

Quantitative Microbial Risk Assessment Tutorial
HSPF Setup, Application, and Calibration of Flows and Microbial
Fate and Transport on an Example Watershed

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Summary

A Quantitative Microbial Risk Assessment (QMRA) infrastructure that automates the manual process of characterizing transport of pathogens and microorganisms, from the source of release to a point of exposure, has been developed by loosely configuring a set of modules and process-based models. Tutorials describe functionality of a QMRA software infrastructure, guide users through software use and assessment options, and provide step-by-step instructions for implementing a mixed-use, watershed-based QMRA. The tutorials are applications to portions of watersheds which provide short descriptions and discussions that allow users to easily move through the QMRA assessment process without having to implement all of the steps. These include:

- Installation of software for watershed modeling in support of QMRA
- Navigation of software that automates data collection and identifies an 8-digit HUC of interest
- Importation of local data files to identify and modify contamination sources and input parameters
- Mathematical formulation of the Microbial Source Module (MSM) that determines microbial loading rates to a watershed
- Implementation of land-applied microbial loadings within a 12-Digit HUC
- Pour-point analysis of land-applied microbial loadings and comparison of simulated and gaging station results
- NLDAS and NCDC meteorological data
- Point source and land-applied microbial loadings within a 12-digit HUC
- Publication of a microbial density time series as a TXT File

This tutorial combines several shorter tutorials and applies them to a complete watershed basin, from source to receptor. Prior to implementation, it is recommended that users become familiar with earlier boutique tutorials since many questions may be answered more concisely by them. This tutorial demonstrates how to

- Identify locations of flow gage stations in a watershed of interest.
- Download flow and microbial observations from a USGS gaging station and text file, respectfully.
- Export flow and microbial observations.
- Prepare PEST input files for HSPF flow and microbial parameter calibrations.
- Calibrate HSPF flow and microbial parameters with PEST.
- View results of HSPF flow and microbial parameter calibration with PEST.
- Compare observed, uncalibrated, and calibrated results.

The Manitowoc watershed is a 525 mi² basin that is used to illustrate a complete source-to-receptor assessment on a full-size watershed. The results published here are for illustrative purposes only and do NOT represent a final or verified assessment of the Manitowoc watershed.

HSPF Setup, Application, and Calibration of Flows and Microbial Fate and Transport on an Example Watershed

PURPOSE

Automate data acquisition to meet input requirements for the HSPF, MSM, PEST, and BASINS models.

OBJECTIVE

Implement a quantitative microbial assessment at a gaged watershed.

Pre-populate input data files of the WinHSPF (a.k.a. HSPF), MSM, and PEST models automatically.

DEMONSTRATION

This tutorial reviews screens, icons, and basic functions of the SDMPProjectBuilder (SDMPB) and how to take output from SDMPB; develops microbial spatial and temporal microbial loadings using MSM; performs microbial fate and transport on the Manitowoc River Basin using HSPF; and analyzes and visualizes the results at multiple locations in the watershed using BASINS. Users will learn how to set up, simulate, and calibrate parameters with both hourly and daily flow simulations, although neither requires the other since each simulation is independent. It demonstrates how to

- Identify and delineate a watershed of interest.
- Initiate execution of SDMPB.
- Navigate the SDMPB.
- Use basic functions of the SDMPB tool bar.
- Identify and label a watershed of interest.
- Choose a pour point of the Manitowoc River Basin, delineate the sub-area that contributes to that Pour Point, and collect data for it.
- Capture contextual data for the Microbial Source Module (MSM) and pre-populate its input data files to account for:
 - Land-applied microbial loadings
 - Microbial loadings from septic systems
 - Microbial loadings from direct cattle shedding instream
- Capture contextual data for the watershed model HSPF and pre-populate its input data files to account for:
 - Hydrology and hydrodynamics
 - Snow accumulation/melt
 - Microbial fate and transport
 - Daily and/or Hourly simulations
- Prepare flow observation time series for HSPF parameter calibration with BASINS
- Automate PEST input file preparation for HSPF flow parameter calibration
- Perform HSPF flow parameter calibration with PEST

- Compare uncalibrated, calibrated, and observed simulations at the watershed pour point with BASINS
- Visualize and overlay time series of flow and microbial densities at the watershed pour point with BASINS

This tutorial implements an assessment on a complete river basin, based on a series of tutorials that had previously been developed to aid users in implementing QMRA-related software to assess release, migration, and fate of microbes in a mixed-use watershed setting, as described by [Whelan et al. \(2017a\)](#). For example, [Whelan et al. \(2017b\)](#) presents a shorter version of the assessment presented here, since it demonstrates a pour-point analysis of land-applied microbial loadings and a comparison of simulated and gaging station results by simulating microbial fate and transport using HSPF; it then analyzes and visualizes results at multiple locations in the watershed using BASINS.

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DISCLAIMER

REFERENCES

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APPENDIX B: Flow Calibration: Details of “HSPF_PEST_flow.exe” and “Input_flow.in”

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SECTION 1 CHOOSING A WATERSHED AND EXECUTING HSPF FOR FLOW AND MICROBIAL FATE AND TRANSPORT

SOFTWARE ACCESS, RETRIEVAL, AND DOWNLOAD

Instructions for accessing, retrieving, and downloading the following software, to install on a host computer in support of Quantitative Microbial Risk Assessment (QMRA) modeling, are provided by [Whelan et al. \(2017c\)](#):

- SDMPProjectBuilder (including the Microbial Source Module as part of the installation)
- BASINS (including WinHSPF and WinHSPFit)
- SARA Timeseries Utility
- HSPF_PEST_flow and HSPF_PEST_microbe
- FORTRAN Library
- PEST

When installed, three shortcut icons appear on the desktop:



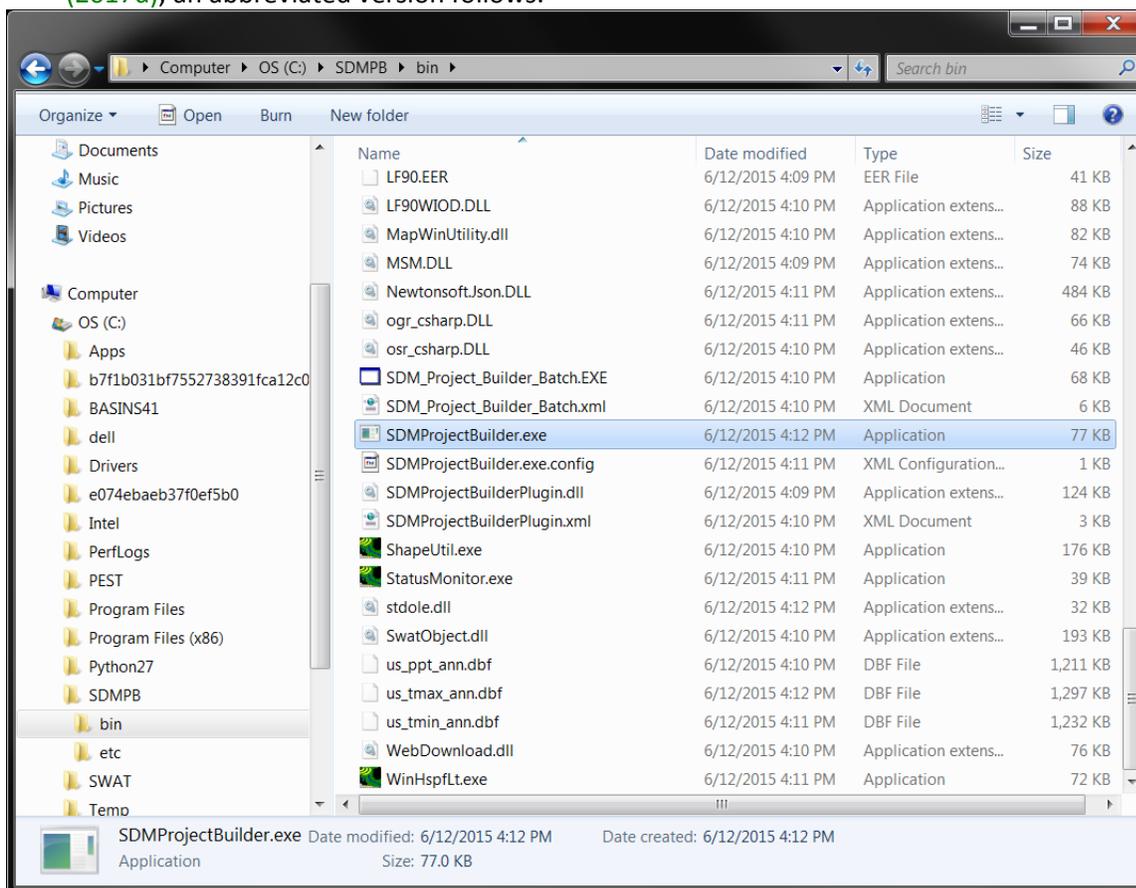
NAVIGATING THE SDMPB AND IDENTIFYING A WATERSHED OF INTEREST

Executing the SDMPProjectBuilder

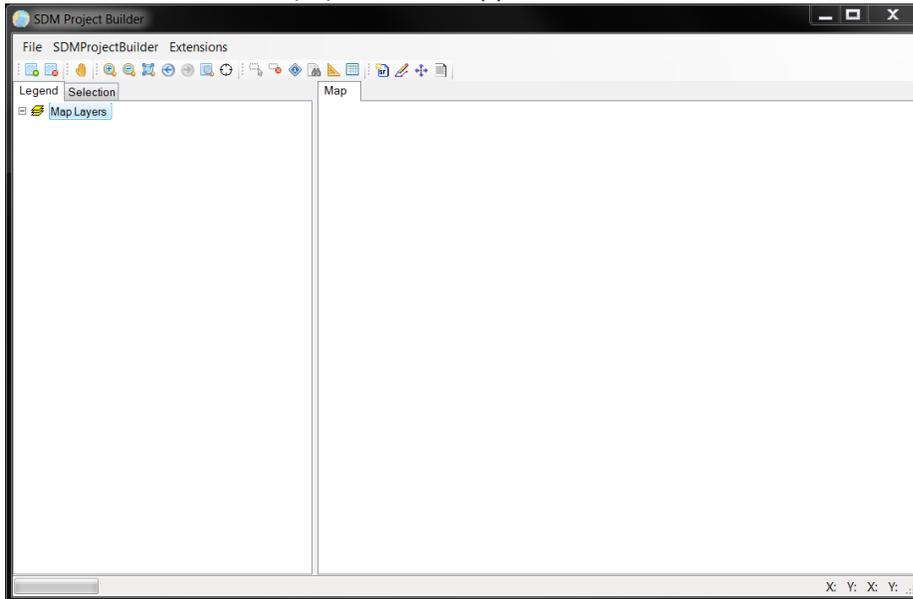
1. Execute the SDMPProjectBuilder (SDMPB) by clicking on the shortcut icon displayed on the computer screen:



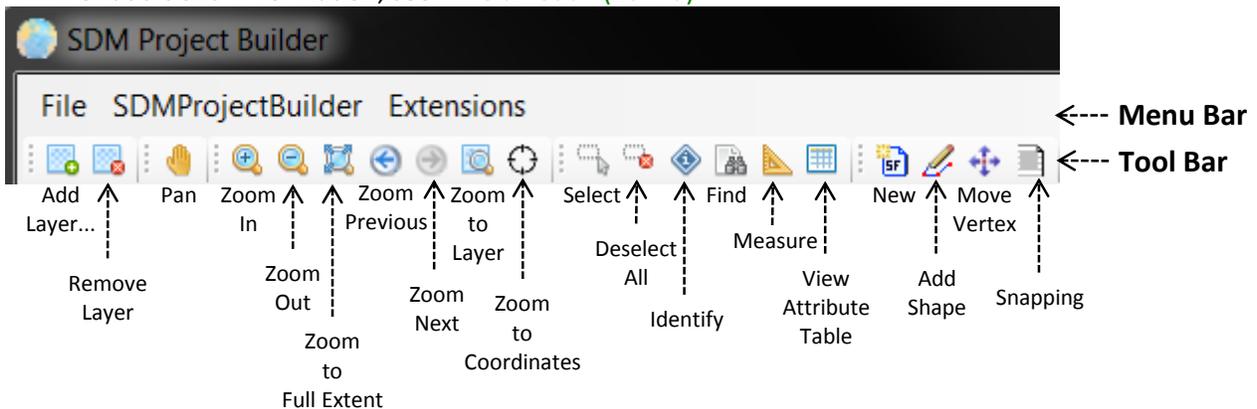
2. If the icon cannot be found on the Desktop, locate the executables on the hard drive (i.e., SDMPProjectBuilder.exe), which are typically in \SDMPB\bin\, as illustrated below. A detailed, more comprehensive tutorial describing how to identify an 8-digit HUC is provided in [Whelan et al. \(2017d\)](#); an abbreviated version follows.



3. The User Interface (UI) of SDMPB appears.

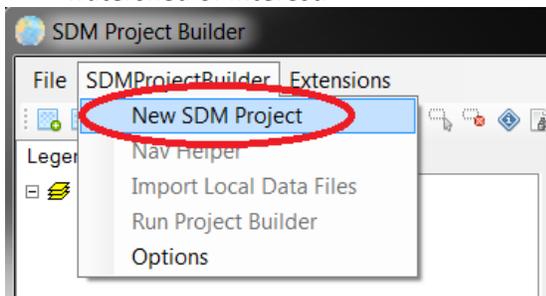


4. Before beginning the application, it is important to understand the meaning of the tool bar icons. For additional information, see [Whelan et al. \(2017d\)](#).

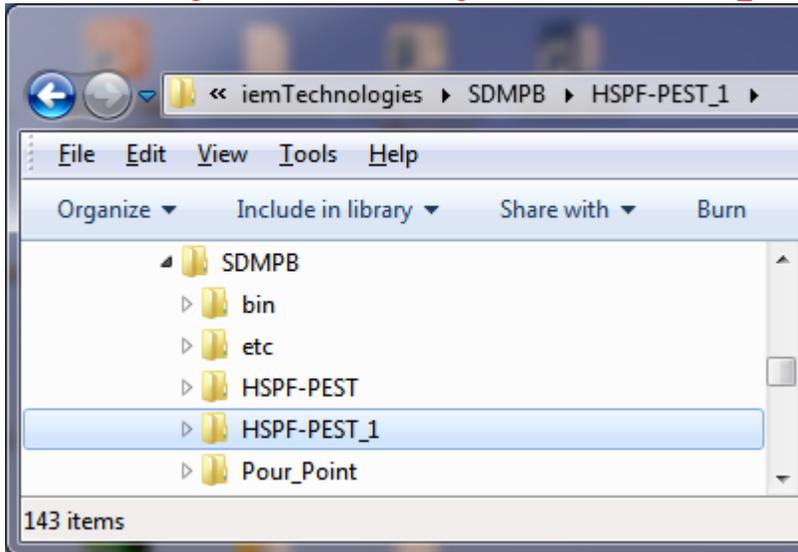


New SDM Project

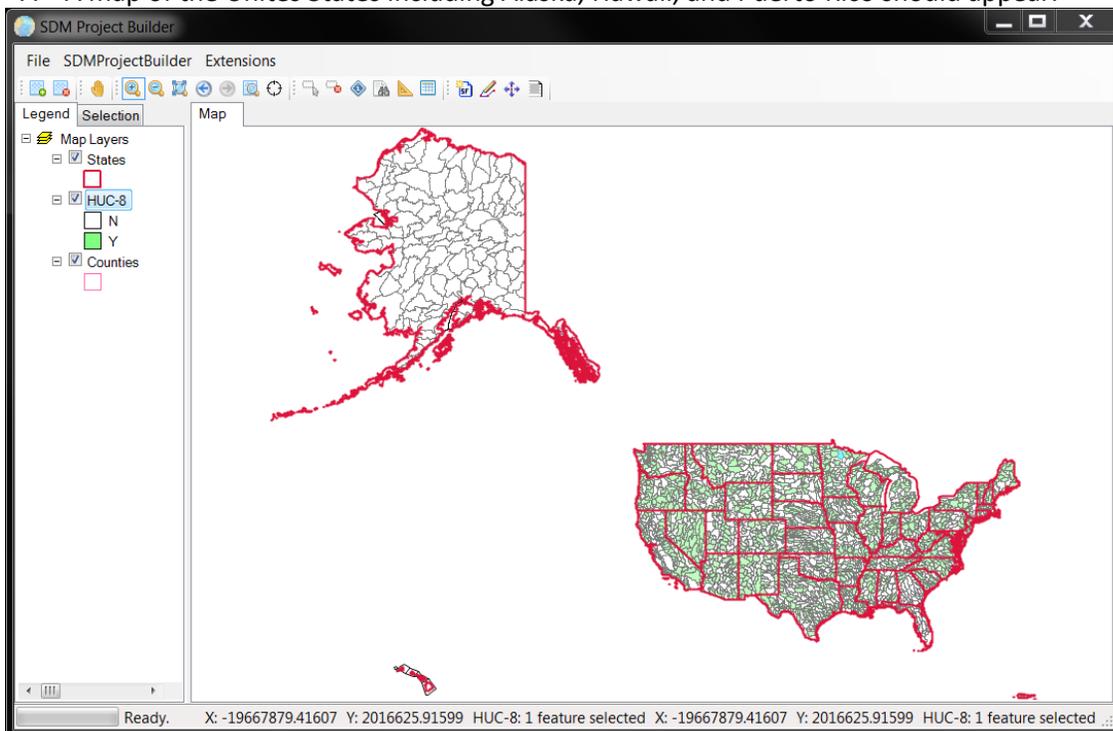
5. From the Menu Bar, select “SDMProjectBuilder>New SDM Project” to begin identifying a watershed of interest.



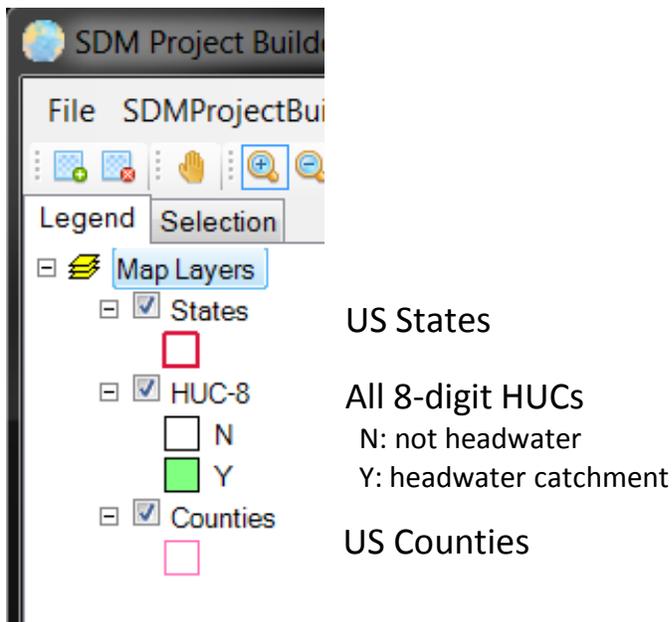
6. Create a folder where you have administrative rights. Below, a new project file was created as “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\ HSPF-PEST_1.dsp”. Click “Save”.



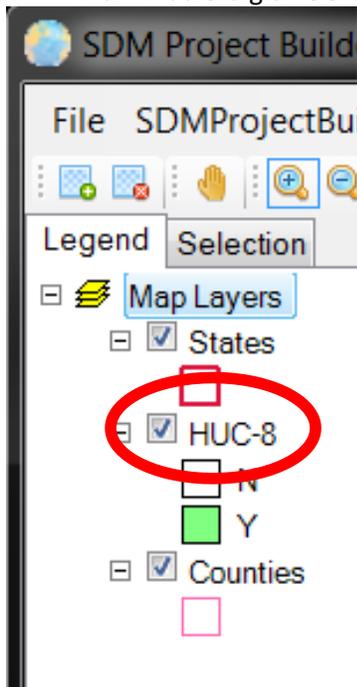
7. A map of the United States including Alaska, Hawaii, and Puerto Rico should appear.



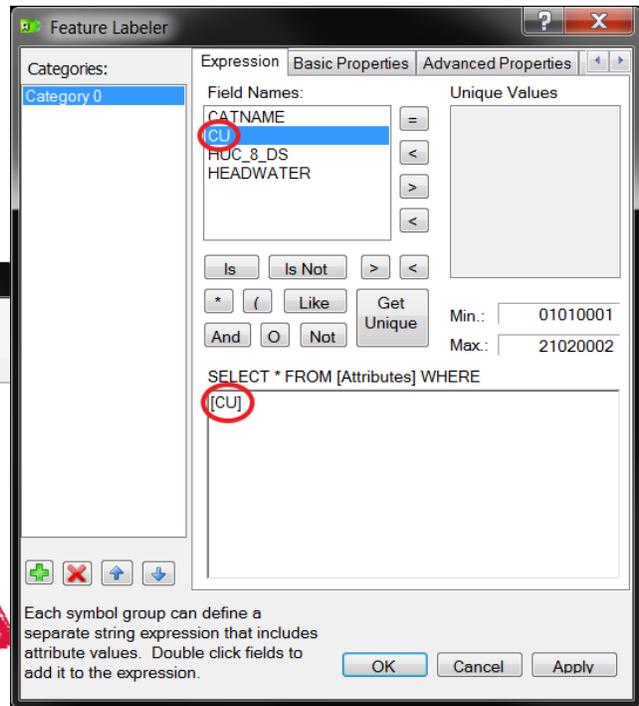
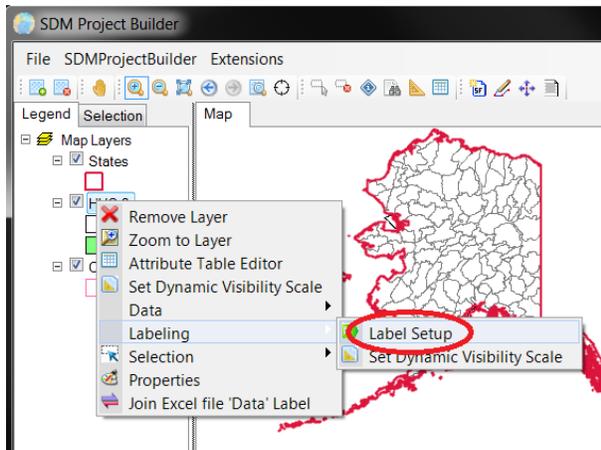
8. In the “Legend”, layers are sequentially displayed, top to bottom. They can be moved by holding the left mouse button down and moving it up or down to the desired position. Layers can be turned on or off by checking (“v”) or un-checking the box at the left of the layer’s name. The map layers’ definitions are shown below.



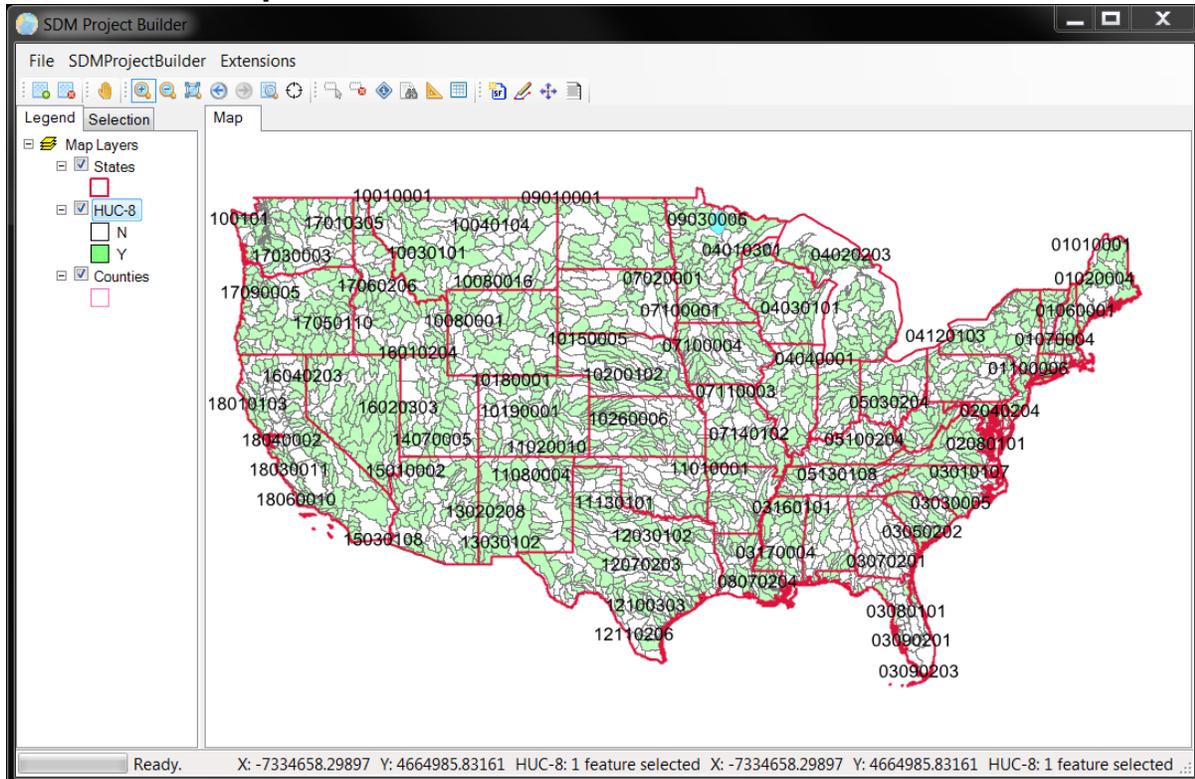
9. To find a watershed and collect the desired data, identify each 8-digit HUC and its unique ID called the Hydrologic Unit Code (HUC) Catalog Unit (CU). Assign CU numbers to the HUC-8s:
 - a. Add 8-digit HUC labels by right-clicking on the “HUC-8” Layer.



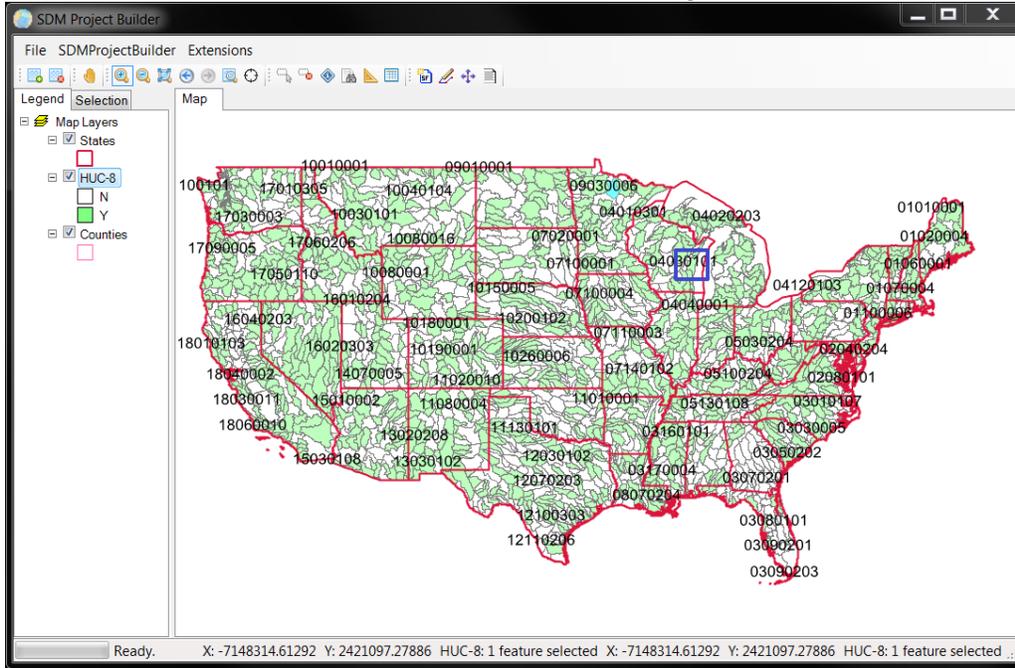
- b. Select “Labeling>Label Setup” and double-click left on “CU”; make sure “[CU]” shows in the “SELECT” box at the bottom of the screen. Click “Apply”, then “OK”.



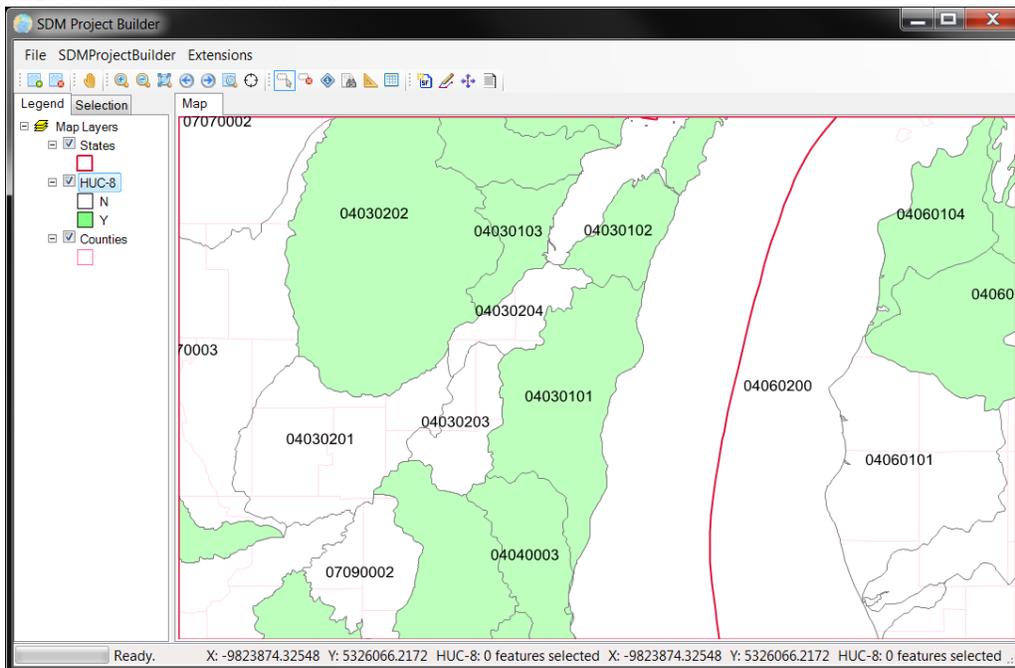
c. The following screen should appear. [Note: All HUC-8s should now have associated CU numbers.]



10. We are interested in the Manitowoc River Basin in the County of Manitowoc, WI (see blue box in figure below), but there are many ways to identify it. For example, we can zoom to the general area using the “Zoom In” button  on the tool bar. Click it, then go to the “Map” screen and identify the area to zoom in on, as with the blue box in the figure below.



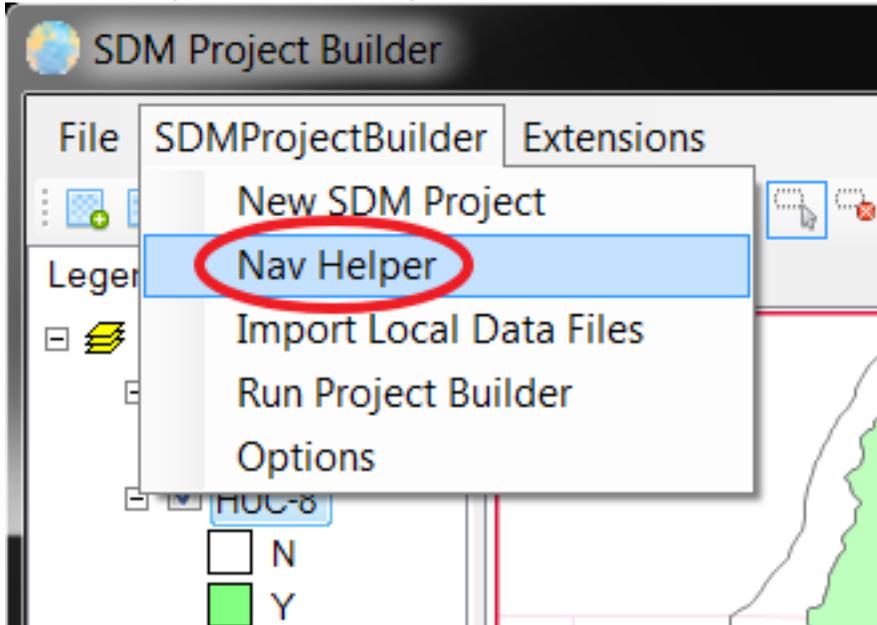
11. The result looks like this.



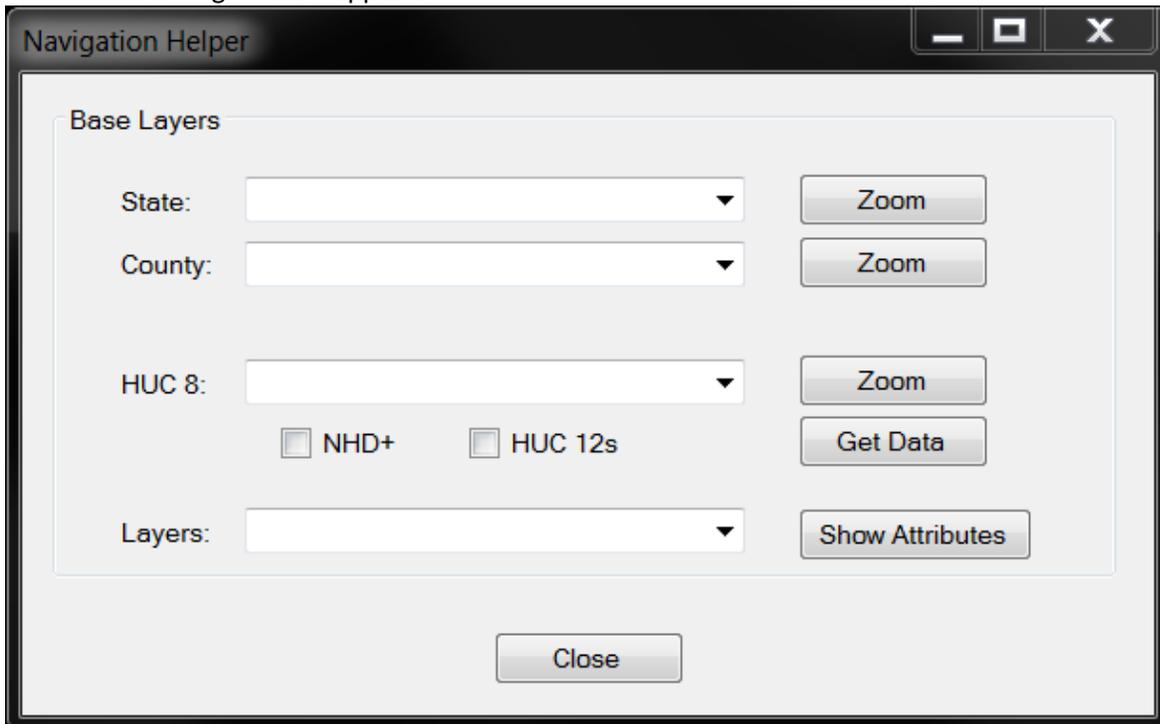
We are interested in the HUC with a CU of 04030101.

Navigation Helper

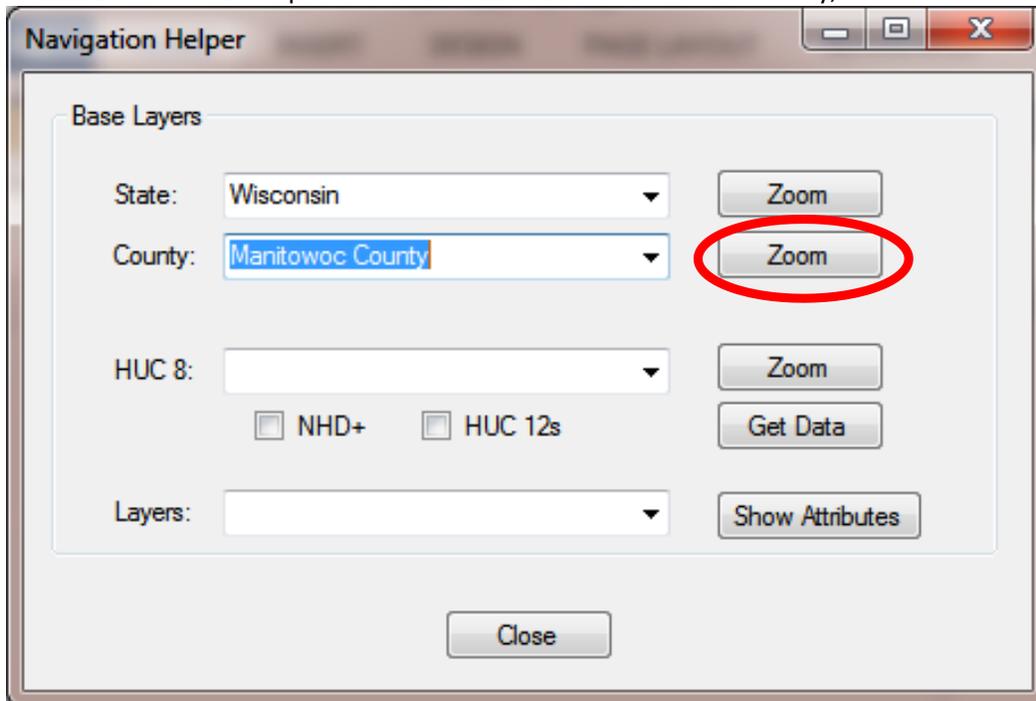
12. Use the "Navigation Helper" to collect the first map layers. On the menu bar, select "SDMProjectBuilder>Nav Helper".



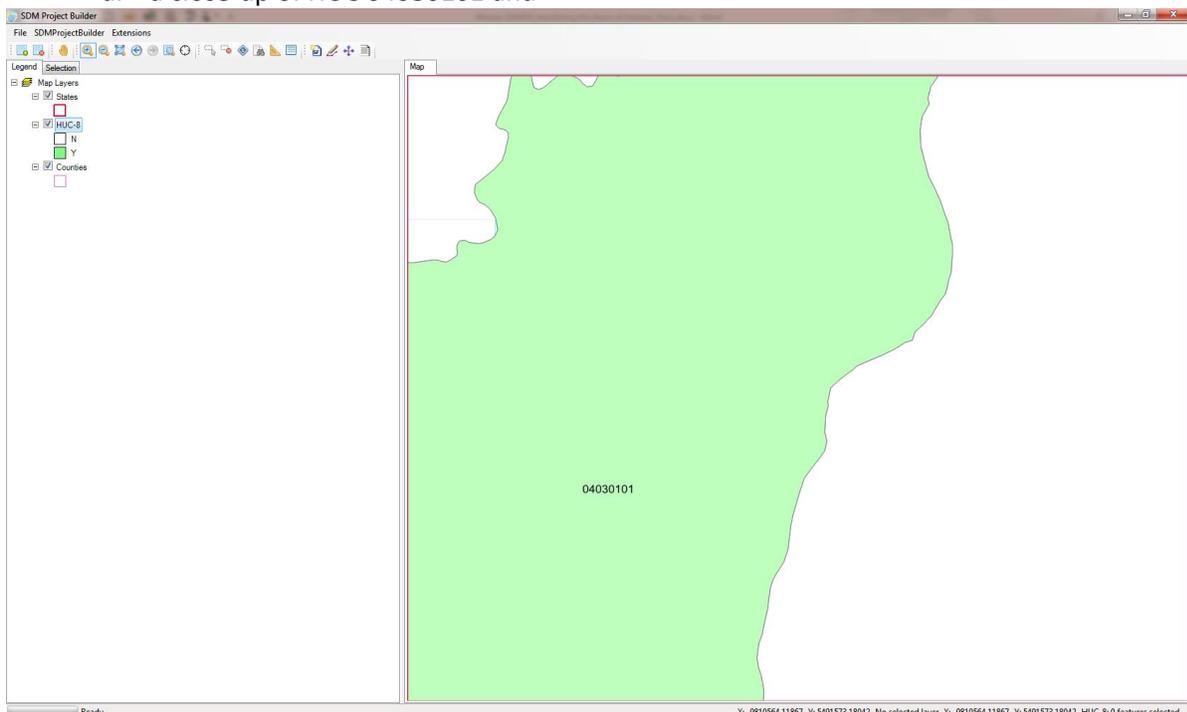
13. The following window appears.



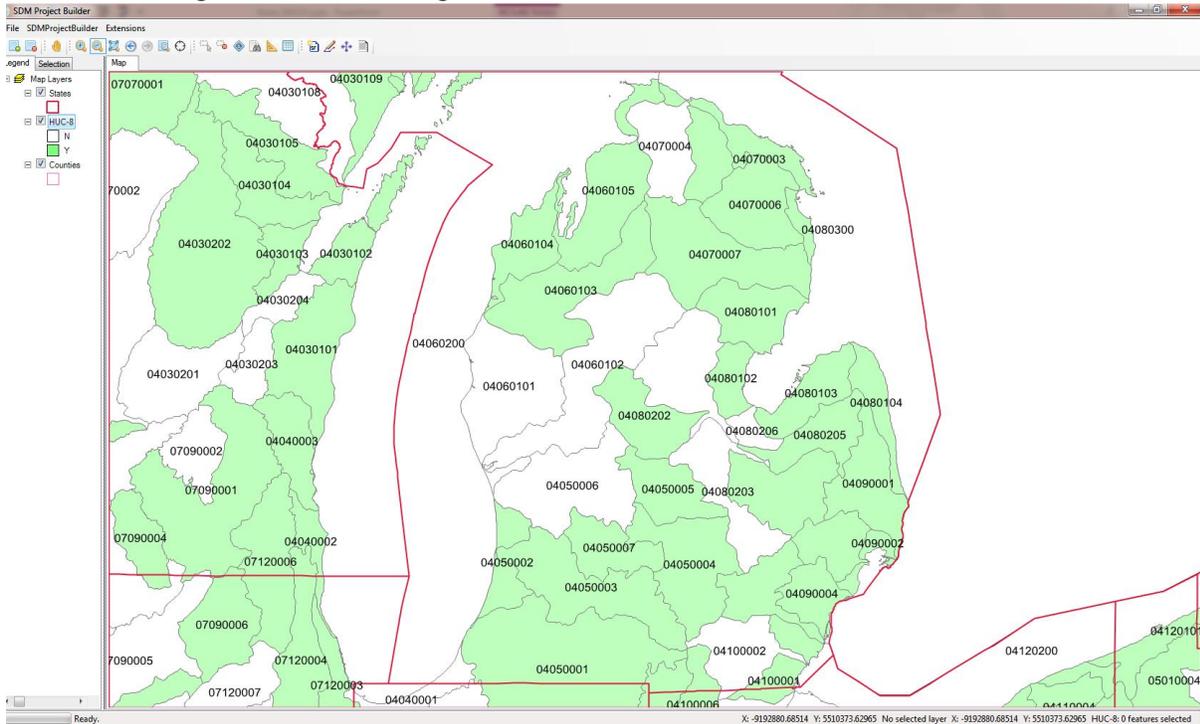
14. With the “Navigation Helper”, zoom to State, County, or HUC-8. If you do not know the HUC 8 identification number, but you do know the location, type in the “State” and “County” and choose “Zoom”. Our example is for the watershed in Manitowoc County, Wisconsin.



15. The following shows
a. a close-up of HUC 04030101 and



b. a regional view, including HUC 04030101

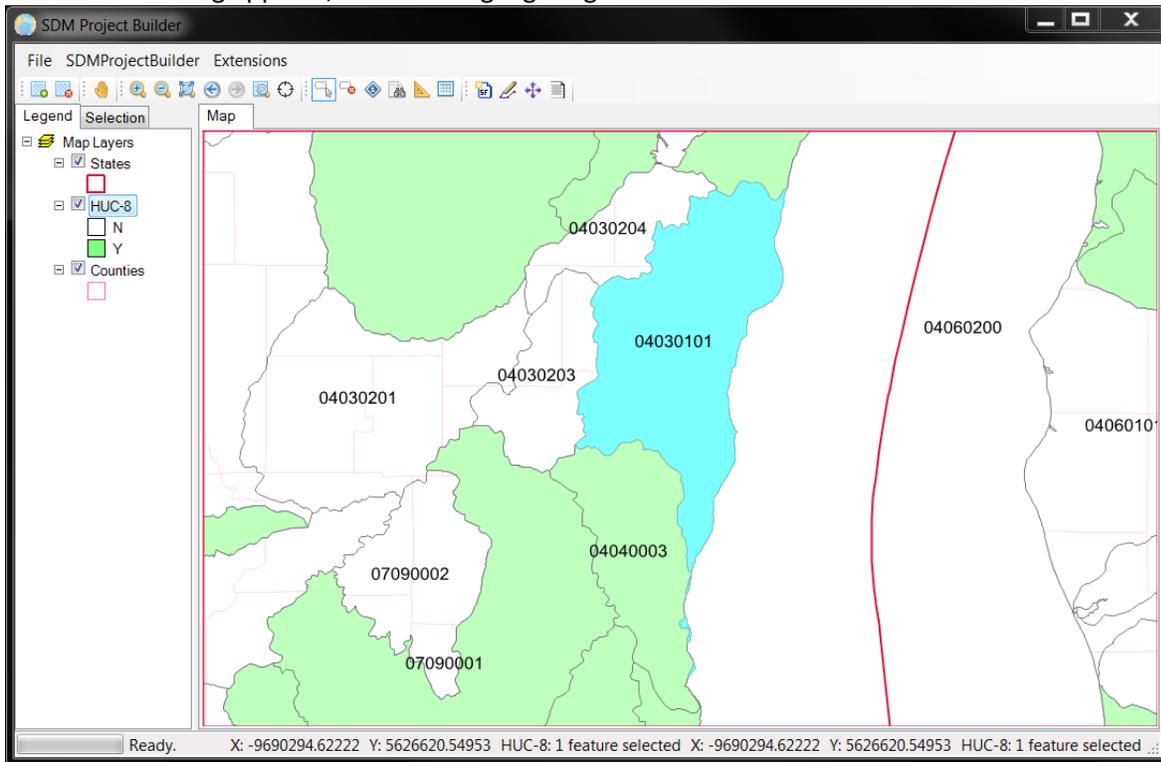


16. From the figure, we see that the HUC-8 CU identification number is 04030101, which we will need for collecting data. Type or choose "04030101" for the "HUC 8", check "NHD+" and "HUC-12" boxes, then click "Zoom" beside "HUC 8".

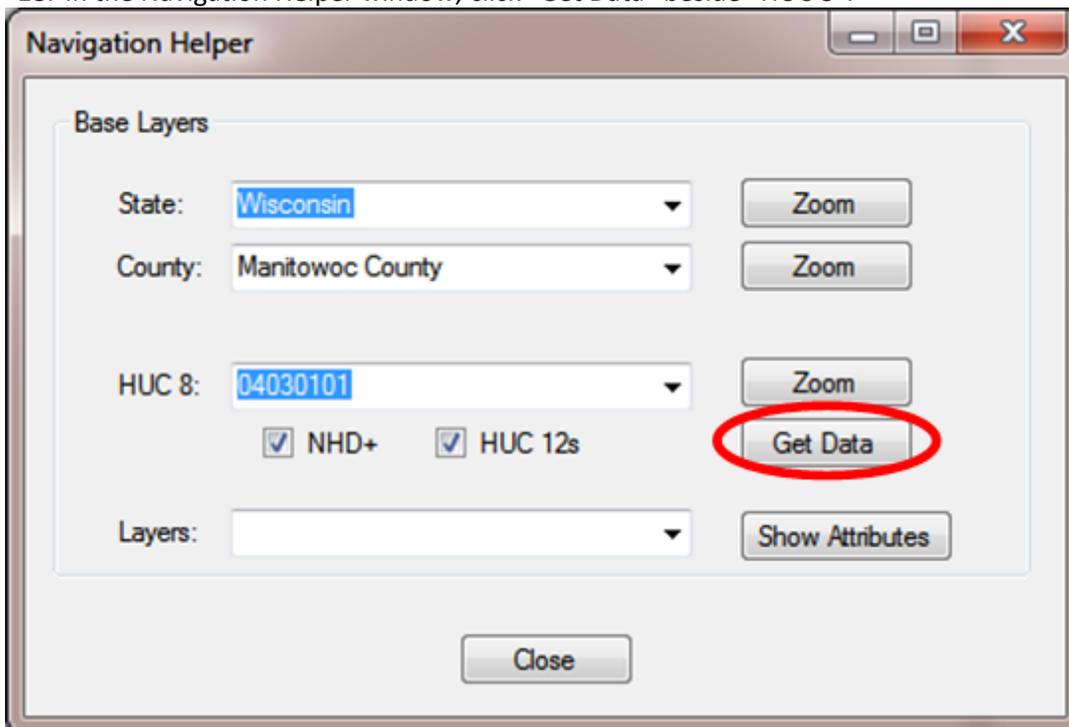
The screenshot shows the 'Navigation Helper' dialog box. The 'Base Layers' section includes the following fields and buttons:

- State: Wisconsin (dropdown menu) with a 'Zoom' button.
- County: Manitowoc County (dropdown menu) with a 'Zoom' button.
- HUC 8: 04030101 (text input field) with a 'Zoom' button circled in red.
- Checkboxes for 'NHD+' and 'HUC 12a', both of which are checked.
- A 'Get Data' button.
- A 'Layers' dropdown menu with a 'Show Attributes' button.
- A 'Close' button at the bottom.

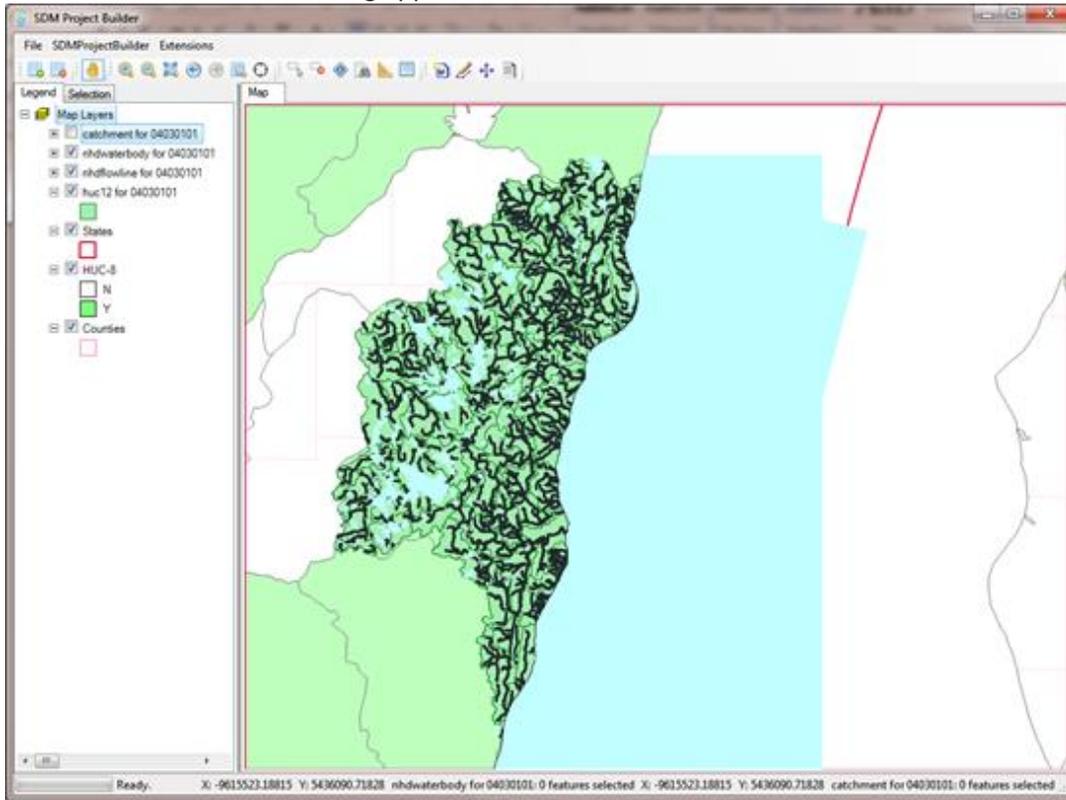
17. The following appears, with blue highlighting.



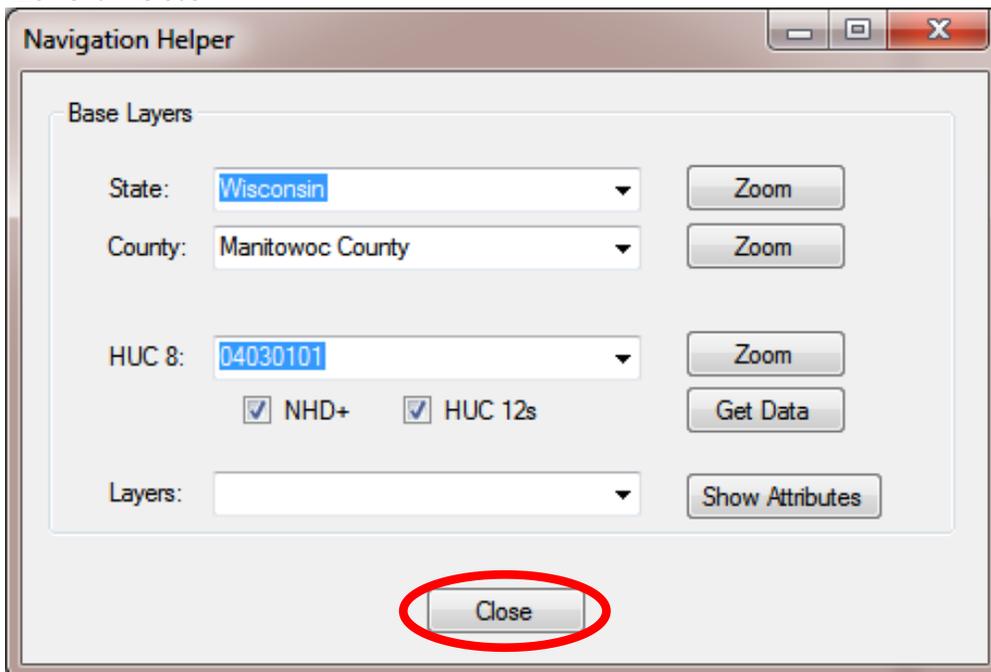
18. In the Navigation Helper window, click "Get Data" beside "HUC 8".



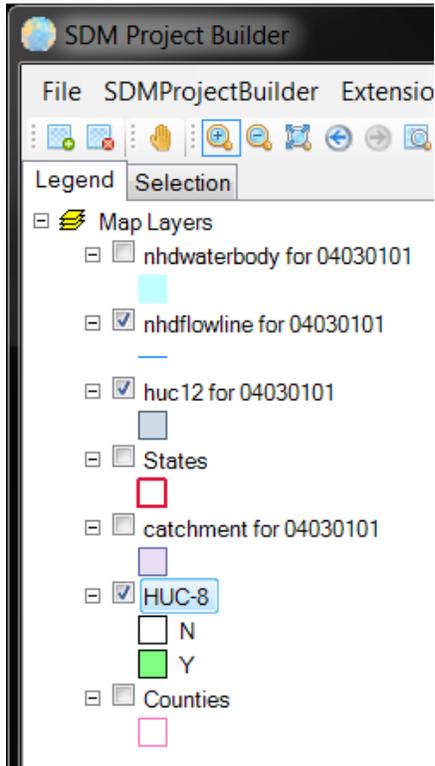
19. A screen like the following appears.



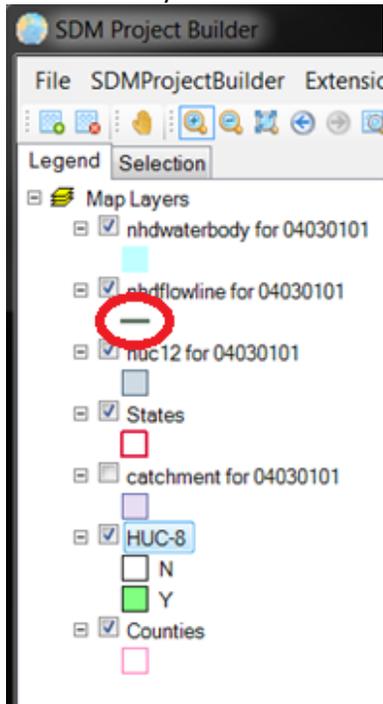
20. Click "Close".



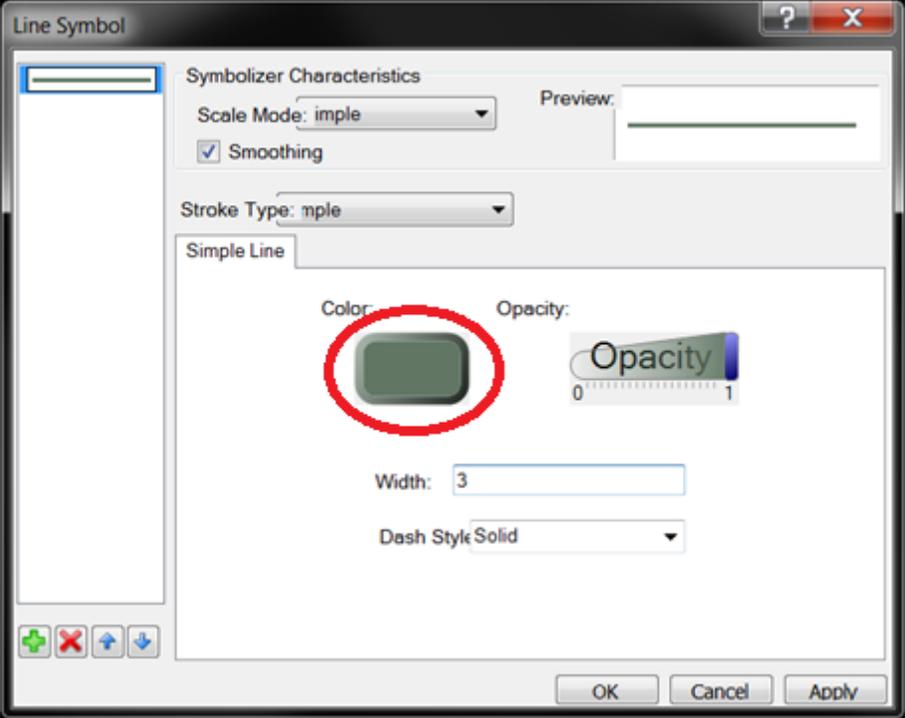
21. Colors associated with map layers can be modified for clarity: for example, turn on “nhdflowline for 04030101”, “huc 12 for 04030101” and “HUC-8”, with other layers turned off.



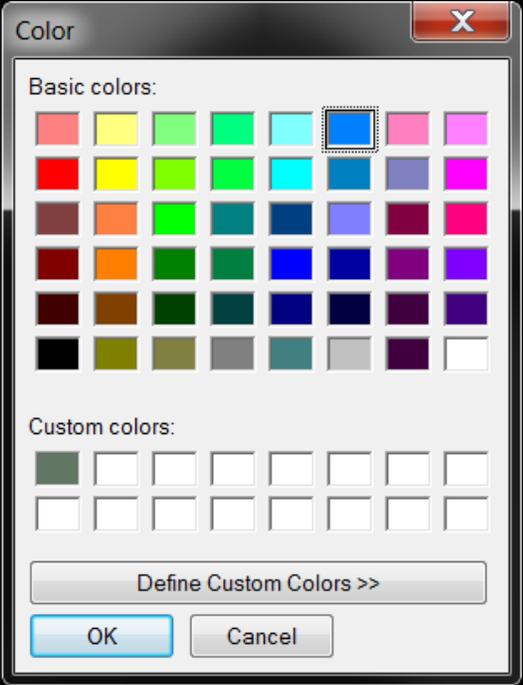
22. To adjust width and color of flowline associated with “nhdflowline for 04030101”, double-click left on the symbol below “nhdflowline for 04030101”.



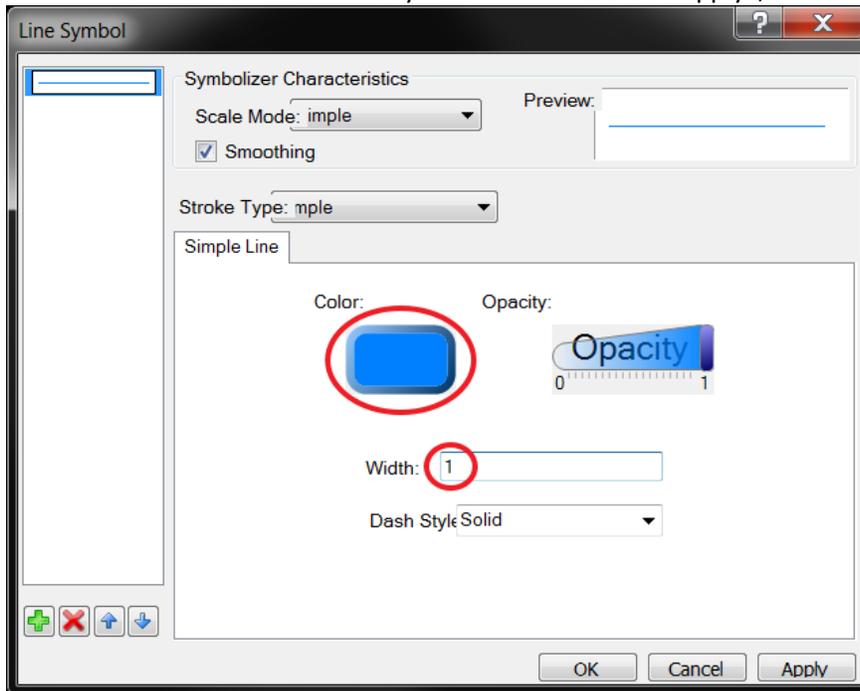
23. The "Line Symbol" window appears. Modify the color by left-clicking on the rounded rectangle to open the "Color" window.



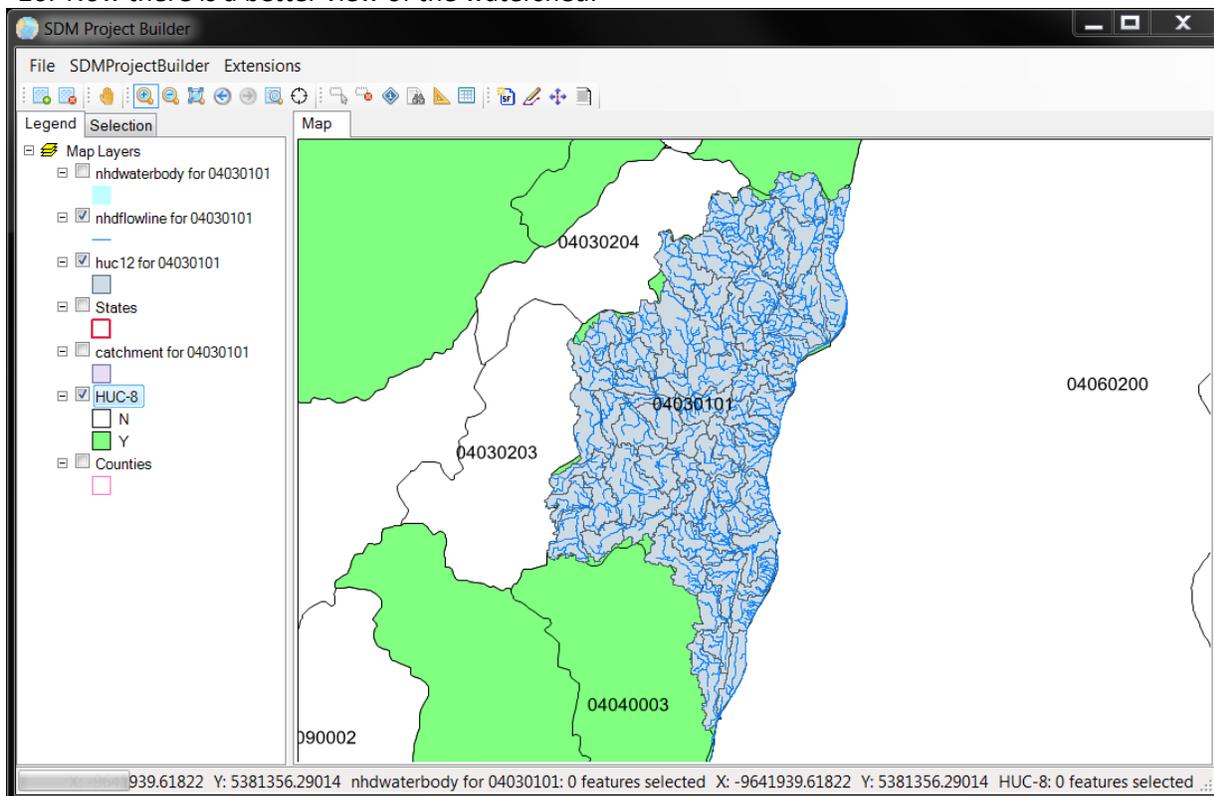
24. A color palette will appear. Select blue and click "OK".



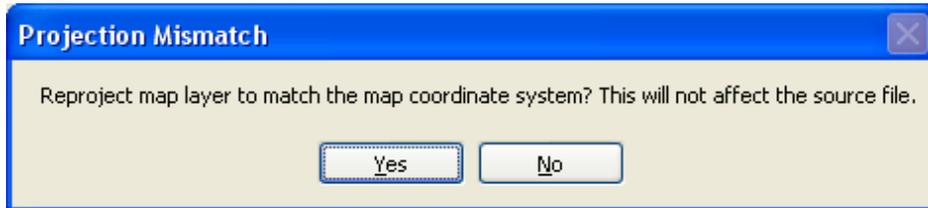
25. Make sure the color of the rounded rectangle changed to blue, like the screen below. Change “Width” to “1” in the “Line Symbol” window. Click “Apply”, then “OK”.



26. Now there is a better view of the watershed.



27. If you see the Projection Mismatch screen (which may appear more than once), choose 'Yes' since you want to re-project these map layers to match the coordinate system.



Identify, Modify, and Import Local Source-term Data

This section identifies and modifies local data files, and imports local data files to the SDMPB. Local source-term data are described in [Whelan et al. \(2017e\)](#) which also describes how to edit the files and register them as map layers in the SDMPB. The user can modify certain source-term parameters and influence the degree of resolution of the watershed through 12 local-data files that are installed when a user begins a new project. They are located in the "...\\LocalData" folder within the working folder. [Whelan et al. \(2017d, 2017f, 2017g\)](#) provide additional examples identifying and modifying the local source-term data example default files. Metadata associated with the parameters contained within each file, including definitions and units, are summarized in [Whelan et al. \(2017e\)](#). Five of the 12 files denote locations: point sources (PointSourceLL.csv), animal locations (AnimalLL.csv), septic systems (SepticsLL.csv), boundary conditions (BoundaryPointsLL.csv), and locations for output results (OutputPointsLL.csv).

Modifications are made to the following local data files:

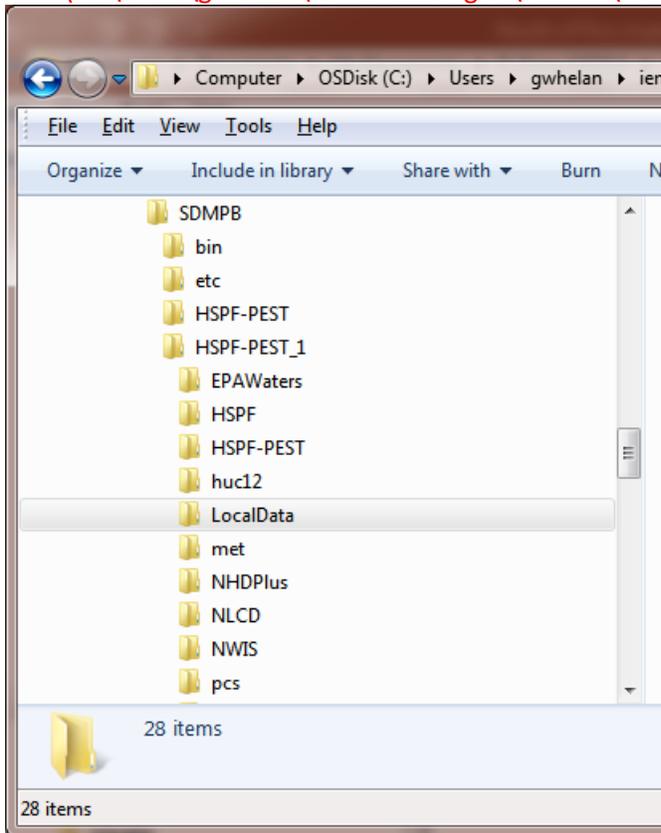
- **BoundaryPointsLL.csv** – Identifies boundary condition locations. The boundary point location (44.027308, -88.164316) was changed to (0.0, 0.0), outside of the watershed and will not impact the assessment. Although no boundary condition is consumed for this example and this modification is unnecessary, it illustrates how one can modify this CSV file.
- **FCProdRates.csv** – Identifies 1) production or shedding rate of microbes from each domestic animal, which equals the multiple of the (a) domestic animal shedding rate in mass of waste (wet weight) per time and (b) microbial concentration based on mass of waste shed by the domestic animal; and 2) identifies typical microbial production or shedding rate per wildlife per unit area. The shedding rate of “BeefCow” was changed to the value for “DairyCow” because half of dairy cows are grazed.

The following local data files will not be changed for this example:

- **AnimalLL.csv** – Identifies domestic animal locations by Latitude and Longitude and domestic animals by numbers and by type.
- **GrazingDays.csv** – Identifies the 1) number of grazing days per domestic animal per month and 2) fraction of the number of grazing days that Beef Cattle spend in a stream per month.
- **ManureApplication.csv** – Identifies the 1) fraction of manure applied to soil each month per domestic animal and 2) fraction of amount of manure shed by the domestic animal incorporated into soil.
- **MonthlyFirstOrderDieOffRateConstants.csv** – Defines monthly microbial first-order die-off rate constants.
- **OutputPointsLL.csv** – Identifies intermediate points, where the user would like the watershed model to produce simulation results, and only exist at subwatershed boundaries; therefore, these locations impact delineation of the watershed, in particular the number and location of subwatersheds.
- **PointSourceLL.csv** – Identifies point source locations.
- **PointSourceData.csv** – Identifies the annual-average flow, and microbial and/or chemical loading rates for each point source.
- **SepticsDataWatershed.csv** – Identifies the number of people per septic unit, average fraction of septic systems that fail, average septic overcharge rate per person, typical microbial density of septic overcharge reaching the stream.
- **SepticsLL.csv** – Identifies septic system locations by Latitude and Longitude.
- **WildlifeDensities.csv** – Identifies typical number of wildlife per unit area by land use type.

Identify Local Source-term Data

28. The 12 default files are located in the “LocalData” directory, as illustrated below (“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\LocalData”).

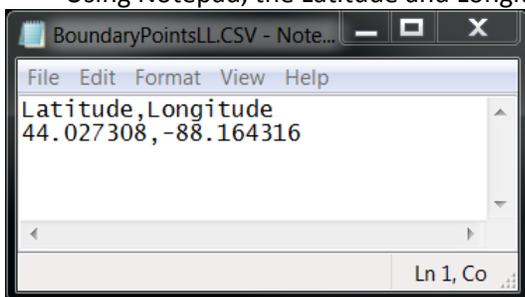


Modify Local Source-term Data

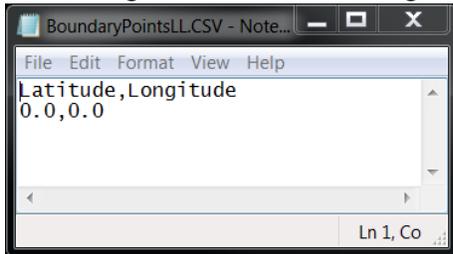
Modifications are made to the following local data files: BoundaryPointsLL.csv and FCProdRates.csv.

BoundaryPointsLL.csv

29. Open BoundaryPointsLL.csv using Notepad, Notepad, WordPad, Excel, or other pertinent editor. Using Notepad, the Latitude and Longitude of the default boundary point locations are as follows:

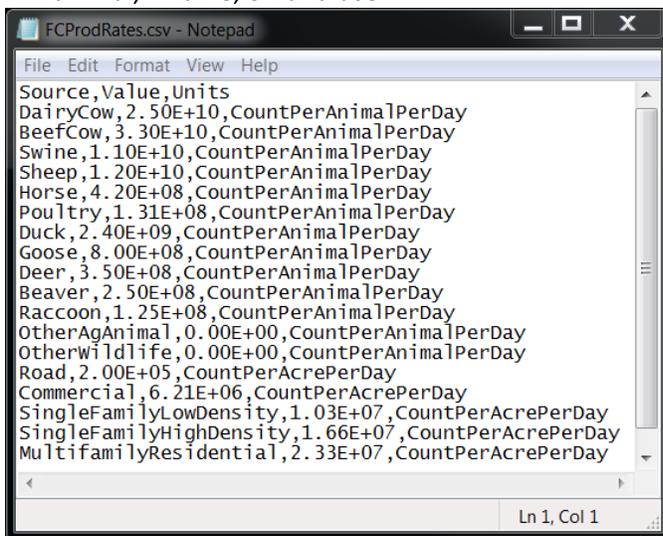


30. Change the Latitude and Longitude to <0.0, 0.0>. Save the file and exit.

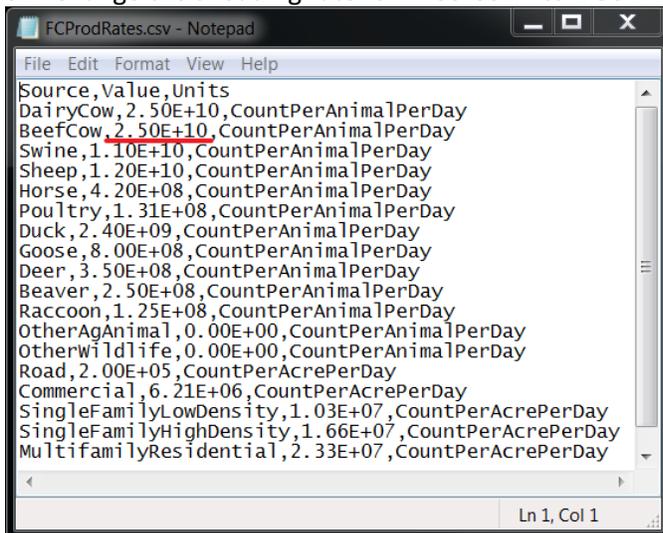


FCProdRates.csv

31. Open FCProdRates.csv using TextPad, Notepad, WordPad, Excel, or other pertinent editor. Using Notepad, the original file includes the production or shedding rate of microbes from each domestic animal, wildlife, or land use.



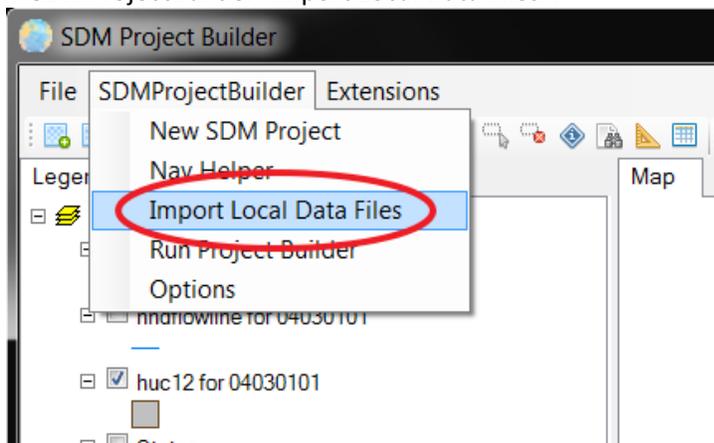
32. Change the shedding rate for "BeefCow" to 2.50E+10. Save the file and exit.



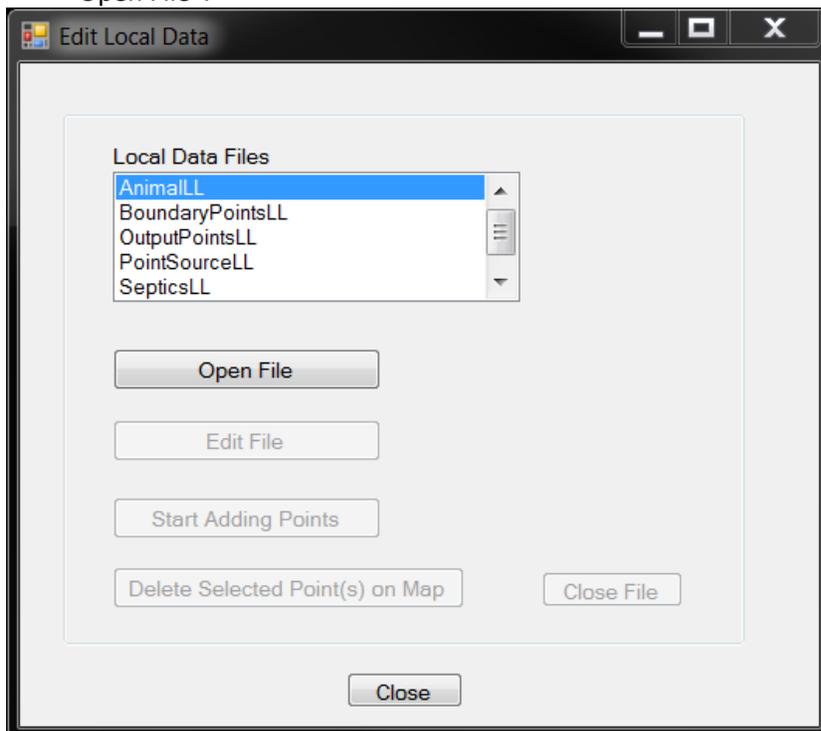
Import Local Source-term Data

Ensure that the old files have been replaced with the new files in the "...\LocalData" working folder. All files in the "LocalData" folder, which is within the working folder, are used, where appropriate, even if the files are not registered as map layers on the SDMPB screen.

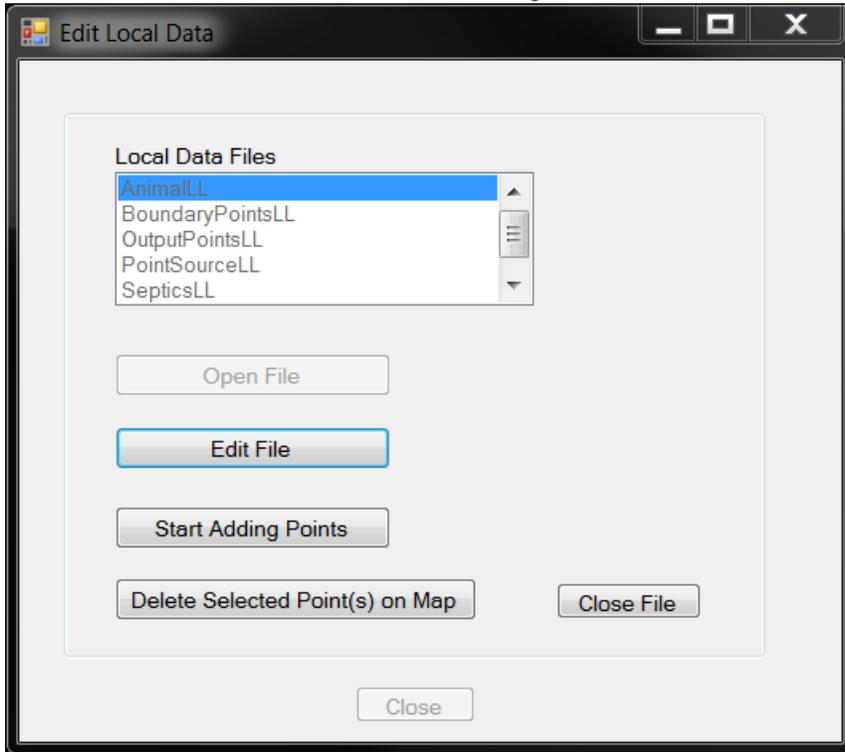
33. To register source locations in the folder "[C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\LocalData](#)" as Map Layers, select "SDMProjectBuilder>Import Local Data Files".



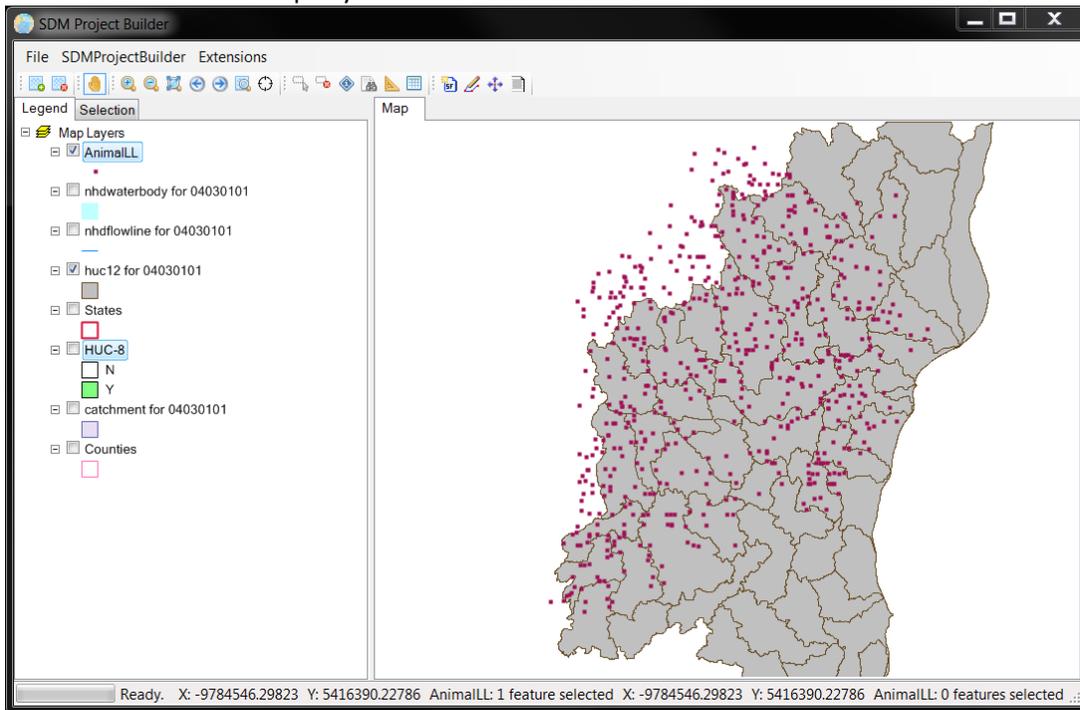
34. The "Edit Local Data" window appears. Select "AnimalLL" in "Local Data Files" section, and click "Open File".



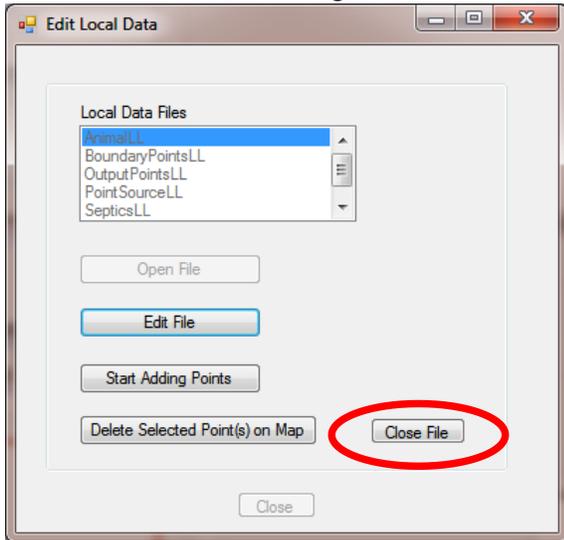
35. The “Edit Local Data” window will change, as shown below.



36. The “AnimalLL” Map Layer will be added to the SDMPB screen as illustrated below.



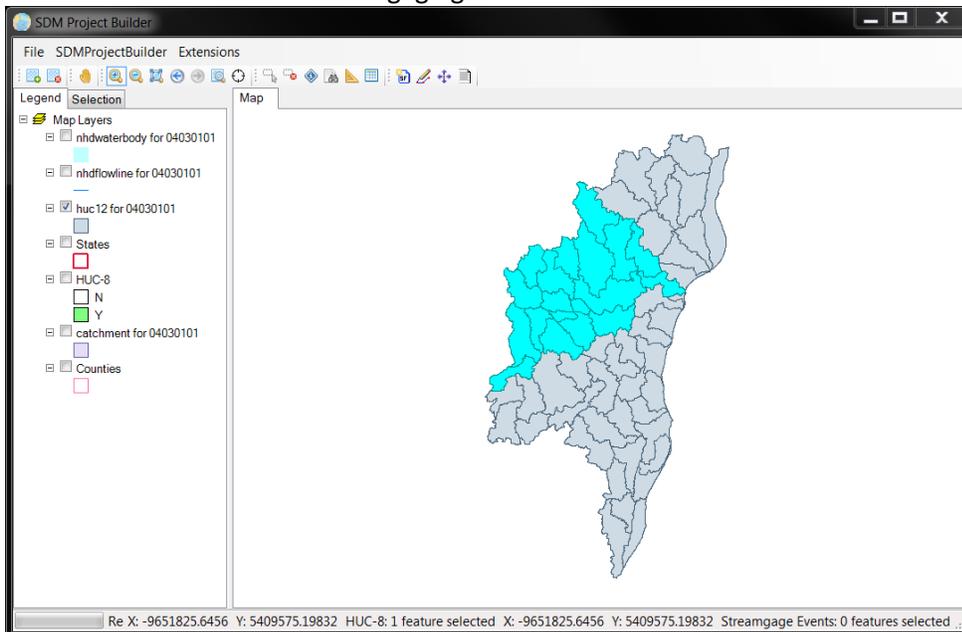
37. When the screen changes, click “Close File.”



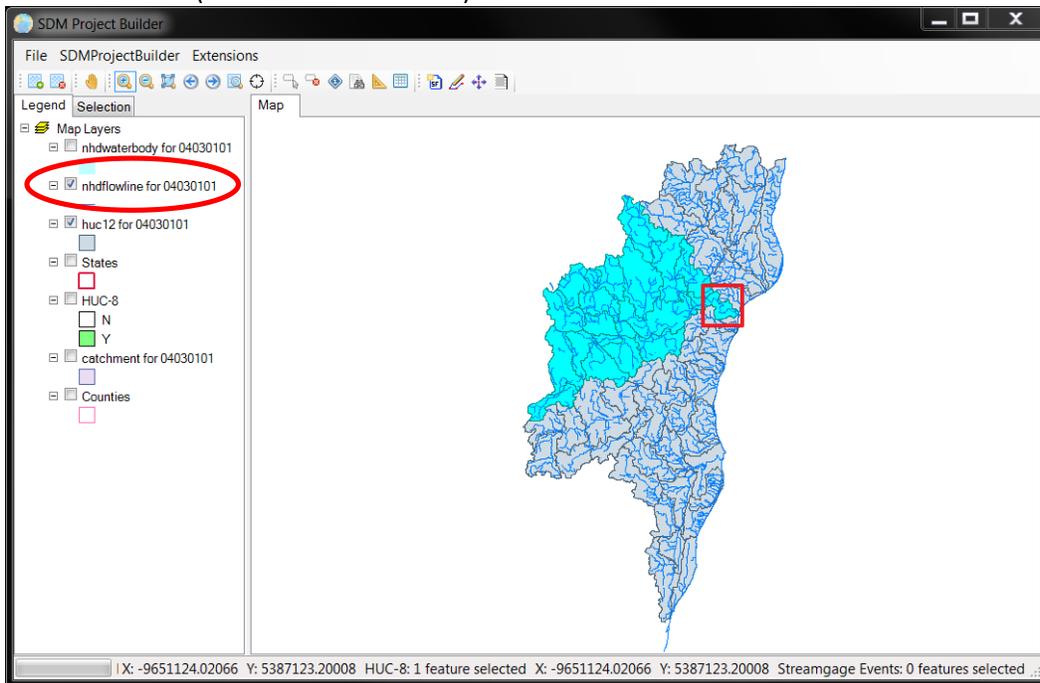
Identify the Pour Point Gaging Station

There are several methods for identifying USGS gaging stations associated with watersheds. As described by [Whelan et al. \(2017b\)](#), one uses BASINS software to download and identify the USGS National Water Information System (NWIS) stations. A second approach, described below, goes directly to the USGS NWIS web site and identifies the location.

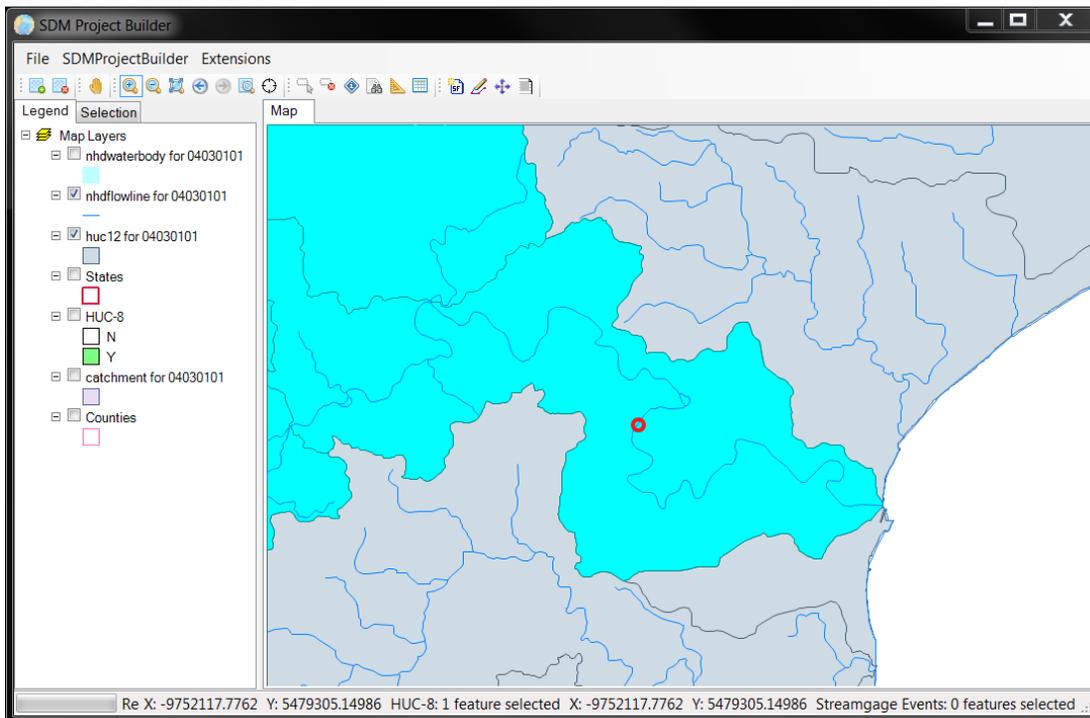
38. The Manitowoc River Basin exists within the HUC-8 “04030101”, as highlighted below. To compare monitored and simulated flows and microbial densities, the watershed must be delineated through the sampling/monitoring location, where the SDMPB allows the user to delineate watersheds at intermediate locations like gaging stations.



41. With this information, the USGS gaging station location can be identified on the SDMPB map layer. Turn on Flowline (“nhdflowline for 04030101”) to see the shape of the river, and zoom to the area of interest (see boxed area below).

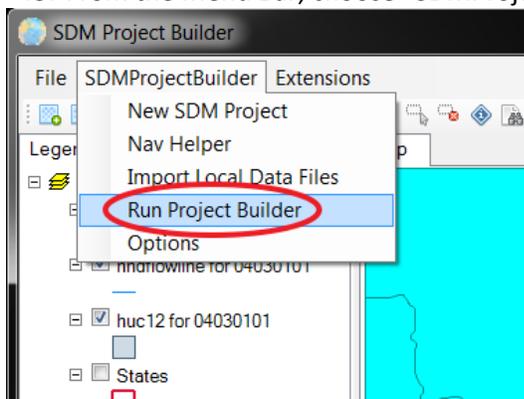


42. An approximate location of the gage station can be estimated on the map layer, as illustrated by the red circle below.

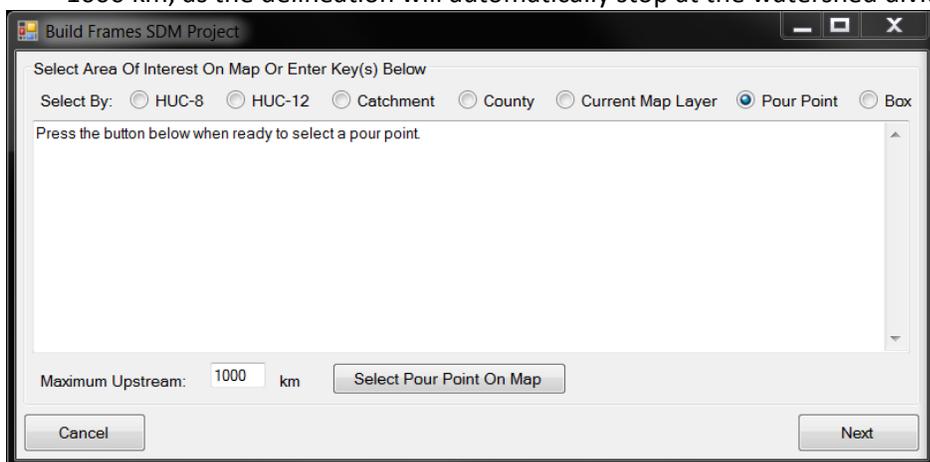


Run Project Builder

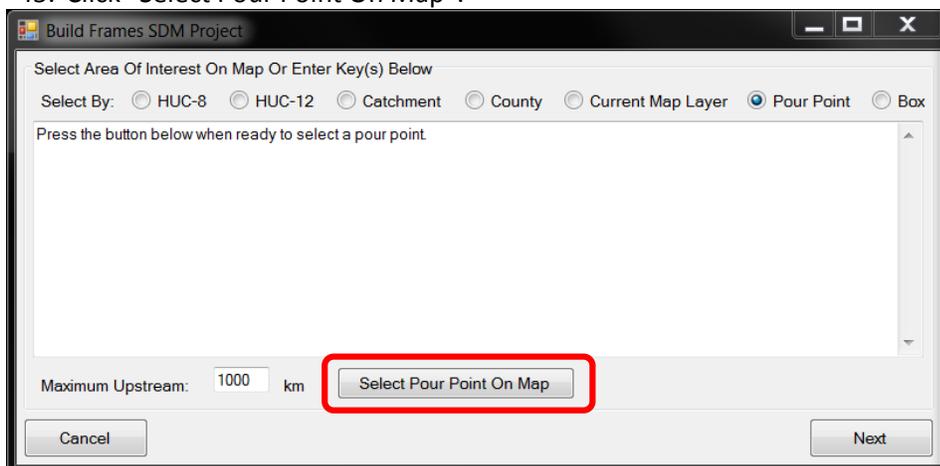
43. From the Menu Bar, choose “SDMProjectBuilder”, then “Run Project Builder”.



44. The “Build Frames SDM Project” window appears. Choose “Pour Point” for “Select By”. For “Maximum Upstream”, pick a distance that goes at least to the watershed divide – arbitrarily use 1000 km, as the delineation will automatically stop at the watershed divide.



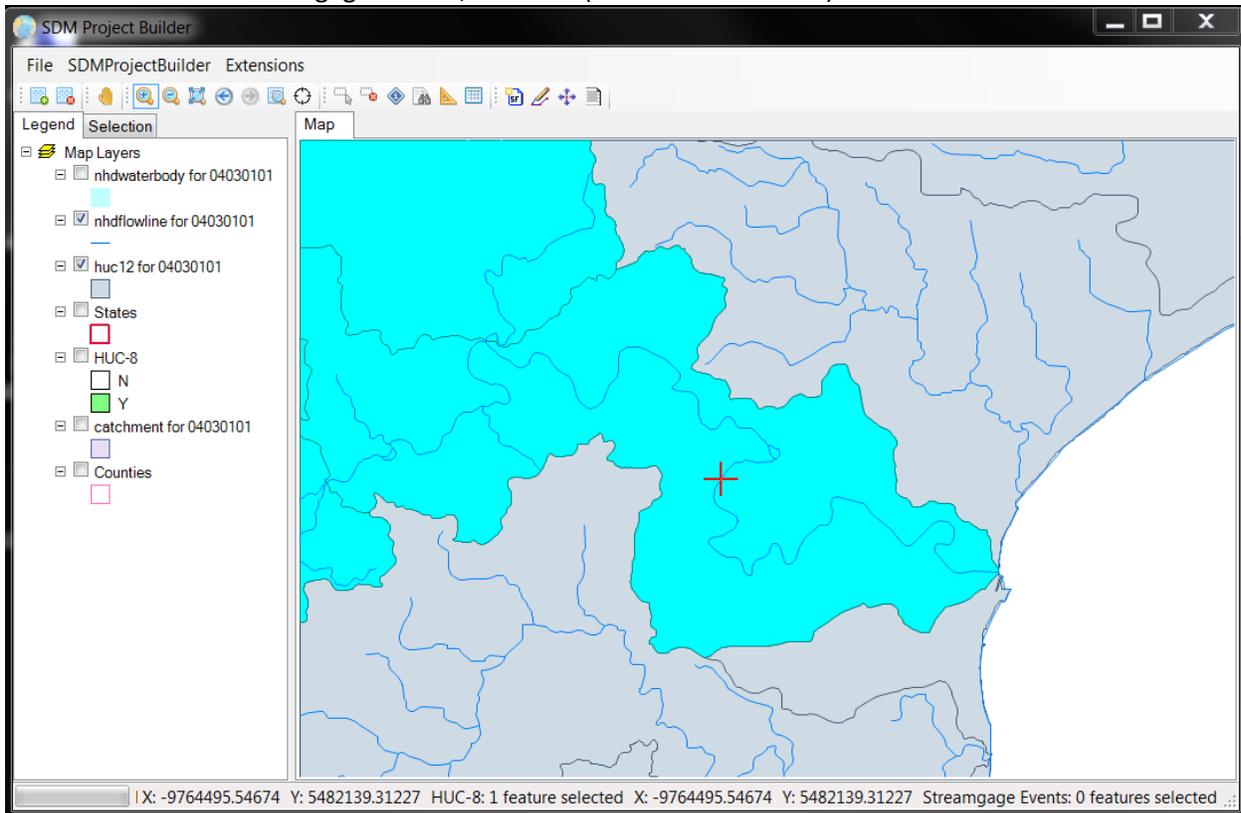
45. Click “Select Pour Point On Map”.



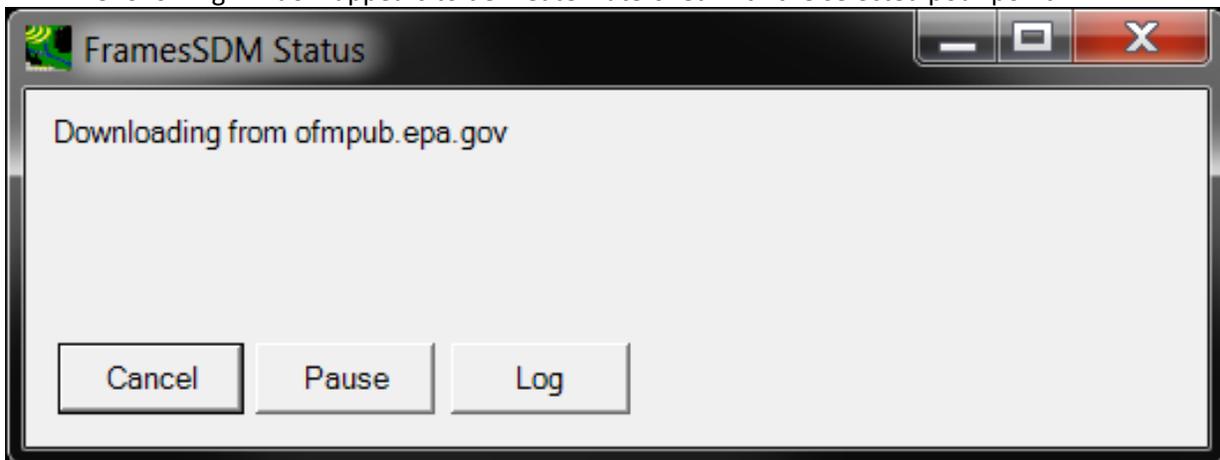
46. Go back to the map, and zoom in on the gage station location (representing the pour point of the



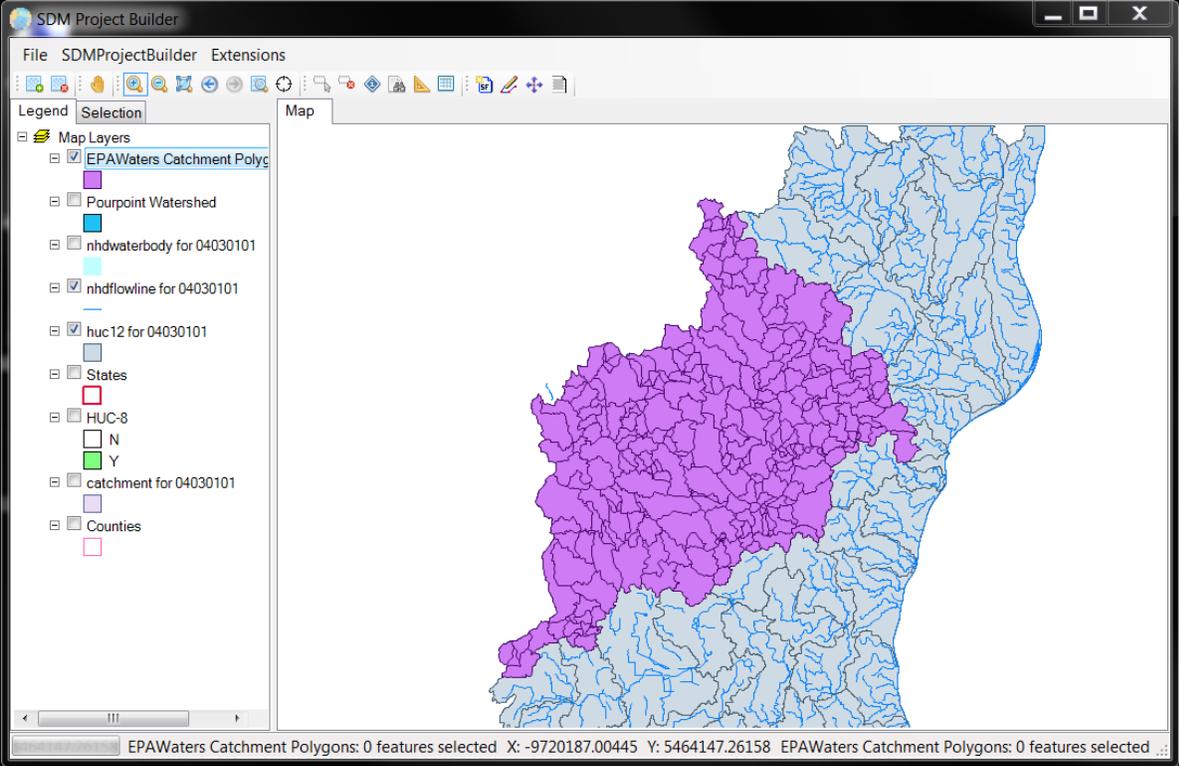
watershed); use the Zoom icon to clearly see the location highlighted with the red cross. Zoom in because identifying the location is crucial to placing the pointer; if this location is incorrectly identified, you may include more area than is needed for the assessment by inadvertently getting too close to the HUC-12 boundary. On the map, move the cursor to the location of the USGS gage station, and click (see red cross below).



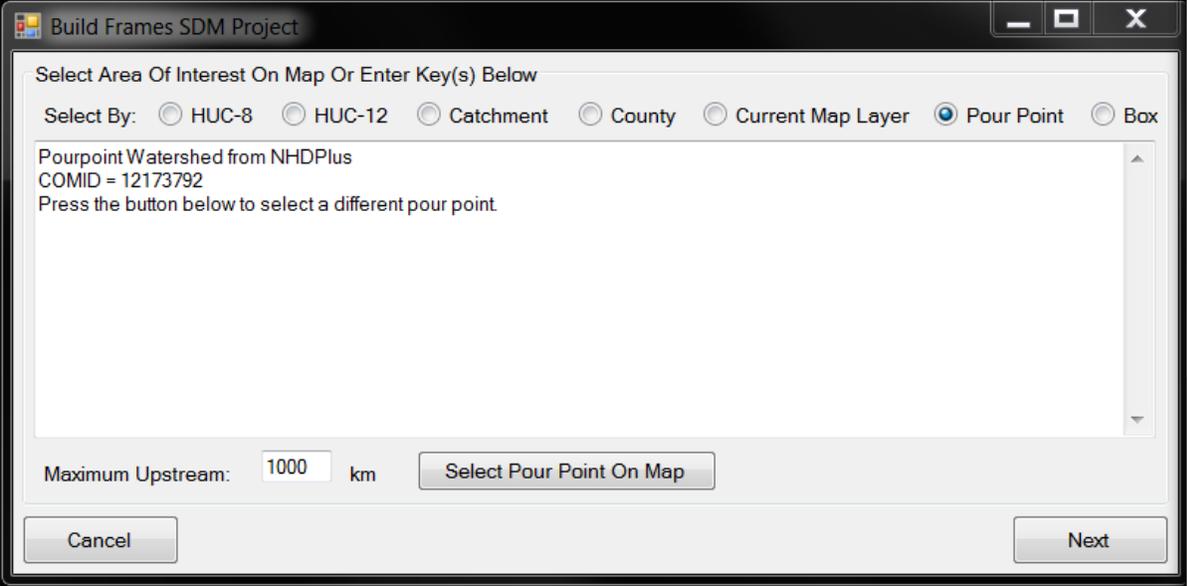
47. The following window appears to delineate watershed with the selected pour point.



48. When the window disappears, the delineated watershed with the selected pour point is indicated on the map.



49. Click “Next” on the “Build FRAMES SDM Project” interface.



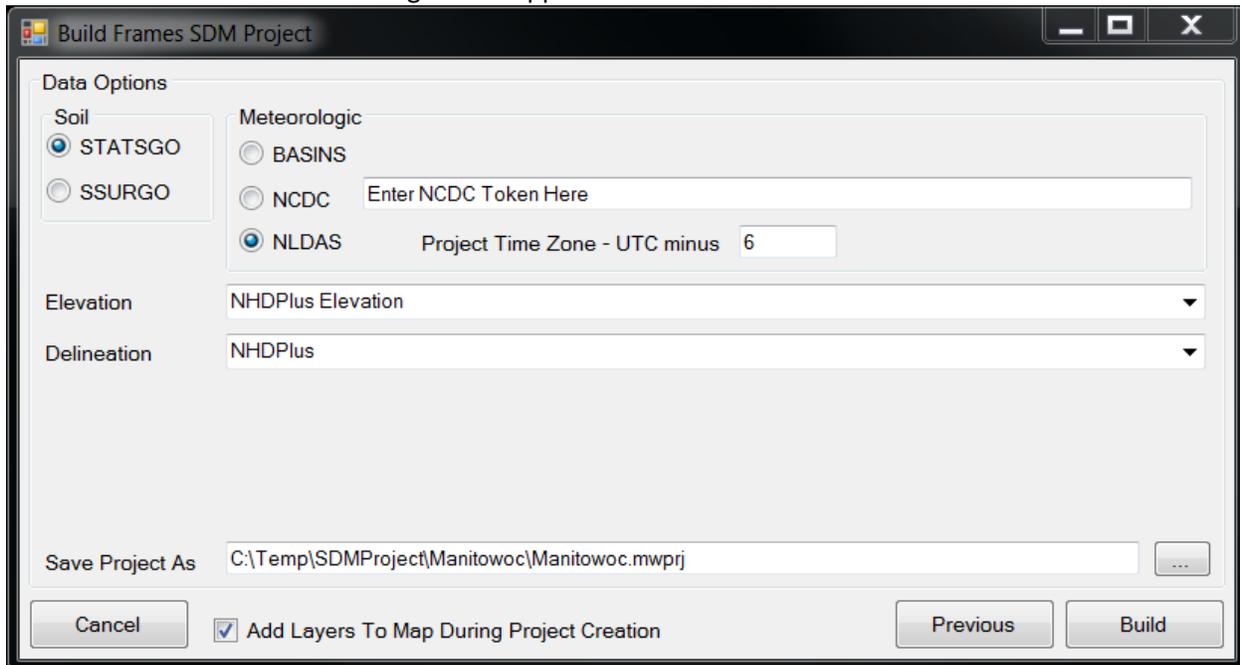
50. Complete the “Build FRAMES SDM Project” as shown, using values included in this figure.
- To ensure adequate sizes, define the “Minimum Catchment Size” and “Minimum Flowline Lengths” as “15” and “15”, respectively. The Minimum Catchment Size and Minimum Flowline Length ensure that subwatersheds and stream segment length are not too small.
 - Land areas that are less than 5% of the total have been factored into other Map Layers, as noted by the “Ignore Landuse Areas Below Fraction” of “0.05”.
 - Check “HSPF.”
 - The “Degree Day” method is chosen to account for snow accumulation and melt.
 - Select “Microbes” for the contaminant of concern.
 - Output is “Hourly”.
 - Segmentation is “Individual”, which allows model segments to be associated with each subwatershed (not each meteorological station, which can have multiple subwatersheds assigned to them).

The screenshot shows a dialog box titled "Build Frames SDM Project" with the following settings:

- Minimum Catchment Size (square kilometers): 15
- Minimum Flowline Length (kilometers): 15
- Ignore Landuse Areas Below Fraction: 0.05
- Simulation Start Year: 2000
- Simulation End Year: 2012
- HSPF
 - Output Interval: Hourly
 - Snow: Degree Day
 - Segmentation: Individual
- Microbes
- Land-Applied Chemical
-
- SWAT
 - SWAT 2005 Database: C:\BASINS41\bin\Plugins\SWAT\Databases\SWAT2005.mdb
 - Report Flow Units: Linear Log

Buttons at the bottom: Cancel, Previous, Next.

51. Click “Next” and the following screen appears. Use the choices illustrated in the screen below.



Use the choices and values:

- Choose “STATSGO” which is less detailed than SSURGO for soil options.
- Choose “NLDAS” under Meteorologic which refers to MET data. 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; Whelan et al., 2017h). This is used in conjunction with NCDCC NOAA meteorological data which supplies information for regional data, such as air temperature. BASINS uses cached NCDCC data up to 2009. For direct access to hourly NCDCC data, one would choose “NCDCC”, but the user must obtain a Token ID. MET stations are assigned to the nearest subwatersheds (based on centroid).
- 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”.
- Coordinated Universal Time (UTC) is the world standard for civil time, irrespective of the local standard time [i.e., Greenwich Mean Time (GTM)]. Update the “Project Time Zone – UTC minus” to the civil time zone of the study area (i.e., Manitowoc, WI). This can be obtained from Figure 1 as “-6”.

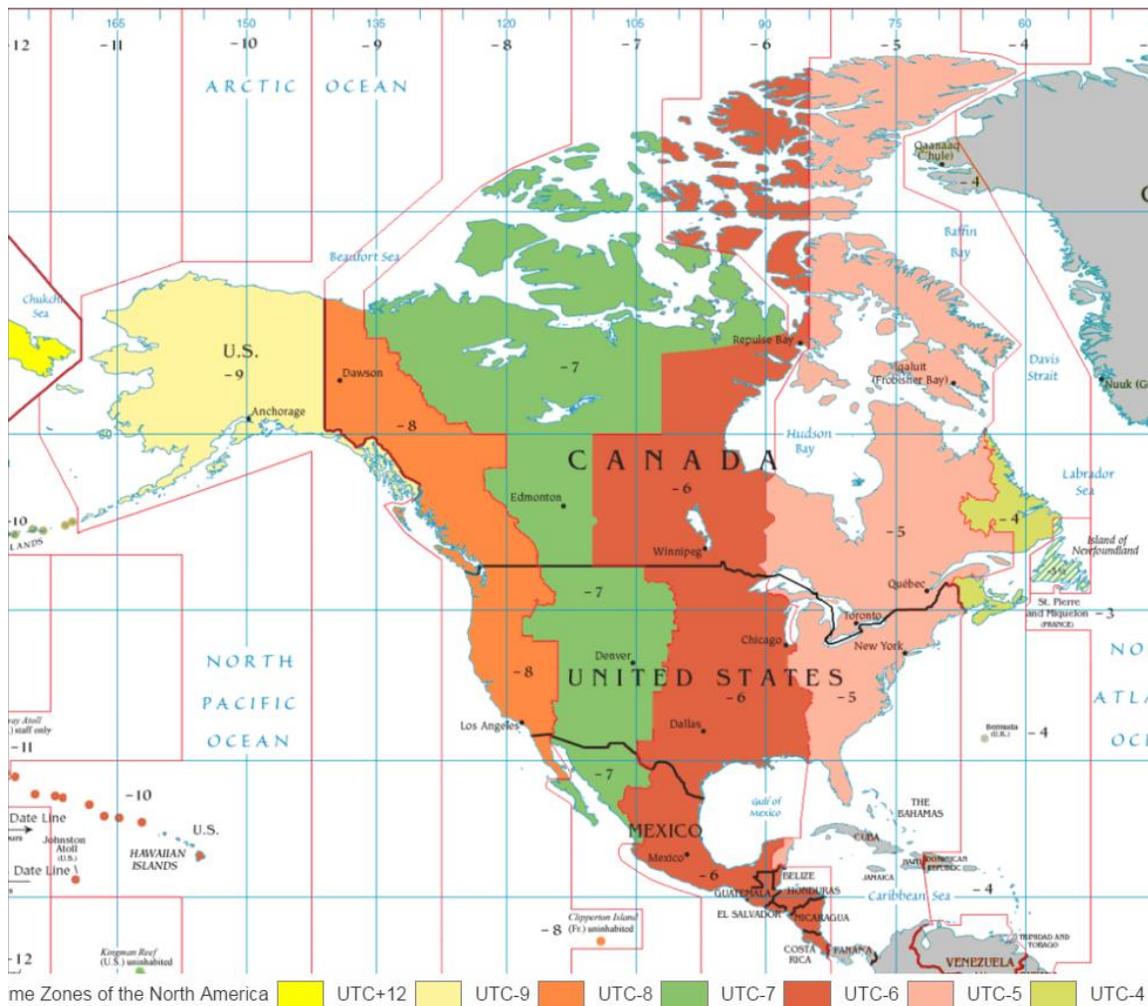
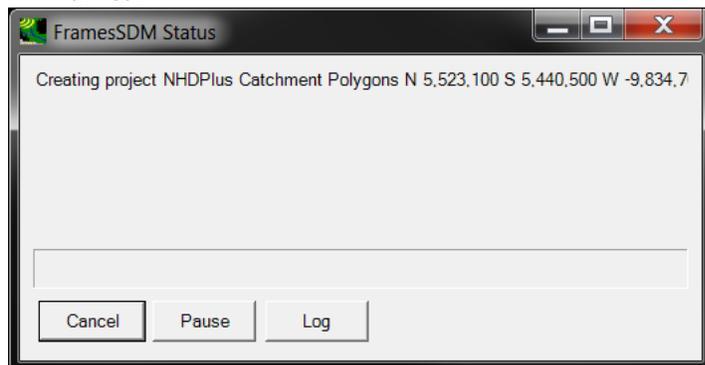


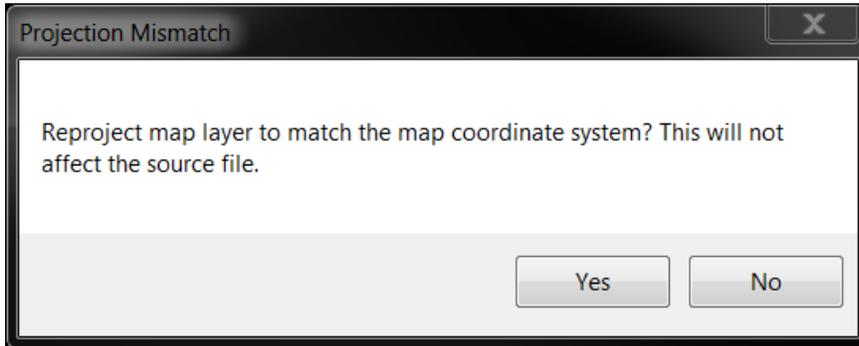
Figure 1. Coordinated Universal Time (UTC) for North America (For Daylight Savings time, increase one hour in those areas that adhere.)

[https://en.wikipedia.org/wiki/Eastern_Time_Zone#/media/File:Timezoneswest.PNG]

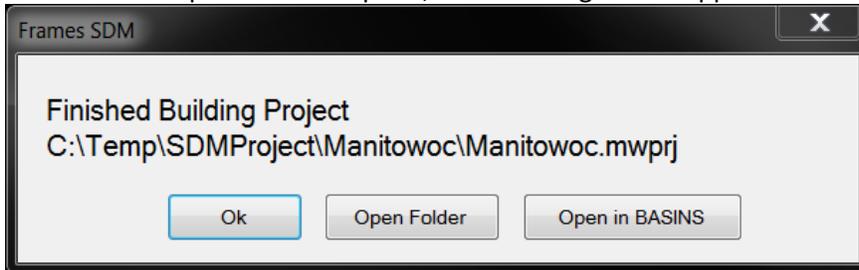
52. Click the “Build” button; progress windows like the one below will appear and disappear several times.



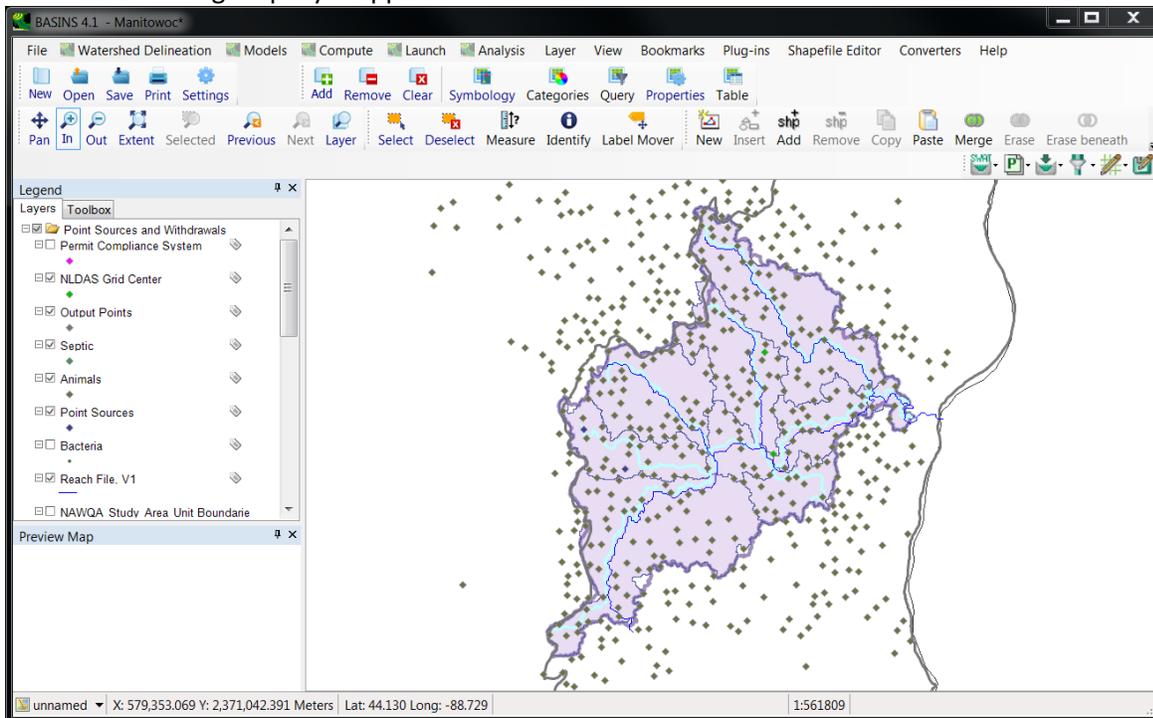
53. The message in the window below will appear several times during the process. Click “Yes” each time.



54. When the process is complete, the following screen appears. Click “Open in BASINS”.

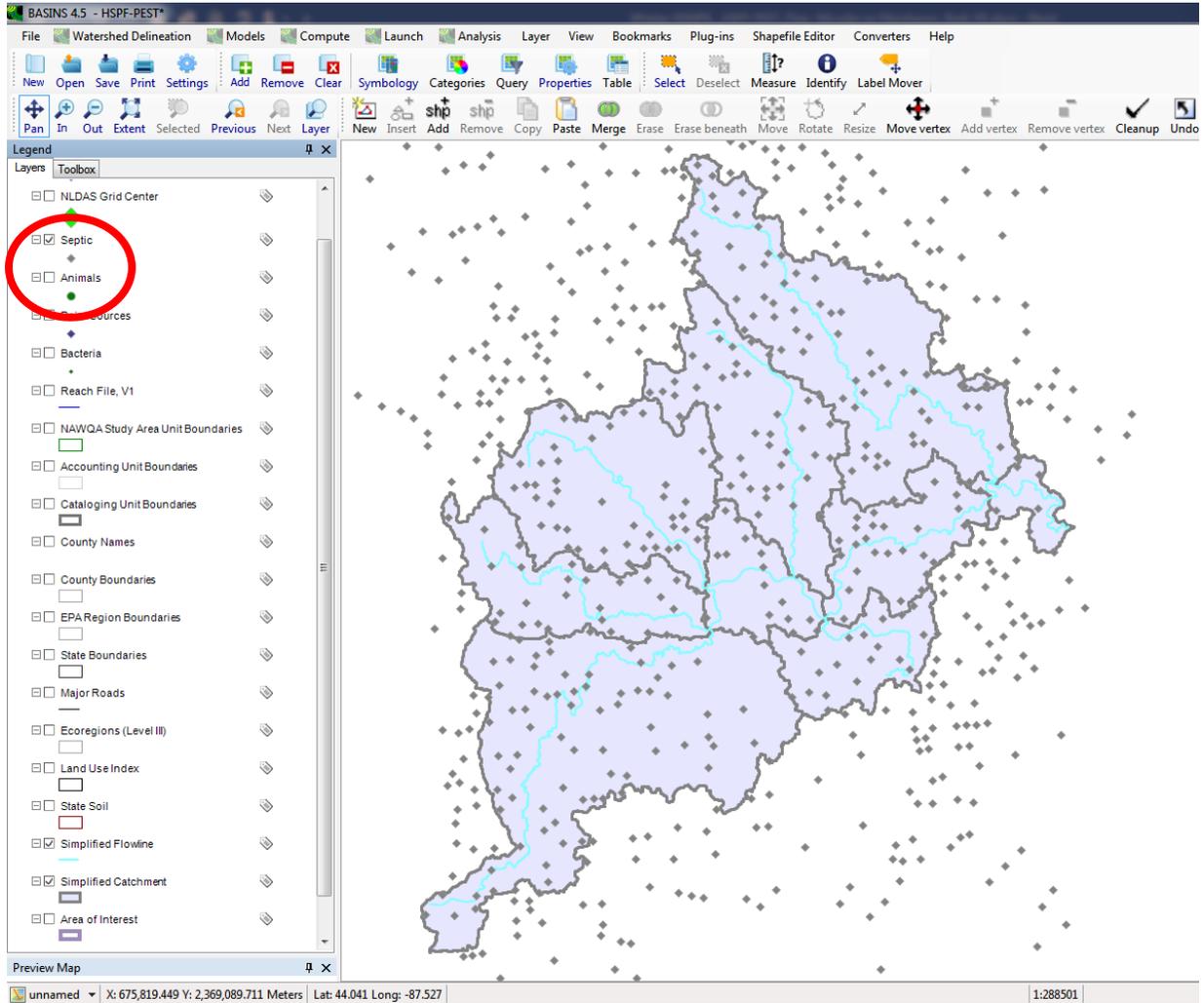


55. The following map layer appears.

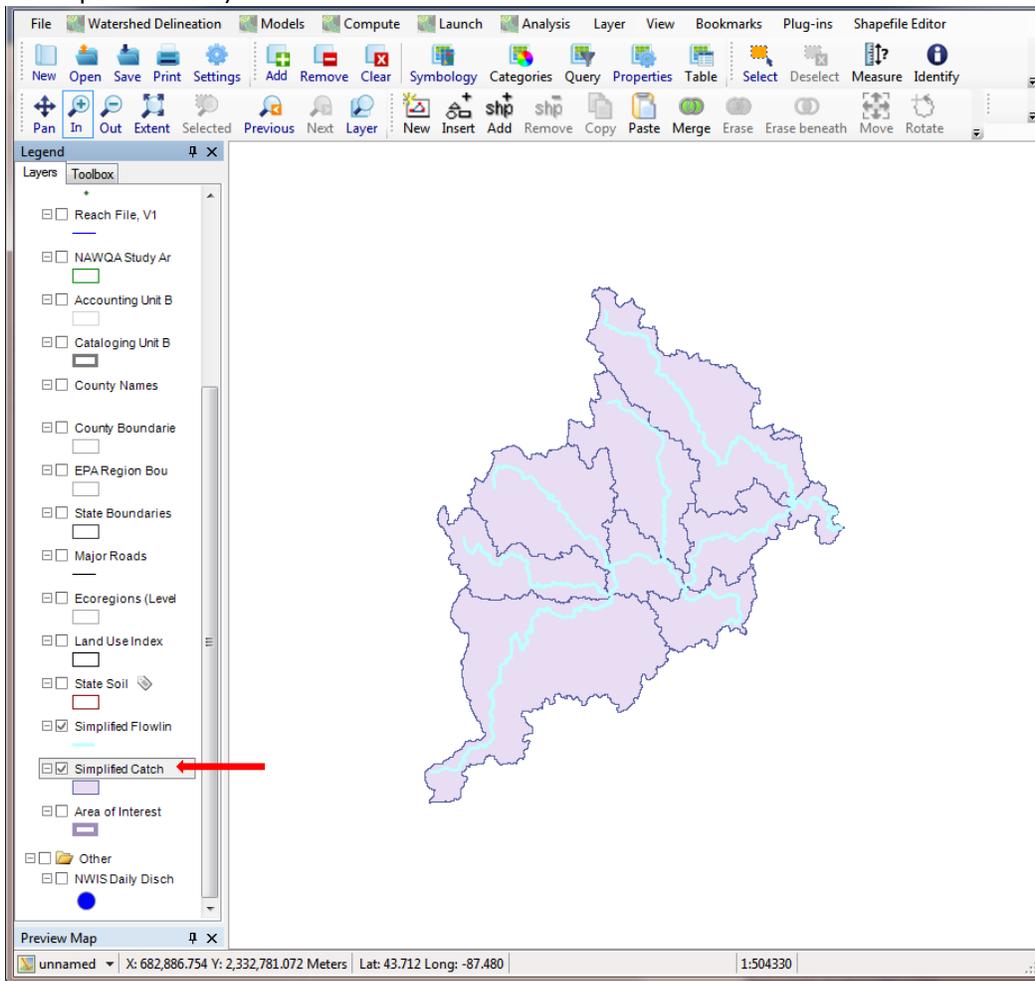


LABEL SUBWATERSHED WITH AN IDENTIFICATION NUMBER

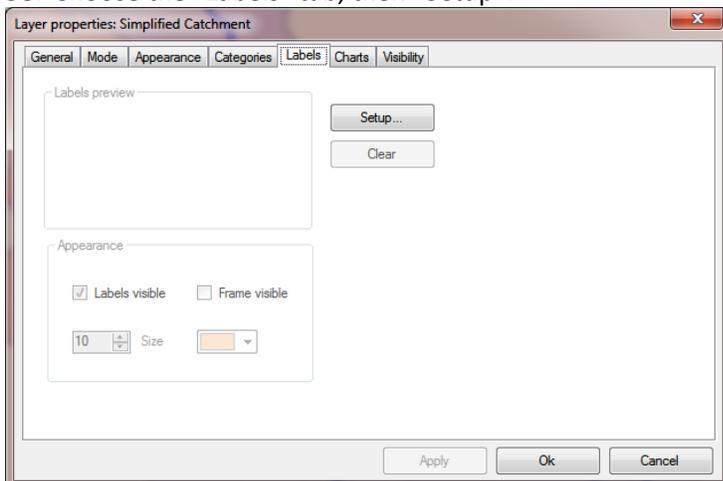
56. Unclick the Septic and “Animals” map layers on the left side of the screen, which simplifies the screen.



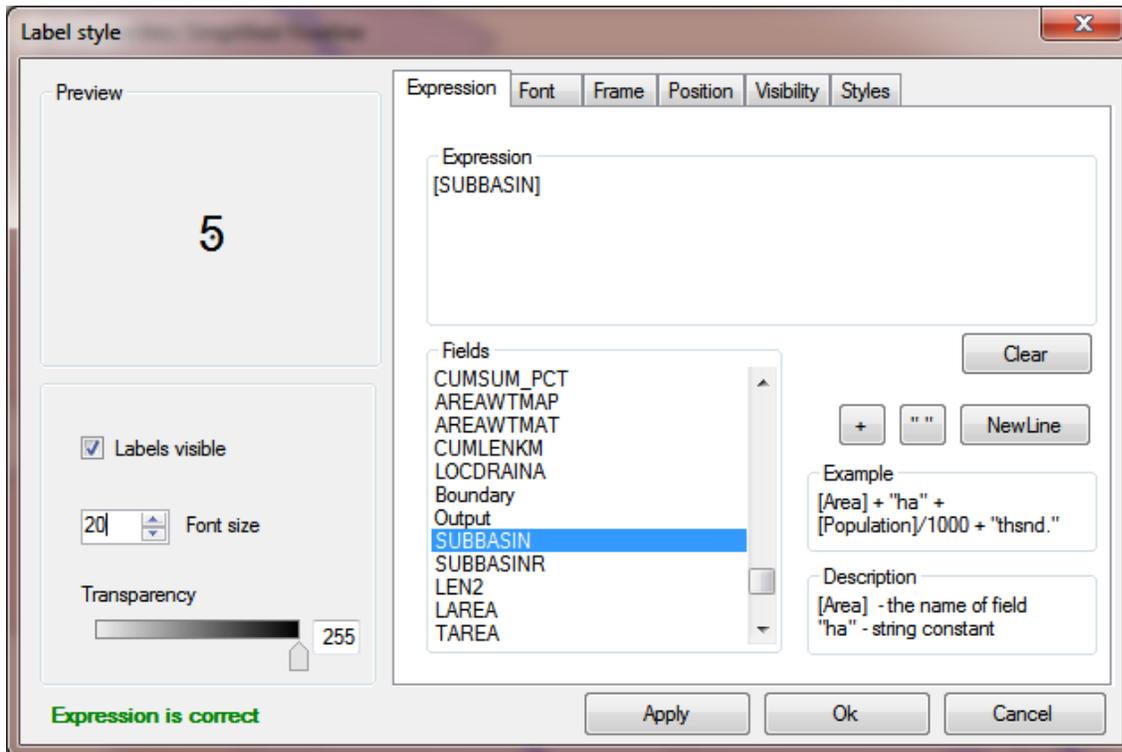
57. To label subwatersheds with an identification number, so they match the numbering scheme in the HSPF workflow, double-click on the map layer “Simplified Catchment” (the red arrow in the screen capture below):



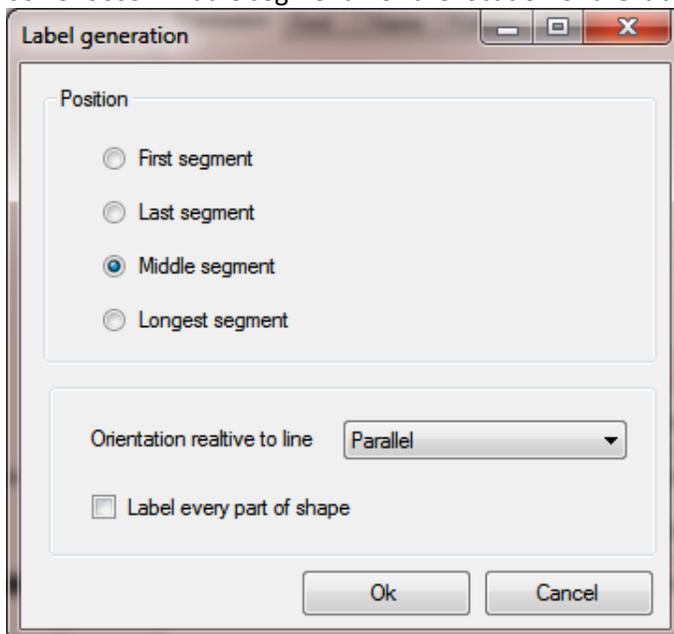
58. Choose the “Labels” tab, then “Setup”:



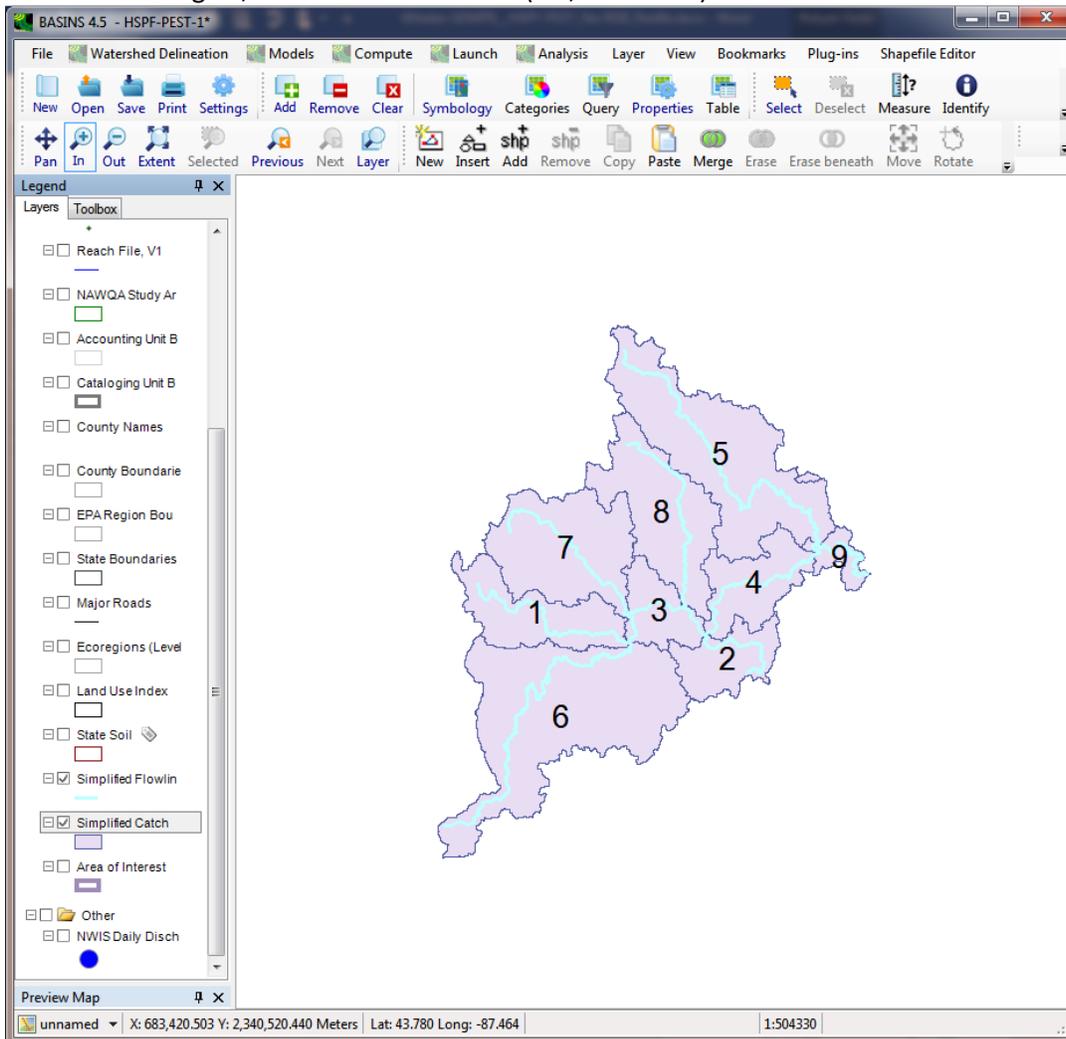
59. Under “Expression”,
- choose “SUBBASIN” under “Fields”
 - change the Font size to 20.
 - click “Ok”



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

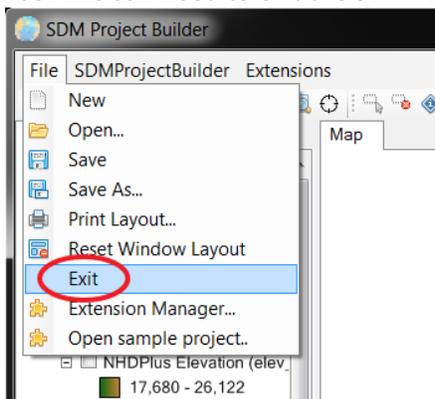


61. Click “Ok” again, and the subwatershds (i.e., subbasins) are labeled.



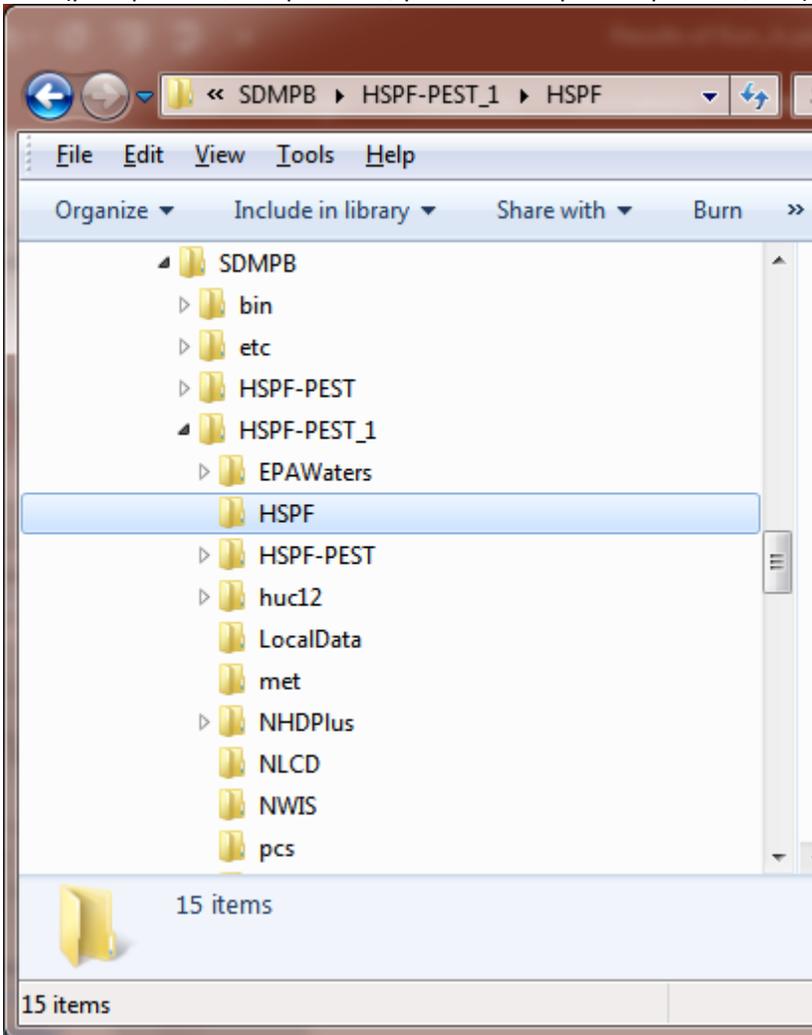
62. Click “File>Save”, then “File>Exit”.

63. We still need to exit the SDMPB, so exit the SDMPB by selecting “File>Exit”.



In this example, HSPF input files can be found in “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF”. Three input files are required for HSPF modeling:

1. 04030101.uci: The User Control Input File, a flat file that contains all non-time series data, including model parameters.
2. 04030101.wdm: The binary Watershed Data Management file that captures modeling flow results such as time series of flow calculation
3. met.wdm: The binary Watershed Data Management file that contains meteorological data (precipitation, temperature, potential evapotranspiration, etc.) for HSPF modeling.



The microbial loading rates published in the HSPF *.uci file will need to be updated; these vary by land-use type and subwatershed.

MODIFY MICROBIAL LOADING RATES IN THE HSPF *.UCI FILE

HSPF considers up to nine land-use types. For this application only four land-use types will be populated with microbial loading rates in the example. This section describes how the user can modify the microbial loading rates to land-use types.

Identify Microbial Loading Rates in the HSPF *.uci File which need to be Set Equal to Zero

The Microbial Source Module (MSM) estimates microbial loading rates to four land-use types: Urbanized/Built, Forest, Cropland, and Pasture. The SDMPB retrieves these estimates and automatically pre-populates the HSPF input *.uci file with microbial loading rates in Cells/ac/d. [Note: The UCI file writes the units as “Lbs/ac.d”.] These rates are published for nine HSPF-designated land-use types:

- Water/Wetlands
- Urban
- Barren or Mining
- Forest
- Upland Shrub Land
- Agriculture – Cropla
- Grass Land
- Agriculture – Pastur
- Traditional

where Urban, Forest, Agriculture – Cropla, and Agriculture – Pastur correspond to Urbanized/Built, Forest, Cropland, and Pasture, respectively, in the MSM documentation ([Whelan et al., 2017i](#)). The remaining land-use types are pre-populated with loading rates that represent holding places and at levels significantly smaller than those associated with Urban, Forest, Cropland, and Pasture.

This section describes the process for modifying microbial loading rates in the HSPF *.uci file by using a text editor or the HSPF user interface. In this example, microbial loading rates will be zeroed-out for the following five land-use types while leaving the others (Urban, Forest, Cropland, and Pasture) unchanged:

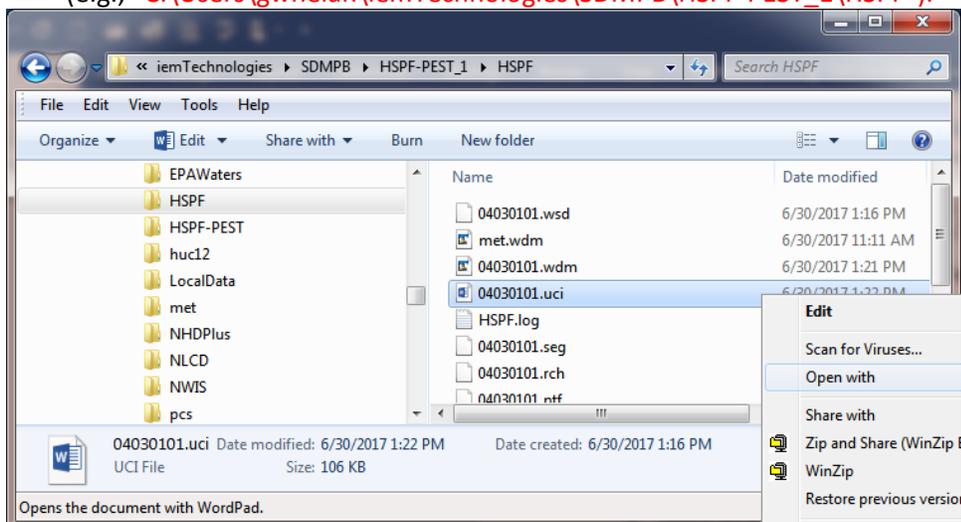
- Water/Wetlands
- Barren or Mining
- Upland Shrub Land
- Grass Land
- Traditional

Two different procedures for zeroing out microbial loading rates are discussed, of which only one should be implemented:

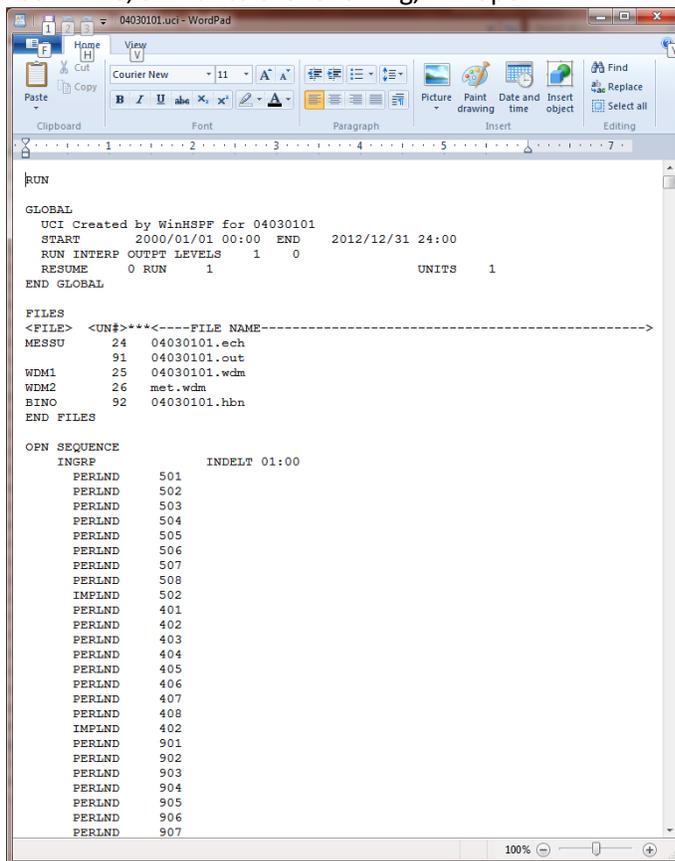
- Modify Microbial Loading Rates in the HSPF *.uci File by Using a Text Editor
- Modify Microbial Loading Rates in the HSPF *.uci File by Using the HSPF User Interface

Modify Microbial Loading Rates in the HSPF *.uci File by Using a Text Editor

64. Using a text editor (e.g., WordPad), open the *.uci file, in this case “04030101.uci”, located in the working folder: <...\\HSPF\\ (e.g., “C:\\Users\\gwhelan\\iemTechnologies\\SDMPB\\HSPF-PEST_1\\HSPF”).

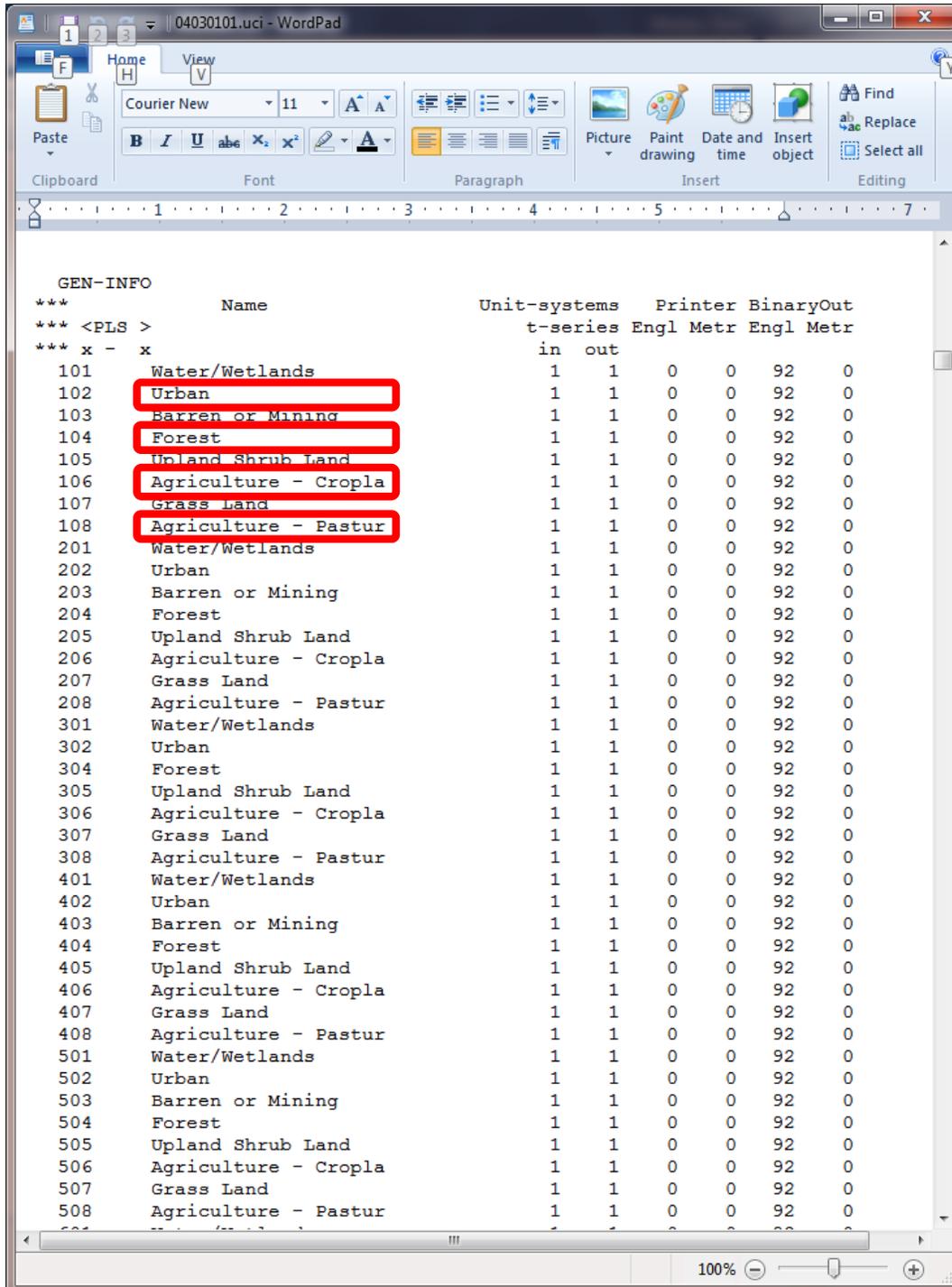


65. A file, similar to the following, will open:



Identify Land-use Types by Subwatershed

66. To identify which land-use types are associated with which subwatersheds (or subbasins), scroll down to the “GEN-INFO” section.

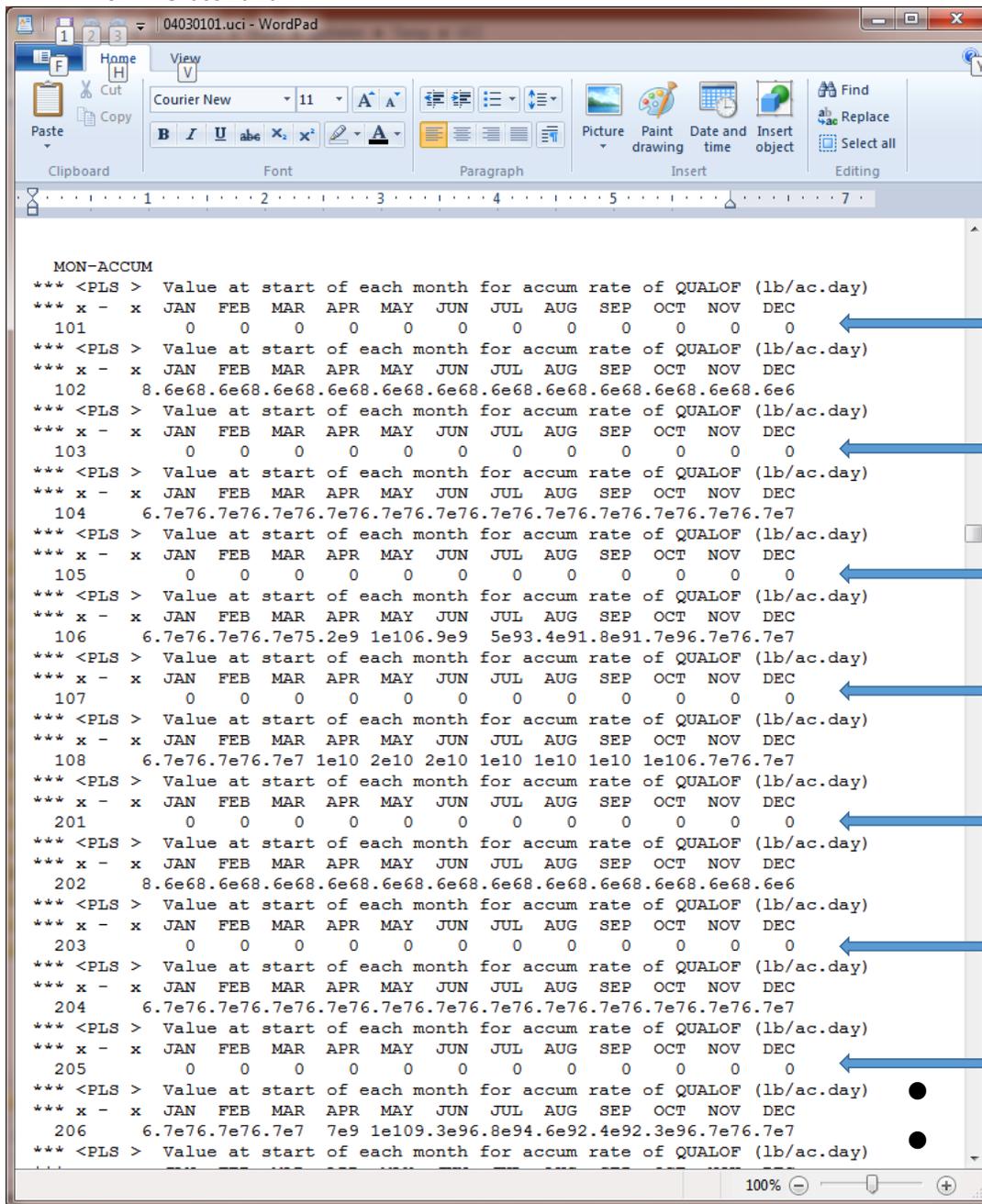


GEN-INFO							
***	Name	Unit-systems		Printer	BinaryOut		
***	<PLS >	t-series	Engl	Metr	Engl	Metr	
***	x - x	in	out				
101	Water/Wetlands	1	1	0	0	92	0
102	Urban	1	1	0	0	92	0
103	Barren or Mining	1	1	0	0	92	0
104	Forest	1	1	0	0	92	0
105	Upland Shrub Land	1	1	0	0	92	0
106	Agriculture - Cropla	1	1	0	0	92	0
107	Grass Land	1	1	0	0	92	0
108	Agriculture - Pastur	1	1	0	0	92	0
201	Water/Wetlands	1	1	0	0	92	0
202	Urban	1	1	0	0	92	0
203	Barren or Mining	1	1	0	0	92	0
204	Forest	1	1	0	0	92	0
205	Upland Shrub Land	1	1	0	0	92	0
206	Agriculture - Cropla	1	1	0	0	92	0
207	Grass Land	1	1	0	0	92	0
208	Agriculture - Pastur	1	1	0	0	92	0
301	Water/Wetlands	1	1	0	0	92	0
302	Urban	1	1	0	0	92	0
304	Forest	1	1	0	0	92	0
305	Upland Shrub Land	1	1	0	0	92	0
306	Agriculture - Cropla	1	1	0	0	92	0
307	Grass Land	1	1	0	0	92	0
308	Agriculture - Pastur	1	1	0	0	92	0
401	Water/Wetlands	1	1	0	0	92	0
402	Urban	1	1	0	0	92	0
403	Barren or Mining	1	1	0	0	92	0
404	Forest	1	1	0	0	92	0
405	Upland Shrub Land	1	1	0	0	92	0
406	Agriculture - Cropla	1	1	0	0	92	0
407	Grass Land	1	1	0	0	92	0
408	Agriculture - Pastur	1	1	0	0	92	0
501	Water/Wetlands	1	1	0	0	92	0
502	Urban	1	1	0	0	92	0
503	Barren or Mining	1	1	0	0	92	0
504	Forest	1	1	0	0	92	0
505	Upland Shrub Land	1	1	0	0	92	0
506	Agriculture - Cropla	1	1	0	0	92	0
507	Grass Land	1	1	0	0	92	0
508	Agriculture - Pastur	1	1	0	0	92	0

The first subwatershed with its eight land-use types have been highlighted. The arrows represent the rows in the first subwatershed that need to be zeroed out. Obviously, this is repeated for each subwatershed.

68. Zero out those rows that are represented by the following land-use types:

- x01 Water/Wetlands
- x03 Barren or Mining
- x05 Upland Shrub Land
- x07 Grass Land

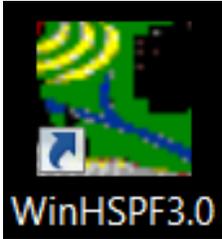


There is no “Traditional” land-use type in the file.

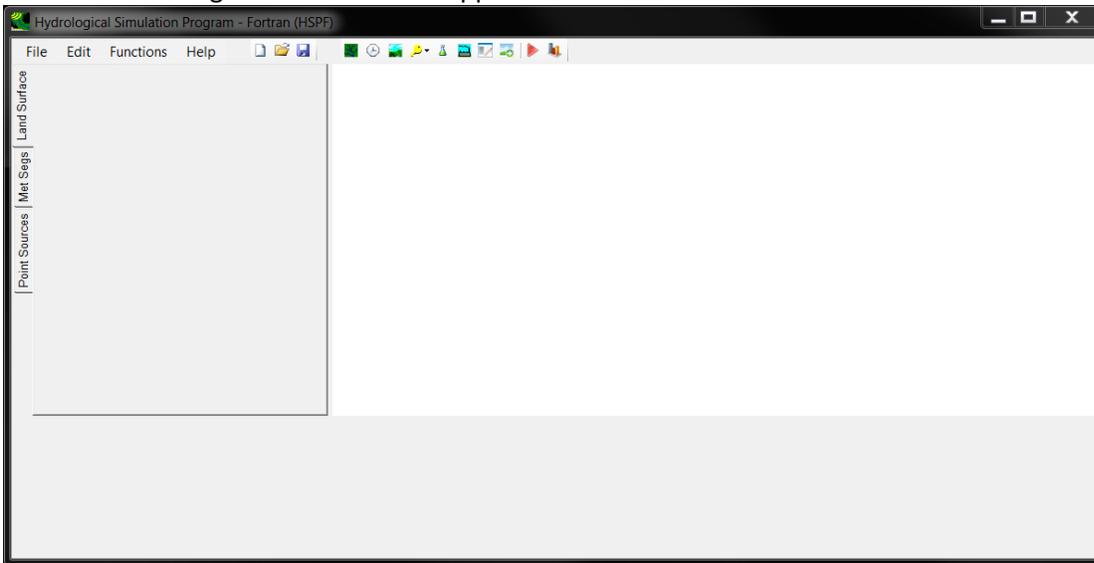
69. Save the file and exit.

Modify Microbial Loading Rates in the HSPF *.uci File by Using the HSPF User Interface

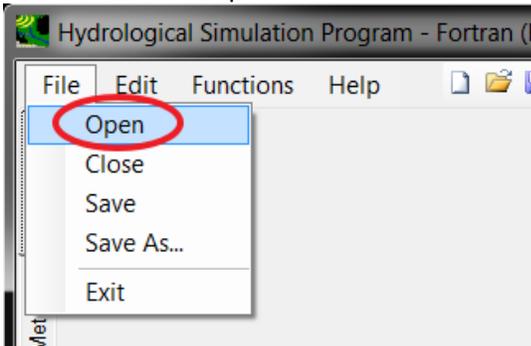
70. Open WinHSPF by double-clicking (left) on the icon to execute WinHSPF3.0. If the icon cannot be found on the Desktop screen, locate the executables on the hard drive (WinHSPF.exe), typically in <...\\BASINS45\\models\\WinHSPF30\\bin\\>.



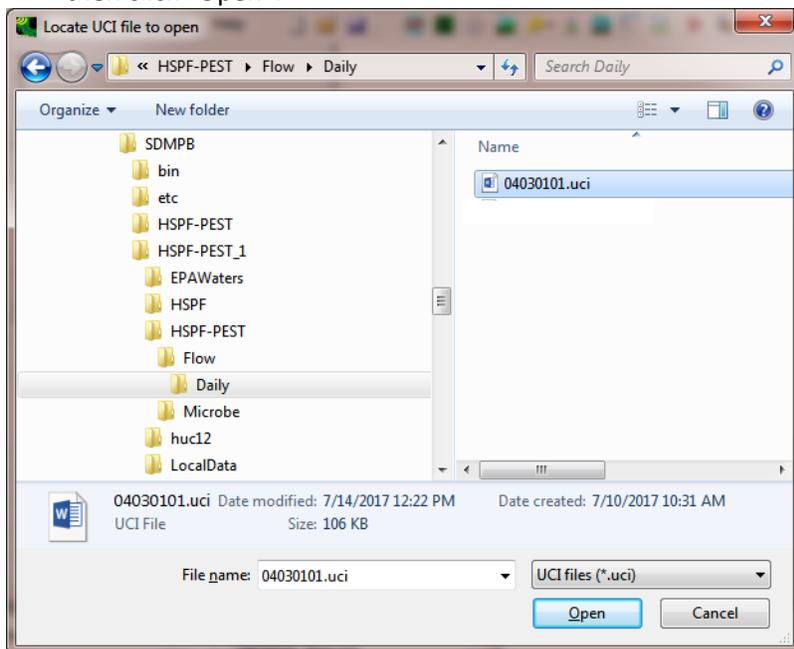
71. The following WinHSPF window appears.



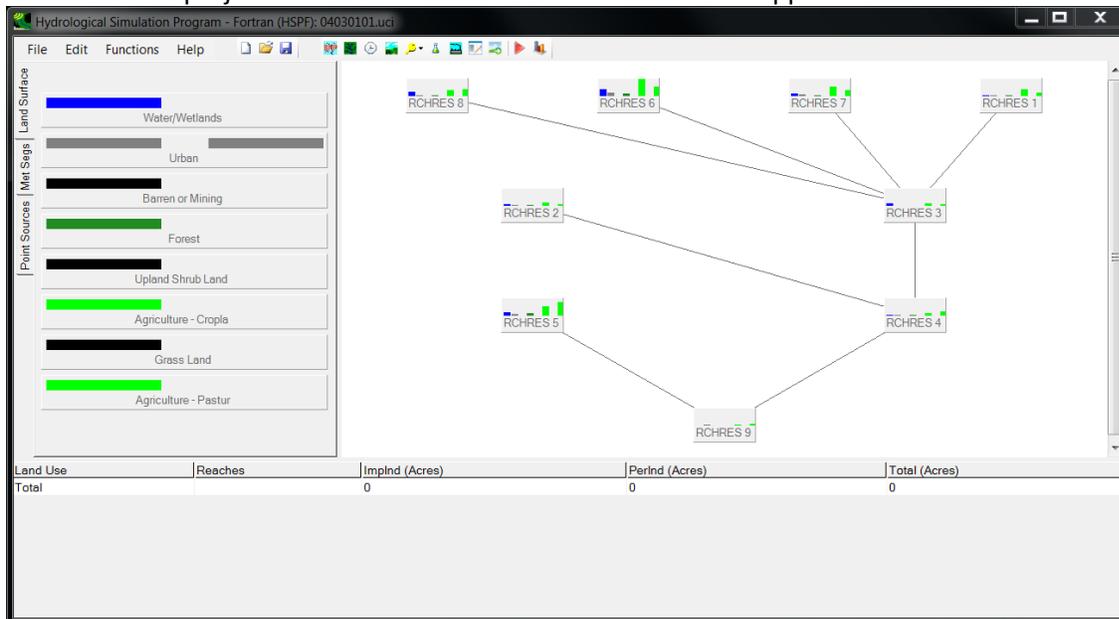
72. Select “File>Open”.



73. The following window appears. Browse to the *.uci folder. In this example, it can be found at “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily\04030101.uci”, then click “Open”.

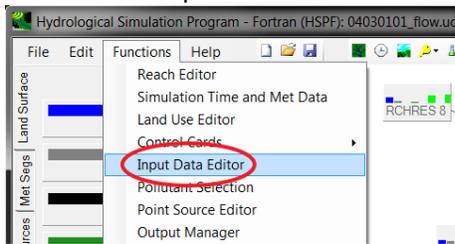


74. The HSPF project workflow for the Manitowoc River Basin appears.



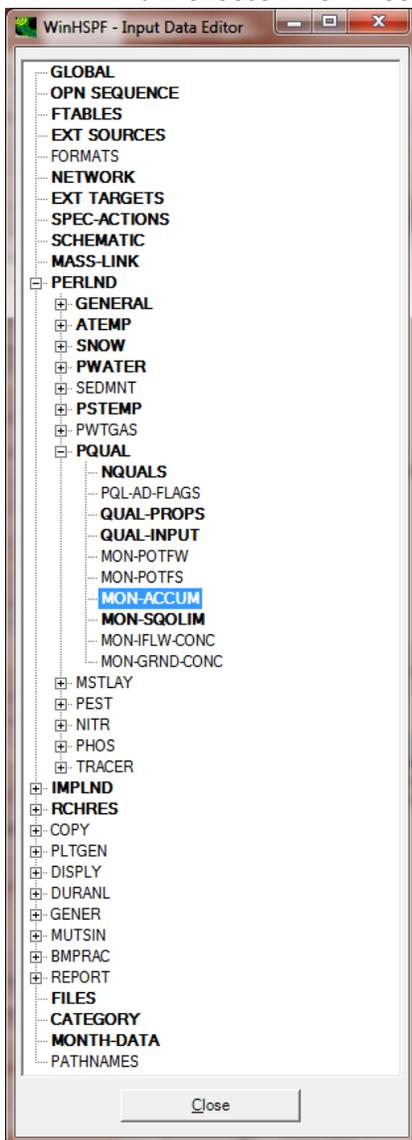
The user may want to copy the original UCI file and save it someplace safe, in case an unforeseen accident occurs with the one being edited.

75. Select “Functions>Input Data Editor” or click  in the tool bar to view the calibrated HSPF microbial parameters.



76. The following “Input Data Editor” window appears. Only bolded sections have records in the UCI file. For example, “FORMATS” does not contain data, but “FTABLES” does.

- a. Expand “PERLND” by clicking “+” at the left and “PQUAL”.
- b. Choose “MON-ACCUM”.



77. The screen containing the parameter values of "ACQOP" ("MON-ACCUM") appear.

OnNum	Description	QUAJAN	QUAFEB	QUAMAR	QUAAPR	QUAMAY	QUAJUN	QUAIII	QUAALIG	QUASEP	QUAOCT	QUANOV	QUADec
101	Water/Wetlands	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
102	Urban	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6							
103	Barren or Mining	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
104	Forest	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7							
105	Upland Shrub Land	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
106	Agriculture - Cropla	6.7e7	6.7e7	6.7e7	5.2e9	1E+10	6.9e9	5E+09	3.4e9	1.8e9	1.7e9	6.7e7	6.7e7
107	Grass Land	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
108	Agriculture - Pastur	6.7e7	6.7e7	6.7e7	1E+10	2E+10	2E+10	1E+10	1E+10	1E+10	1E+10	6.7e7	6.7e7

Table: MON-ACCUM, Monthly values of accumulation rate of QUALOF at start of each month. This table is only required if VQOFG in Table-type QUAL-PROPS is 1. This table should be repeated for each quality constituent.

*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
 *** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

The first subwatershed (i.e., 1xx) with its eight land-use types (e.g., 101, 102, 103, ..., 108) have been circled in red. Example rows needing to be zeroed-out are x01, x03, x05, and x07, where the example arrows are shown.

78. Zeroed-out rows designated by x01, x03, x05, and x07, of which the first subwatershed is circled in red.

OpNum	Description	QUAJAN	QUAFEB	QUAMAR	QUAAPR	QUAMAY	QUAJUN	QUAJUL	QUAUG	QUASEP	QUAOCT	QUANOV	QUADEC
101	Water/Wetlands	0	0	0	0	0	0	0	0	0	0	0	0
102	Urban	8.6e6											
103	Barren or Mining	0	0	0	0	0	0	0	0	0	0	0	0
104	Forest	6.7e7											
105	Upland Shrub Land	0	0	0	0	0	0	0	0	0	0	0	0
106	Agriculture - Cropla	6.7e7	6.7e7	6.7e7	5.2e9	1E+10	6.9e9	5E+09	3.4e9	1.8e9	1.7e9	6.7e7	6.7e7
107	Grass Land	0	0	0	0	0	0	0	0	0	0	0	0
108	Agriculture - Pastur	6.7e7	6.7e7	6.7e7	1E+10	2E+10	2E+10	1E+10	1E+10	1E+10	1E+10	6.7e7	6.7e7
201	Water/Wetlands	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
202	Urban	8.6e6											
203	Barren or Mining	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
204	Forest	6.7e7											
205	Upland Shrub Land	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
206	Agriculture - Cropla	6.7e7	6.7e7	6.7e7	7E+09	1E+10	9.3e9	6.8e9	4.6e9	2.4e9	2.3e9	6.7e7	6.7e7
207	Grass Land	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
208	Agriculture - Pastur	6.7e7	6.7e7	6.7e7	2E+10	3E+10	2E+10	2E+10	2E+10	2E+10	2E+10	6.7e7	6.7e7
301	Water/Wetlands	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
302	Urban	8.6e6											
304	Forest	6.7e7											
305	Upland Shrub Land	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
306	Agriculture - Cropla	6.7e7	6.7e7	6.7e7	1.8e9	3.3e9	2.3e9	1.7e9	1.2e9	6.3e8	6.1e8	6.7e7	6.7e7
307	Grass Land	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
308	Agriculture - Pastur	6.7e7	6.7e7	6.7e7	3.5e9	4.8e9	3.8e9	3.2e9	2.8e9	2.5e9	2.5e9	6.7e7	6.7e7
401	Water/Wetlands	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
402	Urban	8.6e6											
403	Barren or Mining	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
404	Forest	6.7e7											
405	Upland Shrub Land	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
406	Agriculture - Cropla	6.7e7	6.7e7	6.7e7	5.4e9	1E+10	7.2e9	5.2e9	3.5e9	1.8e9	1.8e9	6.7e7	6.7e7
407	Grass Land	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000
408	Agriculture - Pastur	6.7e7	6.7e7	6.7e7	8.9e9	1E+10	9.9e9	8.3e9	6.9e9	5.9e9	5.9e9	6.7e7	6.7e7
501	Water/Wetlands	10000	10000	10000	100000	100000	100000	100000	100000	100000	10000	10000	10000

Table: MON-ACCUM, Monthly values of accumulation rate of QUALOF at start of each month. This table is only required if VQOFG in Table-type QUAL-PROPS is 1. This table should be repeated for each quality constituent.
 Parameter:
 *** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
 *** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

79. When all appropriate rows have been zeroed-out, the screen will look like the following:

OpNum	Description	QUAJAN	QUAFEB	QUAMAR	QUAAPR	QUAMAY	QUAJUN	QUAJUL	QUAUG								
101	Water/Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102	Urban	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6						
103	Barren or Mining	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
104	Forest	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7						
105	Upland Shrub Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
106	Agriculture - Cropla	6.7e7	6.7e7	6.7e7	5.2e9	1E+10	6.9e9	5E+09	3.4e9	1.8e9	1.7e9	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7
107	Grass Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
108	Agriculture - Pastur	6.7e7	6.7e7	6.7e7	1E+10	2E+10	2E+10	1E+10	1E+10	1E+10	1E+10	1E+10	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7
201	Water/Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
202	Urban	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6						
203	Barren or Mining	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
204	Forest	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7						
205	Upland Shrub Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
206	Agriculture - Cropla	6.7e7	6.7e7	6.7e7	7E+09	1E+10	9.3e9	6.8e9	4.6e9	2.4e9	2.3e9	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7
207	Grass Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
208	Agriculture - Pastur	6.7e7	6.7e7	6.7e7	2E+10	3E+10	2E+10	2E+10	2E+10	2E+10	2E+10	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7
301	Water/Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
302	Urban	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6						
304	Forest	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7						
305	Upland Shrub Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
306	Agriculture - Cropla	6.7e7	6.7e7	6.7e7	1.8e9	3.3e9	2.3e9	1.7e9	1.2e9	6.3e8	6.1e8	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7
307	Grass Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
308	Agriculture - Pastur	6.7e7	6.7e7	6.7e7	3.5e9	4.8e9	3.8e9	3.2e9	2.8e9	2.5e9	2.5e9	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7
401	Water/Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
402	Urban	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6						
403	Barren or Mining	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
404	Forest	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7						
405	Upland Shrub Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
406	Agriculture - Cropla	6.7e7	6.7e7	6.7e7	5.4e9	1E+10	7.2e9	5.2e9	3.5e9	1.8e9	1.8e9	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7
407	Grass Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
408	Agriculture - Pastur	6.7e7	6.7e7	6.7e7	8.9e9	1E+10	9.9e9	8.3e9	6.9e9	5.9e9	5.9e9	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7
501	Water/Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
502	Urban	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6	8.6e6						
503	Barren or Mining	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
504	Forest	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7						
505	Upland Shrub Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
506	Agriculture - Cropla	6.7e7	6.7e7	6.7e7	4.4e9	8.5e9	5.9e9	4.3e9	2.9e9	1.5e9	1.5e9	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7	6.7e7
507	Grass Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table: MON-ACCUM, Monthly values of accumulation rate of QUALOF at start of each month. This table is only required if VQOPG in Table-type QUAL-PROPS is 1. This table should be repeated for each quality constituent.

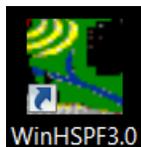
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
 *** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

80. Click "Apply", then "Ok".

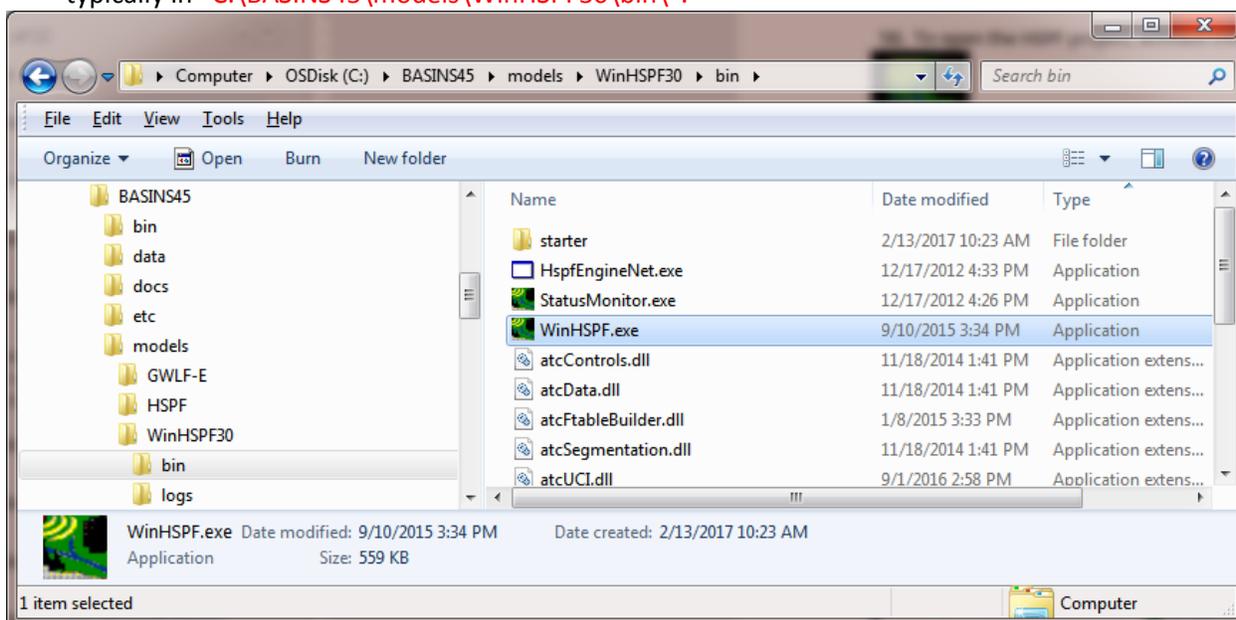
81. Click "File>Save", then "File>Exit".

EXECUTING HSPF

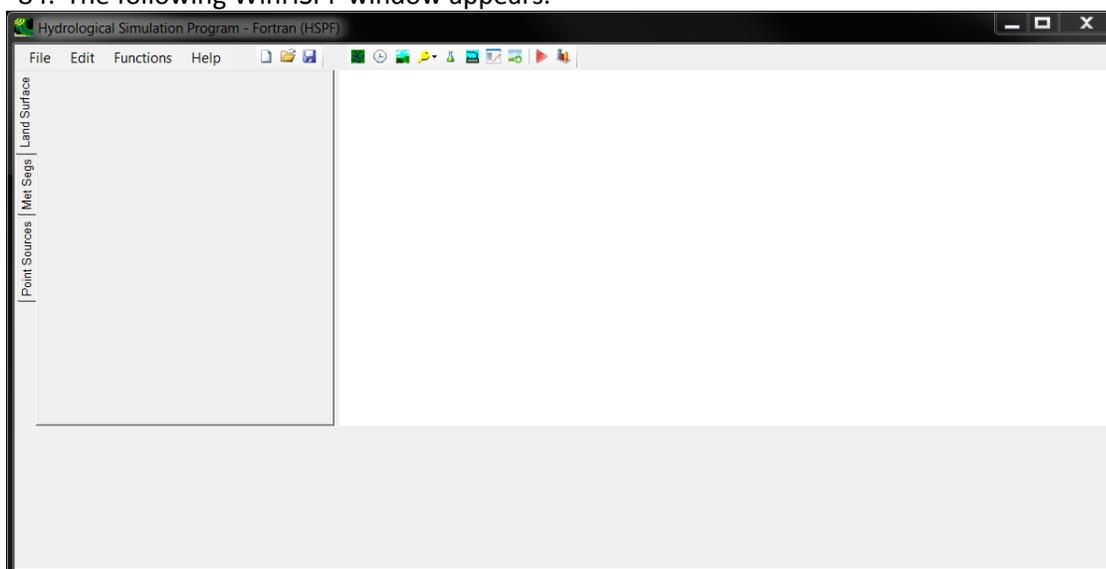
82. If HSPF is not open, activate the WinHSPF3.0 icon on the Windows desktop:



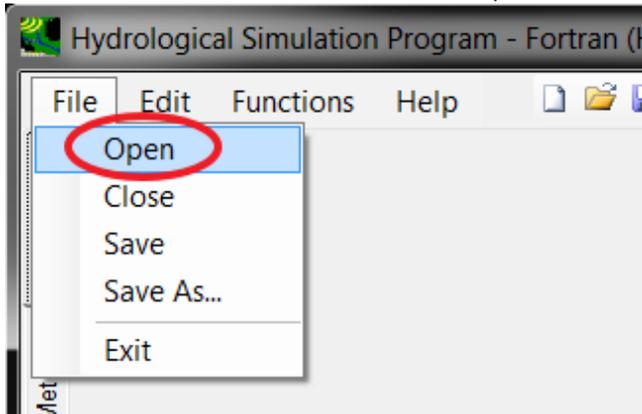
83. If the icon cannot be found on the Desktop, locate the executable on the hard drive (WinHSPF.exe), typically in **"C:\BASINS45\models\WinHSPF30\bin\"**.



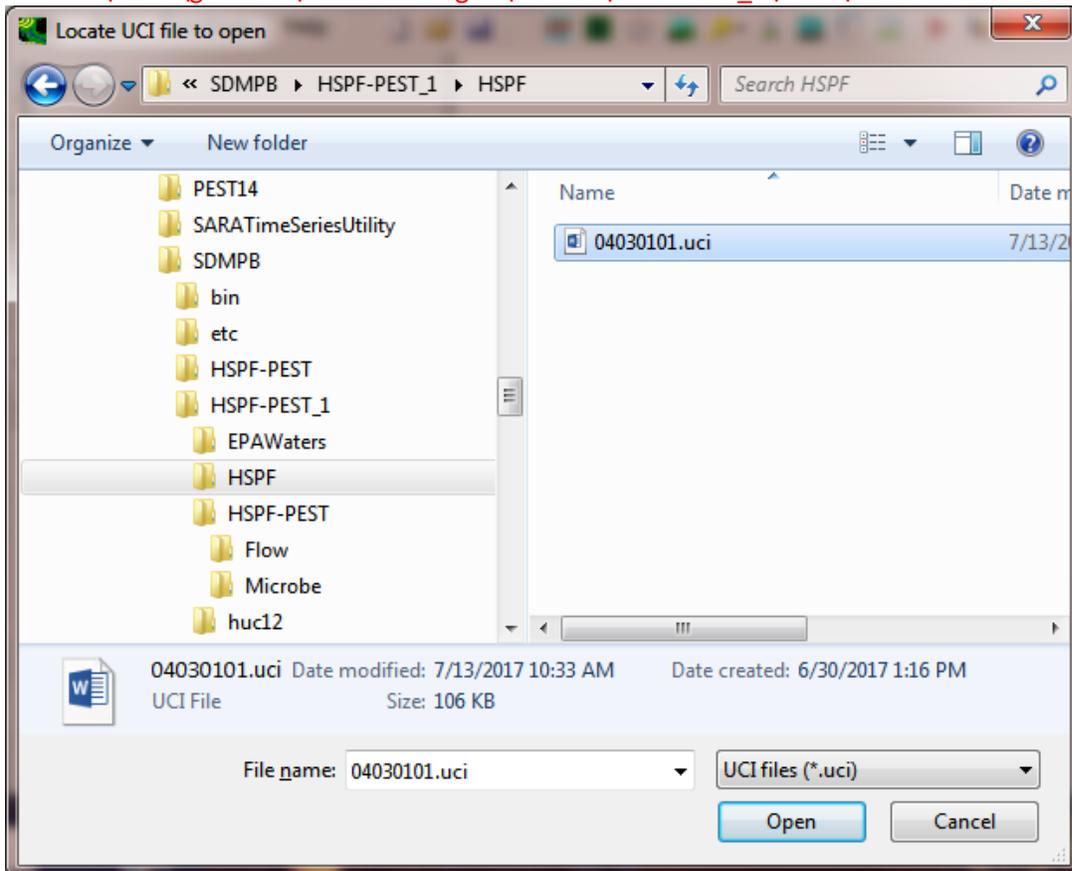
84. The following WinHSPF window appears.



85. In the window below, select “File>Open”.

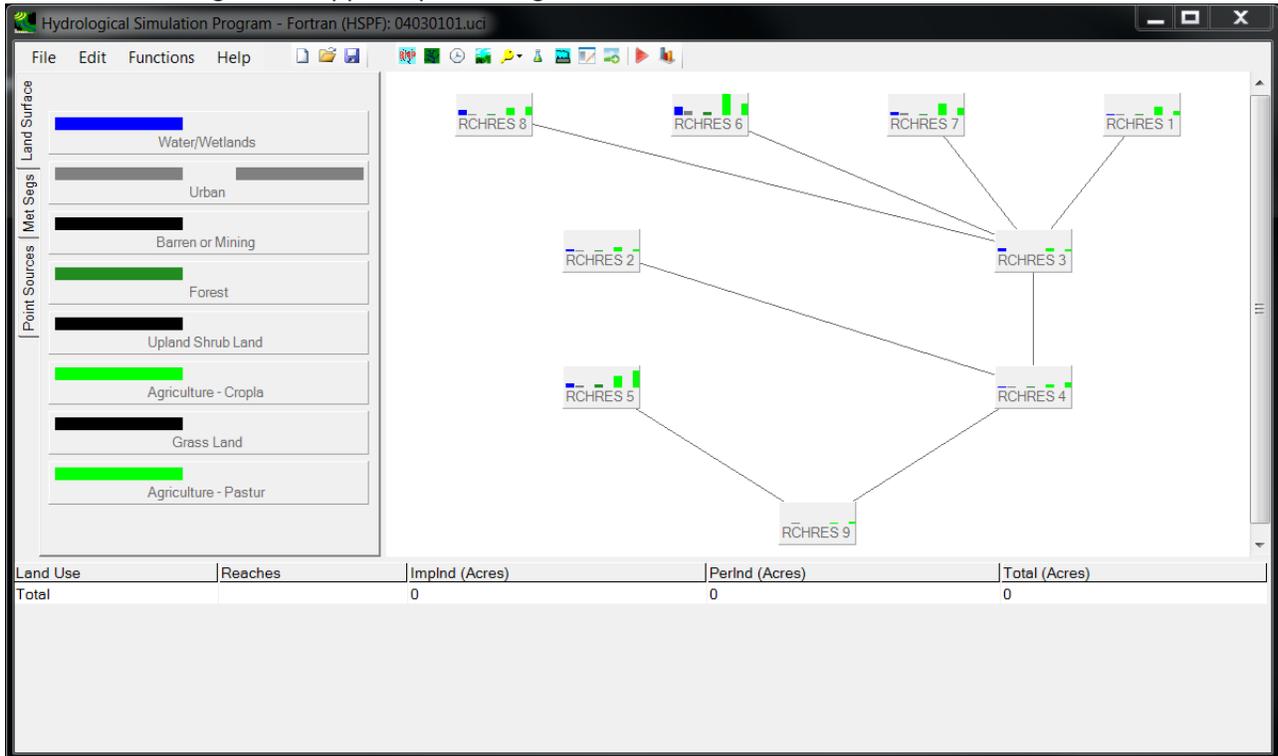


86. The following window appears. Browse “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF\04030101.uci” and click “Open”.

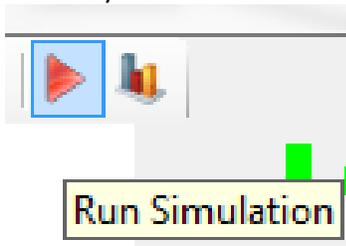


The HSPF project on Manitowoc River Basin will appear in the HSPF GUI, with the workflow schematic shown below. The WinHSPF UI shows linkage of subwatersheds, proportion of land use type in each subwatershed, etc. Details about WinHSPF UI can be found in the WinHSPF Manual, typically in “...\BASINS45\docs\WinHspf30.chm”.

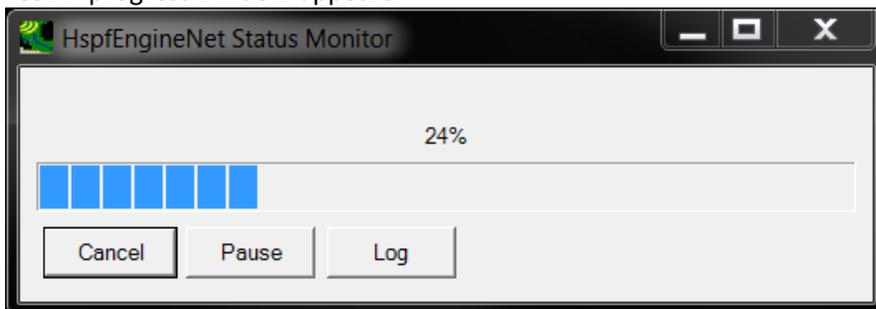
87. The following screen appears presenting the basin workflow.



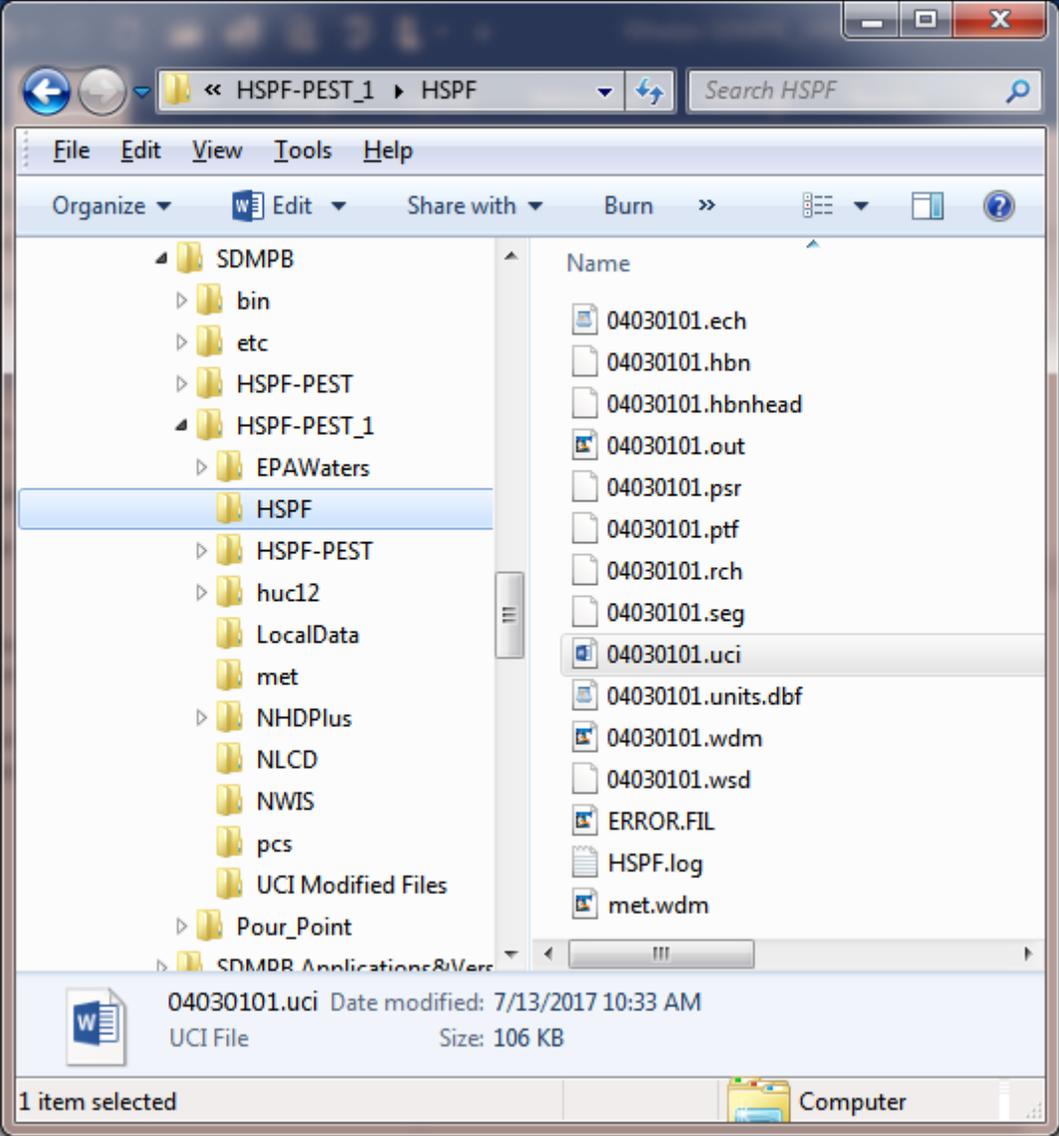
88. To run the HSPF simulation, click the “Run Simulation” icon. Save the HSPF project by clicking “File”, then “Save” on the main menu bar. Leave the HSPF workflow schematic screen open, since you may want to refer to it while operating in the BASINS interface.



89. A progress window appears.



90. When the simulation finishes, the progress window will disappear, and you will find output files in the working folder, similar to the following.

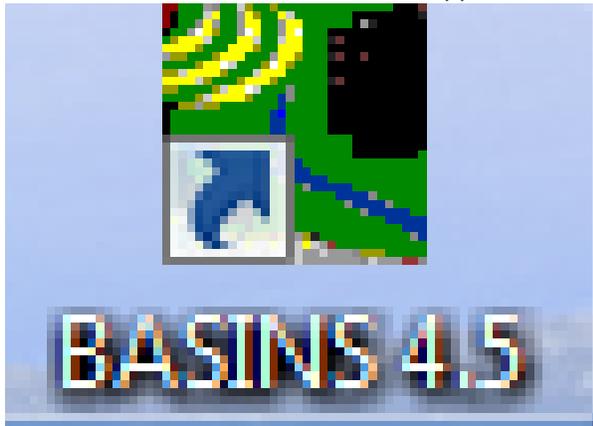


SECTION 2 CALIBRATING FLOW-RELATED PARAMETERS

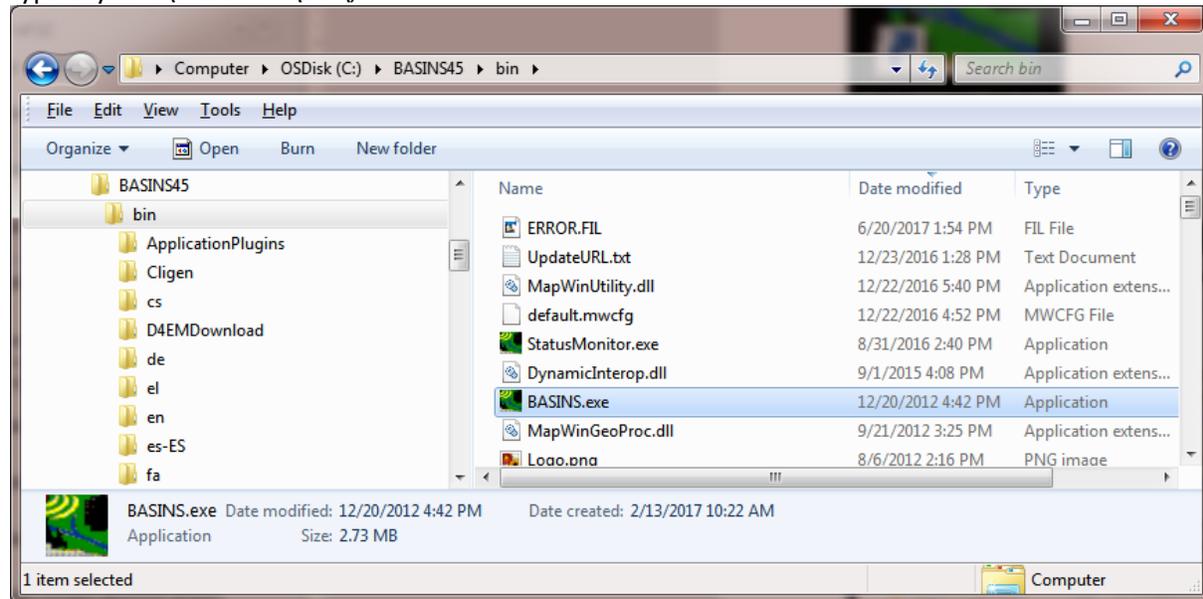
DOWNLOADING AND EXPORTING A TIME SERIES OF FLOW OBSERVATIONS

For flow-related parameter calibration, observed discharge data are required. This section describes discovery, access, and retrieval of observed discharges associated with the USGS gaging station near the pour point of the Manitowoc River basin. BASINS will be used initially to download a time series of flow observations and export those data in a form consistent with input requirements of PEST.

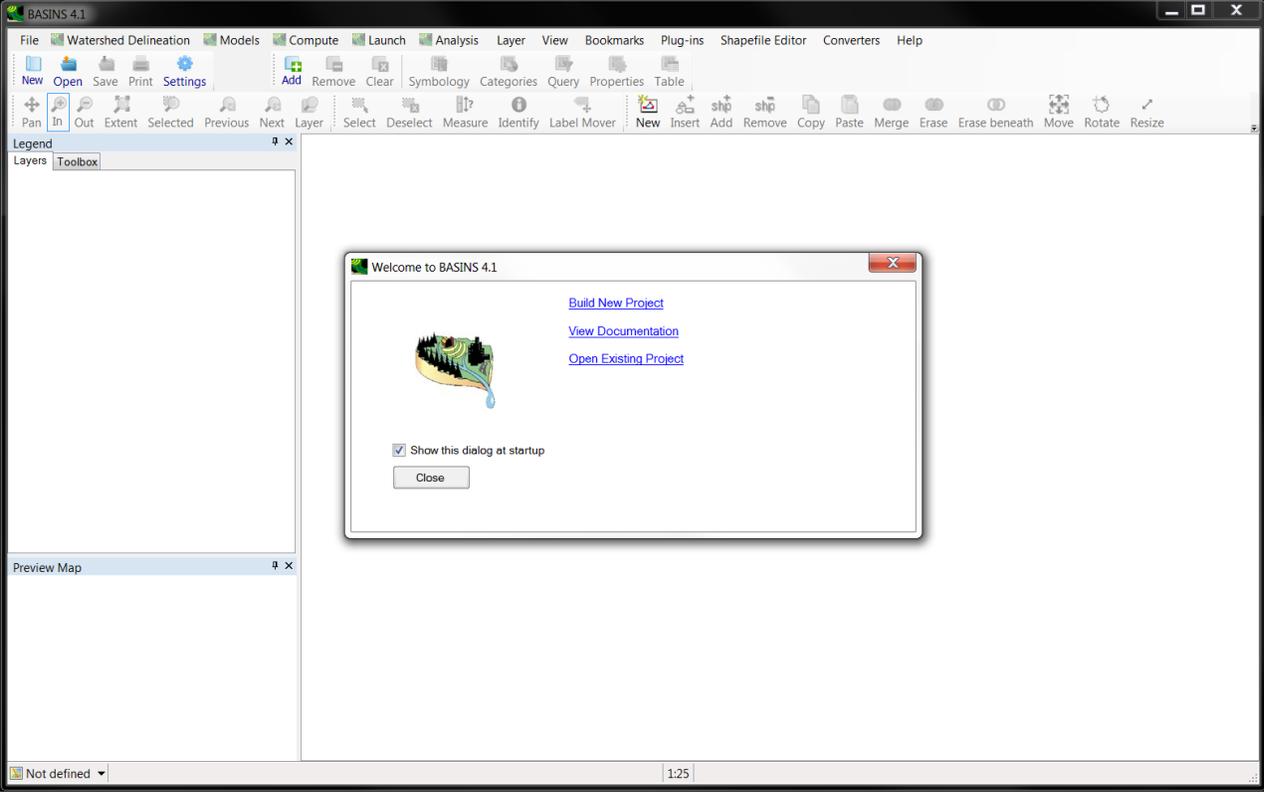
91. A BASINS shortcut icon should appear on the computer's desktop.



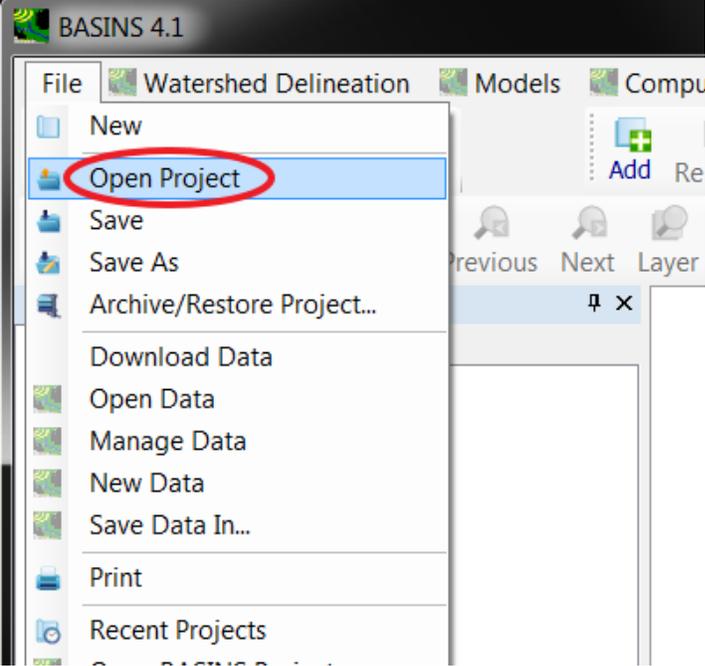
If the icon cannot be found on the Desktop, locate the executable ("BASINS.exe") on the hard drive, typically in ...\\BASINS45\\bin\\, as illustrated below.



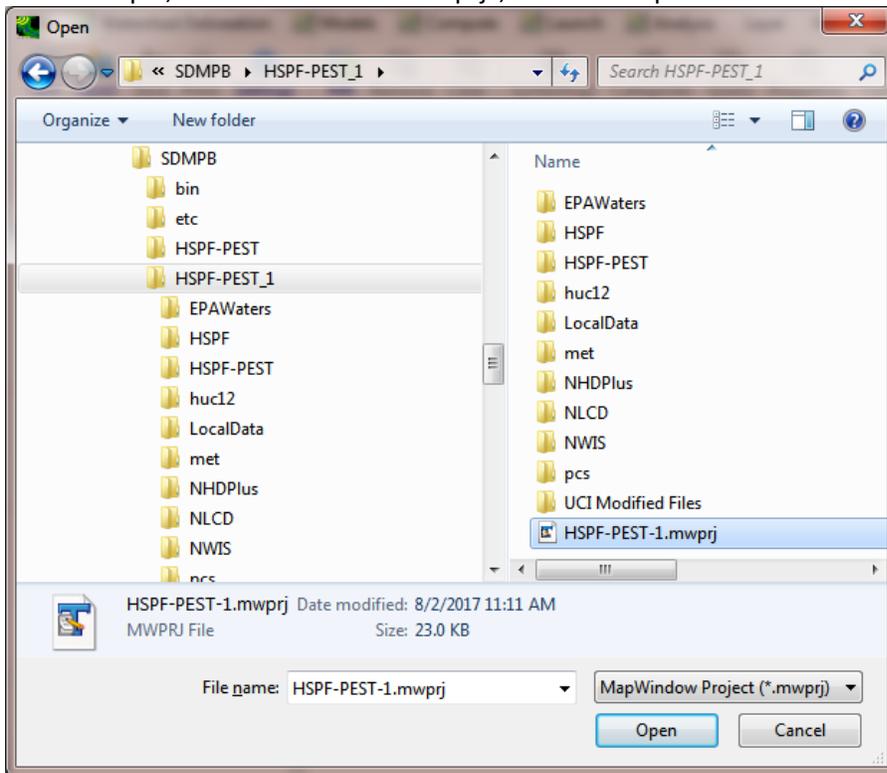
92. Double-click left on the icon to execute BASINS. The User Interface (UI) of BASINS appears. Click “Close” on the “Welcome to BASINS 4.1” window, even though BASINS4.5 is being executed.



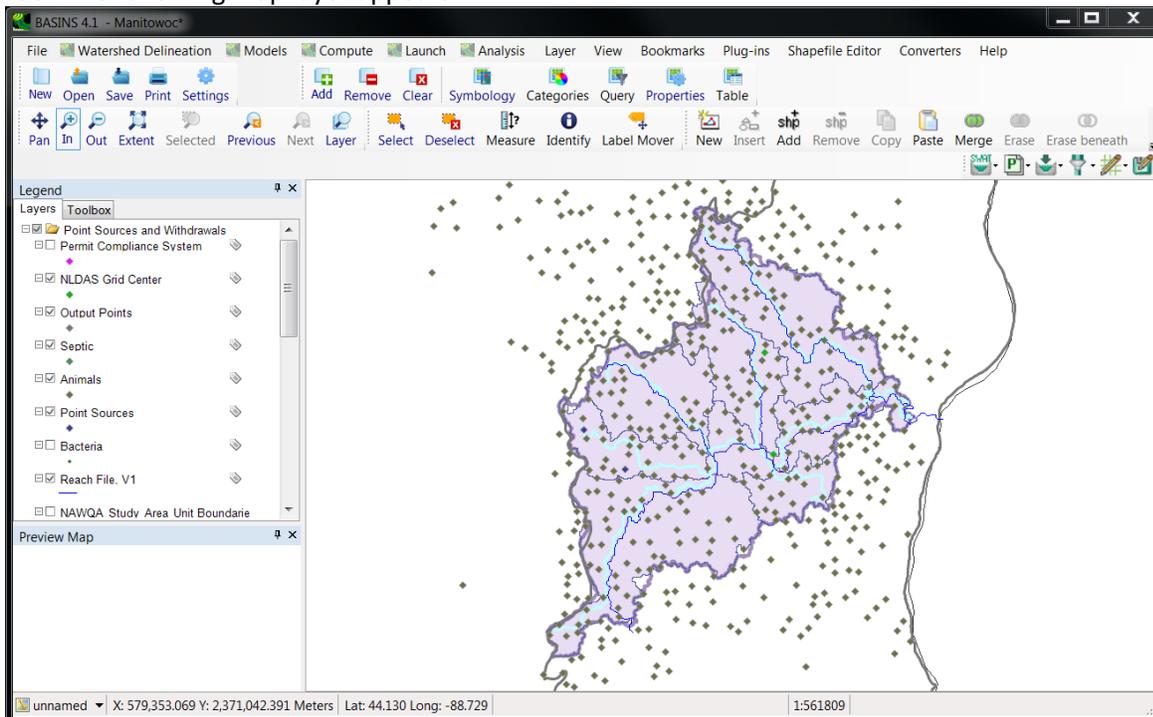
93. On the menu bar, select “File>Open Project”.



94. To open your Mapwindow project file (in this case, “Manitowoc.mwprj”), which was created by SDMPB and is located “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\” in this example, select “Manitowoc.mwprj”, and click “Open”.

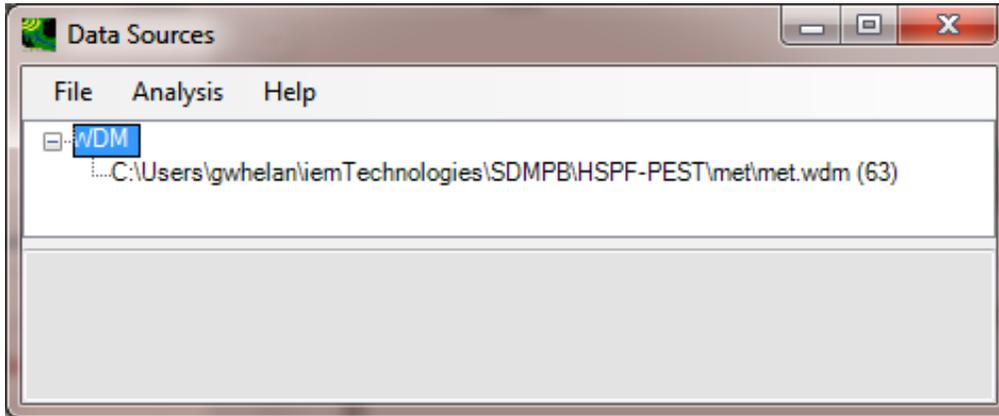


95. The following map layer appears.

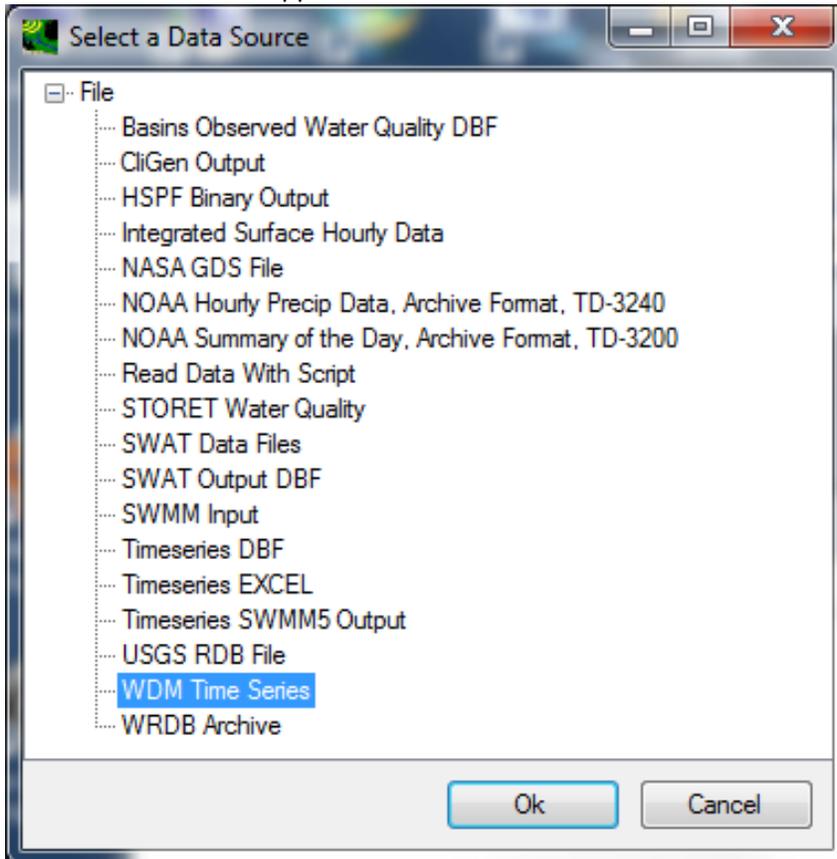


Register Simulation Results for the Manitowoc River Basin

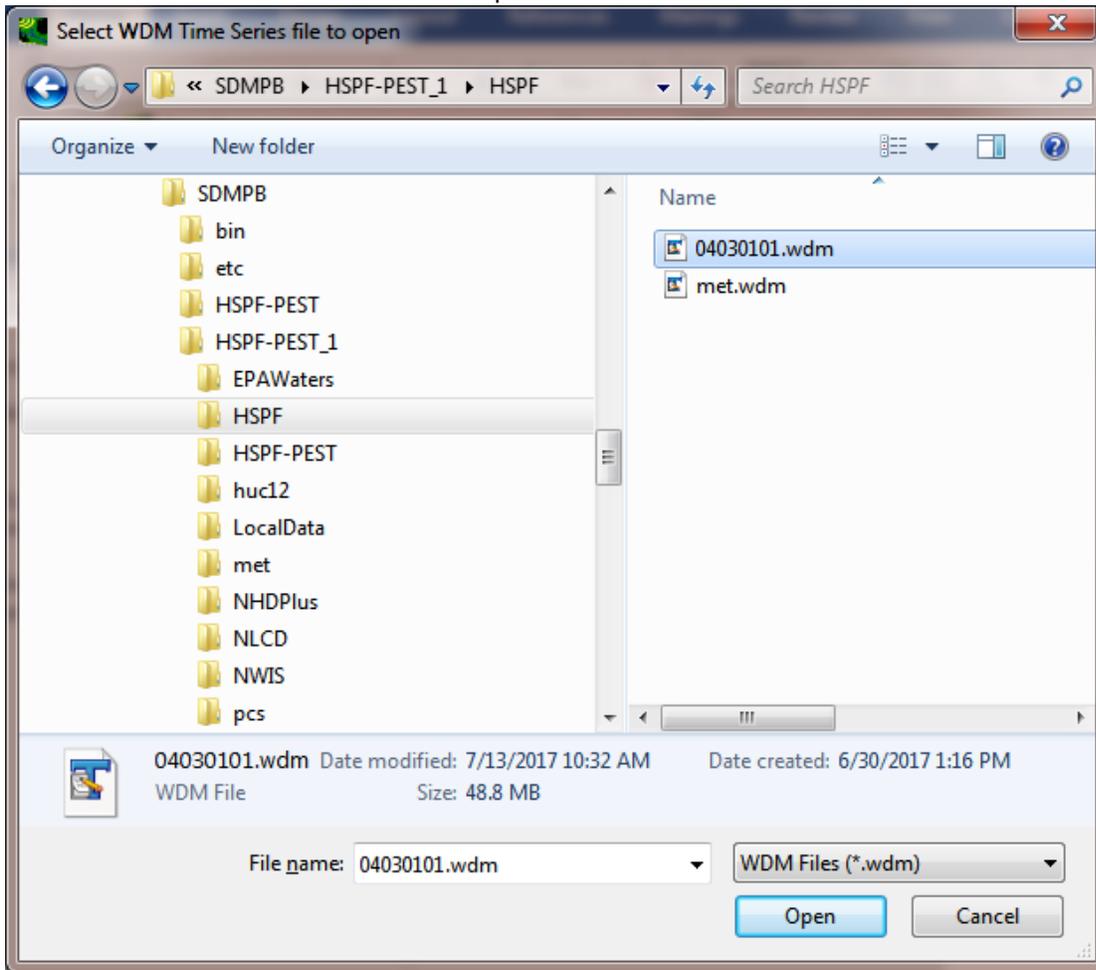
96. Go to the “File”, “Manage Data” menu in the BASINS menu bar. With the “Data Sources” window open, see that no times series data sources are pre-loaded except, possibly, a met.wdm file. Time series data sources from the HSPF simulation are needed to view the simulation results, so they will be added.



97. To add time series data source, select “File”, then “Open” from the “Data Sources” window. A selection window appears:

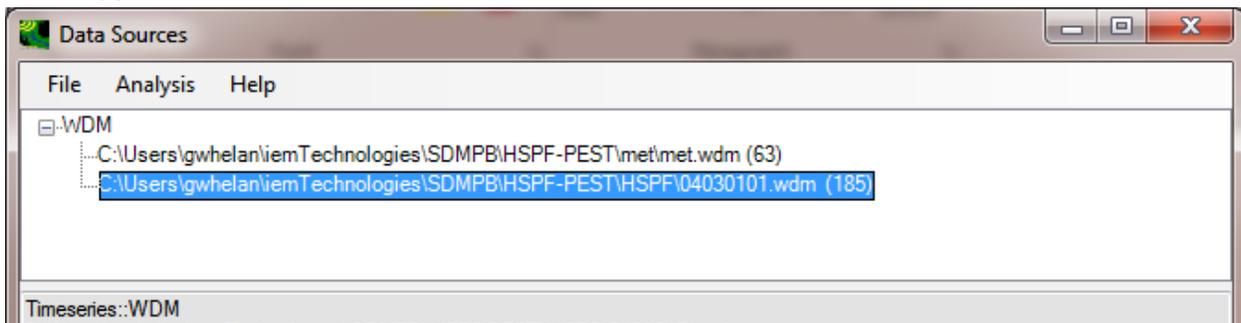


98. Select “WDM Time Series”, then “OK”. Navigate to the project folder, and select the file “04030101.wdm”. It contains the output time series written from HSPF to WDM.



Note: For the pour point simulation, the *.wdm file name may be “SDMProject” (e.g., SDMProject.wdm) for a pour point analysis. The name may reflect the HUC-8 ID number (i.e., “04030101.wdm”) as in this case. Do not select the met.wdm file.

99. With this data source open, the file name similar to the following appears in the “Data Sources” window.

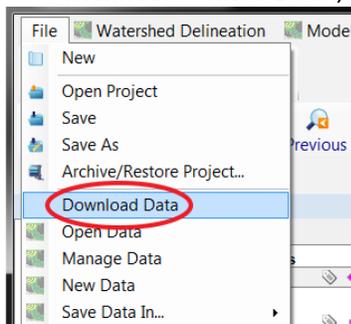


Download Discharge Data Associated with Gage Stations in the Manitowoc River Basin

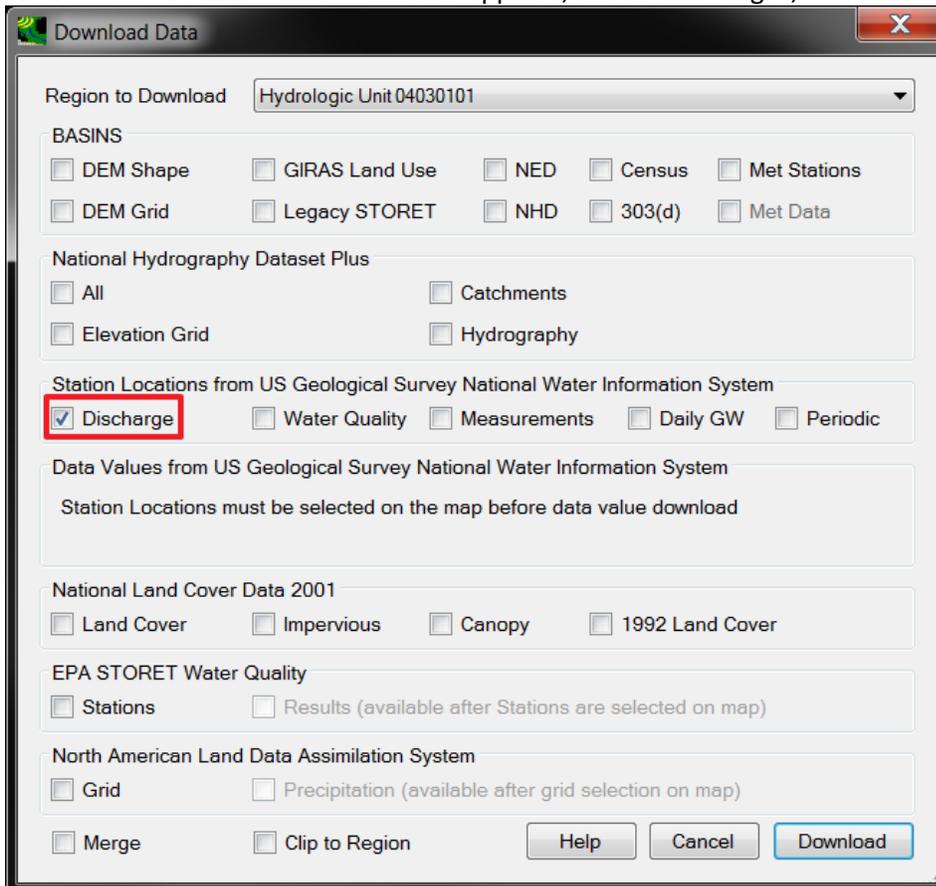
This Section describes the procedure for downloading USGS gage station daily flow observations for the entire Manitowoc River Basin and daily and instantaneous flow observations at the pour point of the Manitowoc River Basin.

Daily Discharge Time Series for USGS Gaging Stations on the Manitowoc River Basin

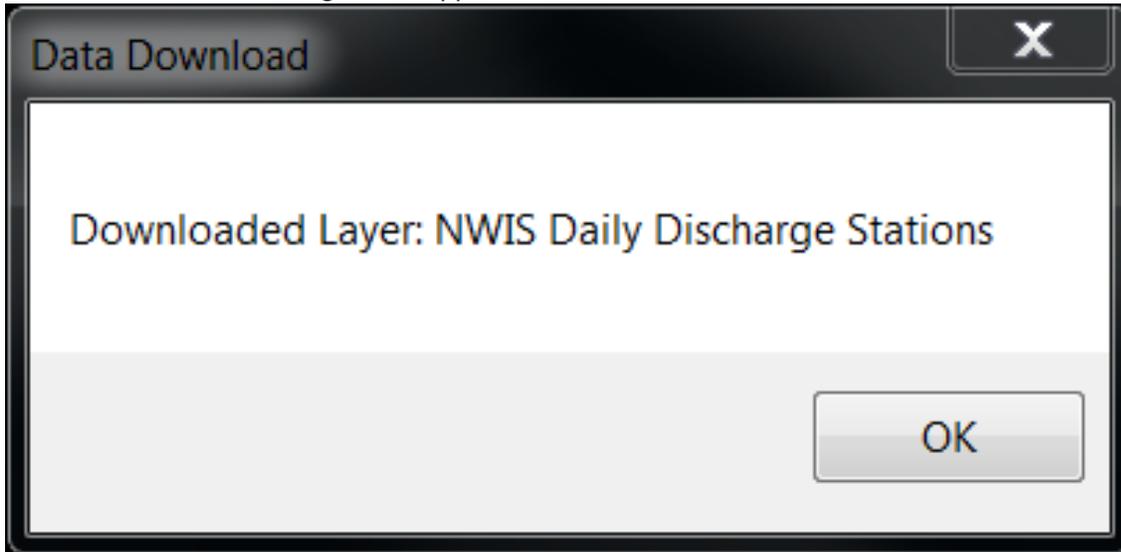
100. To download locations of observed discharge data associated with flow gage stations in the Manitowoc River Basin, select “File>Download Data” on the menu bar.



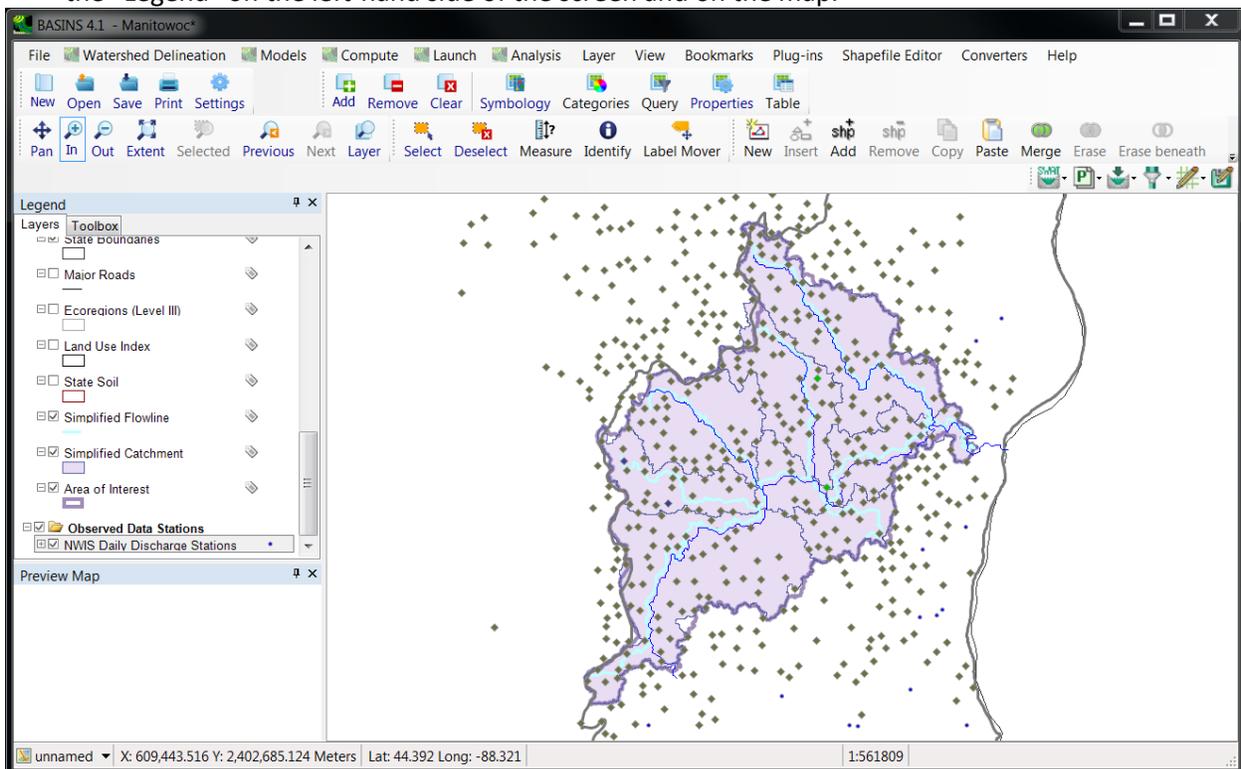
101. The “Download Data” window appears; check “Discharge”, then click “Download”.



102. When the following screen appears, click "OK".

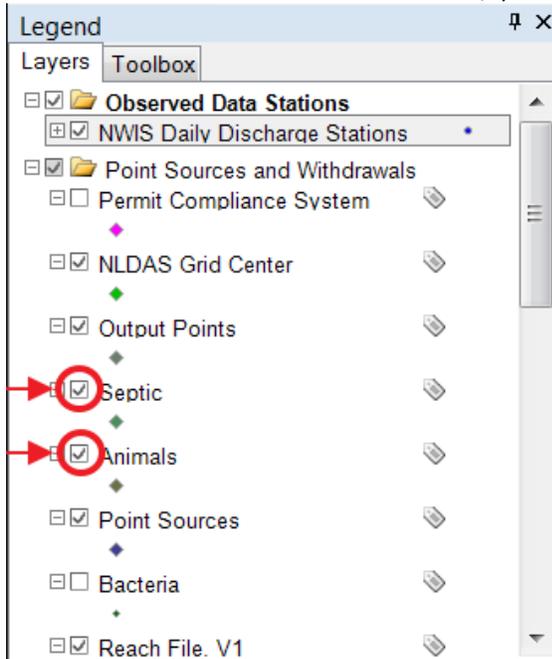


103. BASINS will download locations of USGS gage stations, and it will be displayed at the bottom of the "Legend" on the left-hand side of the screen and on the map.

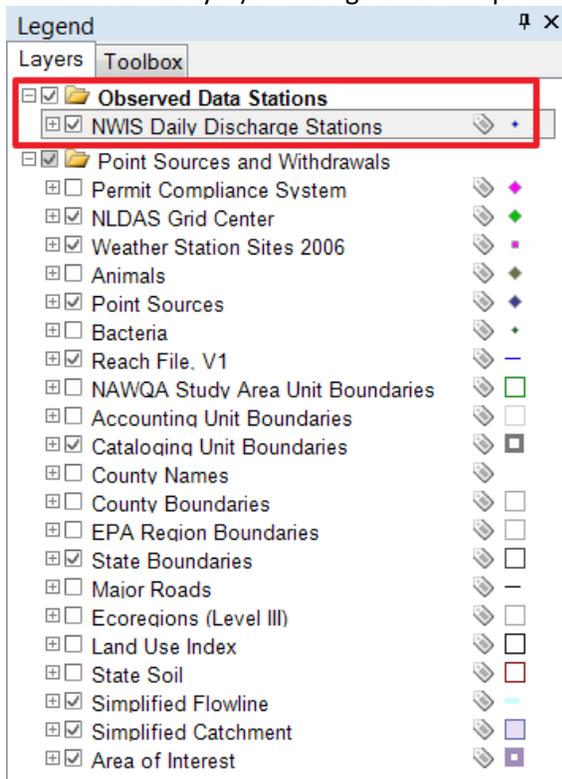


Map layers can be turned off, symbols for the gage stations can be changed, and labels can be added to see the stations more clearly on the map.

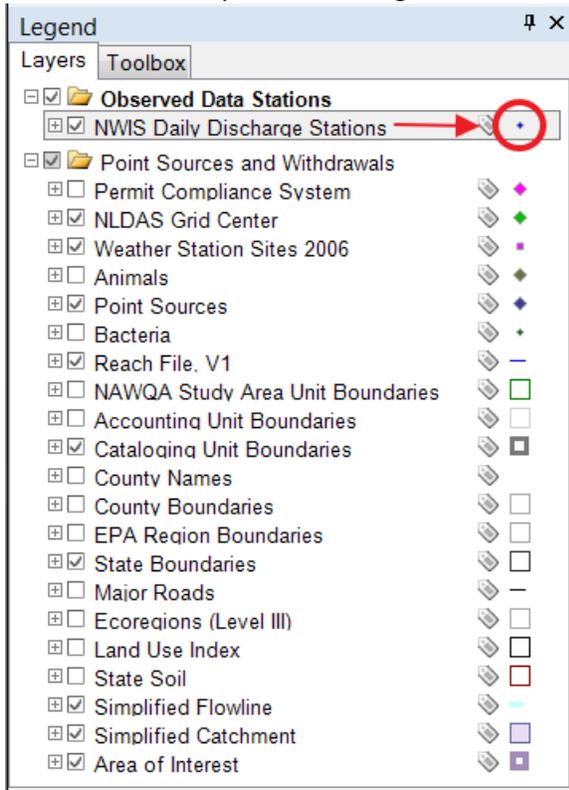
104. In the “Legend” panel, turn off the “Animals” and “Septic” map layer by clicking on the box at the left to remove the check mark (✓).



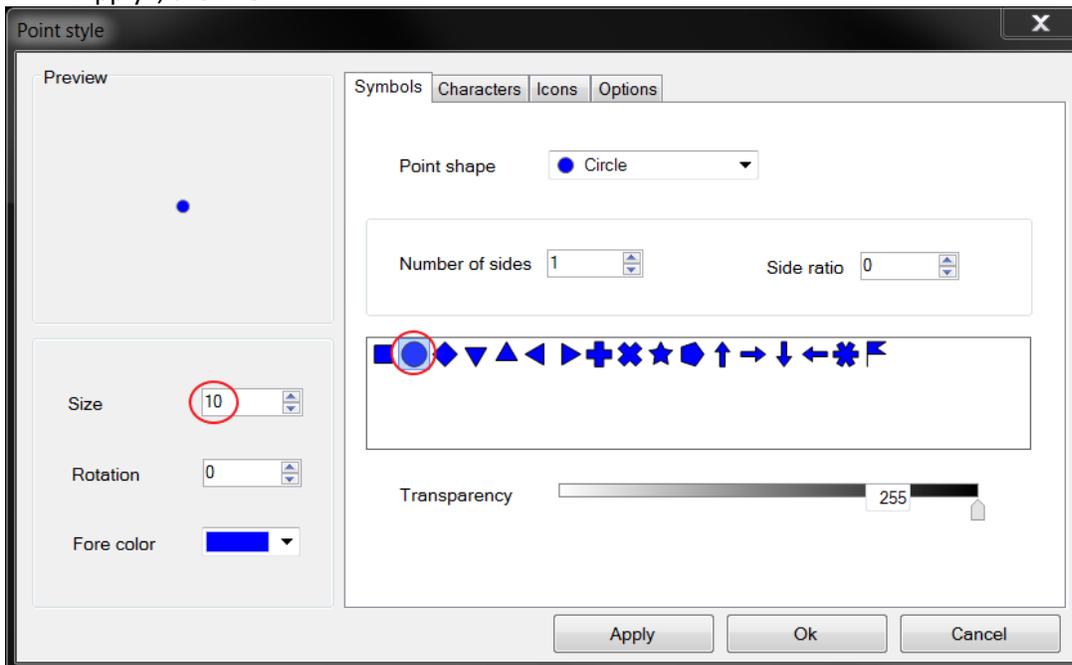
105. On the “Legend” panel, click on “Observed Data Stations” (including the “NWIS Daily Discharge Stations” layer) and drag it to the top.



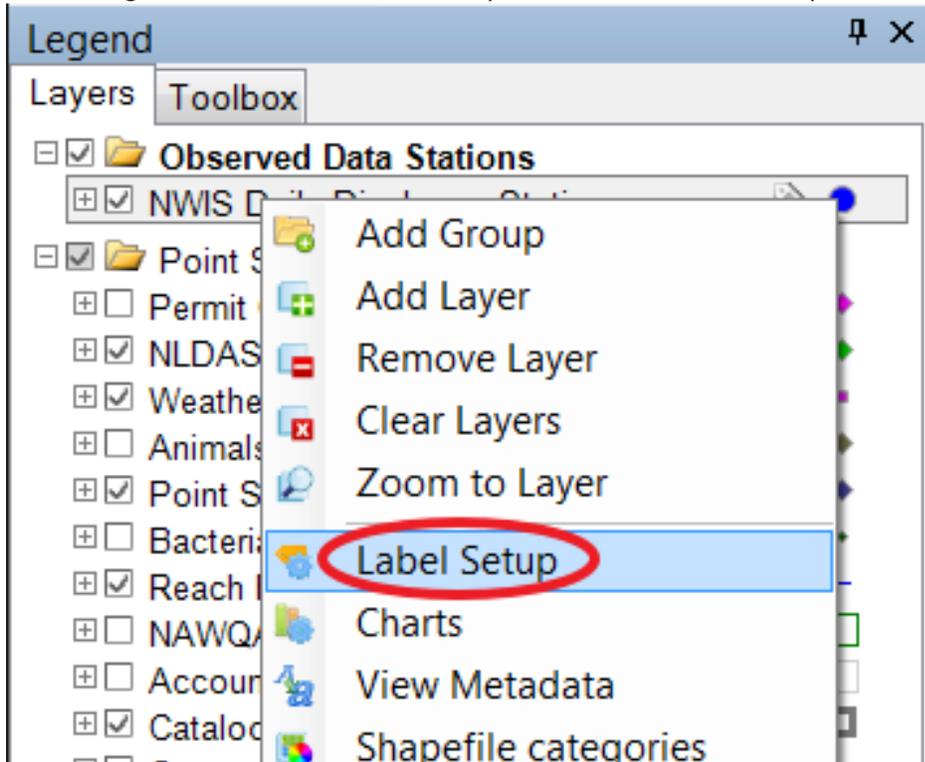
106. Click the symbol at the right of the “NWIS Daily Discharge Stations” layer.



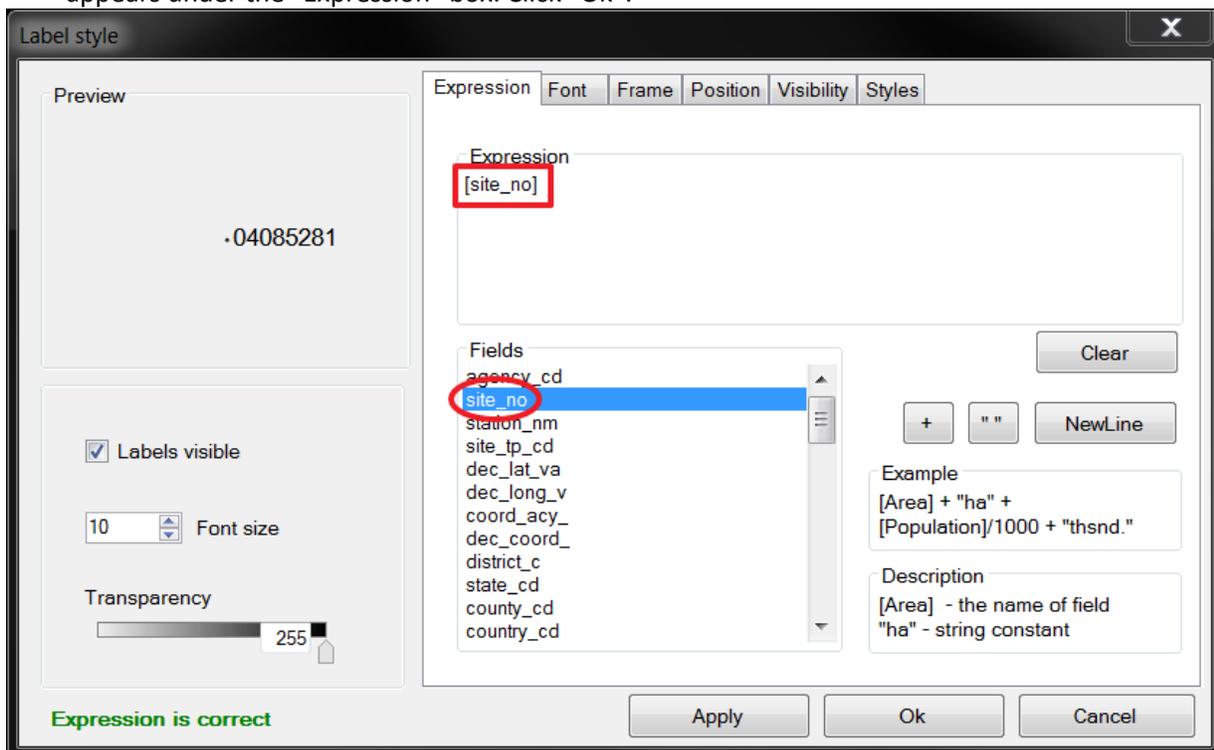
107. The “Point style” window appears. Put “10” for “Size”, click the circle in the “Symbols” tab, click “Apply”, then “Ok”.



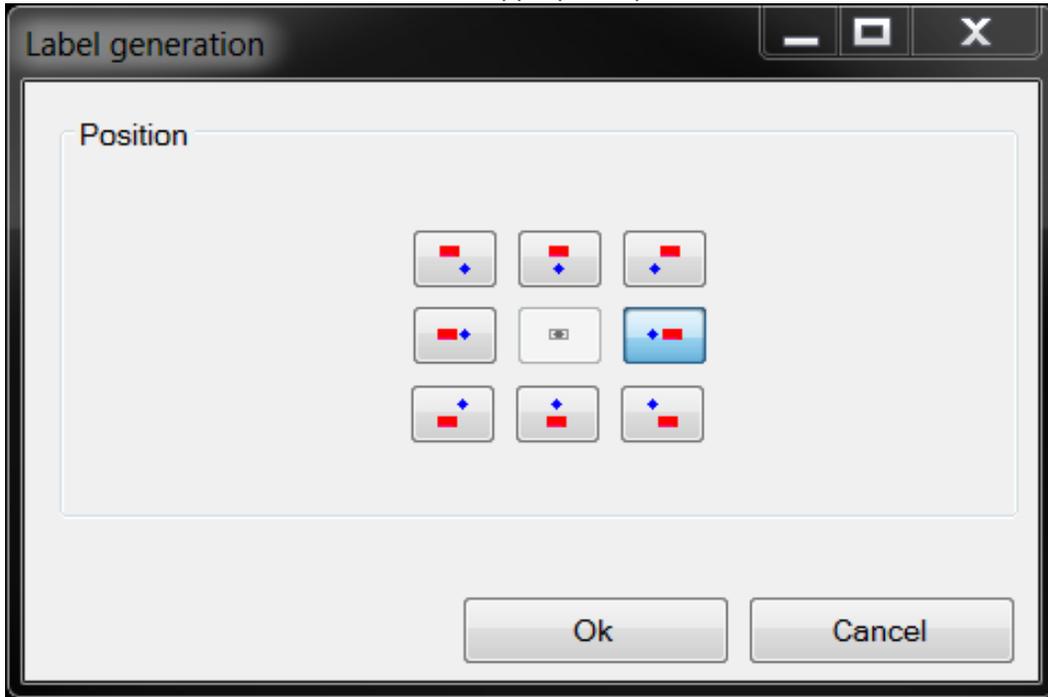
108. Right-click on the name of the layer, then select "Label Setup".



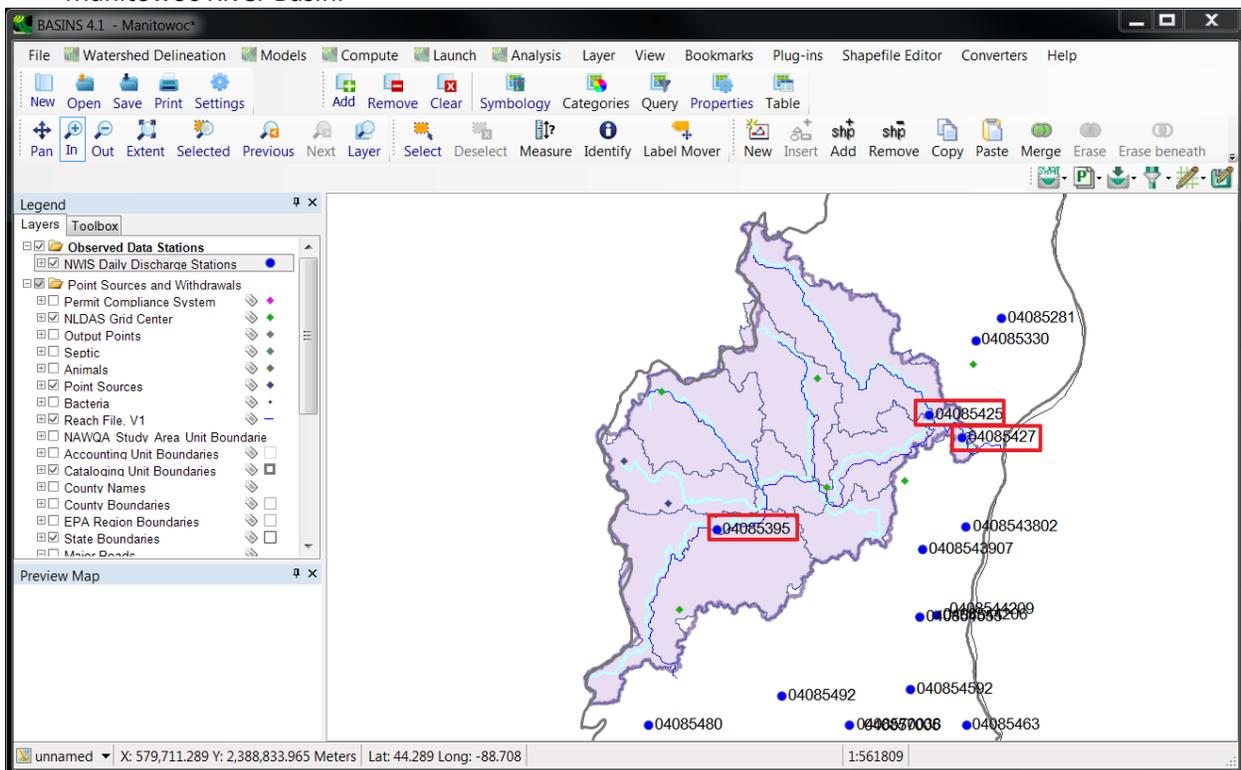
109. The following window appears. Double-click "site_no" under "Fields", and ensure "[site_no]" appears under the "Expression" box. Click "Ok".



110. In the window below, select the appropriate position of the label, then click “Ok”.

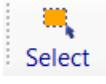


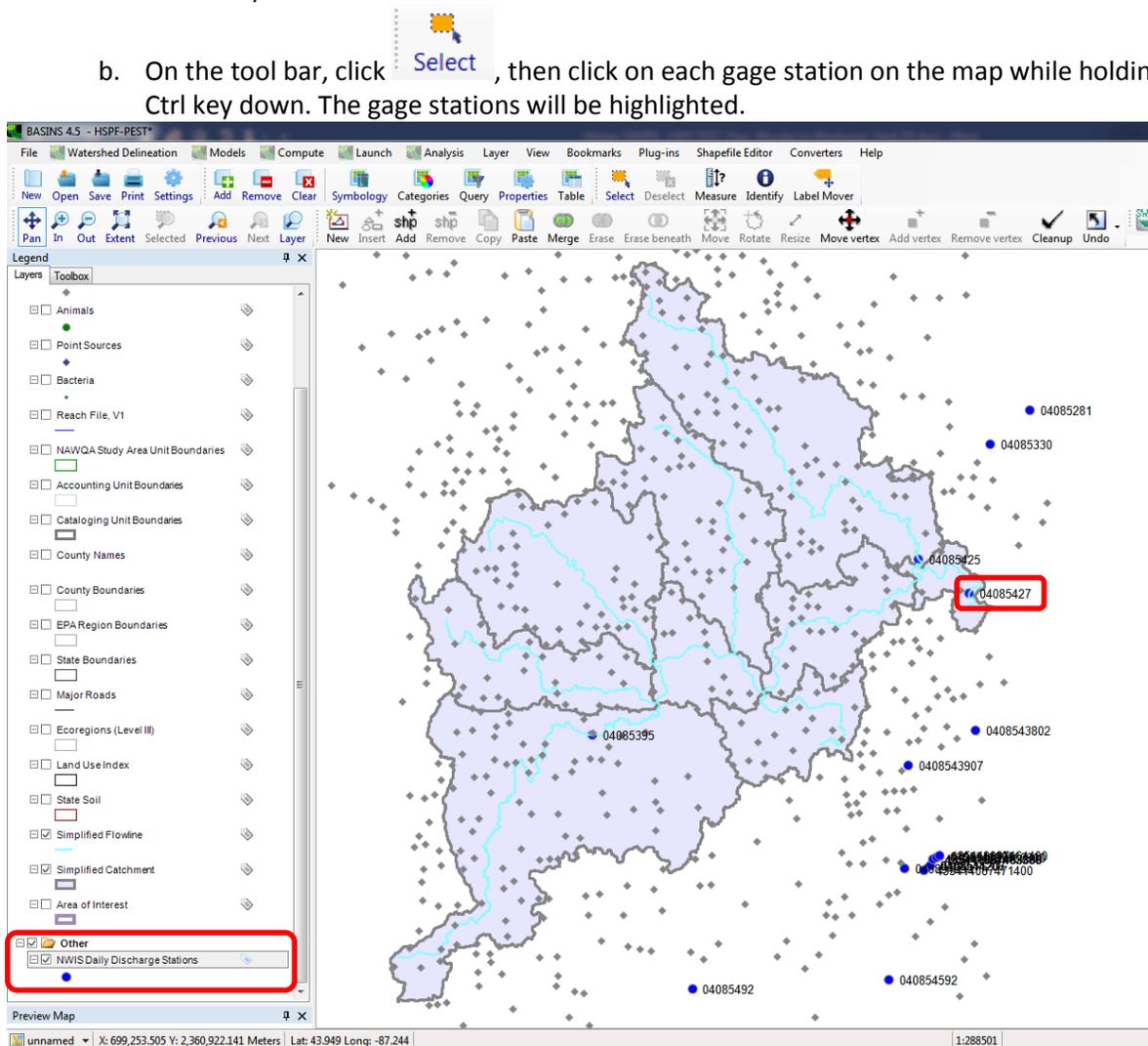
111. The following figure appears with larger symbols and codes of the USGS gage stations in the Manitowoc River Basin.



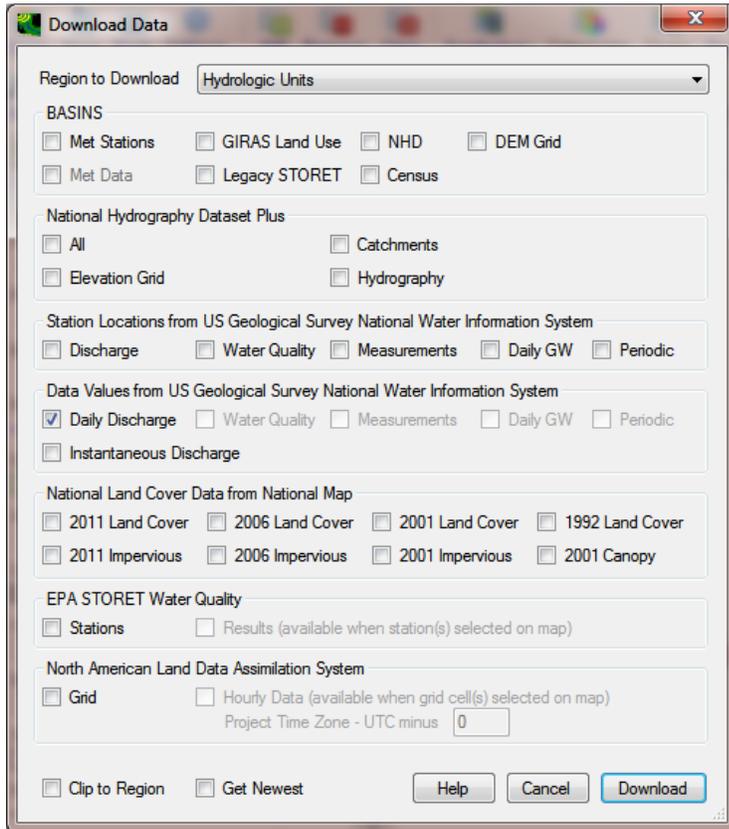
In the figure, three gage stations in the Manitowoc River Basin have been highlighted with red boxes: 04085427 is located at the outlet (near the pour point) of the watershed, and 04085395 and 04085425 are within the watershed. Flow observations at the 04085427 gage station will be downloaded in this example, first for the daily flow observations, then for the “instantaneous” flow observations.

Daily Discharge Time Series for the USGS Gaging Station 04085427

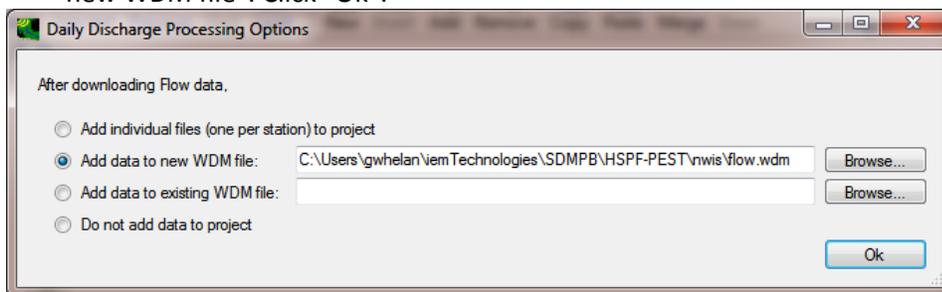
112. To download discharge data at the 04085427 gage station,
 - a. Highlight the “NWIS Daily Discharge Stations” layer in the “Legend” panel (bottom, left-side of screen).
 - b. On the tool bar, click  , then click on each gage station on the map while holding the Ctrl key down. The gage stations will be highlighted.



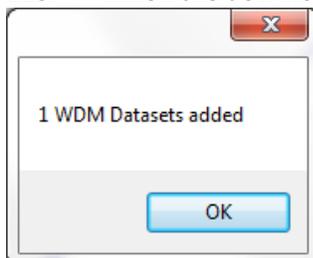
113. Choose “File”, then “Download Data” again, this time specifying download “Daily Discharge” data values. Click “Download”.



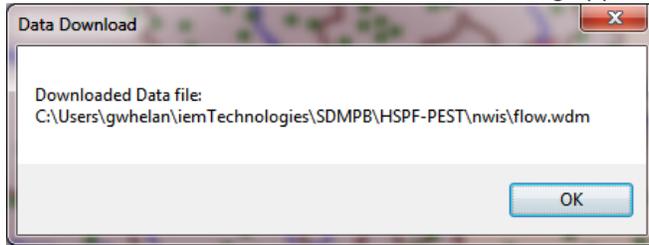
114. The window similar to the following appears. The daily flow observation time series file name will already be identified, but you can pick a different name or folder location. Choose “Add data to new WDM file”. Click “OK”.



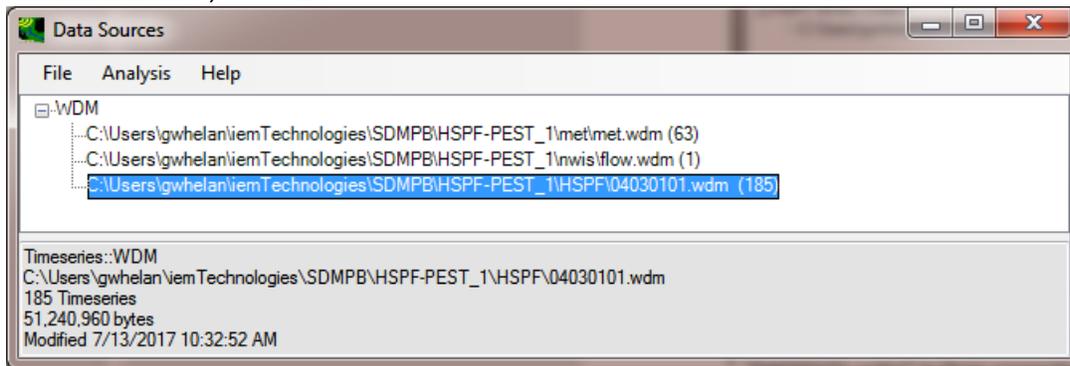
115. When the download is complete, this message appears. Click “OK”:



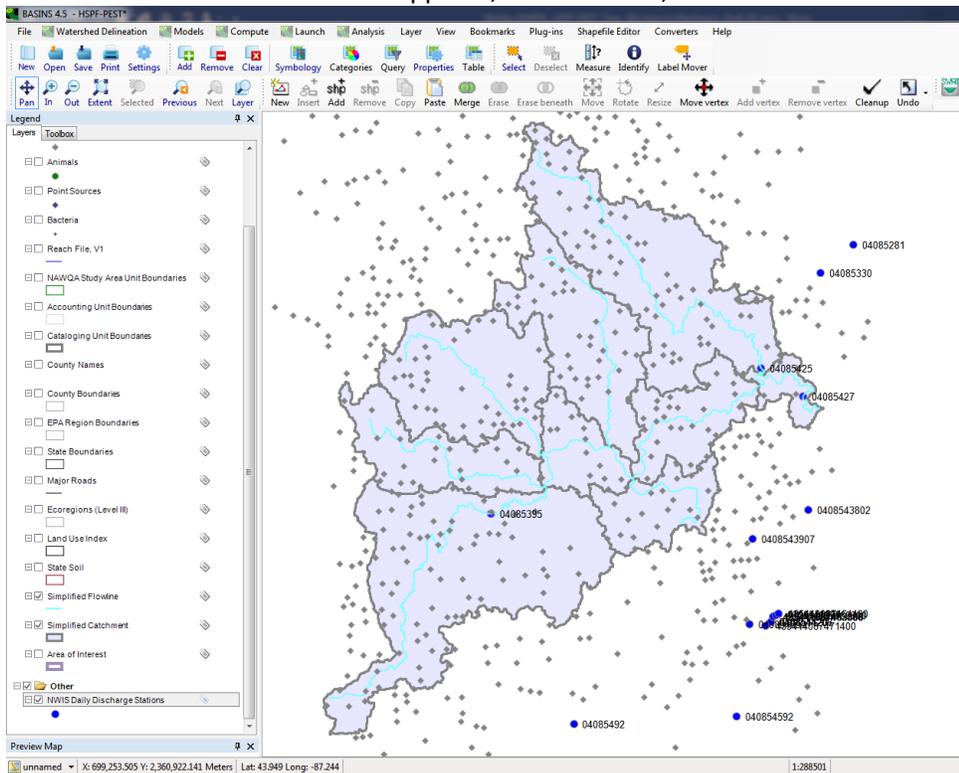
116. When a screen similar to the following appears, click “OK”.



117. The “Data Sources” window appears, indicating NWIS data have been added to the project. Choose “file”, then “Exit”.

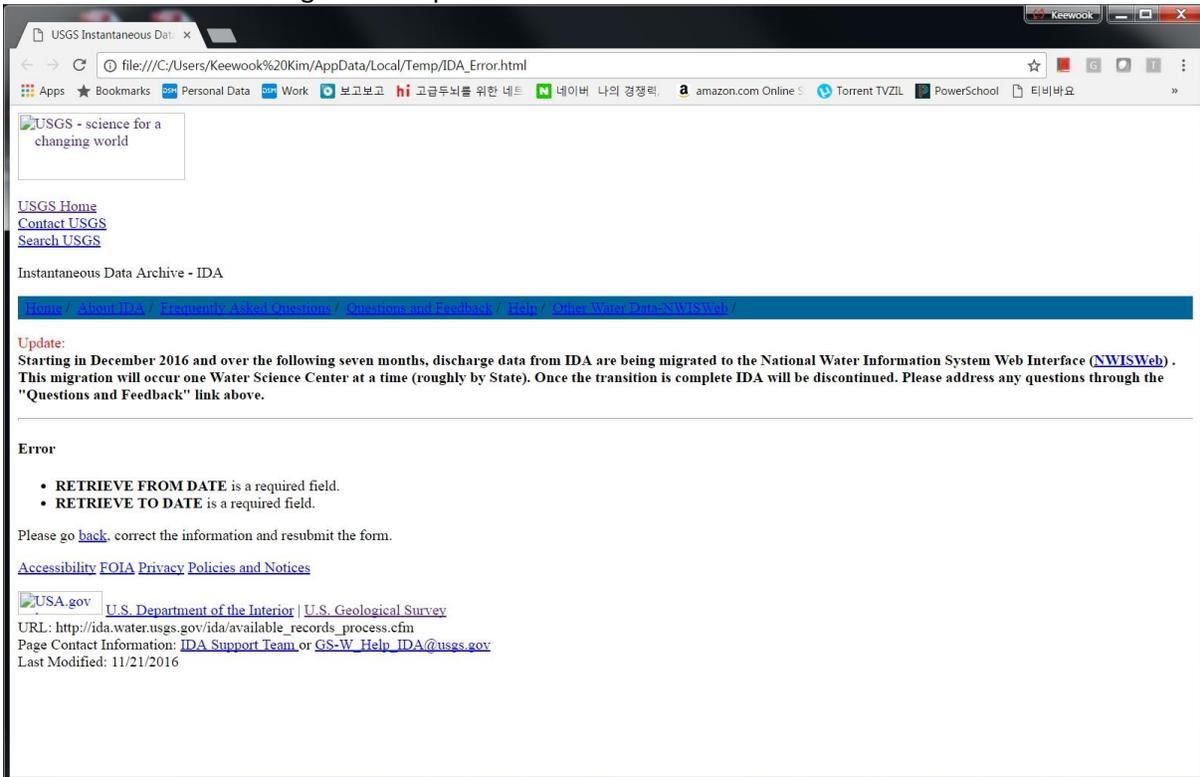


118. The main BASINS screen appears; choose “File”, then “Save” in the menu.



Instantaneous Discharge Data for USGS Gage Station 04085427

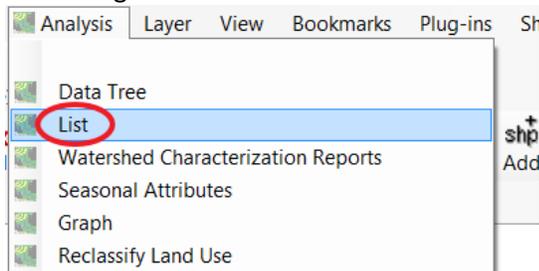
The USGS Instantaneous Data Archive (IDA) for Instantaneous Discharge data provides hourly and sub-hourly discharge data at USGS gaging stations. As of June 23, 2017, access to USGS Instantaneous Data Archive (IDA) for Instantaneous Discharge data is not available on the USGS web site, as illustrated in the following screen capture.



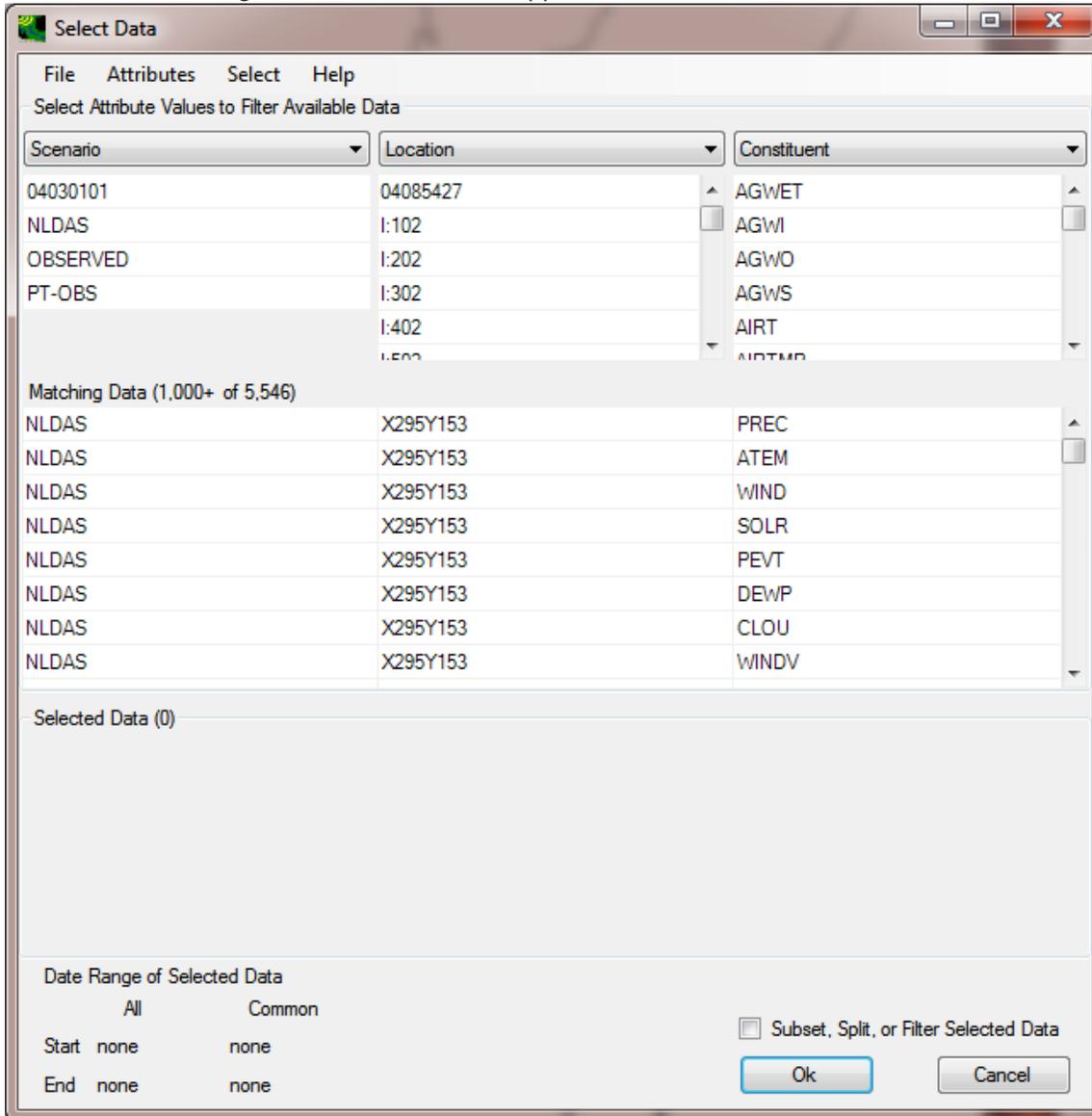
In the event that USGS IDA for Instantaneous Discharge data become available and the web service is activated within the SDMPB, Appendix A describes how the user can access and retrieve the instantaneous discharge data using the BASINS download data tools.

View Observed Data

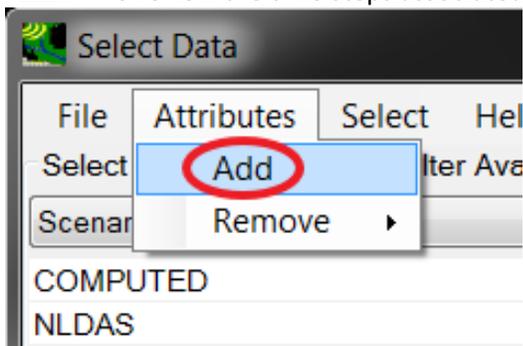
119. Flow observation data must be exported to prepare files for flow-related parameter calibration using the PEST inverse model. On the menu bar, select "Analysis>List".



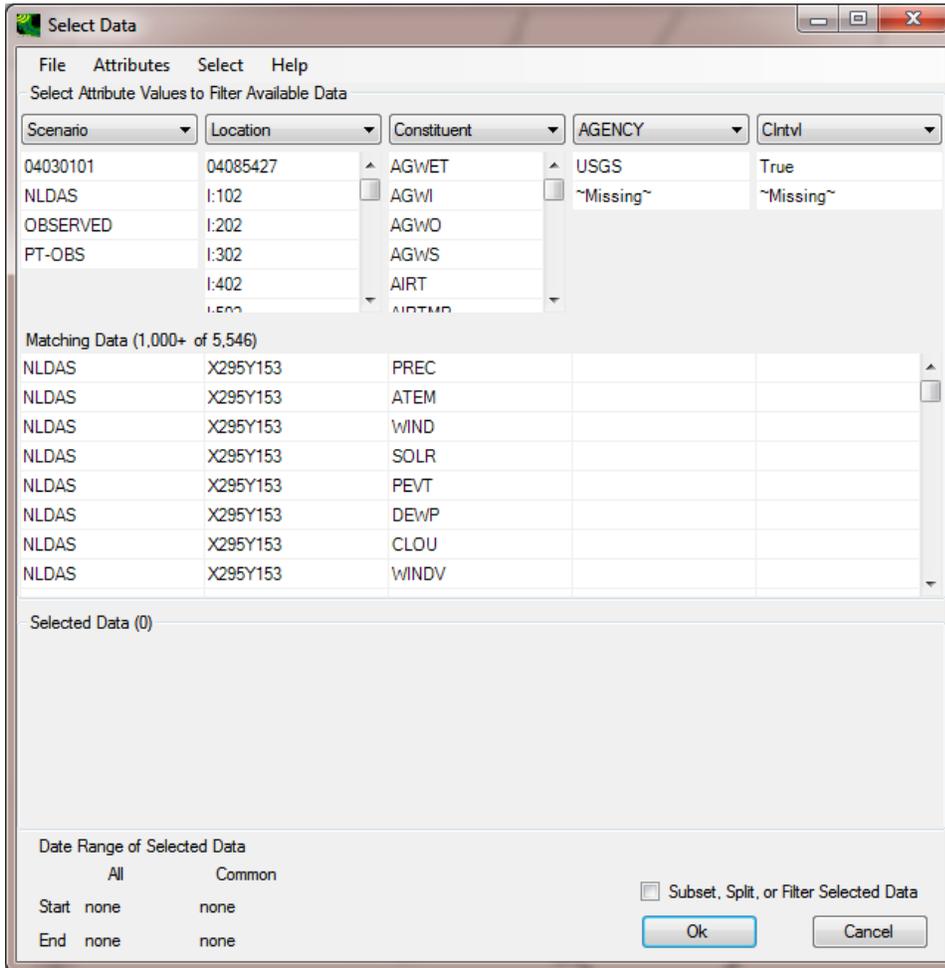
120. The following “Select Data” window appears.



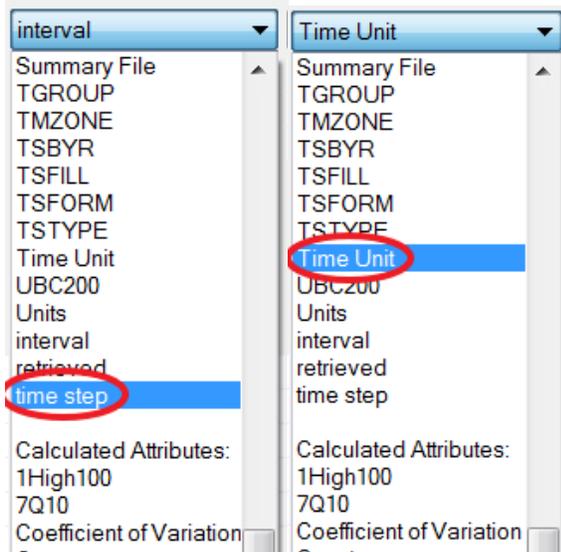
121. To review the time steps associated with the time series, select “Attributes>Add”. Repeat once.



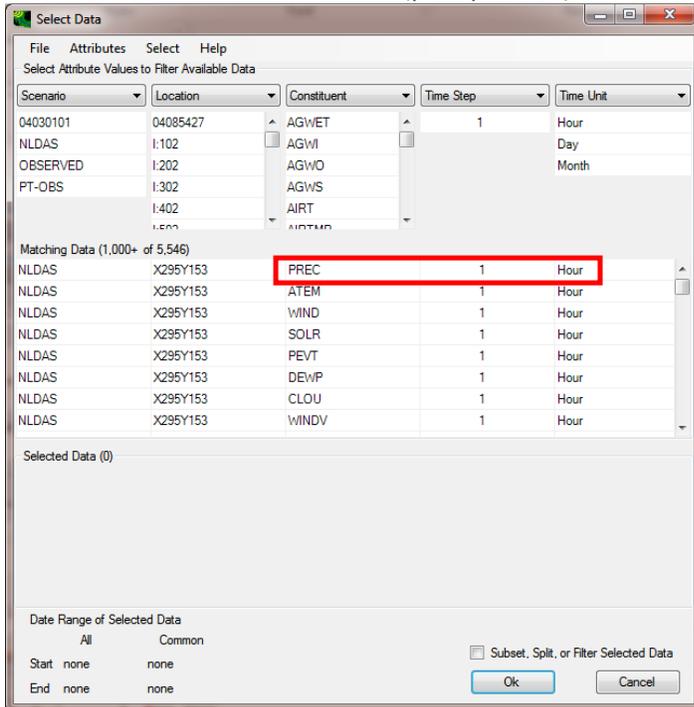
122. Two additional attribute columns will be added in the “Select Data” window.



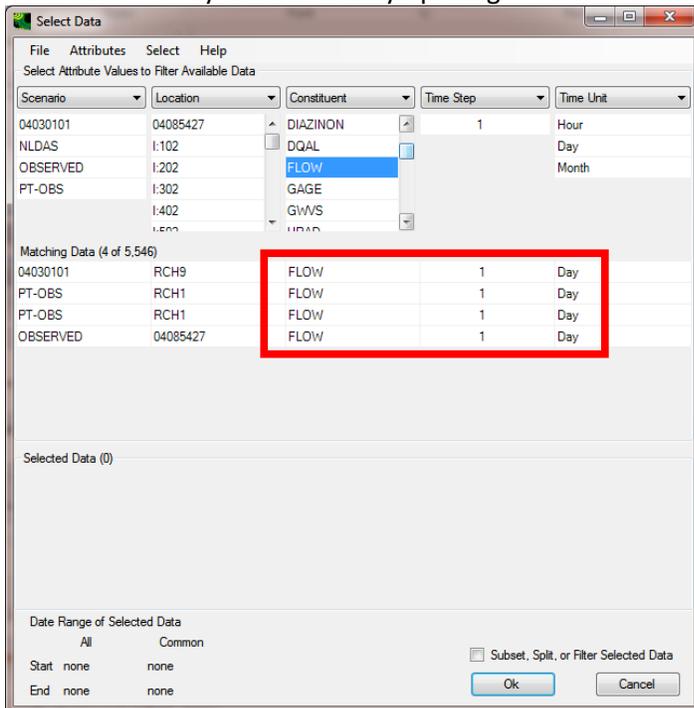
123. For the two additional attribute columns, select “time step” and “Time Unit”.



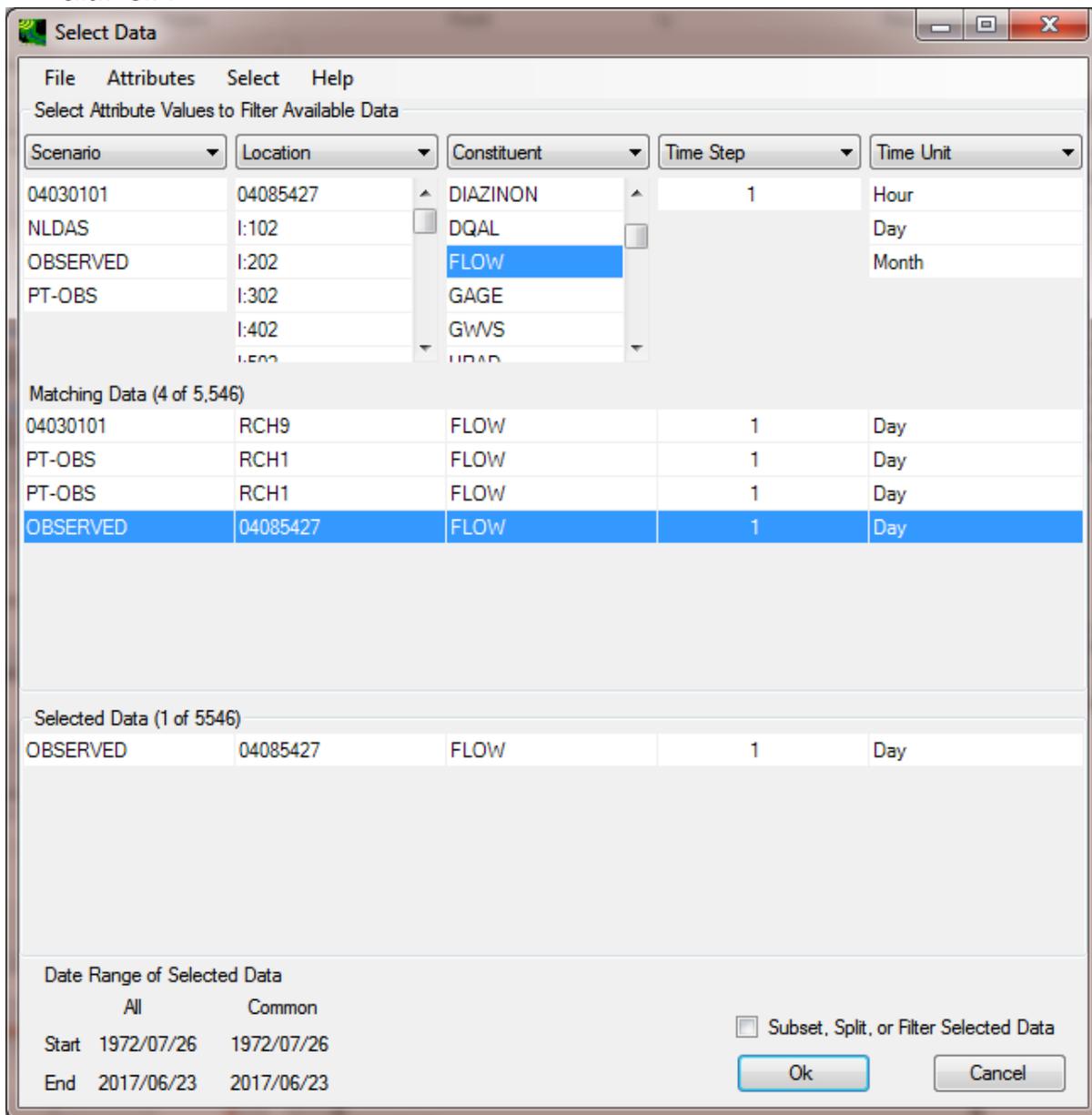
124. After being chosen, the data time step appears in “Matching Data”. For example, in the figure below, “OBSERVED” “PREC” (precipitation) at “X295Y153” has a “1” “Hour” time step.



125. In the “Constituent” column, find “FLOW” for daily flows by clicking on “FLOW”. In the “Matching Data” section, the “Time Unit” for “FLOW” is daily (“Day”). “Time Step” and “Time Unit” can be easily determined by opening tabulated data.



126. To check the “Time Unit”, select “04085427” in “Matching Data”. Ensure that “04085427” appears in “Selected Data” section. This ensures that data with their own time step will appear. Click “OK”.



127. The following window appears. The “Time Unit” of the data can be easily identified as daily increments. Close the “Timeseries List” window.

History 1	from flow.wdm
Constituent	FLOW
Id	1
Min	7
Max	8,000
Mean	324.31
07/26/1972 24:00	69
07/27/1972 24:00	65
07/28/1972 24:00	57
07/29/1972 24:00	58
07/30/1972 24:00	57
07/31/1972 24:00	54
08/01/1972 24:00	48
08/02/1972 24:00	66
08/03/1972 24:00	64
08/04/1972 24:00	63
08/05/1972 24:00	60
08/06/1972 24:00	70
08/07/1972 24:00	84
08/08/1972 24:00	105

In this example, HSPF input flow parameters will be calibrated with daily flow observations. If the user would like to use 15-minute or hourly flow observation data for the HSPF flow parameter calibration, a similar procedure could be used for these data sets, using the observation data download described in Appendix A.

Export Flow Data as a Text File for Parameter Calibration

Parameter calibration will be performed using daily flow observations. This section describes the procedure used in preparing a text (*.txt) input file of observed flow for use in the calibration of HSPF flow-related parameters by PEST. Because calibration is iterative and over writes existing files, files associated with the initial HSPF simulation must be maintained in a different folder location. The time period associated with this calibration is from January 1, 2000 (2000/01/01) to December 31, 2012 (2012/12/31), respectively.

128. To export flow observation data, open the “Select Data” window again (from “analysis” and “List” from the BASINS menu icons). In the “Constituent” column, choose “FLOW”. In “Matching Data”, select “04085427” which is the gaging station that is nearest to the outlet of the Manitowoc River Basin and will be used for HSPF flow parameter calibration. Ensure that “04085427” appears in “Selected Data”.

Scenario	Location	Constituent	Time Unit	Time Step
04030101	04085427	DEWTMP	Hour	1
NLDAS	I:102	DIAZINON	Day	
OBSERVED	I:202	DQAL	Month	
PT-OBS	I:302	FLOW		
	I:402	GAGE		
	I:502	CHLOR		

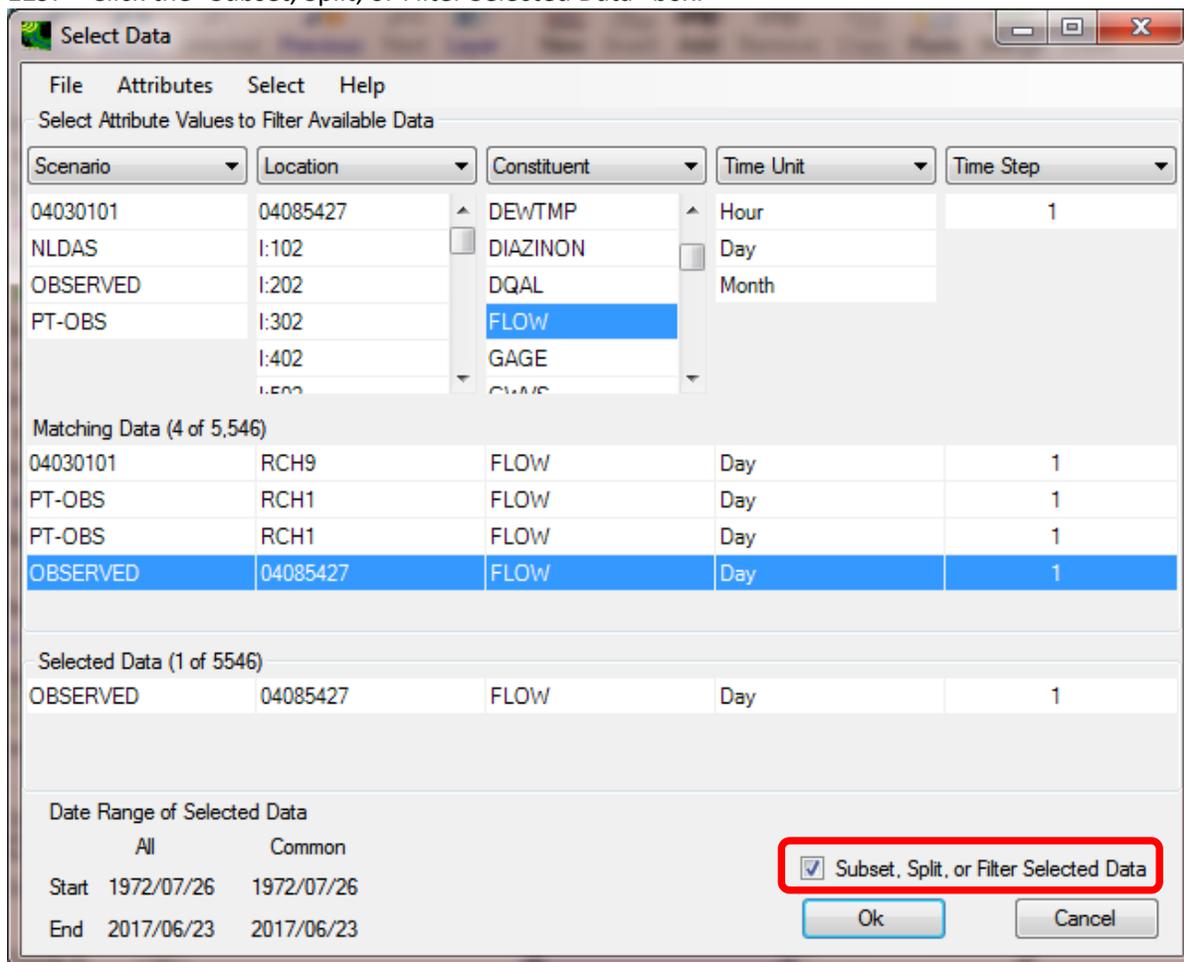
Matching Data (4 of 5,546)				
Scenario	Location	Constituent	Time Unit	Time Step
04030101	RCH9	FLOW	Day	1
PT-OBS	RCH1	FLOW	Day	1
PT-OBS	RCH1	FLOW	Day	1
OBSERVED	04085427	FLOW	Day	1

Selected Data (1 of 5546)				
Scenario	Location	Constituent	Time Unit	Time Step
OBSERVED	04085427	FLOW	Day	1

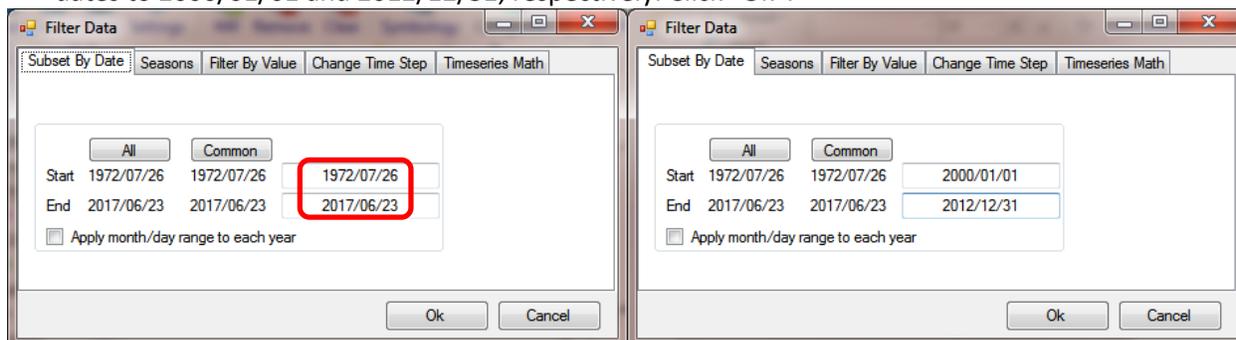
Date Range of Selected Data			
	All	Common	
Start	1972/07/26	1972/07/26	
End	2017/06/23	2017/06/23	

Although we are going to perform HSPF modeling from 2000 to 2012, the “Date Range of Selected Data” section indicates the daily flow observations are available from 1972/07/26 to 2017/06/23. This will affect to model parameter calibration and validation period; therefore, the start and end dates need to be changed to 2000/01/01 and 2012/12/31, respectively.

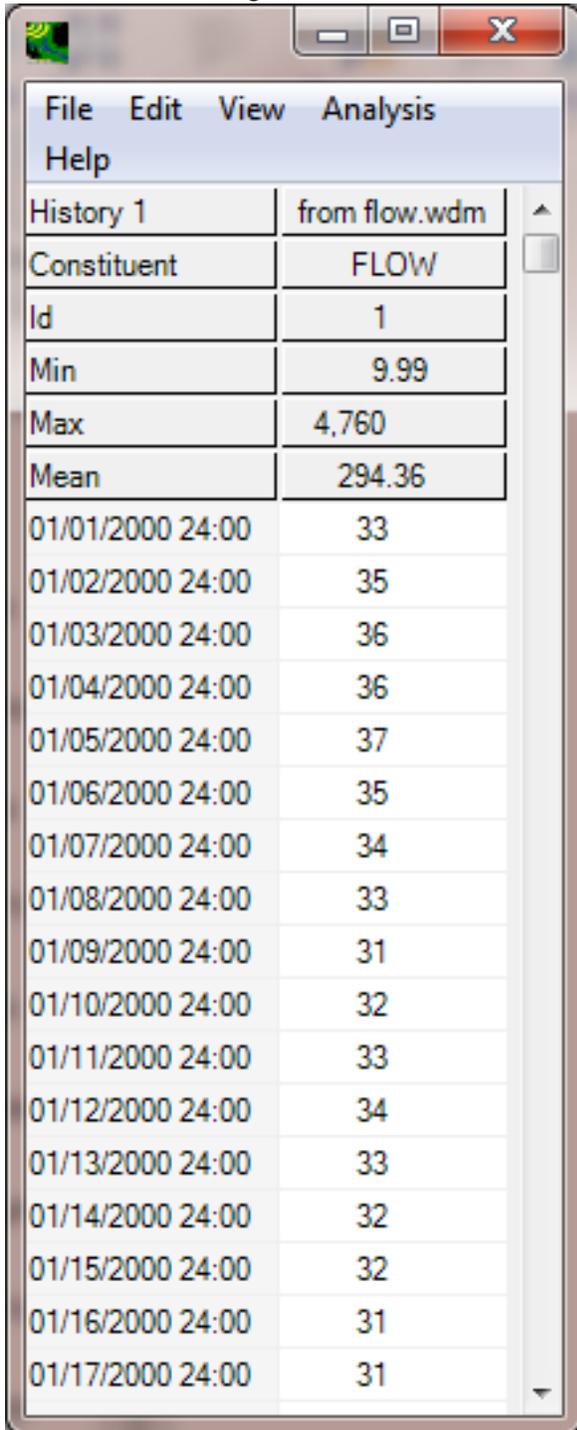
129. Click the “Subset, Split, or Filter Selected Data” box.



130. The “Filter Data” screen appears. Under the “Subset By Date” tab, change the “Start” and “End” dates to 2000/01/01 and 2012/12/31, respectively. Click “OK”.



131. The following "Timeseries List" window appears.

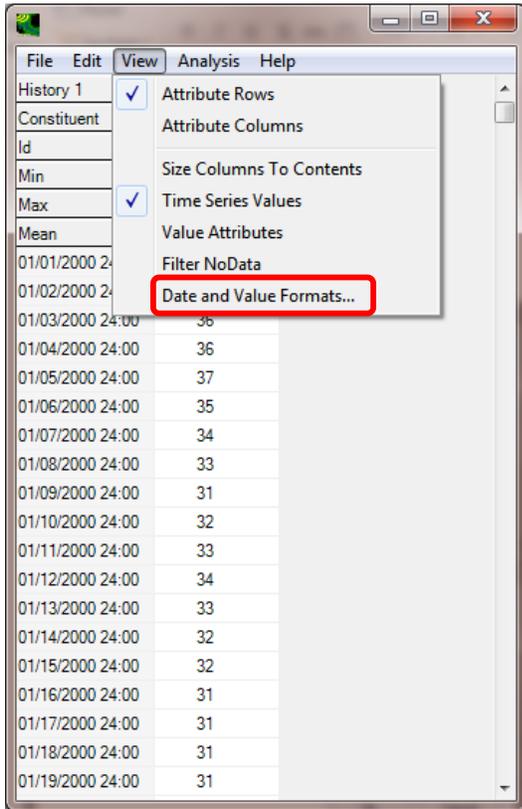


The screenshot shows a window titled "Timeseries List" with a menu bar containing "File", "Edit", "View", "Analysis", and "Help". The window displays a table with two columns: the first column contains dates and times, and the second column contains numerical values. The table is titled "History 1" and is sourced from "flow.wdm". The data points are as follows:

History 1	from flow.wdm
Constituent	FLOW
Id	1
Min	9.99
Max	4,760
Mean	294.36
01/01/2000 24:00	33
01/02/2000 24:00	35
01/03/2000 24:00	36
01/04/2000 24:00	36
01/05/2000 24:00	37
01/06/2000 24:00	35
01/07/2000 24:00	34
01/08/2000 24:00	33
01/09/2000 24:00	31
01/10/2000 24:00	32
01/11/2000 24:00	33
01/12/2000 24:00	34
01/13/2000 24:00	33
01/14/2000 24:00	32
01/15/2000 24:00	32
01/16/2000 24:00	31
01/17/2000 24:00	31

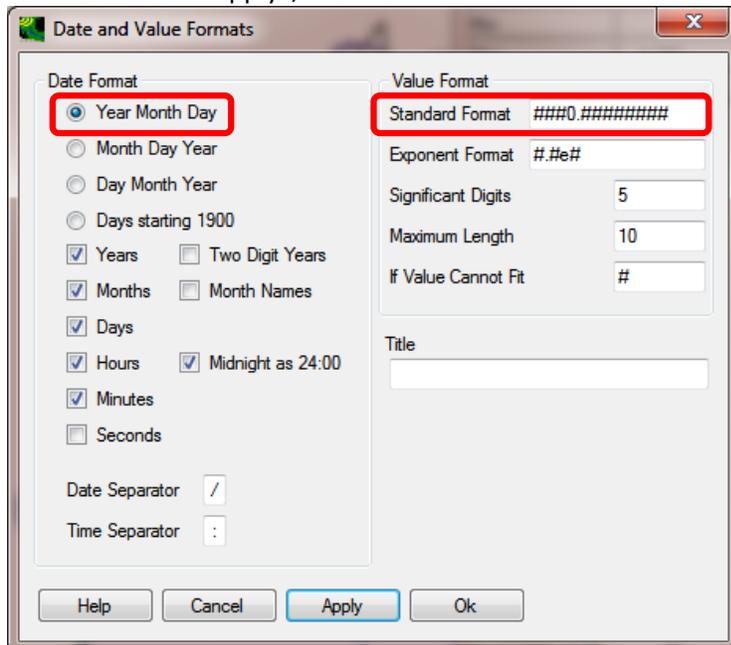
Formats associated with the dates and values may need to be checked and changed, if necessary. The dates need to have a format of yyyy/mm/dd. The values must not contain commas, so they must be removed from the numbers, if they exist (e.g., change 1,240 to 1240).

132. Select “View”, then “Data and Value Formats...”.

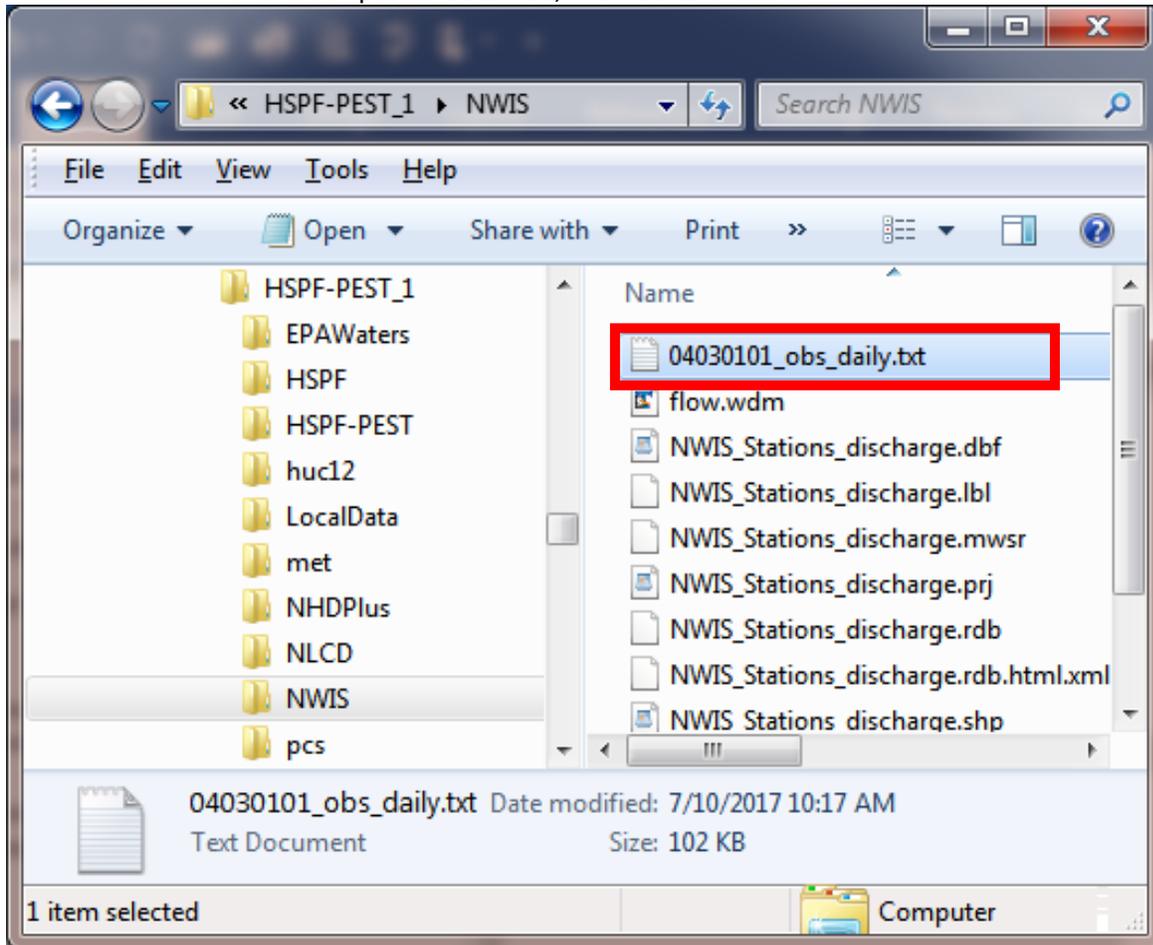


133. The “Formats” window appears as follows.

- If a comma (,) appears in the “Standard Format” remove it. In this case, no comma appears.
- Choose “Year Month Day”, if not chosen.
- Click “Apply”, then “Ok”.



136. In the window below, file name and the location can be defined. Here, the time series will be stored as
"C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\NWIS\04030101_obs_daily.txt". Once the file name and folder path are defined, click "Save".

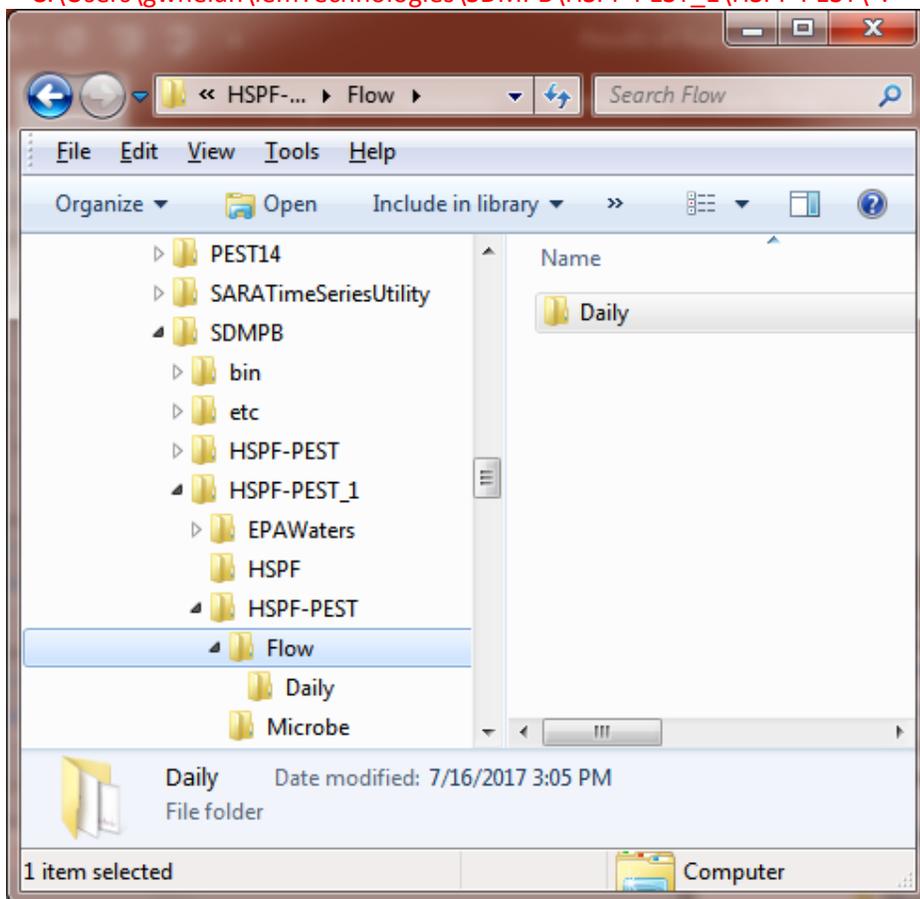


137. Close the "Timeseries List" window, using the upper right-hand corner "x".

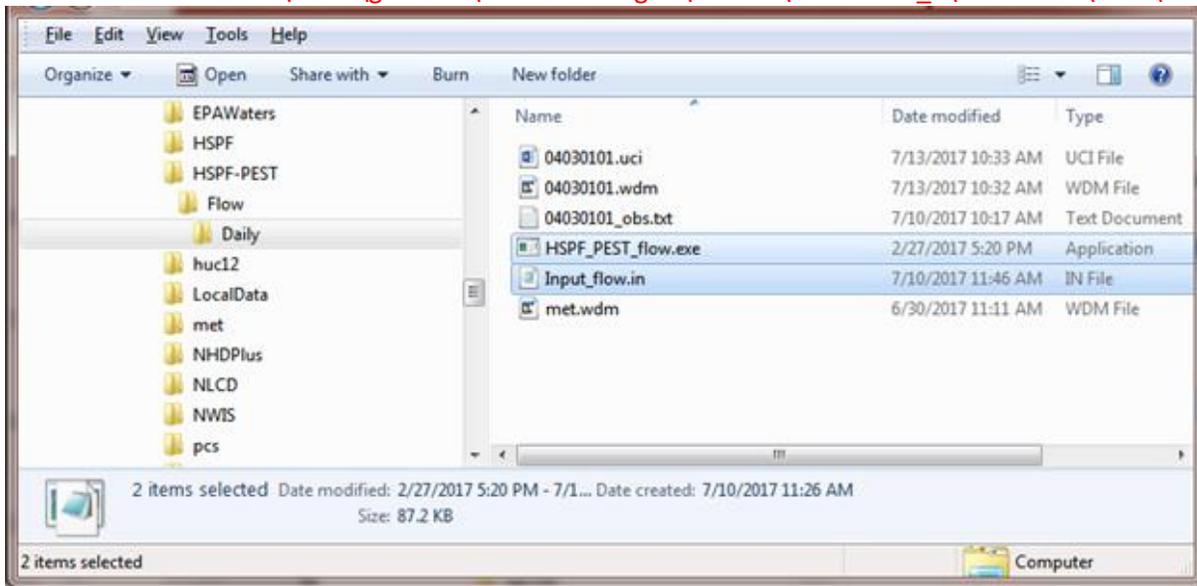
PREPARING PEST INPUT FILES FOR HSPF FLOW PARAMATER CALIBRATION

Parameter calibration will be performed using daily flow observations. This section describes the procedure to prepare PEST input files for calibration of HSPF flow-related parameters. Because calibration is iterative and writes over existing files, files associated with the initial HSPF simulation that are over-written must be saved in a different location.

138. Create a new folder (“...\Flow\Daily\”) in
“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\”.



139. Copy the meteorological and flow time series data, and HSPF input files to new folders.
- Copy three HSPF input files (04030101.uci, 04030101.wdm, and met.wdm) from “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF” to the new “...\Flow\Daily” folder:
“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily”
 - Copy “04030101_obs_daily.txt” from “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\NWIS” to the new “...\Flow\Daily” folder:
“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily”, and change the name of the file to “04030101_obs.txt”.
 - Copy “HSPF_PEST_flow.exe” and “Input_flow.in” from “C:\Users\gwhelan\iemTechnologies\SDMPB\bin\Data\HSPF-PEST” to
 - “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST”
 - “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily”.



The executable “HSPF_PEST_flow.exe” prepares files necessary for HSPF flow parameter calibration with PEST.

- A. Three PEST input files
 - a. PEST control file (.pst): PEST parameters, model parameters metadata (names, initial values, ranges, etc.), parameter groups, observed flow data, and path of model executables.
 - b. PEST template file (.tpl): Structure of the model input file and location of where the calibrating parameter values are to be placed.
 - c. PEST instruction file (.ins): How PEST will read the model output file.
- B. Two batch files
 - a. “runHSPF.bat”: Executes HSPF (i.e., WinHSPFLt.exe)
 - b. “runPEST.bat”: Executes HSPF parameter calibration with PEST
- C. Flow observation time series file: Flow observation date with missing values as “-9999”. This file is not used for parameter calibration.

“Input_flow.in”, the default input file used with the “HSPF_PEST_flow.exe”, contains details for preparing PEST input files: “HSPF_PEST_flow.exe” and “Input_flow.in” which can be found in Appendix B.

“Input_flow.in” defines

- A. Folder paths of HSPF (i.e., WinHSPFLt.exe), PEST (i.e., pest.exe) and a working folder where HSPF input files, generated by SDMPB, are located. In this example, the folder path for the daily calibration is
“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily”
- B. Calibration parameter names and ranges for each land use group.
- C. Land use groups that have different parameter values.
- D. Number of years for model warm-up.

As the default, “HSPF_PEST_flow.exe” and “Input_flow.in” are located in

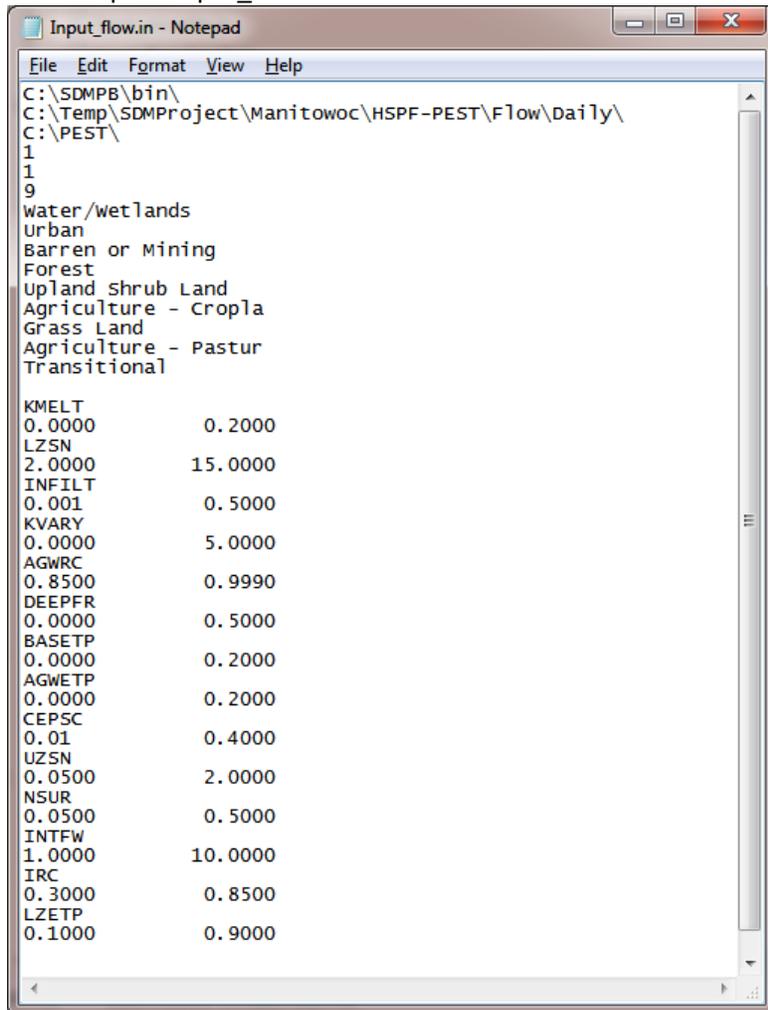
“C:\Users\gwhelan\iemTechnologies\SDMPB\bin\Data\HSPF-PEST”, created by SDMPB, and copied to “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST”. These files can be located in any folder, but both must be in the same folder. In this example for parameter calibration with daily flow observations, “HSPF_PEST_flow.exe” and “Input_flow.in”, respectively, must be located in working folder (e.g., “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily”).

The working folder paths in “Input_flow.in” must be updated to reflect the locations of the 1) batch version of HSPF (i.e., WinHSPFLt.exe), 2) working folder, and 3) inverse model PEST. This information is captured in the first three lines of the “Input_flow.in” file, as discussed in Appendix B. The inverse model, PEST, estimates specific HSPF input parameters to minimize differences between observed and simulated results (flows and microbial densities). When automating the calibration process, a non-Windows-based version of HSPF (i.e., WinHSPFLt.exe) is required, one which allows batch runs with no user interaction. Because different organizations constructed software builds for BASINS and SDMPB installation, the current software installation process installs WinHSPFLt.exe in two different locations:

- C:\BASINS45\models\HSPF\bin\ and
- <...\SDMPB\bin\>

as both include WinHSPFLt.exe; hence, there is the possibility that two different versions of the software might exist. **To ensure consistency, the version of WinHSPFLt.exe contained in the SDMPB build (i.e., <...\SDMPB\bin\>) will be the one used in the calibration process.**

140. Open "Input_flow.in" in each folder with a text editor.



```
File Edit Format View Help
C:\SDMPB\bin\
C:\Temp\SDMProject\Manitowoc\HSPF-PEST\Flow\Daily\
C:\PEST\
1
1
9
Water/wetlands
Urban
Barren or Mining
Forest
Upland Shrub Land
Agriculture - Cropla
Grass Land
Agriculture - Pastur
Transitional

KMELT
0.0000      0.2000
LZSN
2.0000      15.0000
INFILT
0.001       0.5000
KVARY
0.0000      5.0000
AGWRC
0.8500      0.9990
DEEPPFR
0.0000      0.5000
BASETP
0.0000      0.2000
AGWETP
0.0000      0.2000
CEPSC
0.01        0.4000
UZSN
0.0500      2.0000
NSUR
0.0500      0.5000
INTFW
1.0000      10.0000
IRC
0.3000      0.8500
LZETP
0.1000      0.9000
```

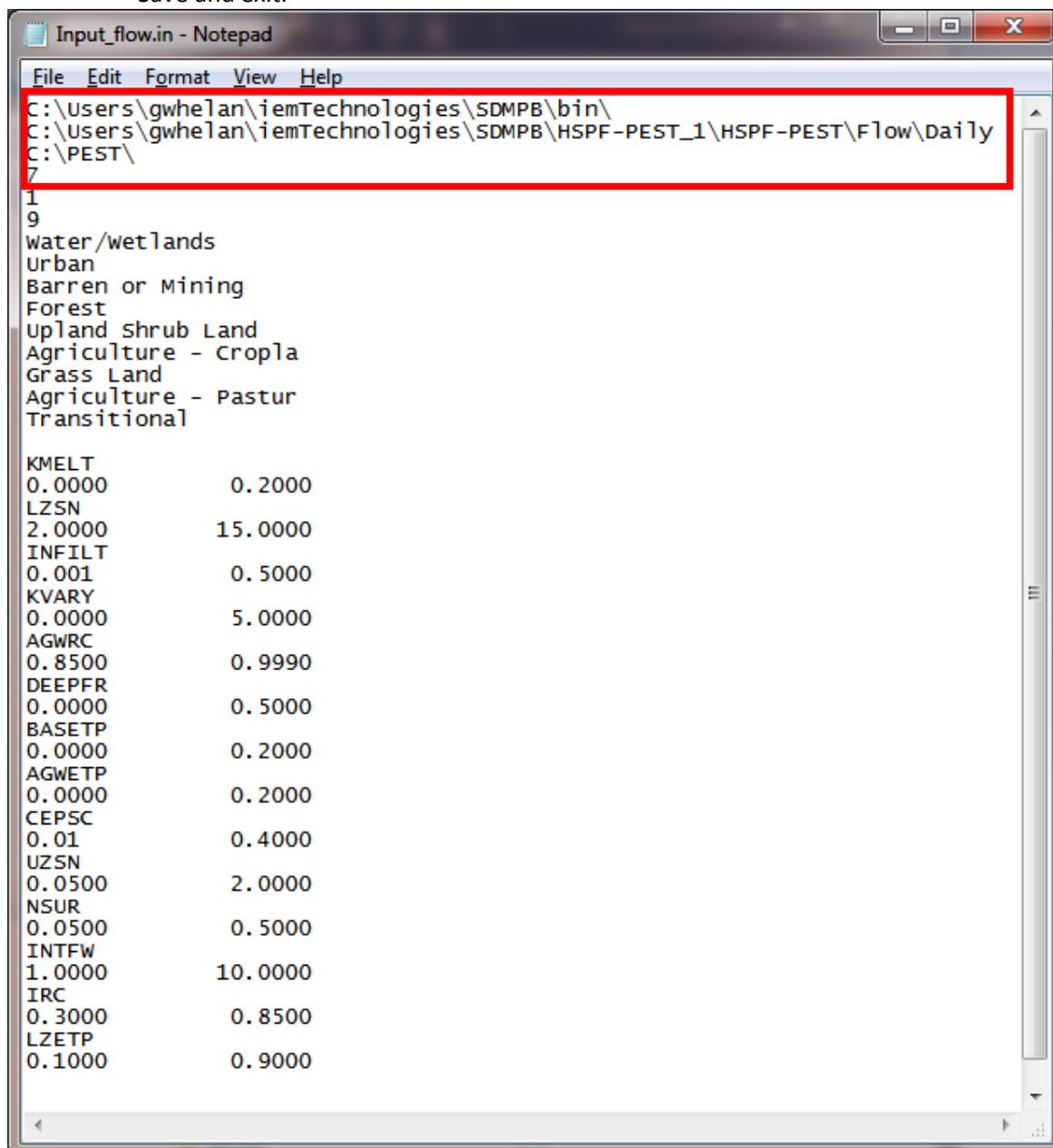
The following lines in "Input_flow.in" may need to be updated. Ensure that these lines are correct.

- Line 1 identifies the path of the folder location of WinHSPFLt.exe.
- Line 2 identifies the path of the working folder here input UCI file, WDM files, and a flow observation file are located, and output files of "HSPF_PEST_flow.exe" will be generated.
- Line 3 identifies the path of the folder location of PEST.exe.
- Line 4 identifies the number of years for model warm-up, from start of the simulation as it appeared in the input UCI file

Refer to Appendix B for additional information on modifying the "Input_flow.in" file. **Ensure that the name of the folder locations end with a backslash (\) for the first three lines.**

The time period associated with this calibration is from January 1, 2000 (2000/01/01) to December 31, 2012 (2012/12/31), respectively. For this example, parameter calibration with daily observations will use the first seven years (i.e., 2000-2006) for model warm up and the final five years for calibration (i.e., 2007-2012). As such, the fourth line will need to contain a "7".

141. For this example, change the
- first three lines to the appropriate folder locations.
 - fourth line from a "1" to a "7".
 - Save and exit.



```
File Edit Format View Help
C:\Users\gwhe1an\iemTechnologies\SDMPB\bin\
C:\Users\gwhe1an\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily
C:\PEST\
7
1
9
water/wetlands
Urban
Barren or Mining
Forest
Upland Shrub Land
Agriculture - Cropla
Grass Land
Agriculture - Pastur
Transitional

KMELT
0.0000      0.2000
LZSN
2.0000      15.0000
INFILT
0.001       0.5000
KVARY
0.0000      5.0000
AGWRC
0.8500      0.9990
DEEPFR
0.0000      0.5000
BASETP
0.0000      0.2000
AGWETP
0.0000      0.2000
CEPSC
0.01        0.4000
UZSN
0.0500      2.0000
NSUR
0.0500      0.5000
INTFW
1.0000      10.0000
IRC
0.3000      0.8500
LZETP
0.1000      0.9000
```

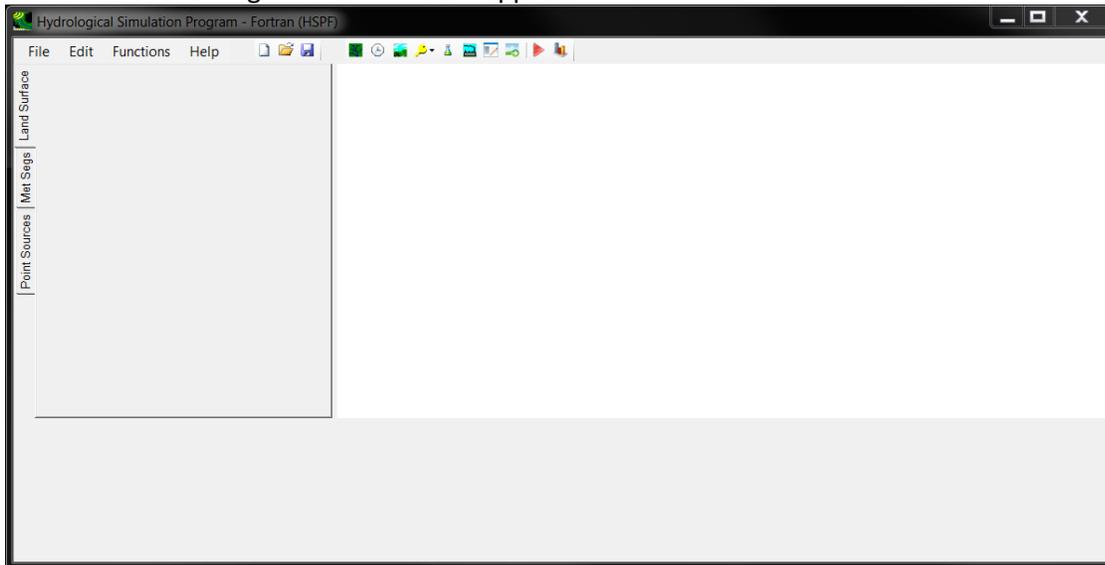
Prepare HSPF for the Flow Calibration Period

HSPF input files were prepared with MET data from 2000 to 2012 which needs to be divided into two sub-periods: one for parameter calibration and one for validation. In this example, parameter calibration with daily flow observations will be performed for 2007 to 2012, with first seven years as model warm-up.

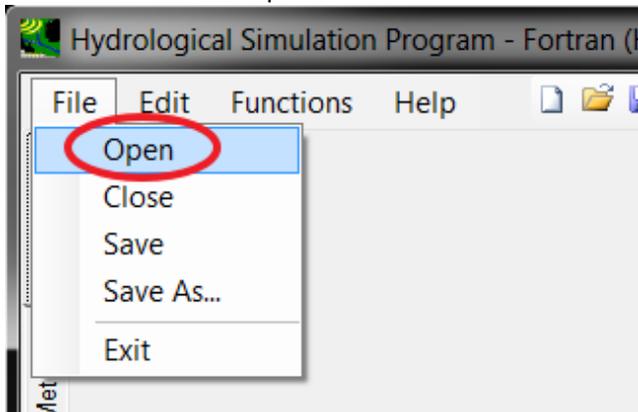
142. Open WinHSPF by double-clicking (left) on the icon to execute WinHSPF3.0. If the icon cannot be found on the Desktop screen, locate the executables on the hard drive (WinHSPF.exe), typically in <...\\BASINS45\\models\\WinHSPF30\\bin\\>.



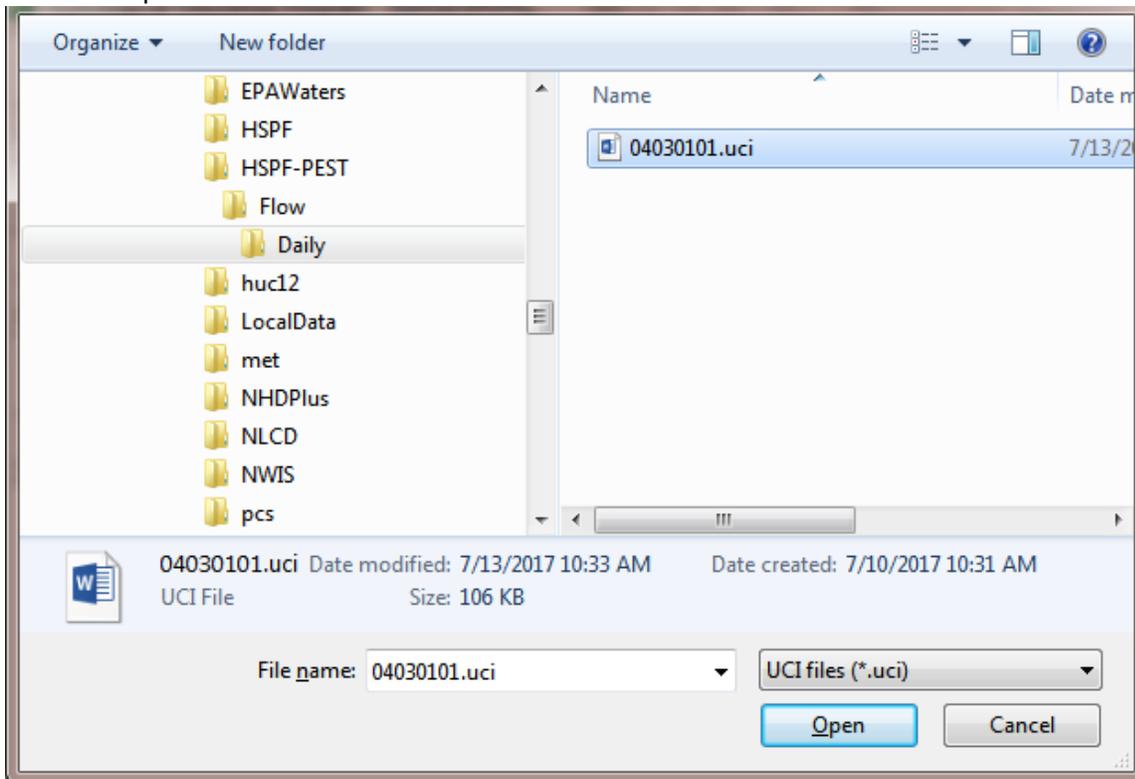
143. The following WinHSPF window appears.



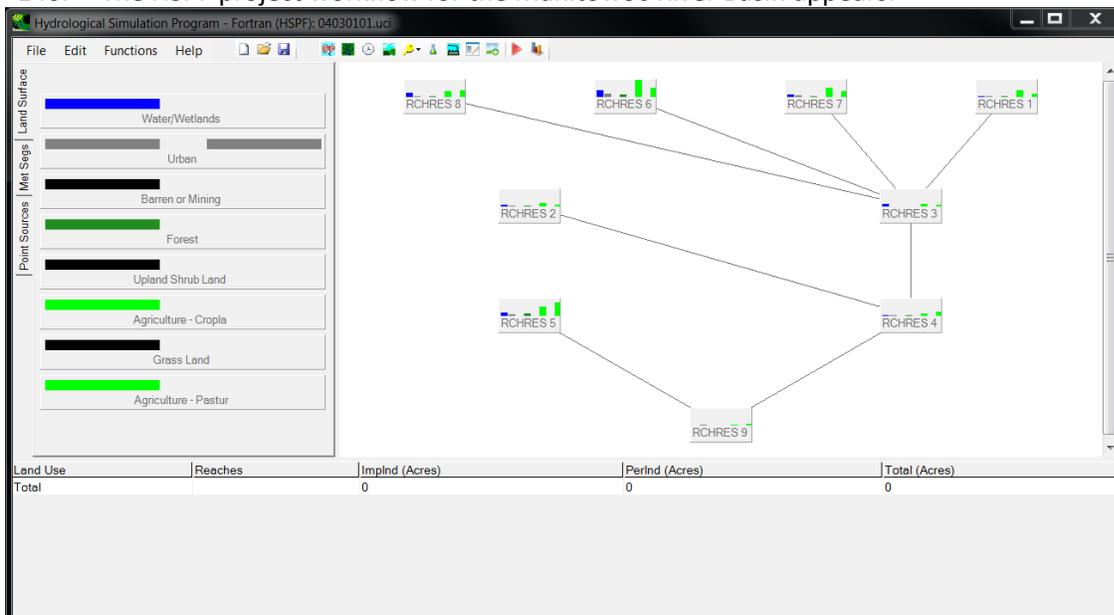
144. Select "File>Open".



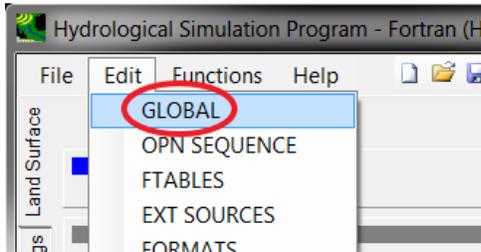
145. The following window appears. Browse to
 “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily\04030101.uci”, then
 click “Open”.



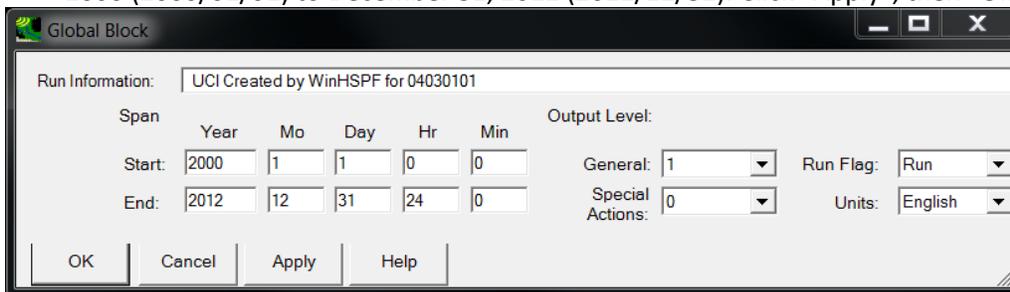
146. The HSPF project workflow for the Manitowoc River Basin appears.



147. To change the simulation period to reflect the calibration period (2007-2012), select “Edit>GLOBAL”.



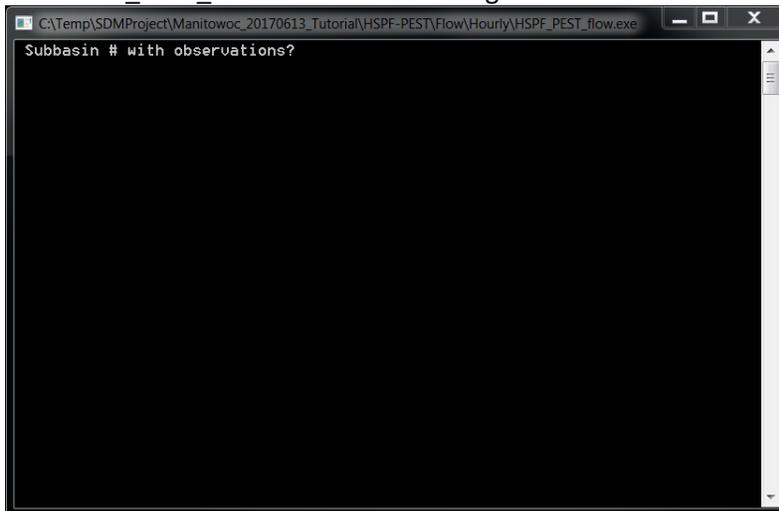
148. The “Global Block” window appears. Check to ensure that the simulation time goes January 1, 2000 (2000/01/01) to December 31, 2012 (2012/12/31). Click “Apply”, then “OK”.



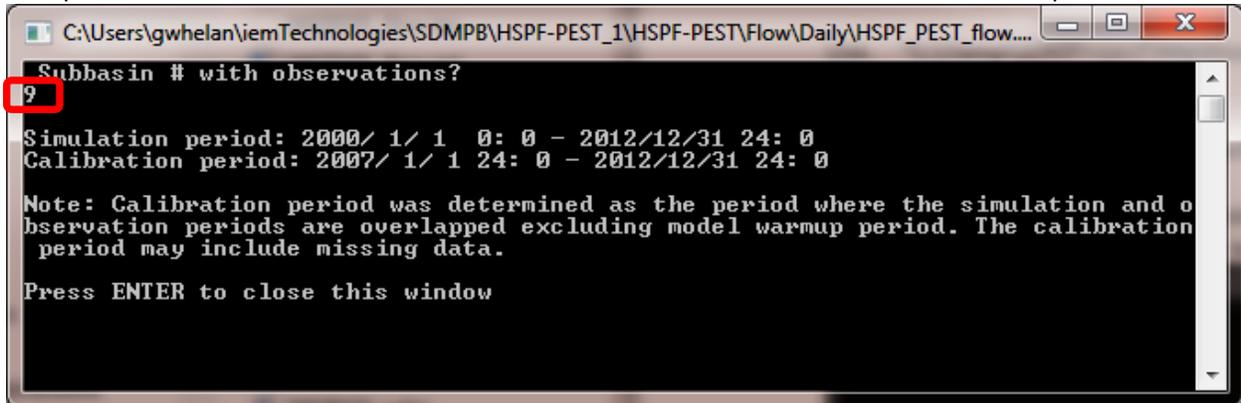
149. In the WinHSPF UI, save the changes by clicking  or “File>Save”. Close WinHSPF.
150. “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily\04030101.uci” does not need to be modified.

Execute HSPF for the Flow Calibration Period

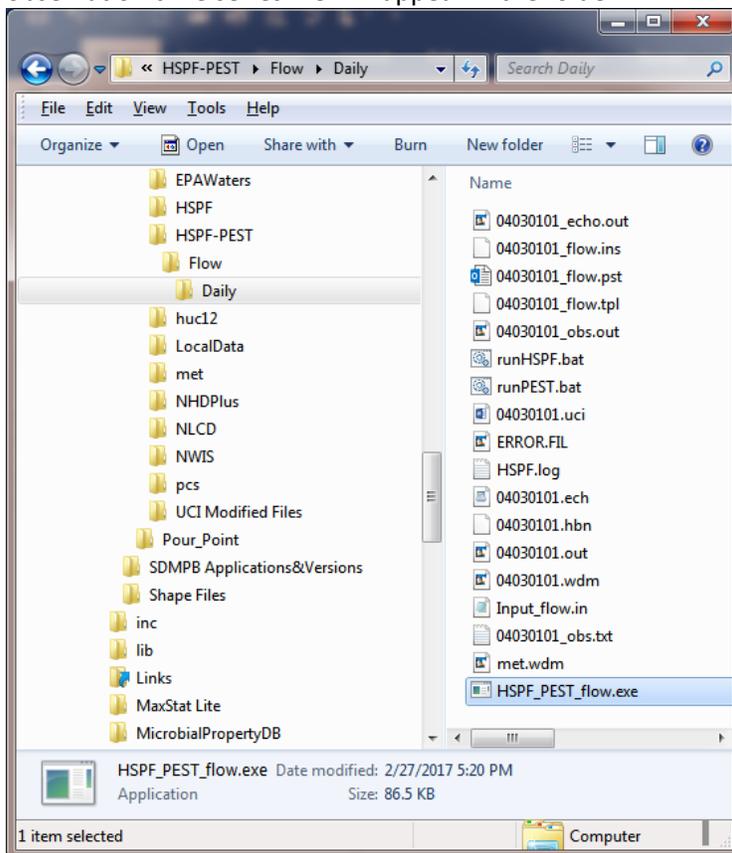
151. In “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily”, execute “HSPF_PEST_flow.exe”. The following command window will appear.



152. In this example, we calibrate parameters at the outlet of the watershed. From the figure in the Step 124, one can easily indicate the watershed outlet is Subwatershed 9 (i.e., RCHRES 9). Put “9” in the command window and press ENTER. When the command window appears (shown below), press ENTER to close it. The command window indicates simulation and calibration periods.



153. Once “HSPF_PEST_flow.exe” is executed, the three PEST input files, two batch files, and a flow observation time series file will appear in the folder.



Now PEST input files for HSPF flow parameter calibration process have been prepared for daily flows.

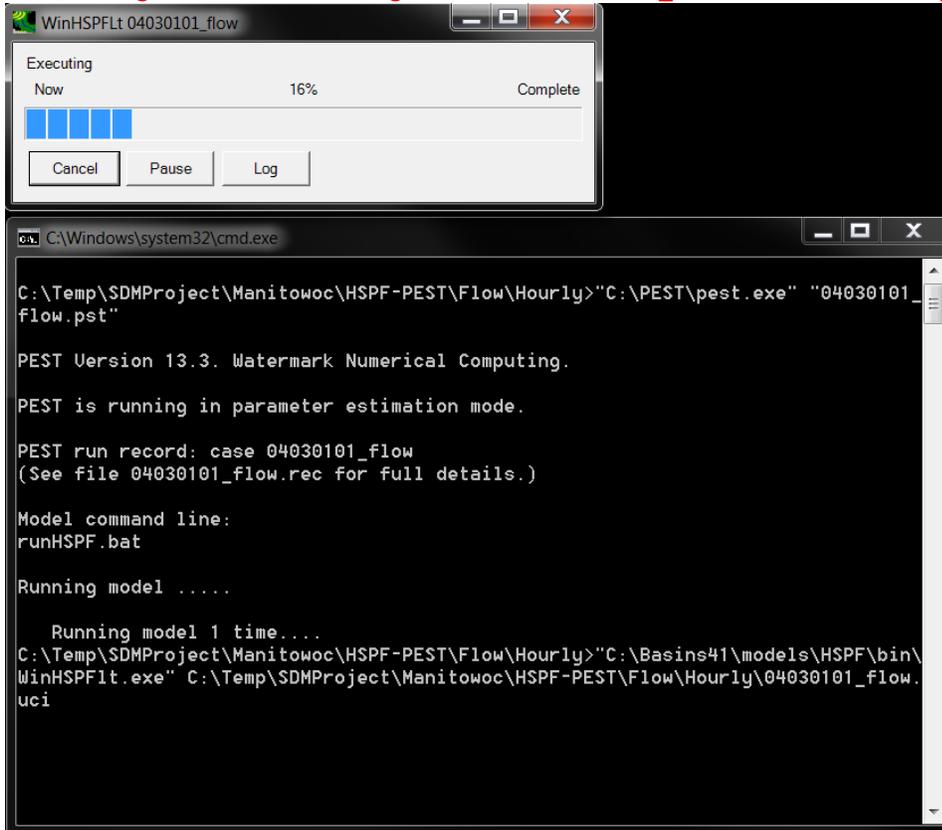
CALIBRATING HSPF FLOW PARAMETERS WITH PEST

“runPEST.bat” is a batch file that executes calibration for HSPF flow input parameters located in the following folder (for this example):

“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily”.

154. Execute “runPEST.bat” in

“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily”.



During parameter calibration, a command window will show calibration progress as it processes, and the HSPF monitoring window will appear and disappear multiple times, illustrated in the following figure.

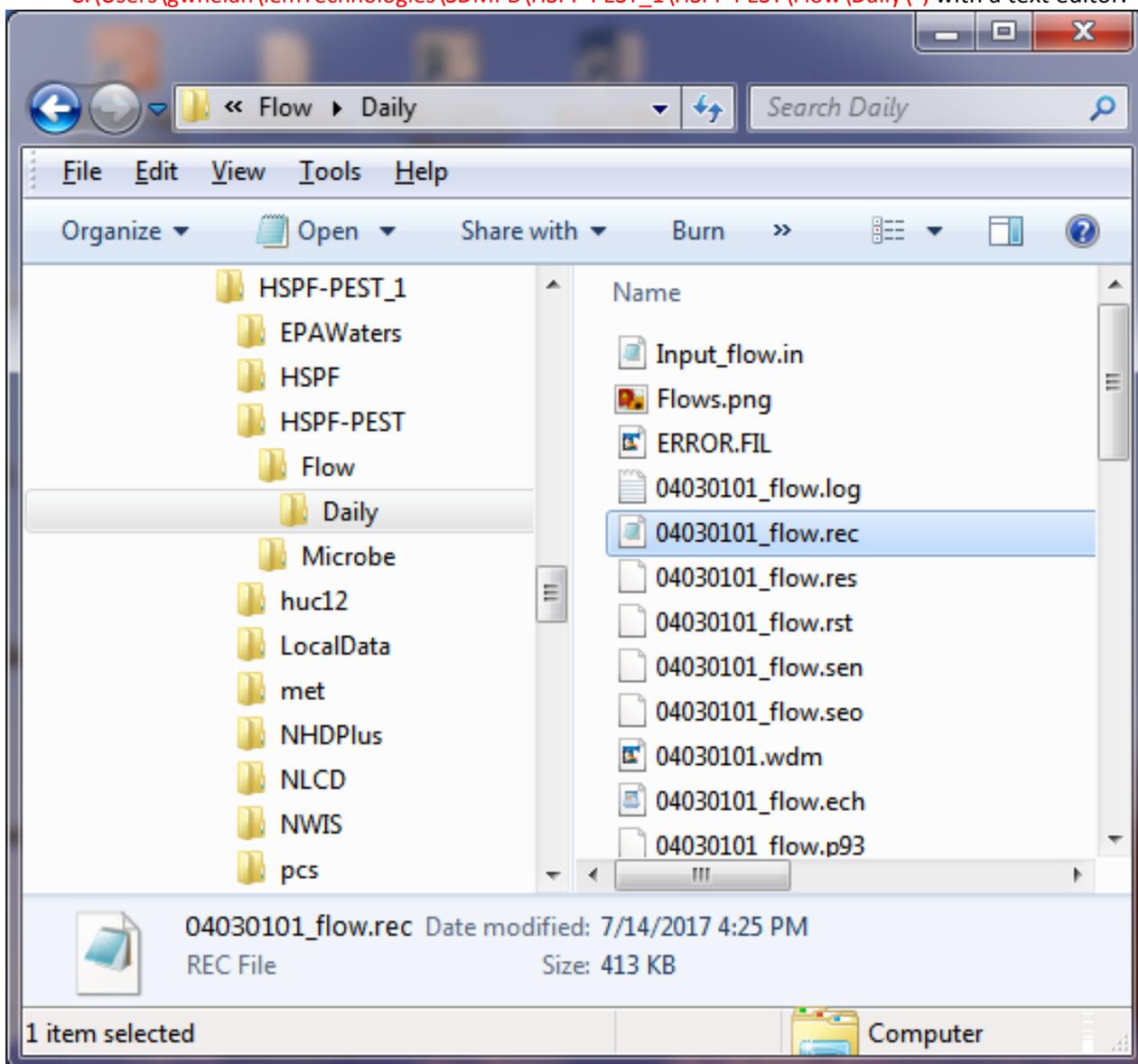
155. HSPF flow parameter calibrations with PEST will conclude when the command window disappears.

VIEWING OUTPUT FILES OF THE FLOW CALIBRATION RESULTS

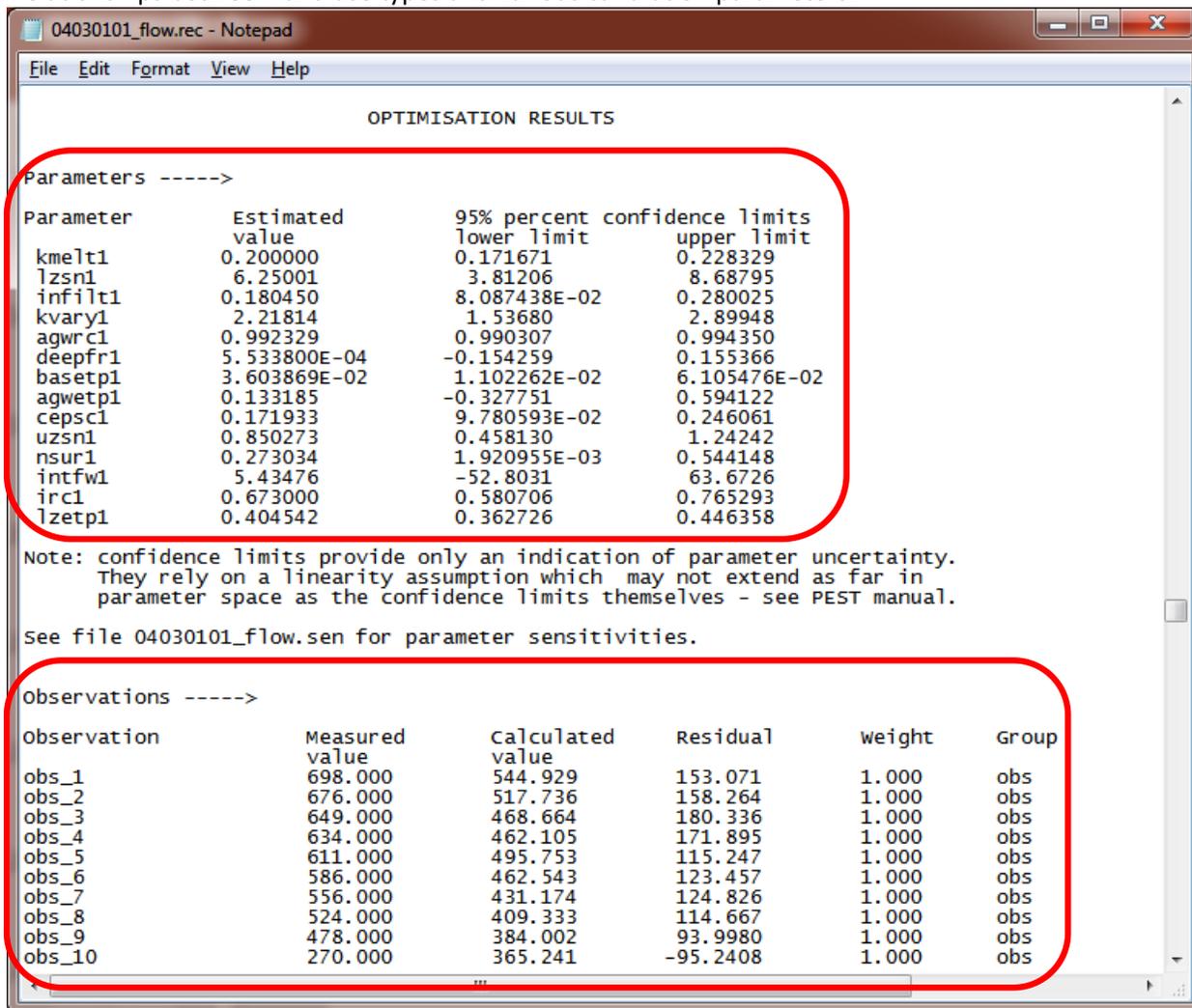
View PEST Output Files of Flow Calibration Results with a Text Editor

The parameter calibration results are recorded in the “.rec” file. In this example, “04030101_flow.rec” in “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily” contains parameter calibrations with daily flow data.

156. To view results of daily flow calibrations, open “04030101_flow.rec”, located in “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily”, with a text editor.



157. Daily results are presented in the figure below. In the example, daily flow parameter calibration results are summarized in “OPTIMISATION RESULTS” which contains calibrated parameter values (under “Estimated value”) and their confidence limits, followed by iterative comparisons of flow calculations and observations (see “Observations ----->”). For additional insight on relationships between calibration parameters and environmental factors, Appendix C provides heuristic relationships between land use types and various calibration parameters.



158. Statistics between calculations and observations are listed in “Objective Function ----->” and “Correlation coefficient ----->”, as illustrated below. The sum of squared weighted residuals is a measure of the discrepancy between the data and an estimation model. The correlation coefficient (“*r*”) is a statistical measure of the degree in the change of one parameter because of change in another. When done, close the file.

```

04030101_flow.rec - Notepad
File Edit Format View Help
obs_2182      133.000      245.232      -112.232      1.000      obs
obs_2183      170.000      223.739      -53.7391     1.000      obs
obs_2184      150.000      202.358      -52.3582     1.000      obs
obs_2185      139.000      187.191      -48.1913     1.000      obs
obs_2186      132.000      176.284      -44.2840     1.000      obs
obs_2187      130.000      167.943      -37.9429     1.000      obs
obs_2188      133.000      161.792      -28.7920     1.000      obs
obs_2189      129.000      160.793      -31.7933     1.000      obs
obs_2190      123.000      166.421      -43.4210     1.000      obs
obs_2191      118.000      161.750      -43.7502     1.000      obs
obs_2192      124.000      154.086      -30.0859     1.000      obs

See file 04030101_flow.res for more details of residuals in graph-ready format.
See file 04030101_flow.seo for composite observation sensitivities.

Objective function ----->
sum of squared weighted residuals (ie phi) = 1.5852E+08

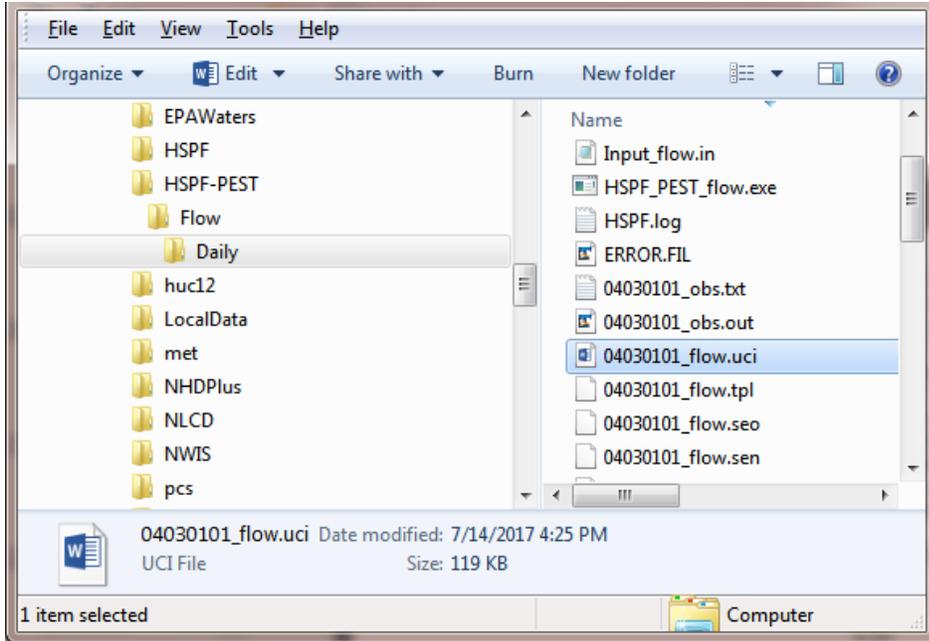
Correlation coefficient ----->
Correlation coefficient = 0.85832

Analysis of residuals ----->
All residuals:-
Number of residuals with non-zero weight = 2192
Mean value of non-zero weighted residuals = 15.53
Maximum weighted residual [observation "obs_72"] = 1897.
Minimum weighted residual [observation "obs_466"] = -1832.
Standard variance of weighted residuals = 7.2784E+04
Standard error of weighted residuals = 269.8

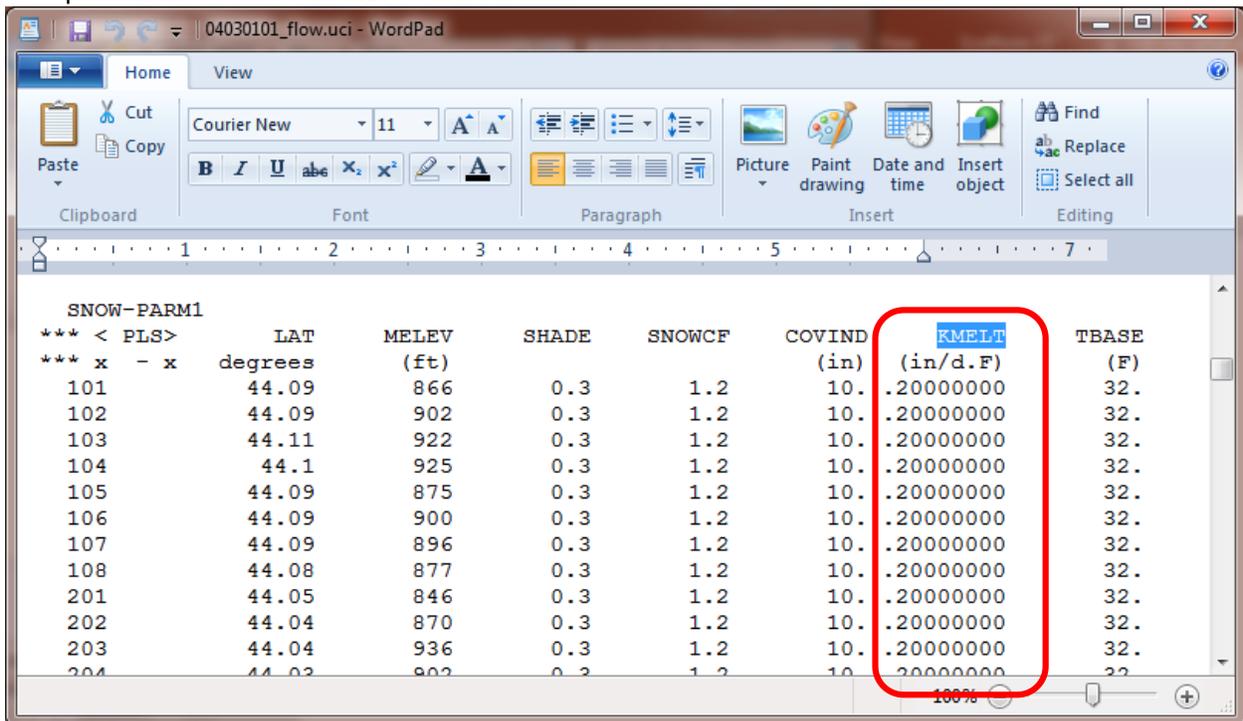
Note: the above variance was obtained by dividing the objective
function by the number of system degrees of freedom (ie. number of
observations with non-zero weight plus number of prior information
articles with non-zero weight minus the number of adjustable parameters.)
If the degrees of freedom is negative the divisor becomes
the number of observations with non-zero weight plus the number of
prior information items with non-zero weight.

```

159. The HSPF UCI file written by PEST (“04030101_flow.uci”) contains parameters calibrated by PEST, which represents the final HSPF simulation associated with flow calibration. Daily calibrated flow results in “04030101_flow.uci” are located, respectively, in the following folders:
 “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily”.



160. Open “04030101_flow.uci” in “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily” with any text editor, and go to the “SNOW-PARM1” section, where the calibrated parameter value of “KMELT” can be found.



161. In “PWAT-PARM2” section, calibrated parameter values of “LZSN”, “INFILT”, “KVARY”, and “AGWRC” can be found.

The screenshot shows a WordPad window titled "04030101_flow.uci - WordPad". The document content is as follows:

```

PWAT-PARM2
*** < PLS>
*** x - x
FOREST
LZSN      INFILT      LSUR      SLSUR      KVARY      AGWRC
(in)      (in/hr)     (ft)      (1/in)     (1/day)
101      0. 6.2500050 .18044987  500 0.000151 2.2181366 .99232890
102      0. 6.2500050 .18044987  500 0.000151 2.2181366 .99232890
103      0. 6.2500050 .18044987  500 0.000151 2.2181366 .99232890
104      1. 6.2500050 .18044987  500 0.000151 2.2181366 .99232890
105      1. 6.2500050 .18044987  500 0.000151 2.2181366 .99232890
106      0. 6.2500050 .18044987  500 0.000151 2.2181366 .99232890
107      1. 6.2500050 .18044987  500 0.000151 2.2181366 .99232890
108      0. 6.2500050 .18044987  500 0.000151 2.2181366 .99232890
201      0. 6.2500050 .18044987  500 0.000309 2.2181366 .99232890
202      0. 6.2500050 .18044987  500 0.000309 2.2181366 .99232890
203      0. 6.2500050 .18044987  500 0.000309 2.2181366 .99232890
204      1. 6.2500050 .18044987  500 0.000309 2.2181366 .99232890
205      1. 6.2500050 .18044987  500 0.000309 2.2181366 .99232890
206      0. 6.2500050 .18044987  500 0.000309 2.2181366 .99232890
207      1. 6.2500050 .18044987  500 0.000309 2.2181366 .99232890
208      0. 6.2500050 .18044987  500 0.000309 2.2181366 .99232890
301      0. 6.2500050 .18044987  500 0.000146 2.2181366 .99232890
302      0. 6.2500050 .18044987  500 0.000146 2.2181366 .99232890
304      1. 6.2500050 .18044987  500 0.000146 2.2181366 .99232890
305      1. 6.2500050 .18044987  500 0.000146 2.2181366 .99232890
  
```

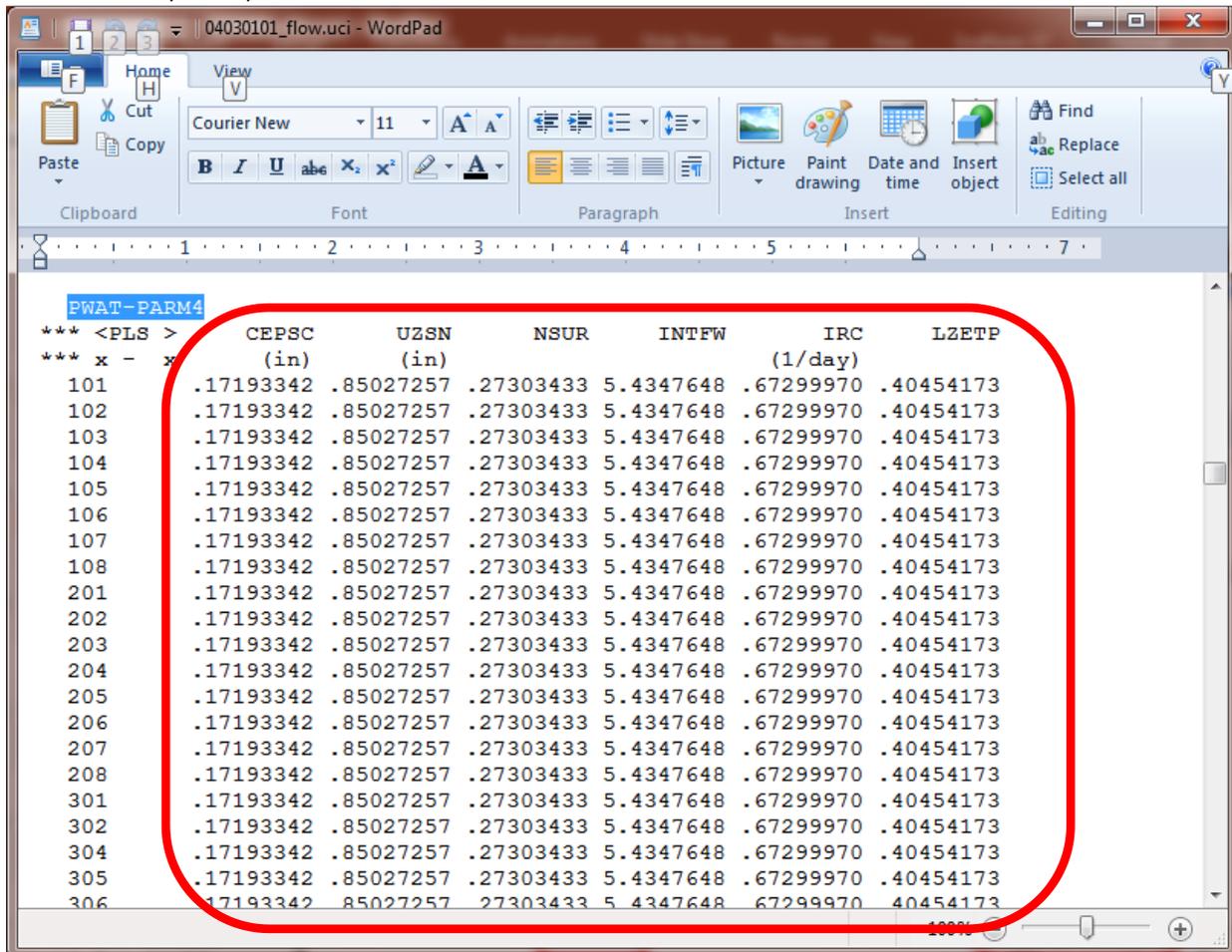
162. In the “PWAT-PARM3” section, calibrated parameter values of “DEEPPFR”, “BASETP”, and “AGWETP” can be found. Note that “AGWETP” was only calibrated for “Water/Wetlands”, and the value was fixed as “0” for other land uses, (EPA, 2000).

The screenshot shows a WordPad window titled "04030101_flow.uci - WordPad". The text content is as follows:

```

PWAT-PARM3
*** < PLS>
*** x - x
PETMAX      PETMIN      INFEXP      INFILD      DEEPPFR      BASETP      AGWETP
(deg F)     (deg F)
101          40.           35.          2.           2.           5.5338E-4  .03603869  .13318532
102          40.           35.          2.           2.           5.5338E-4  .03603869   0.
103          40.           35.          2.           2.           5.5338E-4  .03603869   0.
104          40.           35.          2.           2.           5.5338E-4  .03603869   0.
105          40.           35.          2.           2.           5.5338E-4  .03603869   0.
106          40.           35.          2.           2.           5.5338E-4  .03603869   0.
107          40.           35.          2.           2.           5.5338E-4  .03603869   0.
108          40.           35.          2.           2.           5.5338E-4  .03603869   0.
201          40.           35.          2.           2.           5.5338E-4  .03603869  .13318532
202          40.           35.          2.           2.           5.5338E-4  .03603869   0.
203          40.           35.          2.           2.           5.5338E-4  .03603869   0.
204          40.           35.          2.           2.           5.5338E-4  .03603869   0.
205          40.           35.          2.           2.           5.5338E-4  .03603869   0.
206          40.           35.          2.           2.           5.5338E-4  .03603869   0.
207          40.           35.          2.           2.           5.5338E-4  .03603869   0.
208          40.           35.          2.           2.           5.5338E-4  .03603869   0.
301          40.           35.          2.           2.           5.5338E-4  .03603869  .13318532
302          40.           35.          2.           2.           5.5338E-4  .03603869   0.
304          40.           35.          2.           2.           5.5338E-4  .03603869   0.
305          40.           35.          2.           2.           5.5338E-4  .03603869   0.
306          40.           35.          2.           2.           5.5338E-4  .03603869   0.
  
```

163. In the “PWAT-PARM4” section, calibrated parameter values of “CEPSC”, “UZSN”, “NSUR”, “INTFW”, “IRC”, and “LZETP” can be found.



For details about the HSPF UCI file, see [Bicknell et al. \(2005\)](#) or “C:\BASINS45\docs\HSPF.chm”.

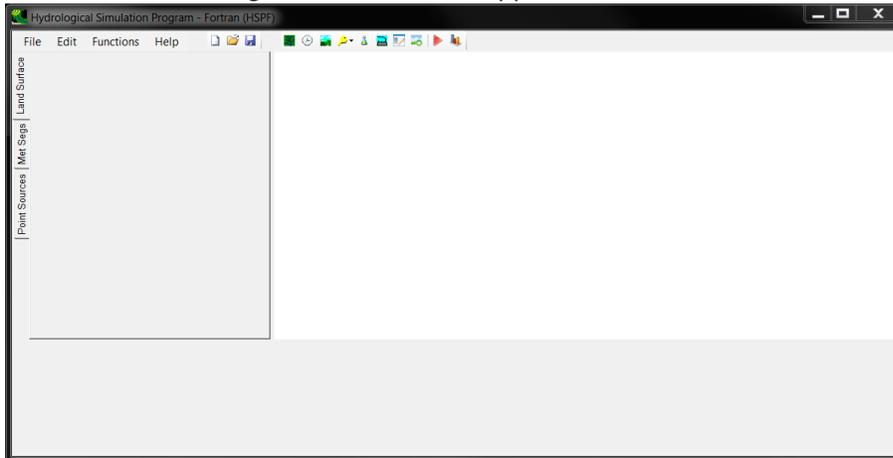
View Calibrated Flow Parameter Values with WinHSPF

The WinHSPF user interface can be used to view calibrated parameter values.

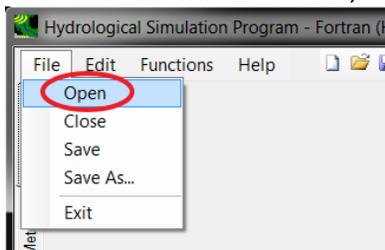
164. Double-click (left) on the icon to execute the WinHSPF.



165. The following WinHSPF window appears.

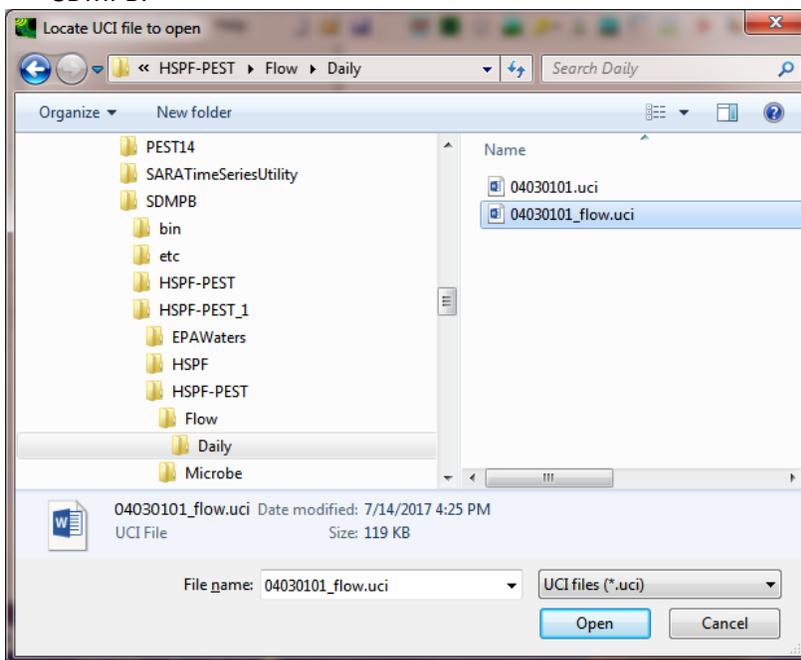


166. In the window above, select "File>Open".

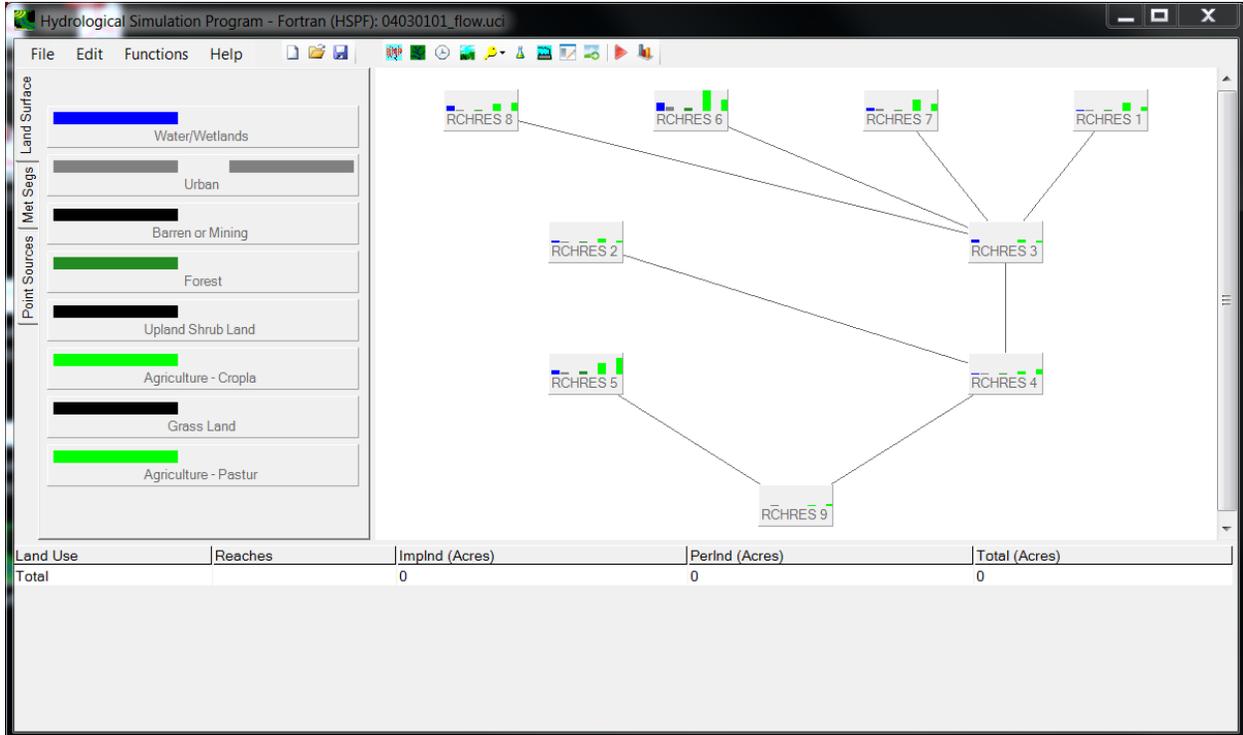


167. The following window appears. Browse and choose

"C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily\04030101_flow.uci", then click "Open". Make sure NOT to select "04030101.uci", since it is the initial UCI file prepared by SDMPB.



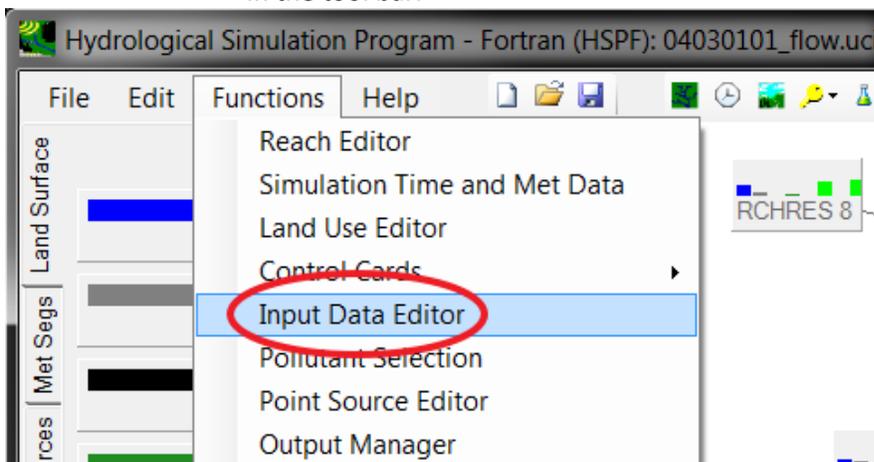
168. The HSPF project on the Manitowoc River Basin will populate the WinHSPF UI which illustrates linkage of subwatersheds, proportion of land use types in each, etc. Details about WinHSPF UI can be found in the WinHSPF Manual, typically in the install folder “\BASINS45\docs\WinHspf30.chm”.



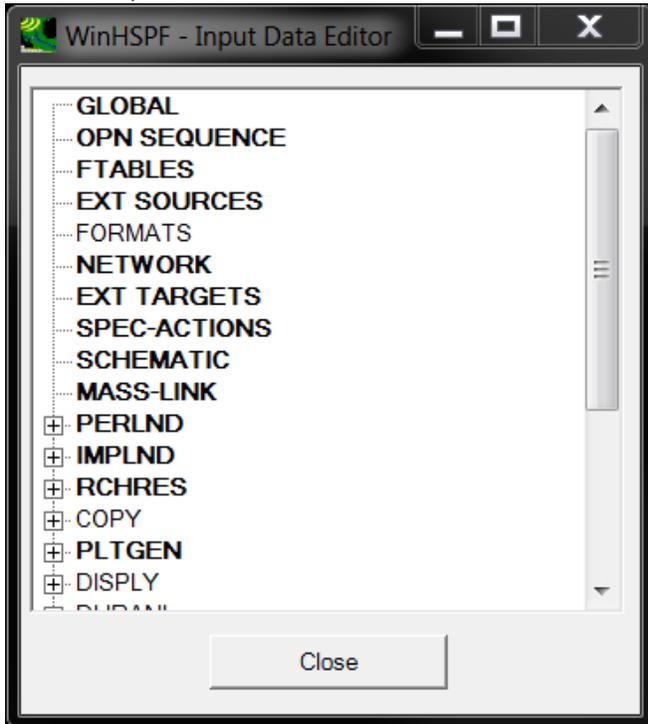
169. To view the calibrated HSPF flow parameters, select “Functions>Input Data Editor” or click on



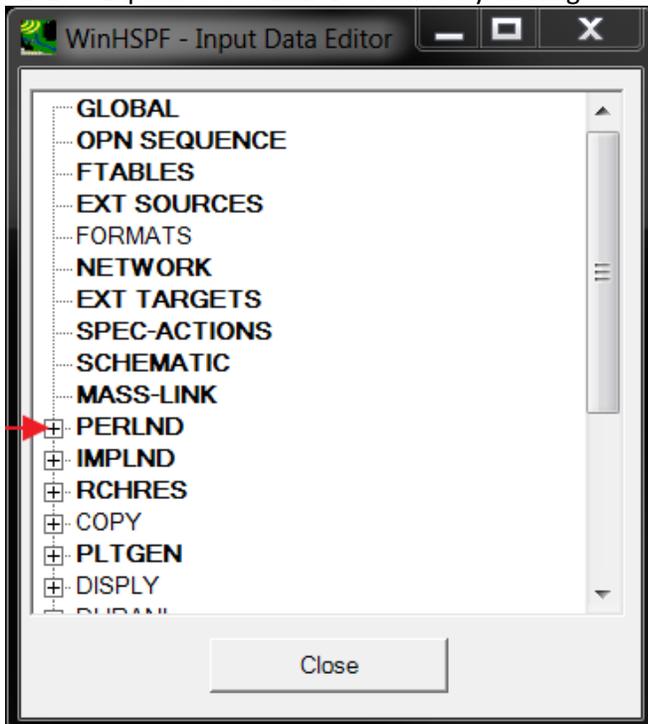
in the tool bar.



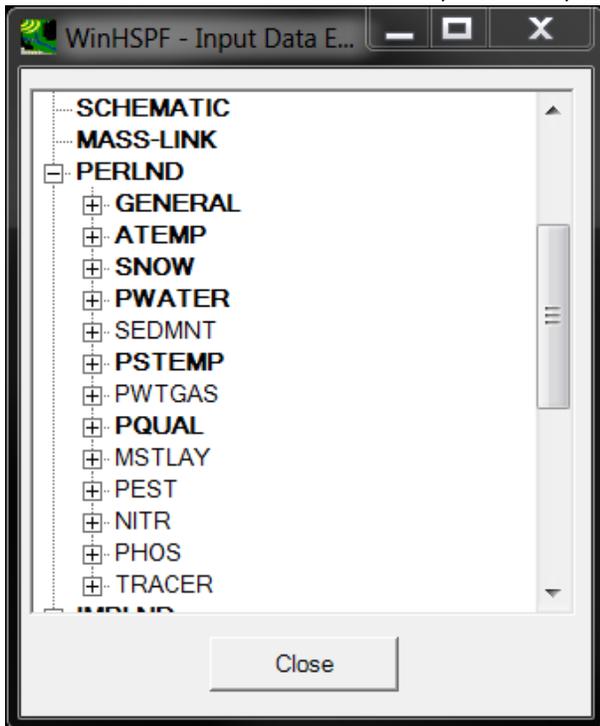
170. The following window appears. Note that only bolded sections have records in the UCI file. For example, "FORMATS" has no records in the UCI file, but "FTABLES" does.



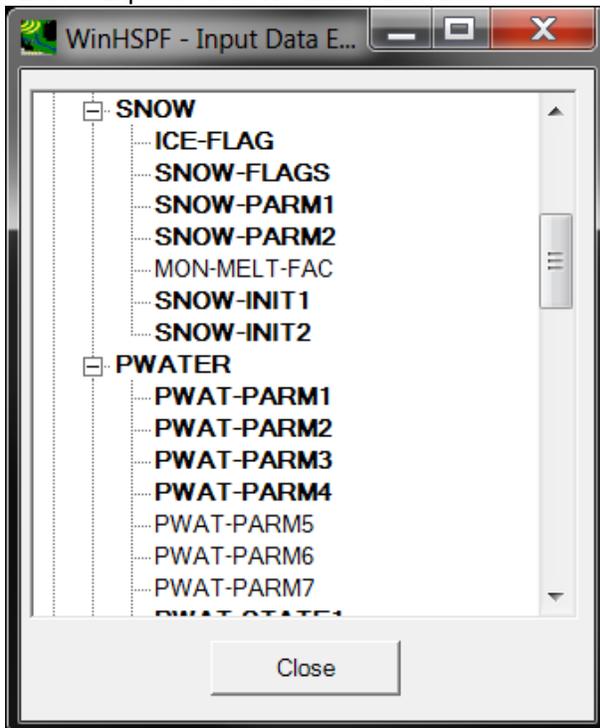
171. Expand the "PERLND" section by clicking + at the left.



172. Expanding “PERLND”, by clicking “+” to the right, produces the following figure which indicates there are records in “GENERAL”, “ATEMP”, “SNOW”, “PWATER”, “PSTEMP”, and “PQUAL”.



173. Expand “SNOW” and “PWATER”.



174. Double-click (left) on “SNOW-PARM1” to open the window below, where the calibrated parameter value of “KMELT” can be found. Click “OK” to close.

Table: SNOW-PARM1, First group of SNOW parameters.

OpNum	Description	LAT	MELEV	SHADE	SNOWCF	COVIND	KMELT	TBASE
101	Water/Wetlands	44.09	866	0.3	1.2	10.	20000000	32.
102	Urban	44.09	902	0.3	1.2	10.	20000000	32.
103	Barren or Mining	44.11	922	0.3	1.2	10.	20000000	32.
104	Forest	44.1	925	0.3	1.2	10.	20000000	32.
105	Upland Shrub Land	44.09	875	0.3	1.2	10.	20000000	32.
106	Agriculture - Cropla	44.09	900	0.3	1.2	10.	20000000	32.
107	Grass Land	44.09	896	0.3	1.2	10.	20000000	32.
108	Agriculture - Pastur	44.08	877	0.3	1.2	10.	20000000	32.
201	Water/Wetlands	44.05	846	0.3	1.2	10.	20000000	32.
202	Urban	44.04	870	0.3	1.2	10.	20000000	32.

*** < PLS> LAT MELEV SHADE SNOWCF COVIND KMELT TBASE
 *** x - x degrees (ft) (in) (in/d.F) (F)

175. In the “Input Data Editor” window, double-click (left) on “PWAT-PARM2” to open the following window, where calibrated parameter values for “LZSN”, “INFILT”, “KVARY”, and “AGWRC” can be found. Click “OK” to close.

Table: PWAT-PARM2, Second group of PWAT-PARM Parameters.

OpNum	Description	FOREST	LZSN	INFILT	LSUR	SLSUR	KVARY	AGWRC
101	Water/Wetlands	0.	6.2500050	.18044987	500	0.000151	2.2181366	.99232890
102	Urban	0.	6.2500050	.18044987	500	0.000151	2.2181366	.99232890
103	Barren or Mining	0.	6.2500050	.18044987	500	0.000151	2.2181366	.99232890
104	Forest	1.	6.2500050	.18044987	500	0.000151	2.2181366	.99232890
105	Upland Shrub Land	1.	6.2500050	.18044987	500	0.000151	2.2181366	.99232890
106	Agriculture - Cropla	0.	6.2500050	.18044987	500	0.000151	2.2181366	.99232890
107	Grass Land	1.	6.2500050	.18044987	500	0.000151	2.2181366	.99232890
108	Agriculture - Pastur	0.	6.2500050	.18044987	500	0.000151	2.2181366	.99232890
201	Water/Wetlands	0.	6.2500050	.18044987	500	0.000309	2.2181366	.99232890

*** < PLS> FOREST LZSN INFILT LSUR SLSUR KVARY AGWRC
 *** x - x (in) (in/hr) (ft) (1/in) (1/day)

176. In the “Input Data Editor” window, double-click (left) on “PWAT-PARM3” to open the following window, where calibrated parameter values for “DEEPPFR”, “BASETP”, and “AGWETP” can be found. Click “OK” to close.

OpNum	Description	PETMAX	PETMIN	INFEXP	INFILD	DEEPPFR	BASETP	AGWETP
101	Water/Wetlands	40.	35.	2.	2.	5.5338E-4	.03603869	.13318532
102	Urban	40.	35.	2.	2.	5.5338E-4	.03603869	0.
103	Barren or Mining	40.	35.	2.	2.	5.5338E-4	.03603869	0.
104	Forest	40.	35.	2.	2.	5.5338E-4	.03603869	0.
105	Upland Shrub Land	40.	35.	2.	2.	5.5338E-4	.03603869	0.
106	Agriculture - Cropla	40.	35.	2.	2.	5.5338E-4	.03603869	0.
107	Grass Land	40.	35.	2.	2.	5.5338E-4	.03603869	0.
108	Agriculture - Pastur	40.	35.	2.	2.	5.5338E-4	.03603869	0.
201	Water/Wetlands	40.	35.	2.	2.	5.5338E-4	.03603869	.13318532

Table: PWAT-PARM3, Third group of PWATER Parameters.

```

*** < PLS>   PETMAX   PETMIN   INFEXP   INFILD   DEEPPFR   BASETP   AGWETP
*** x  - x   (deg F)  (deg F)

```

Buttons: OK, Cancel, Apply, Help

177. In the “Input Data Editor” window, double-click (left) on “PWAT-PARM4” to open the following window, where calibrated parameter values for “CEPSC”, “UZSN”, “NSUR”, “INTFW”, “IRC”, and “LZETP” can be found. Click “OK” to close.

OpNum	Description	CEPSC	UZSN	NSUR	INTFW	IRC	LZETP
101	Water/Wetlands	.17193342	.85027257	27303433	5.4347648	.67299970	.40454173
102	Urban	.17193342	.85027257	27303433	5.4347648	.67299970	.40454173
103	Barren or Mining	.17193342	.85027257	27303433	5.4347648	.67299970	.40454173
104	Forest	.17193342	.85027257	27303433	5.4347648	.67299970	.40454173
105	Upland Shrub Land	.17193342	.85027257	27303433	5.4347648	.67299970	.40454173
106	Agriculture - Cropla	.17193342	.85027257	27303433	5.4347648	.67299970	.40454173
107	Grass Land	.17193342	.85027257	27303433	5.4347648	.67299970	.40454173
108	Agriculture - Pastur	.17193342	.85027257	27303433	5.4347648	.67299970	.40454173
201	Water/Wetlands	.17193342	.85027257	27303433	5.4347648	.67299970	.40454173

Table: PWAT-PARM4, Fourth group of PWATER Parameters.

```

*** < PLS >   CEPSC     UZSN     NSUR     INTFW     IRC     LZETP
*** x  - x   (in)      (in)

```

Buttons: OK, Cancel, Apply, Help

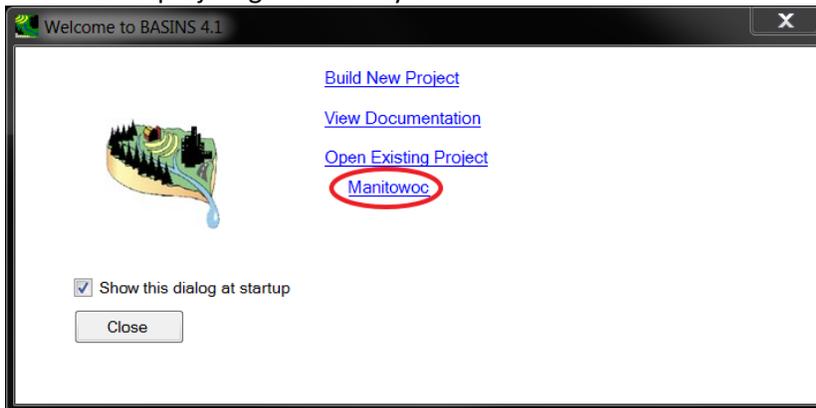
SECTION 3

VISUALIZING HSPF FLOW CALIBRATION AND SIMULATION RESULTS

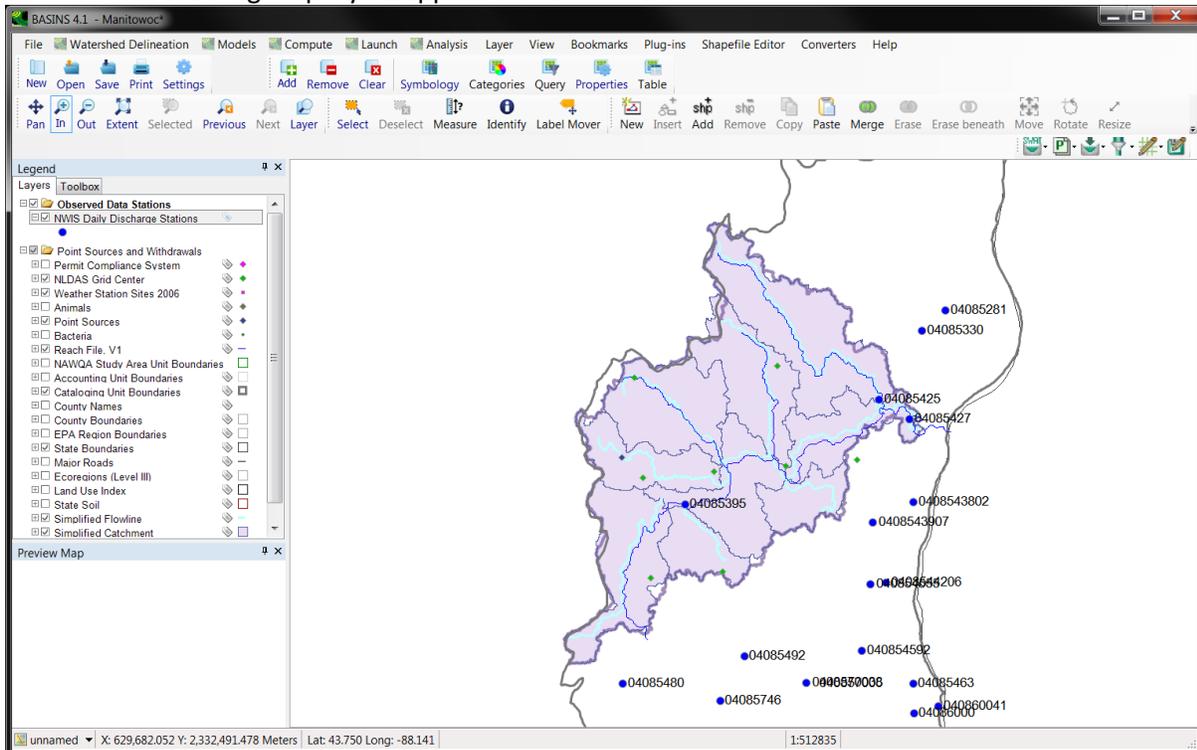
REGISTERING CALIBRATION RESULTS WITH BASINS

This section registers flow results for calibrated simulations (<...\HSPF\Flow\Daily\04030101.wdm>).

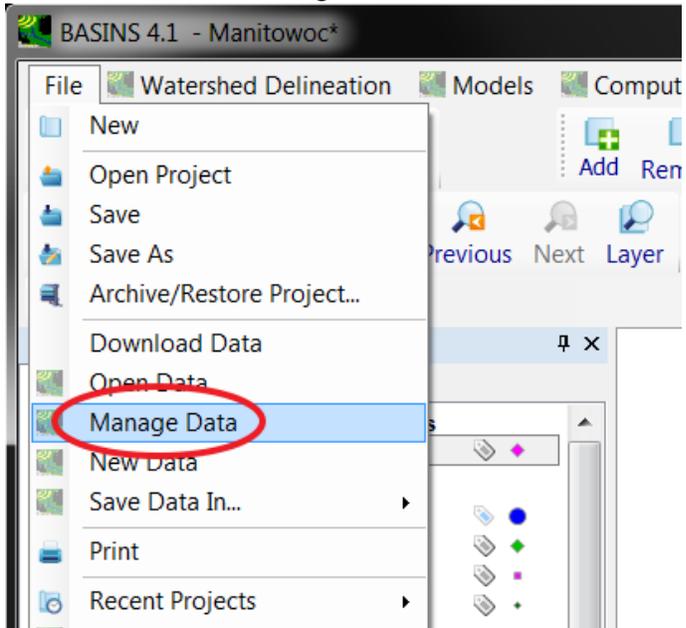
178. Execute BASINS. When “Welcome to BASINS 4.5” appears, click “Manitowoc” to open the BASINS project generated by SDMPB.



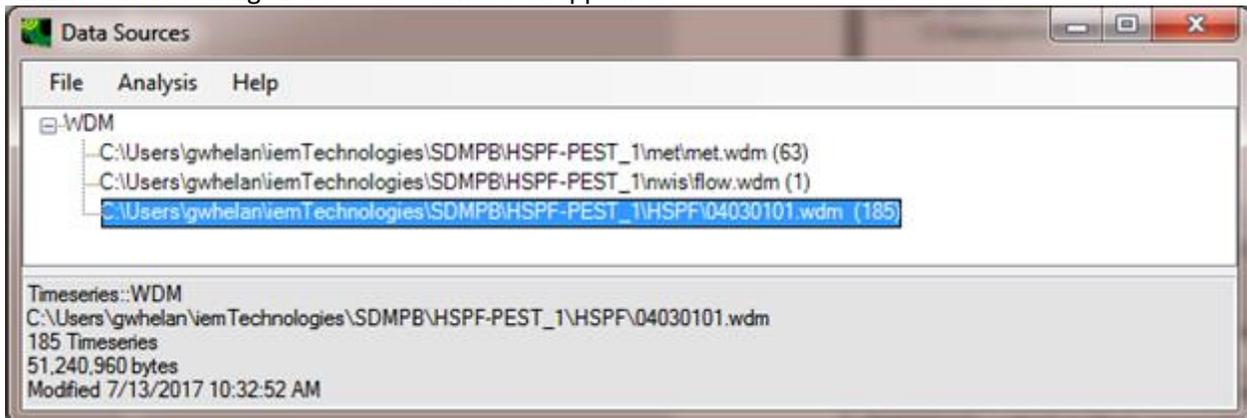
179. The following map layers appear in the BASINS UI.



180. Select “File>Manage Data”.



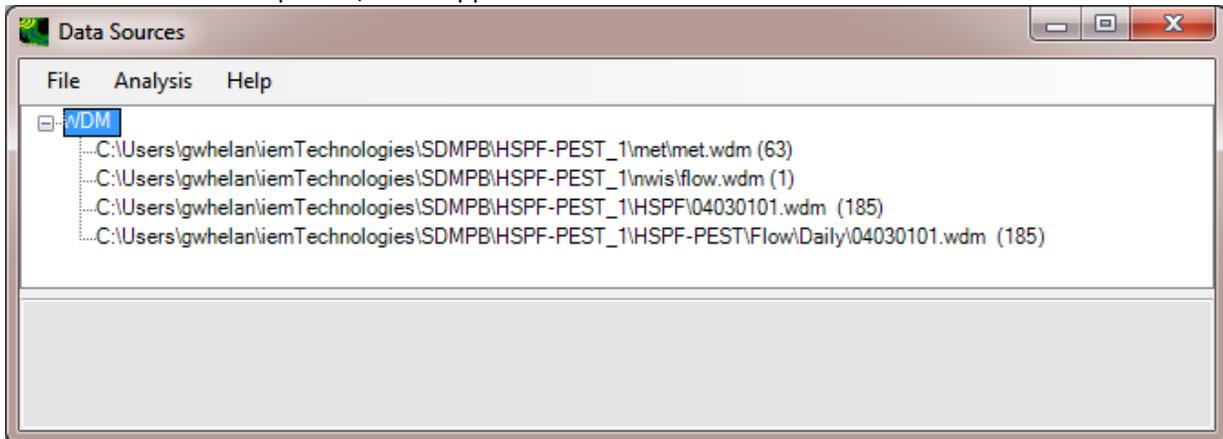
181. The following “Data Sources” window appears.



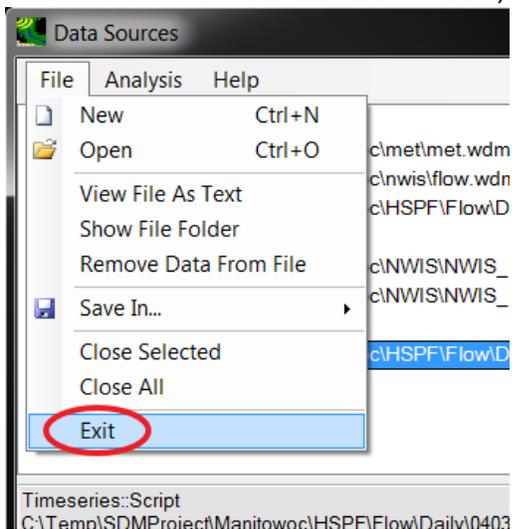
HSPF daily flow simulation results, based on calibrated parameter values, were stored in the “04030101.wdm” file located in the “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily\” folder.

182. In the “Data Sources” window, select “File>Open” which results in the “Select a Data Source” window.
 - a. Select “WDM Time Series” by double-clicking on it.
 - b. Browse and select “04030101.wdm” in
 “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily\”.
 - c. Click “Open”.

Once the file is imported, it will appear in the “Data Sources” window.



183. Close the “Data Sources” window, by selecting “File>Exit”.



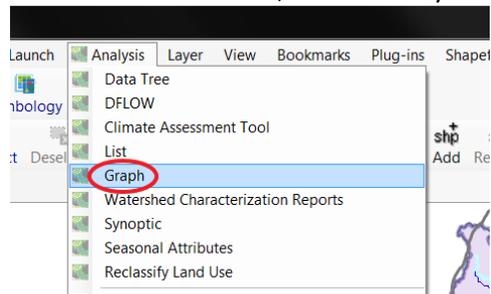
COMPARING HSPF FLOW SIMULATION RESULTS BY PLOTTING MULTIPLE TIME SERIES

HSPF performs hourly simulations and can publish the results as hourly, daily, monthly, etc. The observed flows obtained from the USGS gage station are daily values, so the calibrated results are associated with the observed daily values.

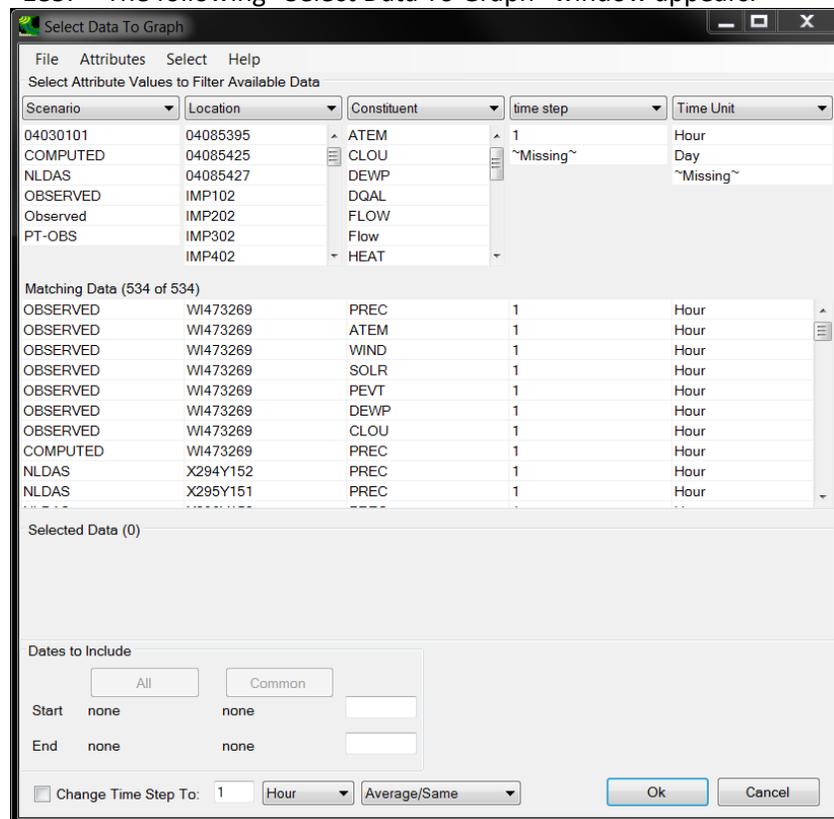
Identify Data Sources Containing Daily Flow

To plot daily flow data time series of discharges, the file containing the time series data must be identified within BASINS plotting tools. Once identified, calibrated and observed flow time series can be plotted simultaneously.

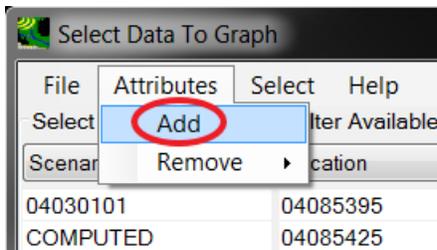
184. Within BASINS, select “Analysis>Graph”.



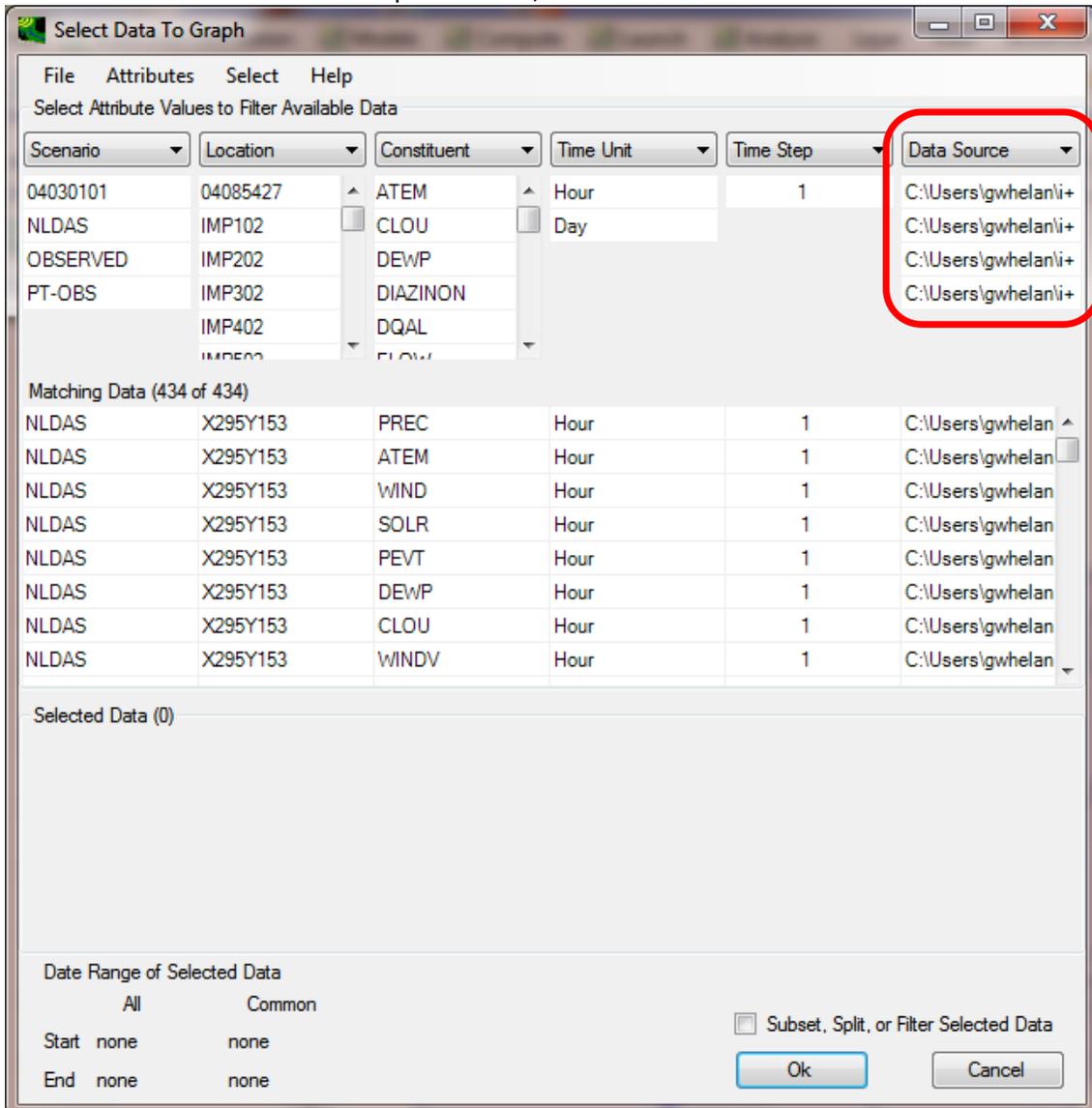
185. The following “Select Data To Graph” window appears.



186. To identify data source locations, a column of “Data Sources” must be added. Select “Attributes>Add”.



187. In the “Select Data To Graph” window, select “Data Source” for the column to be added.



188. To see the full path of the data source, the width of each column must be adjusted. In “Matching Data”, click and drag the vertical lines between adjacent columns to adjust widths.

Matching Data (24 of 24)		
OBSERVED	WI473269	PREC
OBSERVED	WI473269	ATEM
OBSERVED	WI473269	WIND
OBSERVED	WI473269	SOLR
OBSERVED	WI473269	PEVT
OBSERVED	WI473269	DEWP
OBSERVED	WI473269	CLOU
COMPUTED	WI473269	PREC
NLDAS	X294Y152	PREC
NLDAS	X296Y152	PREC

189. After adjustment, column widths will look like those below.

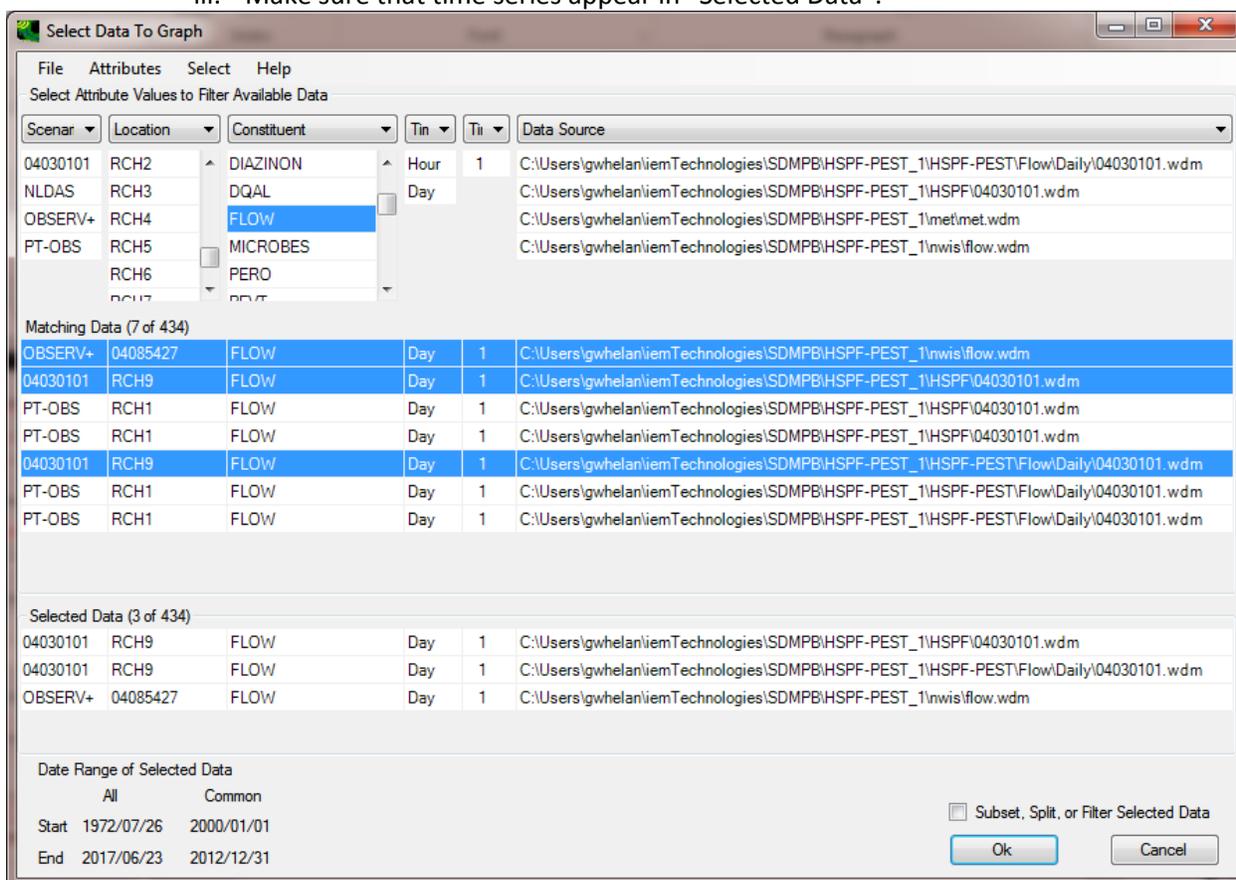
The screenshot shows the 'Select Data To Graph' dialog box. It has a menu bar with 'File', 'Attributes', 'Select', and 'Help'. Below the menu bar is a section titled 'Select Attribute Values to Filter Available Data' with several dropdown menus: 'Scena', 'Location', 'Consti', 'Ti', and 'Ti'. A 'Data Source' dropdown is also present. The main area contains a table with columns for 'Scena', 'Location', 'Consti', 'Ti', 'Ti', and 'Data Source'. Below this is a section for 'Matching Data (434 of 434)' with columns for 'Scena', 'Location', 'Consti', 'Ti', 'Ti', and 'Data Source'. At the bottom, there is a 'Selected Data (0)' section, a 'Date Range of Selected Data' section with 'All' and 'Common' options, and a checkbox for 'Subset, Split, or Filter Selected Data'. 'Ok' and 'Cancel' buttons are at the bottom right.

Scena	Location	Consti	Ti	Ti	Data Source
040301+	04085427	ATEM	Hour	1	C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\HSPF-PEST\Flow\Daily\04030101.wdm
NLDAS	IMP102	CLOU	Day		C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\HSPF\04030101.wdm
OBSER+	IMP202	DEWP			C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\met\met.wdm
PT-OBS	IMP302	DIAZIN			C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\mwis\flow.wdm
	IMP402	DQAL			
	IMP502	FLOW			

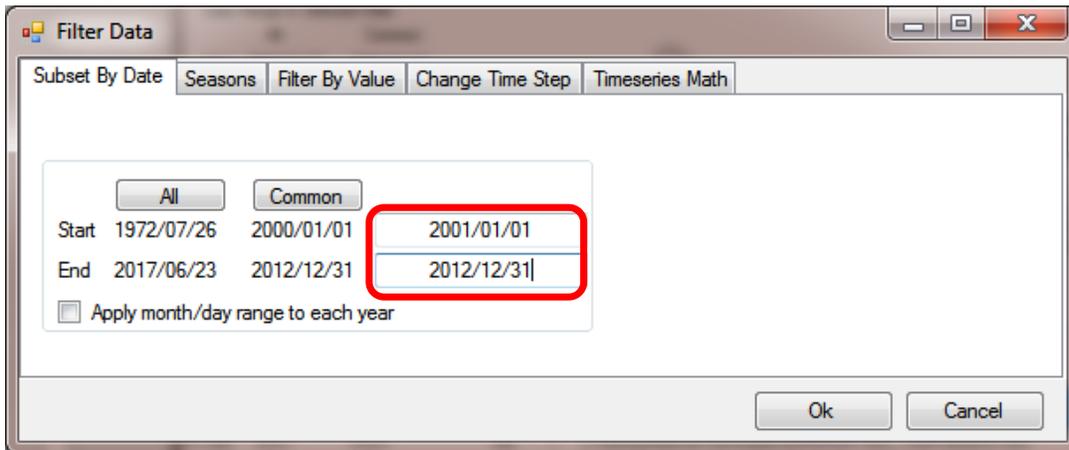
Scena	Location	Consti	Ti	Ti	Data Source
NLDAS	X295Y153	PREC	Hour	1	C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\met\met.wdm
NLDAS	X295Y153	ATEM	Hour	1	C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\met\met.wdm
NLDAS	X295Y153	WIND	Hour	1	C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\met\met.wdm
NLDAS	X295Y153	SOLR	Hour	1	C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\met\met.wdm
NLDAS	X295Y153	PEVT	Hour	1	C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\met\met.wdm
NLDAS	X295Y153	DEWP	Hour	1	C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\met\met.wdm
NLDAS	X295Y153	CLOU	Hour	1	C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\met\met.wdm
NLDAS	X295Y153	WINDV	Hour	1	C:\Users\gwhelan\iemTechnologies\SDMPBI\HSPF-PEST_1\met\met.wdm

View Results for a Daily Time Step

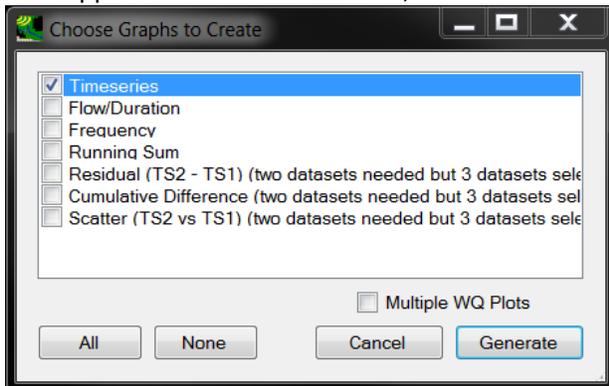
190. Results associated with daily flow time series will be plotted. “FLOW” under the “Constituent” column contains flow time series with daily time steps. These results must be identified and chosen.
- Click “FLOW” in the “Constituent” section. Make sure all “FLOW” time series with selected “Constituents” appear in “Matching Data”.
 - Under “Matching Data”:
 - select “FLOW” for “OBSERVED” and “04085427”, which the observed gaging station daily data at the pour point of the watershed.
 - Select the two “RCH9” “FLOW” data, each representing uncalibrated (“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF\04030101.wdm”) and calibrated (“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily\04030101.wdm”) simulation results.
 - Make sure that time series appear in “Selected Data”.



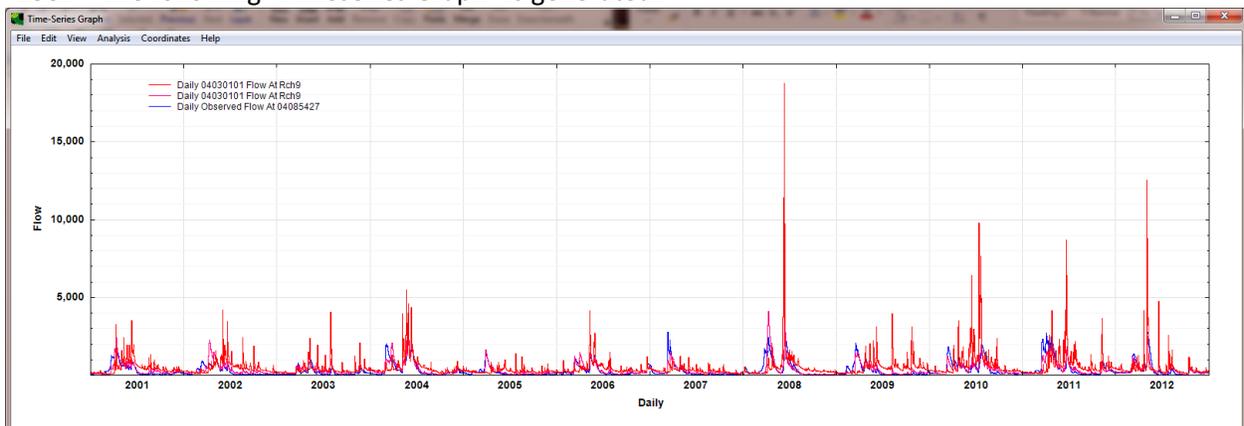
191. The simulation period is from “2001/01/01” to “2012/12/31”, excluding the one-year model warm-up period of 1990.
 - a. Check the “Submit, Split, or Filter Selected Data” box.
 - b. Click “OK”.
 - c. Change the “Start” date to “2001/01/01” and the “end” data to “2012/12/31”.
 - d. Click “OK”.



192. The “Select Data To Graph” window disappears, and the “Choose Graphs to Create” window appears. Check “Timeseries”, then click “Generate”.



193. The following “Timeseries Graph” is generated.

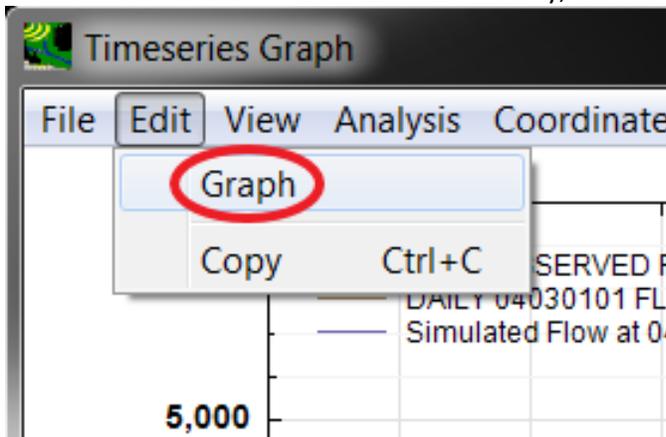


Note that in plot label, the first two labels have the same name, but they can be differentiated, as the labeling order follows that of the Selected Data section:

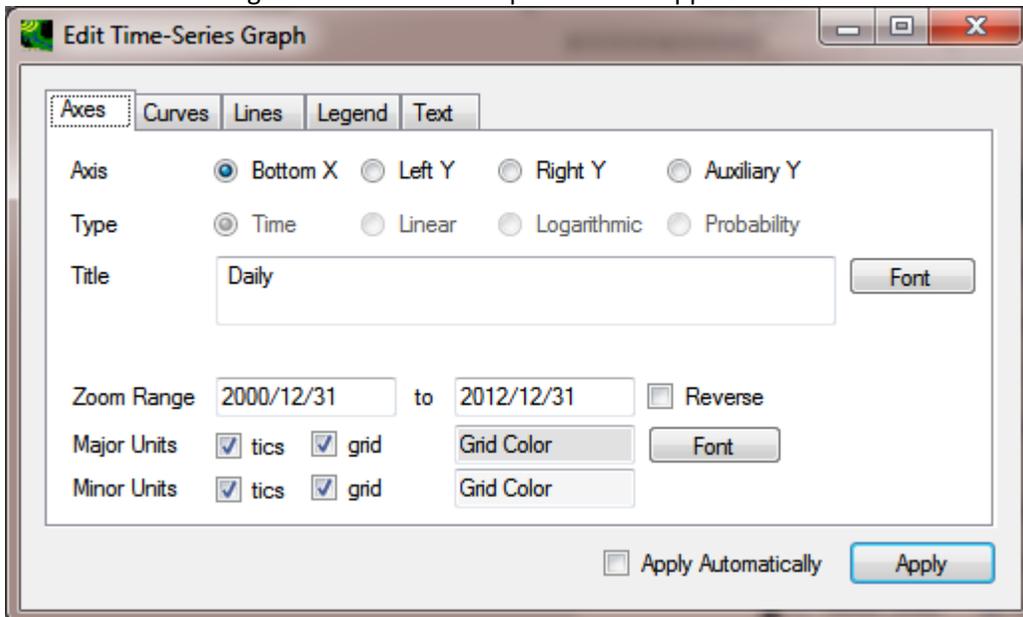
Selected Data (3 of 434)					
04030101	RCH9	FLOW	Day	1	C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF\04030101.wdm
04030101	RCH9	FLOW	Day	1	C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily\04030101.wdm
OBSERV+	04085427	FLOW	Day	1	C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\trwis\flow.wdm

In this case, the first label refers to uncalibrated flows, the second label refers to the calibrated flows, and the third label refers to observed flows. When multiple results are plotted, the first label is usually associated with the left Y-axis. When editing the plot, the software will designate which curve is associated with which axis (e.g., left Y-axis versus right Y-axis).

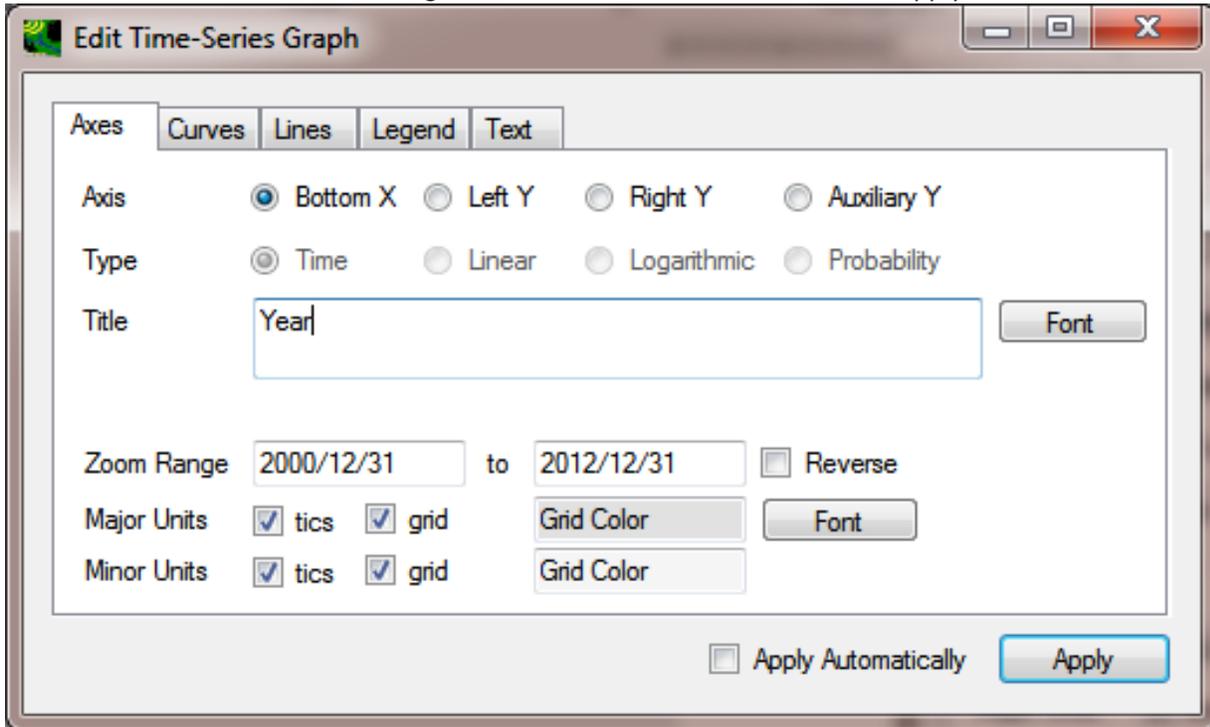
194. To differentiate the curves more easily, users can control curve color. Select “Edit>Graph”.



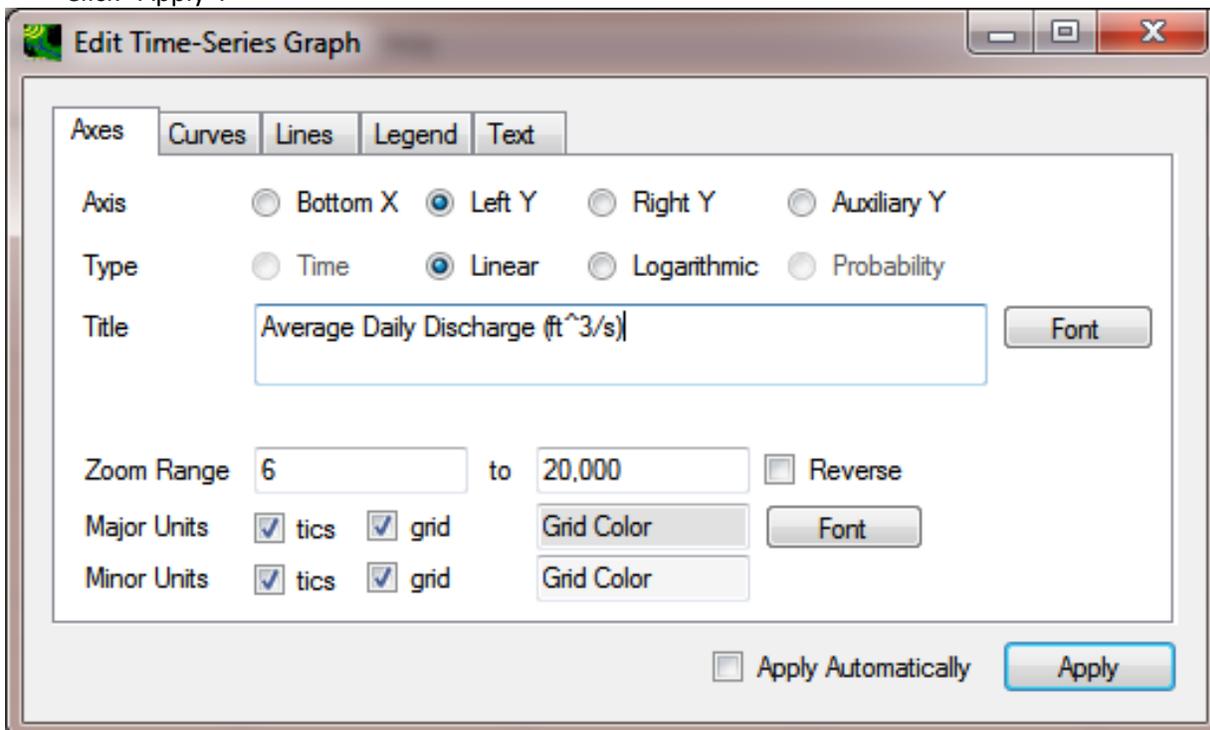
195. The following “Edit Timeseries Graph” window appears.



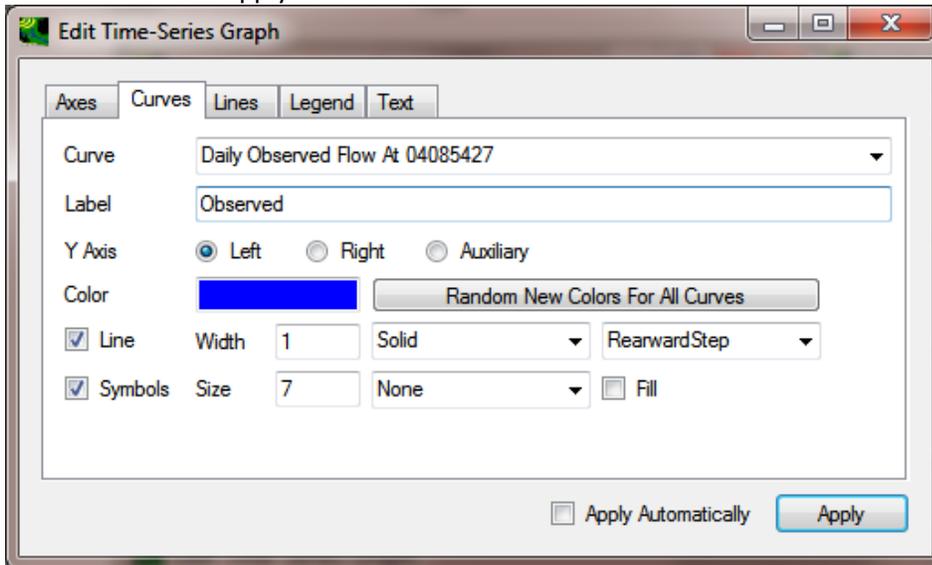
196. Under the “Axes” tab, change the “Title” text box to “YEAR”. Click “Apply”.



197. For “Axis”, select “Left Y”, then change the “Title” text box to “Average Daily Discharge (cfs)”. Click “Apply”.

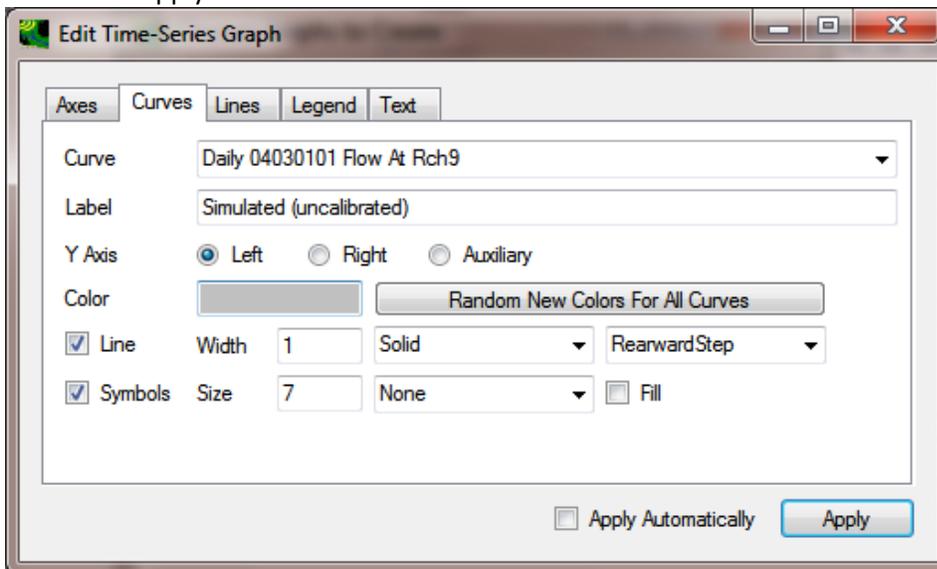


198. Under “Curves”,
 - a. select “Daily Observed Flow At 04085427” for “Curve”,
 - b. change the “Label” text box to “Observed”.
 - c. Change “Color” to blue.
 - d. Click “Apply”.



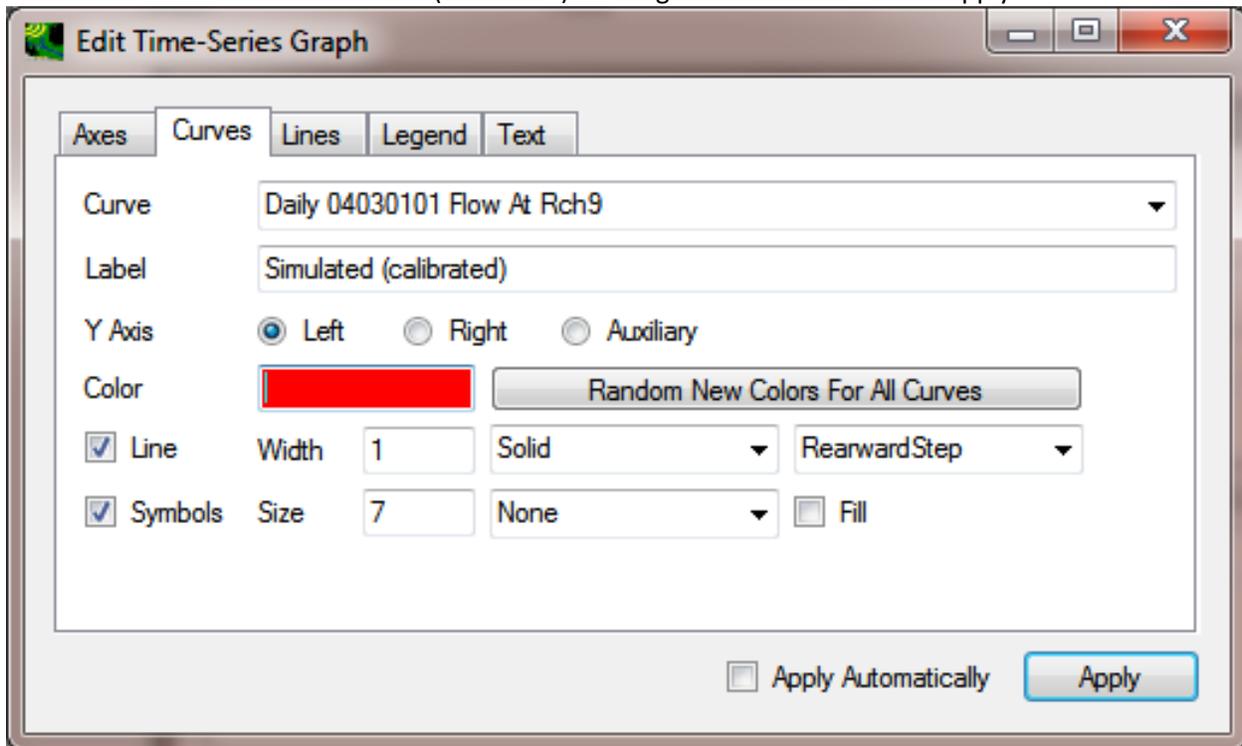
Note that the results of this curve correlate to the “Left Y Axis”.

199. The first and second time series have the same name: “Daily 04030101 Flow At Rch9”. The first (uncalibrated) must be selected first. For “Curve”, select the time series “Daily 04030101 Flow At Rch9”, then change the “Label” text box to “Simulated (uncalibrated)”. Change “Color” to gray. Click “Apply”.



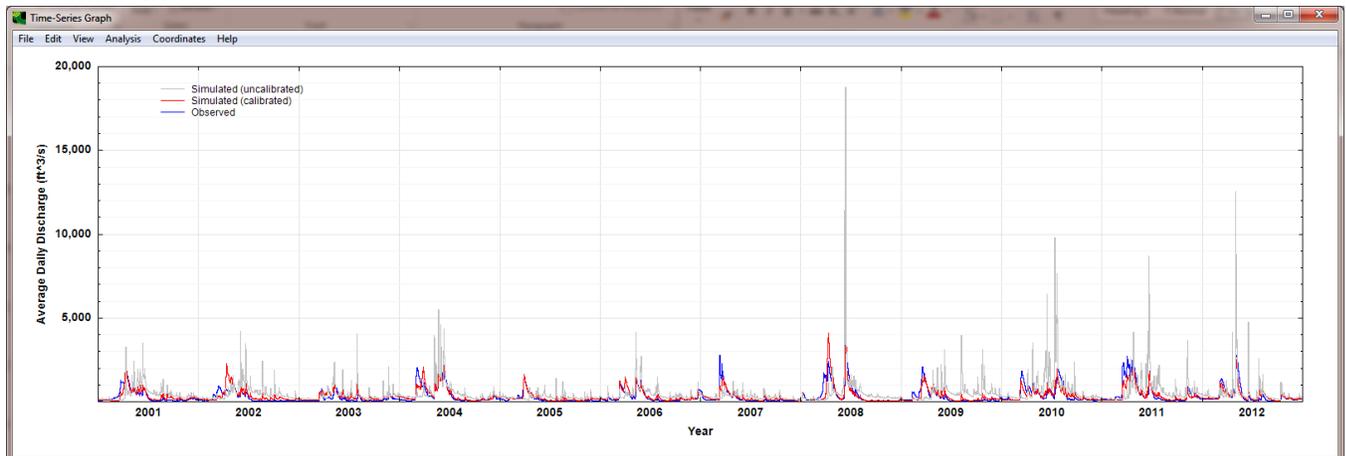
Note that the results of this curve correlate to the “Left Y Axis”.

200. For “Curve”, select the second time series “Daily 04030101 Flow At Rch9”, then change the “Label” text box to “Simulated (calibrated)”. Change “Color” to red. Click “Apply”.



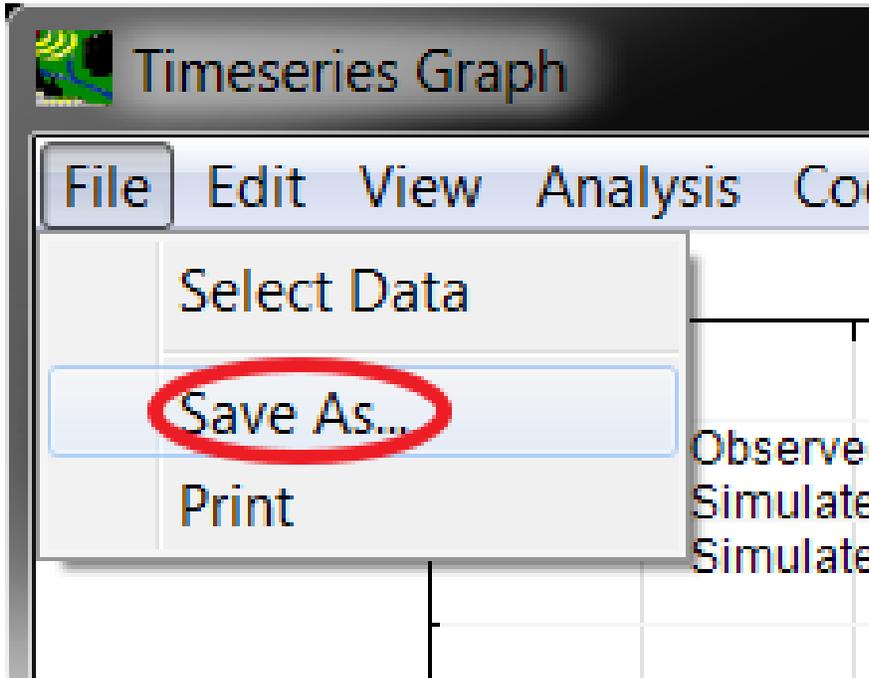
Note that the results of this curve correlate to the “Left Y Axis”.

201. Close “Edit Timeseries Graph” window. Three time series appear in the “Timeseries Graph” window.

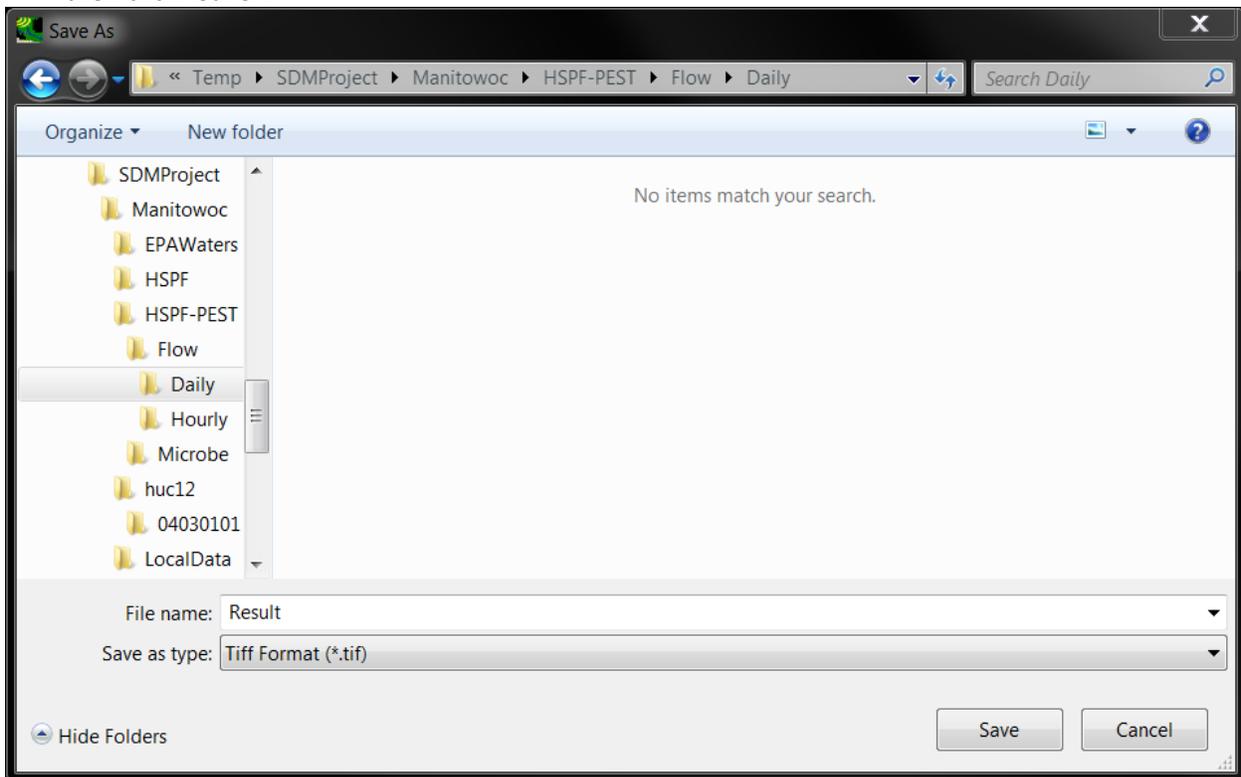


This figure overlays observed, uncalibrated and calibrated flow time series, and illustrates improvements in calibrated over uncalibrated flows, using PEST.

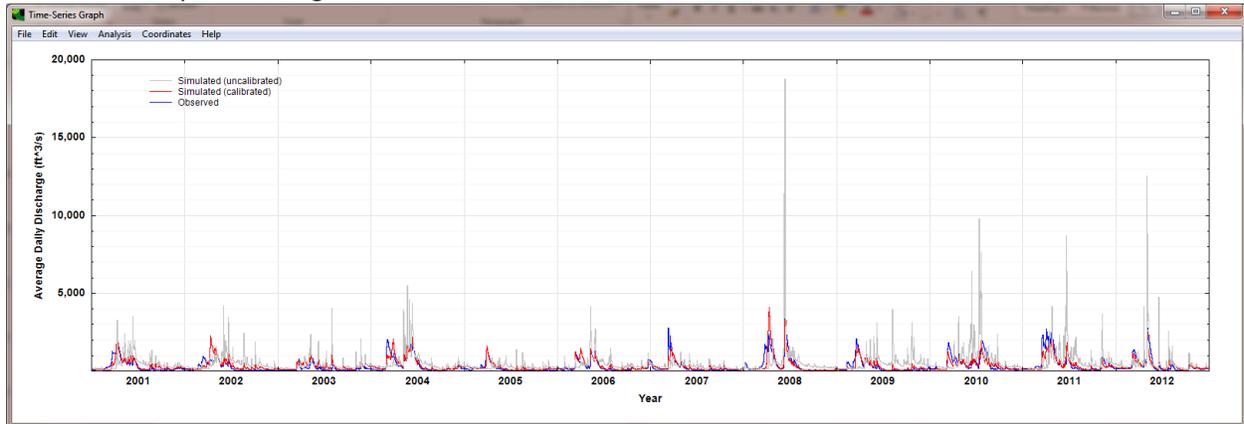
202. The graph can be exported as an image file. In the “Timeseries Graph” window, select “File>Save As...”.



203. Choose the desired file format (.tif, for example), define a file name (Result.tif, for example), then click “Save”.



204. The exported image file is shown below.



205. Close the “Timeseries Graph” window.

SECTION 4

CALIBRATING MICROBIAL-RELATED PARAMETERS

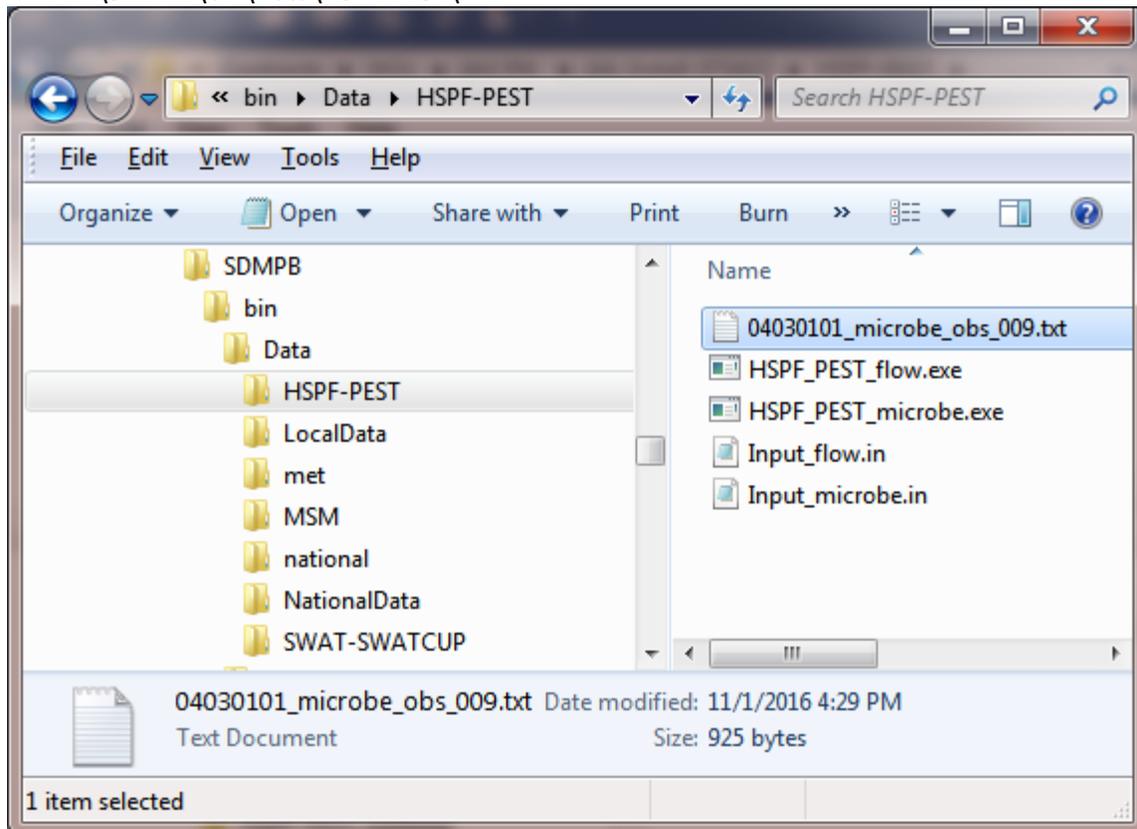
PREPARING MICROBIAL OBSERVATION DATA

HSPF microbial parameter calibration requires microbial observation data at the outlet of the watershed (i.e., “*_microbe_obs_009.txt”). The data needs to be prepared in the following format.

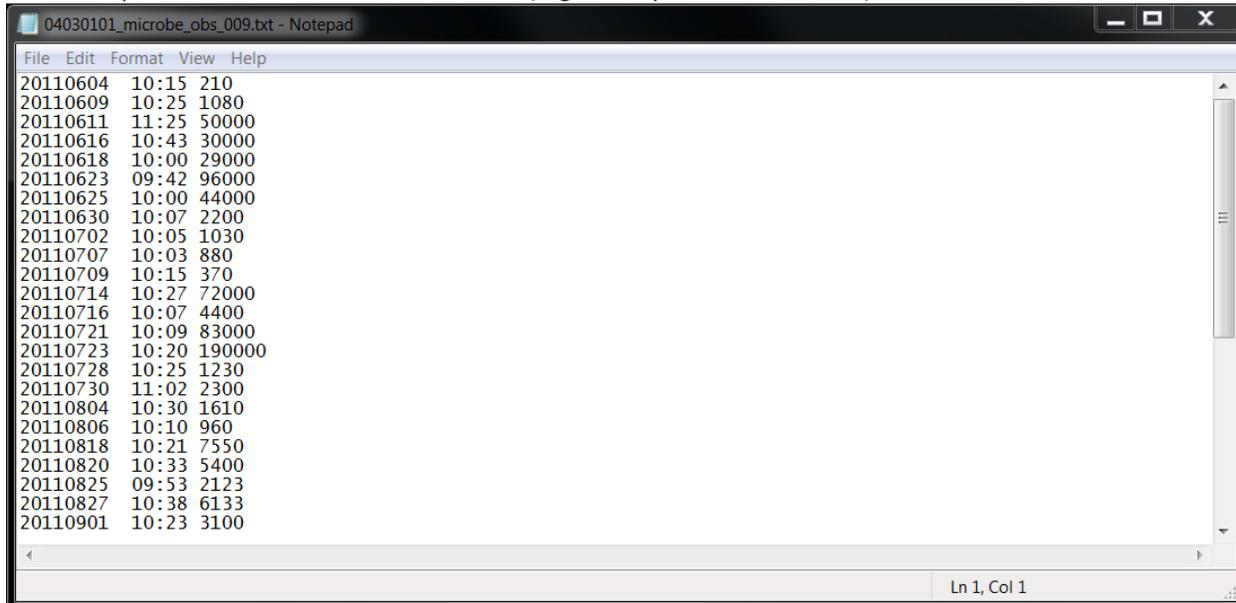
```
yyyyymmdd hh:mm conc(1)  
yyyyymmdd hh:mm conc(2)  
⋮  
yyyyymmdd hh:mm conc(n)
```

yyyyymmdd captures the year (*yyyy*), month (*mm*), and day (*dd*); and *hh:mm* captures the hour (*hh*) and minute (*mm*). *conc(i)* is *i*th observation of microbial density or concentration (Counts/L or Cells/L), and *n* is the number of observations.

206. Locate (or create) a txt file, titled “04030101_microbe_obs_009.txt”. In this example, the “04030101_microbe_obs_009.txt” file can be located in the folder:
< ...\SDMPB\bin\Data\HSPF-PEST\>



207. Open the text file with a text editor (e.g., Notepad, TextPad, etc.)



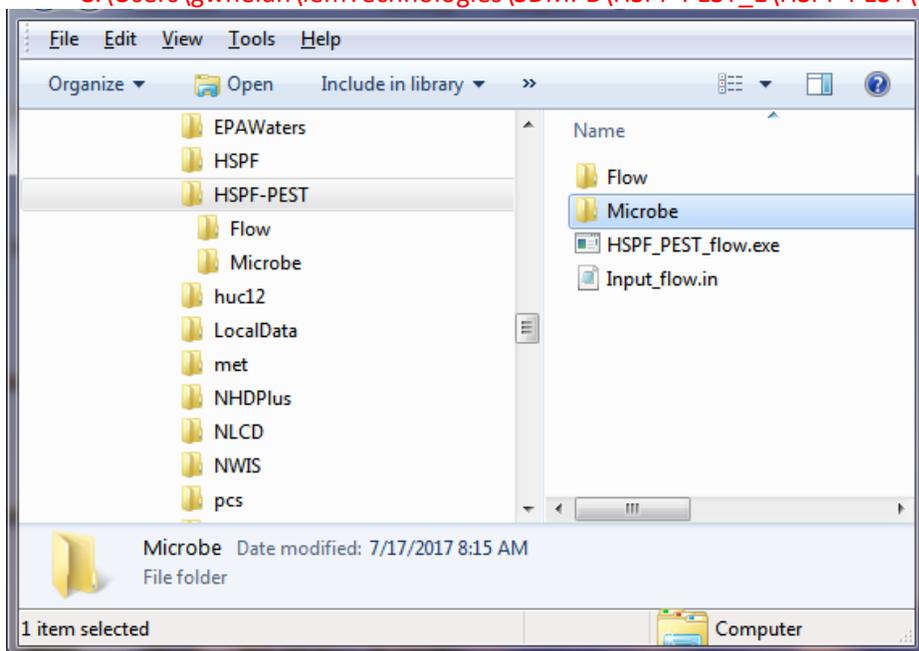
208. Exit the file by "File>Exit".

PREPARING PEST INPUT FILES FOR HSPF MICROBIAL PARAMETER CALIBRATION

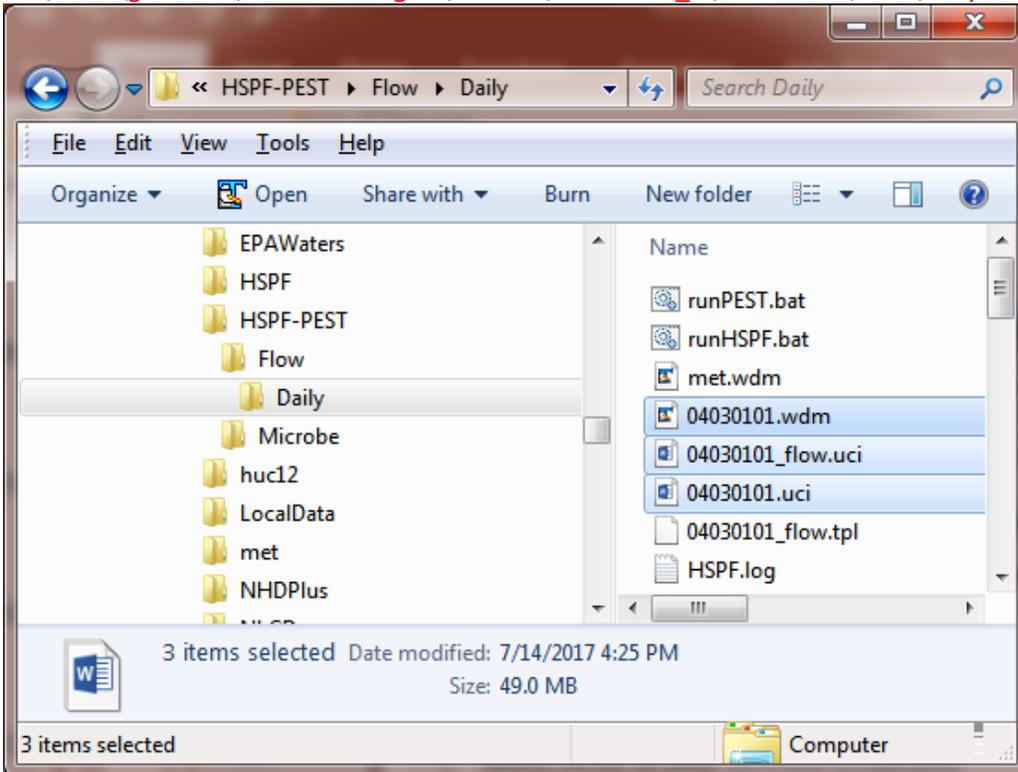
Create Microbial Folder and Populate with Necessary Files

This section prepares the microbial working folder and populates it with PEST input files for the HSPF microbial parameter calibration.

209. Create a new folder (“...\Microbe\”); in this example the subfolder is in “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\”.



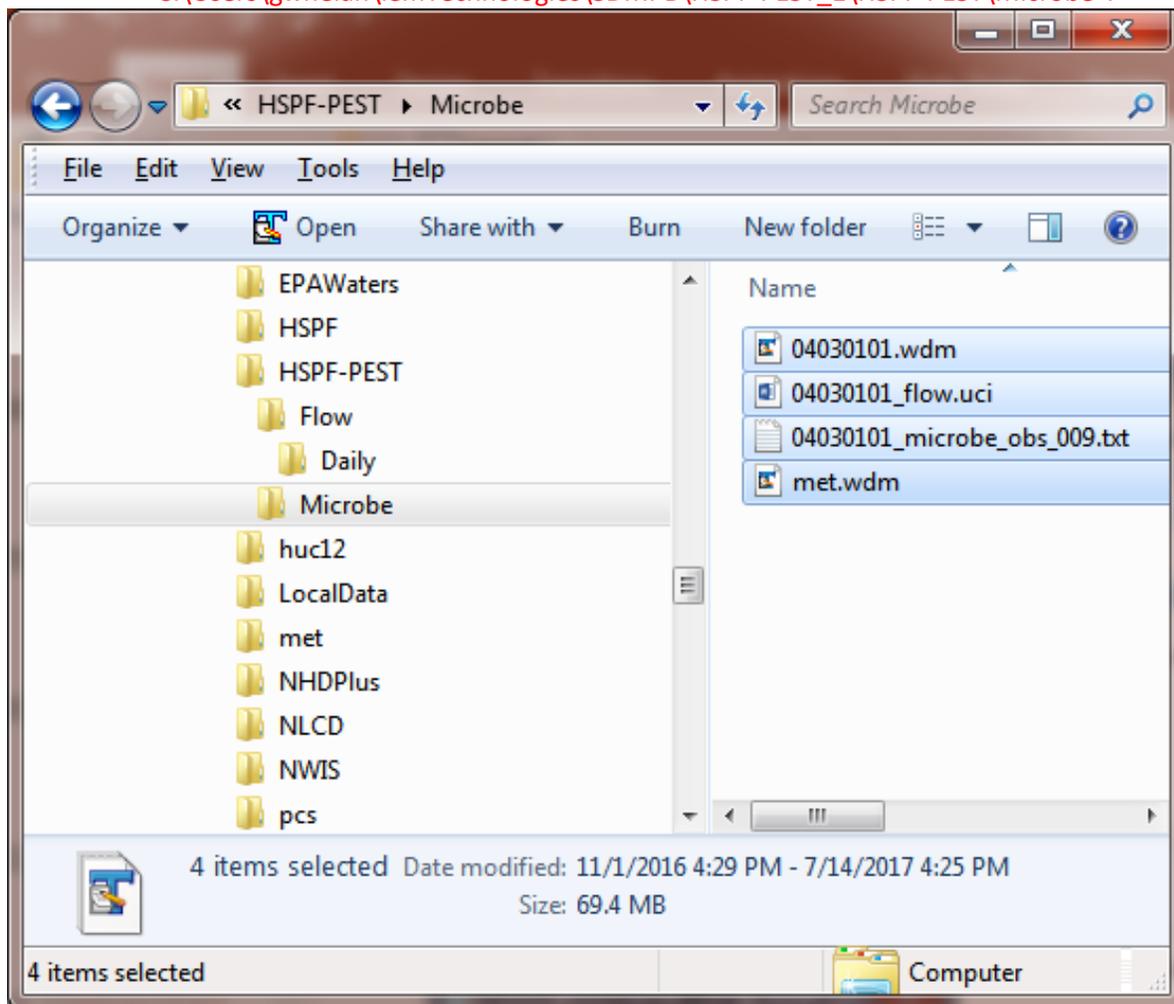
The HSPF UCI file (“04030101_flow.uci”), written by PEST, contains parameters calibrated by PEST which represent the final HSPF simulation associated with flow calibration. The calibrated flow time series is captured in the modified “04030101.wdm” file. In this example, daily calibrated flow results in the “04030101_flow.uci” and “04030101.wdm” files are located in “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily”.



Because microbial calibration will use microbial observations in 2011 and 2012, and closely associated with the flow simulation results, the calibration will use flow parameters calibrated with daily flow from 2007 to 2012.

210. Copy

- 04030101_flow.uci, 04030101.wdm, met.wdm from
“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Flow\Daily” to
“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe” and
- “04030101_microbe_obs_009.txt” to
“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe”.



The executable “HSPF_PEST_microbe.exe” prepares necessary files for the HSPF microbial parameter calibration with PEST.

- Four PEST files
 - **PEST control file (.pst)**: PEST parameters, model parameters metadata (names, initial values, ranges, etc.), parameter groups, observed flow data, and path of model executables.
 - **PAR2PAR TPL file (_P2P.tpl)**: Structure model input file (i.e., “*_microbe.uci”) and locations of where calibrating parameter values are to be placed.
 - **PEST template file (.tpl)**: Structure of the PAR2PAR input file and locations of where calibrating parameter values are to be placed.
 - **PEST instruction file (.ins)**: Describes how PEST will read the model output file for calculating error statistics.
- Two batch files
 - **“runHSPF.bat”**: Executes HSPF (i.e., WinHSPFIt.exe) and PAR2PAR (i.e., par2par.exe)
 - **“runPEST.bat”**: Executes HSPF parameter calibration with PEST

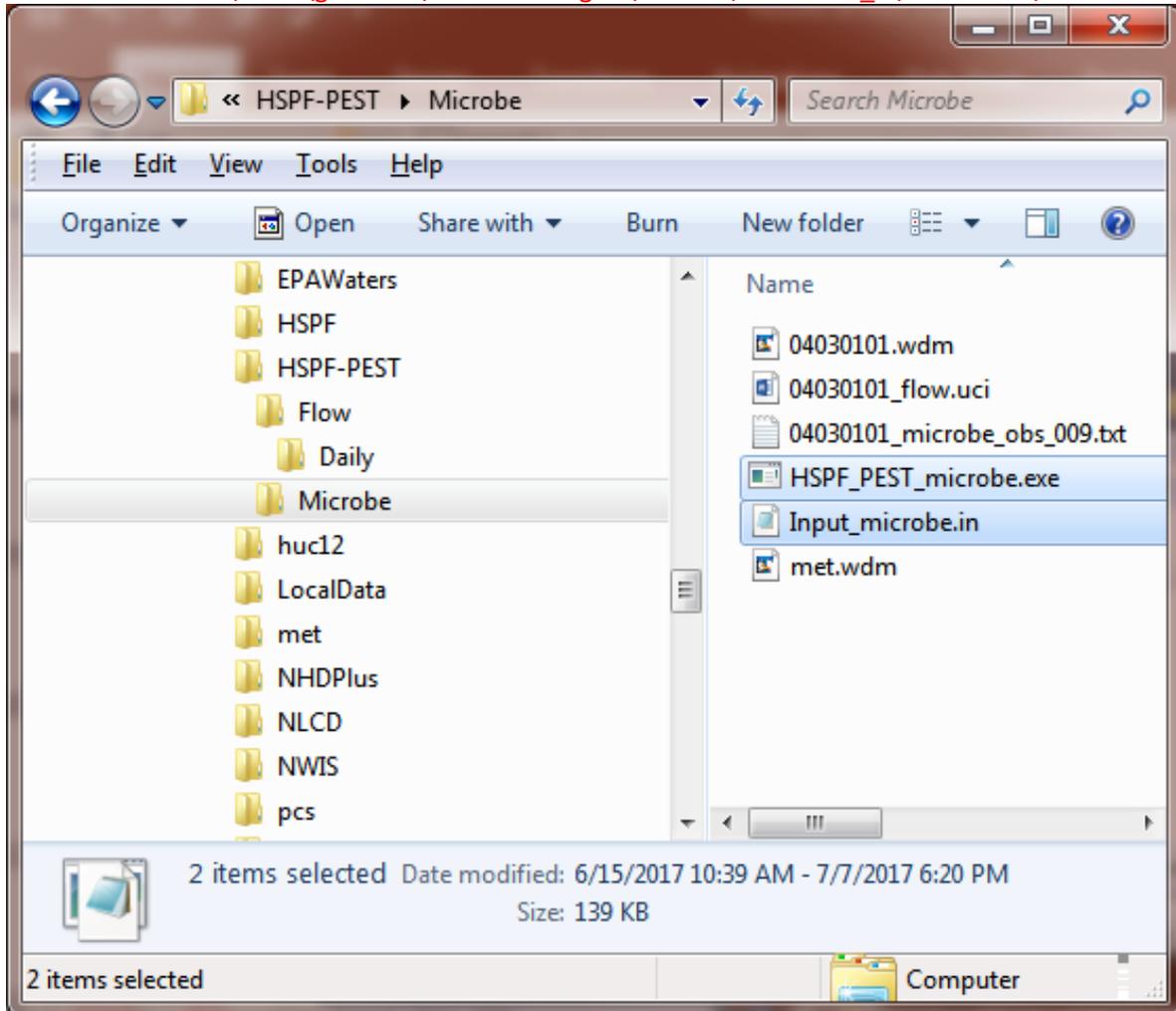
“Input_microbe.in”, the default input file used with “HSPF_PEST_microbe.exe”, contains details for preparing PEST input files which can be found in Appendix D. “Input_microbe.in” defines

- Folder paths of HSPF (i.e., WinHSPFIt.exe), PEST (i.e., pest.exe) and a working folder where HSPF input files are located (i.e., “... \HSPF-PEST\Microbe\”). In this example, the folder path for microbial calibrations is
“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe”.
- Calibration parameter names and their ranges for each land use group
- Land use groups that differentiate parameter values
- Number of years for model warm-up

As default, “HSPF_PEST_microbe.exe” and “Input_microbe.in” are located in

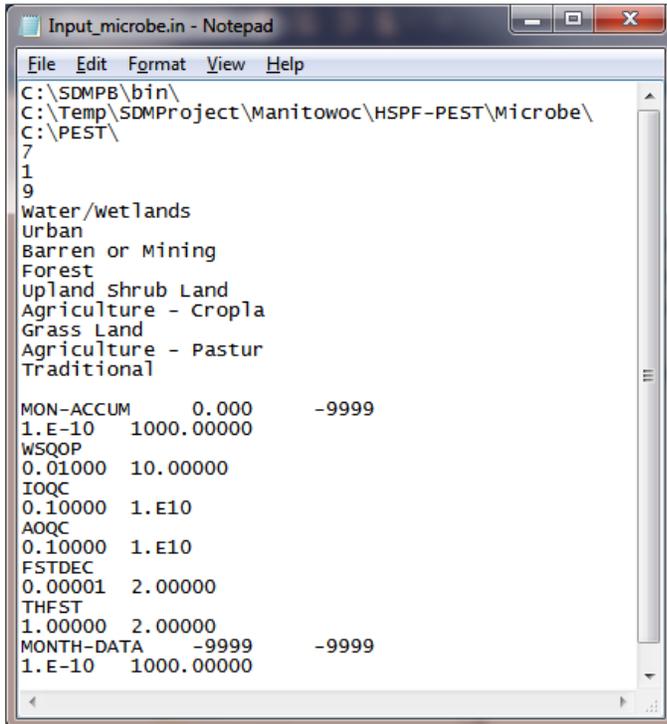
“C:\Users\gwhelan\iemTechnologies\SDMPB\bin\Data\HSPF-PEST”, created by SDMPB, and copied to “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST”. These files can be located in any folder, but both must be in the same folder. In this example for parameter microbial calibrations, “HSPF_PEST_microbe.exe” and “Input_microbe.in” must be located in “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe”.

211. In this example, copy “HSPF_PEST_microbe.exe” and “Input_microbe.in” from
“C:\Users\gwhelan\iemTechnologies\SDMPB\bin\Data\HSPF-PEST” to
- “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST”
 - “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe”.



Once “Input_microbe.in” is located in
“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe”, the working folder
paths in “Input_microbe.in” must be updated.

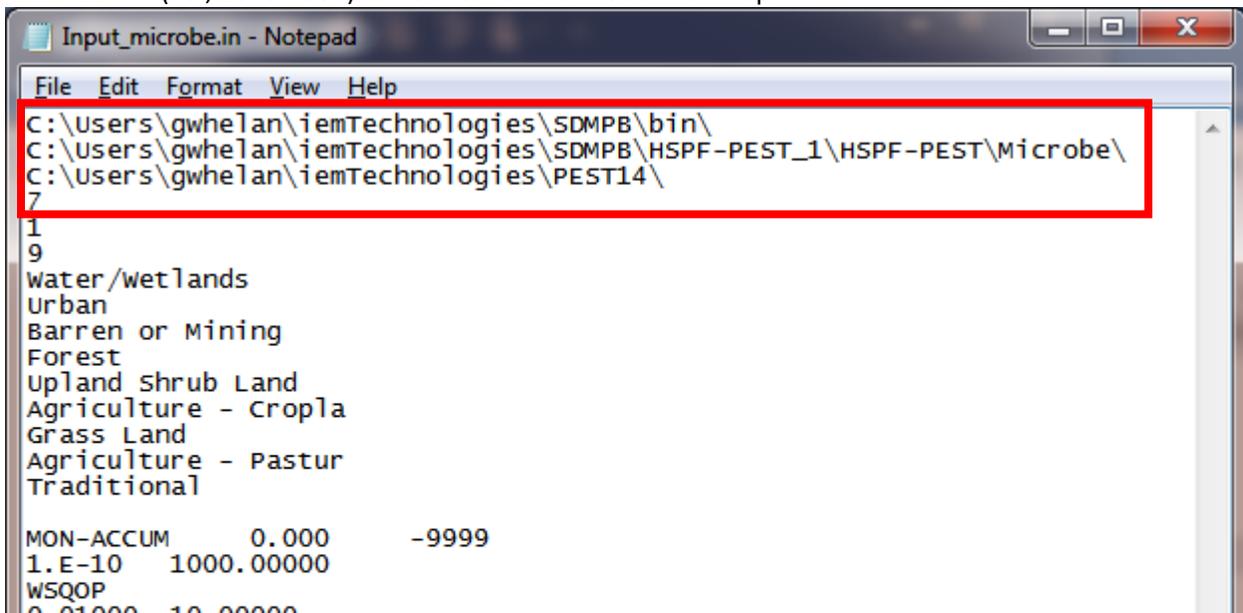
212. Open "Input_microbe.in", which illustrates the updated working folder path for the hourly microbial calibration.



```
File Edit Format View Help
C:\SDMPB\bin\
C:\Temp\SDMProject\Manitowoc\HSPF-PEST\Microbe\
C:\PEST\
7
1
9
water/wetlands
Urban
Barren or Mining
Forest
Upland Shrub Land
Agriculture - Cropla
Grass Land
Agriculture - Pastur
Traditional
MON-ACCUM 0.000 -9999
1.E-10 1000.00000
WSQOP
0.01000 10.00000
IOQC
0.10000 1.E10
AOQC
0.10000 1.E10
FSTDEC
0.00001 2.00000
THFST
1.00000 2.00000
MONTH-DATA -9999 -9999
1.E-10 1000.00000
```

213. With a text editor,

- Update the working folder path on the second line.
- On the fourth line, change the value on line 4 to "7", which indicates the first seven years (i.e., 2000-2006) to be used for the model warm-up.

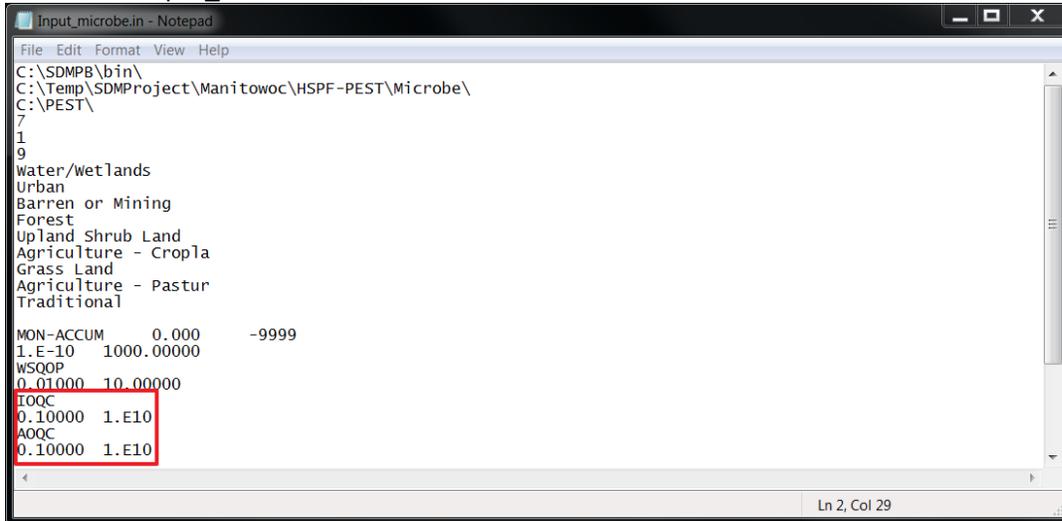


```
File Edit Format View Help
C:\Users\gwhe1an\iemTechnologies\SDMPB\bin\
C:\Users\gwhe1an\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe\
C:\Users\gwhe1an\iemTechnologies\PEST14\
7
1
9
water/wetlands
Urban
Barren or Mining
Forest
Upland Shrub Land
Agriculture - Cropla
Grass Land
Agriculture - Pastur
Traditional
MON-ACCUM 0.000 -9999
1.E-10 1000.00000
WSQOP
0.01000 10.00000
```

Ensure that the folder path for the HSPF and the PEST codes listed on the first and the third lines are also correct and **name of the folder location ends with a backslash (\)**.

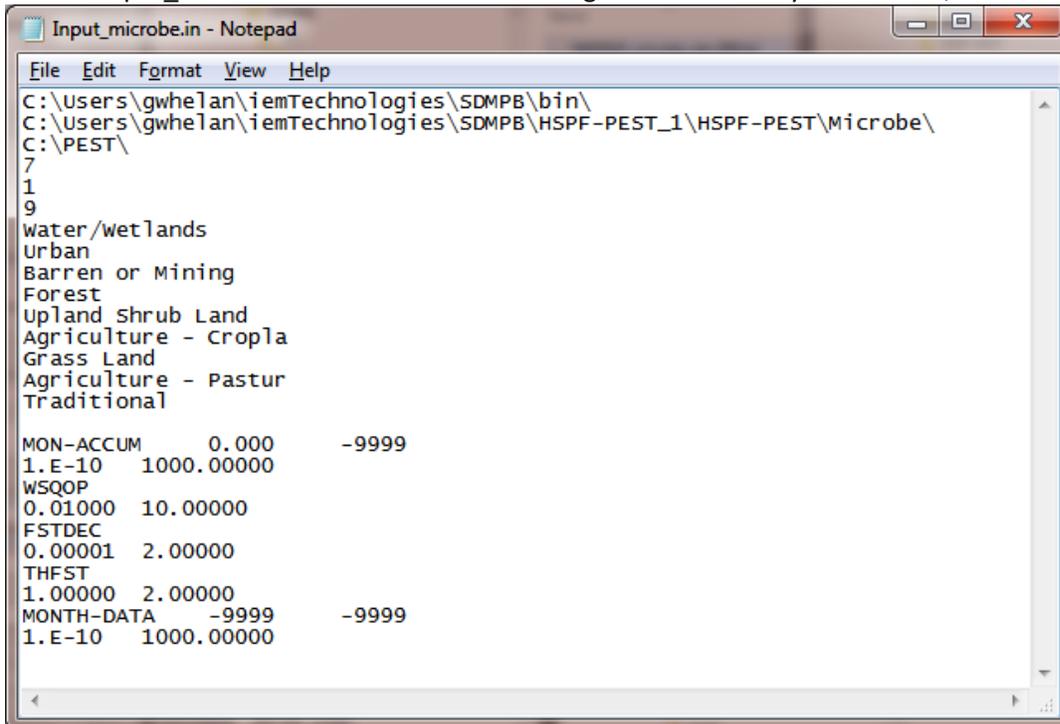
NOTE: Local well data associated with the Manitowoc basin indicate an absence of microbe (i.e., enterococci) in underground water (i.e., interflow and groundwater). Thus, microbial concentrations in interflow and groundwater (i.e., "IOQC" and "AOQC") do not need to be calibrated, so these data can be removed from the file.

214. In "Input_microbe.in", remove the lines associated with "IOQC" and "AOQC".



```
File Edit Format View Help
C:\SDMPB\bin\
C:\Temp\SDMPProject\Manitowoc\HSPF-PEST\Microbe\
C:\PEST\
7
1
9
Water/Wetlands
Urban
Barren or Mining
Forest
Upland Shrub Land
Agriculture - Cropla
Grass Land
Agriculture - Pastur
Traditional
MON-ACCUM 0.000 -9999
1.E-10 1000.00000
WSQOP
0.01000 10.00000
IOQC
0.10000 1.E10
AOQC
0.10000 1.E10
Ln 2, Col 29
```

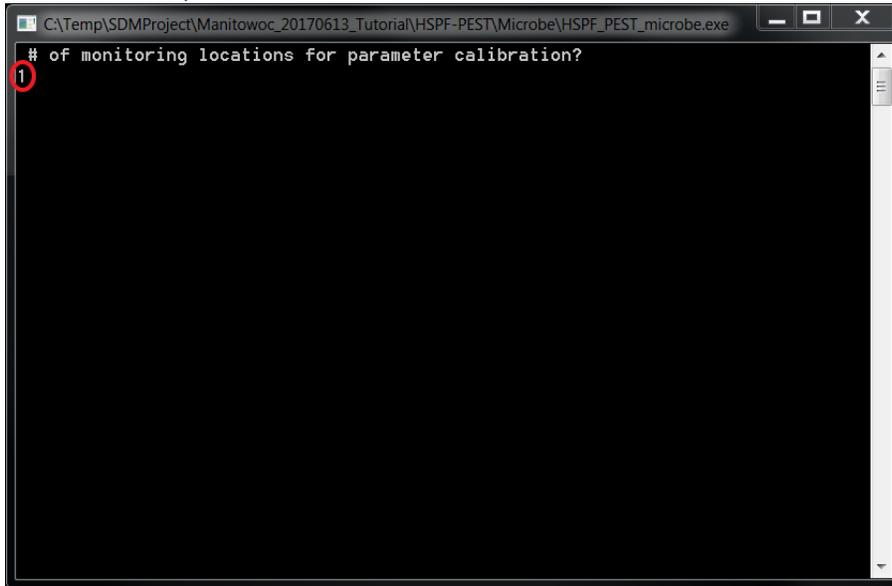
215. "Input_microbe.in" looks like the following. Save and exit by "File>Save", then "File>Exit".



```
File Edit Format View Help
C:\Users\gwhelan\iemTechnologies\SDMPB\bin\
C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe\
C:\PEST\
7
1
9
water/wetlands
Urban
Barren or Mining
Forest
Upland Shrub Land
Agriculture - Cropla
Grass Land
Agriculture - Pastur
Traditional
MON-ACCUM 0.000 -9999
1.E-10 1000.00000
WSQOP
0.01000 10.00000
FSTDEC
0.00001 2.00000
THFST
1.00000 2.00000
MONTH-DATA -9999 -9999
1.E-10 1000.00000
```

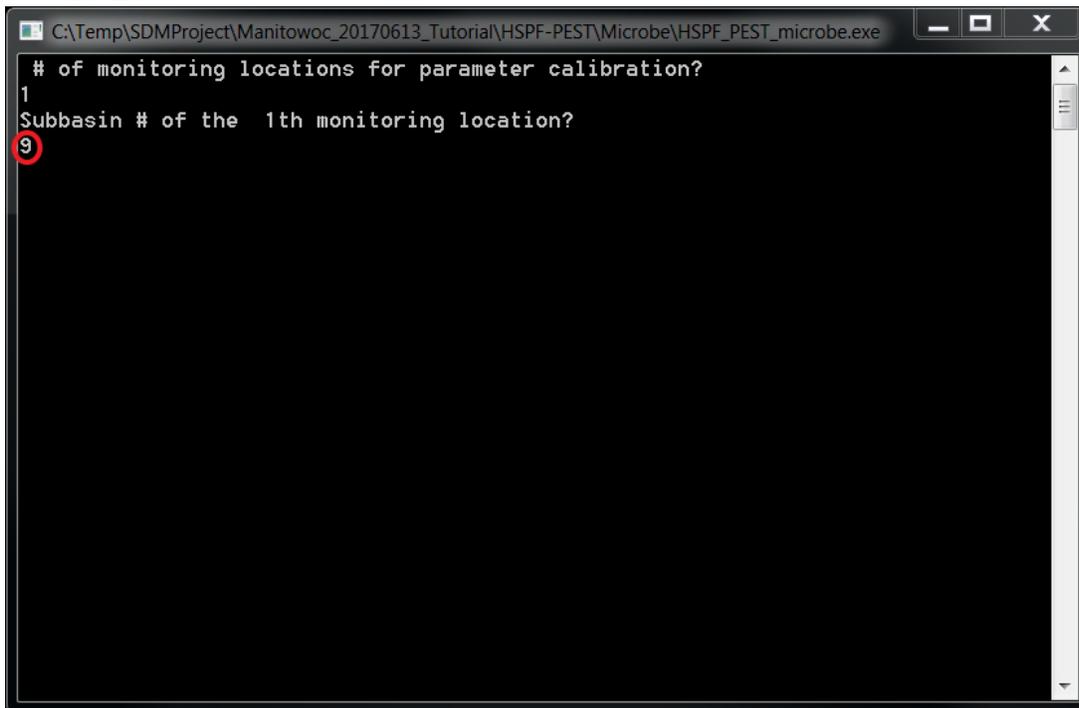
Execute Microbial Calibration using PEST

216. In “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe”, execute “HSPF_PEST_microbe.exe” by double-clicking on the icon. When the command window below appears, put the number of microbial monitoring locations for the parameter calibration, “1” in this case, and press ENTER.



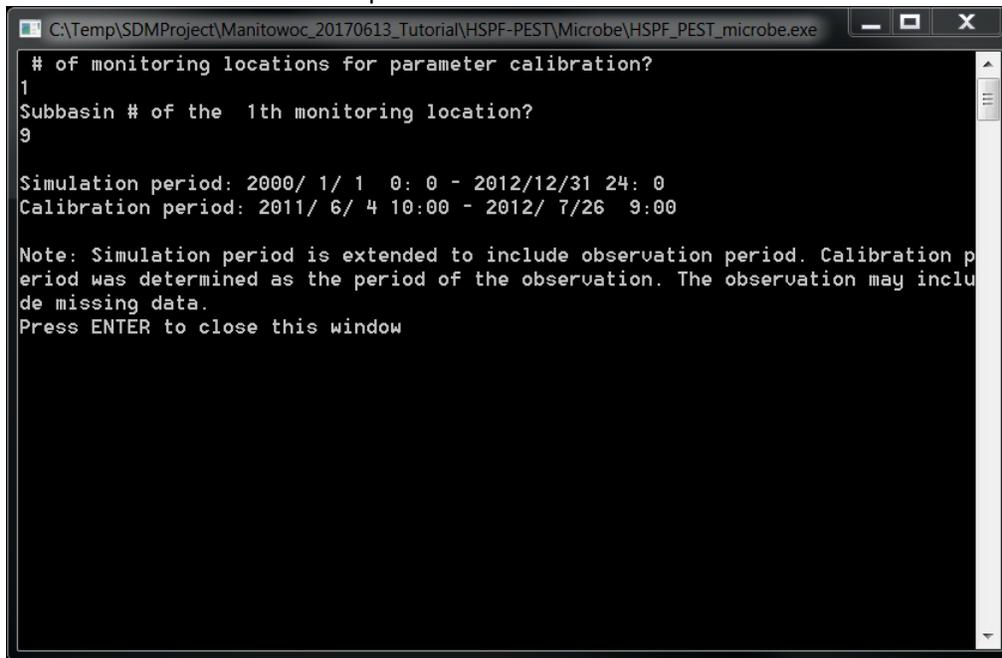
```
C:\Temp\SDMProject\Manitowoc_20170613_Tutorial\HSPF-PEST\Microbe\HSPF_PEST_microbe.exe
# of monitoring locations for parameter calibration?
1
```

217. In the command window below, put “9”, to set the Subbasin 9 as the calibration point, and press ENTER.



```
C:\Temp\SDMProject\Manitowoc_20170613_Tutorial\HSPF-PEST\Microbe\HSPF_PEST_microbe.exe
# of monitoring locations for parameter calibration?
1
Subbasin # of the 1th monitoring location?
9
```

218. In the command window below, press ENTER to close it. The command window indicates simulation and calibration periods.

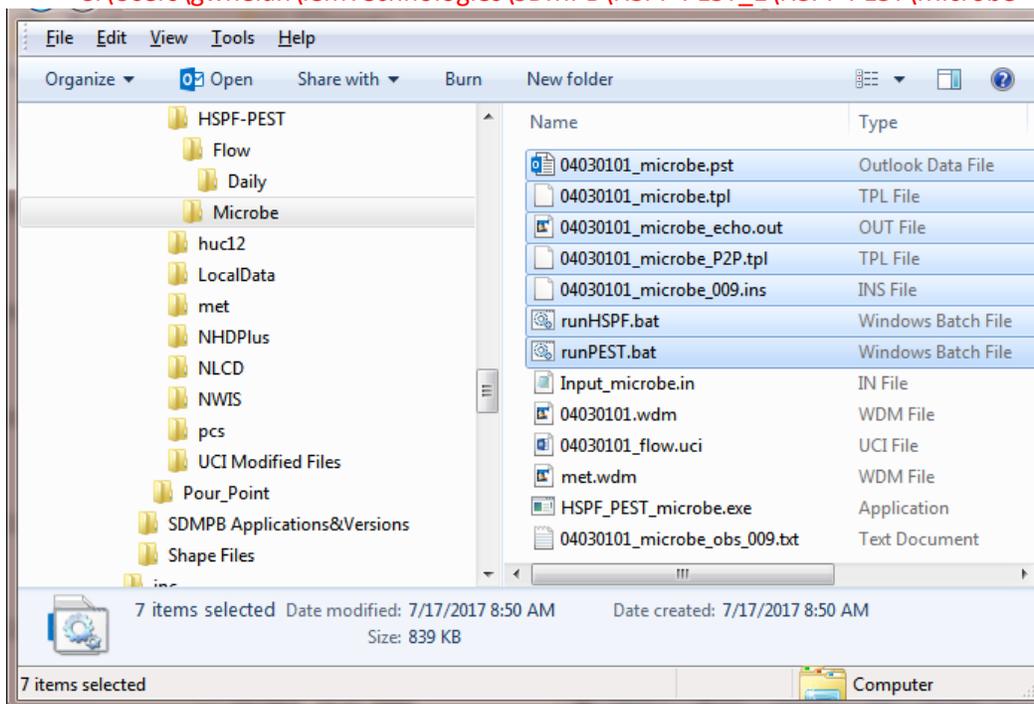


```
C:\Temp\SDMProject\Manitowoc_20170613_Tutorial\HSPF-PEST\Microbe\HSPF_PEST_microbe.exe
# of monitoring locations for parameter calibration?
1
Subbasin # of the 1th monitoring location?
9

Simulation period: 2000/ 1/ 1  0: 0 - 2012/12/31 24: 0
Calibration period: 2011/ 6/ 4 10:00 - 2012/ 7/26  9:00

Note: Simulation period is extended to include observation period. Calibration p
eriod was determined as the period of the observation. The observation may inclu
de missing data.
Press ENTER to close this window
```

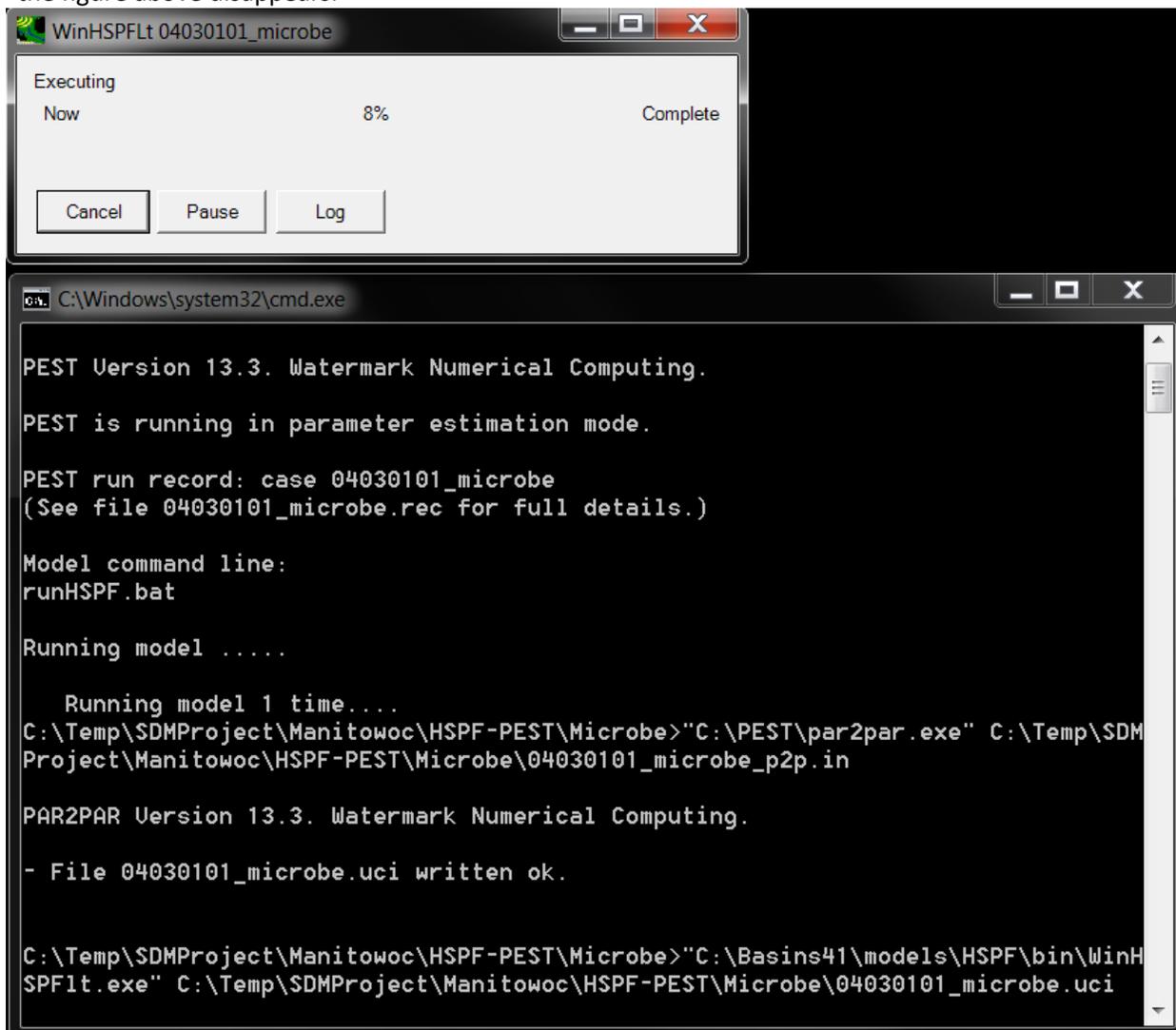
219. Once “HSPF_PEST_microbe.exe” is executed, the necessary microbial calibration files (four PEST input files and two batch files) have been added to the “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe” folder.



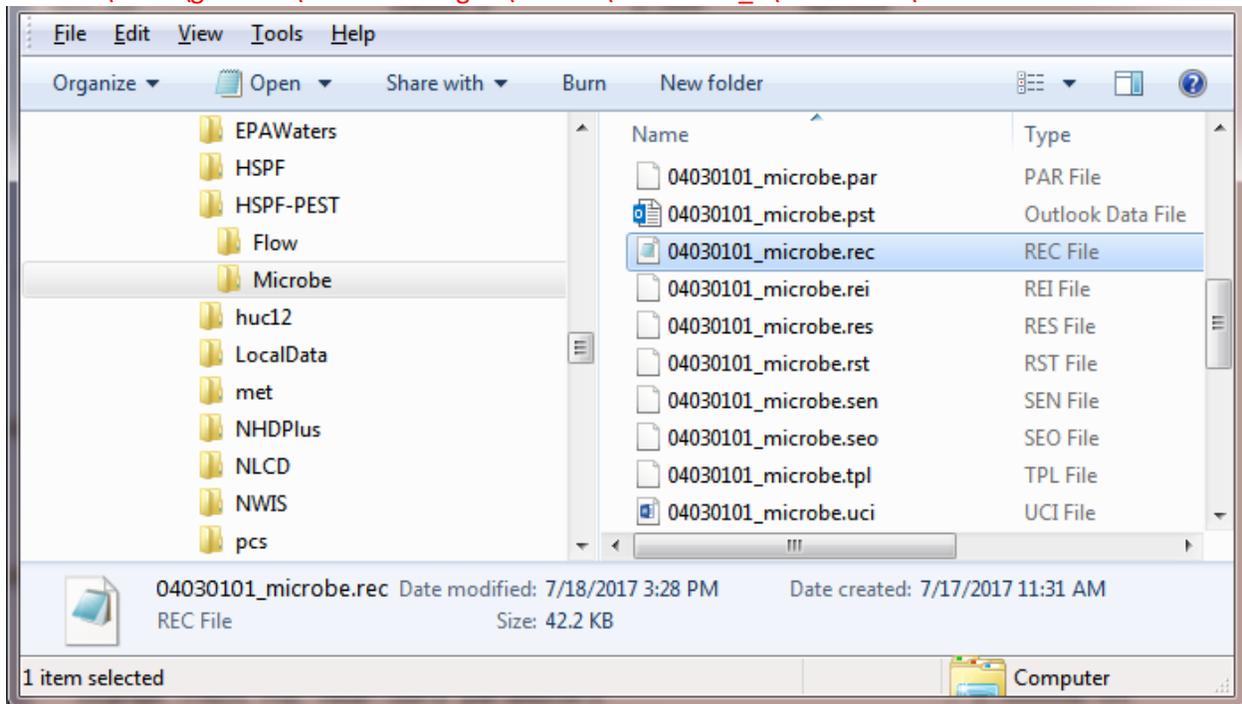
CALIBRATING HSPF MICROBIAL PARAMETERS WITH PEST

Parameter calibration usually takes several hours, depending on the setting in PEST, number of parameters, and model nonlinearity. Users should disable the machine's screen saver during execution, if possible.

220. Within the "C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe" folder, execute "runPEST.bat". During microbial parameter calibration, a command window appears and disappears multiple times, as shown below, which indicates PEST and HSPF are running successfully. Once HSPF microbial parameter calibration with PEST is finished, the command window in the figure above disappears.



221. Parameter calibration results are recorded in the “.rec” file: “04030101_microbe.rec” in “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe”.



222. Open “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe\04030101_microbe.rec” with a text editor to view the results. In this example, microbial parameter calibration results are summarized in “OPTIMISATION RESULTS” which contains calibrated parameter values under “Estimated value”, followed by iterative comparisons of flow calculations with observations (see “Observations ----->”).

```

04030101_microbe.rec - Notepad
File Edit Format View Help

OPTIMISATION RESULTS

Parameters ----->
Parameter      Estimated      95% percent confidence limits
                value          lower limit      upper limit
accum_rate1    22.2488         2.33279         212.196
wsqop1        6.291682E-02   -6.116108E-02   0.186995
fstdec        2.00000         -1.57723         5.57723
thfst         1.00000         0.643323         1.35668
data_rate     5.121392E-03   3.046919E-04    8.608258E-02

Note: confidence limits provide only an indication of parameter uncertainty.
They rely on a linearity assumption which may not extend as far in
parameter space as the confidence limits themselves - see PEST manual.

See file 04030101_microbe.sen for parameter sensitivities.

Observations ----->
Observation      Measured      Calculated      Residual      weight      Group
                  value          value
obs_1            210.000      10545.4         -10335.4       1.000      obs009
obs_2            1080.00      24227.6         -23147.6       1.000      obs009
obs_3            50000.0      87266.6         -37266.6       1.000      obs009
obs_4            30000.0      152858.         -122858.       1.000      obs009
obs_5            29000.0      9890.05         19109.9       1.000      obs009
obs_6            96000.0      35051.7         60948.3       1.000      obs009
obs_7            44000.0      7788.52         36211.5       1.000      obs009
obs_8            2200.00      6967.96         -4767.96       1.000      obs009
obs_9            1030.00      7770.35         -6740.35       1.000      obs009
obs_10           880.000      16498.1         -15618.1       1.000      obs009
obs_11           370.000      9272.65         -8902.65       1.000      obs009
obs_12           72000.0      9687.90         62312.1       1.000      obs009
obs_13           4400.00      10142.6         -5742.57       1.000      obs009
obs_14           83000.0      10563.1         72436.9       1.000      obs009
obs_15           190000.      59605.9         130394.       1.000      obs009
obs_16           1230.00      20474.1         -19244.1       1.000      obs009
obs_17           2300.00      11968.8         -9668.76       1.000      obs009
obs_18           1610.00      10320.7         -8710.69       1.000      obs009
obs_19           960.000      9495.15         -8535.15       1.000      obs009
obs_20           7550.00      6884.33         665.670       1.000      obs009
obs_21           5400.00      7156.18         -1756.18       1.000      obs009
obs_22           2123.00      7820.87         -5697.87       1.000      obs009
obs_23           6133.00      3654.63         2478.37       1.000      obs009
obs_24           3100.00      1359.18         1740.82       1.000      obs009
obs_25           60000.0      9913.38         50086.6       1.000      obs009
obs_26           84000.0      10700.3         73299.7       1.000      obs009
obs_27           70000.0      13221.3         56778.7       1.000      obs009
obs_28           32000.0      16827.7         15172.3       1.000      obs009
obs_29           35000.0      23682.1         11317.9       1.000      obs009
obs_30           18000.0      38495.6         -20495.6       1.000      obs009
obs_31           54000.0      9608.99         44391.0       1.000      obs009
obs_32           39000.0      13051.6         25948.4       1.000      obs009
obs_33           43000.0      10955.2         32044.8       1.000      obs009
obs_34           37000.0      13865.6         23134.4       1.000      obs009
obs_35           27000.0      18733.5         8266.51       1.000      obs009
obs_36           23000.0      23873.3         -873.290      1.000      obs009
obs_37           23000.0      32879.8         -9879.79      1.000      obs009
obs_38           19000.0      79043.4         -60043.4      1.000      obs009
obs_39           70000.0      77966.6         -7966.60      1.000      obs009
obs_40           20000.0      12331.6         7668.39       1.000      obs009
obs_41           249000.      155293.         93707.0       1.000      obs009

```

223. Statistics between calculations and observations are listed in “Objective Function ----->” and “Correlation coefficient ----->”, as illustrated in the figure below. The sum of squared weighted residuals is a measure of discrepancy between the data and an estimation model. The correlation coefficient (“r”) is a statistical measure of degree in change of one parameter because of change in another. When done, close the file.

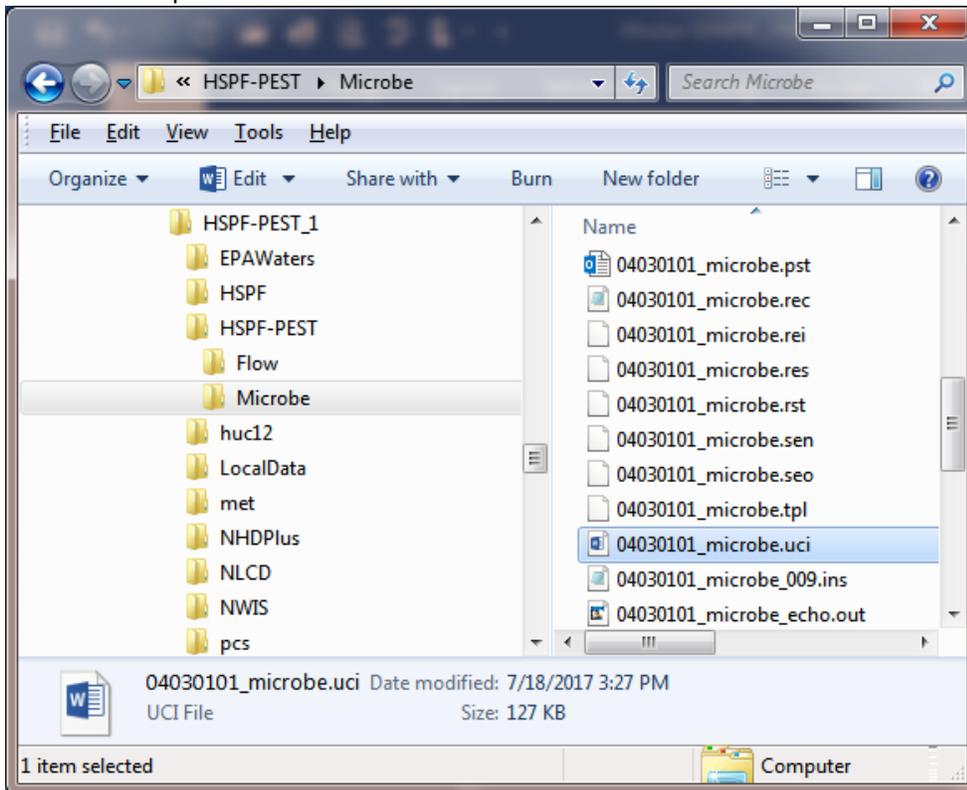
```
04030101_microbe.rec - Notepad
File Edit Format View Help
Objective function ----->
  Sum of squared weighted residuals (ie phi)           = 7.8496E+10
Correlation coefficient ----->
  correlation coefficient                               = 0.54600
Analysis of residuals ----->
  All residuals:-
  Number of residuals with non-zero weight             = 41
  Mean value of non-zero weighted residuals            = 1.0728E+04
  Maximum weighted residual [observation "obs_15"]     = 1.3039E+05
  Minimum weighted residual [observation "obs_4"]     = -1.2286E+05
  Standard variance of weighted residuals              = 2.1804E+09
  Standard error of weighted residuals                 = 4.6695E+04
Note: the above variance was obtained by dividing the objective
function by the number of system degrees of freedom (ie. number of
observations with non-zero weight plus number of prior information
articles with non-zero weight minus the number of adjustable parameters.)
If the degrees of freedom is negative the divisor becomes
the number of observations with non-zero weight plus the number of
prior information items with non-zero weight.
K-L information statistics ----->
  AIC = 888.2824
  AIIC = 890.7530
  BIC = 898.5639
  KIC = 884.6255
Parameter covariance matrix ----->
```

SECTION 5

VISUALIZATING HSPF MICROBIAL CALIBRATION AND SIMULATION RESULTS

VIEWING OUTPUT FILES OF THE MICROBIAL CALIBRATION RESULTS

With the final execution of HSPF using PEST, the HSPF UCI file (04030101_microbe.uci) located in “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe” includes final values for calibrated parameters.

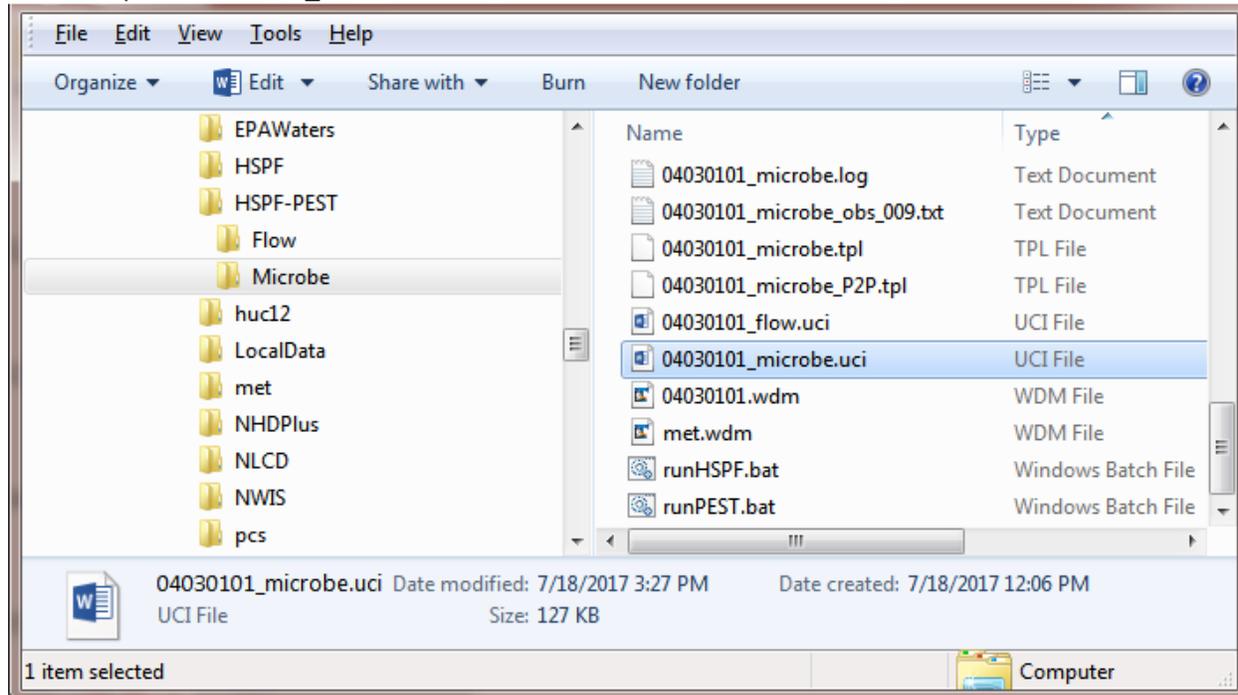


Calibration values in the PEST output file (04030101_microbe.rec) are not final because results differ slightly due to the monthly variability of some parameters, although the statistics (e.g., correlation coefficient) reported are valid and reflect calibration. This section illustrates how to view calibration results using a text editor or from within WinHSPF.

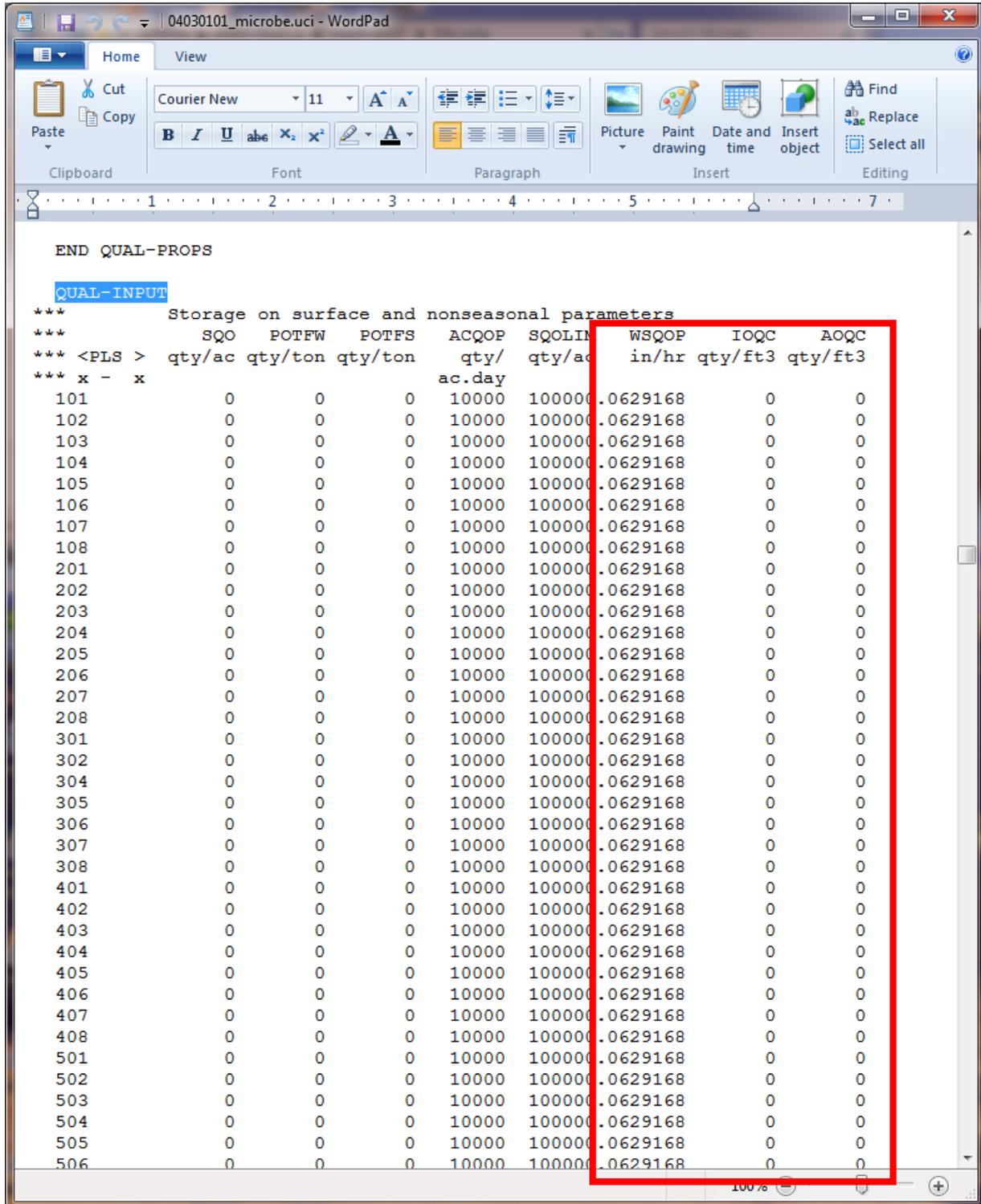
View Microbial Results Using a Text Editor

Appendix D documents the HSPF microbial parameters that were varied in the calibration process, including ACQOP (MON-ACCUM in case of monthly variable), WSQOP, FSTDEC, THFST, and MONTH-DATA. This section reviews their location and values in the UCI file “04030101_microbe.uci”. For details about the HSPF UCI file, see Bicknell et al. (2005) or “C:\BASINS45\docs\HSPF.chm”.

224. Open "04030101_microbe.uci" with a text editor.



226. Go to "QUAL-INPUT" in "PERLND" (pervious land), where calibrated parameter value of "WSQOP" is found. Note that "IOQC" and "AOQC" are not calibrated and assumed as "0".



227. Go to "MON-ACCUM" in "PERLND" (pervious land), where monthly calibrated parameter values of "ACQOP" ("MON-ACCUM") are found.

The screenshot shows a WordPad window titled "04030101_microbe.uci - WordPad". The text content is as follows:

```

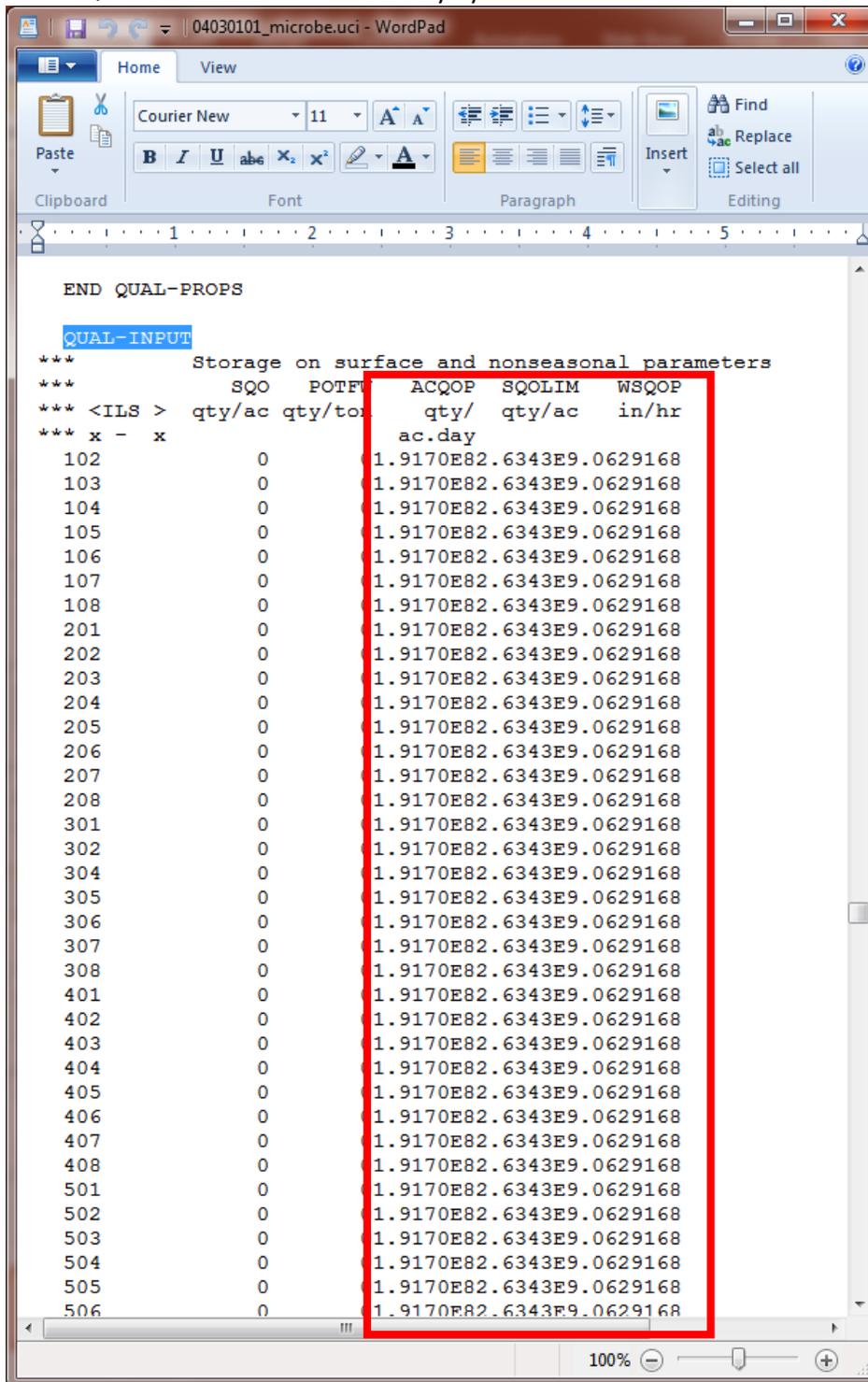
END QUAL-INPUT

MON-ACCUM

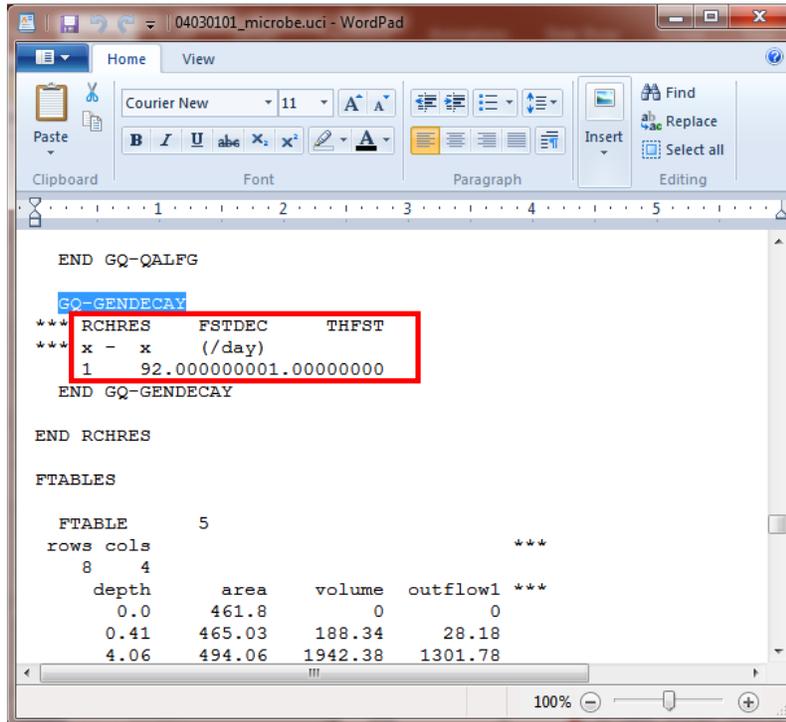
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
101 0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
102 1.9E81.9E81.9E81.9E81.9E81.9E81.9E81.9E81.9E81.9E81.9E81.9E8
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
103 0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
104 1.5E91.5E91.5E91.5E91.5E91.5E91.5E91.5E91.5E91.5E91.5E91.5E9
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
105 0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
106 1.5E91.5E91.5E91.E112.E112.E111.E118.E104.E104.E101.5E91.5E9
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
107 0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
108 1.5E91.5E91.5E92.E114.E114.E112.E112.E112.E112.E111.5E91.5E9
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
201 0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
202 1.9E81.9E81.9E81.9E81.9E81.9E81.9E81.9E81.9E81.9E81.9E8
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
203 0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
204 1.5E91.5E91.5E91.5E91.5E91.5E91.5E91.5E91.5E91.5E91.5E9
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
205 0.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000.0000
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
*** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

```

228. Go to "QUAL-INPUT" in "IMPLND" (**impervious land**), where calibrated parameter values of "ACQOP", "SQOLIM", and "WSQOP" are found. Because these are impervious areas, "ACQOP" and "SQOLIM" in "IMPLND" do not vary by month.



229. Go to “GQ-GENDECAY” in “RCHRES” (**reaches**), where calibrated parameter values of “FSTDEC” and “THFST” are found.

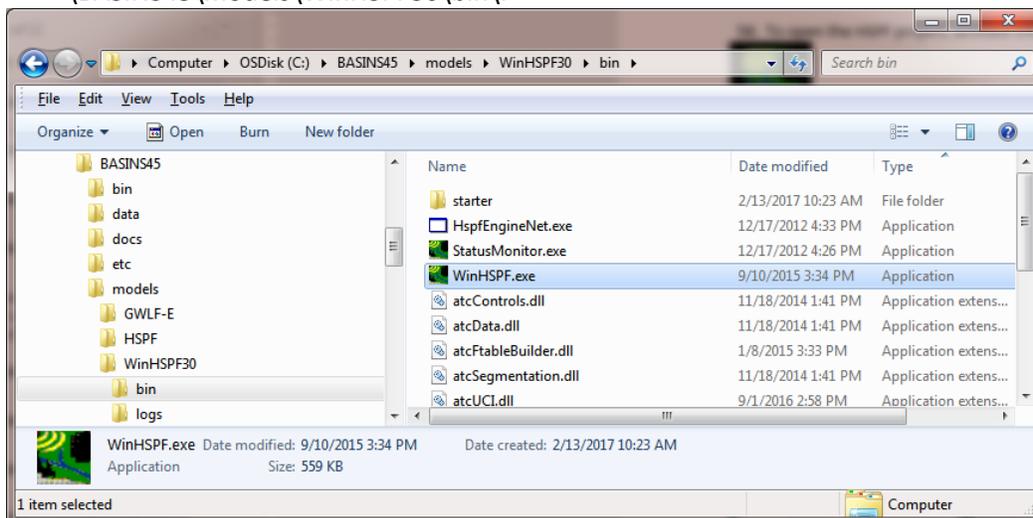


230. Close the text editor.

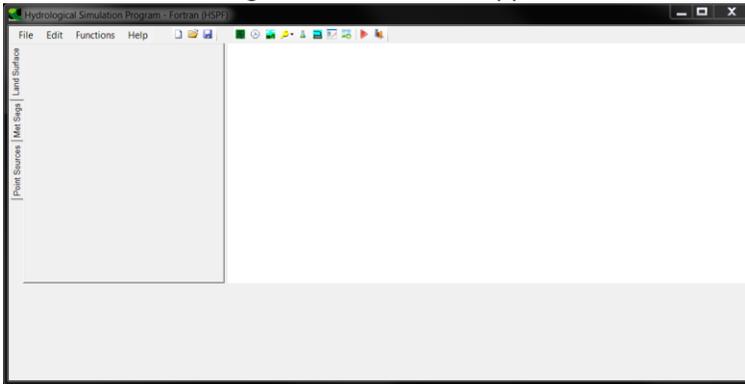
View Microbial Results Using a WinHSPF

The WinHSPF user interface can also be used to view values assigned to calibrated parameter values.

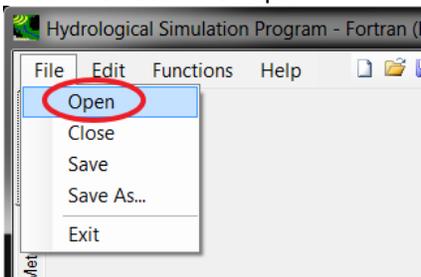
231. Double-click (left) on the icon to execute the WinHSPF. If the icon cannot be found on the Desktop screen, locate the executable on the hard drive (WinHSPF.exe), typically in \BASINS45\models\WinHSPF30\bin\.



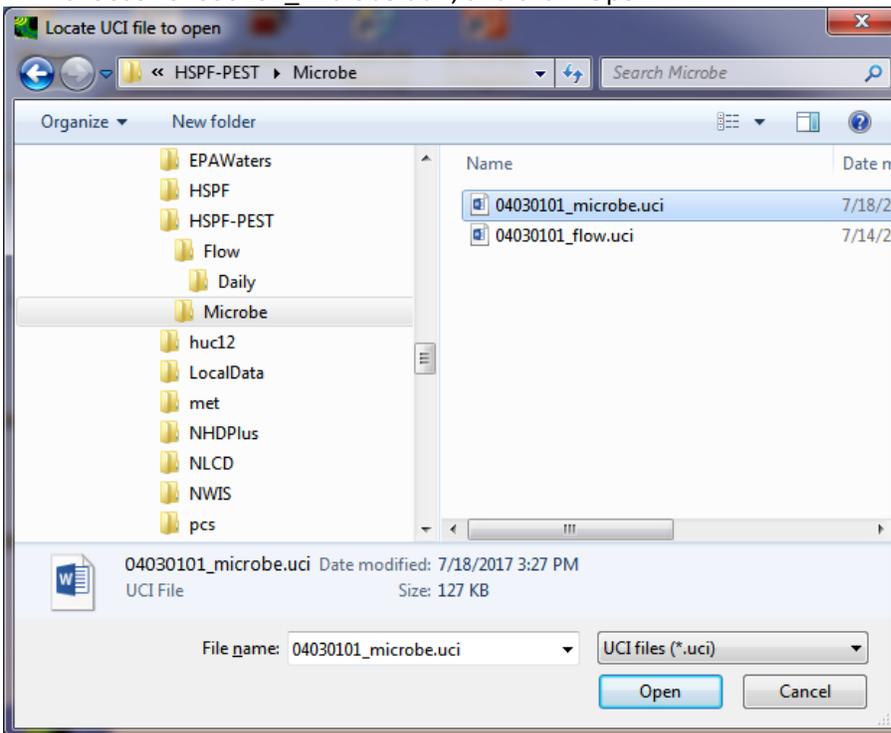
232. The following WinHSPF window appears.



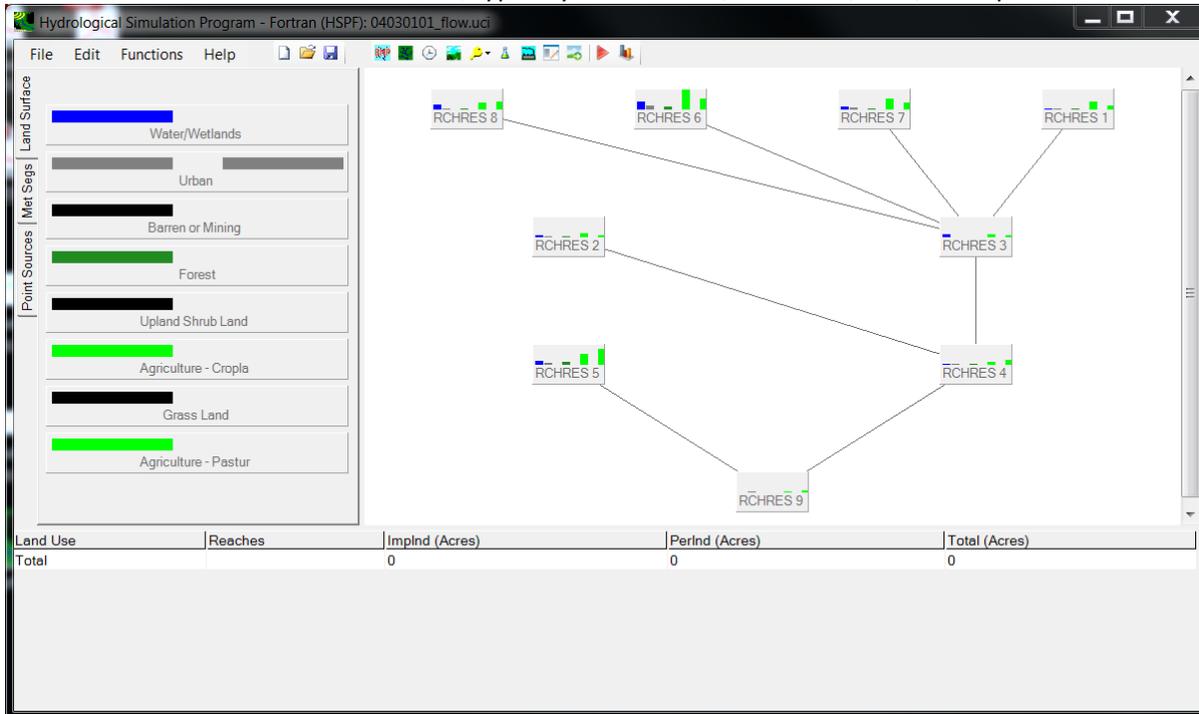
233. Select "File>Open".



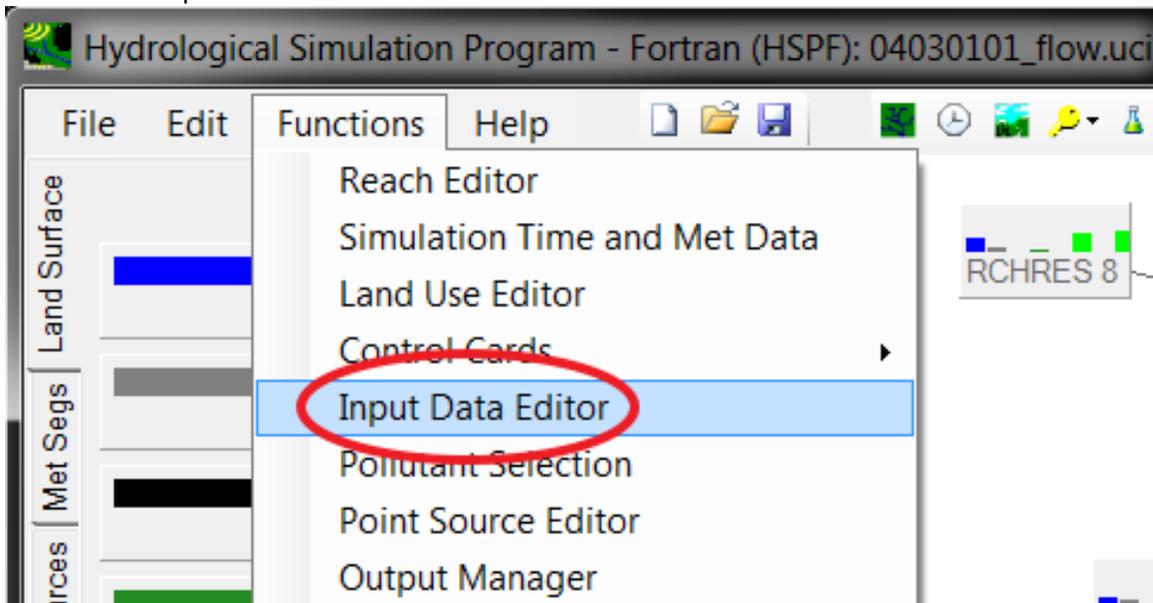
234. Browse "C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe", choose "04030101_microbe.uci", and click "Open".



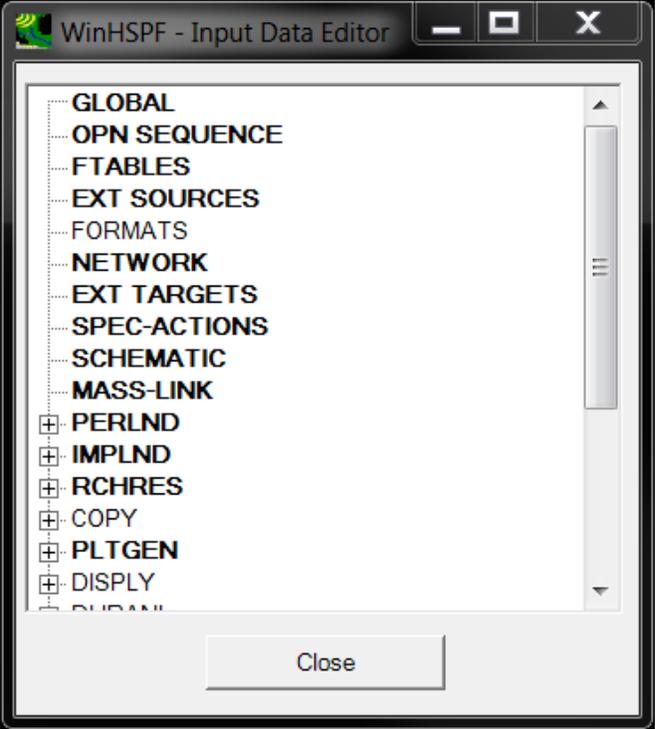
235. The HSPF Manitowoc River Basin workflow appears. The WinHSPF UI shows linkages of the subwatersheds and reaches, proportions of land use type in each, etc. Details about WinHSPF UI can be found in WinHSPF Manual, typically located in “\BASINS45\docs\WinHspf30.chm”.



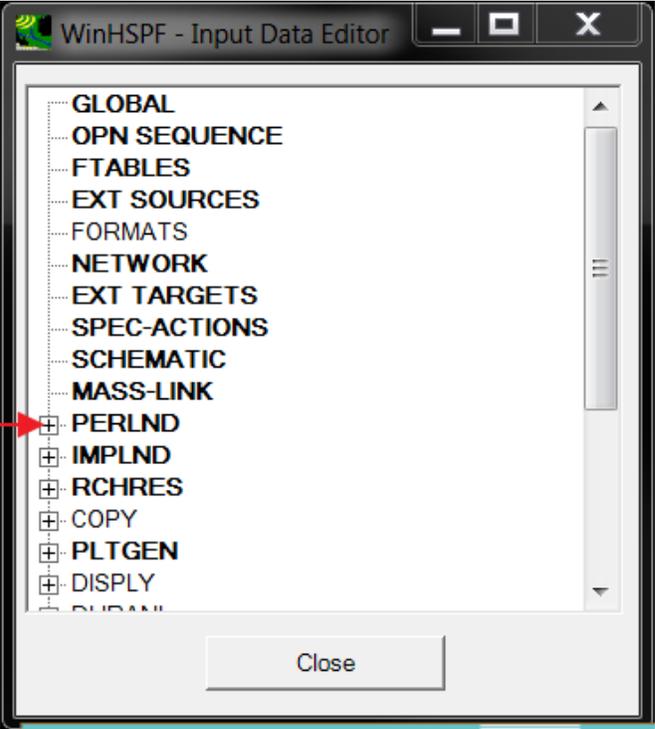
236. Select “Functions>Input Data Editor” or click  in the tool bar to view the calibrated HSPF microbial parameters.



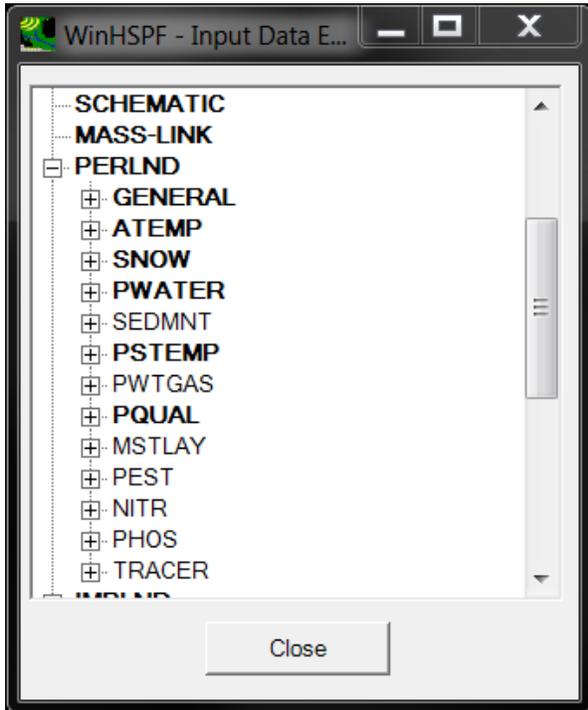
237. The following “Input Data Editor” window appears. Only bolded sections have records in the UCI file. For example, “FORMATS” does not contain data, but “FTABLES” does.



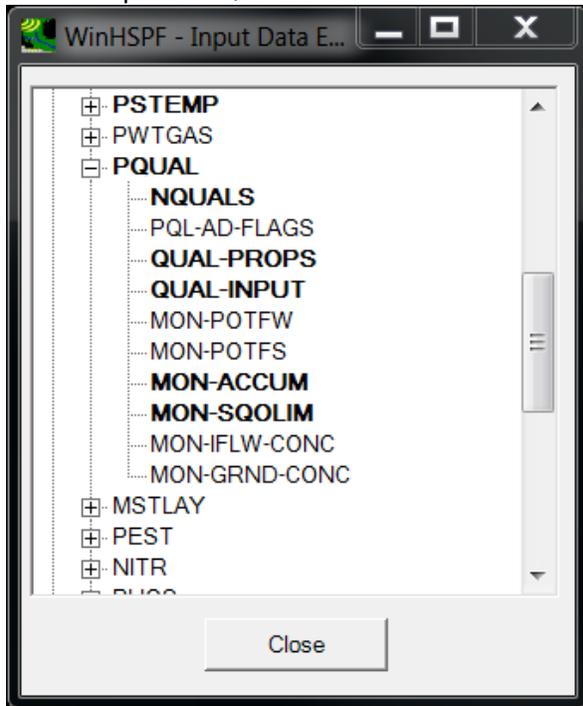
238. Expand “PERLND” by clicking “+” at the left.



239. Subsections in "PERLND" composed of the following records are expanded: "GENERAL", "ATEMP", "SNOW", "PWATER", "PSTEMP", and "PQUAL".



240. Expand "PQUAL".



241. In the “Input Data Editor” window, double-click (left) on “QUAL-INPUT”, under “PQUAL”, to view calibrated parameter values of “WSQOP”, “IOQC”, and “AOQC”. Click “OK” to close.

Table: QUAL-INPUT, Storage on surface and nonseasonal parameter values for section
 This table should be repeated for each quality constituent.

OpNum	Description	SQO	POTFW	POTFS	ACQOP	SQOLIM	WSQOP	IOQC	AOQC
101	Water/Wetlands	0	0	0	10000	100000	.0629168	0	0
102	Urban	0	0	0	10000	100000	.0629168	0	0
103	Barren or Mining	0	0	0	10000	100000	.0629168	0	0
104	Forest	0	0	0	10000	100000	.0629168	0	0
105	Upland Shrub Land	0	0	0	10000	100000	.0629168	0	0
106	Agriculture - Cropla	0	0	0	10000	100000	.0629168	0	0
107	Grass Land	0	0	0	10000	100000	.0629168	0	0
108	Agriculture - Pastur	0	0	0	10000	100000	.0629168	0	0
201	Water/Wetlands	0	0	0	10000	100000	.0629168	0	0
202	Urban	0	0	0	10000	100000	.0629168	0	0
203	Barren or Mining	0	0	0	10000	100000	.0629168	0	0
204	Forest	0	0	0	10000	100000	.0629168	0	0
205	Upland Shrub Land	0	0	0	10000	100000	.0629168	0	0
206	Agriculture - Cropla	0	0	0	10000	100000	.0629168	0	0
207	Grass Land	0	0	0	10000	100000	.0629168	0	0
208	Agriculture - Pastur	0	0	0	10000	100000	.0629168	0	0
301	Water/Wetlands	0	0	0	10000	100000	.0629168	0	0
302	Urban	0	0	0	10000	100000	.0629168	0	0
304	Forest	0	0	0	10000	100000	.0629168	0	0
305	Upland Shrub Land	0	0	0	10000	100000	.0629168	0	0
306	Agriculture - Cropla	0	0	0	10000	100000	.0629168	0	0
307	Grass Land	0	0	0	10000	100000	.0629168	0	0
308	Agriculture - Pastur	0	0	0	10000	100000	.0629168	0	0
401	Water/Wetlands	0	0	0	10000	100000	.0629168	0	0
402	Urban	0	0	0	10000	100000	.0629168	0	0
403	Barren or Mining	0	0	0	10000	100000	.0629168	0	0
404	Forest	0	0	0	10000	100000	.0629168	0	0
405	Upland Shrub Land	0	0	0	10000	100000	.0629168	0	0

*** Storage on surface and nonseasonal parameters ***
 *** SQO POTFW POTFS ACQOP SQOLIM WSQOP IOQC AOQC ***

242. In the “Input Data Editor” window, double-click (left) on “MON-ACCUM” to view monthly calibrated parameter values of “ACQOP” (“MON-ACCUM”). Click “OK” to close.

Edit Table PERLND:MON-ACCUM

Show description Occurrence 1 - Microbe

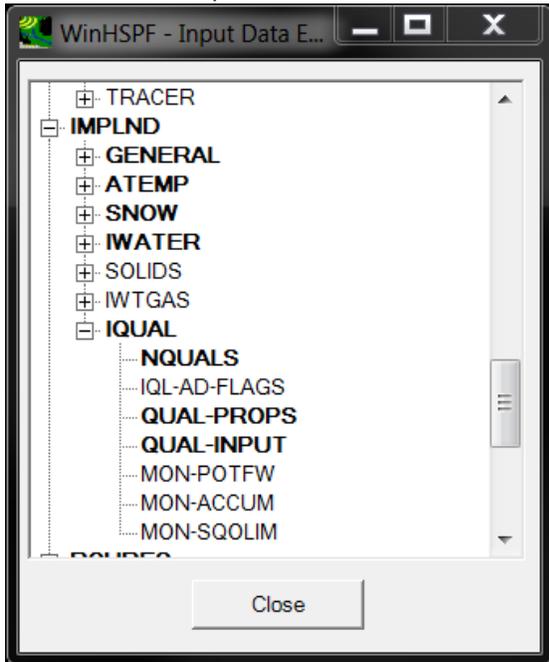
OpNum	Description	QUAJAN	QUAFEB	QUAMAR	QUAAPR	QUAMAY	QUAJUN	QUAJUL	QUAUG	QUASEP	QUAOCT	QUANOV	QUADEC
101	Water/Wetlands	0	0	0	0	0	0	0	0	0	0	0	0
102	Urban	1.9e8	1.9e8	1.9e8	1.9e8	1.9e8	1.9e8						
103	Barren or Mining	0	0	0	0	0	0	0	0	0	0	0	0
104	Forest	1.5e9	1.5e9	1.5e9	1.5e9	1.5e9	1.5e9						
105	Upland Shrub Land	0	0	0	0	0	0	0	0	0	0	0	0
106	Agriculture - Cropla	1.5e9	1.5e9	1.5e9	1E+11	2E+11	2E+11	1E+11	8E+10	4E+10	4E+10	1.5e9	1.5e9
107	Grass Land	0	0	0	0	0	0	0	0	0	0	0	0
108	Agriculture - Pastur	1.5e9	1.5e9	1.5e9	2E+11	4E+11	4E+11	2E+11	2E+11	2E+11	2E+11	1.5e9	1.5e9
201	Water/Wetlands	0	0	0	0	0	0	0	0	0	0	0	0
202	Urban	1.9e8	1.9e8	1.9e8	1.9e8	1.9e8	1.9e8						
203	Barren or Mining	0	0	0	0	0	0	0	0	0	0	0	0
204	Forest	1.5e9	1.5e9	1.5e9	1.5e9	1.5e9	1.5e9						
205	Upland Shrub Land	0	0	0	0	0	0	0	0	0	0	0	0
206	Agriculture - Cropla	1.5e9	1.5e9	1.5e9	2E+11	2E+11	2E+11	2E+11	1E+11	5E+10	5E+10	1.5e9	1.5e9
207	Grass Land	0	0	0	0	0	0	0	0	0	0	0	0
208	Agriculture - Pastur	1.5e9	1.5e9	1.5e9	4E+11	7E+11	4E+11	4E+11	4E+11	4E+11	4E+11	1.5e9	1.5e9
301	Water/Wetlands	0	0	0	0	0	0	0	0	0	0	0	0
302	Urban	1.9e8	1.9e8	1.9e8	1.9e8	1.9e8	1.9e8						
304	Forest	1.5e9	1.5e9	1.5e9	1.5e9	1.5e9	1.5e9						
305	Upland Shrub Land	0	0	0	0	0	0	0	0	0	0	0	0
306	Agriculture - Cropla	1.5e9	1.5e9	1.5e9	4E+10	7E+10	5E+10	4E+10	3E+10	1E+10	1E+10	1.5e9	1.5e9
307	Grass Land	0	0	0	0	0	0	0	0	0	0	0	0
308	Agriculture - Pastur	1.5e9	1.5e9	1.5e9	8E+10	1E+11	8E+10	7E+10	6E+10	6E+10	6E+10	1.5e9	1.5e9
401	Water/Wetlands	0	0	0	0	0	0	0	0	0	0	0	0
402	Urban	1.9e8	1.9e8	1.9e8	1.9e8	1.9e8	1.9e8						
403	Barren or Mining	0	0	0	0	0	0	0	0	0	0	0	0
404	Forest	1.5e9	1.5e9	1.5e9	1.5e9	1.5e9	1.5e9						
405	Upland Shrub Land	0	0	0	0	0	0	0	0	0	0	0	0
406	Agriculture - Cropla	1.5e9	1.5e9	1.5e9	1E+11	2E+11	2E+11	1E+11	8E+10	4E+10	4E+10	1.5e9	1.5e9
407	Grass Land	0	0	0	0	0	0	0	0	0	0	0	0
408	Agriculture - Pastur	1.5e9	1.5e9	1.5e9	2E+11	2E+11	2E+11	2E+11	2E+11	1E+11	1E+11	1.5e9	1.5e9
501	Water/Wetlands	0	0	0	0	0	0	0	0	0	0	0	0
502	Urban	1.9e8	1.9e8	1.9e8	1.9e8	1.9e8	1.9e8						

Table: MON-ACCUM, Monthly values of accumulation rate of QUALOF at start of each month. This table is only required if VQOFG in Table-type QUAL-PROPS is 1. This table should be repeated for each quality constituent.

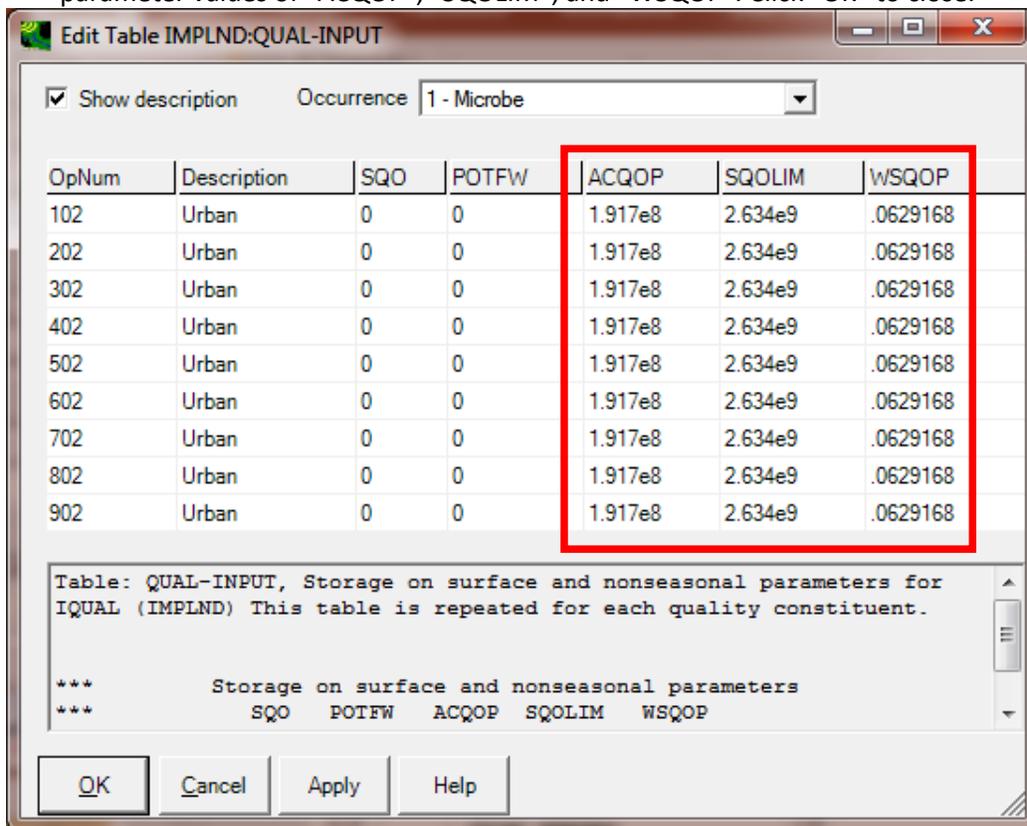
*** <PLS > Value at start of each month for accum rate of QUALOF (lb/ac.day)
 *** x - x JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

OK Cancel Apply Help

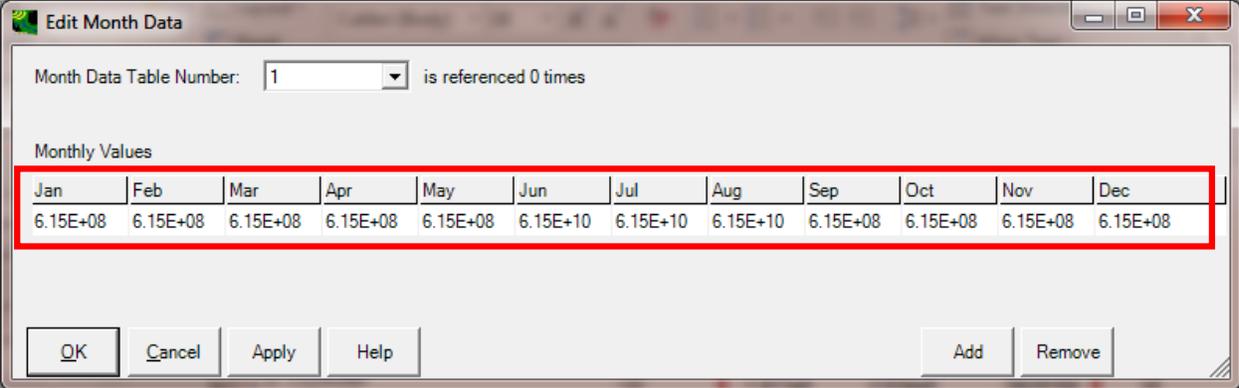
243. In the “Input Data Editor” window, first expand “IMPLND”, then expand “IQUAL”.



244. In the “Input Data Editor” window, double-click (left) on “QUAL-INPUT” to view calibrated parameter values of “ACQOP”, “SQOLIM”, and “WSQOP”. Click “OK” to close.



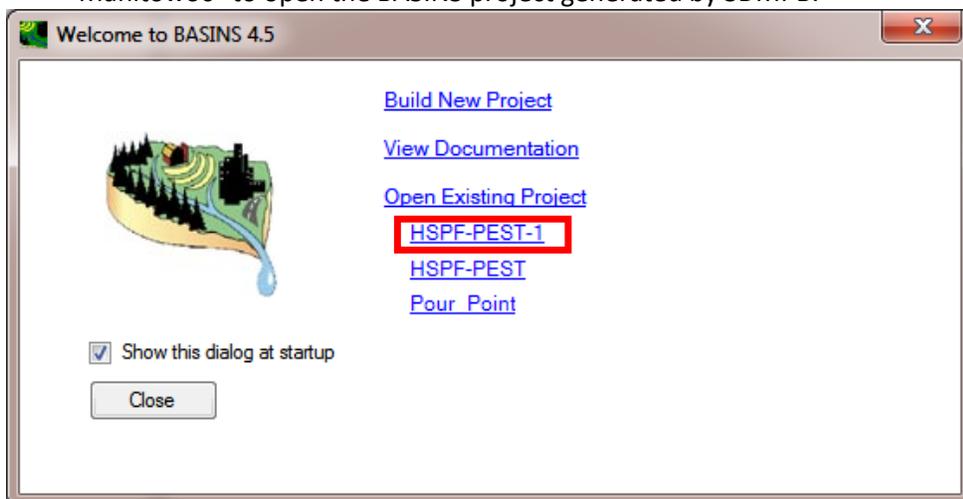
245. In the “Input Data Editor” window, double-click (left) on “MONTH-DATA” to view calibrated parameter values of “MONTH-DATA”. Click “OK” to close.



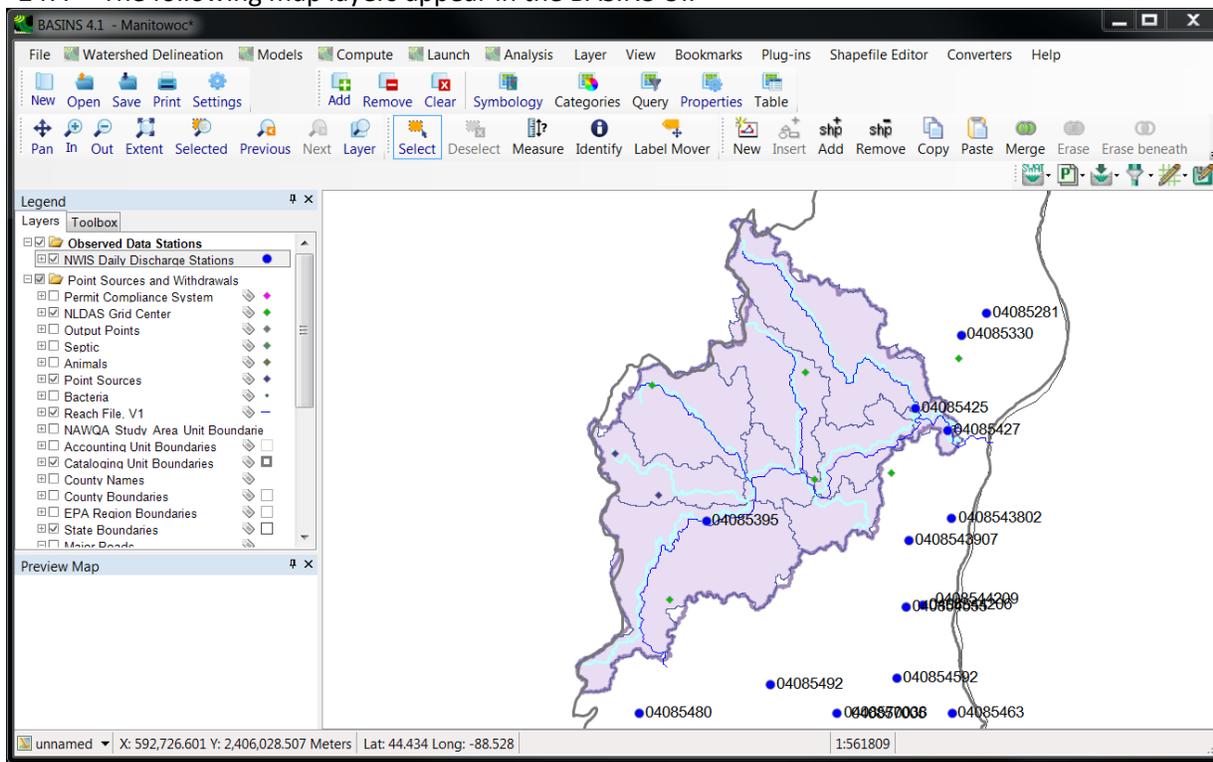
REGISTERING CALIBRATED SIMULATION RESULTS AND OBSERVATIONS WITH BASINS

HSPF microbial calibrated and uncalibrated simulation results with observations will be imported into BASINS for viewing and comparison. This section describes how to register simulation and observation time series results of microbial concentrations with BASINS, which will be used as the viewer.

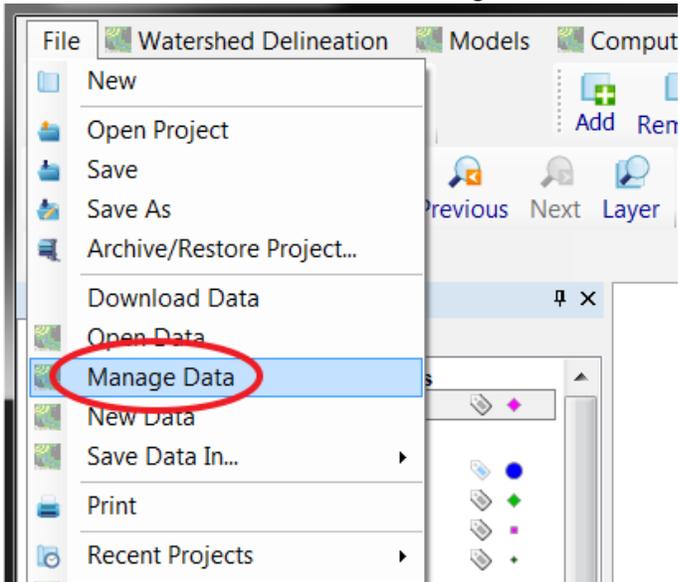
246. Execute BASINS with the BASINS icon. When “Welcome to BASINS 4.5” appears, click “Manitowoc” to open the BASINS project generated by SDMPB.



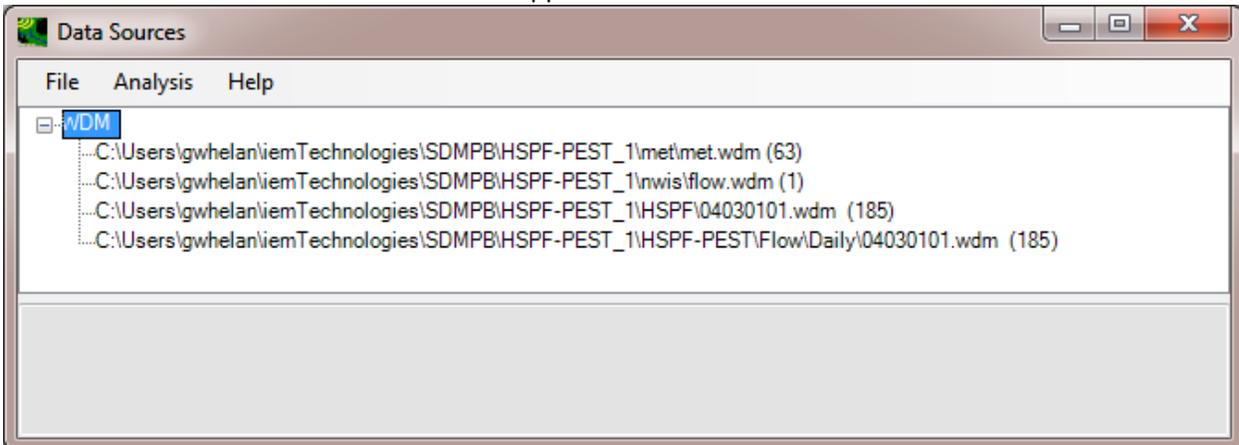
247. The following map layers appear in the BASINS UI.



248. Under “File”, select “File>Manage Data”.



249. The “Data Sources” window below appears.

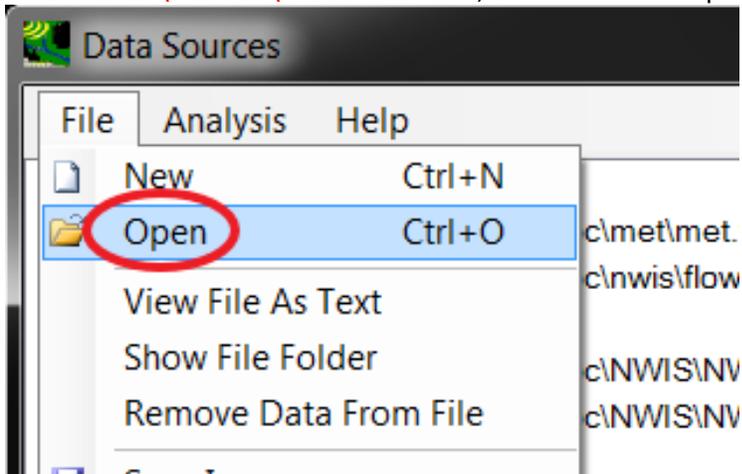


The “Data Source” window indicates that four time-series files have been registered. **C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF\04030101.wdm** contains uncalibrated microbial simulation results.

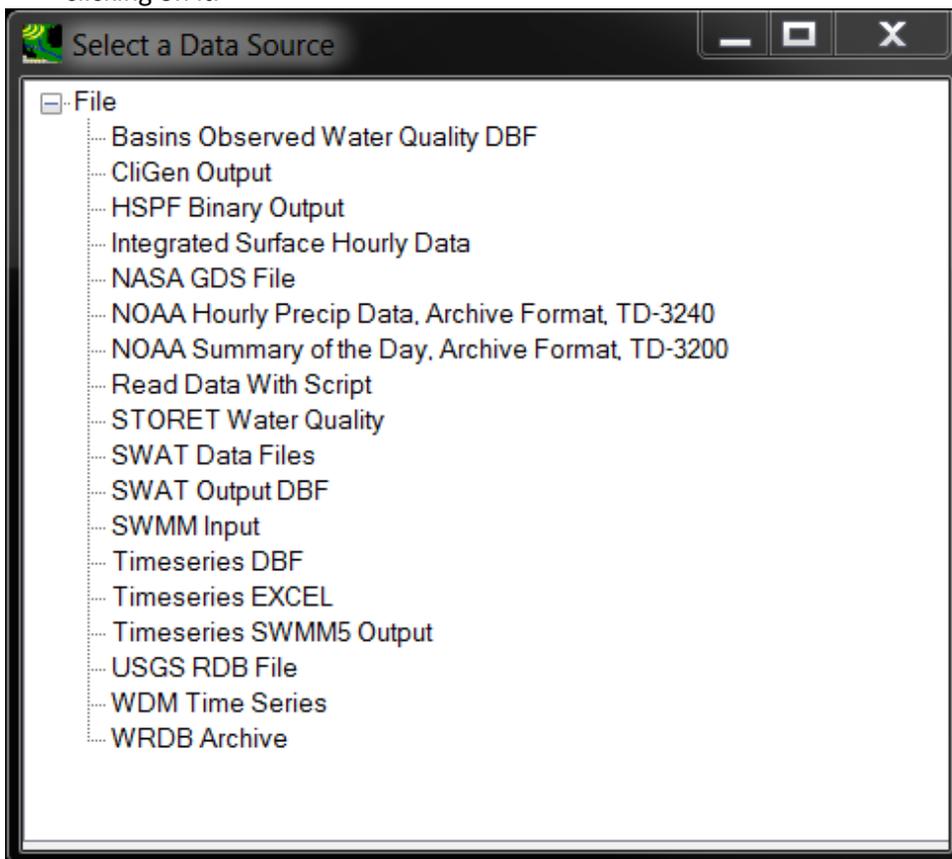
Data stored in the **“C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe\”** folder have not been registered with BASINS, including calibrated microbial simulation results (“04030101.wdm”) and microbial observations (“04030101_microbe_obs_009.txt”). We will register the calibration results with BASINS.

Register Calibrated Microbial Simulation Results

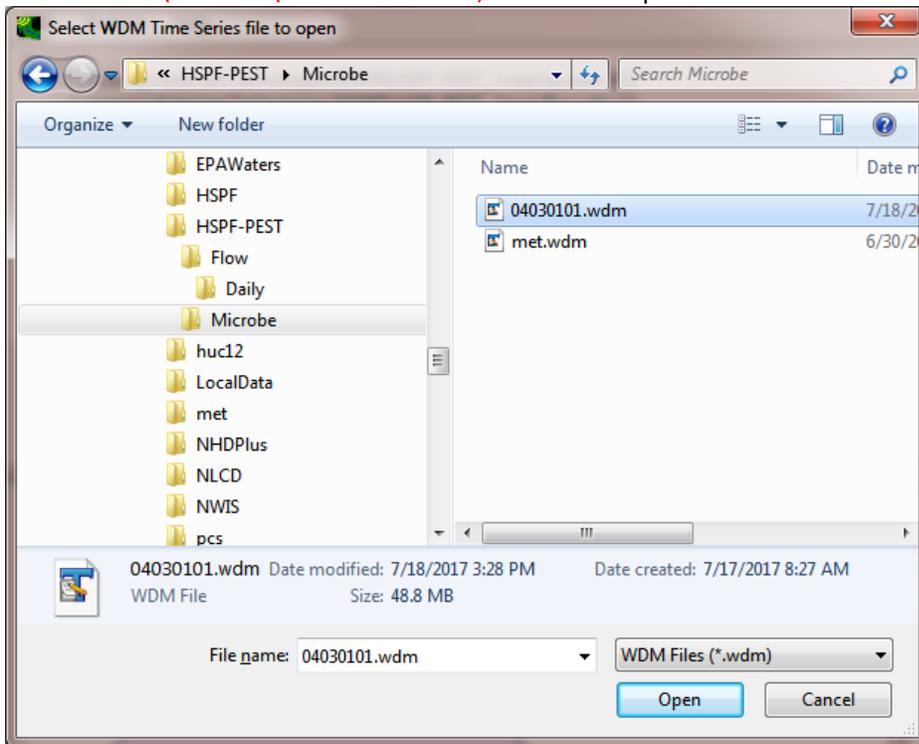
250. To import the calibrated microbial simulation results located in “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe\04030101.wdm”, and select “File>Open”.



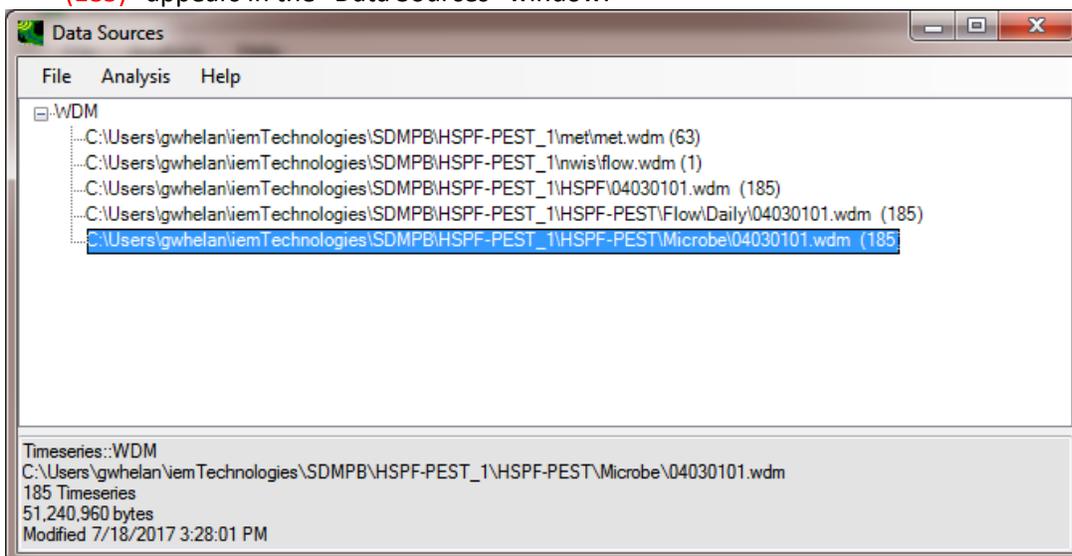
251. The following “Select a Data Source” window appears. Select “WDM Time Series” by double-clicking on it.



252. The following window appears. Browse and select
 “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe\04030101.wdm”, then click “Open”.



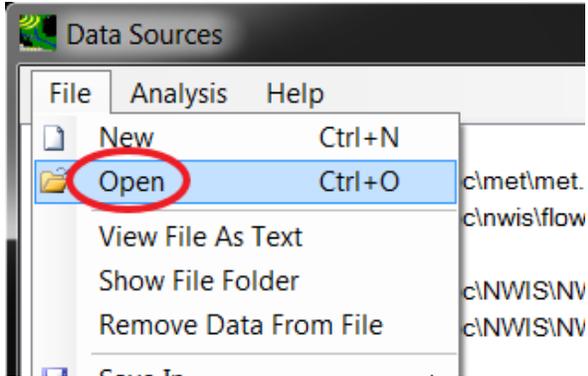
253. “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe\04030101.wdm (185)” appears in the “Data Sources” window.



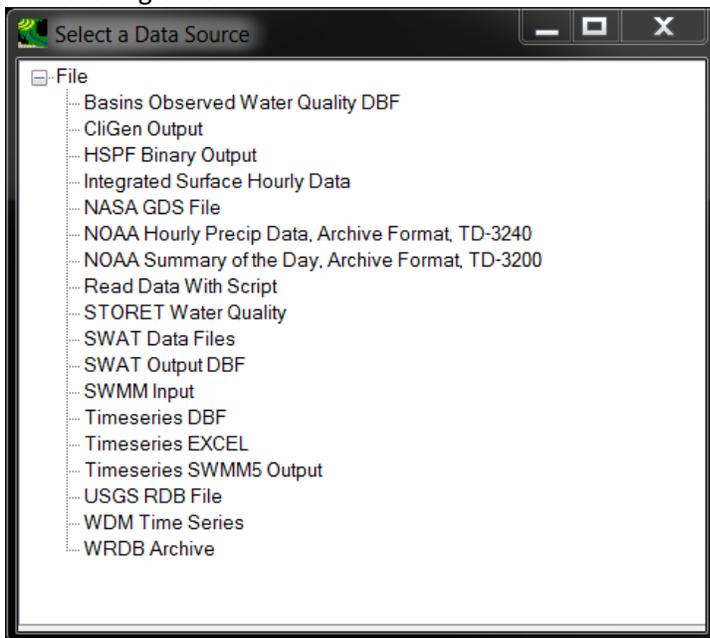
Because the microbial observations are stored in “04030101_microbe_obs_009.txt”, which is a text file, a different method is required to import and register these data with BASINS.

Register Microbial Observations

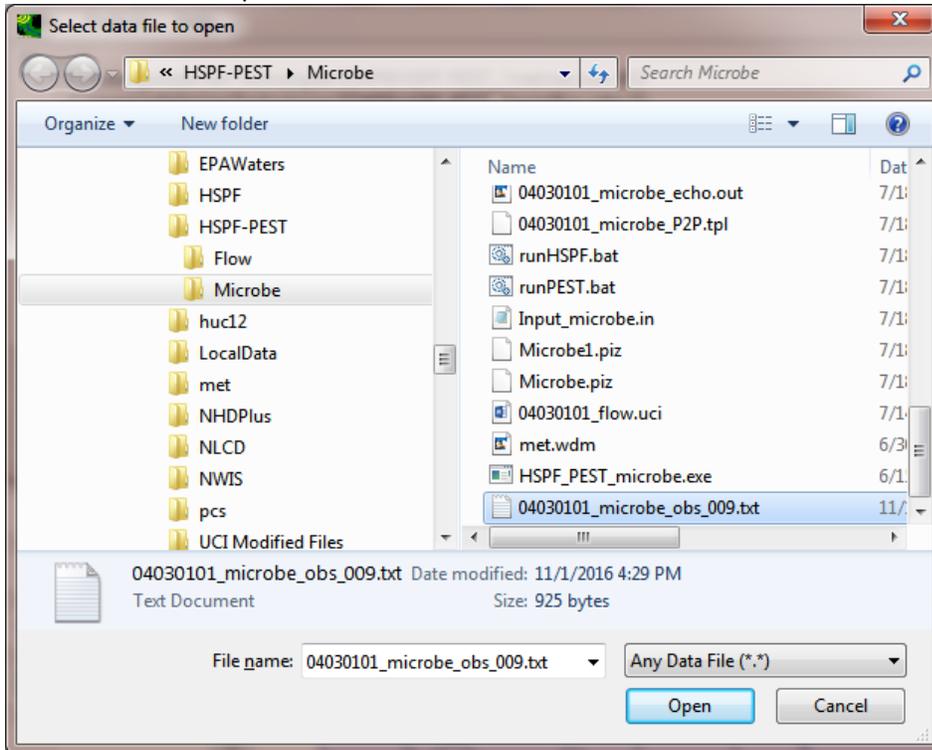
254. In “Data Sources” window, select “File>Open”.



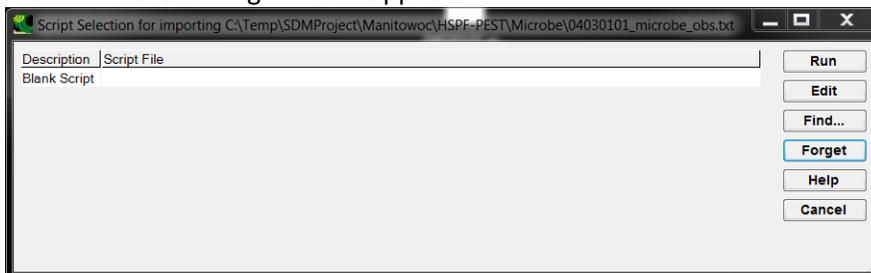
255. The following “Select a Data Source” window appears. Select “Read Data With Script” by double-clicking on it.



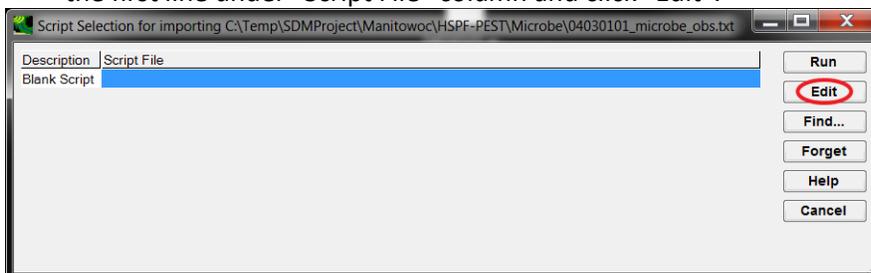
256. The following window appears.
- Browse and select “04030101_microbe_obs_009.txt” in the “C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe\” folder,
 - Click “Open”.



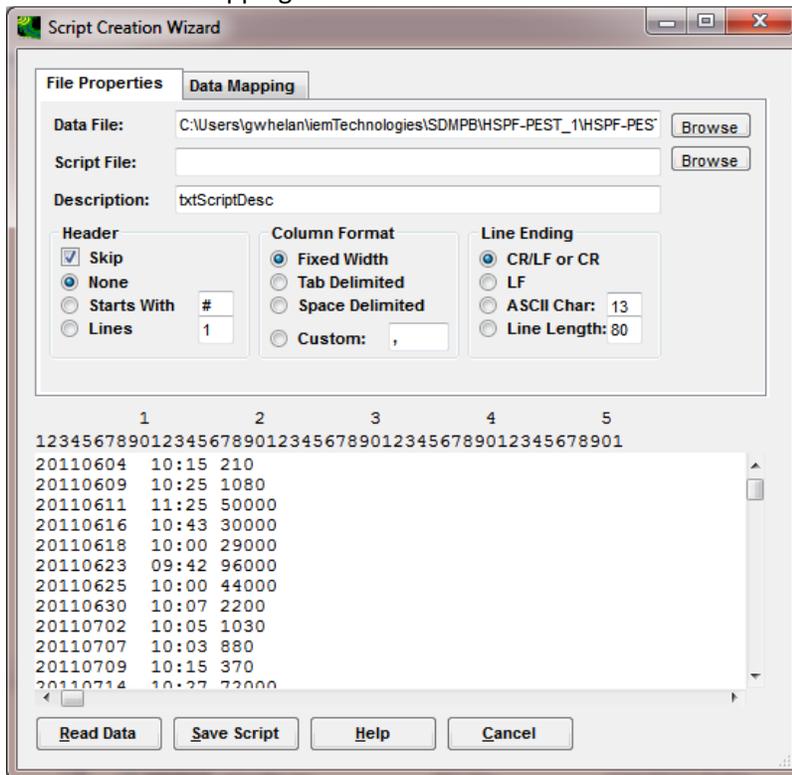
257. The following window appears.



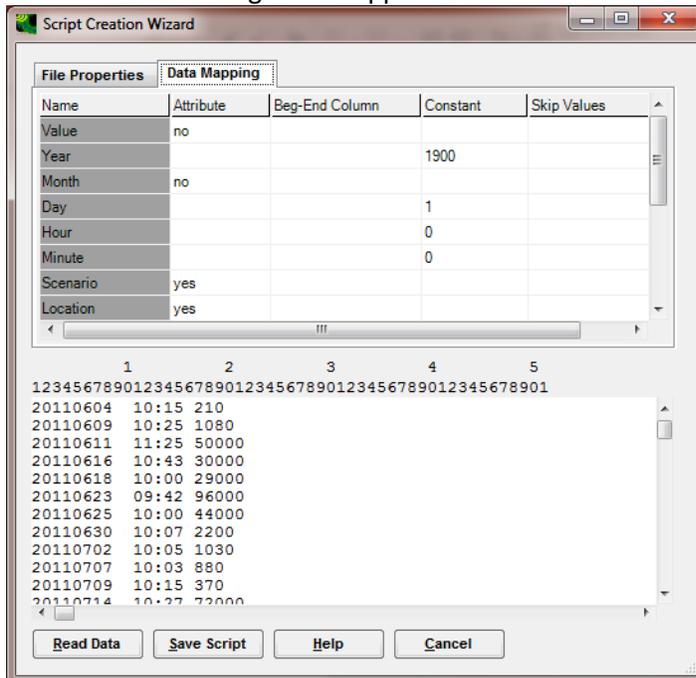
258. Because “04030101_microbe_obs_009.txt” is a text file, a script is required to read it. Highlight the first line under “Script File” column and click “Edit”.



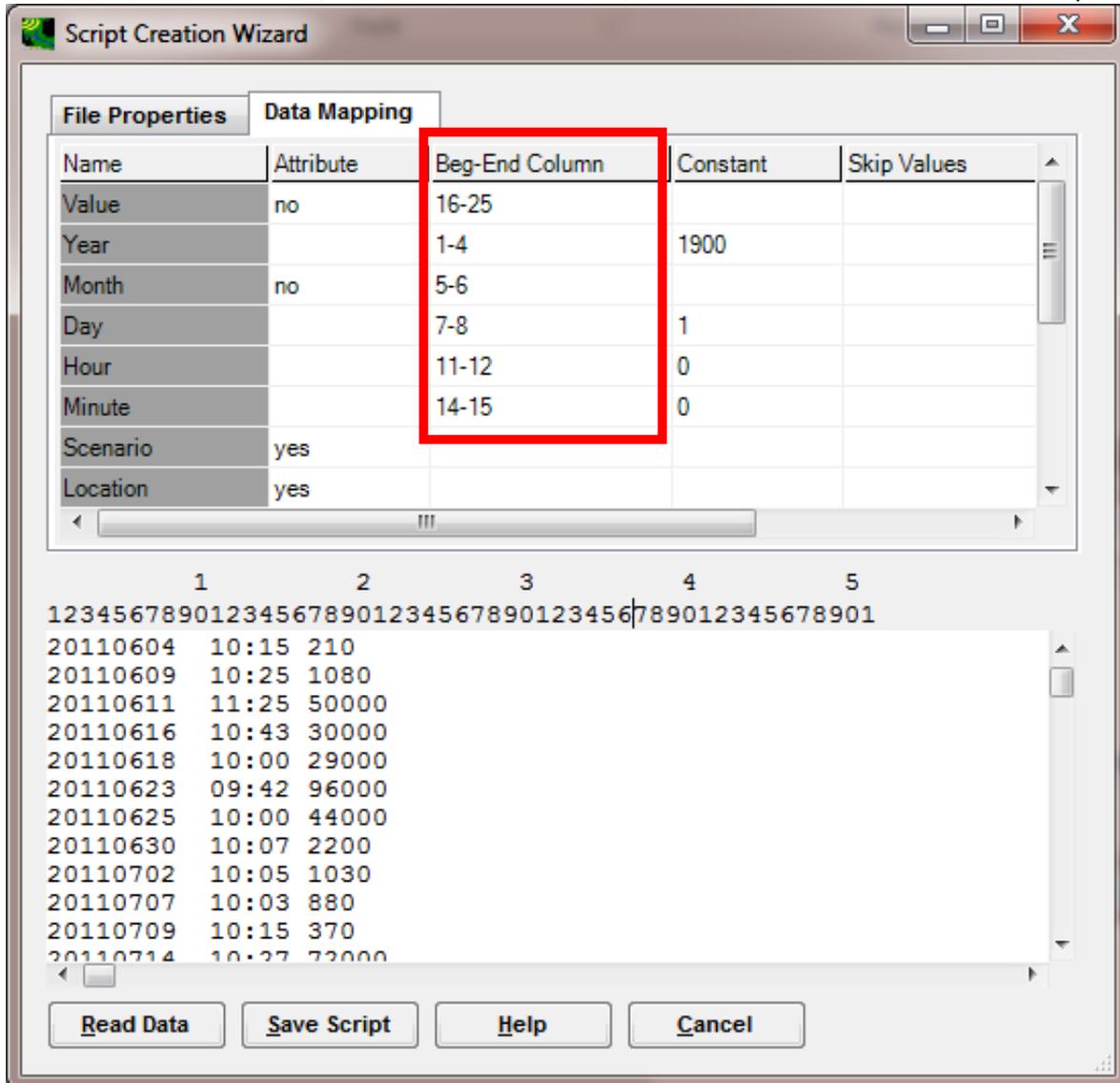
259. The “Script Creation Wizard” window appears. In “04030101_microbe_obs_009.txt”, observation data starts from line 1, so no change at the “File Properties” tab is necessary. Select the “Data Mapping” tab.



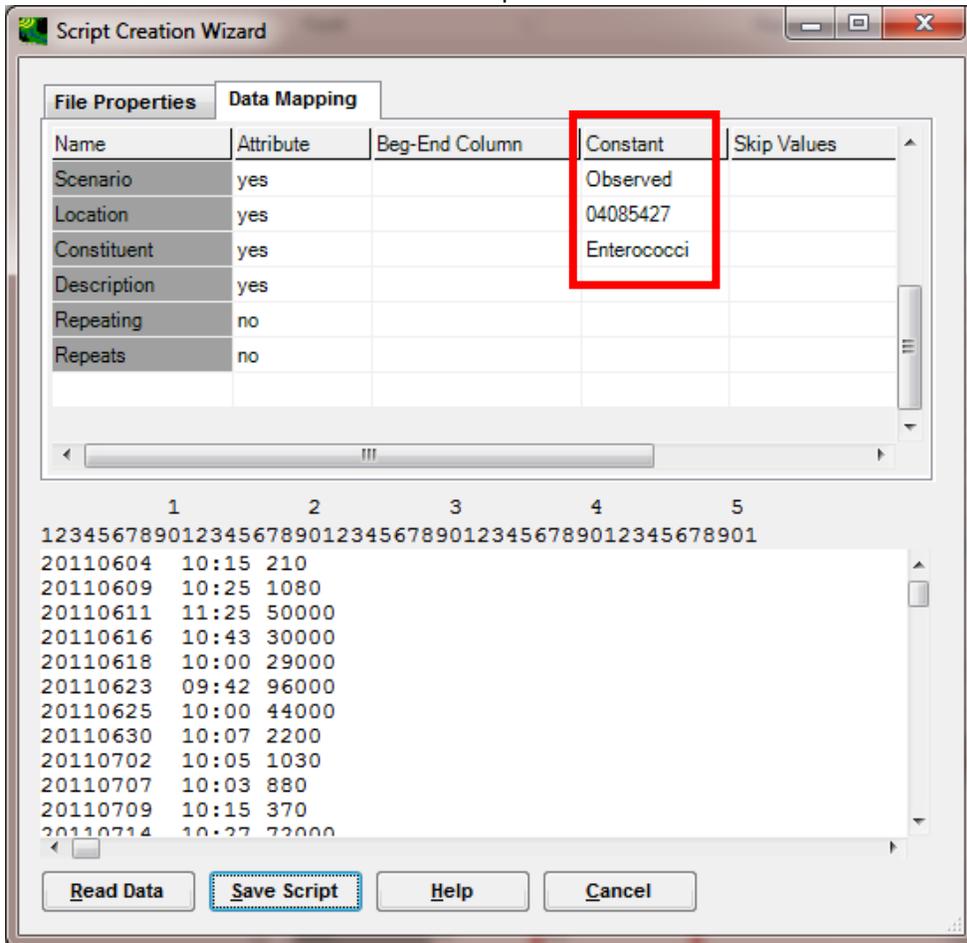
260. The following screen appears.



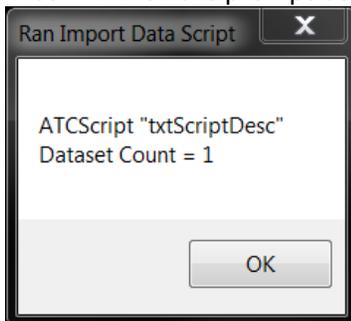
261. At the “Data Mapping” tab,
- use “Beg-End Column” to specify the location of the observation and its corresponding time in the file.
 - fill out the rows, from “Value” to “Minute”, with the values shown in the screen capture.



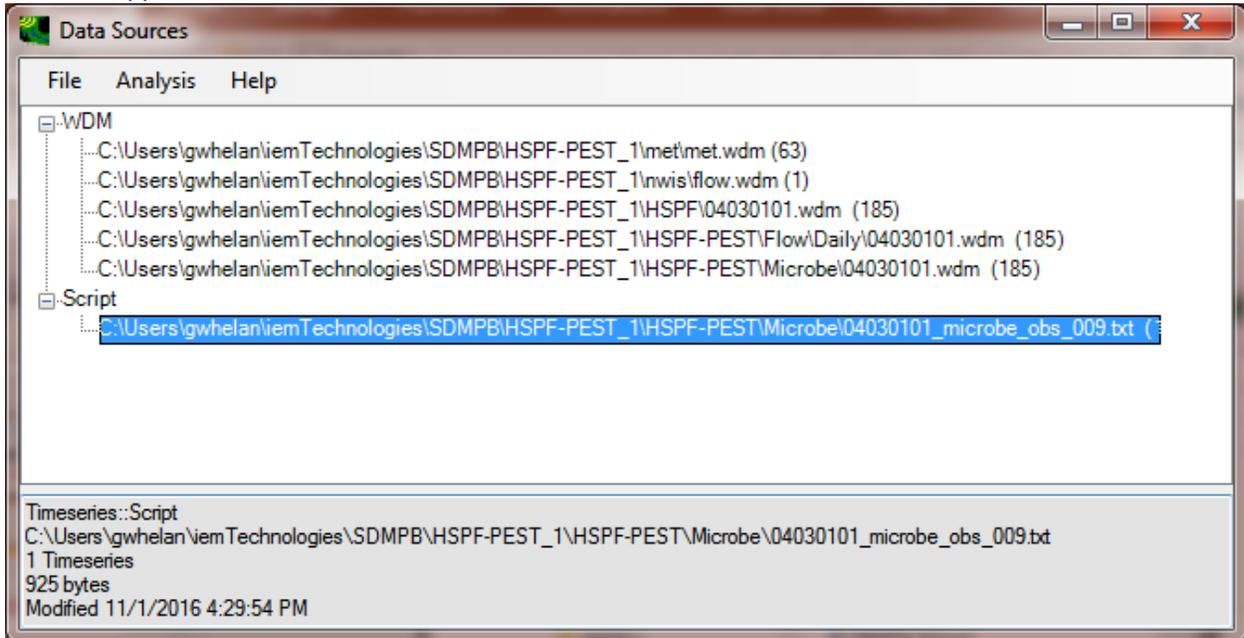
262. Under the "Constant" column,
 - a. scroll down until items under the Name column start with "Scenario",
 - b. under the "Constant" column, record "Observed", "04085427", and "Enterococci" for "Scenario", "Location", and "Constituent", respectively. These refer to the observed enterococci densities at sampling location 04085427.
 - c. Click "Save Script", and save the script as `C:\Users\gwhelan\iemTechnologies\SDMPB\HSPF-PEST_1\HSPF-PEST\Microbe\readtext_microbe_obs.ws` for future use.
 - d. Click "Read Data" on the "Script Creation Wizard" window.



263. When the prompt below appears, click "OK".

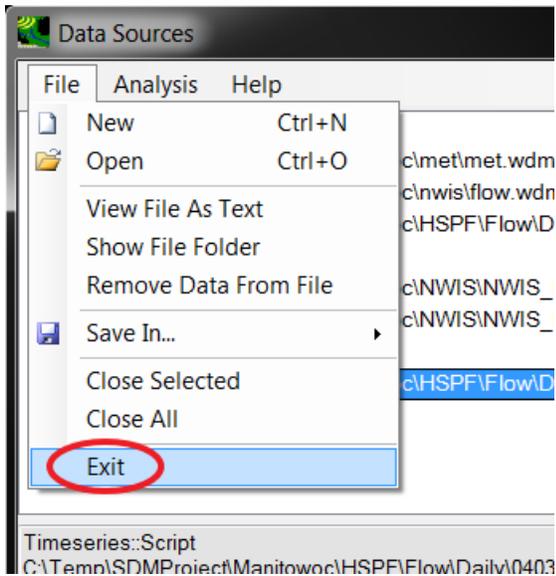


264. "C:\Temp\SDMProject\Manitowoc\HSPF-PEST\Microbe\04030101_microbe_obs_009.txt (1)" will appear in the "Data Sources" window.



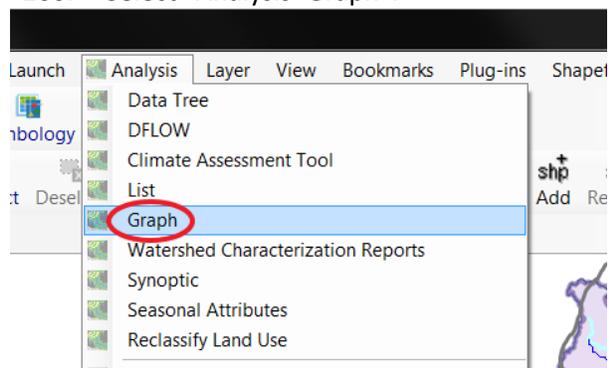
All necessary microbial concentration time series have been imported to the BASINS project to compare microbial uncalibrated, calibrated simulations to observations.

265. Select "File>Exit" to close the "Data Sources" window, then "File>Save" in the BASINS.

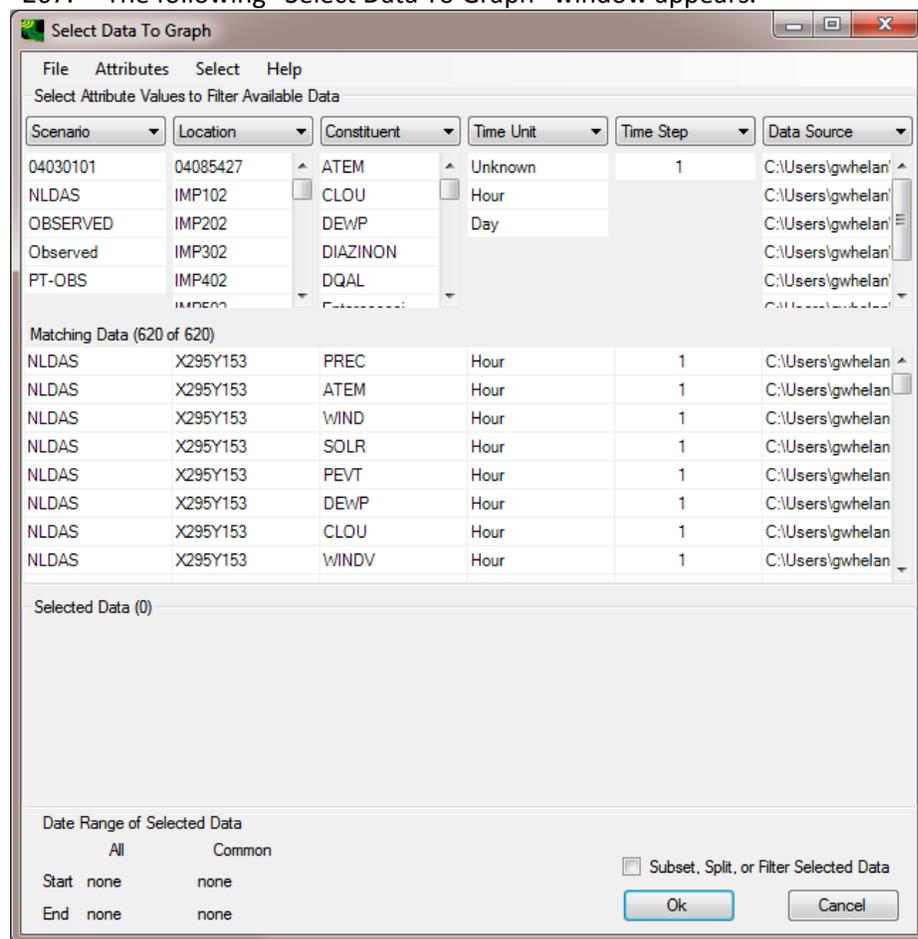


COMPARING HSPF MICROBIAL SIMULATION RESULTS BY PLOTTING MULTIPLE TIME SERIES

266. Select “Analysis>Graph”.

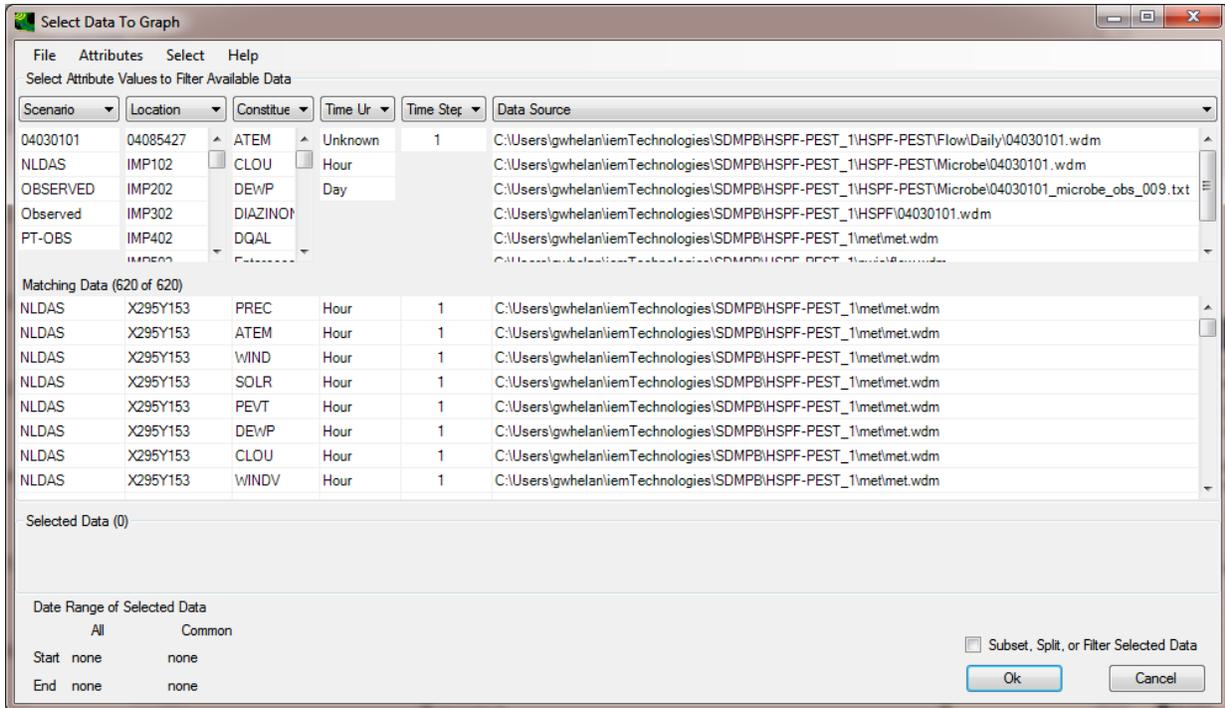


267. The following “Select Data To Graph” window appears.

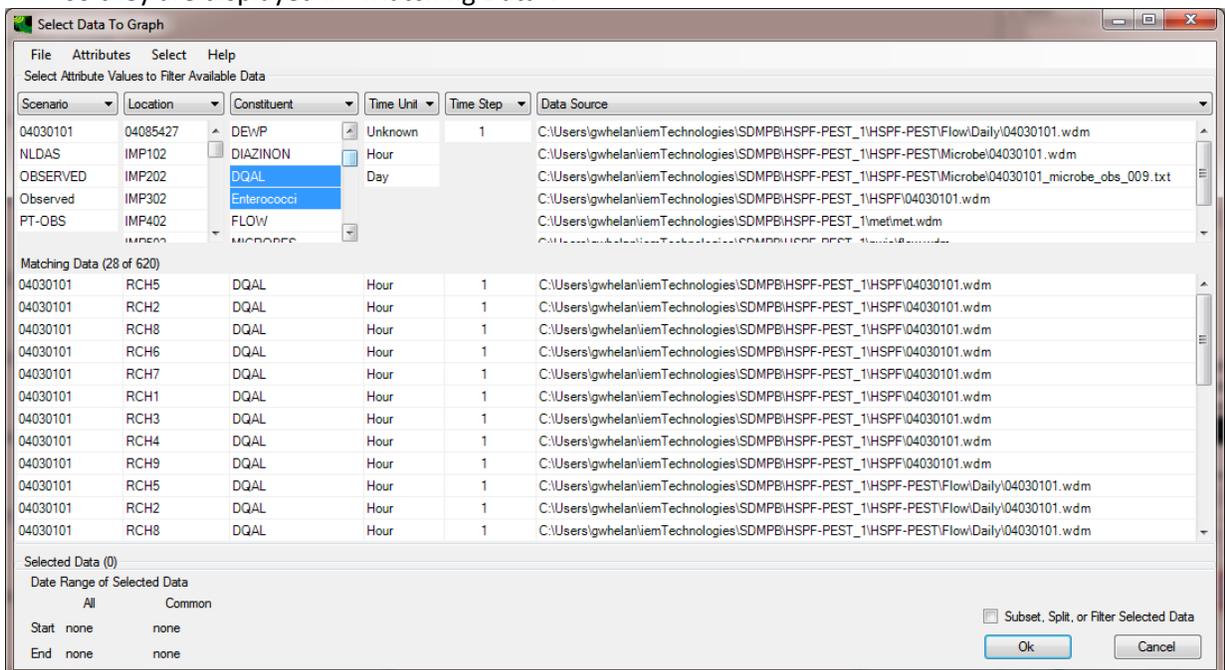


Since the “Data Source” column should have been added when uncalibrated and calibrated flow results with observations were plotted, it should not be necessary to add it again. [As a reminder, “Add” was chosen under “Attributes”, then “Data Source” for the new column.]

268. As described in previous sections, the width of each column should be adjusted so the full path of the data source can be viewed.



269. Under the “Constituent” column, observed data are denoted by “Enterococci”, and uncalibrated and calibrated simulation results are both denoted by “DQAL”. Highlight “Enterococci” and “DQAL”, so they are displayed in “Matching Data”.



“Observed” data (under “Scenario”) near the watershed pour point are at “04085427” (under “Location”). Corresponding simulated data near the watershed pour point are at “RCH9” (under “Location”). The uncalibrated and calibrated simulation results (under “Data Source” column) are captured in the “04030101.wdm” file in the “...\HSPF” and “...\Microbe” folders, respectively.

270. As captured below, choose the three time series indicated in “Selected Data”.

The screenshot shows the 'Select Data To Graph' dialog box. The main table lists 620 matching data points. The 'Selected Data' section contains the following three rows:

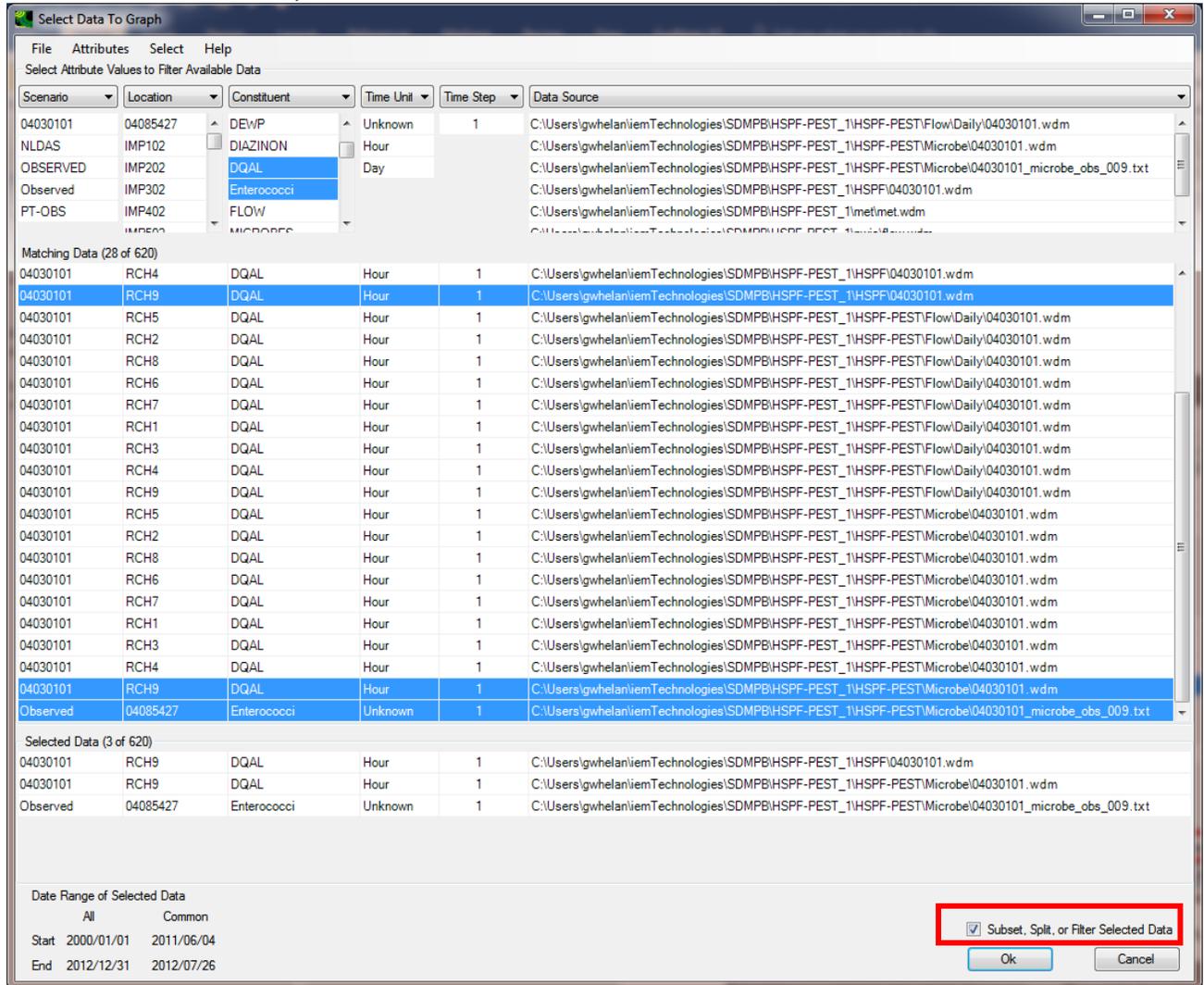
Scenario	Location	Constituent	Time Unit	Time Step	Data Source
04030101	RCH9	DQAL	Hour	1	C:\Users\gwhelan\iemTechnologies\SDMPBIHSPF-PEST_1\HSPF\04030101.wdm
04030101	RCH9	DQAL	Hour	1	C:\Users\gwhelan\iemTechnologies\SDMPBIHSPF-PEST_1\HSPF-PEST\Microbe\04030101.wdm
Observed	04085427	Enterococci	Unknown	1	C:\Users\gwhelan\iemTechnologies\SDMPBIHSPF-PEST_1\HSPF-PEST\Microbe\04030101_microbe_obs_009.txt

The 'Date Range of Selected Data' section shows:

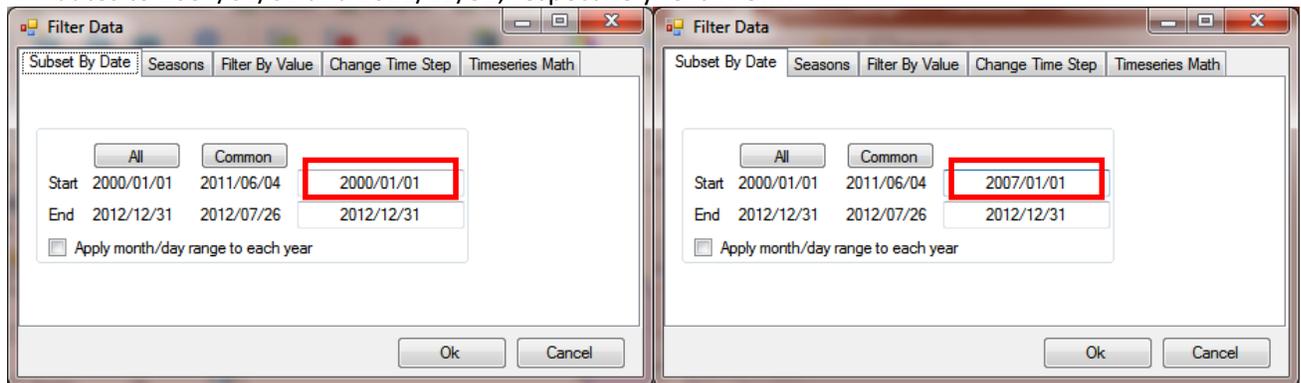
	All	Common
Start	2000/01/01	2011/06/04
End	2012/12/31	2012/07/26

Since the first seven years (2000 – 2006) were used as warm-up for the watershed modeling, they are excluded in the comparison; hence, the dates associated with the viewing the microbial density time series will be from 2007 through 2012 and need to be modified. The start and end dates will be “2007/01/01” and “2012/12/31”.

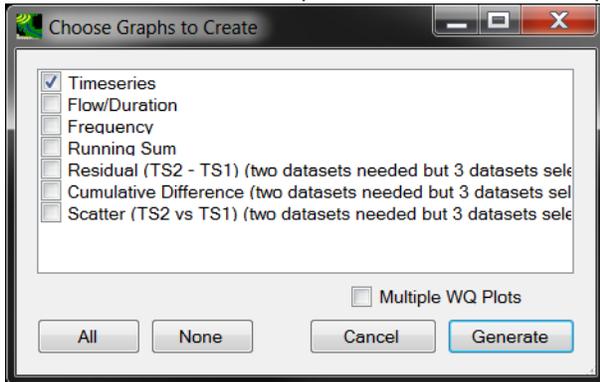
271. Click the “Subset, Split, or Filter Selected Data” box. Click “Ok.”



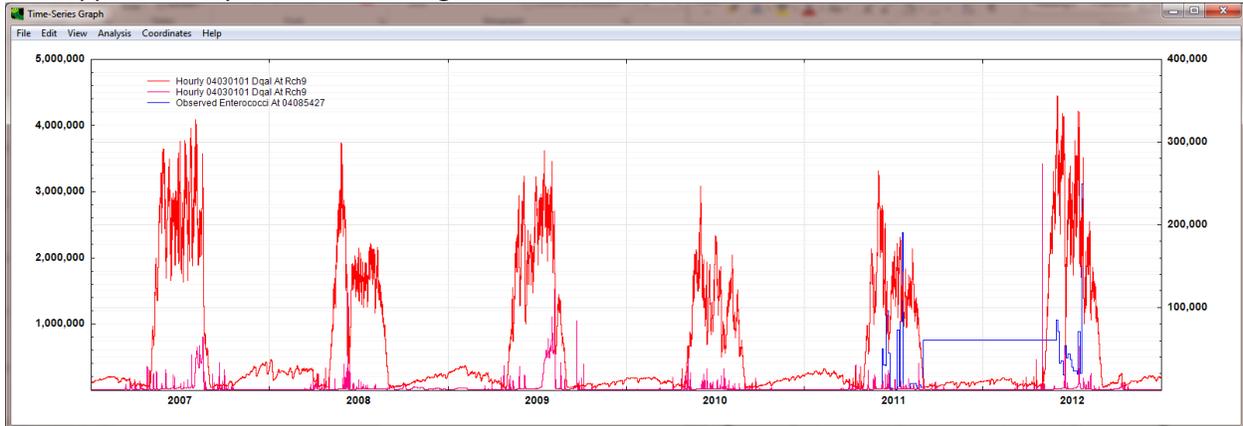
272. The “Filter Data” screen appears. Under the “Subset By Date” tab, change the “Start” and “End” dates to 2007/01/01 and 2012/12/31, respectively. Click “Ok”.



273. The “Choose Graphs to Create” window appears. Check “Timeseries”, then click “Generate”.

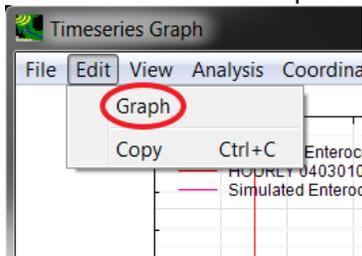


274. The following “Timeseries Graph” is generated, in which two Y-axes appear. This is caused by the large differences in magnitude between time series curves. Values on the axes differ by approximately one-order of magnitude.

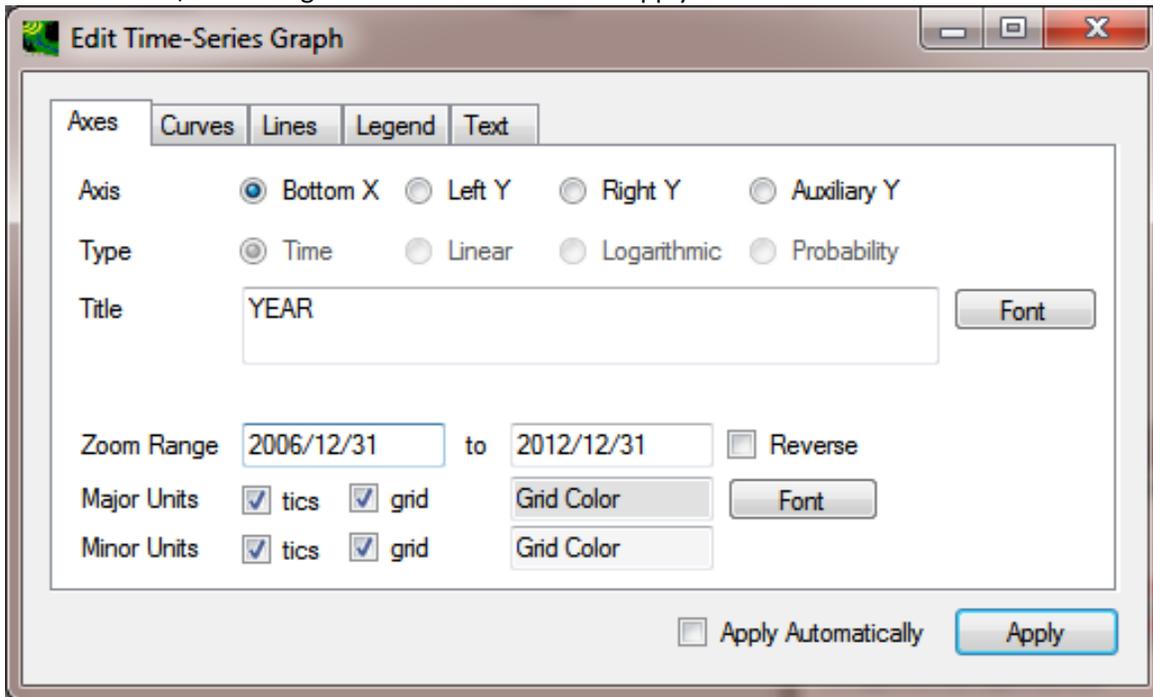


In the above graph, note that two Y-axis are appeared. This is caused by large difference between time series. You can see the values on the both axis have about an order of magnitude difference. To clearly indicate each time series, we can change the color of the curves, and the y-axis can be changed from linear to logarithmic.

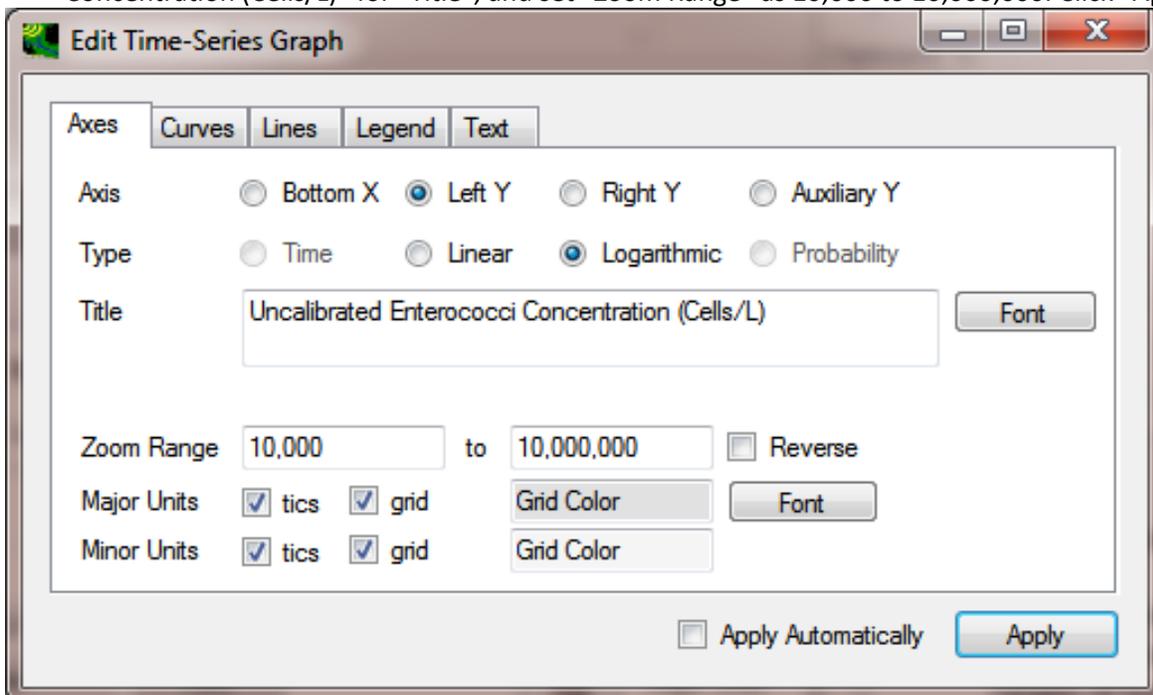
275. Select “Edit>Graph”.



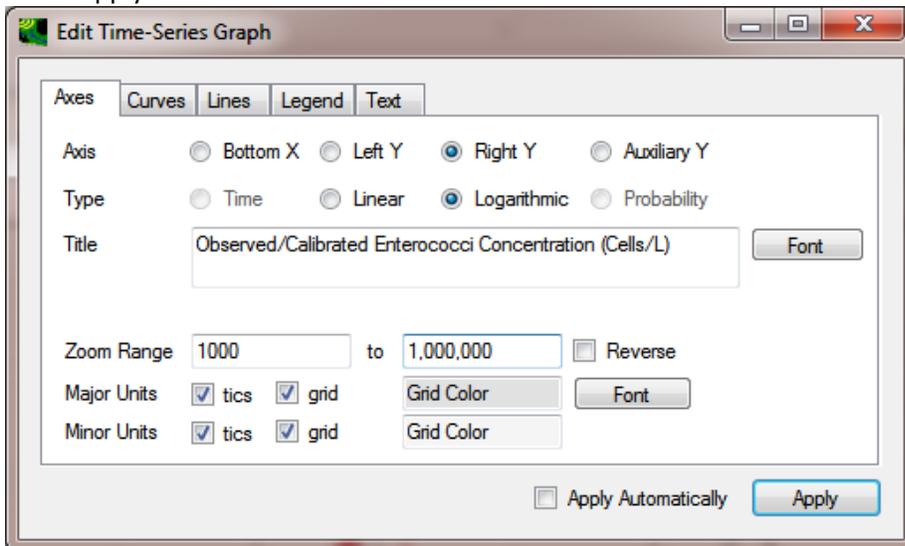
276. The “Edit Timeseries Graph” window below appears. Under the “Axes” tab, choose “Bottom X” for “Axis”, and change “Title” to “YEAR”. Click “Apply”.



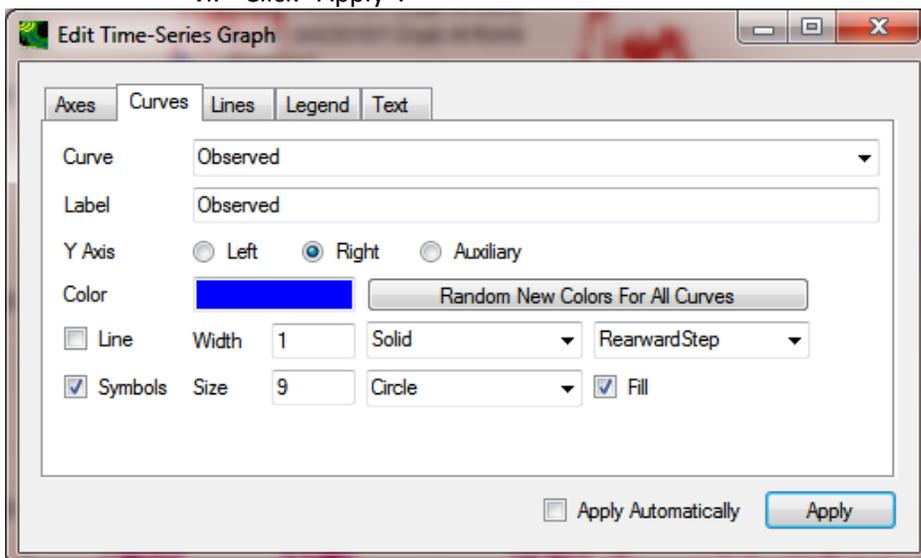
277. Select “Left Y” for “Axis” and “Logarithmic” for “Type”, then type “Uncalibrated Enterococci Concentration (Cells/L)” for “Title”, and set “Zoom Range” as 10,000 to 10,000,000. Click “Apply”.



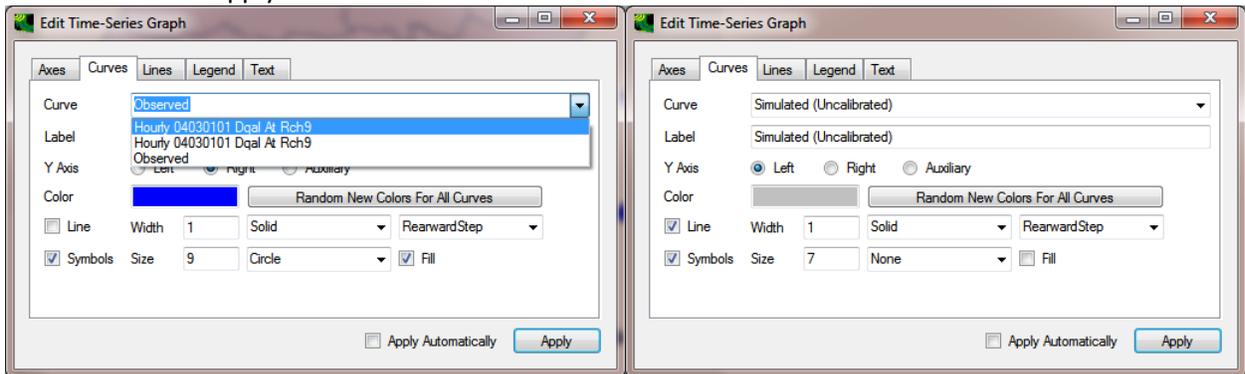
278. Select “Right Y” for “Axis” and “Logarithmic” for “Type”, then type “Observed/Calibrated Enterococci Concentration (Cells/L)” for “Title”, and set “Zoom Range” as 1000 to 1,000,000. Click “Apply”.



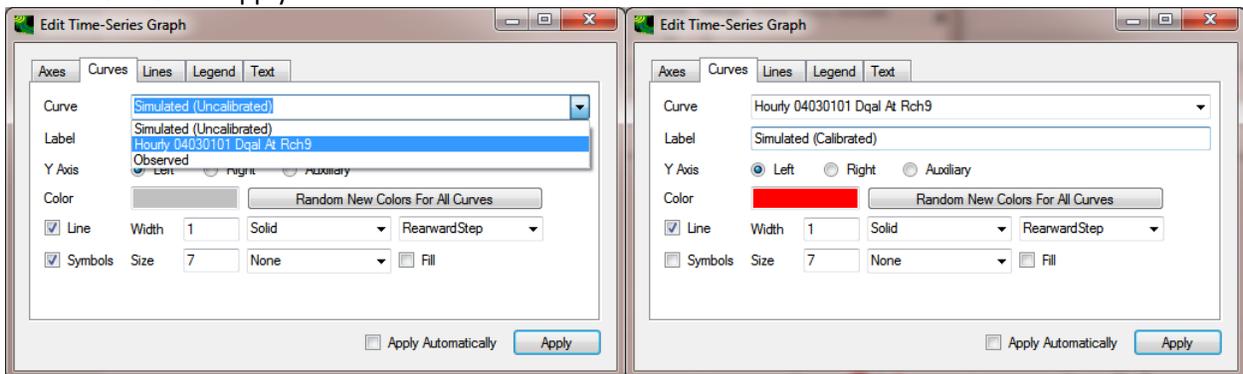
279. Go to the “Curve” tab.
- Select “Observed Enterococci at 04085427” for “Curve”, then change “Label” to “Observed”. Note that the “Y axis” is “Right”.
 - Since this observation is intermittent, only express the data with symbols that do not have a continuous line.
 - Uncheck “Line”.
 - Change “Size” to “9”.
 - Select symbol type as “Circle”.
 - Check “Fill”.
 - Change “Color” to blue.
 - Click “Apply”.



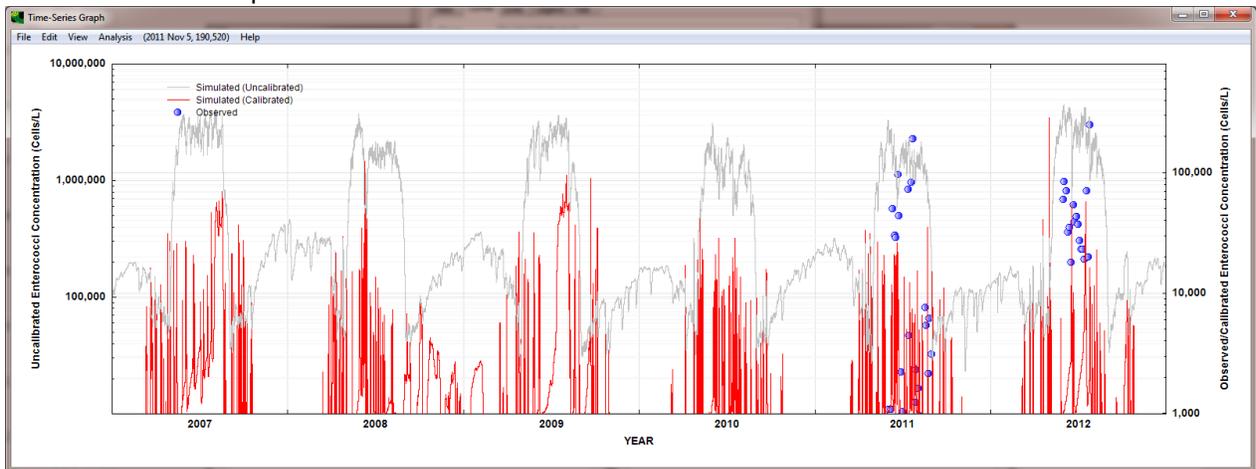
280. Select the first time series, “Hourly 04030101 Dqal at Rch9” for “Curve”. “Left” “Y Axis” has been selected for this time series.
- Change “Label” to “Simulated (Uncalibrated)”.
 - Change “Color” to grey.
 - Click “Apply”.



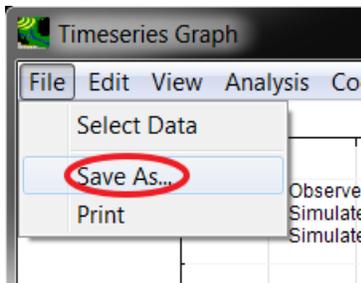
281. Select the second time series, “Hourly 04030101 Dqal at Rch9” for “Curve”. “Left” “Y Axis” has been selected for this time series.
- Change “Label” to “Simulated (Calibrated)”.
 - Change “Color” to red.
 - Click “Apply”.



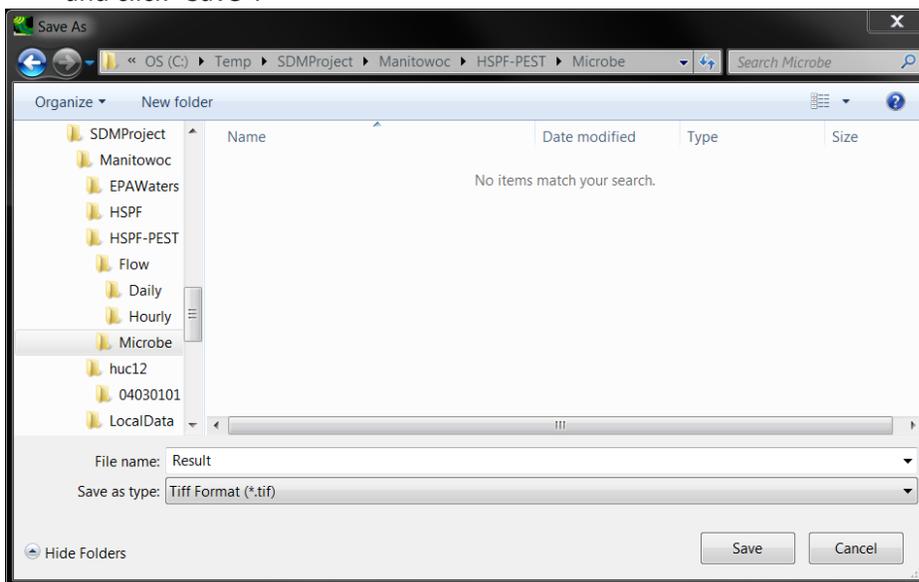
282. Close the “Edit Timeseries Graph” window, and all three time series in “Timeseries Graph” window will be plotted.



283. The graph can be exported as an image file. In the “Timeseries Graph” window, select “File>Save As...”.



284. Choose desired file format (.tif in this example), define the file name (Result.tif in this example) and click “Save”.



DISCLAIMER

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REFERENCES

- Bicknell B.R., Imhoff J.C., Kittle, Jr. J.L., Jobes T.H., Donigian, Jr. A.S. 2005. HSPF version 12.2 user's manual.
- Doherty J. 2005. PEST: Model-independent parameter estimation user manual. 5th edition, Watermark Numerical Computing.
- EPA. 2000. BASINS Technical Note 6: Estimating Hydrology and Hydraulic Parameters for HSPF. 32p. (http://water.epa.gov/scitech/datait/models/basins/upload/2000_08_14_BASINS_tecnote6.pdf)
- Whelan, G., K. Wolfe, R. Parmar, M. Galvin, M. Molina, R. Zepp, K. Kim, P. Duda. 2017a. Quantitative Microbial Risk Assessment Tutorial: Primer. U.S. Environmental Protection Agency, Athens, GA.
- Whelan, G., K. Kim, K. Wolfe, R. Parmar, M. Galvin, M. Molina, R. Zepp, P. Duda, M. Gray. 2017b. Quantitative Microbial Risk Assessment Tutorial: Pour Point Analysis of Land-applied Microbial Loadings and Comparison of Simulated and Gaging Station Results – Updated 2017. EPA/600/B-15/290. U.S. Environmental Protection Agency, Athens, GA.
- Whelan, G., K. Kim, K. Wolfe, R. Parmar, M. Galvin. 2017c. Quantitative Microbial Risk Assessment Tutorial: Installation of Software for Watershed Modeling in Support of QMRA – Updated 2017. 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. 2017d. Navigate the SDMPB and Identify an 8-Digit HUC of Interest – Updated 2017. EPA/600/B-15/273. U.S. Environmental Protection Agency, Athens, GA.
- Whelan, G., R. Parmar, K. Wolfe, M. Galvin, P. Duda, M. Gray. 2017e. Quantitative Microbial Risk Assessment Tutorial – SDMPProjectBuilder: Import Local Data Files to Identify and Modify Contamination Sources and Input Parameters – Updated 2017. EPA/600/B-15/316. U.S. Environmental Protection Agency, Athens, GA.

Whelan, G., K. Kim, R. Parmar, K. Wolfe, M. Galvin, M. Gray, P. Duda, M. Molina, R. Zepp. 2017f. Quantitative Microbial Risk Assessment Tutorial: Land-applied Microbial Loadings within a 12-Digit HUC – Updated 2017. EPA/600/B-15/298. U.S. Environmental Protection Agency, Athens, GA.

Whelan, G., K. Wolfe, R. Parmar, M. Galvin, M. Molina, R. Zepp, P. Duda. 2017g. Quantitative Microbial Risk Assessment Tutorial: Point Source and Land-applied Microbial Loadings within a 12-Digit HUC. U.S. Environmental Protection Agency, Athens, GA.

Whelan, G., K. Kim, R. Parmar, K. Wolfe, M. Galvin, M. Gray, P. Duda, M. Molina, R. Zepp. 2017h. Quantitative Microbial Risk Assessment Tutorial: Using NLDAS and NCDC Meteorological Data – Updated 2017. EPA/600/B-15/299. U.S. Environmental Protection Agency, Athens, GA.

Whelan, G., R. Parmar, G.L. Laniak. 2017i. Microbial Source Module (MSM): Documenting the Science and Software for Discovery, Evaluation, and Integration; Updated – 4/17/17. EPA/600/B-15/315, U.S. Environmental Protection Agency, Office of Research and Development, Athens, GA.

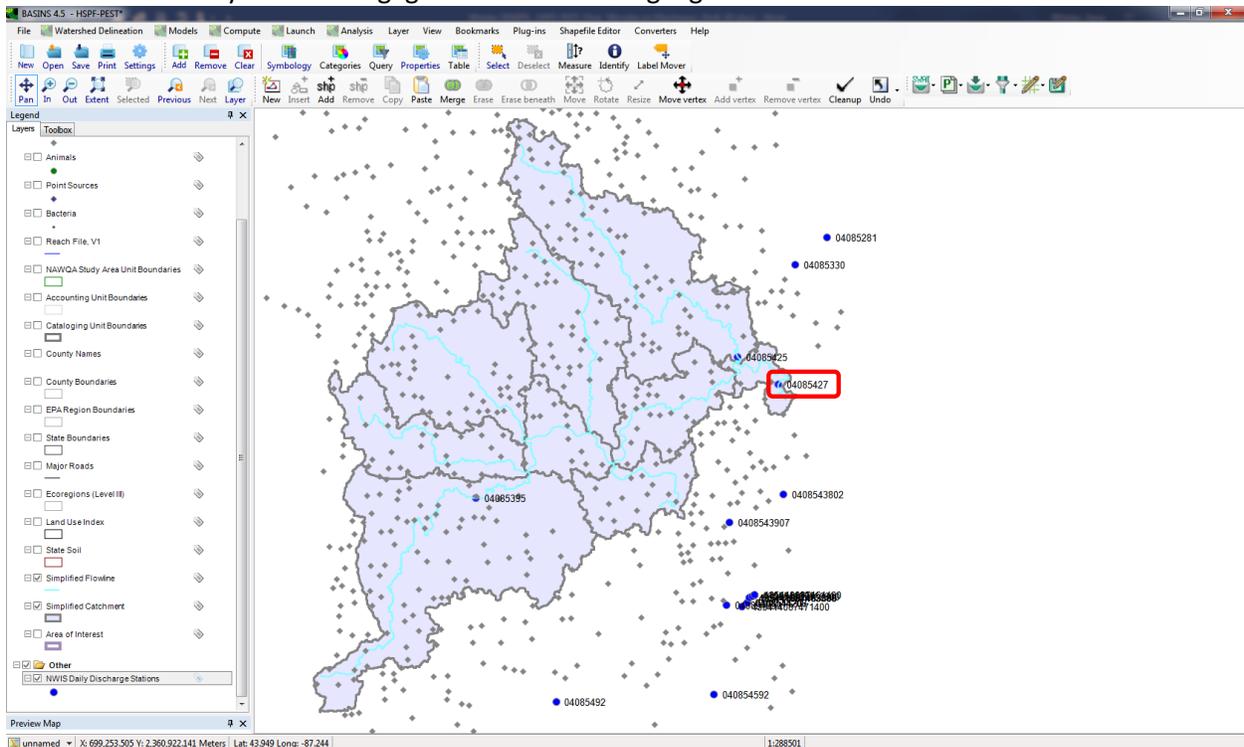
APPENDIX A

USGS Instantaneous Data Archive for Instantaneous Discharge Data using the BASINS Download Data Tools

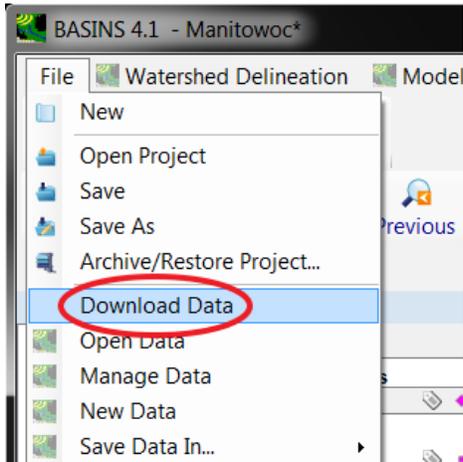
The USGS Instantaneous Data Archive (IDA) for Instantaneous Discharge data provides hourly and sub-hourly discharge data at USGS gaging stations. As noted in the main text, as of June 23, 2017, access to USGS Instantaneous Data Archive (IDA) for Instantaneous Discharge data is not available on the USGS web site. In the event that USGS IDA for Instantaneous Discharge data become available and the web service is activated within the SDMPB, this section describes how the user can access and retrieve the instantaneous discharge data using the BASINS download data tools.

1. To download discharge data at the 04085427 gage station from the USGS web site,
 - c. Highlight the “NWIS Daily Discharge Stations” layer in the “Legend” panel (see red box in the figure below).

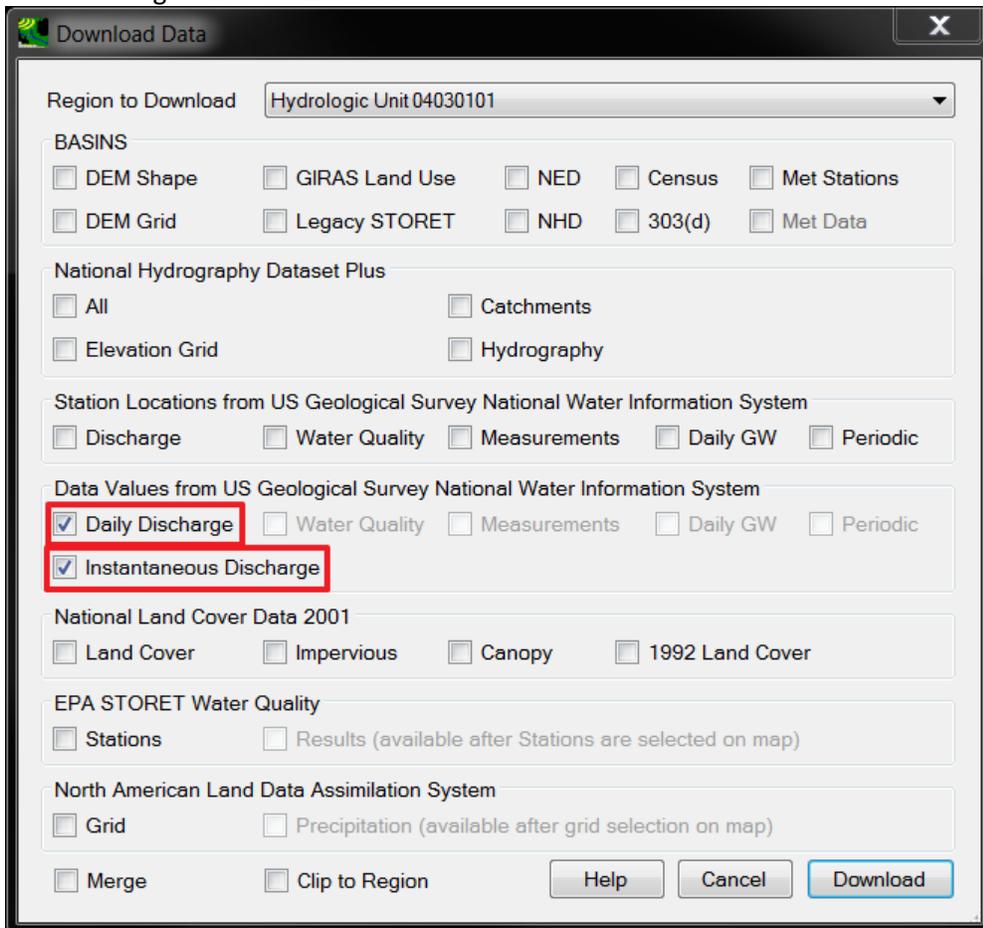
- d. On the tool bar, click  , then click on each gage station on the map while holding the Ctrl key down. The gage stations will be highlighted.



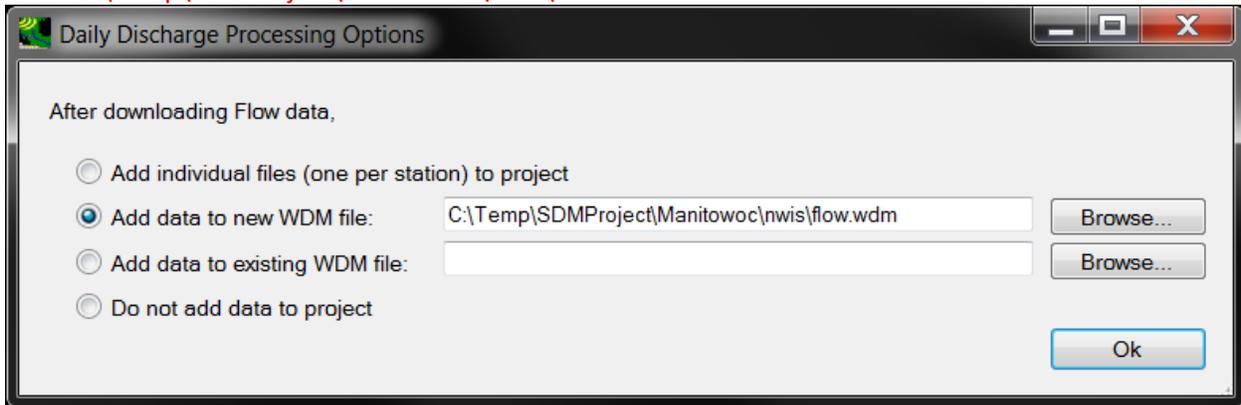
2. On the menu bar, select “File>Download Data”.



3. The “Download Data” window appears. Check “Daily Discharge” and “Instantaneous Discharge”. If the “Daily Discharge” has been chosen in a previous data download, only choose “Instantaneous Discharge”. Click “Download”.

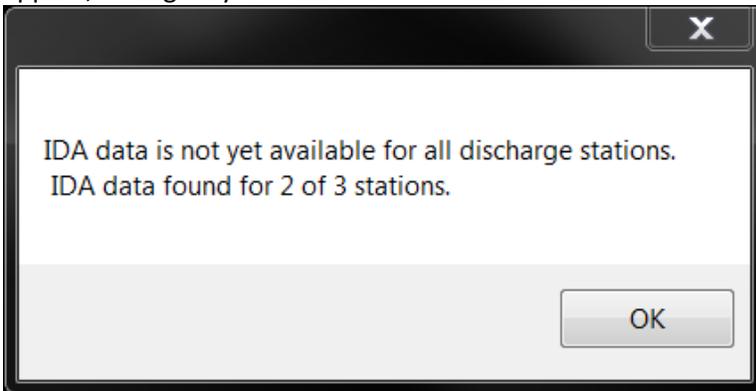


- The following window appears. The daily flow observation time series file name will already be identified, but you can pick a different name or folder location. You can also store the data in an existing WDM file by choosing “Add data to existing WDM file” and locating the WDM file. In this example, a WDM file, “flow.wdm”, will be created in the example folder location “C:\Temp\SDMProject\Manitowoc\nwis\”. Click “Ok”.

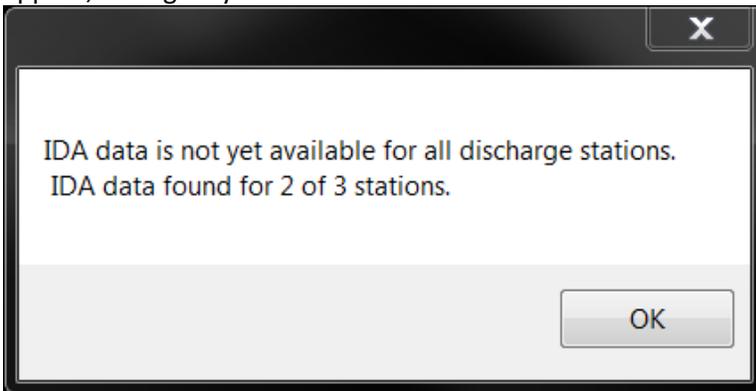


- BASINS will download daily flow data. Click “OK” when the message for “WDM Datasets added” appears.
- BASINS will download instantaneous flow data for only those stations that appear. Click “OK” when the message appears noting: IDA data found for the selected station.
- When the “Data Download” screen appears, click “OK”.

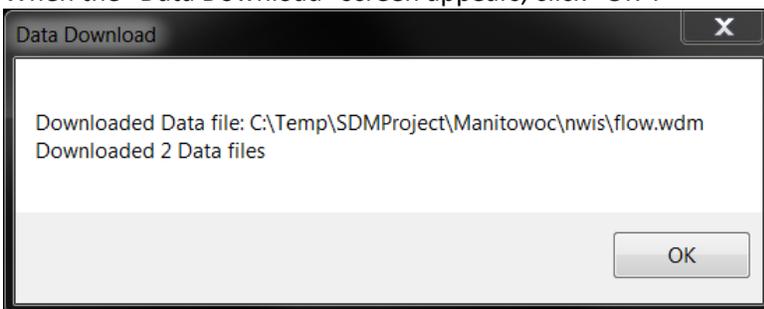
If multiple stations are chosen (which is not in this case), then a message like the following will appear, noting only those stations where instantaneous flow data are available.



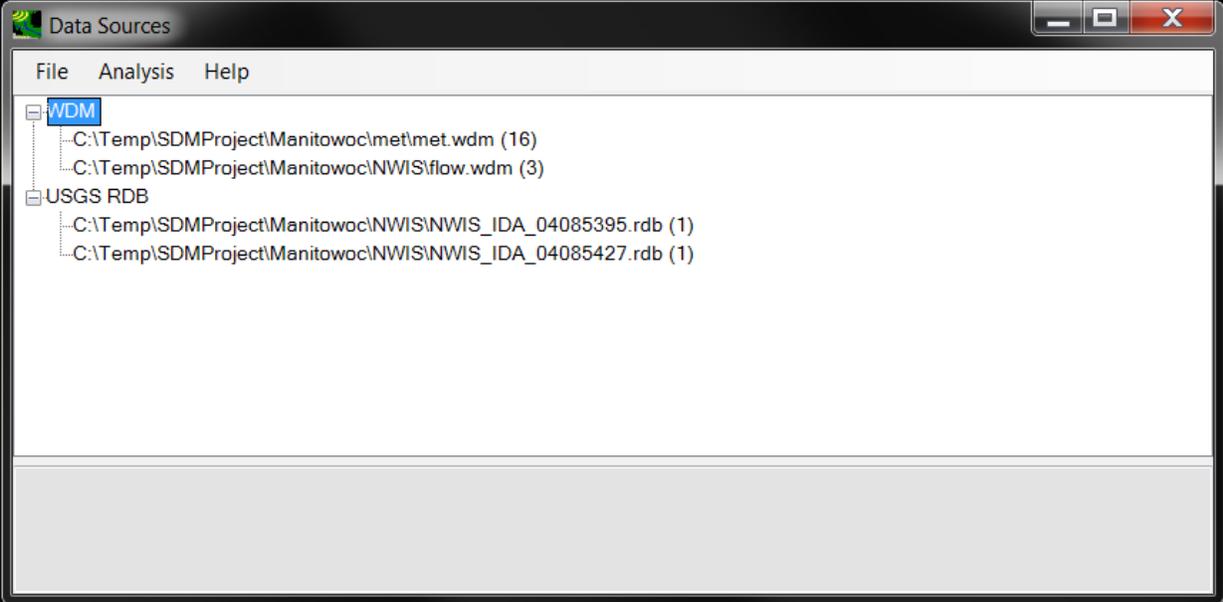
If multiple stations are chosen (which is not in this case), then a message like the following will appear, noting only those stations where instantaneous flow data are available.



When the "Data Download" screen appears, click "OK".



8. The following “Data Sources” window appears to show time series data files associated with this project. Here, there are two WDM files and two RDB files as data sources. Close this window by selecting “File>Exit”.



APPENDIX B

Flow Calibration: Details of “HSPF_PEST_flow.exe” and “Input_flow.in”

This section provides details of the FORTRAN code for preparing HSPF parameter calibration with PEST (i.e., “HSPF_PEST_flow.exe”). “HSPF_PEST_flow.exe” is designed to

- consume the HSPF input UCI file (*.uci) prepared by SDMPB
- consume a flow observation file (*_obs.txt)
- consume a user input file (Input_flow.in)
- prepare PEST input files (*.pst, *.tpl, *.ins)
- prepare batch files for running HSPF and PEST (“runHSPF.bat” and “runPEST.bat”, respectively)
- prepare the file containing observed flows with missing values (“*_obs.out”).

Input files include:

- Input UCI file (“<project name>.uci”): represents the main HSPF input file prepared by SDMPB which includes all input data (e.g., simulation time, time series input file names, output file names, land use segmentation, print options, parameters, etc.), except time series input. Users do not need to directly modify the UCI file, since it can be modified through the HSPF user interface, although experienced users can modify this ASCII file directly. Only one UCI file exists per working folder, as specified in the “Input_flow.in” file.
- Flow observation (“<project name>_obs.txt”): includes observed flow time series with the desired time step for parameter calibration which is downloaded and exported through BASINS. Users do not need to modify this file since it typically reflects USGS gaging station data. The time series in this file can include missing data.
- User input file (“Input_flow.in”): includes information for generating PEST input files.

Figure B.1 presents the generic format of the “Input_flow.in” file. Descriptions of input data are:

```
HSPFPATH
WORKPATH
PESTPATH
ny_warm
nLUgroup
nLU
LU
⋮
(blank line)
para
lower upper
⋮
```

Figure B.1. Constructions of user input file (“Input_flow.in”)

- *HSPFPATH*: path of WinHSPFt.exe. When HSPF is installed with BASINS, WinHSPF 3.0 (with user interface) and its light version, WinHSPFt.exe (without user interface), are installed together.

PEST executes WinHSPFlt.exe as executed on the Command Window. WinHSPFlt.exe is typically located in "<BASINS folder>\models\HSPF\bin\" or "<SDMPB folder>\bin\".

- *WORKPATH*: path of working folder where input UCI file, WDM files, and a flow observation file are located, and output files of "HSPF_PEST_flow.exe" will be generated.
- *PESTPATH*: path of pest.exe.
- *ny_warm*: number of years for model warm-up, from start of the simulation as it appeared in the input UCI file
- *nLUgroup*: number of land use groups. "1" means PEST calibrates the same parameter value for all land use groups. *nLU* and *LU* must be repeated *nLUgroup* times.
- *nLU*: number of land use types included in each land use group. For example, a land use group may include two types such as Agricultural and Forest. There are nine land use types: Water/Wetlands, Urban, Barren or Mining, Forest, Upland Shrub Land, Agriculture-Cropla, Grass Land, Agriculture-Pastur, and Transitional. "Cropla" and "Pastur" refer to Cropland and Pasture.
- *LU*: Land use types included in each land use group. *LU* must be repeated as many as *nLU* times. *LU* must be same as it appears in the input UCI file. If there are land use types that do not appear in the UCI file, the program skips them.
- *para*: name of each parameter. *para* should be the same as it appears in the input UCI file.
- *lower* and *upper*: minimum and maximum values of each parameter in the calibration process. This line must be repeated *nLUgroup* times for each parameter. Possible and recommended parameter ranges can be found in EPA (2000).

Figure B.2 illustrates an example user input file "Input_flow.in". It differentiates parameter values into four land use groups, which means PEST calibrates four different values for each parameter. Output files include:

- PST file ("*<project name>*_flow.pst"): PEST control file that includes PEST parameters, information of model parameters, parameter groups, observed flow, model executables, etc. Users can modify or add PEST parameters, as necessary. Explanation of PEST parameters can be found in the PEST manual (Doherty, 2005) at <http://www.pesthomepage.org/Downloads.php>.
- TPL file ("*<project name>*_flow.tpl"): PEST template file that includes structure of the model input file (i.e., HSPF UCI file) and location of calibrating parameter values.
- INS file ("*<project name>*_flow.ins"): PEST instruction file that explains how PEST reads the model output file for calculating error statistics.
- "runHSPF.bat": Batch file that executes HSPF.
- "runPEST.bat": Batch file that executes the HSPF parameter calibration with PEST.
- Flow observation with missing data ("*<project name>*_obs.out"): A file that includes flow observations with missing data denoted as "-9999"; this file is not used by PEST.

The following assumptions apply when constructing the PEST input file:

- Simulation start and end times, including model warm-up, are assumed to be the same, as they appear in the HSPF input UCI file prepared by SDMPB.
- PEST calibrates HSPF flow parameters during calibration which is when observation and simulation periods overlap. If no overlap occurs, "HSPF_PEST_flow.exe" returns an error, noting that an inconsistency exists between the two periods.

```

C:\Basins45\models\HSPF\bin\
C:\Temp\SDMProject\Manitowoc\HSPF\Flow\Hourly\
C:\PEST\
2
4
1
Urban or Built-up La
2
Agricultural Land
Forest Land
1
Wetlands/Water
1
Barren Land

KMELT
0.0000    0.200
0.0000    0.100
0.0000    0.200
0.0000    0.200
INFILT
0.0010    0.200
0.0010    0.500
0.0010    0.500
0.0010    0.500
AGWRC
0.8500    0.900
0.8500    0.950
0.8500    0.999
0.8500    0.999
BASETP
0.0000    0.050
0.0000    0.200
0.0000    0.200
0.0000    0.200
LZETP
0.1000    0.500
0.1000    0.900
0.1000    0.900
0.1000    0.900

```

Figure B.2. Example user input file "Input_flow.in", differentiating parameter values into four land use groups

- PEST minimizes the squared error between observations and calculations at the outlet of the watershed, as defined in the input UCI file prepared by SDMPB. The outlet of the watershed appears on the last line of “OPN SEQUENCE” section in the input UCI file.
- It changes “Flags” in “PRINT-INFO” and “BINARY-INFO” sections, throughout the input UCI file, to “6” which means “never print” in default output and binary files, thereby saving output size.
- It removes “EXT TARGETS” section in the input UCI file, instead adding a “PLTGEN” section after the “FTABLES” section to print selected flow (i.e., calculated flow discharge at the calibration point within the watershed) in a separate output file. Writing to “PLTGEN” includes adding a name of the separated output file (i.e., *_flow.p93), a “PLTGEN” line in “OPN SEQUENCE” section, and a “NETWORK” section after the “EXT SOURCES” section.
- It indicates the time step of the observed flow in “*_obs.txt”, then writes the “PLTGEN” section accordingly. Thus, if a user prepares 15-minute, 30-minute, or hourly flow observations in “*_obs.txt”, the model writes hourly flow values to calibrate parameters with hourly flow. Only 15-minute, 30-minute, hourly, or daily time steps can be indicated.
- It assumes all parameters do not vary by month, even if some vary in the input UCI file prepared by SDMPB.
- It turns on “Snow Accumulation and Melt”, if it is turned off in the input UCI file.
- It turns off soil temperature and water quality modeling for simulation efficiency.
- If the parameter *AGWETP* is calibrated, it assumes *AGWETP* varies only for the land use type “Wetlands/Water”, and is fixed for other land use types as “0” (EPA, 2000).

APPENDIX C
**Flow Calibration: Heuristic Relationships between Land Use Types
and Various Calibration Parameters**

Parameter ranges and their calibrated values may vary by land use types. Although there are no recommended ranges that vary by land use types, heuristic relationships between land use types for various parameters are defined as follows:

- INFILT – highest for water/wetlands, next highest for forest
- LZSN – highest for forest, lowest for water/wetlands
- CEPSC – may change over the course of the growing season for agricultural land uses and deciduous forest (monthly)
- UZSN – may change over the course of the growing season for agricultural land uses (monthly); highest for water/wetlands, next highest for forest
- LZETP – higher for forest and wetlands, next highest for row crops, then grassland

The above relationships can be used to establish parameter ranges for calibration or to evaluate calibration results.

APPENDIX D

Microbial Calibration: Details of “HSPF_PEST_microbe.exe” and “Input_microbe.in”

This section provides details of the FORTRAN code for preparing HSPF calibration of microbial parameters using PEST (i.e., “HSPF_PEST_microbe.exe”). “HSPF_PEST_microbe.exe” is designed to

- consume the HSPF input UCI file (*_flow.uci) which is prepared during the HSPF flow parameter calibration with PEST
- consume a microbial observation file (*_microbe_obs.txt)
- consume a user microbial input file (Input_microbe.in)
- prepare PEST input files (*_microbe.pst, *_microbe.tpl, *_microbe.ins)
- prepare an input file (*_microbe_P2P.tpl) for PAR2PAR, which is a PEST utility that manipulates parameters
- prepare batch files for running HSPF and PEST (runHSPF.bat and runPEST.bat, respectively).
- prepare a file containing observed microbial densities (concentrations) with missing values “*_microbe_obs.txt”.

Input files include:

- Input UCI file (“<project name>_flow.uci”): the main HSPF input file resulting from HSPF flow parameter calibration process using PEST, which includes calibrated HSPF flow parameters, all input data (e.g., simulation time, time series input file names, output file names, land use segmentation, print options, parameters, etc.), except time series input. Users do not need to modify the UCI file directly, since it can be modified through the HSPF user interface, although experienced users can modify this ASCII file directly. Only one UCI file exists per working folder, as specified in the “Input_microbe.in” file.
- Microbial density observations (“<project name>_microbe_obs.txt”): includes observed microbial densities varying in time, where intermittent or fixed time steps are allowed; this file can include missing data.
- User-defined microbial input file (“Input_microbe.in”): includes information for generating PEST and PAR2PAR input files.

Figure D.1 presents the generic format of the “Input_microbe.in” file. Descriptions of input data are:

- *HSPFPATH*: path of WinHSPFIt.exe. When HSPF is installed with BASINS, WinHSPF 3.0 (with user interface) and its light version, WinHSPFIt.exe (without user interface), are installed together. PEST executes WinHSPFIt.exe, as it is executed in the Command Window. WinHSPFIt.exe is typically located in “<BASINS folder>\models\HSPF\bin\” or “<SDMPB folder>\bin\”.
- *WORKPATH*: path of working folder where the input UCI file, WDM files, and a microbial observation file are located, and where output files of “HSPF_PEST_microbe.exe” will be generated.
- *PESTPATH*: path of pest.exe.
- *ny_warm*: number of years for model warm-up from start of the simulation, as appeared in the input UCI file
- *nLUgroup*: number of land use groups. “1” means PEST calibrates the same parameter value for all land use groups. *nLU* and *LU* have to be repeated *nLUgroup* times.
- *nLU*: number of land use types included in each land use group. For example, a land use group may include two land use types, such as Agricultural and Forest. There are up to nine land use

types: Water/Wetlands, Urban, Barren or Mining, Forest, Upland Shrub Land, Agriculture-Cropla, Grass Land, Agriculture-Pastur, and Transitional. “Cropla” and “Pastur” refer to Cropland and Pasture.

- *LU*: Land use types included in each land use group. *LU* has to be repeated as many as *nLU* times. *LU* must be the same as it appears in the input UCI file. If there are land use types that do not appear in the UCI file, the program skips them.
- *para*: name of each parameter. *para* should be the same as it appears in the input UCI file. Parameters that start with “MON-“ or “MONTH-“ indicate parameters that vary monthly.
 - (*lower*) and (*upper*): minimum and maximum values for those parameters that vary monthly, and are not used if the parameters do not vary monthly. When “-9999” is used, no minimum or maximum value is assigned to the parameter.
- *lower* and *upper*:
 - Parameters that vary monthly represent minimum and maximum values of proportional change, multiplying the initial values of these parameters by this factor. This line must be repeated *nLUgroup* times for each parameter, except ‘MONTH-DATA’, ‘FSTDEC’ and ‘THFST’ since those are not grouped by land use.
 - Parameters that do not vary monthly represent minimum and maximum values.

```
HSPFPATH
WORKPATH
PESTPATH
ny_warm
nLUgroup
nLU
LU
⋮

para    (lower)  (upper)
lower  upper
⋮
```

Figure D.1. Constructions of user input file (“Input_microbe.in”)

An example user input file “Input_microbe.in” is illustrated in **Figure D.2**. It separates parameter values into two land use groups which means PEST calibrates two different values for each parameter. Parameter names in PEST input files are differentiated by numbers following parameter names. Note that only one range can be provided for ‘MONTH-DATA’, ‘FSTDEC’, and ‘THFST’. Output files include:

- PST file (“<project name>_microbe.pst”): PEST control file including PEST parameters, information of model parameters, parameter groups, microbial observation, model executables, etc. Users can modify or add PEST parameters, as necessary. An explanation of PEST parameters can be found in the PEST manual (Doherty, 2005) at <http://www.pesthomepage.org/Downloads.php>.

```

C:\Basins45\models\HSPF\bin\
C:\Temp\SDMProject\Manitowoc\HSPF-PEST\Microbe\
C:\PEST\
1
2
3
Water/Wetlands
Urban
Barren or Mining
6
Forest
Upland Shrub Land
Agriculture - Cropla
Grass Land
Agriculture - Pastur
Traditional

MON-ACCUM  0.000  -9999
0.00000  1000.00000
0.00000  1000.00000
WSQOP
0.01000  10.00000
0.70000  2.20000
IOQC
0.00000  1.E10
0.00000  1.20000
AOQC
0.00000  1.E10
0.00000  1.20000
FSTDEC
0.00001  2.00000
THFST
1.00000  2.00000
MONTH-DATA -9999  -9999
0.00000  1000.00000

```

Figure D.2. Example user input file "Input_microbe.in"

- PAR2PAR TPL file ("*<project name>_microbe_P2P.tpl*") : PAR2PAR template file, indicating the HSPF model input file structure (i.e., "**_microbe.uci*") and locations where calibrating parameter values are to be placed. In PEST calibration, this PEST utility (i.e., "PAR2PAR.exe") must be executed prior to every HSPF execution to prepare the HSPF UCI file with parameters that change proportionally. Details of PAR2PAR can be found in the PEST manual (Doherty, 2005) at <http://www.pesthomepage.org/Downloads.php>.
- PEST TPL file ("*<project name>_microbe.tpl*") : PEST template file indicating structure of the PAR2PAR input file, instructing how to calculate parameters with proportional change, and providing locations where calibrating parameter values are to be placed.
- INS file ("*<project name>_microbe.ins*") : PEST instruction file indicating how PEST will read the model output file for calculating the error statistics.
- "runHSPF.bat": Batch file that executes HSPF (i.e., WinHSPFIt.exe) and PAR2PAR (i.e., par2par.exe).
- "runPEST.bat": Batch file that executes HSPF parameter calibration with PEST

The following assumptions apply when constructing the PEST input file:

- Simulation start and end times include the original simulation period which is indicated by the input UCI file (i.e., "**_flow.uci*") and microbial observation period. Users need to ensure "met.WDM" includes input MET data for the simulation period.
- PEST calibrates HSPF microbial parameters during calibration which is when observation and simulation periods overlap.
- PEST minimizes the squared error between observations and calculations at the outlet of the watershed, as defined in the input UCI file. If a parameter name in the User input file (i.e., "Input_microbe.in") starts with "MON-" or "MONTH-", it assumes the parameter varies by month and sets it to change proportionally throughout calibration. PEST, therefore, does not calibrate the parameter value itself, but the proportional value related to the initial parameter value.
- Soil temperature and water quality modeling in the UCI file are turned on.
- The "PLTGEN" section is added after the "FTABLES" section in the UCI file to print selected microbial concentrations at the calibration points within the watershed in a separate output file. Writing the "PLTGEN" section includes adding a name of the separate output file (**_microbe.p9X*), "PLTGEN" line in the "OPN SEQUENCE" section, and a "NETWORK" section after the "EXT SOURCES" section.