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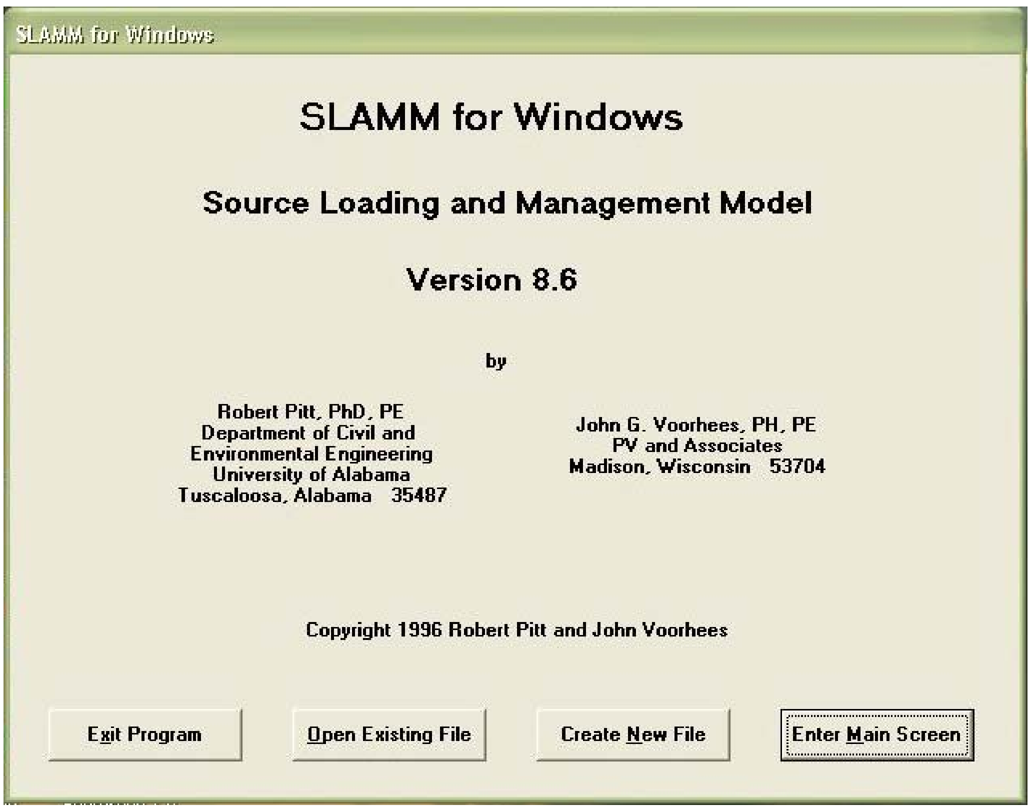
August 5, 2003

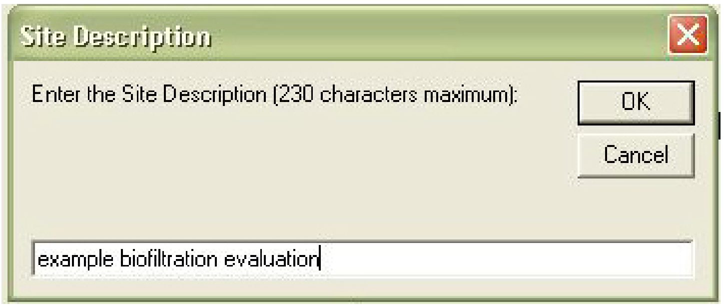
Medium Density Residential Area Biofiltration Example

This example illustrates a basic use of WinSLAMM. A simple medium density residential area and several stormwater biofiltration controls, including a rain garden, are described and evaluated with the model. The following screen dumps illustrate the steps to conduct this analysis.

After installation, click on the WinSLAMM icon on the desktop and the following opening screen appears:



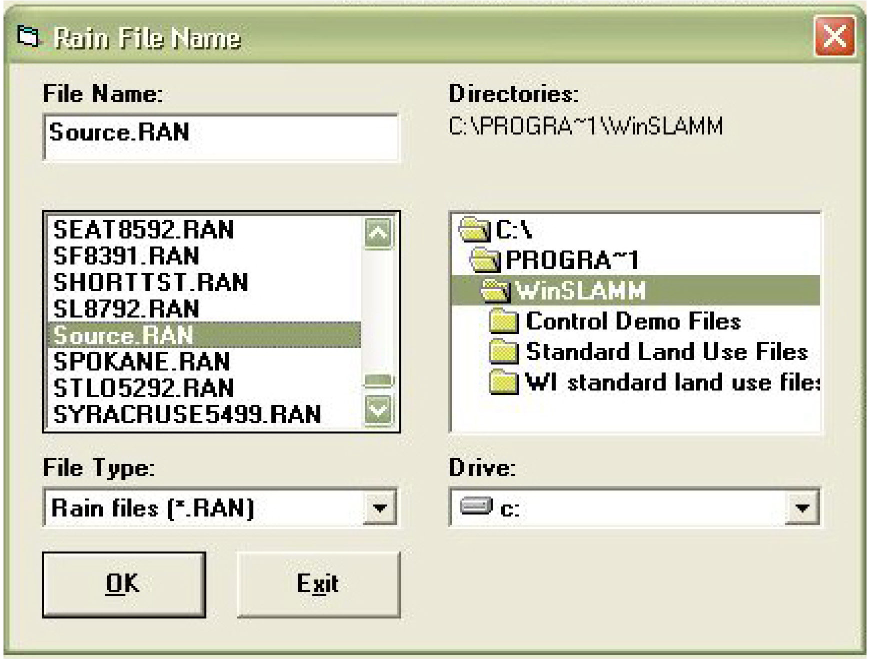
This is an example for a new file, so select the “create new file” option. After naming the new file, the following screen appears to allow a site description to be entered. This description will be printed with all program output, allowing better tracking of program files.

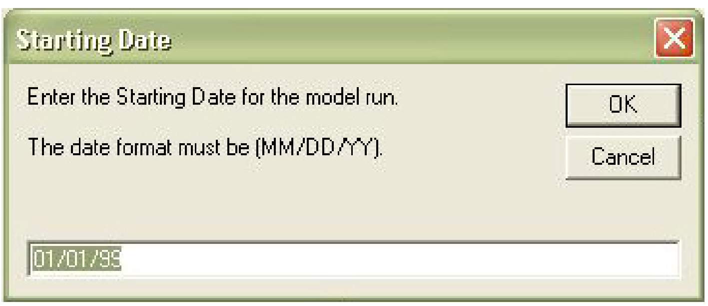


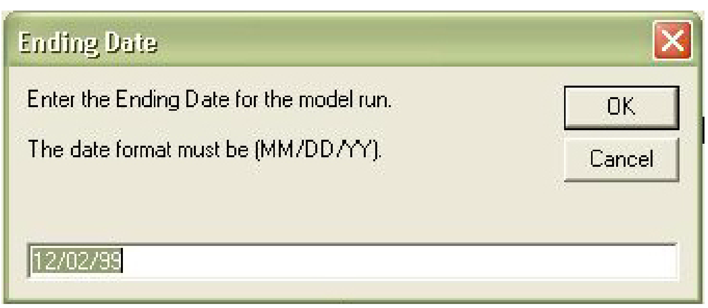
Next, a series of small screens appear, allowing the selection of the program "parameter" files. These files are previously created using either the DOS program MPARA66.EXE, or the "utilities" drop down menu on the main WinSLAMM menu. These files contain much of the information that SLAMM uses in its internal calculations, allowing modifications based on local data, calibration, and verification activities.

The first file to be selected is the rain file. Most of the files listed here were created from EarthInfo CDROMs containing rainfall records from as early as 1948 to the late 1990s. The MPARA66.EXE program contains a utility to semi-automatically create the needed rain files from the CDROMs, after minimal clean-up in a spreadsheet. Other rain information was obtained during stormwater monitoring projects. The files contain the beginning and end dates and times for each rain, plus the total rain depth for each event. Some of these files contain up to five thousand separate rain events covering several decades of data.

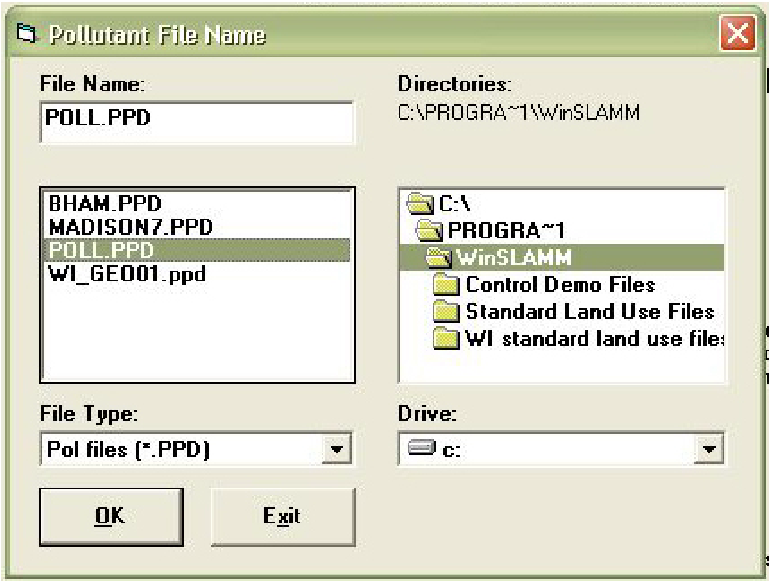
In the following example screen, the SOURCE.RAN file is selected. This file contains data for a short list of rains ranging from 0.01 to 4 inches in depth, with appropriate durations corresponding to typical Birmingham, AL, rain conditions. This file is frequently used to quickly visualize the changing sources of flows and pollutants for different rain depths, and to quantify the benefits of source area and outfall controls in reducing stormwater discharges. After this file is used, and any desired modifications in the input file are made (controls, development characteristics, etc.), a long-term rain file can be selected to quantify the stormwater discharges for more typical conditions.



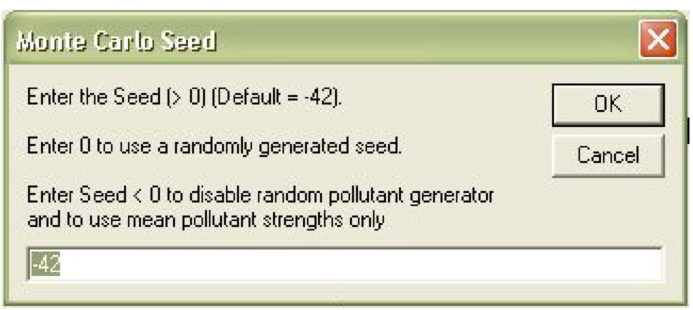




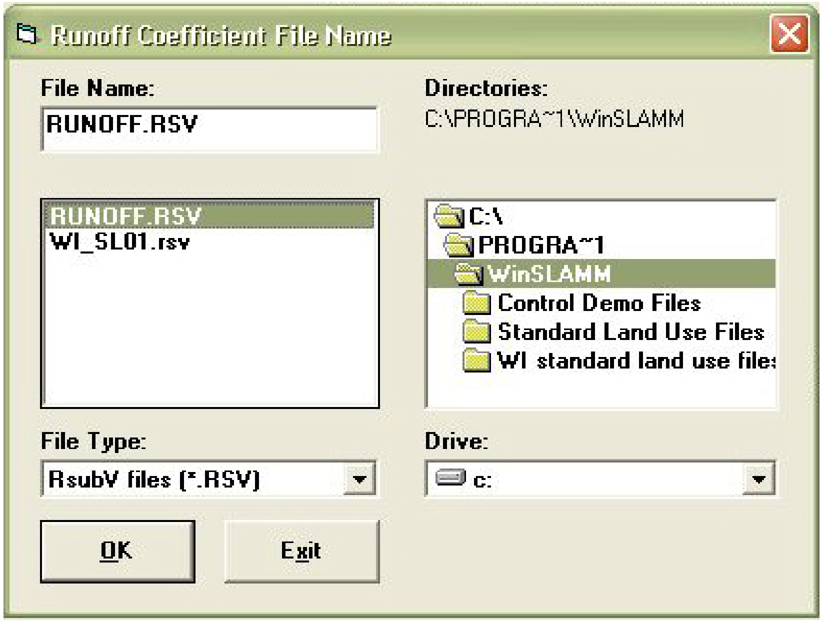
The next file to be selected is the "pollutant probability distribution" file. This file contains the means and variability's for the pollutants for different source area flows.



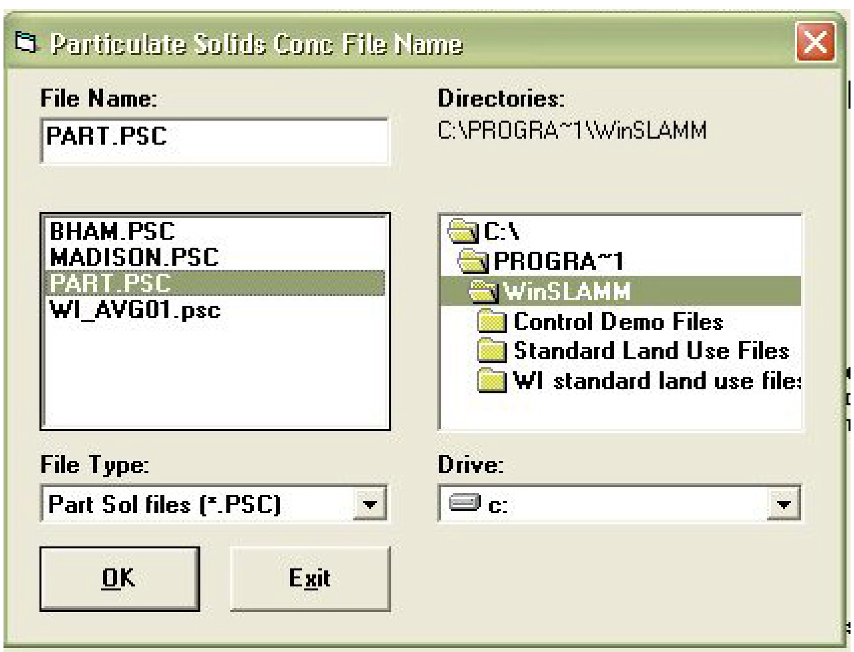
An associated screen then appears requesting a seed value for the Monte Carlo random number distribution calculations (only for pollutants other than suspended solids). Each rain event will use a different set of pollutant characteristics reflecting the naturally occurring large variation observed during field monitoring activities. This seed can be specified so the model will produce identical runs, or a random seed can be selected to more accurately reflect natural conditions. The use of a specified seed (or turning the random number calculations off) are used mostly during program de-bugging operations or for comparing results from short lists of rains (as in this example); in cases where several decades of rains are being evaluated, a value of 0 should be used. In the following example, the default value of -42 is used (with apologies to Douglas Adams).



The next screen selects the runoff coefficient file. These files contain volumetric runoff coefficients for different source areas for different rain depths, plus modifiers describing the benefits of disconnecting impervious source areas. These values can be determined using any model or assumptions desired. The values in the available files here are based on substantial field monitoring in the upper Midwest, the Southeast, and Ontario, and have been verified in many other locations in the US. They can also be easily changed reflecting observed local conditions using the Utility drop down menu in WinSLAMM.

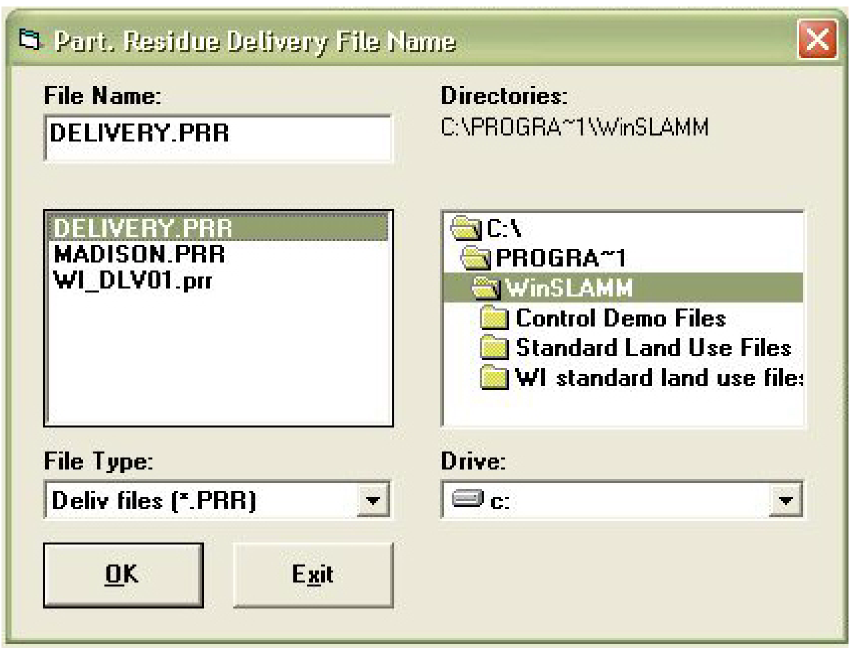


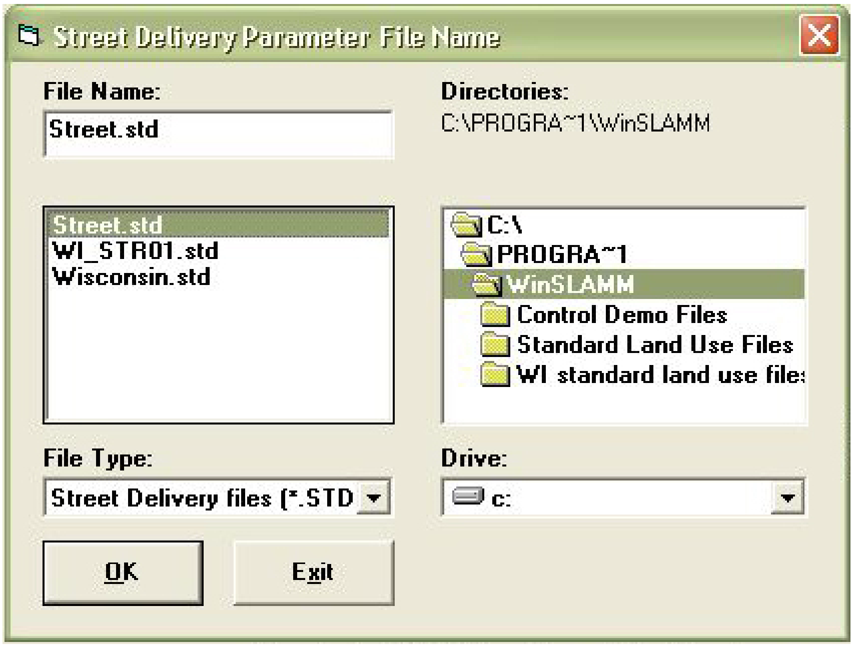
The next file to be selected describes source area first flush characteristics for suspended solids.



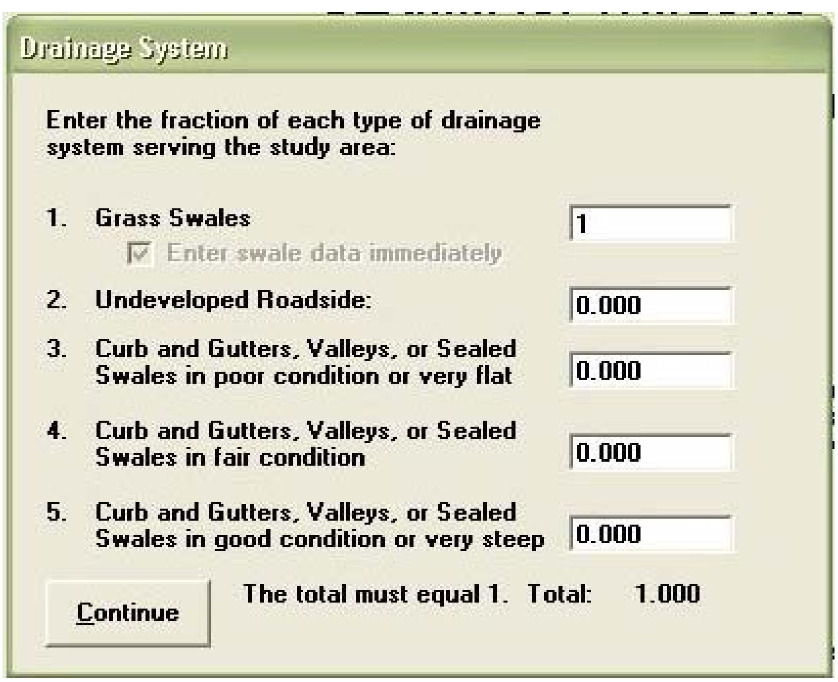
In many cases, high suspended solids concentrations are observed at source areas, but concurrent observations at outfalls from the same areas contain much lower concentrations. Two likely causes for this include independent routing of flows from the different source areas, and deposition of particulates in the drainage system. The following screens allows selection of the "delivery" file that accounts for this reduction in suspended solids concentrations.

Typically, the high "first-flush" suspended solids concentrations observed at parking lots, for example, are substantially reduced before reaching the outfall, while lower concentrations, observed after substantial rain, are less affected. The initial very small flows (having high source area concentrations) have substantially smaller flow energies, while the later flows (having lower concentrations) can have much greater flows. Also, flatter slopes and grass drainages trap much more of the suspended solids than steeper slopes and smooth channels or pipes. WinSLAMM also contains a separate "street delivery" file option that can be modified to account for the maximum rain energy available to wash off street dirt material. In all cases, if suspended solids are not completely moved through the drainage system, the model adds this "wash on" for subsequent rain events.

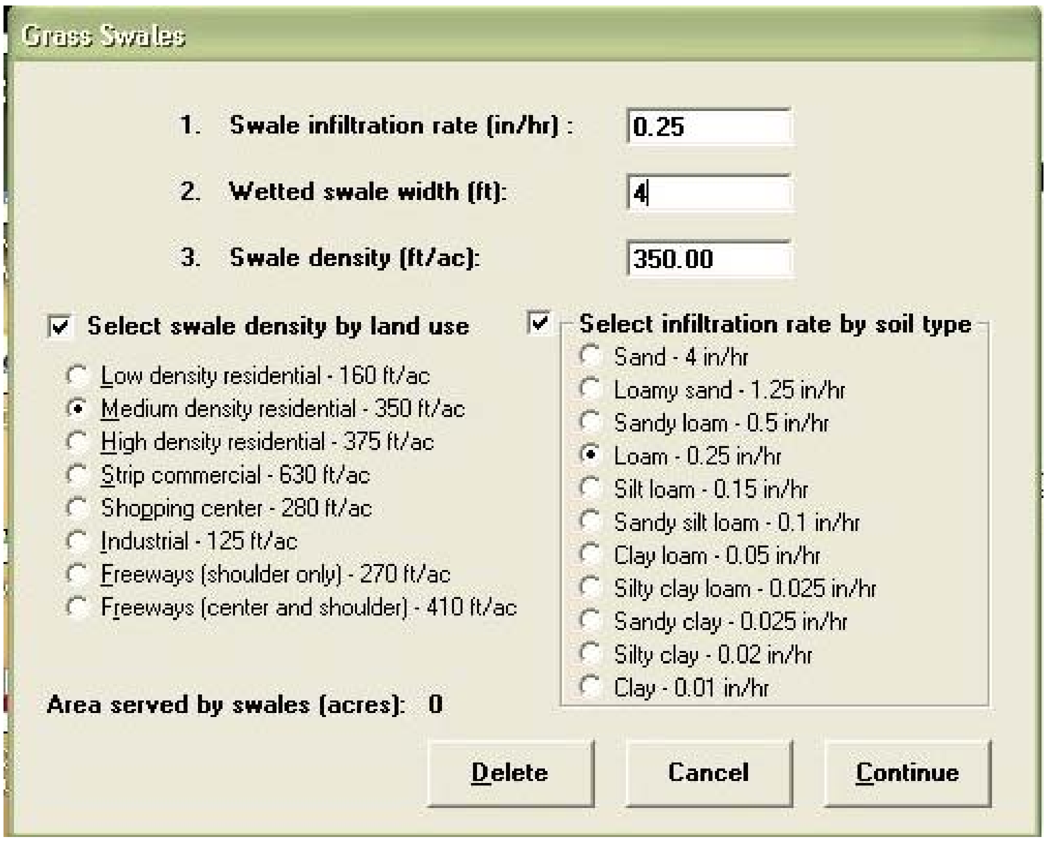




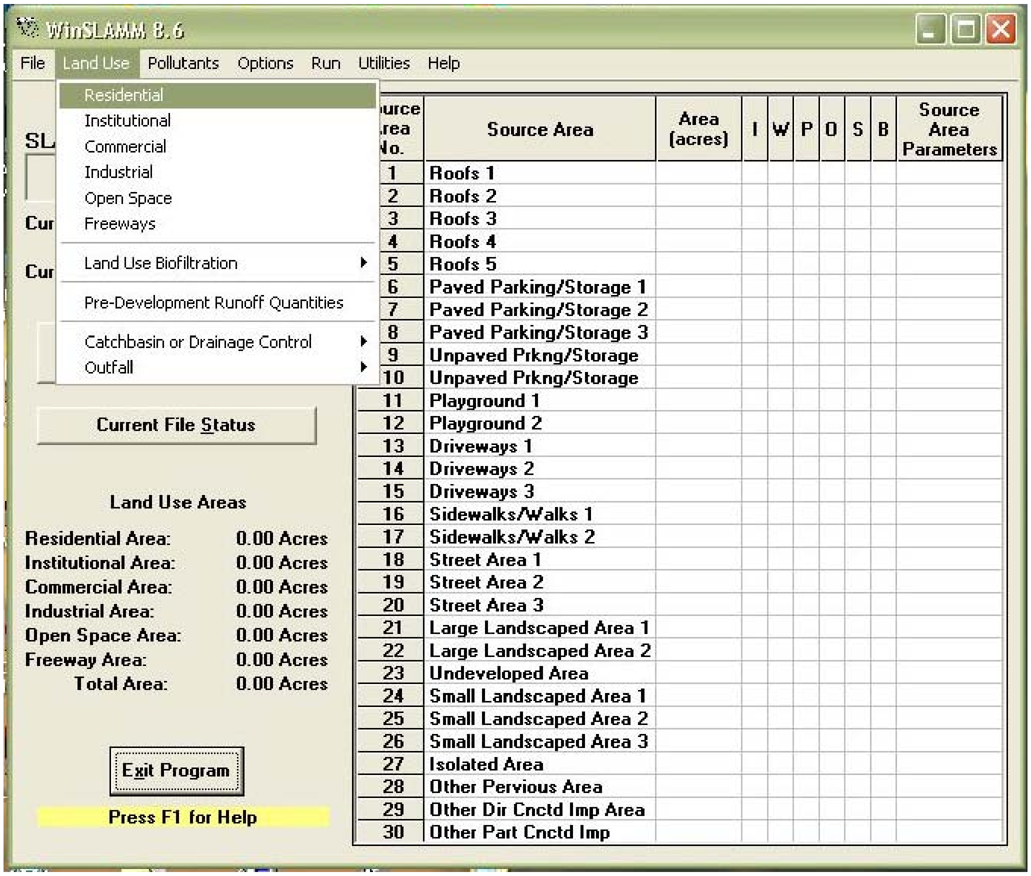
The model needs to know the type of drainage system used. The following screen is used to designate the fraction of each type of drainage in the study area. In this example, grass swales are used throughout the area.



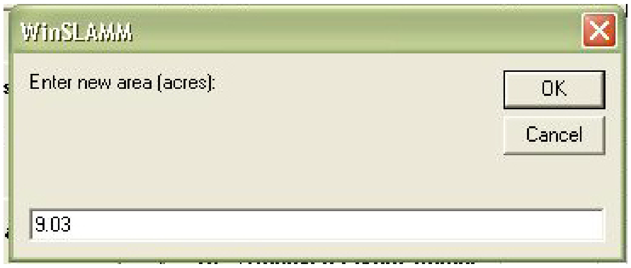
If any grass swales are used in the study area, the following screen is used to enter characteristics describing the swales. The swale density (the linear length of swale per area served) can be directly entered based on site specific measurements, or typical values can be selected based on aerial photograph measurements from many areas. In addition, the infiltration rate for the soil lining the swale can be directly entered, or the general soil type can be selected. The listed infiltration rates are approximately half the values commonly used in ponded situations reflecting the typical measured decrease in infiltration capabilities at flowing water sites. The wetted swale width is used to calculate the area available for infiltration and is assumed to be the relatively flat bottom of the swale.



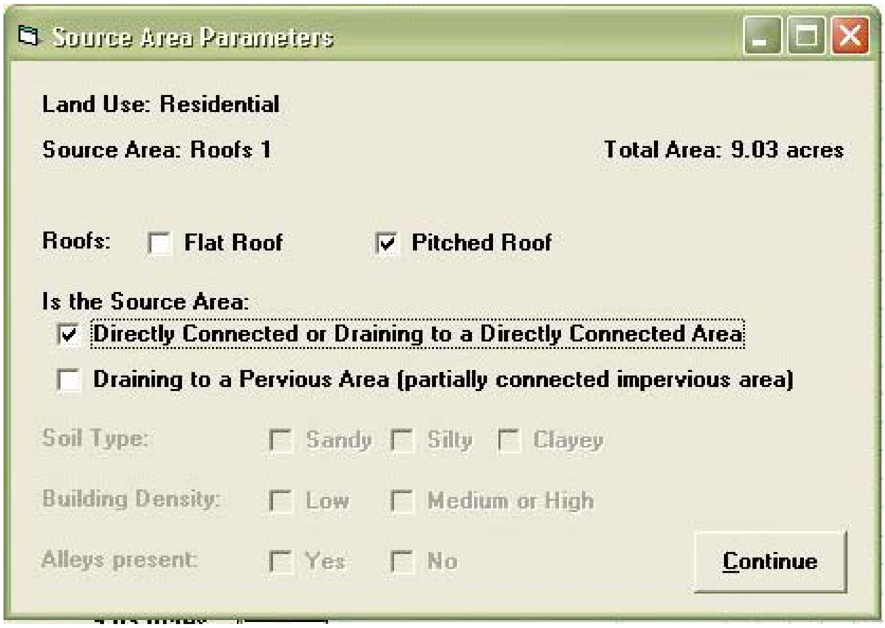
The next step is to select the land use(s) in the study area, on the following screen.



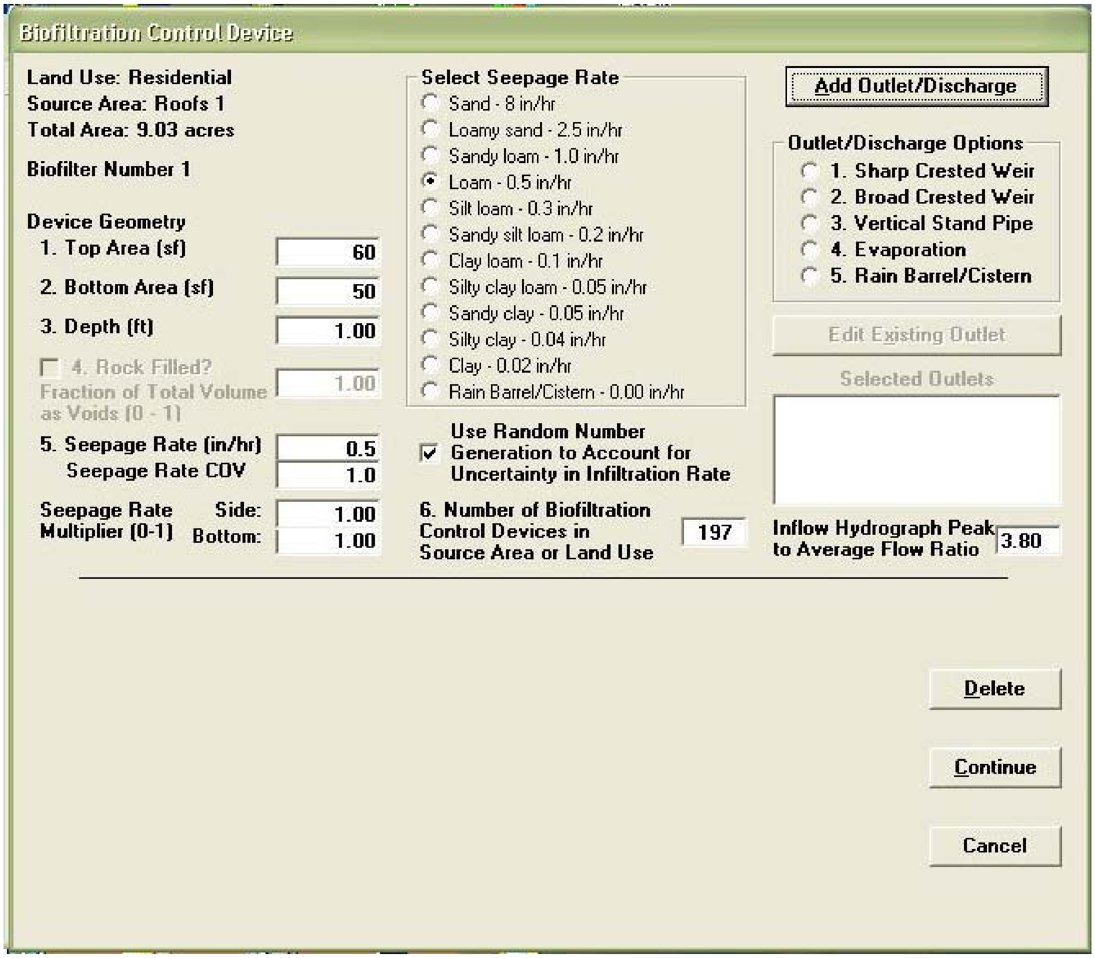
For each source area, double click on the “area” cell and the following screen appears (roof area 1 for this example).



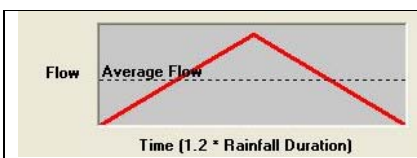
The following screen then appears after the area value is entered. This screen describes the basic roof slope and if the roof drainage is directly connected to the drainage (as in this example), or allowed to drain to the pervious area. If draining to the pervious area, the soil type is needed. If the soil is clayey, then the building density is needed (not needed for sandy or silty soils). If medium or high density, then the model asks about the presence of backyard alleys. Clayey soils, higher building densities, and alleys all decrease the benefits of disconnecting roof runoff.



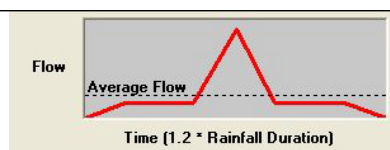
After this information is entered and "continue" is pressed, it is possible to select site specific control options (besides the development characteristics reflected above). In the following example, the "B" option (for biofiltration) is selected for the roof 1 area, bringing up the following biofiltration device screen. This screen can be used to describe many different types of stormwater control devices. This example is for "rain gardens" located at each of the 197 homes in this 100 acre area. Each rain garden is about 60 ft^2 in area, serving each 2,000 ft^2 of roof. A loam soil having a 0.5 in/hr seepage rate (but with a seepage rate coefficient of variation of 1.0, reflecting typical storm-to-storm variability in soil infiltration rates) is used for each device in this example.



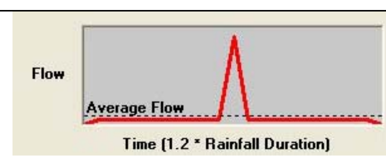
The inflow hydrograph for each rain is calculated based on the total runoff volume and using a complex triangular hydrograph. The default ratio of the peak to average flows for the hydrographs for each event is 3.8, a typical value based on monitoring. A simple triangular hydrograph corresponds to a ratio of 2.0 and may be representative of large areas during relatively small rains. For small source areas and for moderate to larger rains, higher values in this ratio are appropriate. WinSLAMM can be used to describe the sensitivity of the biofiltration device design to these variable inflow hydrograph shapes. In most cases, large ratios actually result in better performance as most of the runoff occurs with relatively low flows, while the very high flows occurring during the short periods can usually be stored in the pond built as part of the biofiltration device. The following are several plots representing different ratios of peak to average flows. In all cases, the runoff volume calculated for the contributing area is used, but the flow rates are distributed according to the hydrograph shape.



Ratio = 2.0

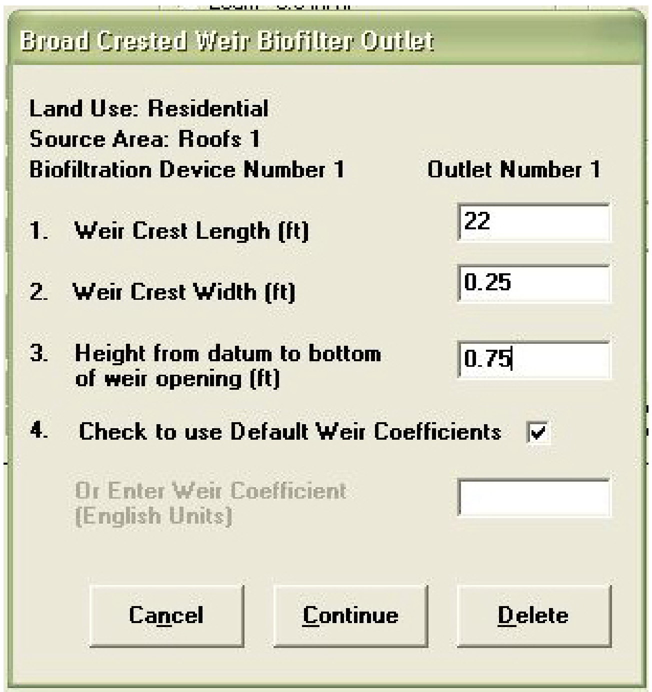


Ratio = 3.8

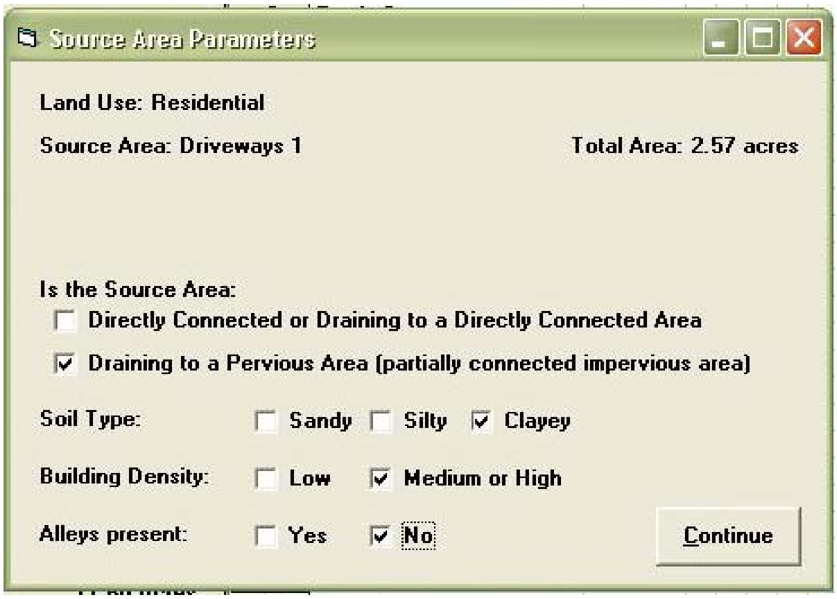


Ratio = 10

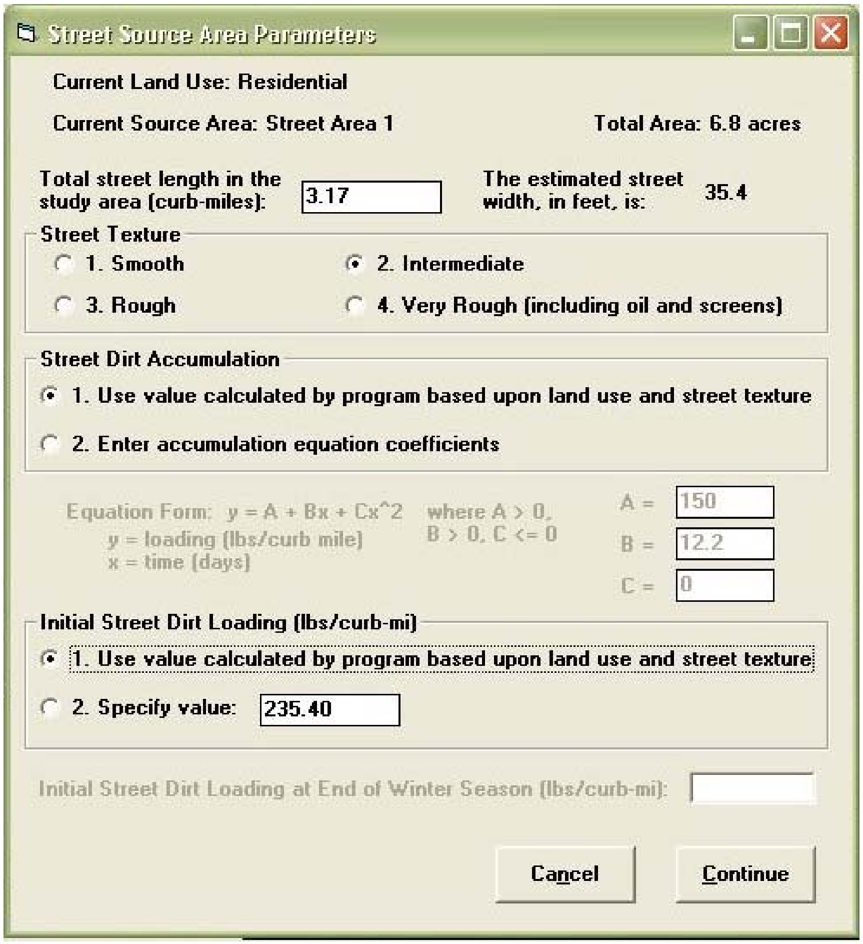
The outlet structures for the biofiltration devices can be simply described as broad-crested weir overflows, with the approximate downstream perimeter as the weir length and several inches for the width. The model routes the flows from the roofs through the biofiltration devices using the modified puls routing procedure (and the above described hydrograph shape), incorporating infiltration, evaporation, and overflows, as described. A rain barrel or cistern is used when calculating the effects of beneficial uses of the runoff water (such as for toilet flushing, irrigation, or other safe use).



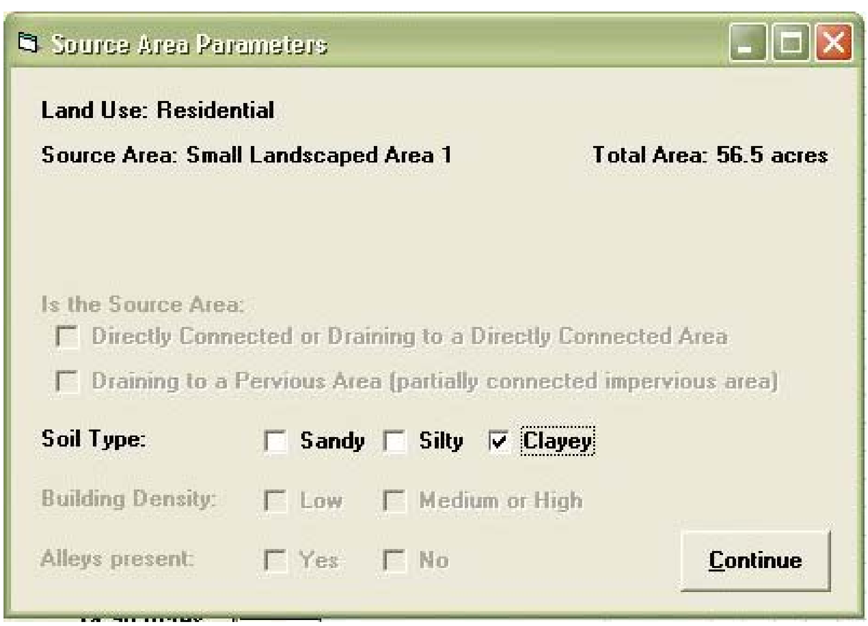
The following is an example screen describing runoff routing for typical paved areas. This example is for the driveways, showing that the runoff is disconnected (flowing to the pervious land), and that the ground has a clayey texture, the building density is high, and no alleys are present. High building densities, or the presence of alleys, all decrease the benefits of disconnections of the source areas by effectively decreasing the flow path length before the water enters the drainage system.



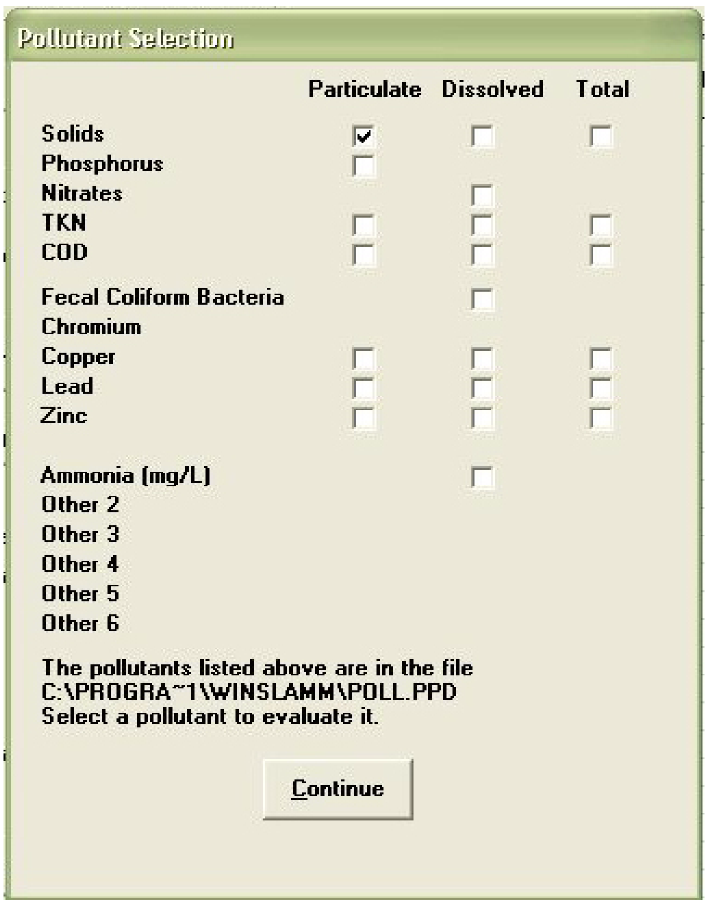
The following screen is the screen used to describe street areas. This screen contains information about the street length (the model calculates the corresponding street width as a check) and the street texture. The model can use the built-in street dirt accumulation rates (based on land use) and initial loading values (based on street texture), or the user can enter specific locally measured values. The initial street dirt loading can be increased to reflect the very large values typically found after snowmelt in the spring, for example. One of the options when entering the rain file is to designate a snow season. During that period, all runoff calculations are ceased. If that option is used, the street source area form then requires the user to designate a street dirt loading value corresponding to high values typically found after the winter season (usually several thousand pounds per curb-mile). This affects the washoff for the early spring rains, along with the effectiveness of the first several street cleaning activities of the year. WinSLAMM does not currently calculate snowmelt.



In this example, the last area to be described is for small landscaped areas. The following screen shows that only the soil type is needed for these areas.

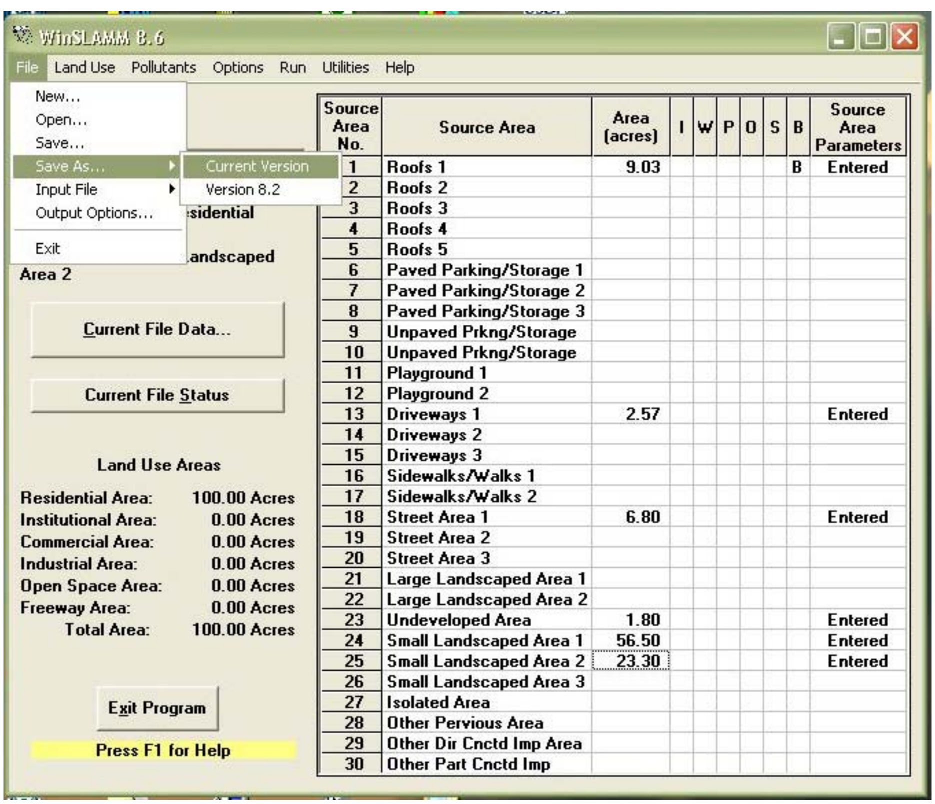


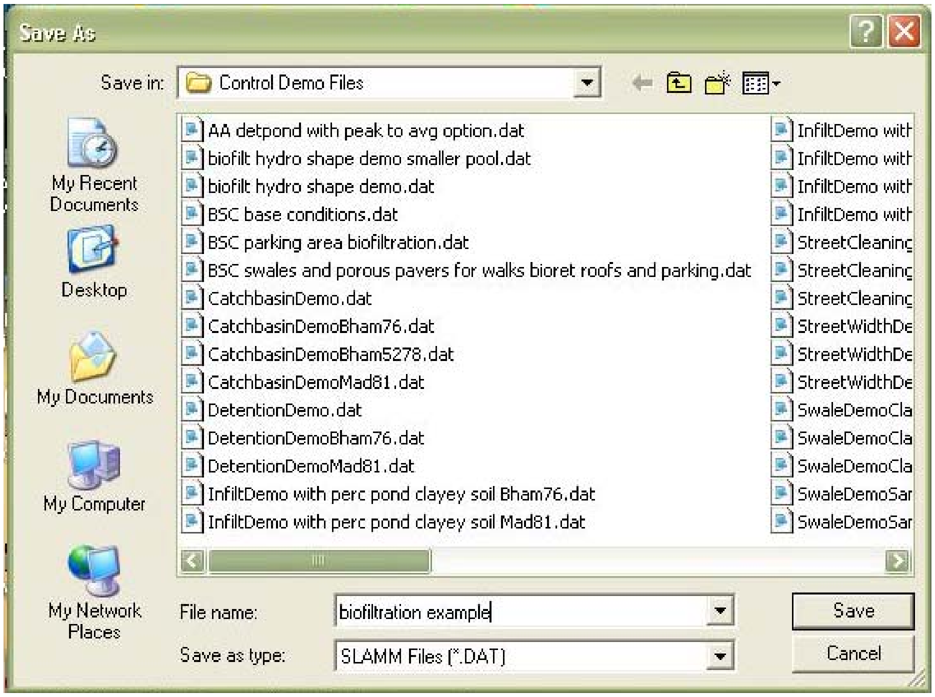
The user can also select the specific pollutants to be analyzed. The following screen shows the pollutants available, based on the previously selected ppd file. The model calculates runoff volume and suspended solids conditions for all cases. Additional parameters can be selected (or de-selected) by clicking on each available box. The dissolved, or particulate-associated, forms of the selected pollutants can be evaluated independently from the total forms, if desired. Depending on the Monte Carlo option previously selected, the concentrations of runoff will vary for each rain from each source area.



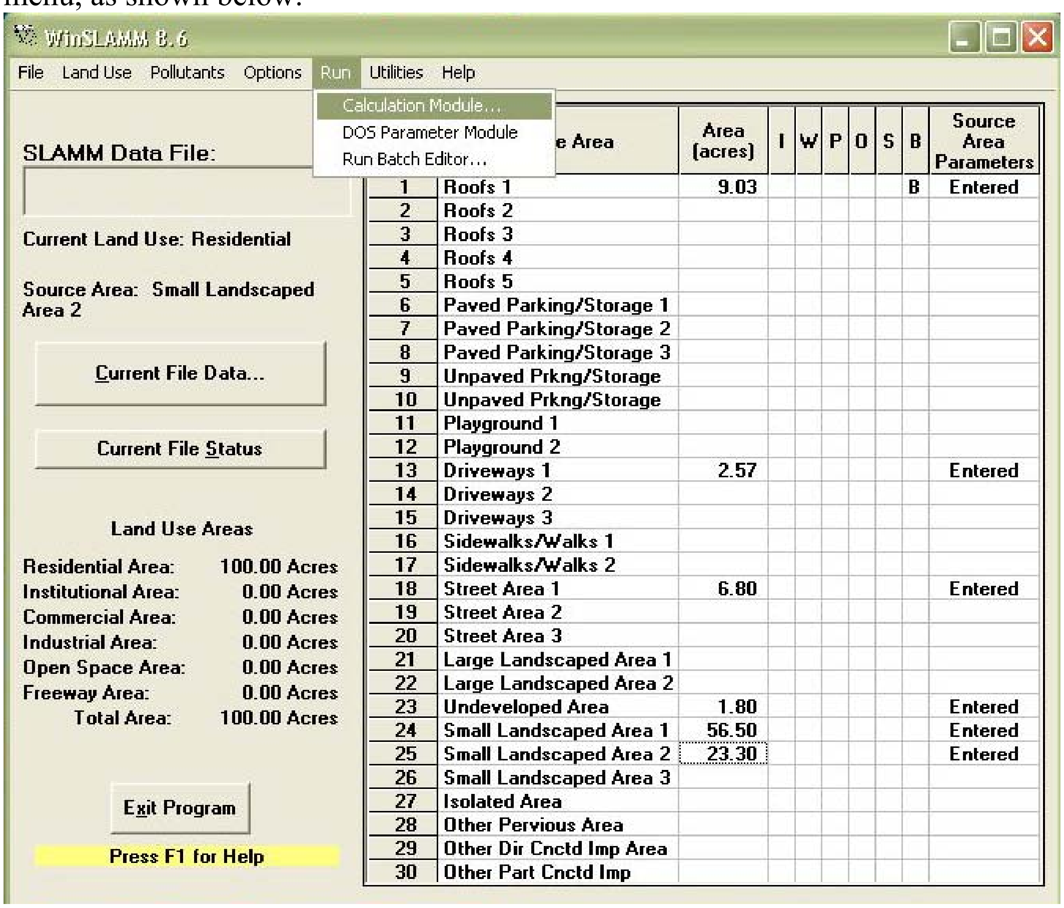
Finally, the form of the output information can be selected by using the “file, output options” drop down menu. The following screen lists the options. Option 4, “Outfall Summaries Only” is the default option. In the following screen, option 5, “One line per event runoff and flow summary” has been selected. This is the most useful option when a large rain file is being used.

The file can be saved at any time during this process by selecting the "file, save", or "file, save as" pull-down menu options.

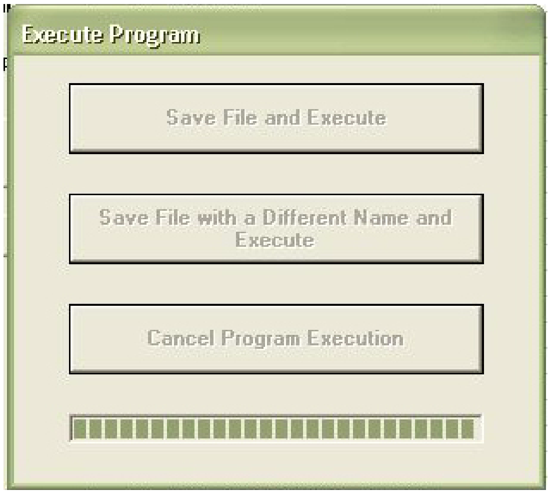




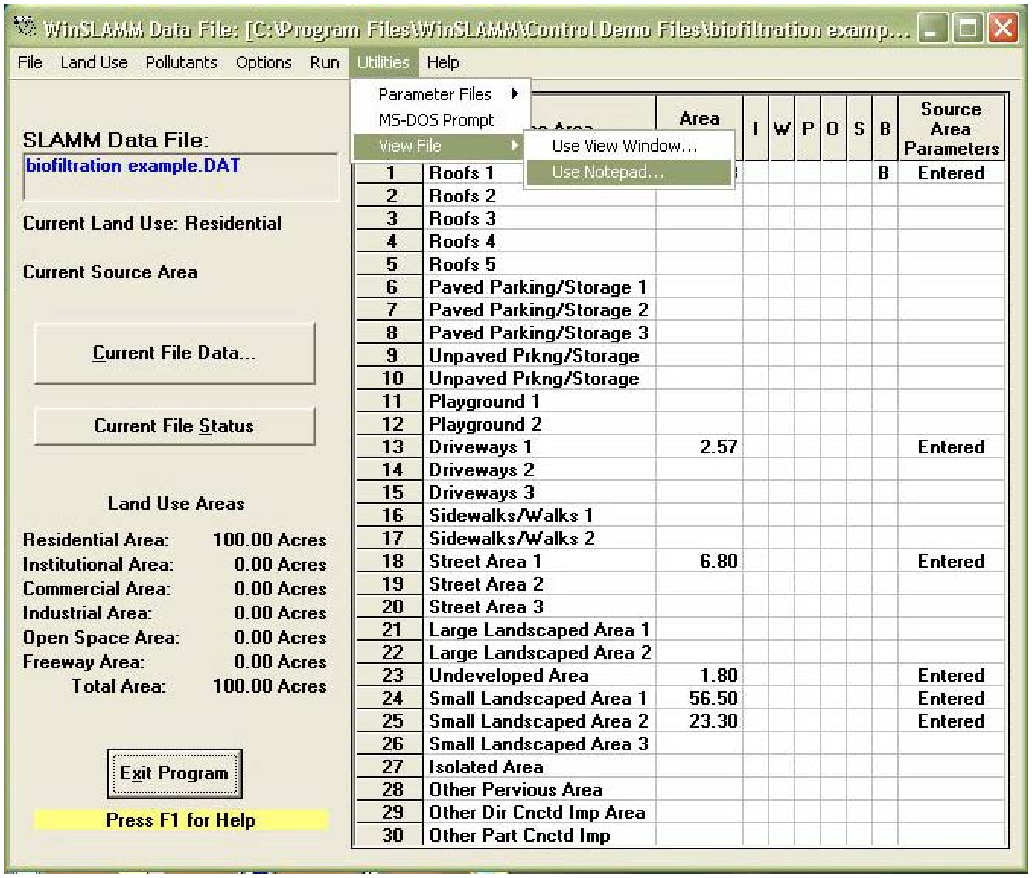
WinSLAMM evaluates the file by selecting the "run, Windows Calculation Module" pull-down menu, as shown below.

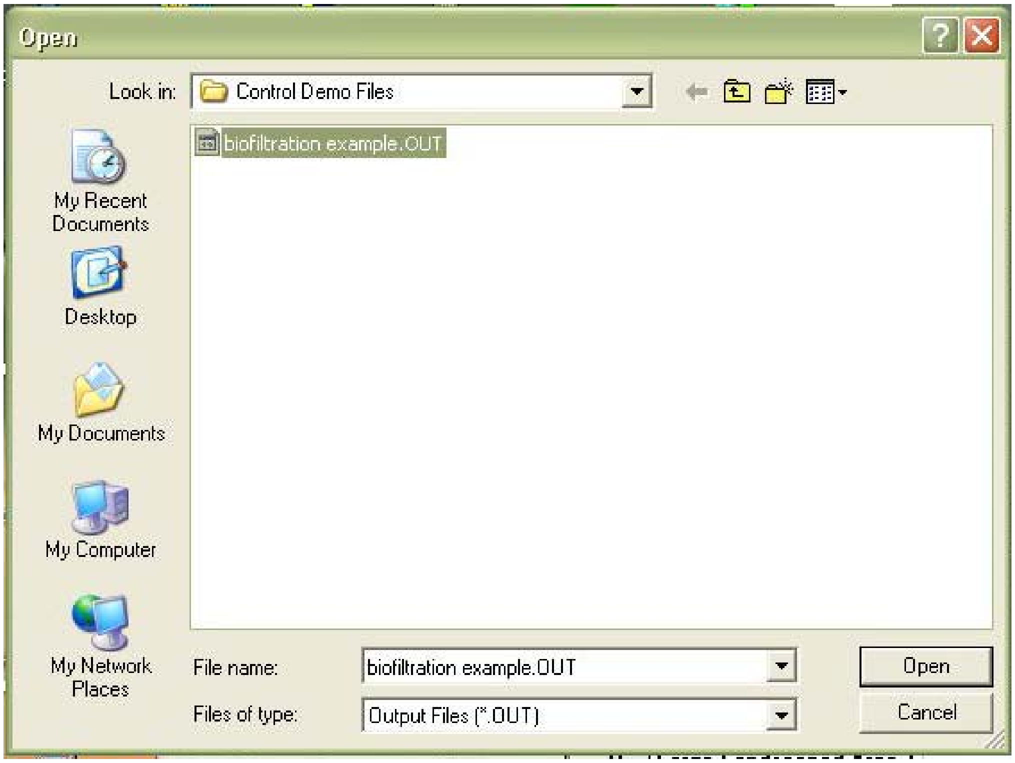


Select the "Save File and Execute." The model has finished execution when the progress bar is filled:

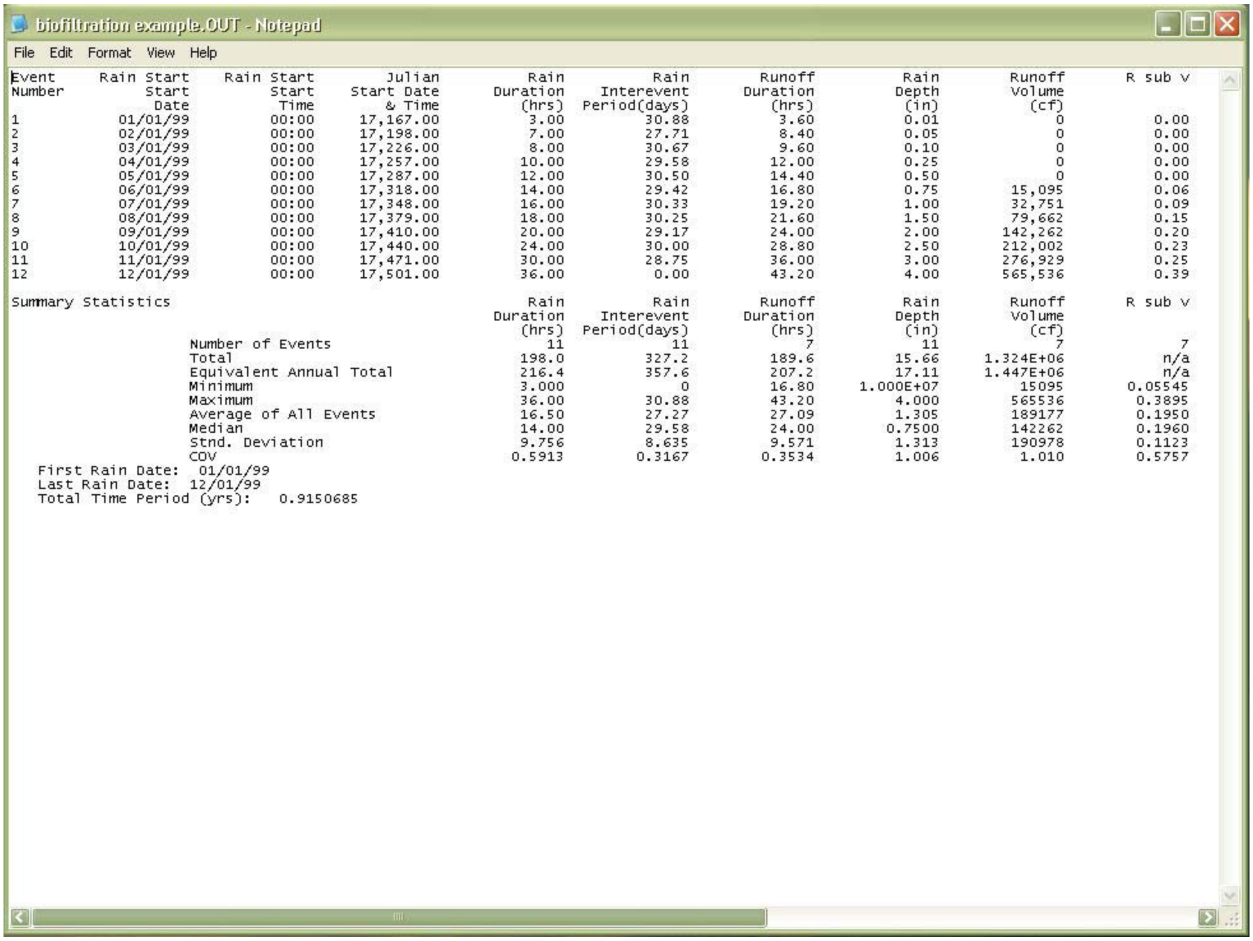


For the "one line per event options" the "utilities, view file" pull down options can be used to select the output file for viewing, as shown below:





The following is a partial screen dump of this output file. In this example, the "annual" values have no meaning, as this example is only intended to illustrate variations for different rain depths.


biofiltration example.OUT - Notepad

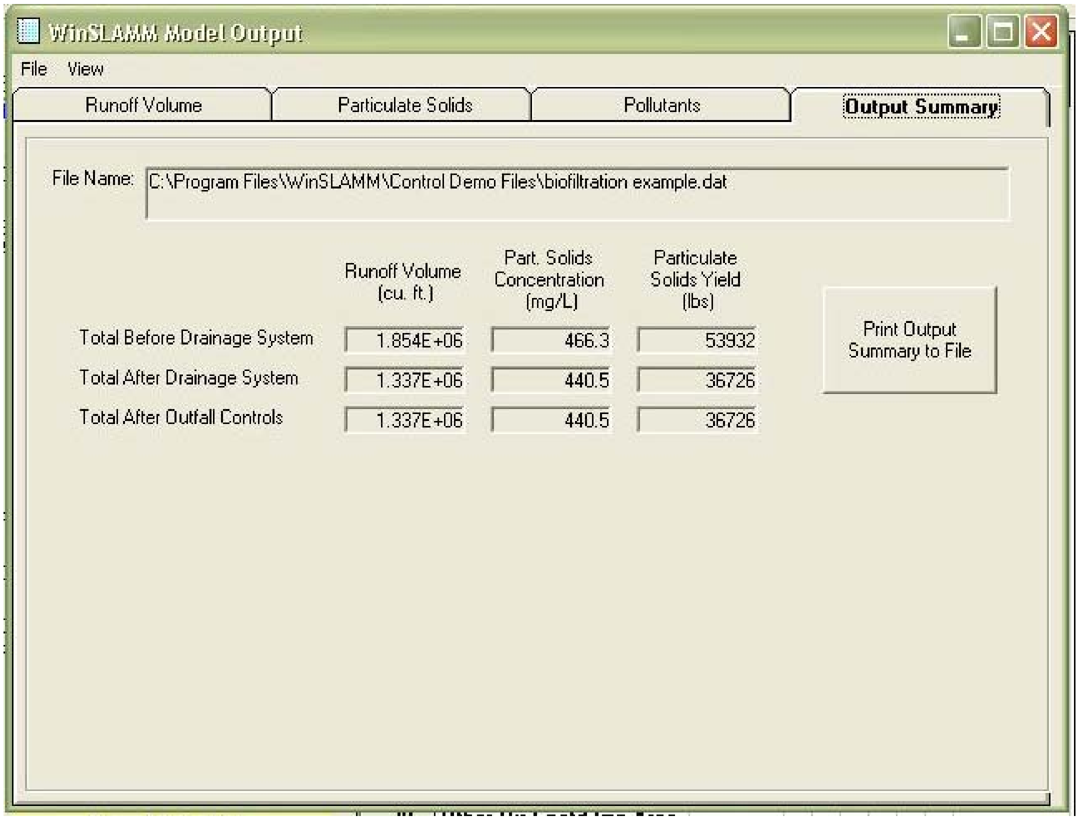
File Edit Format View Help

Event Number	Rain Start Start Date	Rain Start Start Time	Julian Start Date & Time	Rain Duration (hrs)	Rain Interevent Period(days)	Runoff Duration (hrs)	Rain Depth (in)	Runoff Volume (cf)	R sub v
1	01/01/99	00:00	17,167.00	3.00	30.88	3.60	0.01	0	0.00
2	02/01/99	00:00	17,198.00	7.00	27.71	8.40	0.05	0	0.00
3	03/01/99	00:00	17,226.00	8.00	30.67	9.60	0.10	0	0.00
4	04/01/99	00:00	17,257.00	10.00	29.58	12.00	0.25	0	0.00
5	05/01/99	00:00	17,287.00	12.00	30.50	14.40	0.50	0	0.00
6	06/01/99	00:00	17,318.00	14.00	29.42	16.80	0.75	15,095	0.06
7	07/01/99	00:00	17,348.00	16.00	30.33	19.20	1.00	32,751	0.09
8	08/01/99	00:00	17,379.00	18.00	30.25	21.60	1.50	79,662	0.15
9	09/01/99	00:00	17,410.00	20.00	29.17	24.00	2.00	142,262	0.20
10	10/01/99	00:00	17,440.00	24.00	30.00	28.80	2.50	212,002	0.23
11	11/01/99	00:00	17,471.00	30.00	28.75	36.00	3.00	276,929	0.25
12	12/01/99	00:00	17,501.00	36.00	0.00	43.20	4.00	565,536	0.39

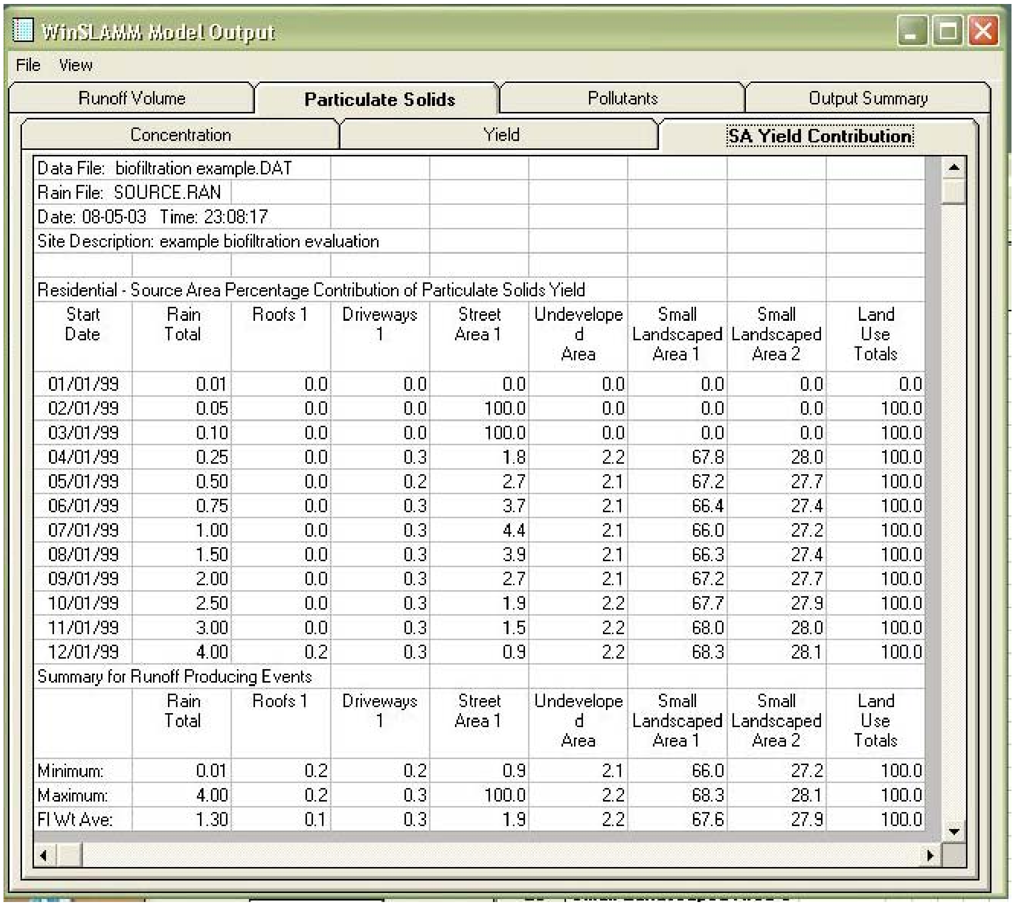
Summary Statistics	Rain Duration (hrs)	Rain Interevent Period(days)	Runoff Duration (hrs)	Rain Depth (in)	Runoff Volume (cf)	R sub v
Number of Events	11	11	7	11	7	7
Total	198.0	327.2	189.6	15.66	1.324E+06	n/a
Equivalent Annual Total	216.4	357.6	207.2	17.11	1.447E+06	n/a
Minimum	3.000	0	16.80	1.000E+07	15095	0.05545
Maximum	36.00	30.88	43.20	4.000	565536	0.3895
Average of All Events	16.50	27.27	27.09	1.305	189177	0.1950
Median	14.00	29.58	24.00	0.7500	142262	0.1960
Stnd. Deviation	9.756	8.635	9.571	1.313	190978	0.1123
COV	0.5913	0.3167	0.3534	1.006	1.010	0.5757

First Rain Date: 01/01/99
Last Rain Date: 12/01/99
Total Time Period (yrs): 0.9150685

An example of printout option 2 is shown below. This option is best for short rain files (such as for this rain example) if detailed information for each rain and source area is desired. In this case, it is possible to see how effective each source area control is in reducing runoff discharges for different types of rains. The output is automatically displayed in a small spreadsheet form that automatically appears when the calculation is completed:



The various tabs can be selected to show more detailed information, such as the following that presents the source area particulate solids (suspended solids) relative contributions:



Data File: biofiltration example.DAT
Rain File: SOURCE.RAN
Date: 08-05-03 Time: 23:08:17
Site Description: example biofiltration evaluation

Residential - Source Area Percentage Contribution of Particulate Solids Yield

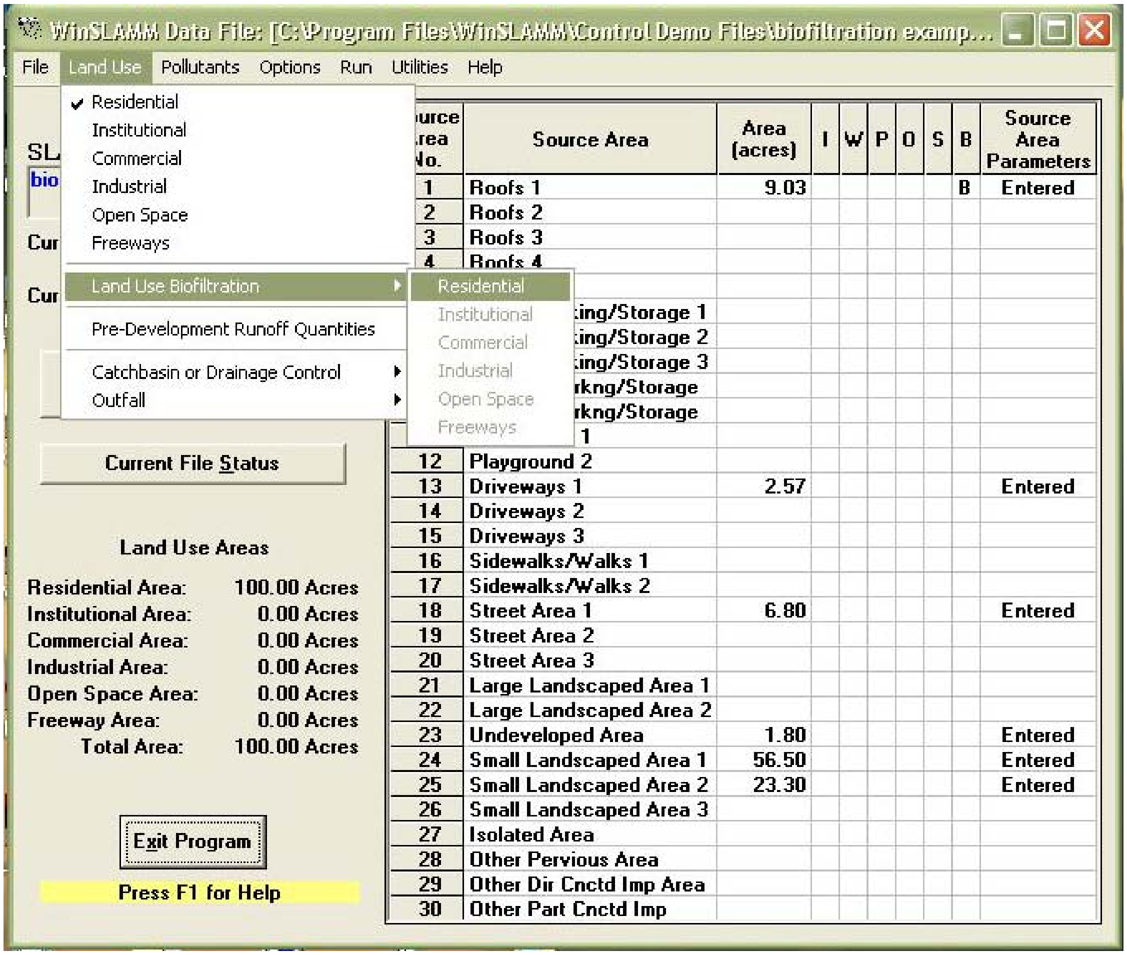
Start Date	Rain Total	Roofs 1	Driveways 1	Street Area 1	Undeveloped Area	Small Landscaped Area 1	Small Landscaped Area 2	Land Use Totals
01/01/99	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
02/01/99	0.05	0.0	0.0	100.0	0.0	0.0	0.0	100.0
03/01/99	0.10	0.0	0.0	100.0	0.0	0.0	0.0	100.0
04/01/99	0.25	0.0	0.3	1.8	2.2	67.8	28.0	100.0
05/01/99	0.50	0.0	0.2	2.7	2.1	67.2	27.7	100.0
06/01/99	0.75	0.0	0.3	3.7	2.1	66.4	27.4	100.0
07/01/99	1.00	0.0	0.3	4.4	2.1	66.0	27.2	100.0
08/01/99	1.50	0.0	0.3	3.9	2.1	66.3	27.4	100.0
09/01/99	2.00	0.0	0.3	2.7	2.1	67.2	27.7	100.0
10/01/99	2.50	0.0	0.3	1.9	2.2	67.7	27.9	100.0
11/01/99	3.00	0.0	0.3	1.5	2.2	68.0	28.0	100.0
12/01/99	4.00	0.2	0.3	0.9	2.2	68.3	28.1	100.0

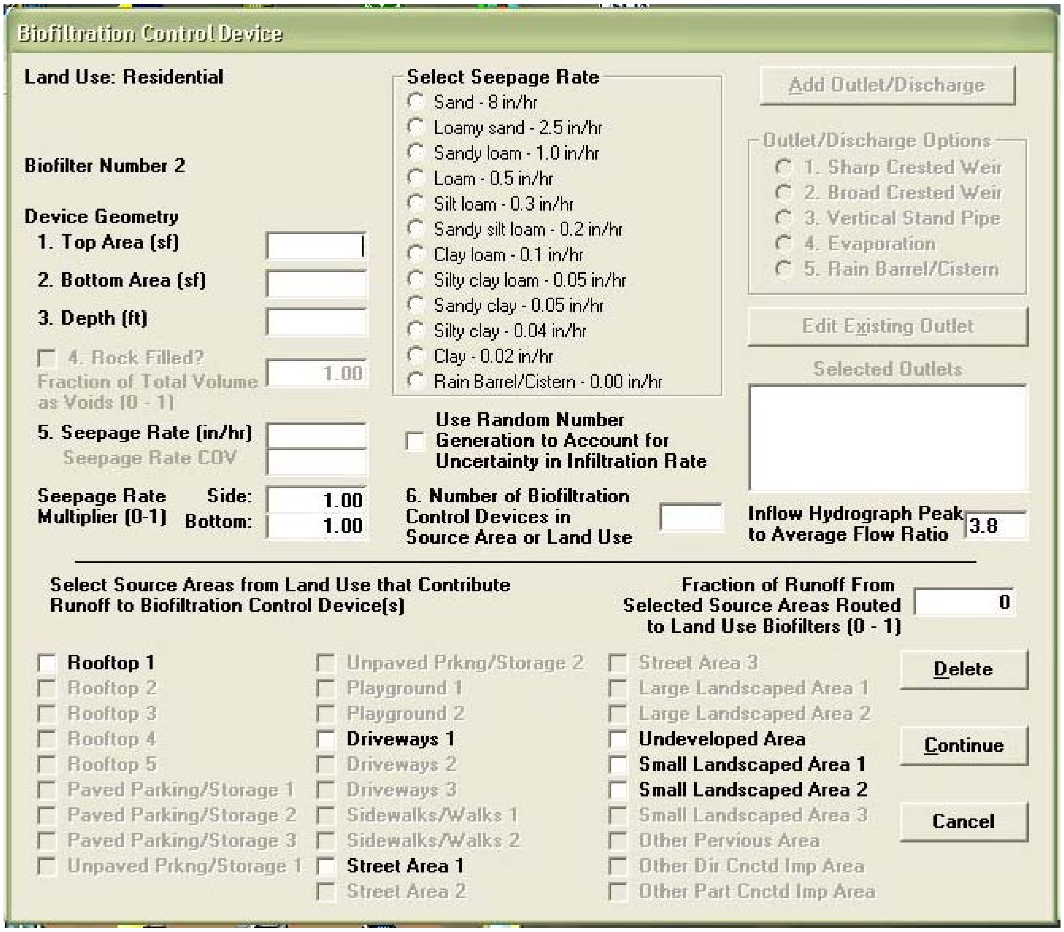
Summary for Runoff Producing Events

	Rain Total	Roofs 1	Driveways 1	Street Area 1	Undeveloped Area	Small Landscaped Area 1	Small Landscaped Area 2	Land Use Totals
Minimum:	0.01	0.2	0.2	0.9	2.1	66.0	27.2	100.0
Maximum:	4.00	0.2	0.3	100.0	2.2	68.3	28.1	100.0
Fl Wt Ave:	1.30	0.1	0.3	1.9	2.2	67.6	27.9	100.0

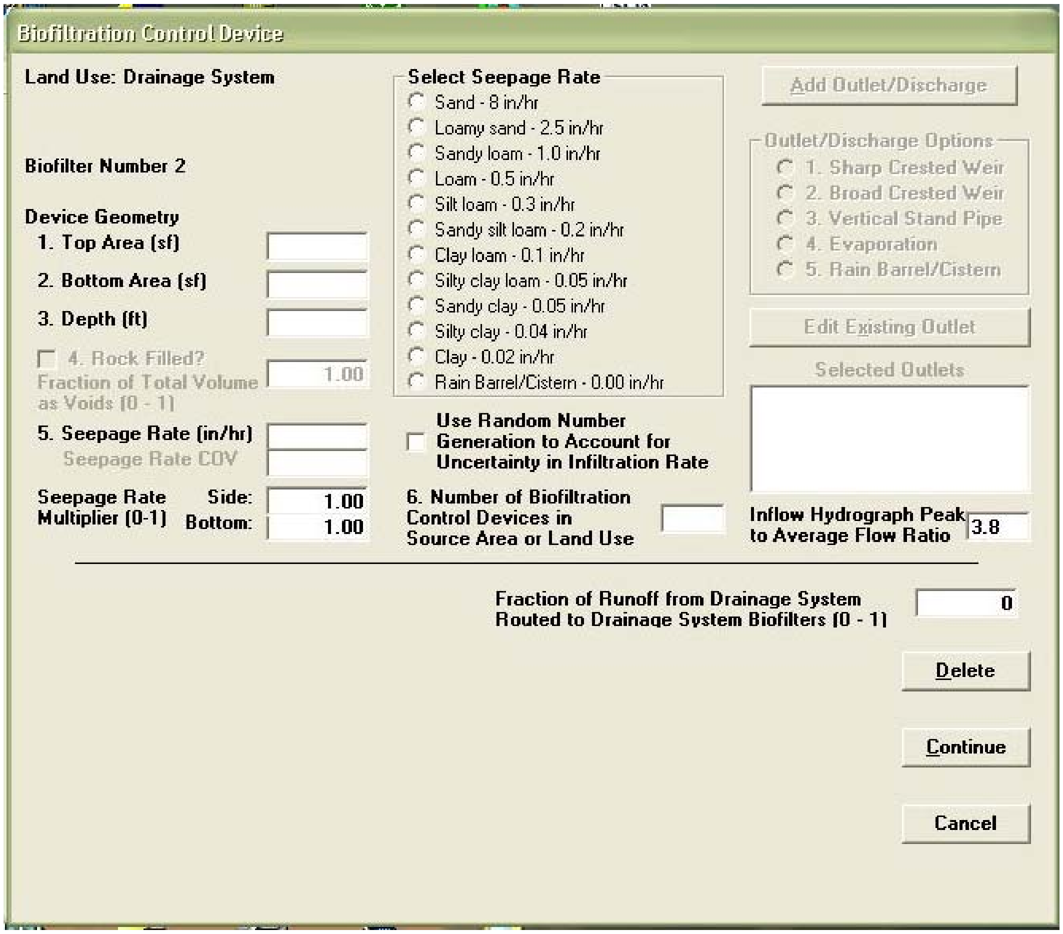
There are many other control options available in WinSLAMM that were not used in this example. The following screens are examples of the information requested for some of these other options.

The following screens show biofiltration controls for a complete land use. It is similar to the source area biofiltration screen, except that it also lists the available source areas in the bottom area of the form. It is therefore possible to combine some of the source areas together for control, such as rooftop and driveway runoff combined. In addition, it is possible to designate only a fraction of the combined flows to the biofiltration areas. As an example, a fraction of the roof runoff and driveway runoff can be directed to a cistern for storage of runoff for later use during dry weather for on-site irrigation (or toilet flushing, etc.). In the rain barrel/cistern "outlet/discharge" option, monthly water uses are entered so the model can track water use and re-filling of the tanks during storms.

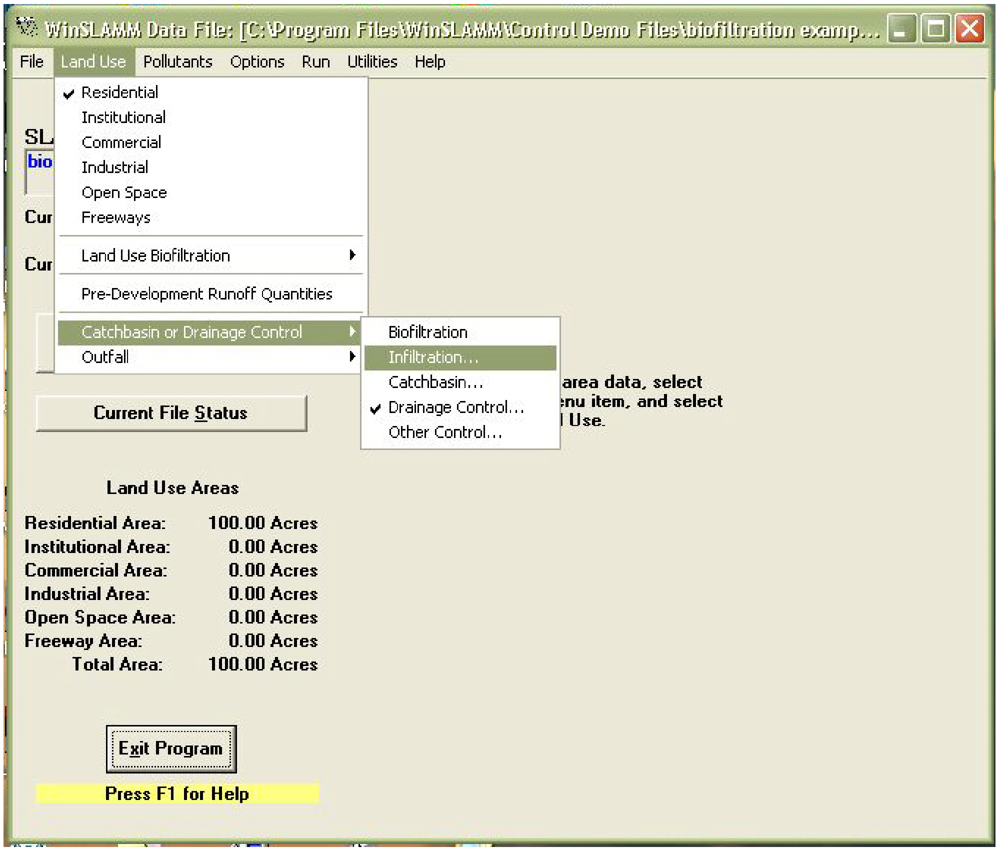

WinSLAMM Data File: [C:\Program Files\WinSLAMM\Control Demo Files\biofiltration examp...
File
Land Use
Pollutants
Options
Run
Utilities
Help
Residential
Institutional
Commercial
Industrial
Open Space
Freeways
Land Use Biofiltration
Pre-Development Runoff Quantities
Catchbasin or Drainage Control
Outfall
Residential
Institutional
Commercial
Industrial
Open Space
Freeways
Source Area
Area (acres)
I
W
P
O
S
B
Source Area Parameters
1 Roofs 1 9.03 B Entered
2 Roofs 2
3 Roofs 3
4 Roofs 4
12 Playground 2
13 Driveways 1 2.57 Entered
14 Driveways 2
15 Driveways 3
16 Sidewalks/Walks 1
17 Sidewalks/Walks 2
18 Street Area 1 6.80 Entered
19 Street Area 2
20 Street Area 3
21 Large Landscaped Area 1
22 Large Landscaped Area 2
23 Undeveloped Area 1.80 Entered
24 Small Landscaped Area 1 56.50 Entered
25 Small Landscaped Area 2 23.30 Entered
26 Small Landscaped Area 3
27 Isolated Area
28 Other Pervious Area
29 Other Dir Cnctd Imp Area
30 Other Part Cnctd Imp
Current File Status
Land Use Areas
Residential Area: 100.00 Acres
Institutional Area: 0.00 Acres
Commercial Area: 0.00 Acres
Industrial Area: 0.00 Acres
Open Space Area: 0.00 Acres
Freeway Area: 0.00 Acres
Total Area: 100.00 Acres
Exit Program
Press F1 for Help

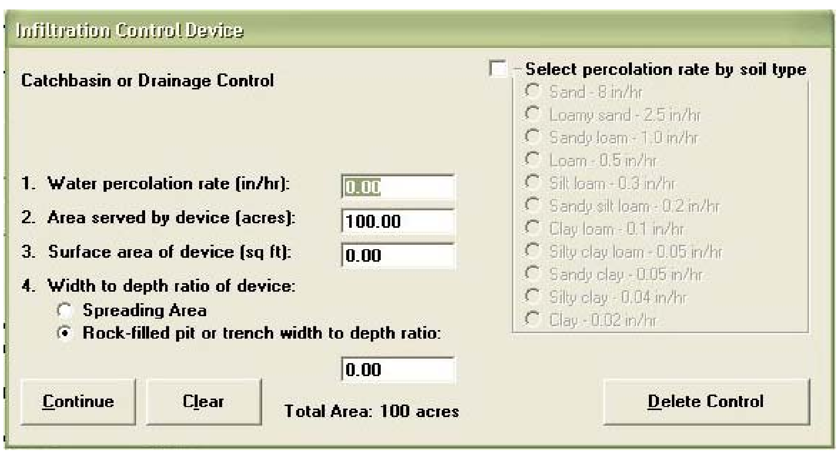


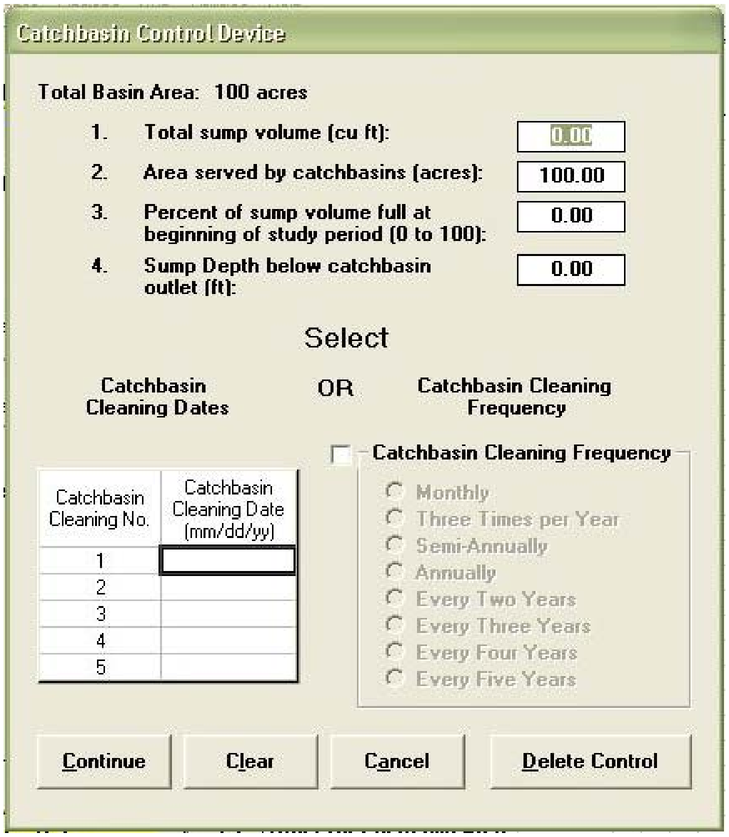
The following “drainage system” biofiltration control screen allows infiltration and routing of stormwater as part of the drainage system for the complete area, such as for perforated pipe.



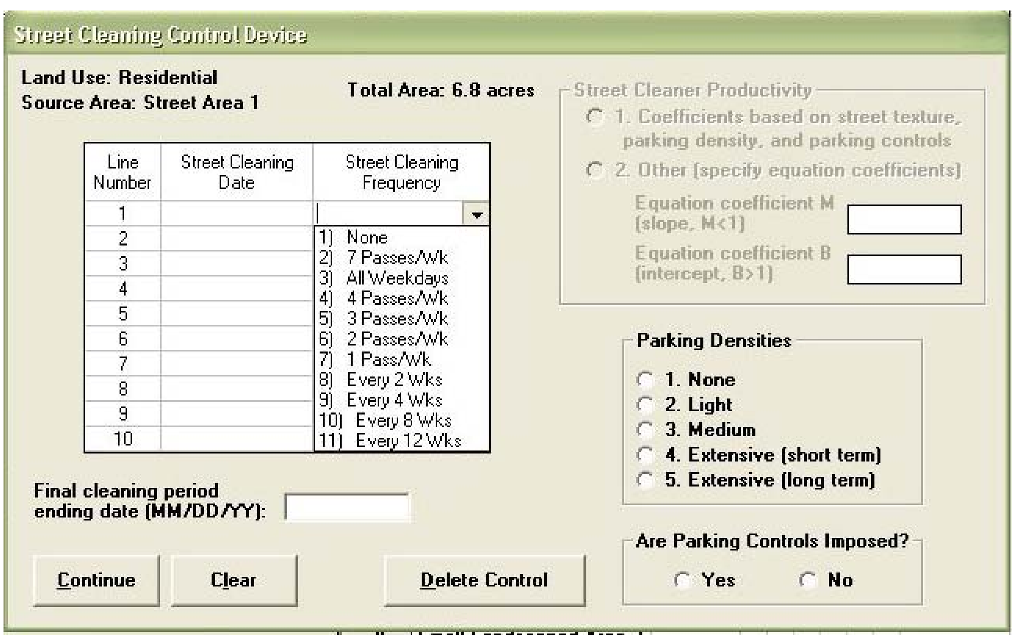
Catchbasin sumps have been shown to capture large particulate matter that enter the storm drainage system. Some communities also have used perforated catchbasins allowing some of the water to percolate. The following screens are used to describe these functions.


WinSLAMM Data File: [C:\Program Files\WinSLAMM\Control Demo Files\biofiltration examp...
File
Land Use
Pollutants
Options
Run
Utilities
Help
Residential
Institutional
Commercial
Industrial
Open Space
Freeways
Land Use Biofiltration
Pre-Development Runoff Quantities
Catchbasin or Drainage Control
Outfall
Biofiltration
Infiltration...
Catchbasin...
Drainage Control...
Other Control...
area data, select
enu item, and select
l Use.
Current File Status
Land Use Areas
Residential Area: 100.00 Acres
Institutional Area: 0.00 Acres
Commercial Area: 0.00 Acres
Industrial Area: 0.00 Acres
Open Space Area: 0.00 Acres
Freeway Area: 0.00 Acres
Total Area: 100.00 Acres
Exit Program
Press F1 for Help


Infiltration Control Device
Catchbasin or Drainage Control
1. Water percolation rate (in/hr): 0.00
2. Area served by device (acres): 100.00
3. Surface area of device (sq ft): 0.00
4. Width to depth ratio of device:
Spreading Area
Rock-filled pit or trench width to depth ratio:
0.00
Select percolation rate by soil type
Sand - 8 in/hr
Loamy sand - 2.5 in/hr
Sandy loam - 1.0 in/hr
Loam - 0.5 in/hr
Silt loam - 0.3 in/hr
Sandy silt loam - 0.2 in/hr
Clay loam - 0.1 in/hr
Silty clay loam - 0.05 in/hr
Sandy clay - 0.05 in/hr
Silty clay - 0.04 in/hr
Clay - 0.02 in/hr
Continue
Clear
Total Area: 100 acres
Delete Control

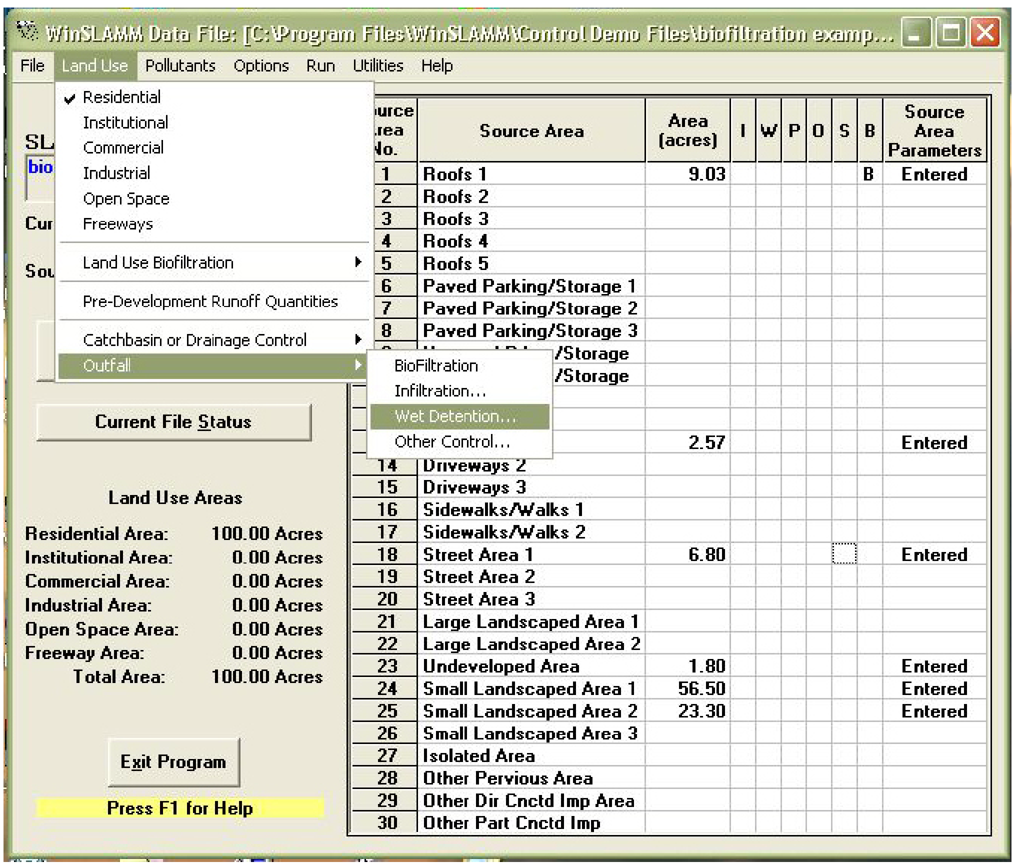


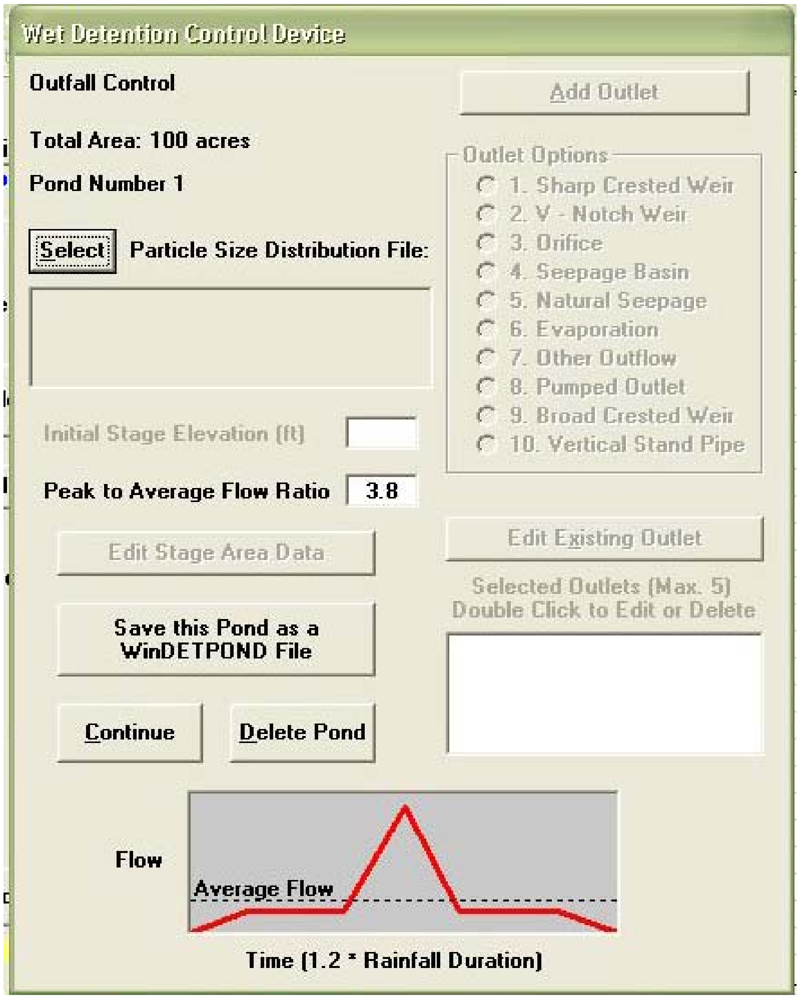
Street cleaning can also be simulated with WinSLAMM. The following screen is used to describe the street cleaning program in for a specific street area.



Evaluations of concurrent use of catchbasins and street cleaning may be misleading for study areas that are mostly streets, as little field data is available to document this combination of controls for these areas. In these cases, extensive street cleaning removes most of the larger particulates that would be trapped in the catchbasins, reducing the predicted effectiveness of the catchbasin. Therefore, WinSLAMM doesn't allow the simultaneous use of these two controls.

The following screens are used to describe wet detention ponds at source areas and at outfalls. The particle size distribution is selected (by selecting from a list of pre-developed parameter files) and the pond geometry is entered. Finally, pond outlets are also described from the list, including weirs, percolation, evaporation, pumps, and seepage basins located after the pond. The inflow hydrograph is developed based on the total runoff volume entering the pond and using a standard triangular hydrograph. Any upland infiltration/biofiltration device located prior to the pond reduces the flow entering the pond. The standard modified-puls method for routing the flows through the ponds are used, in conjunction with the surface overflow rate procedure for routing suspended solids.





The following tables illustrate the outputs for a typical analysis, comparing source area biofiltration controls to a similar analysis having no controls and all paved and roof areas being connected.

Data File: biofilt example but all connected and no control

Rain File: BHAMSRCE.RAN

Date: 04-30-01 Time: 15:25:33

Site Description: example biofiltration evaluation

Residential Areas - Runoff Volume (cu. ft)

Start Date	Rain Total	Roofs 1	Driveways 1	Street Area 1	Undeveloped Area	Small Landscaped Area 1	Small Landscaped Area 2	Land Use Totals	Rv	Total Losses (in.) *	Calculated CN
01/01/1999	0.01	21	0	0	0	0	0	20.81	0.01	0.01	99.6
02/01/1999	0.05	578	143	378	0	0	0	1098	0.06	0.05	98.6
03/01/1999	0.1	2277	431	1141	0	0	0	3850	0.11	0.09	97.8
04/01/1999	0.25	7143	1314	3477	185	5820	2400	20339	0.22	0.19	96.4
05/01/1999	0.5	15419	2899	7672	561	17597	7257	51405	0.28	0.36	94.2
06/01/1999	0.75	23554	4648	12298	971	30472	12566	84509	0.31	0.52	92.1
07/01/1999	1	31822	6295	16657	1377	43234	17829	117214	0.32	0.68	90.1
08/01/1999	1.5	48185	11009	29128	2236	70173	28939	189670	0.35	0.98	86.7
09/01/1999	2	64902	15703	41548	3429	107634	44387	277603	0.38	1.24	84.4
10/01/1999	2.5	81128	20221	53503	4909	154078	63540	377377	0.42	1.46	82.7
11/01/1999	3	97353	24976	66084	6394	200706	82769	478282	0.44	1.68	81.1
12/01/1999	4	129804	34355	90900	10293	323098	133242	721694	0.5	2.01	79.3
Summary for All Events											
Minimum:	0.01	21	0	0	0	0	0	20.81	0.01	0.01	79.3
Maximum:	4	129804	34355	90900	10293	323098	133242	721694	0.5	2.01	99.6
Average:	1.31	41849	10166	26899	2530	79401	32744	193588	0.41	0.77	90
Total:	15.66	502186	121994	322786	30355	952812	392929	2.32E+06		9.27	

Total Area, with Drainage and Outfall Controls - Runoff Volume (cu. ft)

Start Date	Rain Total (inches)	Total Before Drainage System	Total After Drainage System	Total After Outfall Controls	Rv	Total Losses (in) *	Calculated CN
01/01/1999	0.01	20.81	20.81	20.81	0.01	0.01	99.6
02/01/1999	0.05	1098	1098	1098	0.06	0.05	98.6
03/01/1999	0.1	3850	3850	3850	0.11	0.09	97.8
04/01/1999	0.25	20339	20339	20339	0.22	0.19	96.4
05/01/1999	0.5	51405	51405	51405	0.28	0.36	94.2
06/01/1999	0.75	84509	84509	84509	0.31	0.52	92.1
07/01/1999	1	117214	117214	117214	0.32	0.68	90.1
08/01/1999	1.5	189670	189670	189670	0.35	0.98	86.7
09/01/1999	2	277603	277603	277603	0.38	1.24	84.4
10/01/1999	2.5	377377	377377	377377	0.42	1.46	82.7
11/01/1999	3	478282	478282	478282	0.44	1.68	81.1
12/01/1999	4	721694	721694	721694	0.5	2.01	79.3
Number of Rains:		12	12	12			
Minimum:	0.01	20.81	20.81	20.81	0.01	0.01	79.3
Maximum:	4	721694	721694	721694	0.5	2.01	99.6
Average:	1.31	193589	193589	193589	0.41	0.77	90
Total:	15.66	2.32E+06	2.32E+06	2.32E+06		9.27	

Data File: bilfiltration example.DAT

Rain File: BHAMSRCE.RAN

Date: 04-30-01 Time: 15:19:16

Site Description: example biofiltration evaluation

Residential Areas - Runoff Volume (cu. ft)

Start Date	Rain Total	Roofs 1	Driveways 1	Street Area 1	Undeveloped Area	Small Landscaped Area 1	Small Landscaped Area 2	Land Use Totals	Rv	Total Losses (in.) *	Calculated CN
01/01/1999	0.01	0	0	0	0	0	0	0	0	0.01	N/A
02/01/1999	0.05	0	0	378	0	0	0	377.5	0.02	0.05	98.2
03/01/1999	0.1	0	0	1141	0	0	0	1141	0.03	0.1	96.8
04/01/1999	0.25	0	279	3477	185	5820	2400	12162	0.13	0.22	95.2
05/01/1999	0.5	4315	822	7672	561	17597	7257	38223	0.21	0.39	92.8
06/01/1999	0.75	7426	1412	12298	971	30472	12566	65146	0.24	0.57	90.4
07/01/1999	1	20416	1992	16657	1377	43234	17829	101505	0.28	0.72	88.8
08/01/1999	1.5	37271	3239	29128	2236	70173	28939	170986	0.31	1.03	85.5
09/01/1999	2	44645	5032	41548	3429	107634	44387	246675	0.34	1.32	82.7
10/01/1999	2.5	66320	7169	53503	4909	154078	63540	349518	0.39	1.54	81.4
11/01/1999	3	79308	9315	66084	6394	200706	82769	444577	0.41	1.78	79.6
12/01/1999	4	124036	14919	90900	10293	323098	133242	696489	0.48	2.08	78.4
Summary for All Events											
Minimum:	0.01	0	0	0	0	0	0	0	0	0.01	N/A
Maximum:	4	124036	14919	90900	10293	323098	133242	696489	0.48	2.08	98.2
Average:	1.31	31978	3682	26899	2530	79401	32744	177233	0.37	0.82	89
Total:	15.66	383737	44179	322786	30355	952812	392929	2.13E+06		9.81	

Total Area, with Drainage and Outfall Controls - Runoff Volume (cu. ft)

Start Date	Rain Total (inches)	Total Before Drainage System	Total After Drainage System	Total After Outfall Controls	Rv	Total Losses (in) *	Calculated CN
01/01/1999	0.01	0	0	0	0	0.01	N/A
02/01/1999	0.05	377.5	0	0	0	0.05	N/A
03/01/1999	0.1	1141	0	0	0	0.1	N/A
04/01/1999	0.25	12162	0	0	0	0.25	N/A
05/01/1999	0.5	38223	1313	1313	0.01	0.5	82.9
06/01/1999	0.75	65146	22521	22521	0.08	0.69	84.2
07/01/1999	1	101505	58881	58881	0.16	0.84	84.5
08/01/1999	1.5	170986	128361	128361	0.24	1.15	82.2
09/01/1999	2	246675	204050	204050	0.28	1.44	80
10/01/1999	2.5	349518	306893	306893	0.34	1.65	79.2
11/01/1999	3	444577	401952	401952	0.37	1.89	77.6
12/01/1999	4	696489	653865	653865	0.45	2.2	76.9
Number of Rains:		12	12	12			
Minimum:	0.01	0	0	0	0	0.01	N/A
Maximum:	4	696489	653865	653865	0.45	2.2	84.5
Average:	1.31	177233	148153	148153	0.31	0.9	87.1
Total:	15.66	2.13E+06	1.78E+06	1.78E+06		10.77	

As shown in the following summary table, runoff occurs during all rains, even during the smallest 0.01 inch event (although the Rv for this event is only 0.01), when all areas are directly connected to the drainage system and no infiltration or biofiltration controls are used. When the infiltration devices are used, runoff only occurs for rains greater than about 0.5 inches. The runoff volume is even reduced during the largest 4 inch rain by about 10 percent when using these controls. The control benefits for suspended solids mass discharges are similar. They are greater than the benefits for runoff volume for the moderate rains (0.50 to 1.50 inches), but the suspended solids reductions are actually slightly less than the volume reductions for the larger rains. This is likely because of the infiltration of relatively clean roof runoff in the "rain gardens" compared to infiltration of runoff from other areas, and the significantly increased suspended solids discharges from landscaped areas during these large rains. It is therefore reasonable to expect about 80%, or greater, runoff and suspended solids reductions for all rains up to about 0.75 inches in depth with this example control scenario.

Rain depth (inches)	Rv with no controls and all pavement and roofs are directly connected	Rv with biofiltration controls and with disconnected pavement and roofs	% runoff volume reductions with controls	Suspended solids with no controls and all pavement and roofs are directly connected (lbs/ac)	Suspended solids with biofiltration controls and with disconnected pavement and roofs (lbs/acre)	% suspended solids reductions with controls
0.01	0.01	0.00	100%	<0.1	0	100%
0.05	0.06	0.00	100%	<0.1	0	100%
0.10	0.11	0.00	100%	0.15	0	100%
0.25	0.22	0.00	100%	3.6	0	100%
0.50	0.28	0.01	96%	10	0.12	99%
0.75	0.31	0.08	74%	16	2.5	84%
1.00	0.32	0.16	50%	23	8.6	63%
1.50	0.35	0.24	31%	40	27	33%
2.00	0.38	0.28	26%	61	49	20%
2.50	0.42	0.34	19%	87	76	13%
3.00	0.44	0.37	16%	110	100	10%
4.00	0.50	0.45	10%	180	170	6%

This area was further evaluated using a continuous series of rains over a 37 year period (1953 through 1989) that contained 4,011 separate rains ranging from 0.01 to 13.58 inches in depth. The minimum rain duration was 1 hour (by definition), while the maximum duration was 93 hours (the median was 4 hours). The interevent times ranged from 6 hours (used to define separate rain events) to 44 days (the median was 1.9 days).

The following table summarizes these results for several alternatives. The "as-built" condition is based on actual conditions in the Birmingham area derived from neighborhood surveys and aerial photographic measurements. The "totally connected" condition is this same area, but assuming that all roofs and driveways are directly connected to the drainage system, while the "totally disconnected" condition assumes that these paved and roof areas all drain to the clayey soils. The "skinny street" option reduces the measured street widths from 35 to 20 ft, keeping the same street lengths, and increasing the landscaped areas by the reduction in street area. The swales and roof garden option is similar to the above evaluation, but the last option shown also had amended soils in the swales and roof gardens to increase the infiltration rates to about 0.5 in/hr (loam conditions).

The current (partially connected) conditions produce about 10% less runoff and about the same amount of suspended solids compared to totally connected conditions. If the current conditions were built with skinny streets, the runoff reductions would slightly improve to about 13%. Substantial runoff and suspended solids reductions (about 60 to 65%) would occur for totally disconnected conditions, plus the use of rain gardens to improve roof runoff and the use of amended soils in both the rain gardens and swales to improve infiltration in the clayey soils.

	Flow-weighted Rv	Suspended solids discharges (lb/ac/yr)
Totally connected	0.34	1390
As built and surveyed	0.31	1380
% reduction	9%	0%
As built, but with “skinny” streets	0.30	1430
% reduction	13%	3% increase
Totally disconnected	0.27	1380
% reduction	21%	<1%
Totally disconnected with swales	0.25	1060
% reduction	26%	24%
Totally disconnected, swales, roof rain gardens, and amended soils	0.12	590
% reduction	65%	58%

Obviously, these are only predictions for a single area and the specific results would vary substantially for other areas having different rains, soils, and development characteristics. However, this example does illustrate how WinSLAMM can be used to calculated expected benefits of different types of biofiltration controls in a typical medium density residential area.