

MICHIGAN DEPARTMENT OF TRANSPORTATION

DRAINAGE AND UTILITIES GUIDANCE

Preamble

This Document provides guidance to administrative, engineering, and technical staff. Engineering practice requires that professionals use a combination of technical skills and judgment in decision making. Engineering judgment is necessary to allow decisions to account for unique site-specific conditions and considerations to provide high quality products, within budget, and to protect the public health, safety, and welfare. This manual provides the general operational guidelines; however, it is understood that adaptation, adjustments, and deviations are sometimes necessary. Innovation is a key foundational element to advance the state of engineering practice and develop more effective and efficient engineering solutions and materials. As such, it is essential that our engineering manuals provide a vehicle to promote, pilot, or implement technologies or practices that provide efficiencies and quality products, while maintaining the safety, health, and welfare of the public. It is expected when making significant or impactful deviations from the technical information from these guidance materials, that reasonable consultations with experts, technical committees, and/or policy setting bodies occur prior to actions within the timeframes allowed. It is also expected that these consultations will eliminate any potential conflicts of interest, perceived or otherwise. MDOT Leadership is committed to a culture of innovation to optimize engineering solutions.

The National Society of Professional Engineers Code of Ethics for Engineering is founded on six fundamental canons. Those canons are provided below.

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform Services only in areas of their competence.
3. Issue public statement only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, reasonably, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

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INTRODUCTION

MDOT Engineering Support Services Unit in partnership with MDOT Hydraulics Unit has prepared this software guide for design and analysis of stormwater drainage systems with the Drainage and Utilities module of Bentley Systems OpenRoads Designer software, for MDOT trunkline projects. This document is intended to be used along with the MDOT Drainage Manual. Please refer to the MDOT Drainage Manual for design guidelines, requirements, and notes on intended calculation methods. If information that is presented in this document conflicts with anything in the MDOT Drainage Manual, the Drainage Manual has precedence.

For questions related to this guidance and/or the use of Bentley OpenRoads Designer Drainage and Utilities Software for MDOT projects contact:

MDOT-Drainage-Utility@michigan.gov

For questions regarding hydraulic design procedures contact the MDOT Hydraulics Unit.

The *Drainage and Utilities* (D&U) module of Bentley Systems OpenRoads Designer software includes tools for storm drainage design and analysis.

D&U has two drainage calculation options:

Analysis mode will not change the physical characteristics of the storm drainage

Design mode may change the physical characteristics.

At this time, MDOT is not recommending the use of the design mode of the program for storm drainage layout.

Drainage and Utilities is not permitted for culvert design. For appropriate software for the sizing of culverts please see 5.3.1 in the MDOT Drainage Manual.

The program contains drainage components, feature definitions and flex tables that have been configured to follow MDOT standards and methods. These are meant to aid the engineer. The engineer is responsible to verify drainage item properties.

Please note that if your network extends over 100 Inlets in one model you will trigger an additional license.

D&U uses the terrain model referenced into a DGN file to display the storm drainage and other utilities in 2D and 3D. Drainage structures and conduits are fully integrated in graphic and database functions.

D&U can be used to:

- Analyze the existing storm drainage for a project site, a single system or multiple
- Analyze the existing storm drainage and upgrade for a project site as needed/required
- Analyze proposed storm drainage system(s) for a project site
- Analyze conflicts between existing utilities and proposed drainage.
- Report on Spread, Structure Sizes, and Conduit sizes

SECTION 1 - DRAINAGE AND UTILITIES TOOLS

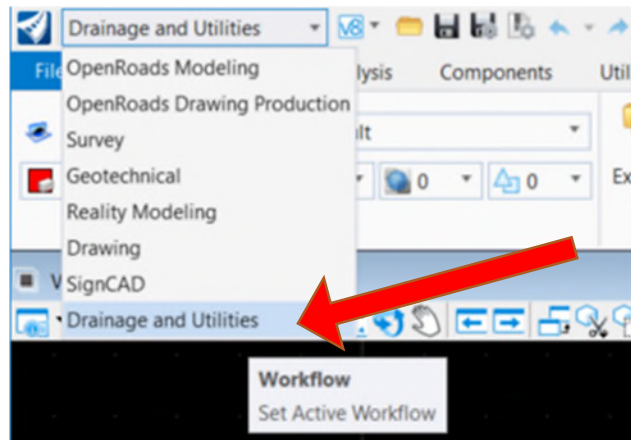
This guide provides an overview of the D&U tools that are most commonly used for MDOT projects. See the Bentley Online Help or contact Engineering Support for commands not detailed in this document.

Drainage and Utilities Interface

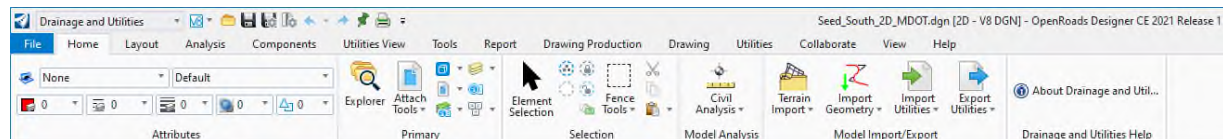
To access the D&U tools within OpenRoads Designer, select the Drainage and Utilities workflow from the drop-down list at the upper left side of the ribbon.

This sets the active workflow and loads the D&U ribbon.

The ribbon is organized with *Tabs* and *Groups*.



Home Tab



Attributes – Shows all attributes that are active

Primary – opens the explorer, properties, attach tools for references and raster files, level manager, level displays (common MicroStation tools)

Selection – houses the Element Selection tools, Cut, Paste and Fence tools

Model Analysis – Civil Analysis gives the user the option to analyze various items

Model Import/Export - various import and export options.

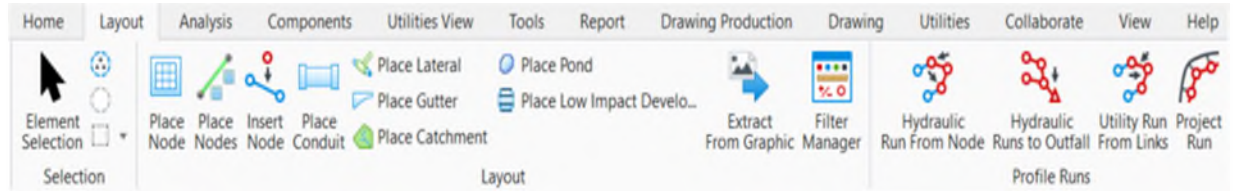
Terrain Import – creates a terrain model from File, Ascii File, Elements, and Point Cloud etc., see Bentley Online help for more Terrain options.

Import Geometry – from various file types.

Import Utilities – import drainage data from various other software Bentley Online help.

Export Utilities – export drainage data to various other software, see Bentley Online help

Layout Tab



The **Layout** tab allows the user to place utility structures and connect the structures with conduits. The utilities can be below the surface, on the surface or above the surface.

Layout - this is the main tool bar used to place utilities, such as drainage structures and pipes.

Place: Nodes, Conduit, Lateral, Gutter, and Catchment - are the tools to place the physical locations of the elements of the Drainage Model. These are predominately place with Pre-defined Feature definition built from MDOT's Standards.

Profile Runs - are profiles along a series of structures. Different profiles can be created from the Start Node or the Outfall and Links can be added to a profile run.

Toggles – allows for turning on/off Civil Accudraw and Civil Message Center. Civil message center displays errors, messages, and MicroStation commands.

Note: Place Pond and Low Impact Development Tools are not recommended at this time.

Analysis Tab



The **Analysis** tab sets calculation parameters, standards, constraints, and scenarios for drainage items.

Calculation - Contains tools to set up and compute analysis of the Drainage & Utilities systems.

Scenarios – contains the Scenario Manager and Scenario Comparisons.

Alternatives – contains the various hydraulic parameters that can be adjusted within the networks.

Options – contains the analysis calculation options.

Compute – runs the analysis for the current scenario.

Validate – checks the network for errors and warnings prior to analyzing the network.

Calculation Summary – summary of the active network.

Notifications – displays network warnings or errors.

Analysis Tools – holds the Compute Center (one toolbox for access to calculations), Default Design Constraints are set from the MDOT workspace and should be reviewed for project specific constraints (i.e. max. spread, conduit slope), Show Gutter Flow will show the path of any bypass from catch basins.

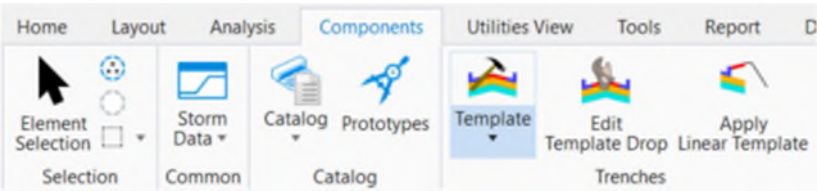
Compute Center – this Controls the global Parameters used for drainage calculations in the model.

Show Gutter Flow – shows gutter flow paths within the drainage dgn.

Default Design Constraints – contains values for gravity pipe, node, and inlet that will produce warnings if conditions are not met during analysis.

Analysis Views – contains the flex tables – MDOT specific flex tables for hydraulic analysis have been established to mirror desired deliverables, queries can be used to report on specific item

Components Tab



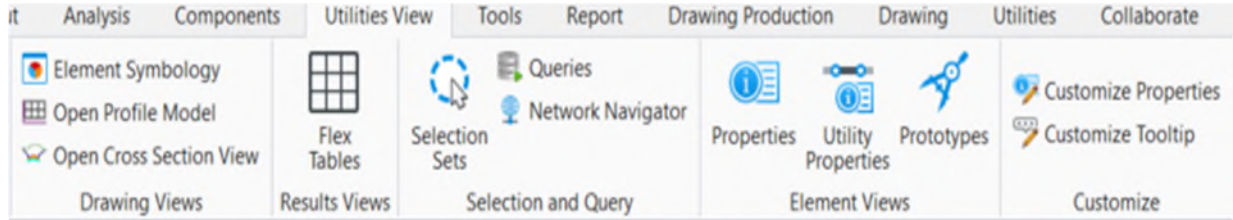
The **Components** tab is used to establish project specific storm data, drainage properties and settings

Common – Storm Data, contains Global Storm Events and project wide parameters including Time of Concentration

Catalog - access to engineering libraries, inlet – gutter – conduit catalogs, culvert inlet coefficients and rainfall curves from csv files. Prototypes for drainage items are set in workspace and can be updated to project specific data if needed.

Trenches - access to template tools – edit template drop – apply linear template for trenches used in the design

Utilities View Tab



The **Utilities View Tab** tools open views of various drainage properties.

Drawing Views - element symbology allows control how elements and associated label are displayed; open profile model generates a view presenting a desired feature in profile; open cross section view creates a dynamic cross section of a selection item; these are the ORD Modeling tools. These have been preset in the MDOT Workspace.

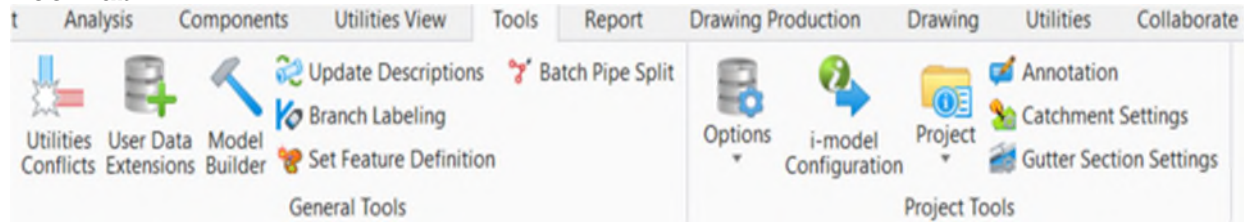
Results Views - houses the Flex Tables – MDOT Flex Tables for hydraulic analysis have been established and the user can verify the input data and see results for all elements of a specific type in a tabular format.

Selection and Query - create, edit, and navigate selection sets; display all queries in the current hydraulic model; open the network navigator.

Element Views - Properties displays a dialog box containing selected elements associated properties; Utility Properties displays the subsurface utilities and hydraulic analysis of a selected element; Prototypes displays and allows edit to default values for elements in a network. Prototypes have been set-up to MDOT Standards, the engineer needs to verify the items in the project to ensure correct conditions apply (See MDOT Drainage Manual).

Customize - Customize Properties allows customization and changes to default user interface; Customize Tooltip allows customization of tooltips that appear when hovering over an element.

Tool Tab



The **Tools tab** is divided into general tools and project tools.

General Tools

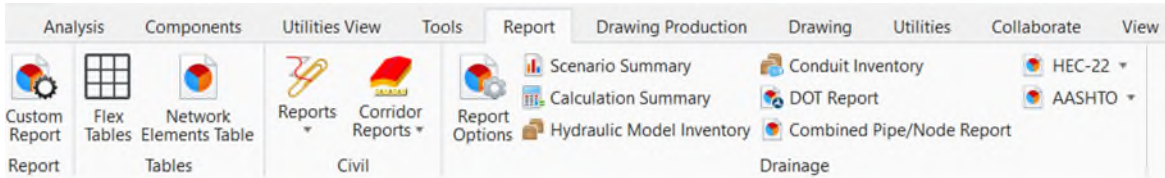
Utilities Conflicts allows detection of physical clashes and clearances between elements within influence area.

User Data Extensions allows adding data fields to the hydraulic model toolbox.

Model Builder allows existing GIS assets to construct a new model or update an existing model; update descriptions of conduits in the model; branch labeling sets the labels of conduits; set feature definition allows setting/locking a feature definition. Model builder also serves as a database import clearinghouse for the user data extension information.

Project Tools - houses project defaults, i-model configuration to export drainage calculations, project properties, synchronize drawing and annotation tool to label the drainage items.

Report Tab



The **Report tab** gives the user fast access to various reports for Tables, Civil and Drainage and Utilities.

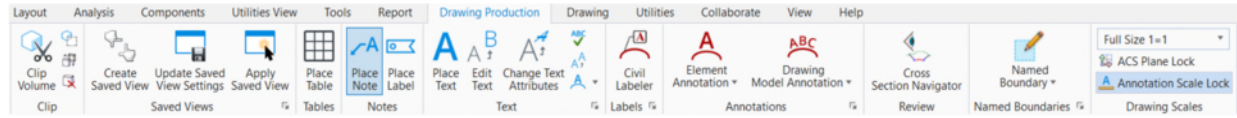
Report - Custom Report allows the user to assemble a wide variety of model input, results, graphs, etc. in a customized report.

Tables - access to all Flex Tables and Network Elements Table for the utility project

Civil - access to civil reports such as horizontal geometry report and corridor reports

Drainage - access to various reports and summaries for the drainage design

Drawing Production Tab



The **Drawing Production tab** is divided into tables, notes, text, annotation and named boundaries,

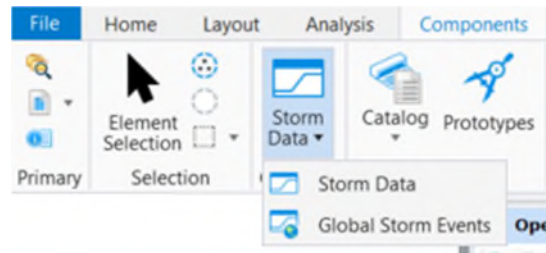
Drawing Production tools enables the user to place notes and labels; place and edit text; annotate an individual element or an entire model; enables sheet production through the Named Boundary tool.

SECTION 2 - GETTING STARTED

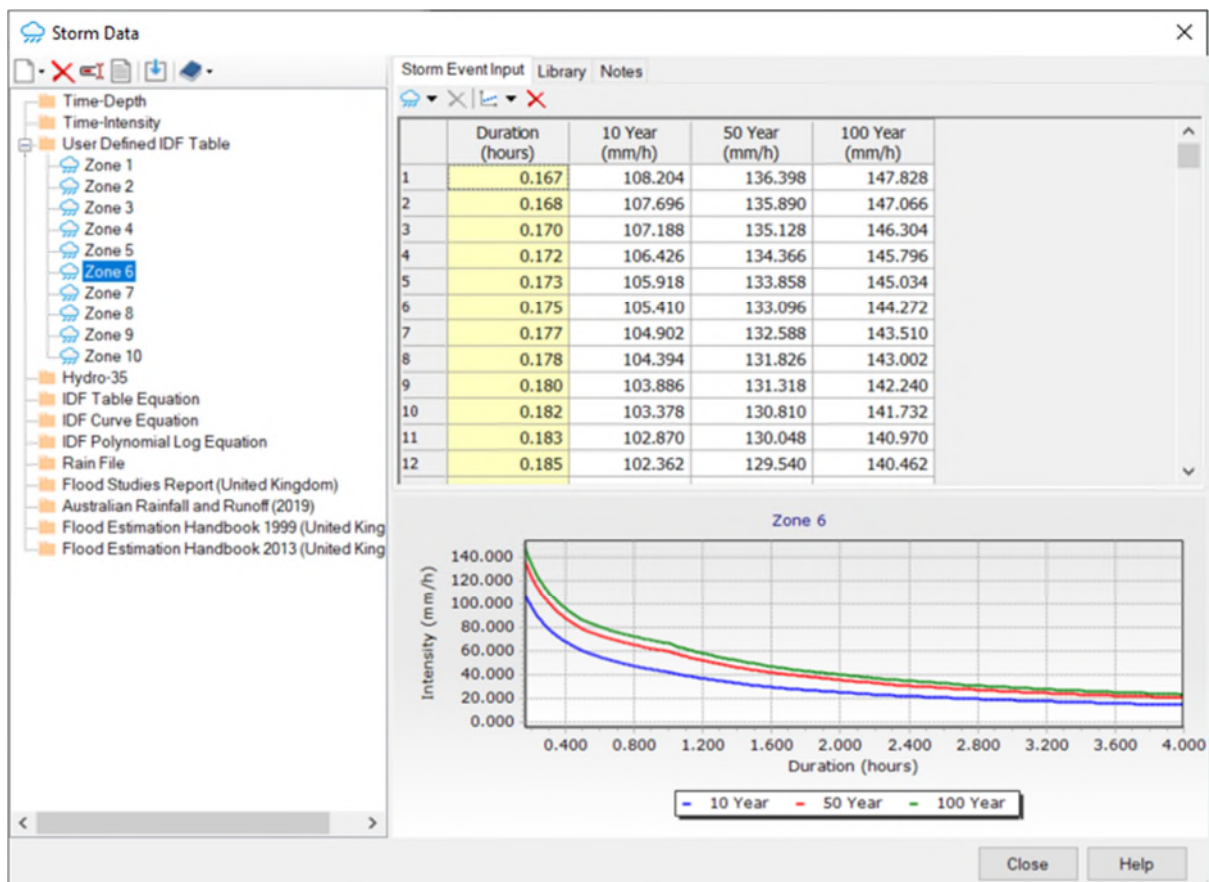
Compile the information and material necessary to complete a drainage design. Required items for a drainage design (existing or proposed) include *storm data* and *terrain data* for the project.

IDF Tables

The MDOT workspace contains pre-populated IDF Tables which contain the rainfall data from the Drainage Manual. The Designer should make sure the correct seed file is used and the correct rainfall zone is selected.



The **IDF-Tables** for the project storm data are located in the Storm Data dialog. The options available for use of an IDF-table will be covered later in this manual.



Terrain

Drainage and Utilities uses the terrain model referenced into a DGN file to display the storm drainage and other utilities in 2D and 3D models. Drainage structures and conduits are fully integrated in graphic and database functions. The data **is stored in** the graphics within the design file (*.dgn file).

Drainage and Utilities can use the elevations from the active terrain, but Drainage and Utilities can only work with **one terrain**; this can make it necessary to merge terrains such as existing, LIDAR, point clouds and/or proposed into one terrain. The designer should create a specific “drainage terrain” for use with the drainage layout and calculations.

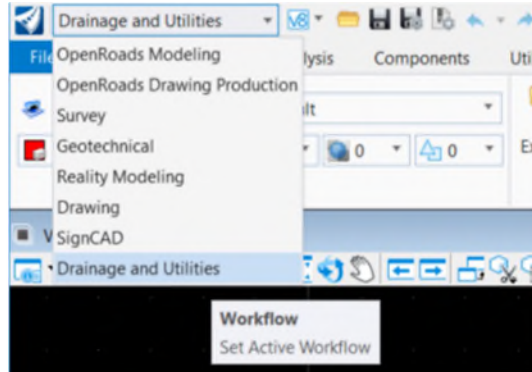
This “drainage terrain” is in its own MicroStation DGN file and is referenced into the “drainage” MicroStation DGN file.

Create Drainage Model (DGN file)

Ensure OpenRoads Designer Connect Edition is set to the correct Workspace and Workset. Create a new *.dgn file (2D) exclusively for your storm drainage layout, calculations, and utility conflicts.

1. From the **New** dialog box, **browse** to the proper discipline folder, enter the file Name.

2. Change the workflow to: **Drainage and Utilities** (upper left corner), open the **Drainage and Utilities Model** within the Explorer dialog box.



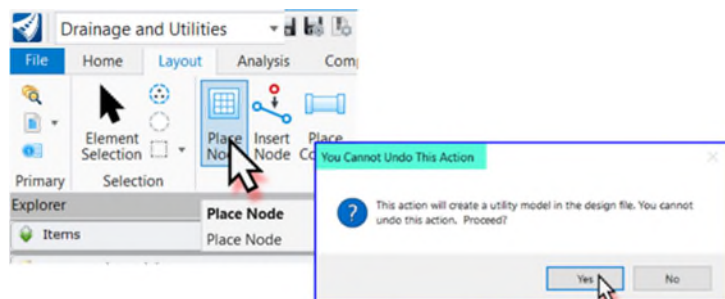
3. From the **Home** tab use the **Attach Tools - References** to attach the survey, terrain, aerials, and design files as needed. **Turn OFF** Levels as needed from the individual files.

4. Set the **Active Terrain**. Using the **Element Selection tool** click on the boundary line for the terrain, hover over it, select the tool **Set As Active Terrain Model**, this will make the terrain active and will be used for placing the drainage structures.

5. In the **2D view (Default)** override the Symbology and **turn off** triangles. Open the **Default 3D view** and set-up as needed to your preference.

6. **Save settings.**

7. The **Drainage and Utilities Hydraulic Engine** needs to be activated. From the **Layout** tab, select the **Place Node** command. This only has to be done once per utility model to create a hydraulic project. The Program only supports **One hydraulic project per dgn file**, but multiple systems can be placed and calculated.



The **You Cannot Undo This Action** message box will open, **click Yes**. This will open and prepare the Drainage and Utilities project in your DGN file, some context

menus will pop-up and disappear, wait until completed and your cursor comes back. Now you are ready to place your structures, conduits, catchment areas and do your calculations.

Set Defaults and Constraints

Some project specific properties, defaults and constraints need to be reviewed and set for each project, where possible MDOT standards have been set.

1. **Click** on the **Tools** tab and **select Options - Drainage**. The **Options** box opens.
 - **Hydraulic Model** tab: Pipe Length – Use 3D Length? Make sure this is unchecked.
 - **Units** tab: default unit system for new project is set to: **US Customary**, make sure all units are set correctly.

Click **OK**.

2. Click on the Analysis tab and select Default Design Constraints.

The MDOT workspace contains Defaults that are Pre-set. These constraints will trigger warnings within the design for you to edit at a later point.

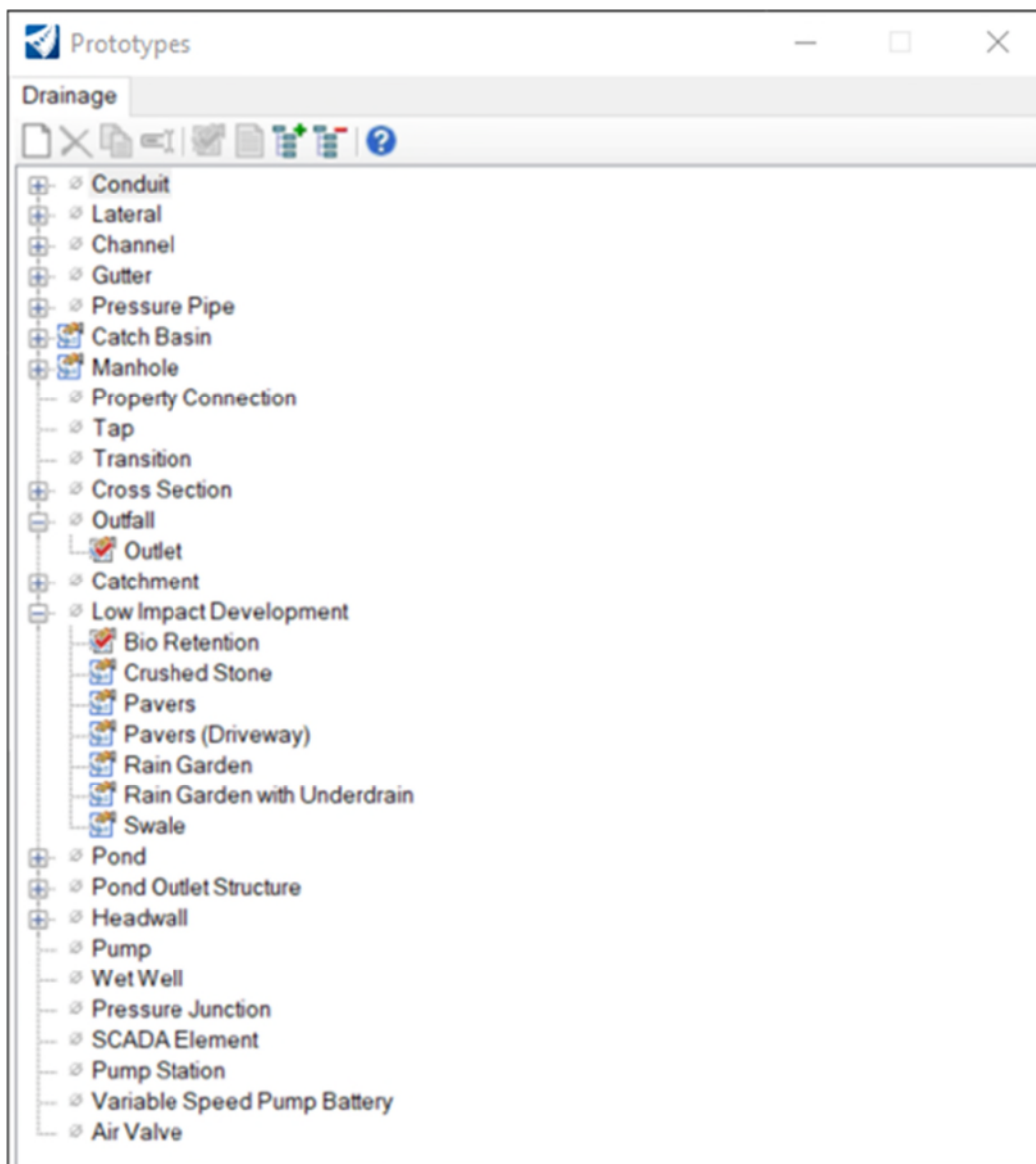
The constraints have been set to follow the *MDOT Drainage Manual* where possible. If you want Drainage and Utilities to design your drainage system, it is especially important to review Warnings received from these constraints. **The “Design” Function may change your default parameters**. The **Drainage and Utilities Help** menu should be used for each specific explanation of the **Default Design Constraints** topic. Project specific spread requirements may be different and may require further review.

PROTOTYPES

Prototypes allow for entering default values for elements in a drainage network and are used to **define the hydraulic properties of features**. A prototype works in cooperation with element templates and feature definitions to define the characteristics of a drainage feature. The most widely used conduits, gutters, catch basins, manholes, cross sections, catchments, and headwalls etc. have been set to **MDOT Standards**.

The properties for existing Features are loaded within prototypes within the items Hydraulic Analysis.

Click on **Components – Catalog - Prototypes**.



SECTION 3 – LAYING OUT THE DRAINAGE NETWORK

Creating a drainage DGN-file using the 2D seed as described previously will attribute items to the feature definitions that contains your feature symbology, level, element templates and annotations.

These feature definitions contain relevant information and properties will be updated as needed when feature definitions change.

Inlet Catalog

Needed Inlets inside MDOT workspace should be attached to corresponding Feature Definitions. The dimensions of all the inlet nodes (structures) available for design are stored in the **Inlet Catalog**.

Conduit Catalog

Conduits are placed between nodes such as catch basins, manholes and head- and endwalls.

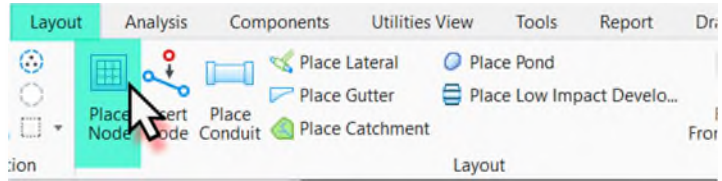
The conduit types within the MDOT workspace have been attached to the appropriate Feature Definition.

To view the inlet catalog: Click the **Components** tab – **Catalog – Inlet Catalog**

Place Node

Turn off the **Fill** in **View Attributes** to only see the outline of structures (catch basin, etc.), this will help when placing nodes and conduits.

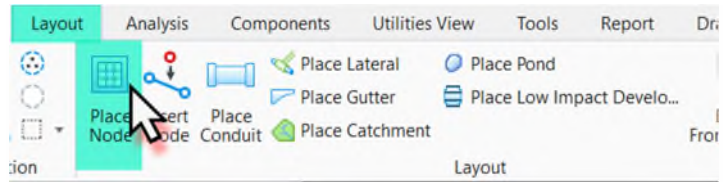
1. Select the **Place Node** command to lay out the drainage structures: catch basins, endwalls, etc.



2. Select the **Feature Definition**
3. Click on the reference element for node elevation (active terrain, edge of road, or preferably 3D corridor Line) or click reset to type a node elevation, type in 0.00 for vertical offset, this can be changed later. Rotate as needed to place.
4. Hover over the node to enable the context toolbox: properties, utility properties and delete. The node can be moved and rotated.
5. Continue placing more structures (catch basins, end structures or manholes). After you placed the last structure, right click once more, and select the Element Selection tool to end the Place Node command.

Place Culvert End (Node)

1. Select the **Place Node** command to place a culvert end.



2. Select the **Feature Definition**

3. Click on the reference element for node elevation (Use a corridor or a 3D line as an elevation reference) or click reset to type a node elevation, type in 0.00 for vertical offset. Rotate as needed to place.

4. After the conduit is placed click and hover over the culvert end for the context menu, click on properties.

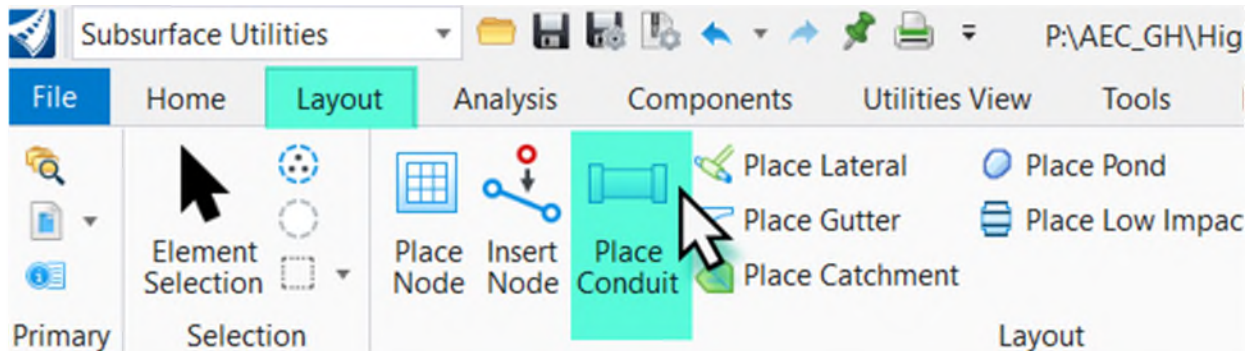
5. In the properties box, change the following

- Use Slope of Surface = **False**
- Match Slope of Conduit = **True**

Place Conduit

Conduits are placed between nodes such as catch basins, manholes and headwalls and end sections.

Note: If a structure is deleted all associated conduits connected to the node are also deleted.



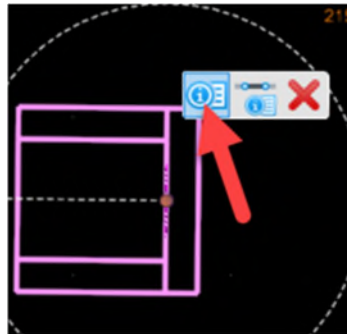
1. Select the **Place Conduit** command, choose the **Feature Definition** for the pipe you want to place. The Type: is greyed out – this comes from the conduit catalog already attached, for **Description** click on the down arrow to select the pipe size (example: 15”).
2. Follow the prompts: Select **Start Node**, in the drawing hover your cursor over/close to the first inlet (node i.e. catch basin), it will snap to the node where the conduit can connect, this is called the **Connection Region**. **Accept** (left click).
3. Select next node to make a connection. Again, hover your cursor close to the inlet to connect the conduit to (second node i.e. catch basin). **Accept** (left click).
4. Continue to place conduits to connect the drainage structures from the first inlet to the outlet for the system. Select the Element Selection tool to end the place conduit command.
5. Conduits will only attach to Nodes of the same Network Type (Storm conduits will not link with other networks such as communication, electric, etc.)

Input Invert Elevations

After completing the layout for the drainage structures and conduits you will enter the invert elevations for all structures and conduits, Drainage and Utilities sets conduit inverts to the bottom of the structures by default.

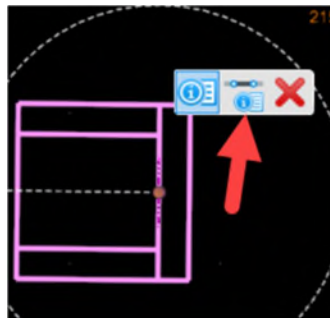
By selecting a placed utility feature, some feature properties can be edited, rotated and/or moved in the graphics. Also, the context toolbox displays and offers two options to input/edit utility information:

Properties - lists the properties such as level, color, feature, feature definition etc.;



Origin	6.588m,2.472m
Scale X	1.00000
Scale Y	1.00000
Feature Definition	HW_Outlet_18in
Feature Name	ES
Description	
Elevation is the In	False
Ground Elevation	215.074m
Invert Elevation	215.074m
Use Slope of Surf	True
Elevation Reference	
Baseline Reference	None
Utility ID	19
Match Slope of Cc	False
Utility Properties	Open Utility Properties
Point	6.588m,2.472m
X	6.588m
Y	2.472m
Rotation	179.351°
Rotation Reference	None
Absolute Angle	True

Utility Properties- lists every available hydraulic property including user customized properties. Note top menu in utility properties dialog grants access to both menus.



Properties - Storm Water Node - ES (19)	
Utilities: Drainage	
Add to Selection	
Property Search	
General	ES
Label	ES
Notes	<Collection 0 Items>
GIS-IDs	<Collection 0 Items>
Hyperlinks	<Collection 0 Items>
Referenced Culvert	<None>
Feature Definition	Node/StormWaterNode/Culv End Sect
Manufacturer 3D ID	1212
Manufacturer 2D ID	1208
Geometry	
X (m)	6.58
Y (m)	2.47
Station (Calculated) (m)	(N/A)
Set Out X (m)	0.00
Set Out Y (m)	0.00
Set Out Elevation (m)	0.00
Node Orientation (degrees)	179.35
Active Topology	True
Boundary Condition	
Boundary Condition Type	Free Outlet
Inflow (Wind)	
Inflow (Wind) Collection	<Collection 0 Items>
Physical (Culvert)	
Inlet Description	Smooth tapered inlet throat
Point Outlet	
ID	Unique identifier assigned to the element.

Utility Properties

Drainage and Utilities tools represent the merger of two diverse technologies. OpenRoads Designer builds the 3D models of the utilities, but Bentley's Haestad technology (StormCAD) executes the analytic modeling for hydraulic and utility engineering.

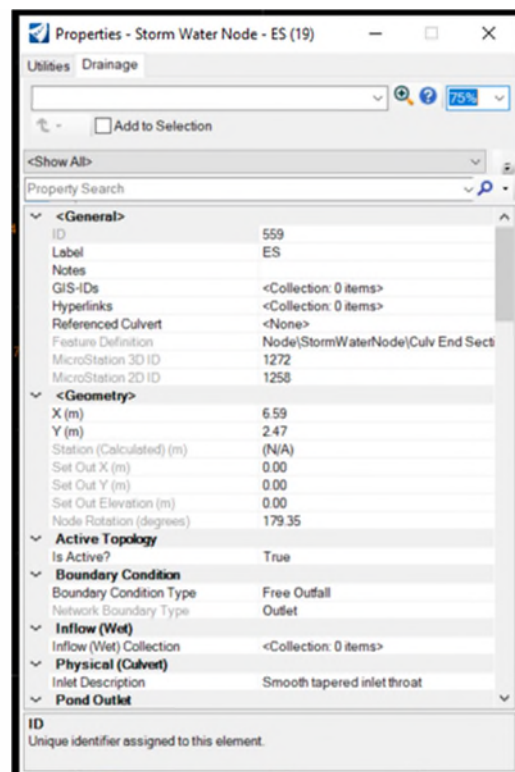
Utility Properties - Node

Click and **hover over** a node (catch basin or manhole) from the context toolbox select **Utility Properties**, click on the **Drainage** tab.

Check and edit the physical properties for the node:

- Elevation (Ground) = Terrain elevation at node
- Set Rim to Ground Elevation? False/True
- Elevation (Rim) = Top of Grate elevation
- Elevation (Invert) = bottom elevation of structure
- Update and edit Inlet properties for the node:
- Inlet Type: set to Catalog Inlet
- Inlet: click the down arrow and select from the available structures

The Inlet catalog has been set-up for MDOT catch basin standards. The catalog should be available automatically when starting the drainage engine.



Utility Properties - Conduit

Click and **hover over** a conduit, in the context toolbox select **Utility Properties**, click on the **Drainage** tab.

Check and edit as needed the Physical Properties for the conduit:

- Conduit Type: Catalog Conduit
- Catalog Class: click the down arrow and select: Concrete, PVC, CMP
- Size: click down arrow and select size
- Invert (Start): enter elevation
- Invert (Stop): enter elevation
- Has user Defined Length? True (default) or False
- Length (user defined) enter length
- Other items will be edited later

The MDOT Workspace has feature definitions pre-populated for the commonly used conduits.

Define Drainage Areas (Catchment Properties)

Drainage areas are defined using existing and proposed terrains, which can be merged with terrains coming from various other sources.

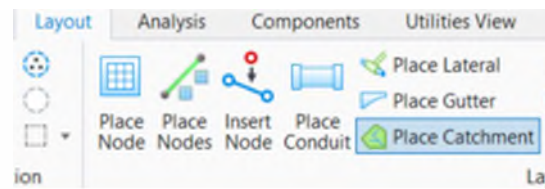
There are several options to place catchment areas (see Bentley Help):

- [Place Catchments by Picking Shapes](#)
- [Place Catchments by Picking Points](#)
- [Place Catchments by Flood Fill](#)

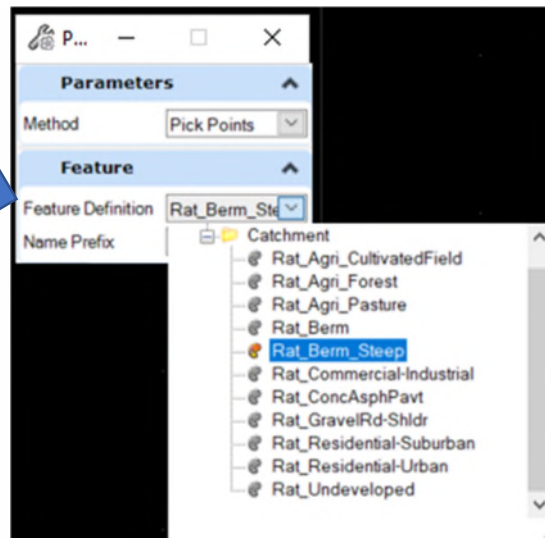
Catchment properties include catchment area, runoff coefficient, time of concentration types, and time of concentration. Note you may create multiple catchments and attach them to the same structure

Catchment Area

1. From the **Layout Tools** select **Place Catchment** and select the Method that best serves your purpose: example **Pick Points**



2. From the **Feature Definition** pick the land use most appropriate for the catchment area: example **Pavement**



3. Multiple land uses may be assigned to one Catch basin to create an aggregate CN

For each land use, prototypes have been created that follow the MDOT Drainage Manual. The designer should adjust the Runoff Coefficient (Rational) for the project if needed in the Drainage tab in the Properties menu for the catchment area.

4. Follow the command prompts: **Select First Vertex**, **Select Next Vertex**, **(Reset) To Complete**, **Select Outflow**, and **Select Reference Surface**.

Runoff Coefficient

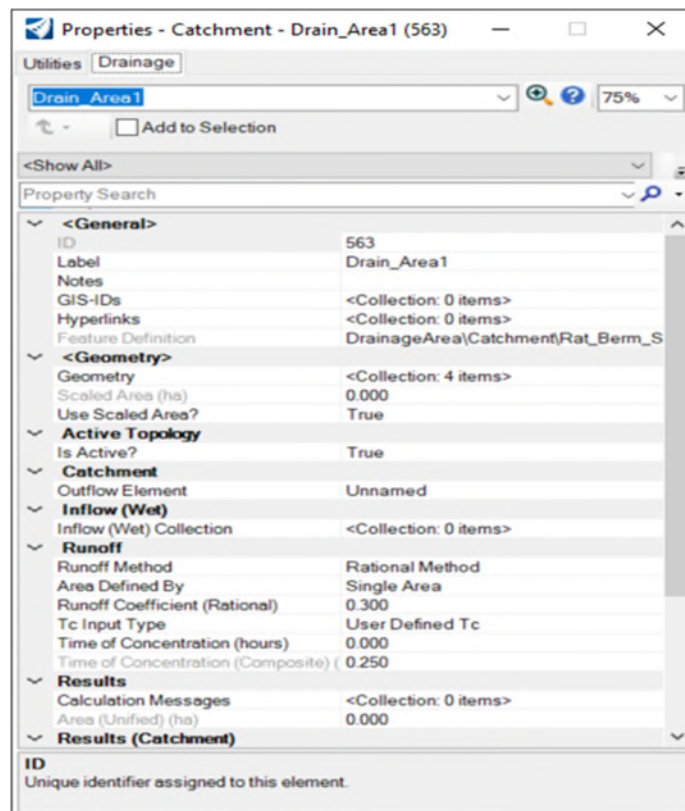
Runoff Coefficients have been defined as prototypes following the MDOT Drainage Manual.

Time of Concentration

Time of Concentration (Tc) is defined as the time required for a particle of runoff to flow from the hydraulically most distant point to the outlet or design point (catch basin etc.). Factors affecting the Tc are length of flow, slope of flow path and roughness of flow path. Please see the **Drainage Manual** for more information.

Tc Input Types:

- **User Defined Tc** -where the user inputs minutes for Tc or
- **Composite Tc** -where the user inputs a data collection of Tc's (Tc Data Collection)



Note: Drainage tab allows user to enter project specific data.

MDOT Feature Definitions are pre-set to values per Drainage Manual.

Time of Concentration using Tc Data Collection

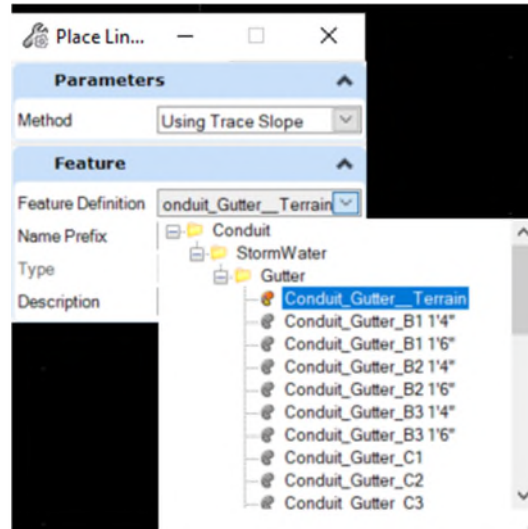
This follows the **Drainage Manual** Tc data collection method.

Placing Gutter Structure

Gutters are the method by which a catch basin bypass flow is assigned to a downhill catch basin (inlet). Gutters only represent the hydraulic relationship between the inlets and are not accurate 2D and 3D models.

To display and add gutters to a drainage system:

Turn Off Annotation Scale Lock (it is usually turned on by default): **Drawing Production tab – Drawing Scales tools – Annotation Scale Lock**



1. From the **Layout** tab, select the **Place Gutter** tool.
2. From the **Feature Definition** select the Gutter needed for your project.

For Gutters used to calculate spread, for Method **select "Trace Slope Method"** and **select Feature Definition "Conduit_Gutter_Terrain"**

3. Follow the prompts: **Select Start Node**.
4. **Select next node to make connection**. <Alt> to place curve. <Ctrl> to place bends. <Reset> to select start node. Example select the next node.
5. After placing the gutters **turn off** the analytic symbology under view attributes.

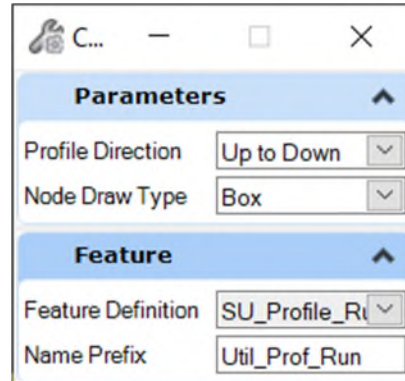
Placing Profile Runs

Profile Runs are the method used by the Program to both create profiles and analyze drainage networks.

To add Profile Run:

Go to Layout tab – Profile Runs

You may select **Hydraulic Run from Outfall** or select **Hydraulic run from Node**



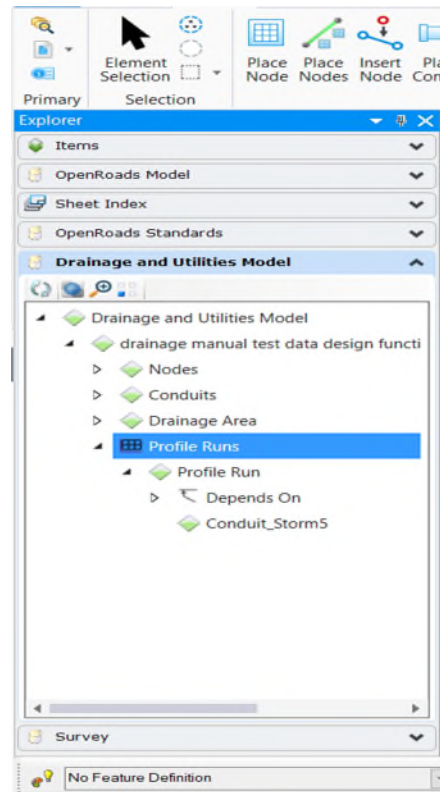
1. For **Hydraulic Run from Outfall**, select the Feature Definition "SU_Profile_Run" by Clicking **Feature Definition – Linear – SU - SU_Profile_Run**.

2. Select end Section and The Program will create your Profile Runs

3. To View: **Open Explorer- Select Drainage and Utilities Model- Click Profile Runs**.

4. For **Hydraulic run from Node**. repeat above process but select start and stop nodes of your choosing.

Note: Typically used for profile sheets and display purposes.

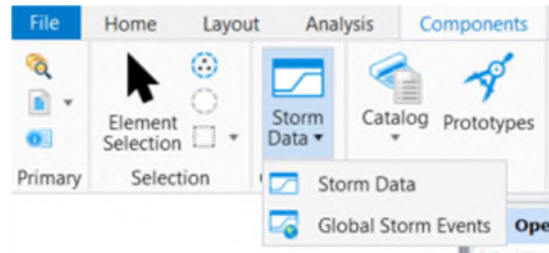


Using Storm Data

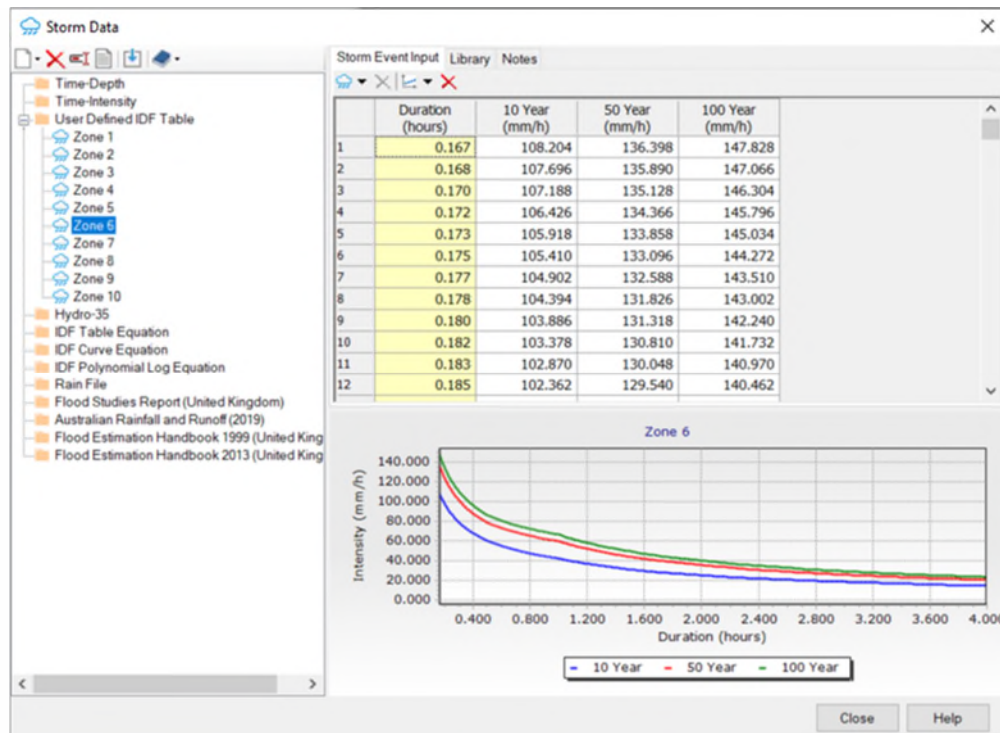
Storm Data is a single rainfall curve that represents one rainfall event for a given recurrence interval. Once the storm data is created it can be used globally by selecting Global Storm Events.

Select the **Components** tab and click on the **Storm Data** tool.

Several methods for specifying storm data are available, the **User Defined IDF Table** will be discussed and used.



2. Open **User Defined IDF Table**, **Select Project Rainfall Zone** Per Drainage Manual



3. **Close** the Storm Data box.

4. Select the **Tools** tab, click **Options, Drainage** – this will open the **Options** box.

8. In the Options box click on the **Units** tab. Scroll down to the **Rainfall Intensity** and **ensure** that it matches the units in the IDF file. Click **OK**.

SECTION 4 – DRAINAGE COMPUTATION

Setting Global Storm Events and Alternatives

Drainage and Utilities calculations are run on groups of settings called **Scenarios**, which have distinct subgroups of settings focused on aspects of drainage design or analysis. The subgroups are called **Alternatives** and include scopes as Physical Alternative, Design Option Alternatives and **Rainfall Runoff Alternatives** (focus here). Each *Rainfall Runoff Alternative* points to a **Storm Event** selected from the Storm Data collection (the IDF-Table imported previously).

Bentley discusses scenarios in more detail and has information available on the [Bentley Learn Server - ORD CE - 09 - Drainage Modeling](#) and [ORD CE – 10 – Drainage Hydraulics](#) learning path.

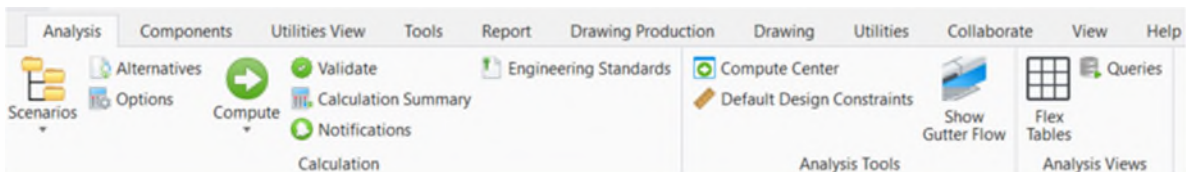
Storm Events used for analysis and design of storm drainage systems are usually:

- 10-year for the drainage system
- 50-year for sag condition

1. Select the **Components** tab, click on **Storm Data**, click on **Storm Data**. Select project specific alternative.

2. Select the **Analysis** tab, these tools are combined to calculate and report on the drainage scenarios.

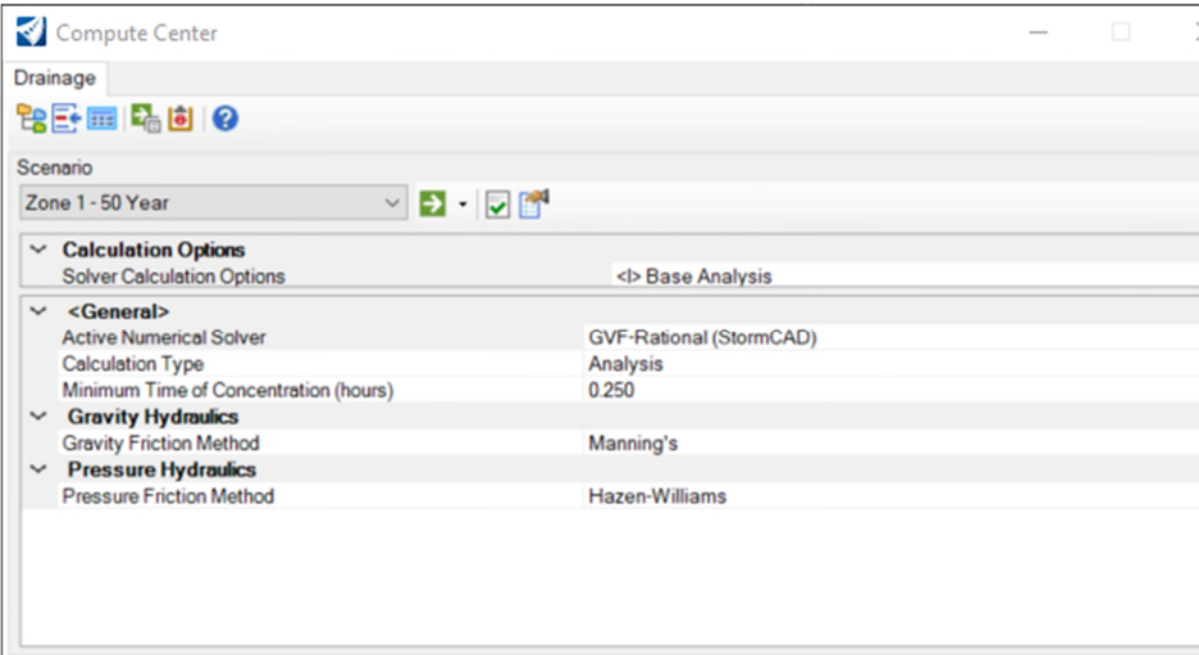
As shown in [Section 1 - Introduction and Tools](#), the **Analysis** tab is split into three (3) sections: **Calculation**, **Analysis Tools** and **Analysis Views**. Most tools in the *Calculation* section are also available in the **Compute Center** box from the *Analysis Tools* section.



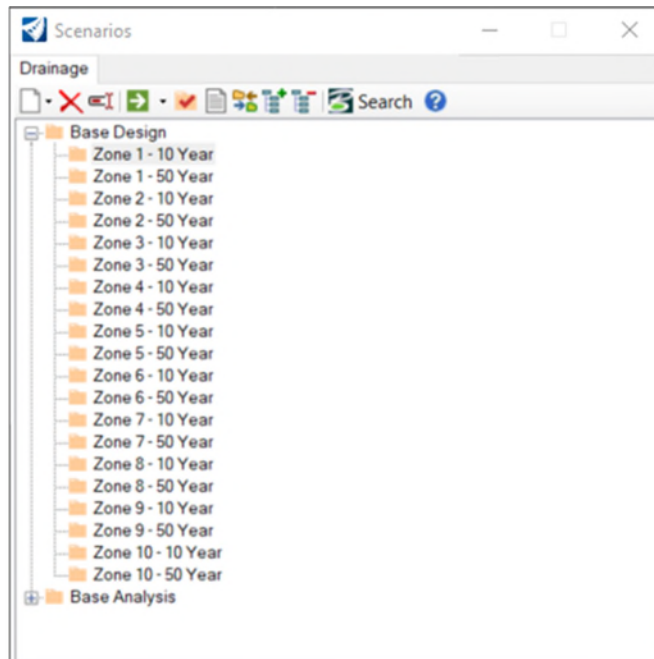
Select the **Scenarios** icon, there are two Scenarios: **Base Design** and **Base Analysis**.

Base Design will resize pipes, change inverts to *Default Design Constraints*. **This option is not recommended.**

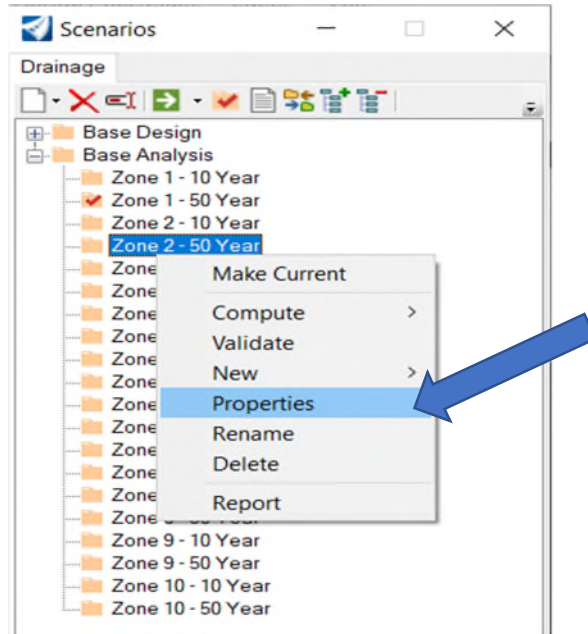
Base Analysis will not resize pipes or change inverts but will check if pipes and inverts conform to *Default Design Constraints*. Any discrepancies will be shown in 'User Notifications' after verified or computed. **(Recommended)**



1. **Click** on the **Scenarios** icon for the Scenarios box to open.

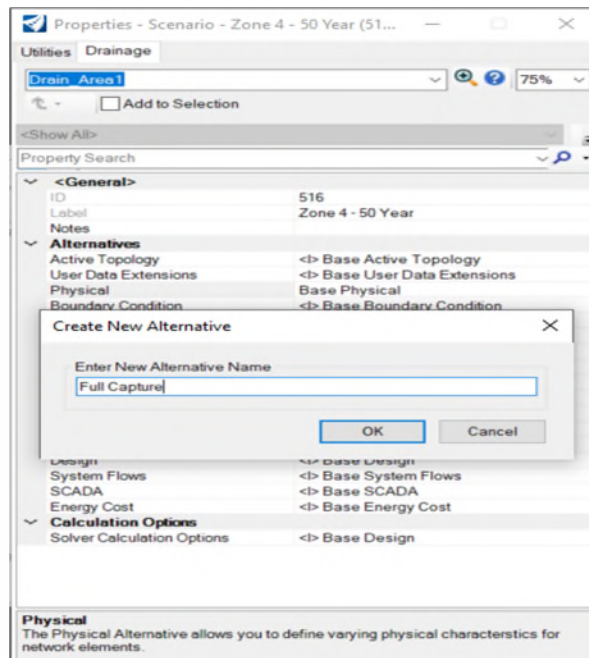


2. **Select** the **Base Analysis**, **right-click** and click on **Properties**, click on the **Drainage** tab in properties.



3. Click on **Physical**, click on the **down arrow** next to Base Physical and click **<New...>**.

4. In the **Create New Alternative** box enter a new rainfall alternative for your Project: **Full Capture**, click **OK**.



You will **NEED BOTH Full Capture** and **Spread Calculation** scenarios. The **Full Capture** calculation is to determine the size of the pipes whereas the **Spread Calculations** are to ensure we don't exceed maximum spread on roadway.

5. Select the **Base Analysis** you want to run, example: **Zone 4 - 50-yr.** as well as Physical Scenario, Example: **Full Capture.** **Close** the properties box. **Close** the Scenarios box.

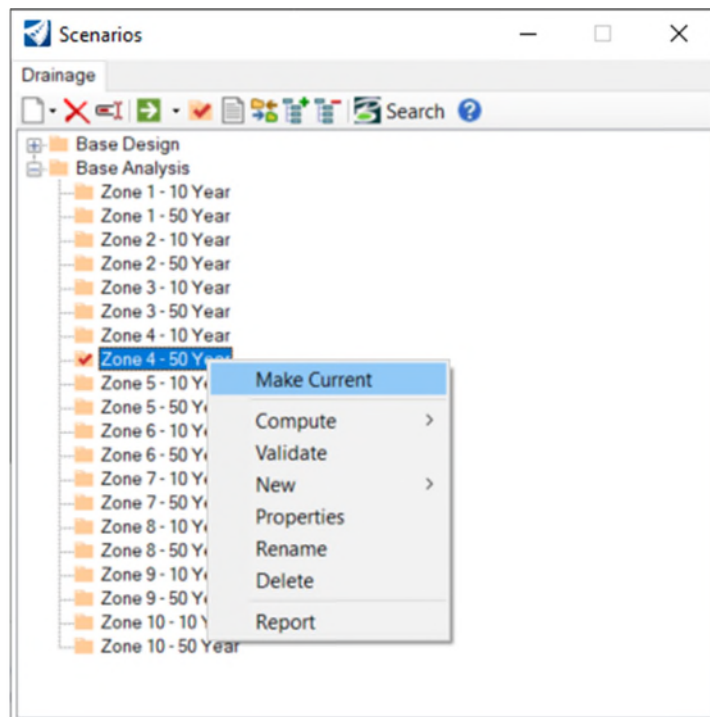
6. Select the **Components** tab, click on **Global Storm Events.** There are now additional alternatives.

7. **Select** the **Analysis** tab and **select** the **Scenarios** icon. **Right-click** on **Base Design** and select **Properties.** Click on the **Drainage** tab.

8. **Change** the **Rainfall Runoff** to the **Base Analysis** as previously.

9. Select zone, year, right click and select **Make Current**

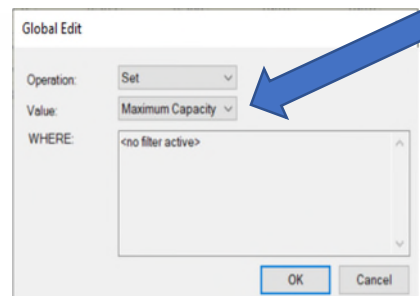
The current process will have a red check box



This is the minimum preparation needed to **Compute** the storm drainage system(s) for a project.

10. Once Computed with Catalog inlets. Repeat calculations with the **Full Capture** Scenario.

For full capture: open the **MDOT Inlet Spacing** Flex Table, right click on **Inlet**

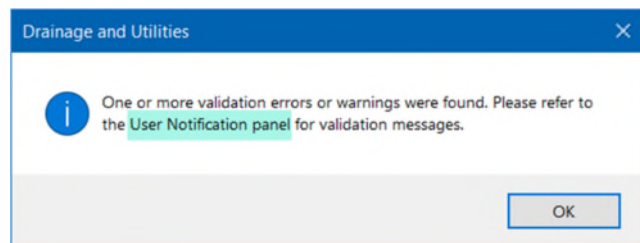


Type select **Global Edit** change the value to **Full Capture**

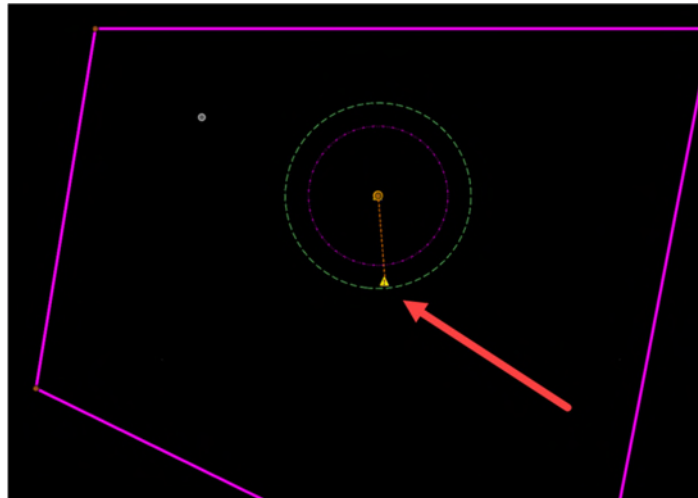
Validate

The **Validate** command is in the **Analysis** tab – **Calculation** section and within the **Compute Center** menu box. The **Validate** command will run a diagnostic check on the network data (drainage system) and alert you to possible problems that could be encountered during the calculations. This is a manual validation and checks only for input data errors. The **Compute** command is the automatic validation that Drainage and Utilities runs when it is initiated, and it will check for input data errors and for network connectivity errors as well as many other things beyond the manual validation checks. It is a good idea to first check (**validate**) the drainage system for any input data errors or missing items/data especially when there is a large system. This may need to be done multiple times, because some errors may be hidden after the initial validation

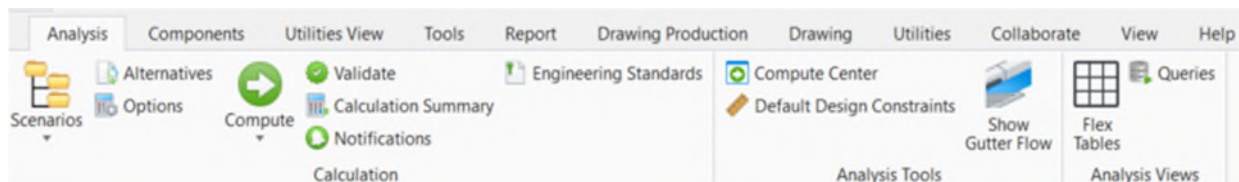
Click on the **Validate** command, you will/may get a message for errors or warnings: Click **OK**.



After the validation is complete you will typically see two different kinds of error markers in your 2D view window (usually View 1, Default).



Click on **Notifications** or the **User Notification** icon in the Compute Center.



The notifications window will come up displaying a list of warnings generated during the validation process. There are two types:

Red error **must** be corrected before the model (system) can be computed.

Yellow **does not** prevent successful calculation of the model, but element does not meet certain criteria.



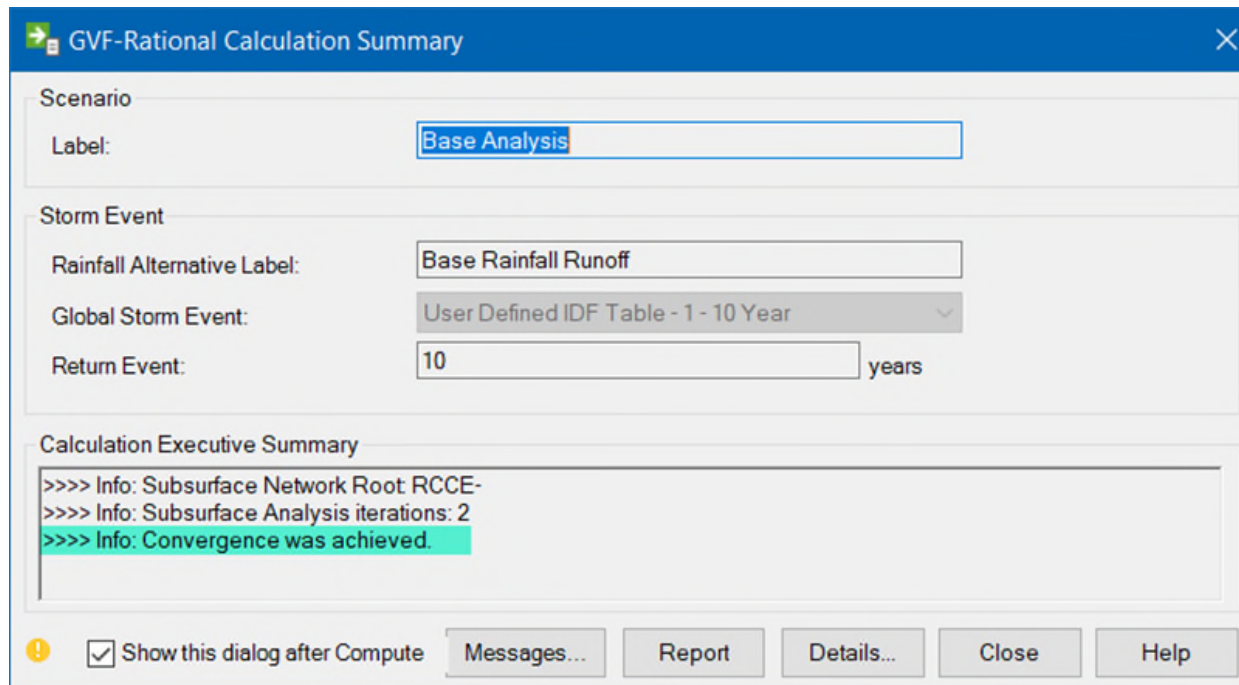
In the user Notification box, you will see messages with the **RED** and/or **YELLOW** icon as well as a toolbox (see below).

Computation and Results

You are ready to compute after all **RED** issues are resolved and all **YELLOW** issues are modified or considered.

1. Click the **Compute** icon. Located in the **Analysis** Tab

Drainage and Utilities will run the calculations, you will see window(s) pop-up, wait until the **GVF-Rational Calculation Summary** box opens.



2. Calculations were successful if you see: **Convergence was achieved** in the Calculation Executive Summary box.
3. Click on **Messages...** to see the newest User Notifications, if there is an error, the calculations will stop at that point, you will have to solve the error and rerun calculations.
4. Click on **Report** and for the **Scenario Summary** preview, this can be printed.
5. Click **Details...** the **Calculation Detailed Summary** box will open showing:
 - **Calculation Options**
 - **Catchment Summary**
 - **Link Summary**
 - **Node Summary**
 - **Inlet Summary**
 - **Pond Summary**
6. Click on **Report** to get one combined report to **review/print/save**. For individual and more complex reports use **Flex Tables**.

Flex Tables

Drainage and Utilities shows the engineering data in tabular format called **Flex Tables**. The most common flex tables have been established as **MDOT Flex Tables** and have been formatted for Nodes, Links and Culverts. Any flex table can be edited to best fit the project. The designer should use the drainage manual as a guide to determine the information needed to represent the drainage system.

Drainage and Utilities has 'predefined tables' set-up that can be edited as needed. **Expand** the Tables – **Hydraulic Model** folder, **Flex Tables** are available for use and are formatted to show all information and data required. Should you have to edit to reflect information/data needed for the drainage computations, they still can be edited as needed specific to the project. **Copy** the **flex table** and **rename** project specific.

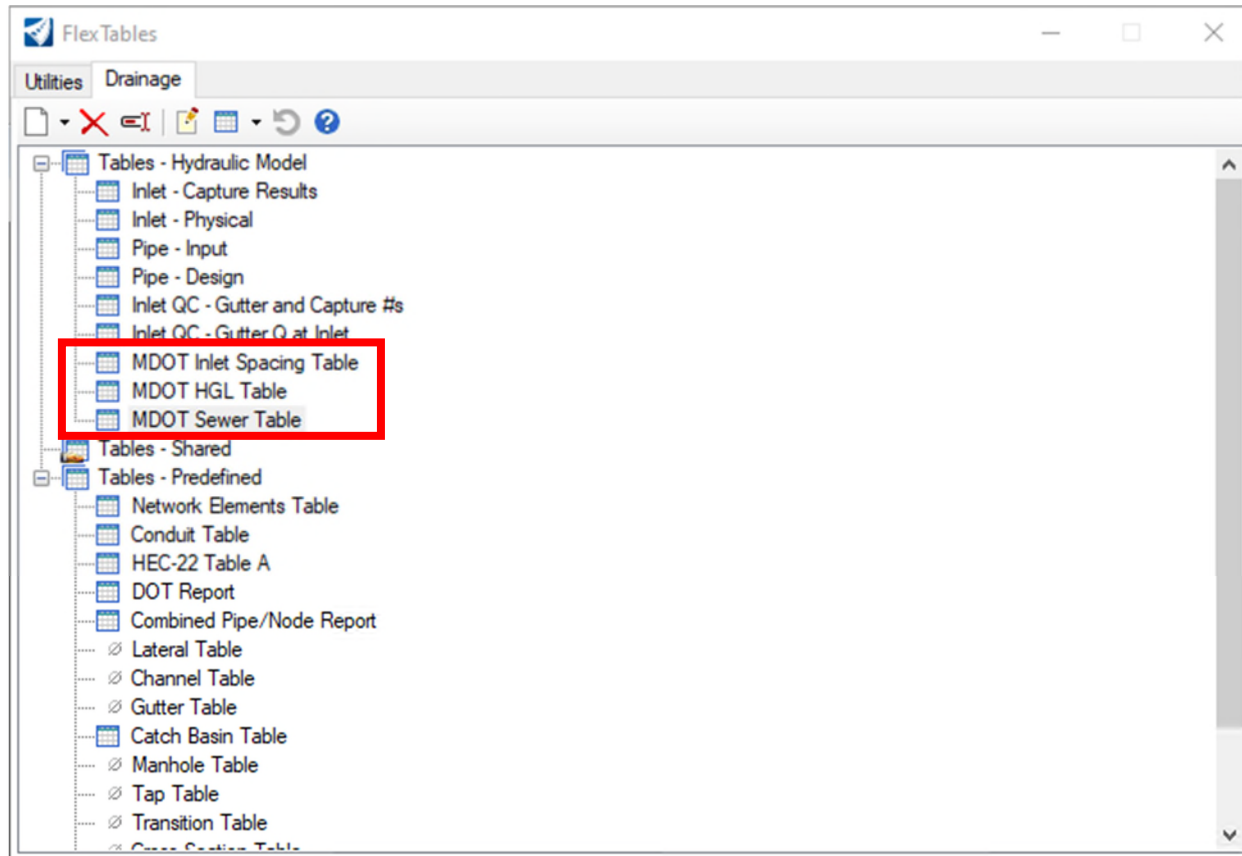
Export to File...— creates a text or csv file to work within Excel or shape file if needed.

Edit... — allows columns to be added or removed from the flex table

Zoom To...— **highlight** a row and click on **Zoom To**, the active view will zoom in to the item/row selected and is highlighted.

Report... — creates a report that can be printed. Paper size and page set-up can be edited in the report page.

Options...— gives the ability to create selection sets.



The Flex tables built into the workspace provide an output that allows a clearer review process from MDOT reviewers.

MDOT HGL Table

Conduit FlexTable: MDOT HGL Table (Current Time: 0.000 hours) (drainage manual test data design function test 10-11 upgrade 2 -- Del

	Upstream Structure	Invert (Start) (ft)	Invert (Stop) (ft)	Length (3D) (ft)	Size (Display)	Manning's n	Flow (cfs)	Upstream Structure Headloss (ft)
597: Conduit_St	2H	839.28	834.83	274.506	012 in	0.024	0.21	0.10
598: Conduit_St	2E	834.83	832.72	345.280	030 in	0.013	0.19	0.10
599: Conduit_St	2C	832.72	831.34	211.349	030 in	0.013	0.18	0.10
600: Conduit_St	2A	831.34	830.18	260.005	036 in	0.013	0.17	0.10
601: Conduit_St	1L	835.90	830.18	35.317	024 in	0.013	0.41	0.10
602: Conduit_St	1K	830.18	829.66	152.535	036 in	0.013	0.47	0.10
603: Conduit_St	MH3	829.66	828.56	213.491	036 in	0.013	0.46	0.10
604: Conduit_St	1F	828.56	827.23	74.116	042 in	0.013	0.45	0.10
605: Conduit_St	1D	827.23	820.40	270.313	042 in	0.013	0.44	0.10
606: Conduit_St	1C	820.40	820.20	48.982	042 in	0.013	0.44	0.10
607: Conduit_St	MH4	820.20	810.73	31.981	042 in	0.013	0.43	0.10
608: Conduit_St	MH5	810.73	797.15	45.431	048 in	0.013	0.43	0.10
609: Conduit_St	MH6	797.15	802.50	17.247	048 in	0.013	0.43	0.10

1 upgrade 2 -- Default.stsw

13 of 13 elements displayed

Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Energy Grade Line (In) (ft)	Energy Grade Line (Out) (ft)	Velocity (In) (ft/s)	Depth (In) (ft)	Velocity (Out) (ft/s)	Depth (Out) (ft)	Depth (Critical) (ft)
839.48	835.07	839.53	835.10	1.91	0.20	1.42	0.24	0.19
834.97	832.96	835.01	832.97	1.75	0.14	0.82	0.24	0.14
832.86	831.57	832.90	831.58	1.72	0.14	0.76	0.23	0.14
831.47	830.51	831.51	830.51	1.51	0.13	0.40	0.33	0.13
836.12	830.51	836.19	830.53	2.19	0.22	1.19	0.33	0.22
830.41	829.97	830.47	829.99	1.88	0.23	1.23	0.31	0.21
829.87	828.86	829.94	828.88	2.13	0.21	1.27	0.30	0.21
828.76	827.53	828.82	827.55	2.07	0.20	1.14	0.30	0.20
827.43	820.71	827.49	820.72	2.07	0.20	1.08	0.31	0.20
820.61	820.49	820.66	820.51	1.90	0.21	1.12	0.29	0.20
820.39	811.01	820.46	811.03	2.06	0.19	1.15	0.29	0.19
810.91	806.60	810.98	806.60	2.02	0.19	0.03	9.45	0.19
806.50	806.50	806.50	806.50	0.03	9.35	0.03	4.00	0.19

MDOT Inlet Spacing Table

Catch Basin FlexTable: MDOT Inlet Spacing Table (Current Time: 0.000 hours) (drainage manual test data design function test 10-11 upgrade 2 -- Default.stsw)



	Feature Definition	Baseline Station (ft)	Inlet	Elevation (Rim) (ft)	Inlet Drainage Area (acres)	Inlet C	Intercepted Tc (hours)	Intercepted Intensity (in/h)	Local Rational Flow (cfs)	Inlet Type	Flow (Known) (cfs)	Headloss Method	Manning's n (Inlet)	Longitudinal Slope (Inlet) (ft/ft)	Gutter Cross Slope (ft/ft)
i83: 2H	Node\StormWat...	0+00	48" CB-K	845.28	0.184	0.400	0.250	3.970	0.29	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i84: 2E	Node\StormWat...	0+00	60" CB-D	847.58	(N/A)	(N/A)	0.250	3.970	0.00	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i85: 2C	Node\StormWat...	0+00	72" CB-D	847.33	(N/A)	(N/A)	0.250	3.970	0.00	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i86: 2A	Node\StormWat...	0+00	60" CB-D	846.42	(N/A)	(N/A)	0.250	3.970	0.00	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i87: 1K	Node\StormWat...	0+00	72" CB-C	844.56	(N/A)	(N/A)	0.250	3.970	0.00	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i88: 1L	Node\StormWat...	0+00	60" CB-K	844.66	0.459	0.400	0.250	3.970	0.73	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i89: MH3	Node\StormWat...	0+00	60" CB-D	841.72	(N/A)	(N/A)	0.250	3.970	0.00	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i90: 1F	Node\StormWat...	0+00	60" CB-C	837.32	(N/A)	(N/A)	0.250	3.970	0.00	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i91: 1D	Node\StormWat...	0+00	60" CB-C	835.99	(N/A)	(N/A)	0.250	3.970	0.00	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i92: 1C	Node\StormWat...	0+00	60" CB-C	829.16	(N/A)	(N/A)	0.250	3.970	0.00	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i93: MH4	Node\StormWat...	0+00	72" CB-D	827.20	(N/A)	(N/A)	0.250	3.970	0.00	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i94: MH5	Node\StormWat...	0+00	72" CB-D	827.20	(N/A)	(N/A)	0.250	3.970	0.00	Catalog Inlet	0.00	Absolute	0.020	0.0200	
i95: MH6	Node\StormWat...	0+00	72" CB-D	813.39	(N/A)	(N/A)	0.250	3.970	0.00	Catalog Inlet	0.00	Absolute	0.020	0.0200	

13 of 13 elements displayed

Road Cross Slope (ft/ft)	Carryover Rational Flow (cfs)	Total Rational Flow to Inlet (cfs)	Depth (In) (ft)	Gutter Width (ft)	Spread / Top Width (ft)	Inlet Location	Flow (Captured) (cfs)	Flow (Total Bypassed) (cfs)	System Rational Flow (cfs)	System Flow Time (min)	Notes
0.0200	0.00	0.29	0.30		4.352	On Grade	0.21	0.09	0.21	15.000	
0.0200	0.00	0.00	0.24		0.000	On Grade	0.00	0.00	0.19	17.401	
0.0200	0.00	0.00	0.24		0.000	On Grade	0.00	0.00	0.18	20.600	
0.0200	0.00	0.00	0.23		0.000	On Grade	0.00	0.00	0.17	22.567	
0.0200	0.00	0.00	0.33		0.000	On Grade	0.00	0.00	0.47	25.435	
0.0200	0.00	0.73	0.32		6.129	On Grade	0.41	0.33	0.41	15.000	
0.0200	0.00	0.00	0.31		0.000	On Grade	0.00	0.00	0.46	26.791	
0.0200	0.00	0.00	0.30		0.000	On Grade	0.00	0.00	0.45	28.446	
0.0200	0.00	0.00	0.30		0.000	On Grade	0.00	0.00	0.44	28.830	
0.0200	0.00	0.00	0.31		0.000	On Grade	0.00	0.00	0.44	30.078	
0.0200	0.00	0.00	0.29		0.000	On Grade	0.00	0.00	0.43	30.507	
0.0200	0.00	0.00	0.29		0.000	On Grade	0.00	0.00	0.43	30.566	
0.0200	0.00	0.00	9.45		0.000	On Grade	0.00	0.00	0.43	30.652	

MDOT Sewer Table

Conduit FlexTable: MDOT Sewer Table (Current Time: 0.000 hours) (drainage manual test data design function test 10-11 upgrade 2 -- Default.stsw)

	Upstream Structure	Invert (Start) (ft)	Invert (Stop) (ft)	Diameter (in)	Length (3D) (ft)	Slope (Calculated) (ft/ft)	System CA (acres)	Upstream Inlet Tc (hours)	System Intensity (in/h)	Flow (cfs)	Size (Display)	Manning's n	Time (Pipe Flow) (hours)	System Flow Time (min)	Capacity (Full Flow) (cfs)	Velocity (ft/s)
597: Conduit_St	2H	839.28	834.83	12.0	274.506	0.0162	0.052	0.250	3.970	0.21	012 in	0.024	0.040	15.000	2.46	1.91
598: Conduit_St	2E	834.83	832.72	30.0	345.280	0.0061	0.052	0.000	3.680	0.19	030 in	0.013	0.053	17.401	32.02	1.80
599: Conduit_St	2C	832.72	831.34	30.0	211.349	0.0065	0.052	0.000	3.390	0.18	030 in	0.013	0.033	20.600	33.17	1.79
600: Conduit_St	2A	831.34	830.18	36.0	260.005	0.0045	0.052	0.000	3.233	0.17	036 in	0.013	0.048	22.567	44.54	1.51
601: Conduit_St	1L	835.90	830.18	24.0	35.317	0.1641	0.102	0.250	3.970	0.41	024 in	0.013	0.001	15.000	91.64	7.32
602: Conduit_St	1K	830.18	829.66	36.0	152.535	0.0034	0.154	0.000	3.046	0.47	036 in	0.013	0.023	25.435	38.95	1.88
603: Conduit_St	MH3	829.66	828.56	36.0	213.491	0.0052	0.154	0.000	2.970	0.46	036 in	0.013	0.028	26.791	47.88	2.15
604: Conduit_St	1F	828.56	827.23	42.0	74.116	0.0179	0.154	0.000	2.880	0.45	042 in	0.013	0.006	28.446	134.78	3.21
605: Conduit_St	1D	827.23	820.40	42.0	270.313	0.0253	0.154	0.000	2.860	0.44	042 in	0.013	0.021	28.830	159.94	3.61
606: Conduit_St	1C	820.40	820.20	42.0	48.982	0.0041	0.154	0.000	2.806	0.44	042 in	0.013	0.007	30.078	64.22	1.90
607: Conduit_St	MH4	820.20	810.73	42.0	31.981	0.3102	0.154	0.000	2.785	0.43	042 in	0.013	0.001	30.507	560.30	8.55
608: Conduit_St	MH5	810.73	797.15	48.0	45.431	0.3131	0.154	0.000	2.782	0.43	048 in	0.013	0.001	30.566	803.74	8.41
609: Conduit_St	MH6	797.15	802.50	48.0	17.347	-0.3242	0.154	0.000	2.777	0.43	048 in	0.013	0.134	30.652	817.86	0.03