WASHINGTON STATE
DEPARTMENT OF
E C O L O G Y

Western Washington Hydrology Model
Version 2.1

User's Manual

DRAFT

Printed on Recycled Paper

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Version 2.1

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User's Manual

Prepared by

AQUA TERRA Consultants

Printed on Recycled Paper

To download the Western Washington Hydrology Model
and the electronic version of this user's manual,
please visit our website at:

http://www.ecy.wa.gov/programs/wq/stormwater/wwhm_training/wwhm/wwhm_v2/instructions_v2.html

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Introduction

The WWHM 2 is the 2nd edition of the Western Washington Hydrology Model. It was designed by the Washington State Department of Ecology and AQUA TERRA Consultants. This version is faster, more flexible and in many ways easier to use than its predecessor. Because of its flexibility you can now model a wide variety of projects including multiple basin models, water quality, and detention facility design.

Purpose

Size storm water control facilities that mitigate the effects of increased runoff (peak discharge, duration, and volume) from a proposed development on a stream using a computer model that represents the following:

• a uniform method for western Washington
• a more accurate method than single event design storms
• an easy–to–use software package

The computer program is based on:
• continuous simulation hydrology (HSPF)
• actual recorded precipitation
• measured pan evaporation
• historic vegetation
• regional HSPF parameters
Parameter values can be modified for local conditions.

What's New In Version 2

Land Use / User Interface
With extensive testing and use of the WWHM version 1, it became clear that users needed a software package with more flexibility to model a wide range of project types. Now users can enter multiple basins, ponds, and splitters in a visual schematic format. The model is no longer limited to single design, off-site, or bypass basins. Users may also enter different areas for pre- and post-developed scenarios to accommodate most any situation. Groundwater can also be modeled in version 2.

Pond Design
All pond design and stage-storage-discharge table calculations can now be done within the program. The WWHM2 has an extensive pond design interface that automatically computes hydraulic tables based on given pond dimensions and outlet structures. All of the equations for stage, volume and discharge are built in and comply with Department of Ecology standards. The pond design interface supports several pond types including trapezoidal, vault, tank, and irregular user-defined shapes. Users can also import tables generated outside the program, or export pond tables for use with other software packages.

AutoPond
Given current and future land use, the AutoPond feature of the WWHM2 can design a trapezoidal pond that efficiently meets Department of Ecology requirements. The user can adjust how thorough or fast the AutoPond will function.

Water Quality The WWHM2 will calculate the volume needed for a water quality facility based on current DOE requirements.

Computer Requirements
• Windows 9x/ME/2000/XP with 50 MB uncompressed hard drive space
• Internet access (only required for downloading program, not required for executing WWHM)
• Pentium 2 or faster processor (desirable)
• Color monitor (desirable)

Before Starting the Program
• Site location or street address
• A real distribution of existing site soil by category (outwash, till, wetland)
• A real distribution of proposed development (residences, streets/sidewalks, landscaped areas) in relation to the soil categories
• At least a first approximation for storm water control facility (top surface area)
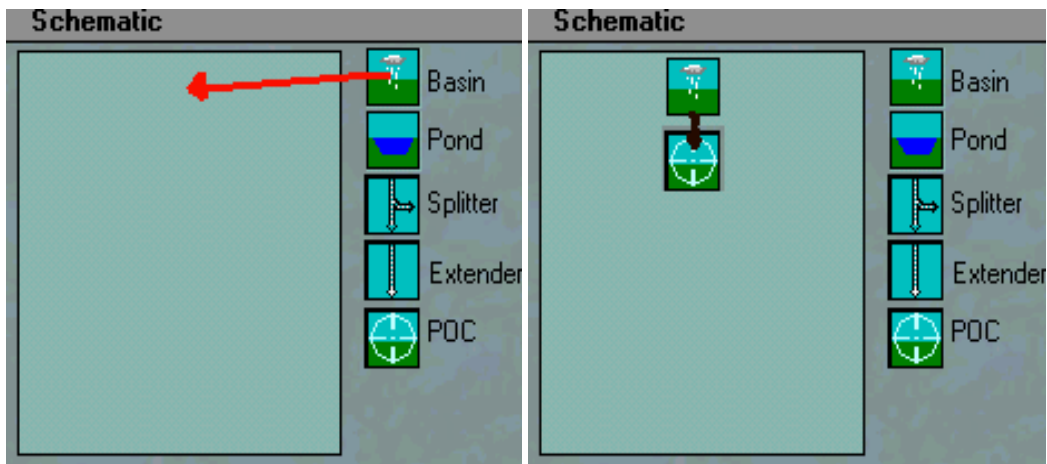
Quick Start

Here is a brief set of steps to demonstrate pond sizing using the WWHM2.

1.   On the map screen (the first screen that shows up) click somewhere within the county boundaries.
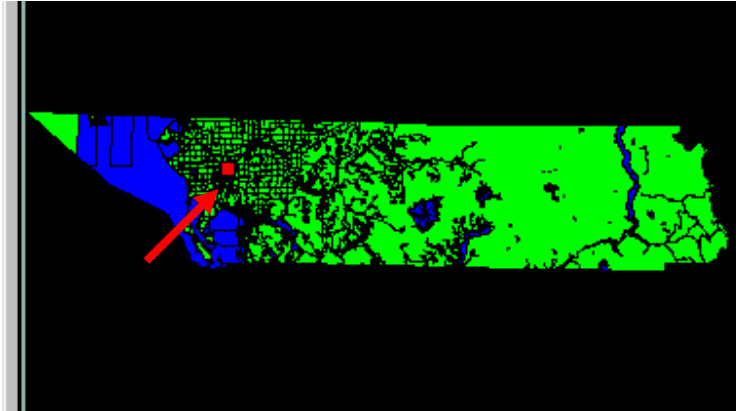
Tool bar

2.   On the Tool bar (above the map screen) click the second button to switch to the Scenario Editor.

Schematic

3.   Drag and drop the Basin Icon somewhere towards the top of the Schematic. You should then have a basin in your schematic flowing to the Point of Compliance (POC) The POC represents outflow or the sum of all flow from your project.

4.   Left click on the basin you just added. This will open a window on the right where you can enter land use for this basin.

Basin Information

5.   Enter 10 acres in the field for Till Forest, and then click the Update button. You have now set your pre-developed conditions to 10 acres of Till Forest.

Change Scenarios

6.   Now press the Developed Unmitigated button just below the schematic. Now you can enter basins and land use for your Developed unmitigated Scenario.

Now drag and drop a basin as you did in step 3. Click on it to enter land use as in step 4. This time instead of 10 acres of till forest, enter:

5 acres of Streets/Sidewalks/Parking.
3 acres of Landscaped Area.
1 acre of Impervious Area (Roof).
1 acre of Pond.

Be sure it's all in the middle column indicating it's on till soils as in the pre-developed Scenario. The screen should look like this:
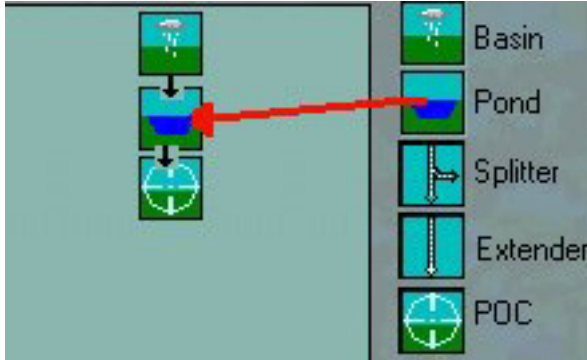

Developed Land Use

Then click the update button.

7.   Now click the Developed Mitigated button below the schematic. This brings you to the final Scenario where your detention facility will be placed. Notice that your Developed basin is already there. Now drag and drop a pond into the space just below the basin. The schematic should look like this:

8.

Drag and drop a pond

8.   Click on the pond to open the pond-editing window. You can edit any aspect of the pond from here, but for now, just click the Auto Pond button at the bottom. This will open up the **Pond Wizard** window.
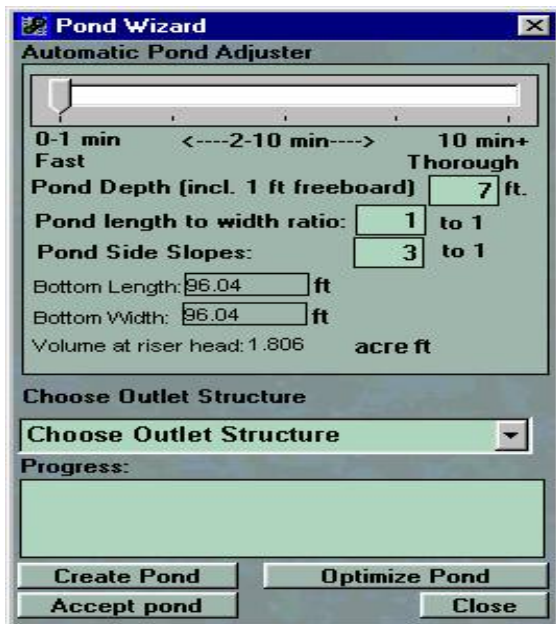

Pond Wizard

First choose an outlet structure from the drop-down list in the middle of the Pond Wizard form. Select the first option (1 Orifice & Rectangular Notch).

Next, press the Create Pond button. You will see a progress bar pop up to indicate that HSPF is running the model and the pond wizard is creating a pond according to the results.

9.   The Pond Wizard will then automatically bring you to the **Run Model** screen.
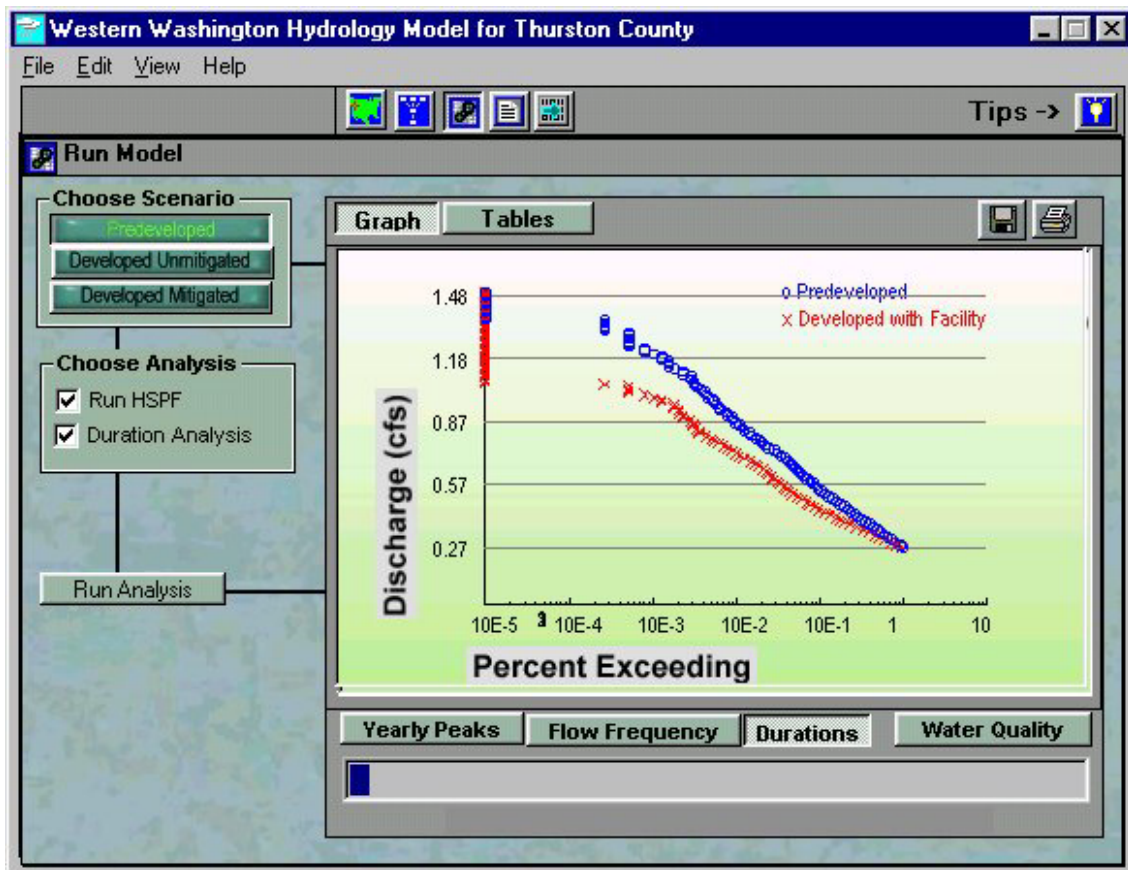
Run Model Screen

You can view the results in graphs or tables. For yearly peaks, select a scenario to view (upper left) and click the yearly peaks button. Flow frequency and durations always show pre-developed vs. developed mitigated.

If you wish to change the pond and re-run the model, take the following steps:

Go back to the Scenario editor (2nd Tool bar button).
Chose the Developed Mitigated Scenario.
Click on your pond.
Change one or more pond values and click Update.
Go back to the Run Model screen (3rd Tool bar button).
Chose the developed mitigated Scenario.
Check the Run HSPF and Duration Analysis check boxes.
Click Run Analysis.

Main Screens

Tool bar

You can navigate through the main screens by using the view menu or by pressing the buttons on the tool bar.
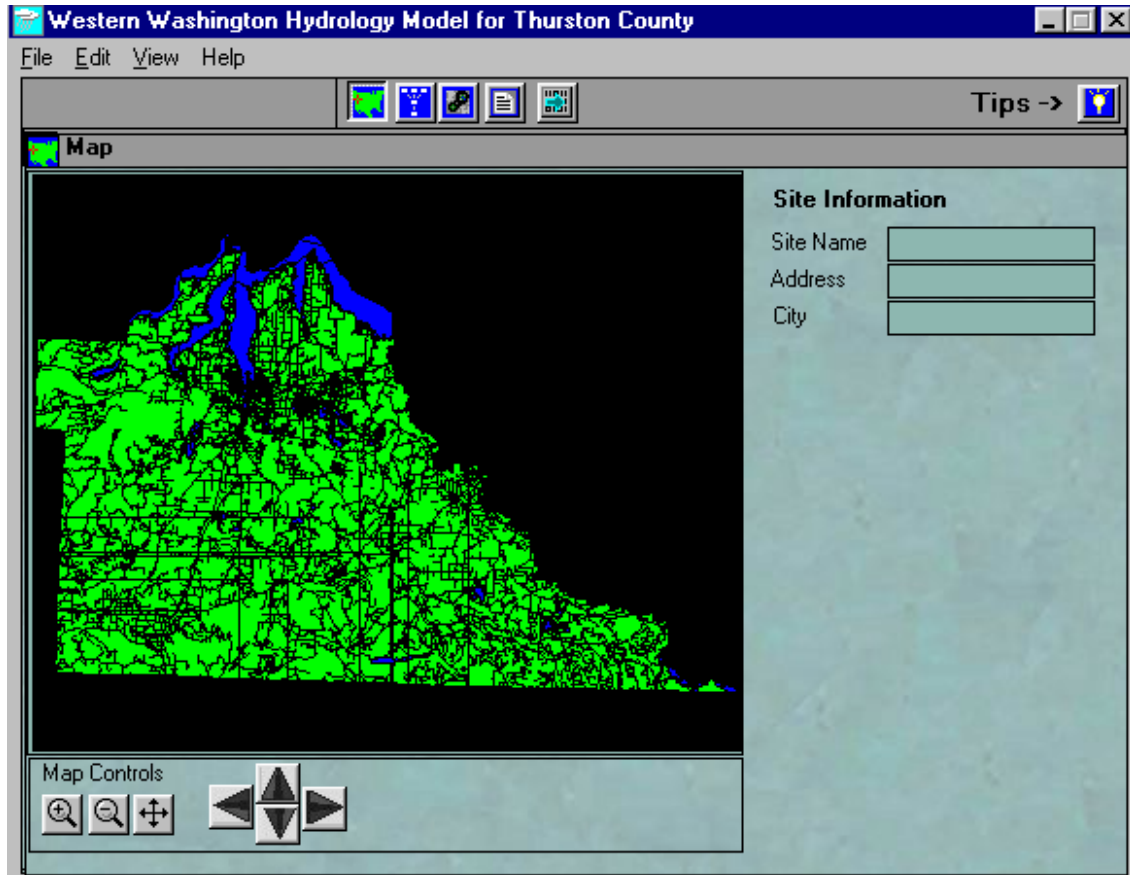
The screens are:

MAP

SCENARIO EDITOR

RUN MODEL   VIEW RESULTS   WATER QUALITY

REPORT GENERATOR

VIEW / EXPORT Time Series Data.

Map

The map contains regional information about the county you are working in. Evaporation and Precipitation factors vary by project site location.

Map Screen

Map controls:
Left-click on the map to place your project site.
Right-click on the map to re-center the view.
The + and - buttons zoom in and out.
The cross hair button zooms out to the full county view.
The arrow keys scroll the map view.

The fields on the right are for entering the site information. They do not affect the model, but will be stored along with the project and viewed in the project report.

As you zoom in closer, street names will appear on the map and a button called Hide Street names will appear just to the right of the map controls. Press it if you don't want the street names to be displayed.

Scenario Editor
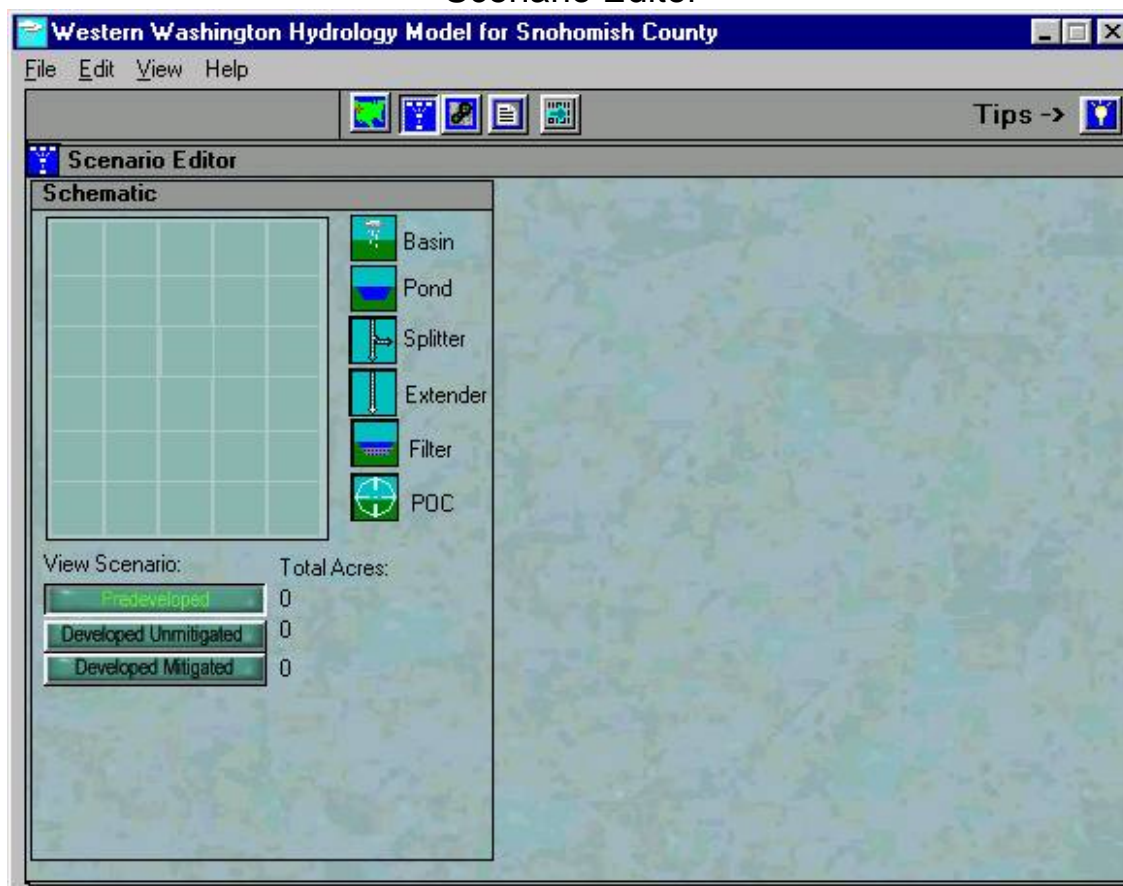
Scenario Editor

Use the Scenario editor to edit the layout of pre-developed, developed unmitigated and developed mitigated conditions of your development. To switch between the scenarios, click the respective buttons just below the Schematic.

Pre-developed --The existing conditions before the development. Runoff from this scenario is used as a target for your mitigated scenario to comply with. Unless there are special circumstances, DOE requires that all land use be entered as Forested. The model will accept any land use for this scenario.

Developed Unmitigated-- This is used to show the impact of the development before the main detention facility is built. It is used for the automated pond sizing and for water quality.

 Developed Mitigated-- This is the final scenario, which is used for sizing detention pond(s). The flow from this scenario is compared to the flow from the pre-developed scenario to determine compliance with DOE standards.

The space on the right of the screen will contain all of the information for any element in the schematic you select. If you have placed a basin on the schematic, then click on it, a window will pop up here with all of the information about that basin.

Schematic Editor
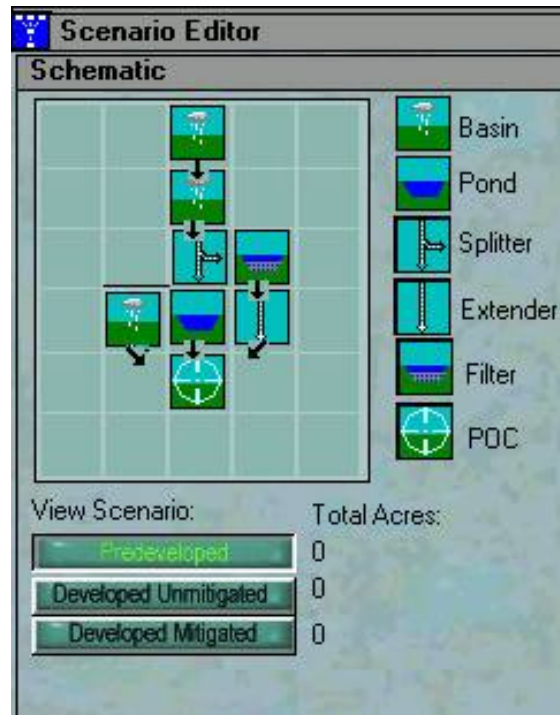
Schematic

The Schematic Editor allows you to graphically place the elements in your project according to how water flows through them. To add an element to your schematic, such as a basin, simply drag the basin icon to somewhere on the schematic window. The elements at the top of your schematic represent the most upstream parts of your project. The small black arrows represent the direction of downstream flow.

In the figure (above) the top most basin is off site inflow. It is flowing into another basin (design basin), which then flows to a splitter. The splitter diverts some of the flow to a water quality pond to the right, while the rest goes to a detention facility. To the left of the detention pond there is another basin that is considered bypass because it bypasses all ponds and flows straight to the point of compliance. The water quality pond also goes to the point of compliance via a flow extender.

Basins

The basin icon on the schematic:

A basin can have any combination of soil types, vegetative covers and land uses. The sum of all the rainwater for a given basin drains to the next downstream element in the schematic. To create a basin in the WWHM, use the mouse to drag the basin icon to somewhere on the schematic as shown in figure 1.

Figure 1
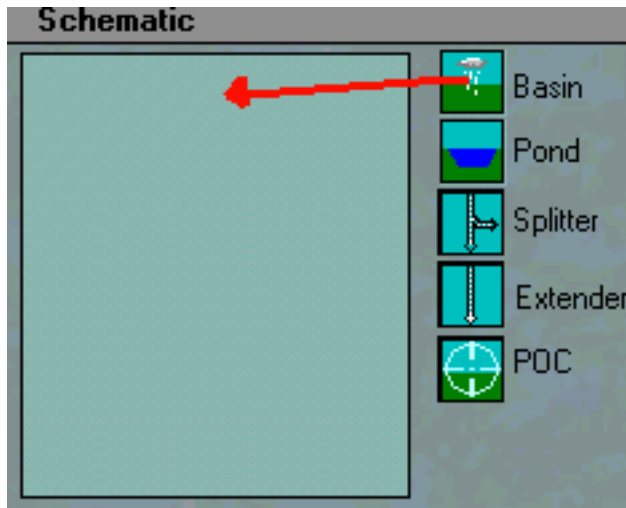
Once it is placed, a small black arrow will appear below it and a point of compliance. The point of compliance symbol is automatically placed below the arrow. This indicates that all storm water runoff from this basin will be considered outflow or water leaving the project.
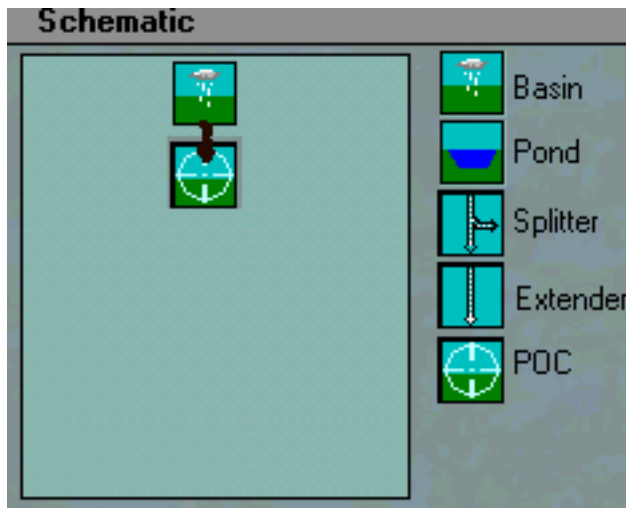
Figure 2

To edit a basin click on it and the Basin Information Window will appear on the right side of the schematic.

Basin Information Screen

All of the text boxes can be edited to change information about the selected basin.

When a basin is created it is automatically given a default name; in this case, "Basin 1." You can rename the basin to any name you wish.

Below the basin name is a box labeled Flows To. This box shows the name of whatever is directly downstream of the selected basin. In this case it is a Point of Compliance, so the word "Outflow" appears. You can control where a basin (or any element in the schematic) flows to by using the arrow symbol.

There are 6 basic land use categories and 3 soil types available in the WWHM2:

Impervious Area (Roof):
This is modeled as impervious area with the ability to apply flow credits for roof runoff. It is possible to infiltrate or disperse a percentage of roof runoff.

Streets/Sidewalks/Parking:
This is modeled as impervious area with the ability to apply porous pavement credits.

Landscaped Area. This is modeled as lawn.

Forest:
This is modeled as 2nd growth Douglas Fir that is the primary type of forest vegetation for much of Western Washington. According to the DOE Stormwater Manual all pre-developed area must be considered forest unless special requirements are met. If the developed scenario Includes forested area, then DOE requires some legal assurance that the area will remain forested. The WWHM2 allows any combination of land use to be modeled in any scenario.

Pasture:
This can be used for both pre and post developed conditions, provided DOE requirements are met.

Pond:
Although ponds are shown separately on the schematic, they are physically located *within* a basin that is part of your development. A certain area that once was forested (or some other pre-developed condition) becomes pond area in your developed scenario. The WWHM2 treats pond area as impervious. When designing the basin, enter an estimated pond area in the developed unmitigated scenario.

Standard Residential:
For housing developments see Standard Residential.

Credits:
Used to model dispersal or infiltration of roof runoff, and apply credit for porous pavement. See Runoff Credits.

When you have finished entering all the information for your basin, click the **Update** button.

Standard Residential

The standard residential land use window is used for housing developments when the developer doesn't know exactly how much of each type of land use/ vegetative cover each lot will be. The WWHM can calculate land use for the model based on the number of residential lots to be developed and some assumptions about residential land use in Western Washington. If you know the exact areas to be used in a housing development you simply enter them in the **Land Use / Vegetative Cover** portion of the basin, without using the Standard Residential option.

To add some standard residential lots to a basin, click anywhere on the bar labeled Standard Residential Land Use.

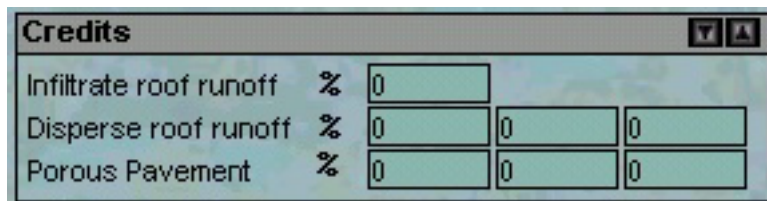| Standard Residential Land Use	▼	▲	
Lot Acres	0	0	0
Number of Lots	0	0	0

Standard Residential Land Use Window

The window will drop down showing 2 rows labeled **Lot Acres**, and **Number of Lots**. The columns line up with the above land use columns which represent the 3 different soil types available in the WWHM2: **Outwash**, **Till**, and **Saturated**.

Lot Acres: The number of acres, which are set aside for your residential development in each soil type.

Number of Lots: How many residential lots you have within the lot acres. The WWHM2 can model a maximum of 10 lots per acre.

For each soil type, the WWHM2 assumes **4200** square feet of impervious area for each lot. The rest is considered Landscaped Area. Of the impervious area, **3200** square feet is considered roof area and **1000** square feet is considered driveway.

Runoff Credits

Credits Window

If you are applying building practices that reduce the runoff from your development, then enter them here.

The 3 columns of text boxes appear below the normal land use in the basin window when you open up the credits window. These represent percentages of land to which credits are applied in the 3 soil types that are available: A/B soils, C soils and D/Wetland soils. You can enter percentages of each credit for each of the three soil types.

Infiltrate Roof Runoff: This allows for a percentage of roof runoff to be removed from the system by infiltrating it into groundwater. It can only occur on A/B soils and when DOE requirements are met.

Disperse Roof Runoff: This causes a percentage of roof area in your development to be modeled as grass/lawn.

Porous Pavement: If you are using porous pavement as specified in the DOE Stormwater Manual, then enter the percentage of total pavement that is porous.

Groundwater Button: This button, located at the top right of the Basin Editor, sets whether or not groundwater is included in the model.

Ponds

Ponds are represented in the schematic by the pond icon:

A pond represents a stage-storage-discharge table in the model. The WWHM supports several pond types with different types of outlet structures. To add a pond, left click on the pond icon in the Schematic Editor, then drag it to somewhere on the Schematic.
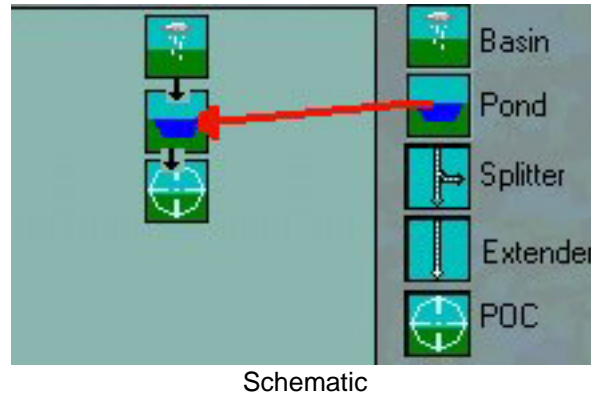
Schematic

In the figure above, we have placed the pond directly beneath a basin. The runoff from that basin will now flow into the pond. To edit the pond, click on it in the schematic. The Pond Information/Design window will appear on the right.

Pond Information/Design

Pond Info. Design Screen

When a pond is created it is automatically given a default name; in this case, "Pond 1." You can change that to any name you wish.

Below the pond name is a drop down box where you can select what pond type this will be. There are 4 types of ponds in the WWHM:

Trapezoidal Pond
Tank
Vault
Irregular

Below the pond type is a box labeled "Flows To." This box shows the name of the element that is directly downstream of the selected pond. In this case it is a point of compliance, then the words "Point of Compliance" appear. You can control where a pond (or any element in the schematic) flows to by using the arrow symbol.

There are 2 options for Facility Type: Detention Facility and Water Quality. Detention facilities are designed to store water and release it according to flow duration guidelines. Water quality facilities are designed to store a specific volume of water for a certain amount of time according to water quality guidelines. Choosing one option or the other has no effect on the model except that the facility type is noted and included in the report.

The Bottom Elevation text box is used to set the bottom elevation for the pond table. All pond stage calculations will be done relative to this number. The default value is 0 ft (sea level). Negative numbers are not allowed.

There are 4 windows available to enter your pond data. The Dimensions, Riser/Wier, and Infiltration windows contain all the data needed for the WWHM to calculate the SSD (Stage Storage Discharge) table. The SSD window shows the SSD table for the selected pond and allows you to save or load a pond.
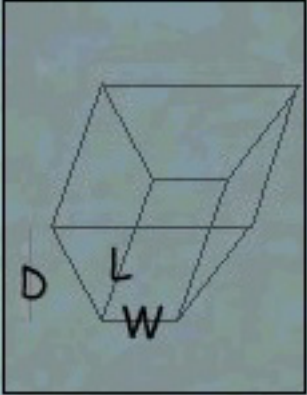
When you have entered all your pond information press the Update button to store all the data and compute the pond (SSD) table for that pond.

Pond Types / Dimensions

The physical layout of your pond depends on the pond type you have chosen.

Trapezoidal Pond:

Trapezoidal Pond Dimensions
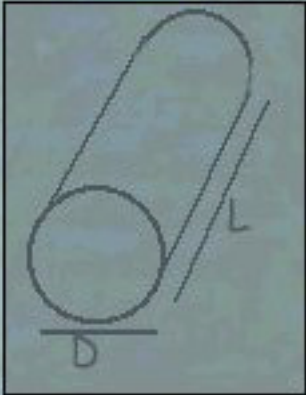
A trapezoidal pond has 4 sides, 4 side slopes and a depth. Its top and bottom are rectangular. The user enters the bottom length and width. The top length and width are calculated automatically based on the side slopes.

The side slopes are numbered clockwise around the pond, so sides 1 and 3 are opposite each other and represent the *width* of the pond, while sides 2 and 4 represent the *length.*

Note: The depth of a pond is relative to the pond elevation. If you entered 30ft for pond bottom elevation and 7 ft for the pond depth, the top of the pond will be at 37 ft elevation.

Tank:
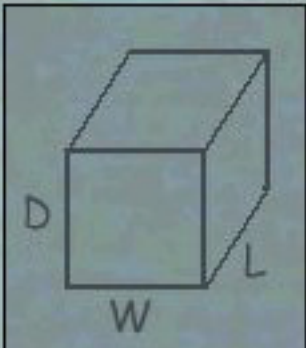
Tank Dimensions

A tank is a cylinder which is laid on its side. It is represented in the WWHM with a diameter and a length. If the tank is arched (oval shaped on the ends) then select the Arched button and enter in the height, width and length.

Vault:

Vault Dimensions

The vault is defined by a length, width and effective depth (the entire depth of the vault).

Irregular Pond:
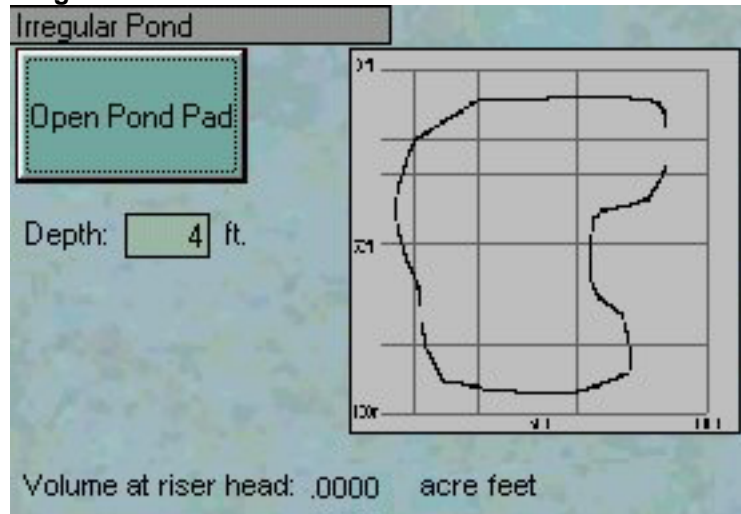
Irregular Pond

To enter ponds of any shape, choose irregular pond. Enter the desired depth (including overflow) and then press the Open Pond Pad button. This opens the Pond Pad interface where you can graphically define the top edge of your pond as well as the side-slopes for all the sides.

Pond Table:

This is for ponds that have been generated outside the WWHM2 and the table has been imported into the WWHM2. The program will use the pond table when running the model, but cannot modify the dimensions or outlet structure of an imported pond.

Pond Pad Interface

PondPad was originally designed as a stand-alone tool for generating hydraulic Stage Area Storage tables from user-defined shapes, then it was fully integrated into the WWHM2 as another way to define your pond shape.

The pond shape and size is defined by the grid scale, the outline of the **top** of the pond and the side slopes.

Quick steps to define a pond

1 Select the **line** button (second from the top)

2 Move the mouse over the grid somewhere near the top left corner and press the mouse button. This will set the first point where the first side will be drawn from. Next click the mouse somewhere to the right of your previous dot.
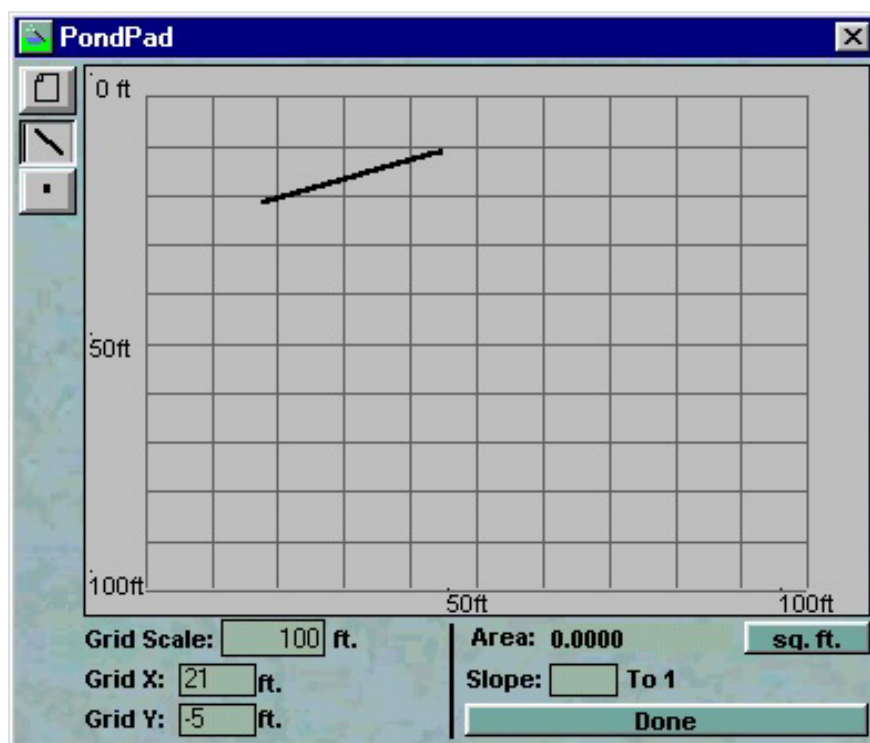
(Making the First Side)

3. Continue making lines around the perimeter of your pond. **You must draw the perimeter of your pond in a clockwise fashion.** As you do this you will notice the last side of your pond is automatically drawn for you and the area in square feet is automatically calculated as you draw the pond and this information is shown on the right just below the grid.
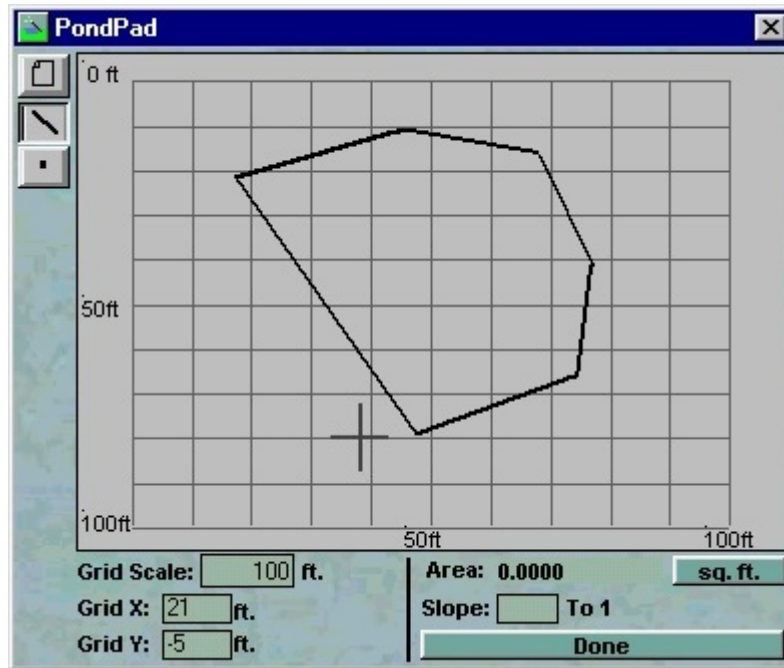
(drawing the perimeter)

4. Once the pond is drawn then you can adjust the points by selecting the Point Tool on the left. Red circles will appear at the vertices between each side. You can left-click on these points and drag them around to adjust your pond.
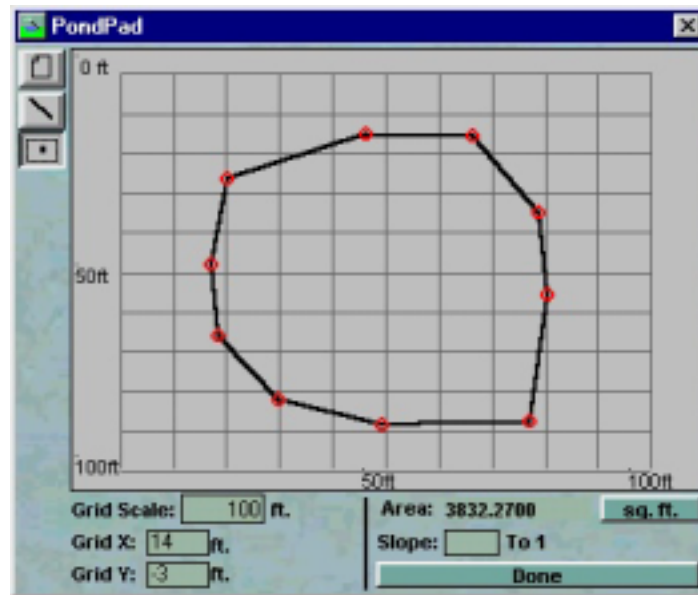
(moving the points)

5. Once you have adjusted the perimeter of your pond, you can define the side slopes by right clicking on any of the sides. The selected side will turn red and its slope will be displayed below the grid in the **Slope** text box. The default slope for all sides is 3 to 1. You can change this for any given side by entering a number in the slope text box.

If you have changed the slope, then a button will appear to the right titled **Change All**. If you press this then all side slopes will be changed to the value you have just entered for the selected side.

6. Press Done and the Stage Storage Area part of the SSD table for your pond will be automatically calculated based on the pond you have entered.

Controls and Numbers

Clear:	The Clear button clears all the lines.
Line:	The Line button allows the user to draw new lines with the mouse.
Point:	The Point button allows the user to move around the points to alter the pond shape.
Sq ft:	Converts the computed pond area between square feet and acres.
Done:	Closes Pond Pad and computes the SSD table for your irregular pond.
Grid Scale:	Changes the maximum area of the grid. Default = 100 feet. Changing the Grid Scale will change the overall area of your pond accordingly.
Grid Y:	This is the Y location of your cursor in feet. (0 ft being the upper left corner)
Grid X:	This is the X location of your cursor in feet. (0 ft being the upper left corner)
Area:	This is the top area of the pond.
Slope:	This shows the slope for the selected line (side of the pond).

Riser / Weir

Riser/Weir

The Riser / Weir screen is used to enter the specifications for the outlet structure of the selected pond.

The riser can have up to 3 round vertical orifices, and a notch.

The riser is a vertical pipe which controls the flow of water from the pond.

The riser / orifice equations used by the WWHM2 can be found on page 53.

Riser Head: This is the height from the bottom of the pond to the top of your riser. This is generally set at 1 foot below the pond depth.

Riser Diameter: Sets the diameter of the riser. This affects the overflow of the pond.

Orifice Window: This Here you can set the diameter and elevation (from the pond bottom) of up to 3 orifices. If the pond dimensions have already been defined, the Qmax (cfs) or orifice discharge when the pond is full will be automatically calculated and displayed at the bottom of the frame. Use the arrows to switch among the 3 orifices.

Flat/Notched Buttons: If the riser has a notch, select notched. This will open a window to edit the notch specifications.

Notch Type: There are 3 types of notches available in the WWHM2.
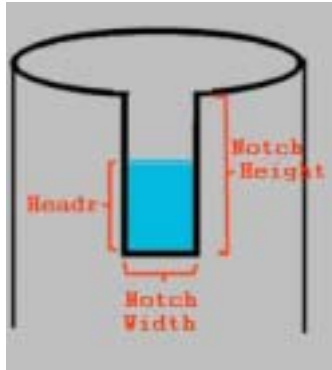
Rectangular Notch

V-Notch

Sutro Notch

Infiltration

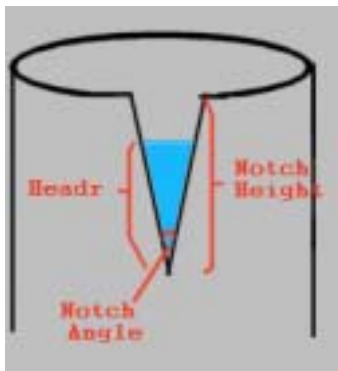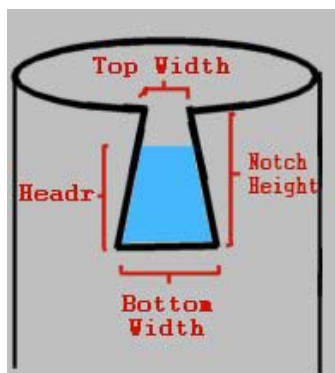Infiltration Screen

Detention ponds may be sited on till soils that are sufficiently permeable for a properly functioning infiltration system (see Section 3.3 of the DOE Stormwater Manual). These detention ponds have a surface discharge and may also utilize infiltration as a second pond discharge. Detention ponds sized with infiltration as a second outflow must meet all the requirements of Section 3.3 for infiltration ponds, including a soils report, testing, groundwater protection, pre-settling, and construction techniques.

To activate the second (infiltration) outlet for your selected pond, press the on/off button in the upper right corner so it is lighted green. Enter your measured infiltration rate in inches per hour. The infiltration safety factor is a less than 1 multiplier (a fraction such as 0.5) which is applied to your Infiltration Rate in the simulation.

If the Use **Wetted Surface Area** button is selected, then infiltration will be applied to the area of the sides of the pond as well as the bottom area. Otherwise just the bottom area is used.

 When the model is run (the user has selected Run Model from the Run Model / View Results screen) volume calculations for the pond will be displayed at the bottom of the infiltration screen. This tells the user how much water in acre-feet has been infiltrated and how much has left the pond through the riser/outlet structure.

Stage Storage Discharge Table

| Dimensions | Riser / Weir | Infiltration | SSD Table |

Stage-Storage-Discharge Table

Stage	Area	Storage	Discharge	Infilt
0.000000	0.993205	0.000000	0.000000	0.000000
0.100000	0.998943	0.099607	0.021262	0.000000
0.200000	1.004698	0.199789	0.030069	0.000000
0.300000	1.010469	0.300548	0.036826	0.000000
0.400000	1.016257	0.401884	0.042523	0.000000
0.500000	1.022062	0.503800	0.047543	0.000000
0.600000	1.027882	0.606297	0.052080	0.000000
0.700000	1.033720	0.709377	0.056253	0.000000
0.800000	1.039574	0.813042	0.060137	0.000000

Increment: 0.1

SSD Table

When the dimensions and outlet structure of the pond are defined, the WWHM2 will automatically calculate a hydraulic stage-storage-discharge table, which represents the pond in an HSPF simulation.

The Increment text box is used to change the increment of the stage column in the table. The refresh/recalculate button (with gears on it) will refresh the table if changes are made in the pond information.

From this screen you can save or load the pond. There are 2 ways to save a pond.*

1. A pond (*.pnd) file. This file contains all the information about the pond including type, dimension and outlet structure as well as it's name and any other information the WWHM2 has about the pond. This file can be loaded back into the WWHM2 as a pnd file and the saved pond will be exactly restored as it was saved.

2.* A text (*.txt) file. This is just the Stage-Storage-Discharge table as shown in the window. It can be loaded into other programs like Word or Excel as a space delimited file. This way you can also import pond tables that have been generated in other programs.

Note: If you load a table as a *txt file then all other pond options are disabled. You can not modify an imported pond.

* **You can also save a pond or a basin by right-clicking on it in the schematic and selecting "save."**

Autopond
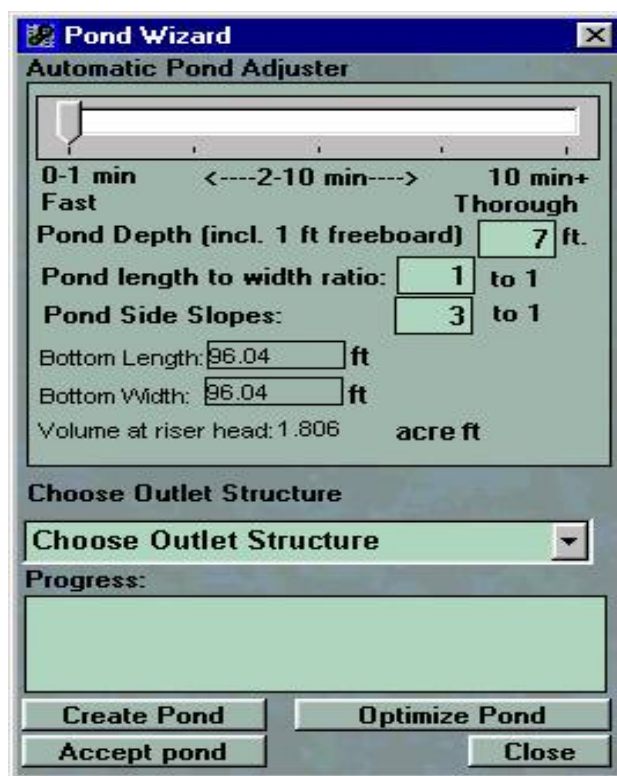
Pond Wizard

Autopond will create a pond, size it and design the outlet structure automatically to meet DOE criteria for durations. With this tool, you can either create a pond from scratch or optimize an existing pond design.

The autopond button appears at the bottom of the pond wizard screen. It appears only in the developed mitigated scenario. To use autopond you must have a basin with some land use which contributes to the pond you wish to have automatically sized.

Once you have a basin draining to a pond in the developed mitigated scenario, click the pond to open the pond editor. At the bottom of the screen, click the autopond button to open the Pond Wizard.

Pond Wizard Controls:

1. Automatic Pond Adjuster: The slider at the top of the Pond Wizard determines how thoroughly the pond will be designed for efficiency. The lowest setting (0-1 minute) constructs a pond with no optimizations. The second setting will create a pond and resize it until it passes DOE requirements. The 3rd, 4th and 5th settings will make more attempts and try more time consuming methods of making the pond more efficient with respect to size. Generally a higher setting will produce a smaller pond, but can take a lot longer.

2. Pond Depth (including 1 foot of freeboard):   This will determine the depth of the pond. There must be at least 1 foot above the riser head. The pond's original depth will be used when optimizing an existing pond. If the user changes this box then the change will override any previous depth value.

3. Pond Length to Width Ratio: This sets an absolute length to width ratio regardless of size or orientation.

4. Side Slopes: This sets how many feet inward the pond bottom slopes for each foot down. 3 to 1 side slope means each side goes down 1 foot for every 3 feet toward the center of the pond until the bottom of the pond is reached. Autopond assumes all sides have the same side slope.

5 Bottom Length/ Width and Depth to Riser Head: These are calculated according to the other information given and autopond routines during pond-sizing. They cannot be changed directly by the user.

6. Choose Outlet Structure: Autopond can create or size a pond that has either 1 orifice and a rectangular notch, or 3 orifices.

7. Progress Window: Gives some indication as to what autopond is doing. When the pond is finished, it will say "Pond Computed."

8. Create Pond: Creates a pond with the given values and outlet structure and optimizes it according to DOE or user-defined pass-fail guidelines.

9. Optimize pond: If an existing pond has one of the 2 available outlet structures, this will optimize the pond either for size according to DOE standards, or user-defined pass-fail guidelines.

10. Accept Pond: Accept Pond will stop it the autopond routine. Note: this button may not respond right away if HSPF is running. It will eventually stop the autopond process.

There are some scenarios for which autopond cannot create an initial pond. If, for example, a splitter is flowing to another splitter, then to the pond, it is difficult for Autopond to determine which land use/runoff will be contributing to the pond.

Splitters

Splitters are represented on the schematic by the splitter icon:

Splitters have 2 outlets: a **primary outlet** and a **secondary outlet**. The primary outlet is represented on the schematic as flowing directly downstream of the splitter (the down arrow). The right arrow represents the secondary outlet.

The flow is split based on a user defined flow value called the **threshold**. All flows under the threshold go to one of the outlets, and flows in excess of the threshold go to the other outlet. The user can define which outlet is primary and which outlet is secondary.
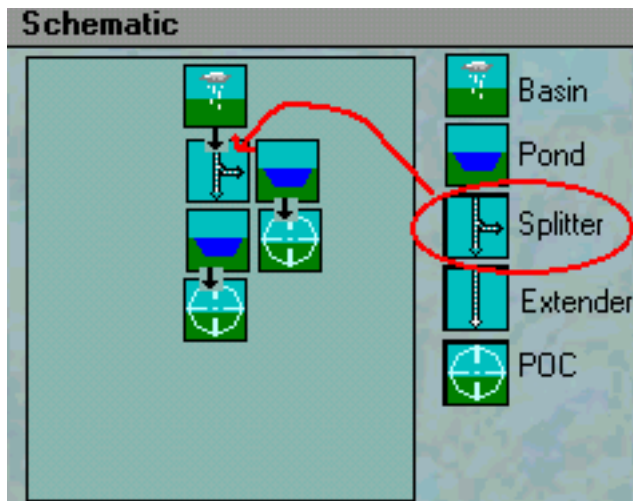
Splitter in the Schematic

Extenders

Extenders are represented on the schematic by a down arrow symbol:

Extender in the Schematic

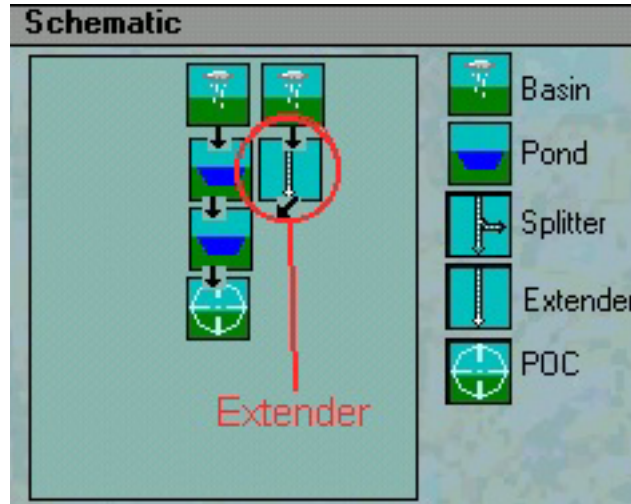To add an extender, drag and drop the extender icon into the schematic where you want it. The extender just routs the flow from one element to another. In this case there is a basin flowing to an extender which is flowing to
a second pond.

Several elements can flow into an extender and the sum of their flows will be
routed either to the next element downstream or to the point of compliance.

Extenders have no effect on the flow other than to change its destination.
If A flows to an extender which then flows to B, it is exactly the same as A flowing to B.

A => [extender] => B   is the same as A => B

Filters

The filter element routs runoff through a filtration material such as sand.

They are represented on the schematic with the filter symbol:

Place the filter on the schematic by dragging and dropping it on to the desired location as you would any other element. A filter acts much like a trapezoidal pond, it has dimensions, an outlet structure, and a stage-storage-discharge table, and it has a filtration element.

Filtration Screen

The Hydraulic Conductivity (in/hr) represents how much water can flow through the filter material in a given amount of time. The filter depth also determines how quickly water can be filtered. The filter discharge is calculated with the following equation:

$Q = K \, I \, A$

Where Q = flow rate in cubic feet per second (cfs).

K = Hydraulic Conductivity (inches/hour). For sand filters K = 1.0 inch/hour. Sand is the default medium and the K value should be set at 1.0 in/hr. However, if another type of medium is used the design engineer can enter the appropriate K supported by documentation and approved by the reviewing authority.

DOE requires at least 91% of the total volume of water going into a filter runs through the filtration material.

To design a filter, first set up it's dimensions and outlet structure just as you would a pond, then press the "Filtration" button to enter the Hydraulic Conductivity and the Filter Material Depth. The default hydraulic conductivity is set at 1 in/hr and the default filter material depth is 1.5 feet.

Once you have a basin and filter set up, select the Run Model icon from the tool bar (or select run model/statistics screen from the view menu) and run HSPF for the scenario in which your filter exists.

Once you have run HSPF, the volume calculations for filtration facilities are automatically updated. Go back to the scenario editor and select the filter on your schematic. Select the filtration button to view the results of these calculations.

Note: The volume calculations will not be correctly updated until you run HSPF for the scenario containing the filter.

Point of Compliance

The point of compliance is represented on the schematic by the POC symbol:

This symbol automatically pops up wherever a pond, basin, splitter or extender is placed on the schematic and no other element is downstream of it. It represents any and all flow leaving the system.

Although there can be several points of compliance shown on the schematic, they all represent exactly the same sum of flows. In other words, if you have 3 basins shown flowing to 3 POC symbols, it's the same as if they were all flowing to 1 POC symbol.

Results Screen
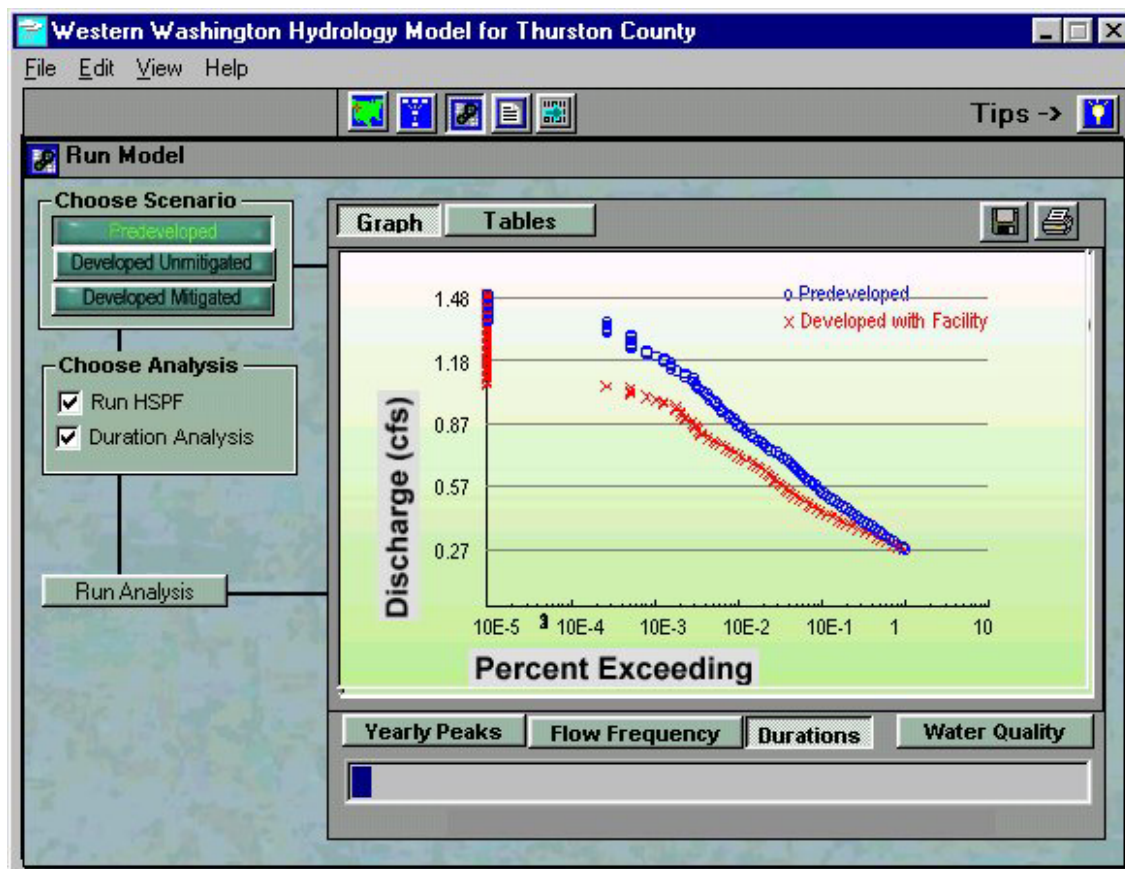
Run Model/View Results

The Run Model screen allows the user to run HSPF for a given scenario and view, save or print the resulting flow frequencies and durations in graphical or tabular form.

To run the model, follow these steps:

1 Choose a scenario to run by clicking either Predeveloped, Developed Unmitigated or Developed Mitigated at the top left.

2 Check **Run HSPF** in the selection box just below the top left. This instructs the program to perform the simulation and do a flow frequency analysis on the results
.
3 Check **Duration Analysis** (optional). After the model runs HSPF, it will perform a duration analysis based on the results. **Note**: Duration analysis is only performed on the **Predeveloped** and **Developed Mitigated** scenarios and HSPF must be run to perform this analysis.

4 Press the **Run Analysis** button. When the analysis is completed, you should see the results on the right side of the screen.

Viewing the Results

There are 4 buttons at the bottom of the Graph Window

1 Yearly Peaks:
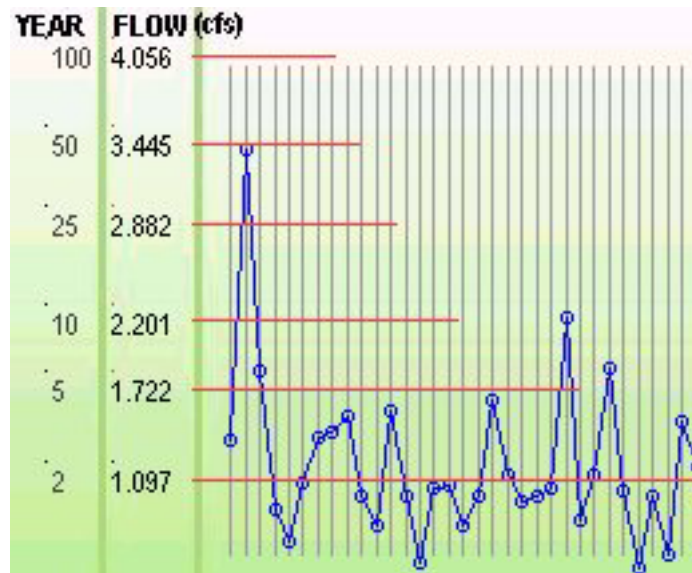
Graph of Yearly Peaks and Flow Frequencies

The Yearly Peaks graph shows all of the yearly peaks as they relate to the flow frequency values from the 2-year flow to the 100 year flow. The column of numbers on the far left show the return periods in years, and the next column of numbers shows the corresponding flows in cfs.

Note: You will only see the graph that represents flows from the scenario selected at the upper left.

Table of Yearly Peaks

The table shows the peak flow (in cfs) for each year in the data period. Scroll down to see the Developed Unmitigated and Developed Mitigated scenarios.
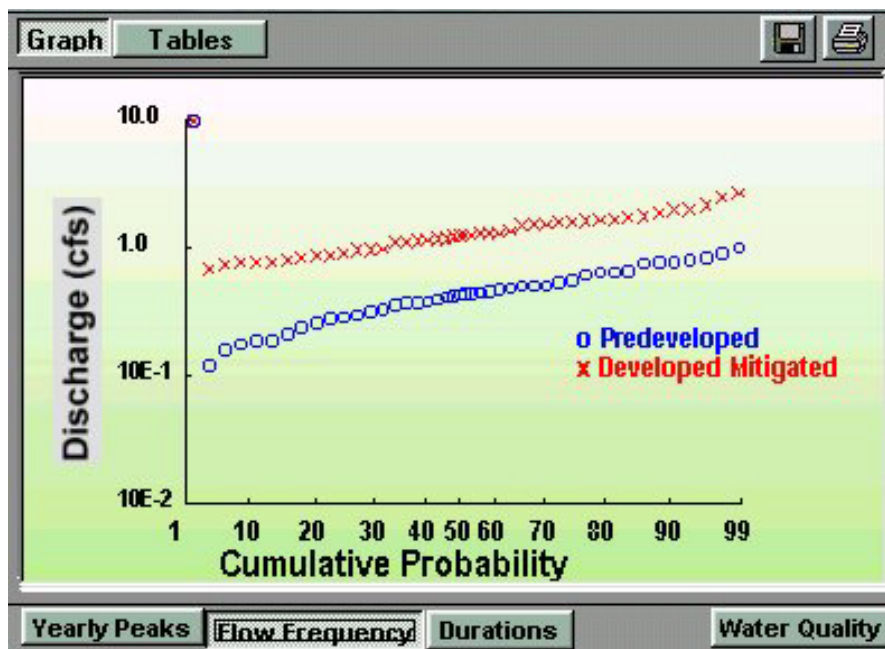
Flow Frequencies:

Flow frequencies are based on the yearly peaks. The WWHM2 has 2 ways of representing flow frequencies:

Flow Frequency Table

Select **Tables** at the top and **FLow Frequency** at the bottom to view the Log Pearson Type III flow frequency results for all scenarios in tabular form. The flows are shown in cfs for the 2 year to the 100-year events.

Flow Frequency Graph

Select **Graphs** at the top and **FLow Frequency** at the bottom to view the Cumulative Probability graph. This graph shows all the yearly peaks according to their statistical rank with respect to each other. A point at 99 indicates that 99 percent of the yearly peak flows in the dataset occur at or below the given discharge.
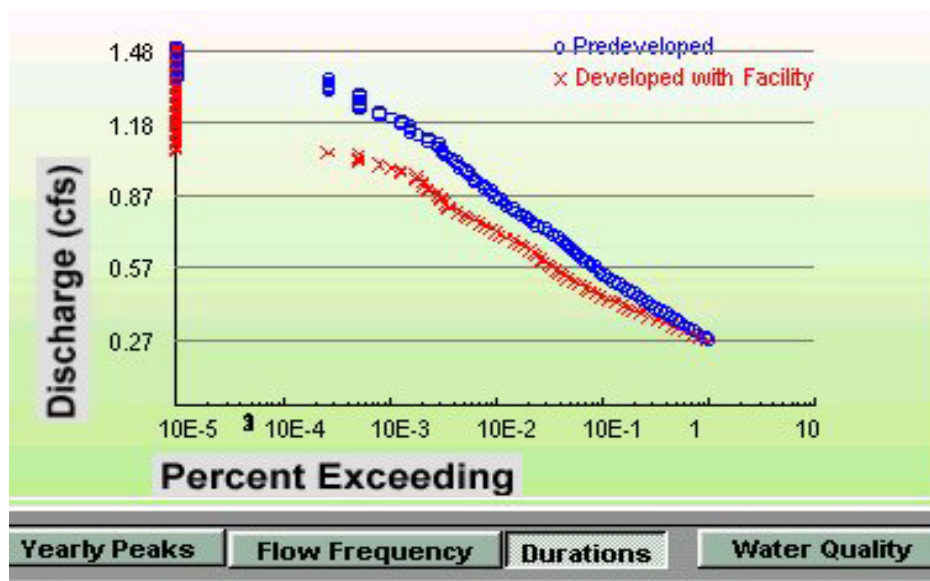
Duration Graph

Select **Graphs** at the top and **Durations** at the bottom to view the Durations graph. This shows what percent of the total date points exceeds a given discharge. At the bottom we see that 10E-2 or 0.01% of the total flows exceed 0.6 cfs (roughly). Select **Tables** to see the table of numbers from which this graph was made.

```
Flow(CFS)  Predev   Final  Percentage  Pass/Fail
000.2695   3888     3869    99.0           Pass
000.2817   3511     3153    89.0           Pass
000.2939   3142     2710    86.0           Pass
000.3062   2798     2330    83.0           Pass
000.3184   2504     2046    81.0           Pass
000.3306   2243     1785    79.0           Pass
000.3428   2030     1516    74.0           Pass
000.3550   1850     1274    68.0           Pass
000.3672   1661     1063    63.0           Pass
000.3795   1498      891    59.0           Pass
000.3917   1361      772    56.0           Pass
000.4039   1232      678    55.0           Pass
000.4161   1117      607    54.0           Pass
```
Duration Table

The first column is a list of 100 flows (cfs) from 1/2 the 2-year flow, to the 50 year flow. The second and third columns show how many data points in the Predeveloped and Developed With Pond scenarios have exceeded those flows. The next column shows the percentage of the Developed vs the Predeveloped. [(Dev / Predev)*100%] The last column shows either Pass or Fail for each flow.

DOE requirements for passing are:

From 1/2 the 2-year flow to the 2-year flow the percentage must be less than or equal to 100% From the 2-year to the 50 year the percentages could be as high as 110%, however, for half of the flows the percentages must be below 100%.

The Water Quality button brings up the **Water Quality screen** in the graphs/tables window.

Water Quality Analysis

Water Quality Analysis

The Water Quality Analysis screen calculates the target volume and flows for off-line and on-line water quality facilities.

In order to calculate storage and flow rates, at least 1 scenario has to be run. Once you have done this, press the **Calculate Storage and Flow Rates** button. The calculations are iterative and may take up to a minute or so depending on the speed of the machine and the complexity of the project.

The flow rates and storage volume are calculated based on the time series generated by one of the 3 scenarios. Use the buttons on the left of the water quality screen to choose which one the water quality calculations will be based on. Normally you should choose Developed Unmitigated, but if the water quality pond is going to be placed downstream of a detention pond you may want to select Developed Mitigated.

An on-line water quality facility is downstream of the project site and all of the water from the site is routed through it, while an off-line facility receives flow from a splitter or routing device and not necessarily all the water is routed through it.
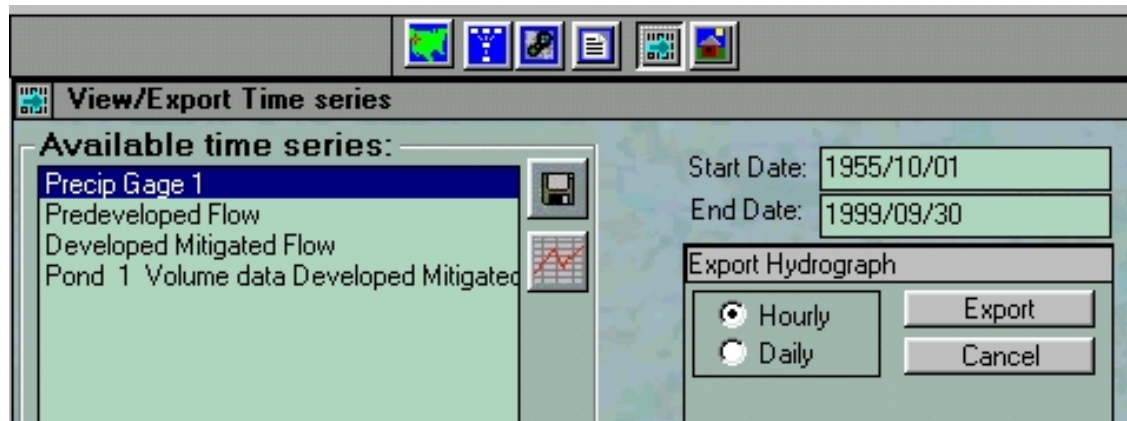
ON LINE VOLUME: This is the volume of a wetpond required to hold 91%* of the total historic runoff volume from the developed site.

*Or a user-defined number specified in Preferences.

View / Export Time Series

To enter the export screen, select the export icon on the tool bar:

Export Time Series

When you select the button, the WWHM will take a moment to populate the list of available time series.

The list will include any precipitation gages used for the selected county and any scenarios that have been run.

There are two buttons to the right of the list: Export Hydrograph and Plot Hydrograph.
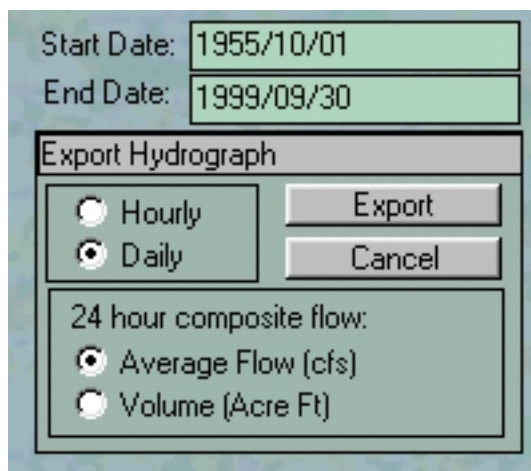
Export Hydrograph

Enter the start date and end date. The default setting is the entire span of the precipitation gage data.

The export may take more time depending on the size of the time interval you select.

Select Hourly to export hourly data (all of the precipitation gages are in hourly data).

Select Daily to export either the average daily flow (in cfs) or the volume (in acre-ft). for each day in the interval.

Once you have chosen what to export, select the Export button to open the Save File dialog. There are 2 formats you can choose from:

Text File: This is the sequential format for hourly data that can be read by HSPF and imported into a WDM file.

Comma Delimited File: This is a 2 column file for easy manipulation in an outside program such as Microsoft Excel. The first column contains the date and time for each data point and the second column contains either flow in units of cfs, or rainfall in inches.

Preferences

The preferences menu item opens the Preferences Window. From this window the user can adjust the PERLND* parameters for the project, and the criteria the program uses to evaluate Storm water detention facilities and water quality ponds.

There are 3 navigational buttons at the top of the Preferences window:
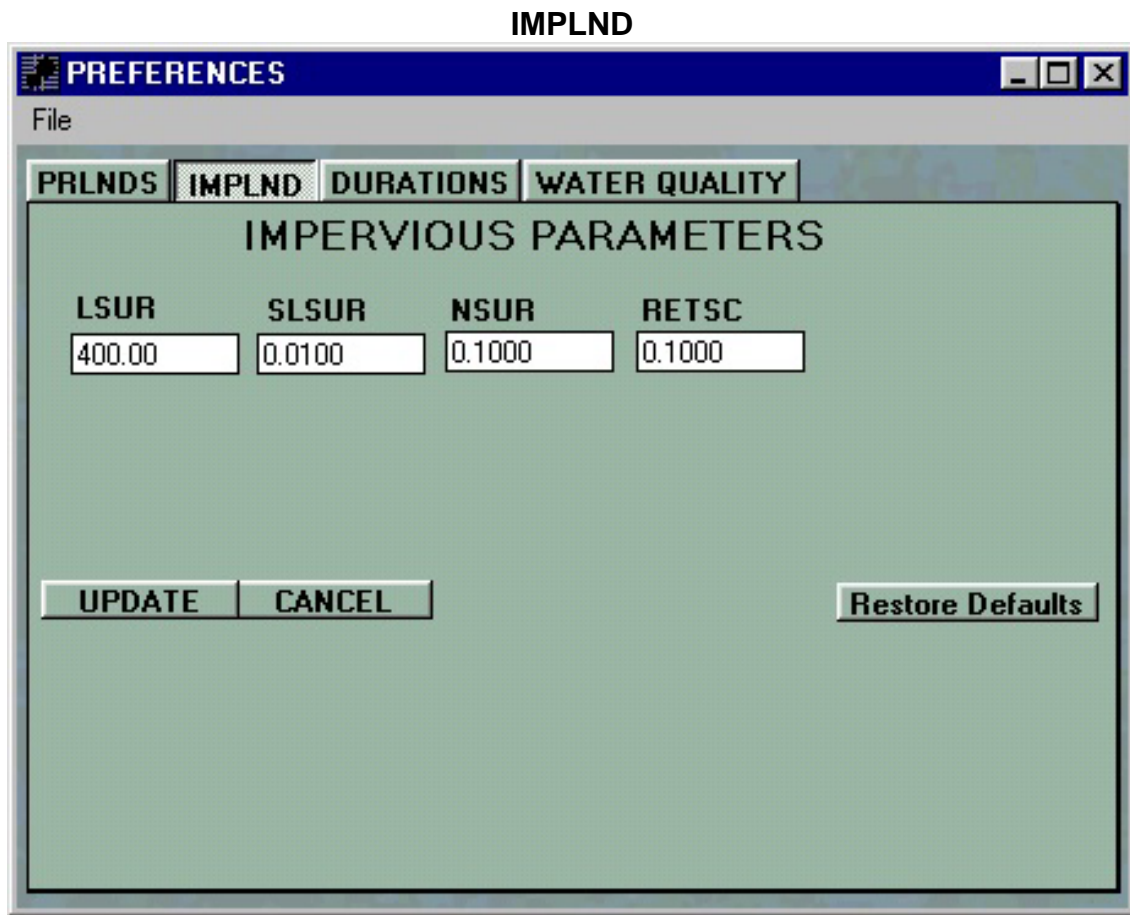
PERLND
IMPLND
DURATION
WATER QUALITY

PERLND

PERLND screen

To edit the HSPF PERLND parameters for a given soil type/vegetative cover, simply click somewhere on the grid and change the number. Click the **UPDATE** button for the change to take effect. The report will include any changes made.

When in the PERLND screen, you can use the File menu to save and load PERLND parameters. If you have made changes you want to save, select Save. Selecting **Cancel** will revert all parameters to the default values or the last updated values.

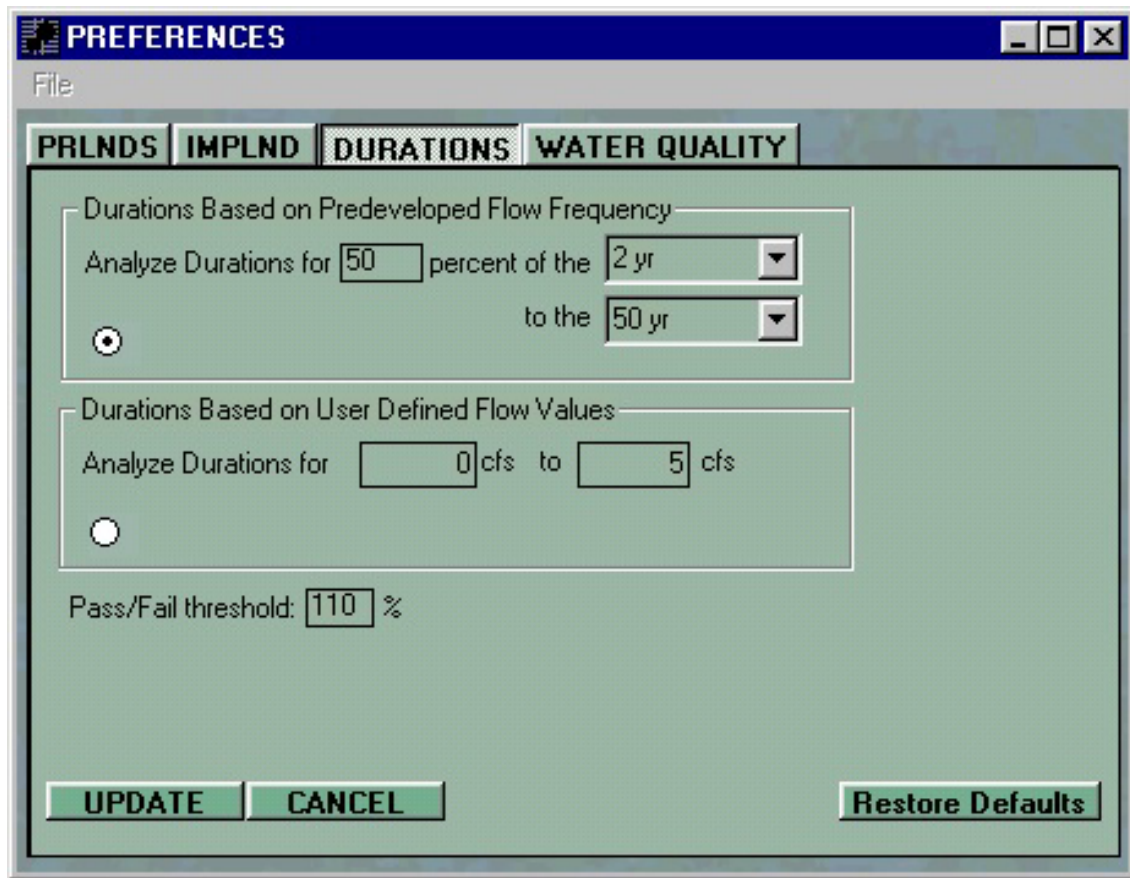**IMPLND**

IMPLND Parameter Screen

This allows you to change the parameters used in the HSPF simulation of impervious area.

*For more information about HSPF IMPLND and PERLND parameters, the full HSPF manual is available at www.hspf.com.

DURATIONS

Durations Preferences Screen

According to the Department of Ecology requirements for stormwater detention facilities, the durations of flows from the development must be less than or equal to those of pre-developed flows from 1/2 the 2 year to the 2 year flow, and not exceed the pre-developed 2 year to 50 year flows by more than 10%. This determines the pass/fail column in the Duration Table.

If you would like to use the WWHM2 to analyze the durations with respect to other requirements, you can change them here. Either choose between a percentage of one of the pre-developed return periods in the drop-down listboxes, or key in your own flow values.

WATER QUALITY
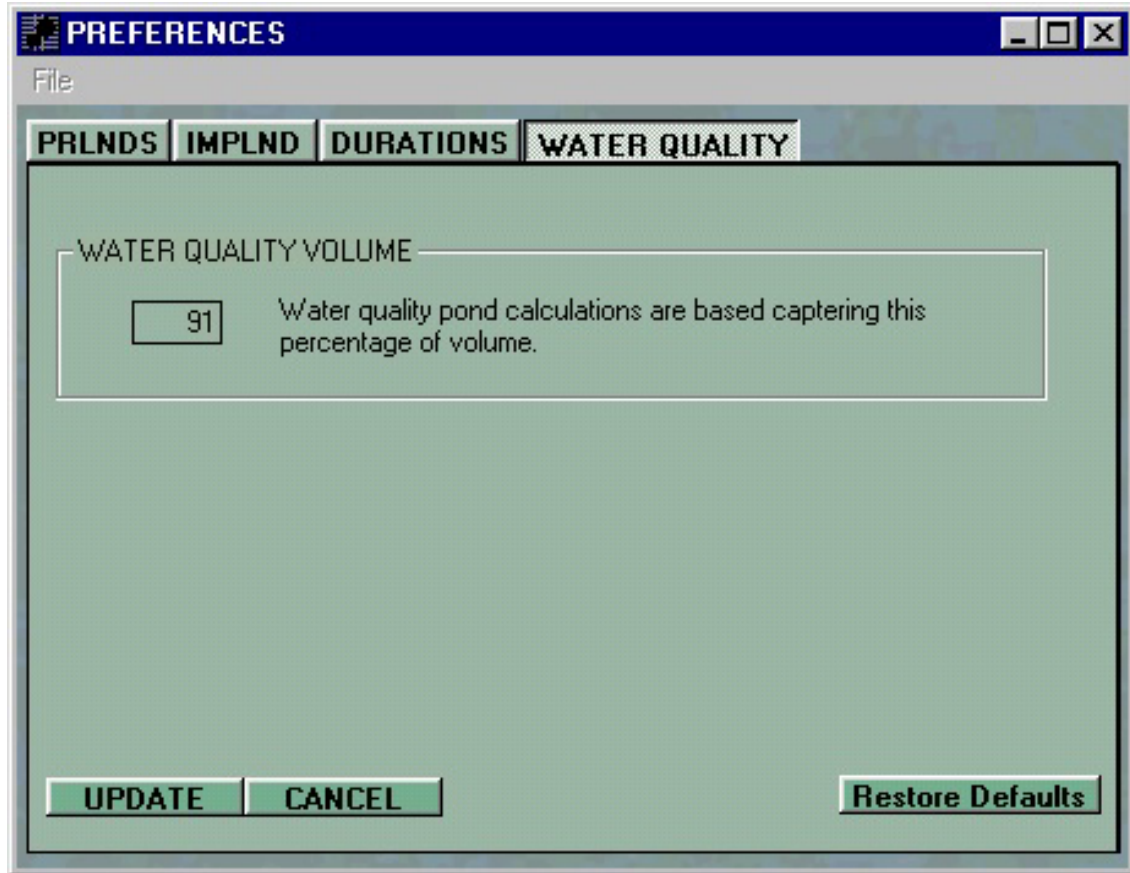
Water Quality Preferences Screen

This allows you to change the percentage of the total runoff volume that your water quality pond will be designed to hold.
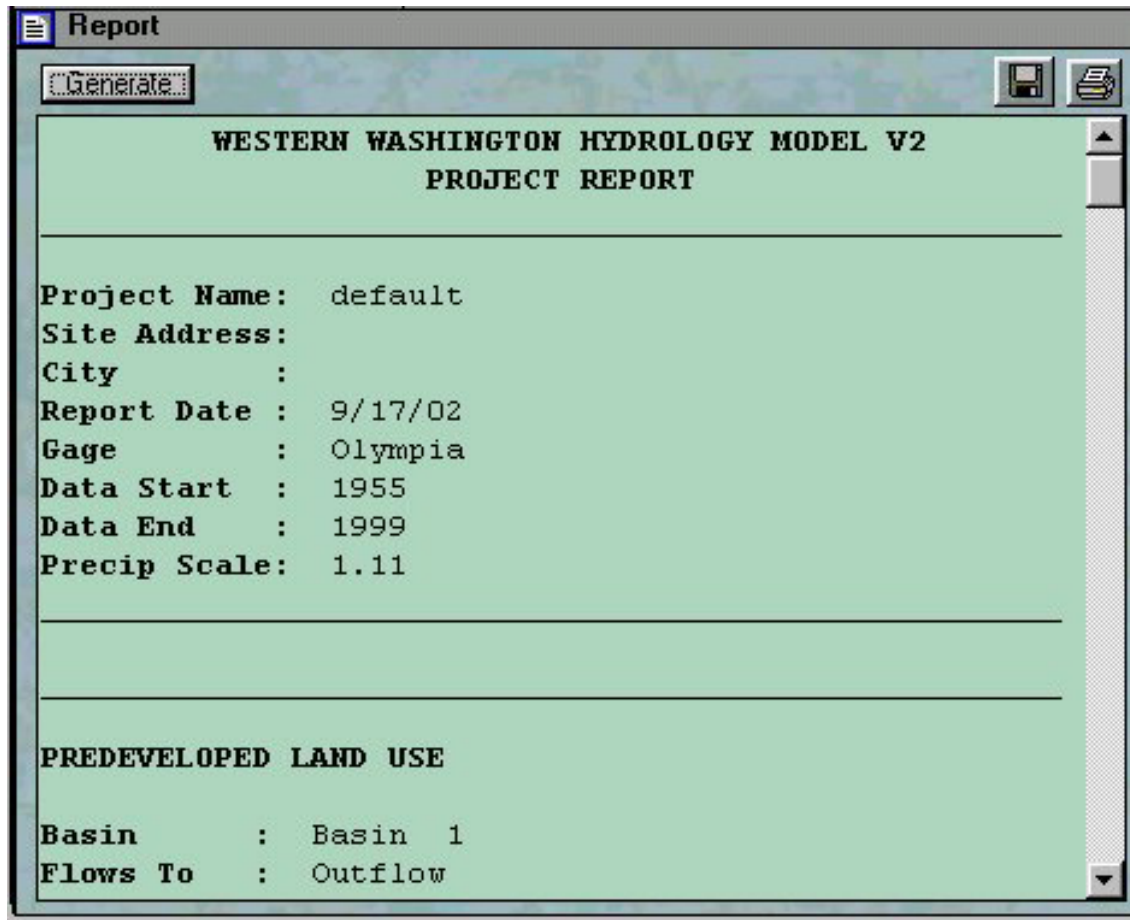
Report Generator

```
Report
 Generate                                                  💾  🖨

        WESTERN WASHINGTON HYDROLOGY MODEL V2              ▲
                   PROJECT REPORT


    Project Name:  default
    Site Address:
    City        :
    Report Date :  9/17/02
    Gage        :  Olympia
    Data Start  :  1955
    Data End    :  1999
    Precip Scale:  1.11



    PREDEVELOPED LAND USE


    Basin       :  Basin  1
    Flows To    :  Outflow                                  ▼
```

Report Screen

At any time during your project you can generate a report based on the current data. Use the Generate button to update the report. It can be saved either as a Rich Text file or a Word document by clicking the disc icon right above the report. You can print the report with the Print Icon.

Note: the printed report contains all the graphs involved in the project as well as the text information.

Equations / Algorithms

The WWHM2 uses the following algorithms/equations:

Outlet structures:

Riser Head
Orifice
Rectangular Notch
Sutro Notch
V-Notch

Analysis:

Where:
headr = the water height over the notch/orifice bottom.
q = Discharge

1. Riser Head

Head = water level above riser

$$q = 9.739 * \text{Riser Diameter} * \text{Head} \wedge 1.5$$

2. Orifice Equation:

$$q = 3.782 * (\text{Orifice Diameter}) \wedge 2 * \text{SQR (Headr)}$$

3. Rectangular Notch:

Rectangular Notch

$$b = \text{NotchWidth} *- (1- 0.2 * \text{Headr})$$
$$\text{where } b >= 0.8$$

$$q = 3.33 * b * \text{Headr} \wedge 1.5$$

4. Sutro Notch

Sutro Notch

Notch Width at water surface:
Wh = Top Width + {(Bottom Width- Top Width) / Notch Height } * Headr
Difference between Wh and Bottom Width
Wd = Bottom Width - Wh (the difference between the bottom and top widths)

Q1 = **(q from rectangular notch equation 2 where Notch Width = Wh)**
Q2 = **(q from rectangular notch equation 2 where Notch Width = Wd)**

q = Q1 + Q2 / 2

5. V-Notch

V-Notch

Notch Bottom = height from bottom of riser to bottom of notch.
Theta = Notch Angle

These are used to calculate Coef (the coefficient of discharge for the notch).

a = 2.664261 - 0.0018641 * Theta + 0.00005761 * Theta ^2
b = -0.48875 + 0.003843 * Theta - 0.000092124 * Theta ^2
c = 0.3392 - 0.0024318 * Theta + 0.00004715 * Theta ^2

YoverH = Headr / (NotchBottom + Headr)
Coef = a + b * Headr + c * Headr ^2

q + (Coef * Tan(Theta / 2)) * (Headr ^ (5 / 2))