Hydraulic Data Requirements

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Typical Hydraulic Data

Drainage Area
Q100
Elevation @ Q100
Backwater
Velocity @ Q100
Gross Waterway Opening Required Below Q100 Elevation (Structure)
Waterway Opening Over Road
Minimum Low Structure Elevation
Approximate Skew
Existing Waterway Opening Below Q100 Elevation (Structure)
Existing Waterway Opening Road
Existing Low Structure
Existing Backwater

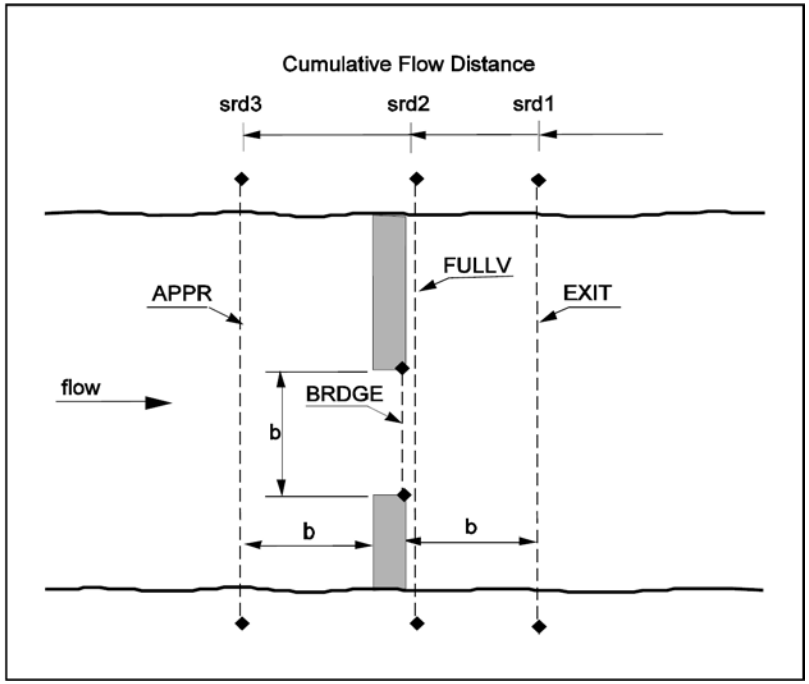
Determining Drainage Area

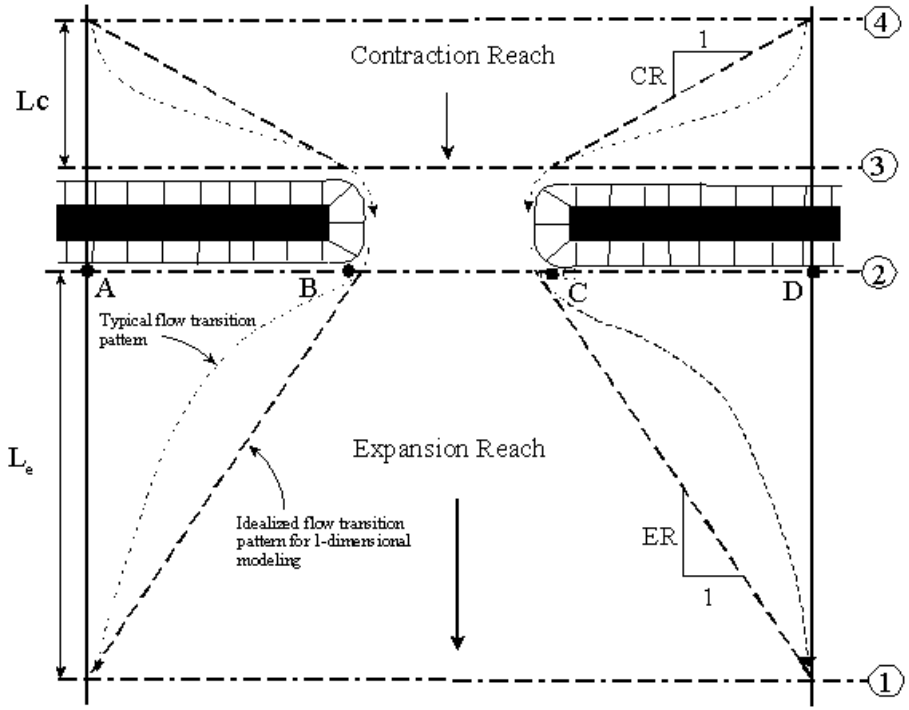
- USGS Quadrangle Topographic Maps
- L-THIA
- Field Investigation
- Drainage Areas of Indiana Streams

Determining Q100

- IDNR Discharge Letter
- Coordinated Discharges
- Gage Stations
- Rational Method
- TR-20
- (see Chapter 202 in the Indiana Design Manual)

WSPRO vs HEC-RAS





Determining Q100 Elevation

River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev
			(cfs)	(ft)	(ft)	(ft)	(ft)
4	PF 1	Existing	1500.00	800.67	809.61		809.64
4	PF 1	Proposed	1500.00	800.67	809.13		809.16
4	PF 1	Natural	1500.00	800.67	808.27		808.34
3	PF 1	Existing	1500.00	800.47	809.57	806.71	809.59
3	PF 1	Proposed	1500.00	800.47	808.67	806.75	808.97
3	PF 1	Natural	1500.00	800.47	808.07		808.14
2.5			Bridge				
2	PF 1	Existing	1500.00	800.40	807.87	806.56	808.69
2	PF 1	Proposed	1500.00	800.40	807.99	806.66	808.53
2	PF 1	Natural	1500.00	800.40	808.00		808.07
1	PF 1	Existing	1500.00	800.00	807.60	806.32	807.67
1	PF 1	Proposed	1500.00	800.00	807.60	806.32	807.67
1	PF 1	Natural	1500.00	800.00	807.60	806.32	807.67

- For HEC-RAS, interpolate between cross-section #2 and #3 (natural conditions) to the downstream bridge face location
- May use cross-section #2 (natural conditions) if #2 is within 0.1 ft of cross-section #3 (natural conditions)

Determining Q100 Elevation

- Should be determined from downstream bridge opening cross-section
- Should be based on previously determined Q100 Elevation
- Should include the area of the piers
- Can be determined using geometry or from model output

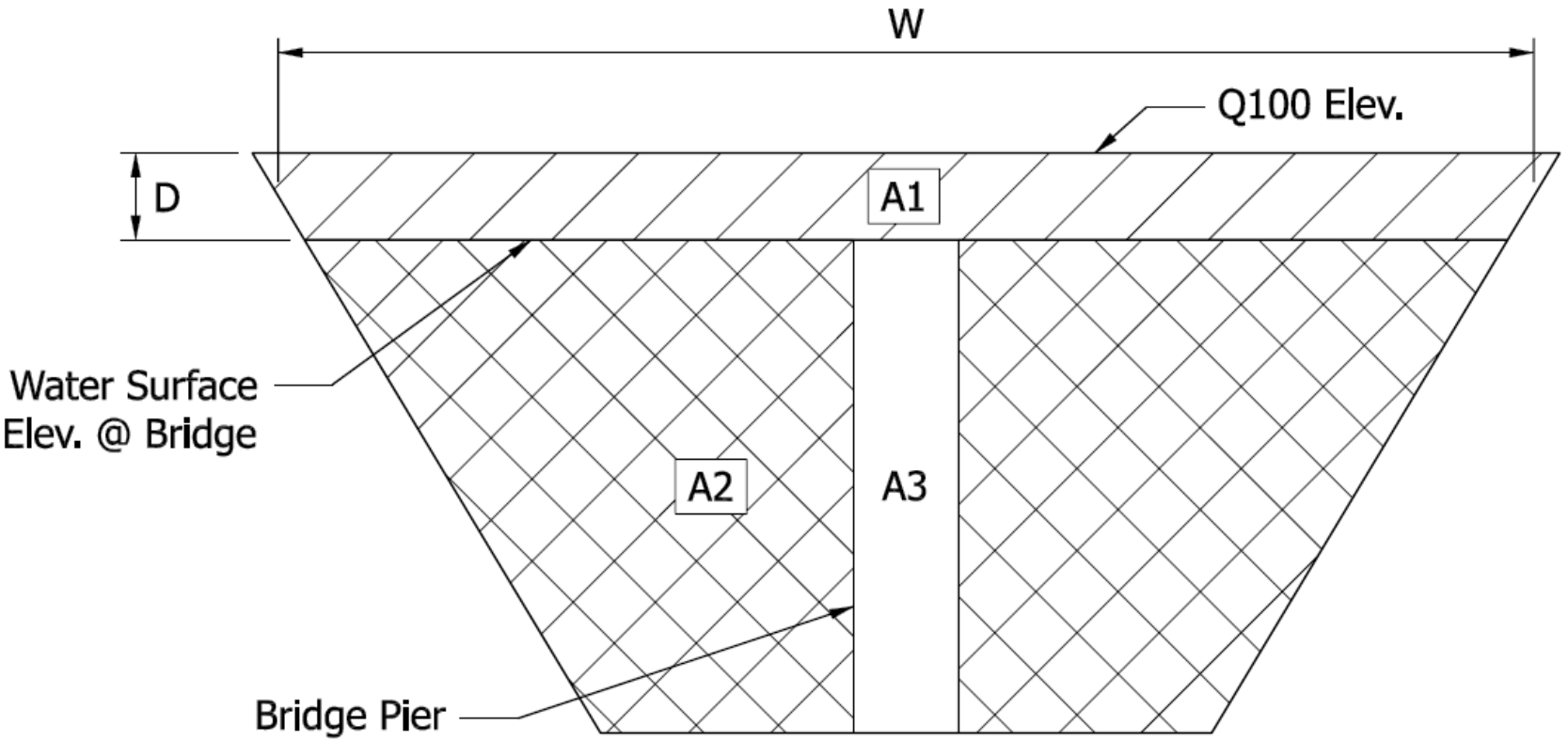
Gross Waterway Area

Opening of Bridge

E.G. US. (ft)	808.97	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	808.67	E.G. Elev (ft)	808.86	808.72
Q Total (cfs)	1500.00	W.S. Elev (ft)	808.02	807.83
Q Bridge (cfs)	1500.00	Crit W.S. (ft)	806.65	806.57
Q Weir (cfs)		Max Chl Dpth (ft)	7.55	7.43
Weir Sta Lft (ft)		Vel Total (ft/s)	6.84	7.06
Weir Sta Rgt (ft)		Flow Area (sq ft)	219.42	212.45
Weir Submerg		Froude # Chl	0.64	0.68
Weir Max Depth (ft)		Specif Force (cu ft)	946.34	930.34
Min El Weir Flow (ft)	812.01	Hydr Depth (ft)	4.20	4.13
Min El Prs (ft)	810.00	W.P. Total (ft)	76.72	75.04
Delta EG (ft)	0.44	Conv. Total (cfs)	23170.1	22304.7
Delta WS (ft)	0.69	Top Width (ft)	52.19	51.44
BR Open Area (sq ft)	330.55	Frctn Loss (ft)	0.13	0.09
BR Open Vel (ft/s)	7.06	C & E Loss (ft)	0.01	0.11
Coef of Q		Shear Total (lb/sq ft)	0.75	0.80
Br Sel Method	Energy only	Power Total (lb/ft s)	5.12	5.64

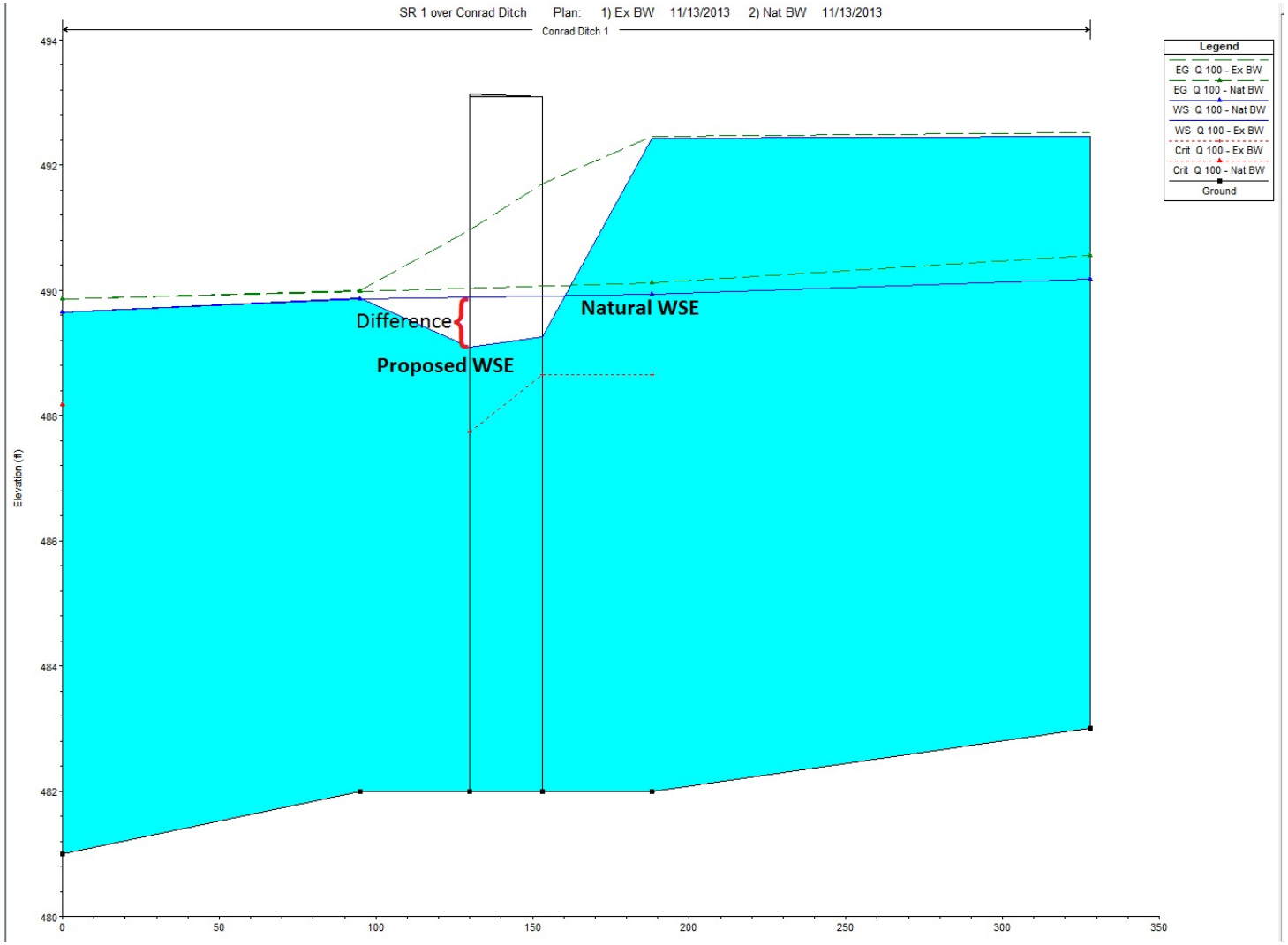
- Start with Flow Area of downstream bridge
- Add the Pier Area from the ground to waterway surface elevation of the bridge
- Add or subtract water surface elevation difference between Q100 elevation and bridge, multiplied by the water surface width at the bridge

Gross Waterway Area



A1 + A2 + A3 = Gross Waterway Area

Gross Waterway Area



Determining Road Overflow

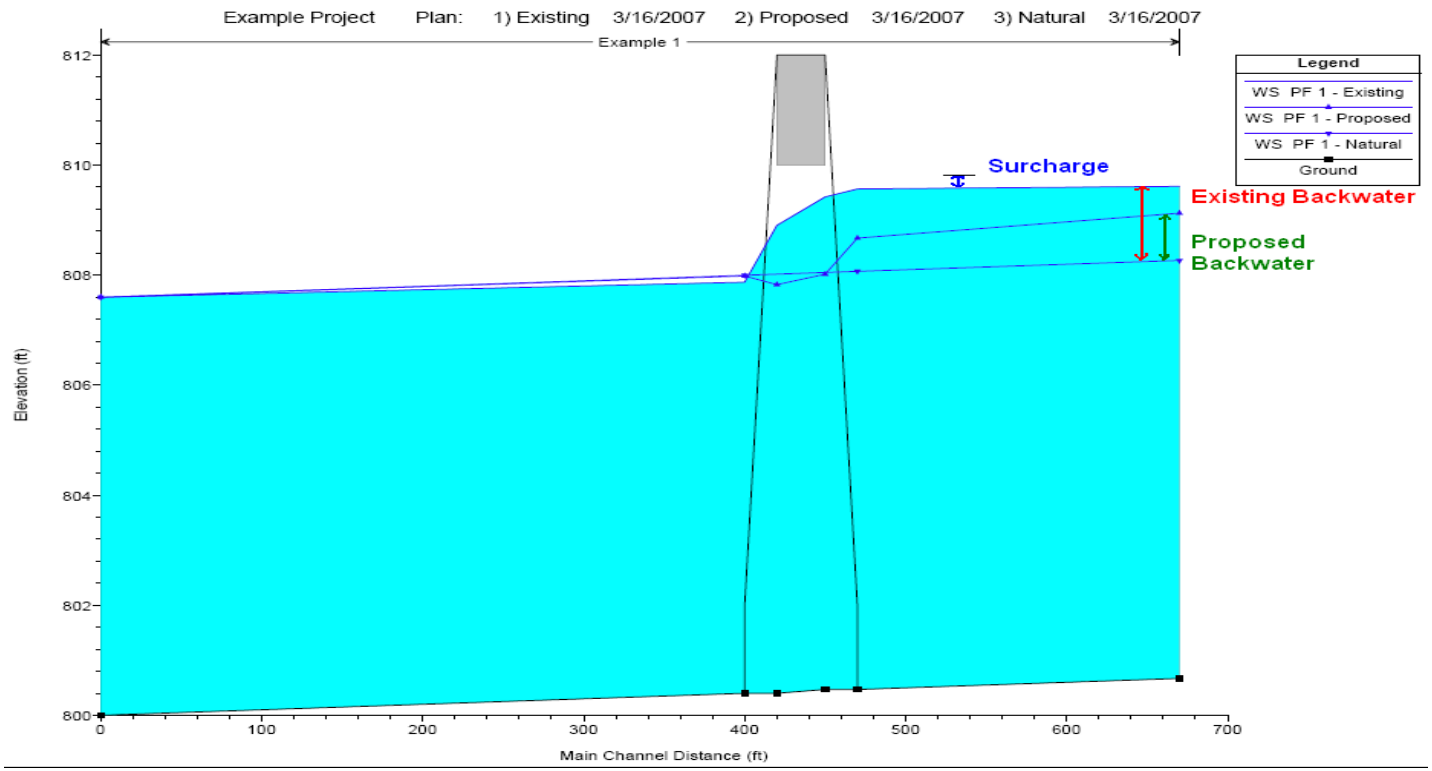
- Choose “Bridge Only” option from Standard Tables
- Add “Weir Flow Area” column from Define Tables option
- Use Weir Flow Area data from Profile Output Table

River Sta	Profile	E.G. US.	Min El Prs	BR Open Area	Prs O WS	Q Total	Min El Weir Flow	Q Weir	Delta EG	Weir Flow Area
		(ft)	(ft)	(sq ft)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(sq ft)
310	Q 10	590.43	590.00	212.55	590.19	1120.00	592.01		0.11	
310	Q 100	593.75	590.00	212.55		2800.00	592.01	732.56	1.06	212.06
310	Q 500	595.86	590.00	212.55		4760.00	592.01	2404.89	1.12	470.41

Determining Road Overflow

- Can subtract out appropriate bridge area from the total flow area given in the bridge output
- May also figure out graphically
- Exact value is not critical to design

Backwater and Surcharge



- Backwater is the difference between the water surface elevation upstream caused by the bridge and the natural water surface elevation (no bridge)
- Surcharge is the increase in water surface elevation over existing conditions

Determining Backwater

- IDNR is mostly concerned with the effects of proposed condition verses existing (surcharge)

- INDOT is concerned with the same plus the effects compared to natural conditions (no bridge)

Determining Backwater

- If existing structure creates backwater > 1.0 ft., the proposed structure must have backwater equal to or less than 1.0 ft.
- If existing structure creates backwater < 1.0 ft., the proposed structure must be equal to or less than existing backwater except...
- If existing structure creates backwater < 0.14 ft., the proposed structure may have backwater up to 0.14 ft.
- For new road alignment, the proposed bridge must have surcharge no greater than 0.14 ft.

Determining Backwater

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4	PF 1	Proposed	1500.00	800.67	809.13
4	PF 1	Natural	1500.00	800.67	808.27
3	PF 1	Existing	1500.00	800.47	809.57
3	PF 1	Proposed	1500.00	800.47	808.67
3	PF 1	Natural	1500.00	800.47	808.07
2.5			Bridge		
2	PF 1	Existing	1500.00	800.40	807.87
2	PF 1	Proposed	1500.00	800.40	807.99
2	PF 1	Natural	1500.00	800.40	808.00
1	PF 1	Existing	1500.00	800.00	807.60
1	PF 1	Proposed	1500.00	800.00	807.60
1	PF 1	Natural	1500.00	800.00	807.60

- Subtract difference between cross-section #4 natural and either proposed or existing conditions
- Exist BW = 809.61-808.27= 1.34 ft.
- Prop BW = 809.13-808.27= 0.86 ft.

Determining Outlet Velocity

Plan: Proposed Example 1 RS: 2.5 Profile: PF 1

E.G. US. (ft)	808.97	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	808.67	E.G. Elev (ft)	808.86	808.72
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Coef of Q		Shear Total (lb/sq ft)	0.75	0.80
Br Sel Method	Energy only	Power Total (lb/ft s)	5.12	5.64

- Use Velocity Total on the downstream side.

Riprap Sizing

- Riprap size will be based on outlet velocity
- Riprap protection should be shown on plans sent for hydraulic review
- Upgrade one riprap size for scour protection on an outside bend

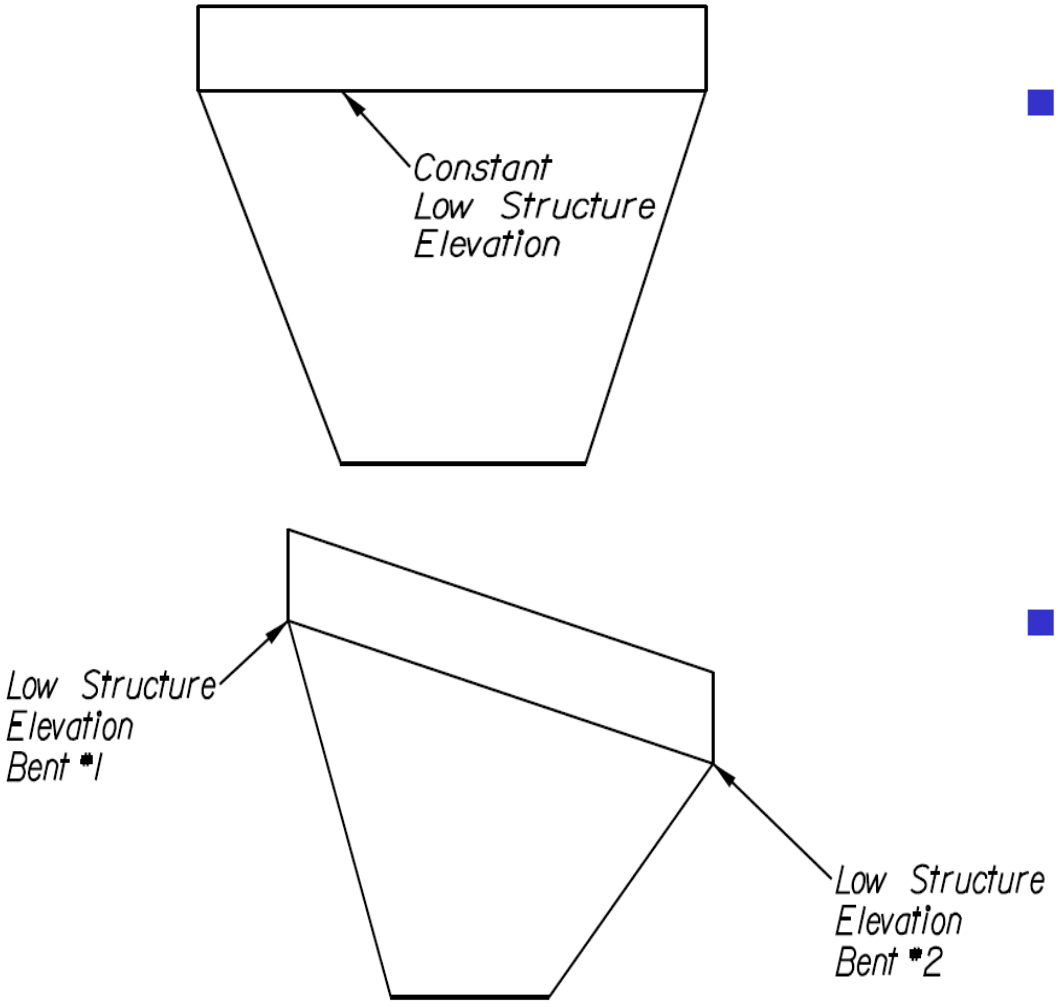
Outlet velocity	**Riprap size**
< 6.5 ft/s	Revetment
6.5 ft/s to 10 ft/s	Class 1
10 ft/s to 13 ft/s	Class 2

Determining Low Structure

- It is desired to have at least 2.0 ft. of freeboard over Q100 Elevation

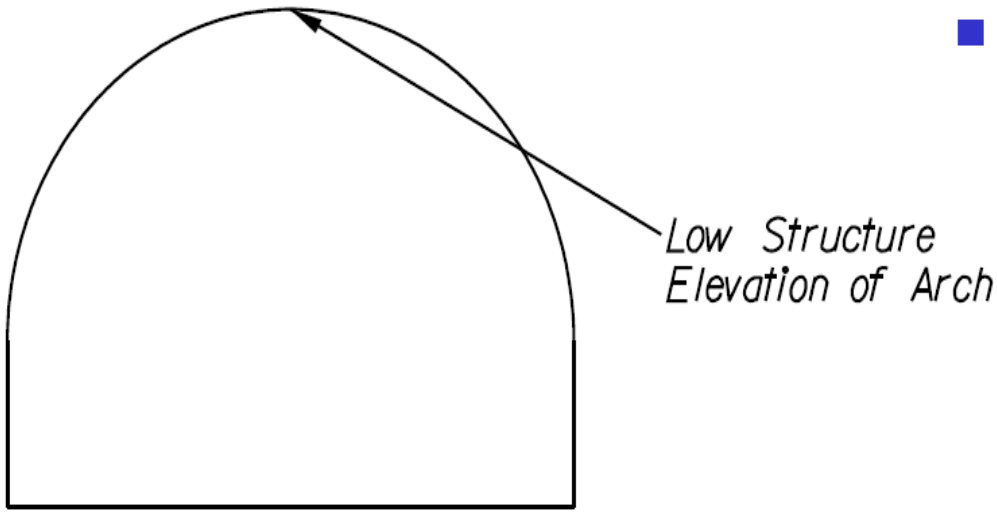
- Low structure elevation given in data will be determined by bridge geometry input

Determining Low Structure



- A flat deck should give the low structure elevation that is constant across the bottom
- A deck on a grade should give low structure elevations for both end bents.

Determining Low Structure

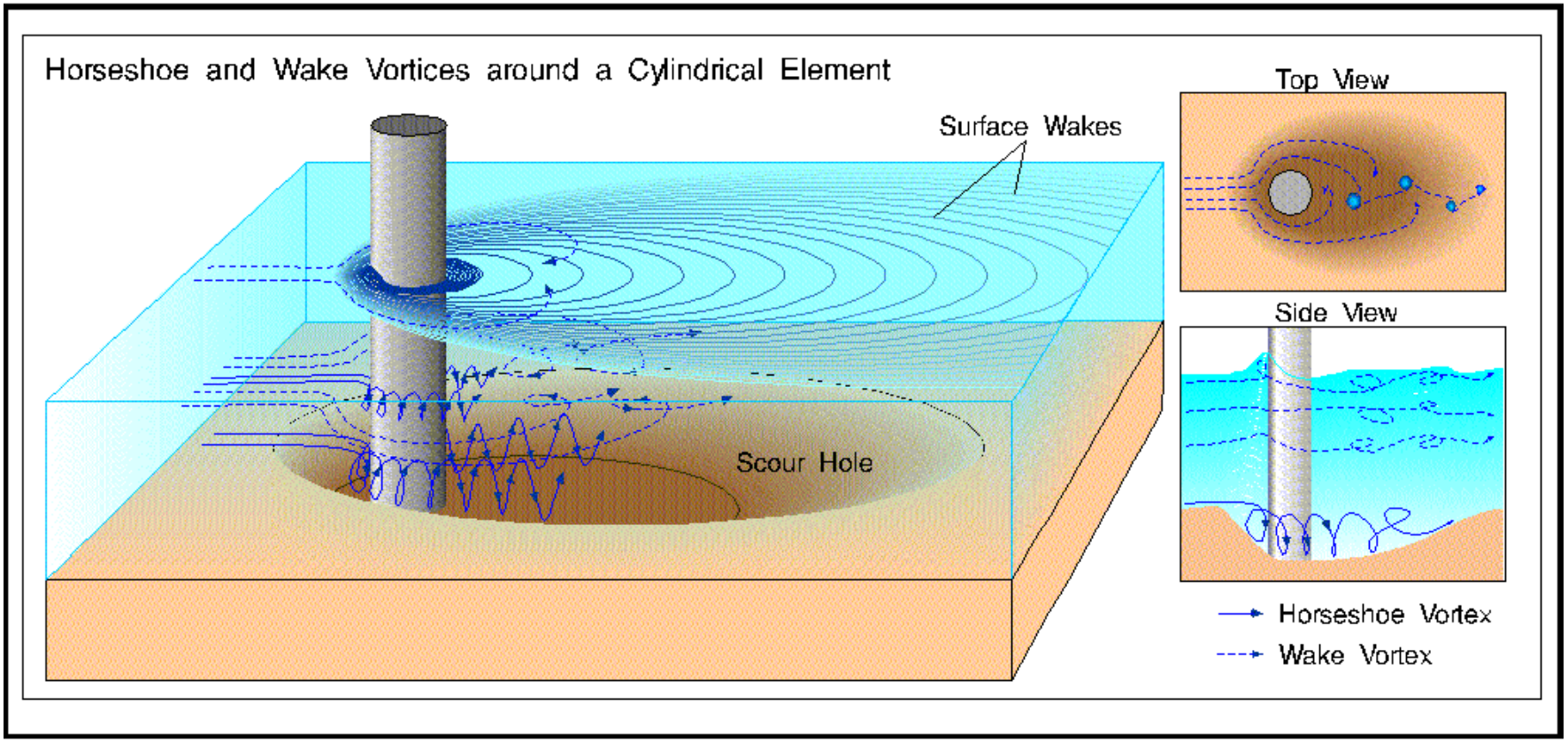


- Low structure elevation of an arch structure should be given at the highest point of the arch

Determining Skew

- More important to be lined up with the stream on the inlet than the outlet
- Compromises may be needed on severe bends
- Make sure calculated waterway opening is normal to the direction of flow
- Areas change very little on skews less than 15 degrees

Scour Data Requirements



Typical Scour Data Summary

Q100 Discharge
Elevation @ Q100
Velocity @ Q100
Contraction Scour Depth
Total Scour Depth
Low Scour Elevation

Q500 Discharge
Elevation @ Q500
Velocity @ Q500
Contraction Scour Depth
Total Scour Depth
Low Scour Elevation

Determining Scour Data

- Q100 & Q500 Elevation determined from hydraulic data
- Q500 is determined from gage data or other hydrologic methods (do not use 1.7 multiplier anymore)
- Q500 Elevation is determined by running model using Q500 storm event and using cross-section #2 (natural conditions) water surface elevation

Determining Scour Data

- See handout for process to use for scour input in HEC-RAS
- Compute scour for both 100 & 500 year storms
- After input data, press “compute” button, then “report” to view scour output

Determining Maximum Velocity

Plan: PropBrFW9-26 RIVER-1 Reach-1 RS: 35.71 BR U Profile: Design

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)
1	LOB	1131.03	1172.60	40.89	29.75	25.92	0.31	1.87	1.37
2	LOB	1172.60	1214.17	681.28	194.61	41.72	5.24	4.68	3.50
3	LOB	1214.17	1255.74	579.14	188.42	49.09	4.45	4.76	3.07
4	Chan	1255.74	1264.05	207.86	47.57	8.53	1.60	5.72	4.37
5	Chan	1264.05	1272.37	409.31	74.24	9.40	3.15	8.93	5.51
6	Chan	1272.37	1280.68	629.27	91.55	8.32	4.84	11.01	6.87
7	Chan	1280.68	1288.99	667.81	94.87	8.32	5.14	11.41	7.04
8	Chan	1288.99	1297.31	699.85	97.55	8.32	5.38	11.73	7.17
9	Chan	1297.31	1305.62	189.54	74.26	29.84	1.46	11.76	2.55
10	Chan	1305.62	1313.93	702.84	97.78	8.31	5.41	11.76	7.19
11	Chan	1313.93	1322.25	702.85	97.79	8.31	5.41	11.76	7.19
12	Chan	1322.25	1330.56	702.84	97.78	8.31	5.41	11.76	7.19
13	Chan	1330.56	1338.88	702.85	97.79	8.31	5.41	11.76	7.19
14	Chan	1338.88	1347.19	702.85	97.79	8.31	5.41	11.76	7.19
15	Chan	1347.19	1355.50	695.43	97.20	8.32	5.35	11.69	7.15
16	Chan	1355.50	1363.82	653.04	93.63	8.33	5.02	11.26	6.97
17	Chan	1363.82	1372.13	588.77	88.38	8.42	4.53	10.63	6.66
18	Chan	1372.13	1380.44	435.84	74.18	8.53	3.35	8.92	5.88

- Cross-section Tables>Type>Flow Distribution in Cross-sections
- Find maximum velocity for both 100 & 500-yr storms from the velocity distribution output

Contraction Scour

Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (ft):	4.70	8.19	4.69
	Approach Velocity (ft/s):	1.80	3.38	2.16
	Br Average Depth (ft):	3.04	6.31	3.02
	BR Opening Flow (cfs):	657.39	1444.54	692.39
	BR Top WD (ft):	42.00	41.00	39.00
	Grain Size D50 (mm):	0.01	0.01	0.01
	Approach Flow (cfs):	584.95	1385.64	829.40
	Approach Top WD (ft):	69.00	50.00	82.00
	K1 Coefficient:	0.690	0.690	0.690
Results				
	Scour Depth Ys (ft):	4.28	3.42	3.69
	Critical Velocity (ft/s):	0.46	0.51	0.46
	Equation:	Live	Live	Live

- Use maximum scour depth
- Stream may migrate

Pier Scour

Pier Scour

All piers have the same scour depth

Input Data

Pier Shape:	Round nose
Pier Width (ft):	3.00
Grain Size D50 (mm):	0.01000
Depth Upstream (ft):	9.00
Velocity Upstream (ft/s):	5.11
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (ft):	35.00
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	0.01000
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (ft):	5.78
Froude #:	0.30
Equation:	CSU equation

Total Scour

Combined Scour Depths

Pier Scour + Contraction Scour (ft):

Left Bank:	10.05
Channel:	9.20

- Total Scour = Contraction + Pier Scour
- Use channel values for Total Scour
- Subtract total scour from flowline elevation to determine low scour elevation

Helpful Websites

L-THIA 2.0
https://engineering.purdue.edu/mapserve/www/lthia_in/index.html

IDNR Division of Water
http://www.in.gov/dnr/water/

US Army Corps of Engineers – HEC-RAS
http://www.hec.usace.army.mil/software/hec-ras/

NOAA – Rainfall Intensity
http://hdsc.nws.noaa.gov/hdsc/pfds/orb/in_pfds.html