

 **BASINS Technical Note 11**

**Infiltration BMP Tutorial for HSPF**

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### **Infiltration BMP Tutorial for HSPF**

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The infiltration BMP tool allows modelers to select a BMP type, channel shape and BMP facility dimensions, flow control devices, and infiltration method. Based on the modeler's selection, the program generates an HSPF-formatted FTABLE. HSPF's Reach module (RCHRES) is used to represent infiltration BMPs. The specific characteristics of each BMP are captured by the FTABLE. Unlike storage BMPs (e.g., detention basins) that store runoff from relatively large areas, infiltration BMPs are source control facilities that capture runoff from small impervious areas (e.g., parking lots or rooftops).

The HSPF BMP tool presented herein is used to design and simulate structural BMPs. Just like storage BMPs, infiltration BMPs use HSPF's reach module (RCHRES). When designing infiltration BMPs, we recommend the use of Maryland's unified stormwater sizing criteria. The unified approach has five specific design objectives: meet pollutant removal goals (WQv), maintain groundwater recharge (Rev), reduce channel erosion (CPv), prevent overbank flooding, and pass extreme floods.

The HSPF Web-based BMP modeling tool can be as a pretreatment facility or as the main treatment facility. Pretreatment is used mainly to capture suspended solids before reaching the treatment facility. The pretreatment volume treats 25% of the water quality volume (WQv) whereas the main treatment facility treats 50% of the water quality volume (WQv). To represent the treatment train in HSPF users should build one FTABLE for the pretreatment and another separate FTABLE for the treatment facility. Tool users must ensure that the two FTABLES are linked through the SCHEMATIC-BLOCK of the User Control Input (UCI) file. Overall, the BMP facility (pretreatment and main treatment) is intended to treat 75% of the water quality volume (WQv) generated from the contributing impervious area.

Representing most infiltration BMPs in HSPF is straightforward. However, to build an FTABLE for some BMPs, i.e. sand filters, may require several steps. Although the tool may be used in many BMP modeling applications, how accurately one can represent a particular BMP depends on a user's skill.

There are several important infiltration BMP related topics that are not covered in this tutorial. For example, this tutorial does not provide discussions on how to delineate small urban watersheds as well as methods to estimate stormwater runoff rates and volumes using HSPF and other models. The primary design considerations for any infiltration BMP are to ensure that the infiltration BMP has the capacity to store the capture volume and to ensure that the underlying soil can adequately drain the design capture volume within the permissible drainage time.

A detailed discussion of HSPF BMP tools will be published as a User's Manual Report. The manual will cover HSPF BMP modeling capabilities. It will specifically address how HSPF represents and simulates storage, infiltration, and vegetative BMPs.

The steps to follow when sizing infiltration facilities are:

1. Estimate the volume of stormwater runoff that the infiltration facility must store and infiltrate. In some cases, the runoff volume is referred to as water quality volume (WQv). Modelers can use Schueler's simple method (1987), U. S. Soil Conservation Service TR-55 Hydrologic Analysis model (1986), or HSPF (Bicknell et al. 2001) to determine the runoff volume generated from an impervious area.
2. Select the BMP type for the site.
3. Estimate storage capacity of the infiltration facility by selecting the appropriate BMP dimensions (make sure the facility adequately stores the runoff capture volume, as estimated above in Step 1).
4. Estimate average infiltration rate of the underlying soil using soil textural classes or field measurements (make sure the selected infiltration rate can sufficiently drain the storage volume within the allowable drain time).
5. Select a flow control device for the infiltration facility. Modelers can select underdrain pipes that drain water particularly for soils with low infiltration capacity and/or overflow devices that safely remove water when the facility fills up (e.g., weirs and riser orifices).
6. Copy and paste the resulting BMP FTABLE to your HSPF UCI file.
7. Run the model to route the pre-development and post-development runoff hydrographs through the BMP facility.

### **A. Infiltration BMPs With Regular Channel Shapes**

To become familiar with HSPF infiltration BMP applications, model users should follow this step-by-step tutorial.

**Step 1.** BMP tool users must select one of the seven BMP types from the pull down menu (Figure 1). These types have different names, but some have similar characteristics. There are two general types of infiltration BMPs: those that store water above the soil surface as a ponding reservoir (e.g., infiltration basins, rain gardens, etc.) and those that store water in backfilled underground reservoirs (e.g., infiltration trench and dry well, etc.). In both types, infiltration rate is controlled by the underlying soil.

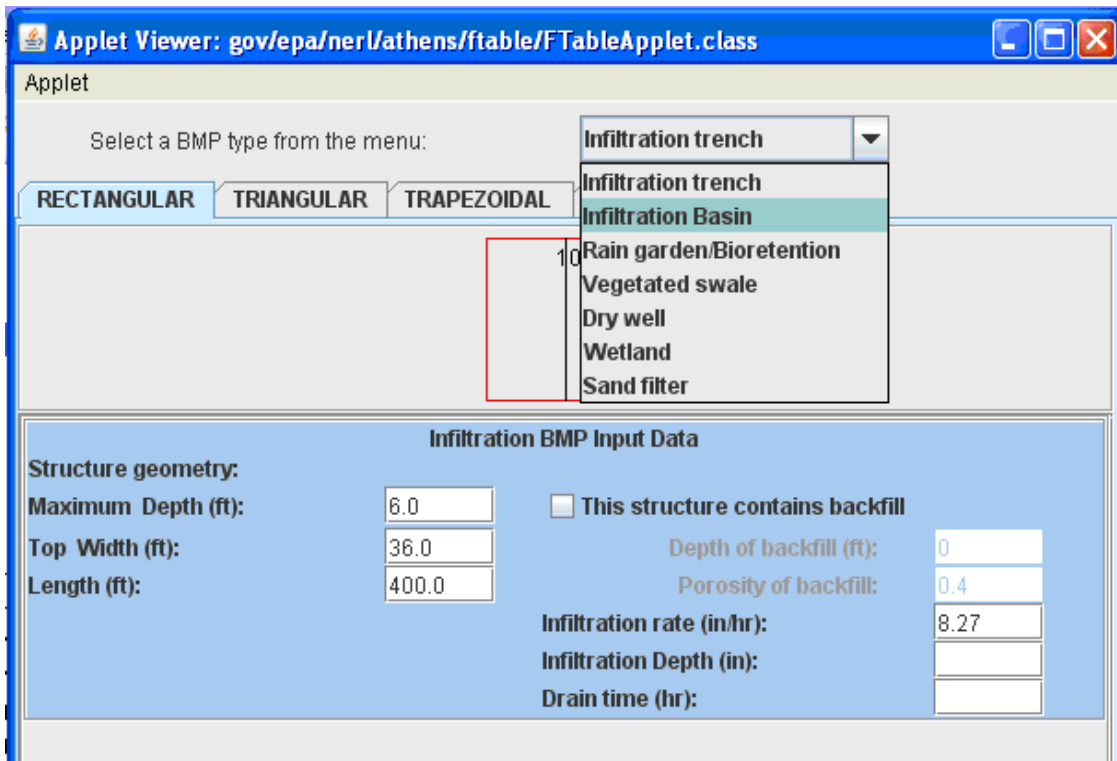


Figure 1. BMP type selection screen.

**Step 2.** Select a channel shape for the BMP (Figure 2). The tool suggests a default channel shape for each BMP type, but users can override the suggestion by clicking on the shape of their choice.

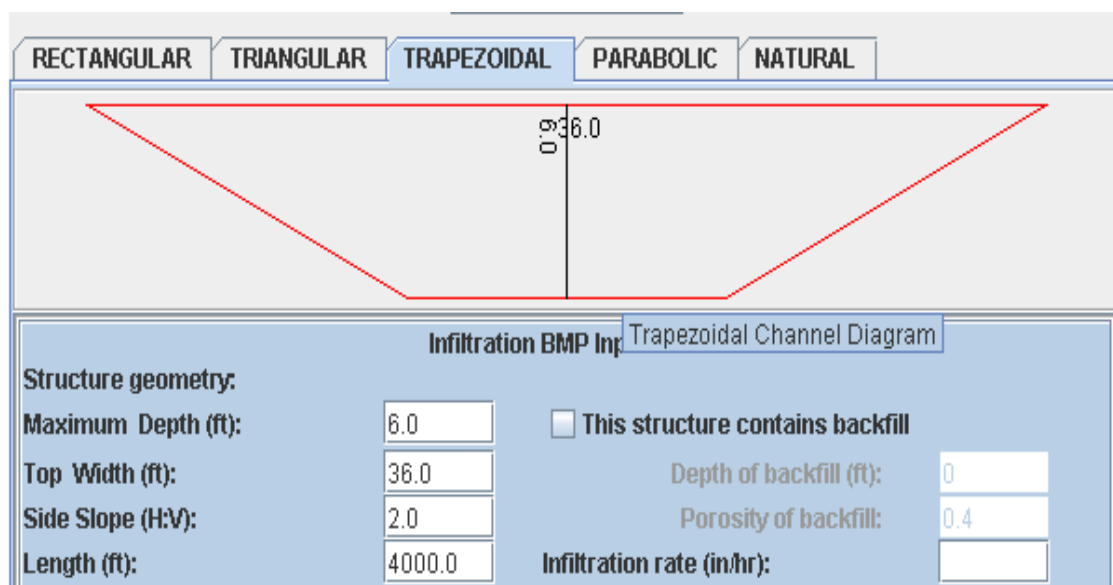

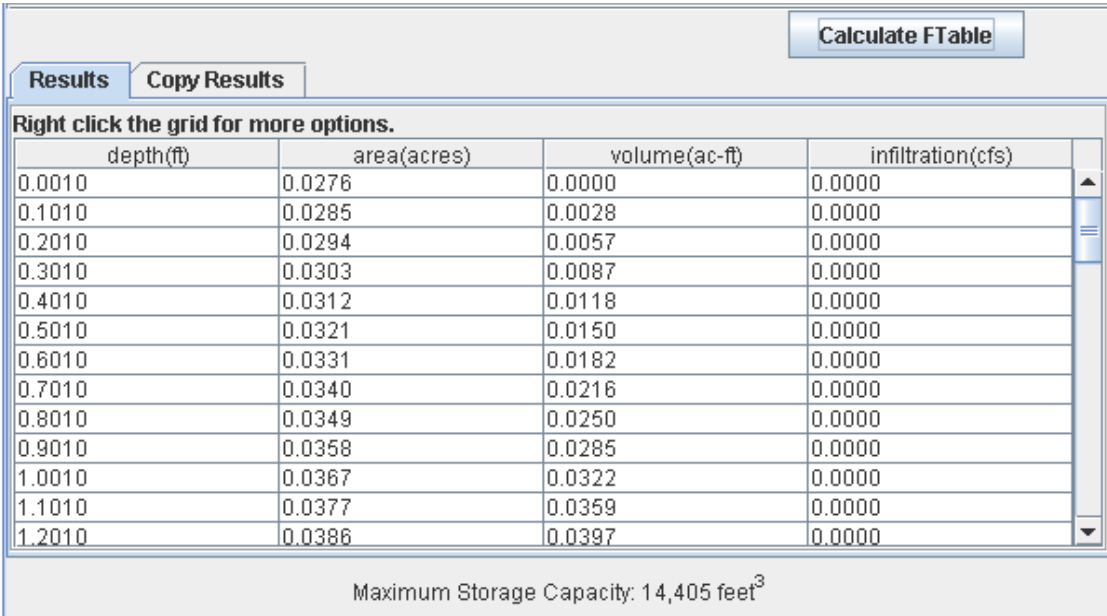


Figure 2. Channel shape selector.

**Step 3.** To store the design runoff volume generated from impervious areas, users must type in channel depth, width, and length for the infiltration BMP (Figure 2). The final selected channel dimensions must adequately store the design runoff capture volume.

**Step 4.** After selecting depth, width, and length channel dimensions, tool users need to click on  to calculate depth-area-storage columns of the FTABLE (Figure 3). The maximum storage capacity for the FTABLE, as shown below, must always be greater than or equal to the calculated design runoff capture volume. To match the design runoff capture volume and the maximum storage capacity of the infiltration BMP, tool users can change the channel dimensions until the calculated maximum storage volume becomes equal to or slightly greater than the design runoff capture volume for the design storm. For trapezoidal channel shapes, make sure that the top width is not mistakenly input as the bottom width. Top width for trapezoidal channels is equal to the sum of the bottom width and two times the product of the side slope ratio and the maximum depth ( $TW = bw + 2.Z.D$ ). Tool users can also add a minimum freeboard to the maximum depth.



depth(ft)	area(acres)	volume(ac-ft)	infiltration(cfs)
0.0010	0.0276	0.0000	0.0000
0.1010	0.0285	0.0028	0.0000
0.2010	0.0294	0.0057	0.0000
0.3010	0.0303	0.0087	0.0000
0.4010	0.0312	0.0118	0.0000
0.5010	0.0321	0.0150	0.0000
0.6010	0.0331	0.0182	0.0000
0.7010	0.0340	0.0216	0.0000
0.8010	0.0349	0.0250	0.0000
0.9010	0.0358	0.0285	0.0000
1.0010	0.0367	0.0322	0.0000
1.1010	0.0377	0.0359	0.0000
1.2010	0.0386	0.0397	0.0000

Maximum Storage Capacity: 14,405 feet<sup>3</sup>

Figure 3. Calculated depth-area-storage columns of the FTABLE.


**Step 5.** Once channel dimensions that provide the desired maximum storage capacity are selected, users then click on  (Figure 4) to determine infiltration rates for the site. Two options are available to estimate infiltration rates for the BMP facility. The first uses the Maryland method to select an infiltration rate from a look-up table (MDE, 1984): it employs soil texture classes to estimate constant infiltration rate of the underlying soil (Rawls, Brakensiek, and Saxton, 1982). The second option uses the Green-Ampt equation to calculate infiltration rate from soil properties.



Figure 4. Infiltration method and flow control device selector.

**Step 6.** Infiltration BMPs use 11 soil textural classes (Figure 5). Each class has distinct soil parameters. Green-Ampt parameter values, such as hydraulic conductivity, suction head, and moisture content were determined from soil properties by Rawls, Brakensiek, and Saxton (1982) and Rawls, Brakensiek, and Miller (1983). Tool users need to select the site's soil type from the pull down menu (See Figure 5).

Figure 5. Soil type selector.

**Step 7.** Tool users can select the Green-Ampt method by clicking on the

**Green and Ampt Method** (Figure 6). The only option available there is the Green-Ampt method. When using the Green-Ampt method, tool users must type in initial water content and depth of the underlying soil (the two blank input areas). Based on the selected soil texture, the program automatically fills the appropriate Green-Ampt parameter values for each soil class.

**Infiltration BMP Input Data**

**Structure geometry:**

Maximum Depth (ft):        This structure contains backfill

Top Width (ft):       Depth of backfill (ft):

Length (ft):       Porosity of backfill:

Infiltration rate (in/hr):

Infiltration Depth (in):

Drain time (hr):

Select Soil Type:  ▼

Maryland Method (Look-up)

Green and Ampt Method       ▼

Residual Water Content	Hydraulic Conductivity (cm/hr)	Effective Porosity
<input type="text" value="0.02"/>	<input type="text" value="11.78"/>	<input type="text" value="0.417"/>
Initial Water Content	Suction Head (cm)	Underlying Soil Depth (ft)
<input type="text"/>	<input type="text" value="4.95"/>	<input type="text"/>
Porosity		
<input type="text" value="0.437"/>		

Applet started.

Figure 6. Green-Ampt parameters.

**Step 8.** Tool users should test if the calculated infiltration rate adequately drains the capture runoff volume within the maximum allowable drain time – which, for most infiltration BMPs, is usually equal to or less than 72 hours. There are several ways of testing whether the calculated infiltration rate drains the design runoff capture volume within a specified drain time. With some assumptions, one can use Green-Ampt equation to calculate drain time (Figure 6). Another option is to run HSPF for several days and observe when the volume stored in the BMP facility becomes zero.

For soils with low infiltration rates, tool users can place an underground pipe to drain water stored in the BMP facility within the allowable drain time. The tool user can select the control device option and select an underdrain orifice. The options presented herein are used if users have no field measured infiltration data. If field-measured infiltration rate data is available, tool users can select the Maryland method and then type in the measured infiltration rate over the Maryland value in the textbox (Figure 6). Make sure that the units are in inches per hour. As shown in the fourth column of Figure 7,

calculated infiltration rates are converted into volumetric rates (cfs) by multiplying infiltration rate by the surface area (bottom and non-vertical side areas) of the infiltration BMP.

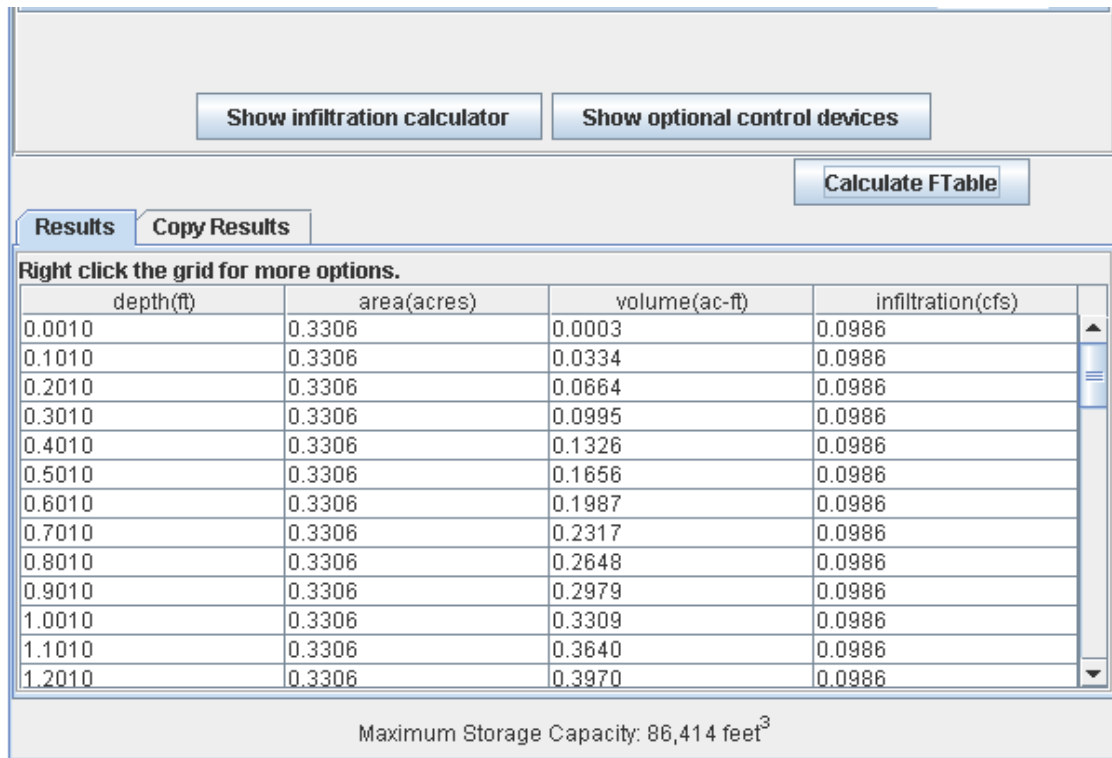
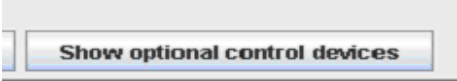


Figure 7. An FTABLE with an infiltration outflow.

**Step 9.** To generate an FTABLE with a control device, tool users must select one or more

flow control devices by clicking on  as shown in Figure 7.



**CONTROL STRUCTURES (optional)**

Vnotch Weir  
Vertex Angle (deg): 30  
Weir Invert (ft): 5

Sharp Crested Weir (Cipoletti)  
Weir Crest Width (ft): 30  
Weir Invert (ft): 5

Broad Crested Weir  
Weir Crest Width (ft): 30  
Weir Invert (ft): 5

Rectangular Weir  
Weir Crest Width (ft): 30  
Weir Invert (ft): 5

Underdrain Orifice  
Orifice Diameter (ft): 5  
Orifice Height (ft): 2

Riser Orifice  
Orifice Diameter (ft): 5  
Weir Invert (ft): 2

Figure 8. Input table for flow control devices (weirs and orifices).

**Step 10.** As an example, we selected a Riser Orifice as shown in Figure 8. Tool users need to type in the orifice diameter and riser invert height to calculate an FTABLE with a riser flow control and then click on **Calculate FTable** (Figure 9). Note that infiltration BMPs show infiltration in the outflow column of the FTABLE, whereas storage BMPs show outflow in the same column. The flow control devices used for the infiltration BMPs are similar to those used for the storage BMPs except that their sizes are smaller than those used for the storage BMPs.

**Results** **Copy Results**

**Right click the grid for more options.**

depth(ft)	area(acres)	volume(ac-ft)	shpcstdwr(cfs)	infiltration(cfs)
0.300000	0.330579	0.099174	0.0	2.7567
0.400000	0.330579	0.132231	0.0	2.7567
0.500000	0.330579	0.165289	0.0	2.7567
0.600000	0.330579	0.198347	0.0	2.7567
0.700000	0.330579	0.231405	0.0	2.7567
0.800000	0.330579	0.264463	0.0	2.7567
0.900000	0.330579	0.297521	0.0	2.7567
1.000000	0.330579	0.330579	0.0	2.7567
1.100000	0.330579	0.363636	3.1942	2.7567
1.200000	0.330579	0.396694	9.0346	2.7567
1.300000	0.330579	0.429752	16.5976	2.7567
1.400000	0.330579	0.462810	25.5537	2.7567
1.500000	0.330579	0.495868	35.7124	2.7567

Figure 9. FTABLE with a control device column.

## B. Transferring Calculated FTABLES to HSPF's UCI File

**Step 11.** Now that the program has generated an FTABLE with the desired channel dimensions, flow control, and infiltration rate, the next step is to transfer the FTABLE to the HSPF UCI file and to ensure that its format is compatible with the UCI file format. To transfer the FTABLE to a UCI file, point the mouse anywhere on the output grid table, right click, and then select "Copy to UCI file" (see Figure 10).

depth(ft)	area(acres)	volume(ac-ft)	riserorf(cfs)
0.00	1.21	0.00	0.0
0.40	1.25	0.47	0.0
0.50	1.29	0.58	0.0
0.60	1.32	0.69	0.0
0.70	1.36	0.80	0.0
0.80	1.40	0.91	0.0
0.90	1.43	1.02	0.0
1.00	1.47	1.29	0.0
1.10	1.51	1.44	0.0

Figure 10. FTABLE transfer to HSPF UCI file.

**Step 12.** After clicking on "Copy to UCI FILE," the program generates an FTABLE that is compatible with the HSPF UCI format (Figure 11). To copy the FTABLE to a UCI file, select the entire FTABLE (left mouse click and drag), then press CTRL+C to export the file to a UCI file. For UCI file related guidance, refer to the section on UCI File modifications (Step 18).

```

TRAPEZOIDAL
FTABLE _ID***
rows cols ***
61 4
depth area volume riserorf***
0.00 1.1 0.00 0.00
0.1 1.14 0.11 0.00
0.2 1.18 0.23 0.00
0.3 1.21 0.35 0.00
0.4 1.25 0.47 0.00

```

Figure 11. Exporting FTABLE to HSPF UCI file.

## C. Infiltration BMPs That Use Natural Channels (e.g., wetlands)

Presently, BASINS/WinHSPF use either of two automated methods to generate FTABLES for a reach cross-section. These are the default and the alternate FTABLE methods. These automated FTABLE generation methods are intended for use in areas with no surveyed channel cross-section data (x, y). In reaches where surveyed channel cross-section data is available, users can select the natural channel option to generate FTABLES from surveyed data.

The natural channel option employs channel cross-section data that is similar to those obtained using the U.S. Army Corps of Engineers' HEC-RAS model. Just like HEC-RAS, when entering (x, y) data, x values must always increase from the left overbank to the right overbank (Figure 12). Although the natural channel program is capable of generating FTABLES for many irregular channel shapes, it may not work for some channel cross-sections. For example, it does not work for divided channels or for channels with fewer than six data points. In such cases, users may increase the number of data points by interpolation, or choose one of the regular channel shapes (e.g., trapezoidal) to approximate the natural channel.

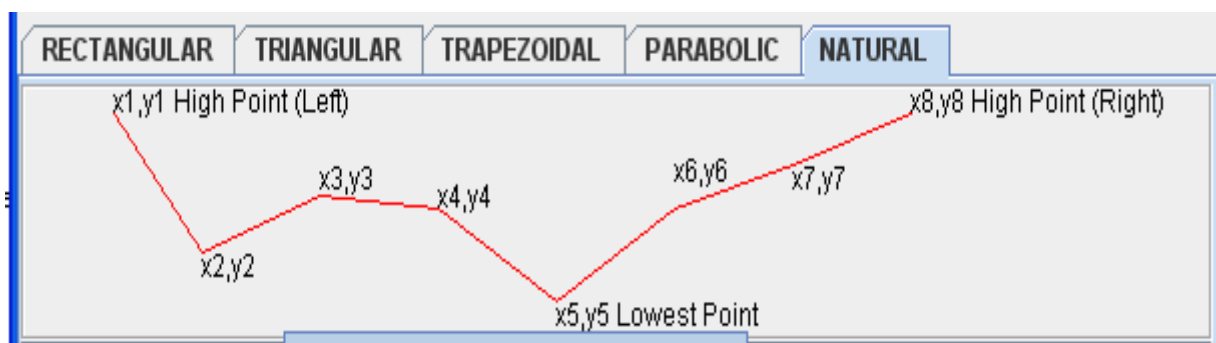


Figure 12. Schematic diagram of a natural channel cross-section.

**Step 13.** To use the natural channel FTABLE option, prepare cross-sectional data (x,y) data in comma-delimited text format (CSV) by using a text editor such as Notepad. The user must first populate the left-hand side of the input grid with channel length and other input parameters that vary with BMP type. To import (x, y) data, point the mouse at the input grid table and then right click to get “import from CSV file” (Figure 13). Also, users have the option to type data in the input table.

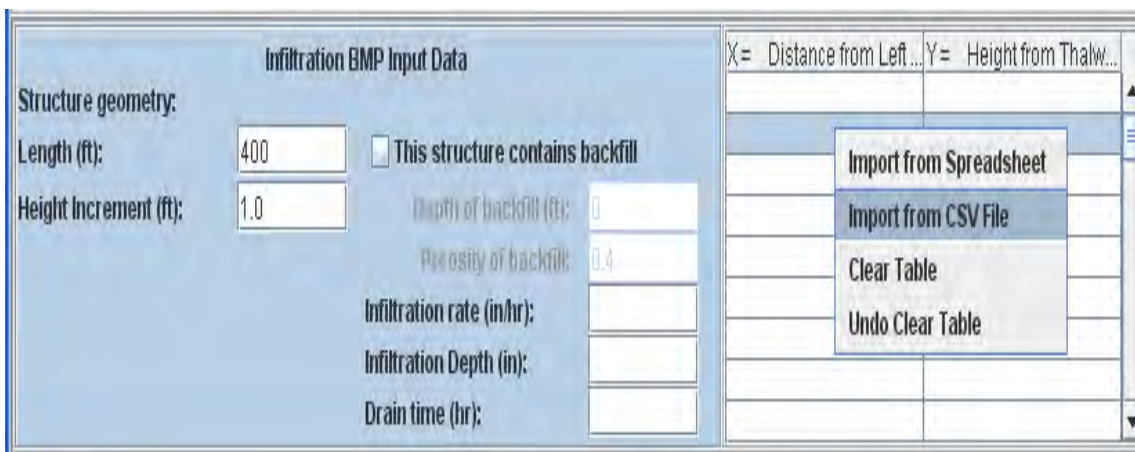


Figure 13. Natural input grid table.

**Step 14.** An empty Java Applet Window (Figure 14) will appear. Go to the input data file containing the (x, y) data (just a notepad not shown here), select all the (x, y) data, then copy it.

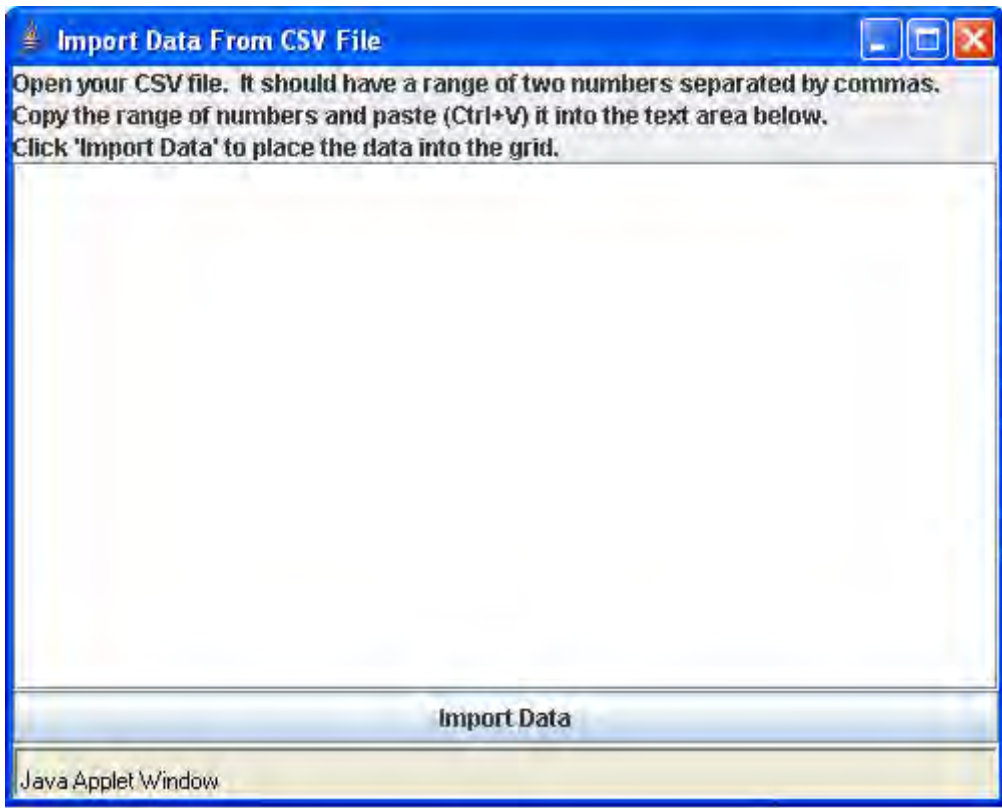


Figure 14. Data import screen.

**Step 15.** An example data file is shown in Figure 15. Go back to the empty Java Applet Window and hit CTRL+V to paste the data into the empty Applet Window shown in Figure 14.

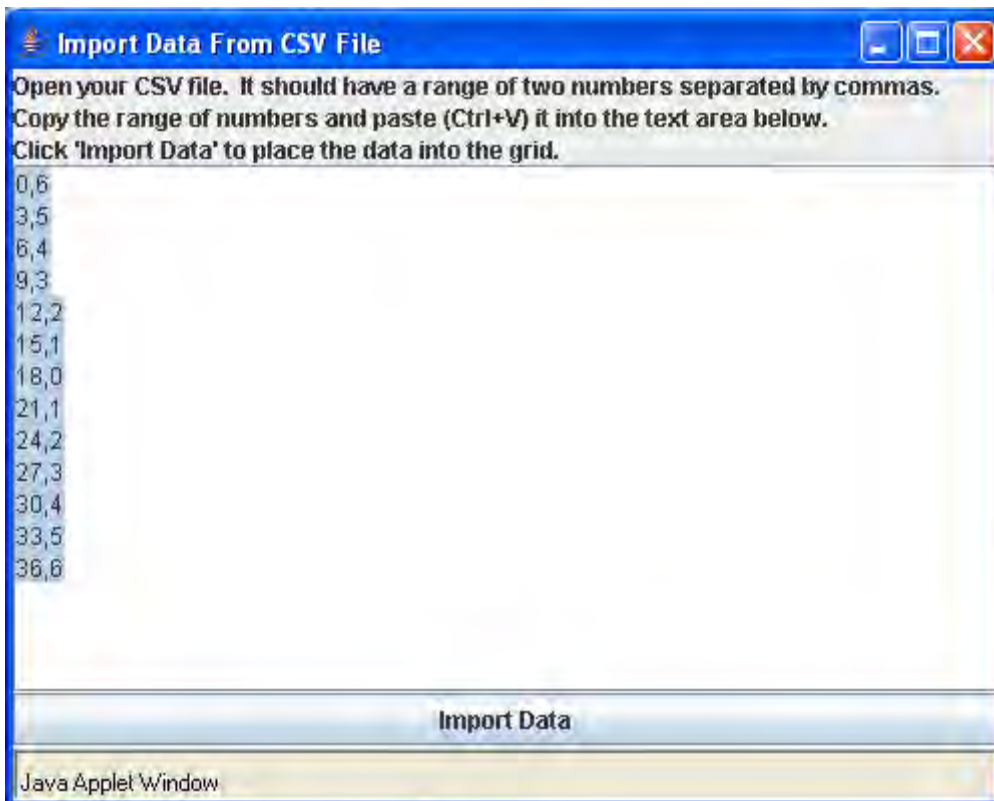


Figure 15. A Java Applet Window showing imported (x, y) data.

**STEP 16.** To transfer the pasted data into the natural channel grid, hit “Import Data” (see the lower side of Figure 15). Make sure that the data is entered into the grid as shown in Figure 16.

Infiltration BMP Input Data		X= Distance from Left...	Y= Height from Thalw...
Structure geometry:		0	6
Length (ft):	<input type="text" value="400"/>	3	5
Height Increment (ft):	<input type="text" value="1.0"/>	6	4
	<input type="checkbox"/> This structure contains backfill	9	3
	Depth of backfill (ft): <input type="text" value="0"/>	12	2
	Porosity of backfill: <input type="text" value="0.4"/>	15	1
	Infiltration rate (in/hr): <input type="text"/>	18	0
	Infiltration Depth (in): <input type="text"/>	21	1
	Drain time (hr): <input type="text"/>	24	2

Figure 16. A natural channel showing imported cross-section data points.

**STEP 17.** Generate an FTABLE by clicking on . Figure 17 shows an FTABLE for a natural channel. The default height increment is one foot for the natural channel. To refine the resolution of the FTABLE, set the height increment to any number

from 0 to 1. The generated FTABLE can be exported to a UCI following instructions given in Section B (transferring the calculated FTABLE to HSPF's UCI File).

Results		Copy Results		
Right click the grid for more options.				
depth(ft)	area(acres)	volume(ac-ft)	shpcstdwr(cfs)	infiltration(cfs)
0.000000	0.000000	0.000000	0.0	0.0000
0.100000	0.005510	0.000275	0.0	0.0459
0.200000	0.011019	0.001102	0.0	0.0919
0.300000	0.016529	0.002479	0.0	0.1378
0.400000	0.022039	0.004408	0.0	0.1838
0.500000	0.027548	0.006887	0.0	0.2297
0.600000	0.033058	0.009917	0.0	0.2757
0.700000	0.038567	0.013499	0.0	0.3216
0.800000	0.044077	0.017631	0.0	0.3676
0.900000	0.049587	0.022314	0.0	0.4135
1.000000	0.055096	0.027548	0.0	0.4594
1.100000	0.060606	0.033333	0.5324	0.5054
1.200000	0.066116	0.039669	1.5058	0.5513

Maximum Storage Capacity: 42,600 feet<sup>3</sup>

Figure 17. FTABLE generated for a natural channel.

## D. HSPF USER CONTROL INPUT (UCI) FILE MODIFICATIONS FOR BMP MODELING

**STEP 18.** To place the generated FTABLE in a UCI file, users must have an HSPF project with existing FTABLES. It is wise to save a backup copy of the UCI file before making any modifications. Select the UCI file to change in the HSPF project, open it with a text editor, identify the FTABLE to change, then paste the calculated FTABLE (copied from the Web-tool) above or below the existing FTABLE. Give the new FTABLE the same ID as the FTABLE being replaced. Make sure to delete or comment out the existing FTABLE.

```

*** TRAPEZOIDAL ***
FTABLE   _ID***
rows cols          ***
 61   5
  depth      area      volume      outflow1      riserorf ***
  0.00      1.1       0.00       0.00         0.00
  0.1       1.14       0.11       1.24         0.00
  0.2       1.18       0.23       3.92         0.00
  0.3       1.21       0.35       7.71         0.00
  0.4       1.25       0.47       12.48        0.00
  0.5       1.29       0.6        18.17        0.00
  0.6       1.32       0.73       24.73        0.00
  0.7       1.36       0.86       32.13        0.00
  0.8       1.4        1          40.33        0.00
  0.9       1.43       1.14       49.34        0.00
  1         1.47       1.29       59.13        0.00

```

Figure 18. An FTABLE generated for a trapezoidal channel.

**STEP 19.** Set the appropriate number of exits in the GEN-INFO block of the RCHRES section of the RCHRES module (Figure 19). Note that only Reach 8 has multiple exits in this example. Also set the Print Flags (not shown here) to 2.0 for the RCHRES section to allow the model to generate an output for each time step. This is important for testing and evaluation.

GEN-INFO									
***	Name	Nexits	Unit Systems		Printer				
***	RCHRES		t-series	Engl	Metr	LKFG			
***	x - x		in	out					
3	CIRCULAR PIPE	1	1	1	1	0	0	0	0
4	CIRCULAR PIPE	1	1	1	1	0	0	0	0
5	CIRCULAR PIPE	1	1	1	1	0	0	0	0
6	CIRCULAR PIPE	1	1	1	1	0	0	0	0
7	CIRCULAR PIPE	1	1	1	1	0	0	0	0
<b>8</b>	<b>NATURAL</b>	<b>5</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>
9	CIRCULAR PIPE	1	1	1	1	0	0	0	0

Figure 19. HSPF input table with a bolded multiple exit reach.

**STEP 20.** Select the exits that have control devices in HYDR-PARM1 and type those whose exit numbers are to be routed downstream. Users can select specific flow control exits by placing the exit numbers (4, 5, 6, 7, and 8) in the UCI file (Figure 20). Placing zero in a HYDR-PARM1 column allows HSPF to ignore the flow from that particular exit of the FTABLE.

```

HYDR-PARM1
***      Flags for HYDR section
***RC HRES VC A1 A2 A3 ODFVFG for each *** ODGTFG for each  FUNCT
for each
*** x - x FG FG FG FG possible exit *** possible exit possible exit
  3      0 1 1 1 4 0 0 0 0 0 0 0 0 0 3 3 3 3 3
  4      0 1 1 1 4 0 0 0 0 0 0 0 0 0 3 3 3 3 3
  5      0 1 1 1 4 0 0 0 0 0 0 0 0 0 3 3 3 3 3
  6      0 1 1 1 4 0 0 0 0 0 0 0 0 0 3 3 3 3 3
  7      0 1 1 1 4 0 0 0 0 0 0 0 0 0 3 3 3 3 3
  8      0 1 1 1 4 5 6 7 8 0 0 0 0 0 3 3 3 3 3
  9      0 1 1 1 4 0 0 0 0 0 0 0 0 0 3 3 3 3 3

END HYDR-PARM1

```

Figure 20. HSPF input table with a bolded multiple exit reach.

**STEP 21.** If more than one control device is used, one must modify the MASS-LINK block to allow volume-dependent outflows from multiple exits to be routed downstream (see bolded row of Figure 20).

```

MASS-LINK 5
<-Volume-> <-Grp> <-Member-><--Mult--> <-Target vols> <-Grp> <-Member-> ***
<Name> <Name> x x<-factor-> <Name> <Name> x x ***
***Reach Transfer of FLOW ***
RCHRES ROFLOW RCHRES INFLOW
RCHRES 8 OFLOW RCHRES INFLOW (multiple exit reach)
END MASS-LINK 5

```

Figure 21. A MASS-LINK Block with outflows from multiple exits.

**STEP 22.** Convert generated FTABLE channel length to miles and place it in the “LEN” Column 1 of HYDR-PARM2. To convert feet to miles, multiply feet by 0.000189394 and substitute that number for the one in the existing FTABLE. Make sure to choose the correct FTABLE ID Number.

```

HYDR-PARM2
*** RCHRES FTBW FTBU LEN DELTH STCOR KS DB50
*** x - x (miles) (ft) (ft) (in)
  1 0. 1 2.8 22 3.2 0.5 0.01
END HYDR-PARM2

```

Figure 22. HSPF input table showing reach length parameter in bold.



**STEP 23.** Save the UCI file and run the project with HSPFLite. If no errors are generated, users can import the project into WinHSPF if they wish to run HSPF this way.

## **E. BMP Modeling Limitations and Assumptions**

The current BMP tool does not support FTABLES for multiple layers. The maximum number of layers represented by a single FTABLE are two: an upper layer with ponded reservoir and a lower layer with a backfilled soil (underground reservoir). In cases where tool users need to use multiple layers, we recommend using separate FTABLES for different layers and then linking the FTABLES. Flow from one layer to another can be linked using the Schematic and the Mass-Link Blocks of the HSPF model. Methods to estimate infiltration rates for layered soils may also be added to a later release.

Infiltration BMPs are not suitable for sites with low infiltration capacity, high water table or in areas where the bedrock is too close to the ground surface.

Some assumption made when developing the tool include:

- 1) The infiltration BMPs use Darcy's law, but we assume that the hydraulic gradient is equal to one. Note that setting the hydraulic gradient equal to one ignores soil water pressure and depth of ponding. For infiltration BMPs that store water within a back-filled soil, the volume of the FTABLE is reduced by multiplying the calculated channel volume by the soil porosity (see the top right side of Figure 6). We assume an instant surface ponding and we ignore infiltration during rainfall events because the BMP filling time is much shorter than the draining time.
- 2) We assume that infiltration rate occurs on the wetted surface area of the surrounding soil. We therefore use surface area to calculate volumetric infiltration rate, but we do not consider infiltration into vertical sidewalls, i.e. rectangular sides. Ignoring infiltration into vertical sidewalls makes the infiltration rate calculation more conservative.

## REFERENCES

Bicknell, B.R., J.C. Imhoff, J.L. Kittle Jr., T.H. Jobs and A.S. Donigian Jr., Hydrological Simulation Program-FORTRAN. User's Manual for Release 12, U.S. EPA Ecosystem Research Division, Athens, Georgia/U.S. Geological Survey, Office of Surface Water, Reston, Virginia, USA (2001).

Maryland Department of Environment, Sediment and Stormwater Administration, Standard and Specifications for infiltration practices, February, 1984.

Rawls, W.J., Brakensiek, D.L., Miller N. 1983. Green-Ampt infiltration parameters from soil data. *Journal of Hydraulic Engineering* Vol. 109:62-70.

Rawls, W. J., D. L. Brakensiek and K. E. Saxton. 1982. Estimation of soil water properties. *Trans. Amer. Soc. of Agric. Engin.* 25(5):1316 1320, 1328..

Schueler, T.R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Metropolitan Washington Council of Governments, Washington, DC.

Soil Conservation Service (SCS), *Urban Hydrology for Small Watersheds*, Tech. Release 55, Washington, DC. 1986. Available online at <http://www.wcc.nrcs.usda.gov/water/quality/common/tr55/tr55.pdf>

## CONTACT US

If you have questions or would like to report bugs or make suggestions regarding the web-tool, please contact Yusuf Mohamoud at [mohamoud.yusuf@epa.gov](mailto:mohamoud.yusuf@epa.gov). Users may also contact the authors through the BASINS Listserver, making sure that the subject line is "HSPF Web-tools".

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