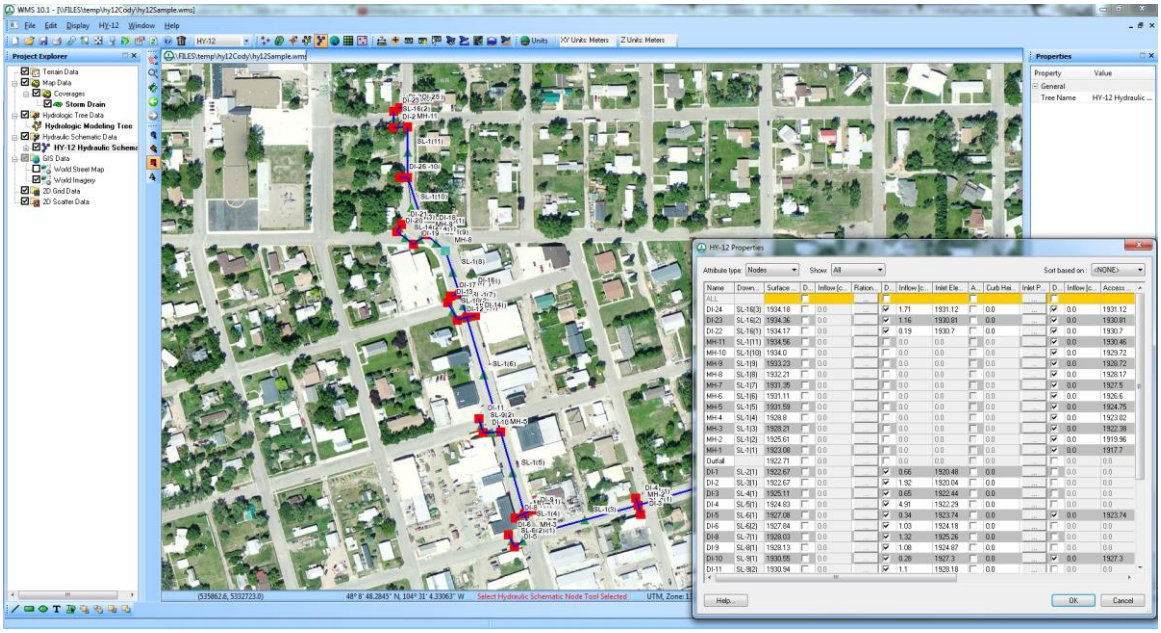
WMS

v. 10.1

WMS 10.1 Tutorial

Storm Drain Modeling – HY-12 Analysis with a Background Map

Setup an HY-12 storm drain model in the WMS interface using a background map with inlet and pipe information



Objectives

Define a storm drain network and its associated data using a background map and assign known access hole and pipe elevations and other storm drain information to the HY-12 model in WMS. Then run the HY-12 model and view the results.

Prerequisite Tutorials

- Introduction – Images
- Introduction – Basic Feature Objects
- Editing Elevations – DEM Basics

Required Components

- Data
- Map
- Hydrology

Time

- 40–50 minutes

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1 Introduction

The US Federal Highway Administration's HY-12 is a DOS-based storm drain analysis program that can be used for designing inlets, pipes, and the general layout of a storm drain network. An HY-12 model can be generated by drawing the proposed pipe and inlet locations in a storm drain coverage. The map module locations are then converted to a 1D schematic where the HY-12 model parameters are defined.

Many of the HY-12 computations, such as channel calculations, curb and gutter calculations, and rational method computations, are based on computations in FHWA's Hydraulic Toolbox software.[1] Refer to the documentation in both the Hydraulic Toolbox and in HY-12 installations to learn about the specific computation methods used in HY-12. Many of the computations used in the HY-12 model are described in FHWA's *Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22* (HEC-22).[2]

HY-12 in WMS is used here to create a model of a storm drain network along a small section of a state highway in Culbertson, Montana. The storm drain network flow direction begins in a northwest to southeast direction and then changes to a northeast direction at a turn in the state highway. The network ends at a wetland outfall and has a total length of about .45 miles from the beginning to the end of the network.

This tutorial specifically demonstrates importing a WMS project containing an image with the schematic of a proposed storm drain network, defining a storm drain network, defining HY-12 structures in the storm drain network and assigning parameters to the structures, assigning pipe invert, access hole, ground, and inlet elevations to the HY-12 model, assigning computed hydrologic model peak flows to HY-12 inlets, running HY-12 to compute the results, and then viewing the results.

[1] See https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm.

[2] See https://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf.

2 Getting Started

Starting WMS new at the beginning of each tutorial is recommended. This resets the data and other WMS settings to their defaults. To do this:

1. If necessary, launch WMS.
2. If WMS is already running, press *Ctrl-N* or select *File* | **New…** to ensure that the program settings are restored to their default state.
3. A dialog may appear asking to save changes. Click **No** to clear all data.

The graphics window of WMS should refresh to show an empty space.

3 Drawing the Storm Drain Schematic

3.1 Importing the Background Image

First, import a WMS project containing a georeferenced background image that has information about the locations of links and nodes in the storm drain schematic model.

1. Select *File* | ***Open*** to bring up the *Open* dialog.
2. Select "WMS XMDF Project Files (*.wms)" from the *Files of type* drop-down.
3. Browse to the *HY12BackgroundMap\HY12BackgroundMap* folder and select "CulbertsonDrainage.wms".
4. Click **Open** to import the project and exit the *Open* dialog.
5. If asked to build image pyramids, click **No**.

The project will appear similar to Figure 1.

Figure 1 Culbertson drainage schematic with background map

3.2 Defining the Storm Drain Network

Now draw the storm drain network using the background map and convert it to a hydraulic schematic that can be used to define HY-12 link and node data.

1. Right-click "Drainage" in the Project Explorer and select *Type* | **Storm Drain**.

Notice that "Drainage" changed to "Storm Drain". Notice the legend showing different structure types in the storm drain network. Access hole names start with "MH", inlet names start with "DI", and pipe names start with "SL".

2. Zoom into the area shown in Figure 2.

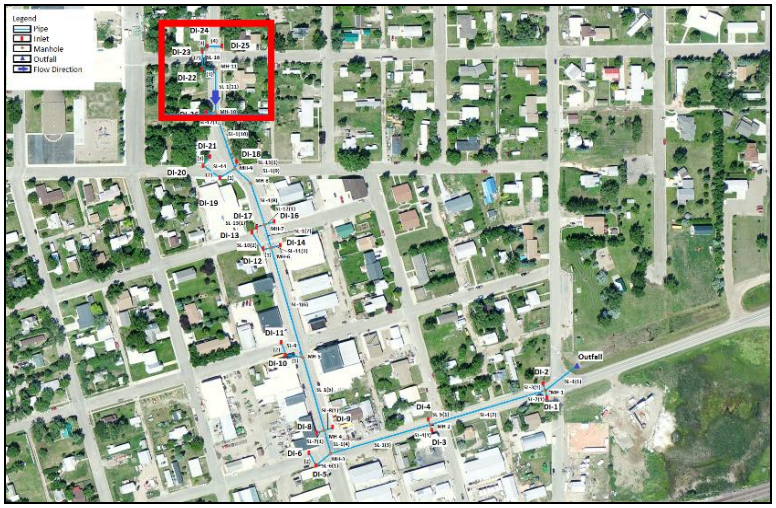

Figure 2 Zoom in to the area marked in red

3. Using the **Create Feature Arc** tool, create an arc from inlet "DI-25" to inlet "DI-24". Double-click to end the arc.

Remember to always create the arcs from upstream to downstream. In the "Map Data" section of the *Display Options* dialog, there is an option for *Link Arrows*. This option can be turned on to determine the flow direction, if needed. If an arc was created from downstream to upstream, use the **Select Feature Arc** tool to right-click on an arc and select **Reverse Directions**.

4. Repeat step 3 for each pipe segment, making nodes at each access hole (MH), inlet (DI), and the outfall at the downstream end of the pipe network. Be sure to create arcs for secondary lines as well.

Do not create extra nodes or vertices. Only the access holes, inlets, and the outfall should be nodes or vertices, and there should be no vertices in between.

5. When finished creating all of the arcs, turn off "Aerial.tif" in the Project Explorer.

6. **Zoom** in and review the pipe network to make sure there are no gaps between pipes, there are no nodes other than those representing access holes, inlets, or outfalls.

7. Select the **Select Feature Vertex** tool.

8. Select *Edit* | **Select All** to select all the vertices.
9. Select *Feature Objects* | **Vertex ↔ Node** to convert all the selected vertices to nodes in order to assign attribute data at these node locations.
10. Right-click "Storm Drain" and select **Zoom To Layer**.

The network should appear similar to Figure 3.

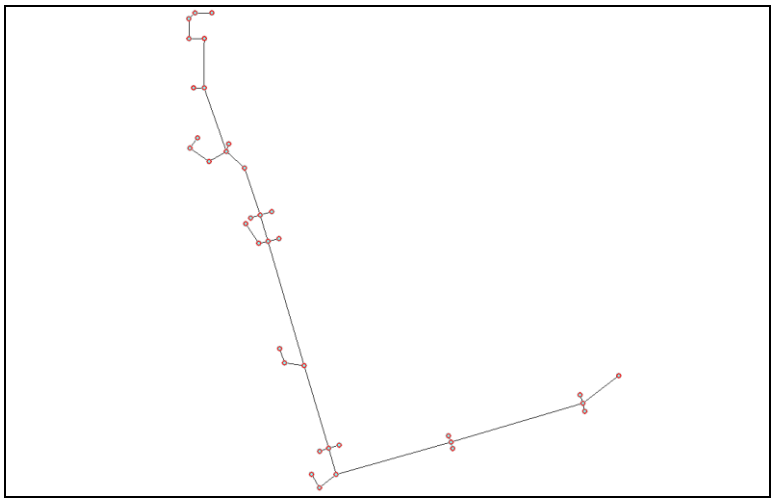

Figure 3 Pipe network with nodes at each access hole, inlet, and outfall

11. Select *Storm Drain* | **Map → 1D Schematic** to bring up the *Select Model* dialog.
12. Select *HY-12* from the drop-down and click **OK** to close the *Select Model* dialog.
13. **Save** the project.
14. Click **No** if asked to save image files to the project directory.

The hydraulic schematic is now created (Figure 4).

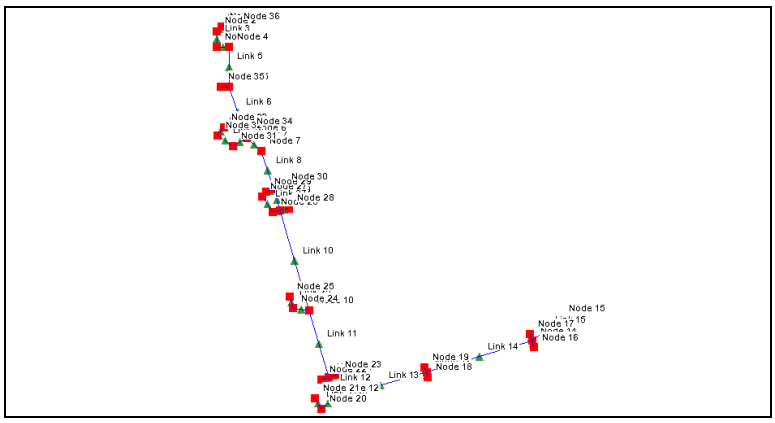

Figure 4 1D schematic of pipe network

4 Defining HY-12 Structure Information

After defining the schematic, it is important to define structure information for the HY-12 model. A structure represents a hydraulic or hydrologic computation object that requires

input and provides output. Some of the output, such as a discharge flow or a hydrograph from a rational method computation, may be used in a structure located downstream in the model. One or more structures are defined at each link or node.

Structures that cannot be represented by a line—such as an access hole, an inlet, or a rational method sub-basin—are defined at nodes. Structures that can be represented by a line—such as a pipe or a gutter—are defined at links. Some structures only have interfaces in the advanced HY-12 interface and must be defined there rather than in the simplified interface.

This tutorial will only work with the pipe network segment downstream from (but not including) the "SL-1(3)" link (the area within the red box in Figure 5). Inlet, access hole, pipe, and outfall names will be entered for this limited set of structures. This is to demonstrate how this information is entered. To save time, the fully-completed project will be then be imported before defining the project parameters for these structures and running HY-12.

For more information about each of these structures, their computations, and their file formats, refer to the WMS Help file or the FHWA HY-12 and Hydraulic Toolbox documentation.[3]

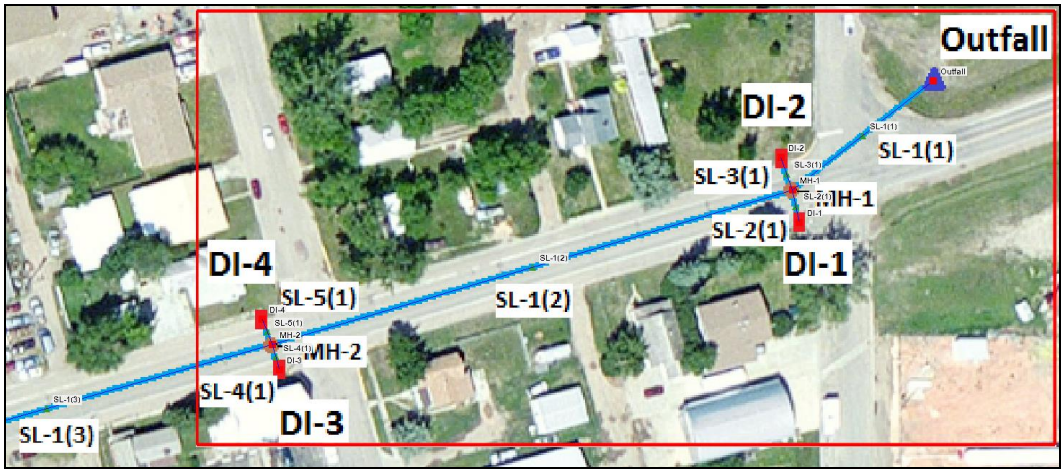

Figure 5 The section of the pipe network discussed in the tutorial

4.1 Defining Names

1. Select "HY-12 Hydraulic Schematic" in the Project Explorer.
2. Turn on "Aerial.tif" in the Project Explorer.
3. **Zoom** in to the area indicated in Figure 5.

Notice that this changes the selected module to the **Hydraulic Modeling** module.

4. Using the **Select Hydraulic Node** tool, double-click on the node labeled "MH-1" on the background map to bring up the *HY-12 Properties* dialog.

[3] See https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm.

5. Enter "MH-1" in the *Name* column of the spreadsheet and click **OK** to close the *HY-12 Properties* dialog.
6. Repeat steps 4–5 for "MH-2", naming it "MH-2".
7. Repeat steps 4–5 for the "Outfall" node, naming it "Outfall".
8. Repeat steps 4–5 for storm drain inlets "DI-4", "DI-3", "DI-2", and "DI-1". Start at "DI-4" and continue downstream to "DI-1".
9. Verify that the names of all of the nodes from the above steps have been changed (meaning they no longer have "Node" in the name).
10. Using the **Select Hydraulic Link** tool, double-click on the link labeled "SL-5(1)" on the background image to bring up the *HY-12 Properties* dialog.
11. Enter "SL-5(1)" in the *Name* column and click **OK** to close the *HY-12 Properties* dialog.
12. Repeat steps 10–11 for the five remaining downstream pipe segments (labeled on the background image as "SL-4(1)", "SL-1(2)", "SL-3(1)", "SL-2(1)", and "SL-1(1)"), using the corresponding name in the background image for each.
13. Verify that the names of all of the links from the steps 10–12 have been changed (meaning they no longer have "Link" in the name).
14. Turn off "Aerial.tif" in the Project Explorer.
15. **Frame** the project.

The pipe network should appear similar to Figure 6.

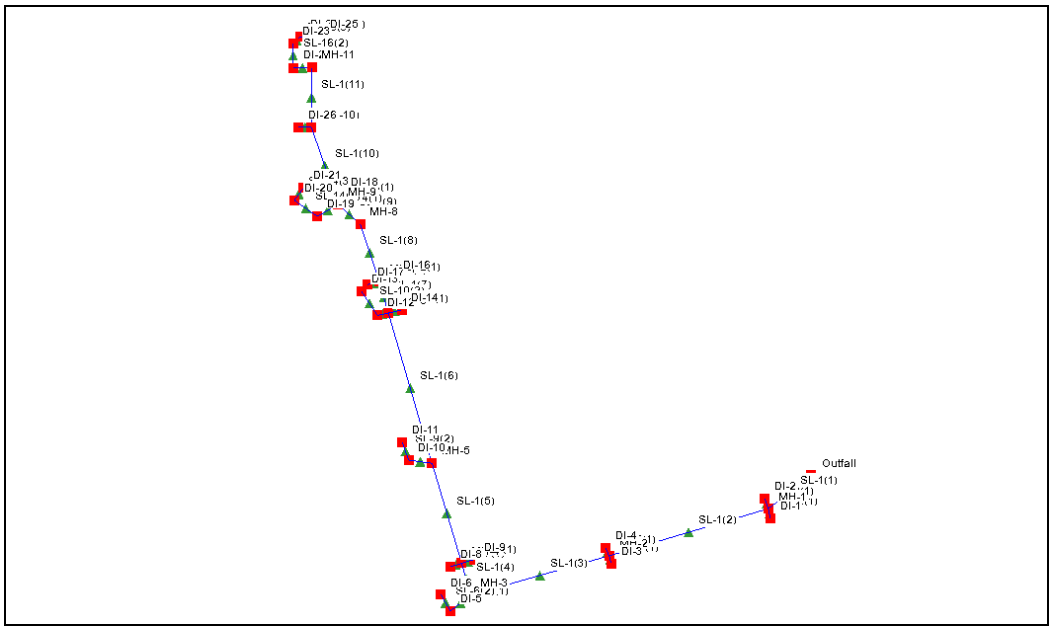

Figure 6 All nodes and links renamed

4.2 Defining Pipes

1. **Zoom** in to the area of the six links edited in the previous section.

2. Using the **Select Hydraulic Link** tool while holding down the *Shift* key, select all six links edited in the previous section, then right click on one of the selected links and select **Edit Parameters…** to bring up the *HY-12 Properties* dialog.
3. On the *ALL* row, select "Pipe" from the drop-down in the *Structure Type* column.
4. On the *ALL* row, select "<NONE>" from the drop-down in the *Shape* column.

Setting the pipe shape to "<NONE>" tells WMS to use the default HY-12 circular pipe shape. This allows manually entering a pipe diameter instead of using the library of diameters in the HY-12 shape database file.

5. For all pipes, set the following:
   - Enter "1.0" in the *Diameter/Span (ft/m)* column.
   - On the *ALL* row, enter "0.08333" in the *Wall Thickness (ft/m)* column.
   - On the *ALL* row, enter "0.013" in the *Pipe Manning's n* column.
6. For pipes "SL-1(1)" and "SL-1(2)", set the following:
   - Enter "2.0" in the *Diameter/Span (ft/m)* column.
   - Enter "0.16666" in the *Wall Thickness (ft/m)* column.
7. For pipe "SL-5(1)", set the following:
   - Enter "1.5" in the *Diameter* column.
   - Enter "0.125" in the *Wall Thickness (ft/m)* column.

4.3 Defining Inlets and Access Holes

1. At the top of the *HY-12 Properties* dialog, select "All" from the *Show* drop-down and "Nodes" from the *Attribute type* drop-down.
2. On the *ALL* row, check the box in the *Define Access Hole* column and enter "4.0" in the *Diameter/Width (ft/m)* column.
3. Select "Name" from the *Sort based on* drop-down.

This turns on access holes for all nodes and assigns a diameter of 4 feet to each. Next, turn off the access holes for nodes that do not have them and adjust the access hole diameter for some of them.

4. Uncheck the box in the *Define Access Hole* column for nodes "DI-1", "DI-2", "DI-3", "DI-4", and "Outfall".
5. Enter "5.0" in the *Diameter/Width (ft/m)* column for "MH-1".
6. Check the box in the *Define Inlet* column for "DI-4", "DI-3", "DI-2", and "DI-1".

This turns on the gutter inlet option for these nodes.

7. Check the box in the *Define Outfall* column for "Outfall".
8. On the *ALL* row, check the box in the *Assume Full Capture* column.
9. Click **OK** to close the *HY-12 Properties* dialog.

10. Select *HY-12* | **Assign Lengths and Orientations**.
11. When advised that links were assigned length, click **OK**.
12. When advised that links were assigned orientation, click **OK**.
13. **Save** the project.
14. If asked to save image files, click **No**.

4.4 Assigning Node Invert and Surface Elevations and Flows

1. Using the **Select Hydraulic Node** tool, double-click on "Outfall" to bring up the HY-12 Properties dialog.
2. Select "All" from the *Show* drop-down.
3. Select "Name" from the *Sort based on* drop-down.
4. Enter the following invert and (ground) surface elevations in the **HY-12 Properties** window.

Node Name	Surface Elevation	Inlet Invert Elevation	Access Hole Invert Elevation	Outfall Invert Elevation
DI-1	1922.67	1920.48		
DI-2	1922.67	1920.04		
DI-3	1925.11	1922.44		
DI-4	1924.83	1922.29		
MH-1	1923.08		1917.7	
MH-2	1925.61		1919.96	
Outfall	1922.71			1917.33

Note that some nodes may have both a gutter inlet and an access hole (this is not the case for the nodes discussed in this tutorial). In such cases, the same value would be entered for both *Inlet Invert Elevation* and *Access Hole Invert Elevation*.

5. Enter the following 10-year inflows for each of the inlets by entering the following values in the *Inflow(cfs/cms)* column immediately to the right of the *Define Inlet* column:

Node Name	Inflow (cfs)
DI-1	0.66
DI-2	1.92
DI-3	0.65
DI-4	4.91

For this tutorial, it is assumed that the access holes do not have any inflows.

4.5 Assigning Pipe Invert Elevations

Now assign the invert elevations for the pipes.

1. Select "Links" from the *Attribute type* drop-down.
2. Select "Name" from the *Sort based on* drop-down.
3. Enter the appropriate values from the following table into the *Upstream Invert Elevation (ft/m)* and *Downstream Invert Elevation (ft/m)* columns:

Link Name	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)
SL-1(1)	1917.70	1917.33
SL-1(2)	1919.97	1918.48
SL-2(1)	1920.49	1920.28
SL-3(1)	1920.05	1919.85
SL-4(1)	1922.46	1922.16
SL-5(1)	1922.31	1921.99

4. Click **OK** button to close the *HY-12 Properties* dialog.
5. **Save** the project.
6. If asked to save image files, click **No**.

5 Defining HY-12 Project Parameters

Project parameters are global parameters that are used in the entire project.

1. Select "HY-12 Hydraulic Schematic" in the Project Explorer to make it active.
2. Select *HY-12* **| Edit Project Parameters…** to bring up the *HY-12 Properties* dialog.
3. In the *Project* section, enter "Culbertson" as the *Project Name*.
4. Enter "10 Year Flows" as the *Project Notes*.
5. Enter your name as the *Project Designer*.

The following are in the *Project Run Parameters* section:

6. Click **Select File…** in the *Units* column to bring up the *Select an HY-12 Material Database File* dialog.
7. Select "txt file (*.txt)" from the *Files of type* drop-down.
8. Select "materialDB.txt" and click **Open** to exit the Select an *HY-12 Material Database File* dialog.

Notice that it now states "File Exists and Read Correctly".

9. Select "English Units" from the *HY12 Unit System* drop-down.
10. Select "Report Errors, Warnings, and Notices" from the *Error Reporting* drop-down.
11. Select "Specify length, angle, and elevations, compute Slope" from the *HY12 Calculate Geometry* drop-down.

The following are in the *Design or Analysis Parameters* section:

12. Select "Analyze" from the *Analyze or Design?* drop-down.
13. Enter "1.0" as the *Drop Allowed in an Access Hole*.
14. Select "Match Crown Elevations" from the *Method to match pipes across access holes* drop-down.

The following are in the *Steady or Unsteady Parameters* section:

15. Select "Steady Flow" from the *Steady or Unsteady Flow* drop-down.
16. Turn off *Use one IDF for Entire Project* and *Ignore Gutter Inlets*.
17. Turn on *Assume Gutter Inlets Capture All Flow*.

The last option is in the *Interface Options* section:

18. Turn off *Use Advanced Interface*.
19. Click **OK** to close the *HY-12 Properties* dialog.
20. **Save** the project.
21. If asked to save image files, click **No**.

6 Importing the Full Project and Running HY-12

In Sections 4 and 5, a limited set of the full parameters was entered. Before proceeding, open a WMS project with all of the parameters entered.

1. Click **New** to reset the WMS settings to their default state.
2. Click **Open** to bring up the *Open* dialog.
3. Select "WMS XMDF Project Files (*.wms)" from the *Files of type* drop-down.
4. Select "CulbertsonDrainageComplete.wms" and click **Open** to import the project and exit the *Open* dialog.
5. Switch to the **Hydraulic Modeling** module.

It is good practice to review all the entered parameters to make sure they have been entered correctly.

1. Using the **Select Hydraulic Node** tool, double-click on "Outfall" to bring up the HY-12 Properties dialog.
2. At the top of the *HY-12 Properties* dialog, select "All" from the *Show* drop-down and "Nodes" from the *Attribute type* drop-down.
3. Review the various parameter columns for the seven nodes to make sure they are complete.
4. Select "Links" from the *Attribute type* drop-down.
5. Review the various parameter columns for the six links to make sure they are complete.
6. Click **OK** to close the *HY-12 Properties* dialog.

6.1 Running HY-12

This project contains all of the necessary HY-12 model parameters, so HY-12 can now be run.

1. Select *HY-12* | **Run HY-12…** to bring up the *Run HY-12 Simulation* dialog.
2. If prompted, locate the HY-12 application on the computer. By default, the file is located at *C:\Program Files (x86)\HY-12 1.2\hy12.exe*.

3. In the *Input Files* section, click **Select File…** in the *Select* column on the *Material Database* row to bring up the *Select an HY-12 Material Database File* dialog.
4. Select "txt file (*.txt)" from the *Files of type* drop-down.
5. Select "materialDB.txt" and click **Open** to exit the *Select an HY-12 Material Database File* dialog.
6. Verify that the *Selected Material Database* row now has "File Exists and Read Correctly" in the *Filename and path* column.
7. In the *Results Files* section, click **Select File…** in the *Select* column on the *HY-12 Output File* row to bring up the *Select an HY-12 Input File* dialog.
8. Select "h12 file (*.h12)" from the *Files of type* drop-down.
9. Enter "Results.h12" as the *File name* and click **Save** to exit the *Select an HY-12 Input File* dialog.
10. Click **Run Simulation** to bring up the *Model Wrapper* dialog.
11. Once the model finishes, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog and bring up the *View Data File* dialog. If the *Never ask this again* option has previously been checked, this dialog will not appear. If this is the case, skip to step 7.
12. Select the desired text editor from the *Open With* drop-down and click **OK** to close the *View Data File* dialog and open the "Storm Drainage System Report" in the selected text editor.
13. Switch to the WMS window.

Any of the files used to run HY-12 or created by HY-12 can be reviewed by clicking the **View…** button in the *View/Notes* column in the *Run HY-12 Simulation* dialog.

14. Review the HY-12 report file and note the warnings and/or notices. Use the *HY-12 ID Lookup* dialog as a reference to help better understand the report.
15. When done reviewing the "Storm Drainage System Report", click the  in the top right corner of the text editor window to close the text editor and return to WMS.
16. Review any other files as desired. When finished, click **Close** to exit the *Run HY-12 Simulation* dialog.
17. Select *HY-12* | **View HY-12 Structure IDs** to bring up the *HY-12 ID Lookup* dialog.

This dialog displays a table view of the Link and Node names next to the HY-12 IDs. Use this as a reference when reviewing the "Storm Drainage System Report". The report uses HY-12 IDs to reference the various structures in the simulation. The *Sort based on* drop-down can be used to sort the list of IDs by one of the columns.

18. Click **Done** to close the *HY-12 ID Lookup* dialog when done.

7 Viewing HY-12 Output

Whether or not the model run was successful, HY-12 generates a report file. If the run was successful, WMS imports the results, which include the energy and hydraulic grade line (EGL, HGL) elevations at each node in the model. For hydrographic simulations, HY-12 computes a hydrograph at each node in the model.

If desired, view a plot of the EGL or the HGL for a node at each time step in the model. Both of these results are read into WMS after an HY-12 run is completed. This section will show how to view the results in the HY-12 output file and graphically in WMS.

7.1 Viewing Detailed Output

1. **Frame** the project.
2. Using the **Select Hydraulic Node** tool, select any node.
3. Select *HY-12* | **View Detailed Link/Node Output…** to bring up the *View Data File* dialog. If the *Never ask this again* option has previously been checked, this dialog will not appear. If this is the case, skip to step 5.
4. Select the desired text editor from the *Open With* drop-down and click **OK** to close the *View Data File* dialog and open the report in the desired text editor.
5. A report giving detailed link and node computation results about the selected node will appear in the text editor. When done reviewing the HY-12 output file, click the in the top right corner of the text editor window to close the text editor and return to WMS.

Feel free to review any other node computation results as desired.

7.2 Viewing HGL and EGL Plots

Hydraulic Grade Line (HGL) and Energy Grade Line (EGL) plots can be viewed by selecting one or more non-branching links in the model. The plot shows all pipes and access holes between the selected links and nodes.

1. Using the **Select Hydraulic Node** tool, select the "Outfall" node.
2. While holding down the *Shift* key, select node "DI-25" (the most upstream node).
3. Select *HY-12* **| View EGL and HGL Plots…** to bring up the *HGL and EGL Profiles* dialog (Figure 7).
4. Review the HGL, EGL, and ground surface elevation plots and values. When done, click **Done** to close the *HGL and EGL Profiles* dialog.

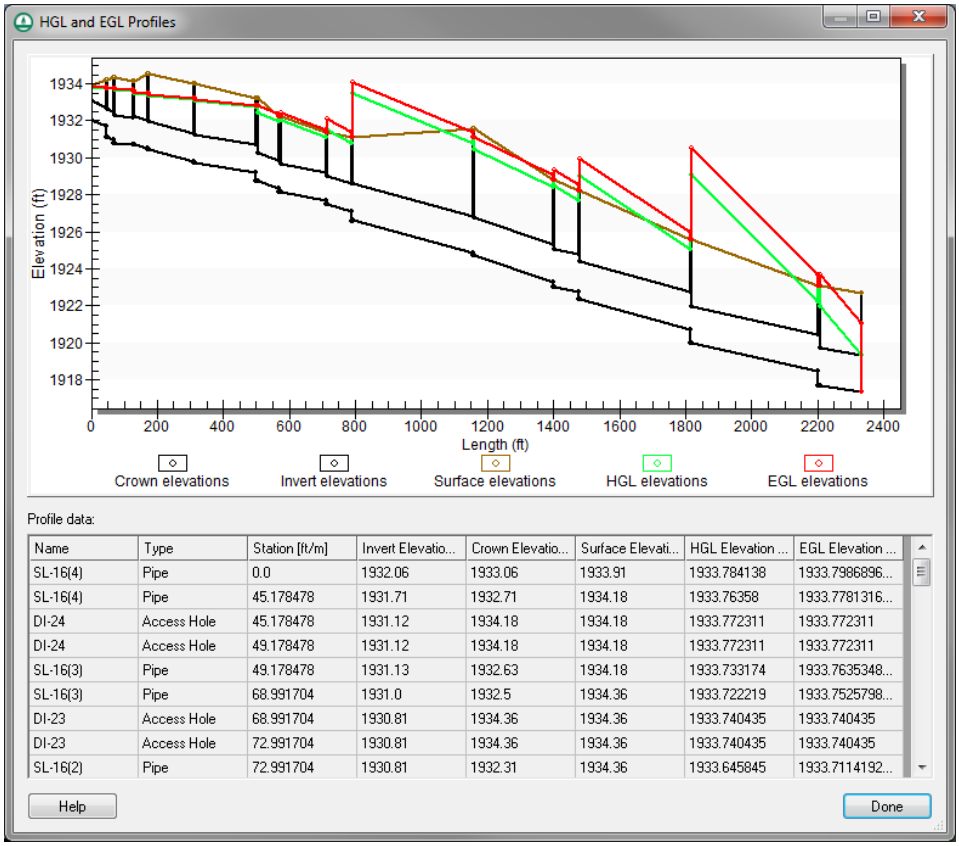

Figure 7 HGL and EGL Profiles dialog

8 Conclusion

This concludes the "Storm Drain Modeling – HY-12 Analysis with a Background Map" tutorial. The following key topics were discussed and demonstrated:

- Drawing a storm drain schematic through importing a background image and defining the network
- Defining HY-12 names, pipes, inlets, and access holes
- Assigning node invert and surface elevations and flows
- Assigning pipe invert elevations
- Defining HY-12 project parameters
- Running HY-12 and viewing detailed output and plots