



INDIANA LTAP  
ROAD SCHOLAR CORE COURSE #10  
**CULVERT DRAINAGE**

Presented by  
Thomas T. Burke, Jr., PhD, PE  
Luke J. Sherry, PE, CFM  
Christopher B. Burke Engineering, Ltd.

# OBJECTIVES

- Review culvert shapes, end sections, and materials
- Types of culvert flow conditions
- Steps to determine culvert size
  - HY-8
- Examine culvert material and shape selection

# CULVERT FLOW

## Conditions

- Full flow (flow under pressure)
- Partially full (free surface)
- Combination





# VARIABLES

## Flow is dependent upon:

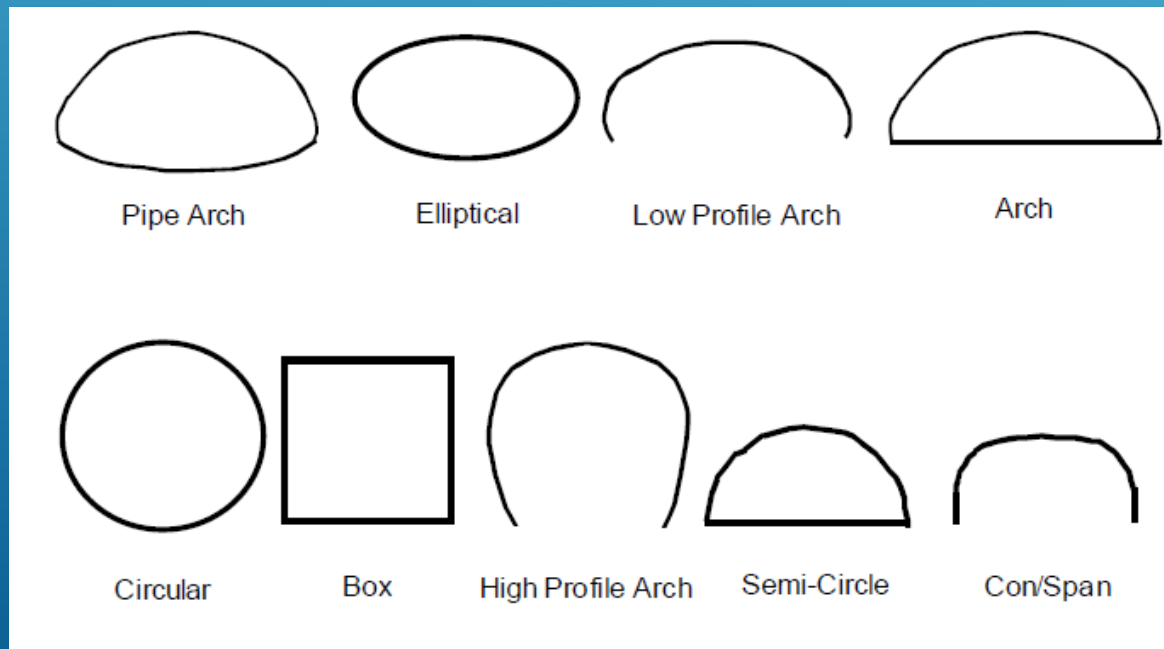
- Inlet geometry
- Roughness
- Slope
- Pipe Diameter
- Length
- Headwater (approach) or tailwater conditions



# CULVERT SHAPES AND MATERIALS

## Typical Materials:

- Corrugated Metal Pipe
- Concrete
- Polyvinyl Chloride (PVC) Pipe
- High-Density Polyethylene
- Ductile Iron Pipe (DIP)
- Clay





# CONCRETE



Concrete Arch



Triple Reinforced Concrete Box Culverts (RCBCs)



Triple Concrete Circular



# PLASTIC & METAL



**High-Density  
Polyethylene (HDPE)**



**Corrugated Metal Arch**



**Corrugated Metal Circular**

# ROUGHNESS COEFFICIENTS

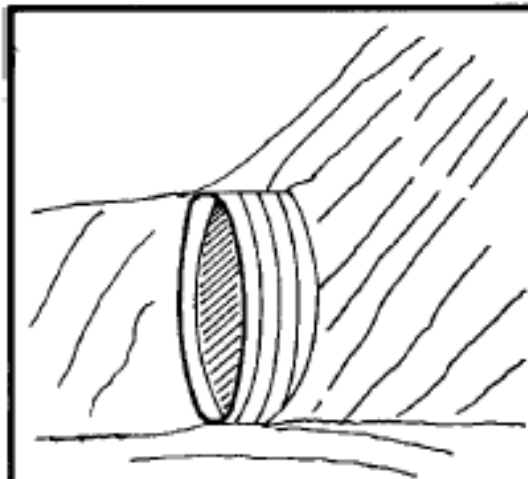
$n$  = Manning's roughness coefficient

Type of Conduit	Wall Description	Manning's $n$
Concrete Pipe	Smooth Interior	0.012
Concrete Box	Smooth Walls	0.012- 0.015
Corrugated Metal Pipe or Arch, Annular or Helical Pipe	2.75 in. x 0.5 in Corrugations	0.024
	6 in. x 1 in. corrugations	0.022-0.025
	5 in. x 1 in. corrugations	0.025-0.026
	3 in. x 1 in. corrugations	0.027-0.028
	6 in. x 2 in. structural plate	0.033-0.035
	9.25 in. x 2.5 in. structural plate	0.033-0.037
<b>Spiral Rib Metal Pipe</b>	<b>Semi-Smooth Interior</b>	<b>0.015</b>
Thermoplastic/HDPE Pipe	Smooth Interior	0.012
Cured in Place Liner (CIPP)	Smooth Interior	0.012

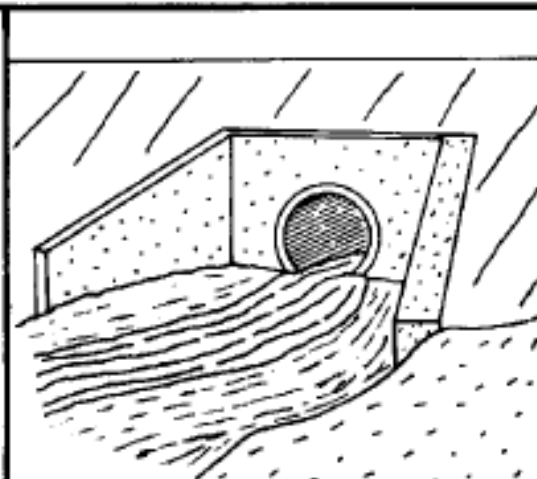
Source: InDOT Design Manual



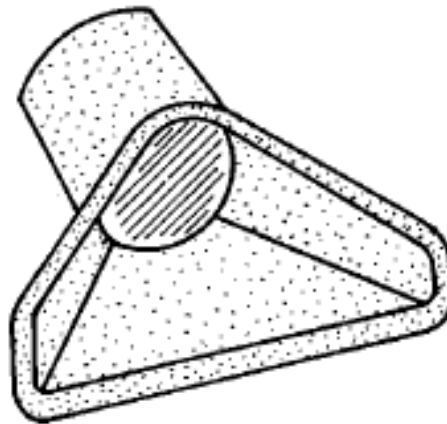
# END SECTIONS



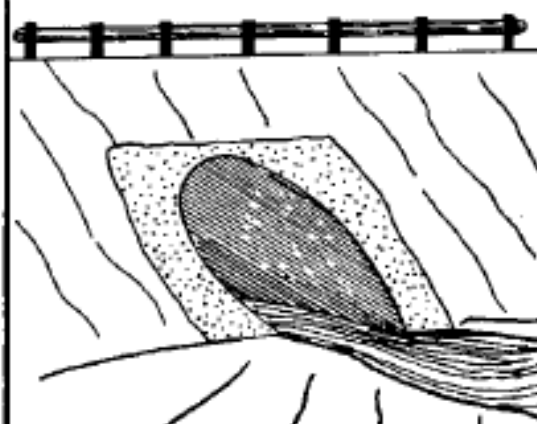
PROJECTING BARREL



CAST-IN-PLACE CONCRETE  
HEADWALL & WINGWALLS



PRECAST END SECTION



END MITERED TO THE SLOPE

# ENTRANCE LOSS COEFFICIENTS

End-Treatment Type	Entrance Type	$K_E$
Grated Box End Section, Type 1	Concrete Pipe, headwall with square edge	0.5
Grated Box End Section, Type 2	Concrete Pipe, headwall with square edge	0.5
Multiple-Pipes Concrete Anchor	Concrete Pipe, projecting from fill, square cut end	0.5
Multiple-Pipes Concrete Anchor	Corrugated Metal Pipe, Projecting from fill	0.9
Metal Pipe End Section	Corrugated Metal Pipe, end section conforming to fill slope	0.5
Precast-Concrete End Section	Concrete Pipe, end section conforming to fill slope	0.5
Safety Metal End Section	Corrugated Metal Pipe, mitered to conform to fill slope	0.7

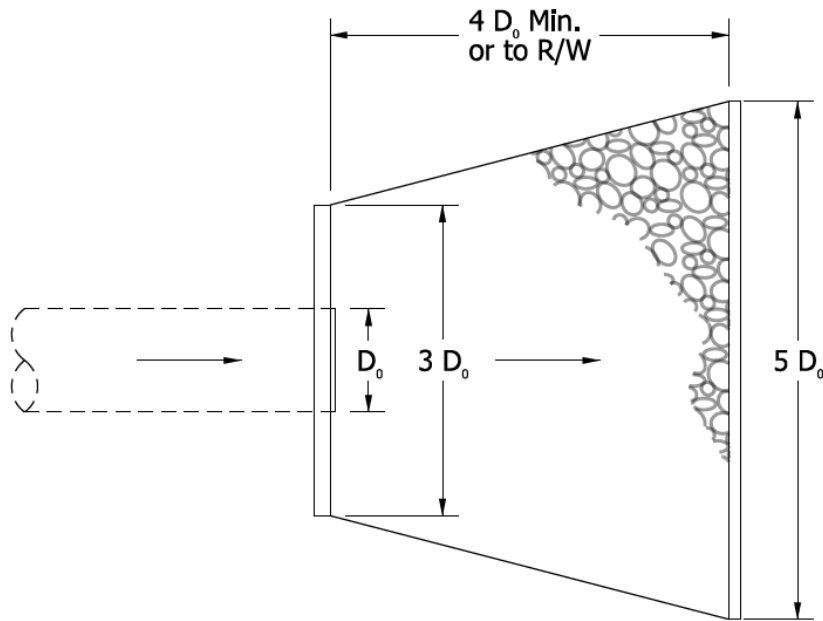
Safety Metal End Section	Corrugated Metal Pipe, end section conforming to fill slope	0.5
Safety Metal End Section	Corrugated Metal Pipe, mitered to conform to fill slope	0.7
Safety Metal End Section	Corrugated Metal Pipe, end section conforming to fill slope	0.5
Single-Pipe Concrete Anchor	Corrugated Metal Pipe, projecting from fill	0.9
Single-Pipe Concrete Anchor	Concrete Pipe, projecting from fill, square cut end	0.5
Single-Pipe Concrete Anchor	Corrugated Metal Pipe-Arch, projecting from fill	0.9
Multiple-Pipe Concrete Anchor	Concrete Pipe-Arch, projecting from fill, square cut end	0.5
Multiple-Pipe Concrete Anchor	Corrugated Metal Pipe-Arch, projecting from fill	0.9

**ENTRANCE-LOSS COEFFICIENT,  $K_E$ ,  
FOR STANDARD INDOT CULVERT**

Source: InDOT Design Manual



# RIPRAP



$D_o$  = Outside Diameter of structure

Source: InDOT Design Manual

Erosion-Protection Method	Velocity, $v$ (ft/s)
Revetment Riprap	$\leq 6.5$
Class 1 Riprap	$6.5 < v < 10$
Class 2 Riprap	$10 \leq v \leq 13$
Energy Dissipator	$> 13$

# CULVERT HYDRAULICS

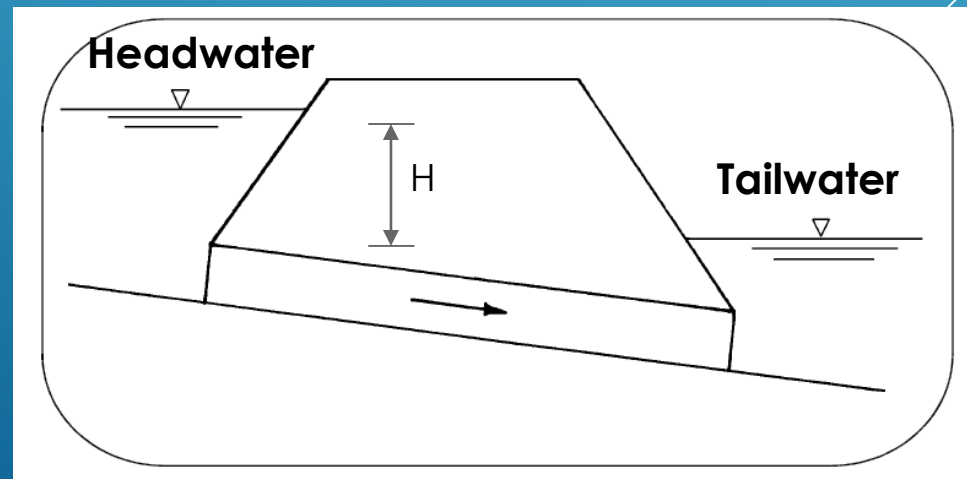
- Flow conditions vary from culvert to culvert
- Flow conditions vary over time
- May flow full or partially full
- Flow control types
  - Inlet
  - Outlet





# HEADWATER AND TAILWATER

- Headwater (HW) - Depth of upstream water surface measured from invert of culvert entrance
  - Should not exceed edge of roadway shoulder elevation to allow for freeboard
  - Should not be so high as to cause flooding upstream
- Tailwater (TW) - Depth of downstream water surface measured from invert of culvert outlet
  - For stream crossings, usually determined by backwater calculations through hydraulic modeling
- $H$  = Difference in elevation of upstream pool level and the water surface at the culvert outlet



# INLET CONTROL

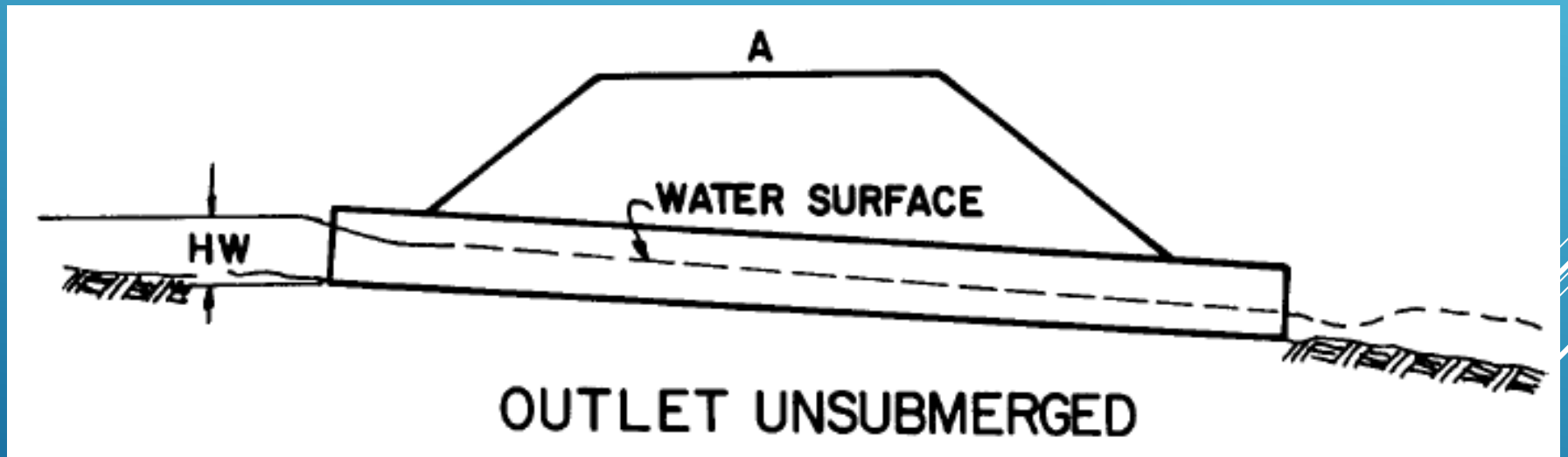
- Culvert inlet controls (or limits) the flow
- More difficult for flow to get through the entrance of the culvert than it is to flow through the remainder of the culvert





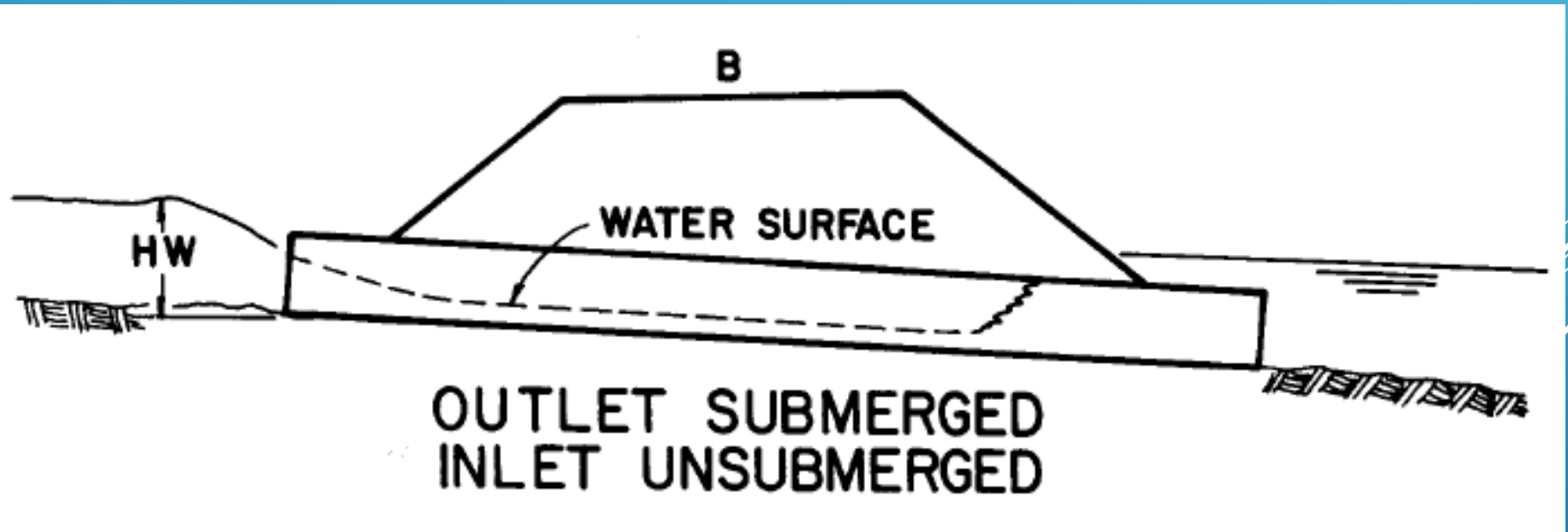
# INLET CONTROL - A

- Pipe flow is partially full
- Outlet not submerged



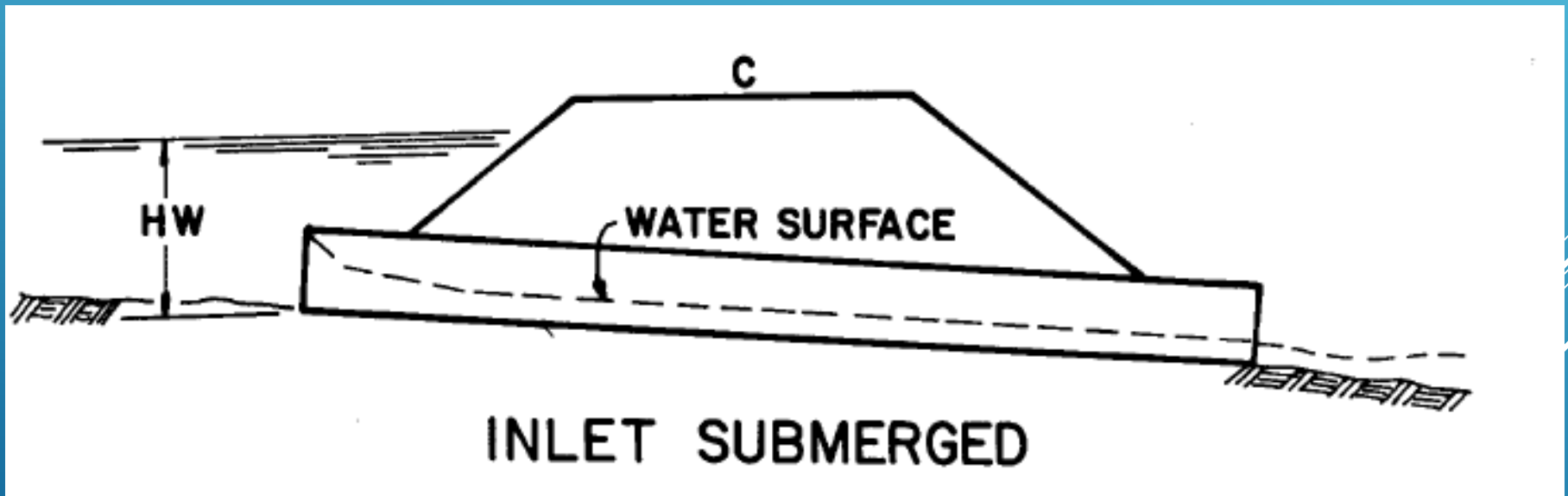
# INLET CONTROL - B

- Inlet not submerged
- Outlet submerged



# INLET CONTROL - C

- Pipe is flowing partially full
- Inlet submerged



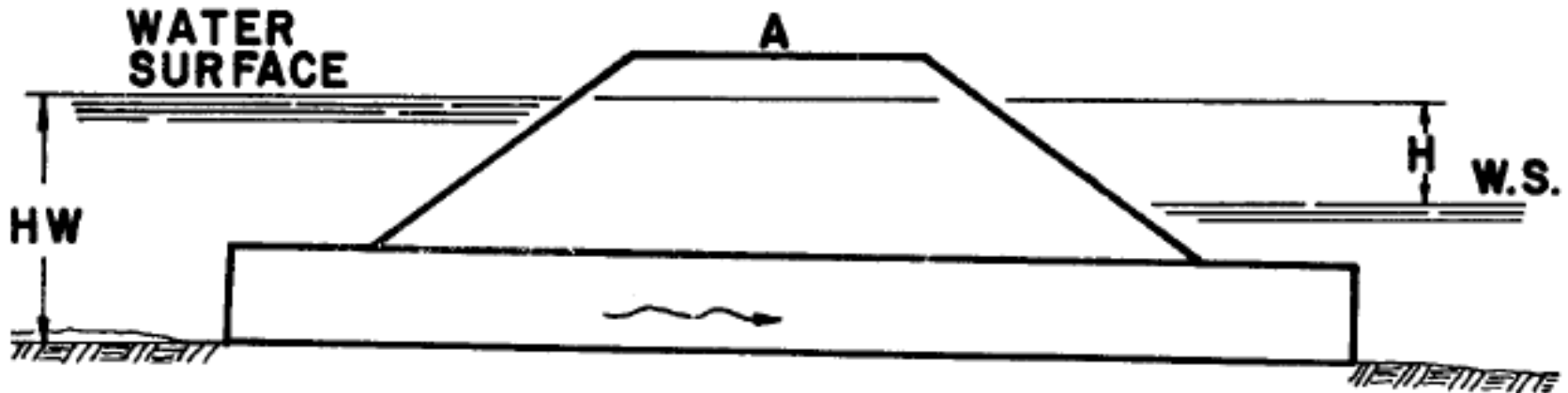


# OUTLET CONTROL

- Culvert barrel capacity or outlet controls (or limits) the flow
- More difficult for flow to negotiate length of culvert than it is to get through the inlet (entrance)

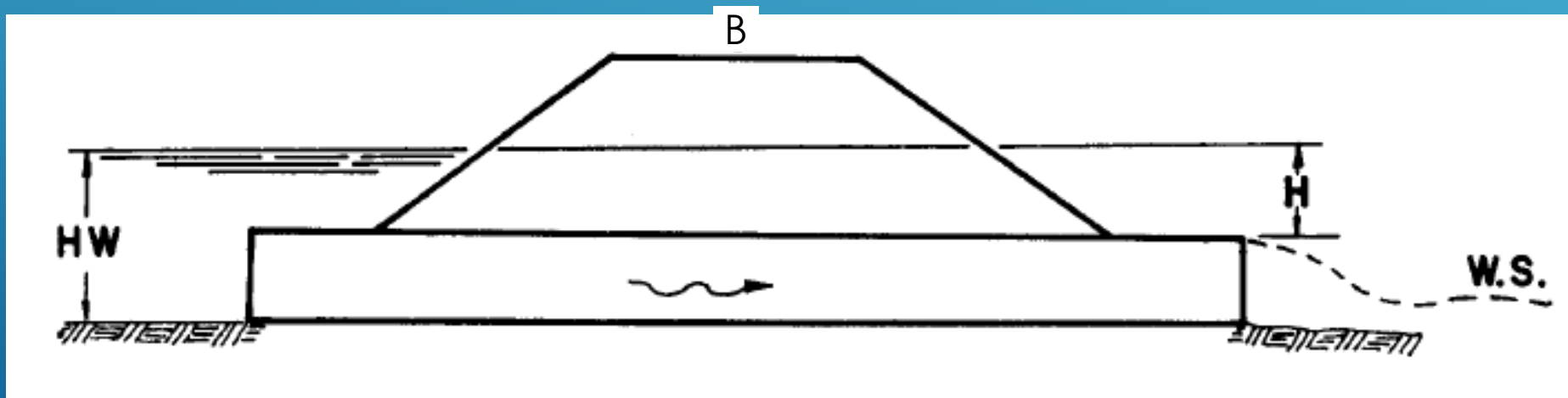
# OUTLET CONTROL - A

- Pressure flow
- Full Flow
- Inlet and outlet submerged



# OUTLET CONTROL - B

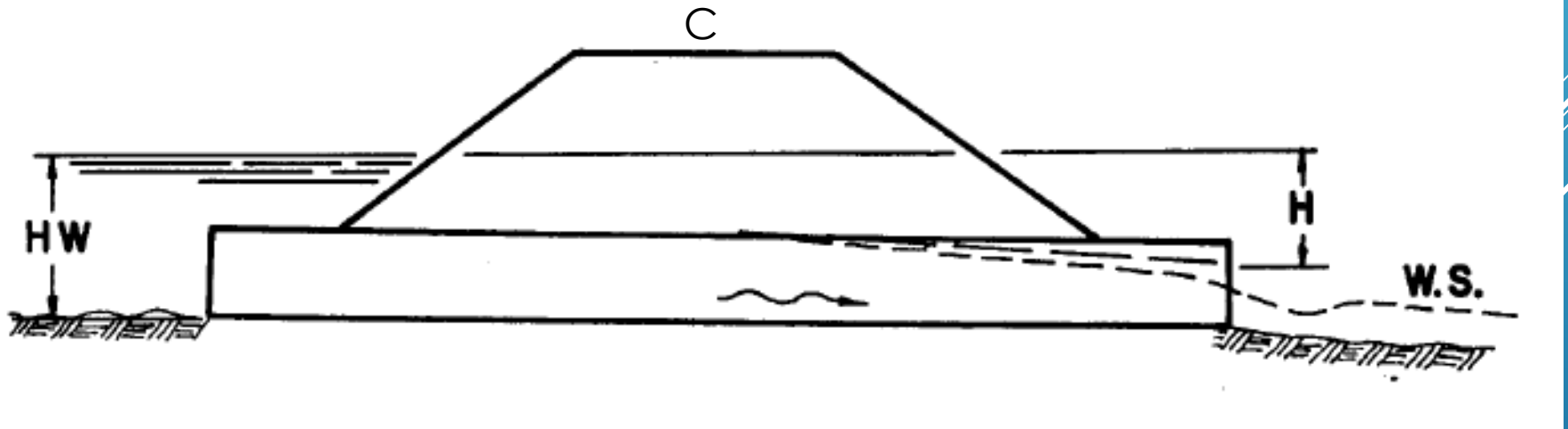
- Submerged inlet
- Outlet not submerged
- Outlet velocities usually high





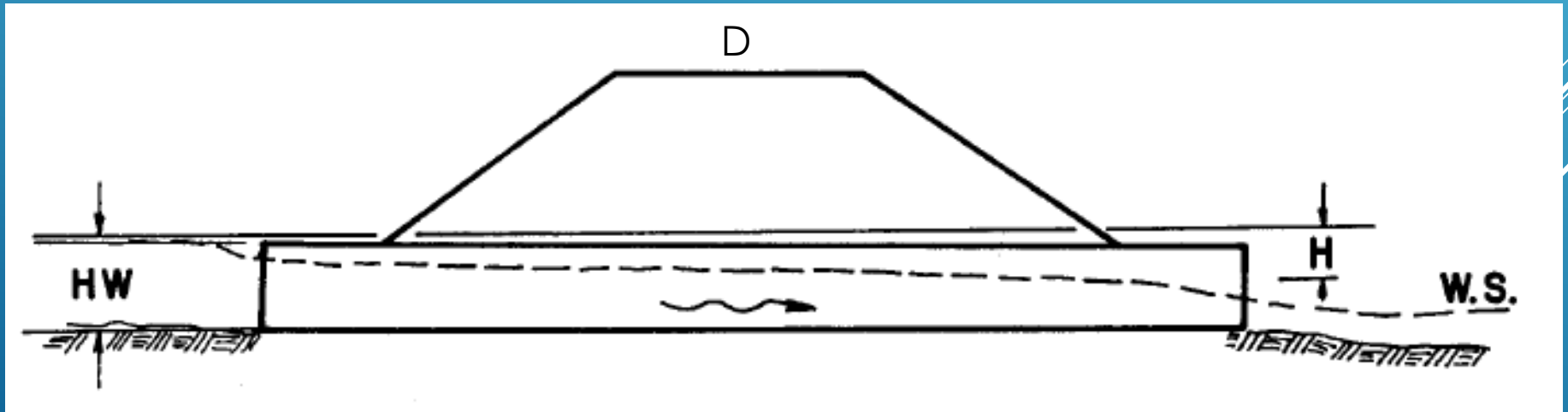
# OUTLET CONTROL - C

- Submerged inlet
- Outlet not submerged
- Low TW



# OUTLET CONTROL - D

- Inlet not submerged
- Outlet not submerged



# CULVERT PERFORMANCE FACTORS

Factor	Inlet Control	Outlet Control
Headwater Elevation	X	X
Inlet Area	X	X
Inlet Edge Configuration	X	X
Inlet Shape	X	X
Pipe Roughness		X
Pipe Area		X
Pipe Shape		X
Pipe Length		X
Pipe Slope		X
Tailwater Elevation		X



# CULVERT DESIGN STEPS

1. Summarize known data: Flowrate (Q) in cfs, target upstream water surface elevation
2. Choose the culvert dimensions (diameter, length)
3. Assume inlet control
4. Use chart to calculate the upstream total head (HW) for the design flowrate using design table
5. Repeat step 3 until the upstream head (HW) satisfies design specifications
6. Use design chart to calculate the head loss (H) from inlet to outlet for the design flowrate
7. Calculate the upstream total head ( $HW = H + TW$ )
8. Compare the inlet and outlet control results
  - The higher headwater governs and indicates the flow control (inlet or outlet control)

# EXAMPLE CALCULATION

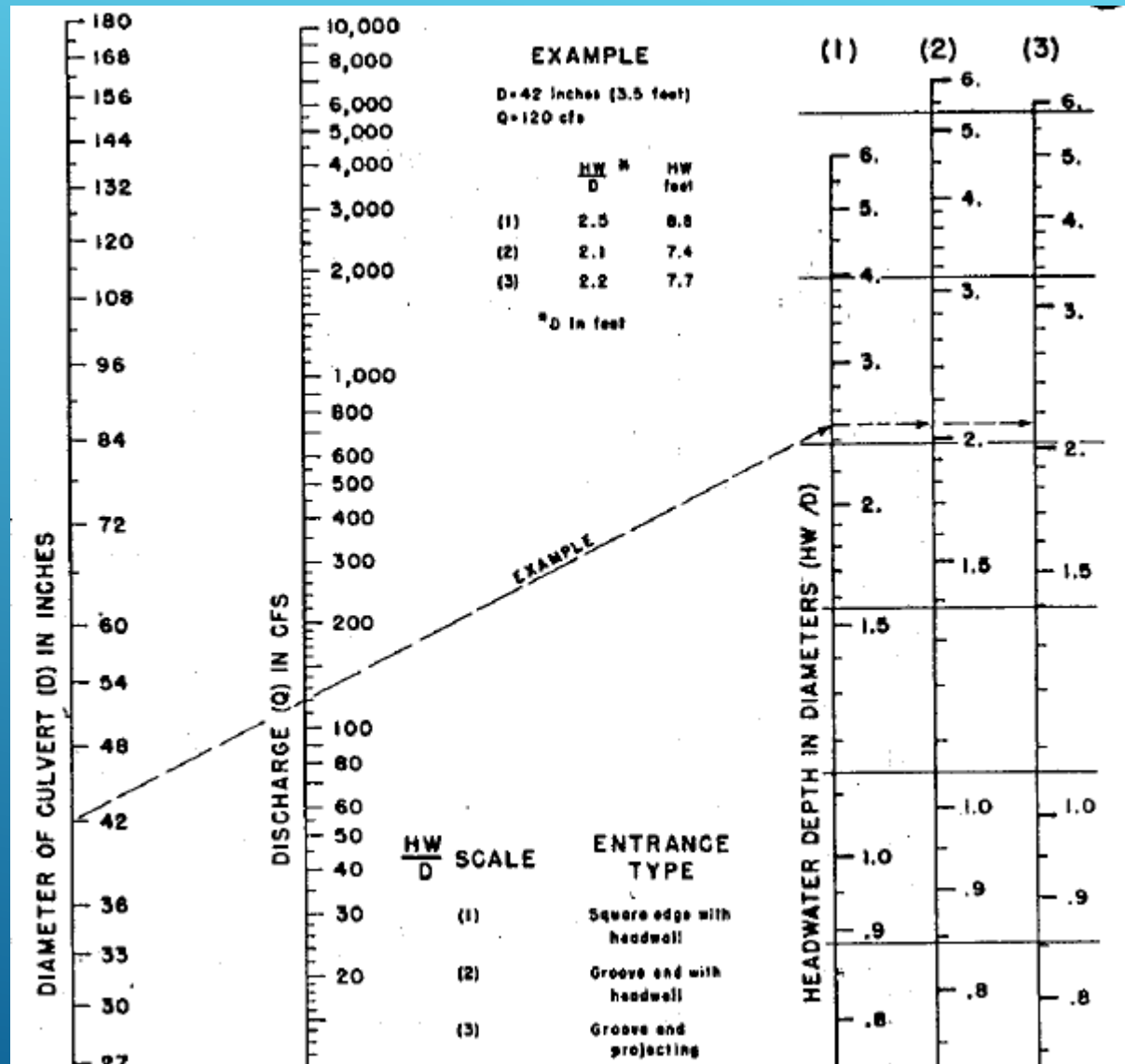
Inlet Control Sheet

Diameter = 42" (3.5 ft)

Q=120 cfs

L=50 ft

Inlet submerged



# INLET CONTROL RESULTS

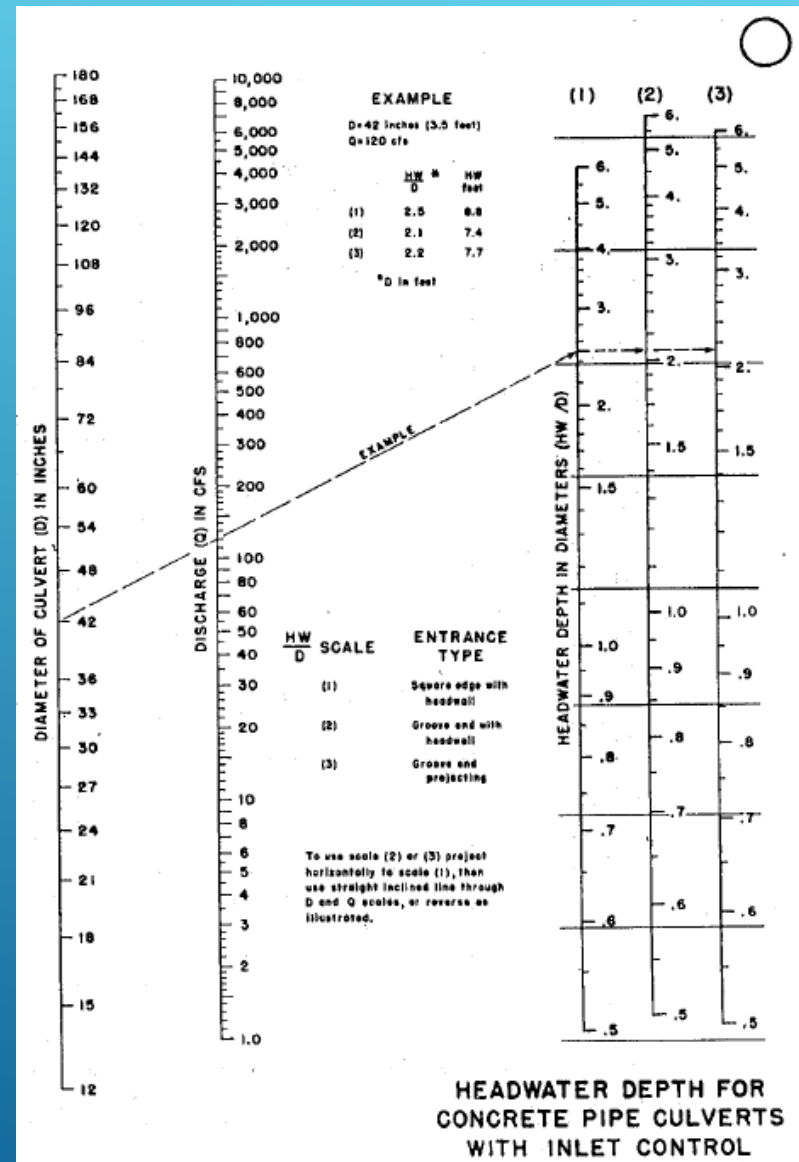
Culvert Diameter ,  $D = 42''$  (3.5 feet)

$Q=120$  cfs

$HW = (HW/D) \times D$  (ft)

1. Square edge with headwall

- $HW/D = 2.5$   
 $= 2.5 \times 3.5$  ft
- $HW = 8.8$  ft





# EXAMPLE CALCULATION

Outlet Control Sheet

Diameter = 42" (3.5 ft)

Q=120 cfs

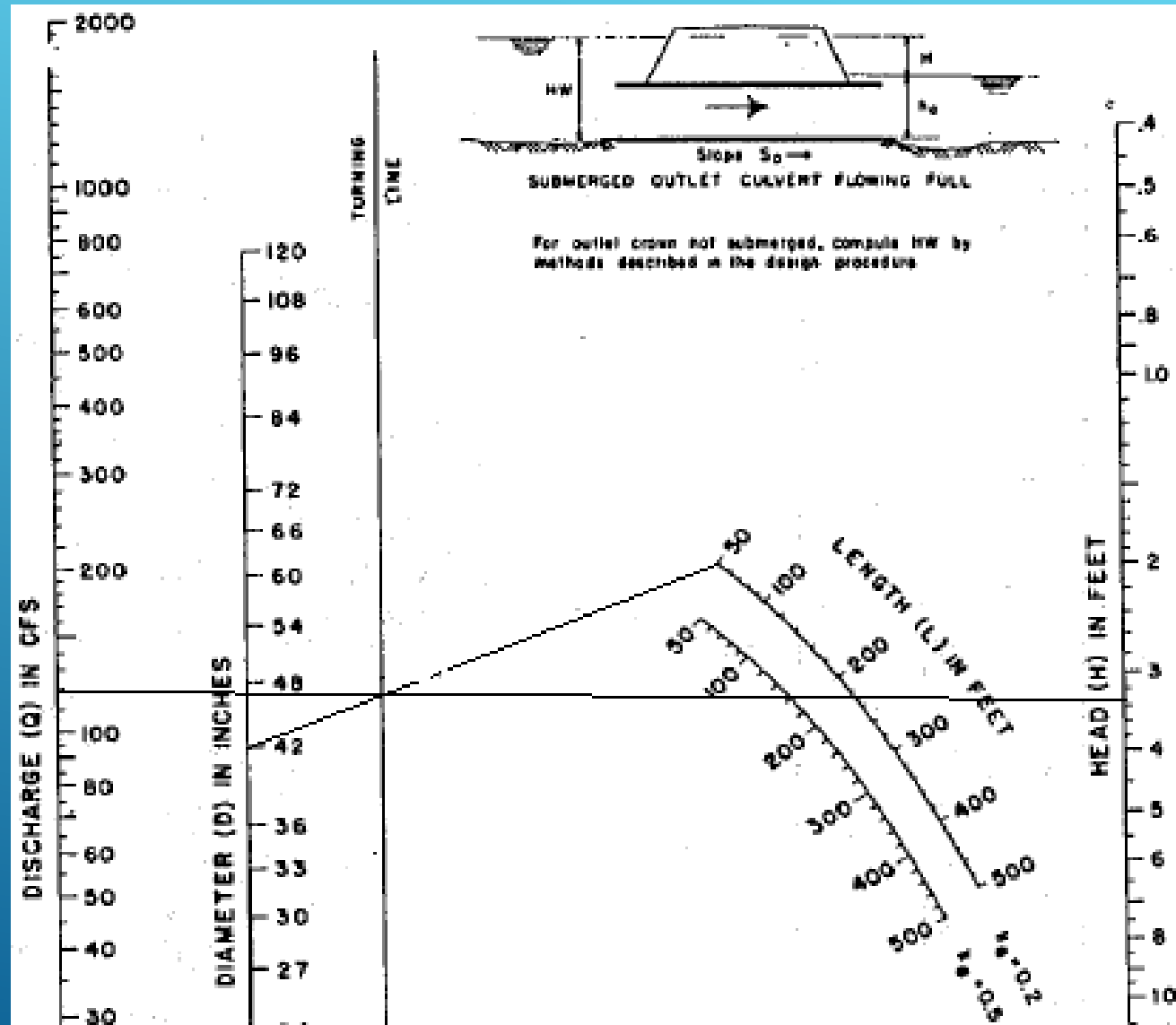
L = 50 ft

TW = 4.3 ft

From chart, H = 3.3'

HW = TW + 3.3'

HW = 4.3' + 3.3' = 7.6'



# INLET CONTROL VS. OUTLET CONTROL RESULTS

Culvert Diameter ,  $D = 42''$  (3.5 feet)

$Q=120$  cfs

$L = 50$  feet

$TW = 4.3$  feet

## INLET CONTROL

$HW = (HW/D) \times D$  (ft)

1. Square edge with headwall

- $HW = 8.8'$  ft

## OUTLET CONTROL

$HW = 7.6$  ft

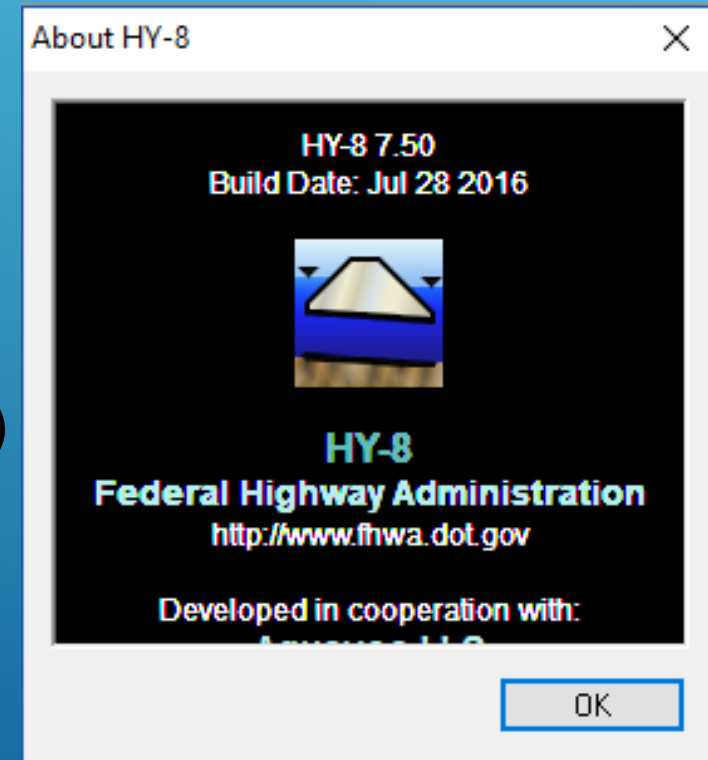
CONCLUSION:  $8.8 \text{ ft} > 7.6 \text{ ft}$

inlet controlled, use

inlet control answer

# HY-8

- Federal Highway Administration culvert analysis program
- Yields headwater rating curve (elevation, Q relationship)
- Parameters:
  - Enter design Q
  - Culvert length
  - Culvert shape and roughness
  - Entrance type
  - Overtop elevation (road profile)
  - Additional inputs:
    - Tailwater rating curve



# HY-8 EXAMPLE PROBLEM #1

Use HY-8 to determine the size of a culvert required for a proposed road crossing. The local ordinance specifies that culverts be sized to pass the 100-year peak flowrate and also provide two feet of freeboard.

The design information for this site is summarized by the following:

- ▶ HYDROLOGY

- ▶ 100-Year Peak Flowrate is 65 cfs (Based on WinTR-20 Hydrologic Model of Tributary Area)

- ▶ SITE DATA

- ▶ Upstream invert elevation = 661.15 ft.
- ▶ Downstream invert elevation = 659.00 ft.
- ▶ Culvert length = 120 ft.
- ▶ Culvert will project from headwall
- ▶ No depression at conventional-type inlet



# HY-8 EXAMPLE PROBLEM #1

## (CONTINUED)

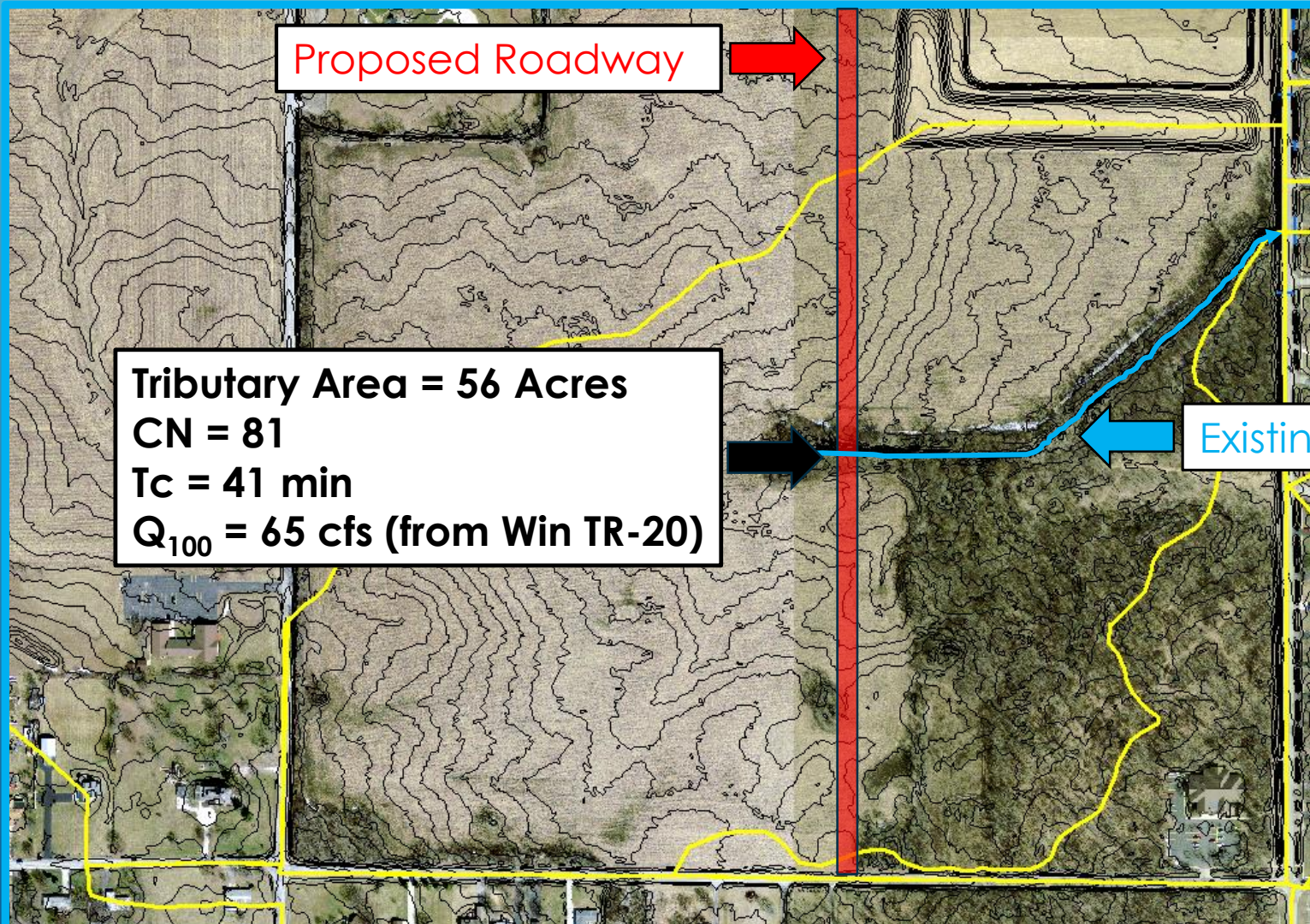
### ▶ WATERWAY DATA

- ▶ Input existing channel information to model tailwater conditions acting on the culvert.

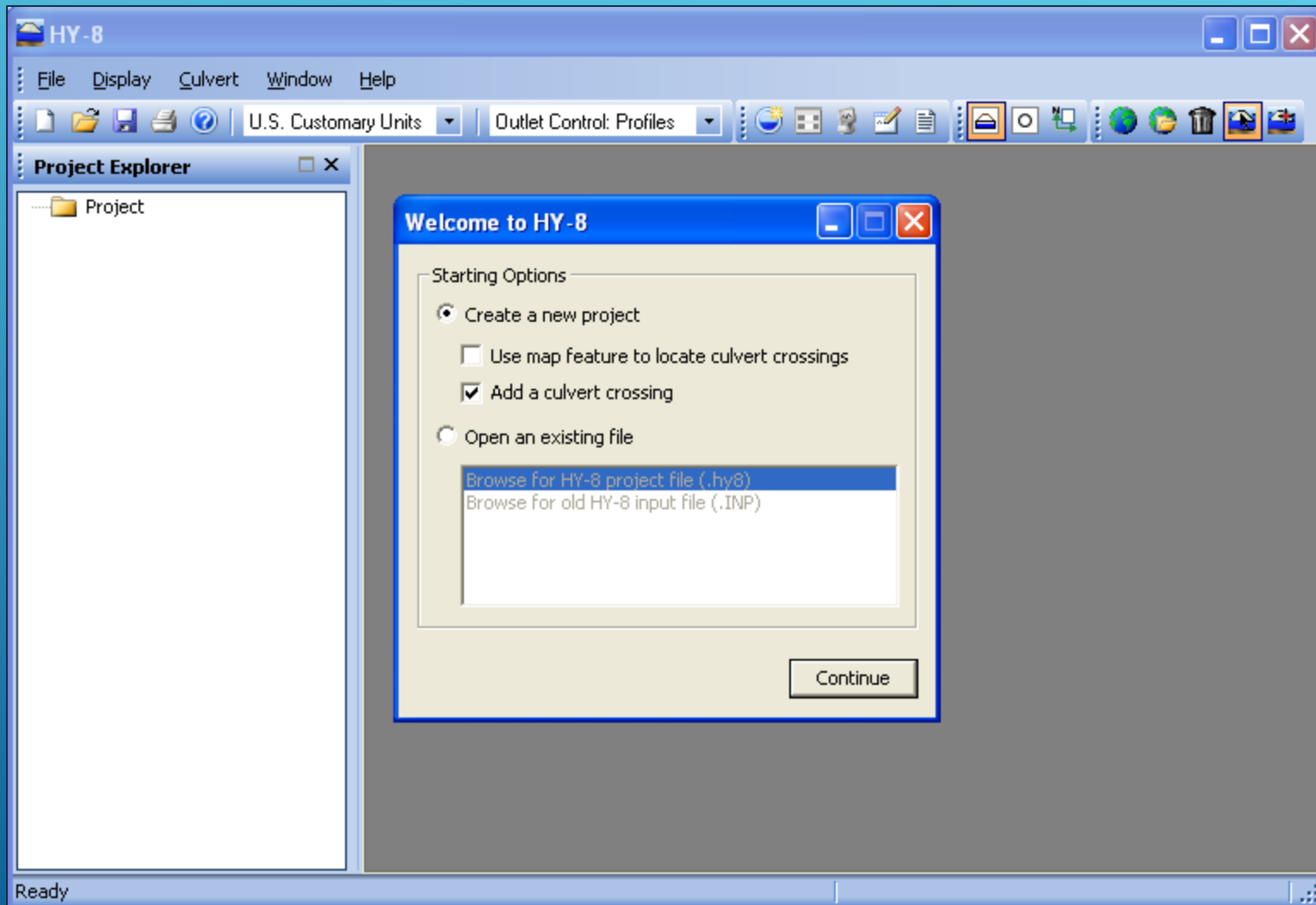
### ▶ ROADWAY DATA

- ▶ Roadway overtopping elevation is 667.0 (Determined from proposed roadway profile).
- ▶ Proposed roadway is 80 feet wide.

# HY-8 EXAMPLE PROBLEM #1 (CONTINUED)



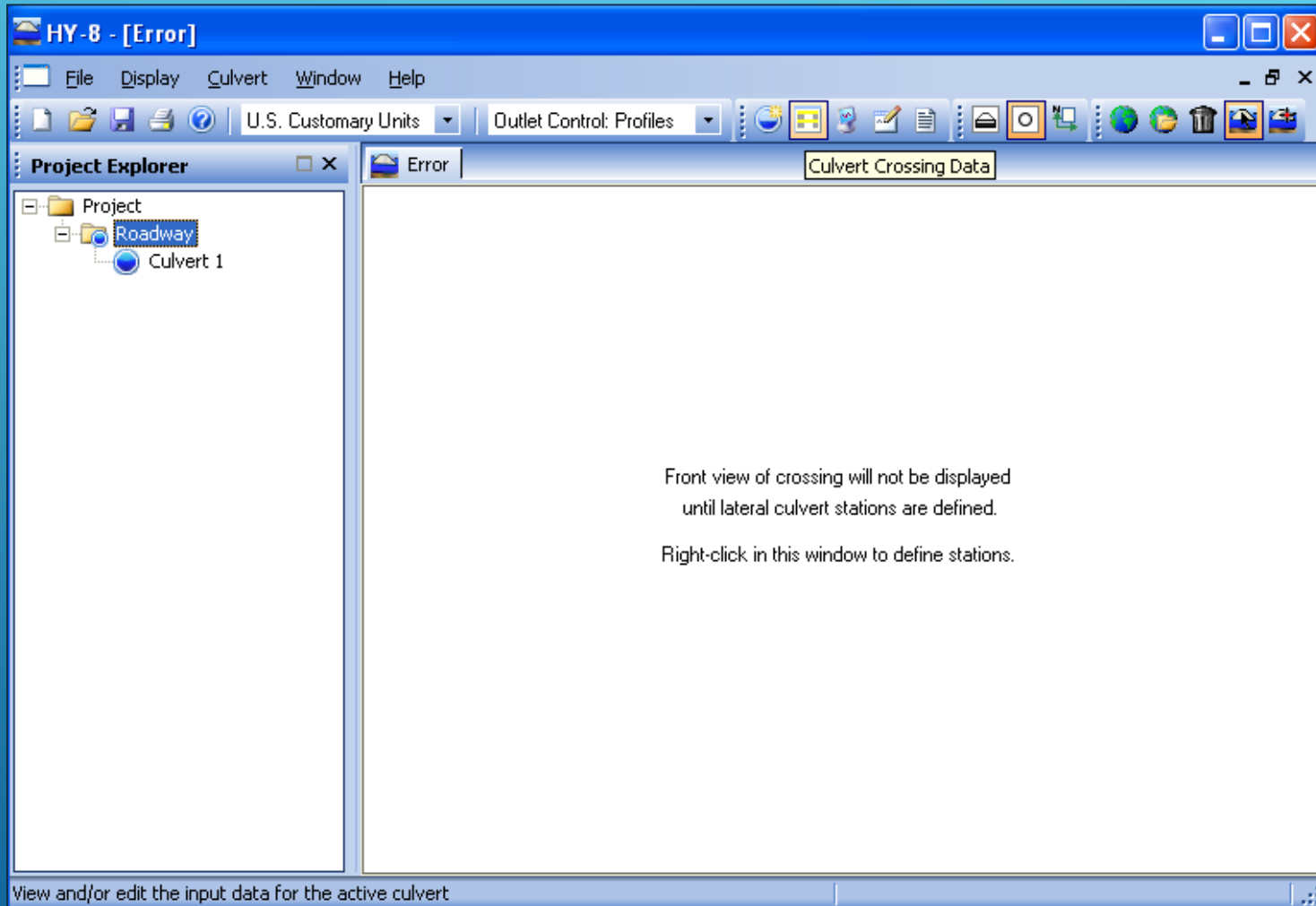
# HY-8: CREATING A NEW PROJECT



HY-8 Introduction Screen



# HY-8: INPUT OF ROADWAY/CULVERT DATA



Use the “Culvert Crossing Data” icon to enter the roadway/culvert information.



# HY-8: INPUT OF CULVERT DATA

Crossing Data - Crossing 1

Crossing Properties

Name:

Parameter	Value	Units
<b>DISCHARGE DATA</b>		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	0.000	cfs
Design Flow	0.000	cfs
Maximum Flow	0.000	cfs
<b>TAILWATER DATA</b>		
Channel Type	Rectangular Channel	
Bottom Width	0.000	ft
Channel Slope	0.0000	ft/ft
Manning's n (channel)	0.000	
Channel Invert Elevation	0.000	ft
Rating Curve	View...	
<b>ROADWAY DATA</b>		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	0.000	ft
Crest Elevation	0.000	ft
Roadway Surface	Paved	
Top Width	0.000	ft

Culvert Properties

Culvert 1

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
<b>CULVERT DATA</b>		
Name	Culvert 1	
Shape	Circular	
Material	Concrete	
Diameter	0.000	ft
Embedment Depth	0.000	in
Manning's n	0.012	
Culvert Type	Straight	
Inlet Configuration	Square Edge with Headwall	
Inlet Depression?	No	
<b>SITE DATA</b>		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	0.000	ft
Outlet Station	0.000	ft
Outlet Elevation	0.000	ft

Help   Click on any icon for help on a specific topic   Low Flow   AOP   Energy Dissipation   Analyze Crossing   **OK**   Cancel

HY-8 Crossing Data Screen

# HY-8: INPUT OF DISCHARGE DATA

The screenshot displays the 'Crossing Data - Crossing 1' window, which is divided into two main sections: 'Crossing Properties' and 'Culvert Properties'.

**Crossing Properties**

Name:

Parameter	Value	Units
<b>DISCHARGE DATA</b>		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	0.000	cfs
Design Flow	65.000	cfs
Maximum Flow	125.000	cfs
<b>TAILWATER DATA</b>		
Channel Type	Rectangular Channel	
Bottom Width	0.000	ft
Channel Slope	0.0000	ft/ft
Manning's n (channel)	0.000	
Channel Invert Elevation	0.000	ft
Rating Curve	<input type="button" value="View..."/>	
<b>ROADWAY DATA</b>		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	0.000	ft
Crest Elevation	0.000	ft
Roadway Surface	Paved	
Top Width	0.000	ft

**Culvert Properties**

Culvert 1

Parameter	Value	Units
<b>CULVERT DATA</b>		
Name	Culvert 1	
Shape	Circular	
Material	Concrete	
Diameter	0.000	ft
Embedment Depth	0.000	in
Manning's n	0.012	
Culvert Type	Straight	
Inlet Configuration	Square Edge with Headwall	
Inlet Depression?	No	
<b>SITE DATA</b>		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	0.000	ft
Outlet Station	0.000	ft
Outlet Elevation	0.000	ft

Help Click on any icon for help on a specific topic

Input of Discharge Data – Enter the design and maximum flow.

# HY-8: INPUT OF TAILWATER DATA

**Crossing Properties**

Name:

Parameter	Value	Units
<b>DISCHARGE DATA</b>		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	0.000	cfs
Design Flow	65.000	cfs
Maximum Flow	125.000	cfs
<b>TAILWATER DATA</b>		
Channel Type	Rectangular Channel	
Bottom Width	Rectangular Channel	ft
Channel Slope	Trapezoidal Channel	ft/ft
Manning's n (channel)	Triangular Channel	
Channel Invert Elevation	Irregular Channel	ft
Rating Curve	Enter Rating Curve Enter Constant Tailwater Elevation View...	
<b>ROADWAY DATA</b>		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	0.000	ft
Crest Elevation	0.000	ft
Roadway Surface	Paved	
Top Width	0.000	ft

**Culvert Properties**

Culvert 1

Add Culvert  
Duplicate Culvert  
Delete Culvert

Parameter	Value	Units
<b>CULVERT DATA</b>		
Name	Culvert 1	
Shape	Circular	
Material	Concrete	
Diameter	0.000	ft
Embedment Depth	0.000	in
Manning's n	0.012	
Culvert Type	Straight	
Inlet Configuration	Square Edge with Headwall	
Inlet Depression?	No	
<b>SITE DATA</b>		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	0.000	ft
Outlet Station	0.000	ft
Outlet Elevation	0.000	ft

Help Click on any icon for help on a specific topic Low Flow AOP Energy Dissipation Analyze Crossing OK Cancel

Input of Tailwater Data – Note that we will input site-specific channel information to model tailwater conditions for this example.

# HY-8: INPUT OF TAILWATER DATA

### Crossing Data - Crossing 1

Crossing Properties

Name:

Parameter	Value	Unit
<b>DISCHARGE DATA</b>		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	0.000	cfs
Design Flow	65.000	cfs
Maximum Flow	125.000	cfs
<b>TAILWATER DATA</b>		
Channel Type	Rectangular Channel	
Bottom Width	Rectangular Channel	ft
Channel Slope	Trapezoidal Channel	ft/ft
Manning's n (channel)	Irregular Channel	
Channel Invert Elevation	Enter Rating Curve	ft
Rating Curve	Enter Constant Tailwater Elevation	
<b>ROADWAY DATA</b>		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	0.000	ft
Crest Elevation	0.000	ft
Roadway Surface	Paved	
Top Width	0.000	ft

Help    Click on any icon for help on a specific topic    Low Flow

### 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	666.000	0.0500
2	4.000	664.000	0.0500
3	9.000	661.000	0.0500
4	12.000	659.000	0.0350
5	16.000	659.000	0.0350
6	18.000	661.000	0.0500
7	25.000	664.000	0.0500
8	30.000	666.000	

Plot

Help

Input of Tailwater Data – Channel Geometry Based on Topography



# HY-8: INPUT OF ROADWAY DATA

Crossing Data - Crossing 1

Crossing Properties

Name: Roadway

Parameter	Value	Units
<b>DISCHARGE DATA</b>		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	0.000	cfs
Design Flow	65.000	cfs
Maximum Flow	125.000	cfs
<b>TAILWATER DATA</b>		
Channel Type	Irregular Channel	
Irregular Channel	Define...	
Rating Curve	View...	
<b>ROADWAY DATA</b>		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	40.000	ft
Crest Elevation	667.000	ft
Roadway Surface	Paved	
Top Width	80.000	ft

Culvert Properties

Culvert 1

Add Culvert  
Duplicate Culvert  
Delete Culvert

Parameter	Value	Units
<b>CULVERT DATA</b>		
Name	Culvert 1	
Shape	Circular	
Material	Concrete	
Diameter	0.000	ft
Embedment Depth	0.000	in
Manning's n	0.012	
Culvert Type	Straight	
Inlet Configuration	Square Edge with Headwall	
Inlet Depression?	No	
<b>SITE DATA</b>		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	0.000	ft
Outlet Station	0.000	ft
Outlet Elevation	0.000	ft

Help Click on any icon for help on a specific topic Low Flow AOP Energy Dissipation Analyze Crossing OK Cancel

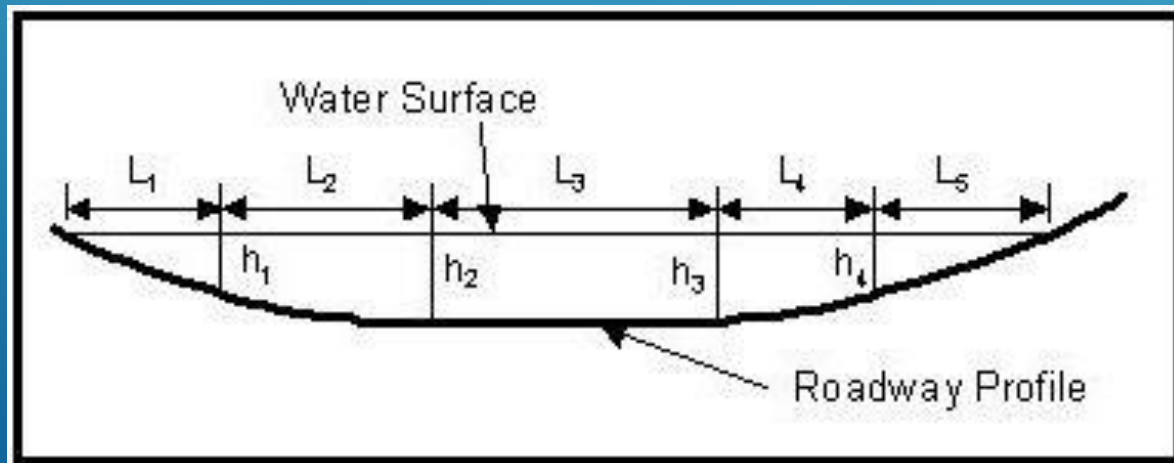
Input of Roadway Data – Overtopping elevation, crest length, width of roadway, and type of surface.

# HY-8: INPUT OF ROADWAY DATA

HY-8 uses the weir equation to calculate flow over a roadway.

When the user specifies a constant roadway elevation with a specified crest length ( $L$ ), HY-8 will calculate the flow using the rectangular weir equation ( $Q = C_d * L * H^{3/2}$ ). If input discharge coefficient is selected, the user will enter a discharge coefficient between 2.5 and 3.095.

For a user-defined (irregular) roadway, HY-8 calculates a weighted average of the  $L$  and  $H$  terms in the weir equation:



# HY-8: INPUT OF CULVERT DATA

Crossing Data - Crossing 1

Crossing Properties

Name:

Parameter	Value	Units
<b>DISCHARGE DATA</b>		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	0.000	cfs
Design Flow	65.000	cfs
Maximum Flow	125.000	cfs
<b>TAILWATER DATA</b>		
Channel Type	Irregular Channel	
Irregular Channel	Define...	
Rating Curve	View...	
<b>ROADWAY DATA</b>		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	40.000	ft
Crest Elevation	667.000	ft
Roadway Surface	Paved	
Top Width	80.000	ft

Culvert Properties


Culvert 1

Add Culvert

Duplicate Culvert

Delete Culvert

Parameter	Value	Units
<b>CULVERT DATA</b>		
Name	Culvert 1	
Shape	Circular	
Material	Concrete	
Diameter	3.000	ft
Embedment Depth	0.000	in
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge with Headwall	
Inlet Depression?	No	
<b>SITE DATA</b>		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	0.000	ft
Outlet Station	0.000	ft
Outlet Elevation	0.000	ft

Help Click on any  icon for help on a specific topic Low Flow AOP Energy Dissipation Analyze Crossing **OK** Cancel

Input of Culvert Data – Note that a 36-inch (3-foot) diameter culvert was used.

# HY-8: INPUT OF SITE DATA

The screenshot displays the 'Crossing Data - Crossing 1' window, which is divided into two main sections: 'Crossing Properties' and 'Culvert Properties'.

**Crossing Properties**

Name:

Parameter	Value	Units
<b>DISCHARGE DATA</b>		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	0.000	cfs
Design Flow	65.000	cfs
Maximum Flow	125.000	cfs
<b>TAILWATER DATA</b>		
Channel Type	Irregular Channel	
Irregular Channel	Define...	
Rating Curve	View...	
<b>ROADWAY DATA</b>		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	40.000	ft
Crest Elevation	667.000	ft
Roadway Surface	Paved	
Top Width	80.000	ft

**Culvert Properties**

Culvert 1

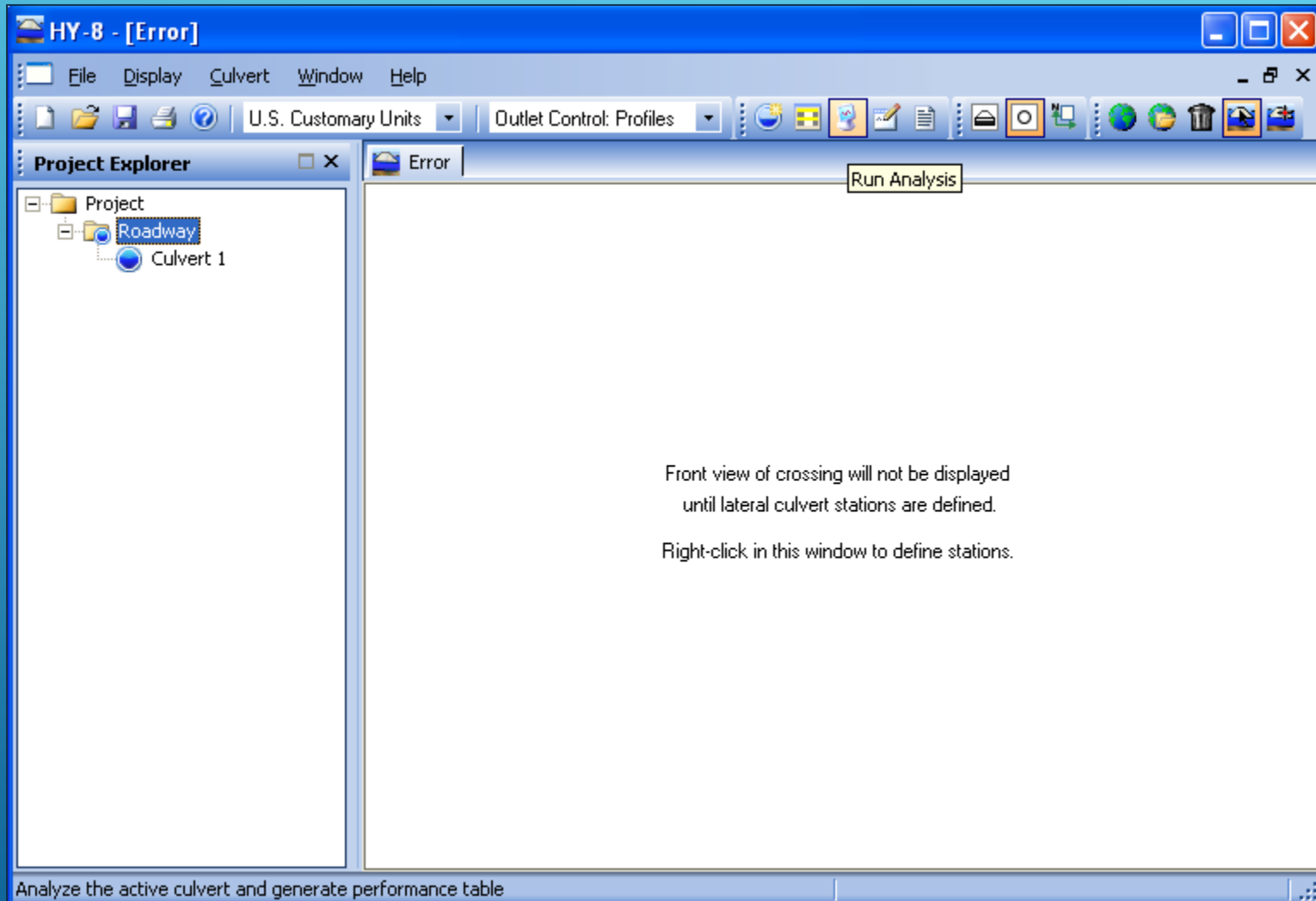
Buttons: Add Culvert, Duplicate Culvert, Delete Culvert

Parameter	Value	Units
Name	Culvert 1	
Shape	Circular	
Material	Concrete	
Diameter	3.000	ft
Embedment Depth	0.000	in
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge with Headwall	
Inlet Depression?	No	
<b>SITE DATA</b>		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	661.150	ft
Outlet Station	120.000	ft
Outlet Elevation	659.000	ft
Number of Barrels	1	

Buttons: Help, Click on any icon for help on a specific topic, Low Flow, AOP, Energy Dissipation, Analyze Crossing, OK, Cancel

Input of Site Data – Culvert length, inverts, and number of barrels.

# HY-8: RUNNING THE CULVERT ANALYSIS



The “Run Analysis” icon on the toolbar performs the culvert analysis.



# HY-8: VIEWING THE OUTPUT

Summary of Flows at Crossing - Roadway

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
661.15	0.00	0.00	0.00	1
662.69	12.50	12.50	0.00	1
663.53	25.00	25.00	0.00	1
664.27	37.50	37.50	0.00	1
665.12	50.00	50.00	0.00	1
666.22	62.50	62.50	0.00	1
666.47	65.00	65.00	0.00	1
667.25	87.50	72.21	15.25	6
667.37	100.00	73.19	26.76	5
667.47	112.50	74.02	38.38	4
667.56	125.00	74.78	50.18	4
667.00	69.97	69.97	0.00	Overtopping

Display

- Crossing Summary Table
- Culvert Summary Table Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table Options...

Geometry

Inlet Elevation: 661.15 ft  
Outlet Elevation: 659.00 ft  
Culvert Length: 120.02 ft  
Culvert Slope: 0.0179  
Inlet Crest: 0.00 ft  
Inlet Throat: 0.00 ft

Outlet Control: Profiles

Plot

- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help Flow Types... Edit Input Data... Energy Dissipation... AOP... Low Flow... Export Report Adobe PDF (\*.pdf) Close

Output for Example #1 – Does the proposed culvert meet the design requirements?

# HY-8: VIEWING THE OUTPUT

Crossing Data - Roadway

Crossing Properties

Name: Roadway

Parameter	Value	Units
<b>DISCHARGE DATA</b>		
Discharge Method	Minimum, Design, and Maximum	
Minimum Flow	0.000	cfs
Design Flow	65.000	cfs
Maximum Flow	125.000	cfs
<b>TAILWATER DATA</b>		
Channel Type	Irregular Channel	
Irregular Channel	Define...	
Rating Curve	View...	
<b>ROADWAY DATA</b>		
Roadway Profile Shape	Constant Roadway Elevation	
First Roadway Station	0.000	ft
Crest Length	40.000	ft
Crest Elevation	667.000	ft
Roadway Surface	Paved	
Top Width	80.000	ft

Culvert Properties

Culvert 1

Add Culvert  
Duplicate Culvert  
Delete Culvert

Parameter	Value	Units
<b>CULVERT DATA</b>		
Name	Culvert 1	
Shape	Circular	
Material	Concrete	
Diameter	4.000	ft
Embedment Depth	0.000	in
Manning's n	0.013	
Culvert Type	Straight	
Inlet Configuration	Square Edge with Headwall	
Inlet Depression?	No	
<b>SITE DATA</b>		
Site Data Input Option	Culvert Invert Data	
Inlet Station	0.000	ft
Inlet Elevation	661.150	ft
Outlet Station	120.000	ft
Outlet Elevation	659.000	ft

Help Click on any icon for help on a specific topic Low Flow AOP Energy Dissipation Analyze Crossing OK Cancel

Upsizing the culvert is an option to meet requirements.

# HY-8: VIEWING THE OUTPUT

Summary of Flows at Crossing - Roadway

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
661.15	0.00	0.00	0.00	1
662.54	12.50	12.50	0.00	1
663.17	25.00	25.00	0.00	1
663.77	37.50	37.50	0.00	1
664.28	50.00	50.00	0.00	1
664.75	62.50	62.50	0.00	1
664.84	65.00	65.00	0.00	1
665.75	87.50	87.50	0.00	1
666.32	100.00	100.00	0.00	1
666.97	112.50	112.50	0.00	1
667.18	125.00	116.22	8.66	7
667.00	113.11	113.11	0.00	Overtopping

Display

- Crossing Summary Table
- Culvert Summary Table Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table Options...

Geometry

Inlet Elevation: 661.15 ft  
Outlet Elevation: 659.00 ft  
Culvert Length: 120.02 ft  
Culvert Slope: 0.0179  
Inlet Crest: 0.00 ft  
Inlet Throat: 0.00 ft

Outlet Control: Profiles

Plot

- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

Help Flow Types... Edit Input Data... Energy Dissipation... AOP... Low Flow... Export Report Adobe PDF (\*.pdf) Close

Output for Example #1 – Note that the headwater elevation at the design flowrate (664.84 ft) is 2.16 feet below the roadway overtopping (667.0 ft).

# HY-8: CREATING A REPORT

The screenshot displays the HY-8 software interface. The main window shows a plot titled "Crossing - Roadway, Design Discharge - 65.0 cfs" with a subtitle "Culvert - Culvert 1, Culvert Discharge - 65.0 cfs". The plot shows Elevation (ft) on the y-axis (ranging from 659 to 666) and Station (ft) on the x-axis (ranging from -20 to 60). A blue line with arrows represents the water surface profile, and a black line represents the culvert invert. A "Create Report" icon is highlighted in the Project Explorer on the left.

The Report Generator dialog box is open, showing the following options:

- Choose crossing(s) to include:** Roadway
- Format:** Report Type: Standard Report, File Format: RTF, File name: HY8Report
- Report Content:**
  - Choose fields to include:** Available Fields: Project Notes, Project Units, Project Outlet Control Option, Crossing Notes, Crossing Summary Table, Crossing Rating Curve Plot, Crossing Front View Plot, Culvert Notes, Culvert Summary Tables, Culvert Performance Plot, Water Surface Profile Plot, Site Data, Culvert Data, Tailwater Data, Tailwater Rating Curve Plot, Roadway Data.
  - Move fields up or down:** Included Fields: Crossing Summary Table, Crossing Rating Curve Plot, Culvert Summary Tables, Culvert Performance Plot, Water Surface Profile Plot, Site Data, Culvert Data, Tailwater Data, Roadway Data.

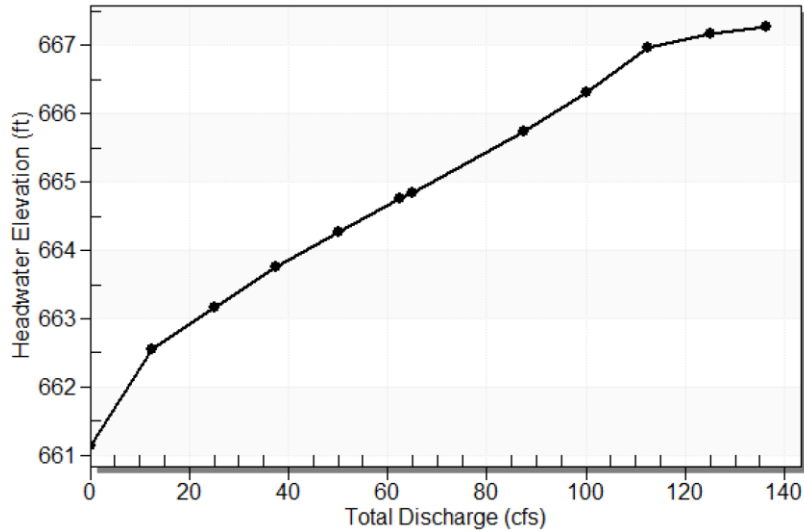
Buttons for "Include All >>", "<< Remove All", "Help", "OK", and "Cancel" are visible at the bottom of the dialog box.

Use the “Create Report” icon to generate detailed output for the culvert analysis. HY-8 gives the user several options to include in the output.

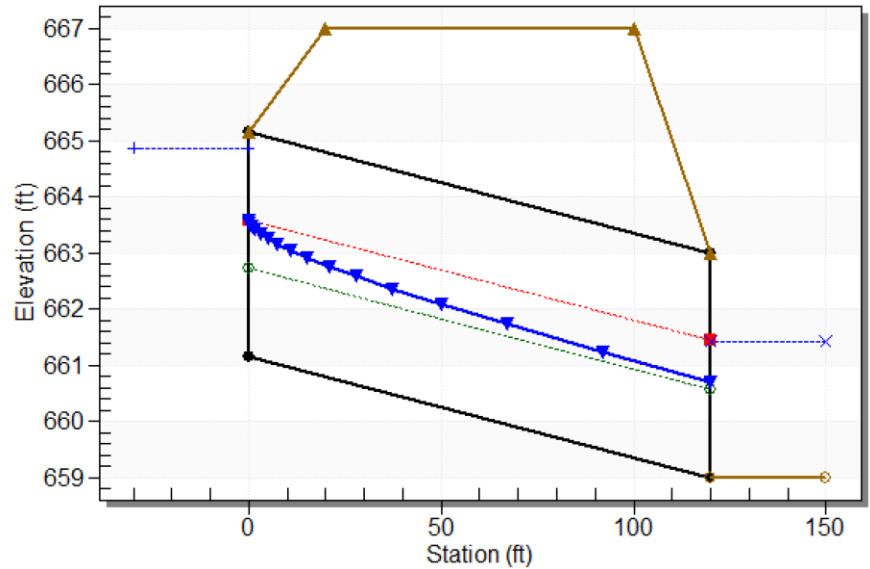
# HY-8: VIEWING THE REPORT

Rating Curve Plot for Crossing: Roadway

Total Rating Curve  
Crossing: Roadway



Crossing - Roadway, Design Discharge - 65.0 cfs  
Culvert - Culvert 1, Culvert Discharge - 65.0 cfs



Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
661.15	0.00	0.00	0.00	1
662.54	12.50	12.50	0.00	1
663.17	25.00	25.00	0.00	1
663.77	37.50	37.50	0.00	1
664.28	50.00	50.00	0.00	1
664.75	62.50	62.50	0.00	1
664.84	65.00	65.00	0.00	1
665.75	87.50	87.50	0.00	1
666.32	100.00	100.00	0.00	1
666.97	112.50	112.50	0.00	1
667.18	125.00	116.22	8.66	7
667.00	113.11	113.11	0.00	Overtopping



# CULVERT DESIGN

- Criteria to keep in mind:

- Return Period

- Interstate – 100-year
- Primary – 25-year
- Secondary – 10-year

- While design criteria may be a 10-year return period, keep in mind potential impacts to adjacent or upstream structures that may warrant an increase to the system capacity

- Minimum cleaning velocity: 3 ft/sec
- Minimum freeboard requirements

Functional Classification	Allowable Backwater	Roadway Serviceability	Allowable Velocity
Freeway	$Q_{100}$	$Q_{100}$	$Q_{50}$
Non-Freeway $\geq 4$ Lanes	$Q_{100}$	$Q_{100}$	$Q_{50}$
Two-Lane Facility			
AADT $\geq 3000$	$Q_{100}$	$Q_{100}$	$Q_{50}$
$3000 > \text{AADT} \geq 1000$	$Q_{100}$	$Q_{25}$	$Q_{25}$
AADT $< 1000$	$Q_{100}$	$Q_{10}$	$Q_{10}$
Drive	$Q_{100}$	$Q_{10}$	$Q_{10}$

*Note: The design-storm frequency for a culvert-extension structure is identical to that for a new culvert structure. Traffic volume is for a 20-year projection.*

DESIGN-STORM FREQUENCY, CULVERT

Source: InDOT Design Manual

# CULVERT SHAPE SELECTION

- Criteria to keep in mind:
  - Minimum pipe size
  - Site / location restrictions – what fits?  
What about installation?
  - County / community ordinance guidelines
  - Cost

Structure Application	Minimum Circular-Pipe Size	Minimum Deformed-Pipe Area
Drive	15 in.	1.1 ft <sup>2</sup>
Mainline or Public-Road Approach (2 lanes)	15 in.	1.1 ft <sup>2</sup>
Mainline or Public-Road Approach ( $\geq 3$ Lanes)	36 in.	6.7 ft <sup>2</sup>

**MINIMUM PIPE-CULVERT SIZE**

Source: *InDOT Design Manual*

# CULVERT MATERIAL SELECTION

- General criteria:
  - Loading / cover over the pipe
    - Minimum cover is typically 2 feet; however, check applicable regulations
    - Boone County, IN requires 3 feet for culverts within ROW
  - Purpose
    - Drain tile versus highway crossing
  - County / community ordinance guidelines
    - Are plastic pipes allowed?
    - Is concrete required?
  - Cost

# INSTALLATION

- Plan and specifications signed by a Licensed PE
- Permits
- Best Management Practices (BMPs)
- Inlet and outlet protection
- Bedding materials
- Backfill
- Inspection

# REFERENCES

- LTAP Stormwater Drainage Manual
- InDOT Design Manual
- HY-8 Users Manual (FHWA)



# QUESTIONS

