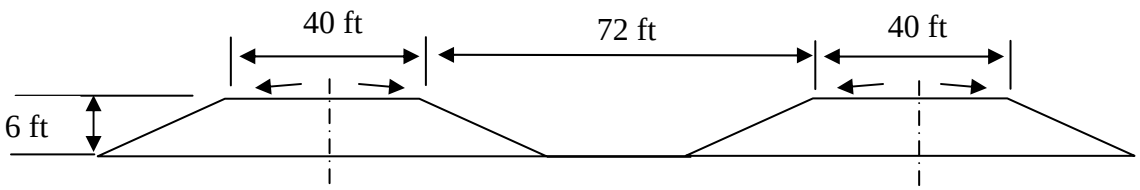
MGS Flood
Example Design Problems

Work Session 1
Design of CAVFS for Water Quality Treatment

A TDA for a section of SR-167 highway near Auburn is to be improved with the addition of carpool lanes in each direction.

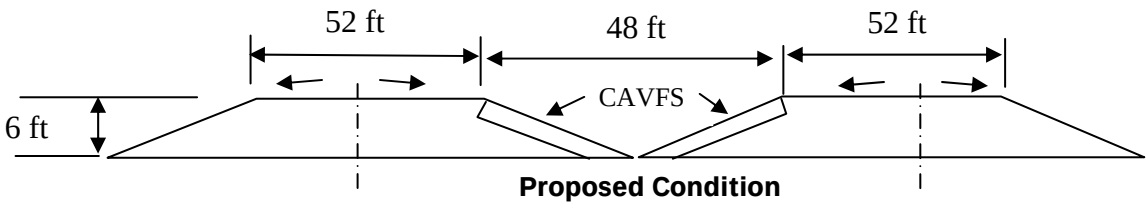
Project Location Map

The existing configuration consists of two 12-foot lanes with 8-foot shoulders in each direction separated by a 72' wide grass median. The existing lanes are crowned so that runoff from only half of the existing impervious surface drains to the median.



Existing Condition

The project will add one 12-foot lane in each direction, while maintaining the current shoulder widths. The new lanes will be added in the freeway median.



Proposed Condition

The project is located on Alderwood soils, which are classified as SCS Hydrologic Group C.

<u>Using this information, design a CAVFS to treat runoff from the new and existing impervious surface that drains to the median for this 1200 foot long section of roadway. The CAVFS data is as follows:</u>

Compost Depth: 1 foot
Compost Hydraulic Conductivity: 1.7 in/hr
Compost Width: (6^2+24^2)^0.5= 25 feet (along slope)
Underlying Soil Infiltration Rate: 0.01 in/hr
Compost Slope: 4H:1V
Gravel Spreader Width: 2 ft
Gravel Spreader Porosity: 30%
Gravel Spreader Hydraulic Conductivity: 2 in/hr

- **<u>Remember the default settings are in ft/day for the Hydraulic Conductivity. You will need to convert the values. For this example change the units to in/hr to match the example problem. The units are under: Tool- Options- 3rd tab Units.</u>**

Note designing the CAVFS is a trial and error procedure. We'll input the CAVFS porosity, run the model, and check the percentage of runoff treated. This process will be repeated until we achieve the 91% volume treatment criteria. Compost porosity is varied in the field by combining the compost with various types of soil until the desire properties are achieved.

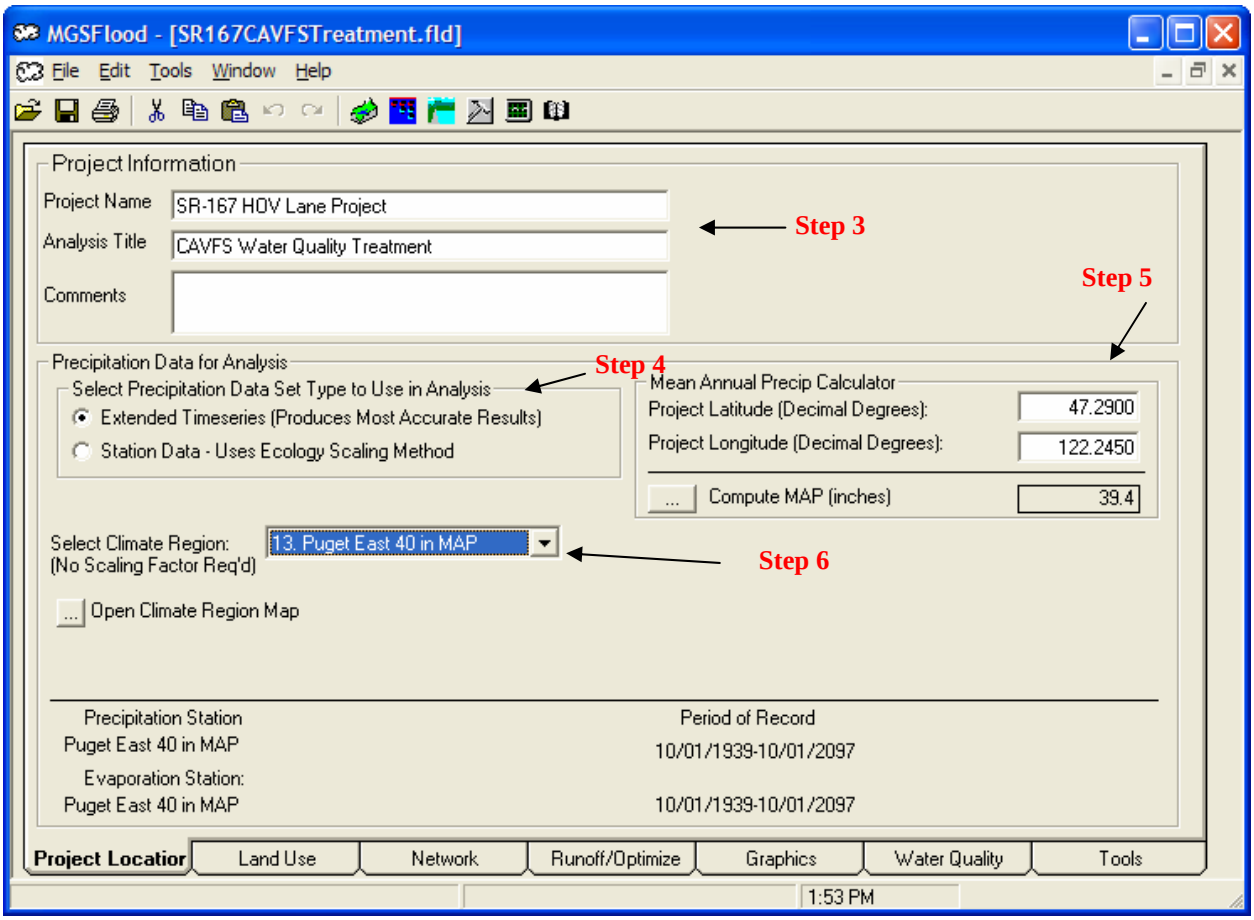
Analysis Steps

Start Program, Save Project File

1. Start program from Windows Start button
   Start-Programs-MGS Software-MGSFlood
2. Click File Save as, Enter "SR167CAVFSTreatment" for file name. Create project folder when prompted

Project Location Tab

3. Enter project name, analysis title, and comments.
4. Check the Extended Precipitation Timeseries Option Button
5. Compute the mean annual precipitation using the calculator,
   From Google Earth Map (above) or Environmental Workbench, Lat=47.29 deg, Long=122.245 deg
6. Select Climate Region 13 Puget East 40 in MAP from the drop down list box.



Land Use Tab

7. Enter Pre- and postdeveloped area. Note, we're only entering the area that drains to the median. Since the areas are identical for the Northbound and Southbound lanes, design the CAVFS using lanes from one direction and use the same design for the other direction.

Predeveloped:

Grass:
½ Median = (36')*1200' = 43,200/43560= **0.992 ac**

Impervious: Include area that drains from road crown toward center:

(12'+8')*1,200' = 24,000/43560= **0.551 ac**

Total predevelopment Area: 1.543 ac

For SCS Type C soil, use Till

Postdeveloped:

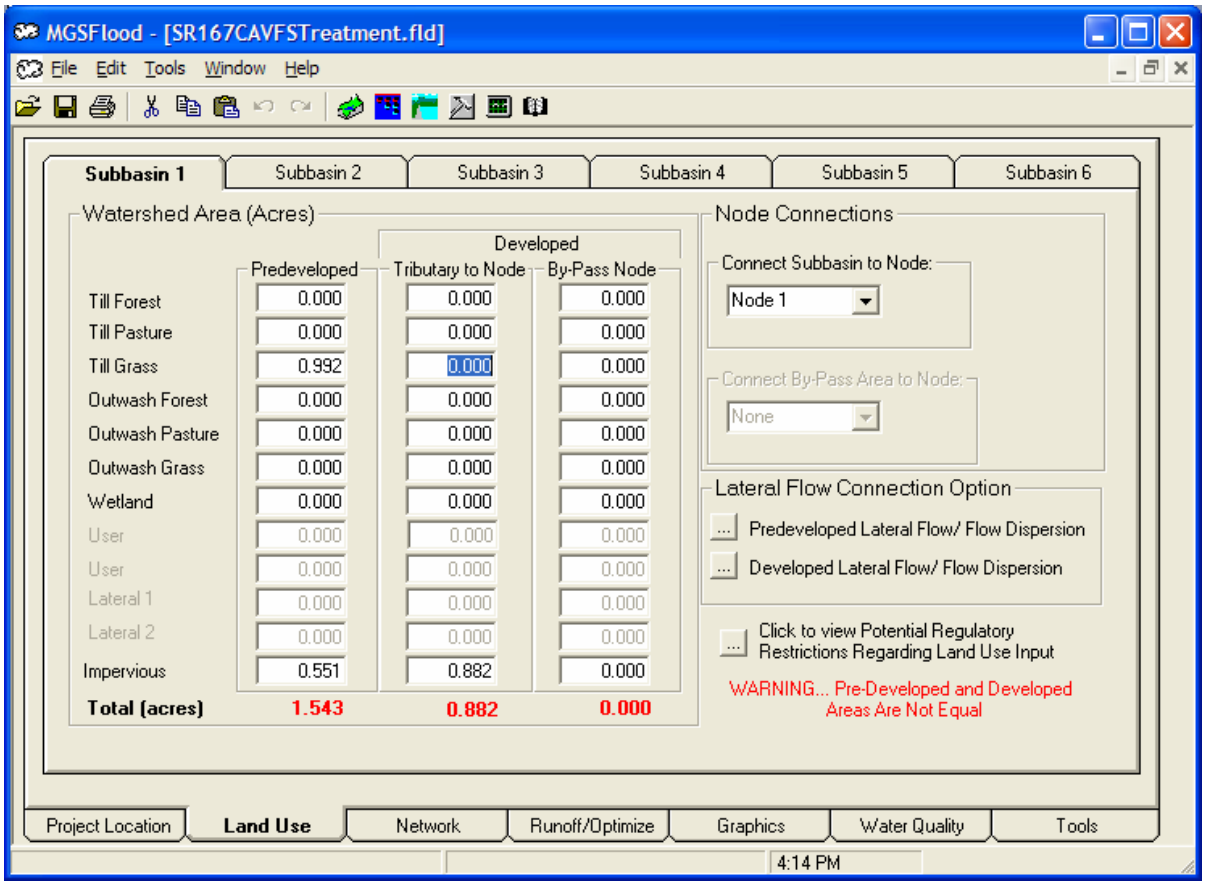
Grass:
½ Median = 24'*1,200= 28,800/43,560= **0.661 ac**
(Note the postdeveloped grass area will be all CAVFS. Precipitation will be simulated on the CAVFS by the CAVFS routine, therefore we don't need to specify this area on the Land Use tab.

Developed Impervious (Existing Lane+Shoulder+New Lane:

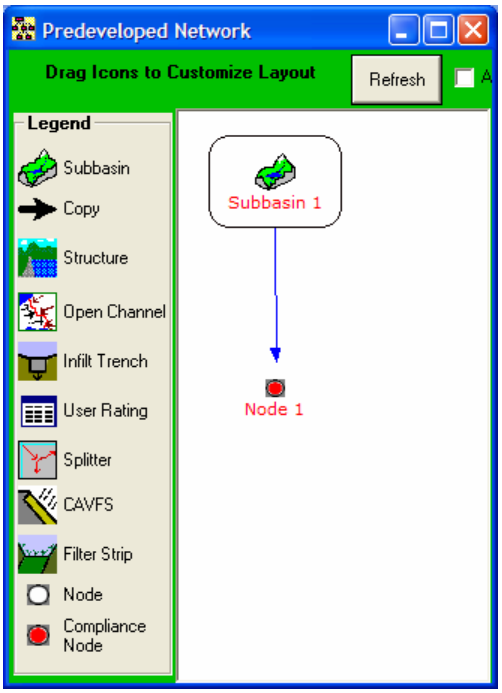
(12'+8+12')*1,200 = 38,400/43,560= **0.882 ac**

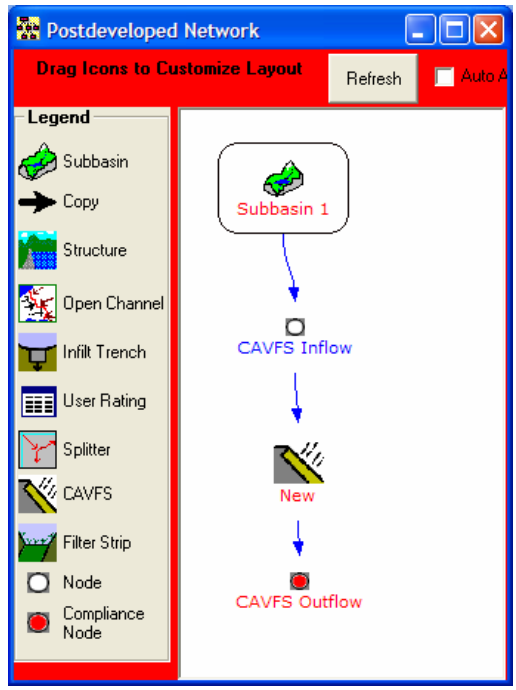
8. Enter land use from above. Note, don't enter the land use for the CAVFS because the precipitation will be applied using the CAVFS module (shown later)

   Connect Subbasin 1 to Node 1



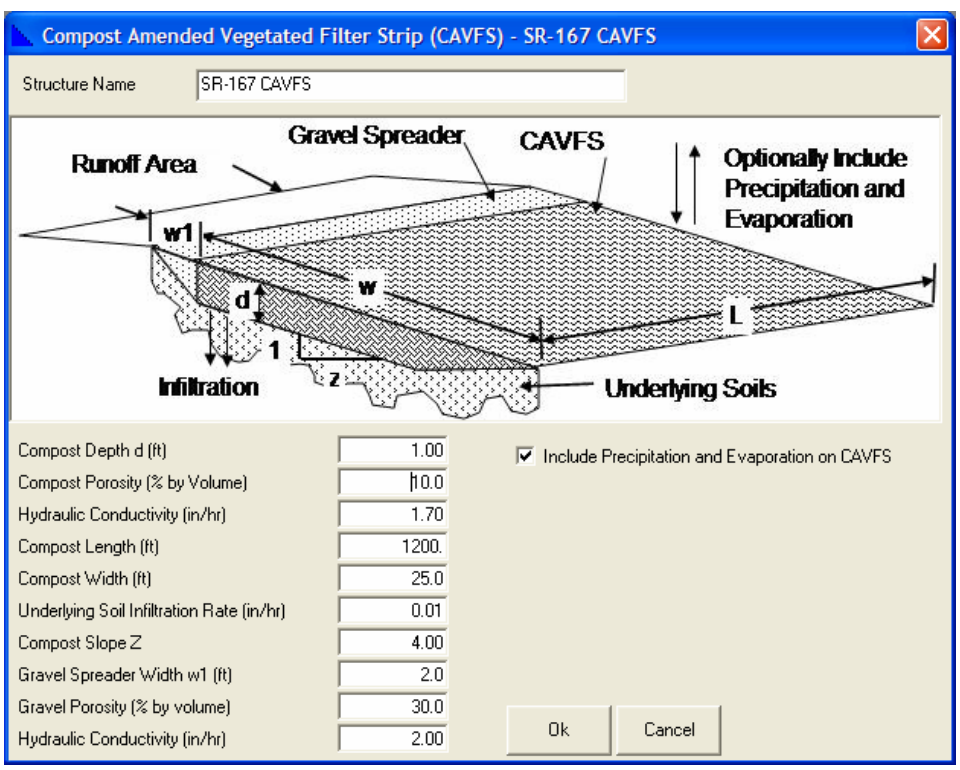
9. Click the Network Tab. No changes are needed for the Existing Condition Scenario.
10. Select the Proposed Condition Scenario. Enter Proposed Condition Node 1 and Node 2 names "CAVFS Inflow" and "CAVFS Outflow", respectively.
11. Define the link connecting Nodes 1 and 2 as a CAVFS
12. Click the watershed schematic button. The watershed schematic should look something like the figure below.





13. Click the Link Definition for the CAVFS to input the CAVFS data.

14. We'll try an initial CAVFS porosity of 10%. Check the option box to include precipitation and evaporation on the CAVFS. Enter the remainder CAVFS information as follows:



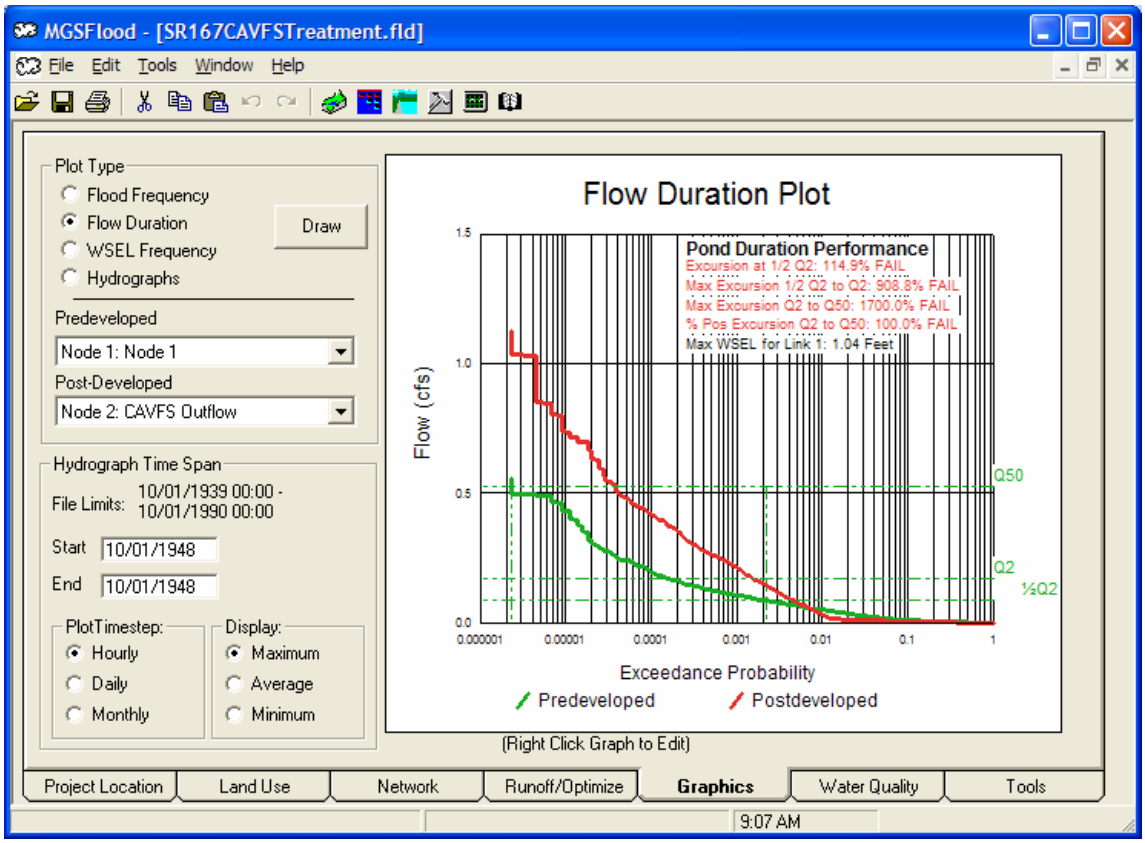
15. Click OK save your input and return to the Network tab.

Runoff/Optimize tab

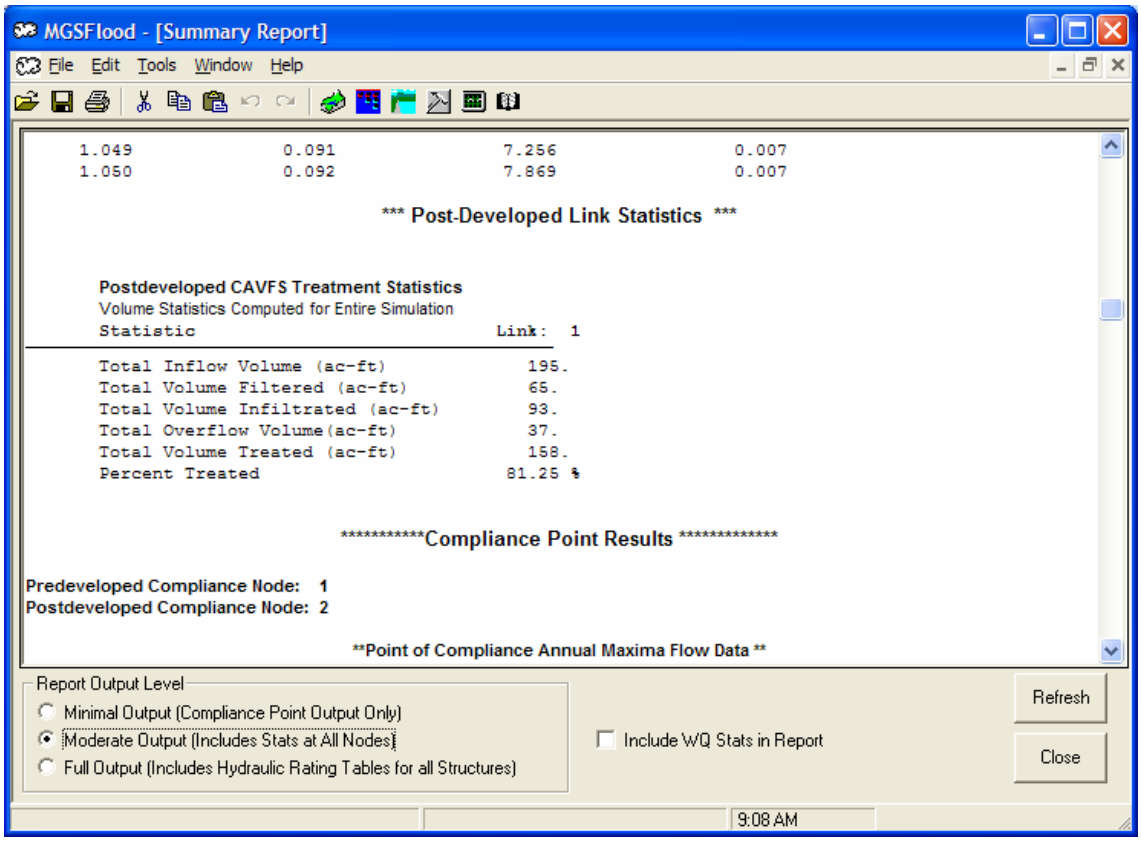
16. Because this is a trial and error solution, reduce the simulation time span by entering 1990 as the end date. Once we have a solution that is close to the 91% volume treatment, we'll run the full record through.

17. Compute runoff for the shortened period of record. Click the *Route* button.

When the simulation is complete, the duration performance will be displayed. We don't care about the duration performance now because we're sizing the CAVFS for water quality treatment only. We'll add a pond later to meet the flow control criteria.



18. Click the project report button and scroll down to the CAVFS treatment statistics. Note the treatment for 10% compost porosity is only 81% < 91%, therefore no good.



19. Repeat the process above with a CAVFS porosity of 20%:

    Treatment Result: 90.5. %

20. Repeat the process above with a CAVFS porosity of 25%:

    Treatment Result: 92.7 % (Good enough)

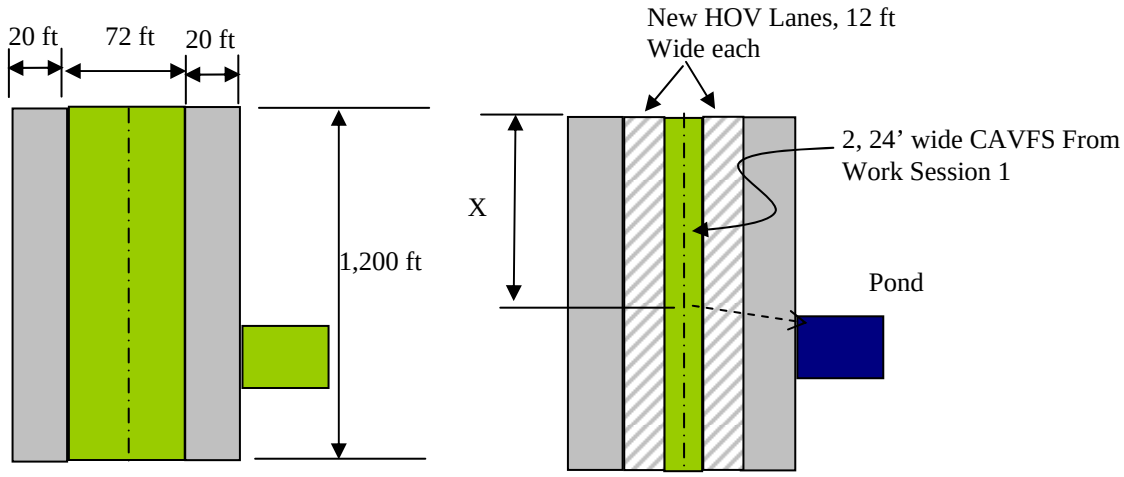
21. Rerun the design with the full 158-year record. Specify the end year as 2097:

    <u>FINAL Treatment Result: 91.3 %</u>

Work Session 2
Design Stormwater Pond with Upstream CAVFS

Design a stormwater pond for the project in Work Session 1 to mitigate the runoff from the new impervious area only. Use the Equivalent Area Method to size the pond and include the CAVFS upstream.

Because runoff draining to the median includes both existing and new impervious, an equivalent area of new and existing area will be piped to the stormwater pond. This will be accomplished by installing a cross culvert from the median to the pond at a location where the quantity of existing and new impervious equals the total new impervious added by the project. The figures below show only the areas draining to the median.



Cross Culvert Location X: New Lanes (1,200*(12+12)=28,800 sf
Equivalent length of new and existing impervious: 28,000/(2*(20+12))= **450'**

Include 3 subbasins, one for north bound lanes, one for the southbound lanes, and the third for the pond. Runoff will be collected at a common node and routed to the pond.

Subbasins 1 and 2 Areas will be the same:

Existing Land Use (All Grass):
Lanes: 1,200*(12)= 14,400/43,560= 0.331 ac
Median: Include median to upstream of cross culvert (450')*(36-12)= 0.248 ac
Total: 0.579 ac

Developed Land Use (All Impervious):
New Lanes: 1,200*(12) = 14,400/43,560= 0.331 ac
Total: 0.331 ac

CAVFS: Simulate PPT/EVAP with CAVFS Routine, 450' long, accounts for 0.248 ac (0.248+0.331=0.579 ac)

Subbasins 3, Pond Area:

Existing Land Use (Grass): 0.25

Developed Land Use (Impervious): 0.25

Save Previous Project File, Begin New Project

1. Click File New to clear inputs from previous project.
2. Click File Save As, Enter "SR167CAVFSPond" for file name. Save the project in the same folder used in the first work session: SR167CAVFSTreatment. Respond "No" when prompted to create a new program directory.

Project Location Tab

3. Enter project name, analysis title, and comments.
4. Select Climate Region 13 Puget East 40 in MAP from the drop down list box as before.

Land Use Tab

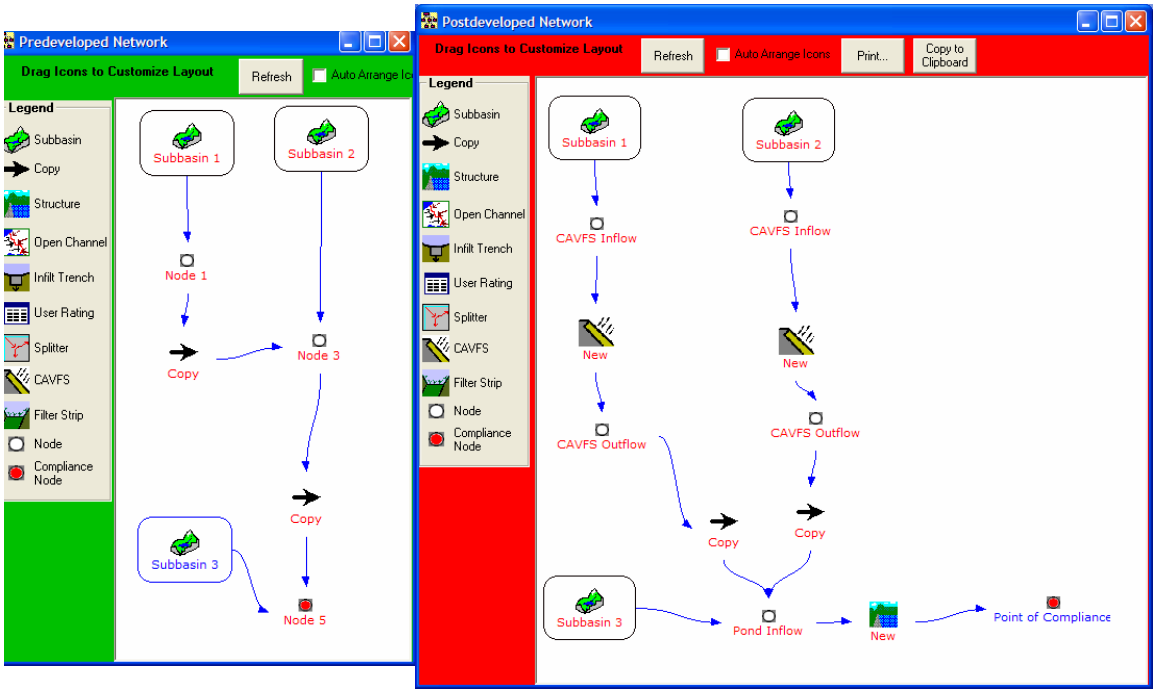
5. Enter Pre- and postdeveloped area, Subbasin 1. Connect Subbasin 1 to Node 1
6. Enter Pre and Postdeveloped area, Subbasin 2, Connect Subbasin 2 to Node 3
7. Enter Pre and Postdeveloped area, Subbasin 3, Connect Subbasin 3 to Node 5

Network Tab.

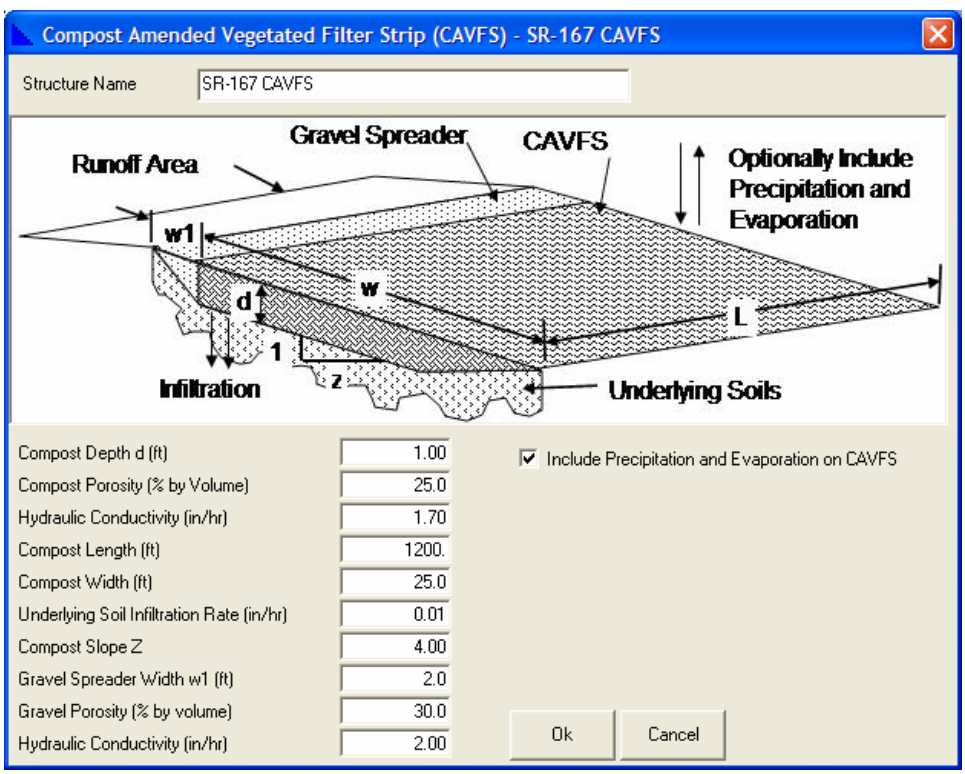
6. Click the Network Tab. Existing Condition Scenario: Connect Node 1 to 3 and 3 to 5. Set the point of compliance at Node 5.
7. Select the Proposed Condition Scenario. Define the links as follows:

Upstream Node/Node Name	Downstream Node	Link Type
1 (CAVFS Inflow)	2	CAVFS
2 (CAVFS Outflow)	5	COPY
3 (CAVFS Inflow)	4	CAVFS
4 (CAVFS Outflow)	5	COPY
5 (Pond Inflow)	6 (Point of Compliance)	Structure

8. Click the watershed schematic button. The watershed schematic should look something like the figure below.



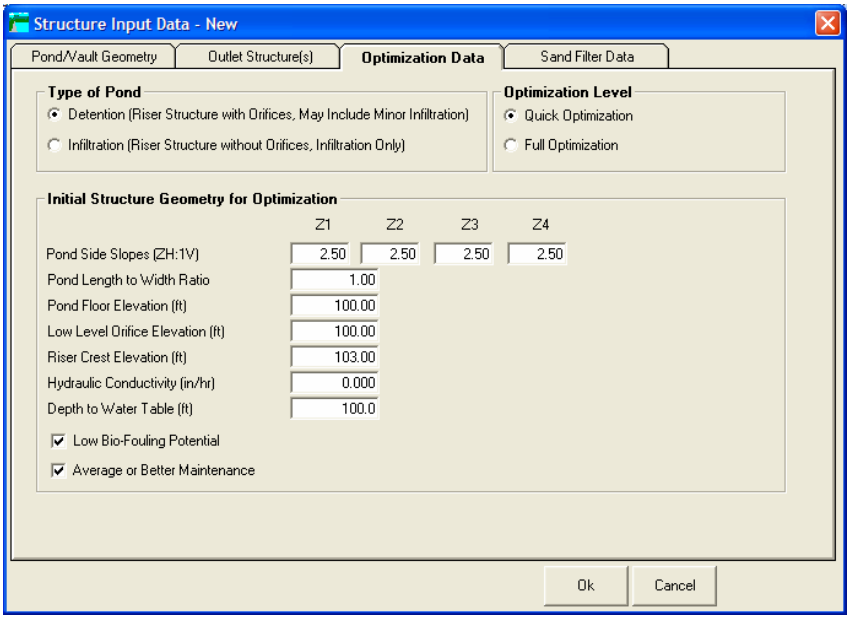
9. Click the Link Definition for the Link 1 CAVFS. Enter the CAVFS design from the first work session. Note that the CAVFS length is 450', the distance to the culvert leading to the pond:



10. Enter the Same data for the NB lanes CAVFS connecting Nodes 3 and 4.

11. Click the Optimize check box next to the Structure Link.

12. Click the Link Definition for the structure. Click the Optimization Data tab.
The first iteration, we want to get a rough idea of how large of a pond we will need for the project. Will it fit into the 0.25 ac pond tract we've designated?
Check Quick Optimization and enter the information shown below.
Click OK save your input and return to the Network tab.



Runoff/Optimize tab

13. Because this is a trial to see roughly how big the pond will be, reduce the simulation time span by entering 1990 as the end date.

14. Check the Optimize Structure Indicated on the Network tab button, and click the *Route* button to start the simulation.

15. Open the project report and Note that the pond area at the maximum elevation 103.5' is 0.110 ac, which will fit easily in the 0.25 acre area allocated. We might actually be able to use a smaller pond. Also, note that the slot orifice width was smaller than that 0.25" minimum value. We'll have to make sure that the final solution meets the minimum structure size requirements.

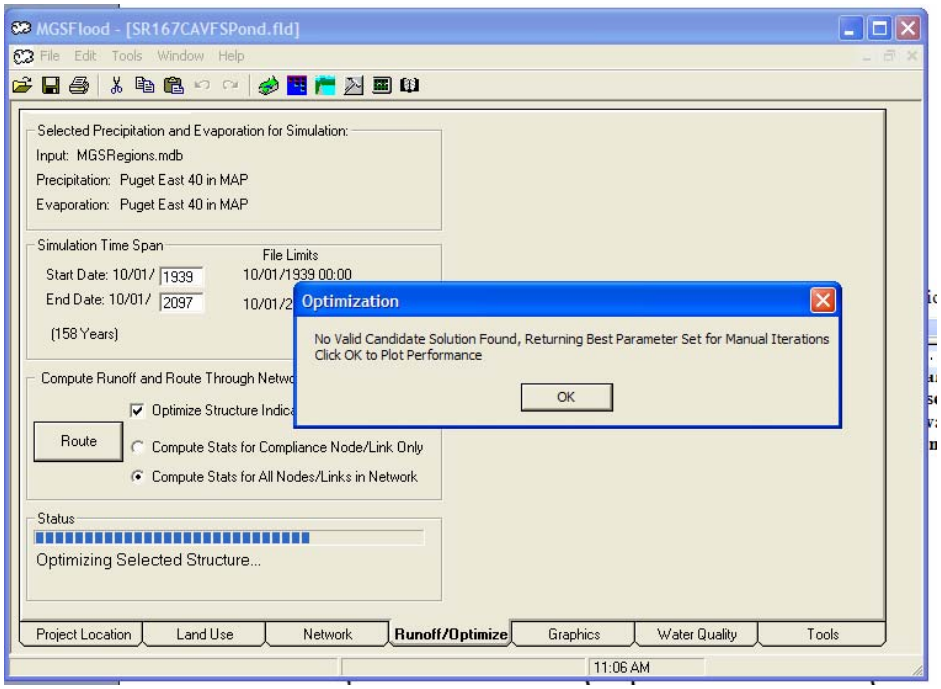
Network tab

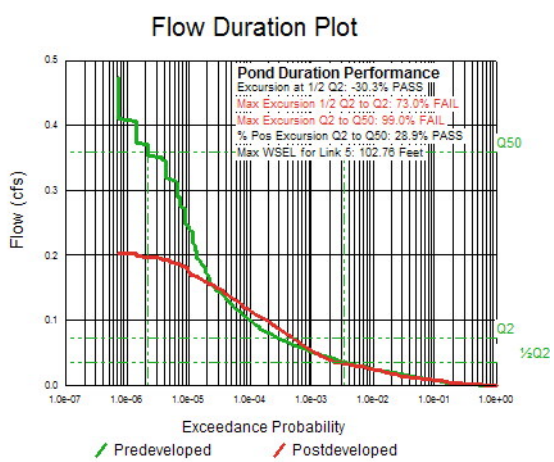
16. Click the Network Tab and Open the Link Definition for the Pond. Click the Optimization Data Tab and Select Full Optimization. Click OK.

Runoff/Optimize tab

17. We'll use the full record to perform a full optimization of the pond. Enter 2097 as the end date for the simulation.

18. Click the *Route* button to start the simulation.

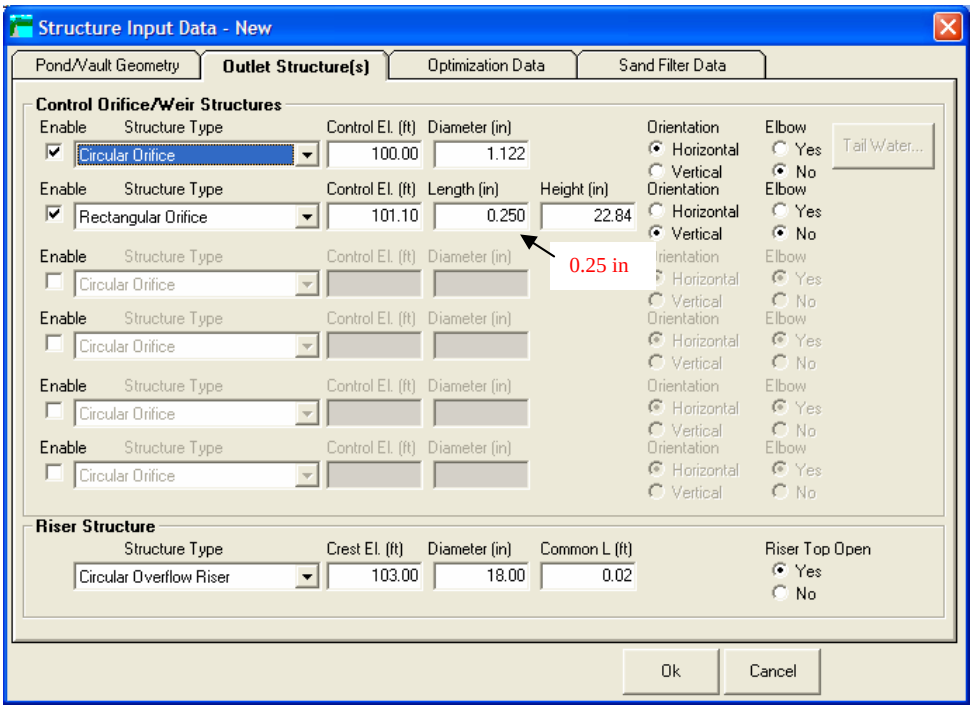




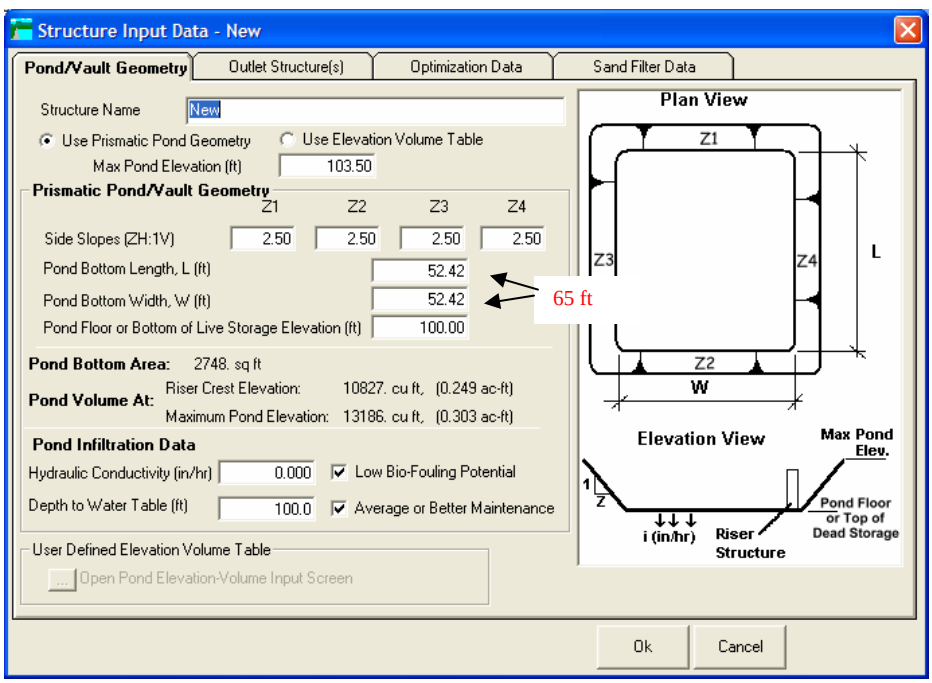
The full optimizer solution was close but did not meet all duration criteria. This due to the flow attenuation produced by the CAVFS upstream. We'll have to perform manual iterations to meet the flow duration standard.

The portion of the curve that does not meet the criteria is between ½ Q2 and Q50. This region is controlled by the vertical slot orifice.

19. Click the *Network* tab, reopen the Structure (Pond) *Link Definition* Screen.
    Click the Outlet Structures tab. We want to reduce the size of the vertical slot, but it's at or near the minimum already. Set it at the minimum width 0.25" (if it's not already)



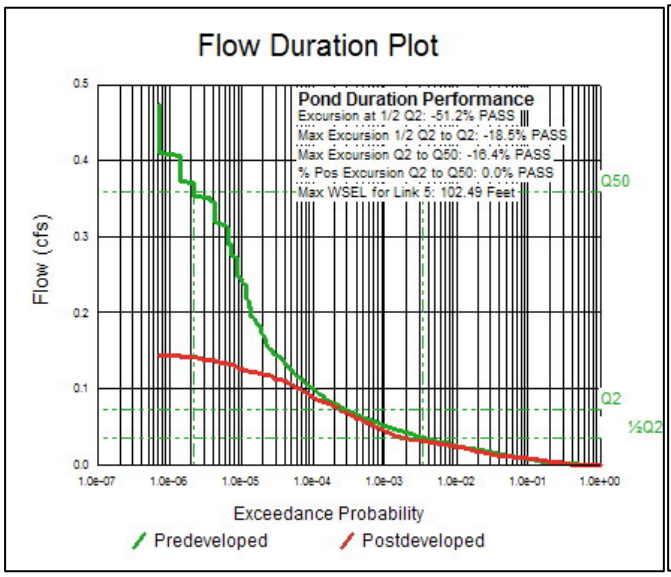
20. Click the *Pond/Vault Geometry* tab. Since we were not able to reduce the slot size, we'll increase the pond length and width to 65 feet. Click OK to return to the Network tab.

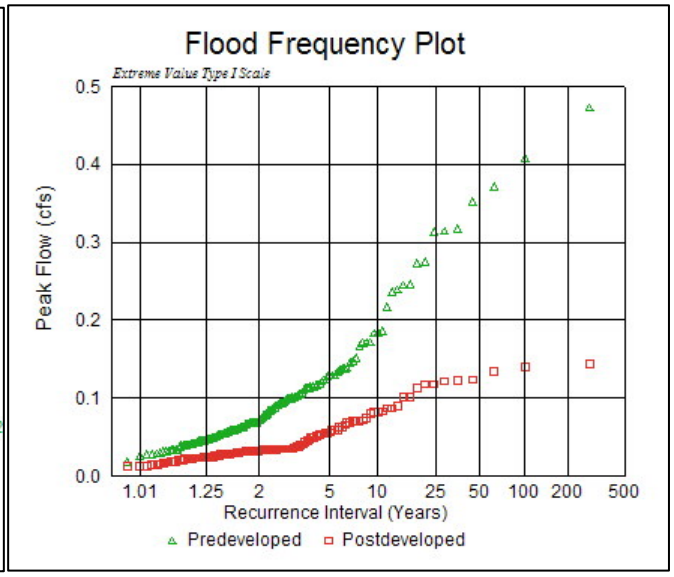


Runoff/Optimize tab

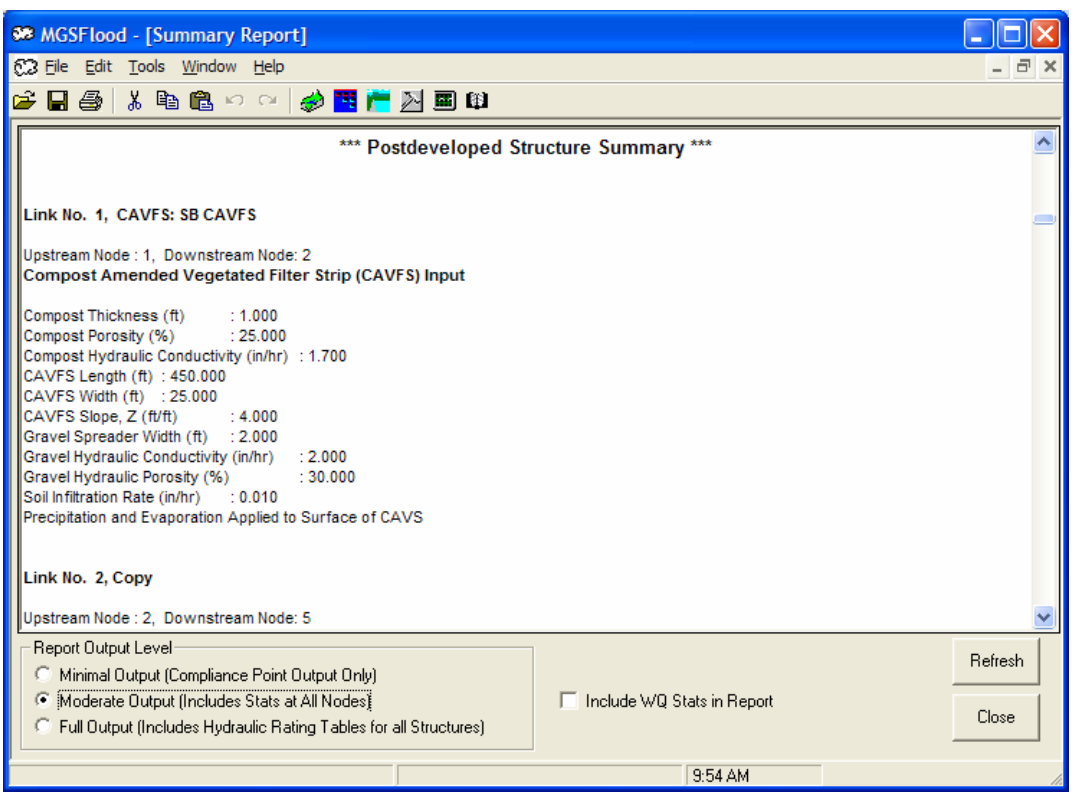
21. Uncheck the *Optimize Structure On Network* box. Click the *Route* button to start the simulation.

22. The resulting duration performance meets the flow duration design criteria.



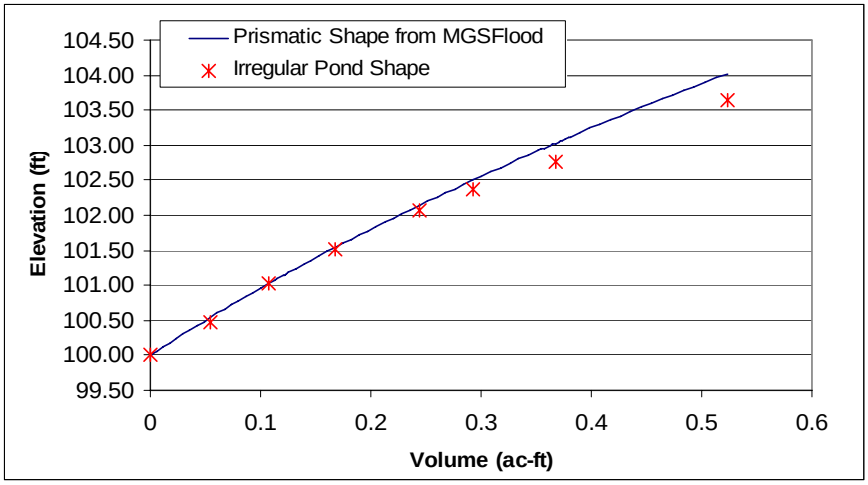


23. View documentation report either from the *File-Print* menu, from the icon on the tool bar, or by opening the .rtf file with a word processor. Any graphs created during the analysis are stored in jpeg files in the project subdirectory.



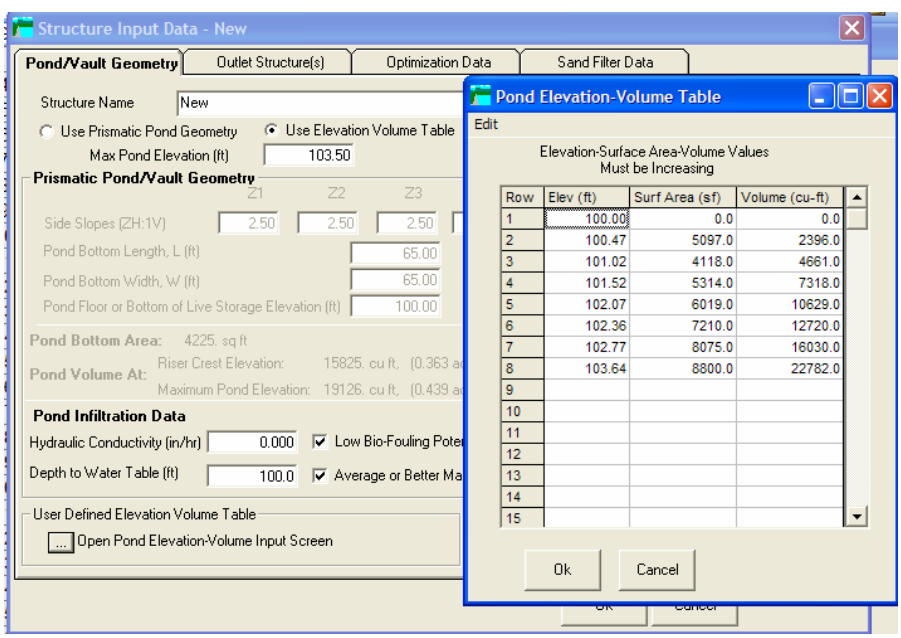
The final pond shape is irregular. The elevation-volume table was developed from CAD and is listed below. Confirm that the irregular shape pond meets the flow duration design criteria.

As a check, plot the irregular shape elevation/volume relationships produced by MGSFlood and for the irregular shaped pond. If the irregular shape pond has higher volume at each elevation than the prismatic shape produced by MGSFlood, then the irregular shape pond will meet the duration criteria.

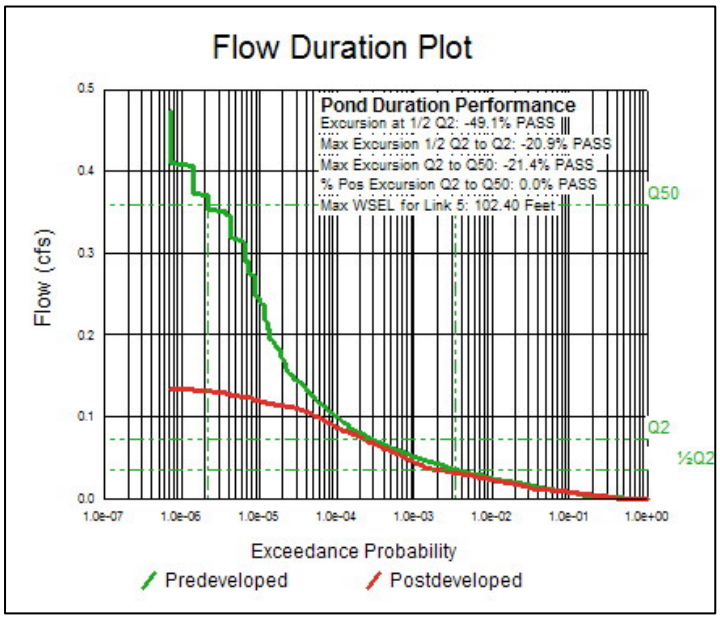


Network tab

24. Click the Link Definition button for the structure.
    Click the Use Elevation Volume Option Table
    Open the Elevation volume table and end the elevation/area/volume data.
    Click Ok to close the elevation/volume table.
    Click Ok to return to the Network tab.

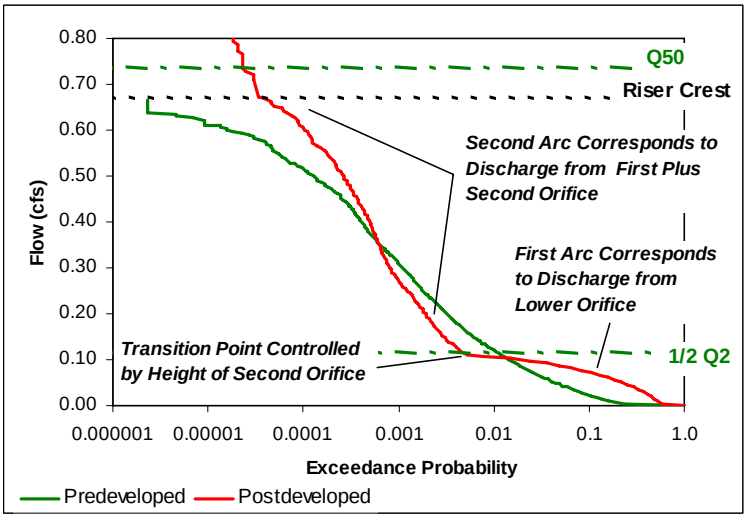


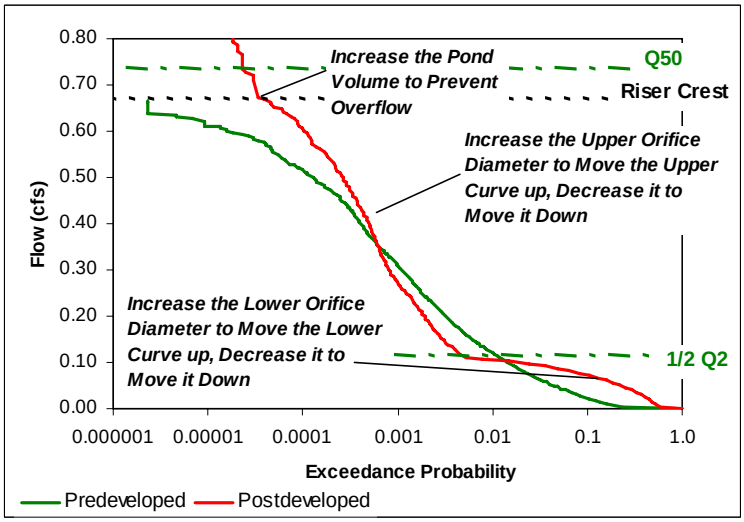
25. Reroute flows from the Network tab. This will confirm that the final design with the irregular pond shape meets the detention criteria.



General Guidance for Adjusting Pond Duration Performance

- Analyze the duration curve from bottom to top, and adjust orifices from bottom to top.
- The bottom arc corresponds with the discharge from the bottom orifice. Reducing the bottom orifice discharge lowers and shortens the bottom arc while increasing the bottom orifice raises and lengthens the bottom arc.
- Inflection points in the outflow duration curve occur when additional structures (orifices, notches, overflows) become active.
- Lowering the upper orifice moves the transition right on the lower arc and raising the upper orifice moves the breakpoint left of the lower arc.
- The upper arc represents the combined discharge of both orifices. Adjustments are made to the second orifice similar to the bottom orifice.
- Increasing the facility volume moves the entire curve down and to the left. This is done to control riser overflow conditions. Decreasing facility volume moves the entire curve up and to the right.





Work Session 2A Design a CAVFS for Flow Control

(Sensitivity of Runoff Response to CAVFS Parameters)

Design a CAVFS to provide flow control treatment for a project that converts 1 acre of till pasture to 1 acre of impervious. The project consists of two lanes, 12 feet wide and 1800 feet long. Assume the project is located in Extended Precipitation Region 13, 40" East.

This will be a trial and error solution. The width and length of the CAVFS will be fixed and we will iterate increasing the depth of the CAVFS until the flow duration criteria are met. CAVFS Length=1800 feet, CAVFS width=24 feet.

Save Previous Project File (if open), Begin New Project

1. Click File New to clear inputs from previous project.
2. Click File Save As, Enter "CAVFSFlowControl" for file name. Save the project in the same folder used in the first work session: SR167CAVFSTreatment. Respond "Yes" when prompted to create a new program directory.

Project Location Tab

3. Enter project name, analysis title, and comments.
4. Select <u>Climate Region 13 Puget East 40</u> in MAP from the drop down list box as before.

Land Use Tab

5. Enter Pre- and postdeveloped area, Subbasin 1. Connect Subbasin 1 to Node 1.

   Predeveloped: Road Area 2*12*1,800= 1.0 ac (Pasture)
   CAVFS Area: 1,800*24= 1.0 ac (Pasture)

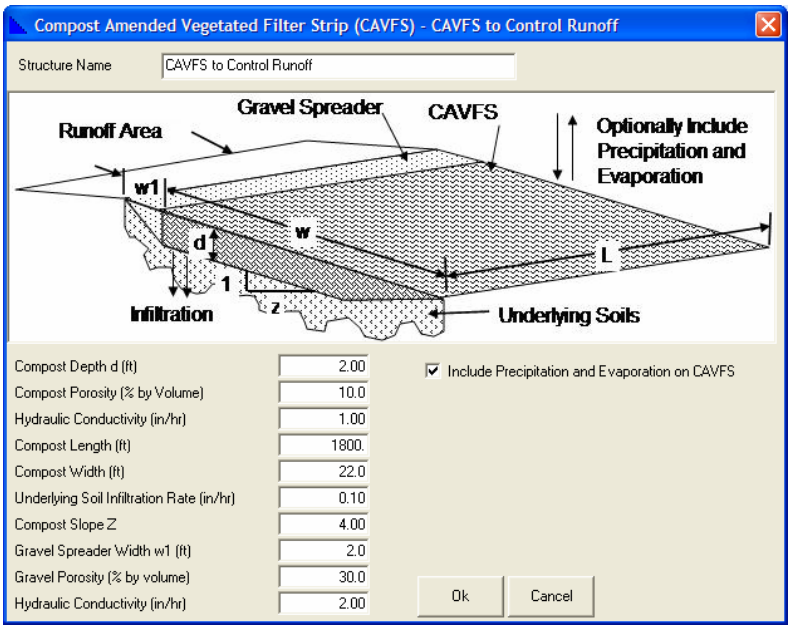
   Postdeveloped: Impervious 2*12*1800= 1.0 ac
   The Rainfall and Evap on the CAVFS area will be simulated using the CAVFS module.

6. Click the Network Tab. Node 1 will be the point of compliance, no other changes here.
7. Click the Proposed Condition tab. Define the link connecting Nodes 1 and 2 as a CAVFS.

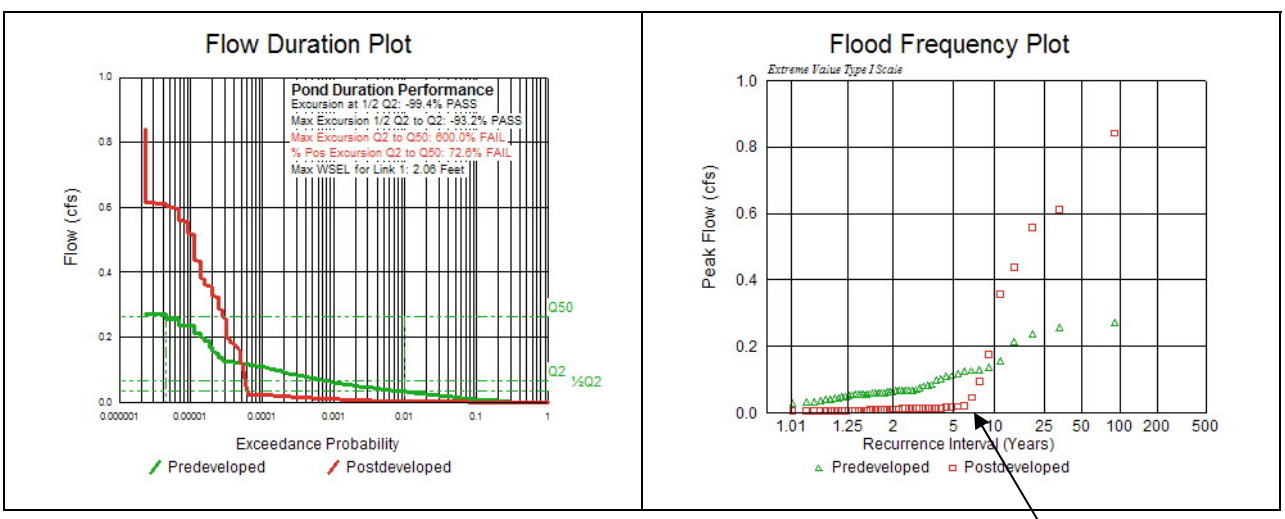
8. Click the Link Definition button and enter the following CAVFS data:
9. **<u>Remember the default settings are in ft/day for the Hydraulic Conductivity. You will need to convert the values. For this example change the units to in/hr to match the example problem. The units are under: Tool- Options- 3rd tab Units.</u>**

10.

Note that the total CAVFS area is roughly equal to the amount of impervious surface routed to it.

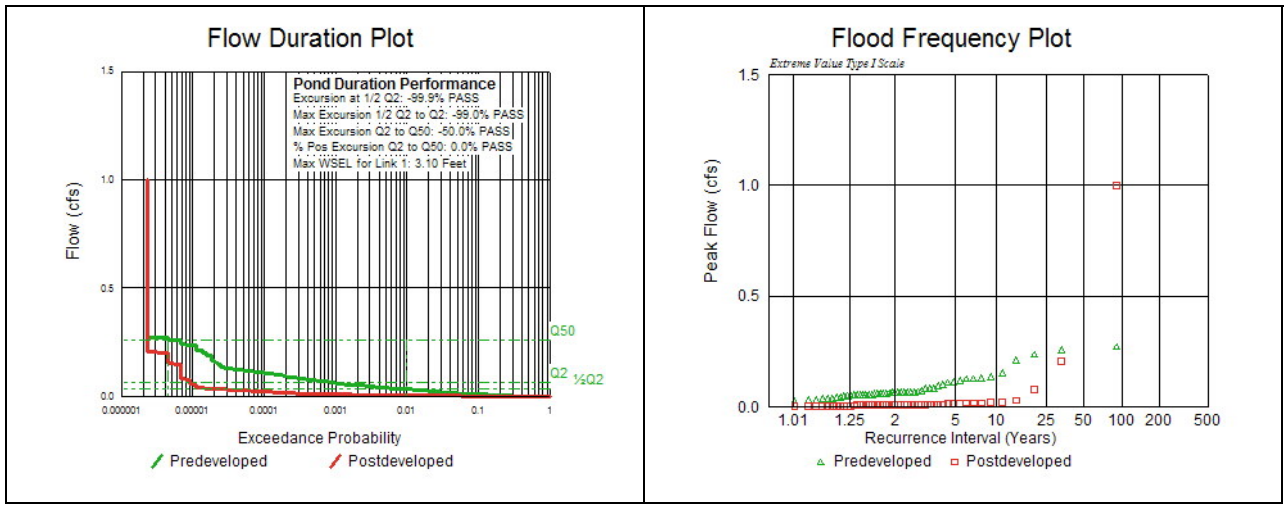


11. Click the Runoff/Optimize tab. To shorten the simulation time, enter 1990 for the end date of the simulation. Click the Route button.
12. View Flood Peak and Duration Graphs. CAVFS saturates and overflows at an 8 year recurrence interval.

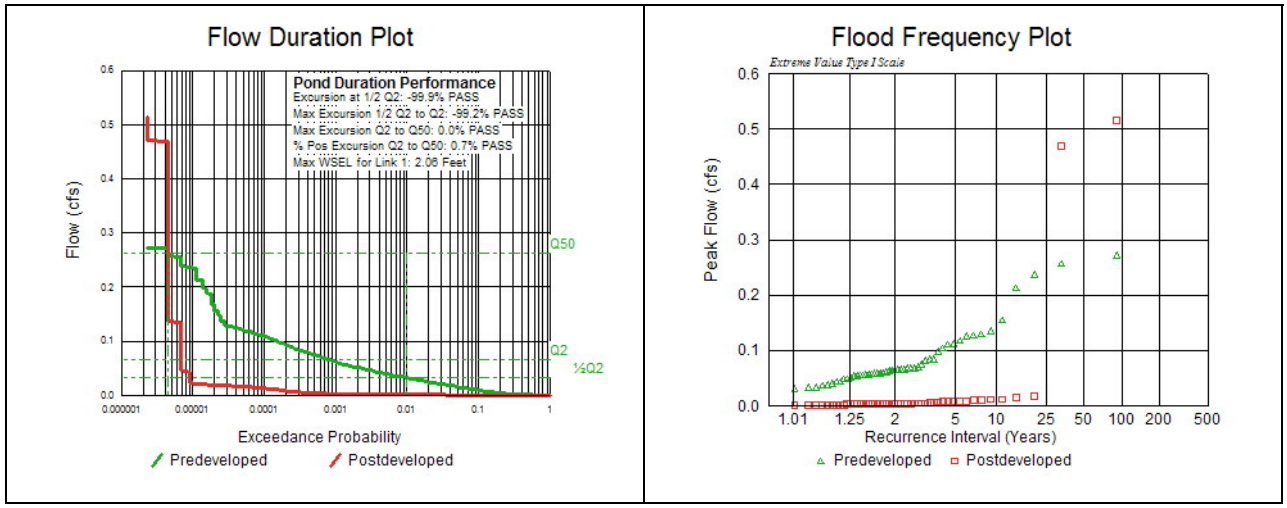


Frequency Where CAVFS Saturates and Overflows

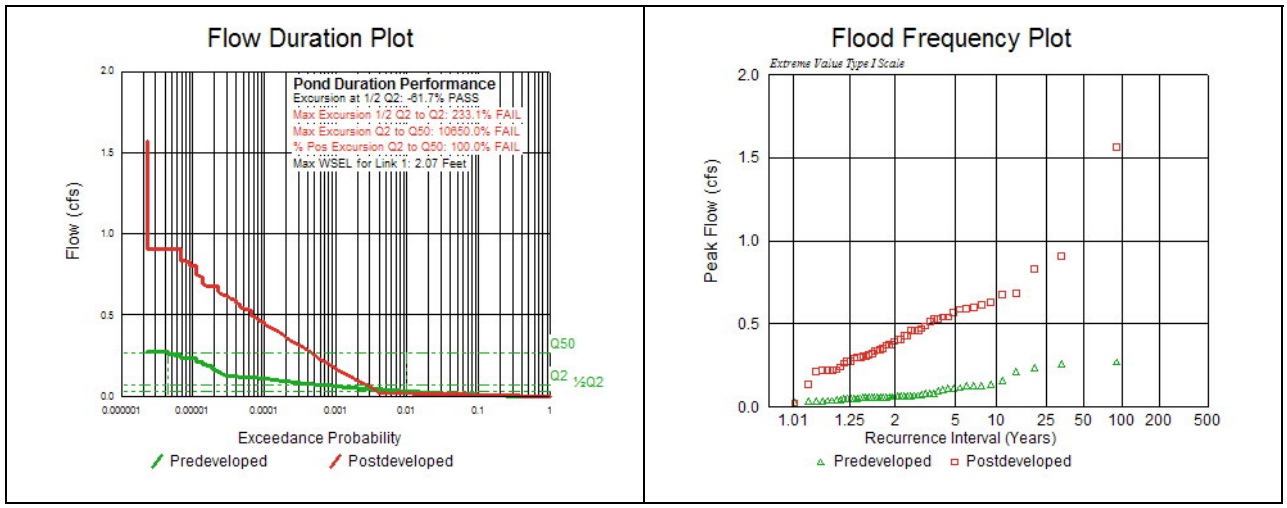
13. Set the CAVFS depth to 3 feet and repeat the simulation.



14. Set the CAVFS depth to 2 feet and the infiltration rate of the underlying soils to 0.2 in/hr.



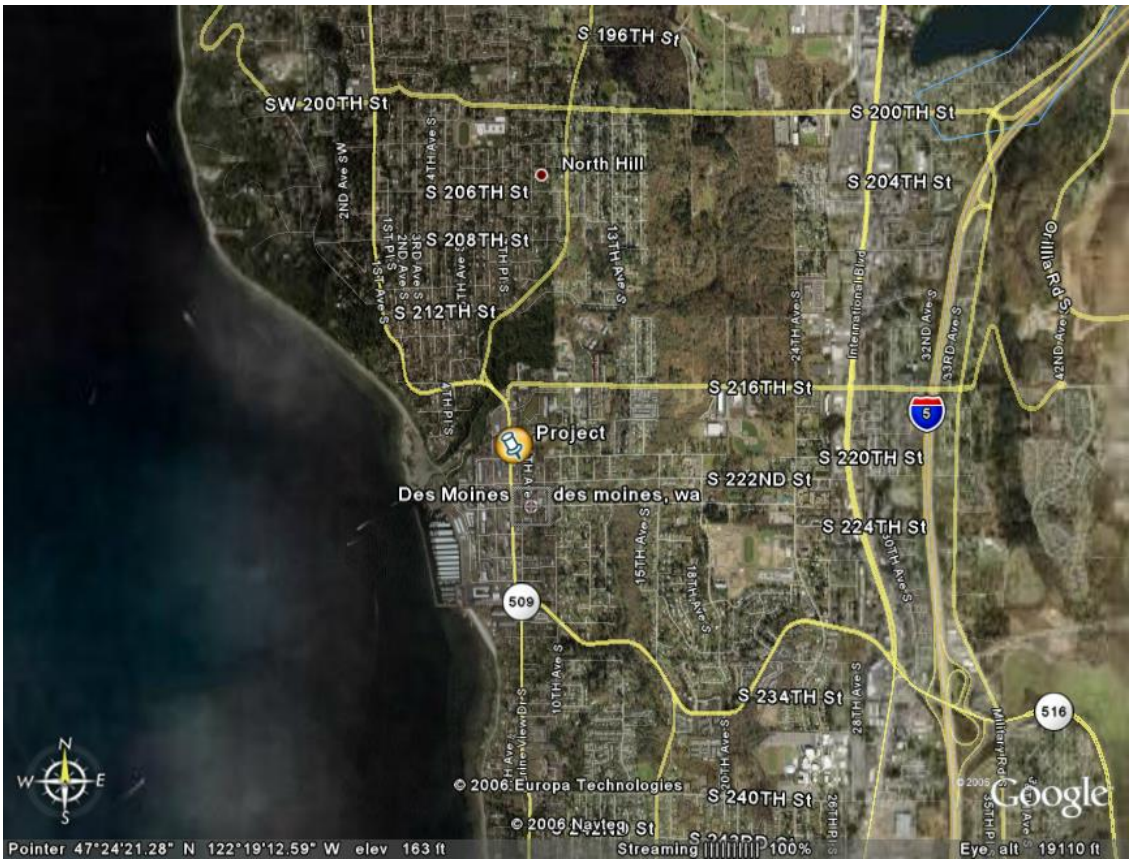
15. Set the CAVFS depth to 2 feet and the infiltration rate of the underlying soils to 0.01 in/hr.



Work Session 3 – Water Quality Design Examples

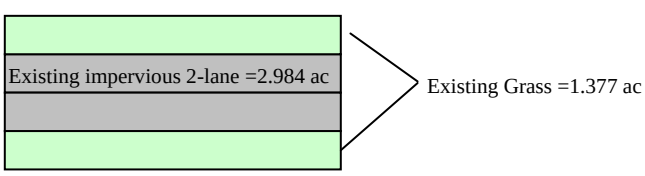
A section of highway near the city of Des Moines is to be improved with an additional lane in each direction. Design an on-line filter strip for water quality treatment. Size a flow control pond downstream of the filter strip to the flow duration standard.

As an alternative to the filter strip, determine the volume of a "Large" wet pond and the depth of water quality dead storage required.

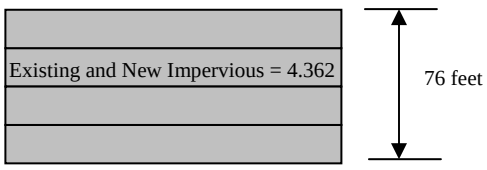


Project Location Map

The existing configuration consists of one 12-foot lane with a 6-foot shoulder on one side and an 8-foot shoulder on the other (including ditches) in each direction. The project will add one 12-foot lane in each direction, while maintaining the current shoulder widths. Both lanes will be added on the outside of the existing lanes.



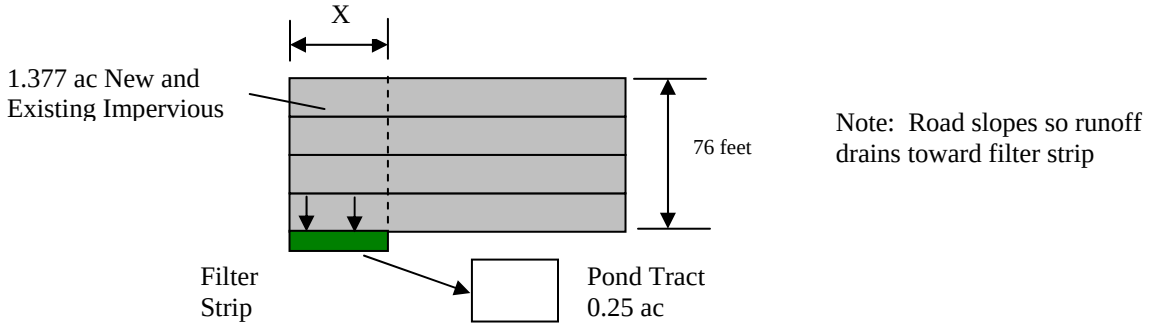
Existing



Proposed

Equivalent Area Representation:

- Design Pond to treat runoff for conversion of 1.377 ac grass to 1.377 ac impervious.
- Direct 1.377 ac of new and existing impervious to the pond.



Compute length (X) of new and existing impervious equal to new area added.

X=1.377*43560/76= **789 feet**

Start Program, Save Project File

1. Start program from Windows Start button
   Start-Programs-MGS Software-MGSFlood
2. Click File Save as, Enter "DesMoinesWQ1" for file name. Create project folder when prompted

Project Location Tab

3. Enter project name, analysis title, and comments.
4. Check the Extended Precipitation Timeseries Option Button
5. Compute the mean annual precipitation using the calculator,
   From Google Earth Map, Lat= 47.405 deg, Long=122.320 deg =37.7" MAP
6. Select <u>Climate Region 12 Puget East 36</u> in MAP from the drop down list box.

Land Use Tab

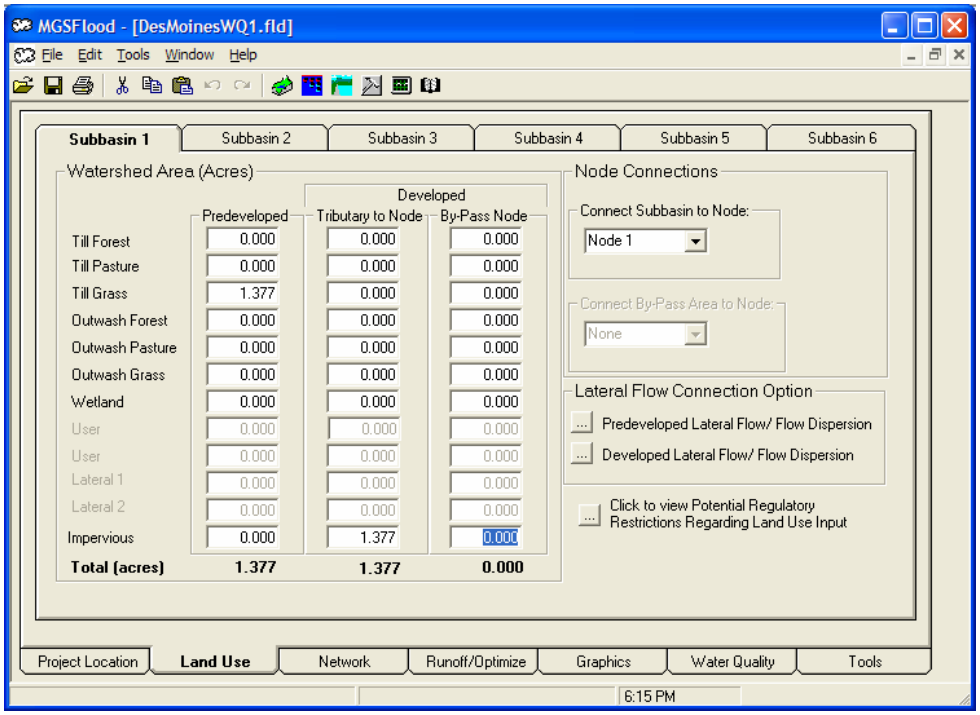
7. Enter Pre- and postdeveloped area. **<u>Predeveloped:</u>**

   <u>Grass:</u> = **1.377 ac**

   For SCS Type C soil, use Till

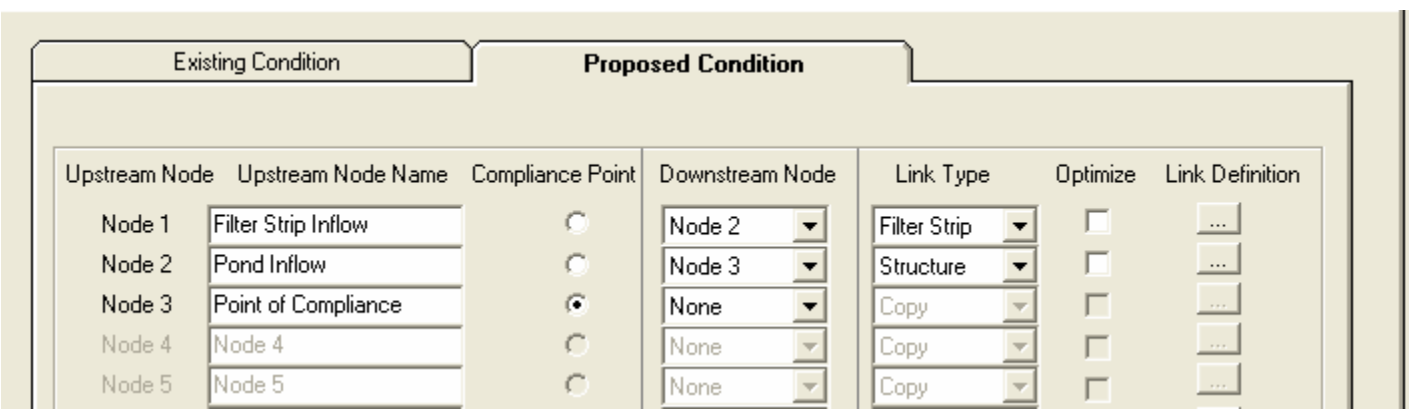
   <u>Postdeveloped:</u>

   Impervious: **1.377 ac**



Network Tab,

8. Existing Condition Scenario – Define Node 1 as the Point of Compliance.
9. Proposed Condition Scenario – Define the network as shown below, Node 1 is the filter strip inflow, Node 2 will be the pond inflow, Node 3 is the Point of Compliance.

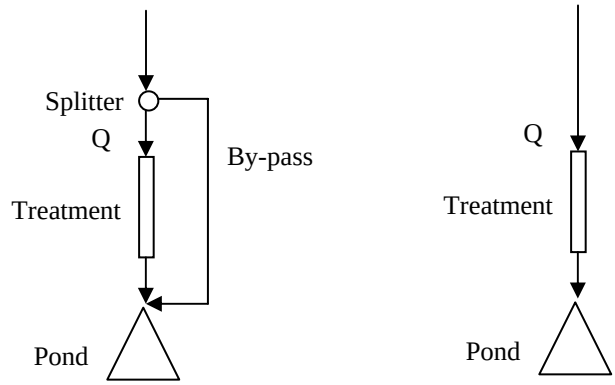


We need the On-Line water quality design discharge rate at Node 1 to size the filter strip. We have to simulate runoff through the network to get this. Use the default values for the filter strip and pond. No changes here.

Runoff/Optimize Tab,

10. Use the full period of record and click the Route button from the Runoff/Optimize tab.

Water Quality Tab,
Determine the "on-line" and "off-line" design discharge rate for the pond inflow node.



Upstream of Detention Facility, Off-Line **Upstream of Detention Facility, On-Line**

11. Click the *Water Quality Data* tab.
12. Select Node 1 from the drop down list, which represents the inflow to the filter strip.
13. Click the *Compute Water Quality 15-minute Design Discharge* button. On-line and off-line discharge rates will be reported on the tab and in the project report. Our filter strip is on-line.

On-Line Rate: Q_{wq}=0.19 Off-Line Rate: Q_{wq}=0.11 cfs

14. **Size Biofilter Strip**

    a. Apply Adjustment factor to design flow rate
    Filter Strip Design Rate: $Q_{vfs} = kQ_{wq}$
    $k = 1.41\ (P_{6\text{-month}}) - 0.052$
    6-Month, 24-Hour Precipitation for project = 1.5 inches
    $k = 1.41\ (1.5) - 0.052 = 2.06$

    Q_{vfs}=2.06*0.19= **0.39 cfs**

    b. Calculate the design flow depth at Q_{vfs}. The design flow depth is calculated based on the length of the vegetated filter strip (same as the length of the pavement edge contributing runoff to the vegetated filter strip) and the lateral slope of the vegetated filter strip parallel to the direction of flow. Design flow depth is calculated using a form of Manning's Equation:

$$y = \left[\frac{nQ_{vfs}}{1.49Ls^{1/2}}\right]^{3/5}$$

where: Q_{vfs} = vegetated filter strip design flow rate (cfs)

n = Manning's roughness coefficient. Manning's *n* can be adjusted by specifying soil and vegetation conditions at the project site, as specified in Table RT.02.1
L = length of the vegetated filter strip parallel to the pavement edge (ft)
s = slope of the vegetated filter strip parallel to the direction of flow (ft/ft). 2%< s < 15%

For this project, Q_{vfs}= 0.39 cfs, s=10%, L=789 feet, n=0.20 (fully compacted and hydroseeded)

y=((0.20*0.39)/(1.49*789*0.10^.5))^3/5=0.0062 feet

c. Calculate the design flow velocity passing through the vegetated filter strip atthe vegetated filter strip design flow rate.

$$V_{WQ} = \frac{Q_{vfs}}{Ly}$$

where: V_{WQ} = design flow velocity (ft/sec)
y = design flow depth
L= Length of filter strip.

V_{WQ}=0.39/(789*0.0062)=0.08 ft/s

d. Calculate the vegetated filter strip width. The width of the vegetated filter strip is determined by the residence time of the flow through the vegetated filter strip. A 9-minute (540-second) residence time is used to calculate vegetated filter strip width:

$W = 540\ V_{WQ}$

where: *W* = vegetated filter strip width (ft)
V_{WQ} = design flow velocity
A minimum width of 8 feet is recommended in order to ensure that the long-term effectiveness of the vegetated filter strip will occur.

W=540*0.08=**43 feet**

Go back and design stormwater pond with upstream filter strip. We'll have to include the area occupied by the filter strip and stormwater pond as an additional subbasin in the model.

Land Use Tab

15. Include Subbasin 2 for Pond tract and filter strip.

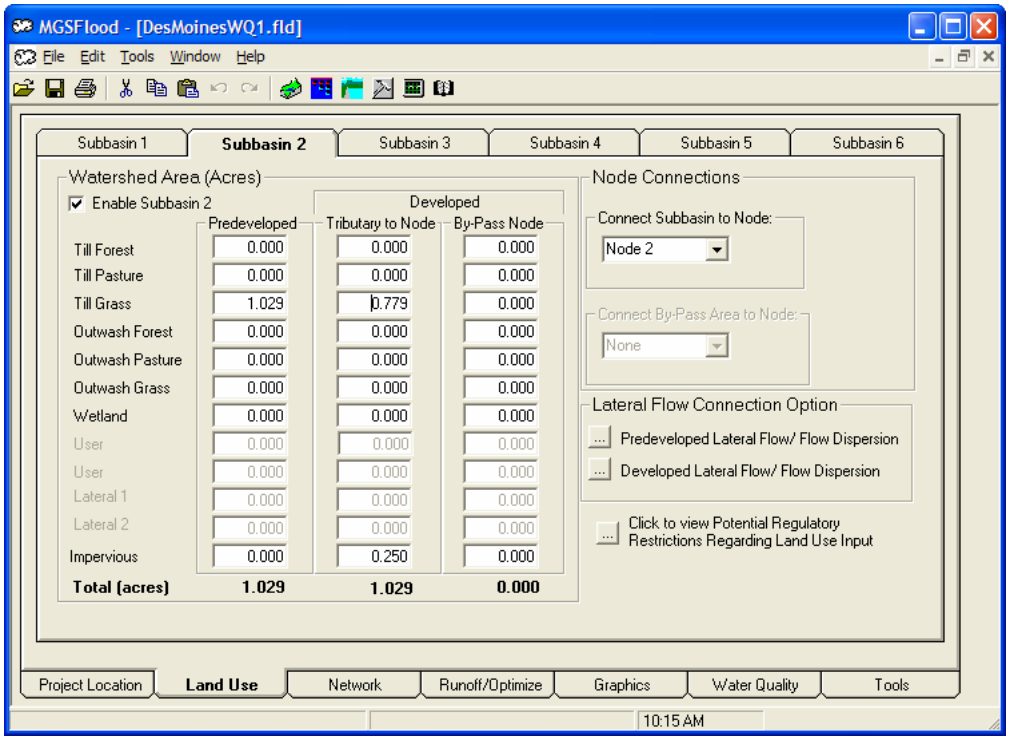
<u>Predeveloped:</u>

Pond = 0.25 ac (grass)
Filter Strip = 43*789= 0.779 ac (grass)
Total: **1.029 ac grass**

<u>Postdeveloped:</u>

Pond = **0.25 ac (Impervious)**
Filter Strip = **0.779 ac (grass)**

Connect Subbasin 2 to Node 2 (the pond inflow Node)

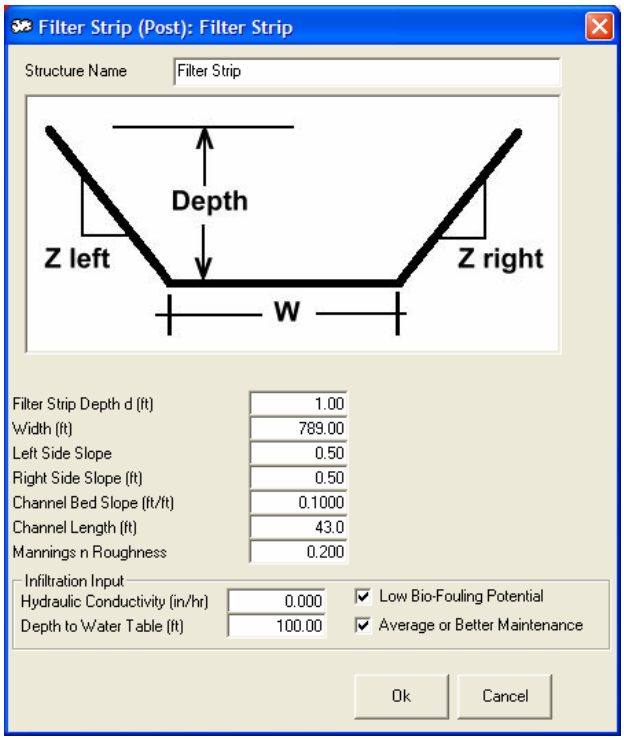


Network Tab,

16. Existing Condition Scenario – Connect Node 1 to Node 2 with Copy. Set Node 2 as the point of compliance.

17. Proposed Condition Scenario – Open the Link definition for the filter strip. Enter the geometry of the filter strip just sized.

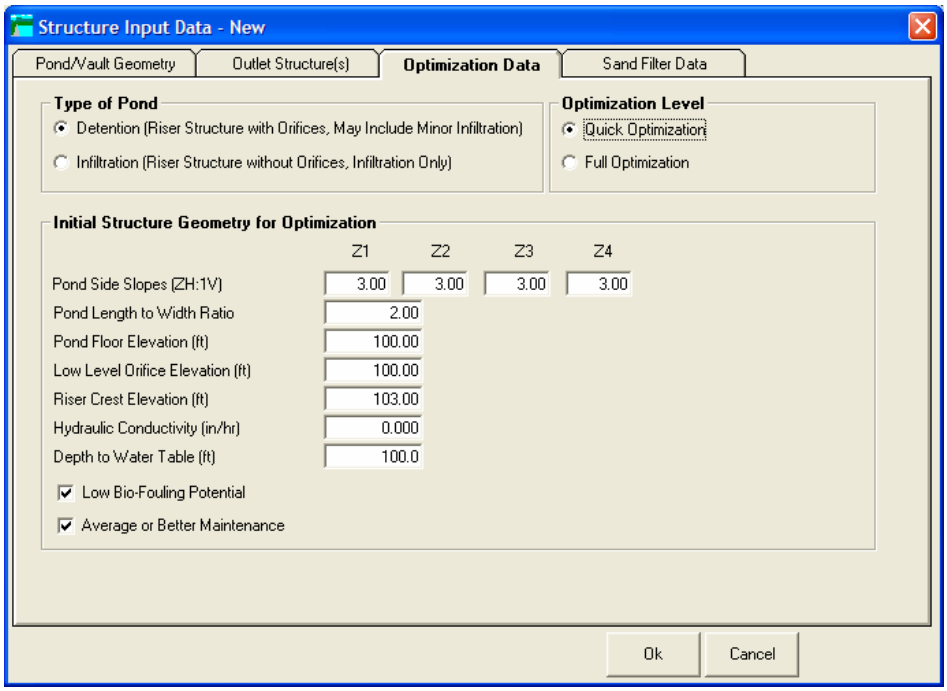
Filter strips are sized using a trapezoidal cross sectional shape. Enter a depth of 1 foot and side slopes of 0.5H:1V for all filters.

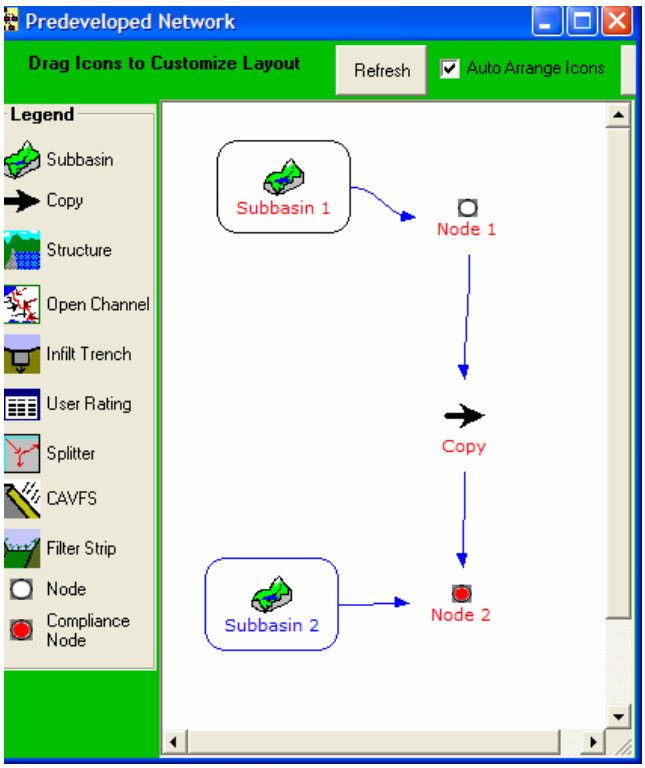


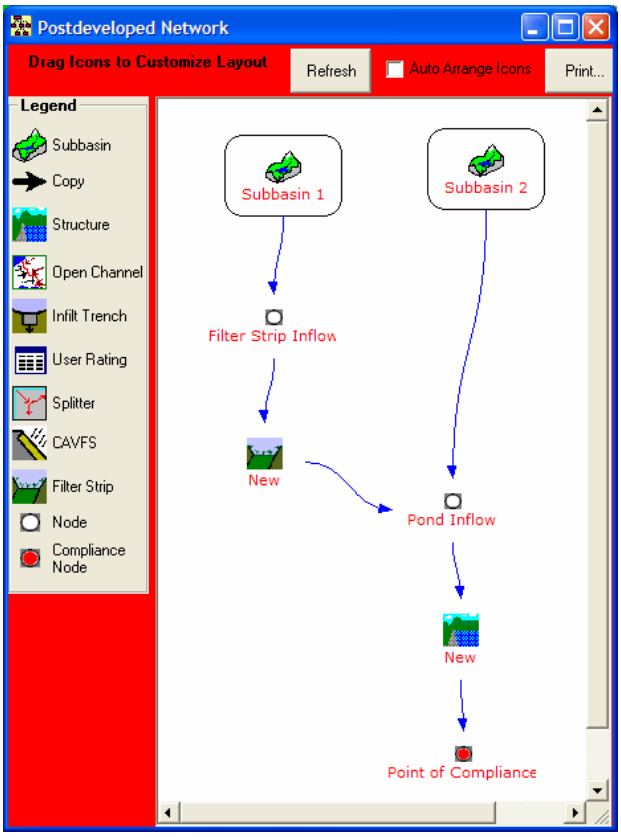
Click Ok to save your changes.

18. Proposed Condition Scenario – Click the Optimize Check box next to the Structure.

19. Open the Link Definition for the Structure. Click the Optimization tab. Select <u>Quick Optimization</u> with the data shown below. Click Ok to save your changes.



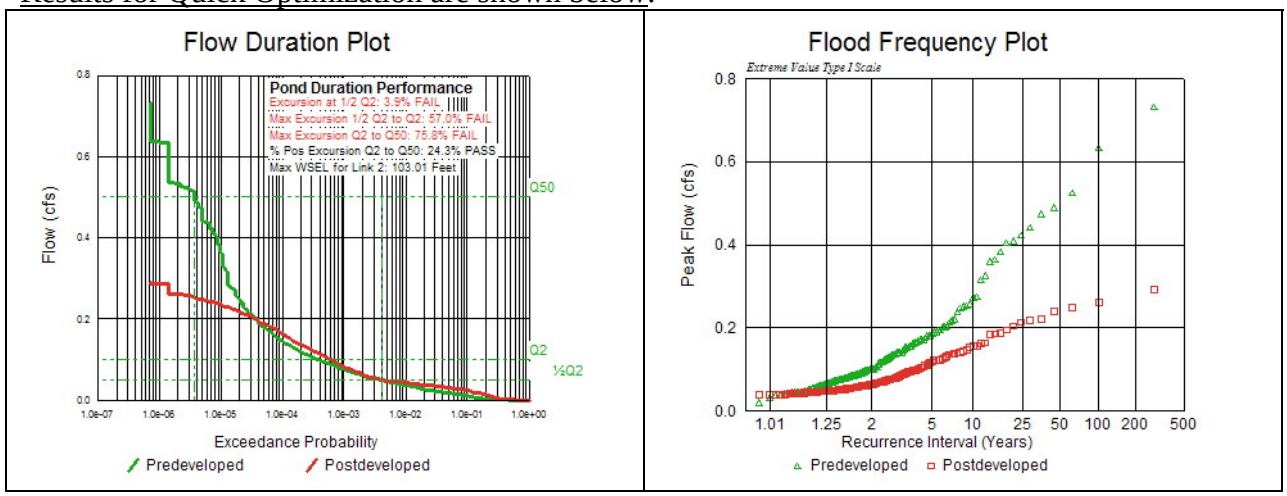




Runoff/Optimize Tab,

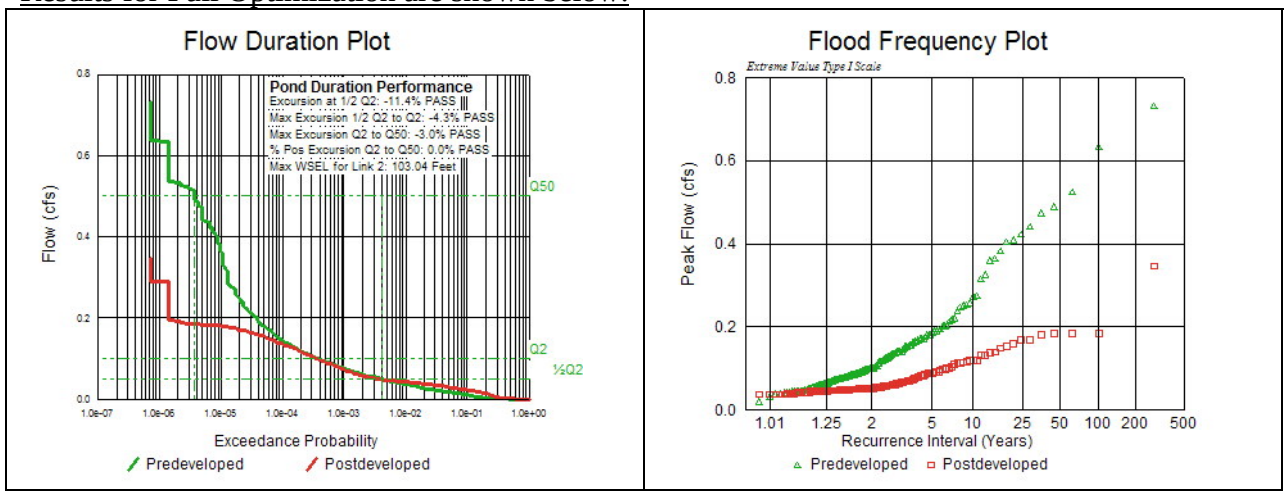
20. Use the full period of record and click the Route button from the Runoff/Optimize tab.

<u>Results for Quick Optimization are shown below</u>.



Pond Bottom Length : 89.4 ft
Pond Bottom Width : 44.7 ft
Pond Bottom Area : 3996 sq-ft
Area at Riser Crest El: 6,734. sq-ft
Volume at Riser Crest : 0.365 ac-ft

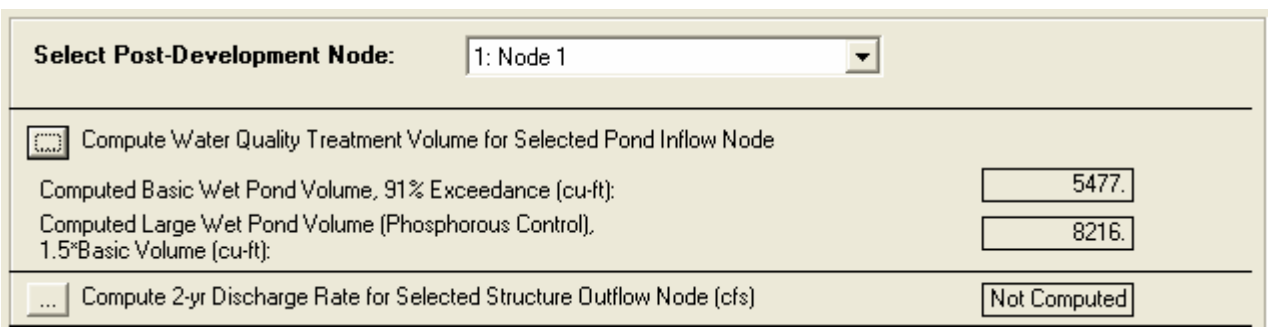
Results for Full Optimization are shown below.



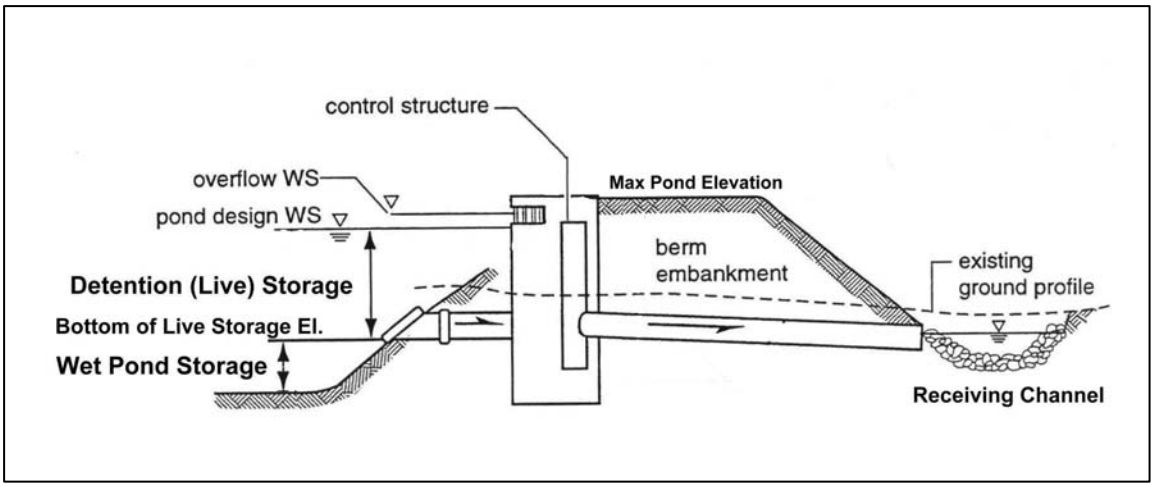
Pond Bottom Length : 95.1 ft
Pond Bottom Width : 47.6 ft
Pond Bottom Area : 4525 sq-ft
Area at Riser Crest El: 7,417. sq-ft
Volume at Riser Crest : 0.407. ac-ft

Design a combined wet pond for the previous project (this would be an alternative to the filter strip for water quality treatment)

21. Click the *Water Quality* tab. The basic wet pond volume is calculated using the node containing the runoff from the impervious area (Node 1). Select Node 1 and click the Compute Water Quality Treatment Volume button. The results will be displayed on the form. The "Large" wet pond volume is also provided, which is the basic volume multiplied by 1.5.



1. Compute Depth of Wet Pond Storage



Dead Storage Volume: $V = D\left(\frac{A_t + A_b + \sqrt{A_t A_b}}{3}\right)$

D= Storage Depth (Unknown)
V= Water Quality Volume (8216 cu-ft)
A_t= Top of Wet Pond Storage Area (3996 sf)
A_b= Bottom of Wet Pond Storage Area Computed by:

A_b= (L-2ZD)(W-2ZD)
L= Length of Pond at Top of Wet Pond Storage (89 ft)
W= Width of Pond at Top of Wet Pond Storage (45 ft)
Z=Pond Side slopes (3)

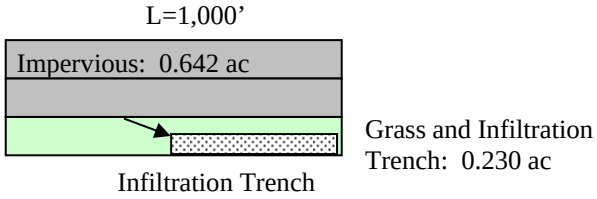
By trial, A_b= 2036 , D=2.8 ft (minimum) (WetPondDepthCalculator.xls)

Work Session 4
Off Ramp Design, WSDOT Highway Runoff Manual
Infiltration Trench Design

A new off-ramp is being constructed near Vancouver. The existing condition consists of grass right of way. The off-ramp will be 1,000 feet long, 28 feet wide pavement, and 10 foot wide grass slope on one side. Geologic investigations indicate permeable alluvium soil with characteristics similar to outwash.

Design a pipe-end infiltration trench system that meets the flow duration standard for this project using the Optimization Routine. Assume that the infiltration trench is 3 feet wide by 2 feet deep.

Geologic investigations indicate minimum depth to groundwater of 15 feet below the trench during the winter months. Use saturated hydraulic conductivity of 1 inch per hour for native material and a porosity of 30% for the trench gravel. Assume low bio-fouling and average or better maintenance.



Developed Condition

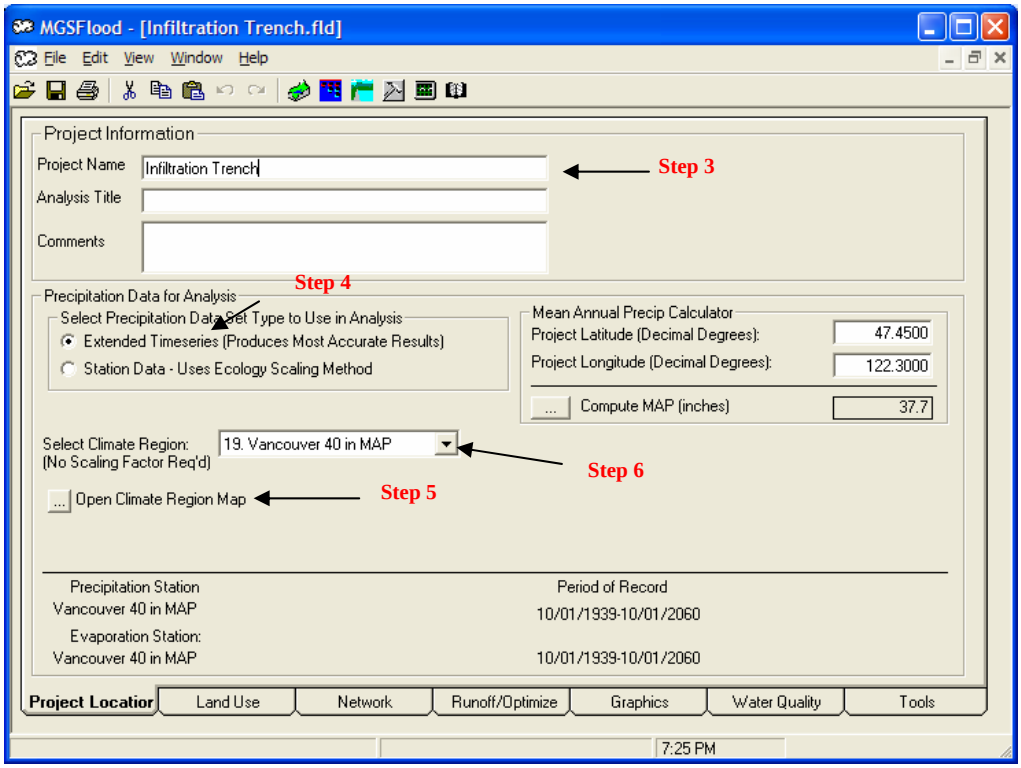
Start Program, Save Project File

1. Start program from Windows Start button
2. Click *File Save As*, Enter "InfiltrationTrench" for Project Title. Create project folder when prompted.

Project Location Tab

3. Enter project name, analysis title, and comments.
4. Check the Extended Precipitation Timeseries Option Button
5. Click the *Map* button under Climate or refer to the printed copy of the map. Locate Vancouver on the map. Note the Timeseries Region and the mean annual precipitation for the project. Click the X on the Map window to close it. You could also use the calculator to determine the Mean Annual Precipitation for the project site.

6. Select Climate Region 19. Vancouver 40 in MAP from the drop down list box.



Land Use Tab

The pond will be designed for the mitigated (new impervious) area only. Subbasin 1 consists of the new impervious area and Subbasin 2 consists of the remaining area discharging to the pond.

7. Compute Pre- and postdeveloped area.

<u>Subbasin 1: Total Area Draining to Trench</u>

<u>Predevelopment</u>

<u>Outwash Grass:</u>
(28'+10')*1,000'=38,000/43560 = **0.872 ac**

<u>Post-Development</u>

<u>Impervious:</u>
28'*1000'=28,000/43560 = **0.642 ac**

<u>Outwash Grass</u>
10'*1000'=10,000/43560=**0.230 ac**

<u>Subbasin 1 Total: 0.872 acres</u>

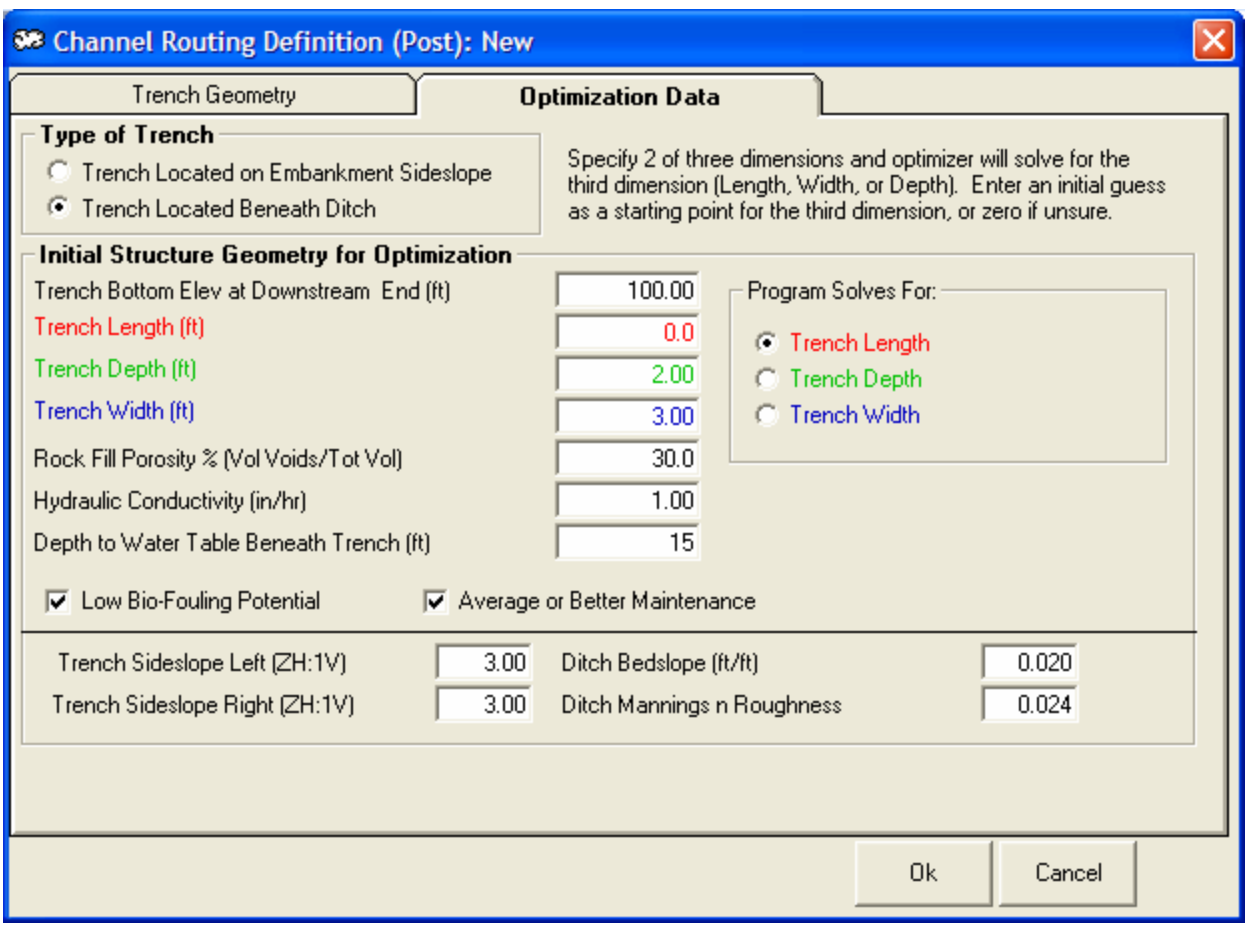
Network Tab

8. Existing Condition – Set Node 1 as the Point of Compliance.
9. Proposed Condition – Connect Node 1 to Node 2, Define the Link as an infiltration Trench.
10. Click the Link Definition Button for the trench, then click the Optimization tab.

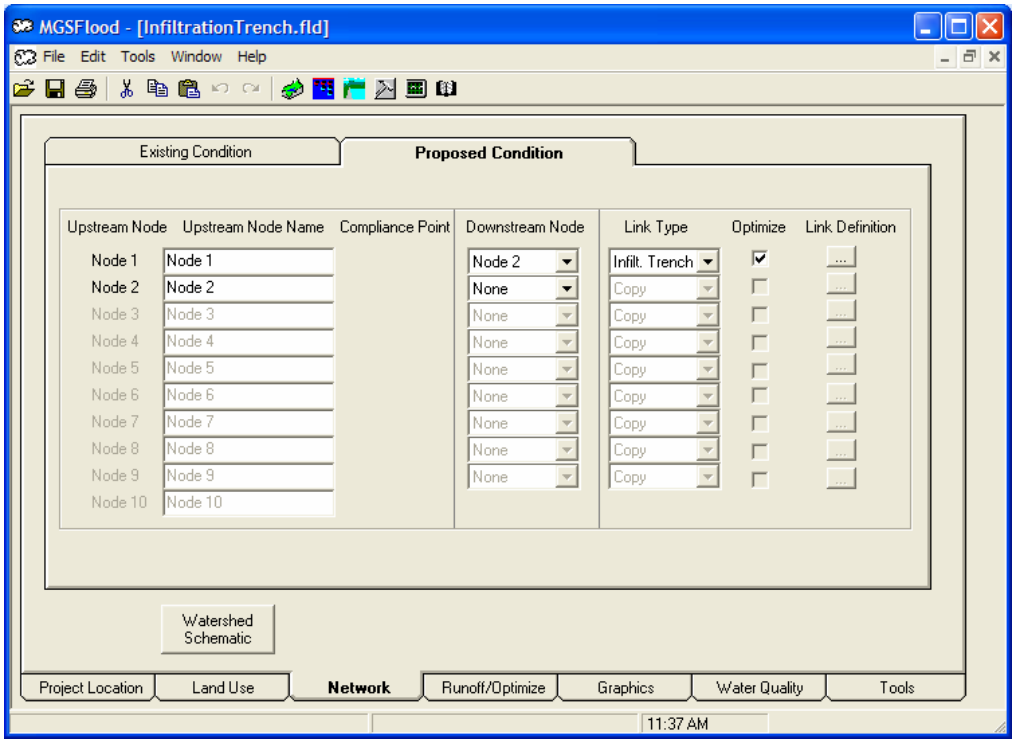
    Select infiltration trench located beneath ditch.
    Since we know the trench depth and width and want to solve for length, enter 0 for the trench length and check the Solve for Trench Length Option.

    Enter the remainder of the information as shown below then Click Ok to return to the Network tab.

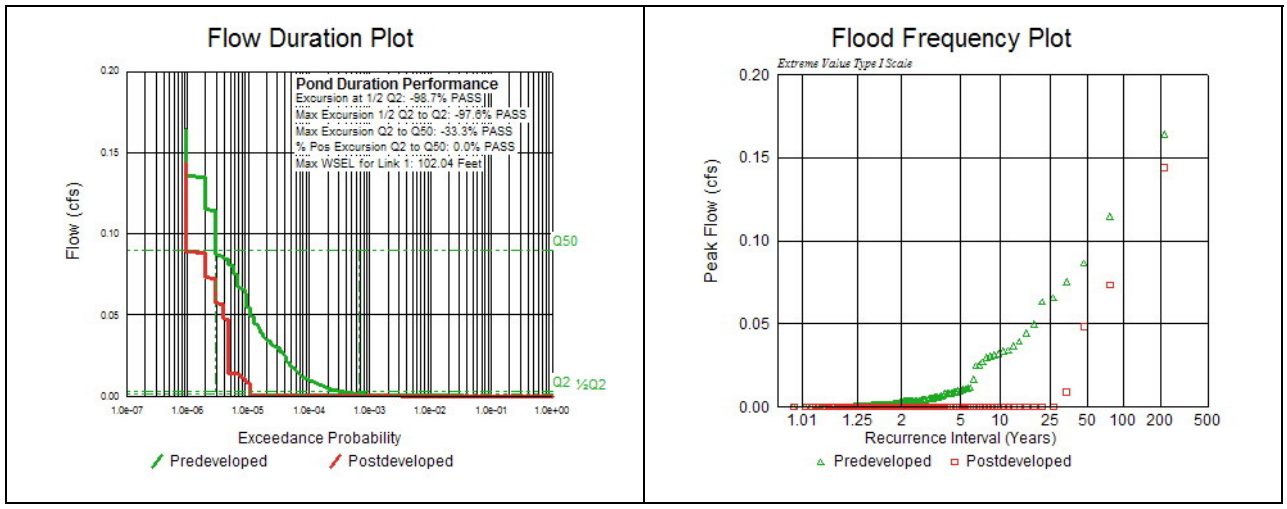
- **Remember the default settings are in ft/day for the Hydraulic Conductivity. You will need to convert the values. For this example change the units to in/hr to match the example problem. The units are under: Tool- Options- 3rd tab Units.**



Check the Optimize button next to the Infiltration Trench Link.



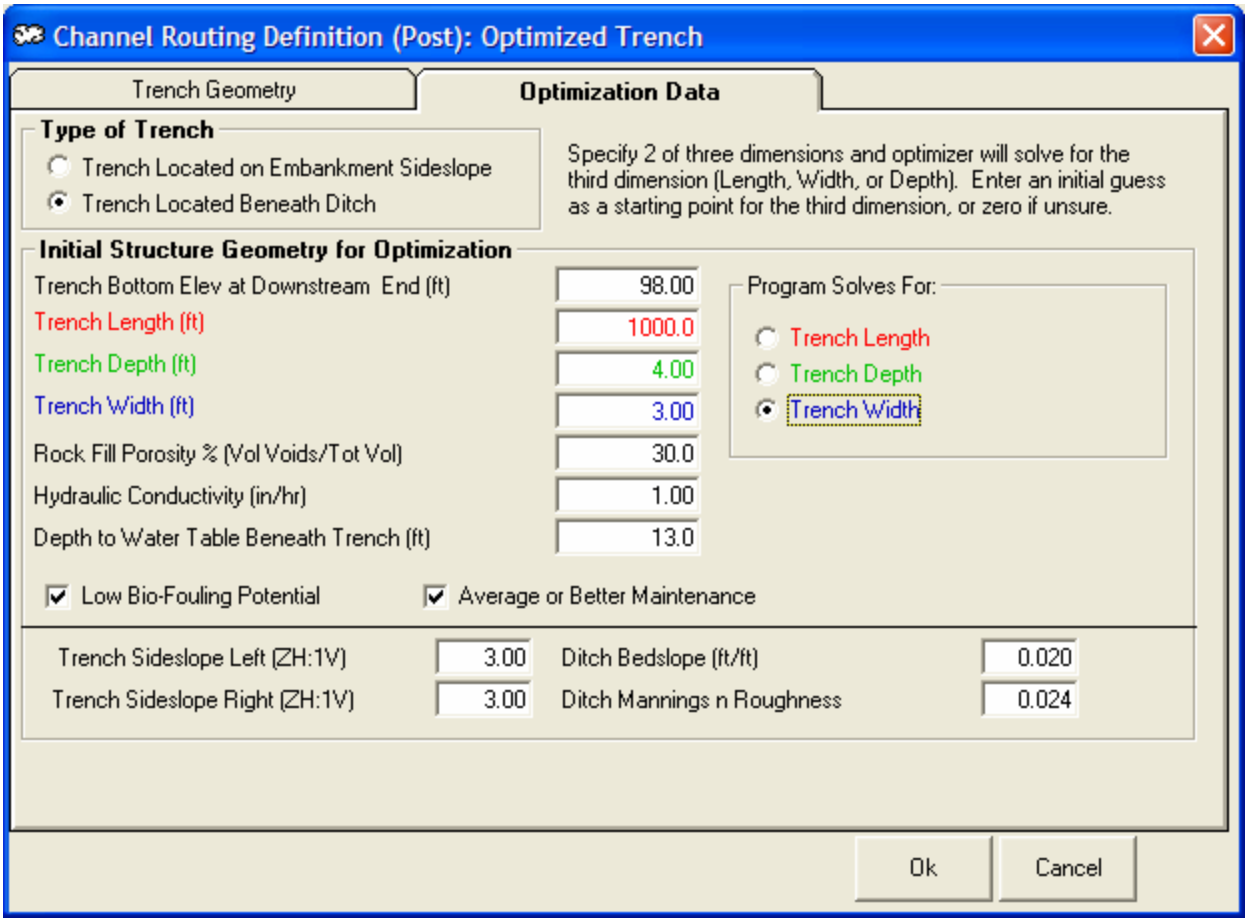
1. **Click the Runoff/Optimize tab.** Make sure the Optimize box is checked. Click the Route button. Review final trench size and runoff stats.



Trench Geometry:

Length: 2,803 feet (<u>Note this trench is too long to fit within 1000' long area</u>)
Try again, this time limit the trench length to 1000 feet and make trench deeper.

How wide would the channel have to be if the trench length were limited to 1,000 feet with a depth of 4 feet? Note we have to change the depth to water table because the trench is 2 feet deeper now.

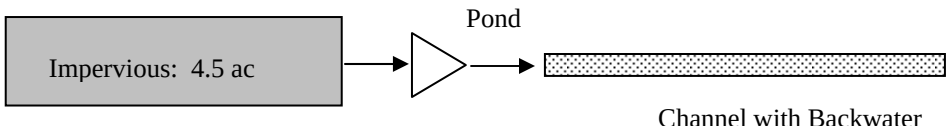


Final Trench Geometry:

Length: 1,000 feet
Width: 4.9 feet, Specify 5' trench width
Depth: 4 feet

Work Session 5
Orifice with Tailwater Design

A pond is to be constructed in an area that is influenced by backwater conditions during floods. The project consists of 4.5 acres of till forest converted to impervious. The project is located in Puget West 40 inches of mean annual precipitation.



Open channel hydraulic calculations resulted in the following elevation/discharge relationship for the channel:

Elevation	Discharge (CFS)
99.5	0
100.5	0.063
101.5	0.141
103.0	0.213

Analysis Steps

First, we'll size the pond assuming that there is no backwater using the optimizer routine. Next, we'll replace the low level orifice with an orifice with backwater and adjust the pond configuration to meet the duration standard.

Start Program, Save Project File

1. Click File Save as, Enter "Backwater" for file name. Create project folder when prompted

Project Location Tab

2. Enter project name, analysis title, and comments.
3. Check the Extended Precipitation Timeseries Option Button
4. Select Extended precipitation timeseries number 3, Puget West 40 inches MAP

Land Use Tab

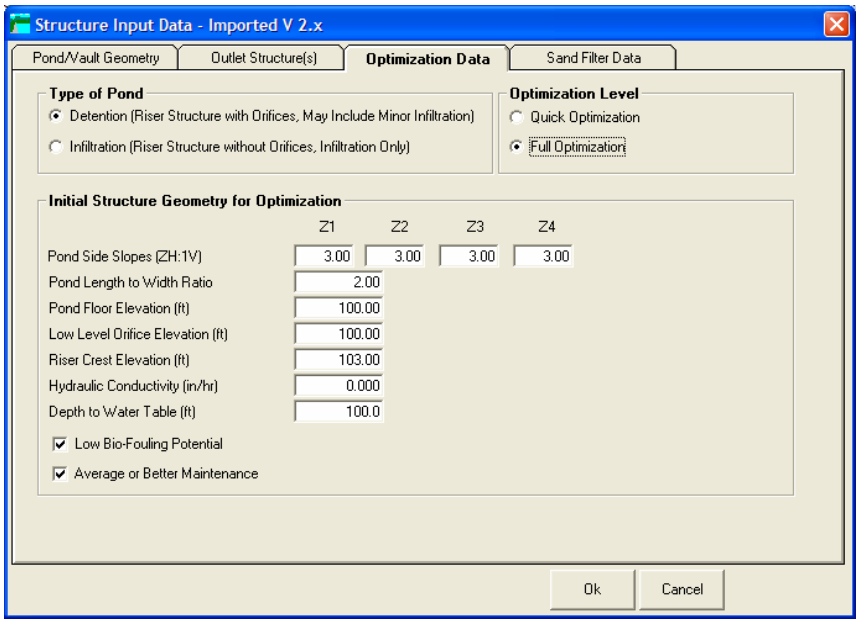
5. Enter Predeveloped and Developed land use
   Predeveloped: Till Forest 4.5 acres
   Developed: Impervious 4.5 acres

Network Tab

Existing Condition Scenario
Set Node 1 as the Point of Compliance

Proposed Condition Scenario
Connect Node 1 to Node 2 and define the link as a structure.

Click the Link Definition for the structure, Click the Optimization tab. Enter the information below.

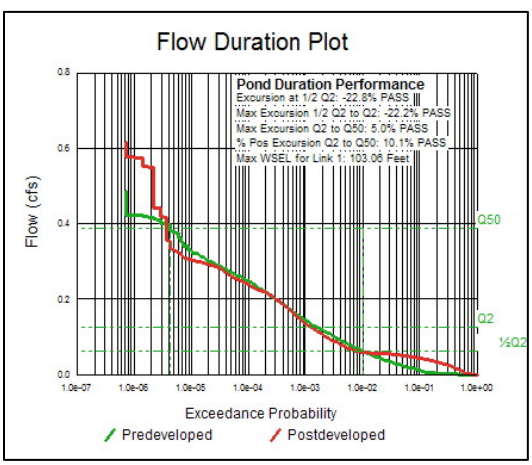


Click Ok to save the changes

Check the optimize box next to the link connecting Nodes 1 and 2.

Runoff/Optimize Tab

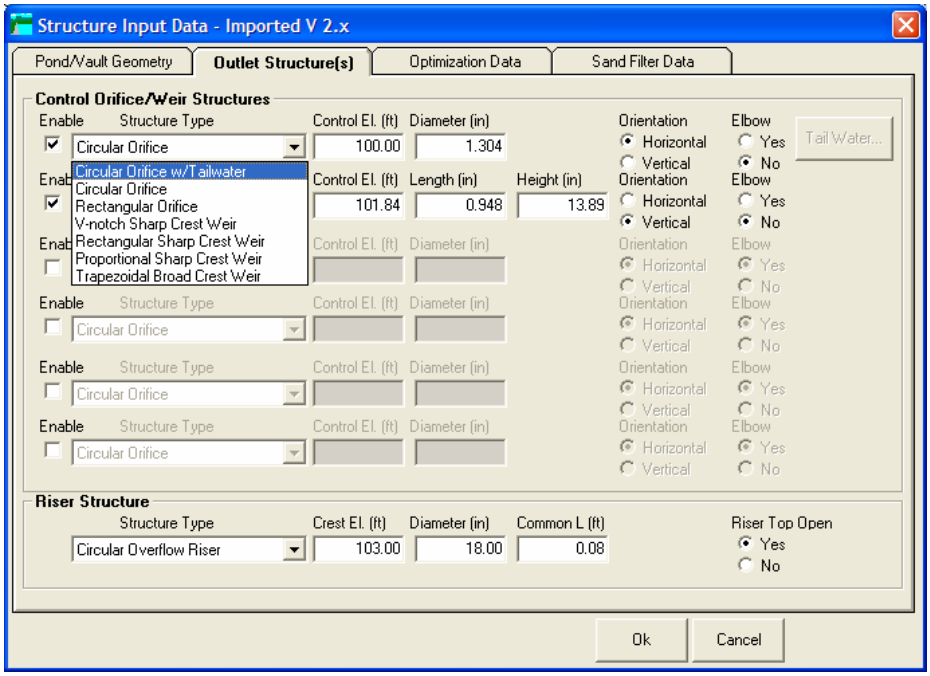
Check the Optimize Structure box and Click Route.



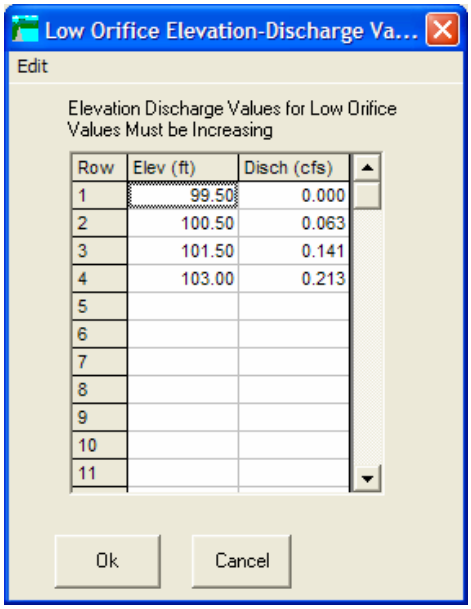
Resulting Flow Duration Curve (No Backwater)

Network Tab

Next, we'll modify the pond outlet and include backwater on the low level orifice. Click the link definition for the pond. Click the outlet structure tab. Select Orifice with Tail water.



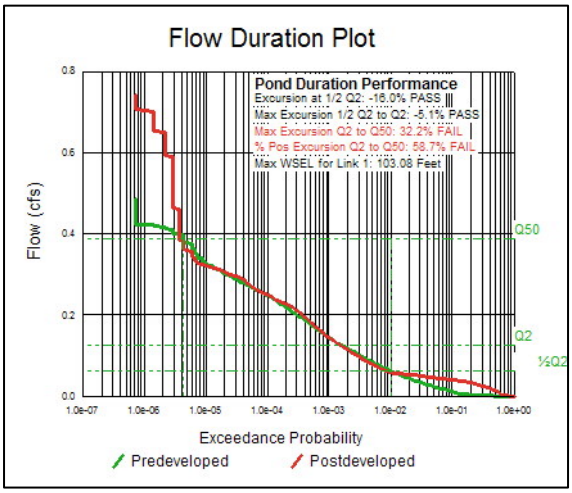
Click the tailwater button and enter the tail water data (elevation/discharge). This table defined the water surface elevation in the receiving channel for various discharge rates.



Click Ok to close the Elevation-Discharge table, and then Ok to close the structure definition window

Route/Optimize Tab

Uncheck the Optimize Structure box and click Route. This will route flows through the pond with while accounting for backwater effects on the lower orifice.

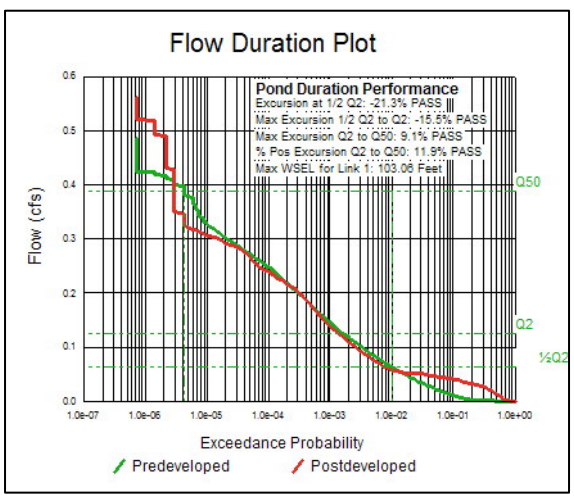


Note that the backwater caused the pond to fail the performance criteria.

Network Tab

Open the link definition for the stormwater pond and increase the size.

Make the length 260 feet and the width 130 feet. This increases the volume from 2.449 ac-ft to 2.577 ac-ft, a 5% increase. Reroute flows through the pond.

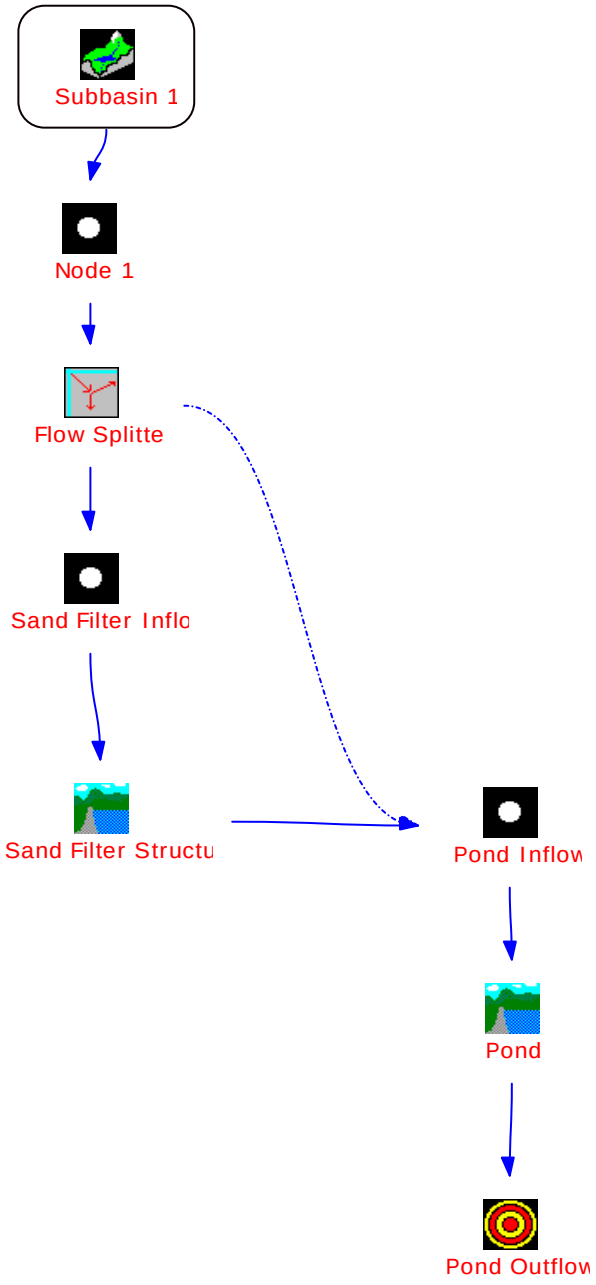


Pond with backwater and volume increased by 5%.

Sand Filter Design Example

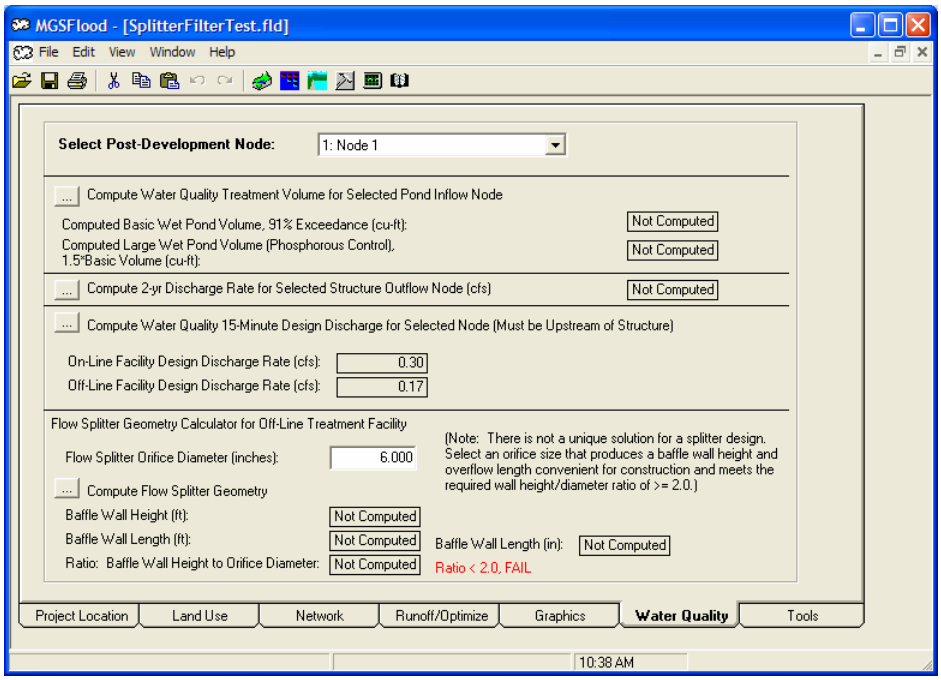
Design an “off-line” sand filter upstream of a stormwater pond to provide 91% runoff treatment.

1. Open the project SplitterFilterTest.fld stored on your computer.
   The project schematic for the post developed is shown below.

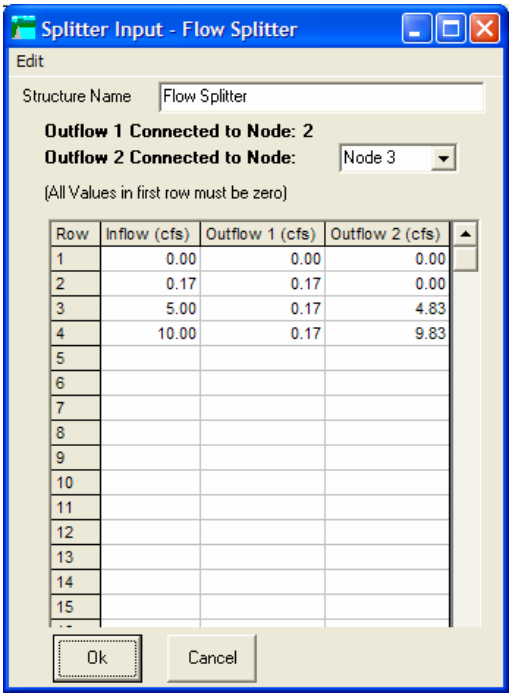


2. Design the flow splitter to carry the off line water quality discharge rate to the sand filter. We need to know what the off line rate is. We'll simulate runoff for the project then go to the Water Quality tab and compute the off-line water quality discharge rate.

   Click the Runoff/Optimize tab. Uncheck the Optimize Structure check box. Click Route Flows
3. On the Water quality tab, select Node 1 as the post-developed node (this is the node upstream of the flow splitter). Click the Compute Water Quality 15-Minute Design Discharge Rate.



4. The flow splitter was designed to pass the off line water quality discharge rate of (0.17 cfs) to the sand filter. Flows in excess of this are bypassed downstream of the sand filter to the stormwater pond inflow node. The splitter table is as follows:



Row	Inflow (cfs)	Outflow 1 (cfs)	Outflow 2 (cfs)
1	0.00	0.00	0.00
2	0.17	0.17	0.00
3	5.00	0.17	4.83
4	10.00	0.17	9.83
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

Define a range of inflow values that extend well beyond what would be expected for the inflow.

Enter 0.0 cfs as the first row, then enter the water quality discharge as the second row.

Outflow 1 is connected to Node 2, the sand filter. Set this discharge rate to the water quality discharge rate (0.17 cfs).

Outflow 2 is connected to Node 3, the pond inflow, and represents the flows that bypass the filter. Enter the difference between the value in the Inflow Column and the Outflow 1 column.

5. Next, we'll size the sand filter. The sand filter is simulated as a structure in MGSFlood. The structure connecting Nodes 2 and 3 is defined as a sand filter. Sizing the sand filter is a trial and error procedure.

   A good starting point is to size the filter so that it passes the water quality design discharge rate at maximum pool. We can compute this using a rearranged form of Darcy's Equation:

$$A = \frac{Qt}{K(t+d)} * 43200$$

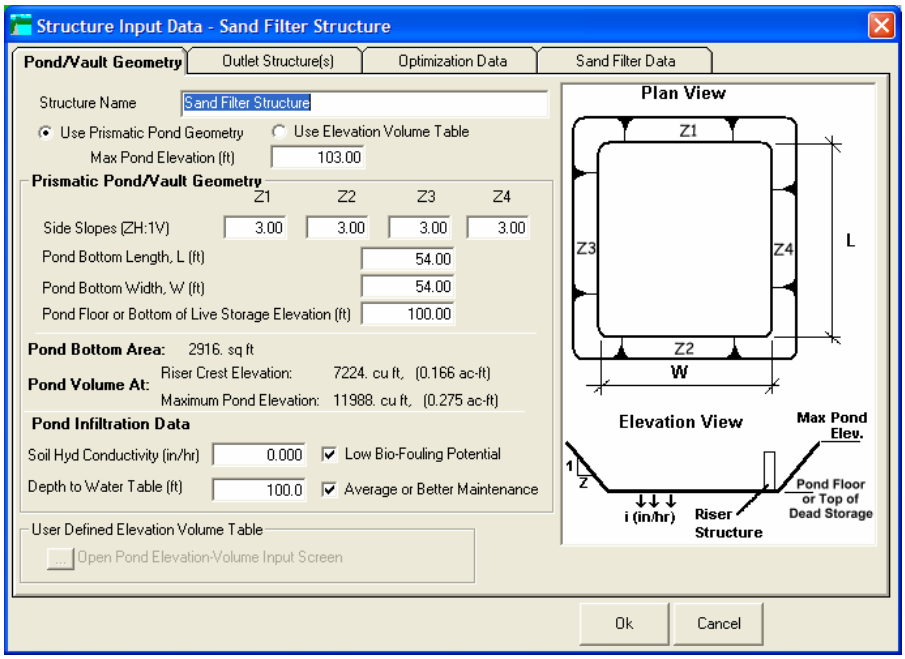
Where: Q is the water quality discharge rate in cfs
t is the thickness of the sand filter in feet
K is the permeability of the sand in in/hr
d is the distance between the top of the filter and the riser crest elevation
43200 is a conversion factor

In our case, the sand is 3 feet thick with permeability of 1.5 inches per hour; the distance from the filter top to the riser crest is 2 feet (We'll set the overflow riser 2-feet above the filter). The Water quality discharge is 0.17 cfs.

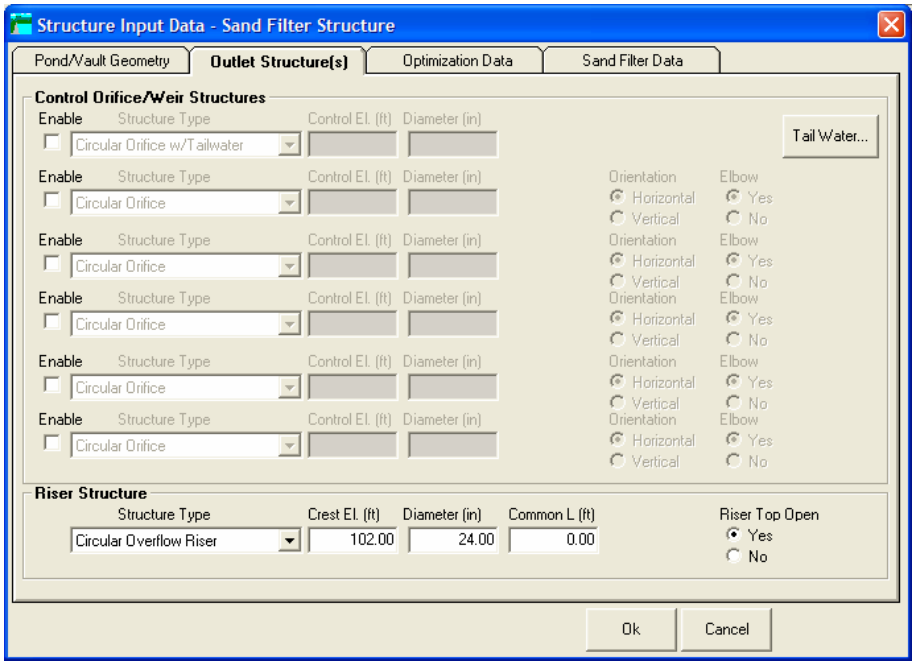
Using the equation above, the required sand filter area would be:

A=(0.17 * 3)/ [1.5 (3+2)]*43200= 2,940 sf

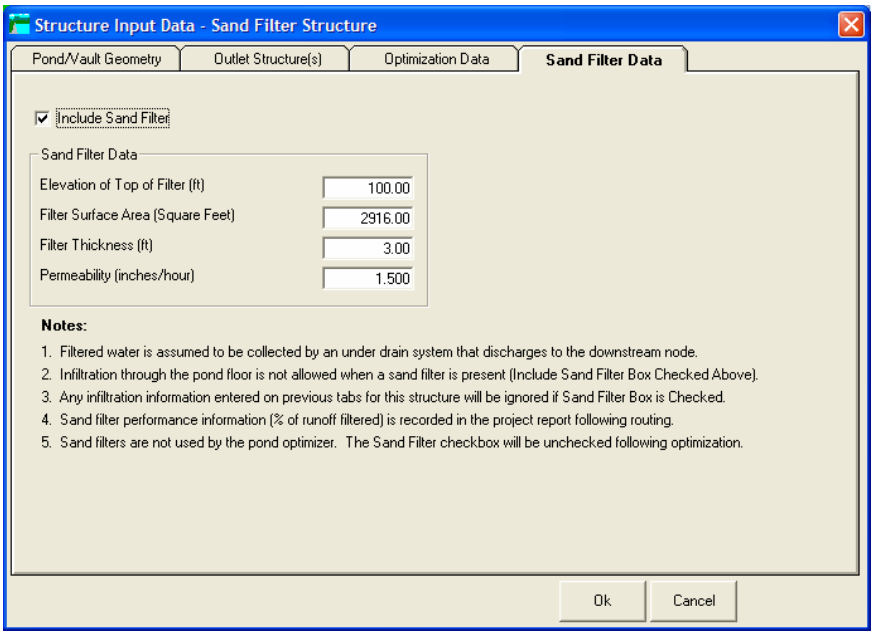
Thus, we'll use a pond with length and width of 54.



Set the overflow riser at 102', thus, the sand filter will store 2-feet before overflowing. No other outlets need to be defined on the Outlet Structures tab (see figure below)



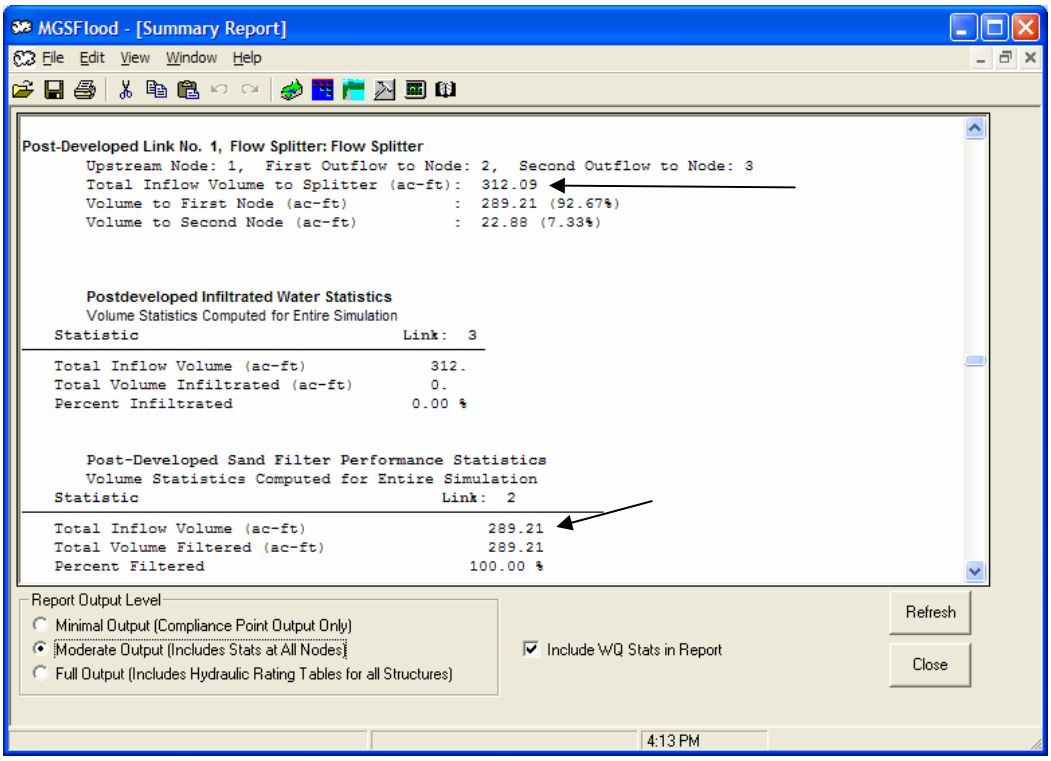
6. On the Sand Filter Data tab, check the Include Sand Filter button.
   Next, enter the surface area of the sand filter, in this case 2,916 sf (length and width of 54 feet). Enter the thickness of the sand, and the permeability. Click OK.



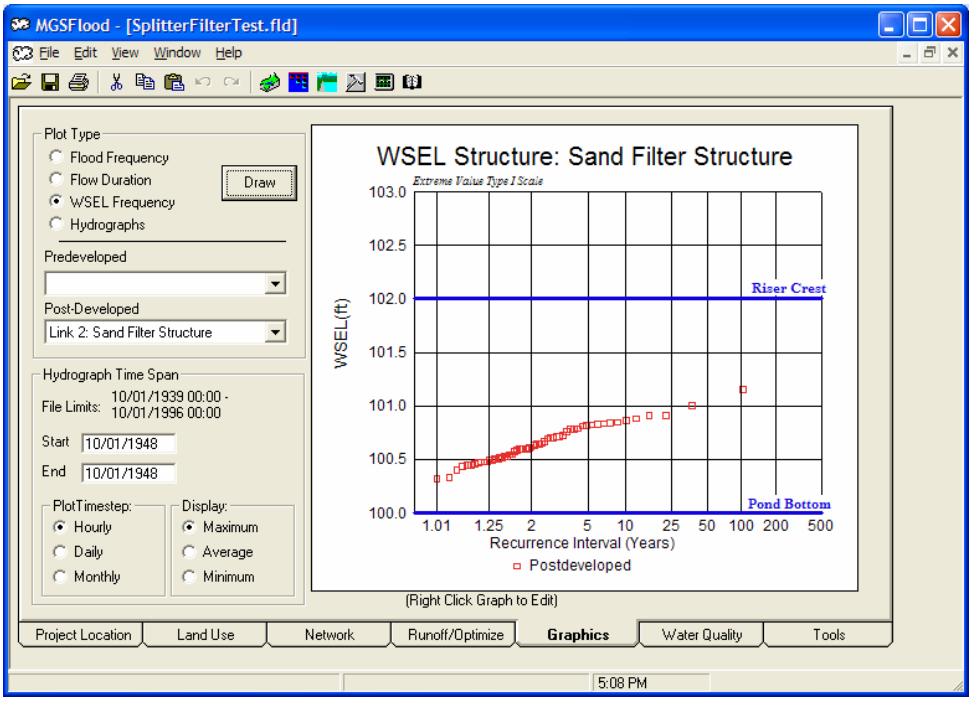
7. Click the Runoff/Optimize tab. Set the end date to 1996 to speed up the calculation. Click the Route button to perform the simulation. Make sure the compute statistics at all nodes is checked.

8. Open the project report and locate the flow splitter and sand filter volume statistics. In this case, 289 ac-ft of runoff out of 312 was filtered (93%). This is greater than the required 91% treatment so the design is acceptable.

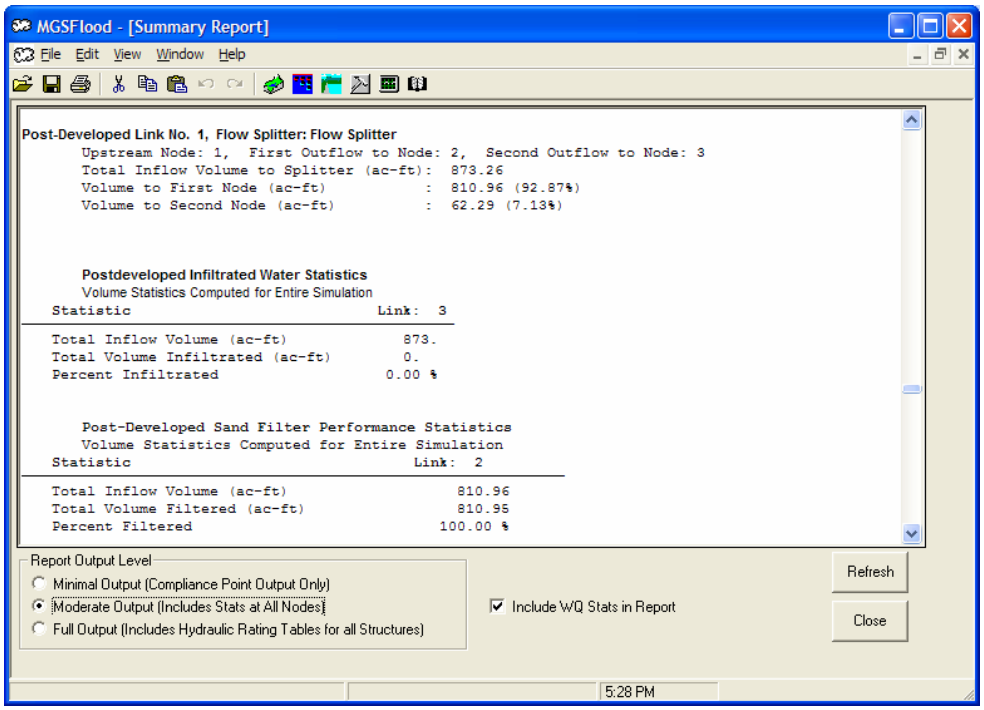
   Checking the water surface elevation frequency plot (see below) for the sand filter shows that water level is between the pond bottom and the riser crest. Thus, we're using the storage volume above the sand filter, but we're not reaching the overflow. We'll refine the design by reducing the size of the sand filter.

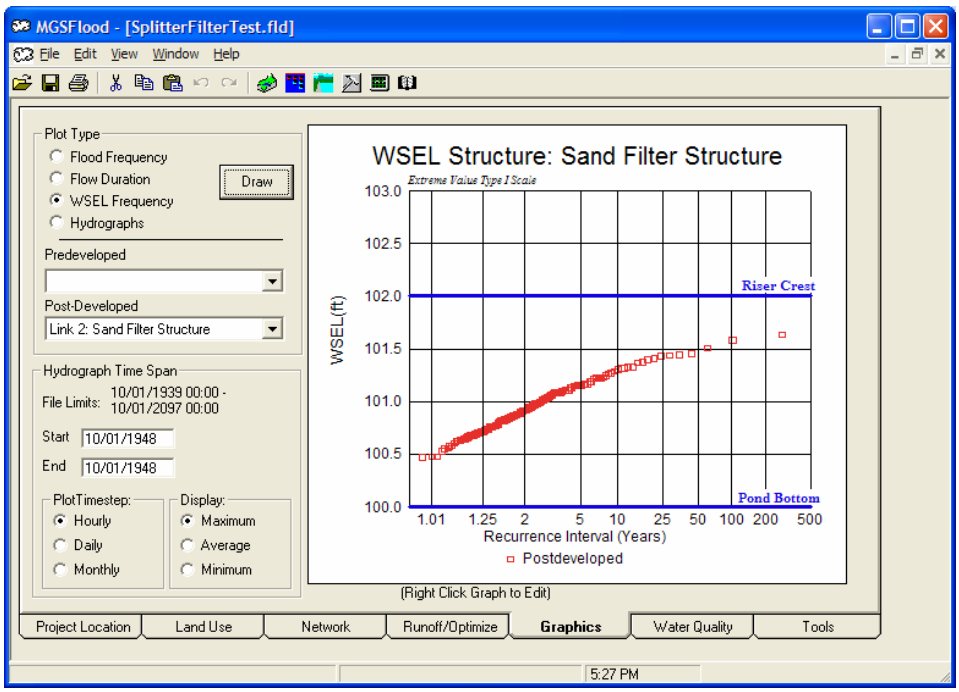


Simulation Results with 59-year Record



9. Next, reduce the pond length and width to 50 feet and the sand filter area to 2500 sf. This was found to be acceptable, i.e. the storage above the filter was utilized nearly to the riser crest elevation. The model was then rerun using the full 158-year simulation period. The results for the final sand filter configuration are shown below. The filter is treating 93% of the volume of runoff during the 158-year simulation. OK.


MGSFlood - [Summary Report]
File Edit View Window Help
Post-Developed Link No. 1, Flow Splitter: Flow Splitter
Upstream Node: 1, First Outflow to Node: 2, Second Outflow to Node: 3
Total Inflow Volume to Splitter (ac-ft): 873.26
Volume to First Node (ac-ft) : 810.96 (92.87%)
Volume to Second Node (ac-ft) : 62.29 (7.13%)
Postdeveloped Infiltrated Water Statistics
Volume Statistics Computed for Entire Simulation
Statistic Link: 3
Total Inflow Volume (ac-ft) 873.
Total Volume Infiltrated (ac-ft) 0.
Percent Infiltrated 0.00 %
Post-Developed Sand Filter Performance Statistics
Volume Statistics Computed for Entire Simulation
Statistic Link: 2
Total Inflow Volume (ac-ft) 810.96
Total Volume Filtered (ac-ft) 810.95
Percent Filtered 100.00 %
Report Output Level
Minimal Output (Compliance Point Output Only)
Moderate Output (Includes Stats at All Nodes)
Full Output (Includes Hydraulic Rating Tables for all Structures)
Include WQ Stats in Report
Refresh
Close
5:28 PM


MGSFlood - [SplitterFilterTest.fld]
File Edit View Window Help
Plot Type
Flood Frequency
Flow Duration
WSEL Frequency
Hydrographs
Draw
Predeveloped
Post-Developed
Link 2: Sand Filter Structure
Hydrograph Time Span
File Limits: 10/01/1939 00:00 - 10/01/2097 00:00
Start 10/01/1948
End 10/01/1948
PlotTimestep:
Hourly
Daily
Monthly
Display:
Maximum
Average
Minimum
WSEL Structure: Sand Filter Structure
Extreme Value Type I Scale
WSEL(ft)
103.0
102.5
102.0
101.5
101.0
100.5
100.0
Riser Crest
Pond Bottom
1.01 1.25 2 5 10 25 50 100 200 500
Recurrence Interval (Years)
Postdeveloped
(Right Click Graph to Edit)
Project Location
Land Use
Network
Runoff/Optimize
Graphics
Water Quality
Tools
5:27 PM