STORMSHED 3G BEGINNER TRAINING

Alex Nguyen, PE
HQ Hydraulics Section

StormShed3G
Learning Outcomes

- WSDOT Hydraulic Design and Stormwater Design Processes

- What is StormShed3G?

- Understand some basics and limitations behind the model

- Run StormShed3G to size pipe and ditch networks for conveyance design

- Be able to review and compare StormShed3G output

2

StormShed3G
AGENDA

Time	Activity
8:00 – 9:00	StormShed3G Introduction and install on computers
9:00 – 9:45	Work Session 1 - Overview and Project Configuration
9:45 – 10:00	Break
10:00 – 11:30	Work Session 2 - Basins and Conveyance Design Storms
11:30 – 12:30	Lunch
12:30 – 2:00	Work Session 3 - Ditch Design
2:00 – 2:15	Break
2:15 – 4:30	Work Session 4 - Pipe Network Design

3

General
WSDOT Hydraulic and Stormwater Design

- Hydraulic Manual and Highway Runoff Manual
- Pipe Networks, Ditches, Inlet Spacing, Culverts, Fish Passage, Stream Realignment
- Stormwater BMPs
- Hydraulic and stormwater training opportunities on LMS and HQ Hydraulics Webpage

Washington State Department of Transportation

General
WSDOT Hydraulic and Stormwater Design

- 2014 HRM Training (S)
- MGSFlood (S)
- Hydraulics and Hydrology (H)
- StormShed3G Beginner (H)
- StormShed3G Intermediate (S)
  – for eastern Washington only

(S) = Stormwater Class
(H) = Hydraulics Class

Washington State Department of Transportation

General
Where to Begin?

Just been tasked with the Hydraulic Design for your project?

Congratulations!

Congrats!   Congrats!

Now what?

Washington State Department of Transportation

General
Where to Begin?

- WSDOT Hydraulics Report Outline
  http://www.wsdot.wa.gov/NR/rdonlyres/9FCA0CE5-B79C-428C-90BC-602011C70428/0/HROnline.pdf
- Hydraulics Report Checklist
  http://www.wsdot.wa.gov/NR/rdonlyres/24B090A2-A8BA-40A4-856C-04F1893B26E1/0/HRChecklist.pdf
- Review Project Summary
- Talk to the local area Maintenance Superintendent
- Walk the project (with Maintenance if possible)
- Stormwater and Hydraulics pre-design meeting
- Install piezometers as soon as possible
- Hydraulics Manual Chapter 1, Flow Chart of Hydraulic Report Review Schedule on Page 1-10 (next slide)

Washington State Department of Transportation

WSDOT HM Page 1-10
(There's no figure number for it yet!)

General
Identifying Hydraulic Design Issues

Scoping

- The scope was developed with input from the Region Hydraulic Engineer and Region Maintenance.

Project Design

- The design team may discover other hydraulic deficiencies as the stormwater and hydraulic design progresses.
  - Stormwater Retrofit or Pipe Retrofits
  - Illicit Discharge Detection and Elimination (IDDE)
  - Existing flooding or hydraulic capacity problems identified by Region Maintenance
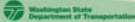
Washington State Department of Transportation

StormShed3G
What is StormShed3G?

- The design of conveyance systems statewide (pipe networks and ditches).
- Runoff treatment and flow control BMPs including bioinfiltration swales, natural dispersion, infiltration and detention ponds. (EWA only).
- WSDOT has 118 shared licenses
- Graphical User Interface with Drag and Drop functions

StormShed3G
How to Run StormShed3G?

- **Design Storm and Precipitation** – conveyance design criteria in Hydraulics Manual Figure 1-4 (and for eastern WA, see the Highway Runoff Manual for Stormwater design requirements).
- **Set up Basins**– determine all areas contributing runoff to the conveyance system (and stormwater BMP for eastern WA)
- **Set up Nodes and Reaches** – Nodes are CB, MH, inlets, etc.; Reaches are pipes, ditches, and channels.
- **Define Conveyance System** – Design pipe and ditch network to meet design guidelines.
- **Design the Stormwater BMP** – for eastern WA only.

StormShed3G
How to Run StormShed3G?

Now you are ready for StormShed3G.

During design remember to:
- Coordinate with the roadway designer regarding the design or any project design changes that could affect hydraulic the design.
- Keep in-touch with Region Hydraulic Engineer.
- Contact Region Maintenance Superintendent about region maintenance practices.
- Ask for help! Both Region and HQ Hydraulics are available to provide assistance.

In this example, you will learn:

- What the program does.

- An introduction of the program views and menus.

- How to customize a project file using the Project Configuration tabs.

What is StormShed3G?

StormShed3G is Single Event Model with an integrated set of hydrology design tools developed to address the need of the Engineers. StormSHED offers SCS (Soil Conservation Service), SBUH (Santa Barbara Unit Hydrograph), the Rational Method, level pool routing, pipe and ditch conveyance system analysis and backwater computation. StormShed3G can design and analyze a whole network of reaches consisting of any combination of circular, arch, box, or elliptical pipe, ditches, and channels. Designers have a choice between using Manning's equation (we call it the travel time shift) or one of four hydrograph routing options: storage, convex, kinematics wave or Muskingum-Cunge routing. Once the runoff has been conveyed to a detention pond, the Reservoir Routing operation would be the final step in the pond design.

In support of reservoir routing (your typical detention pond), StormShed3G permits the user to select any combination of discharge structures to be used with the specified impoundment shape (it can be an above or below ground structure). The list of discharge structures includes weirs, orifice, culverts, vortex valve, infiltration rate (including using Ksat), overflow, and drywells. The user can also specify a secondary discharge control structure and even divert part of the flow.

StormShed3G has options that can customize a design to make following the WSDOT Hydraulics Manual (HM) and Highway Runoff Manual (HRM) requirements easier. For example designers can now set the duration of a design storm (EW short duration storms), making it simpler than the old 24 hour default when using design storms. Designers also have the option of selecting an antecedent moisture condition (AMC) for the project as well as setting constraints on the minimum time of concentration. Multiple precipitation values can be input into a project file, which makes going from a short duration storm to a long duration storm easier. In addition, default settings for all new basins for a project can be set using the PROTOTYPE basin. Lastly, a calculator was added for a quick analysis on flow profiles, swales, and pipes.

At this time, WSDOT supports StormShed3G for conveyance design only in Western Washington. WSDOT utilizes all of StormShed3G capabilities in Eastern Washington.

Overview

The program window is divided into two sections, each of which has several tabs. The major sections are the data <u>Data Tree View</u> and the <u>Layout View</u>. When StormShed3G is opened, it will open to the last file used and this is what it should look like:
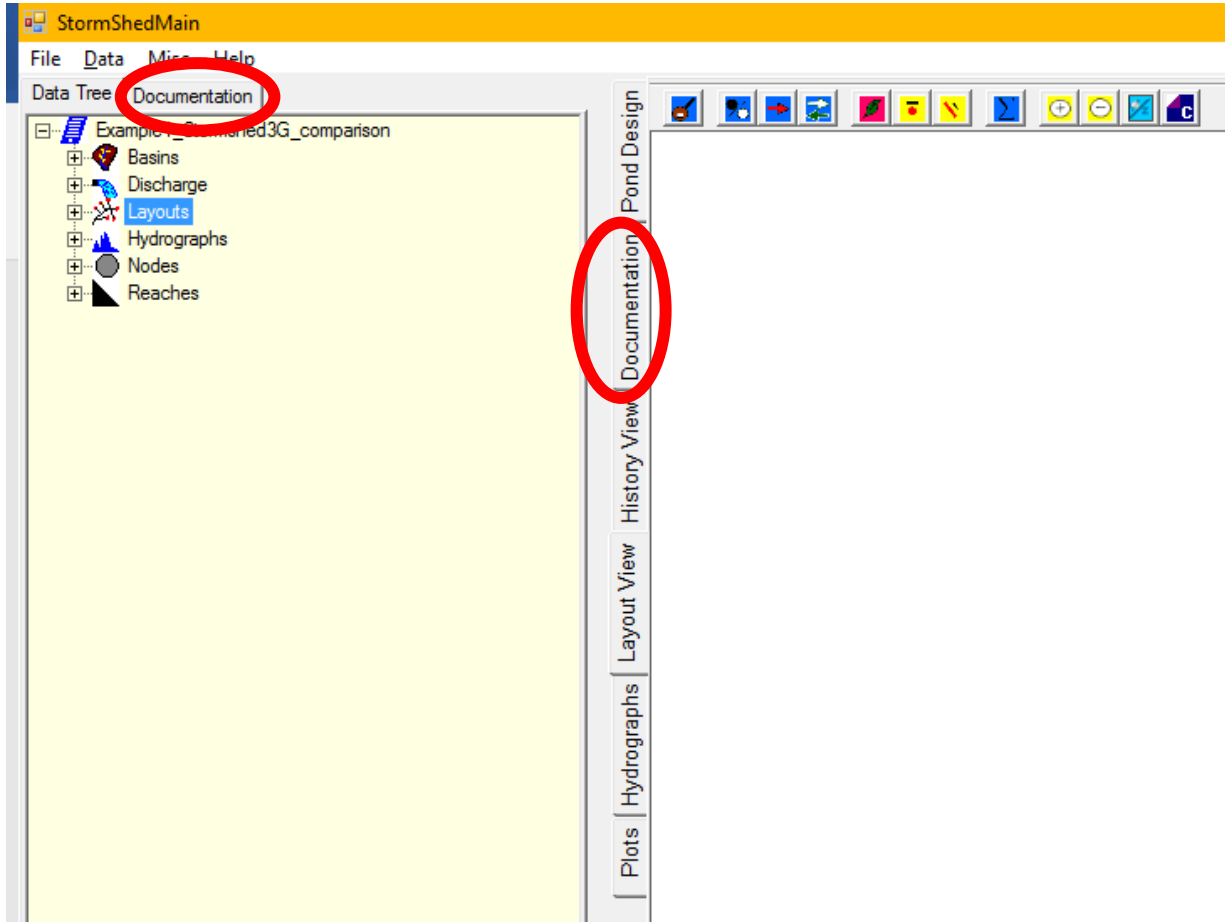
1. ***Data Tree View*** has two tabs.

   - *The Data Tree* tab contains access to all of the items that the project is made up of including the basins, ponds, pipes, ditches, hydrographs, etc.

   - *The Documentation* tab provides information about particular methods used for the analysis. For example if you want to see how the time of concentration is determined or how runoff is estimated the methods are described in this view.

2. ***Layout View*** has 6 separate tabs, each consisting of different major functions in the program.

   - *Pond Design* is used for designing ponds. Western Washington still uses a modified single event (Stormshed) method for expanding existing detention ponds.

   - *Documentation* displays the selected documentation subject chosen using the Documentation Tree.

- *History View* displays the computed information that affects the hydrographs from the pond design and layout compute command. There is no running log of computations, only the last computation is maintained. The data in the history view will need to be cut and pasted into a word document for the final report.

- *Hydrographs* all hydrographs created by the program are reported here along with several options for manipulating hydrographs.

- *Plots* will generate different plots depending on the input parameters.

- *Layout View* is used to create a graphical representation of the drainage network. It is a schematic layout tool in that the dimensions of the layout (nodes and reaches) are not drawn to scale. A typical layout consists of a series of nodes connected by reaches. The next figure shows the Layout View.
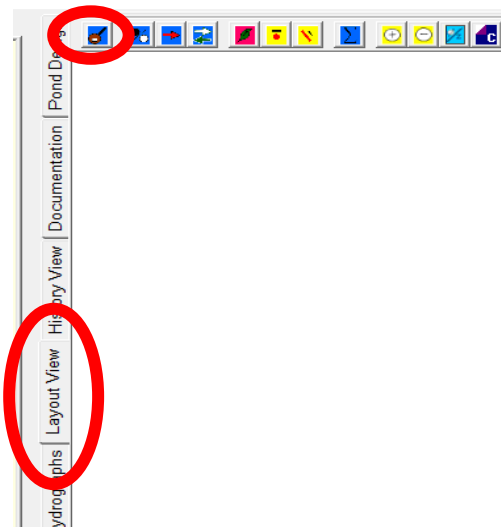
The program makes extensive use of the mouse buttons in the **Layout View** to facilitate program interaction. The following mouse button clicks are supported.

- Left Mouse Button (LMB) click and hold while dragging mouse to reposition a node.

- LMB double click on a node or reach to display appropriate input dialog.

- Right Mouse Button (RMB) single click on a node or reach to activate a popup menu. The popup menu has five choices:

  a: *Delete* - Deletes the node or reach from the layout. It does not delete the node or reach from the database!

  b: *Set TW* Elevation (Nodes only) allows definition of starting HGL elevation. Typically used only for the outlet node.

  c: *Synchoronize Inverts* – This command will reset the invert elevations all way to the final node. This command is especially useful when an invert elevation is modified upstream that requires modification of downstream invert elev.

  d: *Reverse Reach Direction* – when a reach is input in the wrong direction, this command will reverse the direction.

e: *Set as Terminal Node* – Make sure that this is the last node (outlet) of the
conveyance system
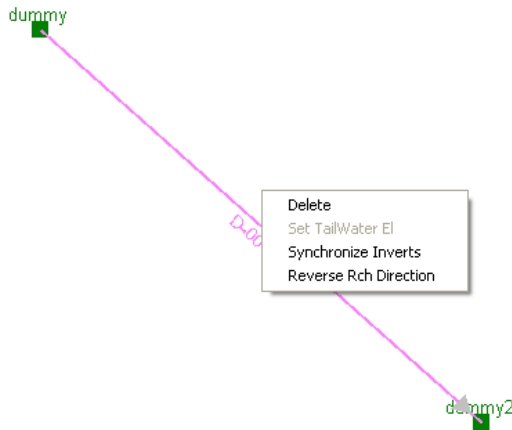
Menu Options

Above the ***Data Tree View***, there are 4 menu options: File, Data, Misc, and Help. All
four are further discussed below.

1. ***File*** – allows the user to open an existing file, create a new file, save a file, delete
   a existing project or exit the program.

2. ***Data*** – The <u>Config</u> command is the starting place for every project and allows the
   designer to set project defaults. The <u>discharge</u>, <u>node</u>, <u>reach</u>, and <u>basin</u> can be
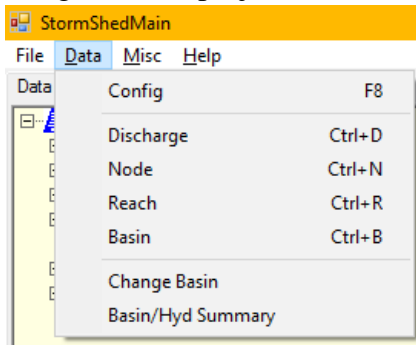
   opened directly from here, as well as in
   the tree view. The <u>Change Basin</u>
   option, allows the designer to change
   the rain type, hydrograph interval, storm
   duration, and design method of all the
   basins selected. The <u>Basin/Hydrograph
   Summary</u> Report allows the user to send
   selected basin or hydrograph
   information to the History View.

3. ***Misc*** – In this tab designers can access a <u>calculator</u>
   used to estimating flow profile, pipe, and swales. The
   <u>Manning pipe</u>, is also a calculator that uses
   Manning's equation to size a pipe. Designers can
   input <u>Soil Logs</u>, open/edit text files, and several
   utilities options (<u>SpaceToTab</u>, <u>TabToComma</u>, and
   <u>CommaToTab</u>) that allow designers to work between
   project files. The <u>Edit ASCII</u> option, allows designers
   to edit .RAC files or other program defaults.
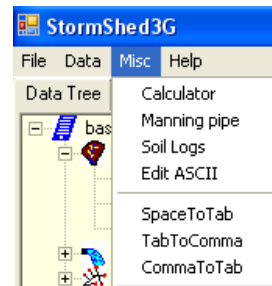
4. ***Help*** – Contains information <u>about</u> licensing, <u>registration</u>, and <u>server URL</u>. The
   <u>ESI Website</u> link allows designers to access the Engenious website directly. The
   <u>Import Project</u> command can be used to import and convert old StormSHED files.
   It should be noted that while StormSHED files can be transferred into
   StormShed3G, **the layouts** created in StormSHED can not be imported.

Designers need to recreate the layouts in 3G. The Revision Log will provide a list of any changes or updates that have been made to the program. If the Start Up Message is checked, the Revision Log will appear everytime 3G is opened.

Data Tree View

The first line in the **Data Tree V**iew begins with the name of the current file (in the view below the project name was 'overview project configuration'). Within each database there are six (6) types of records, they are Basins, Discharge, Hydrographs, Layouts, Nodes and Reaches. A + (plus) symbol to the right of each category indicates the presence of database records for the category.
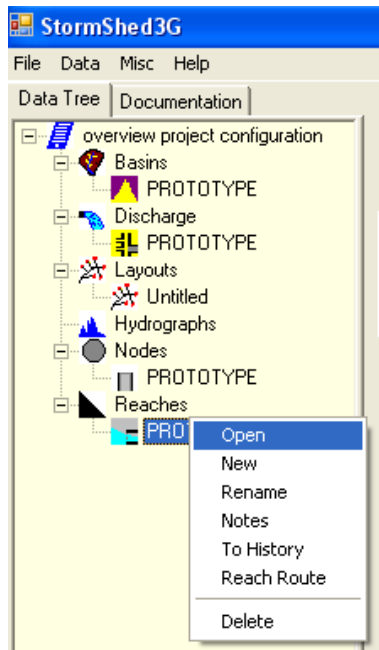
Categories are expanded by Left Mouse Button (LMB) clicking on the + (plus) symbol to the left of the category. Within each category there can be several record types. As an example, for Basins, there can be SBUH, SCS, and Rational basins. The program has a different icon symbol for each record type within a category. This provides a visual clue of the record type without directly accessing the record.

With the exception of the Hydrograph category, all categories have at least a single prototype record when a new project is opened. The *PROTOTYPE* record can be thought of as the default record. When the program creates a new record for a category, it uses the *PROTOTYPE* record as its template. This feature is provided to save on repetitive data input. **DO NOT DELETE OR RENAME THE PROTOTYPE.**

When a record is RMB clicked, it pulls up a dialog of some type. Generally this allows the designer to modify the record including: open, rename, create, write notes, send information to the history view and delete.

When a record is double LMB clicked, the input dialog for that record appears. The input dialog is also accessible through the **Data Tree View** menu as discussed above.

Project Configuration

After a project is created, the next step is to set the project defaults. In this section we will set the project defaults that need to be modified for our example and then review the remaining defaults tabs.

1) Select **Data>Config.**

The Project Configuration box will open as shown below. The defaults set in this dialog box will be reflected in the pull-down menus of other dialog boxes as well as in the layout presentation.

Of the tabs in the **Project Configuration** dialog box, the *Project Defaults* tab will likely be used the most by designers. This is where the precipitation values are set for each project location.

2) Project Precips – After determining the precipitation values (see the short duration and long duration storm sections), input the values as shown.

- To modify an existing value, highlight the design event and then input the precipitation. Accept the change by selecting the update button.

- To add a new value, input a title for the design event and precipitation, then select the add button.

- **Designers must have the Design Event called "2yr 24hr" and input a 2 year 24 hour precipitation value even if the value is not needed for the design of the project.** It is needed for the calculation of sheet flow. StormShed3G will return an error message box either if the "2yr 24hr" Design Event is missing or if the precipitation value is not input. Using "0.00" is a valid input for "Precip".

There are no limits on the number of precipitation values that can be input. That means for projects using the short and long duration storm, all the precipitation values can be input at one time and then selected when needed.

3) Use AMC for Project - The AMC or antecedent moisture condition classifies (groups 1,2, or 3) the preexisting soil wetting at the project site. The three groups are: 1) dry, cracked soils, 2) a typical condition, and 3) saturated soil. All the CN values in the *SCS Land Use Tab* (see several boxes), are based on AMC Group 2. Designers should leave this as Group 2 when starting a project and always input the CN values for group 2. Then after the project is completed, change to group 1 or 3 and the program will automatically adjust the CN values in the final computations, the actual values input will not be modified. There is also an option of temporarily modifying the AMC group value for each basin to see how the runoff could be affect by this change.

4) IDF Curves in Selection Drop Down - StormShed3G supports the Rational Method and allows the designer two options for referencing IDF curves; either by

equation using a table of data (like the data found in Chapter 2 of the Hydraulics Manual) or referencing an IDF curve. In this box the designer can indicate how many options there will be in the **Basins** Dialog input box if the Rational Method as a Design Methods from the pull-down menu. For this training we will not be using the Rational Method, so we will leave it on the default setting of 'Both'.

5) TC Thresholds – Chapter 2 of the Hydraulics Manual requires a minimum Time of Concentration of 5 minutes. In order to ensure this value is 5 minutes, designers have the option of setting minimum Tc values for both the SCS (also applies to SBUH) impervious and pervious conditions as well as for the Rational Method. For this training we will leave the values set at 5 the default values of minutes.

6) Next select the ***Default Labels*** tab. This is where the designer can customize the labels for new reaches, nodes, discharge, and basins. While it is often convenient to use the auto labels, be sure to check the "Enable Auto-Verification of Labels" box. This will allow the designer to override the StormShed3G auto labels and instead create a label that is more meaningful to the project.

Set the defaults to the picture shown below.
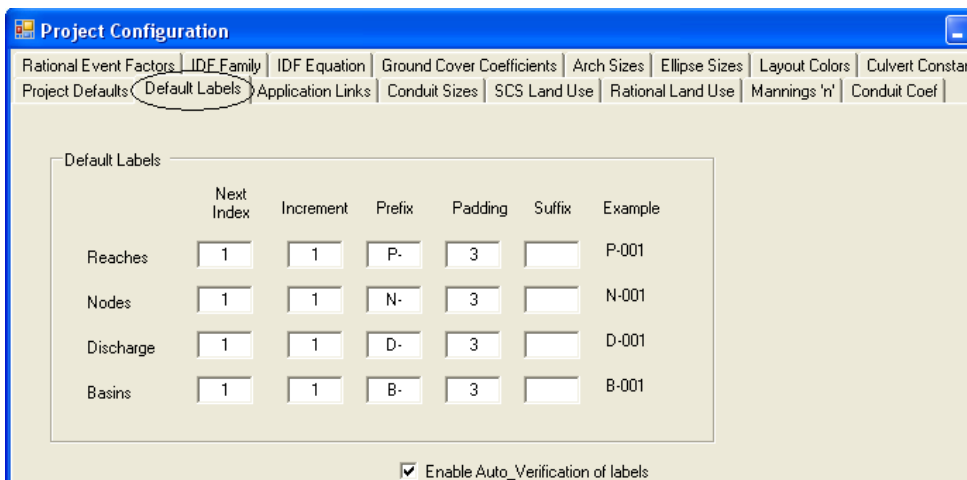
7) The ***Application Links*** tabs, indicates where the RAC Files/IDF Files and Training Videos are located on our computer. **Do not save either** in the same folder as the program or project files, as they could be deleted when the software is upgraded. Instead save them in a completely different folder and path the

location by selecting the '…' button to the left of the clear button.
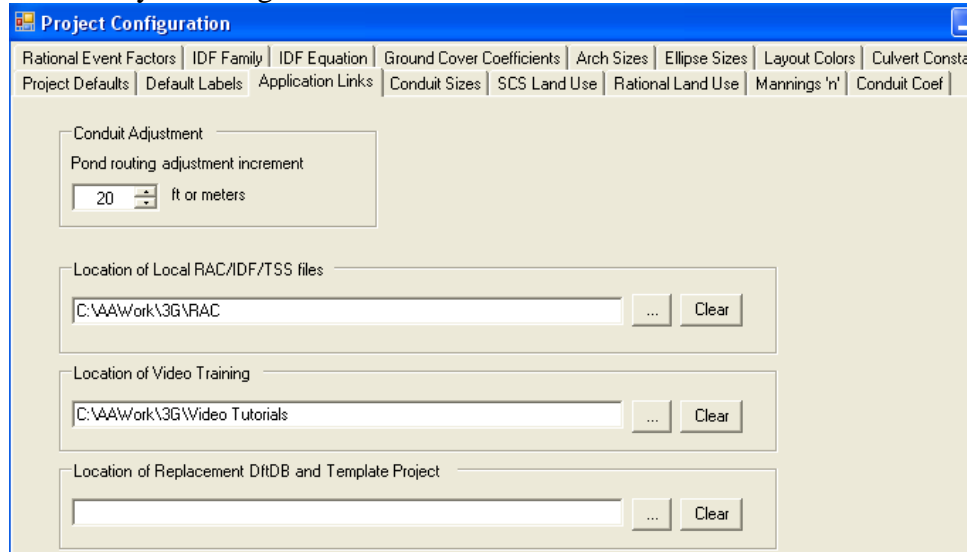
8) ***Conduit Adjustment[1]*** – This option only applies to Detention Ponds that use conduit as a discharge structure; 3G requires that the length be increased automatically. Designers have the option of adjusting the conduit length. Remember the smaller the value, the longer it will take StormShed to perform this computation.
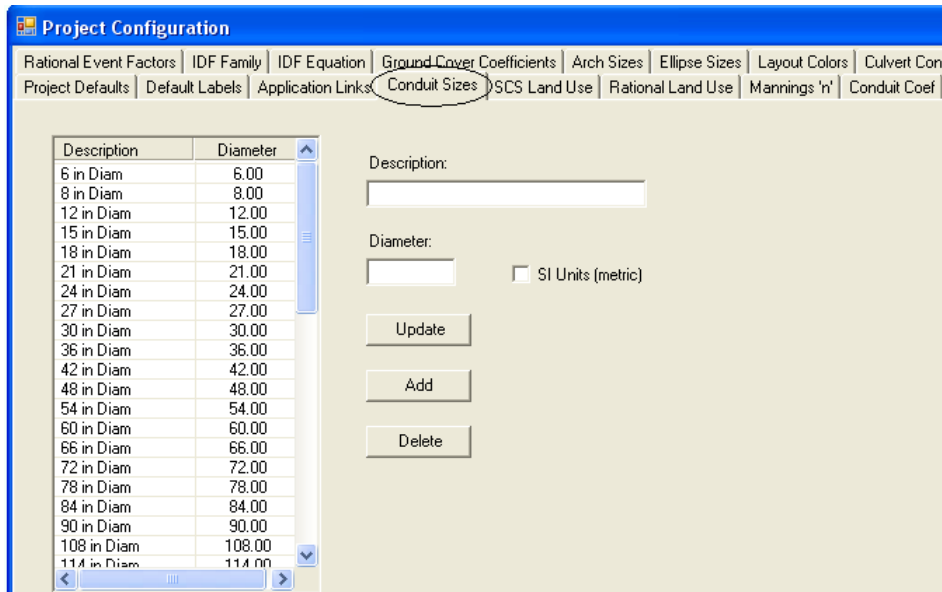

9) The ***Conduit Sizes[1]***, ***Arch Sizes[1]***, and ***Elipse Sizes[1]*** tabs are used to modify or add the default pipe sizes (the ***Conduit Sizes*** tab is shown above). These sizes and dimensions can be found in the Reach Dialog box pull-down menus to set pipe sizes. *Note the SI Units tab is only there to modify a design that is already been created in US units and then change to SI and the report will be printed in metric.*

10) The ***SCS Land Use[1]*** tab contains the CN values for the group 2 AMC. Designers can modify or add CN values in this tab. Notice the CN values are separated by land use; they will be accessed under these categories in the **Basin** pull down

menus.
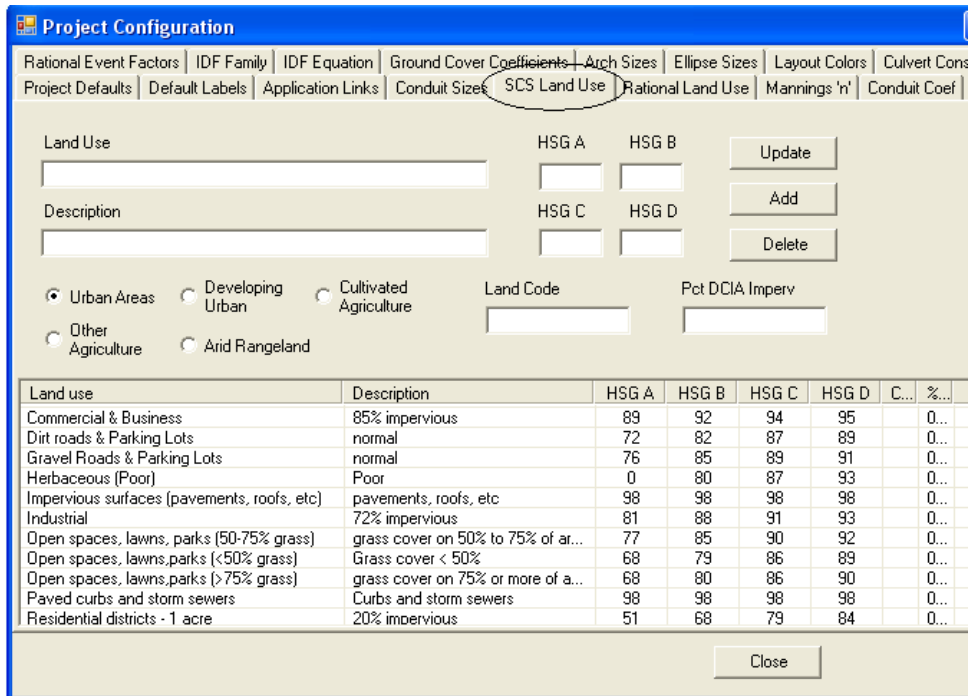
11) The ***Ground Cover Coefficients[1]*** tab, contains the default values for the type of flow (sheet, shallow, concentrated, etc) found in the **Basin** Dialog Box pulldown TC menus. Unique values can be modified or added here.
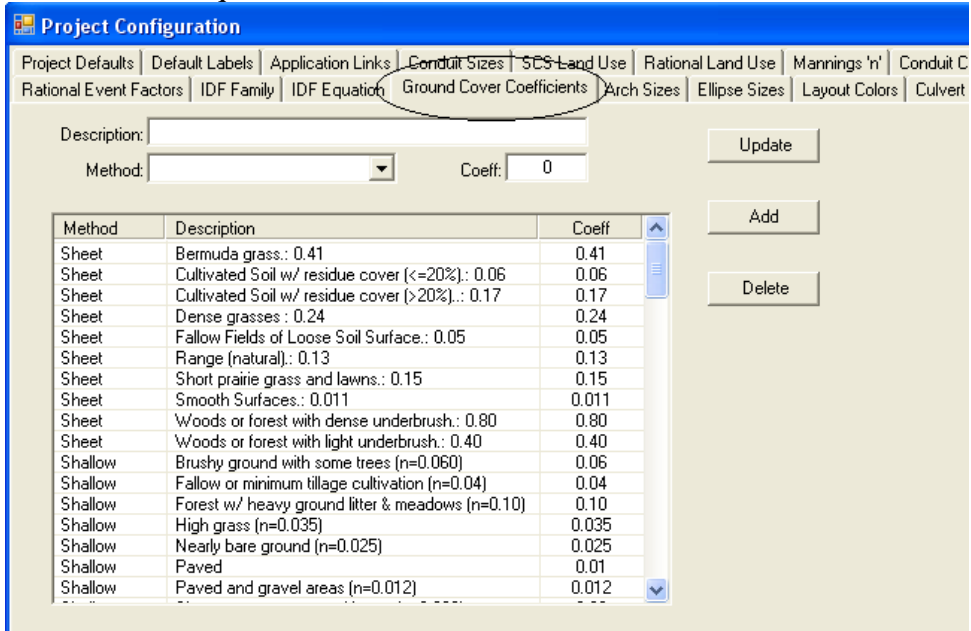

12) The ***Rational Land Use[1]*** tab, contains the coefficients for ground cover that are applied when calculating the Time of Concentration using the Rational Method. These values match the values found in section 2-5 of the Hydraulics Manual 2-5.

This tab can be used to modify or add values that will better represent a project location.
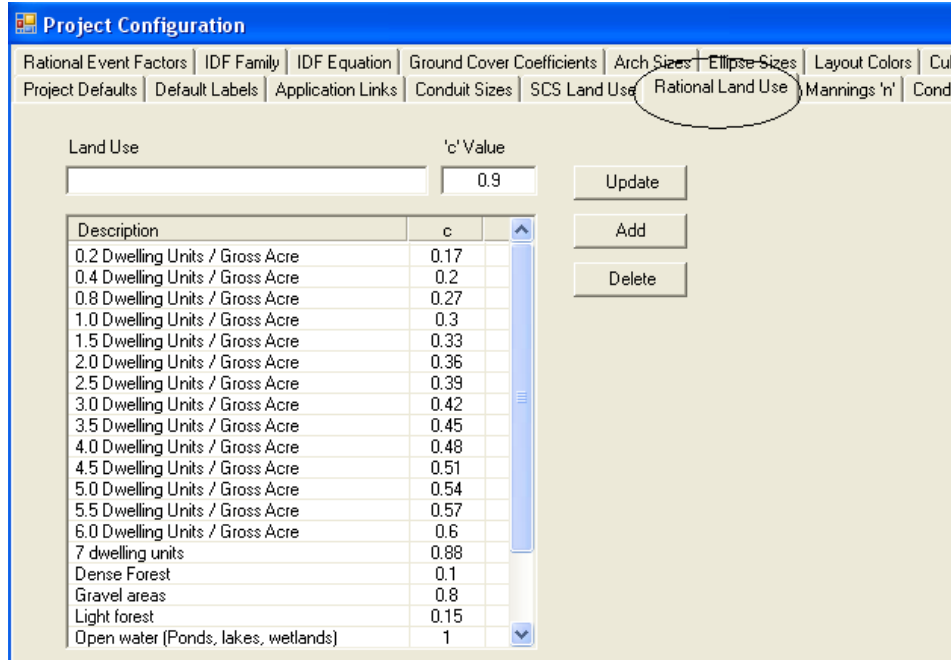
13) The ***Mannings 'n'[1]*** and ***Conduit Coef[1]*** tabs contains Manning's values directly from Appendix 4 of the Hydraulics Manual. These values can be selected from the pull down menu in the **<u>Reach</u>** Dialog Box. Use this tab to modify or add values that will more accurately reflect a project site.
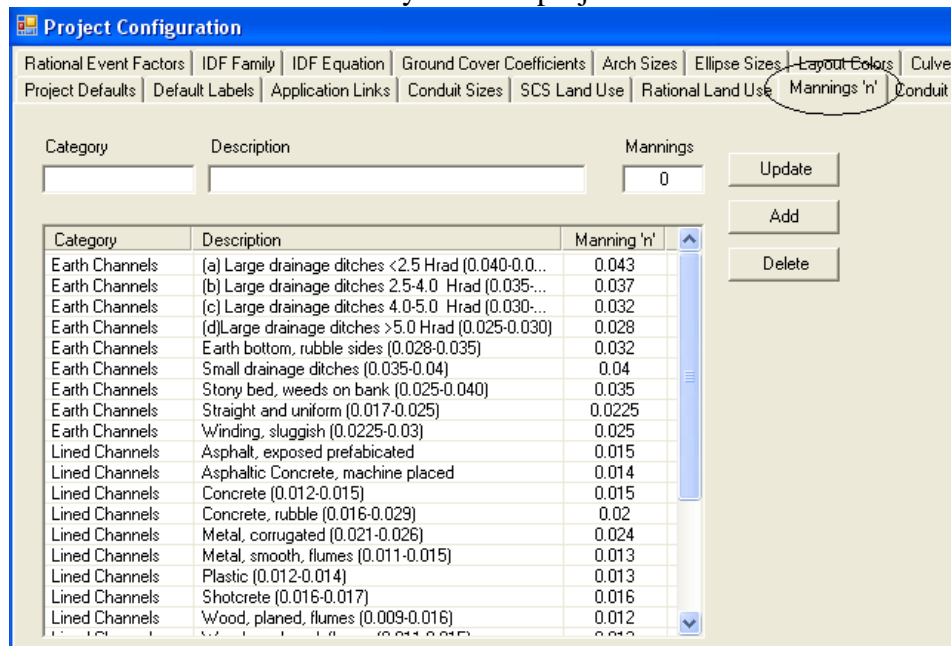
14) The *Culver Constants[1]* tab contains the Coefficient information used in the **Reach** Dialog Box pulldown menus for entrance losses. These values are based on the FHWA guidelines and can not be modified although new values can be added.

15) Finally, the only tab we have not reviewed is the *Layout Colors* tab. Here the settings for the layout can be customized from the colors, the fill, to the line type. It is recommended that the values selected are easy for the designer and reviewer to see and use. *At this time, this feature has been disabled.*
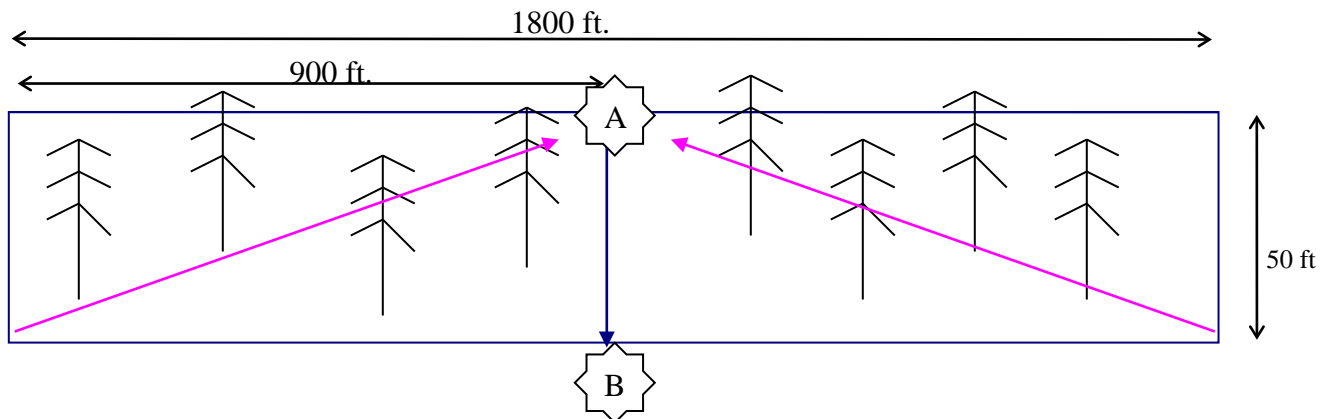
In this example you will learn:

- How to determine the applicable storm duration for a project location.

- How to Create a basin, know the different basin options, and how to estimate runoff from a basin.

- How to transfer basin information to a report.

- The Slope Calculator.

Example Problem

Develop basins for the before and after conditions using the following description:

- A new two-lane roadway section is to be constructed near Seattle, which is in **Climatic Region 3.**

- The SCS soil type for the entire project is **Type C** and the ground cover is primarily forest in fair conditions.

- The project area in the existing site condition currently sags to the middle of its **1800 foot length.** The project area is also about **50 feet** wide. The ground slopes towards point A. Water generally collects at point A and then runs down to point B in a semi-defined ditch. The ground cover is all forested. See Figure 1.

- The calculated time of concentration should be assumed for the forested conditions to be **50 feet** of sheet flow with the remaining **900 feet** as shallow concentrated flow to point A. Finally, runoff concentrates and flows to **50 feet** to point B. The average slope of the ground before the construction was **1%**.

- The proposed conditions for the new impervious roadway will be slightly elevated and will utilize curb and gutter to control the flow. The developed site will have a sag in the profile. See Figures 2 - 4 below.

PLAN VIEW - EXISTING CONDITION
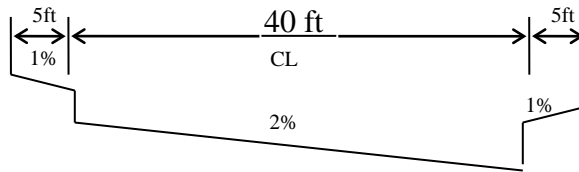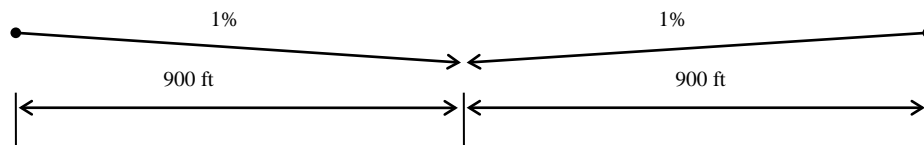### Figure 1

PLAN VIEW – DEVELOPED CONDTIONS
Figure 2

1800 ft.

900 ft.

A

A

50 ft
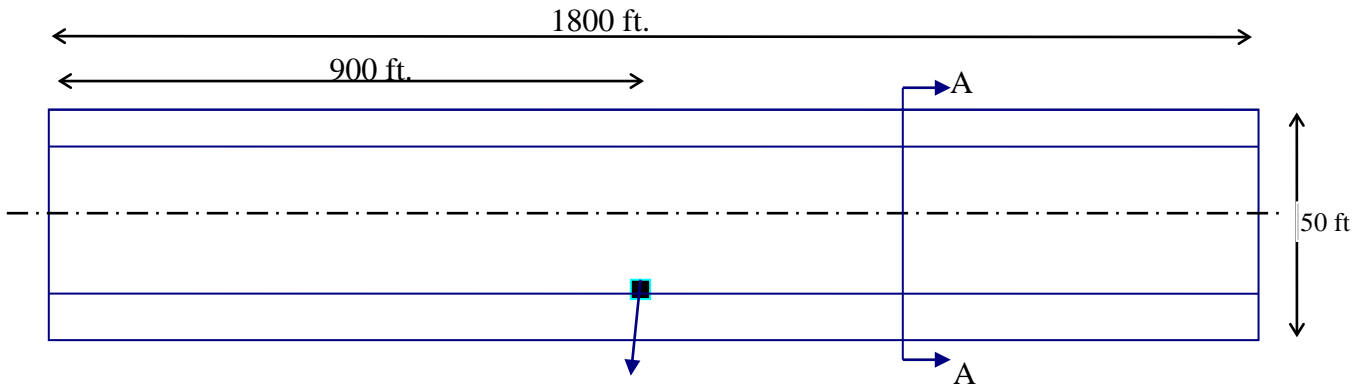
CROSS SECTION A-A
Figure 3

5ft

40 ft

5ft

1%

CL
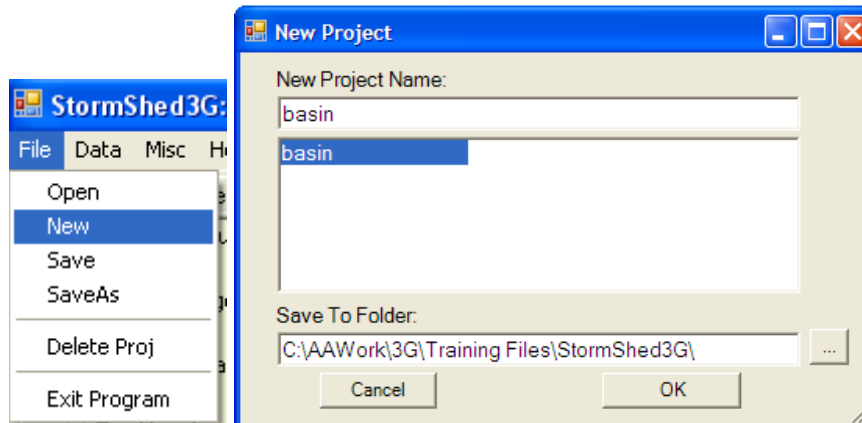
2%

1%

PROFILE
### *Figure 4*

1%

1%

900 ft

900 ft

Creating a New File

When StormShed 3G is opened, it will automatically open to the last file used. The first step for this example is to create a new file.

1) Select **File>New** and input a unique name that will easily remind you of the project. For this example, call the New Project Name: **basin**. Then click on Ok.

The 3G project disclaimer dialog will appear as shown below. This is just a reminder that this is technical software and while the software developer has made every effort to eliminate errors in the program, it is up to the designer to use engineering judgment when reviewing the results.
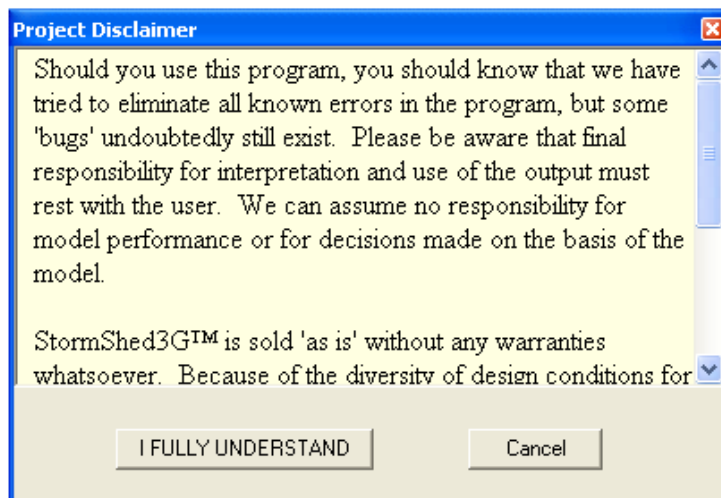
2) Select **I Fully Understand** and the box will close.

Set Project Defaults

After a project is created, the next step is to set the project defaults. In this tutorial we will only modify the items in the Project Defaults tab.

3) Select **Data>Config.**

The Project Configuration box will open as shown below.

To eliminate the Warning dialog box; the Design Event must be typed as "2yr 24hr". If '2 year' is typed, the warning will continue to appear.

4) **WWA – Storm Duration**

Western Washington utilizes the Type 1A 24 hour storm to design conveyance systems. The precipitation values are much simpler to determine than for EWA, as noted below.

A. From the HQ Hydraulics web page, select Links. (<img>http://www.wsdot.wa.gov/Design/Hydraulics)

B. Select the Washington 24-hour Isopluvial Maps link and a set of maps for Washington will open including the one shown below.

C. Locate the project on the map and determine the precipitation values for the 6 month, 2, 10, 25, and 100-year storms.

D. Input these values into the Project Precipitation table (as shown in the picture above).

Washington 2-year 24-hour Precipitation
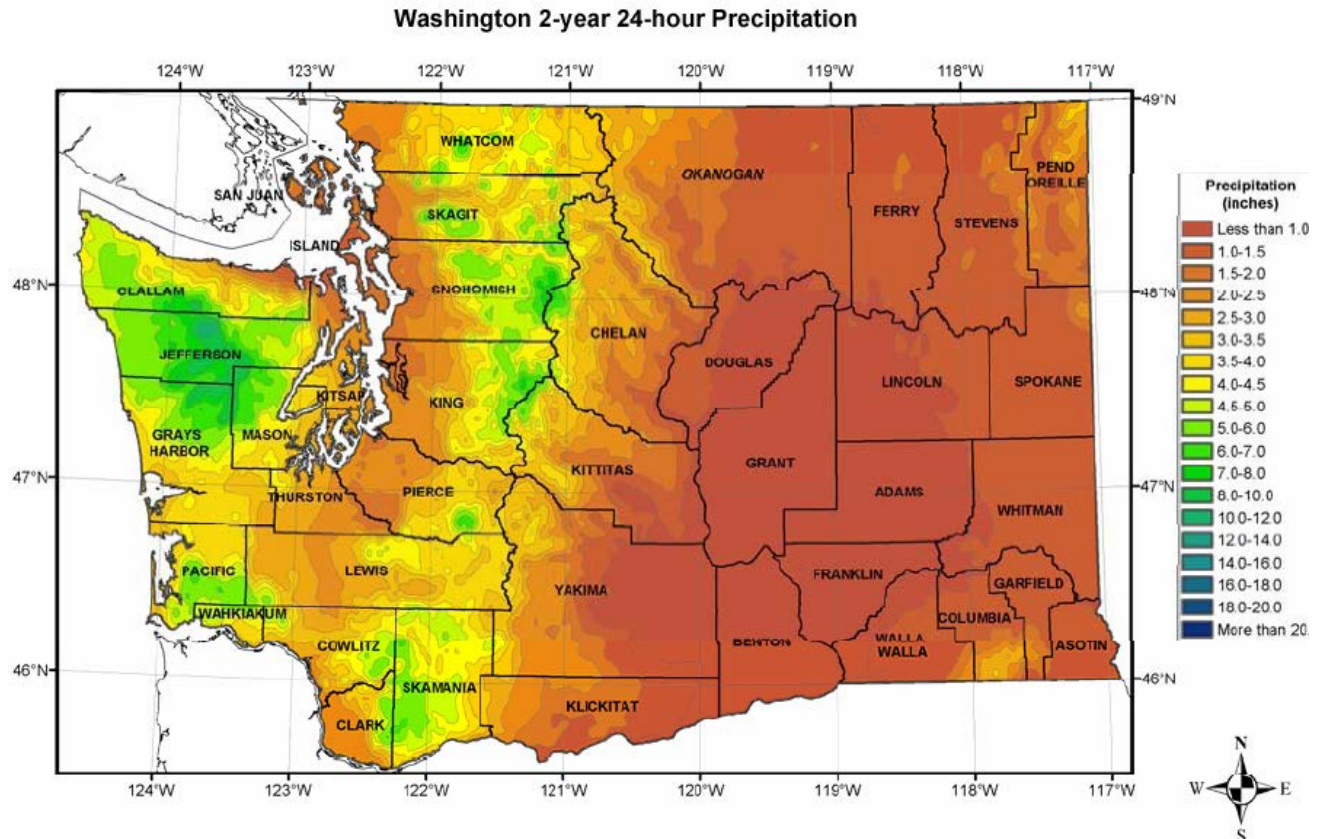
Project Precips – After determining the precipitation values (*see the applicable EWA or WWA storm determination sections of this tutorial*), input the values as shown above.

- To modify an existing value, highlight the Design Event by LMB click on an item and then modify the values in the boxes above. Accept the change by selecting the **Update** button.

- To add a new value, input the design event and precipitation into the blank boxes, then select the **Add** button.

For this tutorial we will leave the default selections for AMC, IDF and Tc as shown above.

Create Basins

First, define the **'before'** drainage basin conditions.
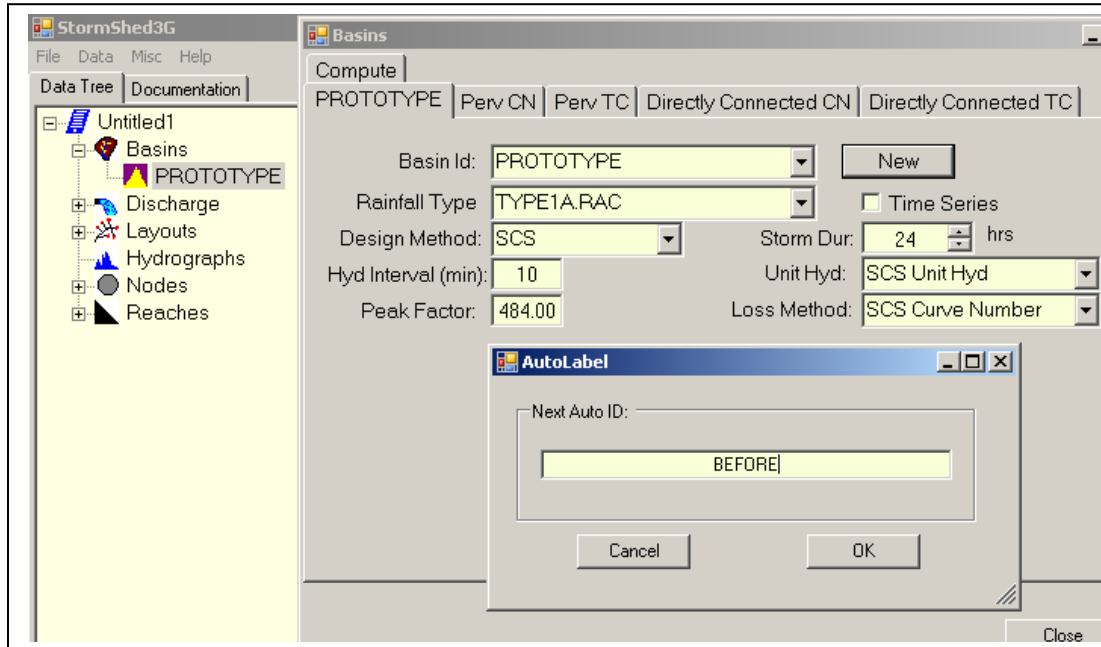
5) Expand the **Basin** option in the *Data Tree View* and then double click on *PROTOTYPE* to open the basin dialog box. The PROTOTYPE dialog box is the template for all other basin records. It will save time if repetitive options are set in the PROTOTYPE dialog box and saved before creating a new basin or use an existing basin to create a new basin. Select the *New* button and input the basin name, for this tutorial use "**BEFORE"**. Then click **OK** to close the dialog box.
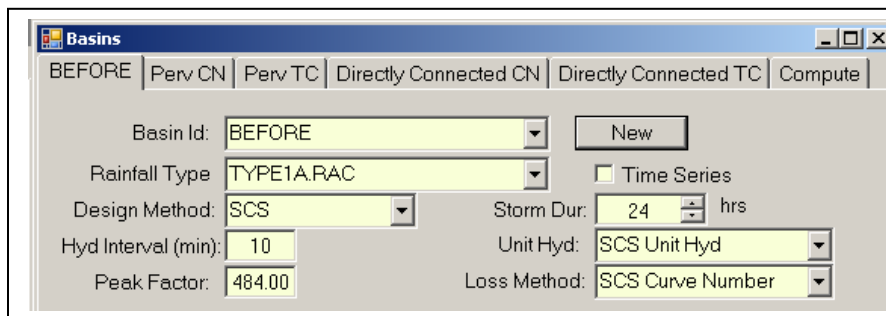
Next, we will review the input boxes on the first tab, labeled the basin name 'before':

- Rainfall Type – This is where the design storm, as specified in Chapter 4 of the HRM, is selected. For this project, we were told to use the **Type1A.RAC for WWA**.

- Storm Duration – the length of a storm is set here and the program will either stretch or shrink a storm distribution to this time line. For this example, set the duration to **24 hours in WWA**.

- Design Method – designers have three methods to select from for the design analysis: SCS, SBUH, or the Rational Method. Either the **SCS or SBUH** is acceptable on WSDOT projects, as both will yield similar results for most WSDOT project. For projects with more pervious surface or in a rural area, consider the SCS method and for projects with more impervious surface or in an urban area consider the SBUH method.

- Hyd Interval – or the hydrograph interval. This is the interval at which data is reported from the 3G analysis; this value does not affect the actual analysis. When the **Type 1A or Long Duration Storm** is used, the **10-minute default** is appropriate.

- Peak Factor – This feature is not modified for WSDOT projects from the default value of **484**. This is a customization feature that will either flatten or heighten the hydrograph.

- Unit Hydrograph – A unit hydrograph basically put represents the affect rainfall has on a particular basin. In 3G there are two options: SCS and Delmarva. The Delmarva only applies to projects in Maryland, so for all WSDOT projects the **SCS Unit Hydrograph** option should be selected.

- Loss Method – there are three options for determining precipitation losses on a project: SCS, Green Ampt, and Holtan. Generally, all WSDOT projects use the **SCS Curve Number** method, which combines infiltration losses with the initial abstraction. The Green Ampt and Holtan method require more information than we usually have on a WSDOT project.

6) The *Perv CN* tab is where the pervious drainage basin area is defined by both the total area in acres and the Curve Number (CN). The CN values can be selected from the pull-down tab based on the land use selected, (Urban, Developing Urban, Cultivated Agriculture, Other Agriculture, and Arid Rangeland) and the HSG (Hydrologic Soils Group). Designers should verify these values are the same as found in Appendix 4B of the HRM, an example is shown on the next page. *Note there are separate CN tables for eastern and western Washington in the HRM; be sure to use the correct table.*

   Notice there are values already set up in the PROTOTYPE basin; these are examples of how to input data and should be **deleted**. Next input the information from the example by typing the values in the boxes as shown below and then selecting the **Add** tab. To modify information already input, LMB click on the data and the information will appear in the upper boxes. Make the necessary changes and then select the **Update** button. The changes should appear in the lower box.

   - For this example, input the data as shown in the box below.

- Move to DCIA – This option allows designers to move pervious basins to the impervious basin tab, a time saver when basins are accidentally input on the wrong tab. Simply highlight the row, select this button, and the basin description, subarea, and CN will be moved to the Directly Connected CN tab.

- Abstraction Coeff – This value can only be modified when using the SCS CN for the loss method. Precipitation has to be greater than 0.2S (the maximum soil water retention parameter) before runoff is generated. While this number can be modified in the Pervious CN tabs only, it should be left as **0.2** for WSDOT applications.

- Total Area – The total pervious area entered for this basin is summed in this box.

- Avg CN – This is the average CN computed based on all the pervious surfaces reported.

  Get CN values in Appendix 4B of the Highway Runoff Manual.

  http://www.wsdot.wa.gov/Environment/WaterQuality/Runoff/HighwayRunoffManual.htm

  OR

  Get CN values using drop down boxes and menus.

Table 4B-2. Runoff curve numbers for selected agricultural, suburban, and rural areas (western Washington).

Cover Type and Hydrologic Condition	A	B	C	D
Curve Numbers for Predevelopment Conditions				
Pasture, Grassland, or Range – Continuous Forage for Grazing:				
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Fair (woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77
Curve Numbers for Postdevelopment Conditions				
Open Space (lawns, parks, golf courses, cemeteries, landscaping, etc.):[1]				
Fair condition (grass cover on 50% to 75% of the area)	77	85	90	92
Good condition (grass cover on >75% of the area)	68	80	86	90
Impervious Areas:				
Open water bodies: lakes, wetlands, ponds, etc.	100	100	100	100
Paved parking lots, roofs,[1] driveways, etc. (excluding right-of-way)	98	98	98	98
Porous Pavers and Permeable Interlocking Concrete (assumed as 85% impervious and 15% lawn):				
Fair lawn condition (weighted average CNs)	95	96	97	97
Good lawn condition (weighted average CNs)	94	95	96	97
Paved	98	98	98	98
Gravel (including right-of-way)	76	85	89	91
Dirt (including right-of-way)	72	82	87	89
Pasture, Grassland, or Range – Continuous Forage for Grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch)	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Poor (forest litter, small trees, and brush are destroyed by heavy grazing or regular burning)	45	66	77	83
Fair (woods are grazed but not burned, and some forest litter covers the soil)	36	60	73	79
Good (woods are protected from grazing, and litter and brush adequately cover the soil)	30	55	70	77

7) Defining the Time of Concentration (TC) is the next step for the pervious surface. Select the *Perv TC* tab and modify the information as shown on the below using the example problem statement summarized below.

- The default values in the description area are for example and need to be either deleted or updated.

- For this example we have **50ft** of **sheet flow** on a **1%** and the land cover type is a **fair forest** condition. The best match for a sheet flow Kf from the pull down menu is, **wood or forest with dense under brush**.

- The second type of pervious flow is **shallow** for a length of **900ft at** a **1%** slope. Select **forest with heavy ground litter and meadows** for the ns value.

- The third type of pervious flow is intermittent channel flow for a length of **50ft** at **1%** (assumed). Select **forested swale with heavy ground litter** for the Kc value.

Now let's review the options in the <u>Flow Type</u> pull-down menu. While there are many options, we generally only use the ones noted below on WSDOT projects:

- <u>Fixed</u> – Rather than having the program calculate the travel time, the designer can manually input the value.

- <u>Sheet Flow</u> – Flow, over a relatively flat surface that does not concentrate more than 0.1' deep, and is less than 100' in length is considered sheet flow. This type of flow will be used to model runoff as it travels off the roadway to the shoulder.

- <u>Shallow Flow</u> – Once flow exceeds the depth and or length requirements for Sheet Flow, it begins to have a defined flow path and is assumed to be Shallow Flow. Runoff traveling along the curb line or in ditches should be modeled as Shallow Flow.

- <u>Channel Flow</u> – Is assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where lines indicating streams are shown on US Geological Survey Maps. There are two options for Channel Flow in 3G: **intermittent and continuous**. The difference between the two is intermittent flow has a lower Hydraulics Radius (0.2) than continuous flow (0.4).

Since in the before condition there is no impervious surface, the next two *Directly Connected* tabs should be left blank.

8) The last tab, *Compute Design Event*, can be used to quickly compute a flow rate and volume of the runoff based on this basins characteristic.

- The <u>Select Design Event</u> pull-down menu references the precipitation values input into the *Program Defaults* tabs. For this example, select **25 year**.

- The AMC group can be changed for just this computation when using the compute command; it is not a permanent change. This will only give the designer an idea of how a different AMC could affect runoff from this basin. Note the Project AMC that was set in the *Project Defaults* tab, is also noted here.

- Select the **Compute** button for a quick look at the runoff generated from the basin. Using this command does not report the data to the history view; instructions for reporting this data are described at the end of this tutorial.

- Save the file before continuing!

9) Next, the **After** drainage basin site conditions will be defined (the new impervious roadway with curb and gutters).

- Click on the **New** button, to create a new basin and then type **"AFTER".** *To save time reselecting the settings, select the **"BEFORE"** basin instead of the prototype basin.*

10) Next, delete any entries in the *Perv* tabs since in the after condition; the pervious surfaces are replaced with pavement. **Or to save time, highlight the pervious basin and hit the Move** DCIA button. This will automatically move the basin to the *Directly Connected CN* tab. Remember to update the **Description** and **CN** to reflect an impervious area.

11) *Directly Connected CN and TC* – This is the location to input impervious areas. The name simply describes what is happening, that is runoff from impervious

areas is directly connected to runoff from pervious areas within that basin. When pervious runoff and impervious runoff are input into separate tabs, the program generates two separate hydrographs (one for the Directly Connected and one for the Pervious areas) and then the two hydrographs are added together. If a composite CN is more representative of a project site runoff, this can still be done by entering both the pervious and impervious areas into the *Perv CN and TC* tabs. Then StormSHED will generate one hydrograph based on the composite CN. Generally two separate hydrographs summed as one, will provide a more accurate representation of a project site runoff. Consider a project with 9 acres of pervious runoff directly connected to 1 acre of impervious runoff. The runoff from the 1 acre of impervious area is going to have a faster travel time than the pervious area.


Next, select the *Directly Connected TC* tab. Each flow path must be defined for the impervious area, below is a summary of the example description.

- For this example we were told there is **5ft** of **sheet flow** at a **1%** and the land cover type is a **paved** condition. Thus when defining the coefficient for sheet flow, select **smooth surfaces** from the pull down menu.

- For this example we were told there is **45ft** of **sheet flow** at a **2%** and the land cover type is a **paved** condition. Thus when defining the coefficient for sheet flow, select **smooth surfaces** from the pull down menu.

- The second type of flow we have on the site is **shallow** for a length of **900ft** at a **1%** slope. From the pull down menu select **paved and gravel areas** as the coefficient value.

    Need to calculate the slope? Select the __Slope Calc__ button below the Coeff. box and the calculator to the left will open. Next input the runoff length and the up and down elevations and select the __Compute__ button. 3G will automatically

transfer the resulting slope to the slope box for the tab that is open in the basin dialog box.
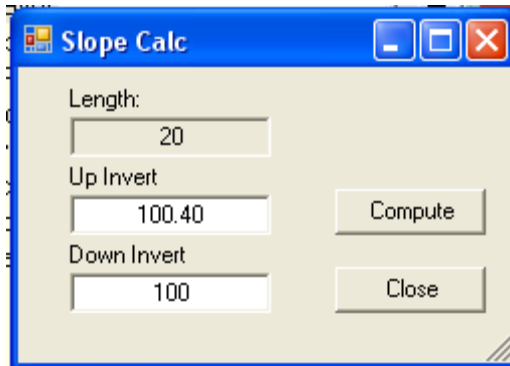
12) Select the last tab, ***Compute***, to quickly compute a flow rate and volume based on the after construction basin runoff as shown below.
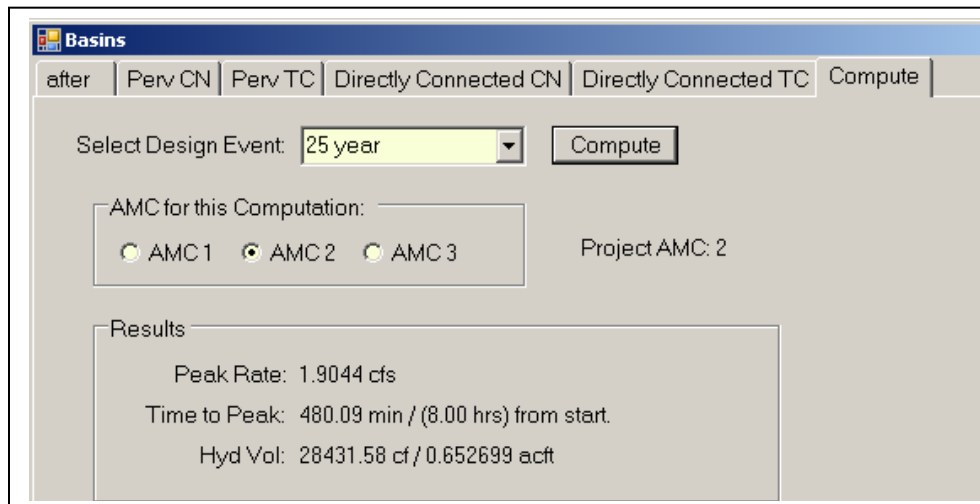
13) Create a Report

Once information for each basin is entered, the designer will need to provide this data in the hydraulic report. There is no formal report writing command in 3G, however information can be sent to the History View and then copied into a word document. This can be done by:

- LMB click to select the basin in the ***Data Tree View***.

- RMB click to open the menu.

- Then LMB click to select the '*To History*' option.

This process should be repeated for each basin.
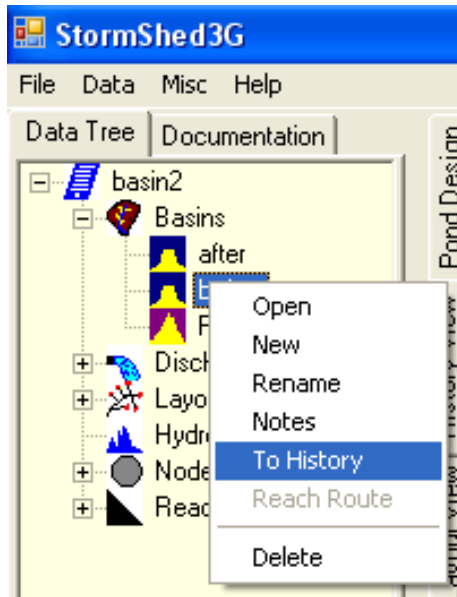
The *History View* will open and should look as shown below. Notice there is information on each precipitation value that was entered in the *Project Configuration* tab as well as all the information input into each basin.

Repeat the process for the 'after' basin. Each item (basin, reach, node, etc) will need to be selected individually as described above and copied from the *History View* into a word document. For larger projects, there is a quicker method that will be reviewed in the Layout Tutorial.

In this tutorial, you will learn about:

- The design criteria for ditches.

- How to model a conveyance ditch.

- An introduction to reaches and nodes.

- How to include infiltration in the ditch design.

- How to use the calculator to estimate a ditch size.

Ditch Example

You have been asked to determine if the 'V' bottom ditch running parallel to the road is adequate to convey the runoff from both the road and back slopes. Figure 4-1 and 4-2 shows the plan and cross section view of the example project and details are noted below:

- The pervious area from the back slopes contributing to and including the ditch is **1.0 acre**.

- The SCS soil type is **Type C** and the ground cover is primarily **forest in fair conditions**.

- The average slope of the ground is **1%**.

- The calculated time of concentration for the forested condition will be **50 ft** of sheet flow and **900 ft** of shallow concentrated flow to the beginning of the ditch.

- The **20' x 900'** *(0.413ac)* roadway, without curbing, contributes to the ditch with a cross slope of **2%.**

- The ditch is **900'** long and has a longitudinal slope of **1%,** with a ground cover as **nearly bare ground**, very little grass. The side slopes are **3:1**.
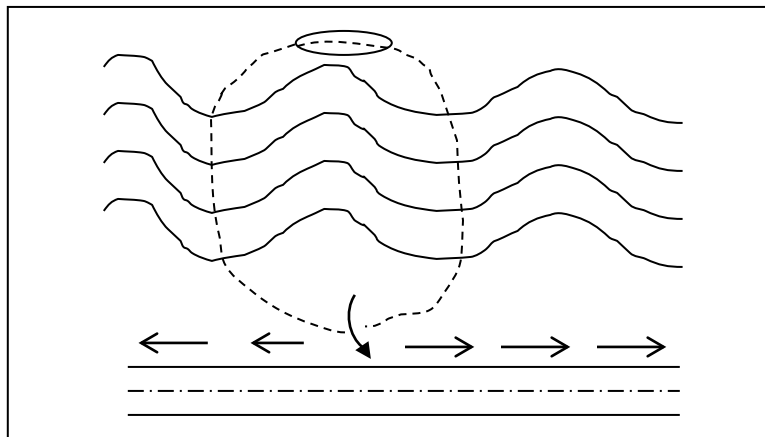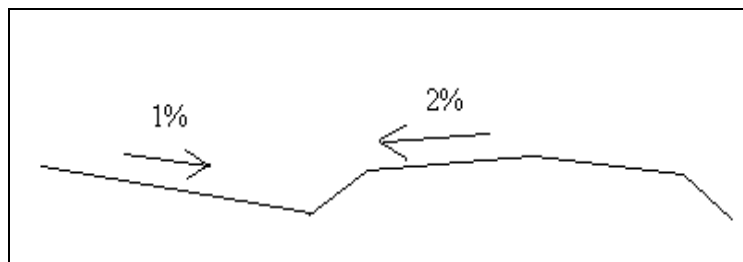
Figure 4-1.   Plan View

Figure 4-2   Cross Section

Design Criteria

Roadside ditches are generally located alongside uncurbed roadways with the primary purpose of conveying runoff away from the roadway. This is different than a bioinfiltration swale or biofiltration swale (or bioswale), in that a ditch only conveys drainage runoff where as a bioswale both conveys runoff and provides runoff treatment by filtering the runoff through vegetation. The shape of a bioswale is a trapezoid. The shape of a roadside ditch is typically a "V" ditch.

The design criteria for ditches are in located in Section 4-3 of the Hydraulics Manual. In short the following is required:

- The design storm is the 10 year recurrence interval.

- The maximum depth of water in the ditch is 0.5' below the bottom of sub-grade.

- Velocities in the ditch should not exceed 5 ft/sec and the ditch slope should be less than 6%.

Creating a New File

1) Select **File>New** and input: **ditch**. Then click on Ok.
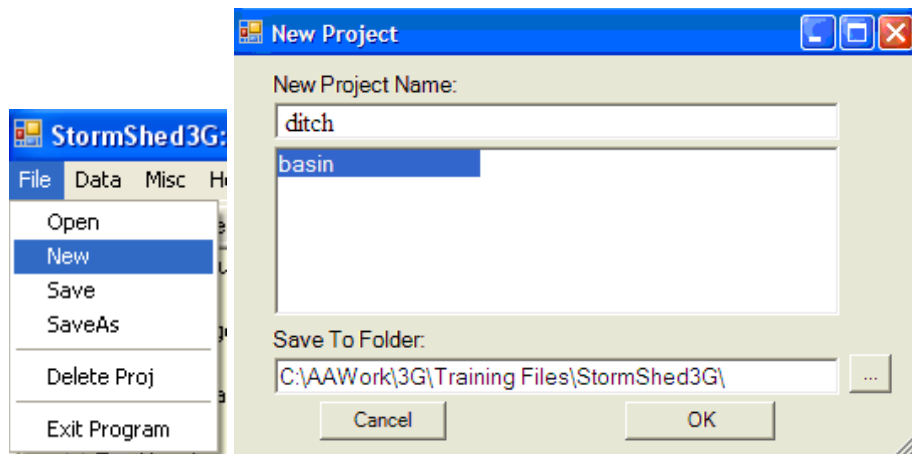
The 3G project disclaimer dialog will appear as shown below. Select **I Fully Understand** and the box will close.
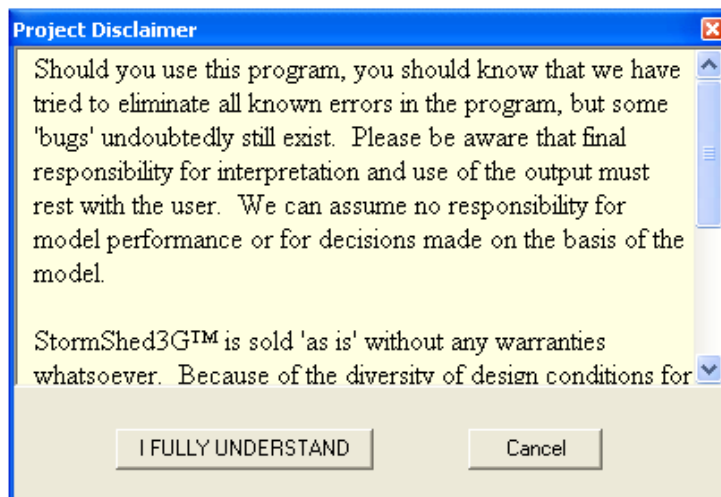
2) **Set Project Defaults**

Select **Data>Config.**

The Project Configuration box will open as shown below.
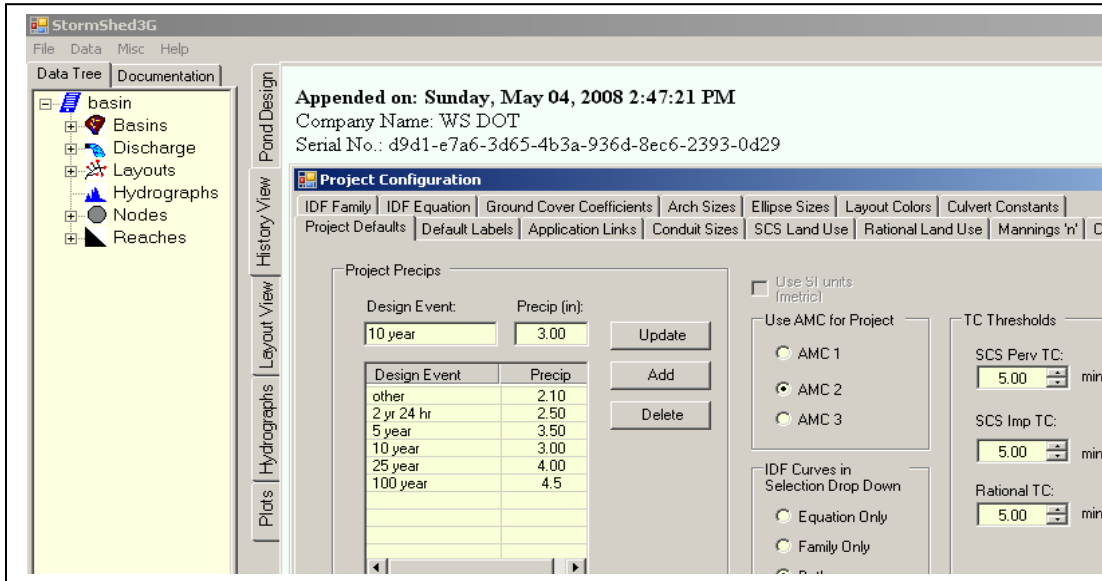
3) Create Basin

1) Create a new basin named '**Ditch**'.
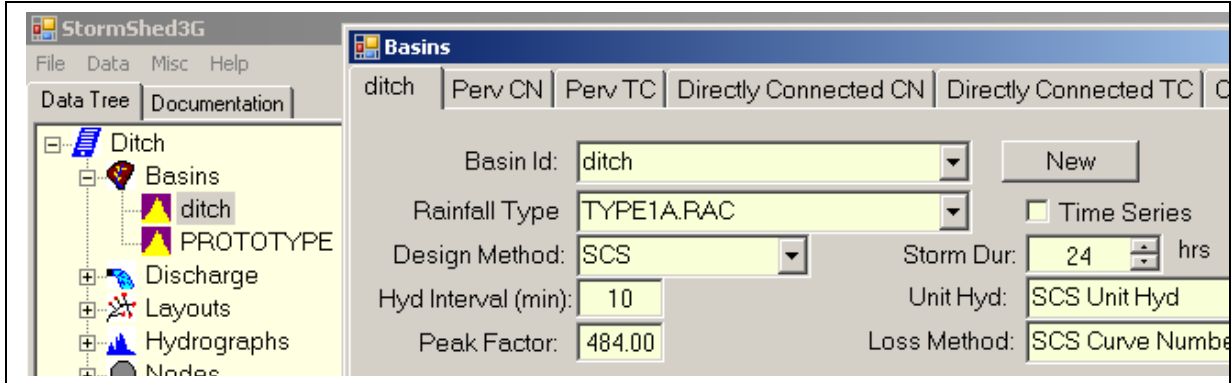
4) Then define the pervious area site conditions in the ***Perv CN*** tab using the ditch example description on the previous page and input the values shown below.
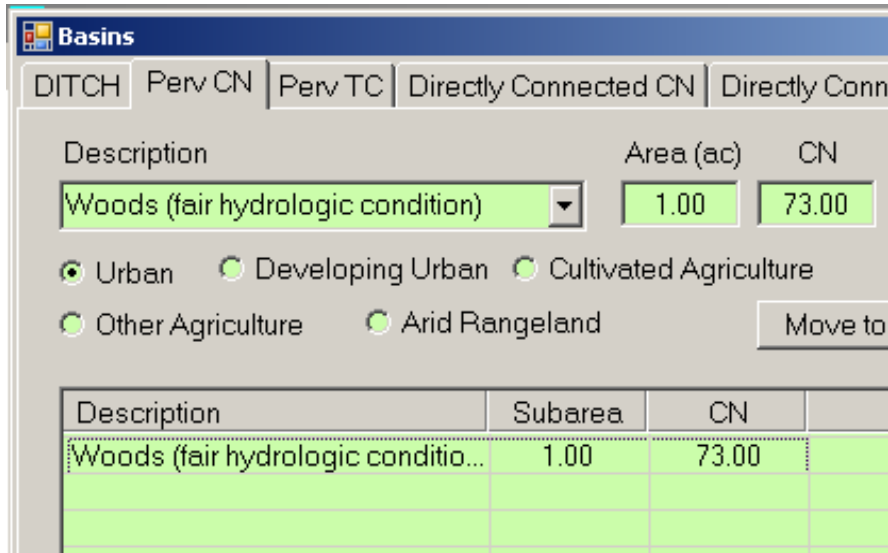
5) Next, select the *Perv TC* tab and define the pervious surface side slope area.
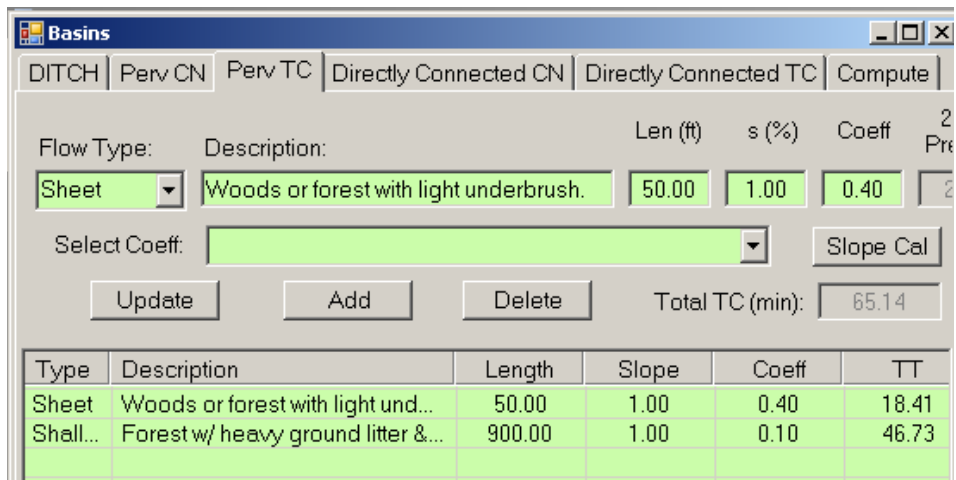
6) Define the impervious basin area (roadway draining toward the ditch) in the *Directly Connected CN* tab.
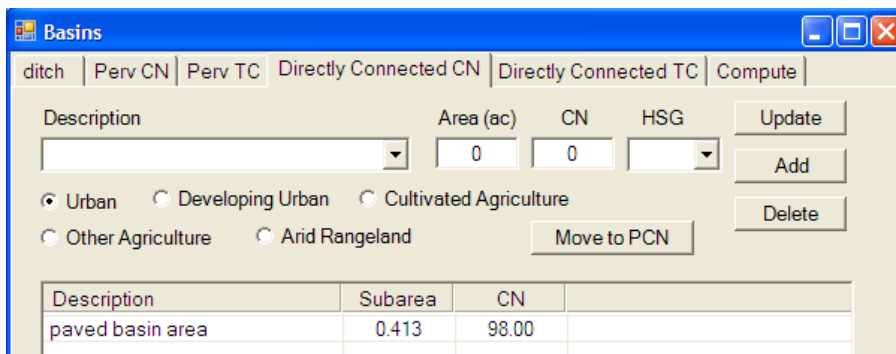
7) Finally, define the flow path from the roadway, into the ditch in the *Directly Connected TC*.

8) Finally, <u>estimate</u> the flow rate of the runoff by using Compute button.

- Select **10 year** from the pull down menu.

- LMB click on the **Compute** button and the results should match as shown below.

- To save and close the basin dialog box, select the **Close** button.

9) **Create a Reach**

Next, we need to create a Reach that will represent the ditch.

- In the *Data Tree View*, click on the "+" symbol next to the Reaches node.

- Double click on "**PROTOTYPE**" under the Reaches node.

- Click on the **New** button in the Reach Definition dialog.

- Override the default label with **D-001** and Click **OK.**

10) After the reach has been named, the next step is to define the "*Section Shape*" or the type of reach. For this application, select **Ditch**.

11) Change the "*Routing Method*" to **TT Shift**.

The '*Routing Method'* box contains 4 hydrologic routing methods and the Travel Time Shift. The hydrologic methods actually route the hydrograph through the reach taking advantage of the storage that is available in the reach. The TT shift uses the Manning's equation to compute the hydraulic parameters based on the peak flow rate and assumes a constant depth. Of the 5 options presented, the Muskingum-Cunge and TT shift are used the most. For most applications the **TT shift** should be used, however there are applications where this method is conservative. For long reaches with flat slopes, the Muskingum-Cunge method provides a more representative analysis because it allows the flow to spread out producing a lower peak.

12) In the "*Uniform Flow Method*" box, there are only two available options available for ditches (or cross sections). Select the Manning's equation, this is the one most commonly used in the United States. The Manning's value can either be input manually, or selected from a table by clicking on the '**…**' box to the right as shown below. *All the values provided in the table are the average values from the Hydraulics Manual Appendix 4-1, Manning's Roughness Coefficients.*

Manning Lookup Form

Description	Manning
▶ Open Channels, Excavated (Straight A...	
Earth, Uniform Section	
Clean, recently completed	0.017
Clean, after weathering	0.0245
With short grass, few weeds	0.0245
In gravelly soil, uniform section, clean	0.0235
Earth, fairly uniform section	
No vegetation	0.0235
Grass, some weeds	0.0275
Dense weeds or aquatic plants in d...	0.0325
Sides clean, gravel bottom	0.0275
Sides clean, cobble bottom	0.035
Dragline excavated or dredged	
No vegetation	0.0305
Light brush on banks	0.0425
Rock	
Based on design section (riprap)	0.035
Based on actual mean section	
Smooth and uniform	0.0375
jagged and irregular	0.0425
Channels not maintained, weeds an...	
Dense weeds, high as flow depth	0.1
Clean bottom, brush on sides	0.065
Clean bottom, brush on sides, high...	0.0405
Dense brush, high stage	0.12

Channel Category — ☑ Close on Select — annels, Excavated (Straight Alignment, Natural Lining) ▼

Using the pull-down menu, select '**Open channels, Excavated (Straight Alignment, Natural Lining)**'. From that table, the closest match is **No vegetation** under the category '**Earth, fairly uniform section'**. LMB click on **No vegetation** and the *Manning Lookup Form* will close and the Manning's value of 0.0235 will automatically be input into the Manning's 'n' input box.

The following bullets apply to the lower options on the **reach dialog** box.

- Notice the "*Node Data*" boxes are blank. They remain blank until the up and down reaches are either defined in the layout view or manually attached.

- The "*Contrib Discharge*" option only applies when the reach is immediately down stream of a detention system. Using the pull down menu, the discharge structure that is coming through the reach can be identified.

- Only check the "*Save Route Hyd*" box, if you would like to see a hydrograph created from runoff going through this reach.

13) Next, select the *Geometry* tab. Notice the "*Size*" and "*Entrance Losses*" option are not available; these options only apply to pipes.

Input the Ditch "*Specific Geometry*" values as shown below.

14) The *Constraints* tab applies mostly to pipes and will be discussed further in the Network Tutorial. The only option that applies to ditches is *infiltration/exfiltration*, which represents flow into and out of the reach. In this case, infiltration is when water is entering a reach (high water table and a perforated pipe) and it is represented by a positive value. Exfiltration is water exiting or leaving a reach (due to a ditch that infiltrates runoff into the soil or a reach with joints not properly sealed) and is represented by a negative value. Right now leave this value at **0,** we will repeat the example using this option.

Click on the **Close** button to close the dialog box.

15) Create Nodes

A node is required for every transition in a reach, even if there is no structure present. In this tutorial, a **Dummy Node** must be defined to represent the ends of the reach so StormSHED 3G can perform the calculations.

- Open the "PROTOTYPE" node in the Nodes section of the *Data Tree View*.

- Click on the **New Node** button.

- Rename the default node ID to **UpstreamDummy**.

- For the "*Description*" type '**upstream point of ditch**'. For larger projects it maybe beneficial to provide more information in the description so when the report is read it is easy to determine the use of the node.

- The "*Node Type*" box is where the application of the node is defined. For the "*Node Type*", select **Dummy Node**. Once the Dummy Node radio button is selected, notice the third tab disappears as there is no structure to define.

- The "*Start EL*' refers to the outlet elevation or in this case the bottom of the ditch elevation or **224**. The "*Max EL*" is the top of the bank for a ditch or the rim elevation of the catch basin or manhole. In the case of trap pond or vault this would be the ground elevation. For this example input the "*Max EL*" **225**.

- The "*Contributing Area*" is the name of the basin that is attached to this node. Once it is selected from the *Contributing Drainage Areas* tab, it will be shown in gray on this tab.

- The "*Contrib Hyd*" pull down menu allows the designer to create a Hydrograph and apply that Hydrograph to the node. For this example, leave it blank.

- Generally the "*North*" and "*East*" boxes are left at zero, inputting a value here only affects the location of the node in the layout view. If no value is entered, StormShed 3G will use the approximate location in the layout view when computing.

- The "*Increment for rating curve*" option, only applies to the number of points plotted on the rating curve. For computing, the program will use as many points as needed to run the analysis.

- All nodes support a "*void ratio*" for the inside of the node. Generally this is left as 100% voids. This could be helpful if the structure is filled with rock for example, the program will compute the correct volume of available in the structure based on the void ratio.

16) Select the ***Contributing Drainage Area*** tab and choose the basin that is contributing runoff to the node, in this case use the area we just created, **ditch**.
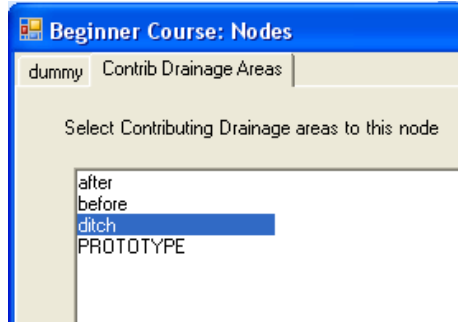
Click on the **OK** button to close the dialog box.

17) Next create the downstream node.

- Re-open the node named UpstreamDummy <u>instead of the PROTOYPE node</u> and select the New Node button. Name the node **DownstreamDummy** and hit OK. By doing this all the values entered in the original node (except the name) are carried over into the new node (including the contributing drainage area).

- Change the "*Start*" and "*Max El*" as shown below.
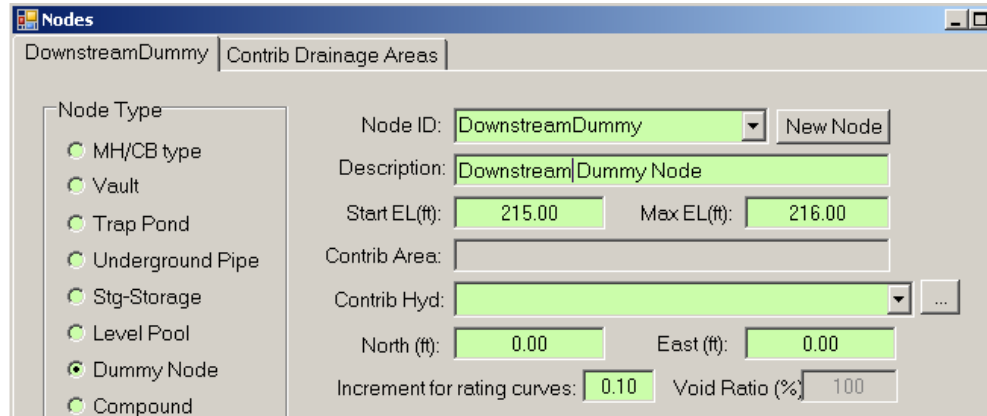
18) The select the ***Contributing Drainage Area*** tab and unselect the basin called "ditch".

Finally close the dialog box.

19) Create a New Layout.
   Next create a layout to represent the ditch.

- In the Layout View, click on the *Layout View* Tab and select the '*Insert Nodes and Reaches*' button in the upper left corner.
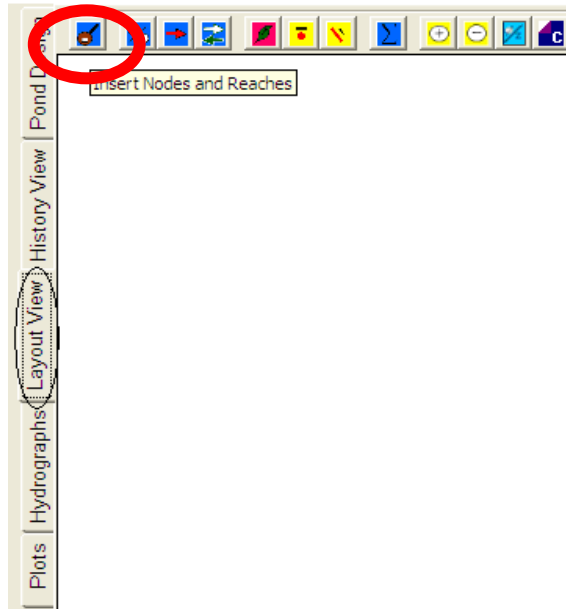
- Before any nodes or reaches can be placed, the program will prompt you to name the layout. Since some projects can have multiple layouts, it is recommended that the name of the layout be meaningful to the area being designed. For this example use '**ditch**'.

- Select **OK** after inputting the layout name.

20) Next select the approximate locations of the up and down nodes as shown below. Click the "Insert Nodes and Reaches" blue button at the top left corner of the layout screen. Since the nodes and reaches have not been defined, the names default to the *PROTOTYPE* record. Click the "Insert Nodes and Reaches" button again to turn it off.
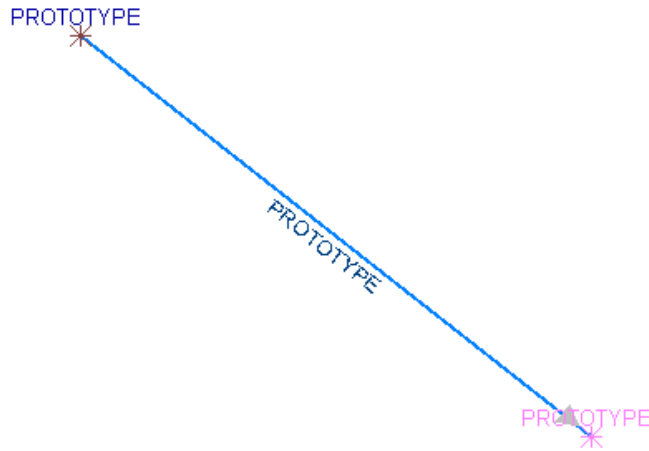
21) Next we will define the nodes and reaches. Double LMB click on the upper node. Use the pull down menu to select **UpstreamDummy** for the Node ID.
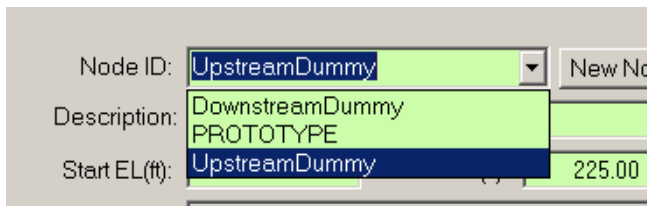
22) Repeat this process to define the reach and down stream node. When finished the layout should appear as shown in the next view.
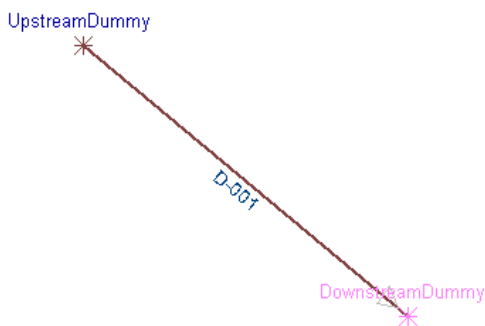
- Save the file. If the names are not shown, use the '*Toggle Node Label*' and '*Toggle Reach Label*' buttons until the node and reach name are shown.
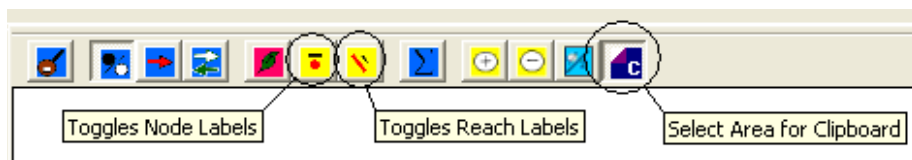
23) To route the design storm through layout, select the compute layout button.
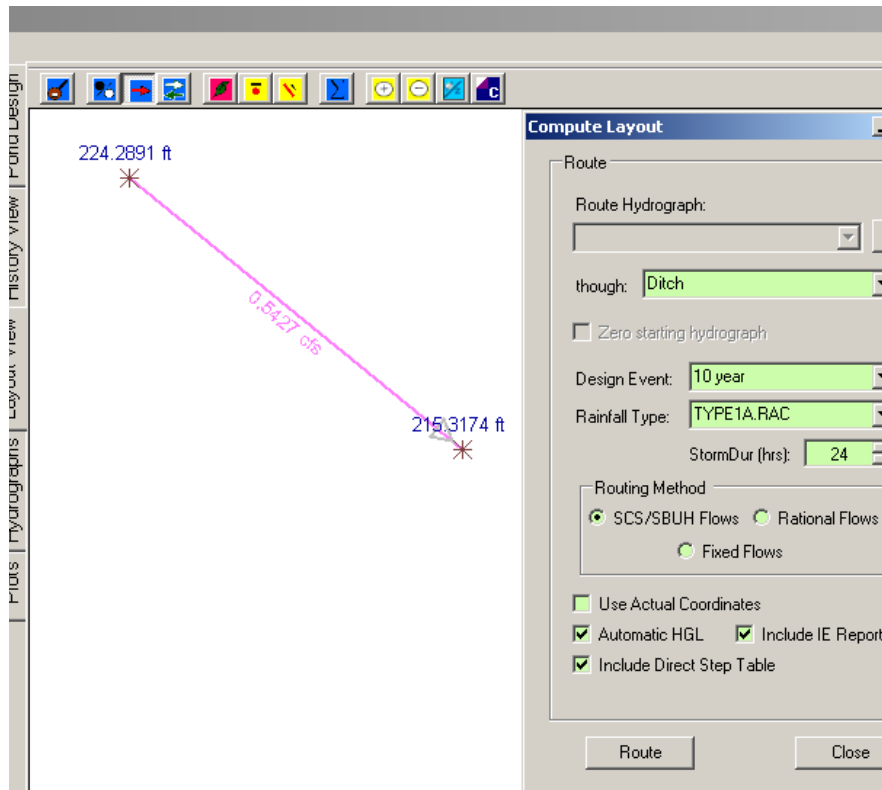
- In the "*through*" box, use the pull down menu to select the name of the layout to run the design storm through. In this case select **ditch**.

- Use the pull down menu to define the Design Event as the **10 year** and Rainfall Type as the **Type IA** for WWA. For the Storm Duration; input **24 hrs** for WWA. Note that while these options were set when defining the basin, the values entered in the compute command override those settings.

- "*Use Actual Coordinates*' – this would only apply if the "*North*" and "*East*" values were input when the nodes were created. For WSDOT projects this option is generally not used.

- "*Route as Rational Network*" – selecting this option would allow the designer to use the Rational Method to analyze the layout. Again this would override whatever design event and rainfall type was input into each basin, for just the compute command (the actual values input in the basin do not change). *Notice when this option is selected the pull-down menu choices change for the Design Event and the Rainfall Type.*

- "*Automatic HGL*" – if this option is selected the HGL analysis will be sent to the History View along with the Conduit Notes. If this box is not marked, only the Gravity Analysis will be sent to the History View. **For this example check this box**.

- "*Include IE Report*" – when this box is selected, a report will be included in the history view of the invert elevations for the reaches and nodes. This option allows the designer to verify the location of the inverts.   **For this example check this box.**

- Finally, select the **Route** button to route the design storm through the layout and then select the close button to **Close** the dialog box.

24) Select the *History View* tab to see the routed information, as shown below.

Appended on: Sunday, May 7, 2017 3:28:33 PM

ROUTEHYD [] THRU [Ditch] USING [10 year] AND [TYPE1A.RAC] NOTZERO RELATIVE SCS/SBUH

Gravity Analysis using 24 hr duration storm

Reach ID	Area (ac)	Flow (cfs)	Full Q (cfs)	Full ratio	nDepth (ft)	Depth ratio	Size	nVel (ft/s)	fVel (ft/s)	Infil Vol (cf)	CBasin / Hyd
D-001	1.413	0.305	----	0.00	0.2559	----	Ditch	1.5529	-----	0.00	DITCH

HGL Analysis

From Node	To Node	HG El (ft)	App (ft)	Bend (ft)	Junct Loss (ft)	Adjusted HG El (ft)	Max El (ft)
							215.2559
UpstreamDummy	DownstreamDummy	224.2344	--na--	--na--	--na--	224.2344	225.0000

Conduit Notes

Reach	HW Depth (ft)	HW/D ratio	Q (cfs)	TW Depth (ft)	Dc (ft)	Dn (ft)	Comment
D-001	0.2344	na	0.305	0.2559	0.2344	0.2559	Direct Step Backwater Calc

Node and Reach invert report

Node and Reach invert report				
Node	UpstreamDummy		Out ie	224.00 ft
	Reach	D-001	I.E. Out	224.00 ft

Licensed to: WSDOT

Flow rate = 0.305 cfs
Ditch velocity = 1.6 ft/second.
Depth of flow in the ditch = 0.26 ft

Ditch Design Complete.

Exfiltration (Create Reach D-002)

Now we will apply Exfiltration to the reach to see how it affects flow in the ditch.

1) Using the same file, in the *Layout View*, double LMB on the "ditch" reach and select the *Constraints* tab.

2) Type '**-2**' into the Exfiltration/Infiltration box. **This represents water leaving the reach at a rate of 2 in/hr.**
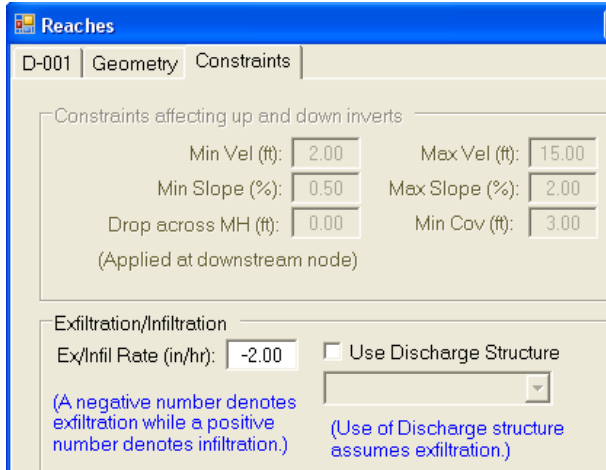
- **Close** the Reach dialog box.

3) Select the **Compute** button and route the **10 year storm** through the layout.

4) **Close** the Compute Layout Form dialog box and select the *History View* tab.

Note the Flow has decreased in the reach from **0.305 to 0.238 cfs**. Using the Exfiltration/Infiltration option will decrease the flow rate Q and Volume, which would decrease the size of a detention facility down stream.

Appended on: Sunday, May 7, 2017 3:38:33 PM

ROUTEHYD [] THRU [Ditch] USING [10 year] AND [TYPE1A.RAC] NOTZERO RELATIVE SCS/SBUH

Gravity Analysis using 24 hr duration storm

Reach ID	Area (ac)	Flow (cfs)	Full Q (cfs)	Full ratio	nDepth (ft)	Depth ratio	Size	nVel (ft/s)	fVel (ft/s)	Infil Vol (cf)	CBasin / Hyd
D-002	1.413	0.2376	----	0.00	0.2329	----	Ditch	1.4597	-----	3454.05	DITCH

HGL Analysis

From Node	To Node	HG El (ft)	App (ft)	Bend (ft)	Junct Loss (ft)	Adjusted HG El (ft)	Max El (ft)
							215.2329
UpstreamDummy	DownstreamDummy	224.2031	--na--	--na--	--na--	224.2031	225.0000

Conduit Notes

Reach	HW Depth (ft)	HW/D ratio	Q (cfs)	TW Depth (ft)	Dc (ft)	Dn (ft)	Comment

| D-002 | 0.2031 | na | 0.2376 | 0.2329 | 0.2031 | 0.2329 | Direct Step Backwater Calc |

Node and Reach invert report

Node and Reach invert report				
Node	UpstreamDummy		Out ie	224.00 ft
	Reach	D-002	I.E. Out	224.00 ft

Licensed to: WSDOT

==

Creating a Report

There is no report command in StormSHED 3G, instead data must be copied from the History View and pasted into a word document. The information in the history view is not cumulative, so it is important to copy the data before sending anything else to the history view.

To copy the basin/node/reach information into a report go to the *Data Tree View* and **RMB click** on the **layout name**, then **LMB click** and select **To History**. Select the *History View* tab, highlight the data, and copy the data by selecting **Ctrl C**. Use **Ctrl V** to paste into a word document.
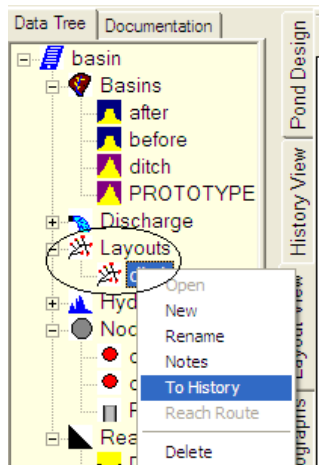
Move Hydrograph Option

The **Compute** option also allows a hydrograph to be routed through a reach. We are going to use the *Move Hydrograph* option to generate a hydrograph from the basin we created. The *Move Hydrograph* option allows as many basins as desired to be moved into one hydrograph based on a specified design event. The benefit of this option is it allows the designer to manipulate the final hydrograph before routing it through the layout.
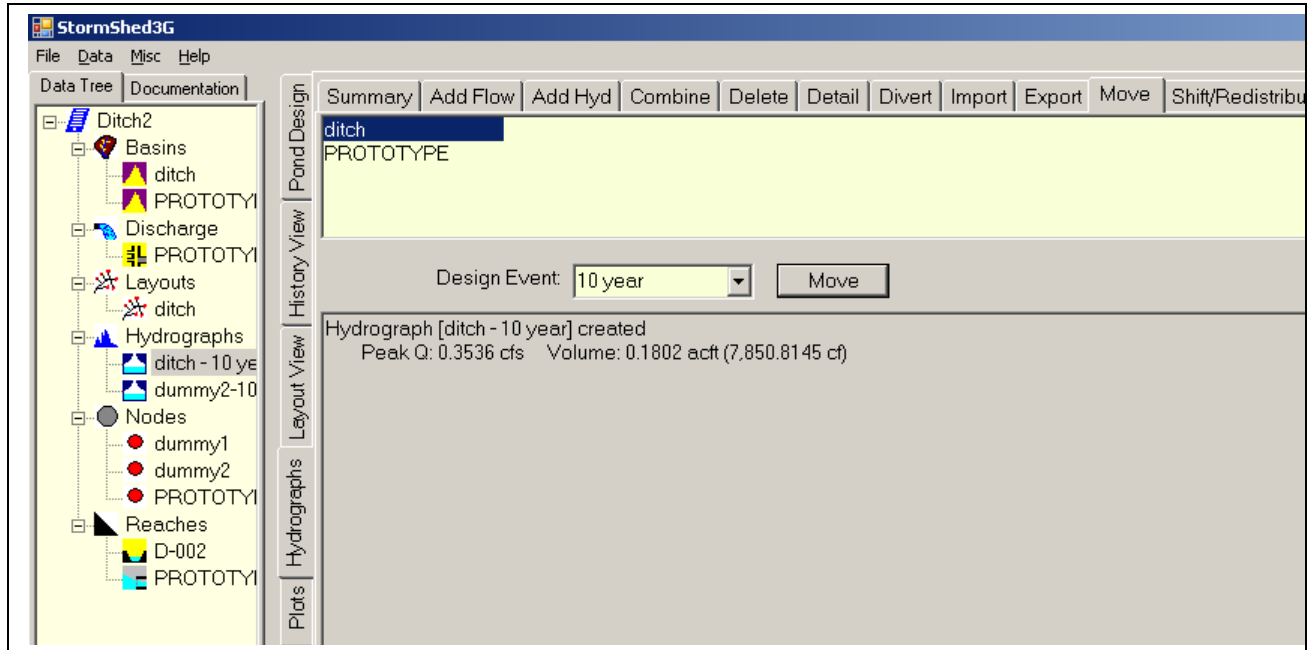
1) Select the ***Hydrograph*** tab and then select the ***Move*** tab.

2) The previously defined basins are shown in the top box, select the basin(s) to be moved. For this example select **ditch**.

3) Next select a <u>Design Event</u> of **10 year** and then hit the **Move** button. After the **Move** button has been pressed, a new hydrograph will be created. The summary data is visible in the lower portion of the ***Hydrograph*** tab as shown above.

4) To view the Hydrograph, select the ***Plots*** tab.

5) Select the **ditch 10 year** hydrograph as shown below.

6) For the "*Type of Plot*", select the **Hydrograph** radio button.

The "*Hydrograph/Basin List*" instructs the program to list just the hydrographs, just the basins, or both in the box to the left. For this example, select the List Both radio button.

The "*Design Event*" pull-down menu allows the designer to select which design event is run through a basin to generate a hydrograph. This option only applies to basins. Since we have already assigned a design event to our hydrograph, changing the event will not change our plot.

If the "*Plot as points*" button were selected, the plot would appear as a series of points instead of line. For this example, **leave the box blank**.
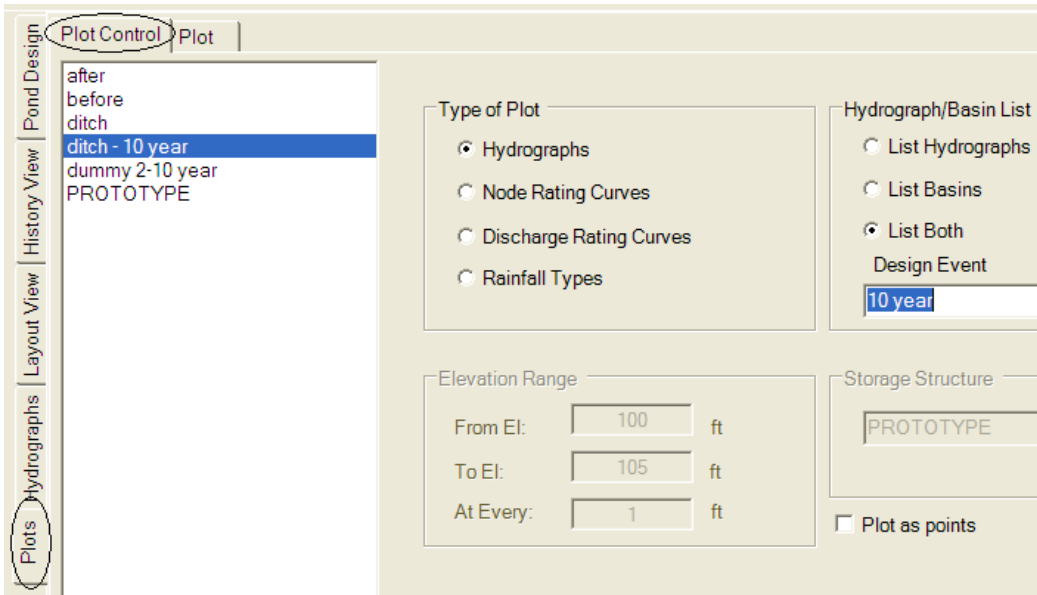
Next select the *Plot* tab.
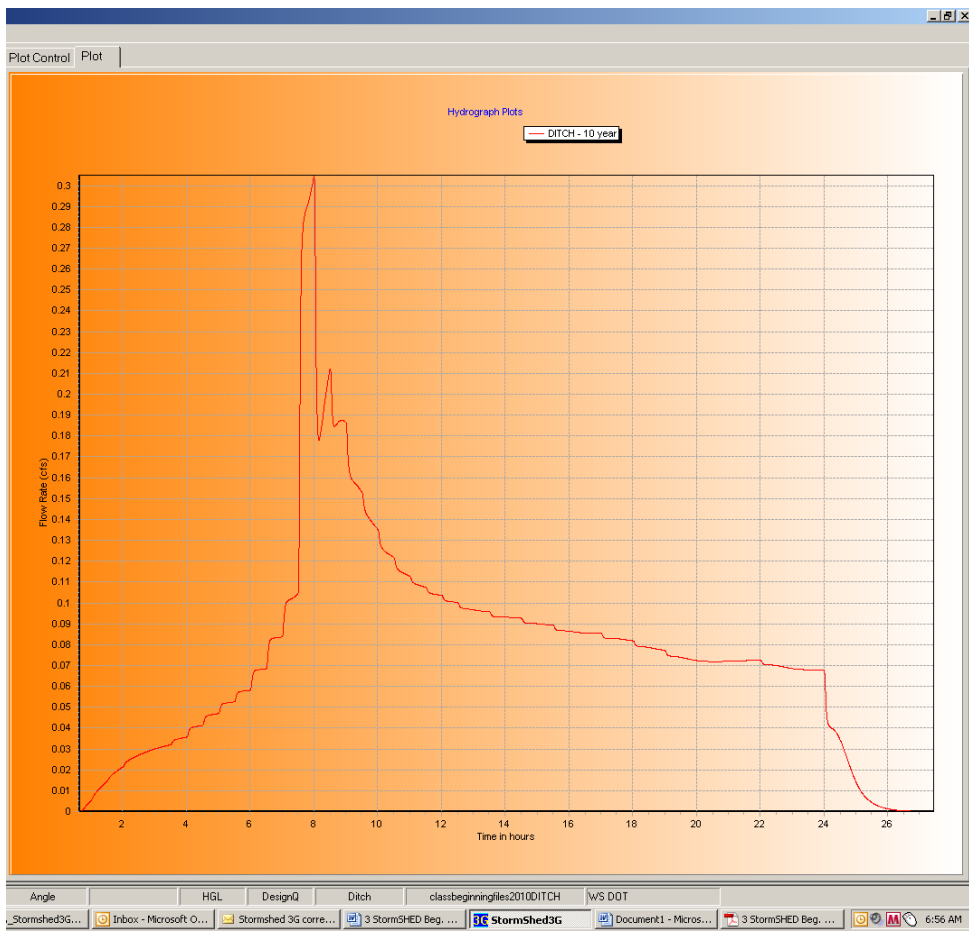
The Hydrograph above should appear.

Calculators

Another tool available in StormSHED 3G is the calculator, which can be used to estimate the size of the ditch. From the main menu select:

> **Misc>Calculators**.

1) From the "*Select Reach*" pull-down menu, select the reach that was created in this example **D-001**. Notice all the values input into the reach dialog box are carried over to the white boxes in the calculator.

2) Modify the "*Flow*" to match the flow rate in the history file and the gray values on the right should match the history file output.

3) Try modifying other parameters to see how the key design criteria limits are affected (velocity, depth, and grade).

   In this example, we increased the width of the original ditch bottom of D-001 from 0 ft to 2.0 feet. The velocity increased from 1.55 ft/sec to 1.28 ft/sec.

   NOTE: Changing parameters in these calculators may change you actual design inputs so please be careful and save your work before using these. I recommend creating different versions of your files as you change different design lengths, widths, flows, etc.

In this tutorial, you will learn about:

- Define Nodes and Reaches.

- How to create layouts.

- How to use the compute command in the layout view.

- How to generate a report for all the elements in the layout view and the output.

Example

Create a storm drain network in the layout view and design the pipes using the 25-year MRI. Determine pipe sizes required given the following information.

- The section of roadway is in a **sag** condition, with CB3 and CB4 located at the low point.

- The curve crest is **600 feet north** of CB1/2 and South of CB5/6, see Figure 1.

- Assume **catch basins type 1** and that each is **100% efficient**, ie.; no bypass flow.

- The pipes should always be designed for the worst case Schedule A pipe, that is a Manning's value of **n=0.013**.

- For the entrance loss coefficient, assume a **square edge with Headwall**.

Figure 1 – PLAN VIEW
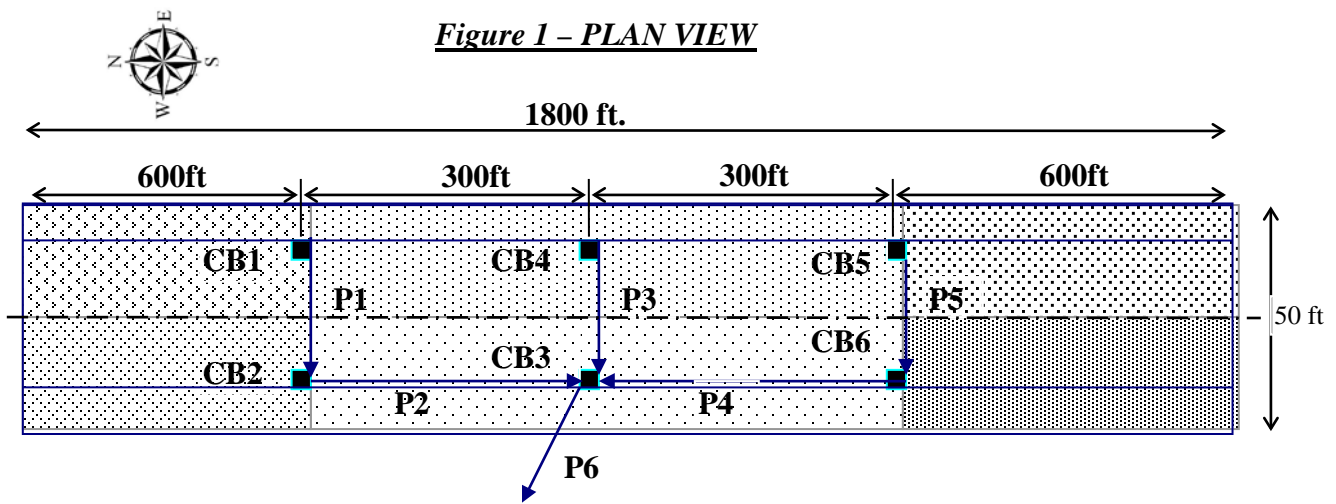
Figure 2 - CROSS SECTION
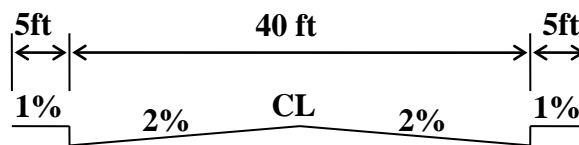
Figure 3- PROFILE
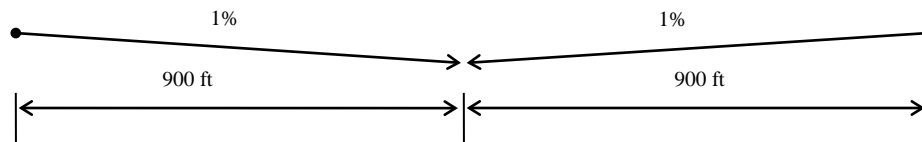
Use the following data when creating nodes and reaches:

Catch Basin	Outlet Inv El.	Rim El.
CB1	332.5	337.0
CB2	332.0	337.0
CB3	330.0	336.0
CB4	330.5	336.0
CB5	334.8	338.5
CB6	334.5	338.5
Dummy	325.0	330.0

Pipe	Length	Upstream Inv.	Slope
P-001	36	332.5	1.39%
P-002	298	332.0	0.67%
P-003	36	330.5	1.39%
P-004	298	334.5	1.51%
P-005	36	334.8	0.83%
P-006	15	330.0	33.33%

Design Criteria for Storm Drains

Chapter 6 of the Hydraulics Manual contains the design requirements for storm drain design. In summary they are:

- Velocity should be between 3 and 10 ft/sec in full condition.

- Inlet structures should be no more than 300 feet apart. (Designers should verify this with Region Maintenance).

- Align the crowns (the internal high point) of pipes that are entering and leaving a junction.

- The minimum pipe diameter is usually 12".

- Pipe slopes should be between 0.5% and 5%.

Determine Project Configuration

1) Create a New Project called **network**.
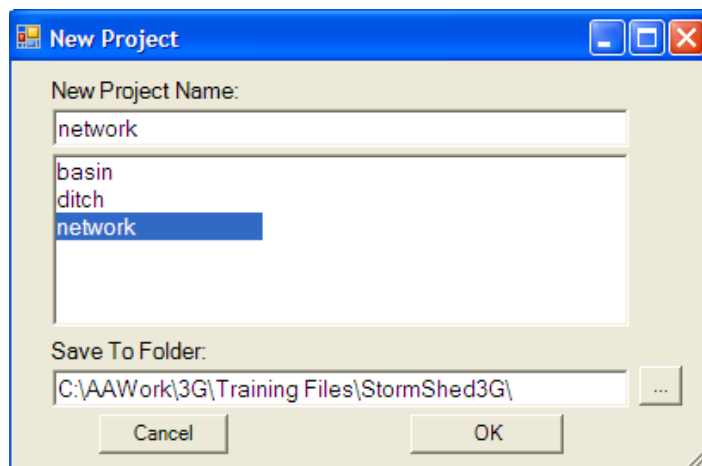
2) The first step in any project is to customize defaults in the ***Project Configuration***. In this case we are going to modify the ***Default Labels*** to something that would be more meaningful for our project including:

- Change the Padding to '**0**' for the Reaches, Nodes, and Basins.

- Change the prefix for Nodes to **CB** and **delete the hyphen** after Basins and Reaches.

- The Default Labels tab should look as shown below:
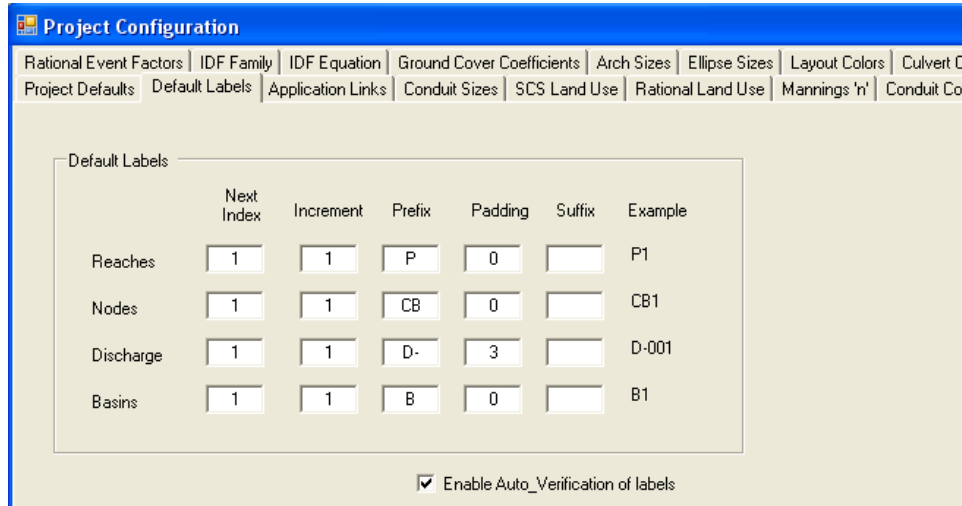
3) Next select the ***Project Defaults*** tab. For this project we will use the precipitation values calculated in '**Basin and Design Storm**' Tutorial, all other default values will remain. After modifying the precipitation values, the '***Project Defaults***' tab should look as shown below.
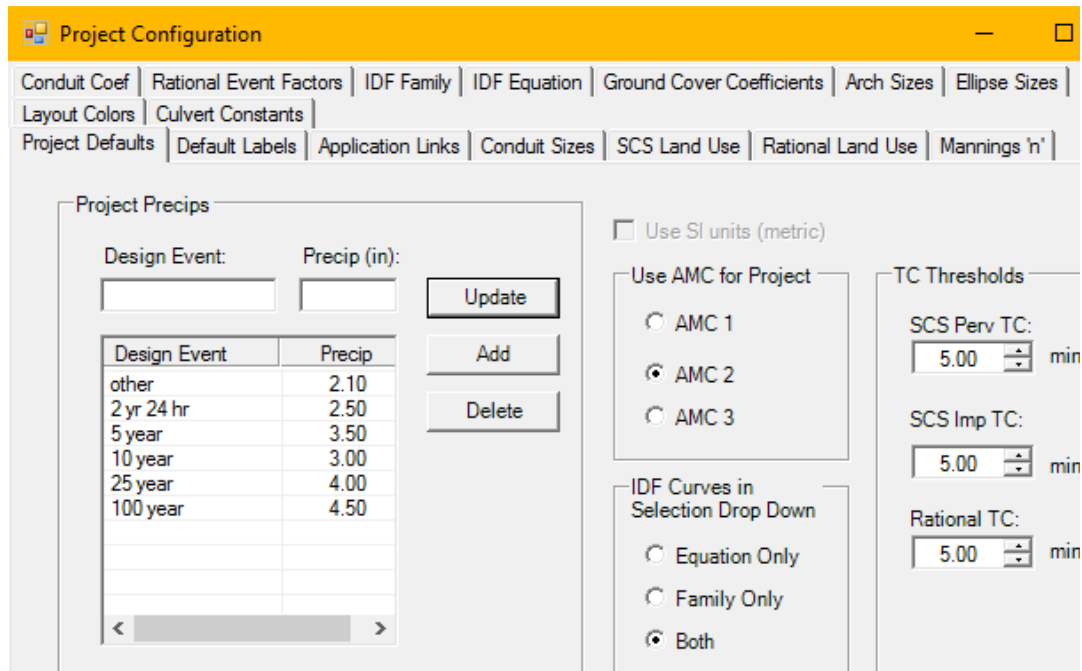
Basin Calculations

4) The next step is to perform the basin calculations, in other words determine how much runoff is going to each inlet. That information will be used to create our basins in 3G.

- Determine the area (in acres) that is contributing runoff to each inlet. Be sure to include the runoff from the 5' wide sidewalk.

  B1 = 25' x 600'/43560sqft/acres = 0.344 acres

- All the basins are the same size; however the length of flow to inlets CB4 and CB3 is only 300', not 600'. Since this will affect the time of concentration calculation, we will need 2 basins for this project; B1 and B2.
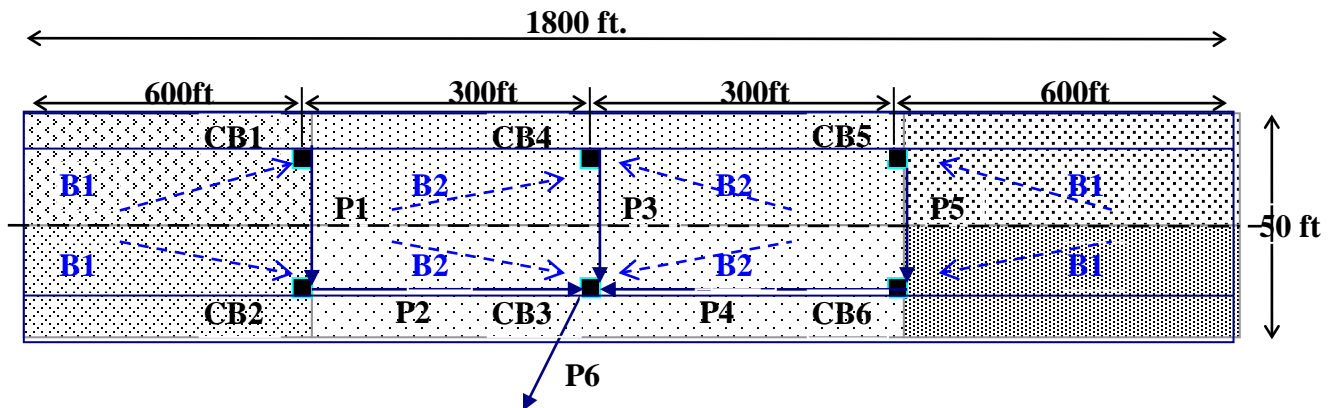
Figure 3 – PLAN VIEW

Hydraulic Report Tip – *Basin calculations need to be verified by someone other than the designer. To expedite the review process, designers should provide basin calculations and plan sheets that are both clearly labeled and to scale. This label should match the name of the basin used in StormShed.*

Basin Definition

5) Next we need to define the two drainage basins for our project. Below is the drainage basin contributing to catch basins CB1/2/5/6.

- Click on the **New** button and the default '**B1**' should appear, select **OK**.

- Change the rainfall type to **Type 1A** for WWA.

- Use **SBUH** for the Design Method.

- The Hyd Interval is **10 min** for WWA.

- And finally the Storm Duration is **24 hours** for WWA.
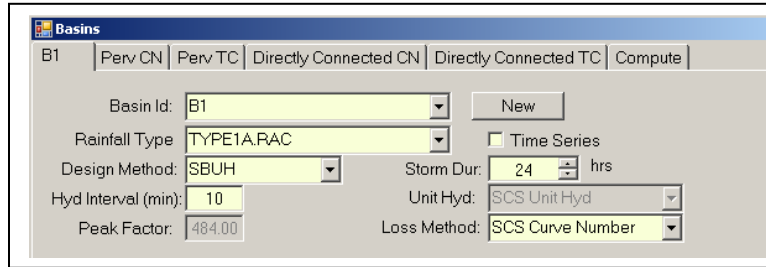
6) Next go to the ***Perv CN*** and ***Perv TC*** tabs.

For this example there are no Pervious surfaces, so delete the default values on these tabs. Next select the ***Directly Connected CN*** tab and input the basin data as shown below.
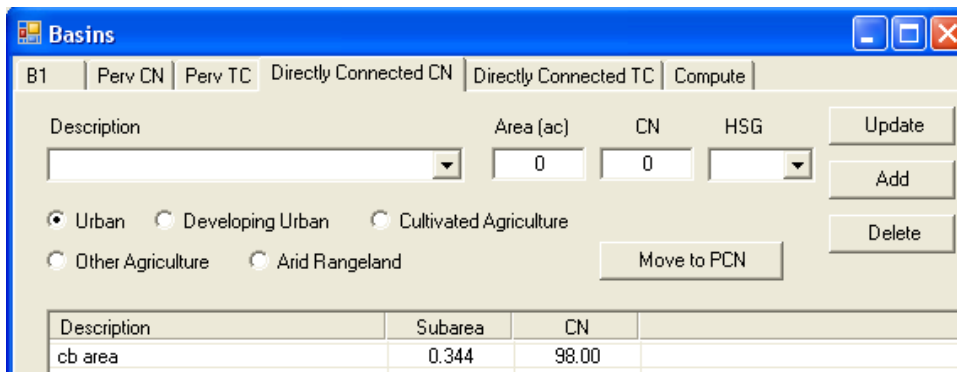
7) Select the ***Directly Connected Tc*** tab to calculate the Time of Concentration for the basin.
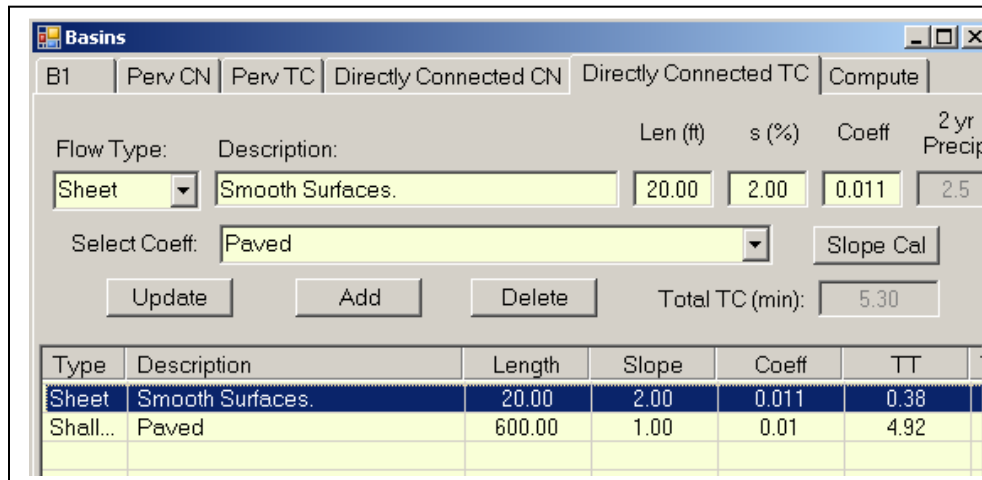
- For the flow type select '**Sheet**' from the pull-down menu.

- The description is automatically determined when the Coefficient is selected from the pull-down menu. Find and LMB click on '**Smooth Surfaces**' in the pull-down menu.

- Type **20'** for the length (note the 5' for the sidewalk was not included, this is because we are only concerned with the longest flow path).

- Input **2%** for the slope and hit the **Add** button to add this record.

- Repeat the steps for Shallow flow and input the values shown above.

    Notice the Total Tc (min) next to the gray box indicates our Tc is 5.30 min. for this basin.

- Select the **Close** button when the record for B1 is complete.

8) Now we will repeat the process for basin **B2**, which is contributing flow to CB3/4. In this case we only need to modify the length of shallow flow.

- The easiest way is to open basin **B1** and then select the **New** button.

- Select the default basin name of **B2** and hit **OK**.

Select the ***Directly Connected Tc*** tab.

- Highlight the Shallow flow type by clicking on the LMB.

- Double LMB click on the **600'** length and retype **300'**.

- Click on the **Update** button and the record should appear as shown above.

*Note the Total Tc (min) is now only 5 minutes, however the sum of the TT (travel time) is less than 5 minutes. In this case the basin has used the default of 5 minutes minimum for travel time in a basin that was set up in the **Project Configuration** menu.*

9) Creating A New Layout

Next we will create a new layout.

- To create a new Layout, click on the *Layout View* Tab and select the '*Insert Nodes and Reaches*' radio button in the upper left corner.

- Input the name '**network**' for this example and select **OK**.

10) Insert Nodes and Reaches

Next we will input the network. This will be a schematic view and not to scale; however, it is important that the angles between the pipes be accurately represented since StormSHED will use these angles to calculate headloss of flow through the system.
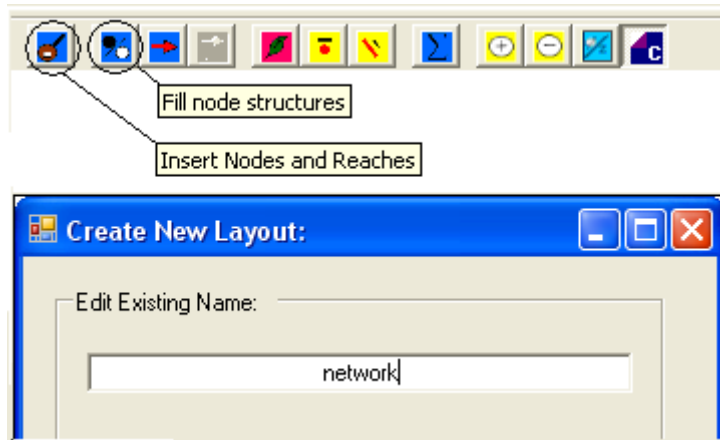
When nodes and reaches are input into the layout view, it is important that they be entered from the most upstream node to the downstream node. The direction the nodes and reaches are input establishes the direction of flow within 3G, as shown with the flow arrows below. In order to input our layout with the correct flow direction, we will have to input our network in three steps.

| **Step 1** | **Step 2** | **Step 3** |
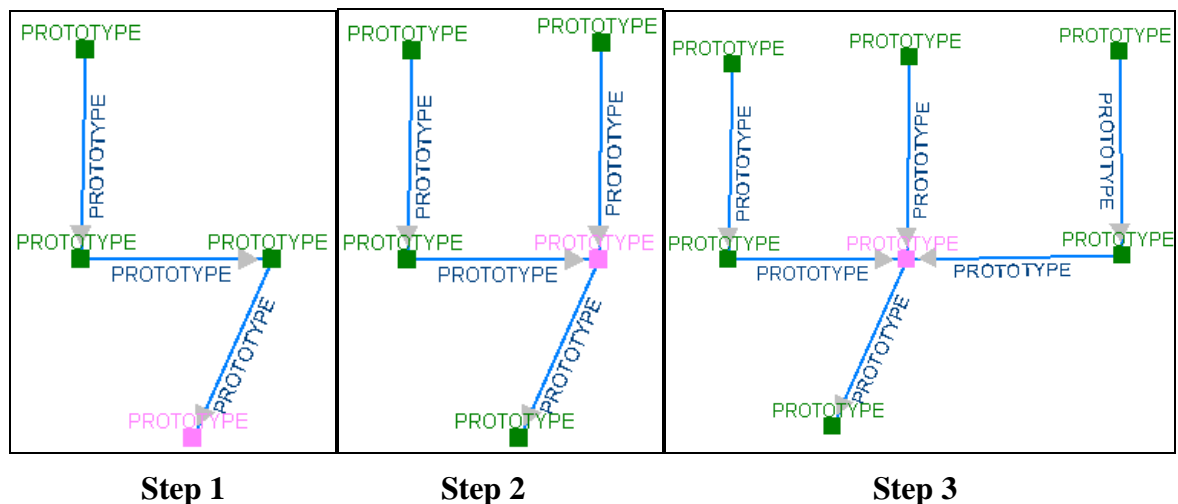
- Toggle the 'insert nodes and reaches' button on and use the LMB to select the approximate location of the 4 nodes in Step 1. Notice the reaches are automatically input between the nodes. Toggle off the insert button after the 4th node has been input.

- For Step 2 we can only add one node and one reach. Toggle back on the 'insert nodes and reaches' button and using the LMB locate the node and reach in the approximate

locations as shown in Step 2. Notice once the pink node is selected, the insert button is automatically toggled off.

- Complete the network by toggling on the radio button and inputting the network as shown in Step 3. Again the insert button will automatically toggle off once the pink node is selected.

Note every structure entered is labeled 'PROTOTYPE'. Verify the flow direction is as designed by toggling on the '*Draw Flow Direction Arrow*' radio button on the top of the layout view. (The button immediately to the left can be used to fill the arrow head).
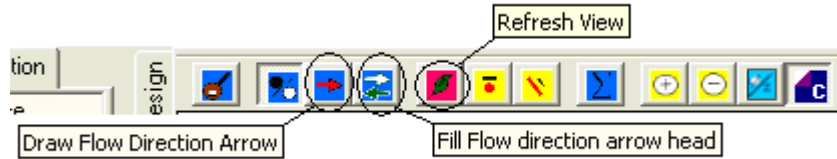
If the arrow heads are not going in the direction expected, RMB click on the reach and select '*Reverse Rch Direction*'. StormShed 3G will automatically reverse the flow direction and the arrowhead. The process is the same to delete a node or reach only select '*Delete*' from the menu. Sometimes after the layout has been modified or an existing file has been opened, it is necessary to use the '*Refresh View*' button to clean up the layout.
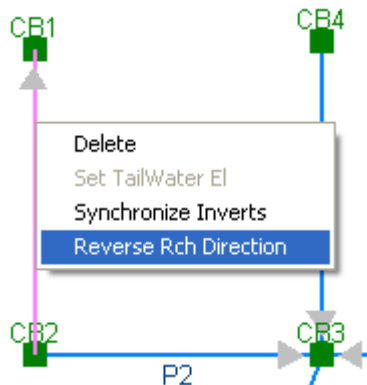
If the view is too large or small, toggle on the 'Zoom In' or 'Zoom Out' button

At the lower left corner of the layout, shows the zoom level. A zoom level of 1.5 is shown below. Also, to the right of the zoom level the name of the layout is shown as 'network'.

Define Nodes and Reaches

First we will create the nodes and reaches, and then we will define them in the *Layout View*.

11) **Node Definition**

We will use the structure information from the first page of this tutorial to create our nodes.

- Start by **double LMB clicking** on the **Prototype** node in the Tree View, the following box should appear.

- Click on the new node button and accept the default name of **CB1**.

- For the description type **catch basin**.

- For Start and Max El. input the values from the table on the first page of this tutorial; **332.5** and **337**.

- Select the *Node Type* radio button for **MH/CB type**. (In other tutorials we will discuss most of the other *Node Types* in more detail).

  Next select the *Contrib Drainage Area* tab. All the basins created in this project will appear.

- Select **B1** by using a single LMB click. (If you go back to the **CB1** tab, note the *Contributing Basin* box will show B1 in gray).

Finally select the *MH/CB Structures* tab, this is where we will define the structure.
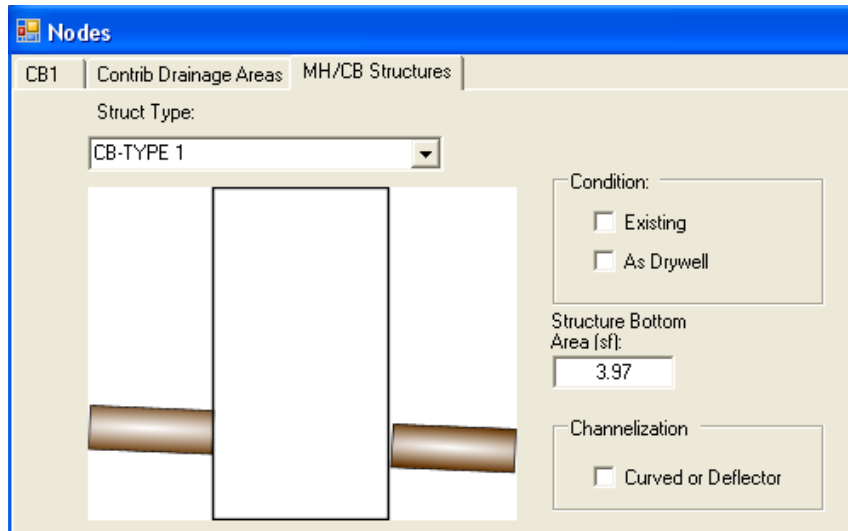
- From the *Struct Type* pulldown menu, select **CB-Type 1**. Notice the Structure Bottom Area (sf) is linked to the Structure Type, in this case it is **3.97**.

- Make sure the *Condition* and *Channelization* boxes are not checked. The *Condition* boxes should only be checked if this is an existing structure or a drywell. The *Channelization* should be selected when the flow line runs along the bottom of the structure without a drop as shown in our example.

    Continue creating nodes using the table on the first page of this tutorial.

12) Directions for the last node (DUMMY) on the table are shown below:
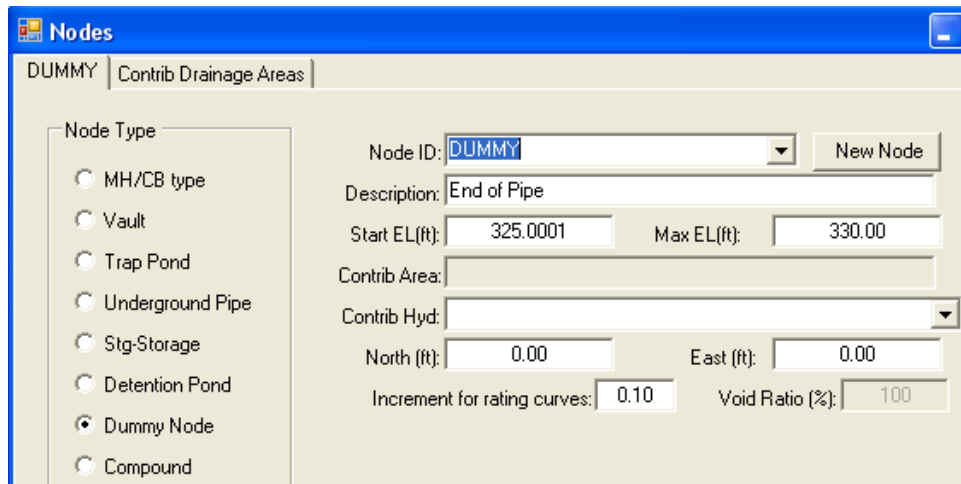
- Select New Node and input **DUMMY**, hit OK.

- For the description, type **End of Pipe**.

- Use the *Start EL(ft)* and *Max EL(ft)* in the table on page 1 of this tutorial, **325** and **330**.

- Select **OK** to accept the Node.

13) **Reach Definition**

   Define the pipes using the Reach Definition from the first page of this tutorial; begin with the minimum allowed pipe diameter (12"). When StormSHED 3G routes flow through the pipe it will determine if a larger pipe is necessary. **Double LMB** click on the **Prototype** Reach in the *Data Tree View* and the following dialog box will open.
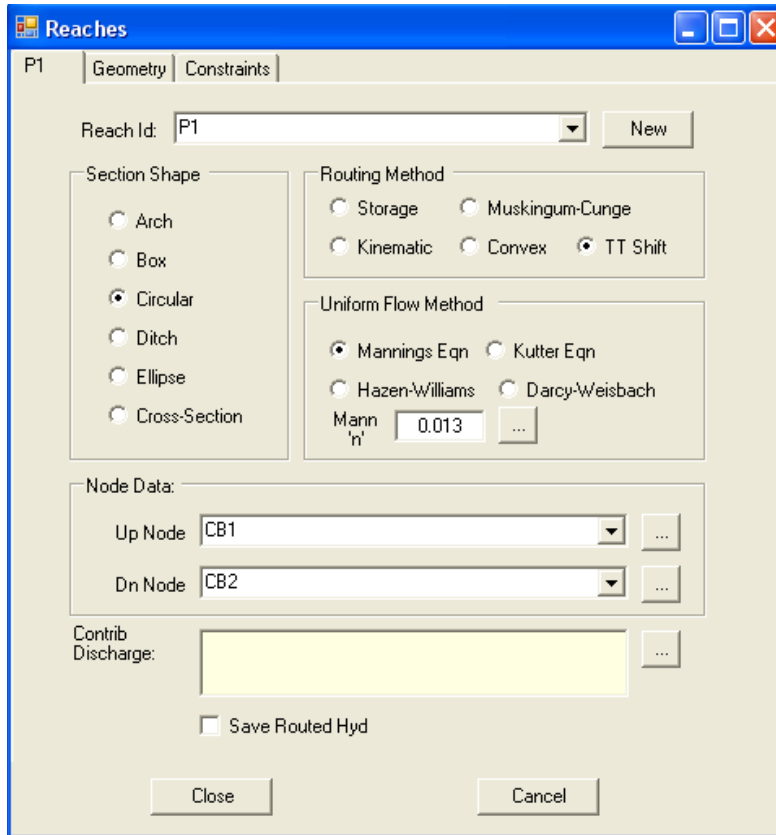
- Select **New** and accept the default of **P1**.

- For the *Section Shape*, select the **Circular** radio button.

- Routing Method, **Travel Time Shift**, most common (uses the Manning's equation) computing the velocity from the top to the bottom of each reach. Muskingum-Cunge would be the only other one we would use for very long pipes.

- *Manning's* is the most commonly used in the US and the one we will be using.

   The *Constraints* tab only applies to underground conduit. Setting these values will do two things: tell the program to a flag a value that falls outside the constraints after computing and when 3G sizes the system it will stay within the constraints. We will show both in more detail later in this tutorial. **Input the values shown in the Constraints tab** below, these are the constraints from the design criteria listed on the 2nd page of this tutorial. Remember if these values are saved in the **PROTOTYPE Reach**, they will be carried over to all reaches created from the PROTOTYPE and will not have to be retyped each time a reach is created.

The besides the design criteria given at the beginning of this tutorial, Constraints affecting up and down inverts, are briefly described below:

- *Min Cover* – Chapter 8 of the Hydraulics Manual requires 2' of cover from the bottom of pavement to the top of the pipe. Determining this value will take some time. Designers will need to determine: the pavement thickness, and wall thickness of the pipe. These values should be added to the 2' depth and that value should be input here. If 2' of depth can not be met, designers should review the shallow cover requirements in Chapter 8 of the Hydraulics Manual.

- *Drop across MH* – this only applies to manholes. The drop refers to the distance between inverts in elevation entering and leaving a node. Checking this option, would do two things: the program would flag a greater elevation that is manually entered after using the compute command or if the program synchronized the inverts or computed diameters/slopes it would use this constraint in the design.

  Exfiltration/Infiltration was explained in the ditch tutorial leave this value at **0** for this example.

  The '*Transition constraints across node*' applies only when 3G is going to calculate the pipe diameters/slopes or the synchronize invert option is used. We will try this later in our tutorial but for now **leave the boxes blank**.

- *Hold Up/Dn IE* – this option will hold the up or down invert elevation when using the synchronize invert option.

- *Match Inverts* – if this box is not checked, the program will align the crowns when the synchronize invert option is used.

- *Allow Smaller Conduits* – when 3G sizes

14) The *Geometry* tab options vary based on what was selected in the *Section Shape* on the first tab. For example, the gray boxes are only available when the ditch or x-section option is selected.
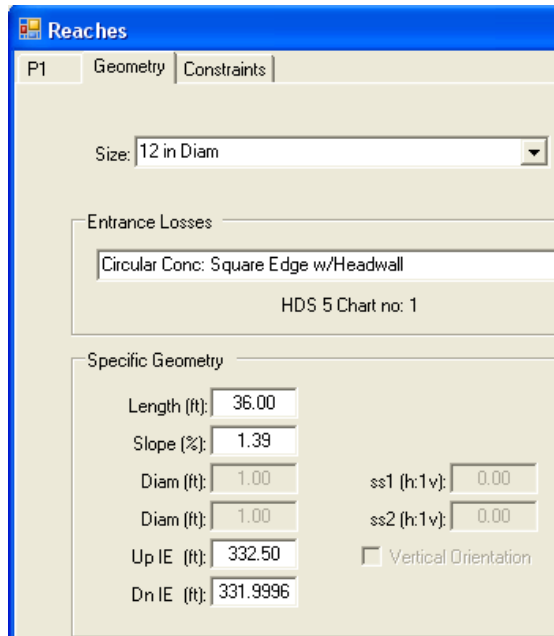
- Use the *Size* pull down menu to select **12 in diam**. This is our first guess for the pipe size, we will find out after running the design storm through the network if this size will work. This method for sizing pipe is considered the trial and error approach, as pipe sizes are modified based on the output. From 3G.

- *Entrance Losses* – the pull-down menu provides a list of different entrance losses that would best describe the shape of the pipe exiting the node. For most nodes, including this example, **Circular Conc: Square Edge w/Headwall** is the best description.

    For Specific Geometry the length, slope and elevation of the pipe will be set.

- For **Length** input **36** ft.

- The **slope** should be **1.39**%, this will have to be set twice because the slope is calculated from the up and down IE or invert elevation.

- Set the **Up IE** at **332.5** ft and the **Dn IE** at **332**. At this point the slope will have to modified again to **1.39**%.

15) Continue to create reaches, using the information provided in the tables on the first page of this tutorial.

16) **Define Reaches and Nodes in Layout View**

    Now we need to show StormSHED the location of each node and reach.

- In the layout view double click on the upper left hand node and the node dialog box will open.

- Using the pull down menu Node ID, select CB1.

- Select Okay to close the dialog box.

- Repeat this process until all the nodes and reaches are defined.
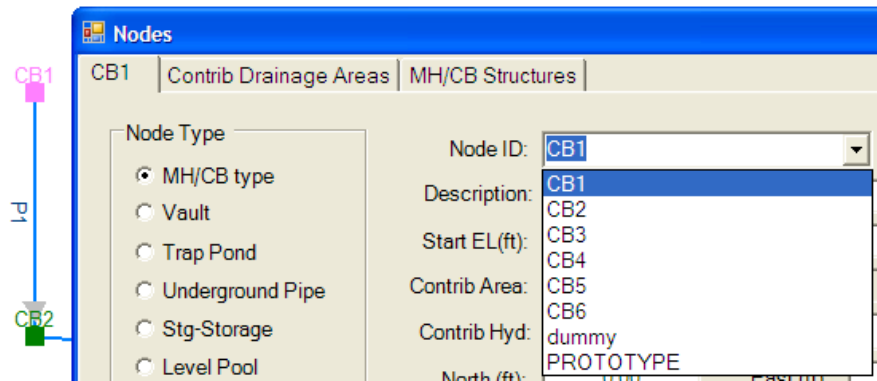
The network should appear as shown below when you are finished.
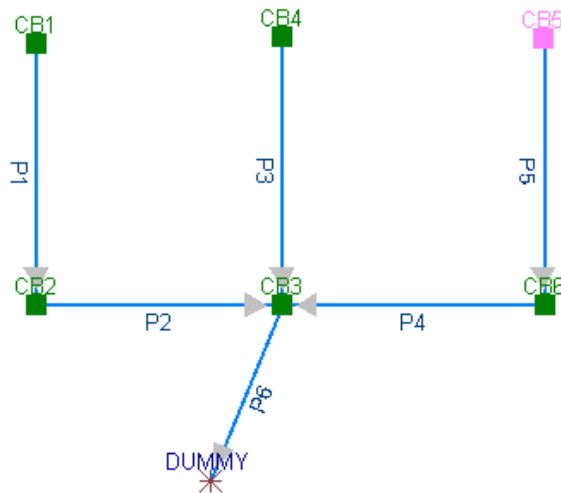
17) Now the network is completely entered and ready for analysis. Using the LMB, select the compute button in the layout toolbar.

The following box should open. This is where we will define the network we are analyzing, as well as the storm that should be used to size the system.

- Select **network** from the pull down menu in the *through:* box.

- The **25 year** Design Event is used to design conveyance systems.

- The *Rainfall Type* for WWA **Type 1A** storm. The *Storm Duration* for WWA it is **24 hour**s.

- For this example, only the **Automatic HGL** should be checked.

- Select the **Route** button and then **Close**.
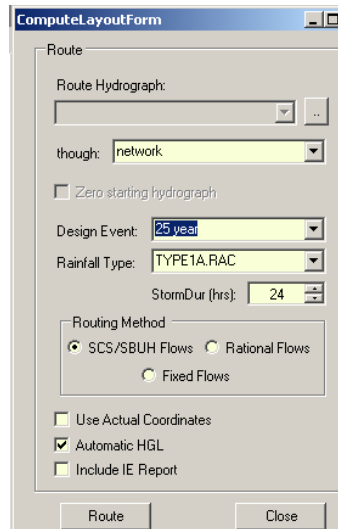
18) First look at the *Layout View* for any red numbers or brackets. This would indicate the design is outside of the constraints.

19) Next select the *History View tab*. Go through the data and make sure all the design criteria parameters are met. Also, the outlet velocity should be compared to the velocities in **section 3-4.7 of the Hydraulics Manual** to determine if an energy dissipater is needed for outlet protection. In this case the outlet velocity from P6 (16.38 ft/sec) is high enough to warrant heavy loose riprap or a concrete splash pad for outlet protection. Designers to review section 3-4.7 of the Hydraulics Manual for the design criteria of Energy Dissipaters.

Outlet Velocity (ft/sec)	**Material**
6-10	Quarry Spalls
10-15	Light Loose Riprap
>15	**Heavy Loose Riprap**

Designers should provide geotextile or filter material between any outlet material and the existing ground for soil stabilization, see section 4-6.3.2 for information..

Outlet Protection Material Size
Figure 3-4.7.1

20) **Creating a Report**

Remember only the last record sent to the *History View* is retained, so once the final compute has been run copy the output and paste it into a word processing program. The history view should appear as shown below.

Appended on: Sunday, May 7, 2017 5:25:40 PM

ROUTEHYD [] THRU [network] USING [25 year] AND [TYPE1A.RAC] NOTZERO RELATIVE SCS/SBUH

Gravity Analysis using 24 hr duration storm

Reach ID	Area (ac)	Flow (cfs)	Full Q (cfs)	Full ratio	nDepth (ft)	Depth ratio	Size	nVel (ft/s)	fVel (ft/s)	Infil Vol (cf)	CBasin / Hyd
P5	0.344	0.3156	3.2546	0.097	0.2104	0.2104	12 in Diam	2.6254	4.1439	0.00	B1
P4	0.688	0.6313	4.3898	0.1438	0.2557	0.2557	12 in Diam	3.982	5.5893	0.00	B1
P3	0.344	0.3157	4.2118	0.0749	0.185	0.185	12 in Diam	3.1558	5.3626	0.00	B2
P1	0.344	0.3156	4.2118	0.0749	0.185	0.185	12 in Diam	3.1557	5.3626	0.00	B1
P2	0.688	0.6313	2.9241	0.2159	0.3157	0.3157	12 in Diam	2.9682	3.7231	0.00	B1
P6	2.064	1.8939	20.6242	0.0918	0.2047	0.2047	12 in Diam	16.3808	26.2595	0.00	B2

HGL Analysis

From Node	To Node	HG El (ft)	App (ft)	Bend (ft)	Junct Loss (ft)	Adjusted HG El (ft)	Max El (ft)
							325.5868
CB3	Dummy	330.7198	------	0.2998	0.1738	331.1934	336.0000
CB6	CB3	334.9499	------	0.1349	------	335.0848	338.5000
CB5	CB6	335.2278	------	------	------	335.2278	338.5000
CB4	CB3	331.1996	------	------	------	331.1996	336.0000
CB2	CB3	332.4541	------	0.2089	------	332.6630	337.0000
CB1	CB2	332.8077	------	------	------	332.8077	337.0000

Conduit Notes

Reach	HW Depth (ft)	HW/D ratio	Q (cfs)	TW Depth (ft)	Dc (ft)	Dn (ft)	Comment
P6	0.7198	0.7198	1.89	0.5868	0.5868	0.2047	SuperCrit flow, Inlet end controls
P4	0.4499	0.4499	0.63	1.1934	0.3308	0.2557	SuperCrit flow, Inlet end controls
P5	0.4278	0.4278	0.32	0.5848	0.2315	0.2104	Outlet Control M1

						Backwater
P3	1.2000	1.2000	0.32	1.1934	0.2315	0.1850	Outlet Control
P2	0.4541	0.4541	0.63	1.1935	0.3308	0.3157	SuperCrit flow, Inlet end controls
P1	0.3077	0.3077	0.32	0.6630	0.2315	0.1850	SuperCrit flow, Inlet end controls

Licensed to: WS DOT

21) To make your hydraulic report complete, you will also need to include the basin, reach and node information and a picture of the layout. This information will need to be sent to the *History View* and copied into a word processing document.
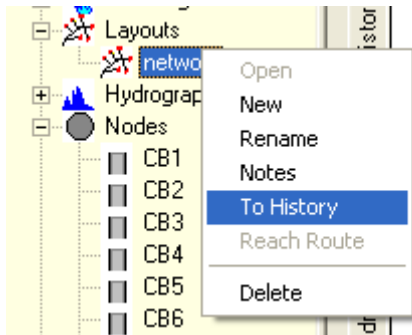
- In the *Data Tree View* click on the name of the layout (**network**) with the LMB.

- Select **To History** and all the records in that layout will be sent to the History View.

Appended on: Sunday, May 7, 2017 5:26:38 PM
Layout Report: network

Event	Precip (in)
other	2.10
2 yr 24 hr	2.50
10 year	3.00
5 year	3.50
25 year	4.00
100 year	4.50

Reach Records

Record Id: P1

Section Shape:	Circular		
Uniform Flow Method:	Manning's	Coefficient:	0.013
Routing Method:	Travel Time Shift	Contributing Hyd	

DnNode	CB2	UpNode	CB1
Material	unspecified	Size	12 in Diam
Ent Losses	Square Edge w/Headwall		
Length	36.00 ft	Slope	1.39%
Up Invert	332.50 ft	Dn Invert	332.00 ft

Conduit Constraints				
Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
3.00 ft/s	10.00 ft/s	0.50%	5.00%	2.50 ft

Drop across MH	0.00 ft	Ex/Infil Rate	0.00 in/hr

Record Id: P2

Section Shape:	Circular		
Uniform Flow Method:	Manning's	Coefficient:	0.013
Routing Method:	Travel Time Shift	Contributing Hyd	
DnNode	CB3	UpNode	CB2
Material	unspecified	Size	12 in Diam
Ent Losses	Square Edge w/Headwall		
Length	298.00 ft	Slope	0.67%
Up Invert	332.00 ft	Dn Invert	329.9999 ft

Conduit Constraints				
Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
3.00 ft/s	10.00 ft/s	0.50%	5.00%	2.50 ft

Drop across MH	0.00 ft	Ex/Infil Rate	0.00 in/hr

Record Id: P3

Section Shape:	Circular		
Uniform Flow Method:	Manning's	Coefficient:	0.013
Routing Method:	Travel Time Shift	Contributing Hyd	
DnNode	CB3	UpNode	CB4
Material	unspecified	Size	12 in Diam
Ent Losses	Square Edge w/Headwall		
Length	36.00 ft	Slope	1.39%
Up Invert	330.50 ft	Dn Invert	330.00 ft

Conduit Constraints				

Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
3.00 ft/s	10.00 ft/s	0.50%	5.00%	2.50 ft

Drop across MH		0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: P4

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.013
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	CB3	**UpNode**	CB6
Material	unspecified	**Size**	12 in Diam
Ent Losses	Square Edge w/Headwall		
Length	298.00 ft	**Slope**	1.51%
Up Invert	334.50 ft	**Dn Invert**	330.00 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
3.00 ft/s	10.00 ft/s	0.50%	5.00%	2.50 ft

Drop across MH		0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: P5

Section Shape:	Circular		
Uniform Flow Method:	Manning's	**Coefficient:**	0.013
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	CB6	**UpNode**	CB5
Material	unspecified	**Size**	12 in Diam
Ent Losses	Square Edge w/Headwall		
Length	36.00 ft	**Slope**	0.83%
Up Invert	334.80 ft	**Dn Invert**	334.50 ft

Conduit Constraints				
Min Vel	**Max Vel**	**Min Slope**	**Max Slope**	**Min Cover**
3.00 ft/s	10.00 ft/s	0.50%	5.00%	2.50 ft

Drop across MH		0.00 ft	**Ex/Infil Rate**	0.00 in/hr

Record Id: P6

Section Shape:	Circular	

Uniform Flow Method:		Manning's	Coefficient:	0.013
Routing Method:		Travel Time Shift	Contributing Hyd	
DnNode		Dummy	UpNode	CB3
Material		unspecified	Size	12 in Diam
Ent Losses		Square Edge w/Headwall		
Length		15.00 ft	Slope	33.33%
Up Invert		330.00 ft	Dn Invert	325.00 ft

Conduit Constraints				
Min Vel	Max Vel	Min Slope	Max Slope	Min Cover
3.00 ft/s	10.00 ft/s	0.50%	5.00%	2.50 ft

Drop across MH		0.00 ft	Ex/Infil Rate	0.00 in/hr

Node Records

Record Id: CB1

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	332.50 ft	Max El.	337.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: CB2

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	332.00 ft	Max El.	337.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: CB3

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	330.00 ft	Max El.	336.00 ft

Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: CB4

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	330.50 ft	Max El.	336.00 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: CB5

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	334.80 ft	Max El.	338.50 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: CB6

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	334.50 ft	Max El.	338.50 ft
Void Ratio	100.00		
Condition	Existing	Structure Type	CB-TYPE 1
		Channelization	No Special Shape
Catch	0.00 ft	Bottom Area	3.97 sf
MH/CB Type Node			

Record Id: Dummy

Descrip:	DUMMY	Increment	0.10 ft
Start El.	325.00 ft	Max El.	330.00 ft
Void Ratio	100.00		
Dummy Type Node			

Contributing Drainage Areas

Record Id: B1

Design Method	SCS	Rainfall type	TYPE1A.RAC
Hyd Intv	10.00 min	Peaking Factor	484.00
Storm Duration	24.00 hrs	Abstraction Coeff	0.20
Pervious Area	0.00 ac	DCIA	0.344 ac
Pervious CN	0.00	DC CN	98.00
Pervious TC	0.00 min	DC TC	5.2975 min

DCI - CN Calc		
Description	SubArea	Sub cn
cb area	0.344 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	Description	Length	Slope	Coeff	Misc	TT
Sheet	Smooth Surfaces.	20.00 ft	2.0%	0.011	0.00 in	0.3783 min
Shallow	Paved	600.00 ft	1.0%	0.01		4.9193 min
Pervious TC						5.2975 min

Record Id: B2

Design Method	SCS	Rainfall type	TYPE1A.RAC
Hyd Intv	10.00 min	Peaking Factor	484.00
Storm Duration	24.00 hrs	Abstraction Coeff	0.20
Pervious Area	0.00 ac	DCIA	0.344 ac
Pervious CN	0.00	DC CN	98.00
Pervious TC	0.00 min	DC TC	5.00 min

DCI - CN Calc		
Description	SubArea	Sub cn

cb area	0.344 ac	98.00
DC Composited CN (AMC 2)		98.00

| DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet	Smooth Surfaces.	20.00 ft	2.0%	0.011	0.00 in	0.3783 min
Shallow	Paved	300.00 ft	1.0%	0.01		2.4596 min
Pervious TC						2.8379 min

Licensed to: WS DOT

22) Print Layout

Last we will print a copy of the layout we created.

- First use the '*Toggle Node Label*' and '*Toggle Reach Label*' buttons until the node and reach names are shown on the next page.

- Then click on the '*Select Area for Clipboard*' radio button.

- LMB click in the upper left portion of the layout and drag a window around the layout. Release the LMB to accept the 2nd point.

- Open the word processing program you are using and use the ***'Paste'* (or Ctrl V)** command to insert the layout. It should appear as shown in the following figure.
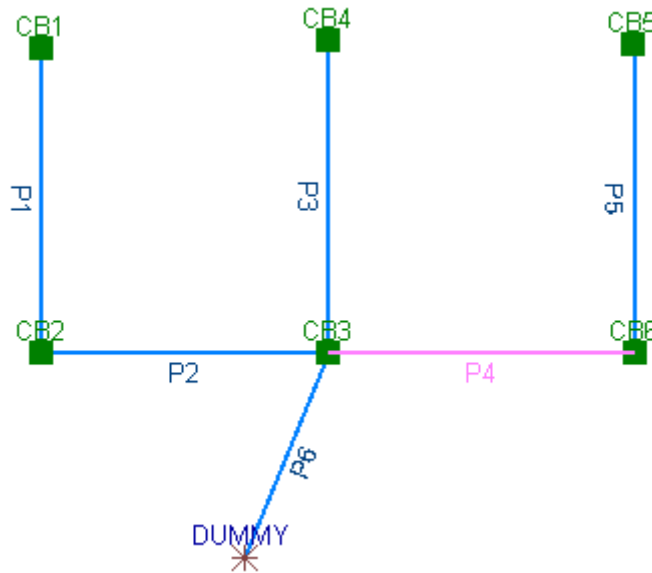
23) Other Options for Pipe Sizing

There are 2 other options for sizing pipe; the first involves using the Calculator located at:

<u>Misc>Calculator</u>

When the calculator shown below opens, select the ***Pipe Calc*** tab.

- Leave the *Select Reach* box empty (or a reach that has already been created can be selected from the pull down menu).

- Input the values shown in the diameter, Manning's n, Slope, and Flow (use the flow from the basin compute option with the 25 year) boxes shown below. The gray boxes are automatically calculated based on the values input. Review the data to determine what pipe size is required, for this example a 12 in diameter pipe will work.
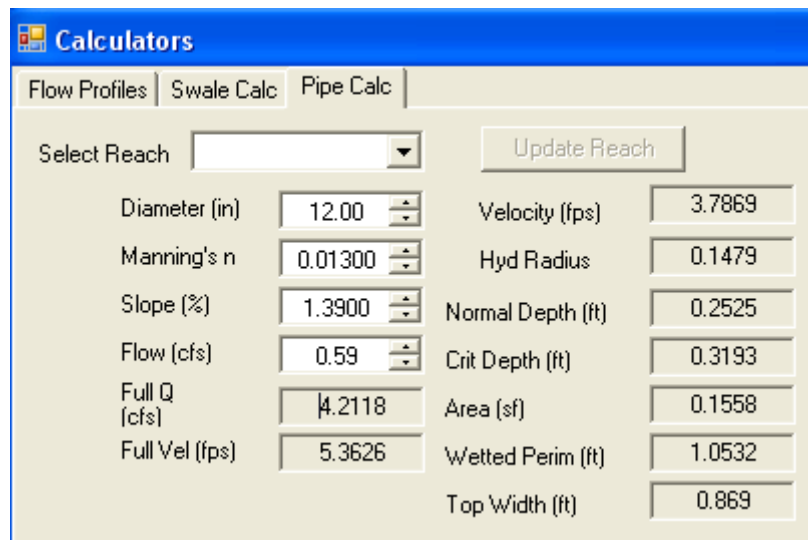
24) Zero Slopes/Diameters

Another option is to allow 3G to compute the diameters and slopes.

- After the network is complete, select the '*Zero Slopes/Diams*' button. This will set all the reach diameters and slopes to zero. (If you are planning to have 3G set the diameters and slopes, set them to zero when creating the reaches).

- Select 'Clear Slopes' and 'Clear Diameters' by LMB clicking in the boxes.

- Highlight the Reaches shown by holding down and dragging the LMB over the reaches.

- Hit the **Clear** button and the box will automatically close.
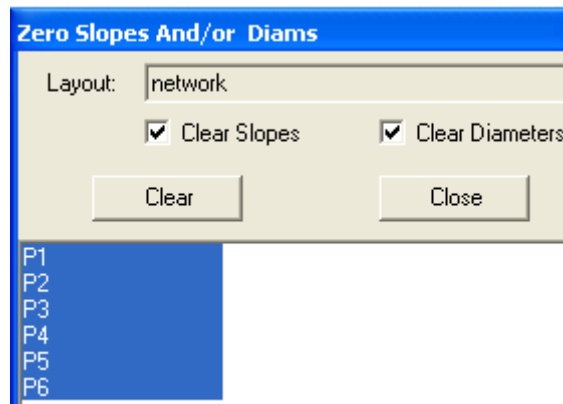
- Open reach P6 and go to the *Constraints* tab. Check the *Hold Dn IE* box. This will hold the elevation for the pipe outlet that we set earlier.
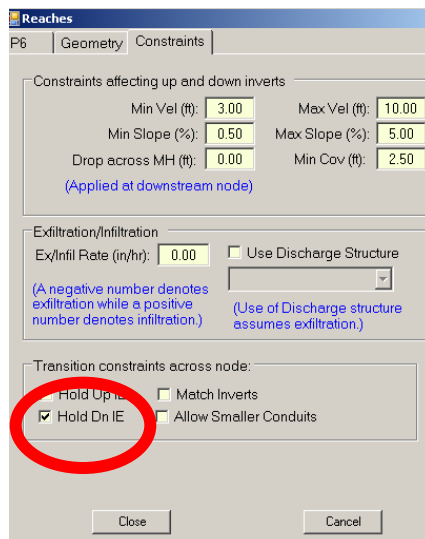
- In the *Layout View*, select the **Compute** button. Select the **Route** button to size the pipes and slopes. **Toggle** through the Reach labels to see what the new diameters and slopes.