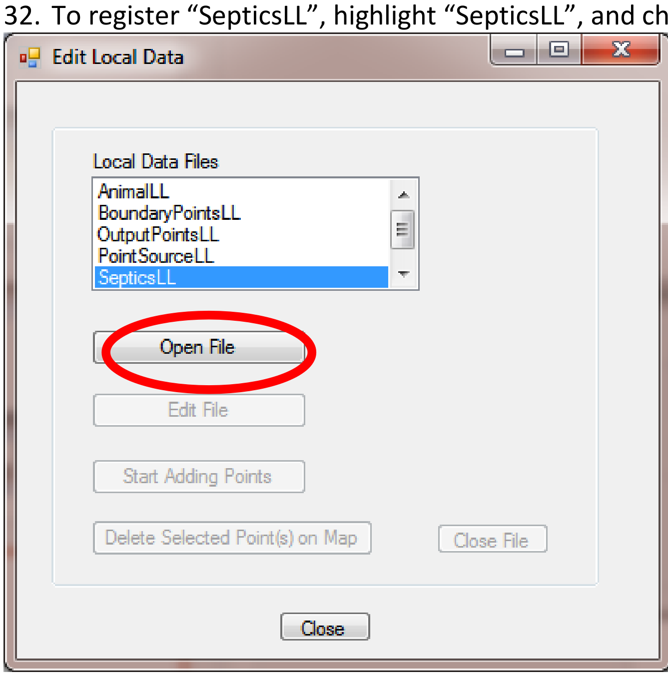
30. Wait until the screen changes, then “Close File.”



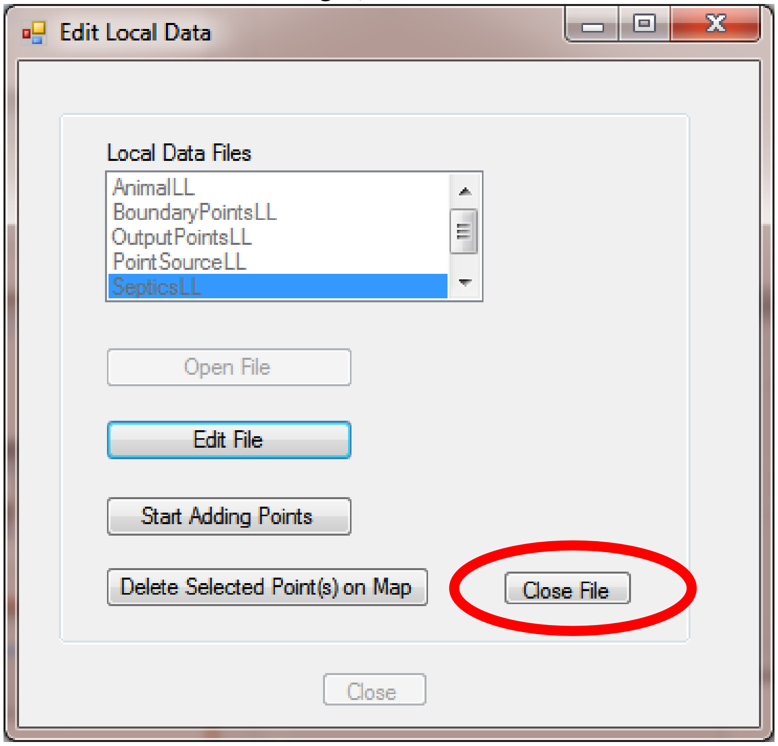
31. The map layer for animal locations (typically farms) will appear on the map, similar to that below:



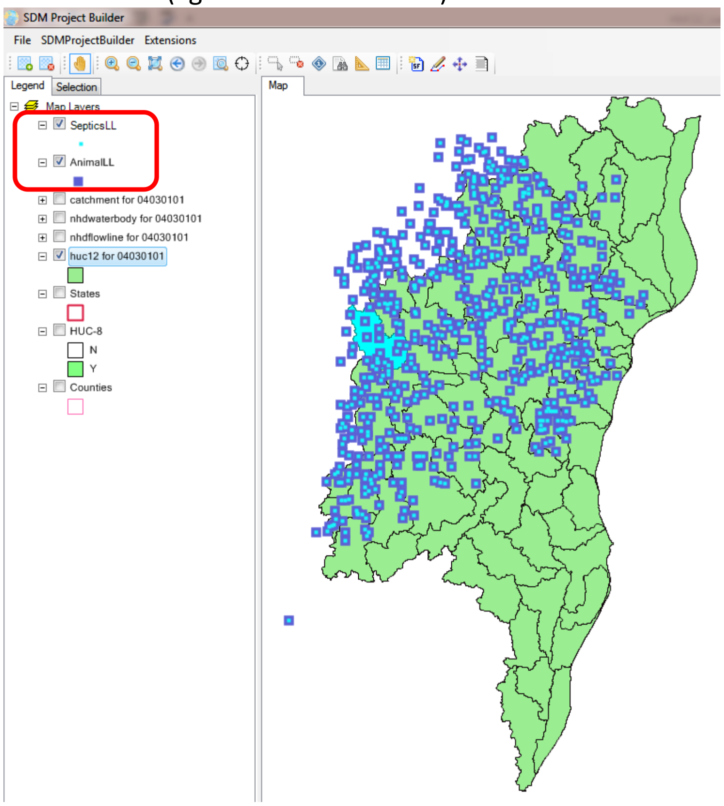
32. To register “SepticsLL”, highlight “SepticsLL”, and choose “Open File”.



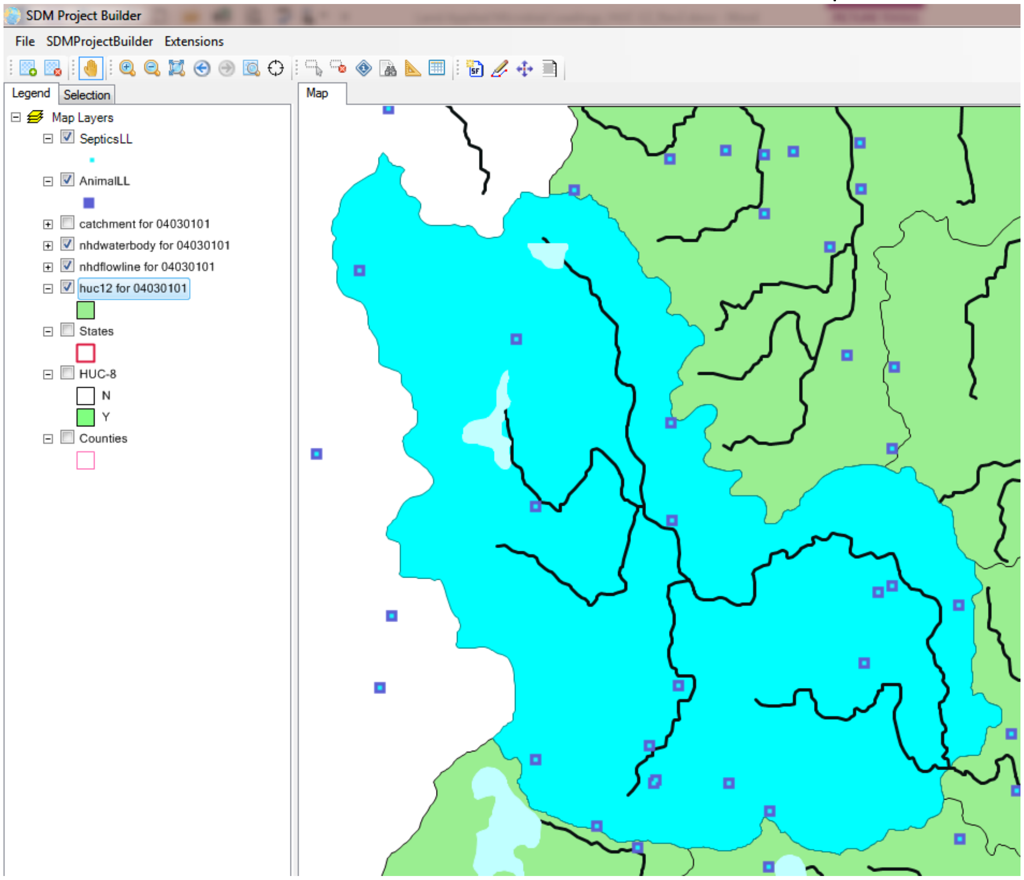
33. When the screen changes, choose “Close File.”



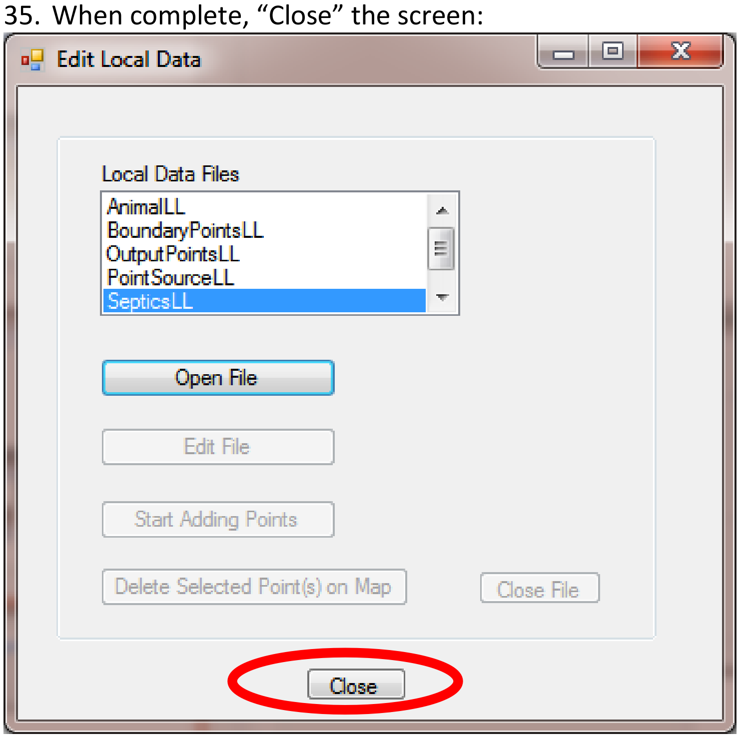
34. The following screen, which includes the Animal (I.e., farm) (dark blue square dots) and septic locations (light blue smaller dots) overlaid on each other, will appear.



Zoom in and view the HUC-12 of interest with animal farm and septic locations:

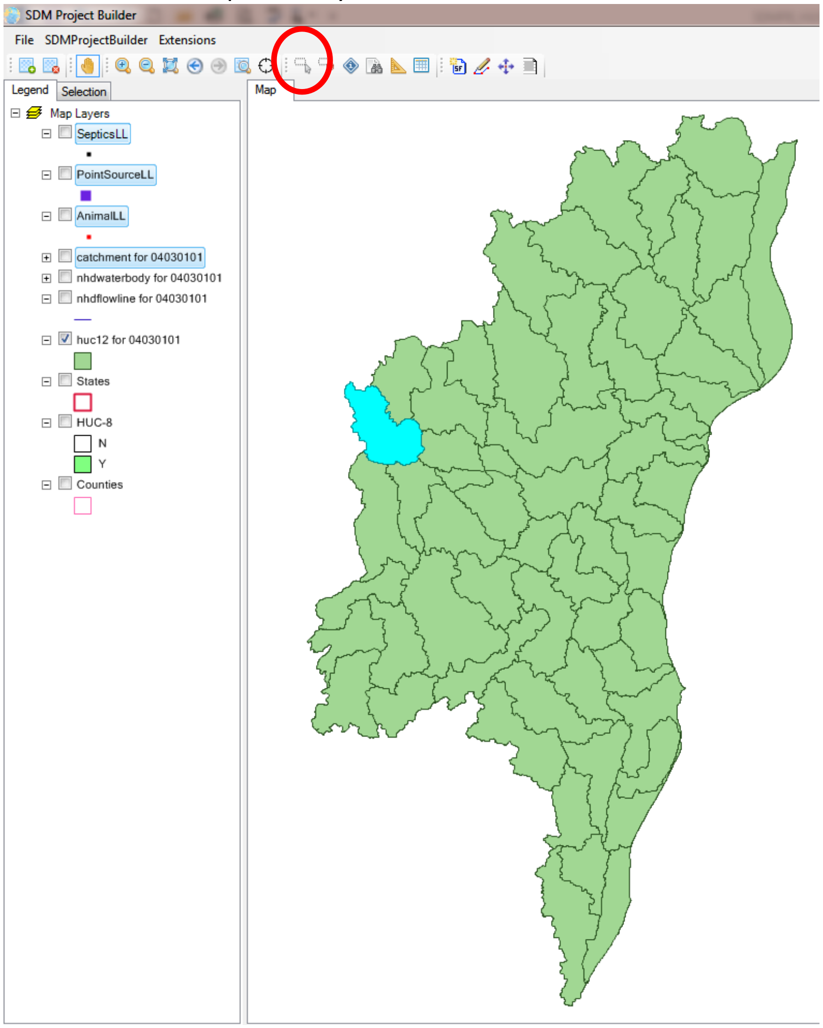


35. When complete, “Close” the screen:

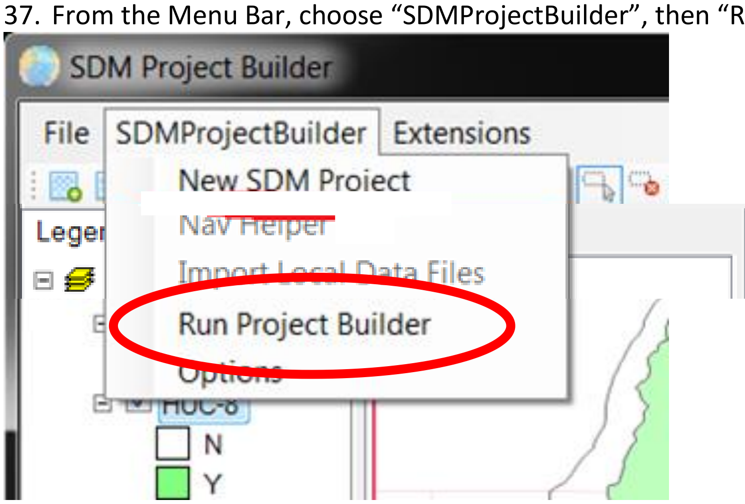


Run Project Builder and Collect Map Layers Describing Environmental Characteristics

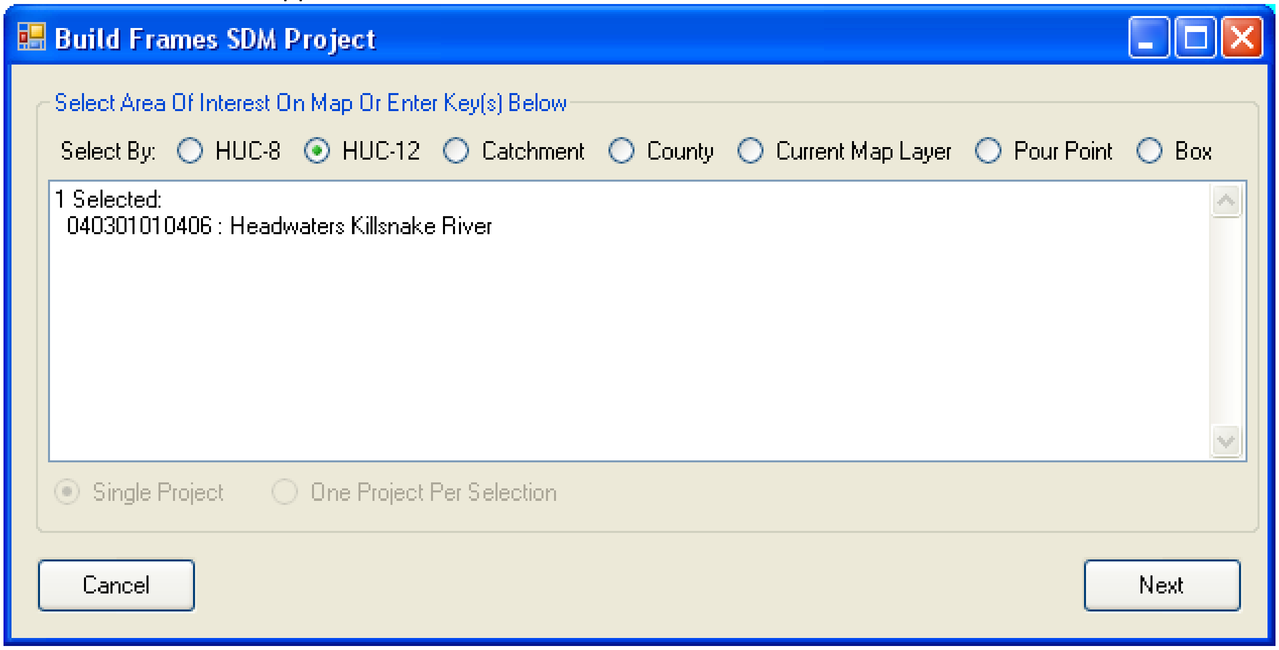
36. A HUC-12 was previously selected. If it was unselected in the meantime, re-select the HUC-12.



37. From the Menu Bar, choose "SDMProjectBuilder", then "Run Project Builder".

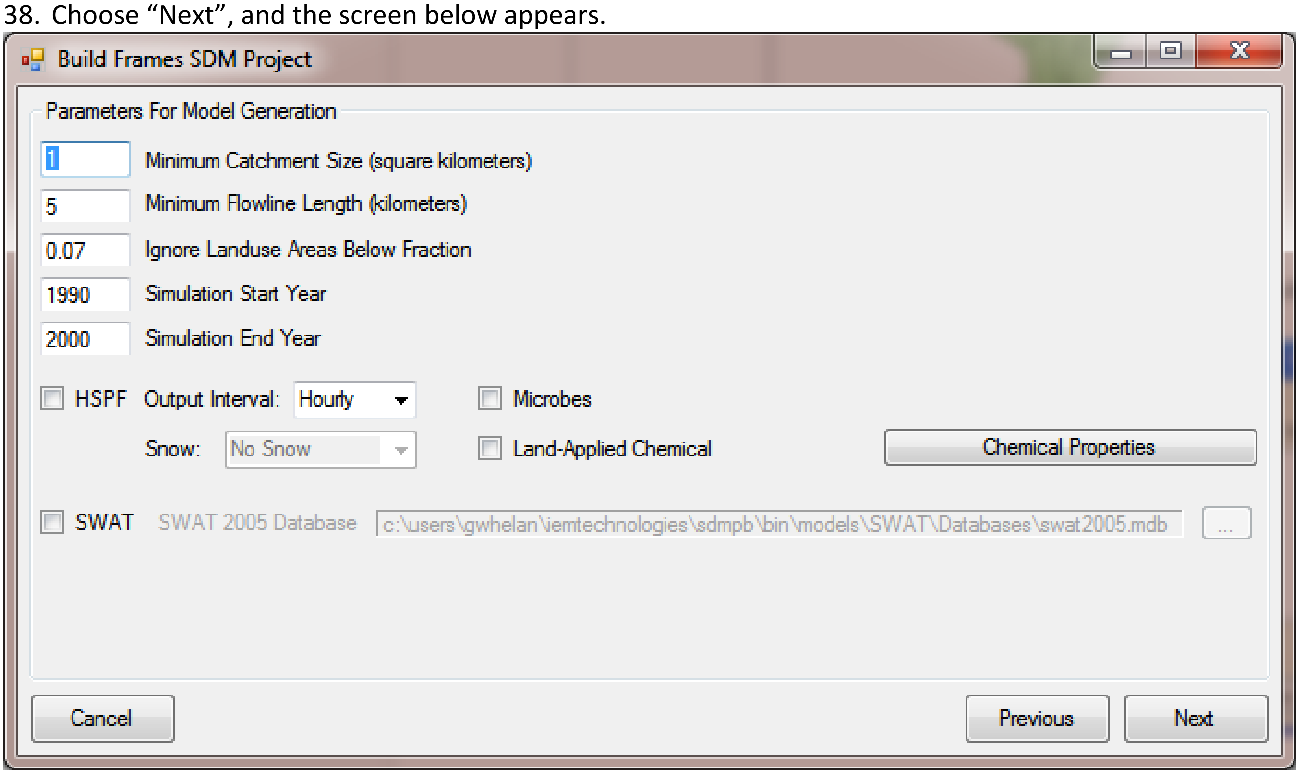


The screen below appears.

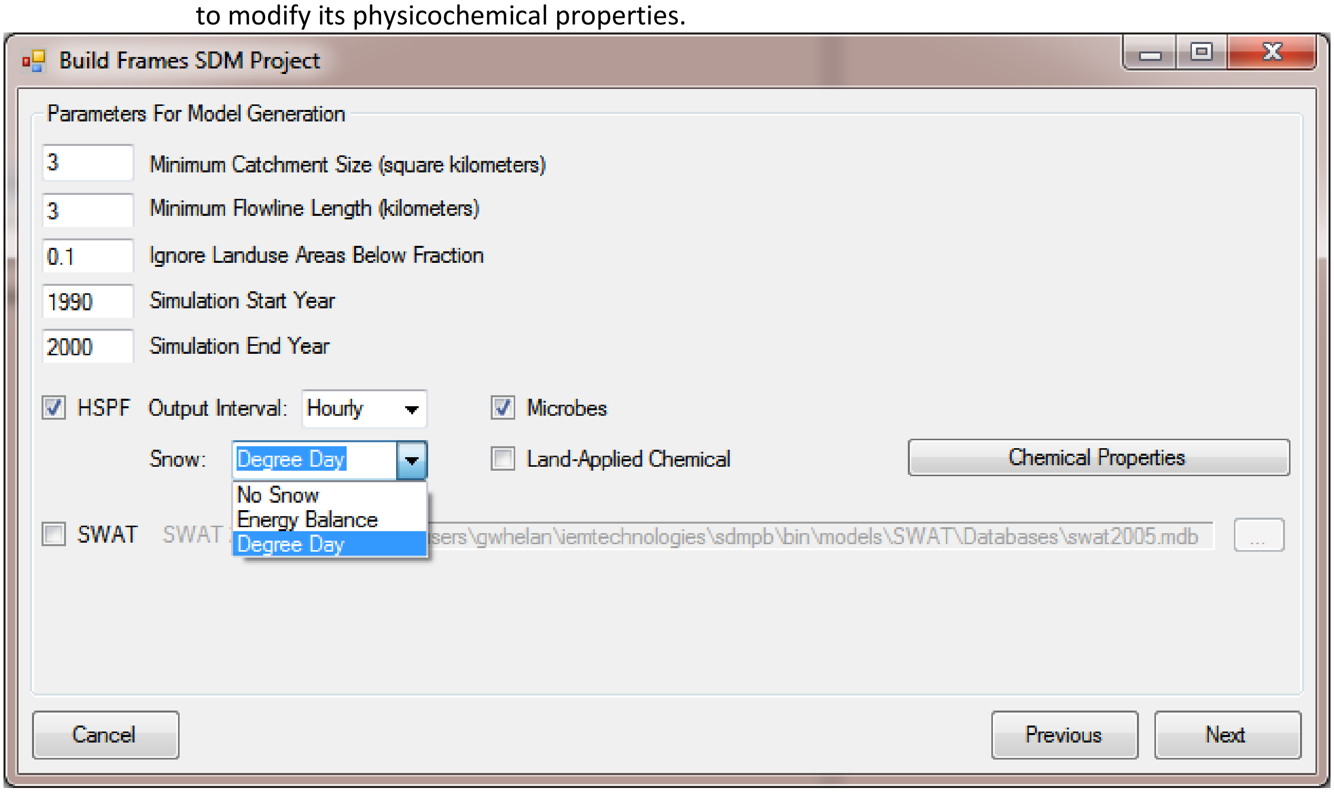


Because a HUC-12 was previously selected, the “040301010406: Headwaters Killsnake River” automatically appears. The software only has been tested for “HUC-12” and “Pour Point” assessments, although it should work for HUC-8 assessments since the only essential difference between a HUC-12 and HUC-8 is size. If the HUC-12 has not already been selected, select it.

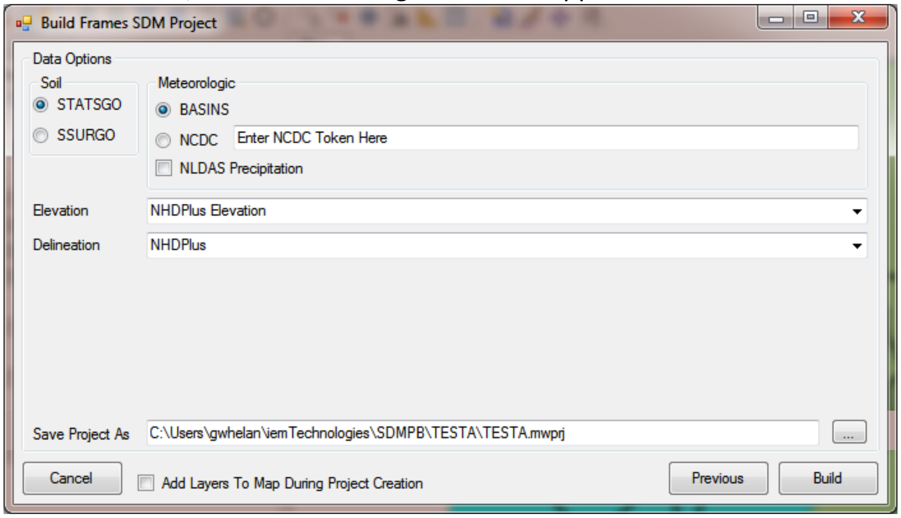
38. Choose “Next”, and the screen below appears.



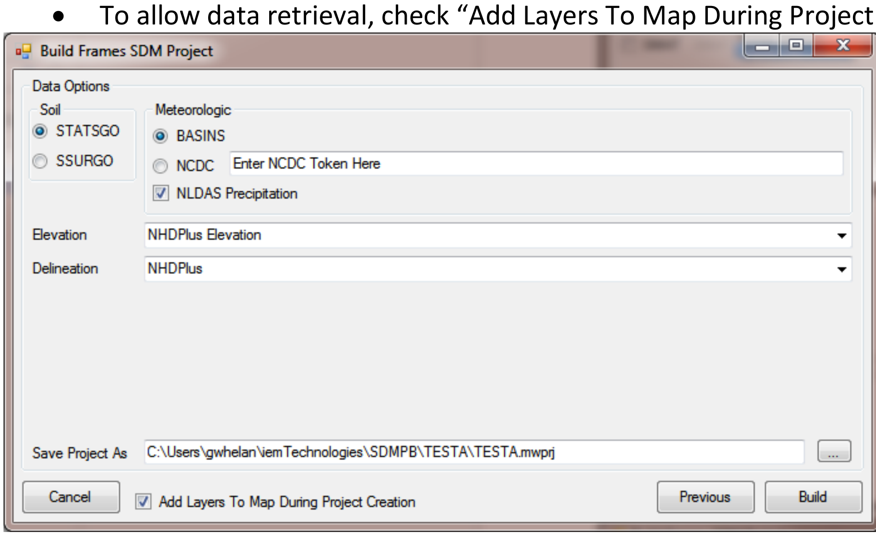
39. Use the choices and values included in this figure:
    - "3" for the "Minimum Catchment Size". During delineation, an attempt will be made to delineate subwatersheds to at least this sizewhich ensures that modeling very small subwatersheds is kept to a minimum.
    - "3" for the "Minimum Flowline Length". During delineation, an attempt will be made to delineate subwatersheds so that river segments have at least this length. This ensures that modeling very small river segments is kept to a minimum.
    - "0.1" for the "Ignore Landuse Areas Below Fraction". During delineation, land use types below this fraction of total land use will be combined. This ensures that modeling *de minimus* land use types is minimized.
    - "1990" for the "Simulation Start Year" which is the year in which the simulation begins.
    - "2000" for the Simulation End Year" which is the year in which the simulation ends.
    - "HSPF" for the watershed model.
        - "Hourly" for the "Output Interval". Simulations are hourly within HSPF, but the output can be presented in a number of units such as hourly, daily, weekly, monthly, annually, etc..
        - "Degree Day" for the "Snow" calculation. This option determines if snow accumulation and melt calculations are included. Choices are No Snow, Energy Balance method, or Degree Day method.
        - "Microbes" determines if microbes will be simulated. If not chosen, all microbial data will be ignored.
        - "Land-Applied Chemical" indicates there is a chemical application equally applied to all agricultural lands within the watershed.
        - "Chemical Properties" indicates that if a chemical is applied, this button allows the user to modify its physicochemical properties.



40. Pick “Next”, and the following screen will appear.

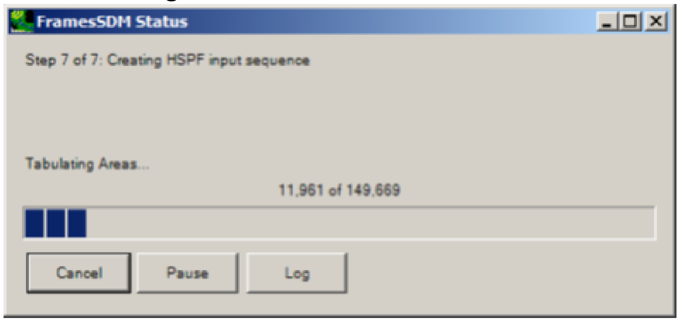


41. Use the choices and values included in this figure:
   - Choose STATSGO which is less detailed than SSURGO for soil options.
   - Choose “NLDAS Precipitation”. NLDAS is the North American Land Data Assimilation System and contains automatic quality control (QC), uses hourly gauge station data and modeled precipitation, provides estimates at hourly intervals with a 1/8th-degree resolution, and provides precipitation time series at specified locations (Kim et al., 2014). This is used in conjunction with NCDC NOAA meteorological data which supplies information for regional data, such as air temperature. BASINS uses cached NCDC data up to 2009. For direct access to hourly NCDC data, choose “NCDC, but the user must obtain a Token ID. Subwatersheds default to the nearest MET station.
   - Choose the “NHDPlus Elevation” for Elevation and “NHDPlus” for Delineation.
   - The name of the file should already be identified, but a different name or location can be selected by choosing the name of the file (e.g., *.mwprj) and where it is saved. The .mwprj file is a MapWindow (mw) Project (prj) file directly consumed by BASINS. The program will automatically identify the working folder structure the user originally created. If a special location and name is chosen, the user may identify a special folder using “Save Project As”.
   - To allow data retrieval, check “Add Layers To Map During Project Creation”.



42. Now choose “Build” which may take several minutes to complete, depending on the computer.

43. Processing takes several minutes for a HUC-12.

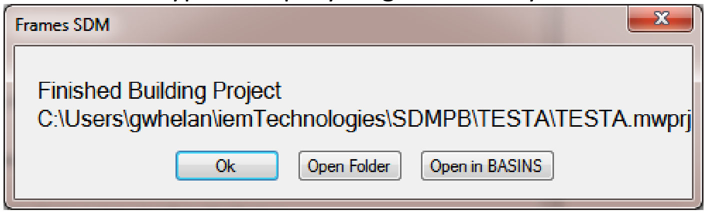


44. Some computers may ask several times if the re-project map layer should match the map coordinate system; choose “Yes” each time.

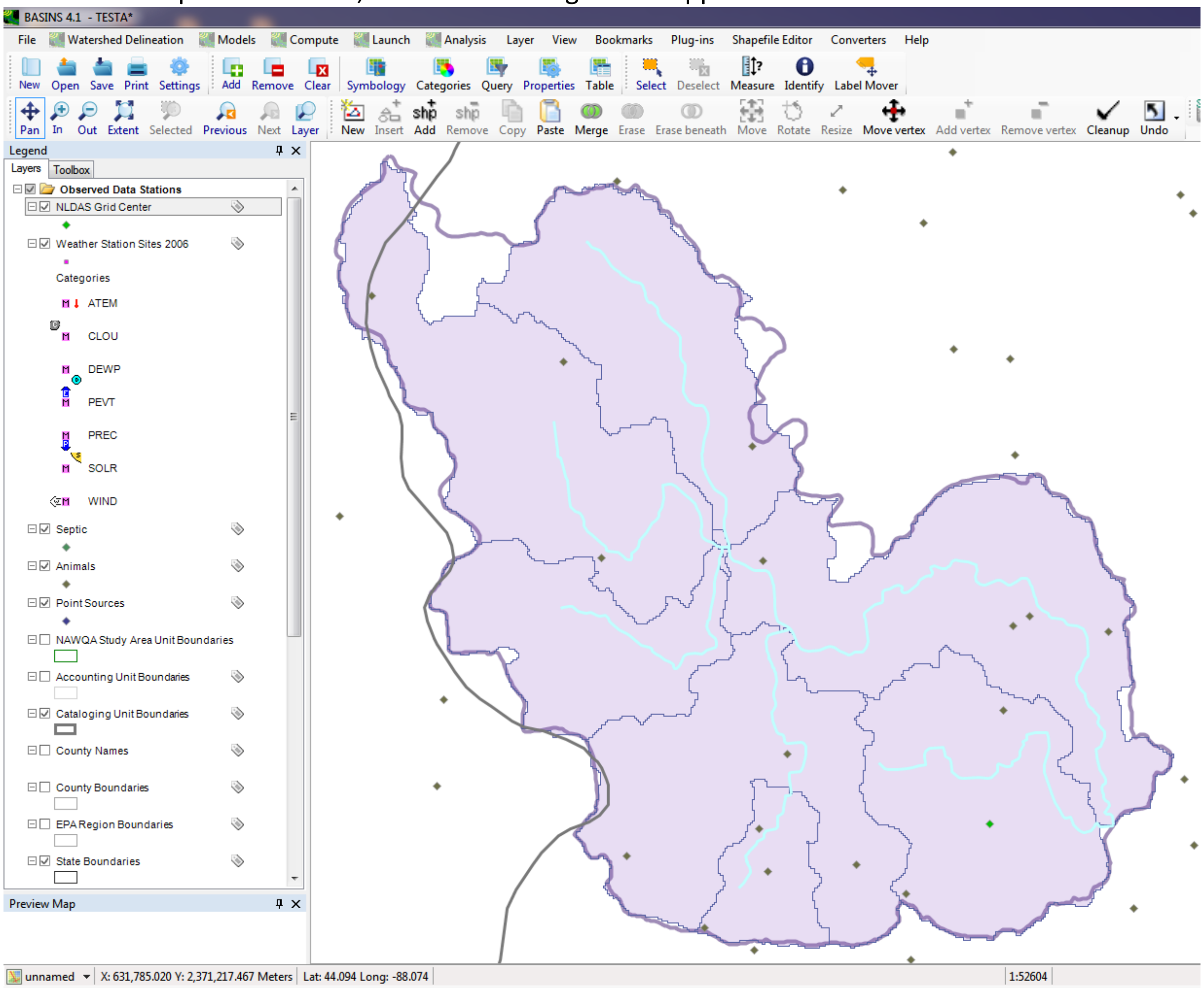
45. When the SDMPB has finished running, you will see the message below. If the user chooses
    - “Ok”, SDMPB will exit and close down.
    - “Open Folder”, the user will be redirected to the working folder location.
    - “Open in BASINS”, BASINS will automatically open with the SDMPB map layers for this assessment.

    When exiting the SDMPB, the following files are created:
    a. BASINS File: *.mwprj, the MapWindow Project file that contains the conceptual layout and map layers of the assessment.
    b. HSPF-related Files pertinent to these examples include the:
        i. *.uci file, which is the User Control Input file. It is a flat file containing all non-time series data. The UCI file is the controlling input file for HSPF. Based on choices of the user, the SDMPB automatically constructs the HSPF UCI file. Appendix A reviews some of the contents of the UCI file related to this tutorial to show where data were captured in this file. It is presented for the more advanced user who is familiar with HSPF and its UCI file and is not required reading for this tutorial.
        ii. *.wdm files, which is the Watershed Data Management files. These binary files contain time series data (i.e., weather, input, output, calibration, etc.).
        iii. *.hbn file, which is the HSPF Binary output file that contains binary output.

    Although not recommended at this time due to a potential error in DotSpatial, ways that a user can view the typical map layers generated by SDMPB are reviewed in Appendix B.



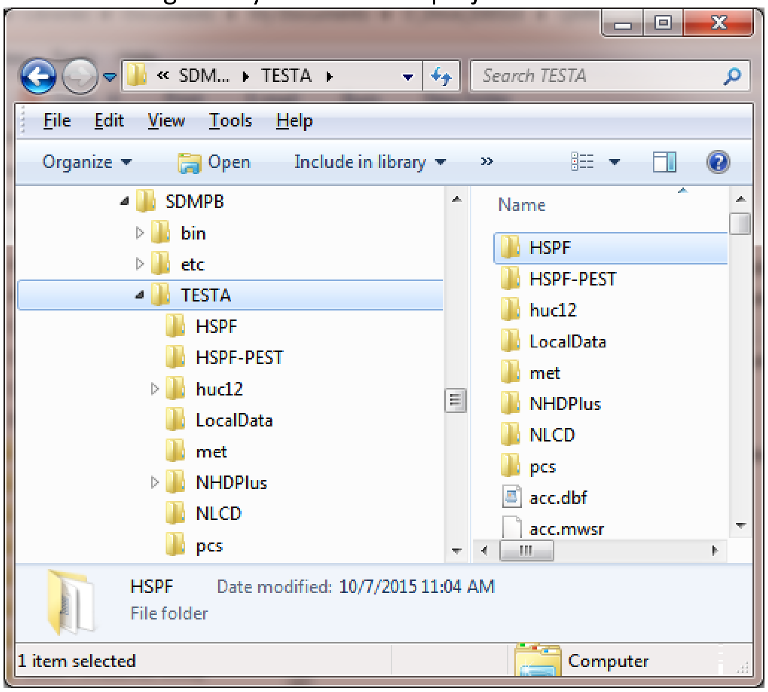
46. Choose “Open in BASINS”, and the following screen appears:



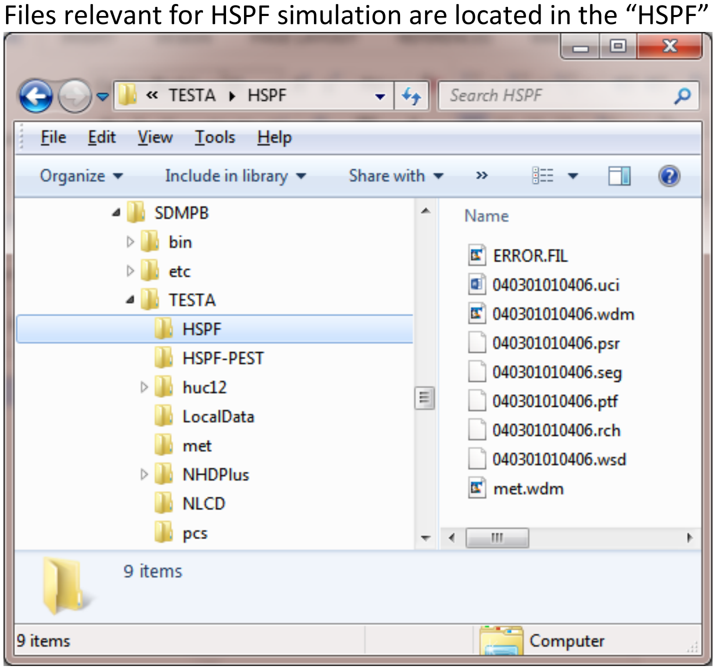
USE HSPF TO SIMULATE THE SDMPB PROBLEM STATEMENT BY PERFORMING AN ASSESSMENT ON A 12-DIGIT HUC

Execute the Assessment with HSPF

47. After clicking “Build” within SDMPB and subsequent processing, the user has a project folder containing GIS layers and other project-related files. An example folder structure is developed:



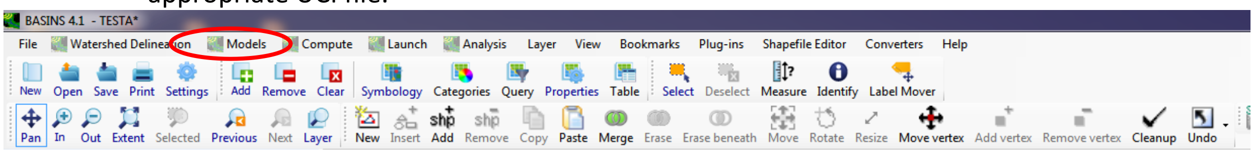
Files relevant for HSPF simulation are located in the “HSPF” subfolder.



48. The user can open HSPF in one of two ways:

a. Use the WinHPSF3.0 icon on the Windows desktop. Pick the appropriate UCI file or

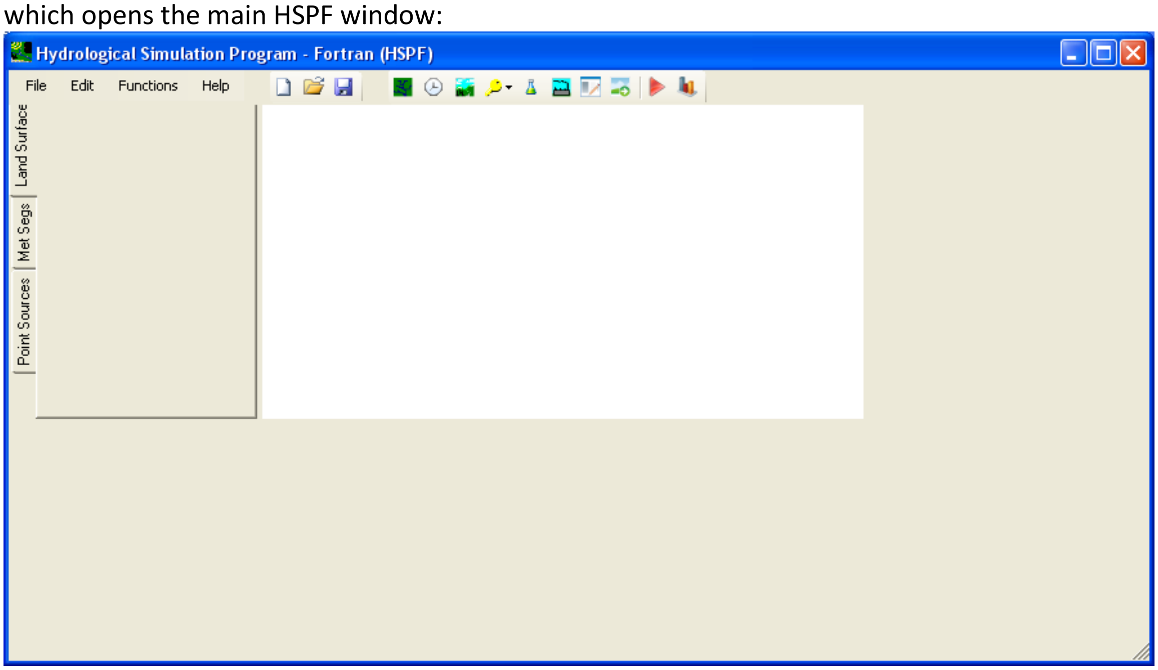
b. From the BASINS menu bar, choose “Models”, “HSPF”, then “Open Existing”. Pick the appropriate UCI file.



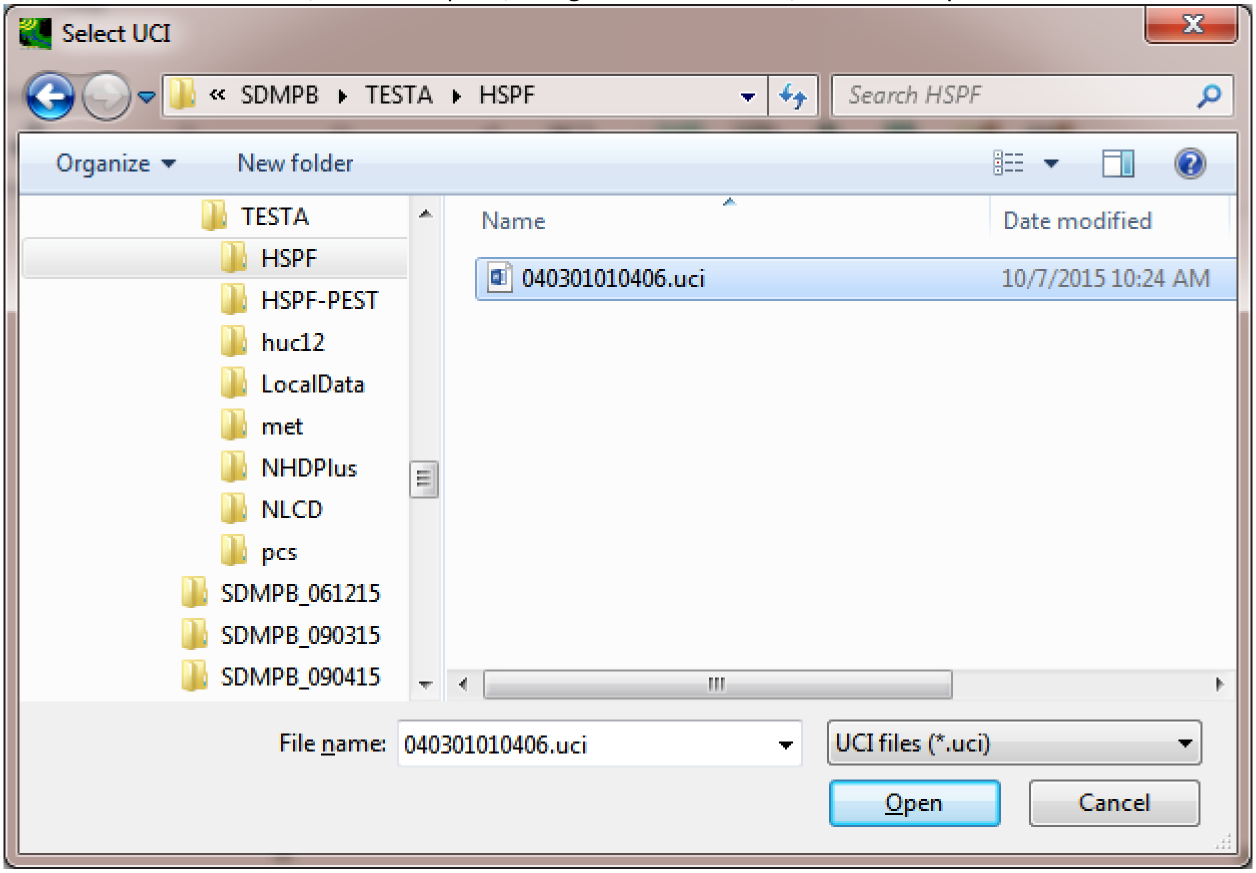
We will use the WinHSPF3.0 icon.

49. To open the HSPF project, activate the WinHSPF3.0 icon on the Windows desktop

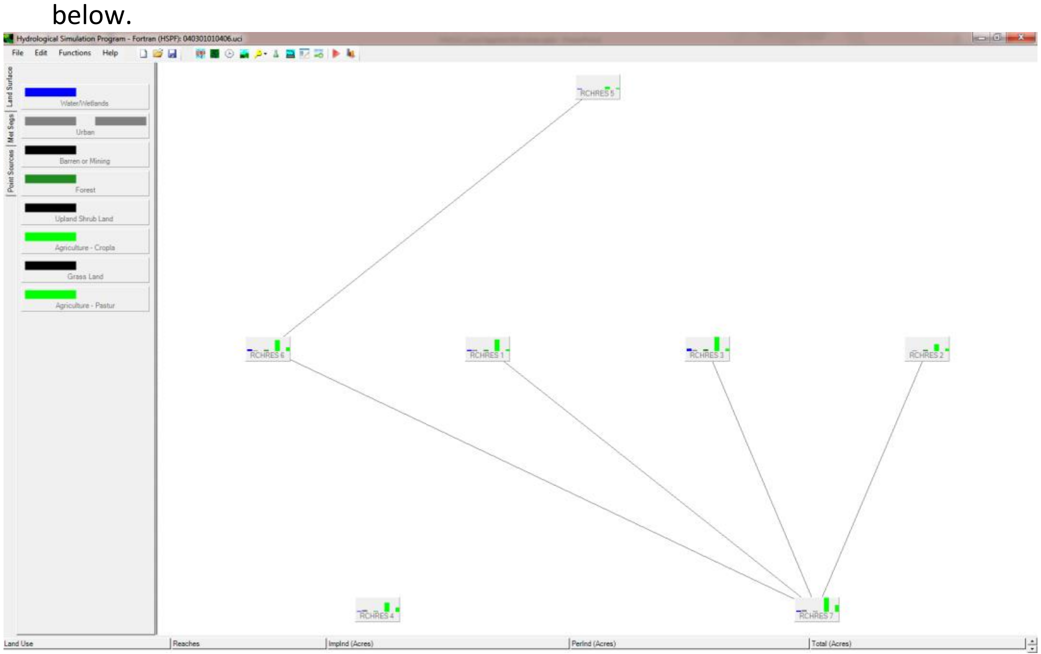
which opens the main HSPF window:



50. From the “File” menu, choose “Open”, navigate to the UCI file, and click “Open”.

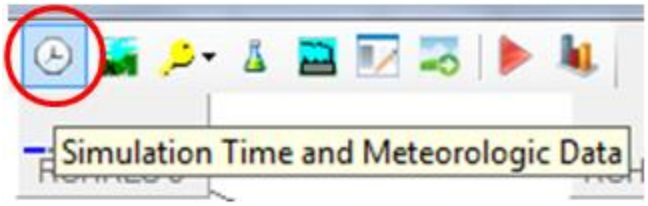


51. The new HSPF project will appear in the HSPF GUI, with the watershed workflow schematic shown below.

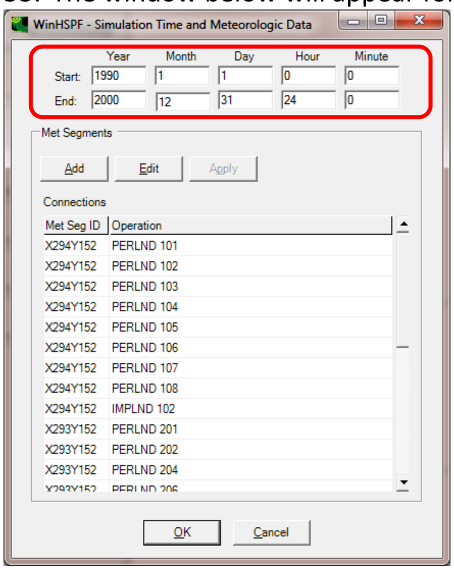


The user may navigate through the HSPF controls to interact with the HSPF project.

52. The simulation period is set by the user in SDMProjectBuilder, and output is set at an hourly time step. The simulation period can be checked or modified by clicking on the “Simulation Time and Meteorologic Data” toolbar button in the HSPF menu bar:



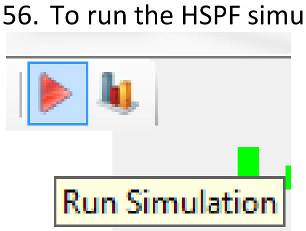
53. The window below will appear for setting simulation start and end dates.



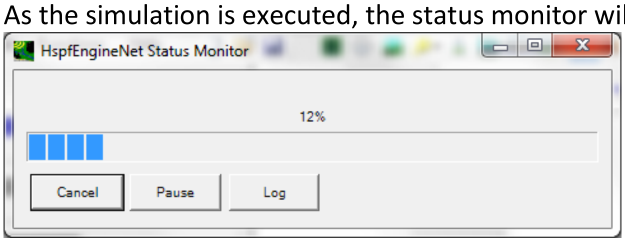
54. The date can be changed, but we will leave the starting and ending dates unchanged for this assessment. Click “OK”.

55. Save the HSPF project by clicking “File”, then “Save” on the main menu bar.

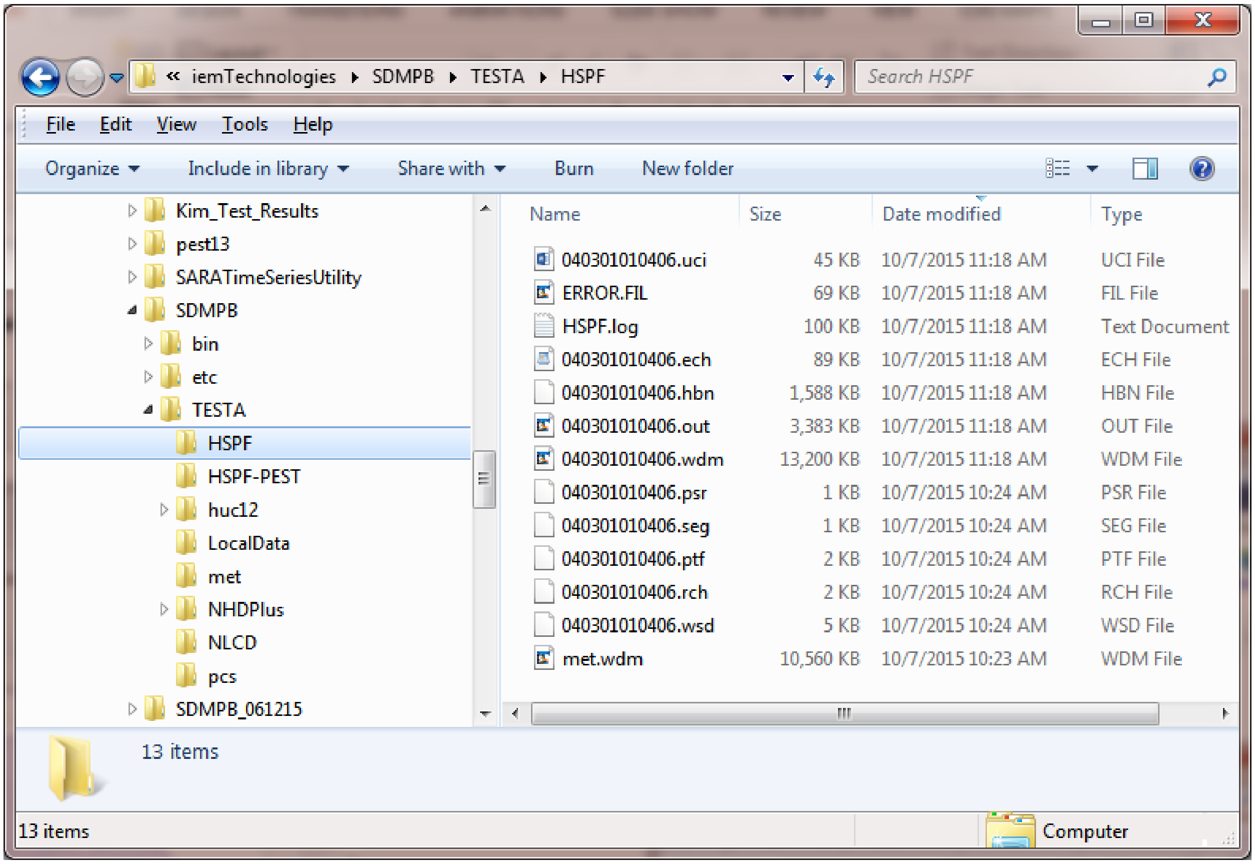
56. To run the HSPF simulation, click the “Run Simulation” icon.



As the simulation is executed, the status monitor will appear.



57. When the simulation is complete, the status monitor disappears. The HSPF subfolder will contain additional files such as the .ech, .out, and .hbn files shown below.



Note that the HSPF binary output file (.hbn) in this example is roughly 1.6 Mb in size. The file size could be an issue for long simulation periods, as the size may approach a limit of 2.0 GB.

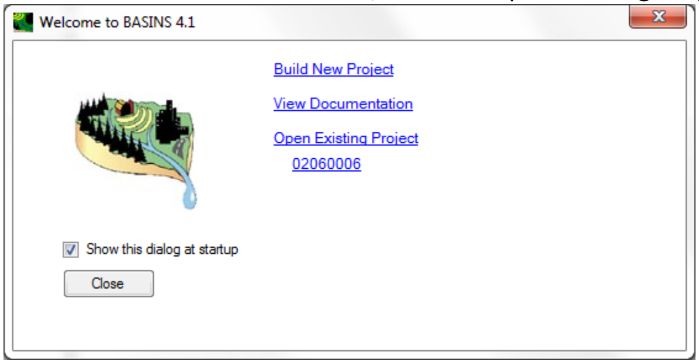
58. Save the HSPF project by clicking “File”, then “Save” on the main menu bar.

Leave the HSPF workflow schematic screen open, as you may want to refer to it when operating in the BASINS interface.

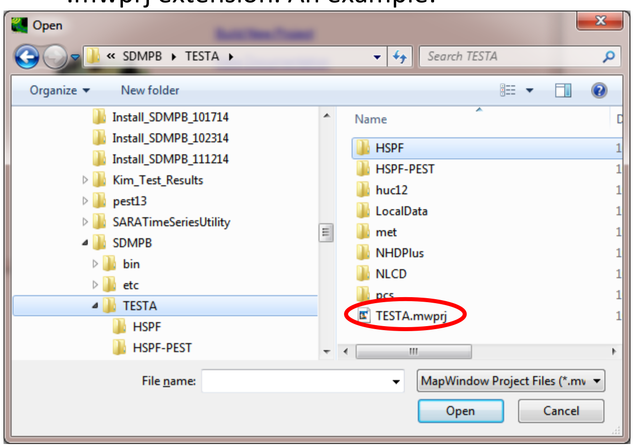
Register the HSPF Simulation with BASINS

59. If BASINS is not already open, start BASINS with the BASINS 4.1 icon on the desktop in order to view results of the simulation:

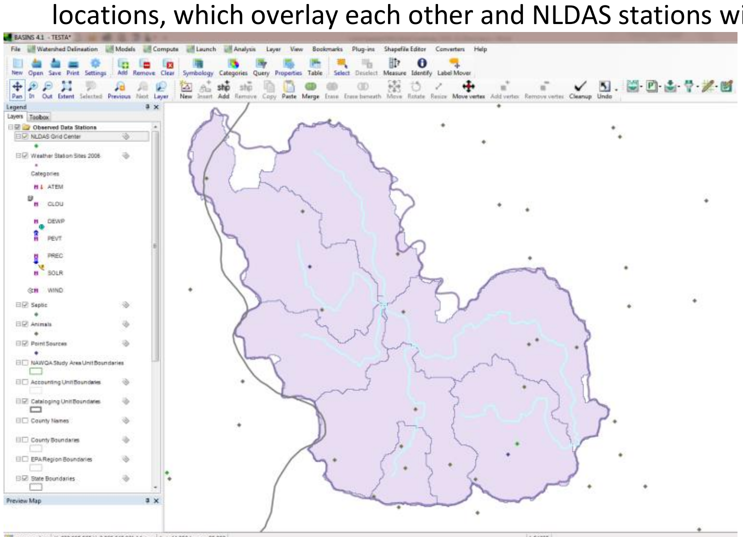
60. At the “Welcome” window, choose “Open Existing Project”.



61. Navigate to the project folder (e.g., TESTA), and select the *.mwprj file. Note that the name of the file reflects your selection. Be certain the file name you assigned to your assessment matches the *.mwprj extension. An example:



62. Click “Open” so the SDMPB project will open in BASINS 4.1. Although all SDMPB map layers may not be displayed within the SDMPB interface, they are visible as BASINS map layers, and data are available in BASINS for HSPF simulations. The following screen including domestic animal and septic locations, which overlay each other and NLDAS stations will appear:

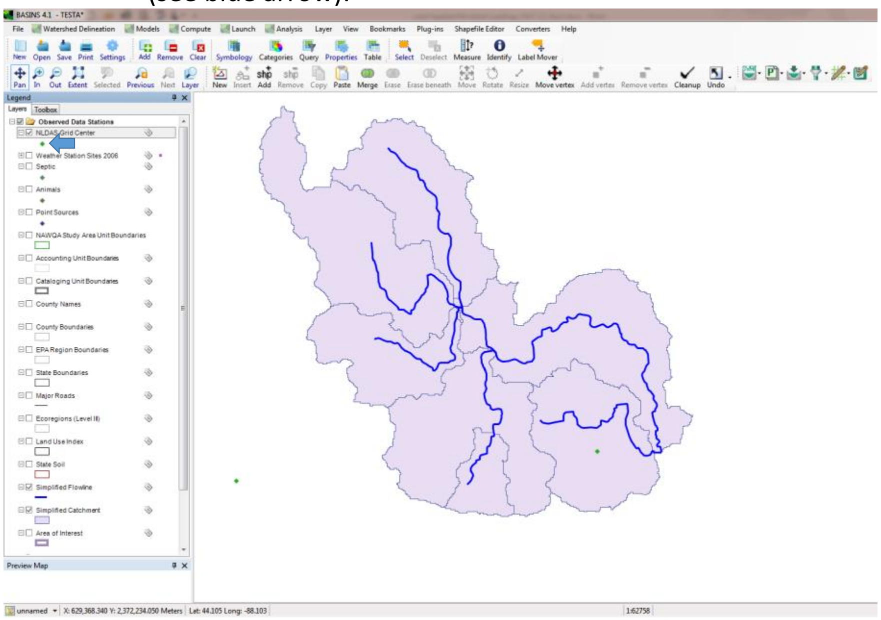


LABEL SUBWATERSHEDS, RIVER REACHES, MET STATIONS

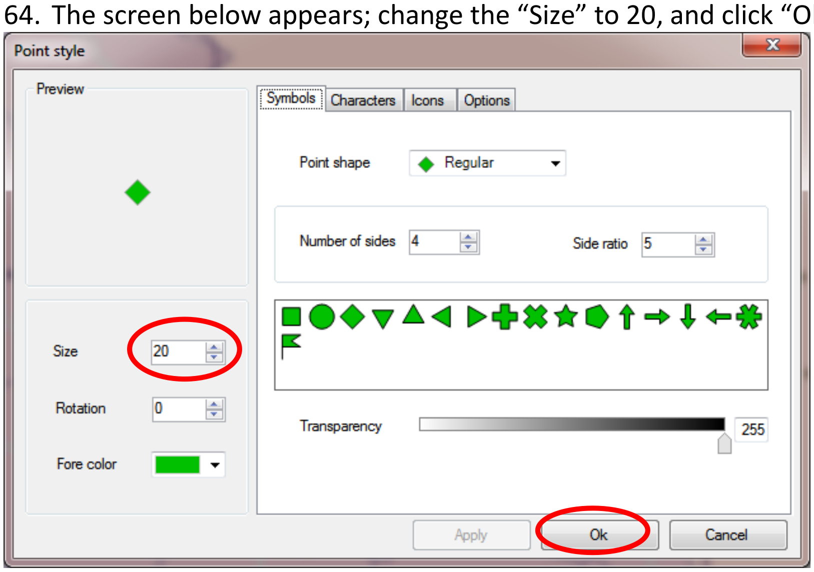
To plot results effectively, the user must identify subwatersheds (i.e., subbasins), stream reaches, and MET stations, etc. with aunique identifier. This section reviews labeling protocols for subwatersheds, river reaches, and MET stations.

Increase the NLDAS Symbol Size

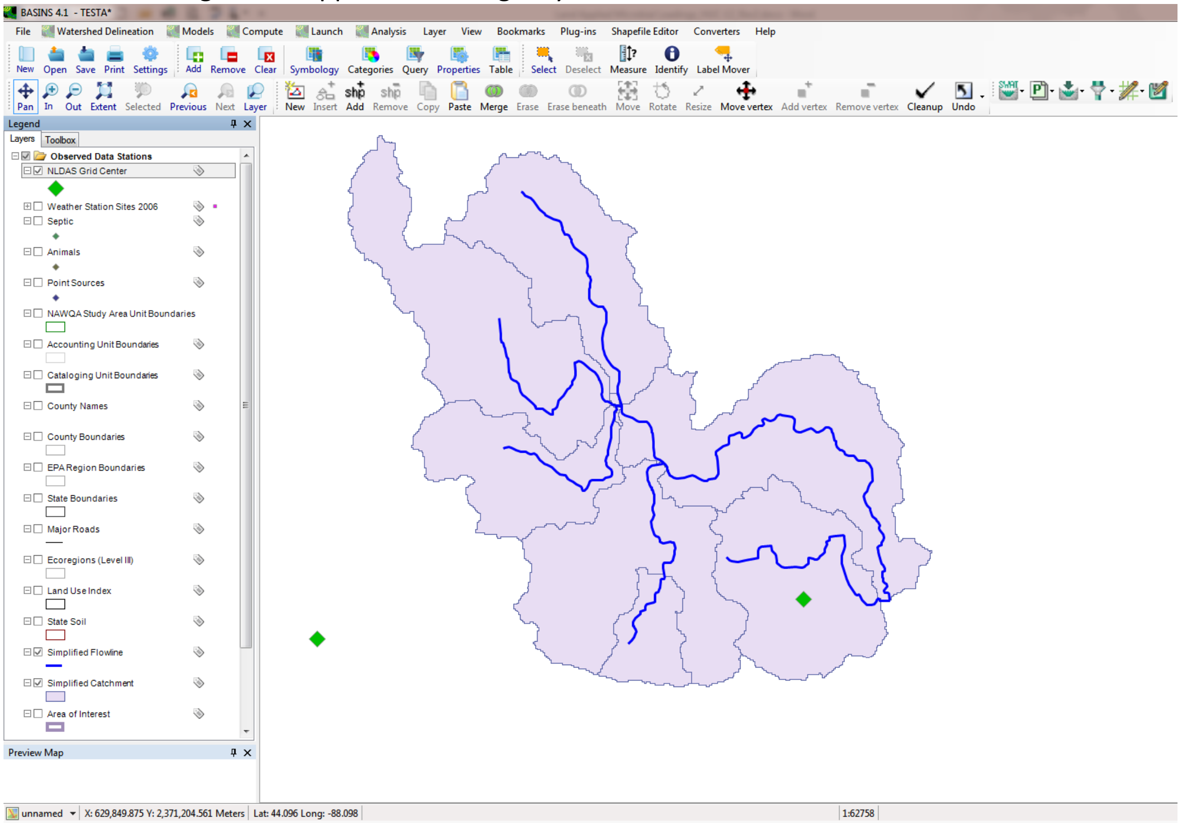
63. It is hard to differentiate NLDAS MET stations from the domestic animal/septic locations, so
    - uncheck the other map layers since NLDAS symbols may actually be hidden behind other symbols and
    - increase the size of the NLDAS symbol by double-clicking on the NLDAS Grid Center symbol (see blue arrow):



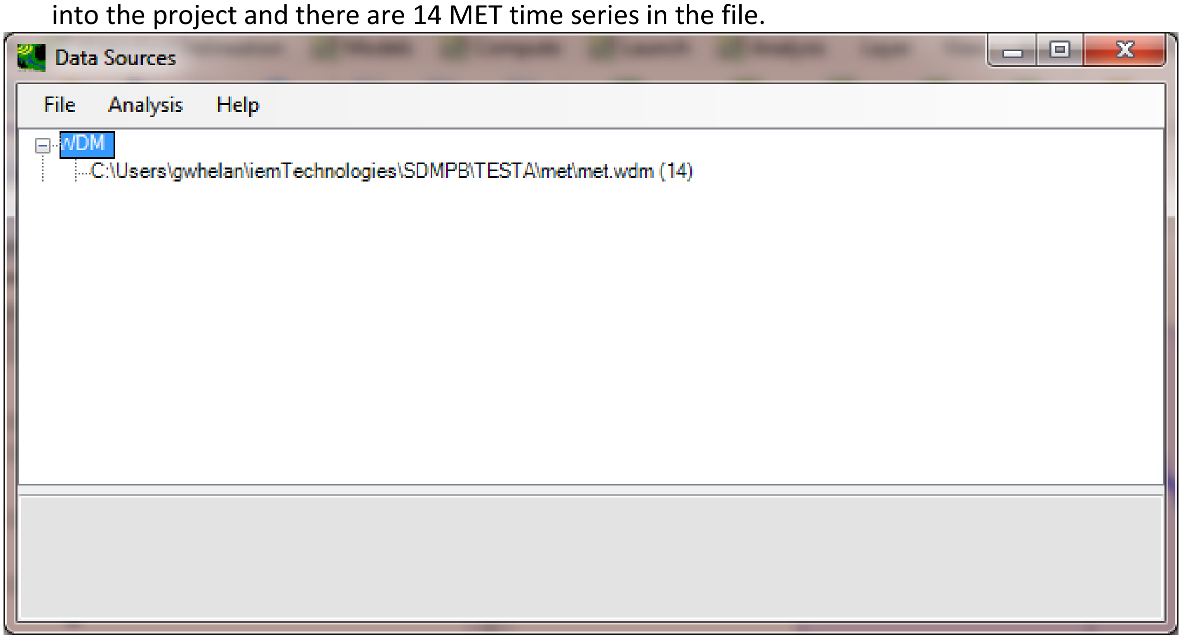
64. The screen below appears; change the “Size” to 20, and click “Ok”.



The following screen appears with larger symbols for the NLDAS stations:



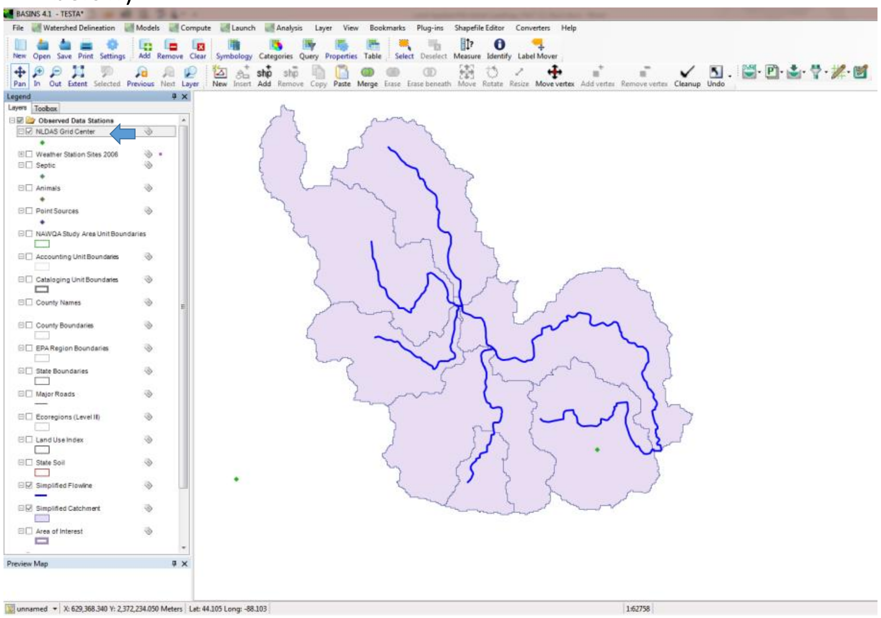
65. By clicking “File,” then “Manage Data” on the menu bar, we can see that the MET data are loaded into the project and there are 14 MET time series in the file.



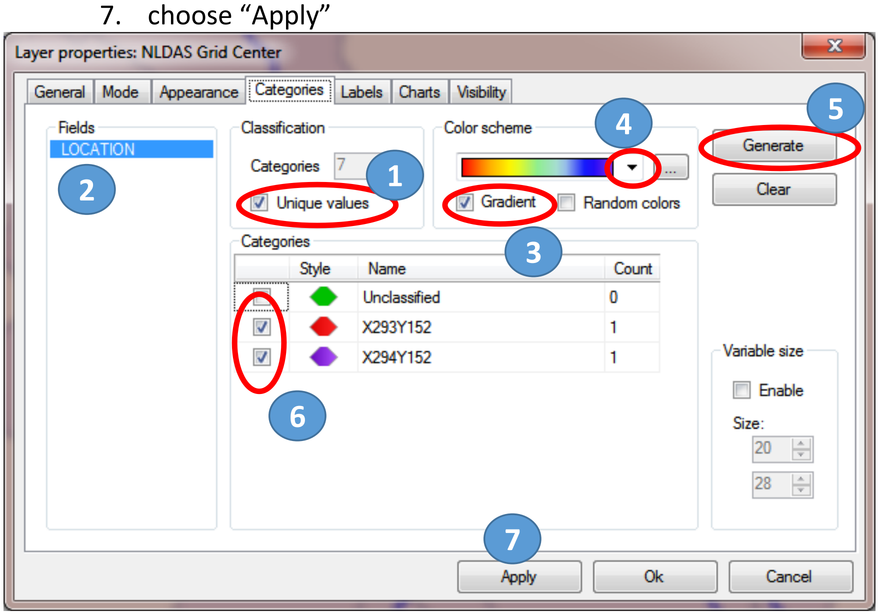
66. Choose “File”, then “Exit” to return to the main screen.

Label and Color-code MET Stations

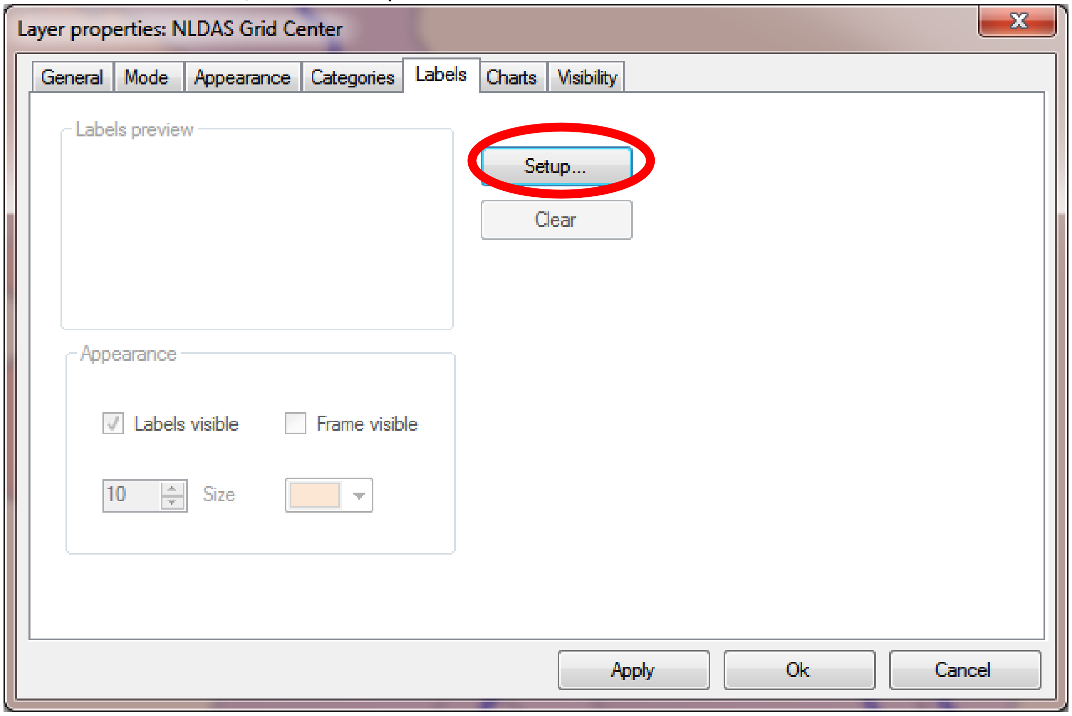
67. To Color-code the MET stations, double-click “NLDAS Grid Center” label (see blue arrow in screen below)



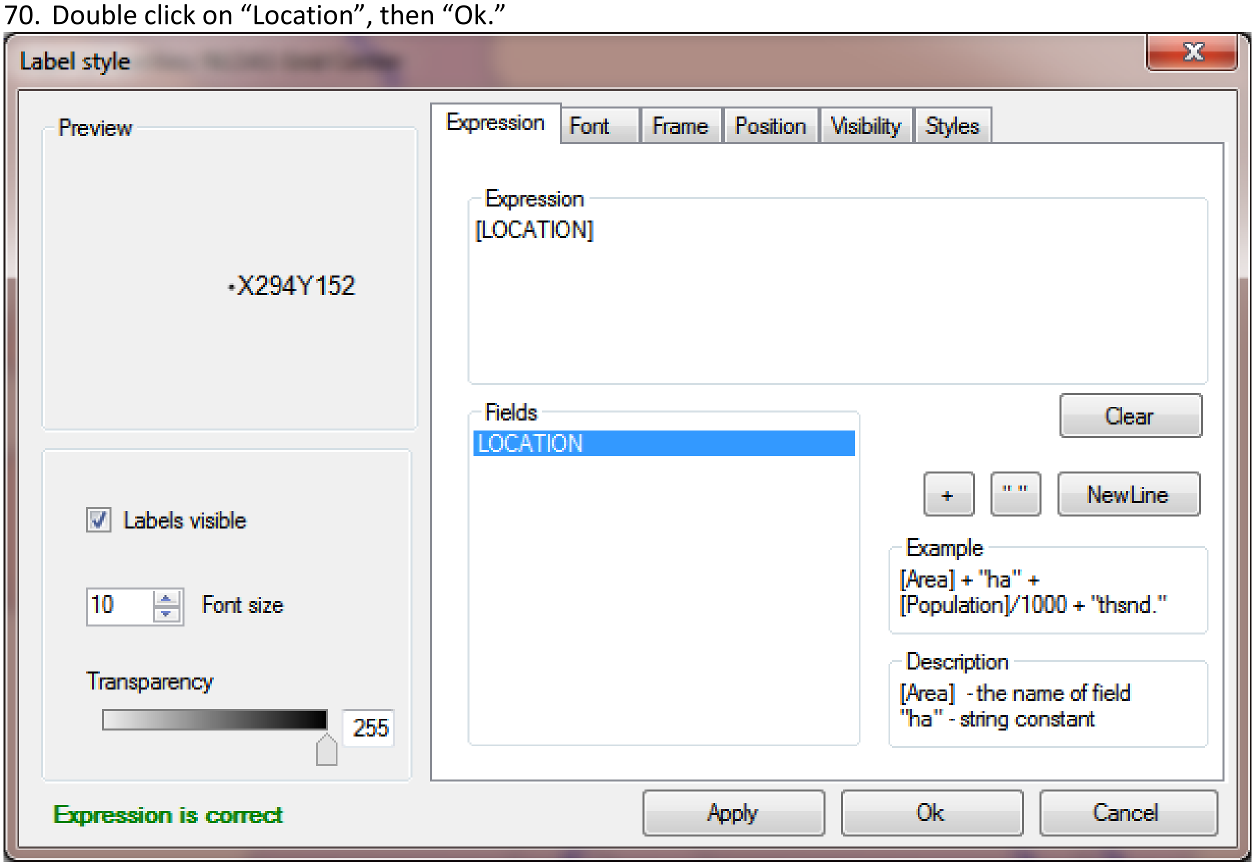
68. Choose “Categories” tab, and
    1. check “Unique values”
    2. select “LOCATION”
    3. check “Gradient”
    4. choose “Color scheme”
    5. click “Generate”
    6. check the boxes with non-zero counts
    7. choose “Apply”



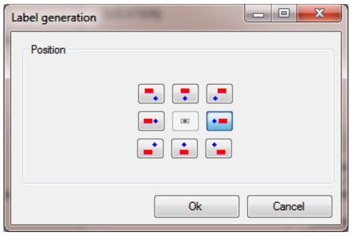
69. Choose “Labels”, then “Setup.”



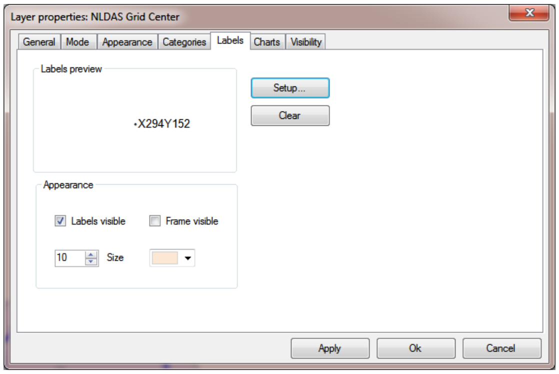
70. Double click on “Location”, then “Ok.”



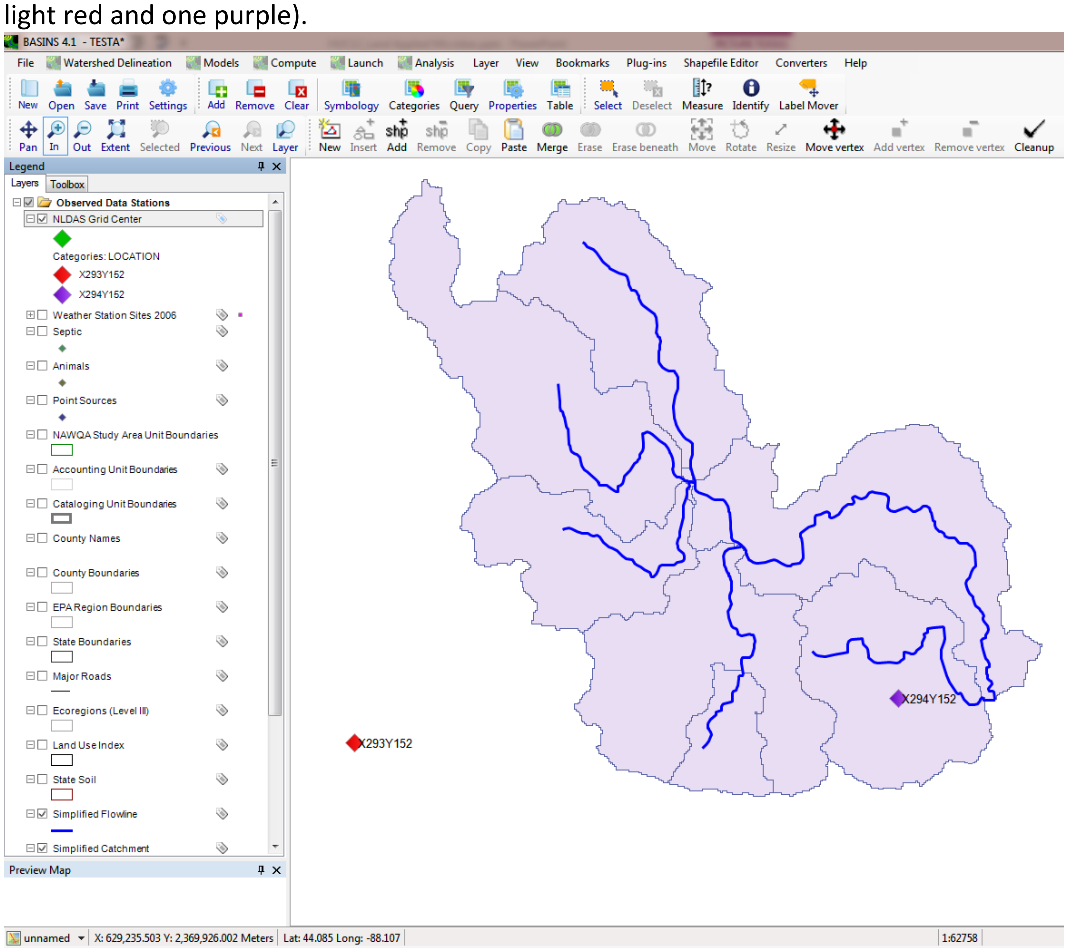
71. Choose the Position, then click “Ok.”



72. Click “Ok.”

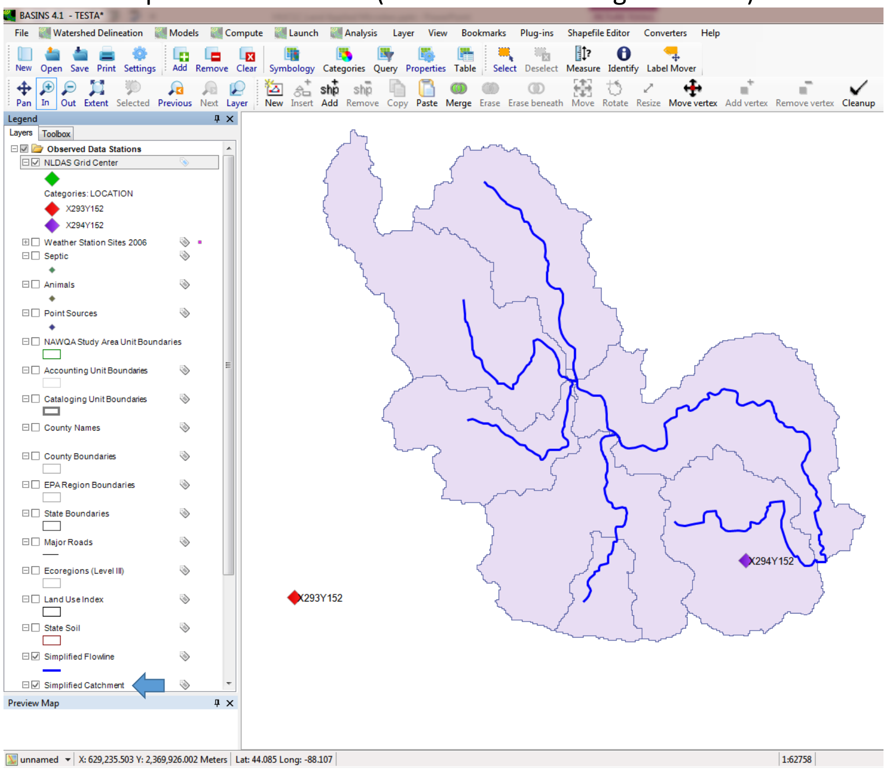


The two MET stations that influence the seven subwatersheds are now labeled and color-coded (one light red and one purple).

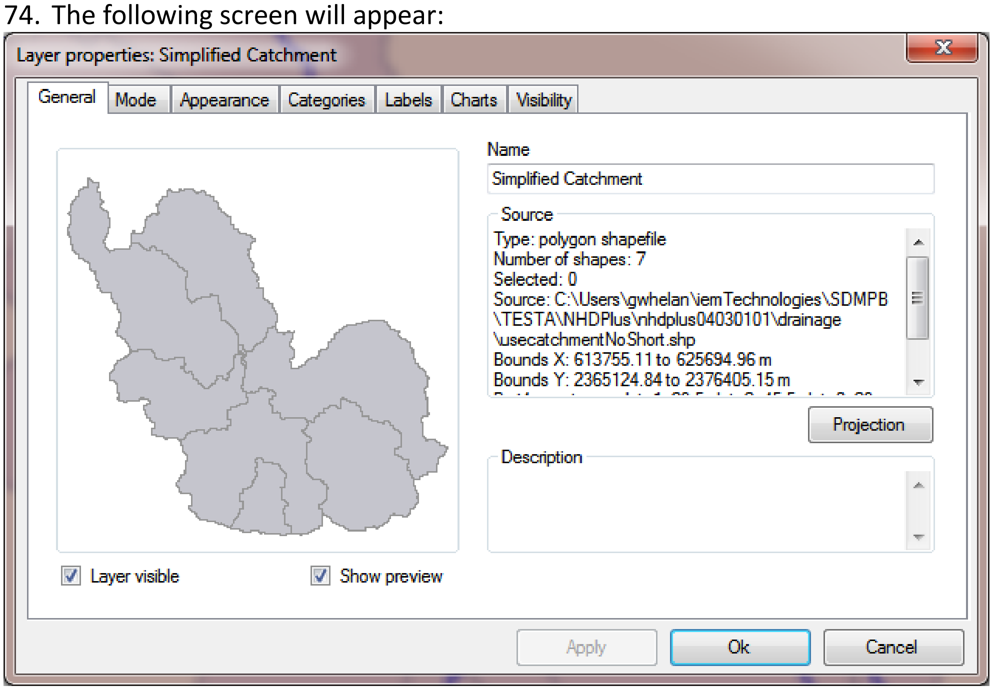


Correlate MET Stations with Subwatersheds

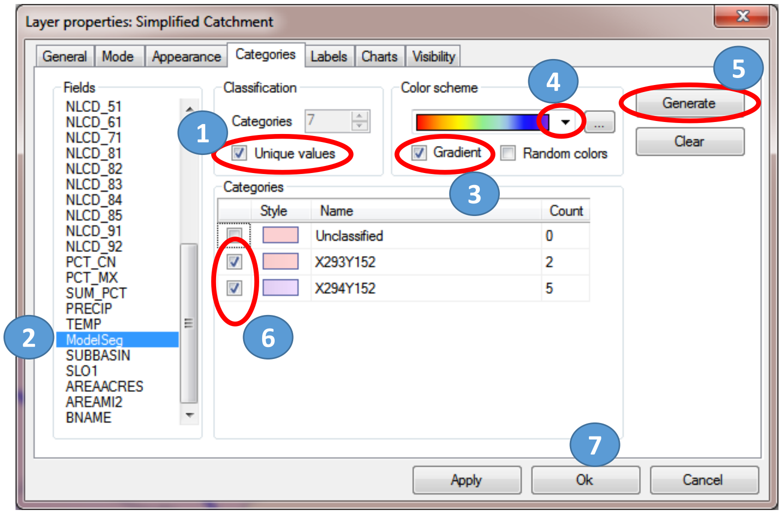
73. To see which subwatersheds (i.e., subbasins) are associated with which MET stations, double-click on “Simplified Catchment” (see blue arrow in figure below):



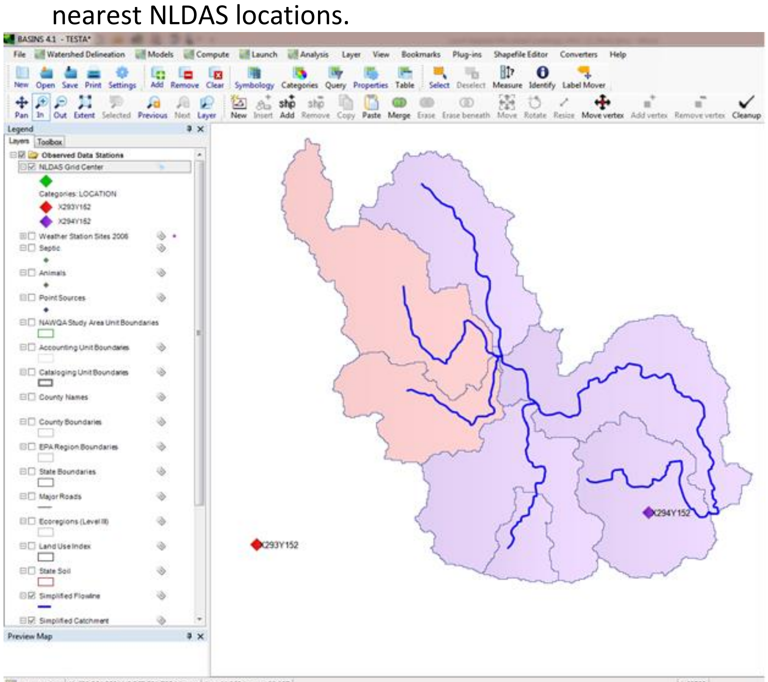
74. The following screen will appear:



75. To color code subwatersheds to match the color-coded MET stations, choose the “Categories” tab, and
    1. check “Unique values”
    2. select “ModelSeg”
    3. check “Gradient”
    4. choose “Color scheme”
    5. click “Generate”
    6. check the boxes with non-zero counts
    7. choose “OK”



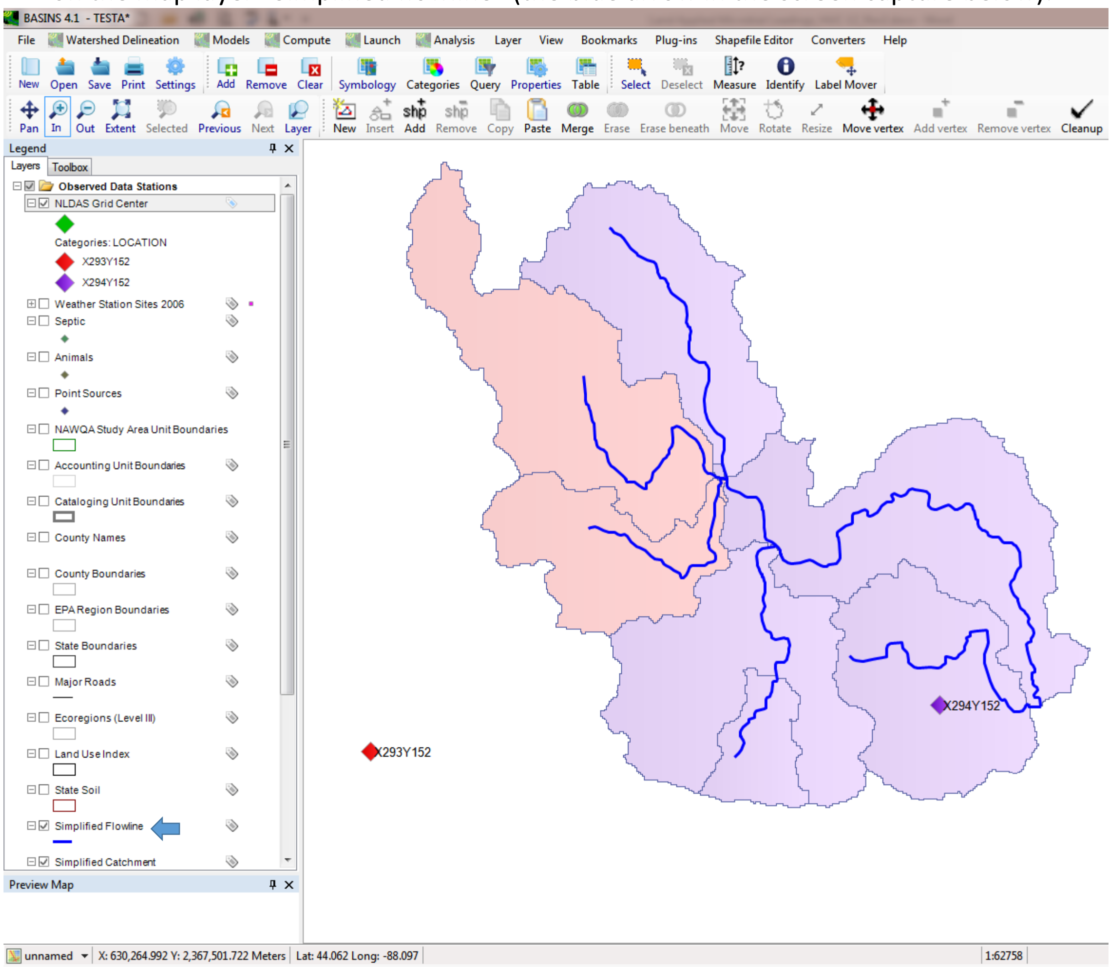
76. From the resulting image, you can see that the subwatersheds have been color-coded with the nearest NLDAS locations.



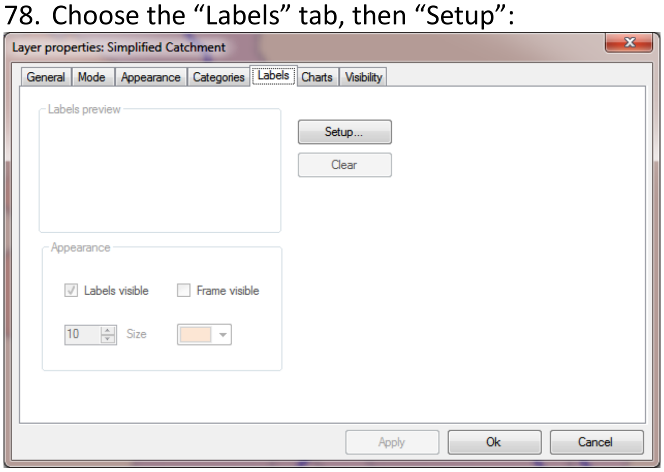
Appendix C illustrates how the HSPF UCI file captures and assigns the two NLDAS stations to the subwatersheds.

Label Stream Reaches

77. To label the stream reaches so they match the number scheme in the HSPF workflow, double-click on the map layer "Simplified flowline" (the blue arrow in the screen capture below):

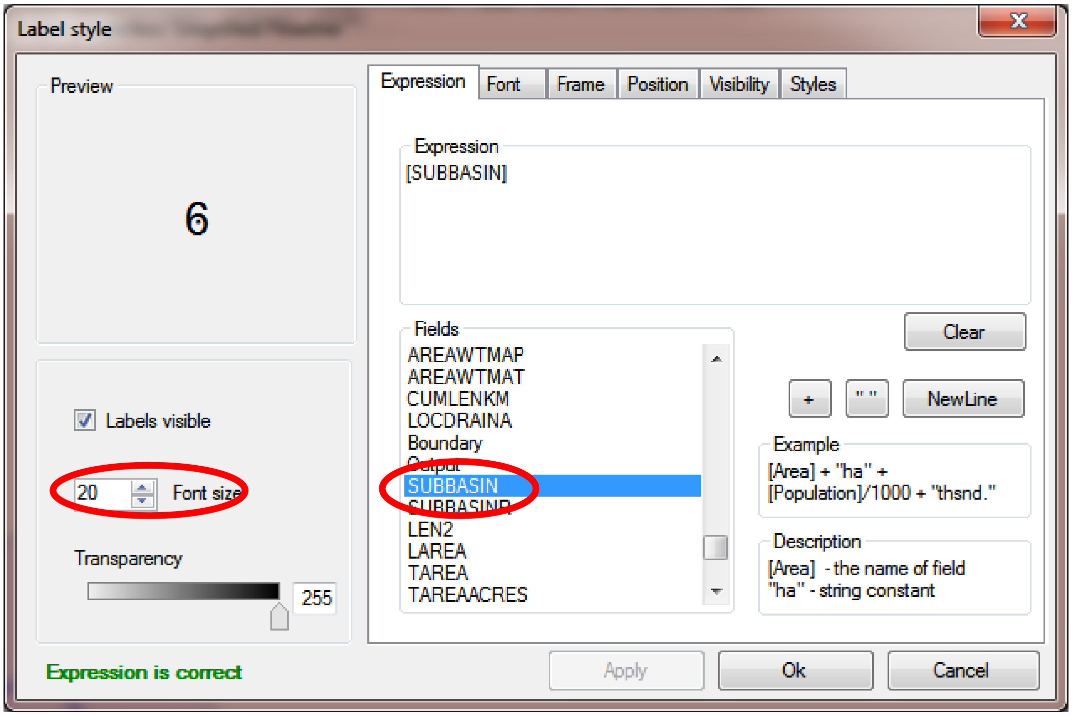


78. Choose the "Labels" tab, then "Setup":

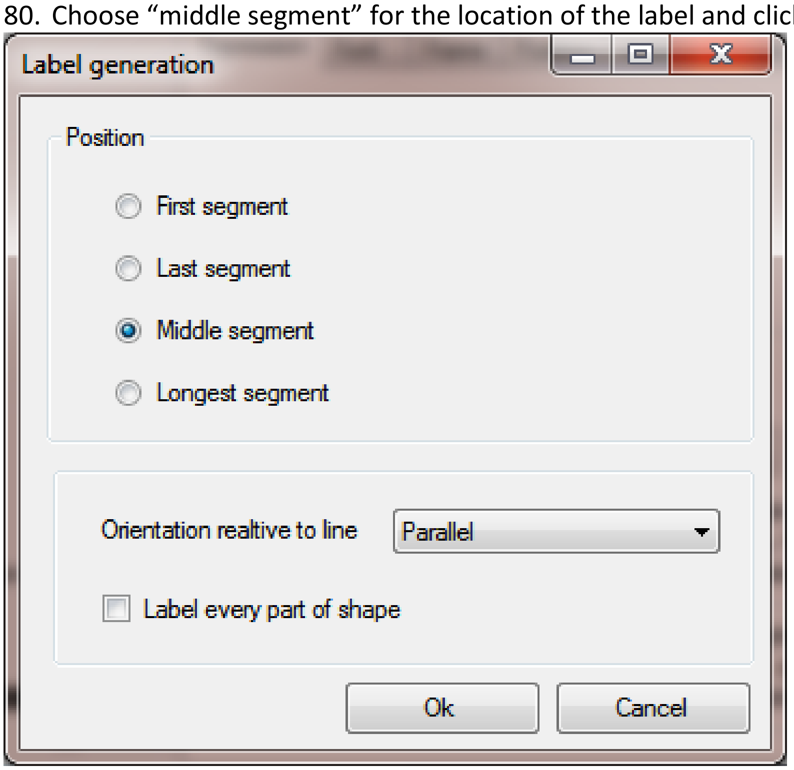


79. Under “Expression”,

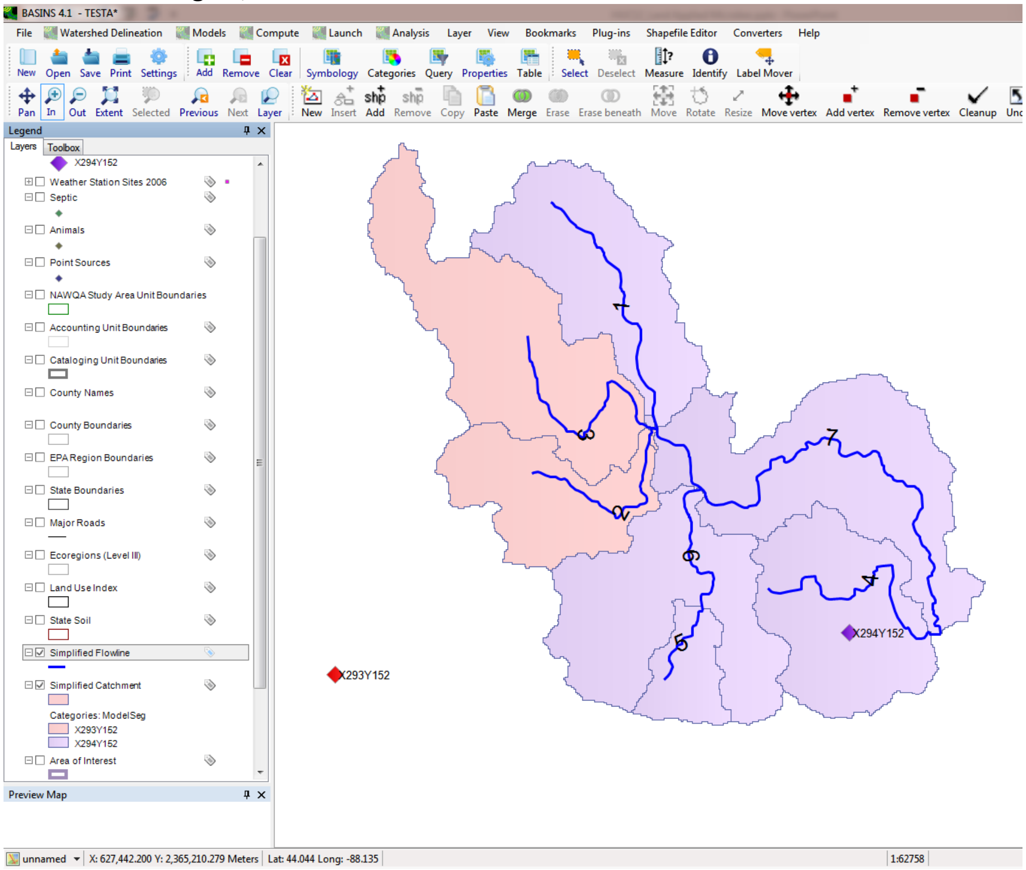
- choose “SUBBASIN” under “Fields”
- change the Font size to 20.
- click “Ok”



80. Choose “middle segment” for the location of the label and click “Ok”.



81. Click “Ok” again, and the stream reaches are labeled.



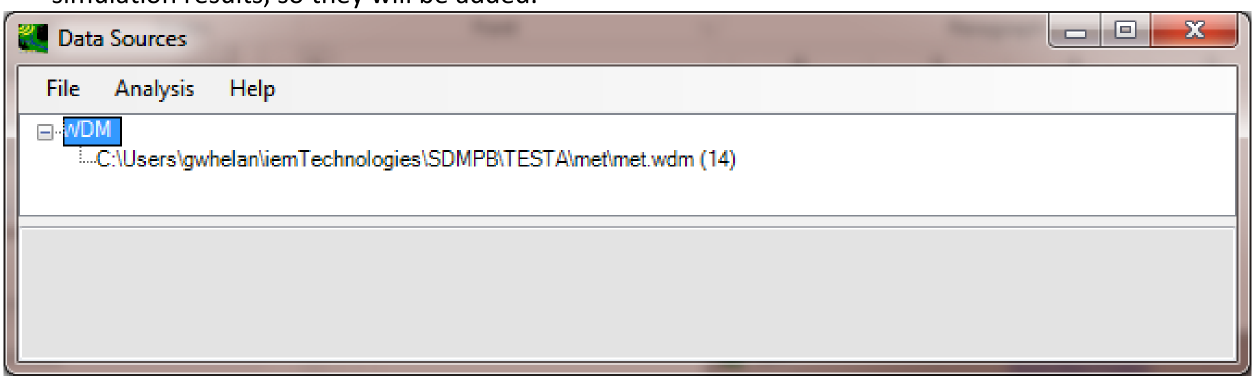
VIEW SIMULATION RESULTS FOR FLOWS AND MICROBIAL DENSITIES USING BASINS

There are two ways to view HSPF simulation results: create a graph of the output time series or view the time series in tabular form. The following related topics will be covered:

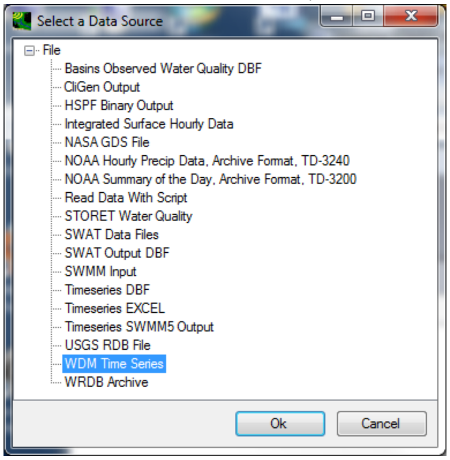
- Register HSPF Simulation and Data Files
- View Graphical Simulation Results for Hourly Discharges at Multiple Locations
- Modify the Look and Feel of the Graphical Plots
- View Simulation Results for Hourly and Daily Discharges at the Same Location
- View Microbial Simulations: Time Series of Microbial Densities at Multiple Locations
- View Tabular Results Associated with Hourly Discharge and Microbial Density Simulations

Register HSPF Simulation and Data Files

82. Go to the "File", then "Manage Data" menu. The user may see a pre-loaded met.wdm file, as illustrated below. Time series data sources from the HSPF simulation are needed for viewing simulation results, so they will be added.

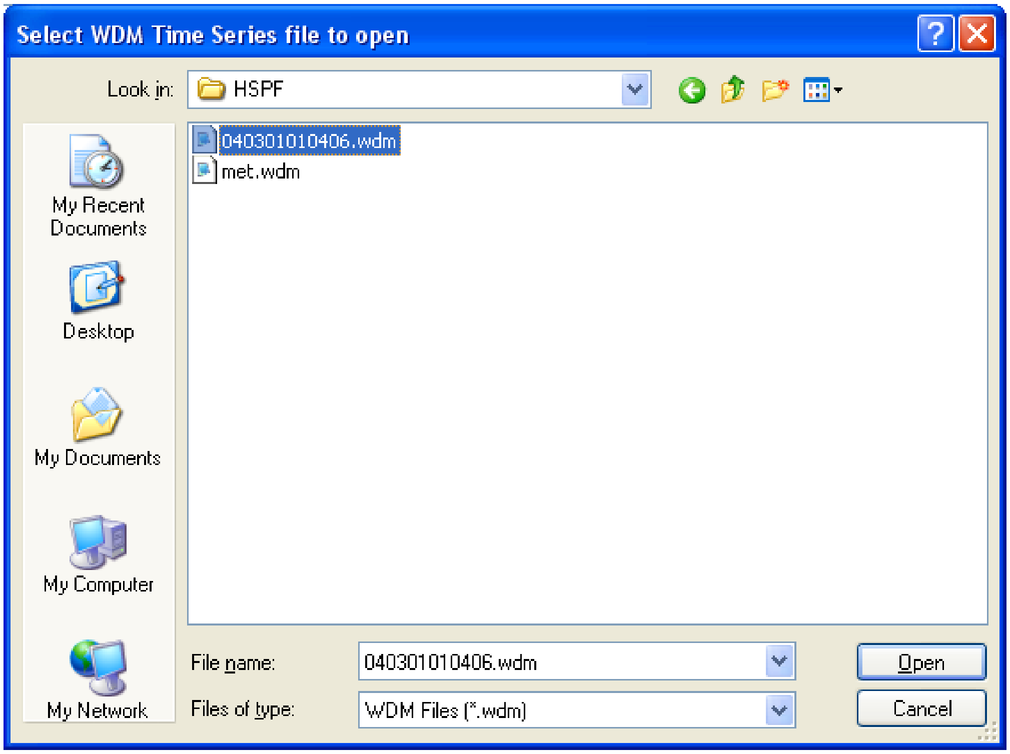


83. The WDM file associated with the watershed of interest contains time series data. From within the Data Sources window, select "File", then "Open". A selection window like the one below appears.

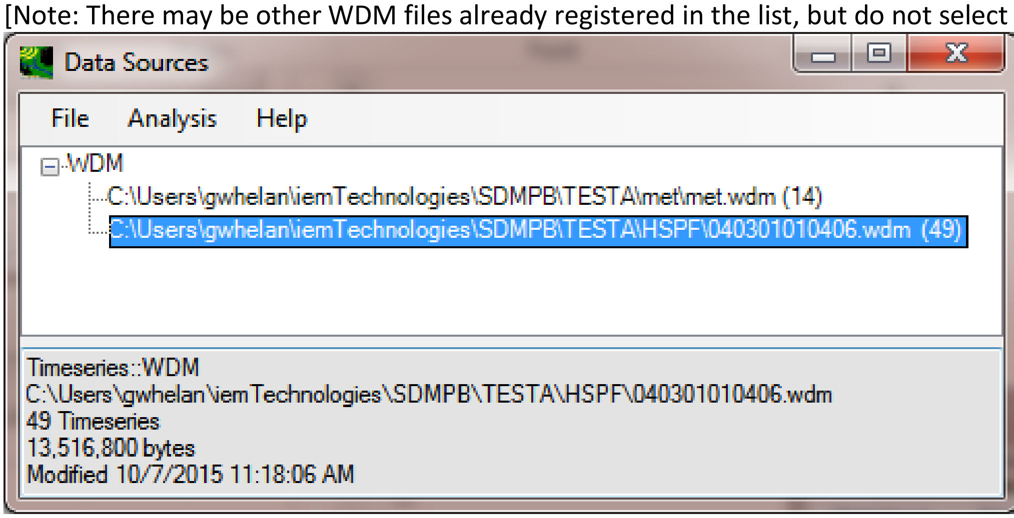


84. Select "WDM Time Series", then "Ok".

85. Navigate to the HSPF project folder, and select the *.wdm file (not met.wdm) associated with your assessment. Here, it is '040301010406.wdm'. This file contains the output time series written from HSPF to the WDM file.



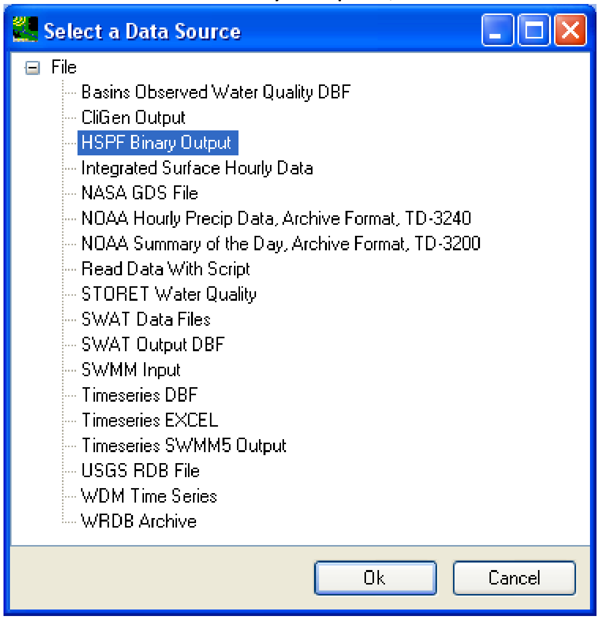
86. With this data source open, the file name will appear in the Data Sources window.
[Note: There may be other WDM files already registered in the list, but do not select met.wdm.]



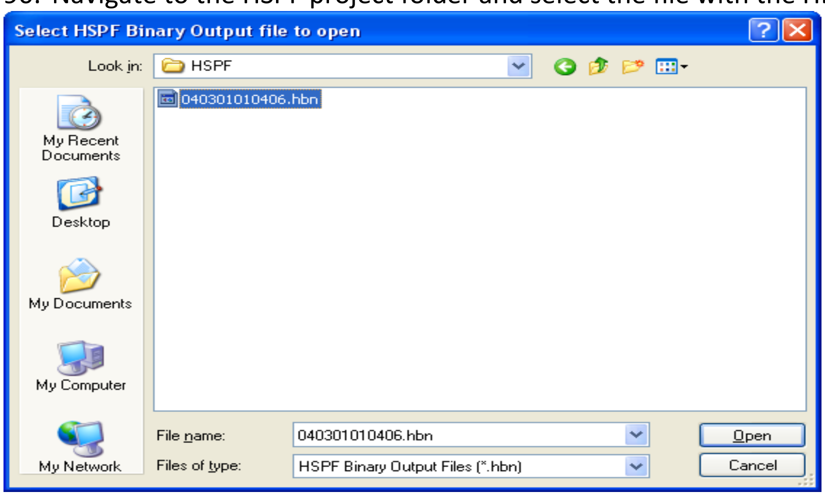
87. The HSPF Binary file (*.hbn) only exists after execution of HSPF; hourly data associated with the "RO" designation (Reach Outflow) are associated with the *.hbn file. To view results of the Microbial simulation, the HSPF binary output file must be added to the current BASINS project.

88. From the "Data Sources" window, choose the "File", then "Open" again.

89. Select “HSPF Binary Output”, then “Ok”.

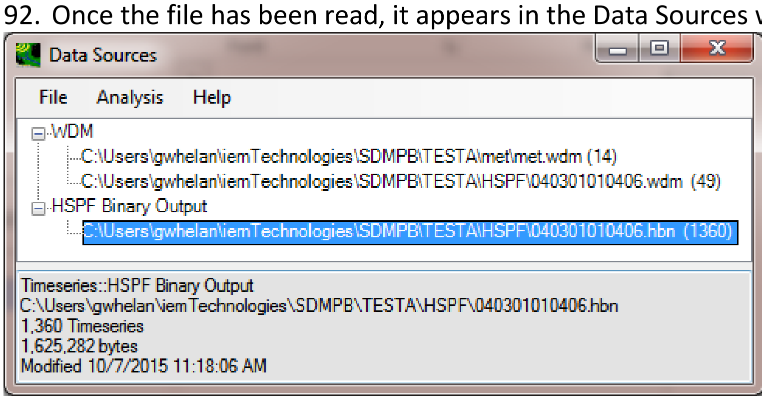


90. Navigate to the HSPF project folder and select the file with the HBN extension.



91. Click “Open”. Because of its large size, the HBN file may take time to read.

92. Once the file has been read, it appears in the Data Sources window.

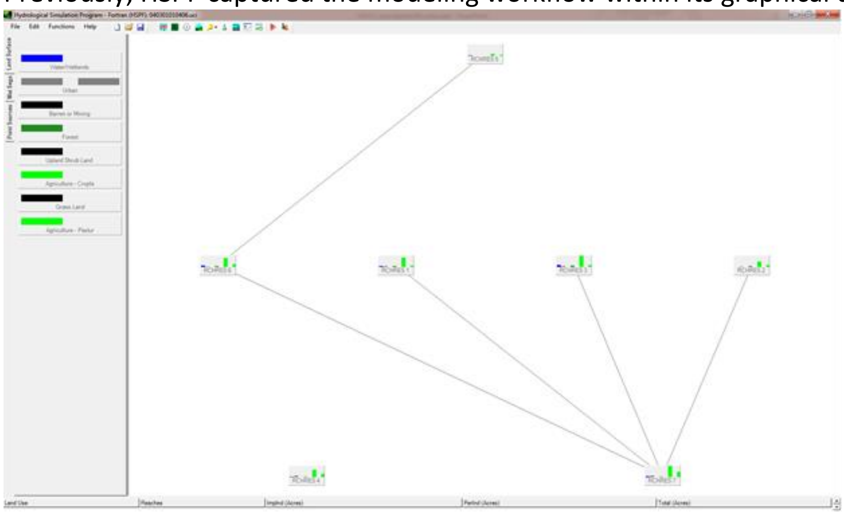


93. Close the Data sources window and save the BASINS project by clicking “File”, then “Save”. Exit the screen.

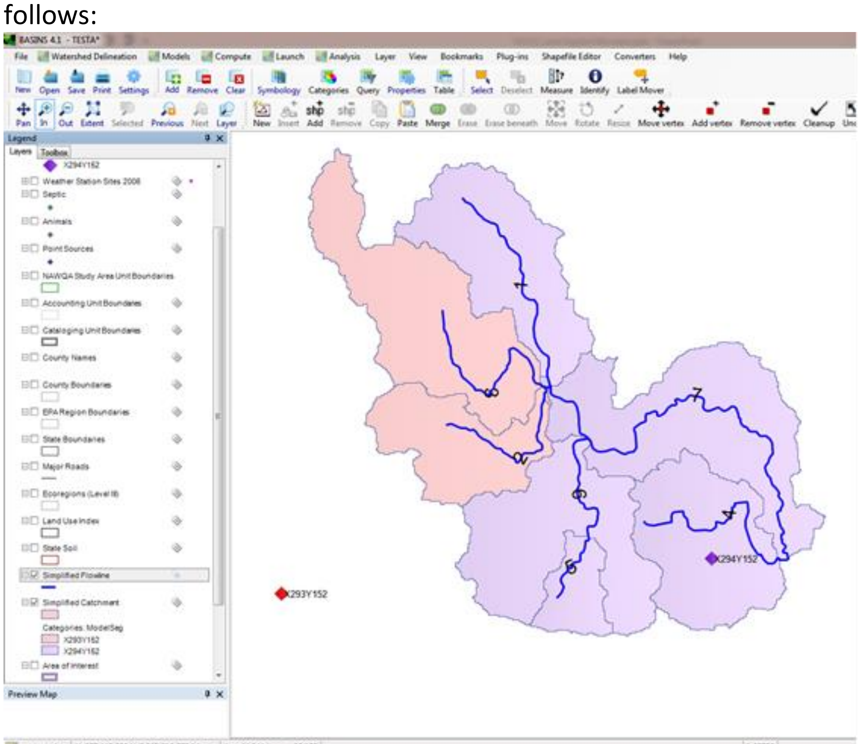
Appendix A showed that the EXT TARGETS block within the HSPF uci file specifies which time series are output. Instream hourly time series for flow (RO) in ft3/s and microbial densities (DQAL) in Cells/L are published for each reach (RCHRES).

View Graphical Simulation Results for Hourly Discharges at Multiple Locations

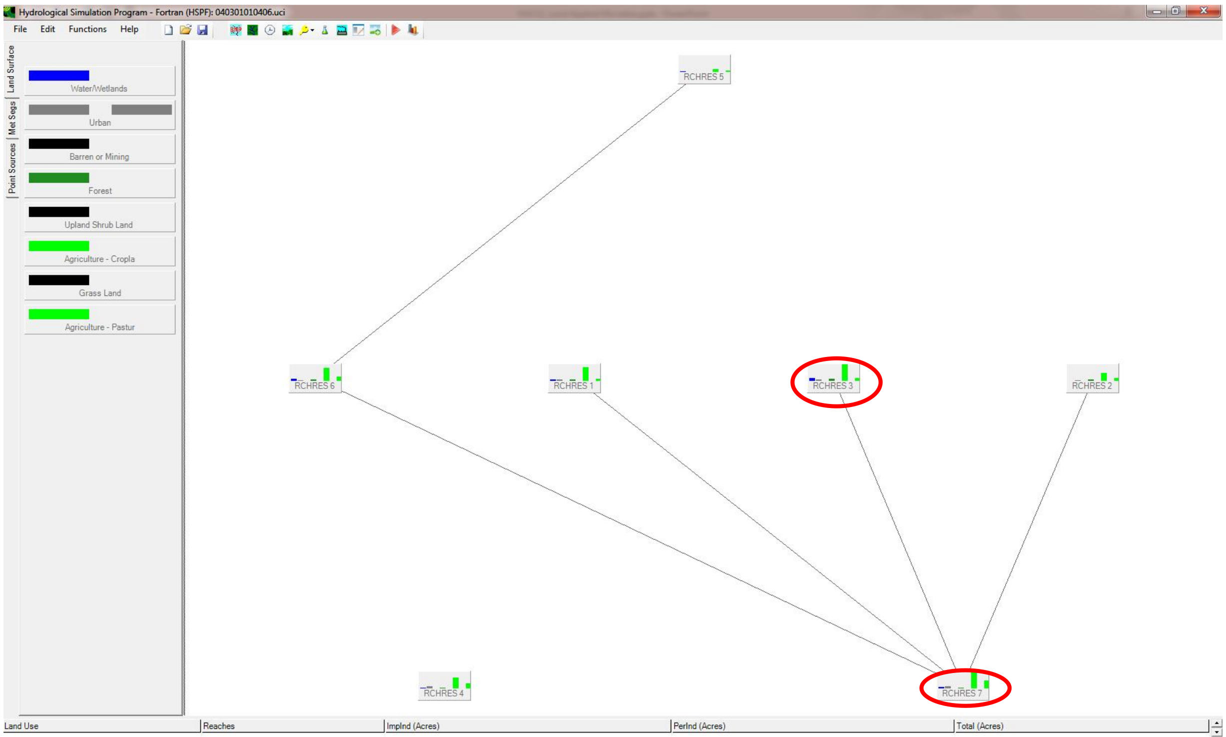
Previously, HSPF captured the modeling workflow within its graphical user interface as



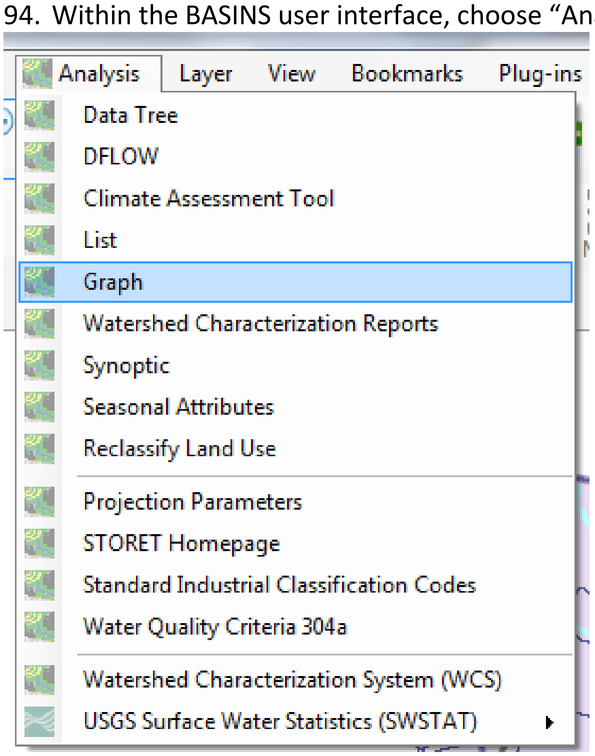
These reaches (RCHRES) correspond to the BASINS schematic, reach number by reach number, as follows:



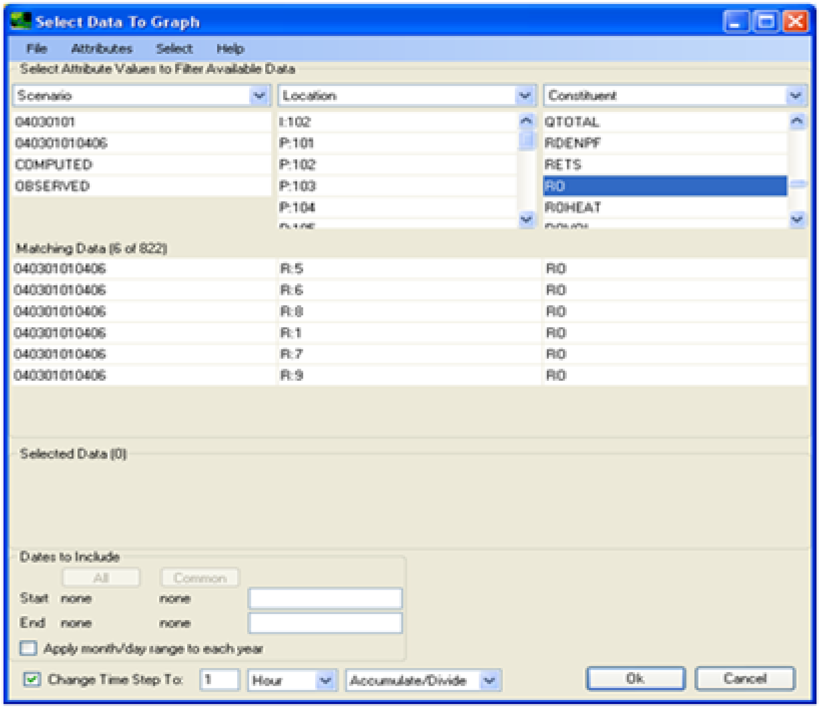
Hourly flow and microbial densities will be viewed at multiple locations; in this case, Reaches (i.e., RCHRES) 3 and 7. The reach ID numbering scheme correlates to the site layout in HSPF, as illustrated in the HSPF workflow below.



94. Within the BASINS user interface, choose "Analysis", then "Graph".

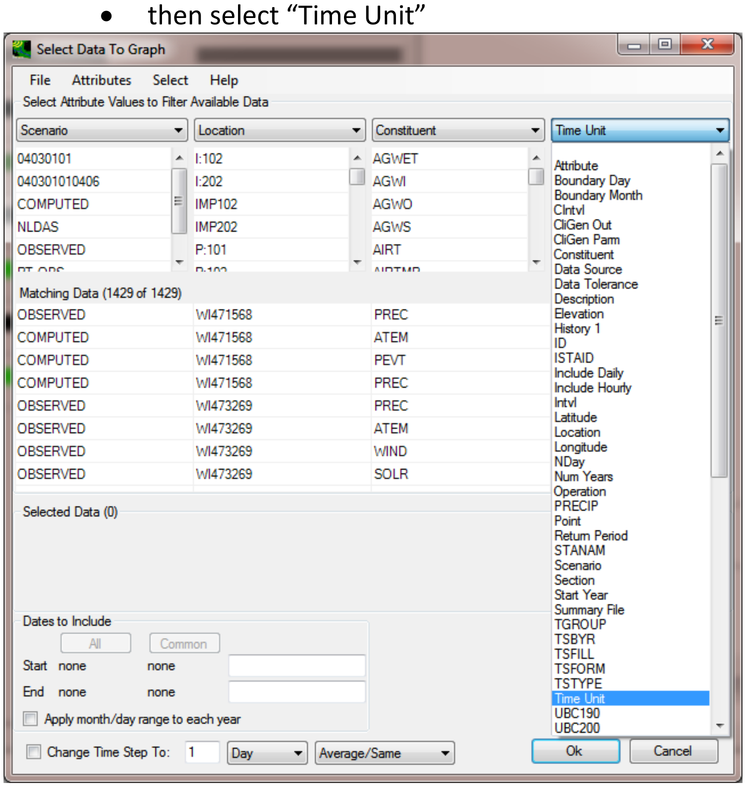


95. The screen below will appear.

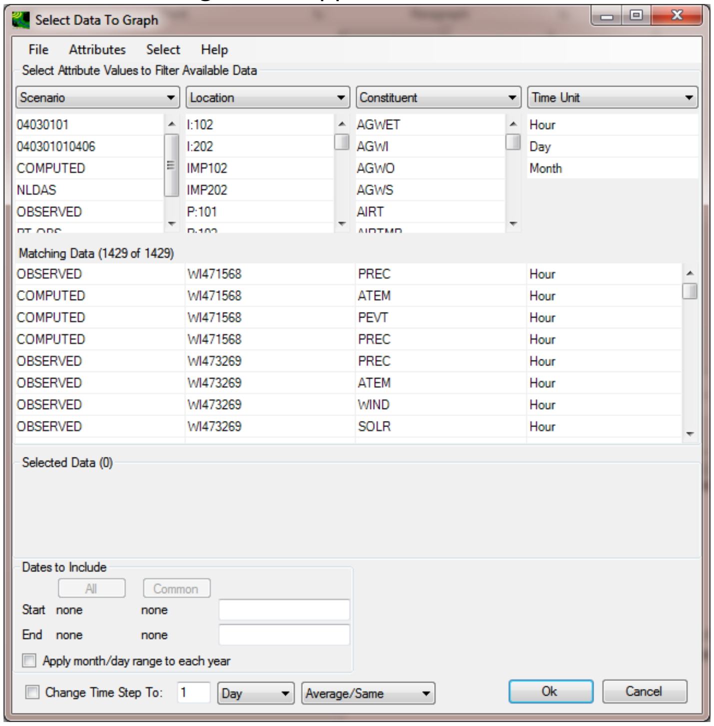


96. To know the time units associated with the plotted results,

- choose “Attributes”,
- then “Add”
- then select “Time Unit”

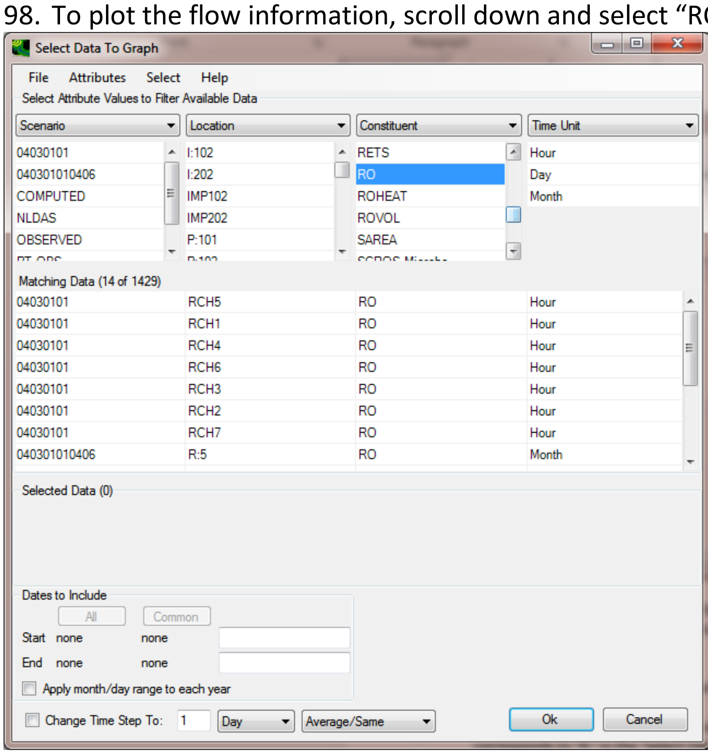


97. The following screen appears.

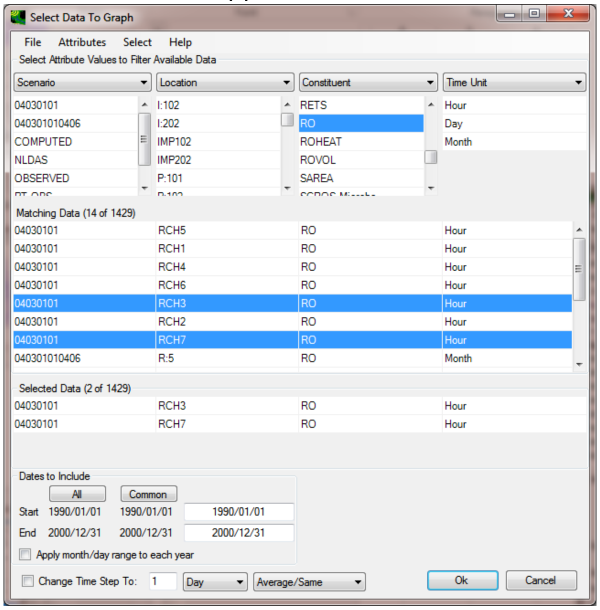


As noted earlier, the constituent name for the instream hourly time series for flow in ft^3/s is "RO" and the constituent name for the instream hourly microbial densities in Cells/L is DQAL. Each is published for the subwatershed location RCHRES which corresponds to hourly time units.

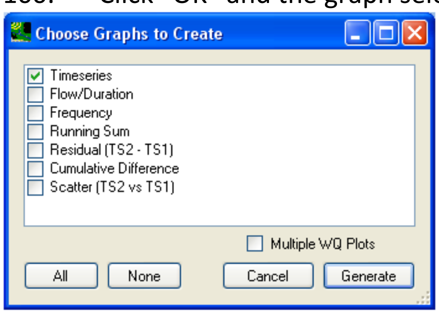
98. To plot the flow information, scroll down and select "RO" under "Constituent".



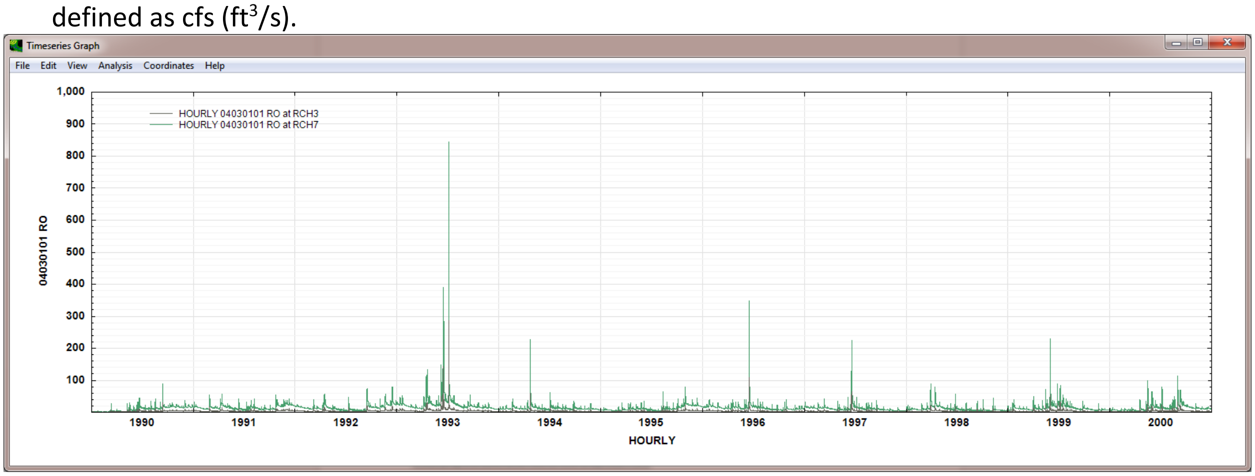
99. A list of reaches with flow data appears under 'Matching Data'. Choose RCH 3 and RCH7, whose selection will appear in "Selected Data":



100. Click "OK" and the graph selection window will appear.



101. Select "Timeseries", then "Generate" to produce the graph below. The discharge was previously defined as cfs (ft^3/s).

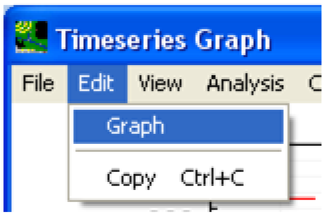


102. Both hydrographs are plotted together.

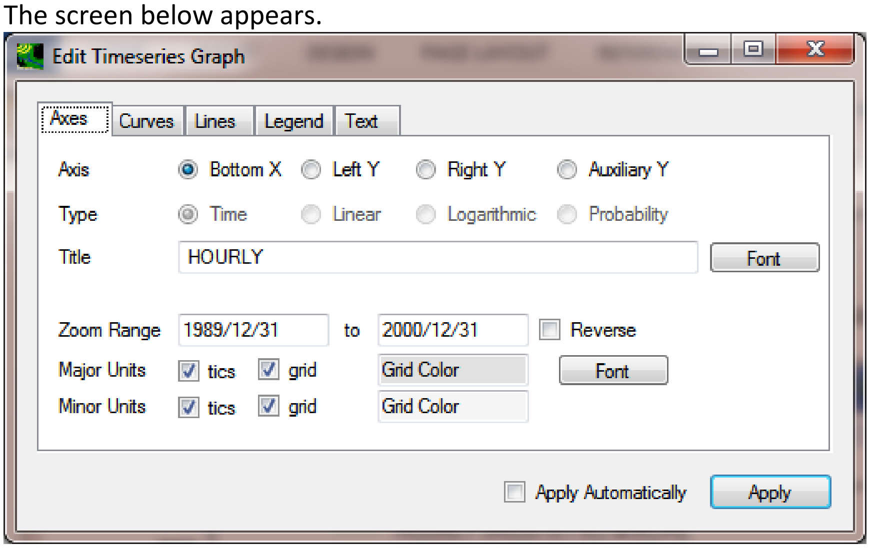
Modify the Look and Feel of the Graphical Plots

If the user wishes to have individual plots, reaches can be selected one at a time for plotting. In the meantime, we will modify the graph, one at a time, and plot them, so results are easier to view.

103. To better differentiate the plots, the y-scale can be changed and curves assigned different colors. Choose “Edit”, then “Graph”.

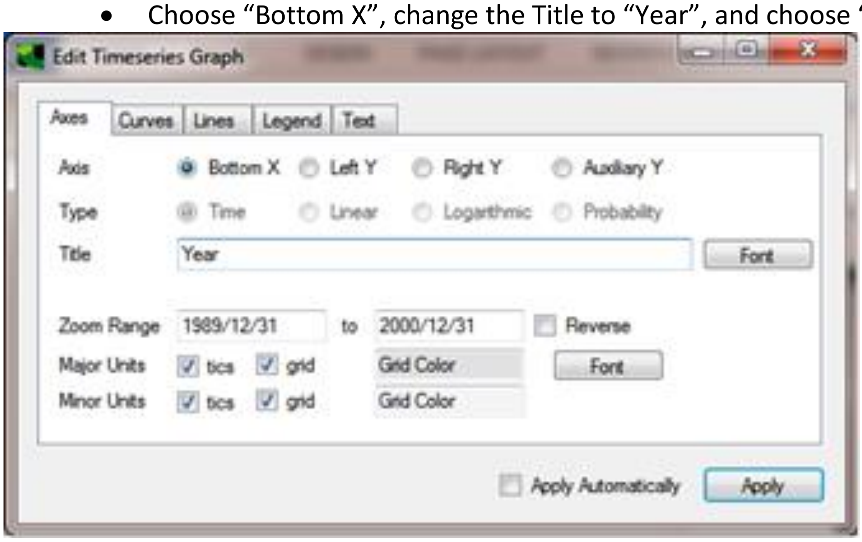


The screen below appears.

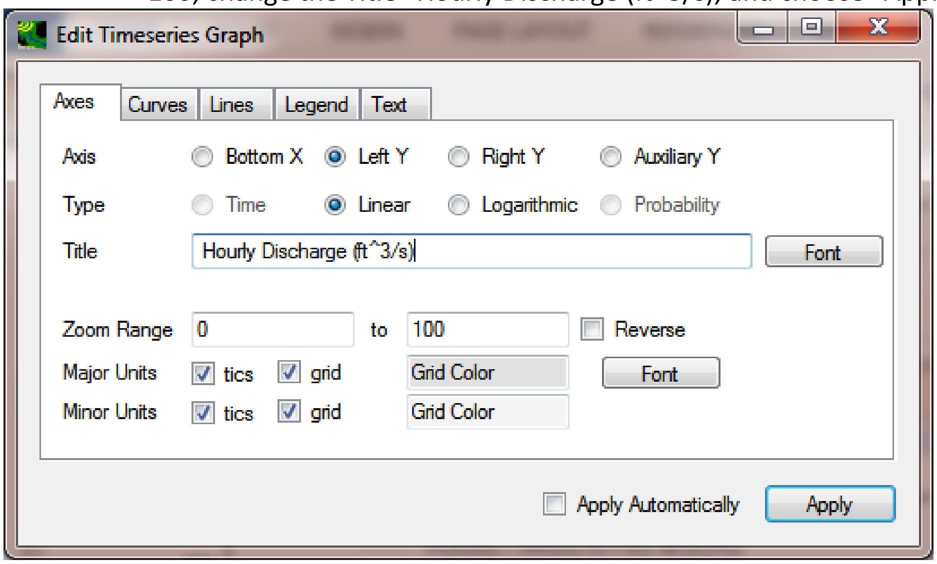


104. To change the ranges and titles of the x and y axes,

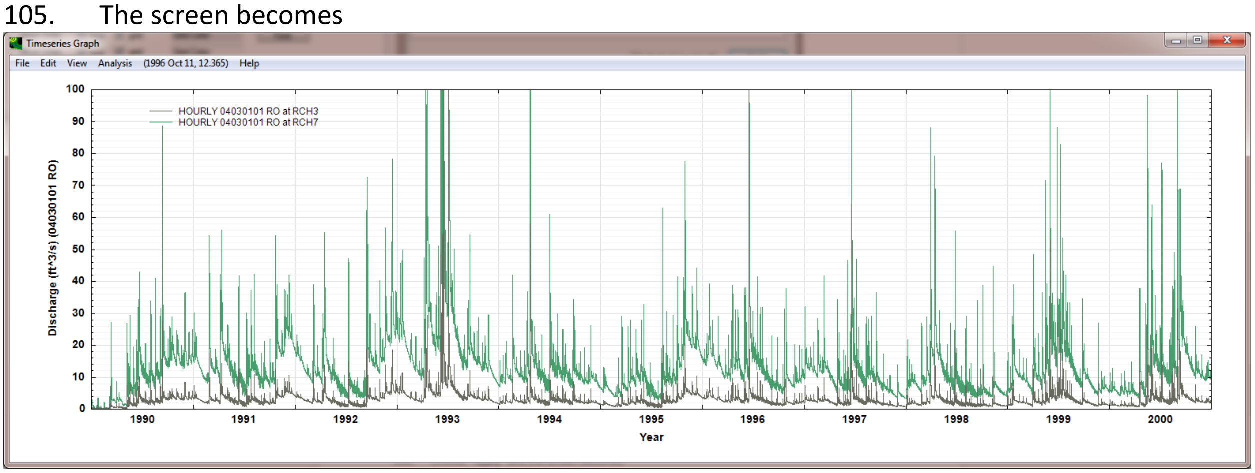
- Choose “Bottom X”, change the Title to “Year”, and choose “Apply”



- Choose “Left Y” and “Linear”, change the “Zoom Range” minimum to 0 and maximum to 100, change the Title “Hourly Discharge (ft^3/s), and choose ”Apply”.

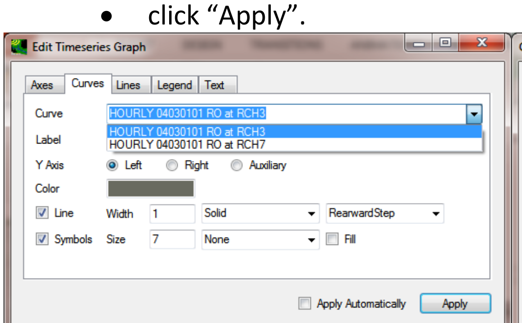


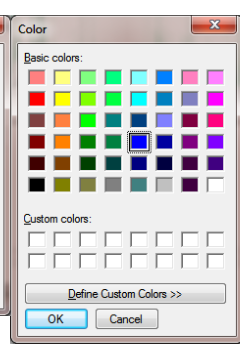
105. The screen becomes

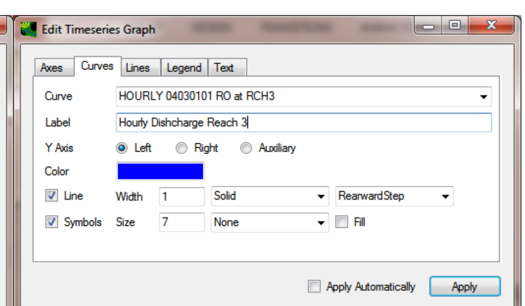


106. To change color and label for the RCH3 curve,

- select “HOURLY 04030101 RO at RCH3” under “Curve”.
- under “Color”, select Blue, then “Ok”.
- under Label, change the name to “Hourly Discharge Reach 3”.
- click “Apply”.

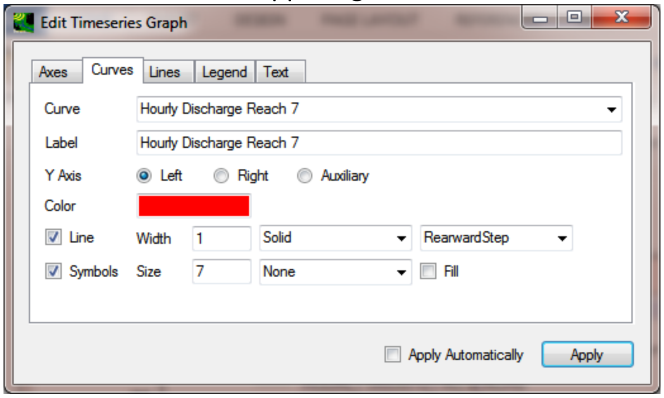




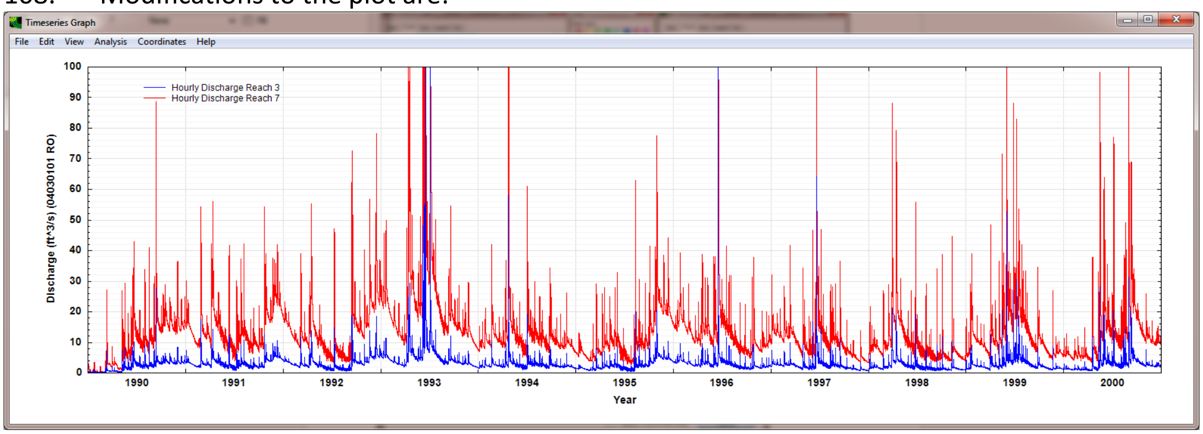


107. To change color and label for the RCH7 curve,

- select “HOURLY 04030101 RO at RCH7” under “Curve”.
- Under “Color”, select the Red, then “Ok”.
- Under Label, change the name to “Hourly Discharge Reach 7”.
- Click “Apply”.
- Click the upper right-hand corner “X”.



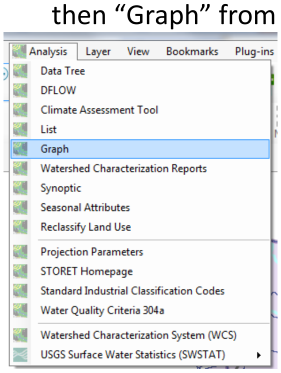
108. Modifications to the plot are:



As one can see, discharges increase from Reach 3 to Reach 7 as the flow moves downstream.

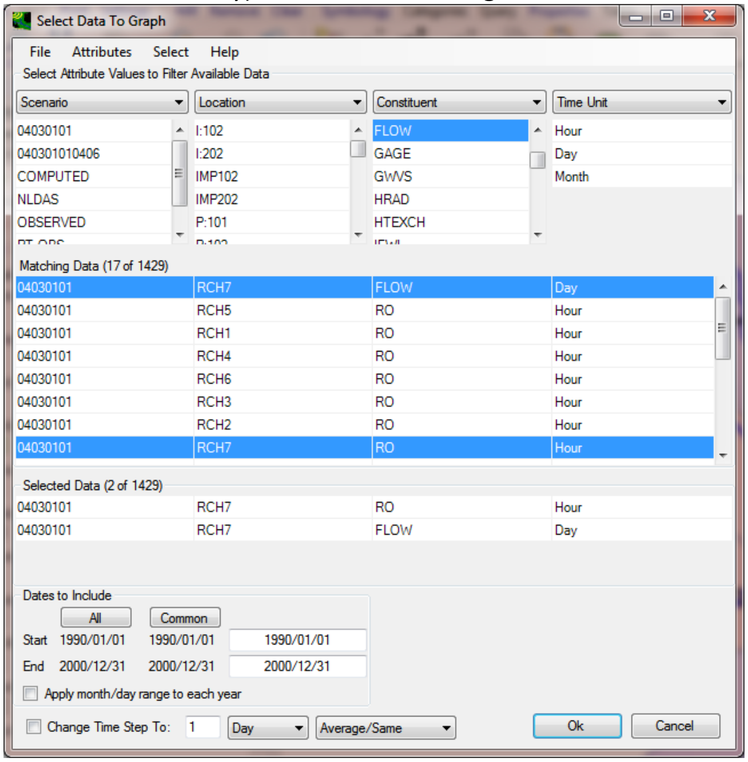
View Simulation Results for Hourly and Daily Discharges at the Same Location

109. To overlay the discharge time series for daily average flows, which represent average flow for each day (sum of hourly flows divided by 24), from the BASINS user interface, choose “Analysis”, then “Graph” from the menu.

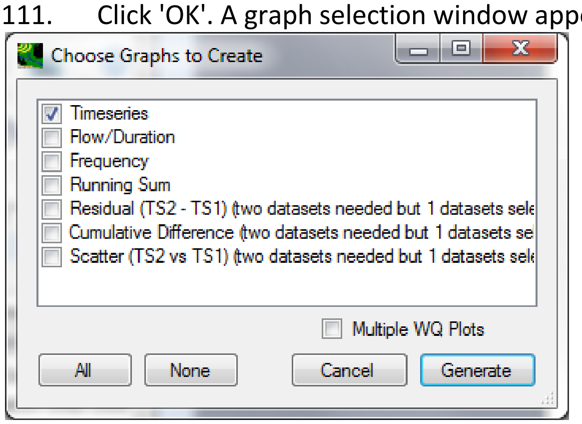


110. Using a similar procedure as before,

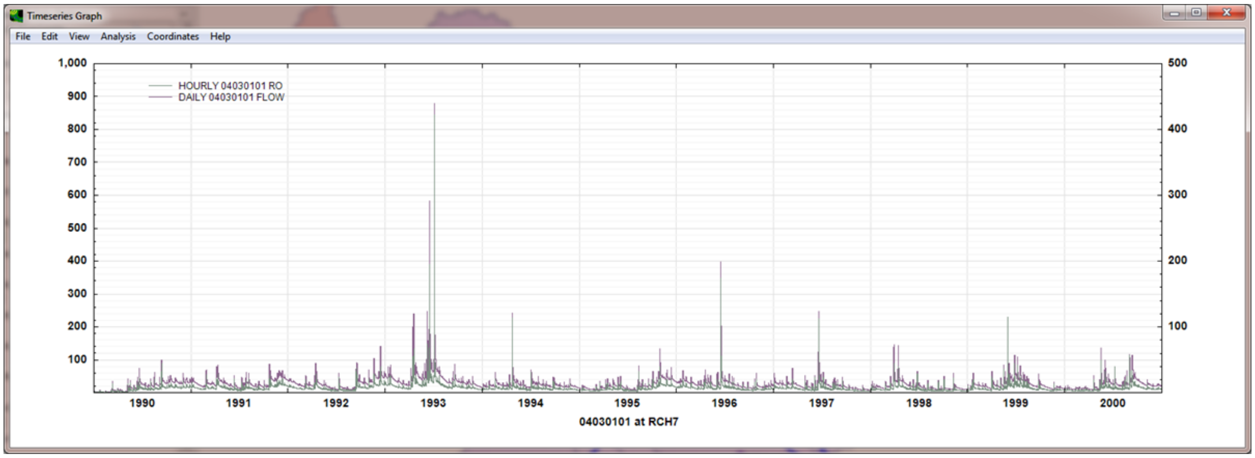
- Select “RO”, then “RCH7” (RO and Hour) under Matching Data section
- Select “FLOW”, which is the daily flow, under the Constituent section, then “RCH7” (FLOW and Day) under the Matching Data section



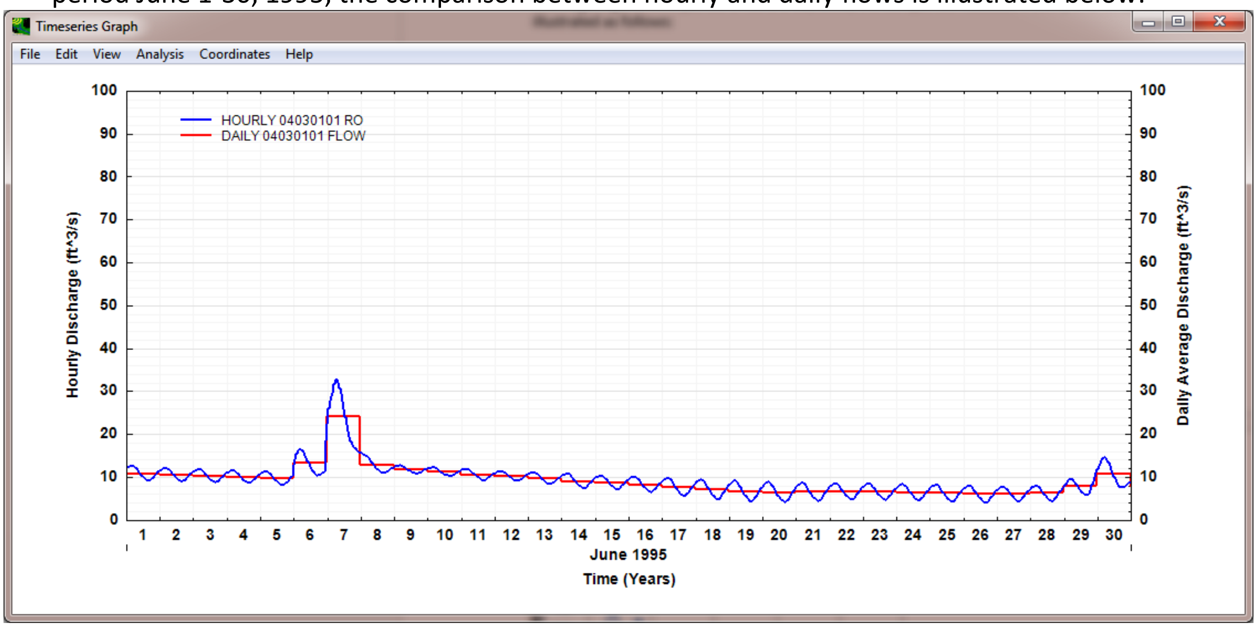
111. Click 'OK'. A graph selection window appears.



112. After “Timeseries” is selected, click “Generate” to produce the graph below. The discharge has been previously defined as cfs (ft^3/s) even though the y-axis does not display the units. This figure can be modified in the same manner as hourly graphs. **NOTE: One curve (HOURLY 04030101 RO) is plotted with the left y-axis (maximum of 1000) and the other curve (DAILY 04030101 FLOW) is plotted with the right y-axis (maximum of 500), making it appear that the daily average flows are higher than the hourly flows. To compare the curves, ensure that ranges associated with the two y-axes are the same.**



113. By making y-axes consistent, changing curve colors, cleaning up labels, and interrogating the period June 1-30, 1995, the comparison between hourly and daily flows is illustrated below:

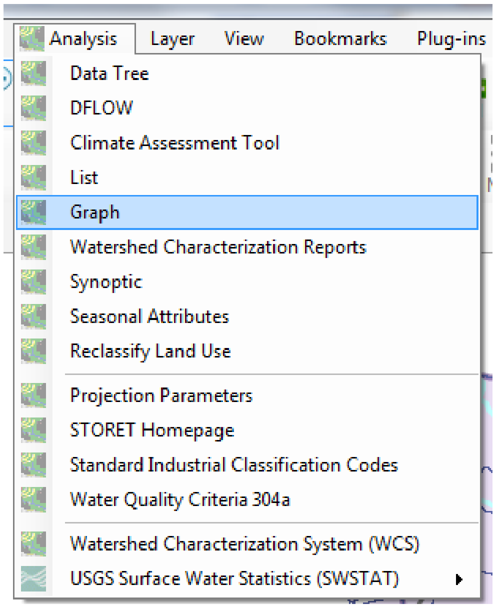


A similar example could be constructed for microbial densities, but density fluctuations would be on a log, not linear, scale. If individual storm events, which could vary hourly, impact exposure levels to sensitive receptors at recreational areas, then producing daily average values could miss critical peak exposure events, hence, the reason for using hourly simulations and capturing hourly results.

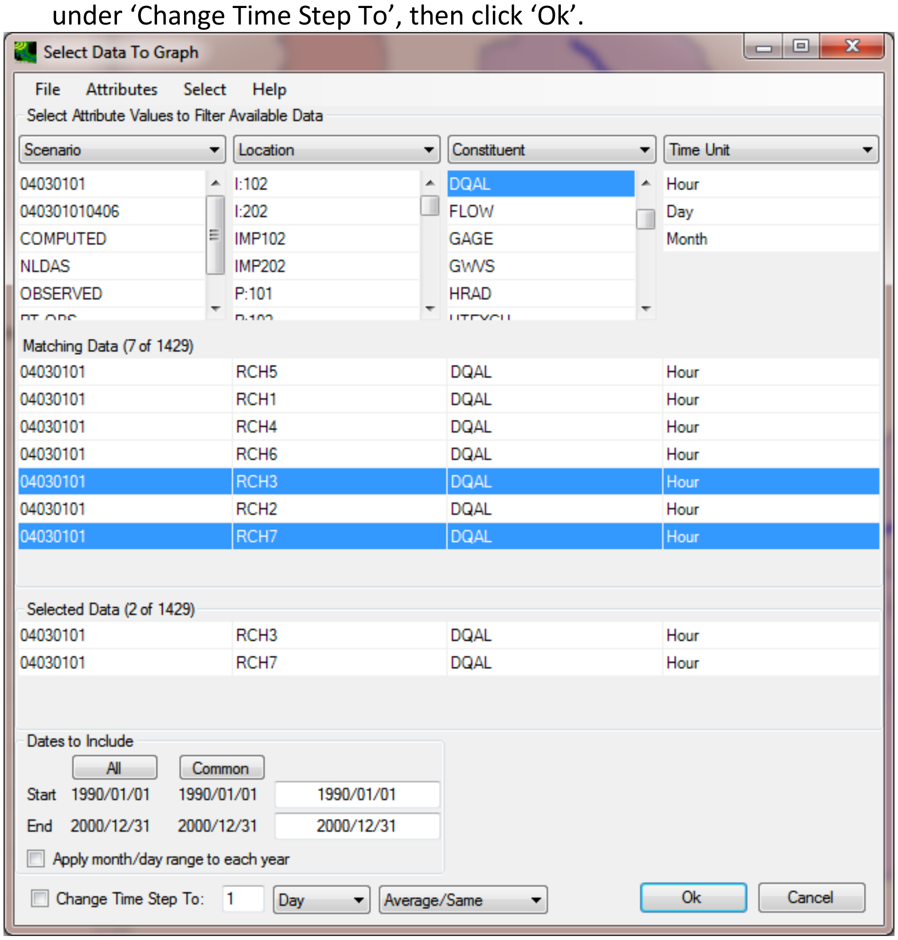
View Microbial Simulations: Time Series of Microbial Densities at Multiple Locations

Viewing a time series for microbial densities uses the same procedure as that used for discharges.

114. From the BASINS user interface, choose “Analysis”, then “Graph” from the menu.



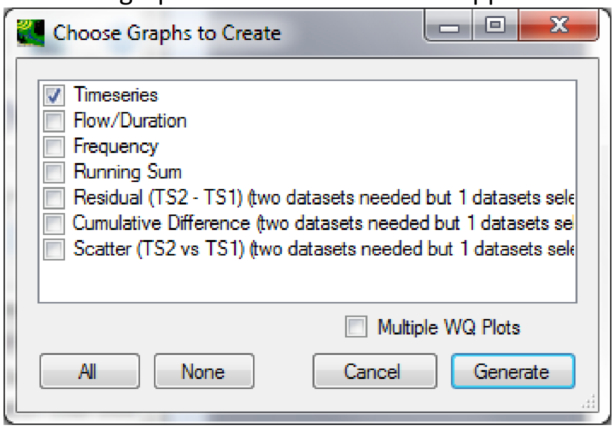
115. Under the Constituent section, choose “DQAL” to provides microbial densities in Counts/L at various reaches. Under Matching Data, choose the reaches corresponding to RCH3 and RCH7, and note they are in hourly outputs and will appear under Selected Data. Ensure that “Hour” is chosen under ‘Change Time Step To’, then click ‘Ok’.



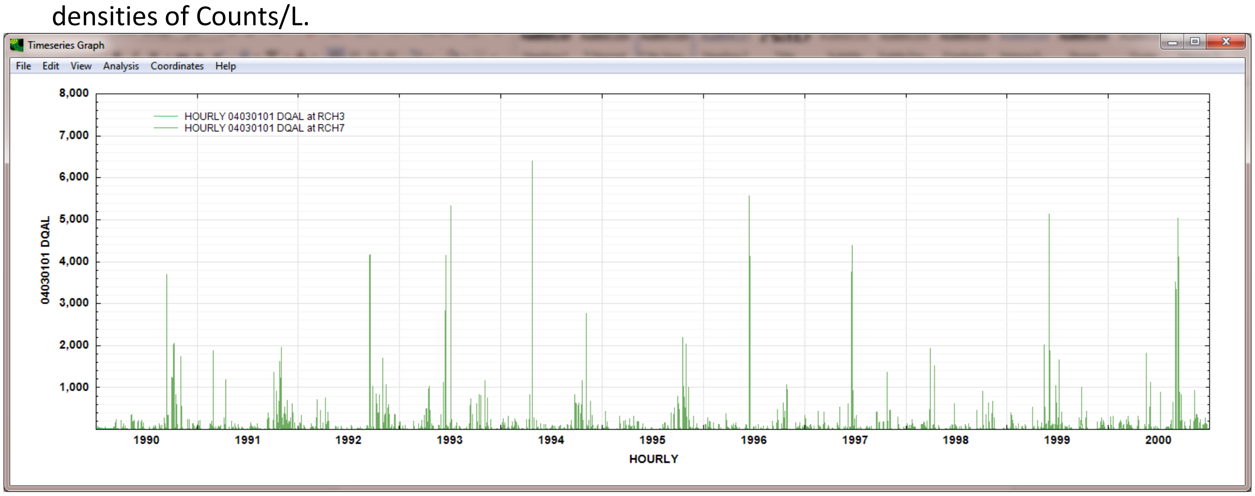
The definitions of the microbial parameters are:

Parameter	Units	HSPF-12.2 Manual (http://water.epa.gov/scitech/datait/models/basins/bsnsdocs.cfm)
Microbe-DDQAL-BIODEG	counts/time interval	amount of parent material decayed by process BIODEG
Microbe-DDQAL-GEN	counts/time interval	amount of parent material decayed by process GEN
Microbe-DDQAL-HYDROL	counts/time interval	amount of parent material decayed by process HYDROL
Microbe-DDQAL-OXID	counts/time interval	amount of parent material decayed by process OXID
Microbe-DDQAL-PHOTOL	counts/time interval	amount of parent material decayed by process PHOTOL
Microbe-DDQAL-TOT	counts/time interval	amount of parent material decayed by process TOT
Microbe-DDQAL-VOLAT	counts/time interval	amount of parent material decayed by process K VOLAT
Microbe-DQAL	counts/L	concentration of "dissolved" microbe (i.e., microbe in water)
Microbe-IDQAL	counts/time interval	input of microbe in water column from upstream reach
Microbe-RDQAL	counts	total storage of microbe in water column
Microbe-RODQAL	counts	microbial outflow quantity
Microbe-RRQAL	counts	microbial storage in reach
Microbe-TIQAL	counts	total inflow of microbes
Microbe-TROQAL	counts	total outflow of microbes
Time interval' is hourly in this case.		

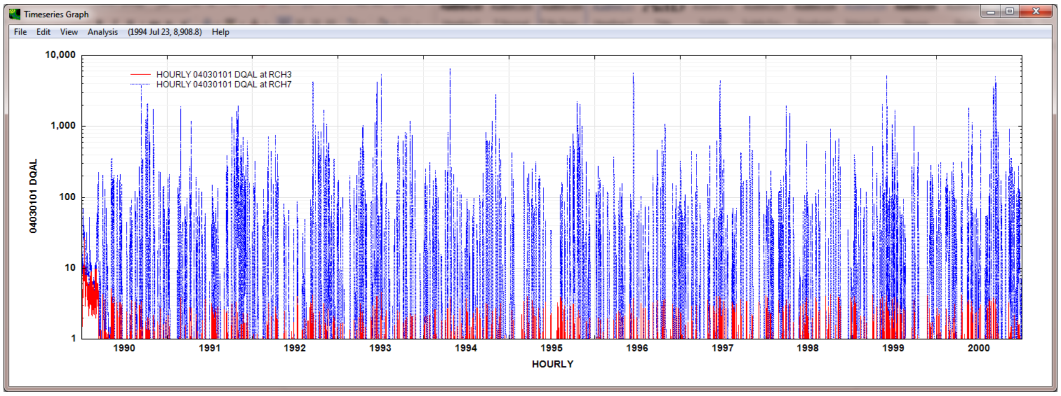
116. A graph selection window will appear. Choose "Timeseries".



117. With "Timeseries" selected, click "Generate". The following graph is produced with microbial densities of Counts/L.

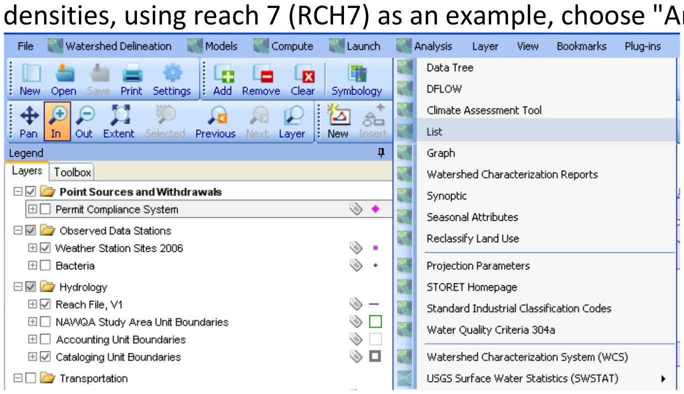


118. By changing curve colors, cleaning up labels, changing the range on the y-axis, and converting it to log scale, microbial densities at reaches 3 and 7 can be compared. NOTE: These are uncalibrated simulations.

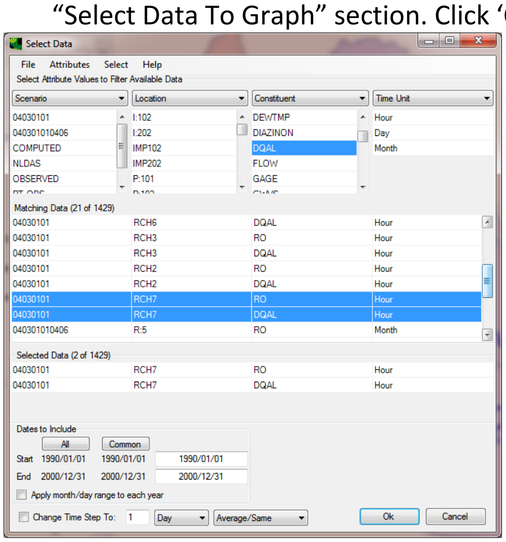


View Tabular Results Associated with Hourly Discharge and Microbial Density Simulations

119. To view tabular results of the time series for hourly discharges and corresponding microbial densities, using reach 7 (RCH7) as an example, choose "Analysis", then "List" from the BASINS menu.



120. Under the Constituent section, scroll down to “RO”, and select RCH7 with the “Hour” Time Unit. The results will appear under the “Select Data To Graph” section. Under the Constituent section, scroll down to “DQAL”, and select RCH7 with the “Hour” Time Unit. Results will appear under the “Select Data To Graph” section. Click ‘Ok’.



121. The following appears. Note that the first column (for time) reports in hourly increments, the second column presents discharges in ft^3/s, and the third column presents corresponding microbial densities in Cells/L (or Counts/L).

Timeseries List

File Edit View Analysis Help

History 1	from 040301010406.wdm	from 040301010406.wdm
Constituent	RO	DQAL
Id	148	149
Min	0.062203	0.026511
Max	842.97	6,392.2
Mean	13.798	38.035
1990/01/01 01:00	129.85	98.918
1990/01/01 02:00	117.54	96.597
1990/01/01 03:00	104.31	93.74
1990/01/01 04:00	91.34	90.82
1990/01/01 05:00	79.274	87.995
1990/01/01 06:00	68.398	85.303
1990/01/01 07:00	58.788	82.748
1990/01/01 08:00	50.404	80.302
1990/01/01 09:00	43.151	77.944
1990/01/01 10:00	36.919	75.658
1990/01/01 11:00	31.599	73.422
1990/01/01 12:00	27.074	71.226
1990/01/01 13:00	23.234	69.083
1990/01/01 14:00	19.982	67.029
1990/01/01 15:00	17.234	65.049
1990/01/01 16:00	14.92	63.129
1990/01/01 17:00	12.976	61.287
1990/01/01 18:00	11.342	59.498
1990/01/01 19:00	9.9674	57.769
1990/01/01 20:00	8.8091	56.104
1990/01/01 21:00	7.8335	54.501
1990/01/01 22:00	7.0116	52.968
1990/01/01 23:00	6.3176	51.482
1990/01/01 24:00	5.7301	50.043
1990/01/02 01:00	5.2313	48.642
1990/01/02 02:00	4.8065	47.291
1990/01/02 03:00	4.4431	45.982
1990/01/02 04:00	4.1311	44.72
1990/01/02 05:00	3.9458	43.513
1990/01/02 06:00	3.8904	42.368
1990/01/02 07:00	3.835	41.248
1990/01/02 08:00	3.7781	40.161
1990/01/02 09:00	3.7195	39.098
1990/01/02 10:00	3.6597	38.032
1990/01/02 11:00	3.5999	36.956
1990/01/02 12:00	3.5401	35.91
1990/01/02 13:00	3.4804	34.912

DISCLAIMER

The findings and conclusions in this presentation have not been formally disseminated by the EPA and should not be construed as representing any Agency determination or policy.

REFERENCES

Kim, K., G. Whelan, M. Molina, S.T. Purucker, Y. Pachepsky, A. Guber, M. Cyterski, D. Franklin. 2015. Rainfall-induced release of microbes from manure: model development, parameter estimation, and uncertainty evaluation on small plots. J Water Health (Submitted).

Kim, K., K. Price, G. Whelan, M. Galvin, K. Wolfe, P. Duda, M. Gray, Y. Pachepsky. 2014. Using Remote Sensing and Radar Meteorological Data to Support Watershed Assessments Comprising IEM. In: Ames, D.P., Quinn, N.W.T., Rizzoli, A.E. (Eds.), Proceedings of the 7th International Congress on Environmental Modelling and Software, June 15-19, San Diego, California, USA. ISBN: 978-88-9035-744-2.

Martinez, G., Pachepsky, Y.A., Sheldon, D.R., Whelan, G., Zepp, R., Molina, M., Panhorst, K. 2013 Using the Q10 model to simulate E. coli survival in cowpats on grazing lands. Environ. Int. 54, 1-10.

WDNR (Wisconsin Department of Natural Resources). 2015. Deer abundance and densities in Wisconsin deer management units. <http://dnr.wi.gov/topic/hunt/maps.html> (Last accessed 23.09.15).

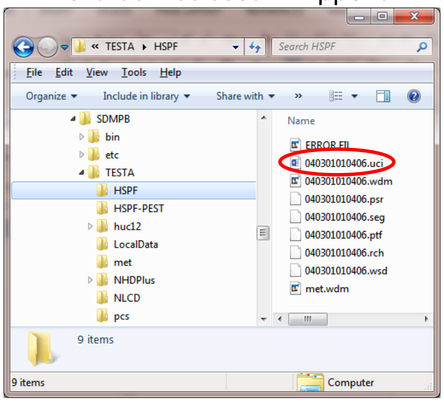
Whelan, G., K. Kim, K. Wolfe, R. Parmar, M. Galvin. 2015a. Quantitative Microbial Risk Assessment Tutorial: Installation of Software for Watershed Modeling in Support of QMRA. EPA/600/B-15/276. U.S. Environmental Protection Agency, National Exposure Research Laboratory, Athens, GA.

Whelan, G., K. Kim, K. Wolfe, R. Parmar, M. Galvin, M. Molina, R. Zepp. 2015b. Navigate the SDMPB and Identify an 8-Digit HUC of Interest. EPA/600/B-15/273. U.S. Environmental Protection Agency, Athens, GA.

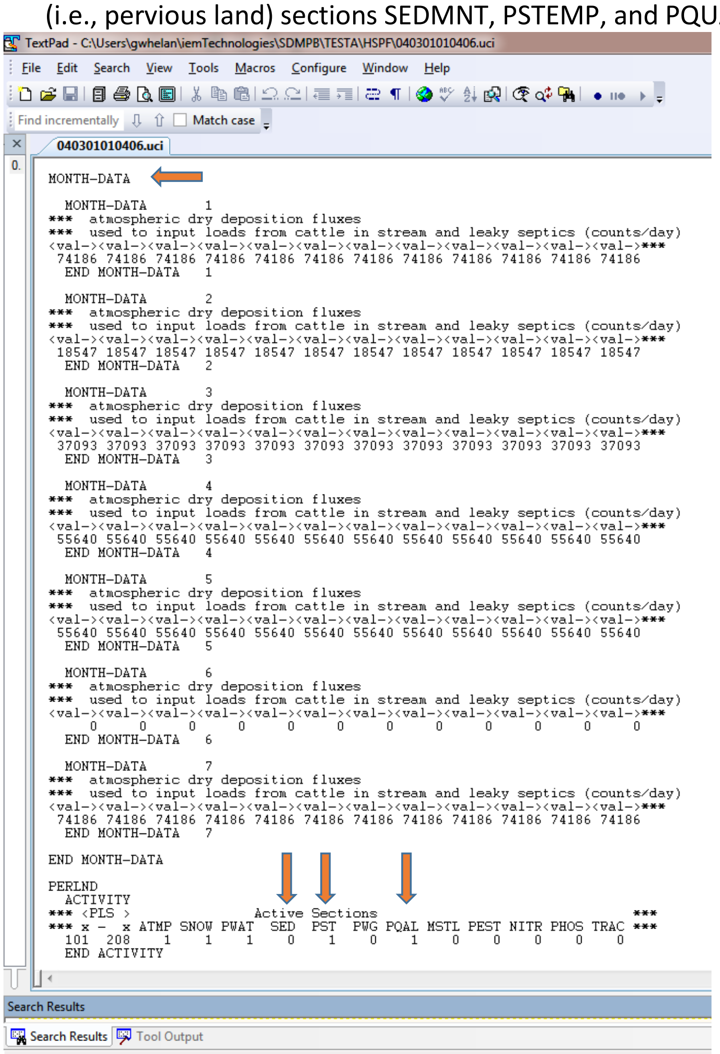
Whelan, G., R. Parmar, K. Wolfe, M. Galvin, P. Duda, M. Gray. 2015c. Quantitative Microbial Risk Assessment Tutorial – SDMProjectBuilder: Import Local Data Files to Identify and Modify Contamination Sources and Input Parameters. EPA/600/B-15/316. U.S. Environmental Protection Agency, Athens, GA.

APPENDIX A
SDMPB-generated HSPF UCI File

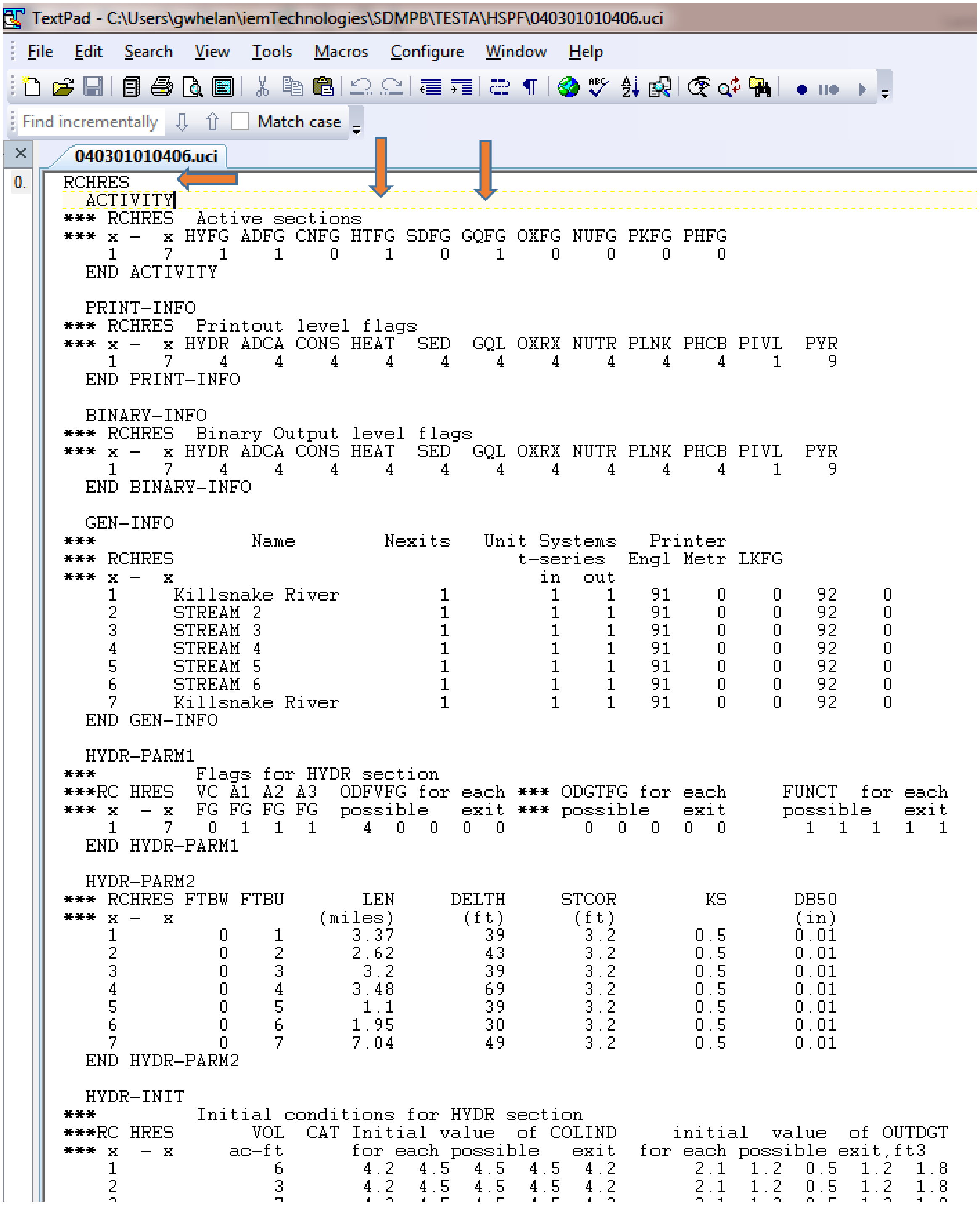
1. Go the HSPF folder and open the UCI file with a text editor such as Notepad, WordPad, or TextPad. TextPad was used in Appendix A.



2. Looking at the UCI, we see the “MONTH-DATA” blocks for Microbes, and that the HSPF “PERLND” (i.e., pervious land) sections SEDMNT, PSTEMP, and PQUAL have been activated.

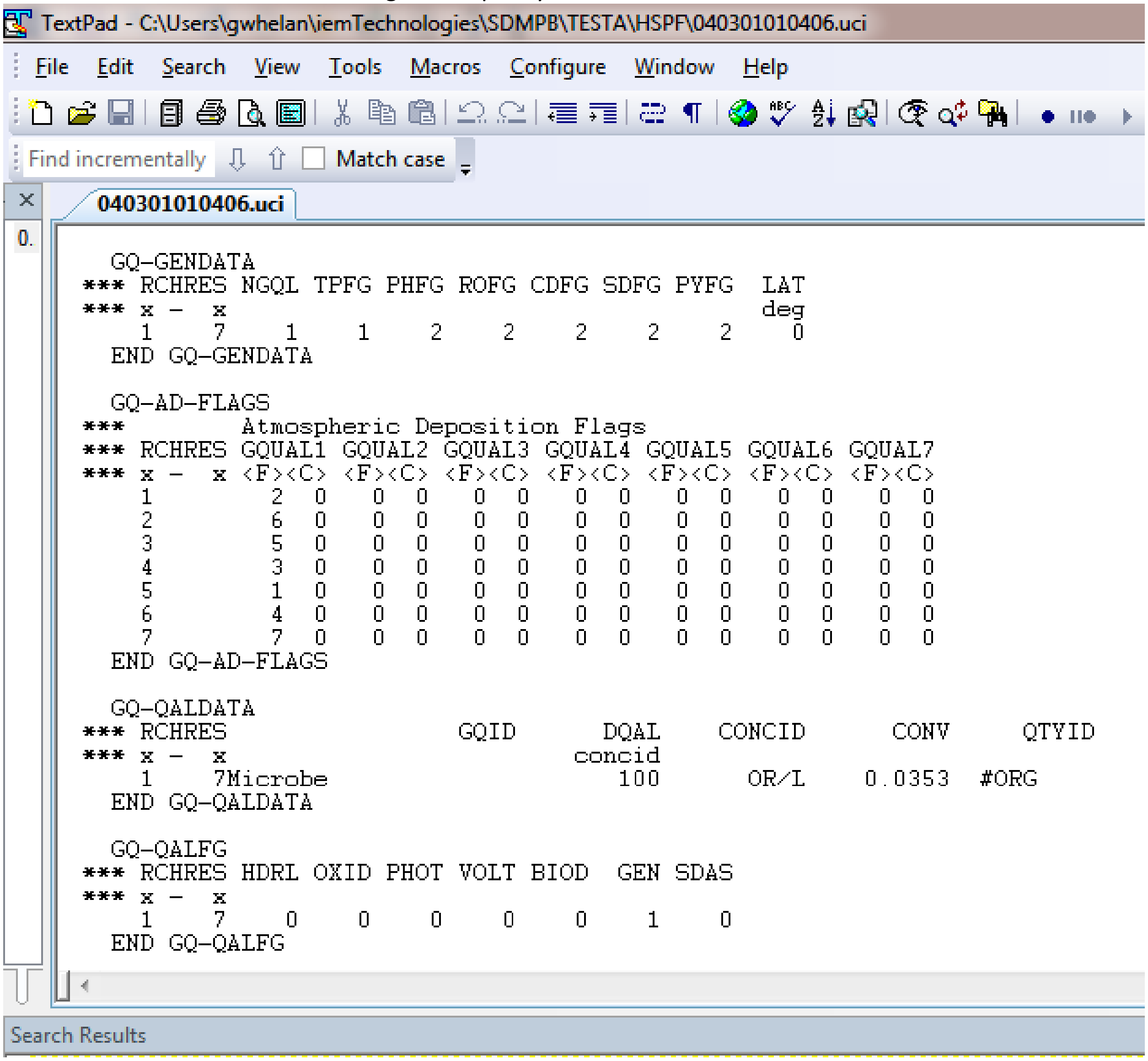


3. HSPF RCHRES sections HTRCH and GQUAL have been activated.



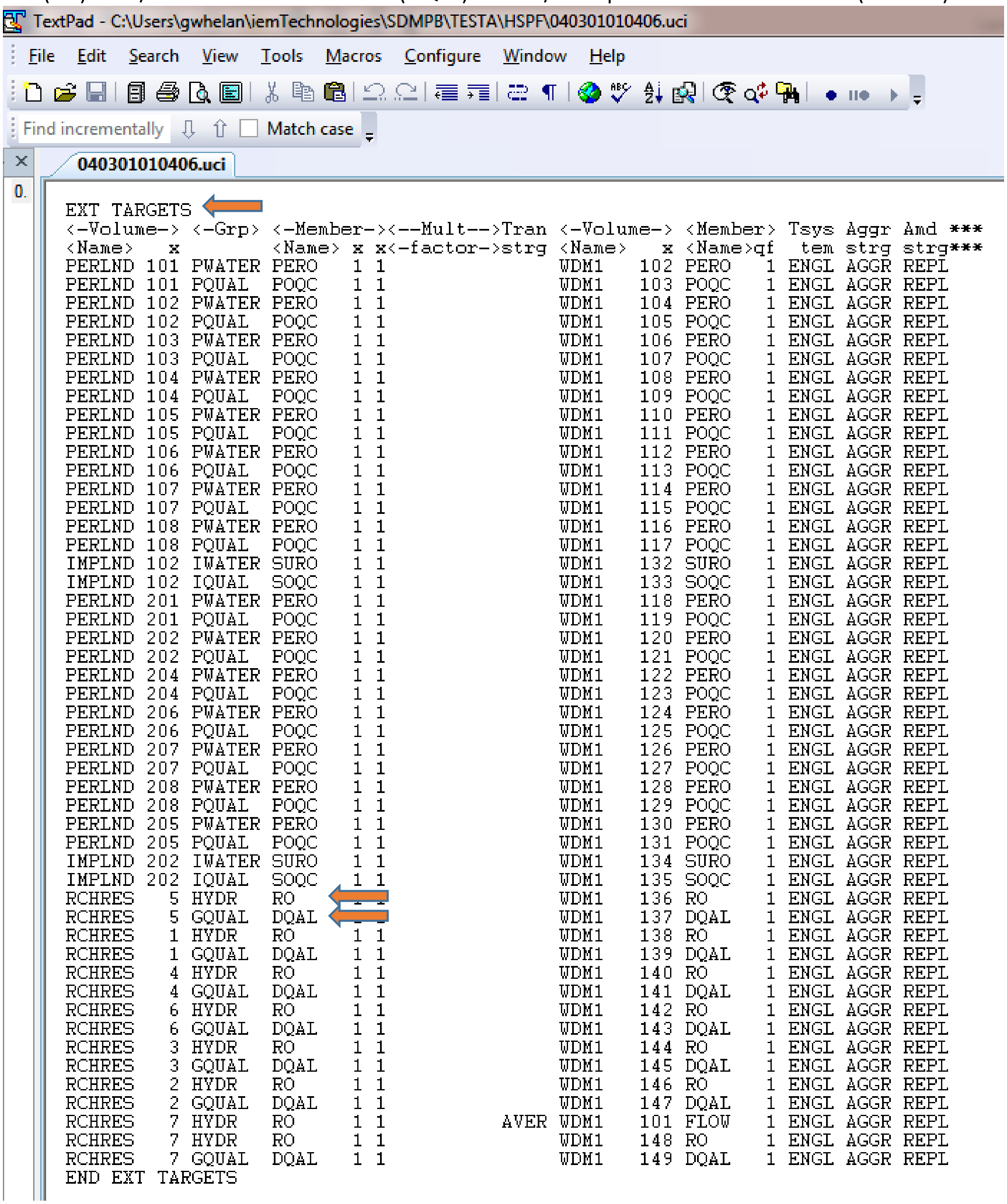
```
RCHRES
  ACTIVITY
*** RCHRES  Active sections
*** x -  x HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG
    1    7    1    1    0    1    0    1    0    0    0    0
  END ACTIVITY

  PRINT-INFO
*** RCHRES  Printout level flags
*** x -  x HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR
    1    7    4    4    4    4    4    4    4    4    4    4    1    9
  END PRINT-INFO

  BINARY-INFO
*** RCHRES  Binary Output level flags
*** x -  x HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR
    1    7    4    4    4    4    4    4    4    4    4    4    1    9
  END BINARY-INFO

  GEN-INFO
***              Name          Nexits   Unit Systems   Printer
*** RCHRES                                t-series  Engl Metr LKFG
*** x -  x                                  in  out
    1     Killsnake River          1         1    1   91    0    0   92    0
    2     STREAM  2                1         1    1   91    0    0   92    0
    3     STREAM  3                1         1    1   91    0    0   92    0
    4     STREAM  4                1         1    1   91    0    0   92    0
    5     STREAM  5                1         1    1   91    0    0   92    0
    6     STREAM  6                1         1    1   91    0    0   92    0
    7     Killsnake River          1         1    1   91    0    0   92    0
  END GEN-INFO

  HYDR-PARM1
***             Flags for HYDR section
***RC HRES   VC A1  A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
*** x   - x  FG FG FG FG  possible    exit *** possible    exit     possible    exit
    1    7    0  1  1  1     4  0  0  0  0        0  0  0  0  0        1  1  1  1  1
  END HYDR-PARM1

  HYDR-PARM2
*** RCHRES FTBW FTBU        LEN     DELTH      STCOR        KS      DB50
*** x -  x                (miles)    (ft)       (ft)                (in)
    1         0    1       3.37        39        3.2       0.5      0.01
    2         0    2       2.62        43        3.2       0.5      0.01
    3         0    3        3.2        39        3.2       0.5      0.01
    4         0    4       3.48        69        3.2       0.5      0.01
    5         0    5        1.1        39        3.2       0.5      0.01
    6         0    6       1.95        30        3.2       0.5      0.01
    7         0    7       7.04        49        3.2       0.5      0.01
  END HYDR-PARM2

  HYDR-INIT
***             Initial conditions for HYDR section
***RC HRES       VOL  CAT Initial value  of COLIND     initial  value  of OUTDGT
*** x   - x    ac-ft      for each possible   exit  for each possible exit,ft3
    1              6       4.2  4.5  4.5  4.5  4.2       2.1  1.2  0.5  1.2  1.8
    2              3       4.2  4.5  4.5  4.5  4.2       2.1  1.2  0.5  1.2  1.8
```

4. The microbes are simulated as general quality constituents in the GQUAL section.




```
  GQ-GENDATA
*** RCHRES NGQL TPFG PHFG ROFG CDFG SDFG PYFG  LAT
*** x -  x                                     deg
    1    7    1    1    2    2    2    2    2    0
  END GQ-GENDATA

  GQ-AD-FLAGS
***         Atmospheric Deposition Flags
*** RCHRES GQUAL1 GQUAL2 GQUAL3 GQUAL4 GQUAL5 GQUAL6 GQUAL7
*** x -  x <F><C> <F><C> <F><C> <F><C> <F><C> <F><C> <F><C>
    1          2  0    0  0    0  0    0  0    0  0    0  0    0  0
    2          6  0    0  0    0  0    0  0    0  0    0  0    0  0
    3          5  0    0  0    0  0    0  0    0  0    0  0    0  0
    4          3  0    0  0    0  0    0  0    0  0    0  0    0  0
    5          1  0    0  0    0  0    0  0    0  0    0  0    0  0
    6          4  0    0  0    0  0    0  0    0  0    0  0    0  0
    7          7  0    0  0    0  0    0  0    0  0    0  0    0  0
  END GQ-AD-FLAGS

  GQ-QALDATA
*** RCHRES                GQID        DQAL    CONCID      CONV     QTYID
*** x -  x                          concid
    1    7Microbe                      100      OR/L    0.0353   #ORG
  END GQ-QALDATA

  GQ-QALFG
*** RCHRES HDRL OXID PHOT VOLT BIOD  GEN SDAS
*** x -  x
    1    7    0    0    0    0    0    1    0
  END GQ-QALFG
```

5. The EXT TARGETS block specifies which time series are output. Instream hourly time series for flow (RO) in ft^3/s and microbial densities (DQAL) in Cells/L are published for each reach (RCHRES).



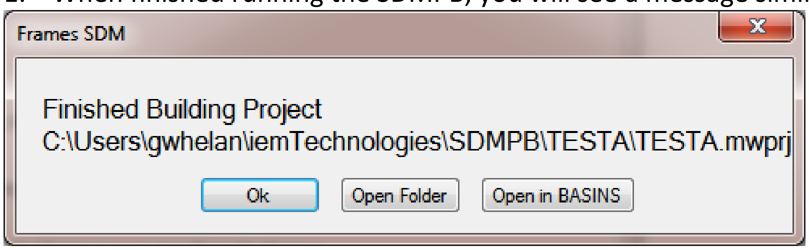

```
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Aggr Amd ***
<Name>   x        <Name> x x<-factor->strg <Name>   x <Name>qf  tem strg strg***
PERLND 101 PWATER PERO    1 1              WDM1   102 PERO    1 ENGL AGGR REPL
PERLND 101 PQUAL  POQC    1 1              WDM1   103 POQC    1 ENGL AGGR REPL
PERLND 102 PWATER PERO    1 1              WDM1   104 PERO    1 ENGL AGGR REPL
PERLND 102 PQUAL  POQC    1 1              WDM1   105 POQC    1 ENGL AGGR REPL
PERLND 103 PWATER PERO    1 1              WDM1   106 PERO    1 ENGL AGGR REPL
PERLND 103 PQUAL  POQC    1 1              WDM1   107 POQC    1 ENGL AGGR REPL
PERLND 104 PWATER PERO    1 1              WDM1   108 PERO    1 ENGL AGGR REPL
PERLND 104 PQUAL  POQC    1 1              WDM1   109 POQC    1 ENGL AGGR REPL
PERLND 105 PWATER PERO    1 1              WDM1   110 PERO    1 ENGL AGGR REPL
PERLND 105 PQUAL  POQC    1 1              WDM1   111 POQC    1 ENGL AGGR REPL
PERLND 106 PWATER PERO    1 1              WDM1   112 PERO    1 ENGL AGGR REPL
PERLND 106 PQUAL  POQC    1 1              WDM1   113 POQC    1 ENGL AGGR REPL
PERLND 107 PWATER PERO    1 1              WDM1   114 PERO    1 ENGL AGGR REPL
PERLND 107 PQUAL  POQC    1 1              WDM1   115 POQC    1 ENGL AGGR REPL
PERLND 108 PWATER PERO    1 1              WDM1   116 PERO    1 ENGL AGGR REPL
PERLND 108 PQUAL  POQC    1 1              WDM1   117 POQC    1 ENGL AGGR REPL
IMPLND 102 IWATER SURO    1 1              WDM1   132 SURO    1 ENGL AGGR REPL
IMPLND 102 IQUAL  SOQC    1 1              WDM1   133 SOQC    1 ENGL AGGR REPL
PERLND 201 PWATER PERO    1 1              WDM1   118 PERO    1 ENGL AGGR REPL
PERLND 201 PQUAL  POQC    1 1              WDM1   119 POQC    1 ENGL AGGR REPL
PERLND 202 PWATER PERO    1 1              WDM1   120 PERO    1 ENGL AGGR REPL
PERLND 202 PQUAL  POQC    1 1              WDM1   121 POQC    1 ENGL AGGR REPL
PERLND 204 PWATER PERO    1 1              WDM1   122 PERO    1 ENGL AGGR REPL
PERLND 204 PQUAL  POQC    1 1              WDM1   123 POQC    1 ENGL AGGR REPL
PERLND 206 PWATER PERO    1 1              WDM1   124 PERO    1 ENGL AGGR REPL
PERLND 206 PQUAL  POQC    1 1              WDM1   125 POQC    1 ENGL AGGR REPL
PERLND 207 PWATER PERO    1 1              WDM1   126 PERO    1 ENGL AGGR REPL
PERLND 207 PQUAL  POQC    1 1              WDM1   127 POQC    1 ENGL AGGR REPL
PERLND 208 PWATER PERO    1 1              WDM1   128 PERO    1 ENGL AGGR REPL
PERLND 208 PQUAL  POQC    1 1              WDM1   129 POQC    1 ENGL AGGR REPL
PERLND 205 PWATER PERO    1 1              WDM1   130 PERO    1 ENGL AGGR REPL
PERLND 205 PQUAL  POQC    1 1              WDM1   131 POQC    1 ENGL AGGR REPL
IMPLND 202 IWATER SURO    1 1              WDM1   134 SURO    1 ENGL AGGR REPL
IMPLND 202 IQUAL  SOQC    1 1              WDM1   135 SOQC    1 ENGL AGGR REPL
RCHRES   5 HYDR   RO      1 1              WDM1   136 RO      1 ENGL AGGR REPL
RCHRES   5 GQUAL  DQAL    1 1              WDM1   137 DQAL    1 ENGL AGGR REPL
RCHRES   1 HYDR   RO      1 1              WDM1   138 RO      1 ENGL AGGR REPL
RCHRES   1 GQUAL  DQAL    1 1              WDM1   139 DQAL    1 ENGL AGGR REPL
RCHRES   4 HYDR   RO      1 1              WDM1   140 RO      1 ENGL AGGR REPL
RCHRES   4 GQUAL  DQAL    1 1              WDM1   141 DQAL    1 ENGL AGGR REPL
RCHRES   6 HYDR   RO      1 1              WDM1   142 RO      1 ENGL AGGR REPL
RCHRES   6 GQUAL  DQAL    1 1              WDM1   143 DQAL    1 ENGL AGGR REPL
RCHRES   3 HYDR   RO      1 1              WDM1   144 RO      1 ENGL AGGR REPL
RCHRES   3 GQUAL  DQAL    1 1              WDM1   145 DQAL    1 ENGL AGGR REPL
RCHRES   2 HYDR   RO      1 1              WDM1   146 RO      1 ENGL AGGR REPL
RCHRES   2 GQUAL  DQAL    1 1              WDM1   147 DQAL    1 ENGL AGGR REPL
RCHRES   7 HYDR   RO      1 1         AVER WDM1   101 FLOW    1 ENGL AGGR REPL
RCHRES   7 HYDR   RO      1 1              WDM1   148 RO      1 ENGL AGGR REPL
RCHRES   7 GQUAL  DQAL    1 1              WDM1   149 DQAL    1 ENGL AGGR REPL
END EXT TARGETS
```

APPENDIX B
Typical Map Layers Generated by the SDMPB

This appendix briefly reviews typical map layers captured by the SDMPB. To view them, save the simulation prior to closing the "Finish Building Project Window". Regardless of whether SDMPB results are saved, the BASINS MapWindow project (*.mwprj) and HSPF UCI (*.uci) files will be created and saved for the watershed analysis. The various map layers can be viewed in BASINS. In this alpha version, it is not recommended to save the results since saving multiple use cases may result in some dotSpatial instability in later runs. This issue will be investigated.

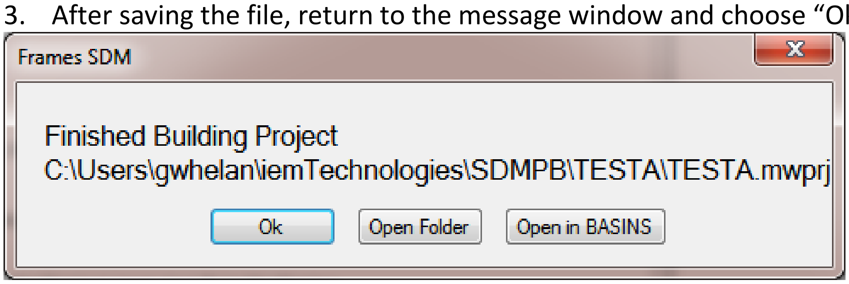
Typical map layers generated by the SDMPB are as follows:

1. When finished running the SDMPB, you will see a message similar to the one below.



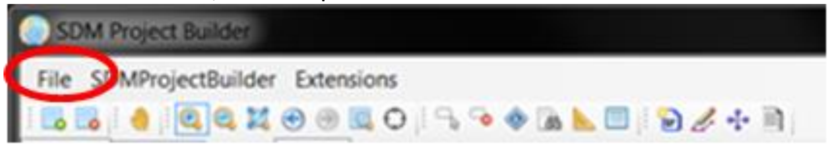
2. Prior to making a choice, go to the SDMPB menu bar, choose "File", then "Save".

3. After saving the file, return to the message window and choose "Ok".



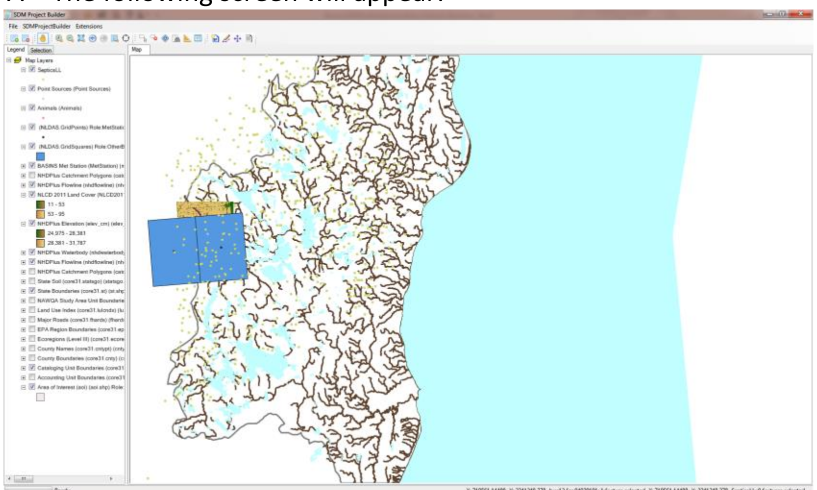
4. The SDMPB will automatically close. To inspect results of the data downloads, execute the SDMProjectBuilder (SDMPB) by clicking on the shortcut icon displayed on the computer screen.

5. Choose “File”, then “Open”.

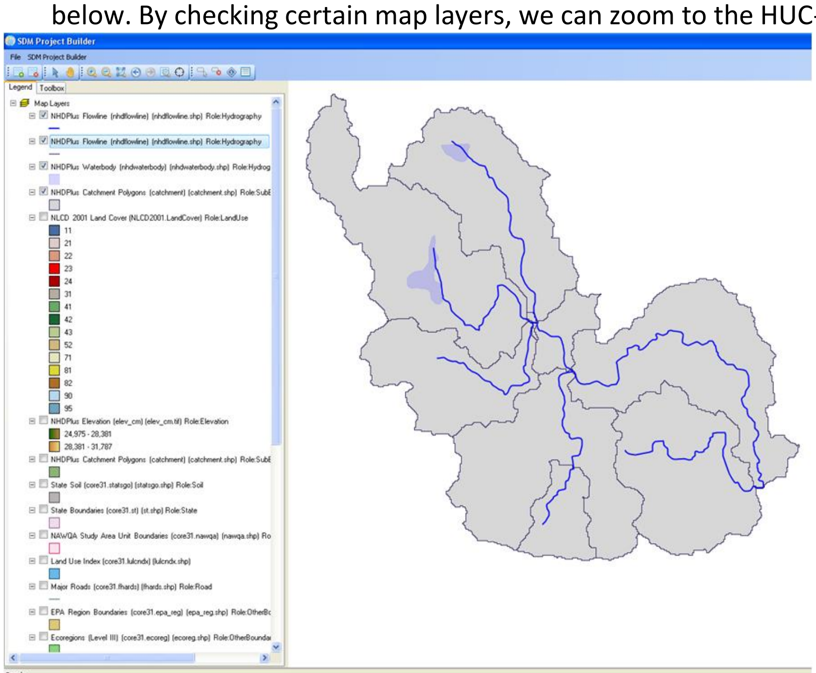


6. Select by double-clicking the *.dspx file in the working folder; here, it would be TESTA.dspx:

7. The following screen will appear:



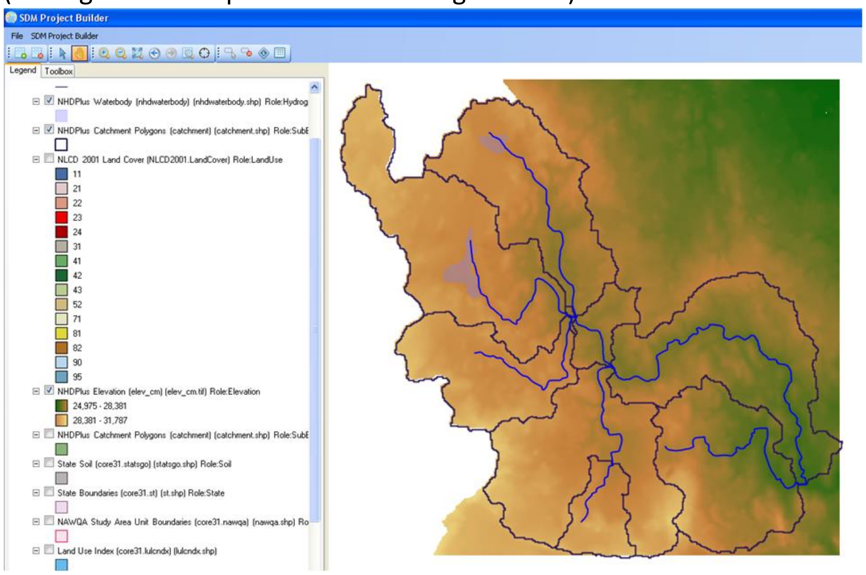
8. A summary of the Map Layers is documented in the Map Layer listing on the left side of the screen below. By checking certain map layers, we can zoom to the HUC-12 of interest.



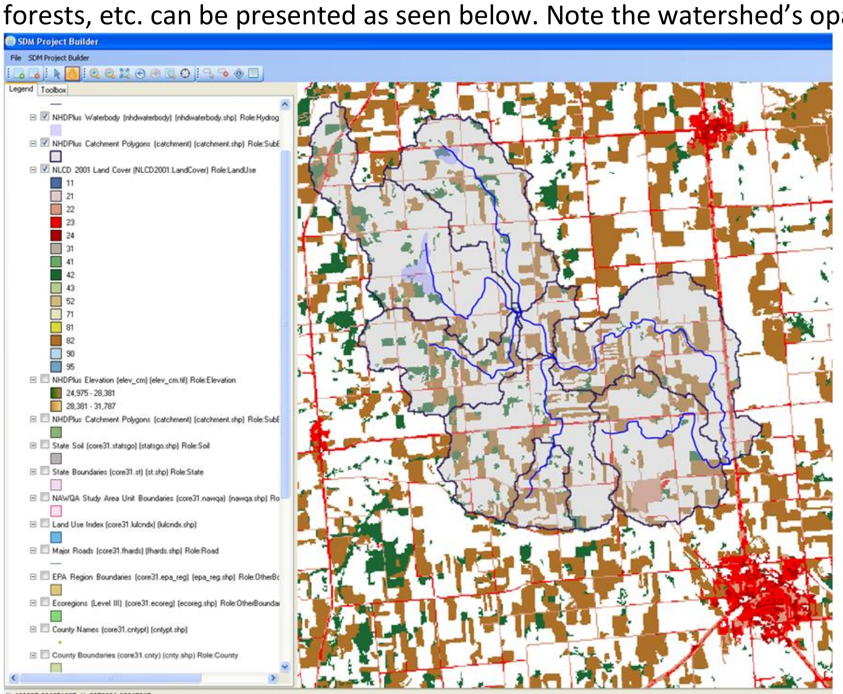
The map displays only checked Map Layers, arranged in the following order:

- NHDPlus Flowline (nhdflowline.shp) Role: Hydrograhy (two of them)
- NHDPlus Waterbody (nhdwaterbody) (nhdwaterbody.shp) Role: Hydrography
- NHDPlus Catchment Polygons (catchment) (catchment.shp) role: SubBasin)

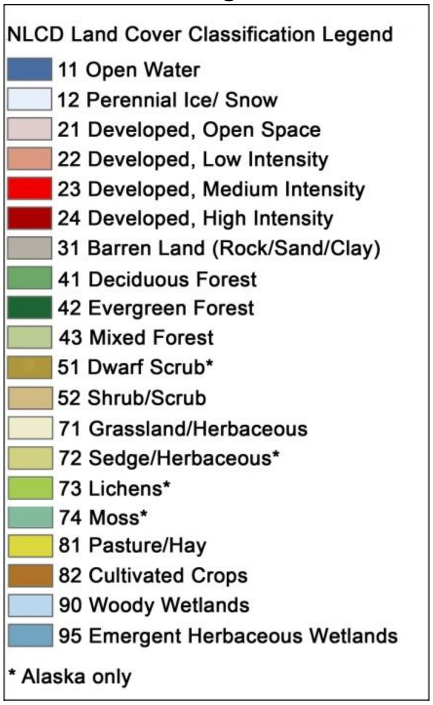
Layers can be interrogated individually by turning various Map Layers "on" and "off" and manipulating color and opaqueness. For example, the NHDPlus elevations (in cm) for the area can be viewed below (color gradation represents elevation gradation):



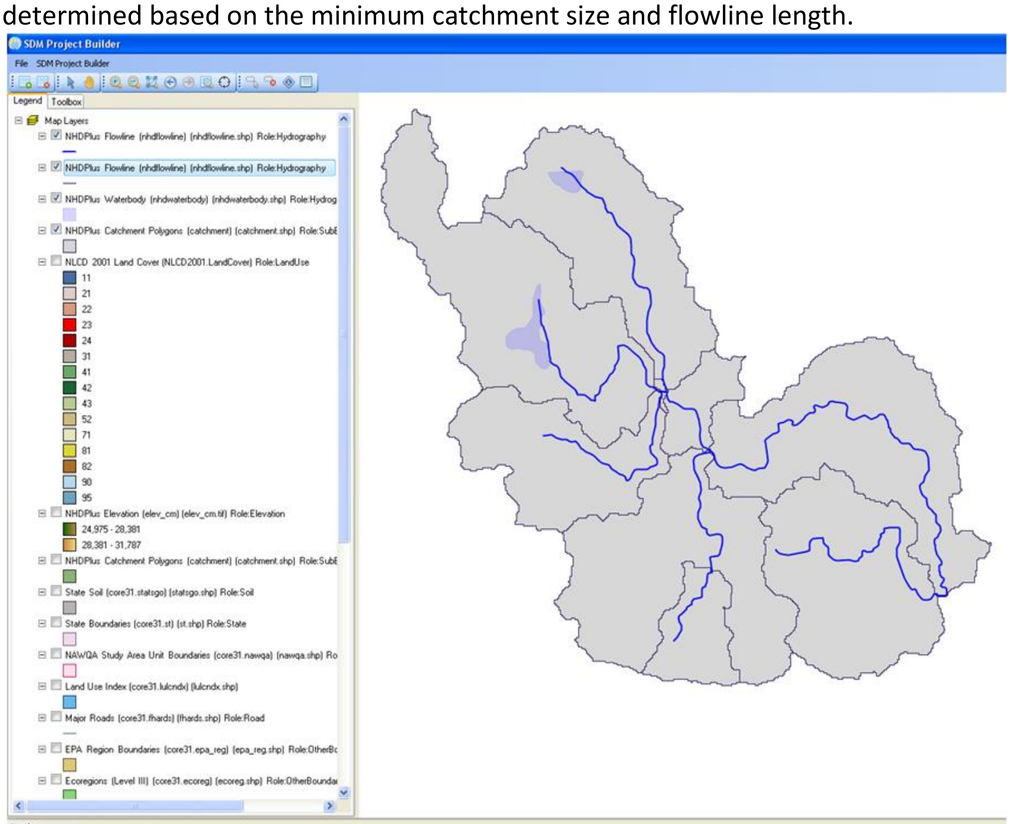
The NLCD Land cover which identifies impervious and pervious areas, and cropland, pastureland, forests, etc. can be presented as seen below. Note the watershed's opacity is less than unity:



where the meanings of the 2006 NLCD codes are:



The 12-digit HUC has been subdivided into much smaller subwatersheds which were automatically determined based on the minimum catchment size and flowline length.



APPENDIX C
NLDAS Stations Recorded in the HSPF UCI File

Looking at the UCI, we see two sets of pervious and impervious land types (PERLND and IMPLND, respectively) corresponding to the two NLDAS locations in use.

```
RUN

GLOBAL
  UCI Created by WinHSPF for 040301010406
  START       1990/01/01 00:00  END    2000/12/31 24:00
  RUN INTERP OUTPT LEVELS    1    0
  RESUME     0 RUN     1                        UNITS    1
END GLOBAL

FILES
<FILE>  <UN#>***<----FILE NAME--------------------------------
------>
MESSU       24   040301010406.ech
            91   040301010406.out
WDM1        25   040301010406.wdm
WDM2        26   met.wdm
BINO        92   040301010406.hbn
END FILES

OPN SEQUENCE
    INGRP              INDELT 01:00
      PERLND     101
      PERLND     102
      PERLND     103
      PERLND     104
      PERLND     105
      PERLND     106
      PERLND     107
      PERLND     108
      IMPLND     102
      PERLND     201
      PERLND     202
      PERLND     204
      PERLND     206
      PERLND     207
      PERLND     208
      PERLND     205
      IMPLND     202
      RCHRES       5
      RCHRES       1
      RCHRES       4
      RCHRES       6
      RCHRES       3
      RCHRES       2
      RCHRES       7
    END INGRP
END OPN SEQUENCE
```

The external sources (EXT SOURCES) block assigns MET data to each subwatershed (subbasin). Since we only pull precipitation data from NLDAS, the other met constituents are from a BASINS station that has the full suite of meteorological data (Green Bay).

```
|
EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member-> ***
<Name>   x <Name> x tem strg<-factor->strg <Name>   x   x        <Name> x x ***
*** Met Seg X294Y152
WDM2     21 PREC     ENGLZERO          SAME PERLND 101 108 EXTNL  PREC
WDM2      6 PEVT     ENGL              SAME PERLND 101 108 EXTNL  PETINP
WDM2      3 ATEM     ENGL              SAME PERLND 101 108 EXTNL  GATMP
WDM2     14 WIND     ENGL              SAME PERLND 101 108 EXTNL  WINMOV
WDM2     15 SOLR     ENGL              SAME PERLND 101 108 EXTNL  SOLRAD
WDM2     17 DEWP     ENGL              SAME PERLND 101 108 EXTNL  DTMPG
WDM2     18 CLOU     ENGL              SAME PERLND 101 108 EXTNL  CLOUD
*** Met Seg X293Y152
WDM2     31 PREC     ENGLZERO          SAME PERLND 201 208 EXTNL  PREC
WDM2      6 PEVT     ENGL              SAME PERLND 201 208 EXTNL  PETINP
WDM2      3 ATEM     ENGL              SAME PERLND 201 208 EXTNL  GATMP
WDM2     14 WIND     ENGL              SAME PERLND 201 208 EXTNL  WINMOV
WDM2     15 SOLR     ENGL              SAME PERLND 201 208 EXTNL  SOLRAD
WDM2     17 DEWP     ENGL              SAME PERLND 201 208 EXTNL  DTMPG
WDM2     18 CLOU     ENGL              SAME PERLND 201 208 EXTNL  CLOUD
*** Met Seg X294Y152
WDM2     21 PREC     ENGLZERO          SAME IMPLND 102     EXTNL  PREC
WDM2      6 PEVT     ENGL              SAME IMPLND 102     EXTNL  PETINP
WDM2      3 ATEM     ENGL              SAME IMPLND 102     EXTNL  GATMP
WDM2     14 WIND     ENGL              SAME IMPLND 102     EXTNL  WINMOV
WDM2     15 SOLR     ENGL              SAME IMPLND 102     EXTNL  SOLRAD
WDM2     17 DEWP     ENGL              SAME IMPLND 102     EXTNL  DTMPG
WDM2     18 CLOU     ENGL              SAME IMPLND 102     EXTNL  CLOUD
*** Met Seg X293Y152
WDM2     31 PREC     ENGLZERO          SAME IMPLND 202     EXTNL  PREC
WDM2      6 PEVT     ENGL              SAME IMPLND 202     EXTNL  PETINP
WDM2      3 ATEM     ENGL              SAME IMPLND 202     EXTNL  GATMP
WDM2     14 WIND     ENGL              SAME IMPLND 202     EXTNL  WINMOV
WDM2     15 SOLR     ENGL              SAME IMPLND 202     EXTNL  SOLRAD
WDM2     17 DEWP     ENGL              SAME IMPLND 202     EXTNL  DTMPG
WDM2     18 CLOU     ENGL              SAME IMPLND 202     EXTNL  CLOUD
```