



# **DRAINAGE DESIGN MANAGEMENT SYSTEM FOR WINDOWS VERSION 6.0.5**

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## **TUTORIAL # 16 HGL EVALUATION OF STORM DRAINAGE SYSTEM**

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**KVL Consultants, Inc.**

# HGL EVALUATION OF STORM DRAINAGE SYSTEM

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# HGL EVALUATION OF STORM DRAINAGE SYSTEM

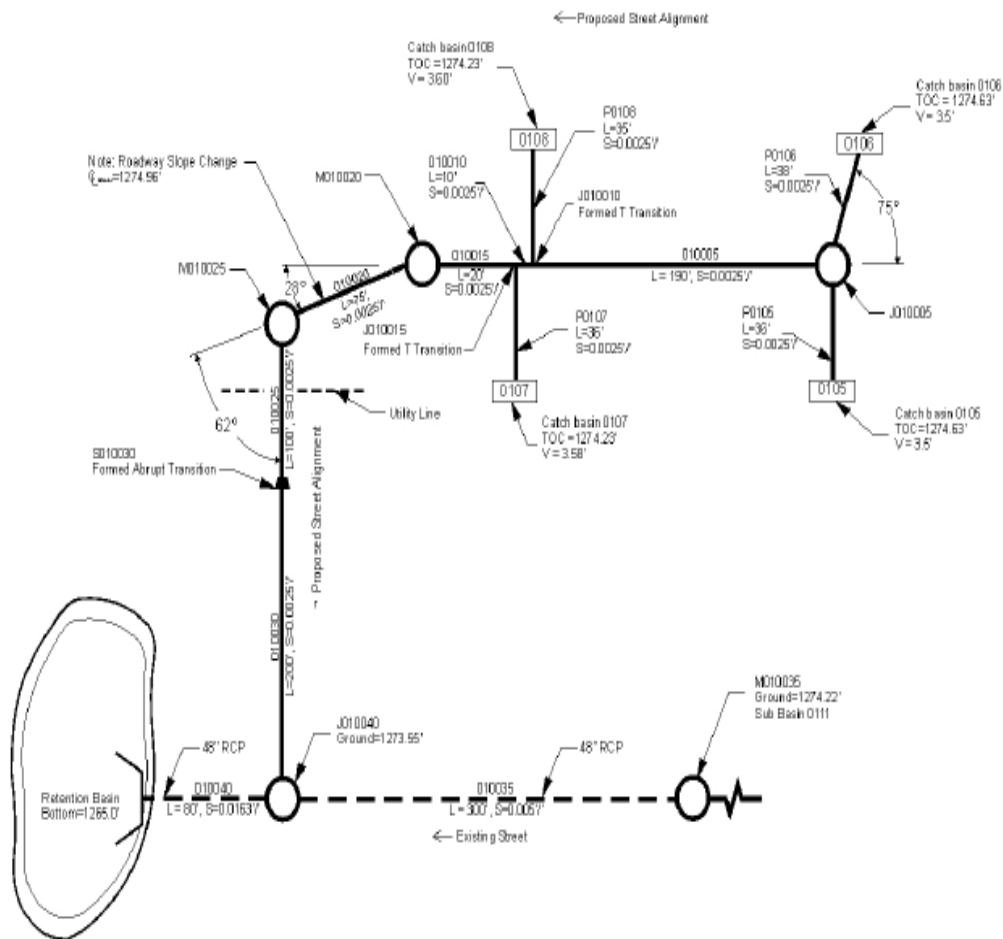
**DATE UPDATED: APRIL 20, 2022**

**TUTORIAL TIME: 45 MINUTES**

## 1.0 INTRODUCTION

This tutorial provides the procedure to develop and solve a storm drainage system model using DDMSW. The problem that is modeled in this tutorial is taken from the Design Example 4.6 presented in the Flood Control District's Hydraulics Manual (2013). The Storm Drain System Layout for the Example Problem is presented below. All the data used in DDMSW are exactly the same data from the Design Example in the Manual.

**INITIAL STORM DRAIN LAYOUT FOR EXAMPLE PROBLEM**



## 2.0 CREATING A NEW PROJECT

After launching DDMSW, open the **SELECT PROJECT** form (**File** → **Select Project**) and click the **'Add'** button to create a new project. Select **Hydrology and Hydraulics** and check **Rational Method**. Enter a unique **Reference** (maximum 16 characters, no spaces) name together with appropriate **Title** (Optional), **Location** (Optional), and **Agency** (Optional). For the purpose of this tutorial, enter the following information:

### Project Reference and Other Info:

<b>Reference</b>	<i>DESIGNEX46</i>
<b>Title</b>	<i>FCDMC Hydraulics Manual Design Example 4.6</i>
<b>Location</b>	<i>Maricopa County, Arizona</i>
<b>Agency</b>	<i>Flood Control District of Maricopa County</i>
<b>Comment Box</b>	<i>Tutorial Project to solve Design Example 4.6 using StormPro</i>

### Project Defaults:

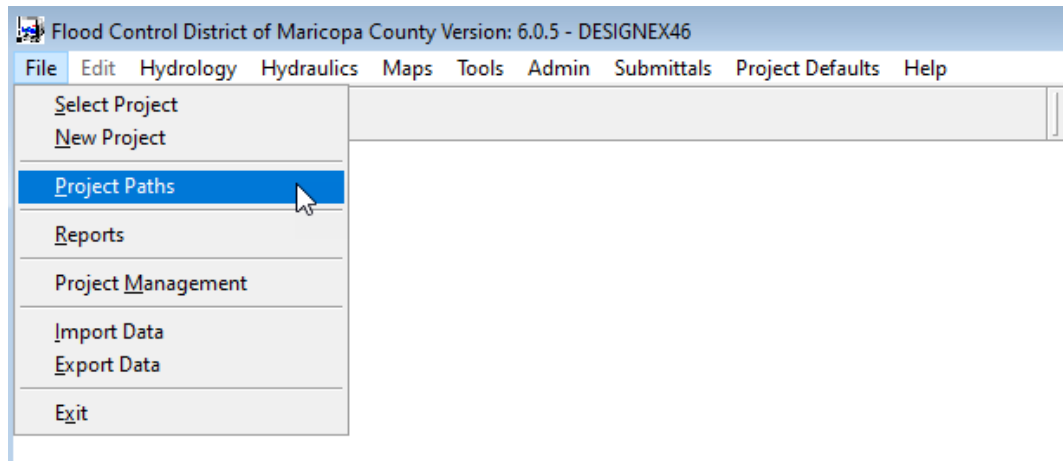
<b>Model</b>	<i>Rational</i>
<b>Land Use</b>	<i>FCDMC</i>
<b>Rainfall</b>	<i>NOAA2</i>
<b>Roads</b>	<i>Phoenix</i>
<b>Inlets</b>	<i>Phoenix</i>

Click **'Save'** to save the entered data for the new project. Click **'OK'** to proceed. Click **'OK'** to accept the defaults.

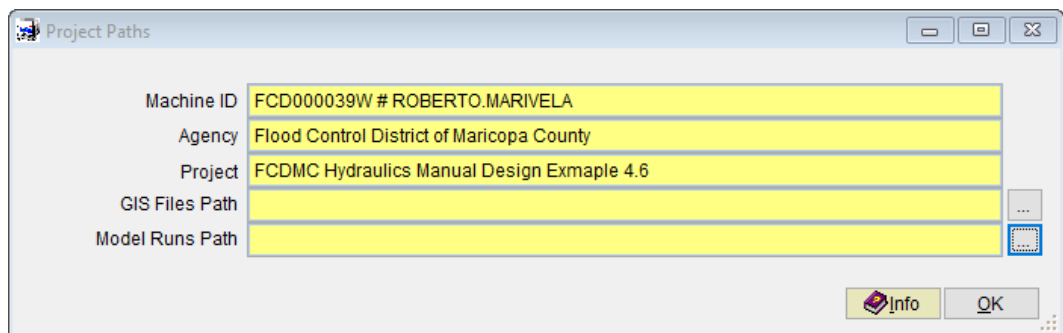
The name of the new project is **DESIGNEX46**.

### 3.0 SET THE PROJECT PATH

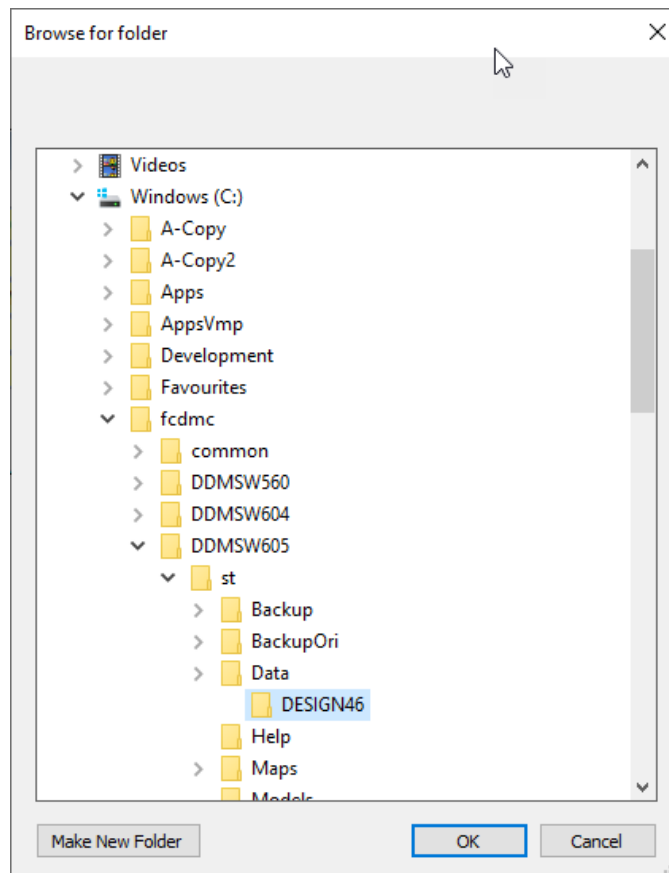
Open the **PROJECT PATHS** form (**File** ➔ **Project Paths**) to define the **Model Runs Path** for the new project.



On the Project Paths form, click the ellipse (...) button on the right of the Model Runs Path textbox field.



On the Browse for folder form, navigate to the desired folder location where model run files for the project will be saved. If the desired folder location does not exist, click the 'Make New Folder' button to create the folder. Rename the folder (use DESIGNEX46) and select it. Click 'OK' to close the form.



On the **PROJECT PATHS** form, click '**Save**' to save the data and click '**OK**' to close the form.

The screenshot shows the 'Project Paths -- Edit' form with the following data:

Field	Value
Machine ID	FCD000039W # ROBERTO.MARIVELA
Agency	Flood Control District of Maricopa County
Project	FCDMC Hydraulics Manual Design Exmaple 4.6
GIS Files Path	
Model Runs Path	C:\FCDMC\DDMSW605\ST\DATA\DESIGN46\

Buttons at the bottom right: Save, Cancel, OK.

## 4.0 DEVELOP THE RAINFALL DATA

Open the **NOAA2 RAINFALL DATA** form (*Hydrology → Rainfall*) to develop the rainfall data for the project. If a **WARNING** dialog box shows up indicating that *'There is no Rainfall data for the project'*, click the **'OK'** button to create a temporary Rainfall Data.

**SPECIAL NOTES:** For this example, NOAA2 Rainfall will be used. This is to replicate the Rainfall Data that is used in the Design Example 4.6 of the Hydraulics Manual. Normally NOAA14 rainfall would be used but to create a similar rainfall data, it is most convenient to use NOAA2. Since the generated rainfall data are but temporary data, the data can be updated to match the data used in Design Example 4.6. In order to accomplish this, enter the following values on the **Details** tab of the **NOAA2 RAINFALL DATA** form:

**Non Adjusted Point Rainfall (in):**

<b>2-Year, 6-Hour Rainfall</b>	<i>1.20 inches</i>
<b>2-Year, 24-Hour Rainfall</b>	<i>1.44 inches</i>
<b>100-Year, 6-Hour Rainfall</b>	<i>3.25 inches</i>
<b>100-Year, 24-Hour Rainfall</b>	<i>3.95 inches</i>

**Location:**

<b>Primary Zone</b>	<i>7</i>
<b>Short duration Zone</b>	<i>8</i>

**Rainfall ID:**

<b>Rainfall ID</b>	<i>DEFAULT</i>
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Click **'Save'** to save the data entered, then click **'Update'** to update the tabulated Rainfall data.

The screenshot shows the 'NOAA 2 Rainfall Data' window. It has a 'List' tab and a 'Details' tab. The 'Details' tab is active, showing two main sections: 'Non Adjusted Point Rainfall (in)' and 'Location'.

**Non Adjusted Point Rainfall (in)**

	2-Year	100-Year
6-Hour	1.20	3.25
24-Hour	1.44	3.95

Below the table is a 'Map' button.

**Location**

Primary Zone: 7  
Short Duration Zone: 8

**Rainfall ID**

Rainfall ID: DEFAULT

At the bottom of the window are buttons for 'Info', 'Print...', 'Graph', 'Update', and 'OK'.

Click **'Yes'** to continue.

The screenshot shows a dialog box titled 'Update NOAA2 Rainfall'. It contains an information icon and the following text:

This will run the Prefre Model to update all the return periods and durations based on the values in the Non Adjusted Point Rainfall.

Do you want to continue?

At the bottom are 'Yes' and 'No' buttons. The 'Yes' button is highlighted with a blue border.

The updated **Rainfall data** generated from the new rainfall information entered are shown below:





## 5.0 DEVELOP THE SUB BASIN DATA

To enter the Sub Basin data, open the **SUB BASINS** form (*Hydrology → Sub Basins*). Click the **'Add'** button to start the data entry process. Enter the data for Sub Basins *0105*, *0106*, *0107*, *0108* and *0111* as shown below. Do not click **'Update'** yet until the land use data has been entered. If you click **'Save'** after entering the **USGE** and **DSGE**, the **Slope** will be automatically calculated.

After data are entered and saved for each Sub Basin, click **'Add'** to enter subsequent **Sub Basin** data. When finished, click **'OK'** to close the **SUB BASINS** form.

Sub Basin	Sort	Area (acres)	Length (ft)	USGE (ft)	DSGE (ft)	Slope (ft/mi)
0105	10	0.47	390	100.0	97.0	40.6
0106	20	0.86	1000	100.0	83.0	89.8
0107	30	0.47	450	100.0	95.0	58.7
0108	40	0.67	510	100.0	97.0	31.1
0111	50	50.00	1350	100.0	90.0	39.1

## 6.0 DEVELOP THE LAND USE DATA

To enter the land use data, open the **LAND USE** form (*Hydrology → Land Use*) then click **Add**. Enter the **Land Use** data for Sub Basins *0105*, *0106*, *0107*, *0108* and *0111* as provided in the table below. It is necessary to modify the **C** values to come close to matching the values in Design Example 4.6

Land Use - MB: 01

List Details

**Land Use**

Major Basin ID 01 Area (acres) 0.47

Sub Basin ID 0105 Area (%) 100.0

Land Use Code 600 General Transportation (Transportation where no detail avail)

**Land Use Data**

	Value	Default	Custom
2-Year C	0.91	0.95	<input checked="" type="checkbox"/>
5-Year C	0.95	0.95	<input type="checkbox"/>
10-Year C	0.95	0.95	<input type="checkbox"/>
25-Year C	0.95	0.95	<input type="checkbox"/>
50-Year C	0.95	0.95	<input type="checkbox"/>
100-Year C	0.95	0.95	<input type="checkbox"/>
Resistance Coefficient (Kb)	MIN	MIN	<input type="checkbox"/>

Info Copy Print... Delete Add MB OK

Sub Basin ID	Land Use Code	Area (acres)	2-Year Custom C	50-Year Custom C	100-Year Custom C
0105	600	0.47	0.91		
0106	600	0.86	0.91		
0107	600	0.47	0.91		
0108	600	0.67	0.91		
0111	200	50.00	0.85	.90	.90

After individual Land Use data are entered into the form, click **'Save'** to save the data and click **'Add'** to enter the next Land Use record. When all the Land use data have been entered, click **'OK'** to close and exit the **LAND USE** form.

## 7.0 UPDATE THE SUB BASIN DATA

To evaluate the parameters of individual Sub Basin with consideration of the Rainfall and the Land Use data developed in the previous Sections 4 and 6, open the **SUB BASINS** form (**Hydrology** → **Sub Basins**). On the **Details** tab of the form, click the **'Update'** button.

The screenshot shows the 'Sub Basins - MB: 01' window. The 'List' tab is selected, showing a table with columns for Major Basin, Sub Basin, and Sort. The 'Details' tab is also visible, showing a 'Sub Basin Hydrology Summary' table and 'Sub Basin Parameters'.

**Sub Basin Parameters**

Area (acres)	0.47
Length (ft)	390
USGE (ft)	100.0
DSGE (ft)	97.0
Slope (ft/mi)	40.6

**Sub Basin Hydrology Summary**

	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Q (cfs)	1.2	1.7	2.1	2.5	2.8	3.1
CA (ac)	0.43	0.45	0.45	0.45	0.45	0.45
Vol (ac-ft)	0.0366	0.0548	0.0656	0.0806	0.0923	0.1035
Custom Tc	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tc (min)	10.0	10.0	10.0	10.0	10.0	10.0
Recession (min)	34.286	36.806	35.358	36.812	37.864	38.478
I (in/hr)	2.82	3.84	4.56	5.46	6.18	6.96

**Sub Basin Parameters**

Kb	0.042	0.042	<input type="checkbox"/>
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Buttons: Info, ReSort, Print..., Delete, Add, MB, Update, OK

For **Sub Basin 0111**, check the **Custom Tc** checkbox for the 2-yr storm event. The rationale for this customized Tc of *14.1 min* is to come close to matching the data in Design Example 4.6.

**Sub Basin**

Major Basin: 01

Sub Basin: 0111

Sort: 50

**Sub Basin Parameters**

Area (acres): 50.00

Length (ft): 1350

USGE (ft): 100.0

DSGE (ft): 90.0

Slope (ft/mi): 39.1

Value Default Custom

Kb: 0.029 0.029 ☐

**Sub Basin Hydrology Summary**

	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
Q (cfs)	102.0	178.6	216.6	259.4	278.1	313.2
CA (ac)	42.50	47.50	47.50	47.50	45.00	45.00
Vol (ac-ft)	3.6125	5.7792	6.9271	8.5104	9.2250	10.3500
Custom Tc	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tc (min)	14.1	10.6	10.0	10.0	10.0	10.0
Recession (min)	37.325	36.384	36.437	37.637	38.165	37.983
I (in/hr)	2.40	3.76	4.56	5.46	6.18	6.96

Comments

Info ReSort Print... Delete Add MB Update OK

Click '**OK**' to close and exit the **SUB BASINS** form.

## 8.0 DEVELOP THE CONVEYANCE FACILITIES DATA

The Storm Drain Layout in Section 1.0 shows one (1) Main Line, one (1) Lateral Line that feeds into the Main Line, and 4 Connector Pipes that feed into the Lateral Line. For this tutorial project, the StormPro backwater model is used to develop the hydraulic grade line (HGL) of the storm drain system. It is, therefore, necessary to sort the Conveyance Facilities in the correct order and establish the Line ID for each Conveyance Facility. With respect to the System Layout, Conveyance Facilities 010035 and 010040 will be **Line ID 10** which outfalls into a Retention Basin. All remaining conveyance facilities (Lateral Line and Connector Pipes) will be designated as **Line ID 20**. **Line ID 20** outfalls into Conveyance Facilities 010040.

The physical data (pipe size, pipe length, pipe invert elevations, etc.) of all the conduits / pipes in the system are tabulated below.

To enter the Conveyance Facilities data, open the **CONVEYANCE FACILITIES** form (**Hydraulics** ➔ **Conveyance Facilities**). Click the '**Add**' button to start the data entry for the first record.

ID			Model Options					Elevations				Section		
Facility ID	Line ID	Sort	Custom Q	Model Road	First Pipe	Outfall	DS Pipe ID	USGE	DSGE	USIE	DSIE	Length	Dia	Road ID
010040	10	10	105.2	X		X		1273.55	1270.50	1266.80	1265.50	80.00	48	PH-MJC-XSE-80
010035	10	20	102.0	X	X			1274.22	1273.55	1268.30	1266.80	300.00	48	PH-MJC-XSE-80
010030	20	30	5.8	X		X	010040	1274.36	1273.55	1269.30	1268.80	200.00	24	PH-MJC-XSE-80
010025	20	40	5.8	X				1274.77	1274.36	1270.05	1269.80	100.00	18	PH-MJC-XSE-80
010020	20	50	5.8					1274.59	1274.77	1270.24	1270.05	75.00	18	
010015	20	60	5.8					1274.44	1274.59	1270.29	1270.24	20.00	18	
010010	20	70	4.7					1274.44	1274.44	1270.31	1270.29	10.00	18	
010005	20	80	3.4	X	X			1274.96	1274.44	1270.79	1270.31	190.00	18	PH-MJC-XSE-80

For the first Conveyance Facilities data, enter the following:

**ID:**

- Facility ID 010040
- Line ID 10
- Sort 10

**Model Options:**

- RP (yrs) 2
- Custom checkbox Check
- Q (cfs) 105.2
- Model Road checkbox Check
- First Pipe checkbox Uncheck
- Outfall checkbox Check
- D/S Pipe ID Blank

**Elevations:**

- U/S Ground Elevation (ft) 1273.55
- D/S Ground Elevation (ft) 1270.50
- U/S Invert Elevation (ft) 1266.80
- D/S Invert Elevation (ft) 1265.50

**Section Type:**

- Section Pipe
- Length (ft) 80.00
- Manning's n 0.013
- Diameter (in) 48
- No. of Barrels 1
- Road ID PH-MJC-XSE-80
- No. of Manholes 0

After entering all the data for the first record (**Facility ID 010040**), press **'Save'**.

Conveyance Facilities - MB: 01

List		Details										
<b>ID</b> MB ID: 01 Facility ID: 010040 Line ID: 10 Sort: 10		<b>Section Type</b> Section: Pipe Length (ft): 80.00 Manning's n: 0.013 Diameter (in): 48 No. of Barrels: 1 No. of Manholes: 0	<b>Calculations</b> Capacity (cfs): 183.2 Slope (ft/ft): 0.0163 Velocity (fps): 15.0 Normal Depth (ft): 2.18 Critical Depth (ft): 3.11 Custom Q (cfs): 105.2 Upstream HGL (ft):									
<b>Model Options</b> Q (cfs): 105.2 Custom Q: <input checked="" type="checkbox"/> Model Road: <input type="checkbox"/> First Pipe: <input type="checkbox"/> Outfall: <input checked="" type="checkbox"/> D/S Pipe ID:		<b>Elevations</b> <table border="1"> <thead> <tr> <th></th> <th>U/S (ft)</th> <th>D/S (ft)</th> </tr> </thead> <tbody> <tr> <td>Ground</td> <td>1273.55</td> <td>1270.50</td> </tr> <tr> <td>Invert</td> <td>1266.80</td> <td>1265.50</td> </tr> </tbody> </table>			U/S (ft)	D/S (ft)	Ground	1273.55	1270.50	Invert	1266.80	1265.50
	U/S (ft)	D/S (ft)										
Ground	1273.55	1270.50										
Invert	1266.80	1265.50										

Comments:

Info ReSort Print... Delete Add Graph MB Update OK

Click '**Add**' to enter the next record. Enter the following data for **Facility ID 010035**.

**ID:**

- **Facility ID** 010035
- **Line ID** 10
- **Sort** 20

**Model Options:**

- **RP (yrs)** 2
- **Custom** checkbox Check
- **Q (cfs)** 102.0
- **Model Road** checkbox Check
- **First Pipe** checkbox Check
- **Outfall** checkbox Uncheck

**Elevations:**

- **U/S Ground Elevation (ft)** 1274.22
- **D/S Ground Elevation (ft)** 1273.55
- **U/S Invert Elevation (ft)** 1268.30
- **D/S Invert Elevation (ft)** 1266.80

### Section Type:

- **Section** *Pipe*
- **Length (ft)** *300.00*
- **Manning's n** *0.013*
- **Diameter (in)** *48*
- **No. of Barrels** *1*
- **Road ID** *PH-MJC-XSE-80*
- **No. of Manholes** *0*

After entering all the data for the second record (**Facility ID 010035**), press **'Save'**.

Conveyance Facilities - MB: 01

**List** **Details**

**ID**

MB ID: 01

Facility ID: 010035

Line ID: 10

Sort: 20

**Section Type**

Section: Pipe

Length (ft): 300.00

Manning's n: 0.013

Diameter (in): 48

No. of Barrels: 1

Road ID: PH-MJC-XSE-80

No. of Manholes: 0

**Calculations**

Capacity (cfs): 101.5

Slope (ft/ft): 0.0050

Velocity (fps): 8.1

Normal Depth (ft): 4.00

Critical Depth (ft): 3.06

Custom Q (cfs): 102.0

Road Depth (ft): 0.15

Upstream HGL (ft):

**Model Options**

Q (cfs): 102.0

Custom Q: ☒

Model Road: ☒

First Pipe: ☒

Outfall: ☐

**Elevations**

	U/S (ft)	D/S (ft)
Ground	1274.22	1273.55
Invert	1268.30	1266.80

Comments:

Info ReSort Print... Delete Add Graph MB Update OK

Click **'Add'** to enter the next record. Enter the following data for **Facility ID 010030**.

### ID:

- **Facility ID** *010030*
- **Line ID** *20*
- **Sort** *30*



**Model Options:**

- **RP (yrs)** 2
- **Custom** checkbox *Check*
- **Q (cfs)** 5.8
- **Model Road** checkbox *Check*
- **First Pipe** checkbox *Uncheck*
- **Outfall** checkbox *Check*
- **D/S Pipe ID** 010040

**Elevations:**

- **U/S Ground Elevation (ft)** 1274.36
- **D/S Ground Elevation (ft)** 1273.55
- **U/S Invert Elevation (ft)** 1269.30
- **D/S Invert Elevation (ft)** 1268.80

**Section Type:**

- **Section** *Pipe*
- **Length (ft)** 200.00
- **Manning's n** 0.013
- **Diameter (in)** 24
- **No. of Barrels** 1
- **Road ID** *PH-MJC-XSE-80*
- **No. of Manholes** 0

After entering all the data for the third record (**Facility ID 010030**), press '**Save**'.

Conveyance Facilities - MB: 01

List		Details										
<b>ID</b> MB ID: 01 Facility ID: 010030 Line ID: 20 Sort: 30		<b>Section Type</b> Section: Pipe Length (ft): 200.00 Manning's n: 0.013 Diameter (in): 24 No. of Barrels: 1 Road ID: PH-MJC-XSE-80 No. of Manholes: 0										
<b>Model Options</b> Q (cfs): 5.8 Custom Q: <input checked="" type="checkbox"/> Model Road: <input checked="" type="checkbox"/> First Pipe: <input type="checkbox"/> Outfall: <input checked="" type="checkbox"/> D/S Pipe ID: 010040		<b>Calculations</b> Capacity (cfs): 35.7 Slope (ft/ft): 0.0250 Velocity (fps): 8.3 Normal Depth (ft): 0.55 Critical Depth (ft): 0.86 Custom Q (cfs): 5.8 Road Depth (ft): Upstream HGL (ft):										
<b>Elevations</b> <table border="1"> <thead> <tr> <th></th> <th>U/S (ft)</th> <th>D/S (ft)</th> </tr> </thead> <tbody> <tr> <td>Ground</td> <td>1274.36</td> <td>1273.55</td> </tr> <tr> <td>Invert</td> <td>1269.30</td> <td>1268.80</td> </tr> </tbody> </table>			U/S (ft)	D/S (ft)	Ground	1274.36	1273.55	Invert	1269.30	1268.80	Comments:	
	U/S (ft)	D/S (ft)										
Ground	1274.36	1273.55										
Invert	1269.30	1268.80										

Info ReSort Print... Delete Add Graph MB Update OK

**Note:** If an error appears try by modifying the Ground – D/S value until the error disappears. After that introduce the correct value.

Click '**Add**' to enter the next record. Enter the following data for **Facility ID 010025**.

**ID:**

- **Facility ID** 010025
- **Line ID** 20
- **Sort** 40

**Model Options:**

- **RP (yrs)** 2
- **Custom** checkbox Check
- **Q (cfs)** 5.8
- **Model Road** checkbox Check
- **First Pipe** checkbox Uncheck
- **Outfall** checkbox Uncheck

**Elevations:**

- **U/S Ground Elevation (ft)** 1274.77
- **D/S Ground Elevation (ft)** 1274.36
- **U/S Invert Elevation (ft)** 1270.05
- **D/S Invert Elevation (ft)** 1269.80

### Section Type:

- **Section** *Pipe*
- **Length (ft)** *100.00*
- **Manning's n** *0.013*
- **Diameter (in)** *18*
- **No. of Barrels** *1*
- **Road ID** *PH-MJC-XSE-80*
- **No. of Manholes** *0*

After entering all the data for the fourth record (**Facility ID 010025**), press '**Save**'.

Click '**Add**' to enter the next record. Enter the following data for **Facility ID 010020**.

### ID:

- **Facility ID** *010020*
- **Line ID** *20*
- **Sort** *50*

### Model Options:

- **RP (yrs)** *2*
- **Custom** checkbox *Check*
- **Q (cfs)** *5.8*
- **Model Road** checkbox *Uncheck*
- **First Pipe** checkbox *Uncheck*

- **Outfall** checkbox *Uncheck*

**Elevations:**

- **U/S Ground Elevation (ft)** *1274.59*
- **D/S Ground Elevation (ft)** *1274.77*
- **U/S Invert Elevation (ft)** *1270.24*
- **D/S Invert Elevation (ft)** *1270.05*

**Section Type:**

- **Section** *Pipe*
- **Length (ft)** *75.00*
- **Manning's n** *0.013*
- **Diameter (in)** *18*
- **No. of Barrels** *1*
- **No. of Manholes** *0*

After entering all the data for the fifth record (**Facility ID 010020**), press '**Save**'.

Click '**Add**' to enter the next record. Enter the following data for **Facility ID 010015**.

**ID:**

- **Facility ID** *010015*
- **Line ID** *20*
- **Sort** *60*

### Model Options:

- **RP (yrs)** 2
- **Custom** checkbox *Check*
- **Q (cfs)** 5.8
- **Model Road** checkbox *Uncheck*
- **First Pipe** checkbox *Uncheck*
- **Outfall** checkbox *Uncheck*

### Elevations:

- **U/S Ground Elevation (ft)** 1274.44
- **D/S Ground Elevation (ft)** 1274.59
- **U/S Invert Elevation (ft)** 1270.29
- **D/S Invert Elevation (ft)** 1270.24

### Section Type:

- **Section** *Pipe*
- **Length (ft)** 20.00
- **Manning's n** 0.013
- **Diameter (in)** 18
- **No. of Barrels** 1
- **No. of Manholes** 0

After entering all the data for the sixth record (**Facility ID 010015**), press '**Save**'.

Conveyance Facilities - MB: 01

**List** **Details**

**ID**

MB ID 01

Facility ID 010015

Line ID 20

Sort 60

**Model Options**

Q (cfs) 5.8

Custom Q ☒

Model Road ☐

First Pipe ☐

Outfall ☐

**Elevations**

	U/S (ft)	D/S (ft)
Ground	1274.44	1274.59
Invert	1270.29	1270.24

**Section Type**

Section Pipe

Length (ft) 20.00

Manning's n 0.013

Diameter (in) 18

No. of Barrels 1

No. of Manholes 0

**Calculations**

Capacity (cfs) 5.2

Slope (ft/ft) 0.0025

Velocity (fps) 3.3

Normal Depth (ft) 1.50

Critical Depth (ft) 0.93

Custom Q (cfs) 5.8

Upstream HGL (ft)

Comments

Info ReSort Print... Delete Add Graph MB Update OK

Click **'Add'** to enter the next record. Enter the following data for **Facility ID 010010**.

**ID:**

- Facility ID 010010
- Line ID 20
- Sort 70

**Model Options:**

- RP (yrs) 2
- Custom checkbox Check
- Q (cfs) 4.7
- Model Road checkbox Uncheck
- First Pipe checkbox Uncheck
- Outfall checkbox Uncheck

**Elevations:**

- U/S Ground Elevation (ft) 1274.44
- D/S Ground Elevation (ft) 1274.44
- U/S Invert Elevation (ft) 1270.31
- D/S Invert Elevation (ft) 1270.29

**Section Type:**

- Section Pipe
- Length (ft) 10.00
- Manning's n 0.013
- Diameter (in) 18
- No. of Barrels 1
- No. of Manholes 0

After entering all the data for the seventh record (**Facility ID 010010**), press **'Save'**.

Conveyance Facilities - MB: 01

List		Details										
<b>ID</b> MB ID: 01 Facility ID: 010010 Line ID: 20 Sort: 70		<b>Section Type</b> Section: Pipe Length (ft): 10.00 Manning's n: 0.013 Diameter (in): 18 No. of Barrels: 1 No. of Manholes: 0	<b>Calculations</b> Capacity (cfs): 4.7 Slope (ft/ft): 0.0020 Velocity (fps): 2.7 Normal Depth (ft): 1.50 Critical Depth (ft): 0.84 Custom Q (cfs): 4.7 Upstream HGL (ft):									
<b>Model Options</b> Q (cfs): 4.7 Custom Q: <input checked="" type="checkbox"/> Model Road: <input type="checkbox"/> First Pipe: <input type="checkbox"/> Outfall: <input type="checkbox"/>		<b>Elevations</b> <table border="1"> <thead> <tr> <th></th> <th>U/S (ft)</th> <th>D/S (ft)</th> </tr> </thead> <tbody> <tr> <td>Ground</td> <td>1274.44</td> <td>1274.44</td> </tr> <tr> <td>Invert</td> <td>1270.31</td> <td>1270.29</td> </tr> </tbody> </table>			U/S (ft)	D/S (ft)	Ground	1274.44	1274.44	Invert	1270.31	1270.29
	U/S (ft)	D/S (ft)										
Ground	1274.44	1274.44										
Invert	1270.31	1270.29										

Comments:

Info ReSort Print... Delete Add Graph MB Update OK

Click 'Add' to enter the next and last record. Enter the following data for **Facility ID 010005**.

**ID:**

- Facility ID 010005
- Line ID 20
- Sort 80

**Model Options:**

- RP (yrs) 2
- Custom checkbox Check
- Q (cfs) 3.4
- Model Road checkbox Check
- First Pipe checkbox Check
- Outfall checkbox Uncheck

**Elevations:**

- U/S Ground Elevation (ft) 1274.96
- D/S Ground Elevation (ft) 1274.44
- U/S Invert Elevation (ft) 1270.79
- D/S Invert Elevation (ft) 1270.31

### Section Type:

- **Section** *Pipe*
- **Length (ft)** *190.00*
- **Manning's n** *0.013*
- **Diameter (in)** *18*
- **No. of Barrels** *1*
- **Road ID** *PH-MJC-XSE-80*
- **No. of Manholes** *0*

After entering all the data for the last record (**Facility ID 010005**), press '**Save**'.

**Conveyance Facilities - MB: 01**

**List** **Details**

**ID**

MB ID: 01  
Facility ID: 010005  
Line ID: 20  
Sort: 80

**Model Options**

Q (cfs): 3.4  
Custom Q: ☒  
Model Road: ☒  
First Pipe: ☒  
Outfall: ☐

**Elevations**

	U/S (ft)	D/S (ft)
Ground	1274.96	1274.44
Invert	1270.79	1260.31

**Section Type**

Section: Pipe  
Length (ft): 190.00  
Manning's n: 0.013  
Diameter (in): 18  
No. of Barrels: 1  
Road ID: PH-MJC-XSE-80  
No. of Manholes: 0

**Calculations**

Capacity (cfs)	339.7
Slope (ft/ft)	10.4800
Velocity (fps)	58.5
Normal Depth (ft)	0.11
Critical Depth (ft)	0.71
Custom Q (cfs)	3.4
Road Depth (ft)	
Upstream HGL (ft)	

**Comments**

Info ReSort Print... Delete Add Graph MB Update OK

To view the list of Facilities Data entered, click the **List** tab.



Sort	Facility ID	Line ID	Size	Length	Slope	RP	Q	Capacity
10	010040	10	48" Dia Pipe	80.00	0.0163	0	105.2	183.2
20	010035	10	48" Dia Pipe	300.00	0.0050	0	102.0	101.5
30	010030	20	24" Dia Pipe	200.00	0.0250	0	5.8	35.7
40	010025	20	18" Dia Pipe	100.00	0.0025	0	5.8	5.2
50	010020	20	18" Dia Pipe	75.00	0.0025	0	5.8	5.2
60	010015	20	18" Dia Pipe	20.00	0.0025	0	5.8	5.2
70	010010	20	18" Dia Pipe	10.00	0.0020	0	4.7	4.7
80	010005	20	18" Dia Pipe	190.00	10.480	0	3.4	339.7

Click '**OK**' to close the **CONVEYANCE FACILITIES** form now that the Conveyance Facilities Data have now been developed.

## 9.0 BUILD THE MODEL NETWORK

Prior to running the Storm Drain system created from the Section 8.0, it is essential to build the model network to define the interconnectivity of the piping / conduit system. To build the model network, open the **RATIONAL METHOD NETWORK** form (**Hydrology → Rational Method → Network**). To start, press the '**Add**' button. Build the model network as shown below. The procedure for building a model network for Rational Method is presented in another tutorial document called, "**Developing a New Project Using Rational Method**".

Rational Method Network - MB: 01

Look for  ☒ First Pipe

Sort	ID	Type	Combine
10	0105	Sub Basin	
20	0106	Sub Basin	
30	0106	Combine	2
40	010005	Convey	
50	0108	Sub Basin	
60	0108	Combine	2
70	010010	Convey	
80	0107	Sub Basin	
90	0107	Combine	2
100	010015	Convey	
110	010020	Convey	
120	010025	Convey	
130	010030	Convey	
140	010030	Hold	
150	0111	Sub Basin	
160	010035	Convey	
170	010030	Receive	
180	0111	Combine	2

**Network**

Major Basin ID

Sort

Type

ID

Combine

Rational Method Network - MB: 01

Look for  ☒ First Pipe

Sort	ID	Type	Combine
30	0106	Combine	2
40	010005	Convey	
50	0108	Sub Basin	
60	0108	Combine	2
70	010010	Convey	
80	0107	Sub Basin	
90	0107	Combine	2
100	010015	Convey	
110	010020	Convey	
120	010025	Convey	
130	010030	Convey	
140	010030	Hold	
150	0111	Sub Basin	
160	010035	Convey	
170	010030	Receive	
180	0111	Combine	2
190	010040	Convey	

**Network**

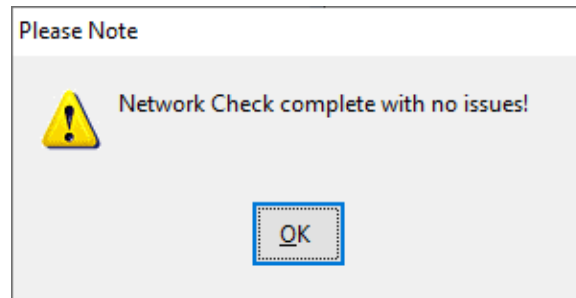
Major Basin ID

Sort

Type

ID  ☐ First Pipe

Once the model network is built (like the one shown above), click the **'Check Network'** button for the program to verify if the model network that was built is complete or has issues.

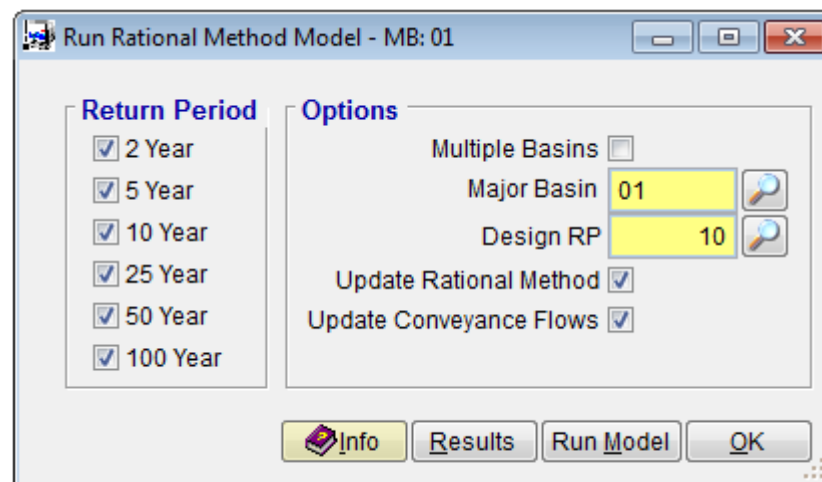


## 10.0 RUN THE MODEL

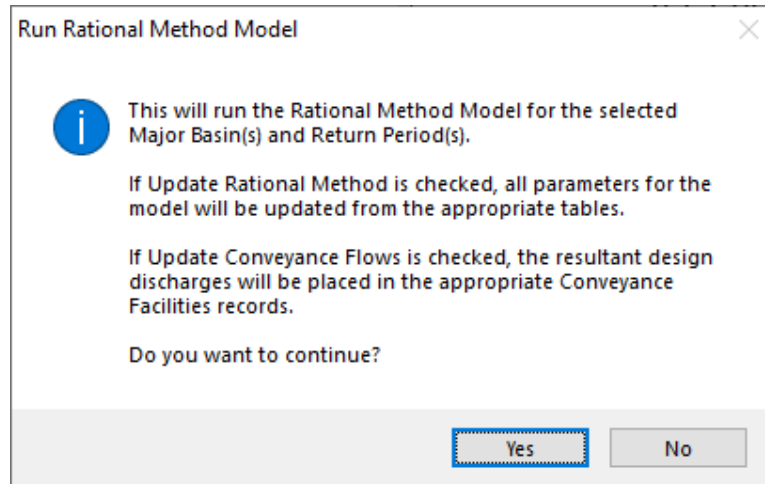
To run the model, open the **RUN RATIONAL METHOD MODEL** form and make the following changes on the form:

- (a) Check all the **Return Periods** (i.e., **2 Year**, **5 Year**, **10 Year**, **25 Year**, **50 Year**, and **100 Year**);
- (b) Check the **'Update Rational Method'** checkbox.
- (c) Check the **'Update Conveyance Flows'** checkbox.

Click the **'Run Model'** button.



Click **'OK'** to continue.

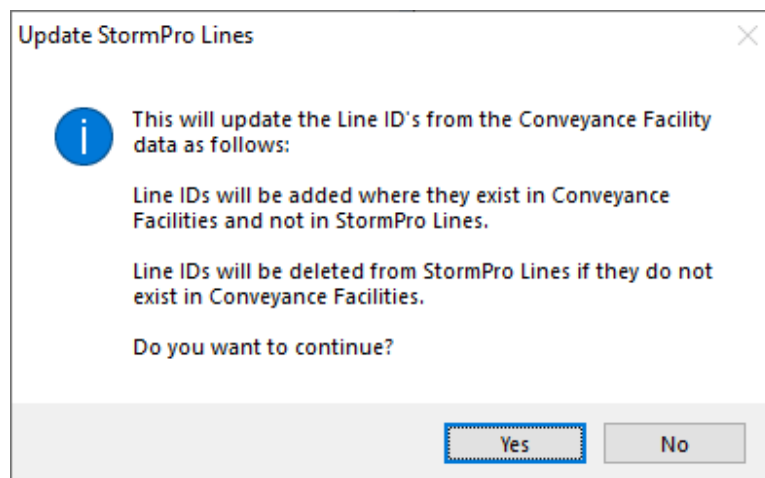


After the model is run, click '**OK**' to close and exit the form.

## 11.0 ESTABLISH DATA FOR THE STORMPRO LINES

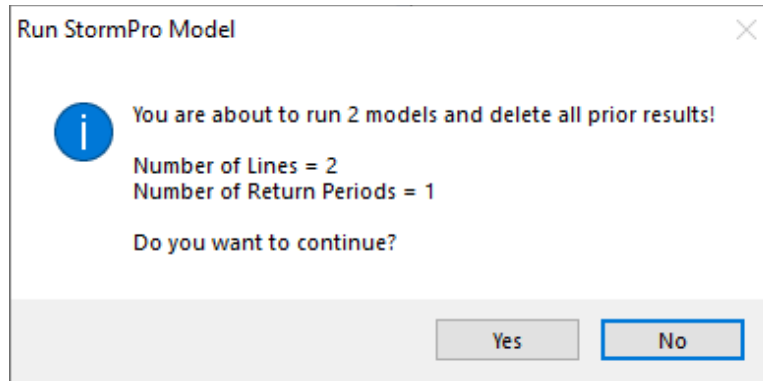
To establish the starting water surface elevation (boundary condition) for **Line ID 10** (the Main Line), open the **STORMPRO LINES** form (*Hydraulics → StormPro Backwater → Lines*). This starting water surface elevation is used to establish the hydraulic grade line (HGL) for the entire drainage system. If left blank, the value will default to  $(D+D_c)/2$ , where  $D$  is the depth of the facility, and  $D_c$  is the critical depth.

On the **STORMPRO LINES** form, press the '**Update**' button to start. On the **UPDATE STORMPRO LINES** form, click '**Yes**' to continue.



For **Line ID 10**, check that it is a '**Main Line**' and enter **1269.90** for the starting water surface elevation. Do not enter any starting water surface elevation for **Line ID 20 (Lateral Line)** as this will be established in the Model Run.





Once the model run is complete, model results viewed by clicking the **'Results'** button and can be graphed by clicking the **'Graph'** on the **STORMPRO RESULTS** form.

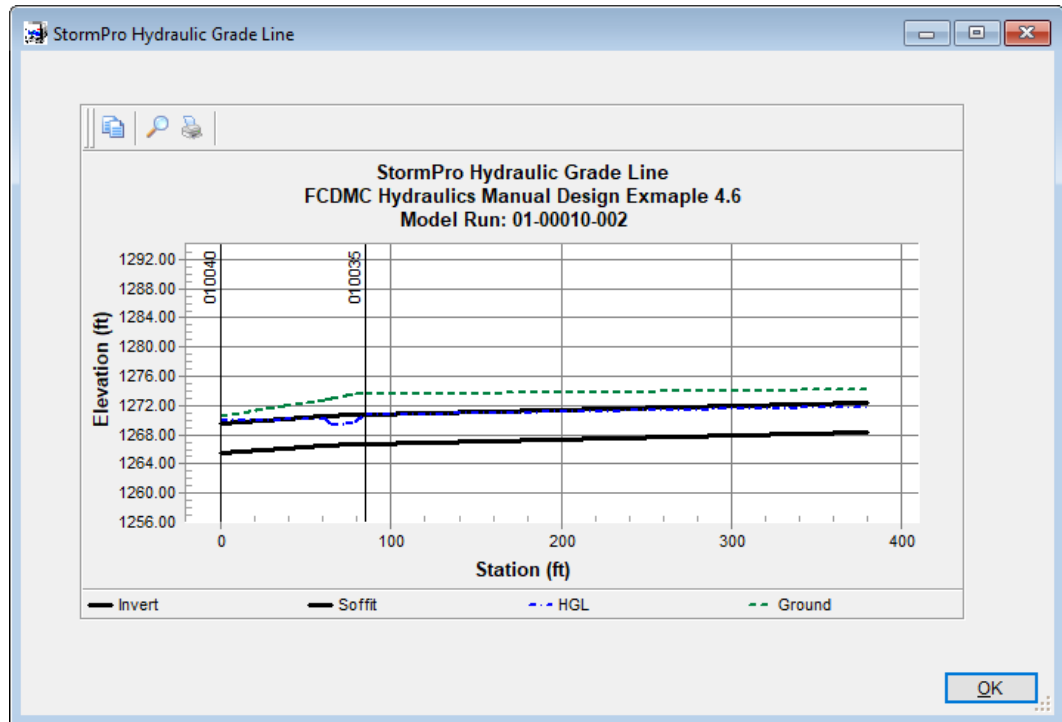
StormPro Results - MB: 01

List Details

☒ Equivalent Box Section

Line ID	RP	ID	Size	Station	Flow	Velocity	Inv	HGL	GE	HGL>GE
10	2	010040	48" Dia Pipe	0.00	106.9	8.51	1265.50	1269.90	1270.50	
10	2	010040	48" Dia Pipe	37.34	106.9	8.51	1266.11	1270.11	1271.92	
10	2	010040	48" Dia Pipe	60.54	106.9	8.92	1266.48	1270.11	1272.81	
10	2	010040	48" Dia Pipe	61.65	106.9	8.96	1266.50	1270.11	1272.85	
10	2	010040	48" Dia Pipe	64.93	106.9	11.70	1266.56	1269.29	1272.98	
10	2	010040	48" Dia Pipe	73.69	106.9	11.15	1266.70	1269.55	1273.31	
10	2	010040	48" Dia Pipe	78.49	106.9	10.63	1266.78	1269.76	1273.49	
10	2	010040	48" Dia Pipe	80.00	106.9	10.14	1266.80	1269.93	1273.55	
10	2	010035	48" Dia Pipe	85.00	101.3	8.16	1266.80	1270.66	1273.56	
10	2	010035	48" Dia Pipe	340.85	101.3	8.55	1268.10	1271.67	1274.13	
10	2	010035	48" Dia Pipe	380.00	101.3	8.65	1268.30	1271.82	1274.22	

Info Print... Graph View MB OK



To see more detailed results, the model output file can be viewed by clicking **'View'**, and selecting **'Output'** for the File Type.

Model View

View Option

Line ID: 10

Return Period: 2

File Type: Results

Graph EGL: ☐

Info OK

Flood Control District of Maricopa County  
Drainage Design Management System  
STORMPRO RESULTS  
Project Reference: DESIGNEX40

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ID	Station	Length	Section	Q (cfs)	Velocity (ft/sec)	Vhd (ft)	So	Sf Avg	Depths (ft)				Elevations				
									Modeled	Normal	Critical	d/D	Invert	EGL	HGL	Ground	
Run File (MB-LINE-RP): 01-00010-002																	
010040	-	37.34	48" Dia Pipe	108.9	8.51	1.12	.01625	.00550	4.40	2.19	3.13	1.00	1,265.50	1,271.02	1,269.90	1,270.50	
	37.34	23.20	48" Dia Pipe	108.9	8.51	1.12	.01625	.00515	4.00	2.19	3.13	1.00	1,266.11	1,271.23	1,270.11	1,271.92	
	60.54	1.10	48" Dia Pipe	108.9	8.92	1.24	.01625	.00488	3.83	2.19	3.13	.91	1,268.48	1,271.35	1,270.11	1,272.81	
	61.65	1.11	48" Dia Pipe	108.9	8.98	1.25	.01625	.00488	3.81	-	3.13	.90	1,268.50	1,271.36	1,270.11	1,272.85	
	64.93	8.75	48" Dia Pipe	108.9	11.70	2.13	.01625	.00799	2.73	2.19	3.13	.68	1,268.56	1,271.41	1,269.29	1,272.98	
	73.69	4.80	48" Dia Pipe	108.9	11.15	1.93	.01625	.00714	2.85	2.19	3.13	.71	1,268.70	1,271.48	1,269.55	1,273.31	
	78.49	1.51	48" Dia Pipe	108.9	10.63	1.78	.01625	.00641	2.98	2.19	3.13	.75	1,268.78	1,271.52	1,269.76	1,273.49	
	80.00	1.51	48" Dia Pipe	108.9	10.14	1.60	.01625	.00604	3.13	-	3.13	.78	1,268.80	1,271.53	1,269.93	1,273.55	
010035	85.00	255.85	48" Dia Pipe	101.3	8.16	1.03	.00508	.00438	3.88	3.24	3.05	.97	1,268.80	1,271.69	1,270.66	1,273.56	
	340.85	39.15	48" Dia Pipe	101.3	8.55	1.14	.00508	.00444	3.57	3.24	3.05	.89	1,268.10	1,272.81	1,271.67	1,274.13	
	380.00	39.15	48" Dia Pipe	101.3	8.65	1.16	.00508	.00444	3.52	-	3.05	.88	1,268.30	1,272.98	1,271.82	1,274.22	