Chapter 5

Advanced Storm Sewer Placement

5.1 Objectives

Create and place stormwater inlets and associated drainage areas in GEOPAK Drainage using advanced placement options
Use existing GEOPAK Road data in drainage design
Create a reach and view the storm sewer profile

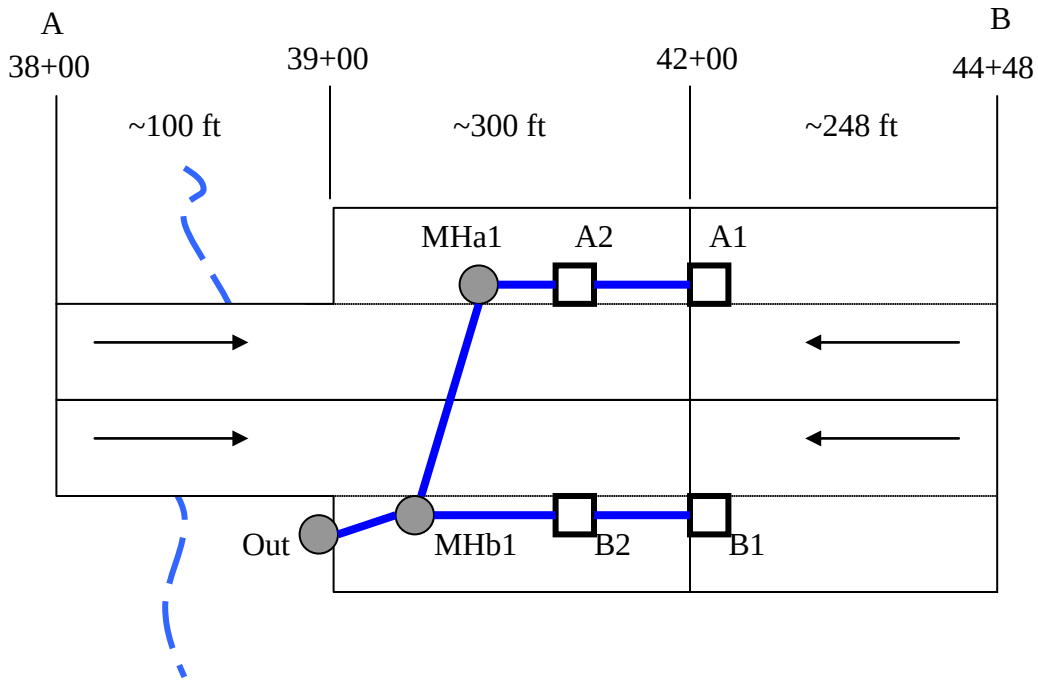
We will be introducing a few new tools and options in this exercise including the Navigator feature in Drainage.

5.2 Overview

GEOPAK Drainage allows the use of existing GEOPAK Road data in the design of drainage systems. Information such as topography, stationing and roadway cross-sections can be incorporated into GEOPAK Drainage, greatly simplifying the manual input of data.

Using existing GEOPAK Road data, we will construct a drainage system as shown below.

Simplified Plan View

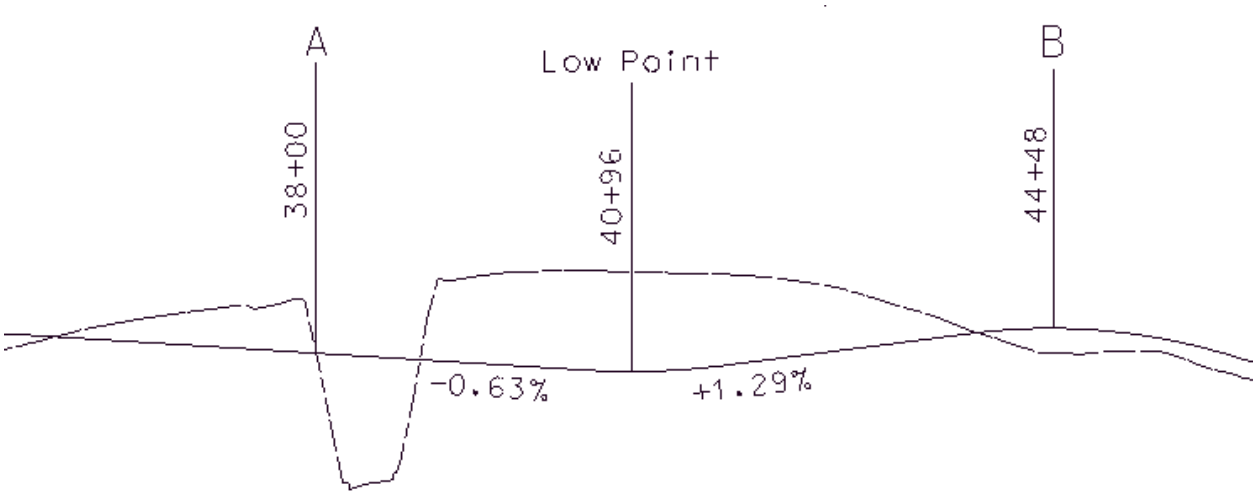


There is a 40 ft wide bridge structure from Sta 38+00 to Sta 39+00 that we will collect runoff from. From Sta 39+00 to Sta 44+48 we will be collecting runoff from centerline out to a distance of 75 feet.

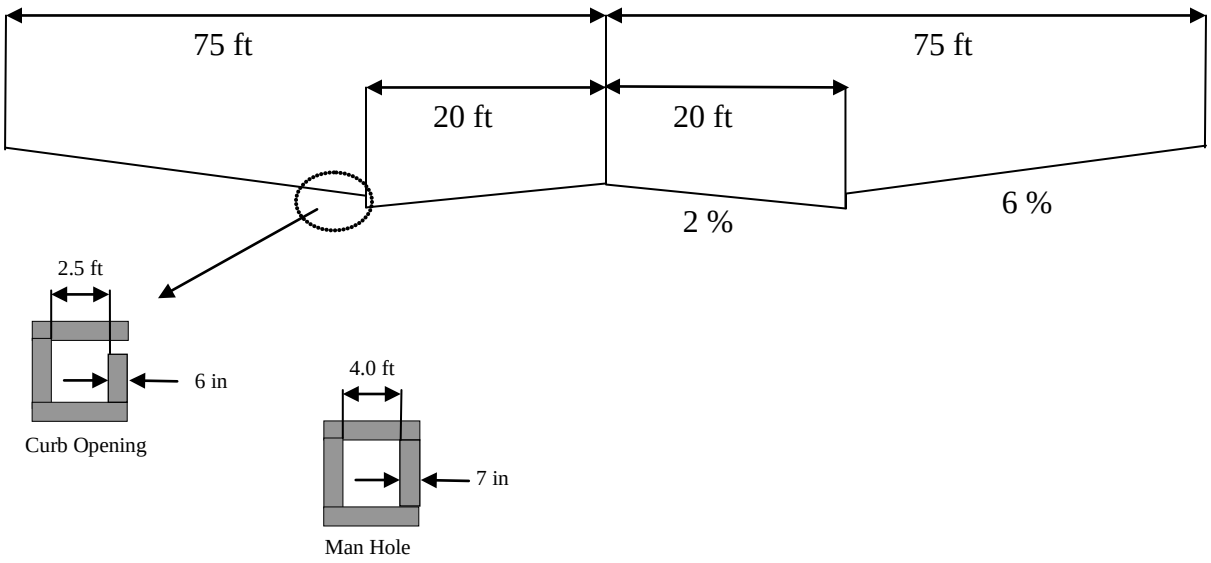
We will design for a **10-year** storm in **District 5**.

Additional geometry that we will use for constructing our system is shown below:

Profile View



Typical Section



5.3 Set Project Preferences

For this exercise we will be working with the Cole\J5EX502 project.

The first few steps will involve creating the files we will be using to construct our drainage system and setting up the project preferences.

1. Using ProjectWise, open the plan_J5EX502.dgn file from the project's data folder

2. Using the MicroStation File menu, choose the Save As option and save as a new file named drainage_J5EX502.dgn

- You can use the No Wizard option when that dialog pops up, and make sure you save your new file to the data directory of the project (it should default to the correct location)
- Make sure to Check-In the plan_J5EX502.dgn file when prompted

A file has already been set up that outlines the land uses for our project area. We simply need to make this file available to us by referencing it into our drainage plan.

3. Access the References dialog box and attach the landuse_J5EX502.dgn file (located in the project data directory) using the Coincident-World orientation

4. In order for Drainage to recognize the land use assignments the geometry must be in the active design file, so using the Merge to Master function merge the landuse_J5EX502.dgn file into the active file and then close the References dialog

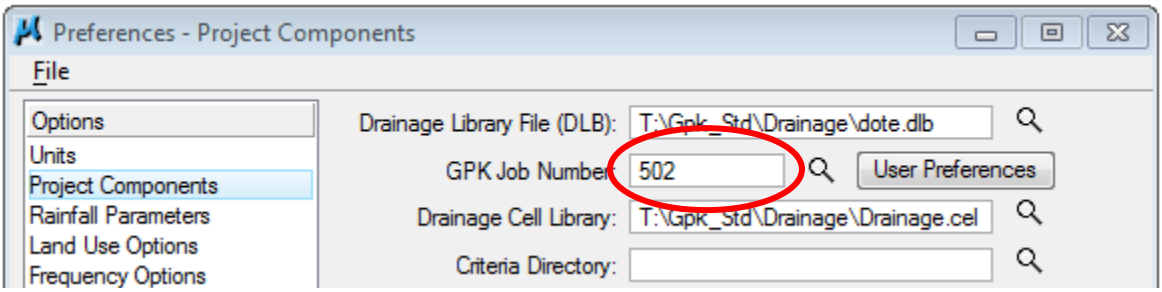
Now we need to set up our drainage preferences for the project.

5. Follow the instructions in Chapter 1 outlined on page 5 for Beginning a New Drainage Project

When you reach step 6 in the instructions name your drainage project **drainage_J5EX502.gdf**

6. Once your project is saved then open the Preferences dialog box again so we can make some changes necessary to fit our project

7. Select the Project Components Option. Associate job502.gpk with this drainage project. The gpk file is located at T:\de-proj\Cole\J5EX502\data.



Also make sure your working directory is set to **\J5EX502\data** in the correct ProjectWise location under the User Preferences

8. Select the Rainfall Parameters Option and choose District 5

9. Make sure the Frequency Option is set to 10 years

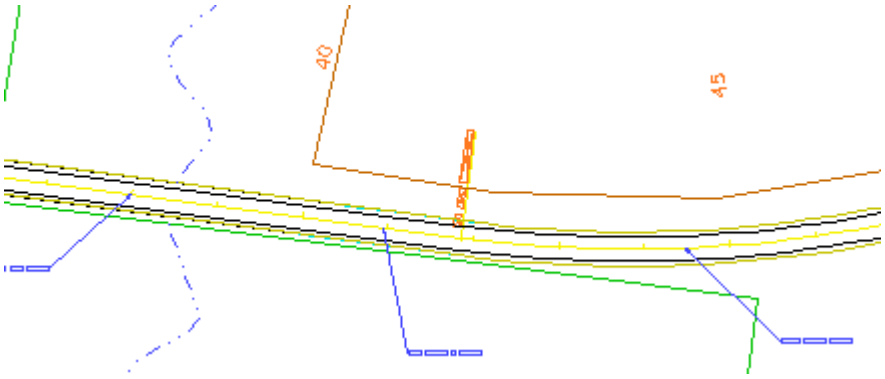
10. Select the Node Option and change the prefix from " CB – " to " A - "

11. Click OK on the Preference dialog and choose Yes when prompted to store changes

12. Under the Drainage Project menu options, choose the Save option

This will store the changes we made to our project GDF file

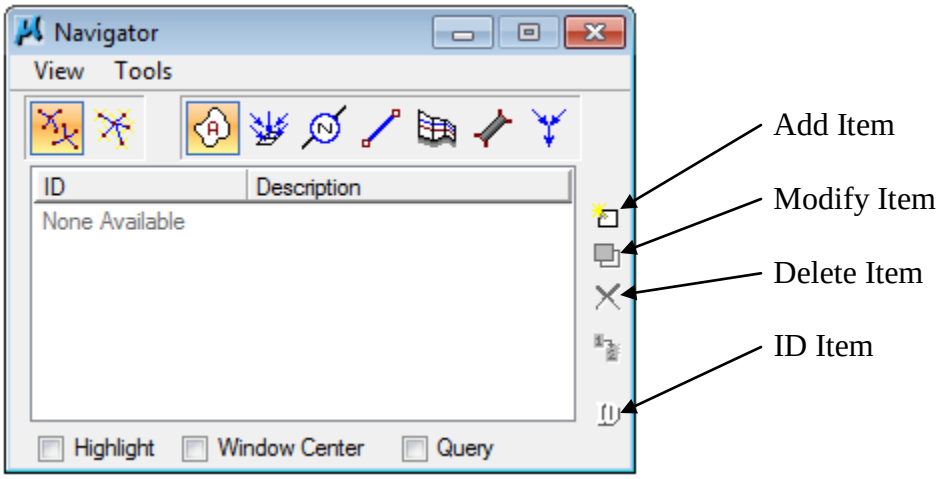
13. Zoom in on area between station 38+00 and station 45+00



5.4 Inlet Placement using Navigator

One of the methods for adding components to a project is with Drainge's Navigator. We will be working with the basic operation of the Navigator throughout the rest of this exercise.

1. **Access the Navigator by going to Utilities >Navigator**



 Displays components for all networks in the Drainage file

 Displays components for only the active network

 Displays the drainage areas

 Displays the inlets

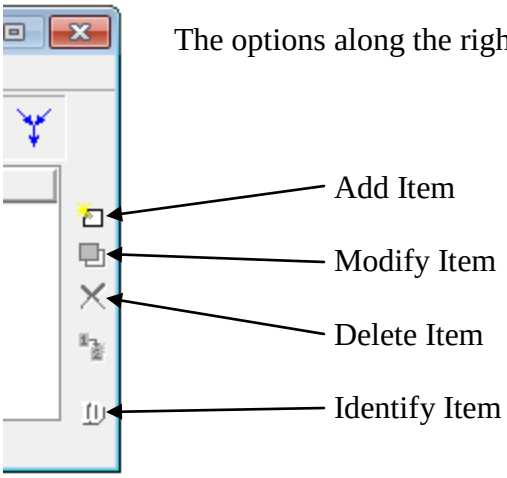
 Diplays the nodes (inlets will also be included)

 Displays the links (pipes or ditches)

 Displays the profiles (reaches)

 Displays the culverts (not covered in this class)

 Displays system routing (not covered in this class)



The options along the right side of the Navigator dialog allow you to:

2. Select the Inlet icon from Navigator and choose the Add Item icon on the right.

3. The inlet should automatically be assigned the name A-1 since we set that up in the Preferences, so click OK to begin assigning the properties of the inlet.

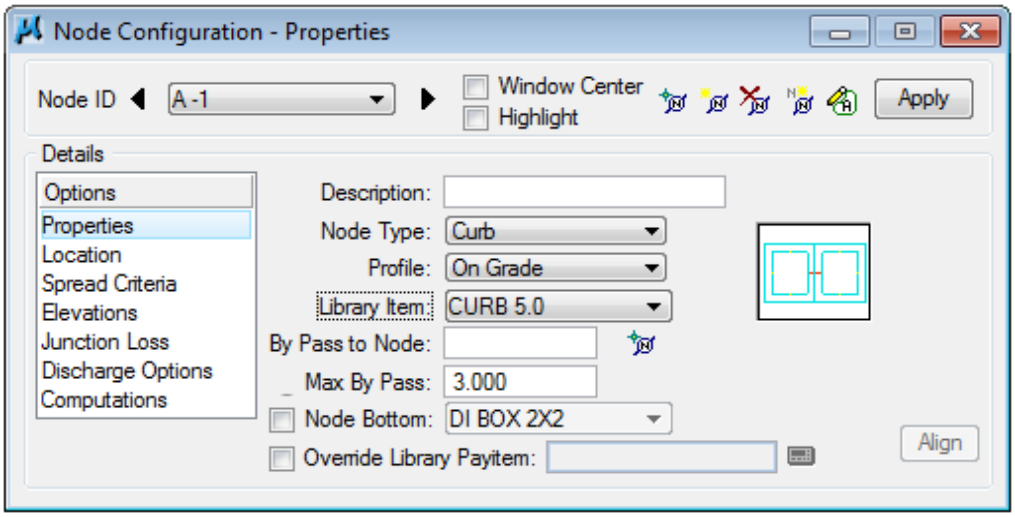
4. Now use the information provided for each option to construct the A-1 inlet.

Instruction 4 involves using the data and screenshots contained on the following 5 pages.

Properties

Node Type: **Curb**
Profile: **On Grade**
Library Item: **CURB 5**

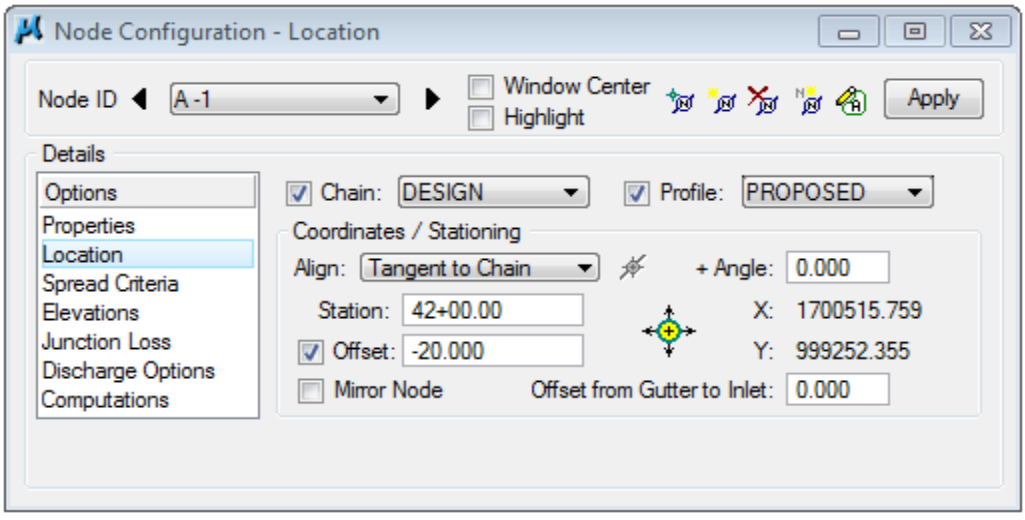
Click Apply in the upper right corner



Location

Reference Chain: **DESIGN**
Profile: **PROPOSED**
Align: Tangent to Chain
Station: **42+00**
Offset: **–20 ft**

Click **Apply**



Spread Criteria

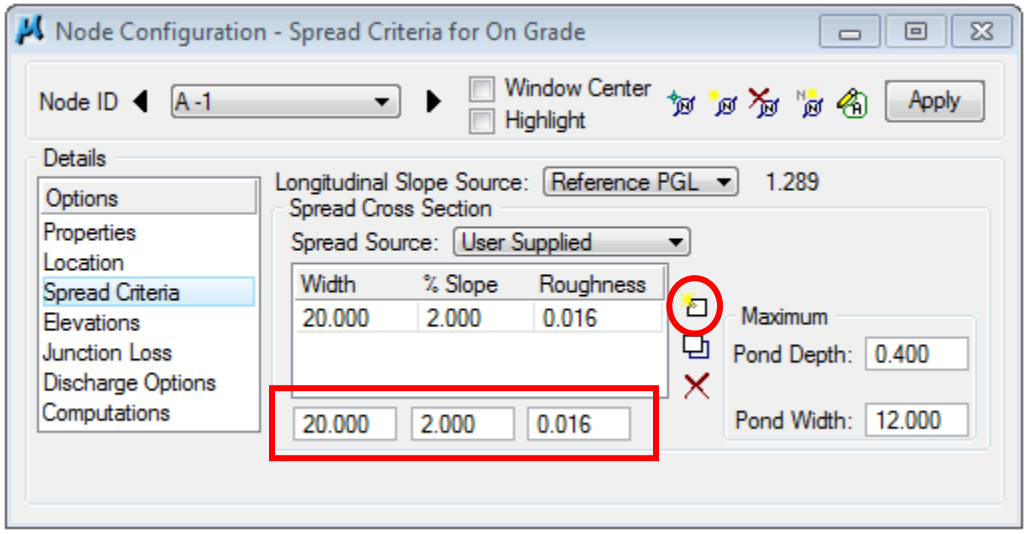
Longitudinal slope: **Reference PGL**

Enter the provided spread section data in the input fields highlighted below and then click the add item icon along the right side.
Width = **20**
Slope = **2%**
Manning's n = **0.016**

Maximum Ponded Depth: **0.4**
For inlets at grade this does not enter into the hydraulic computations. It is merely used for querying the system. The depth is measured at the inside of the curb face. For a 6" curb a maximum allowed depth is 0.4 ft.

Maximum Ponded Width (spread): **12**
This value does not enter into the hydraulic equations. It is merely used for querying the system and generating a warning if the value is exceeded.
Section 640.1.2.2 of the EPG covers Gutter Spread. The allowable spread is based on the functional classification of the roadway. The maximum allowed under any circumstances is 12 ft and so we will use that for our situation.

Click **Apply**



Elevations

Choose a TIN File by selecting the magnifying glass icon and selecting **J5EX502.tin** from the file listing in our data directory.

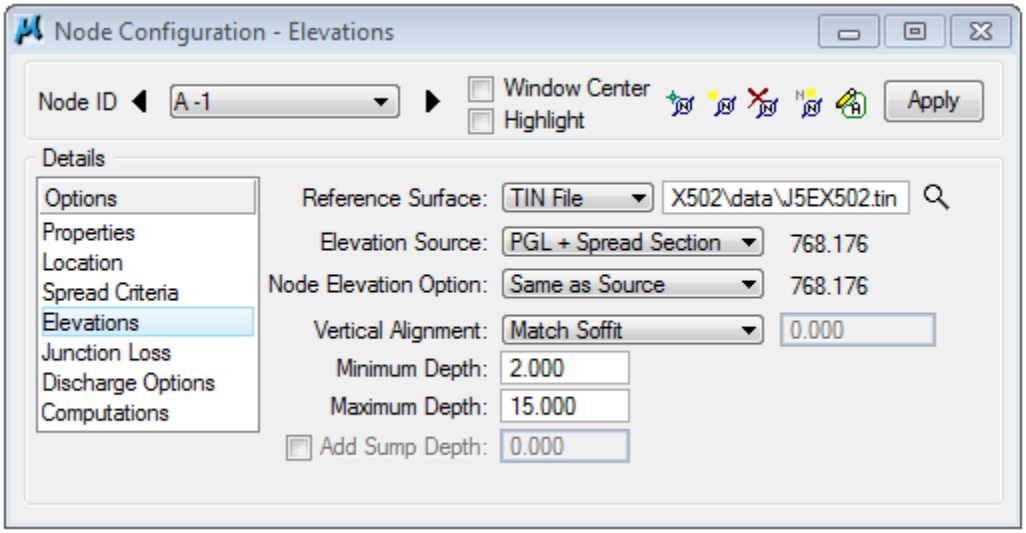
Elevation Source: **PGL+Spread Section**
The program will use the PGL elevation at the specified station in conjunction with the spread section to compute the elevation at the inlet.

Node Elevation Option: **Same as Source**
One of the options is to select constant offset. A possible application would be if a profile were defined along the top of curb. The elevation could be offset a distance of the curb height to achieve the inlet elevation.

Vertical Alignment Preference: **Match Soffit**
Another option that could be utilized is select match surface. Match surface will align the pipes based on the flow line.

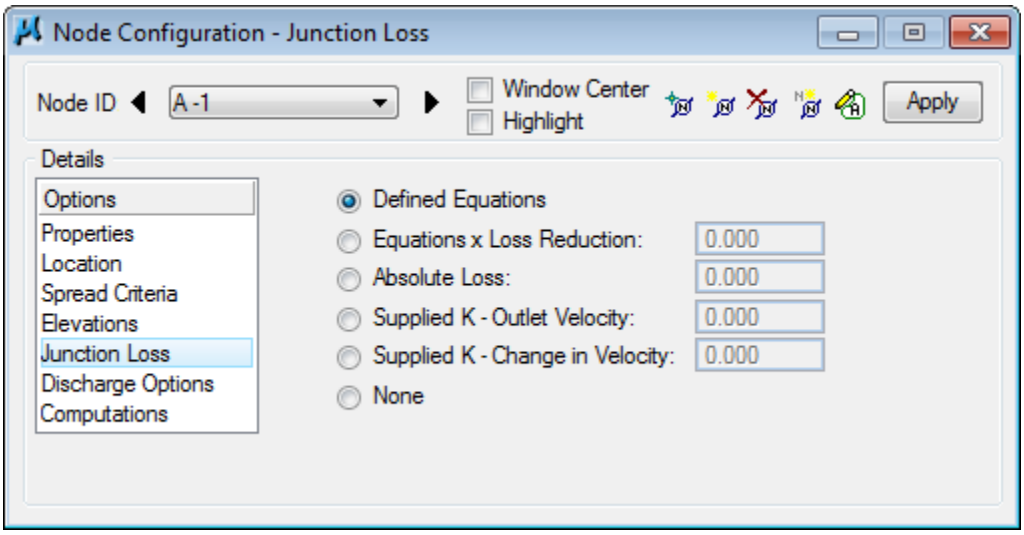
Minimum depth: **2.0**
Maximum depth: **15.0**
This will set the "design envelope" for your pipes.

Click **Apply**



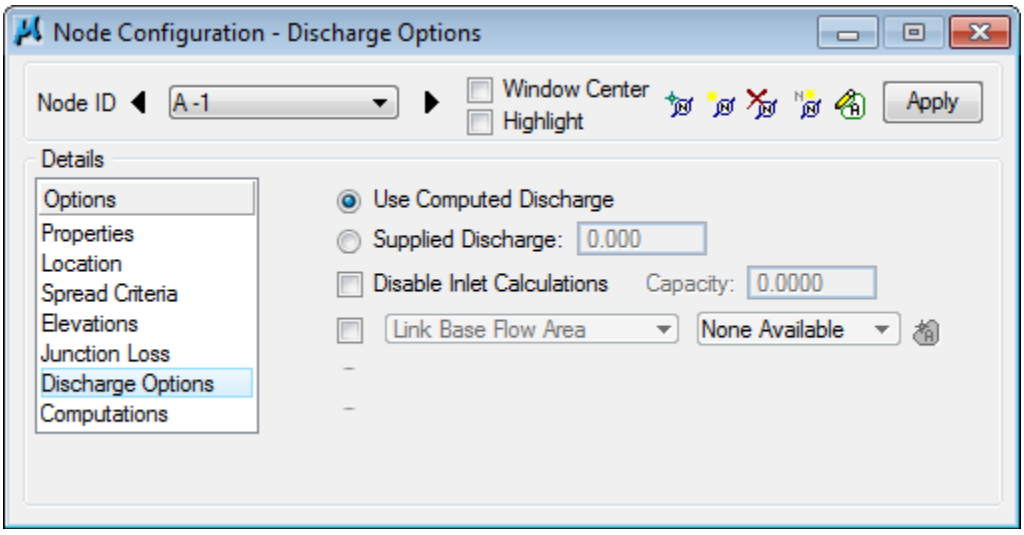
Junction Loss

Select Defined Equations



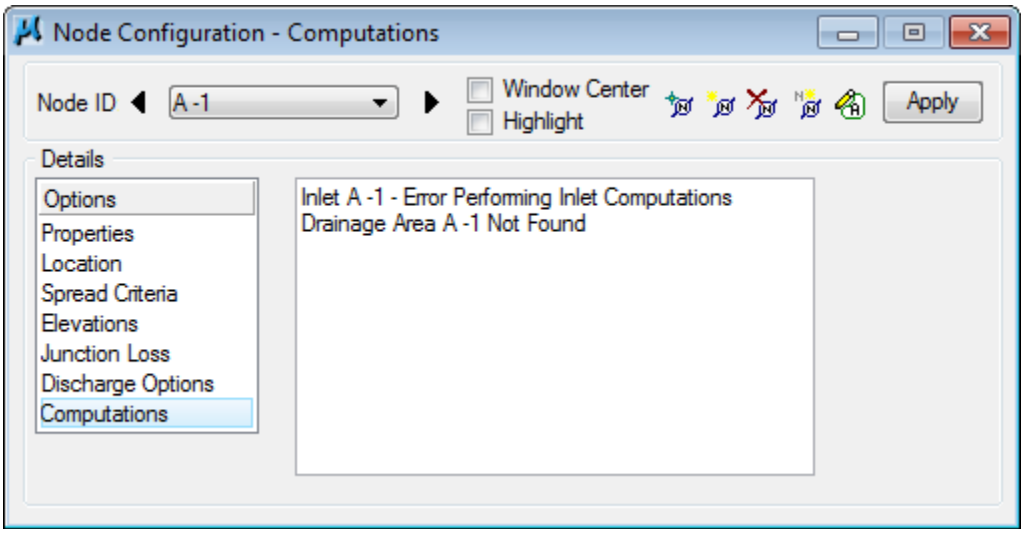
Discharge Options

Select Use Computed Discharge

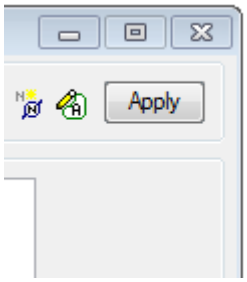


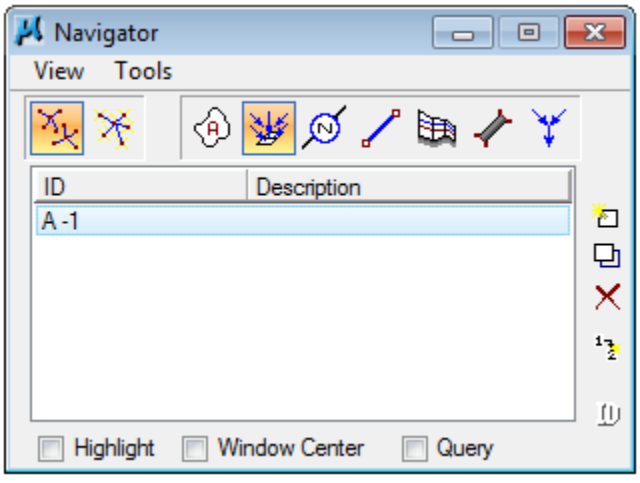
Computations

The computations window will be empty until drainage area A -1 has been added or a discharge has been supplied.



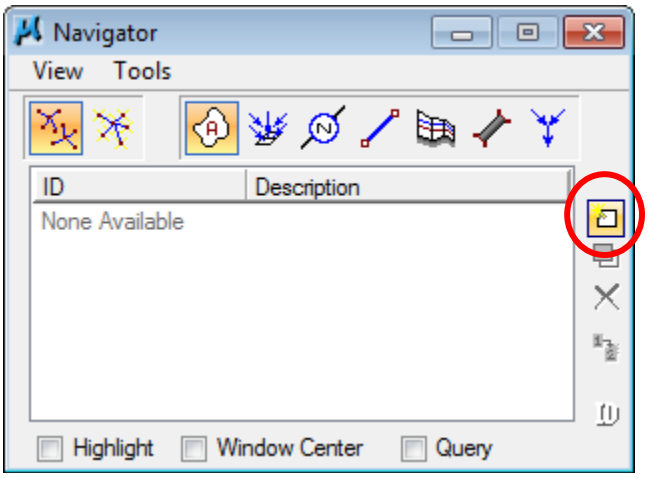
5. Finally click the Apply button to save the inlet to the drainage project. Note that after the inlet has been added it is now contained in the navigator.



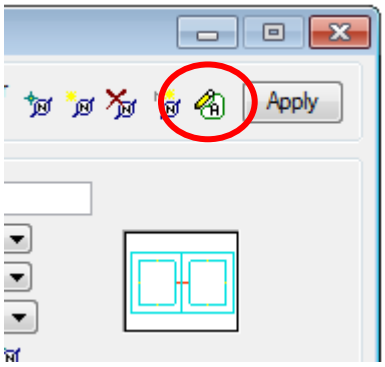


5.5 Area Placement

The area corresponding to inlet A-1 can be placed in several different ways. The first method is accomplished in a similar fashion as inlet A-1 was placed using the Navigator. The second method utilizes the **Edit Area** button within the Node Configuration dialog located in the upper right hand corner.



OR

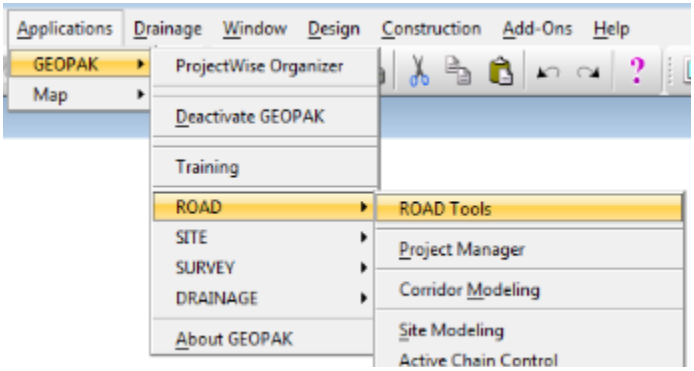


1. Select either of the options above to begin constructing the area

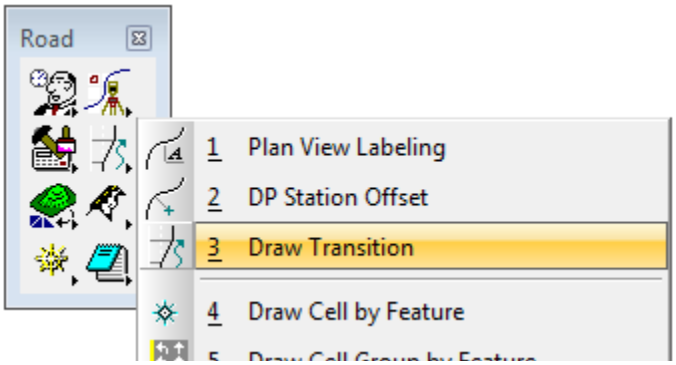
2. Assign the name for your area as A-1 and click OK

Now we need to draw the shape that we will use to establish our physical area boundary. This shape will extend from inlet A-1 to the high point and should have a width of 75 ft measured from the centerline. Utilizing GEOPAK Road tools like **Draw Transition** provides an efficient method of creating the desired shape.

Select the **ROAD Tools** option under GEOPAK >ROAD in the Applications Pull down menu

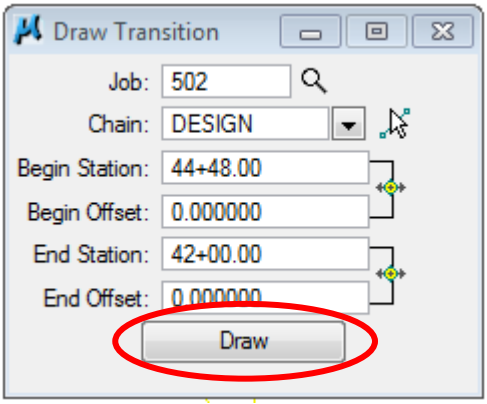


Select the Draw Transition tool from the Plans Preparation set of tools



Key in the job number **502** and select the **DESIGN** chain
Begin Station: **44+48.00**
The high point is located at 44+48.
End Station: **42+00.00**
The inlet at A –1 is located approximately at 42+00.
Begin & End Offset: **0.0000**
For the first line, we want to trace over the top of the centerline from these two locations, so keying in an offset of 0 will ensure this first line will fall directly on top of the existing centerline.

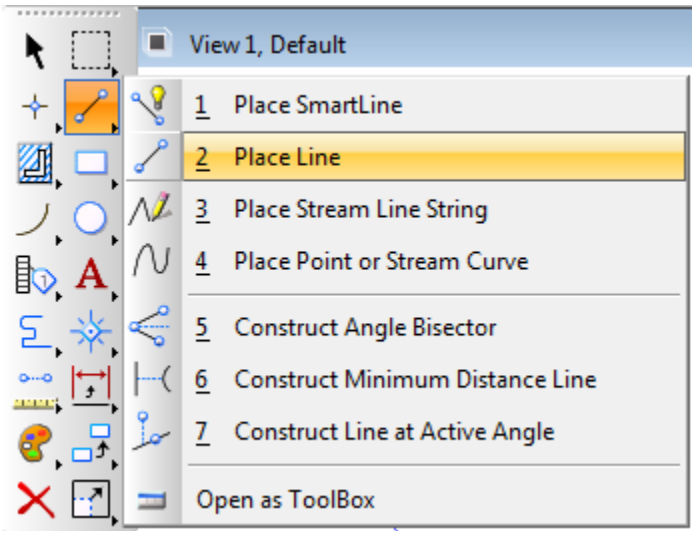
Click the **Draw** button



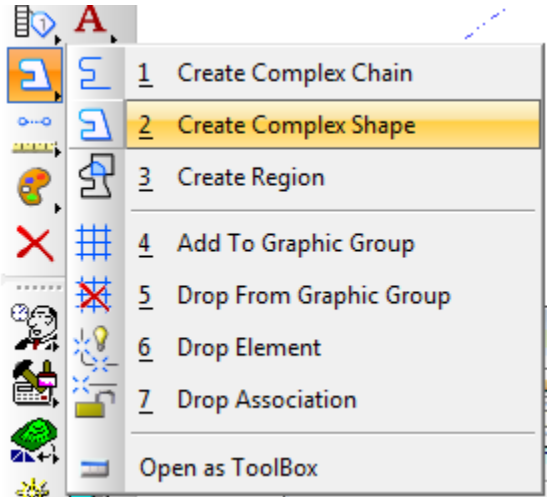
Now we will place the outer boundary of our shape.

With the Draw Transition tool, use the same settings except make the Beginning and Ending Offsets **-75** and click **Draw**

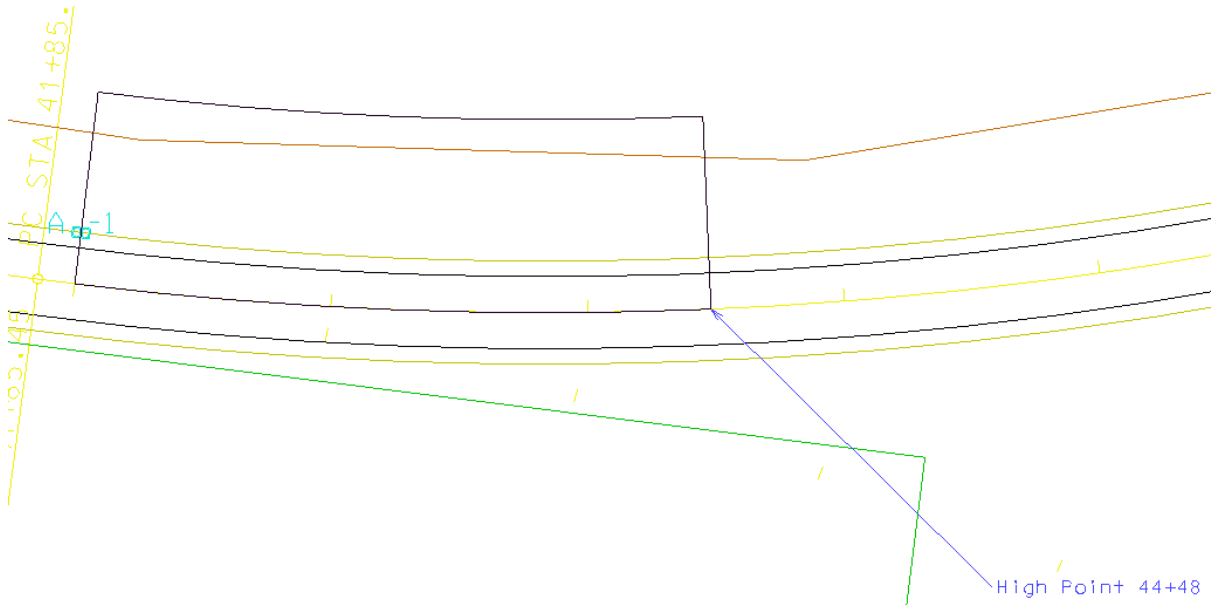
Now using the Place line tool, snap to connect the endpoints of the two chains created in the above steps.



Use the Create Complex Shape tool and select each of the lines and chains that will make up this area



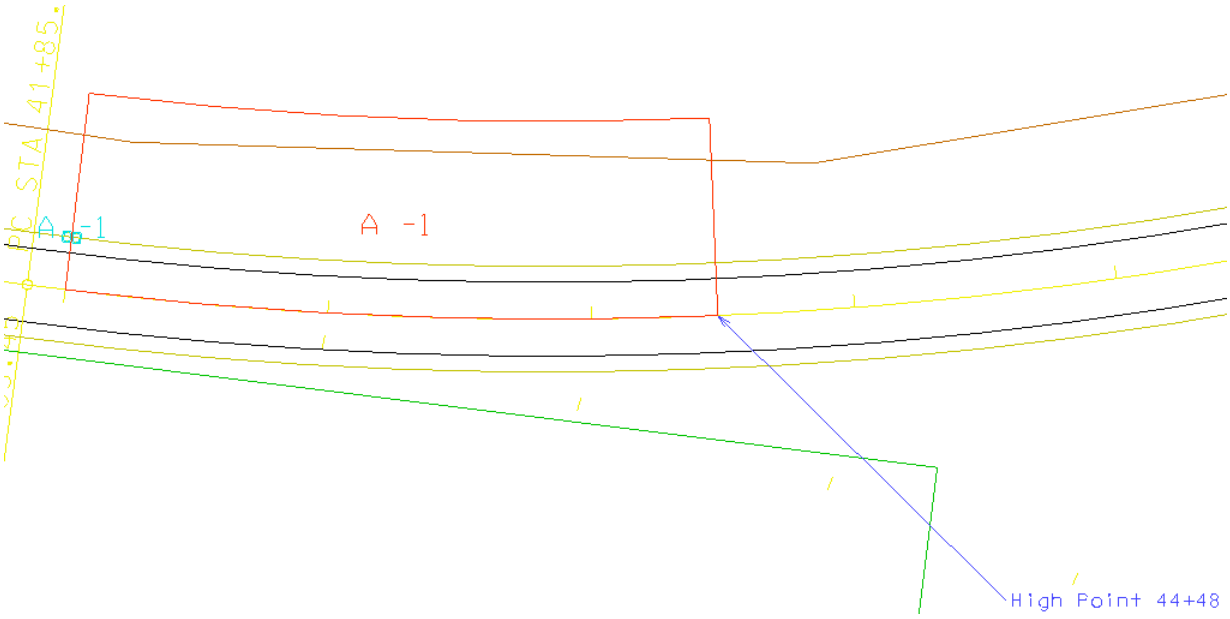
You can use either Manual or Automatic as the Method and you will have to Accept the boundary items once you have all of them selected so that MicroStation will establish the shape.



Now that we have our shape created, we can use it to define the boundary of our first drainage area. We will be using the Drainage Area Definition dialog for this.

3. Click the Select Shape button in the Drainage Area Definition dialog and data point on the drainage area and accept the selection

Once the shape has been accepted the Drainage Area field should be populated. This value will be in acres. The shape that we established in the previous steps should also change to reflect the symbology of a GEOPAK Drainage area and should be labeled with the area name.



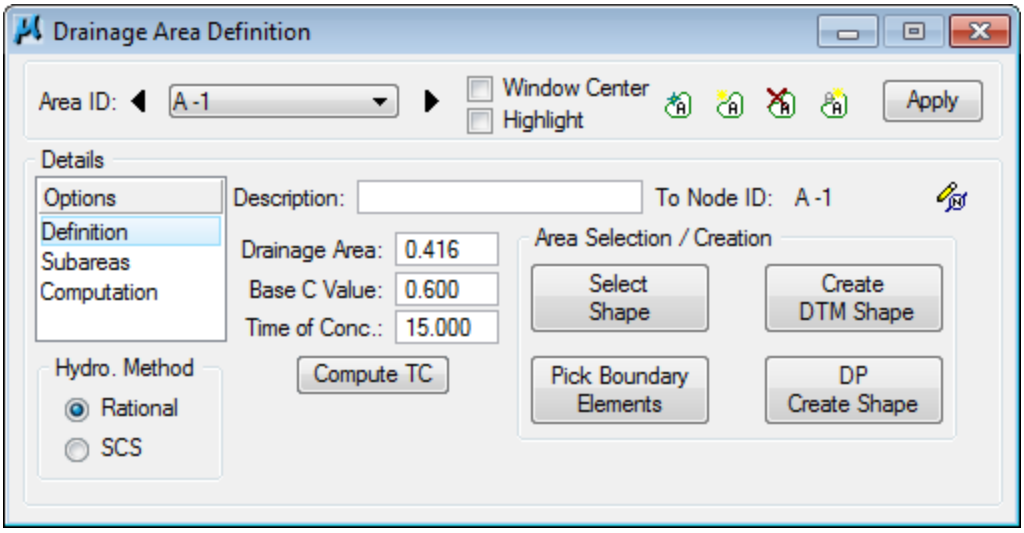
4. Enter the following values for the Definition option:

Base C value: **0.6**

This is the runoff coefficient used in any portions of the drainage area that do not have a pre-defined land use.

Time of Conc.: **15**

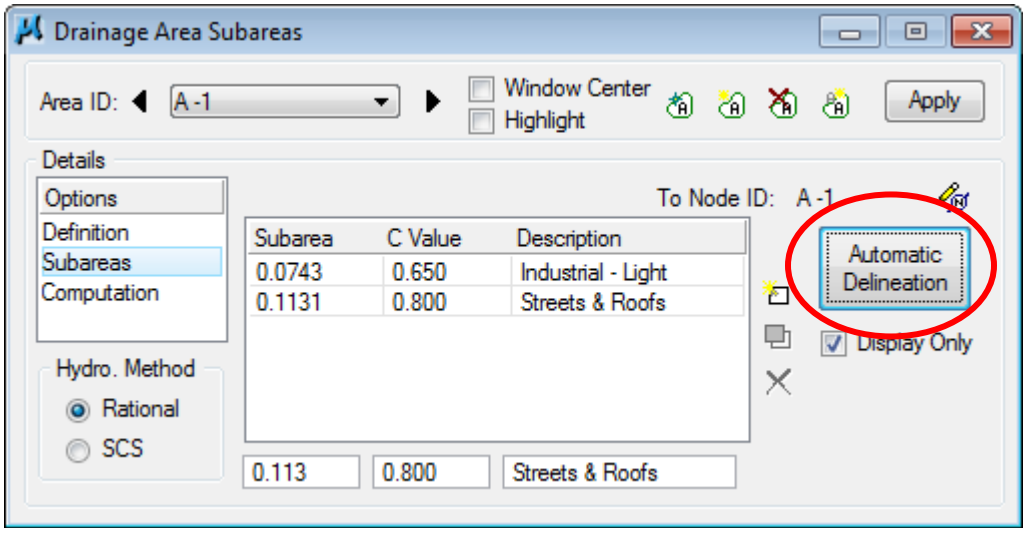
Section 749.5.3 of the EPG outlines Time of Concentration



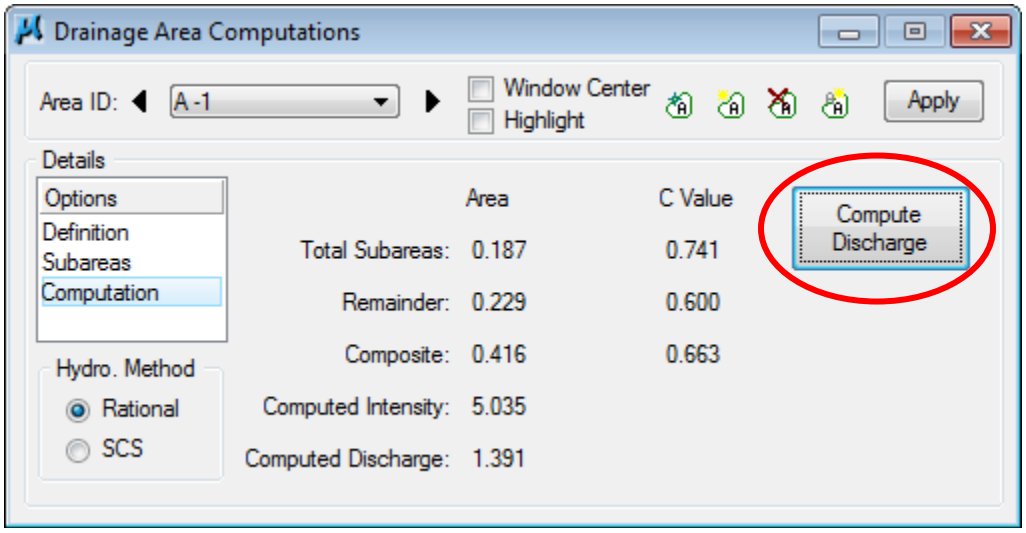
5. Select the Subareas option on the left of the dialog box and use the Automatic Delineation button to delineate the subareas based on the defined land uses

Note that the sub areas will become temporarily shaded based on the corresponding color contained in the drainage library.

If satisfied with the results select the **Apply** button.



6. Select the Computation option and then click the Compute Discharge button to generate intensity and discharge for the drainage area.

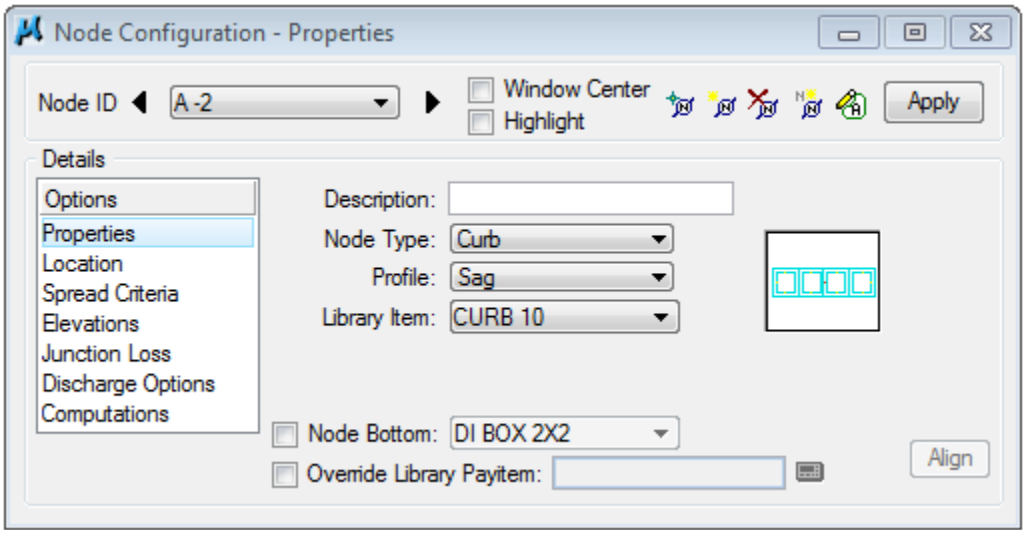


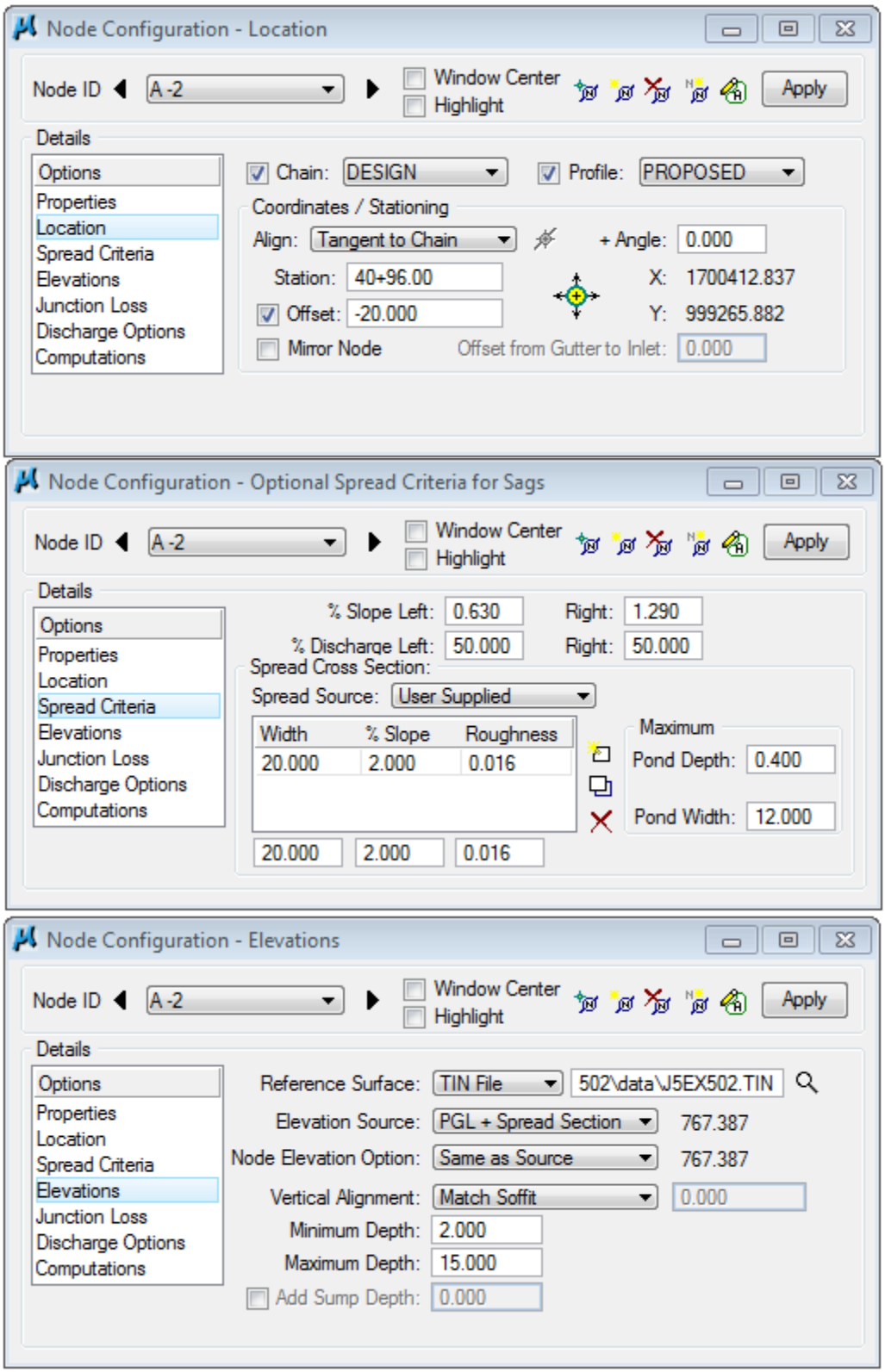
7. Finally select the Apply button to place Drainage Area A-1 in the drainage project

Note that after the area has been added the area is now contained in the navigator.

8. Based on the data supplied in the following screenshots and information, add the remaining nodes and areas.

Inlet A-2

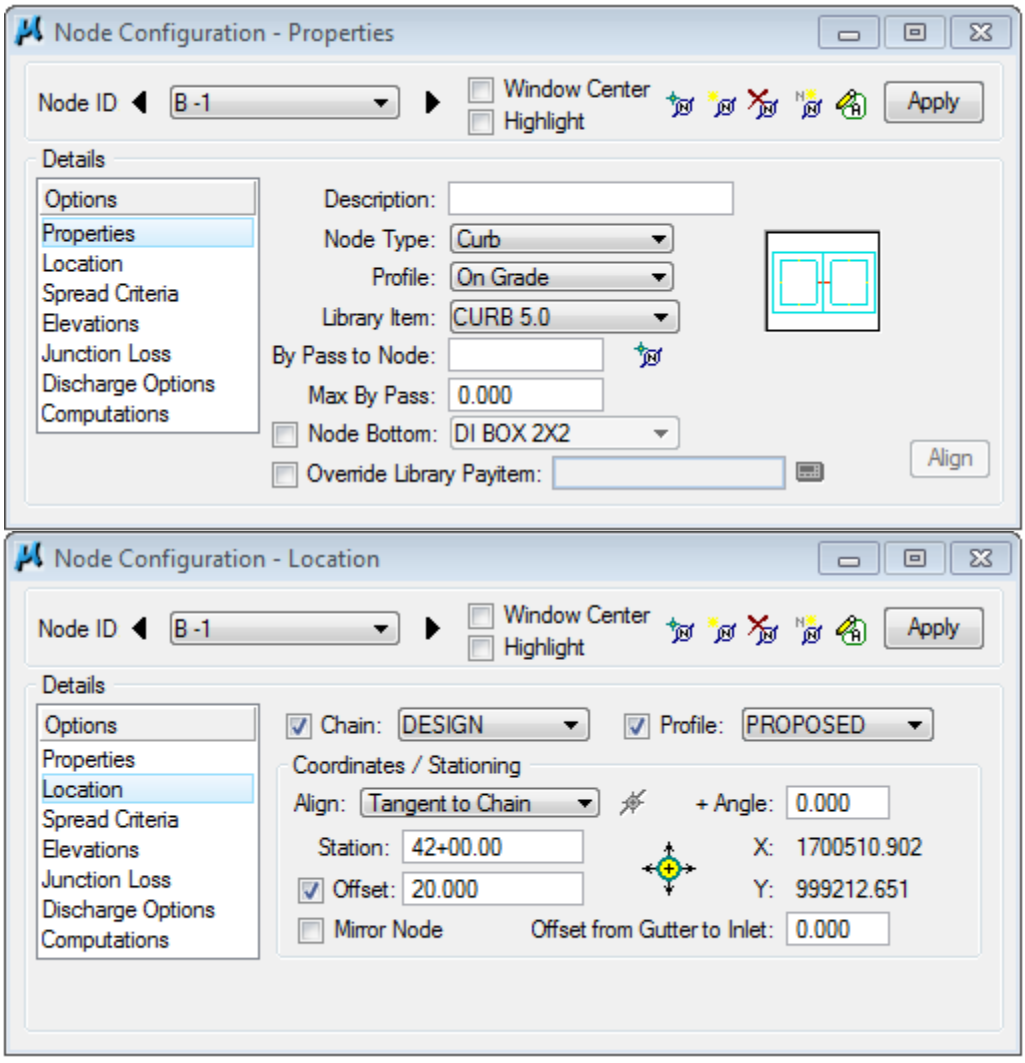


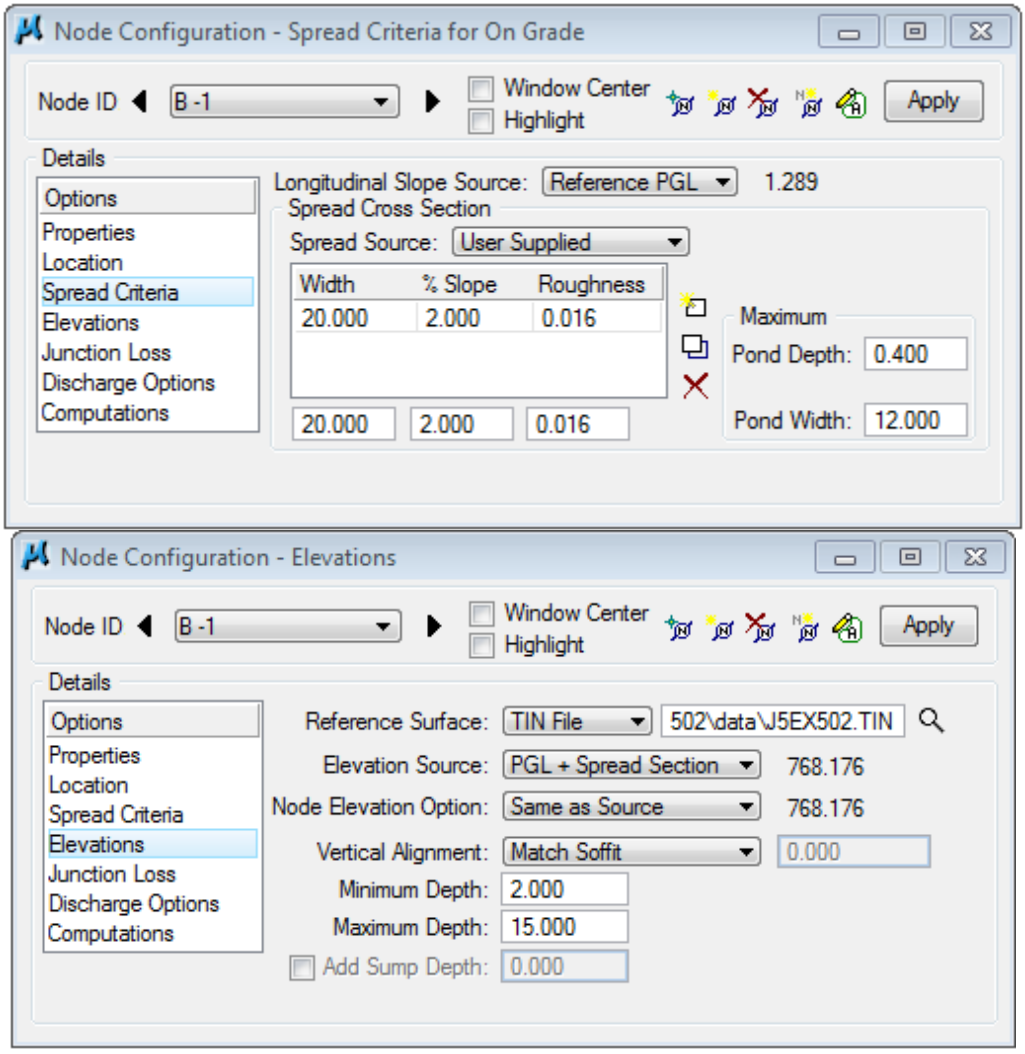

Node Configuration - Location
Node ID A -2
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Chain: DESIGN
Profile: PROPOSED
Coordinates / Stationing
Align: Tangent to Chain
+ Angle: 0.000
Station: 40+96.00
Offset: -20.000
X: 1700412.837
Y: 999265.882
Mirror Node
Offset from Gutter to Inlet: 0.000
Node Configuration - Optional Spread Criteria for Sags
Node ID A -2
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
% Slope Left: 0.630
Right: 1.290
% Discharge Left: 50.000
Right: 50.000
Spread Cross Section:
Spread Source: User Supplied
Width
% Slope
Roughness
20.000
2.000
0.016
Maximum
Pond Depth: 0.400
Pond Width: 12.000
20.000
2.000
0.016
Node Configuration - Elevations
Node ID A -2
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Reference Surface: TIN File
502\data\J5EX502.TIN
Elevation Source: PGL + Spread Section
767.387
Node Elevation Option: Same as Source
767.387
Vertical Alignment: Match Soffit
0.000
Minimum Depth: 2.000
Maximum Depth: 15.000
Add Sump Depth: 0.000

Once you've completed Inlet A-2, you can create and assign Area A-2 in a similar manner to what we used for Area A-1 using the Draw Transition tool in GEOPAK. *Remember that Area A-2 contains the bridge as well as the roadway section, so there will be a change in the width that occurs from Sta 38+00 to Sta. 39+00.

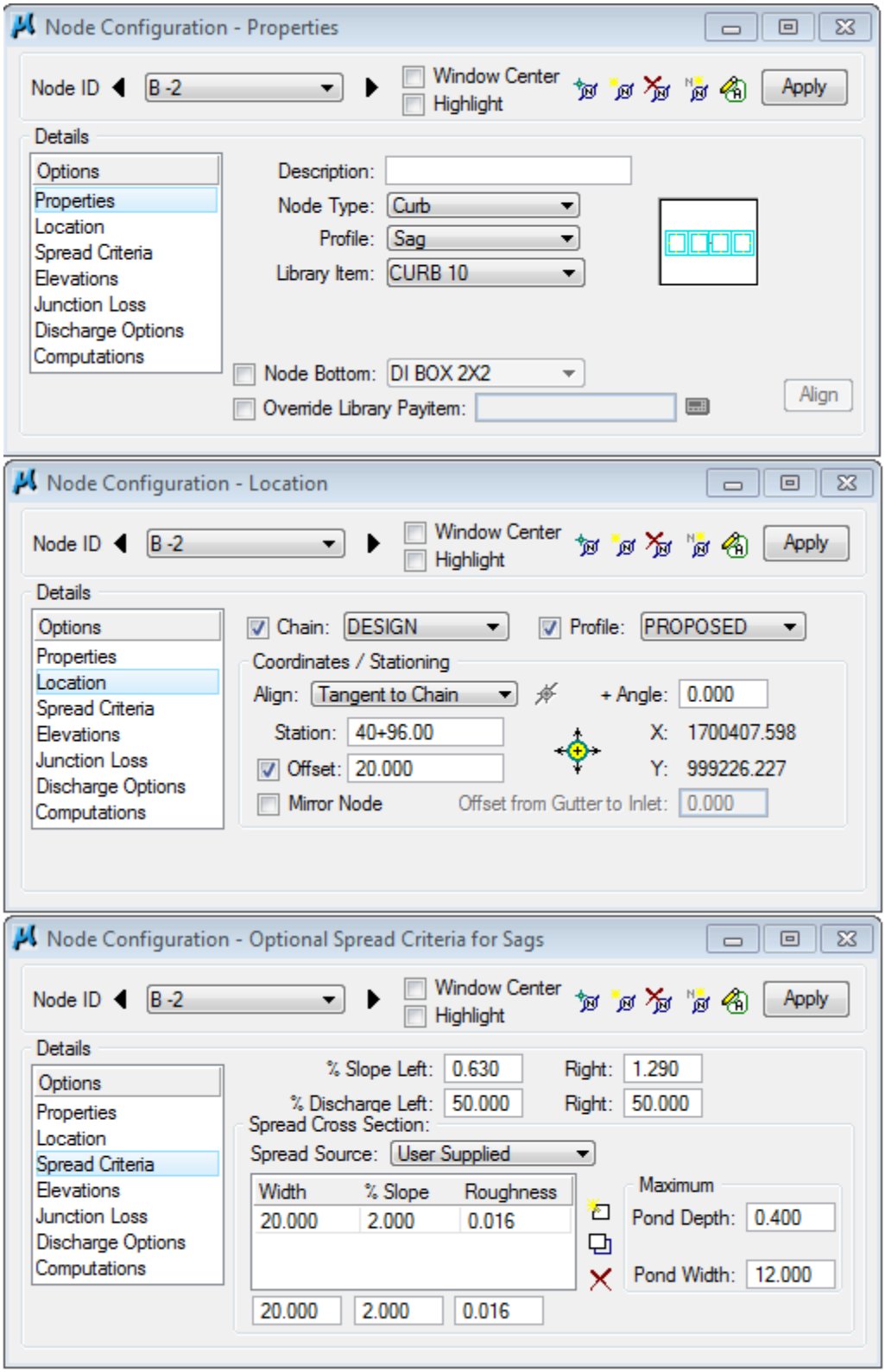
Then follow the same process for creating Areas B-1 and B-2. The only change is that we will use a Tc value of 12 for these areas.
*Area B-2 contains the bridge just like A-2 so there will be a similar offset in width.

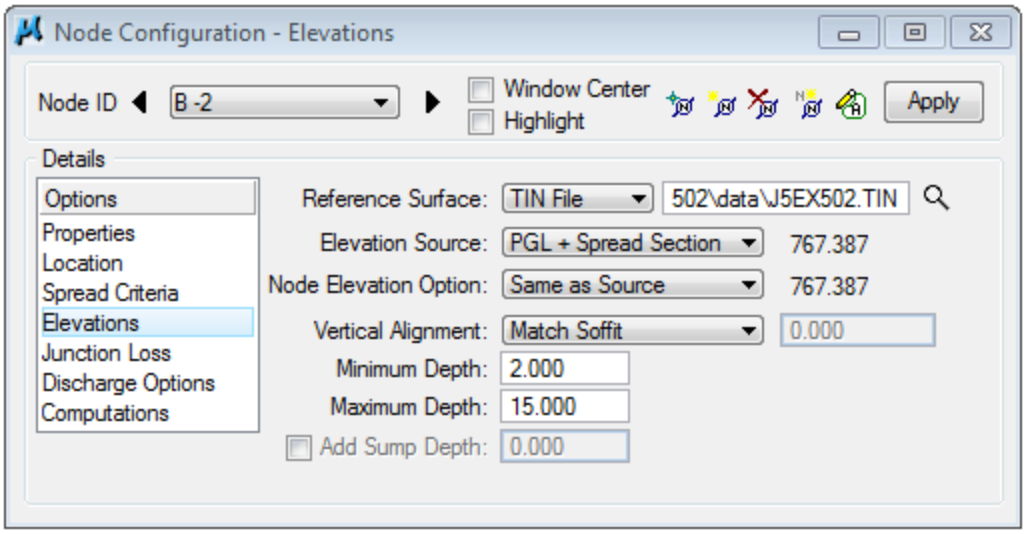
Inlet B-1




Node Configuration - Spread Criteria for On Grade
Node ID
B -1
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Longitudinal Slope Source:
Reference PGL
1.289
Spread Cross Section
Spread Source:
User Supplied
Width
% Slope
Roughness
20.000
2.000
0.016
Maximum
Pond Depth:
0.400
Pond Width:
12.000
Node Configuration - Elevations
Node ID
B -1
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Reference Surface:
TIN File
502\data\J5EX502.TIN
Elevation Source:
PGL + Spread Section
768.176
Node Elevation Option:
Same as Source
768.176
Vertical Alignment:
Match Soffit
0.000
Minimum Depth:
2.000
Maximum Depth:
15.000
Add Sump Depth:
0.000

Inlet B-2

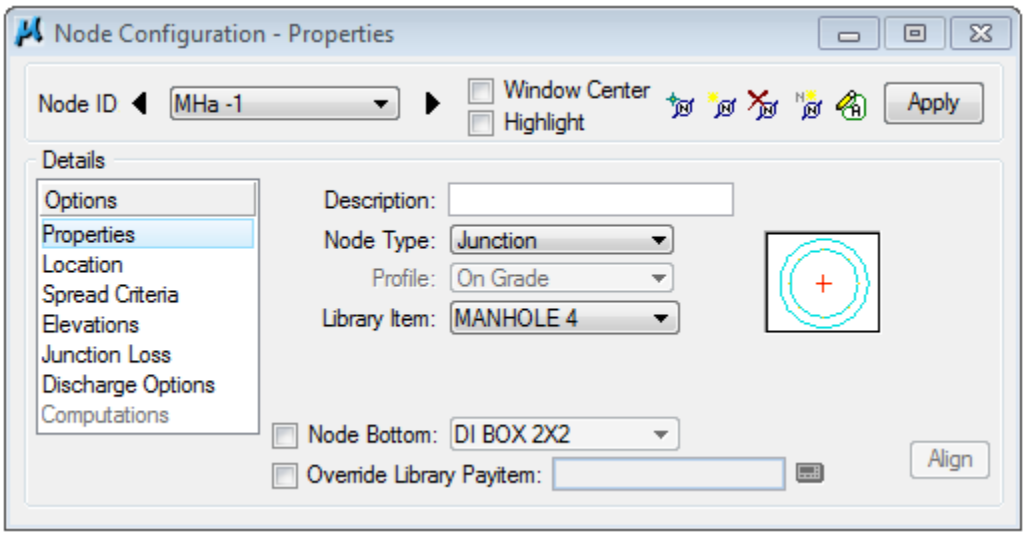

Node Configuration - Properties
Node ID
B -2
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Description:
Node Type:
Curb
Profile:
Sag
Library Item:
CURB 10
Node Bottom:
DI BOX 2X2
Override Library Payitem:
Align
Node Configuration - Location
Node ID
B -2
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
Chain:
DESIGN
Profile:
PROPOSED
Coordinates / Stationing
Align:
Tangent to Chain
+ Angle:
0.000
Station:
40+96.00
X:
1700407.598
Offset:
20.000
Y:
999226.227
Mirror Node
Offset from Gutter to Inlet:
0.000
Node Configuration - Optional Spread Criteria for Sags
Node ID
B -2
Window Center
Highlight
Apply
Details
Options
Properties
Location
Spread Criteria
Elevations
Junction Loss
Discharge Options
Computations
% Slope Left:
0.630
Right:
1.290
% Discharge Left:
50.000
Right:
50.000
Spread Cross Section:
Spread Source:
User Supplied
Width
% Slope
Roughness
20.000
2.000
0.016
Maximum
Pond Depth:
0.400
Pond Width:
12.000
20.000
2.000
0.016

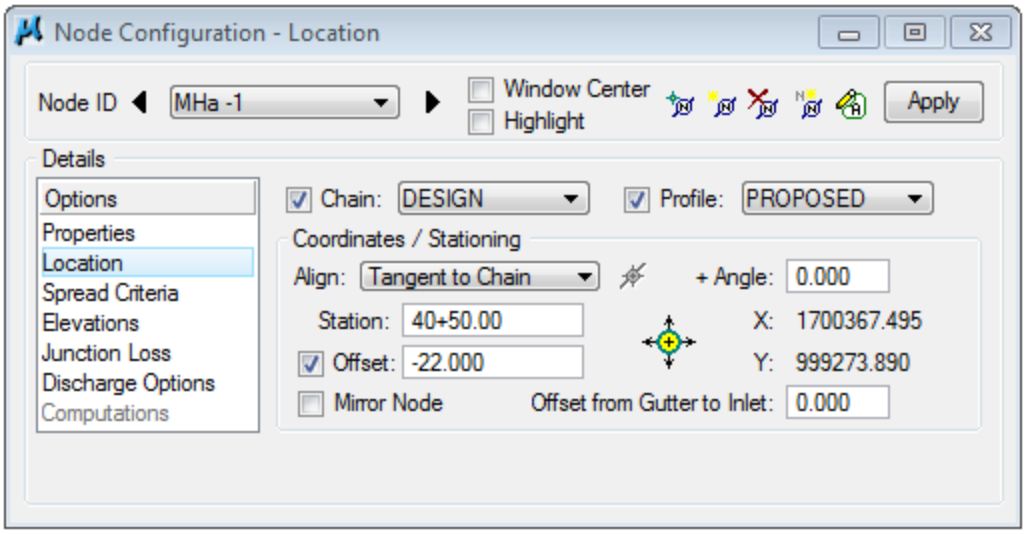


Once you've constructed your 4 inlets as outlined above, make sure you go back to A-1 and B-1 and assign your bypass flow to the downstream inlet.

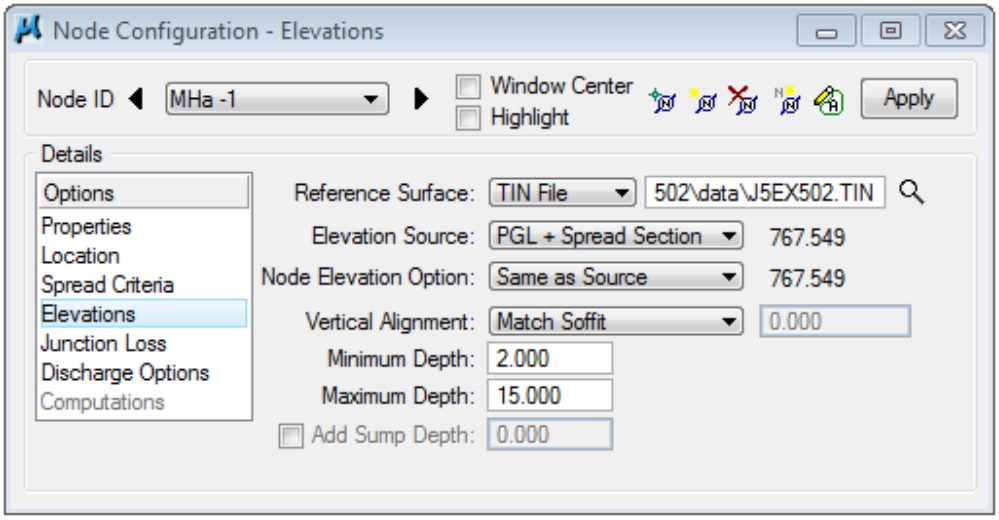
Now we'll place the manholes and the outlet for our system.

Node MHa-1

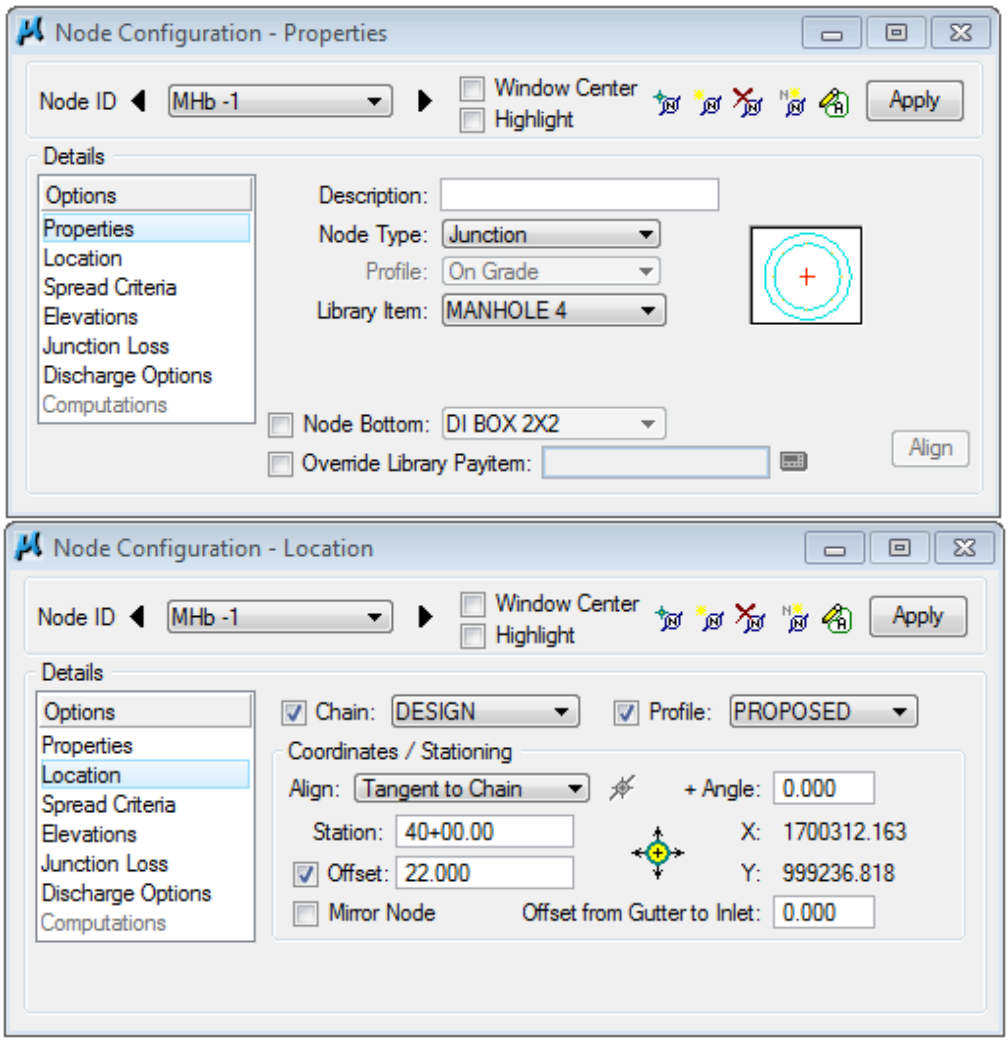




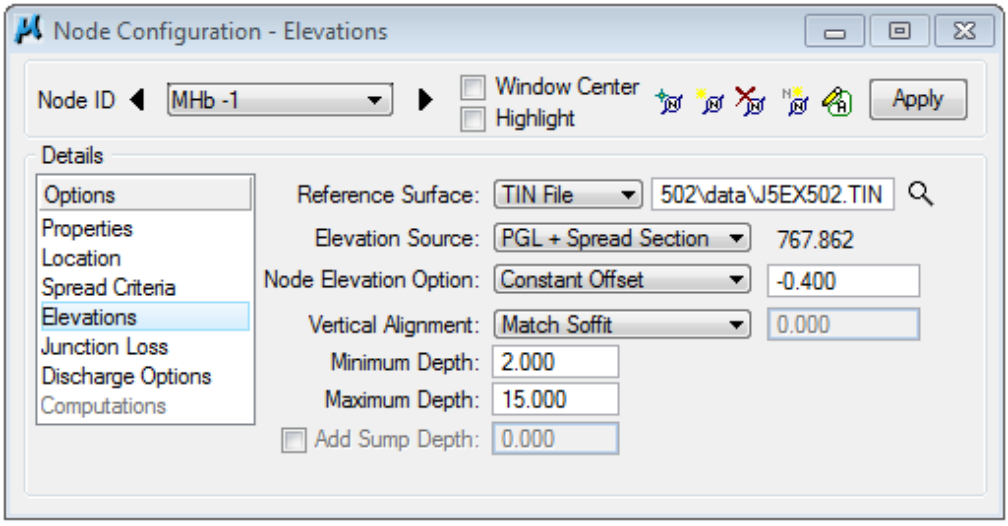
We will use the same Spread Criteria for MHa-1 that we've used for the inlets. This will allow us to use this data to set the Elevation Source by using the PGL + Spread Section option.



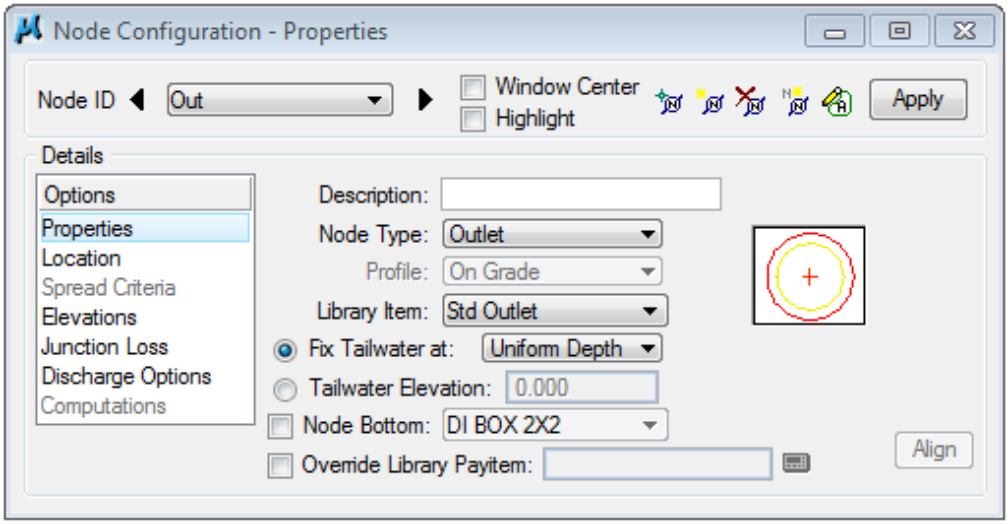
Node MHb-1



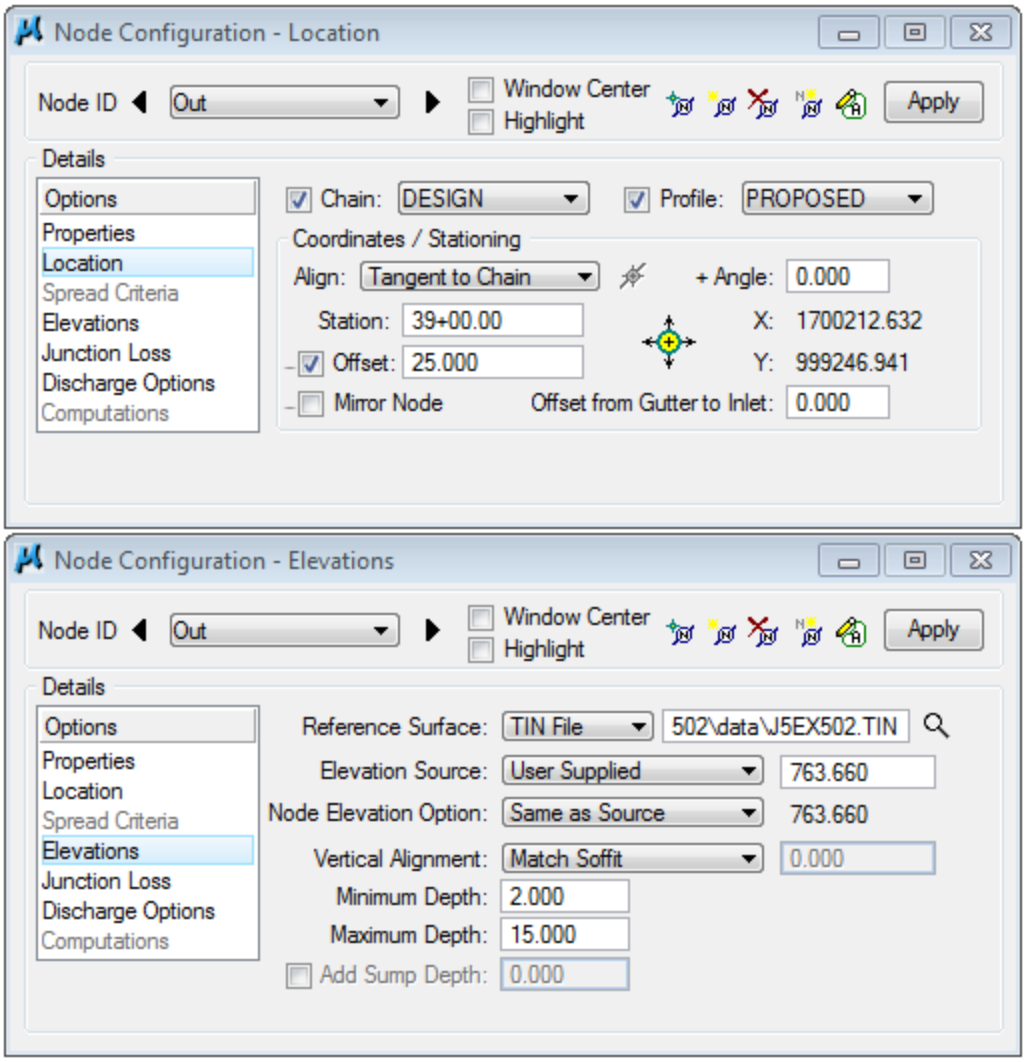
If we use the same Elevation Source and Node Elevation options that we used for the last manhole you'll notice that the elevation is higher than MHa-1. This won't necessarily create a problem since we can always adjust the elevation that the pipes enter MHb-1, but let's adjust the elevation for this node anyway. There are times when you will want to manually set the elevation of a node in order for your system to function properly or to achieve a desired outcome. Drainage offers a couple ways this can be done, we can choose User Supplied and input the elevation we want to set our node at or we can tie the elevation to our GPK referenced data and then adjust the final elevation by using the Constant Offset setting under Node Elevation Options.



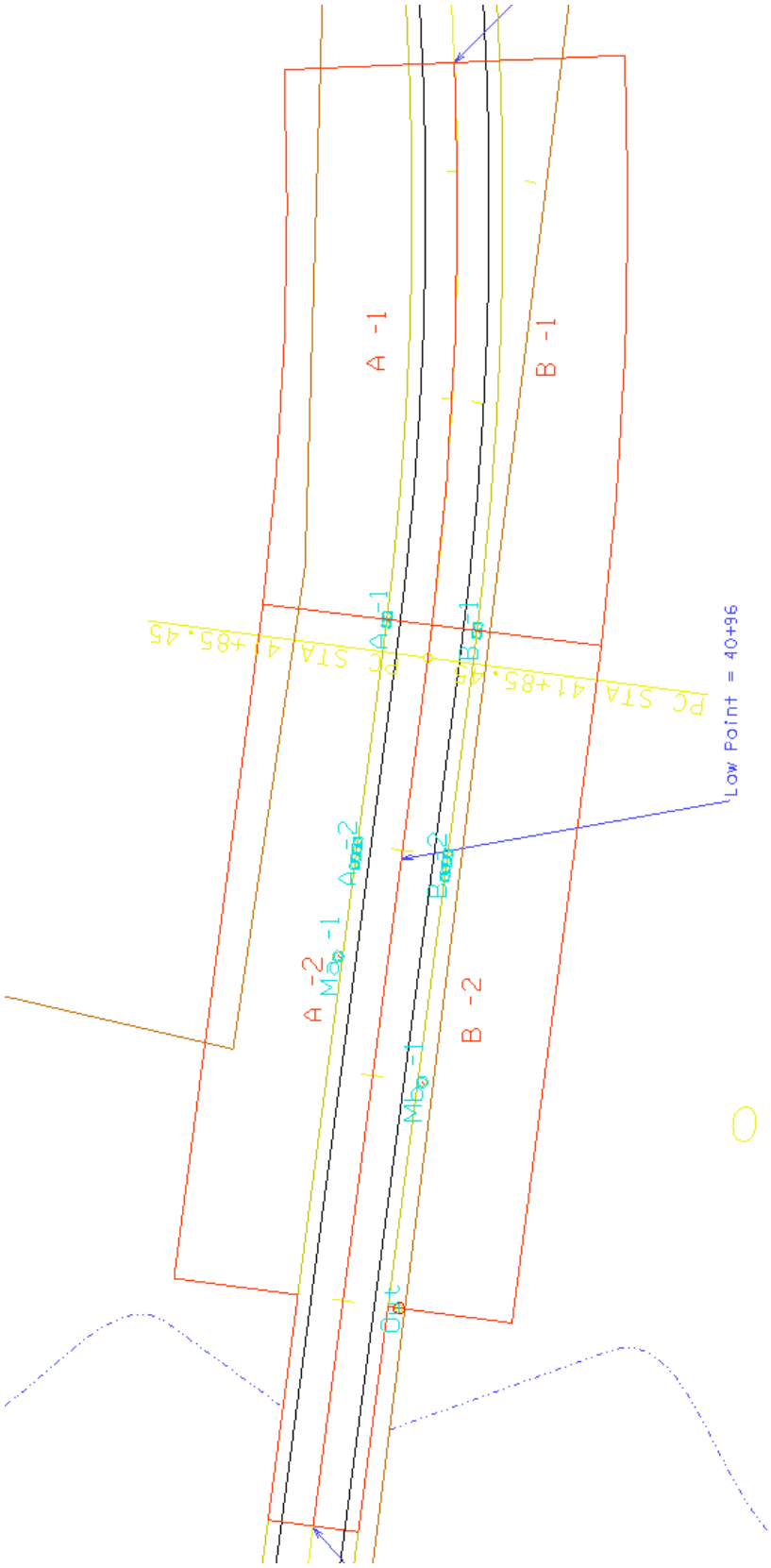
Node Out



We are going to assume a constant normal depth of flow in the channel or stream that we are draining our system into, so we will use the Fix Tailwater at option and use the Uniform Flow setting.



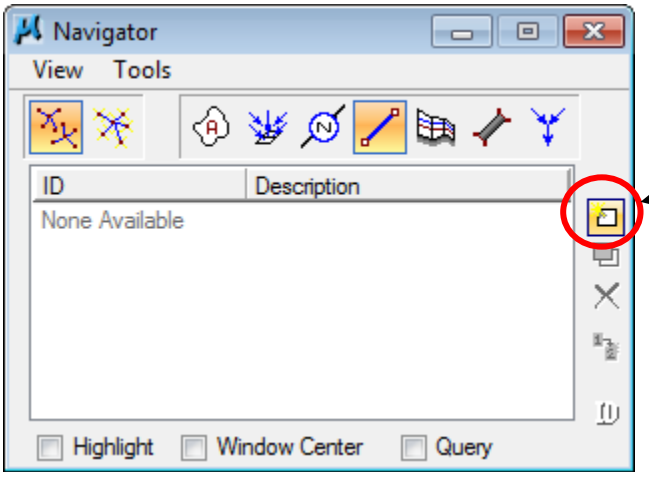
Upon completion you should have a drainage system resembling the screenshot on the next page.


A -1
B -1
PC STA 41+85.45
Low Point = 40+96
A -2
B -2
Out

5.6 Pipe Placement

Now we need to link our inlets and nodes together.

1. Using the Navigator, select the Link icon at the top and then select the Add Item button.



Select the **Add Item** Icon

You could also use the Component drop-down menu from Drainage and choose the Link >Add option to place your pipe. Another option is to launch the Drainage Main Tool Box and use the Link tool set.

We will be using the default naming convention for our pipes, so you can click OK when prompted to name SS -1 for your first link.

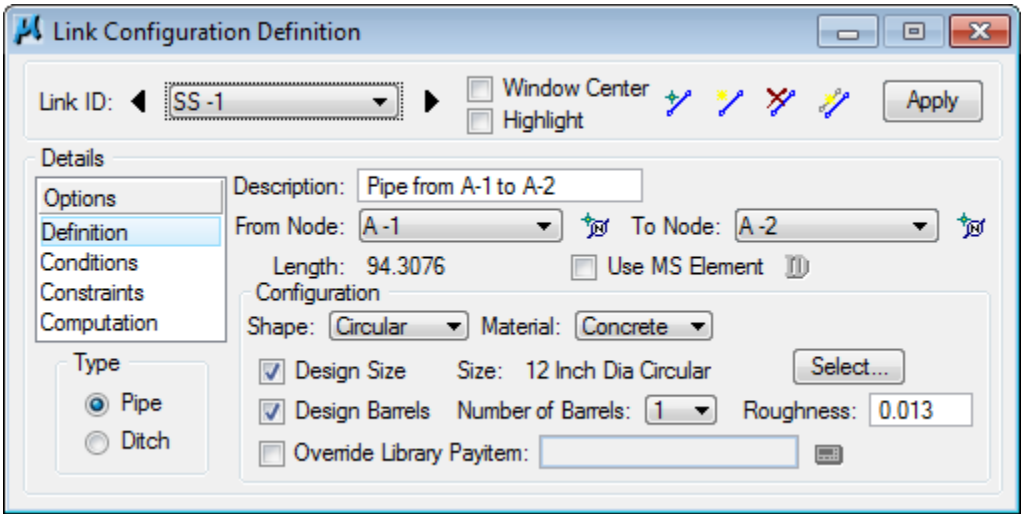
2. Now use the information outlined below to configure SS -1

Definition

Description: **Pipe from A-1 to A-2**

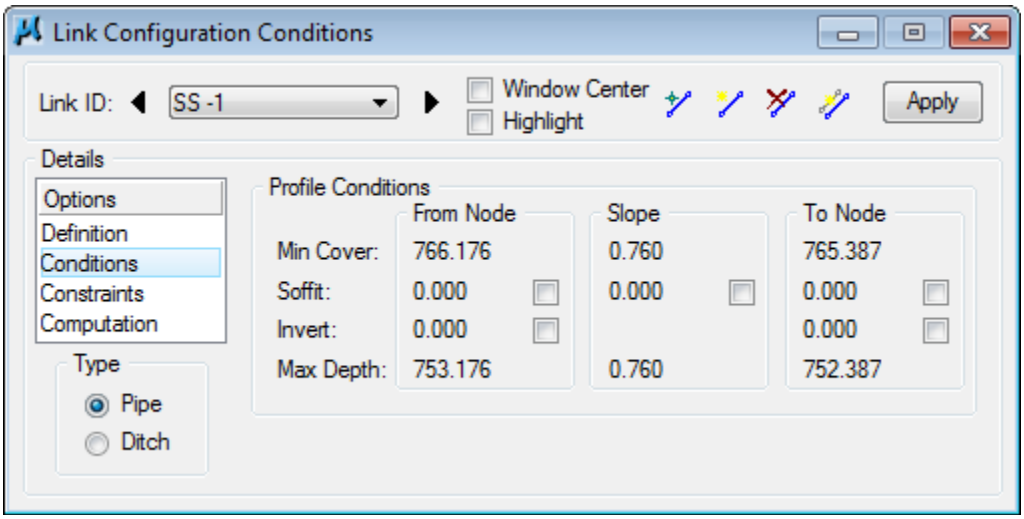
Use the drop-down lists to assign the From Node and To Node

Define the configuration:
Shape: **Circular**
Material: **Concrete**
Size: Select any pipe from the drainage library
Enable Design Size
Number of Barrels: **1**



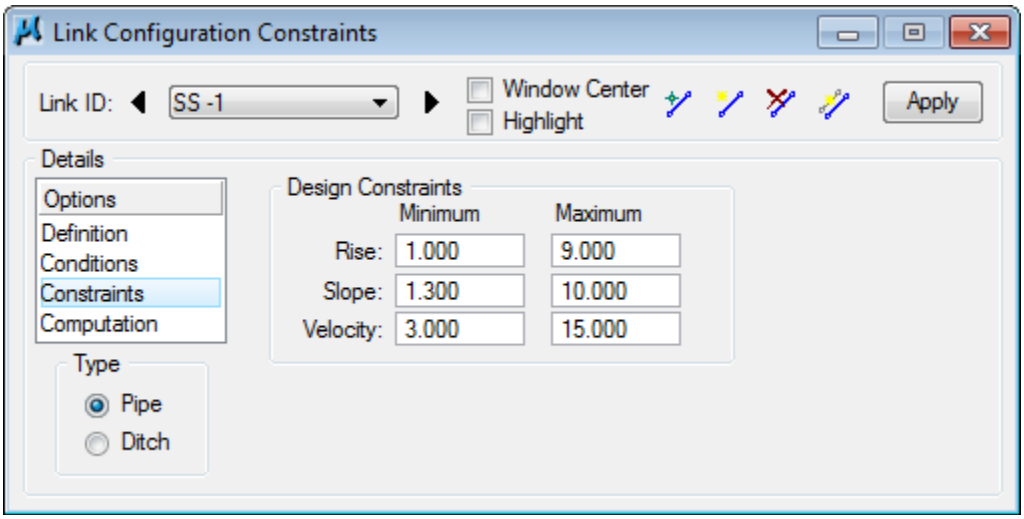
Conditions

The soffit and invert will not be populated until after the network has been created.

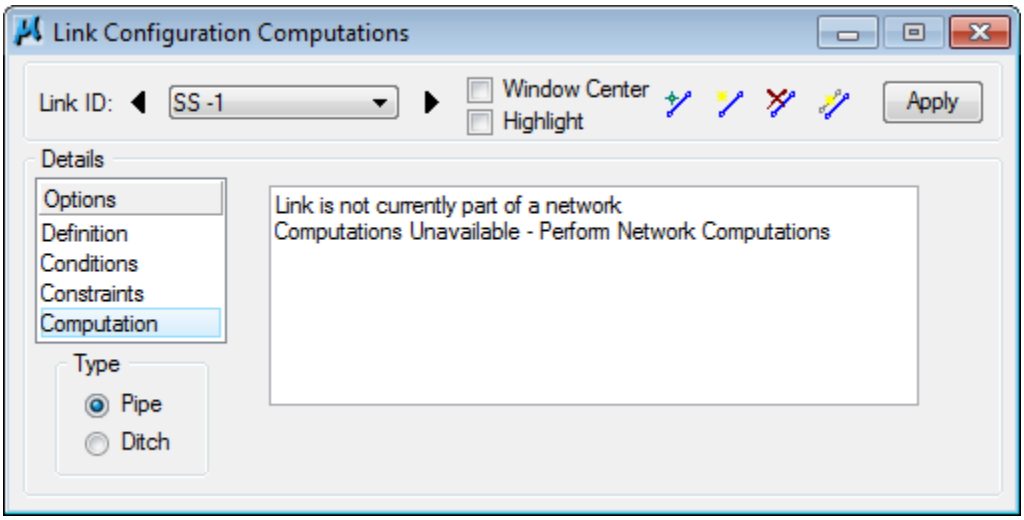


Constraints

Use the design constraints listed at the start of the exercise.



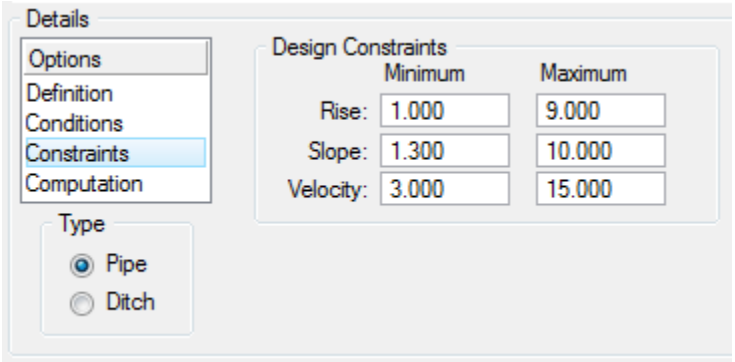
Computations
The network must be created before computations will be performed.



3. **Based on the supplied data add the remaining links.**

Pipe ID	From Node	To Node	Shape	Material
SS -1	A -1	A -2	Circular	Concrete
SS -2	A -2	MHa-1	Circular	Concrete
SS -3	MHa -1	MHb -1	Circular	Concrete
SS -4	MHb -1	Out	Circular	Concrete
SS -5	B -1	B -2	Circular	Concrete
SS -6	B -2	MHb -1	Circular	Concrete

The screenshot below should be used for all pipes when setting the Constraints



5.7 Network Creation

Now that we have our nodes and our links established, we need to build and design our network.

1. Using the Drainage menu bar go to Network and select the Add option

2. Name your network Network-1 and make sure the outlet node is designated as Out

Click OK

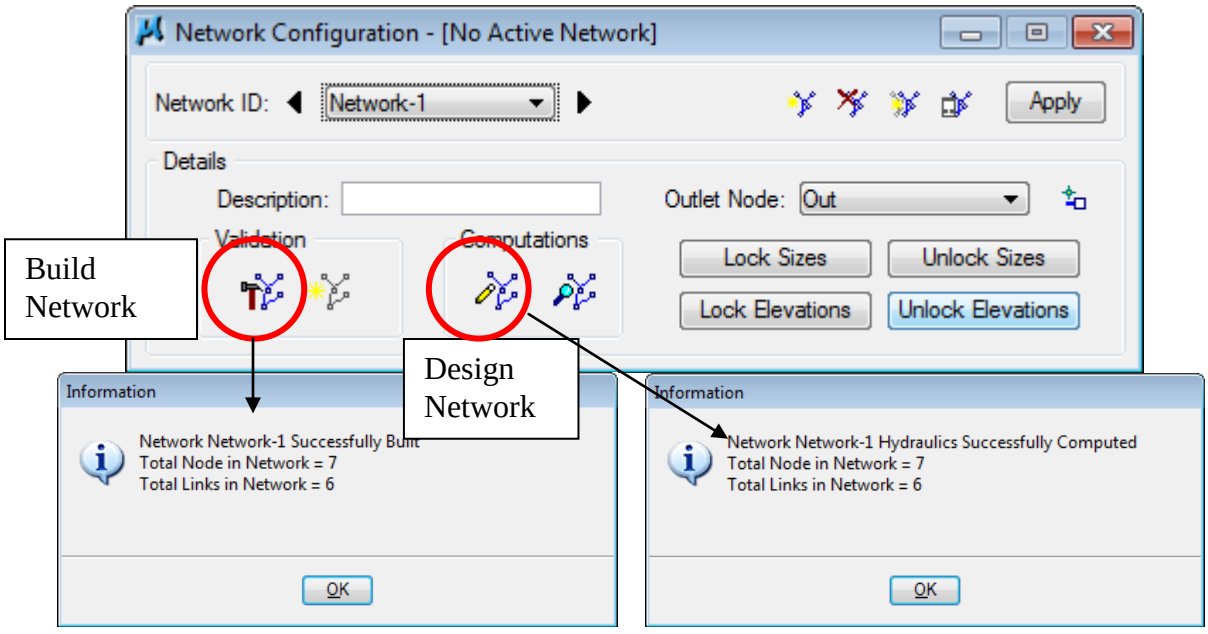
3. Select the Build Network option under Validation

Selecting the **Highlight Network** button will highlight your entire network to show you which components are recognized by GEOPAK as being part of your network

4. Select the Apply button to add the network to the drainage project

5. Select the Design Network option under Computations

The **Design Network** process accounts for any design options that were enabled during the component placement process (for example: we enabled the Design Size function under the Configuration options when we placed our pipes)



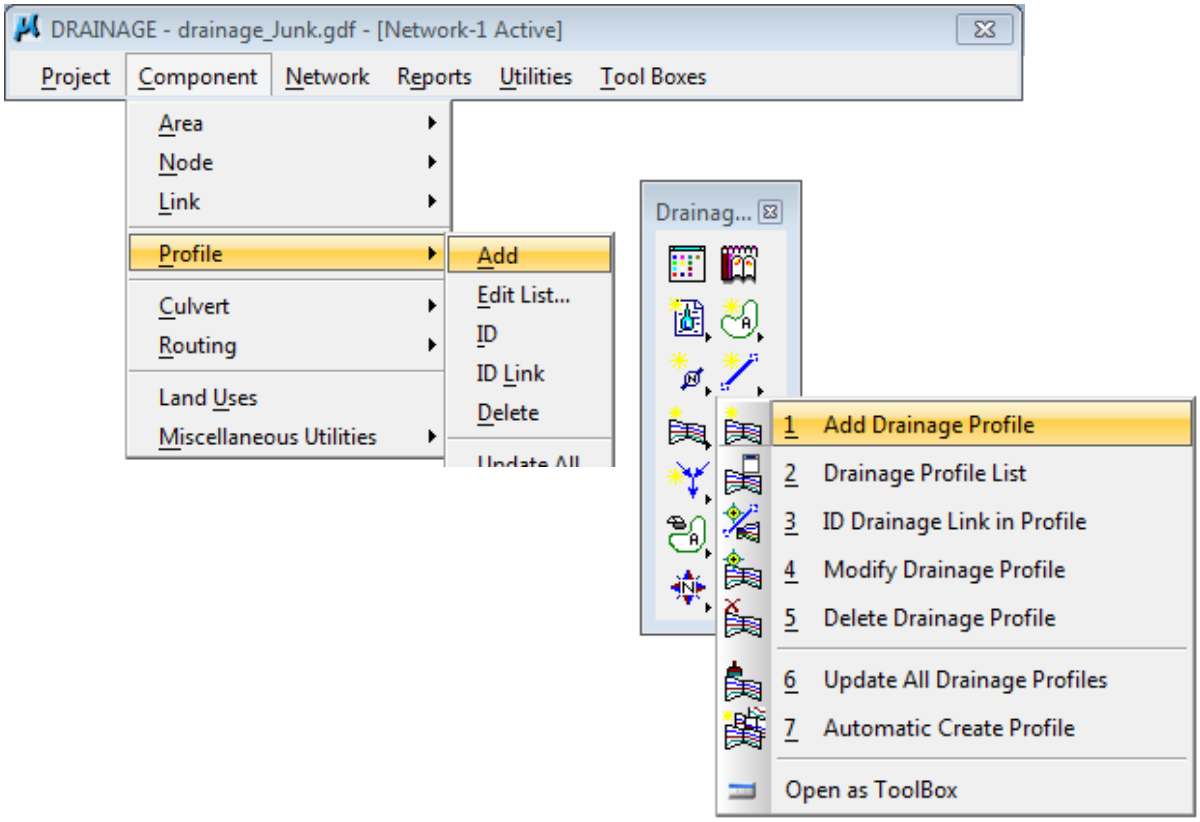
6. Now set the active network by going the Network menu on the Drainage menu bar and selecting the Active Network option then select Network-1 from the list of available networks

The banner should now display **Network-1 Active**

5.8 Profile/Reach Creation

Profiles are constructed in a path running in any direction (upstream or downstream) in a drainage Network and are utilized to visualize the network cross–section. A profile can also be utilized to construct a customized profile (including groundline, pipes, depth of cover, hydraulic gradeline, etc. according to what display options are checked during creation) along any path.

Just like most of our other components, we can use a number of different ways to add our profile. Adding a profile can be done by going to the Component drop-down menu on the Drainage menu bar or by using the Add tool from the Drainage Profile tool set.



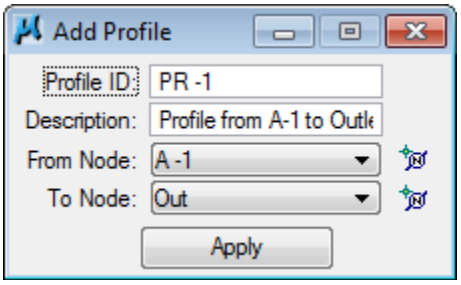
Let's use the **Navigator** to add our profile.

1. Select the Profile option along the top of the Navigator then choose the Add button on the right-hand side

2. Complete the Add Profile information as follows:

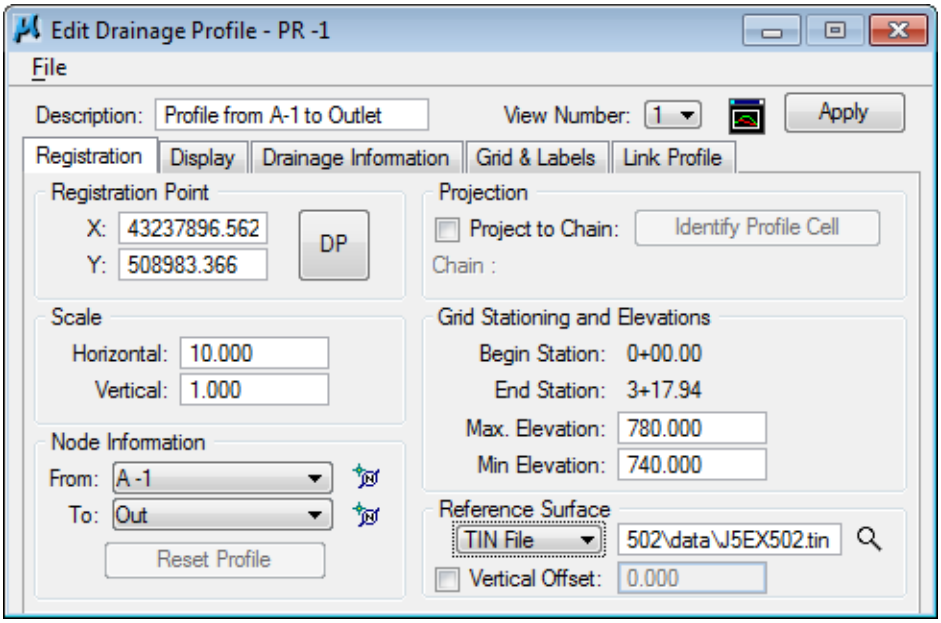
Profile ID: **PR -1**
Description: Profile from A-1 to Outlet
From Node: **A1** (Select from drop-down list or use ID option to select element)
To Node: **Out** (Select from drop-down list or use ID option to select element)

Click **Apply**



In the Registration tab for PR-1 use these settings:

Reference Surface: **TIN File**
Select **J5EX502.tin** (If left blank, individual Node elevations are utilized to construct the ground profile.)



3. Click the DP button in the Registration Point section and then data-point click a spot in your design where you want to place the profile

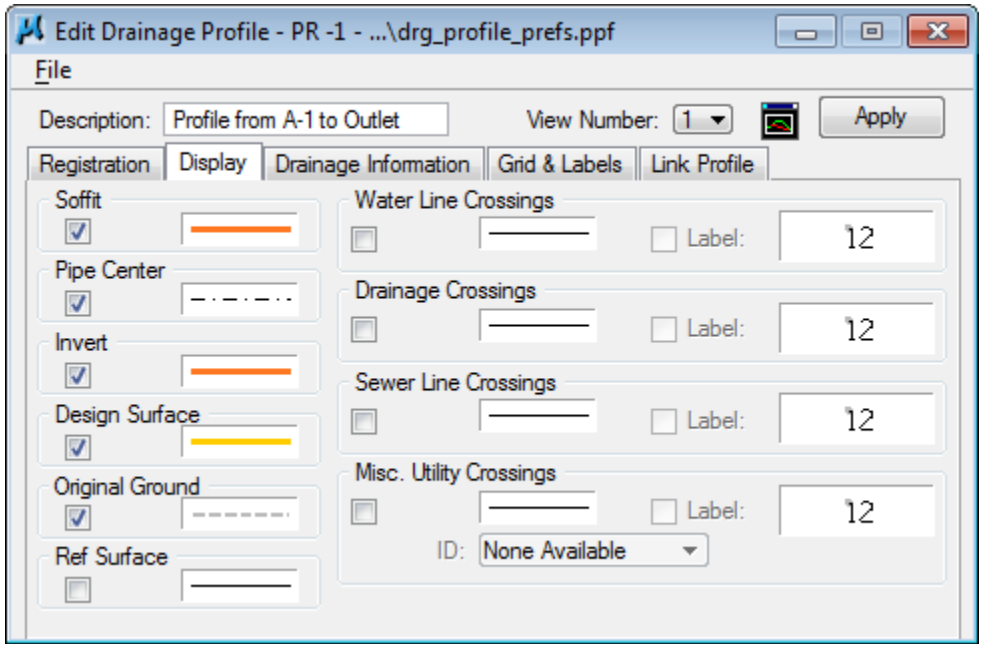
Now before we graphically generate our profile, we will want to set up some of the different options and parameters.

4. Choose the Display tab

At this point you could enable any available option and change the colors and levels as necessary by double-clicking on the symbology box for that item. However, for this example a preference file has been created and saved in our data directory as:

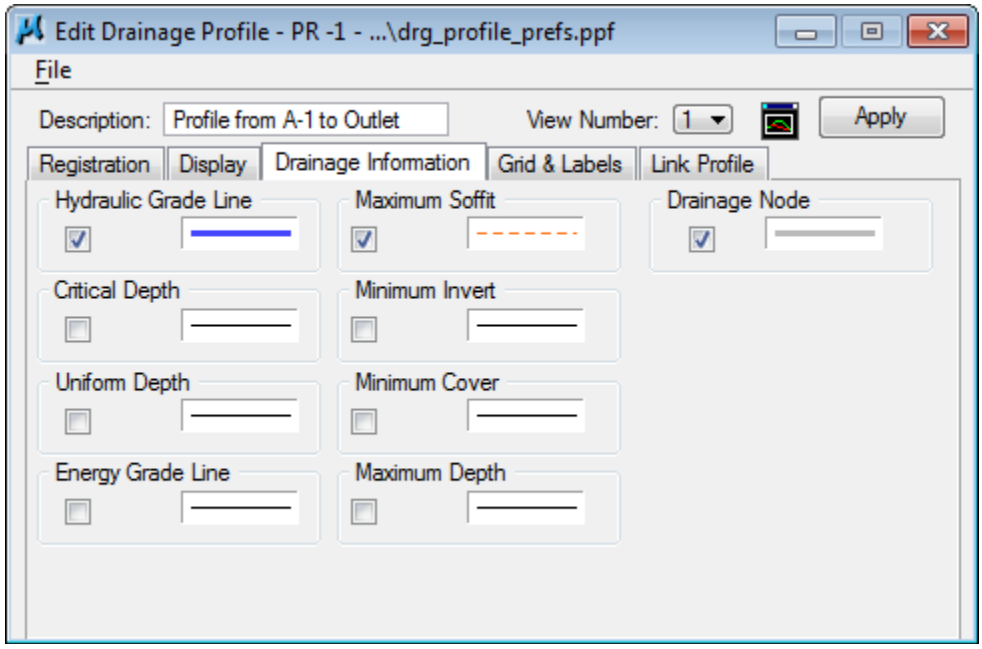
drg_profile_prefs.ppf

Use the File >Open option in the Profile dialog and choose this file to load the preferences for our profile



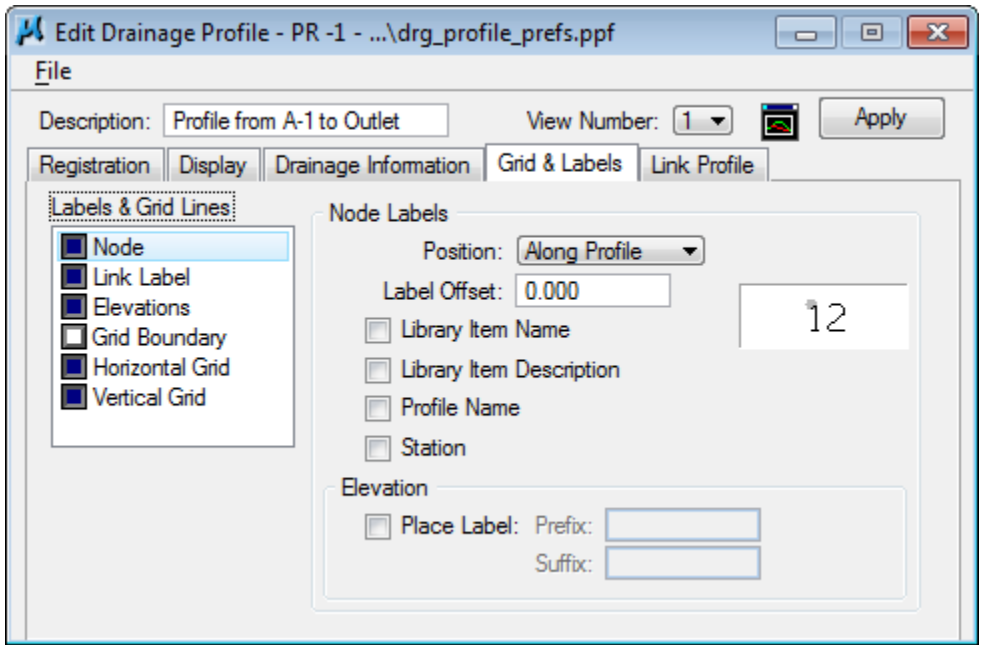
5. Choose the Drainage Information tab

This will allow you to check the items you wish to show on the profile. Loading the preference file in step 5 will check certain items and give them a color and level. You may still choose to show other items here.



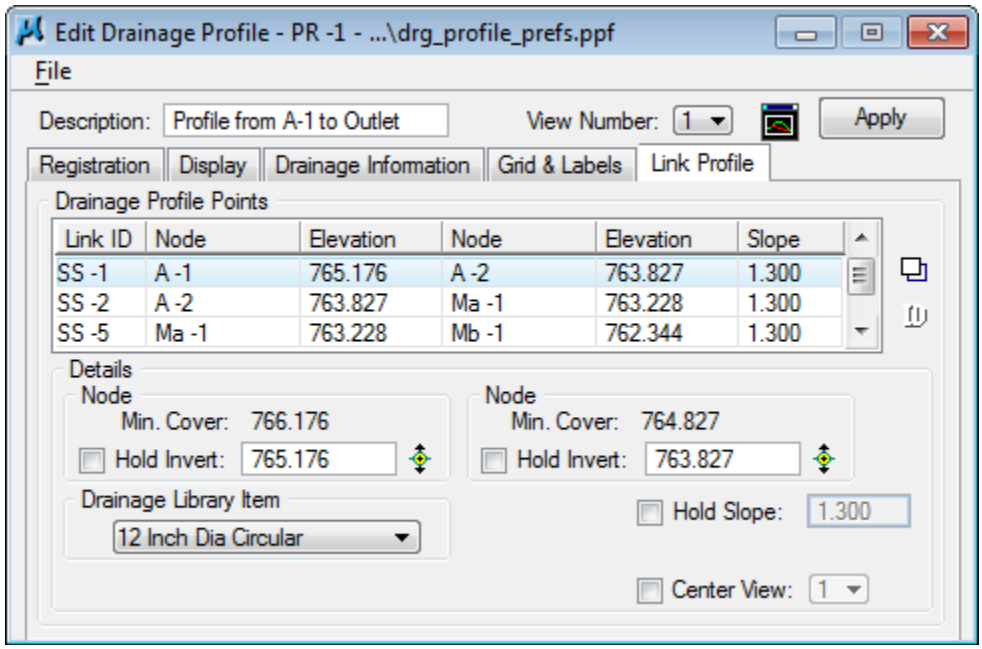
6. Choose the Grid & Labels tab

This tab allows the horizontal and vertical grids to be placed in the profile along with the appropriate text.



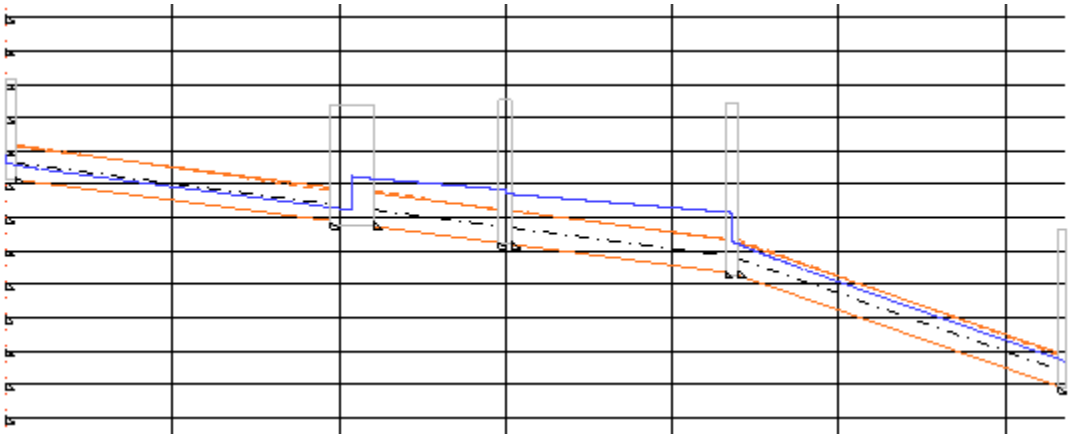
7. Choose the Link Profile tab

This tab displays the link configuration associated with a selected profile. You can gather information on elevations and even edit them in this tab. You can select elevations or key them in, and change the library item currently being used from one section of your network to another.



8. Finally select the Apply button to save the profile to drainage project.

Take a look at the generated profile.



Discuss options to affect the hydraulic jump.