

HY8 Culvert Analysis



- HY-8 Version 7.2 Build Date January 17, 2012
- Federal Highway Administration

<http://www.fhwa.dot.gov/engineering/hydraulics/software/hy8/index.cfm>

SIMPLE

Simple to use

Use for simple culverts and bridges

Normally it would not be used for complicated projects, such as bridges with piers or when precise stream profiles are needed. Also, it will not run with an open channel without a structure

Sample Problem

- Replace an existing culvert with a larger culvert
- **Issue:** CRC wants to replace the existing culvert with a longer culvert. The proposed design increases the size of the culvert as well. Will the larger culvert offset the fact that the culvert will be longer?
- **Existing Culvert:**
 - Length-- 32’.
 - CMP, 42” diameter
 - Low point of road: el 588.20
 - Width of road: 18 feet
 - Stream bottom sandy but stony
 - Stream banks weedy with small brush
 - Stream bottom elevation 579.00
- **Proposed Culvert:**
 - Length– 54’.
 - Concrete Elliptical, 60”x38”
 - Road elevations and width will remain the same

Data Acquisition

Flood Discharge Information

Obtained from DEQ-WRD Hydrologic Studies
and Dam Safety Unit

http://www.michigan.gov/deq/0,4561,7-135-3313_3684_3724-168812--,00.html

DEQ - Request a Flood or Low Flow Discharge Form - Windows Internet Explorer

http://www.michigan.gov/deq/0,4561,7-135-3313_3684_3724-168812--,00.html

File Edit View Favorites Tools Help

DEQ - Request a Flood or Low Flow Discharge Form

MENU

DEQ Contacts Permits Online Services Programs Locations MI.gov

Department of Environmental Quality

DEQ > WATER > WATER MANAGEMENT > HYDROLOGIC DATA COLLECTION & A

Go

Request a Flood or Low Flow Discharge Form

Discharge Request

Authorized by PA 451 of 1994. Completion of this form is voluntary.

Important:

- Please email any additional information to deq-wrd-greg@michigan.gov with "Discharge Request" in the subject line. Our email attachment size limit is 25 MB.
- A confirmation e-mail will be sent to you. If you do not receive it, please e-mail your form information directly to deq-wrd-greg@michigan.gov?subject=Discharge Request. You must click the Submit button at the end of the form to send the request to us and get a confirmation e-mail.

Please fill-in this form to request a flood or low flow discharge. Note that a site location map is required. You may send it by [email](#), fax it to (517) 241-9003 (please note Discharge Request on the cover sheet), or mail it to:

Water Resources Division
PO Box 30458
Lansing, MI 48909-7958

If you have questions about requesting a flood discharge, please call Susi Greiner at (517) 284-5579. If you have questions about requesting a low flow discharge, please call Mario Lesmez at (517) 284-5580.

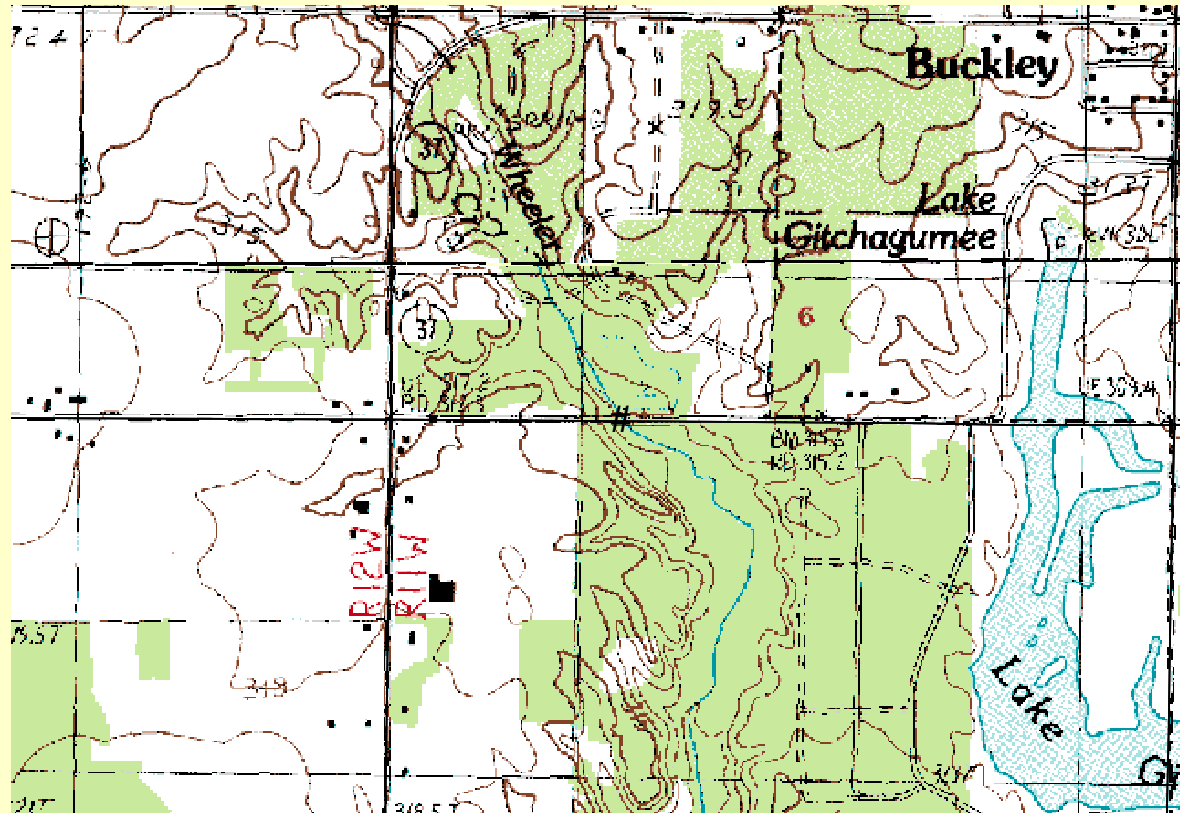
Data Acquisition

Channel Slope

Obtained from survey data or topo maps

Measure distance along stream between contours

Channel Slope = rise/run



Data Acquisition

Manning's n (Channel)

- Several references for Manning's n for various stream conditions
- “Open Channel Hydraulics”, Chow 1959 contains an extensive compilations of n values
- References typically provide color photo with tables of calibrated n values for a range of flows.



Data Acquisition

Project Survey and Design Data

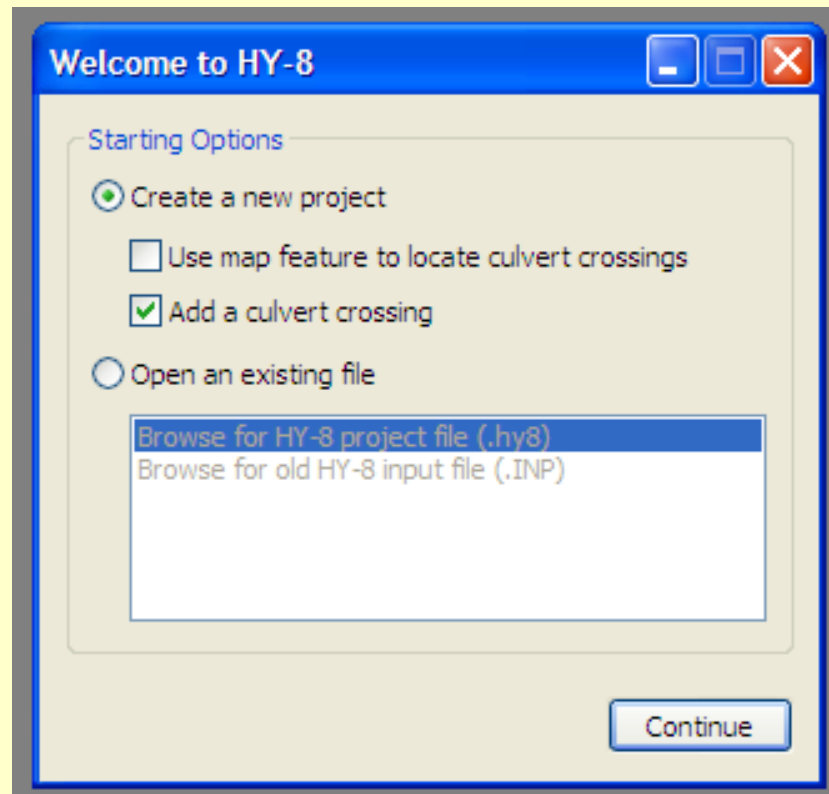
Stream Channel Shape and Streambed Invert Elevation

Culvert Inlet Conditions, Culvert dimensions & Type

Existing and Proposed Road Grade, Width, Crest Length



Start Project



Data Input

Crossing Data - Crossing 1 Existing

Crossing Properties

Name: Crossing 1 Existing

Parameter	Value	Units
DISCHARGE DATA		
Minimum Flow	0.00	cfs
Design Flow	450.00	cfs
Maximum Flow	600.00	cfs
TAILWATER DATA		
Channel Type	Rectangular Channel	
Bottom Width	50.00	ft
Channel Slope	0.0001	ft/ft
Manning's n (channel)	0.0250	
Channel Invert Elevation	579.00	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Irregular	
Irregular Shape	Define...	
Roadway Surface	Paved	
Top Width	18.00	ft

Irregular Roadway Shape

Number of Coordinates (3 - 15): 3

Number	Station (ft)	Elevation (ft)
1	925.00	589.75
2	1000.00	588.20
3	1075.00	588.80

Plot OK Cancel

Data Input

Crossing Data - Crossing 1 Existing

Crossing Properties

Name: Crossing 1 Existing

Parameter	Value	Units
DISCHARGE DATA		
Minimum Flow	0.00	cfs
Design Flow	450.00	cfs
Maximum Flow	600.00	cfs
TAILWATER DATA		
Channel Type	Rectangular Channel	
Bottom Width	50.00	ft
Channel Slope	0.0001	ft/ft
Manning's n (channel)	0.0250	
Channel Invert Elevation	579.00	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Irregular	
Irregular Shape	Define...	
Roadway Surface	Paved	
Top Width	18.00	ft

Culvert Properties

Culvert 1

Add Culvert
Duplicate Culvert
Delete Culvert

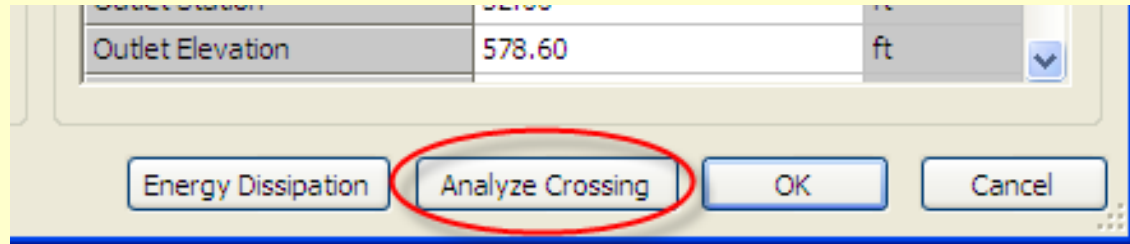
Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Shape	Circular	
Material	Corrugated Steel	
Diameter	3.50	ft
Embedment Depth	0.00	in
Manning's n	0.0240	
Inlet Type	Conventional	
Inlet Edge Condition	Thin Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	ft
Inlet Elevation	578.60	ft
Outlet Station	32.00	ft
Outlet Elevation	578.60	ft
Number of Barrels	1	

Help Click on any icon for help on a specific topic

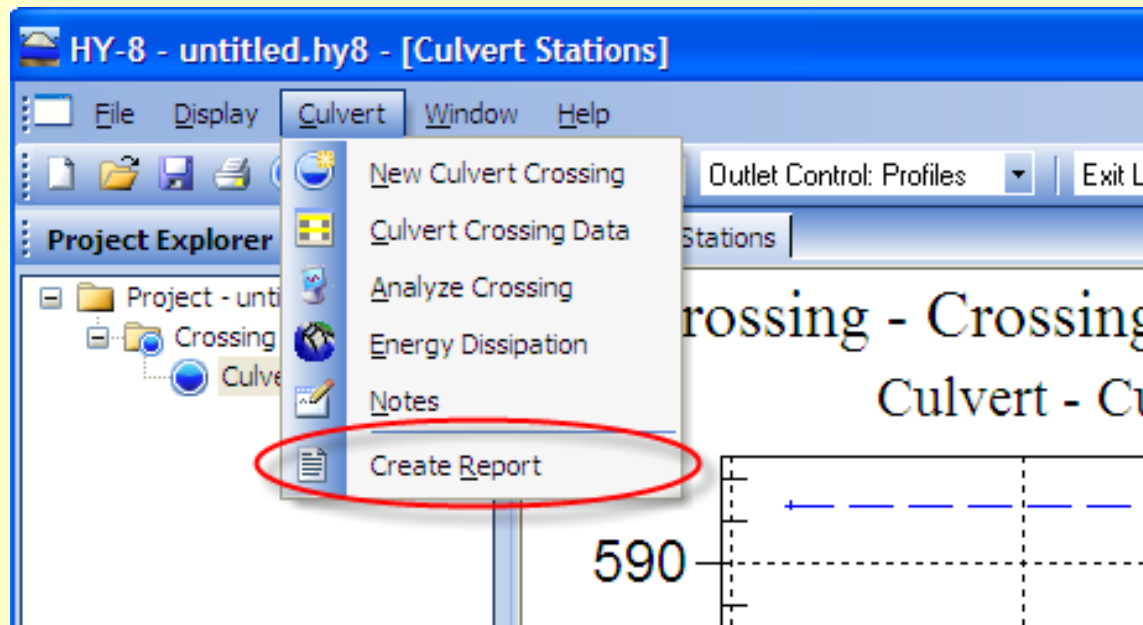
Energy Dissipation Analyze Crossing OK Cancel

Analyze Crossing

After data entry is complete, click “Analyze Crossing”



Create Report



Proposed Design

Crossing Data - Crossing 1 Existing

Crossing Properties

Name: Crossing 1 Proposed

Parameter	Value	Units
DISCHARGE DATA		
Minimum Flow	0.00	cfs
Design Flow	450.00	cfs
Maximum Flow	600.00	cfs
TAILWATER DATA		
Channel Type	Rectangular Channel	
Bottom Width	50.00	ft
Channel Slope	0.0001	ft/ft
Manning's n (channel)	0.0250	
Channel Invert Elevation	579.00	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Irregular	
Irregular Shape	Define...	
Roadway Surface	Paved	
Top Width	18.00	ft

Culvert Properties

Culvert 1

Add Culvert
Duplicate Culvert
Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Shape	Elliptical	
Material	Concrete	
Size	Define...	
Span	60.00	in
Rise	38.00	in
Embedment Depth	0.00	in
Manning's n	0.0120	
Inlet Type	Conventional	
Inlet Edge Condition	Grooved Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	ft
Inlet Elevation	579.00	ft
Outlet Station	54.00	ft
Outlet Elevation	578.95	ft
Number of Barrels	1	

Help Click on any icon for help on a specific topic

Energy Dissipation Analyze Crossing OK Cancel

Calculations & Output

- Total flow through the Culverts
- Flow through individual culverts
- Weir flow
- Pressure and Weir Flow
- Tailwater Elevations (*See HY-8 Help----Limitations*)
- Headwater Elevations
- Outlet velocities (*See HY-8 Help----Limitations*)
- And More....

Culvert Flow



- Cross-section of the culvert
- Slope of the culvert
- “N” value of the culvert
- Manning's equation
- Uses direct step method

Inlet Control vs. Outlet Control

- Computes inlet control headwater elevation, flow passes through critical depth at the culvert entrance and is supercritical in the barrel. The headwater elevation is a function of the entrance size, shape, and inlet type.
- Computes outlet control headwater elevation, the flow in the barrel is subcritical, and the energy equation may be used to find the upstream headwater depth, including entrance & exist losses, and friction losses.
- Uses the higher answer of the two

Weir Flow



- Coefficient of discharge
- Roadway width
- Roadway surface
- Defined roadway

Pressure and Weir Flow



- Calculates weir flow
- Uses a built-in submergence factor
- Balances weir and pressure flows at resulting the same headwater elevation.

Analysis

Make sure it makes sense and data was input correctly!

Headwater

- How does it compare to what you expect?
- How does it compare to existing high water marks?
- How does it compare to the tailwater?

Tailwater

- How does it compare to what you expect?
- How does it compare to existing high water marks?



Analysis Continued

Culverts

- How much flow per culvert?
- What are outlet velocities?
- Is it reasonable?
- Check inverts and lengths.

Weir Flow

- How much water?
- Can it really get there?

Compare

- How does output compare between existing and proposed?



Compare

Proposed = equal or greater hydraulic capacity

Summary of Flows at Crossing - Crossing 1 Existing				
Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
579.00	0.00	0.00	0.00	1
583.09	60.00	60.00	0.00	1
588.45	120.00	114.12	5.70	23
588.85	180.00	116.91	62.82	7
589.03	240.00	118.22	121.53	6
589.19	300.00	117.98	181.62	5
589.33	360.00	120.00	240.53	4
589.45	420.00	120.00	299.66	4
589.50	450.00	120.00	329.87	4
589.66	540.00	120.00	419.85	4
589.76	600.00	120.00	479.77	3
588.20	112.30	112.30	0.00	Overtopping

Display ☒ Crossing Summary Table

Geometry Inlet Elevation:

Summary of Flows at Crossing - Crossing 1 Proposed				
Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
579.00	0.00	0.00	0.00	1
582.02	60.00	60.00	0.00	1
583.91	120.00	120.00	0.00	1
587.46	180.00	180.00	0.00	1
588.76	240.00	197.36	42.41	10
588.97	300.00	199.92	99.79	6
589.14	360.00	197.91	161.92	6
589.30	420.00	191.49	228.24	5
589.37	450.00	188.21	261.37	4
589.56	540.00	180.23	359.23	4
589.66	600.00	180.00	419.89	4
588.20	190.24	190.24	0.00	Overtopping

Display ☒ Crossing Summary Table

Geometry Inlet Elevation:

“Advanced” Options

- Channel Shape and attributes
- Irregular Roadway Profiles
- Culvert Shapes
- Multiple Culverts
- Recessed Culverts
- Simple Bridges

Channel Cross Section Shapes

Crossing Data - Crossing 1 Existing

Crossing Properties

Name: Crossing 1 Proposed

Parameter	Value	Units
DISCHARGE DATA		
Minimum Flow	0.00	cfs
Design Flow	450.00	cfs
Maximum Flow	600.00	cfs
TAILWATER DATA		
Channel Type	Rectangular Channel	
Bottom Width	50.00	ft
Channel Slope	0.0001	ft/ft
Manning's n (channel)	0.0250	
Channel Invert Elevation	579.00	ft
Rating Curve	View...	
ROADWAY DATA		
Roadway Profile Shape	Irregular	
Irregular Shape	Define...	
Roadway Surface	Paved	
Top Width	18.00	ft

Culvert Properties

Culvert 1

Add Culvert
Duplicate Culvert
Delete Culvert

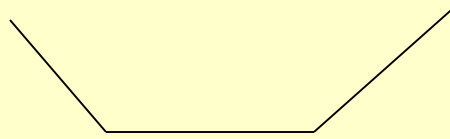
Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Shape	Elliptical	
	Concrete	
	Define...	
	50.00	in
	38.00	in
	0.00	in
Manning's n	0.0120	
Inlet Type	Conventional	
Inlet Edge Condition	Grooved Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	ft
Inlet Elevation	579.00	ft
Outlet Station	54.00	ft
Outlet Elevation	578.95	ft
Number of Barrels	1	

Help Click on any icon for help on a specific topic

Energy Dissipation Analyze Crossing OK Cancel

Standard Channel Cross-Section Shapes

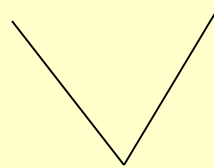
- Trapezoidal



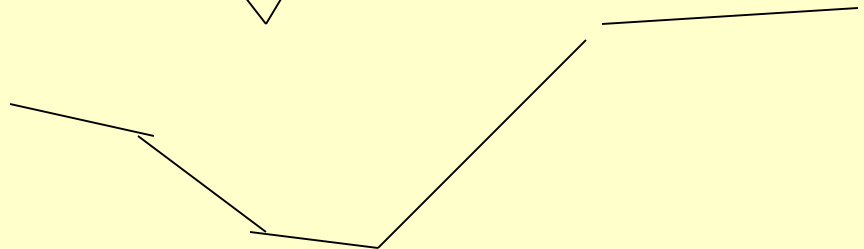
- Rectangular



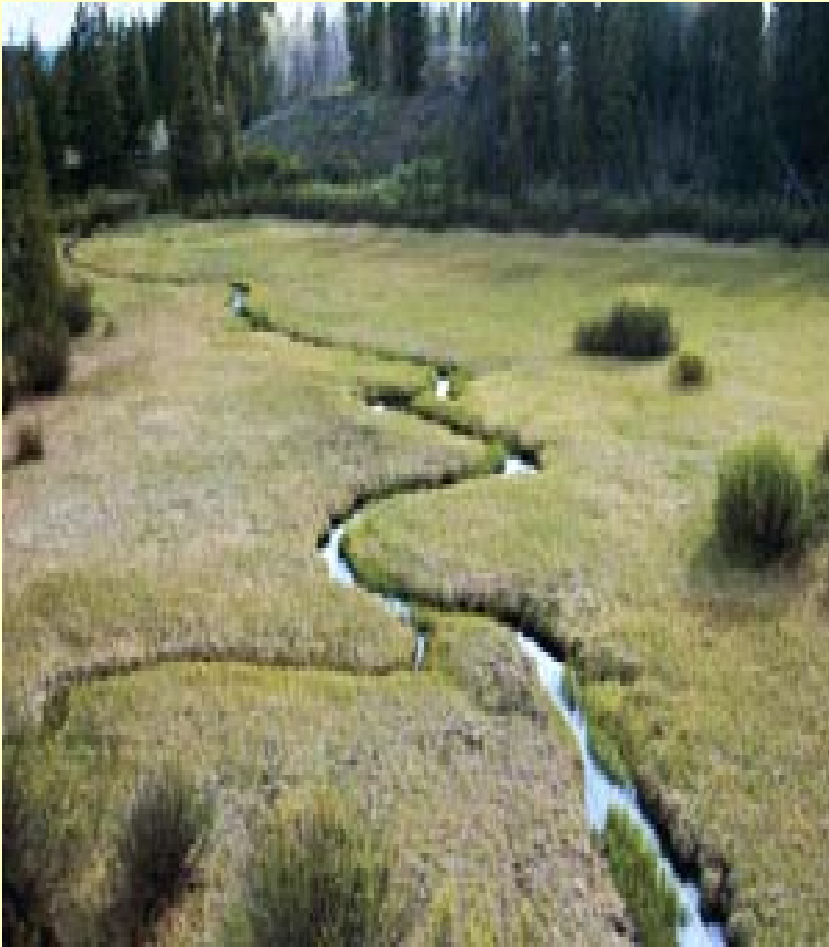
- Triangular



- User defined



User-defined Channel Cross Sections



- 15 coordinates only
- Specify overbank and channel areas
- Mannings “n” values
- Input stations and elevations
- Channel slopes

User Defined Channel Cross Sections

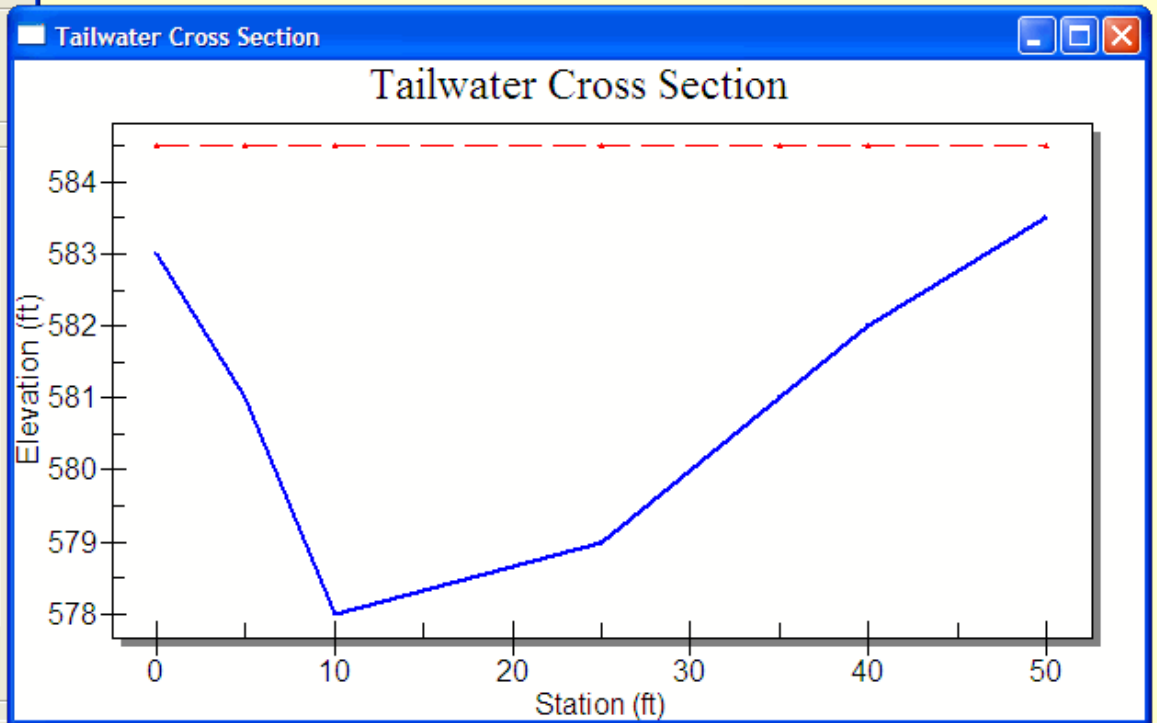
Irregular Tailwater Channel

Tailwater File
Browse for existing .TW file

Tailwater Channel
Slope of tailwater channel: ft/ft
Number of cross-sec points:

Irregular Channel Cross-Section

No.	Station (ft)	Elevation (ft)	Manning n
1	0.000	583.000	0.0500
2	5.000	581.000	0.0400
3	10.000	578.000	0.0400
4	25.000	579.000	0.0250
5	35.000	581.000	0.0400
6	40.000	582.000	0.0500
7	50.000	583.500	



Roadway Options

- Constant or User Defined Profile
- Roadway width
- Paved or gravel?
- Program calculates coefficient of discharge



User-defined Roadway

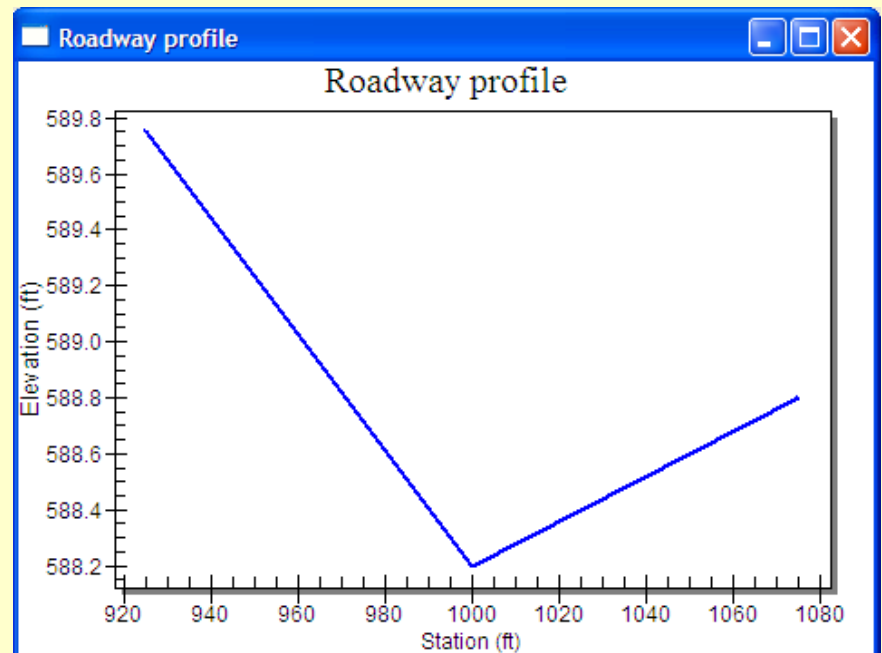
Irregular Roadway Shape

Number of Coordinates (3 -15):

Number	Station (ft)	Elevation (ft)
1	925.00	589.75
2	1000.00	588.20
3	1075.00	588.80

Plot OK Cancel

- Enter 3-15 points
- Station and elevation
- Cannot restrict flow areas



Culvert Options

Crossing Data - Crossing 1 Existing

Crossing Properties

Name: Crossing 1 Proposed

Parameter

DISCHARGE DATA

Minimum Flow

Design Flow

Maximum Flow

600.00

Units

cfs

cfs

cfs

Circular

Concrete Box

Elliptical

Pipe Arch

User Defined

Arch, Open Bottom

Low-Profile Arch

High-Profile Arch

Metal Box

Arch-Box, Concrete

Available Sizes

Click on the spreadsheet to select a size

No.	Span (in)	Rise (in)	Area (ft^2)	Mannings n	Br (in)	Tr (in)	Cr (in)	B (in)
1	23.000	14.000	1.820	0.012	19.940	19.940	6.090	7.00
2	30.000	19.000	3.220	0.012	26.240	26.240	8.210	9.50
3	34.000	22.000	4.100	0.012	29.250	29.250	9.250	11.0
4	38.000	24.000	5.130	0.012	32.800	32.800	10.260	12.0
5	42.000	27.000	6.370	0.012	36.200	36.200	11.450	13.5
6	45.000	29.000	7.340	0.012	39.360	39.360	12.320	14.5
7	49.000	32.000	8.810	0.012	42.660	42.660	13.550	16.0
8	53.000	34.000	10.150	0.012	45.900	45.900	14.000	17.0
9	60.000	38.000	12.850	0.012	51.600	51.600	16.430	19.0
10	68.000	43.000	16.490	0.012	58.400	58.400	18.650	21.5
11	76.000	48.000	20.550	0.012	65.090	65.090	20.670	24.0
12	83.000	53.000	24.770	0.012	71.520	71.520	22.750	26.5
13	91.000	58.000	29.690	0.012	77.950	77.950	24.840	29.0
14	98.000	63.000	34.730	0.012	84.380	84.380	26.930	31.5
15	106.000	68.000	40.530	0.012	90.810	90.810	29.020	34.0
16	113.000	72.000	45.850	0.012	97.240	97.240	31.110	36.0
17	121.000	77.000	52.470	0.012	103.660	103.660	33.190	38.5
18	128.000	82.000	59.200	0.012	110.000	110.000	35.250	41.0

Culvert Properties

Culvert 1

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Shape	Elliptical	
Material	Concrete	
Size	Define...	
Span	60.00	in
Rise	38.00	in
Embedment Depth	0.00	in
Manning's n	0.0120	
Inlet Type	Conventional	
Inlet Edge Condition	Grooved Edge Projecting	
Inlet Depression?	No	
SITE DATA		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.00	ft
Inlet Elevation	579.00	ft
Outlet Station	54.00	ft
Outlet Elevation	578.95	ft
Number of Barrels	1	

OK Cancel

Energy Dissipation Analyze Crossing OK Cancel

More Culvert Options

Culvert Properties

Culvert 1

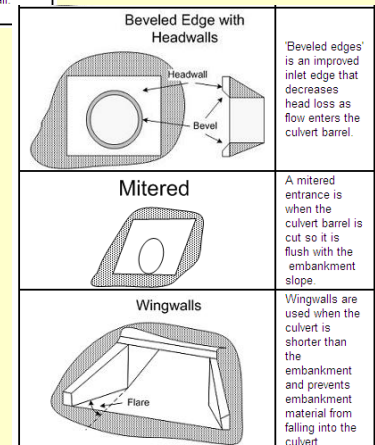
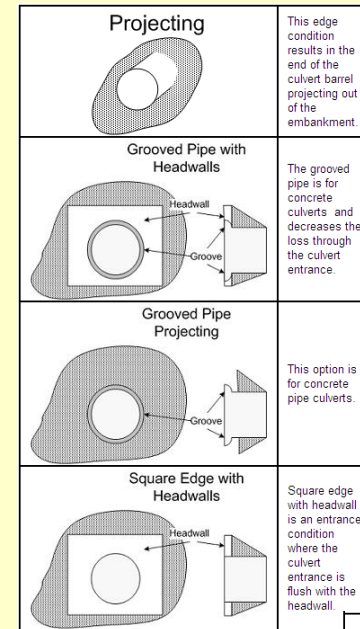
Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
CULVERT DATA		
Name	Culvert 1	
Material	Circular	
Material	Concrete	
Embedment Depth	0.00	ft
Manning's n	0.0120	in
Inlet Type	Conventional	
Inlet Edge Condition	Square Edge with Headwall	
	No	
	Culvert Invert Data	
	0.00	ft
Inlet Elevation	579.00	ft
Outlet Station	54.00	ft
Outlet Elevation	578.95	ft
Number of Barrels	1	

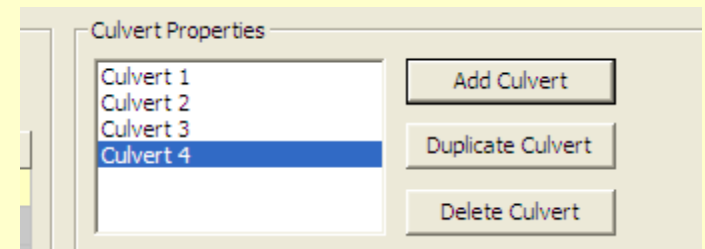
Energy Dissipation Analyze Crossing OK Cancel



Multiple Culverts



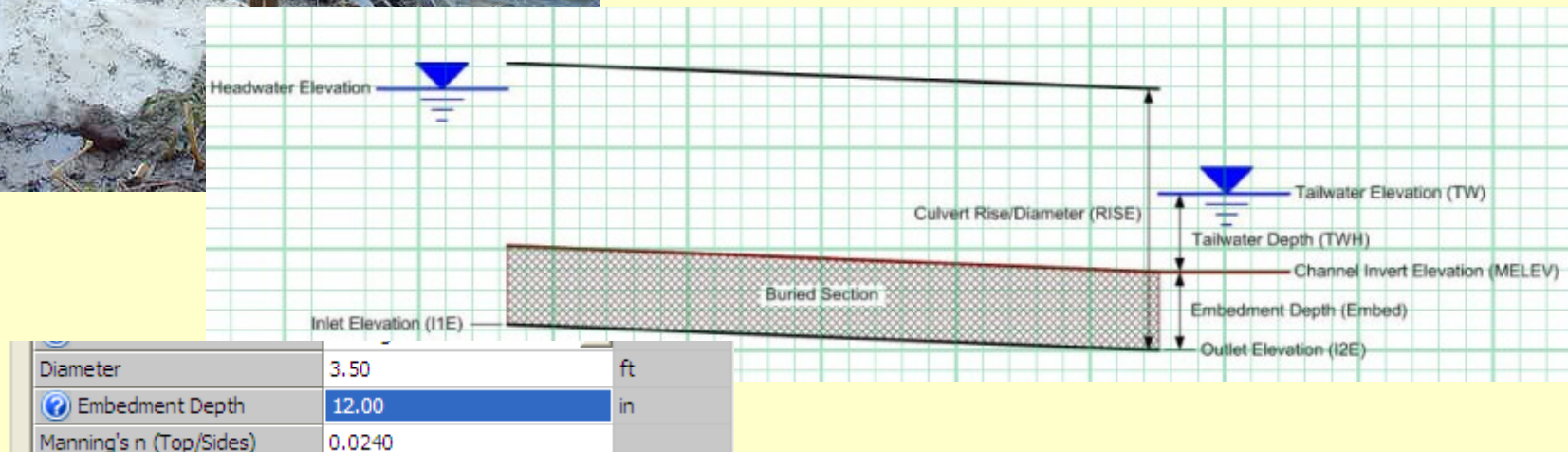
- 99 Barrels
- Different sizes
- Individual inverts and inlet conditions



Embedded Culverts



- Typically recessed 6-12 inches
- Reduce total area by recessed area
- Do not change channel inverts



Simple Bridges



- Simple shapes
- Does not handle piers
- Can specify top and bottom of opening

Using User Defined Culvert Shape to Define a Bridge Opening

The screenshot displays the HY-8 software interface for defining a bridge opening. The main window shows the 'Crossing Data - Crossing 1' tab with 'Bridge' selected. The 'Culvert Properties' section on the right shows 'Culvert 1' with 'User Defined' shape and 'Concrete' material. The 'User Defined Culvert Shape' dialog box is open, showing 4 X points. The 'Culvert Shape' plot shows the resulting trapezoidal cross-section.

Project Explorer

- HY-8 Project
- Project

Crossing Data - Crossing 1

Crossing Properties

Name: Bridge

Parameter	Value
DISCHARGE DATA	
Minimum Flow	0.00
Design Flow	300.00
Maximum Flow	300.00
TAILWATER DATA	
Channel Type	Trapezoidal Channel
Bottom Width	20.00
Side Slope (H:V)	1.00
Channel Slope	0.0030
Manning's n (channel)	0.0400
Channel Invert Elevation	520.00
Rating Curve	View...
ROADWAY DATA	
Roadway Profile Shape	Constant Roadway Eleva
First Roadway Station	0.00
Crest Length	300.00
Crest Elevation	540.00

Culvert Properties

Culvert 1

Add Culvert
Duplicate Culvert
Delete Culvert

Parameter	Value	U.
CULVERT DATA		
Name	Culvert 1	
Shape	User Defined	
Material	Concrete	
Coordinates	Define...	
Span	0.00	ft
Rise	0.00	ft
Embedment D...	0.00	in
Manning's n (Top/...	0.0120	
Manning's n (Bottom)	0.0400	
Inlet Type	Conventional	
Inlet Edge Co...	Square Edge with Hea...	
Inlet Depression?	No	
SITE DATA		

User Defined Culvert Shape

Number of X points (2-19): 4

Each X has a Y-top and Y-Bottom

Irregular Culvert Cross Section

Number	X (ft)	Y-Top (ft)	Y-Bottom (ft)
1	135.0000	535.0000	525.0000
2	140.0000	535.0000	520.0000
3	160.0000	535.0000	520.0000
4	165.0000	535.0000	535.0000

Culvert Shape

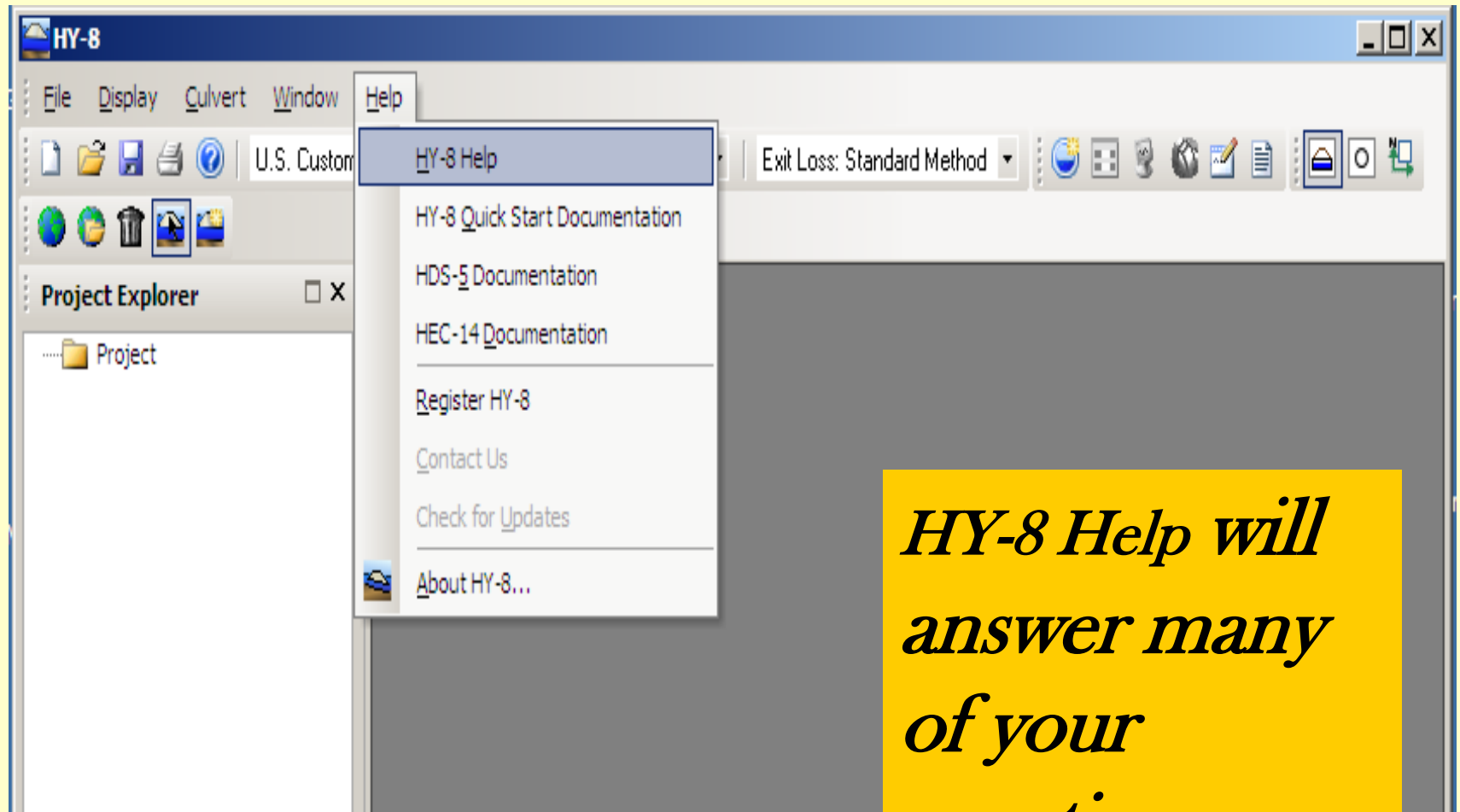
Culvert Shape

Y-Top Y-Bottom

Y (ft)

X (ft)

Plot showing the culvert shape with Y-Top and Y-Bottom points. The Y-axis ranges from 520 to 535 ft, and the X-axis ranges from 140 to 160 ft.



*HY-8 Help will
answer many
of your
questions*

Questions?



Transportation and the Environment Conference

Contact

Sheila Meier 906-346-8558

Jim Watling 517-284-5508

Minmin Shu 517-284-5506

Transportation and Flood Hazard Unit
Water Resources Division
Department of Environment Quality

2014