Bridge Hydraulics Pointers

Darrin Miller, P.E.
Merril Dougherty, P.E.

Items to be covered

- Missing documentation
- Design Memo 18-12
- When is a CIF permit required
- HY8 for bridges

Documentation

- Missing documentation is a frequent cause for resubmittals.
- Reviewer is typically not familiar with the project.

Documentation

- No memo(s)
- Memo(s) not stamped
- Memo in PDF (needs to be in Word)
- Report not stamped
- No HEC-RAS model (zip file for upload if too large)
- Pile driving records not included

Design Memorandum No. 18-12

- LPA Bridges (span > 20 ft) and Small Structures/Large Culverts (span ≥ 4 ft and ≤ 20 ft). Review and approval by the Office of Hydraulics is required when any one or more of the following conditions are met.
  - The structure is one mile or less downstream of an INDOT structure (measured along the stream).
  - The proposed backwater does not dissipate before reaching an upstream INDOT structure.
    - HEC-RAS place a cross section at the INDOT ROW
    - HY8 use backwater divided by upstream channel slope (ft/ft)
  - The structure is 1/2 mile or less upstream of an INDOT structure (measured along the stream).
  - There are levees within the proposed project limits.
- Document in submittal email and/or transmittal letter

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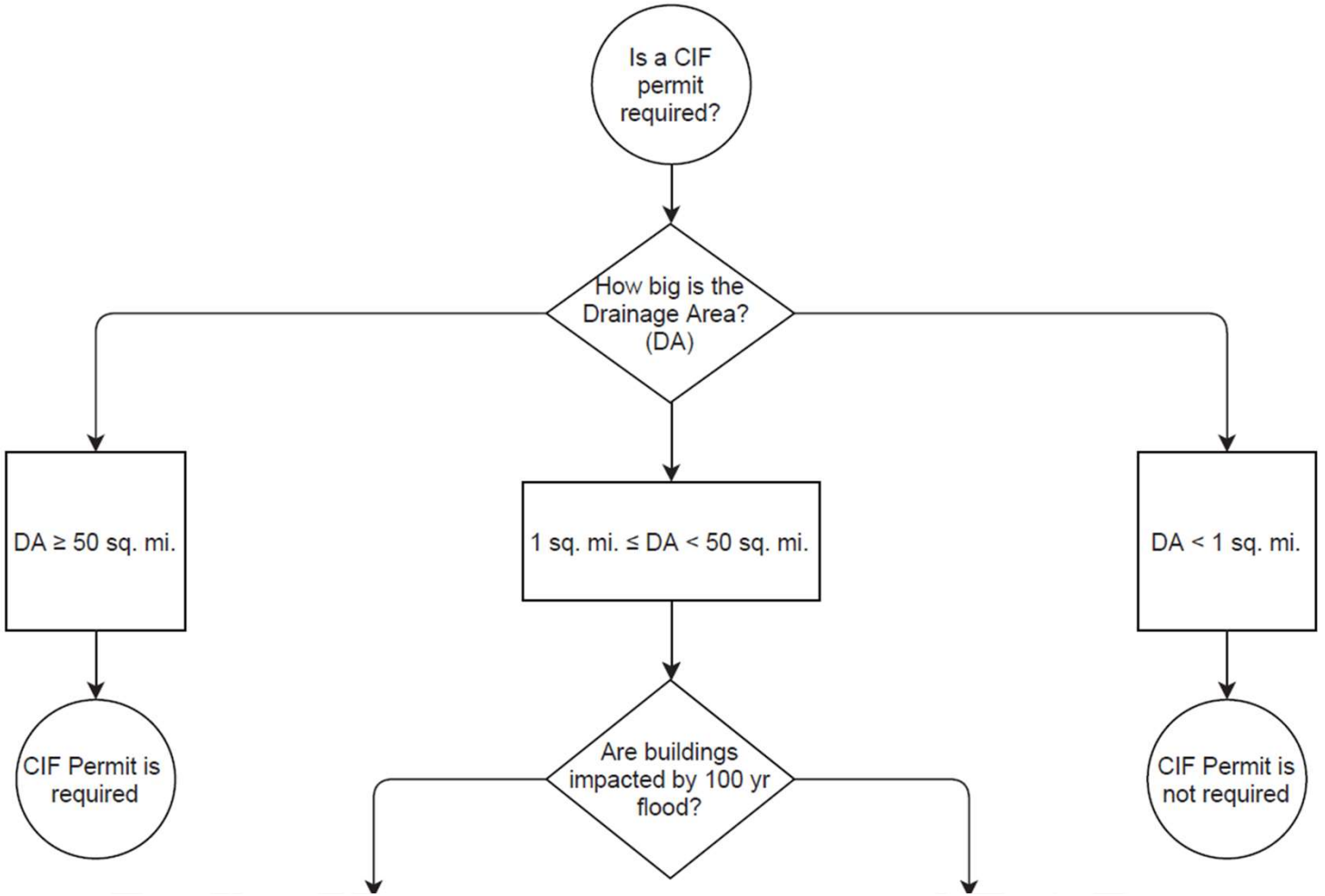
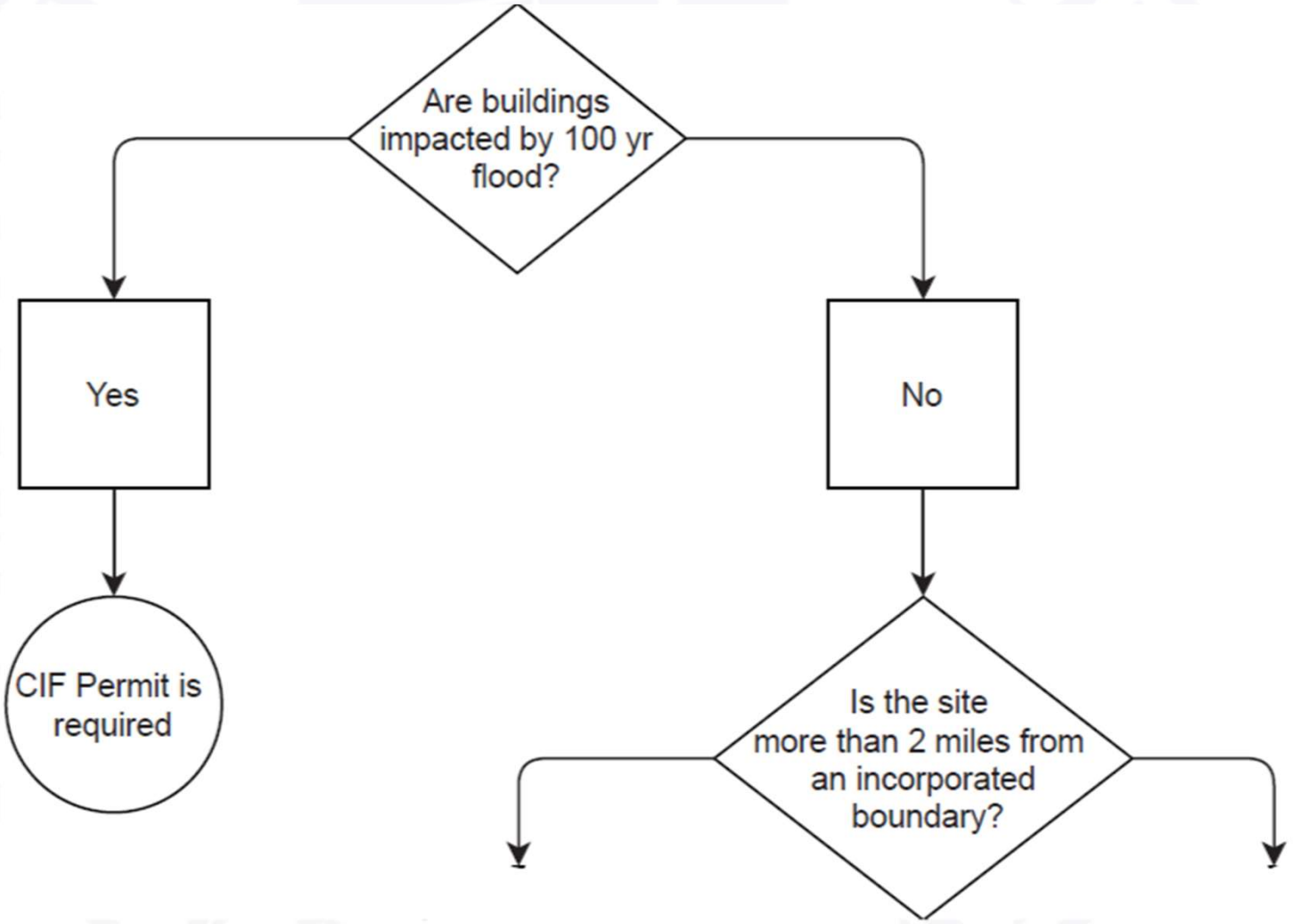
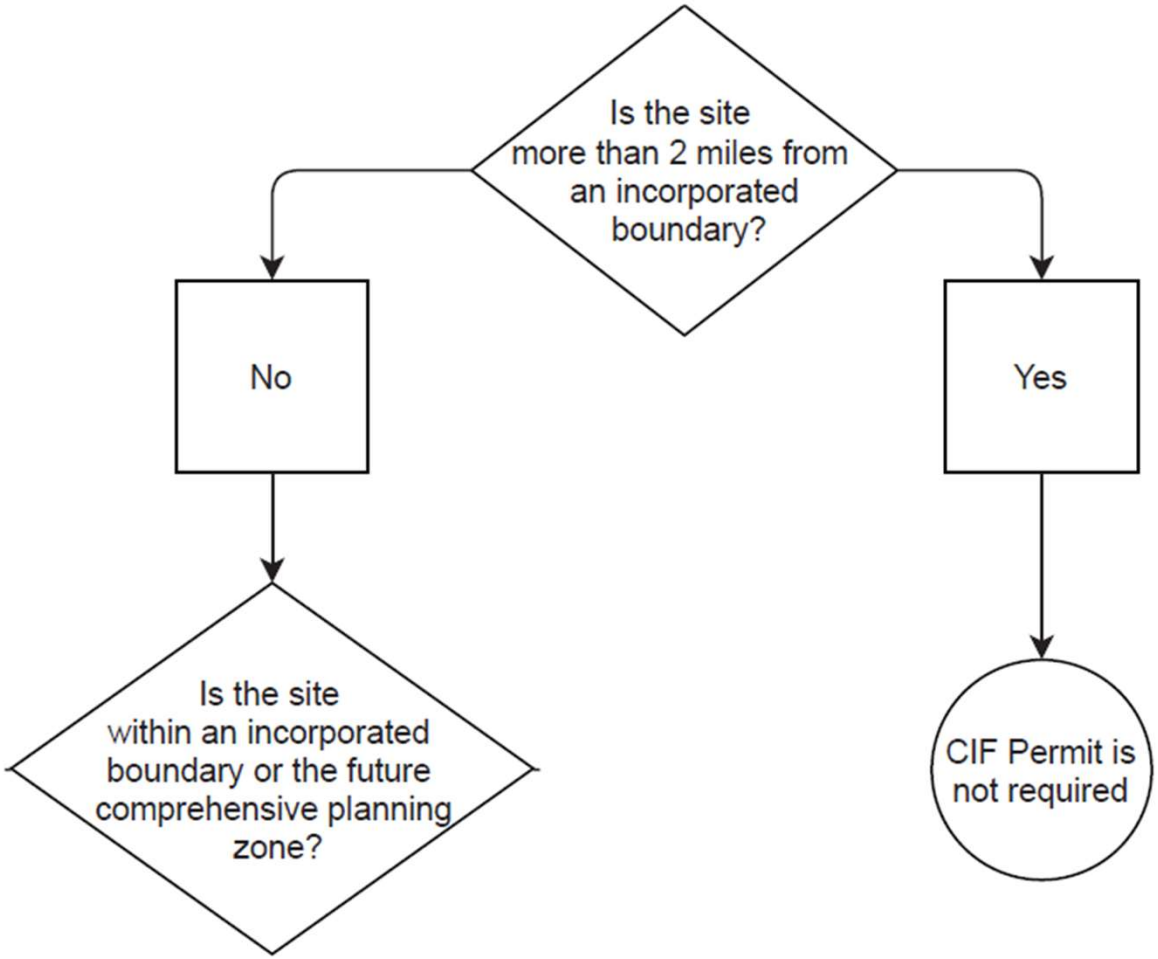
When is a CIF permit required?

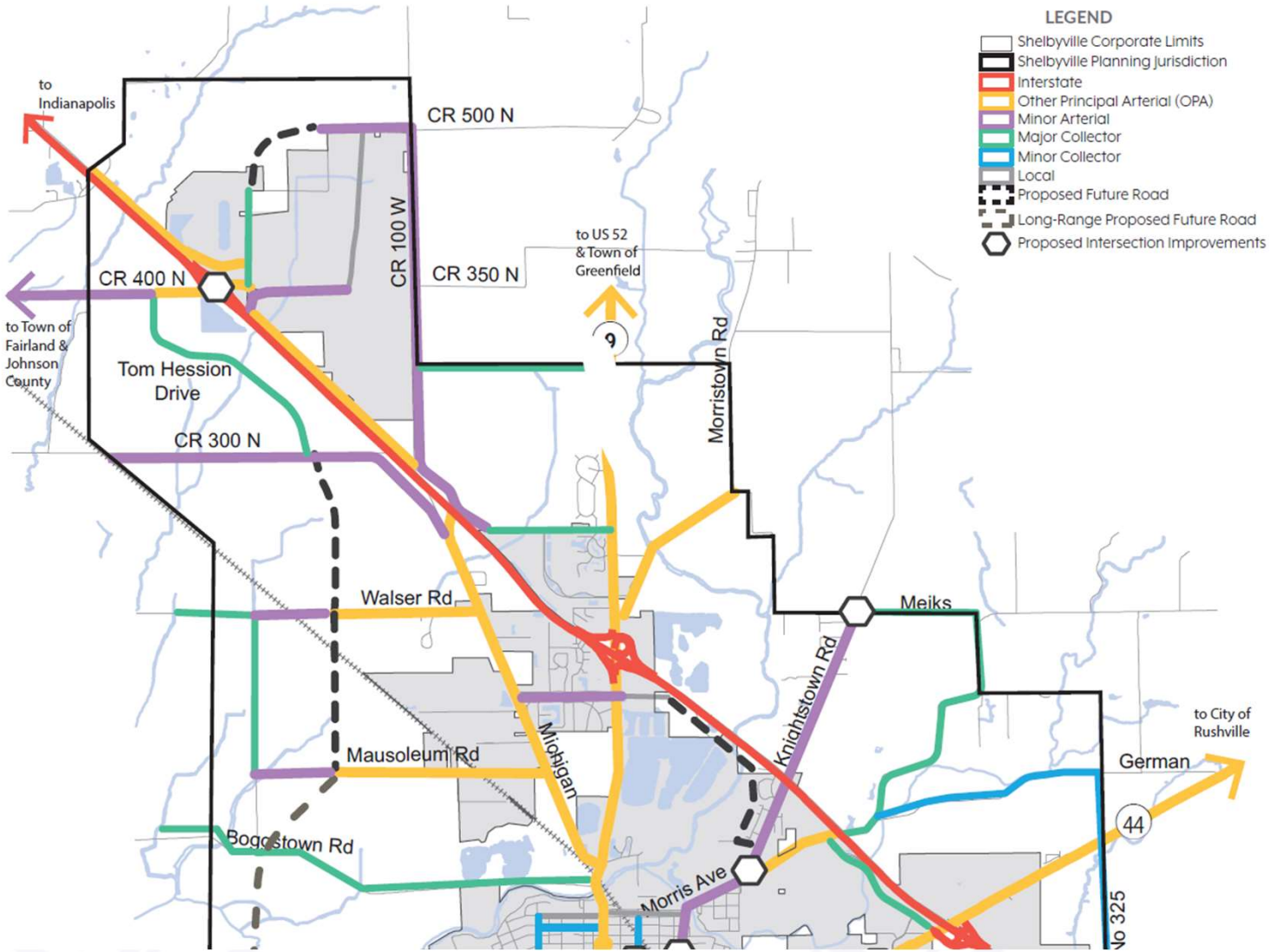


When is a CIF permit required?



When is a CIF permit required?

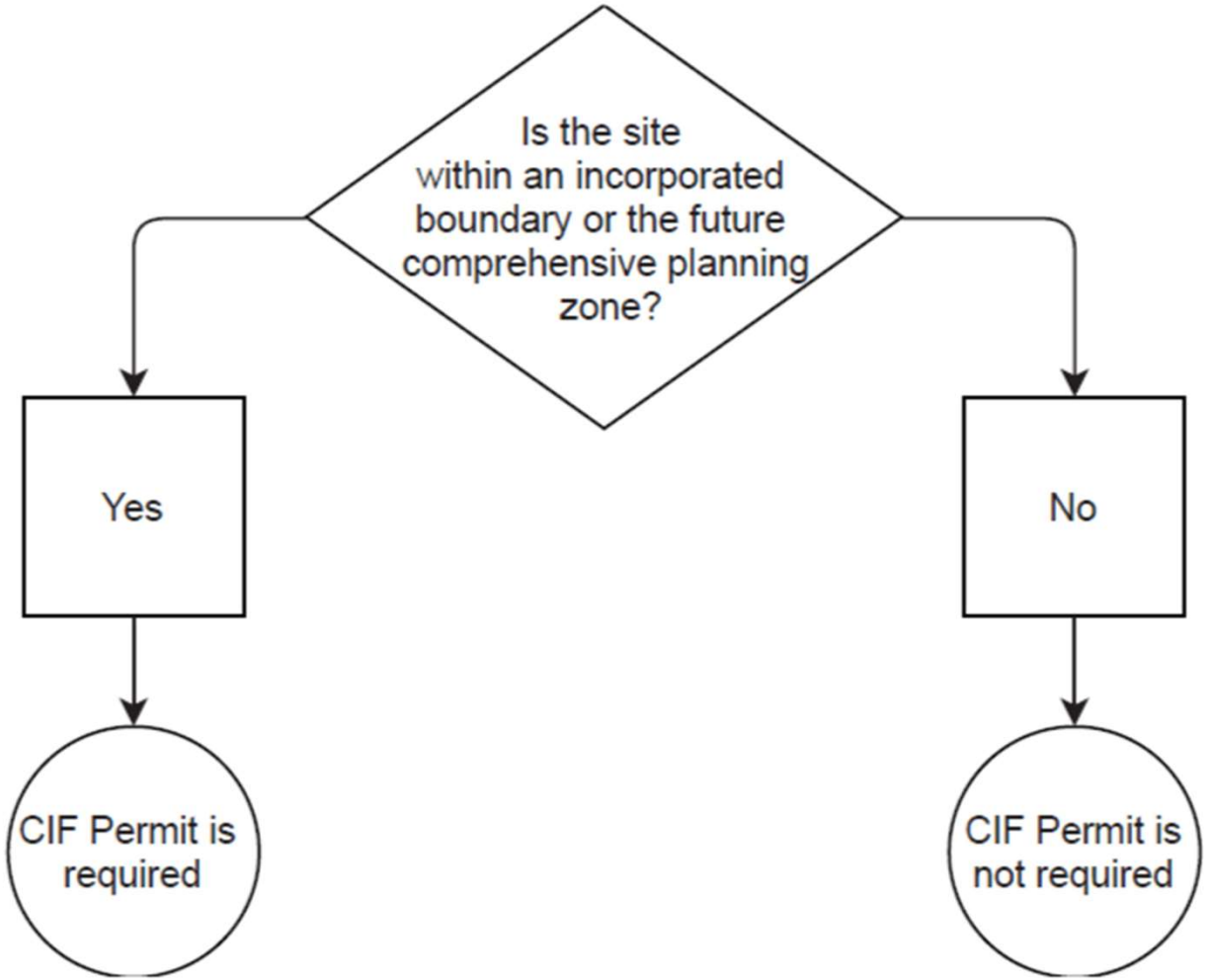



LEGEND
Shelbyville Corporate Limits
Shelbyville Planning Jurisdiction
Interstate
Other Principal Arterial (OPA)
Minor Arterial
Major Collector
Minor Collector
Local
Proposed Future Road
Long-Range Proposed Future Road
Proposed Intersection Improvements
to Indianapolis
CR 500 N
CR 100 W
CR 350 N
to US 52 & Town of Greenfield
CR 400 N
to Town of Fairland & Johnson County
Tom Hession Drive
CR 300 N
Morristown Rd
Walser Rd
Meiks
Knightstown Rd
to City of Rushville
German
Michigan
Mausoleum Rd
Boggstown Rd
Morris Ave
44
325

When is a CIF permit required?

- Determining incorporated boundary and future comprehensive planning zone
  - GIS
  - Contact the city or town

When is a CIF permit required?



HY8 for single span bridges

- Result of JTRP research project
- Requirements
  - Existing and proposed structures ≥ 20 ft and up to 30ft (span perpendicular to the flow)
  - And proposed structures can be modeled with pre-defined shapes in HY8
  - Contact the Office of Hydraulics before modeling slab-top structures in the above range
    - Vertical abutments (not spillthrough)
    - Rectangular shape (relatively flat bottom)

Question 1

Which item does not require an INDOT review for an LPA project?

A. The structure is one mile or less downstream of an INDOT structure (measured along the stream).
B. The proposed backwater does not dissipate before reaching an upstream INDOT structure.
C. The structure is 1/2 mile or less upstream of an INDOT structure (measured along the stream).
D. There is a dam within the proposed project limits.

Question 2

Which item does not requires a Construction in a Floodway permit?

A. Drainage area less than one square mile.
B. Drainage area $\geq$ 50 square miles.
C. Drainage area between 1 square mile and 50 square miles with buildings below the 100 year flood elevation.
D. Drainage area between 1 square mile and 50 square miles and site located in an incorporated boundary.

Question 3

Which bridge sized structure can't be modeled in HY8?

A. Reinforced concrete box
B. Spillthrough bridge
C. Three sided flat top concrete structure
D. Three sided arch top concrete structure

Questions???

Merril Dougherty

mdougherty@indot.in.gov

317-232-6776

Hydraulics Website: http://in.gov/indot/3595.htm

Scour Modeling

Scour Required

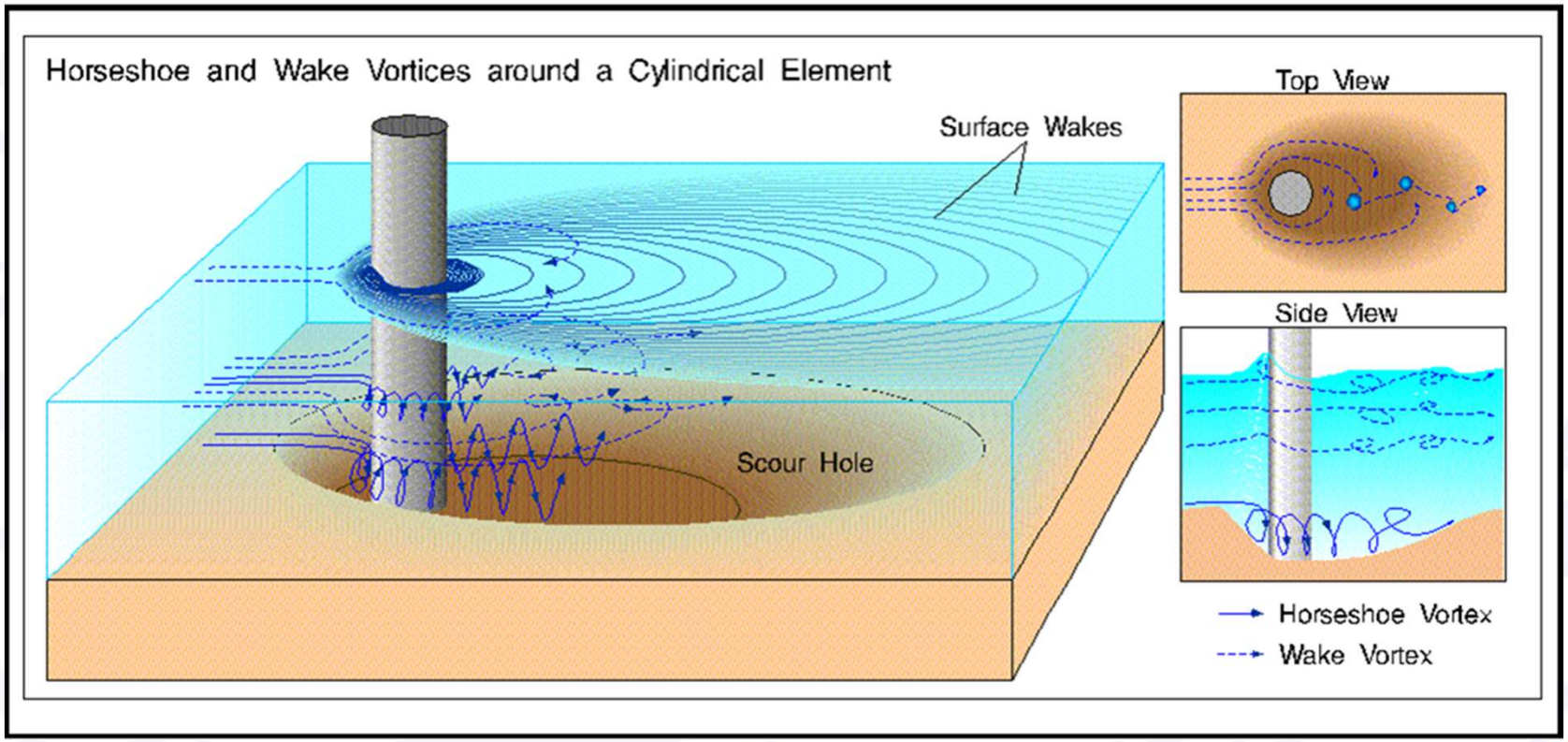
- Needed in design of New Bridges
- Needed in design of Rehabilitation projects
  - Compute local pier scour
  - Compute contraction scour
  - But not abutment scour –
    countermeasure properly sized riprap

Scour Exemptions

- Bridges constructed from 1998 to present
- Bridge maintenance projects: painting, etc
- Thin deck overlays (polymeric only)
- Entire foundation embedded in competent rock (non-scouring)
  - Model may be required for velocity for sizing riprap on abutments
  - However, bridge would be stated as “not scour critical”
- Previous scour analysis already performed
  - Check BIAS
  - Contact INDOT Hydraulics

Scour

- Flow patterns in scour



Scour

Scour hole

Scour

Damaged pier

Scour Process

- Method
  - Consultant does scour analysis and creates a scour report
  - Consultant fills out scour memo and signs and stamps it
  - INDOT reviews scour memo and signs it
  - Scour Memo sent to INDOT bridge section for evaluation (if necessary in Part B)

Scour Memo

- INDOT scour memo template
  - Available on INDOT Hydraulics Webpage www.in.gov/indot/3595.htm in "Submitting Documents" Scour Memo Instructions also found on the INDOT Hydraulics Webpage
  - Scour Memo involves three parts (A, B, and C)
    - Part A - Hydraulics Scour Data (provided by Consultant Hydraulics Engineer)
    - Part B – Bridge Scour Critical Determination (provided by INDOT Bridge Design)
    - Part C – Bridge Scour Critical Determination (provided by Bridge Engineer of Record)

Scour Memo Part A

INDIANA DEPARTMENT OF TRANSPORTATION

100 North Senate Avenue
Room N642-BR
Indianapolis, Indiana 46204

PHONE: (317) 233-2096
FAX: (317) 233-4929

Eric Holcomb, Governor
Joe McGuinness,
Commissioner

< Date >

TO: XXXX XXXXX
INDOT Project Manager, XXXXX District

FROM: XXXX XXXXX
Consultant Hydraulics Engineer

SUBJECT: SCOUR LETTER
Structure: XXXX
Location: XXXXX
Des. #: XXXXX
Crossing: XXXXXX
Consultant: Consultant Firm Name
SPMS Type of Work: XXXXX

PART A - HYDRAULICS SCOUR DATA - PROVIDED BY CONSULTANT HYDRAULICS ENGINEER

ANALYSIS: XXXX XXXXX, PE
Consultant Hydraulics Engineer

REVIEWER: XXXX XXXXX, P.E.
INDOT Hydraulics Engineer

Consultant PE Stamp

Drainage Area = X.X sq.mi.
Q100 = XXX cfs
Q100 Elevation = XXX.X ft

Approved Scour Data	**Three Span**
Q100 Contraction Scour =	XX ft.
Q100 Total Scour =	XX ft.
Flowline Elevation =	XXX.X ft. (from HEC-RAS model)
Q100 Low Scour Elevation =	XXX.X ft
Q100 Max Velocity =	XX.X ft/s.
Q100 Avg Velocity =	XX.X ft/s.

	Location			
	EB 1	Pier 2	Pier 3	EB 4
Bottom of Footing El.	880.93	880.99	880.99	880.93
Low Pile Elevation	858.07	853.07	853.07	858.07
Q_{100} Low Scour Elevation	862.00	862.00	862.00	862.00
Exposed Pile Length (ft.)	18.93	18.99	18.99	18.93
Length of Pile Still Buried (ft.)	3.93	8.93	8.93	3.93
D_{50} of Soil used in Scour Analysis (mm)	0.01	0.01	0.01	0.01
# of Rows of Piles	1	1	1	1

Pile Material Type: XXXX

Provided Narrative as needed...

Part A of this scour letter is provided by the Hydraulics Section and identifies the low scour elevation from the hydraulic analysis and makes recommendations for scour mitigation measures. The information from Part A may be used by the Bridge Section and the Engineer of Record to make the Bridge Scour Critical Determination in Parts B and C of this letter, unless the final determination is made by the Hydraulics Engineer and noted as such in Part A. The stamp and signature provided by the INDOT Hydraulics Section is for the information provided in Part A.

If the bridge is determined to be scour critical the following measures are recommended:

Identify Scour Mitigation Measures…

Part A Scour Status

☐ Final Determination – Parts B and C not applicable

☐ Not Scour Critical

☐ Scour Critical

☐ Scour Status Pending Part B

CIF Permit required: (Y-if scour critical/N)

Justification/Comments:

If you have any questions or comments, please contact me at (XXX) XXX- XXXX.
XXX

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Scour Memo Part A

- Scour Data
  - Data comes from HEC-RAS model
  - Definitions found in INDOT Design Manual 203-3.05

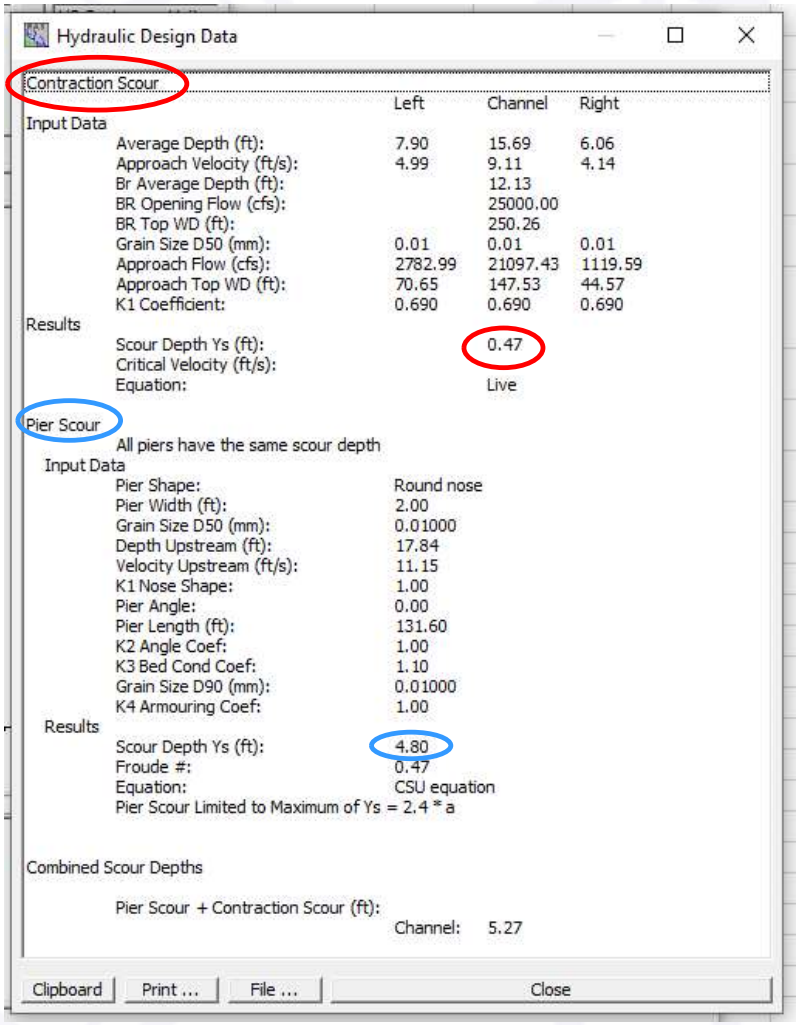
Drainage Area =	X.X	sq.mi.
Q100 =	XXX	cfs
Q100 Elevation =	XXX.X	ft

Approved Scour Data	**Three Span**	
Q100 Contraction Scour =	XX	ft.
Q100 Total Scour =	XX	ft.
Flowline Elevation =	XXX.X	ft. (from HEC-RAS model)
Q100 Low Scour Elevation =	XXX.X	ft
Q100 Max Velocity =	XX.X	ft/s.
Q100 Avg Velocity =	XX.X	ft/s.

Scour Memo Part A

- Scour Data from HEC-RAS model
  - Total Scour = Contraction + Pier
    - Contraction: use maximum of three segments

Drainage Area =	X.X	sq.mi.
Q100 =	XXX	cfs
Q100 Elevation =	XXX.X	ft
Approved Scour Data	**Three Span**	
Q100 Contraction Scour =	XX	ft.
Q100 Total Scour =	XX	ft.
Flowline Elevation =	XXX.X	ft. (from HEC-RAS model)
Q100 Low Scour Elevation =	XXX.X	ft
Q100 Max Velocity =	XX.X	ft/s.
Q100 Avg Velocity =	XX.X	ft/s.

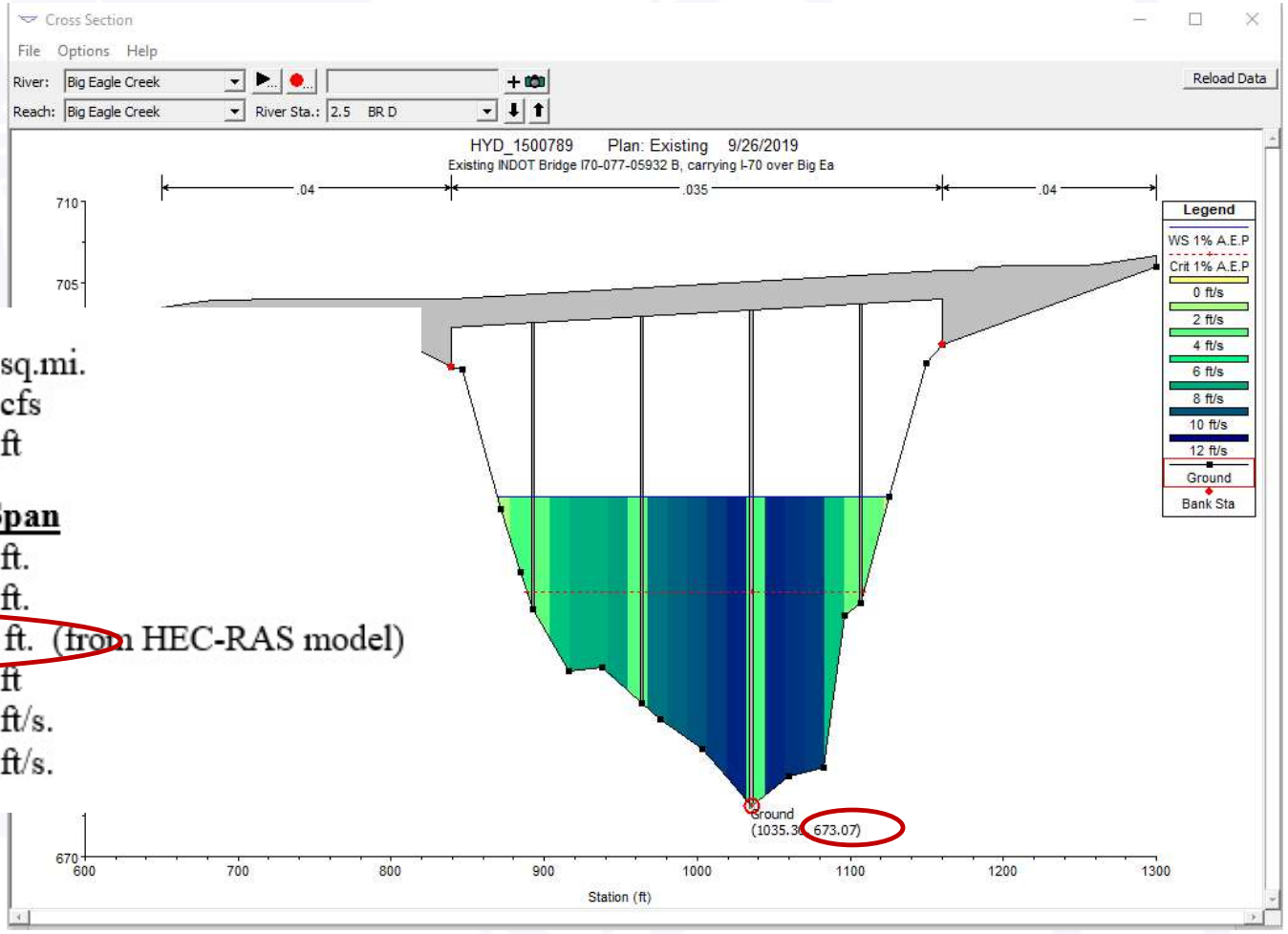


Scour Memo Part A

- Scour Data from HEC-RAS
  - Flowline: lowest invert elevation in model cross sections

Drainage Area =	X.X	sq.mi.
Q100 =	XXX	cfs
Q100 Elevation =	XXX.X	ft

Approved Scour Data	**Three Span**	
Q100 Contraction Scour =	XX	ft.
Q100 Total Scour =	XX	ft.
Flowline Elevation =	XXX.X	ft. (from HEC-RAS model)
Q100 Low Scour Elevation =	XXX.X	ft
Q100 Max Velocity =	XX.X	ft/s.
Q100 Avg Velocity =	XX.X	ft/s.



Scour Memo Part A

- Scour Data from HEC-RAS model
  - Low Scour Elevation = Flowline Elevation – Total Scour

Drainage Area =	X.X	sq.mi.
Q100 =	XXX	cfs
Q100 Elevation =	XXX.X	ft

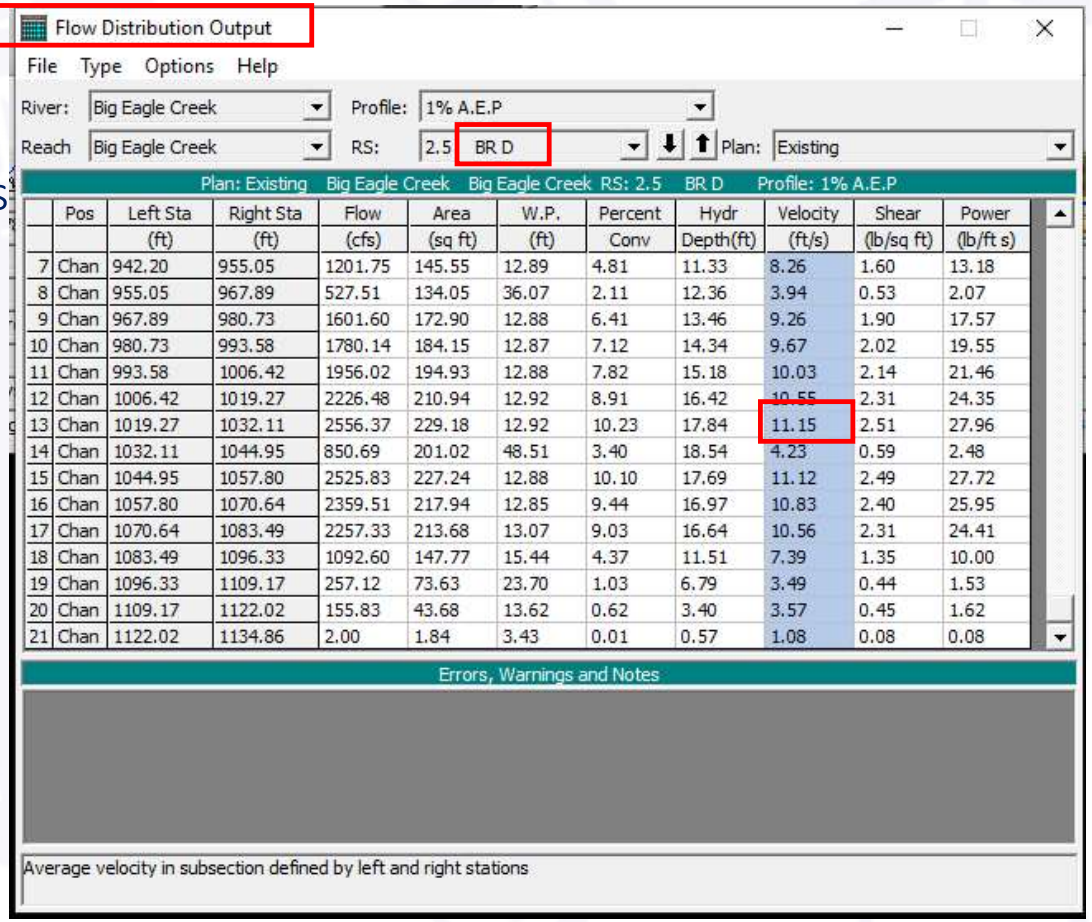
Approved Scour Data	**Three Span**	
Q100 Contraction Scour =	XX	ft.
Q100 Total Scour =	XX	ft.
Flowline Elevation =	XXX.X	ft. (from HEC-RAS model)
Q100 Low Scour Elevation =	XXX.X	ft
Q100 Max Velocity =	XX.X	ft/s.
Q100 Avg Velocity =	XX.X	ft/s.

Scour Memo Part A

- Scour Data from HEC-RAS model
  - Steady flow-> Options -> Flow Distribution
  - 10, 25, 10, velocity distribution in Cross section (with at least 20 subsections across channel).
  - Report highest value of both upstream and downstream bridge sections.
  - *Only used for piers*.

Drainage Area =	X.X	sq.mi.
Q100 =	XXX	cfs
Q100 Elevation =	XXX.X	ft

Approved Scour Data	**Three Span**	
Q100 Contraction Scour =	XX	ft.
Q100 Total Scour =	XX	ft.
Flowline Elevation =	XXX.X	ft. (from HEC-RAS model)
Q100 Low Scour Elevation =	XXX.X	ft
Q100 Max Velocity =	XX.X	ft/s.
Q100 Avg Velocity =	XX.X	ft/s.



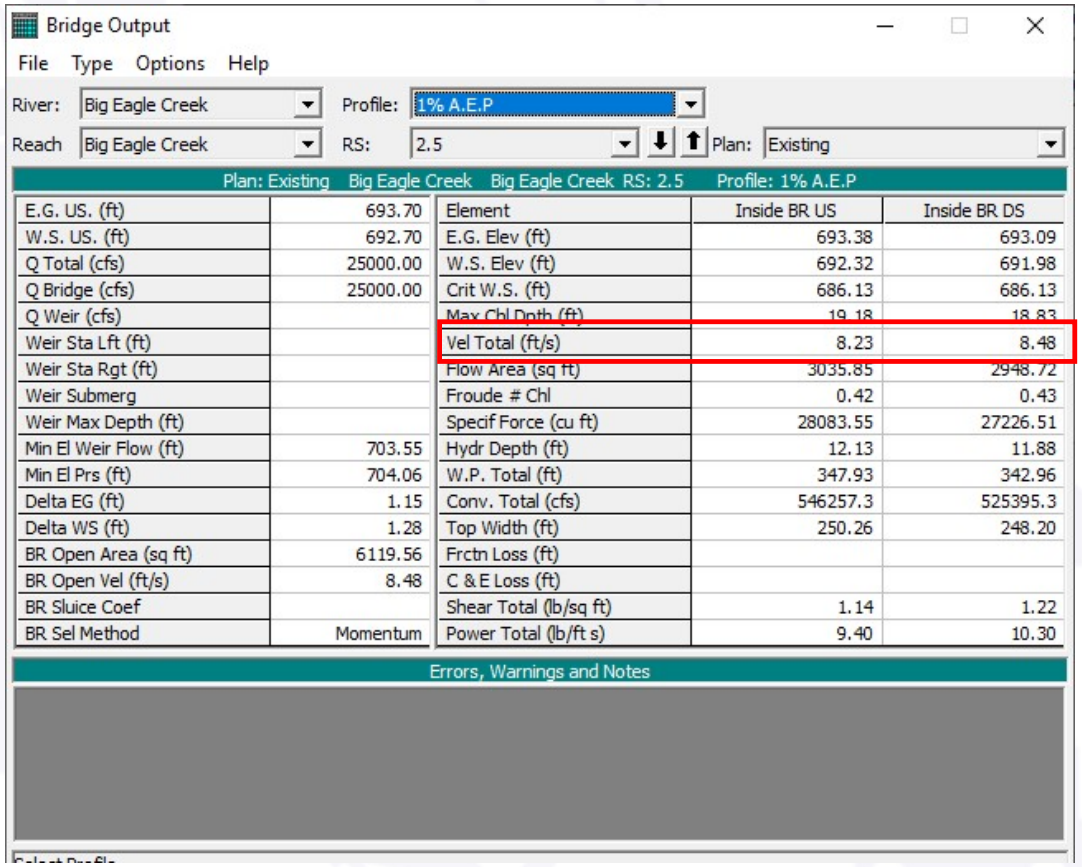
	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)	Shear (lb/sq ft)	Power (lb/ft s)
7	Chan	942.20	955.05	1201.75	145.55	12.89	4.81	11.33	8.26	1.60	13.18
8	Chan	955.05	967.89	527.51	134.05	36.07	2.11	12.36	3.94	0.53	2.07
9	Chan	967.89	980.73	1601.60	172.90	12.88	6.41	13.46	9.26	1.90	17.57
10	Chan	980.73	993.58	1780.14	184.15	12.87	7.12	14.34	9.67	2.02	19.55
11	Chan	993.58	1006.42	1956.02	194.93	12.88	7.82	15.18	10.03	2.14	21.46
12	Chan	1006.42	1019.27	2226.48	210.94	12.92	8.91	16.42	10.55	2.31	24.35
13	Chan	1019.27	1032.11	2556.37	229.18	12.92	10.23	17.84	11.15	2.51	27.96
14	Chan	1032.11	1044.95	850.69	201.02	48.51	3.40	18.54	4.23	0.59	2.48
15	Chan	1044.95	1057.80	2525.83	227.24	12.88	10.10	17.69	11.12	2.49	27.72
16	Chan	1057.80	1070.64	2359.51	217.94	12.85	9.44	16.97	10.83	2.40	25.95
17	Chan	1070.64	1083.49	2257.33	213.68	13.07	9.03	16.64	10.56	2.31	24.41
18	Chan	1083.49	1096.33	1092.60	147.77	15.44	4.37	11.51	7.39	1.35	10.00
19	Chan	1096.33	1109.17	257.12	73.63	23.70	1.03	6.79	3.49	0.44	1.53
20	Chan	1109.17	1122.02	155.83	43.68	13.62	0.62	3.40	3.57	0.45	1.62
21	Chan	1122.02	1134.86	2.00	1.84	3.43	0.01	0.57	1.08	0.08	0.08

Scour Memo Part A

- Scour Data from HEC-RAS model
  - Q 100 Ave Velocity: outlet velocity at the downstream face of the bridge as it exits the structure.
  - Can be found in RAS bridge output velocity for downstream side of bridge.

Drainage Area =	X.X	sq.mi.
Q100 =	XXX	cfs
Q100 Elevation =	XXX.X	ft

Approved Scour Data	**Three Span**	
Q100 Contraction Scour =	XX	ft.
Q100 Total Scour =	XX	ft.
Flowline Elevation =	XXX.X	ft. (from HEC-RAS model)
Q100 Low Scour Elevation =	XXX.X	ft
Q100 Max Velocity =	XX.X	ft/s.
Q100 Avg Velocity =	XX.X	ft/s.



Scour Memo Part A

INDIANA DEPARTMENT OF TRANSPORTATION

100 North Senate Avenue
Room N642-BR
Indianapolis, Indiana 46204

PHONE: (317) 233-2096
FAX: (317) 233-4929

Eric Holcomb, Governor
Joe McGuinness,
Commissioner

< Date >

TO: XXXX XXXXX
INDOT Project Manager, XXXXX District

FROM: XXXX XXXXX
Consultant Hydraulics Engineer

SUBJECT: SCOUR LETTER
Structure: XXXX
Location: XXXXX
Des. #: XXXXX
Crossing: XXXXXX
Consultant: Consultant Firm Name
SPMS Type of Work: XXXXX

PART A - HYDRAULICS SCOUR DATA - PROVIDED BY CONSULTANT HYDRAULICS ENGINEER

ANALYSIS: XXXX XXXXX, PE
Consultant Hydraulics Engineer

REVIEWER: XXXX XXXXX, P.E.
INDOT Hydraulics Engineer

Consultant PE Stamp

Drainage Area = X.X sq.mi.
Q100 = XXX cfs
Q100 Elevation = XXX.X ft

Approved Scour Data	**Three Span**
Q100 Contraction Scour =	XX ft.
Q100 Total Scour =	XX ft.
Flowline Elevation =	XXX.X ft. (from HEC-RAS model)
Q100 Low Scour Elevation =	XXX.X ft
Q100 Max Velocity =	XX.X ft/s.
Q100 Avg Velocity =	XX.X ft/s.

	Location			
	EB 1	Pier 2	Pier 3	EB 4
Bottom of Footing El.	880.93	880.99	880.99	880.93
Low Pile Elevation	858.07	853.07	853.07	858.07
Q_{100} Low Scour Elevation	862.00	862.00	862.00	862.00
Exposed Pile Length (ft.)	18.93	18.99	18.99	18.93
Length of Pile Still Buried (ft.)	3.93	8.93	8.93	3.93
D_{50} of Soil used in Scour Analysis (mm)	0.01	0.01	0.01	0.01
# of Rows of Piles	1	1	1	1

Pile Material Type: XXXX

Provided Narrative as needed...

Part A of this scour letter is provided by the Hydraulics Section and identifies the low scour elevation from the hydraulic analysis and makes recommendations for scour mitigation measures. The information from Part A may be used by the Bridge Section and the Engineer of Record to make the Bridge Scour Critical Determination in Parts B and C of this letter, unless the final determination is made by the Hydraulics Engineer and noted as such in Part A. The stamp and signature provided by the INDOT Hydraulics Section is for the information provided in Part A.

If the bridge is determined to be scour critical the following measures are recommended:

Identify Scour Mitigation Measures…

Part A Scour Status

☐ Final Determination – Parts B and C not applicable

☐ Not Scour Critical

☐ Scour Critical

☐ Scour Status Pending Part B

CIF Permit required: (Y-if scour critical/N)

Justification/Comments:

If you have any questions or comments, please contact me at (XXX) XXX- XXXX.
XXX

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Scour Memo Part A

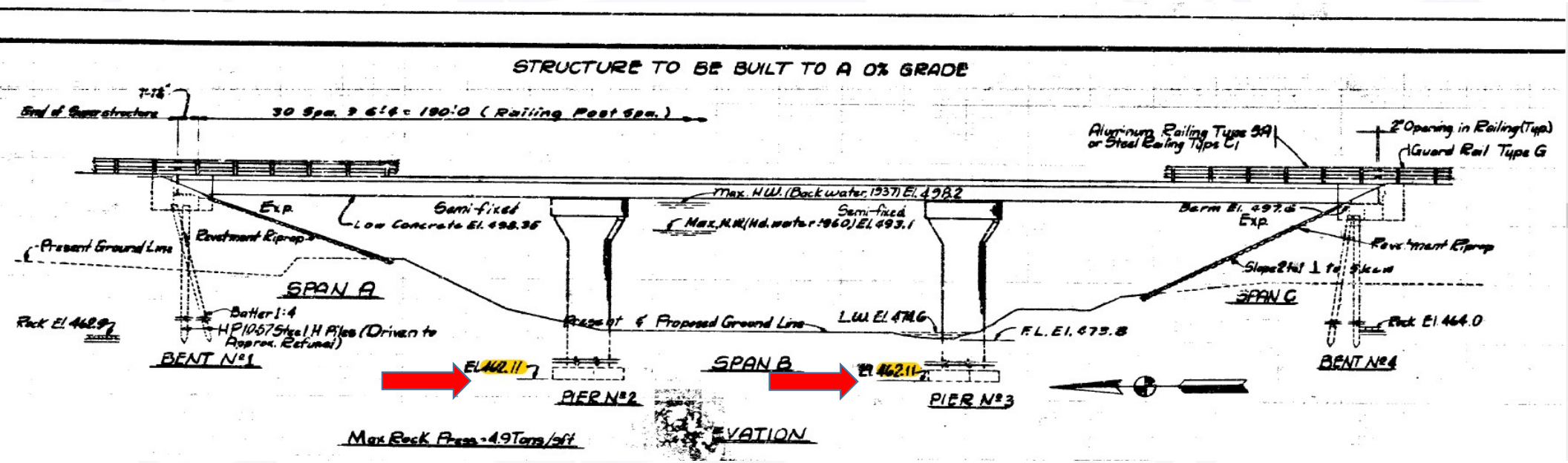
- Bridge Foundation Data
  - State the source of the data (pile driving records, existing plans, quantities, etc)
  - Include the pile driving records and/or existing bridge plans with submittal as separate file
  - State pile material if information is available
  - Include any other explanations of data or reasons for incompletion
  - Be consistent with datum (assumed NAVD88 unless stated otherwise)
  - Data is needed by INDOT for scour evaluation purposes

	Location					
	EB 1	Pier 2[1]	Pier 3	Pier 4	Pier 5[1]	EB 6
Bottom of Footing El.	697.35	664.39	667.72	669.29	664.26	695.64
Low Pile Elevation	692.93	N/A	661.47	660.46	N/A	688.30
Q_{100} Low Scour Elevation	667.80	667.80	667.80	667.80	667.80	667.80
Exposed Pile Length (ft.)[2]	N/A[3]	N/A	0.00	1.49	N/A	N/A[3]
Length of Pile Still Buried (ft.)	4.42[4]	N/A	6.25	7.34	N/A	7.34[4]
D_{50} of Soil used in Scour Analysis (mm)	0.01	0.01	0.01	0.01	0.01	0.01
# of Rows of Piles	1	0	2	2	0	1

Pile Material Type: Bent 1 & 6: 14" SEC Piles Pier 3 & 4: 12" BP53 H Piles

Scour Memo Part A

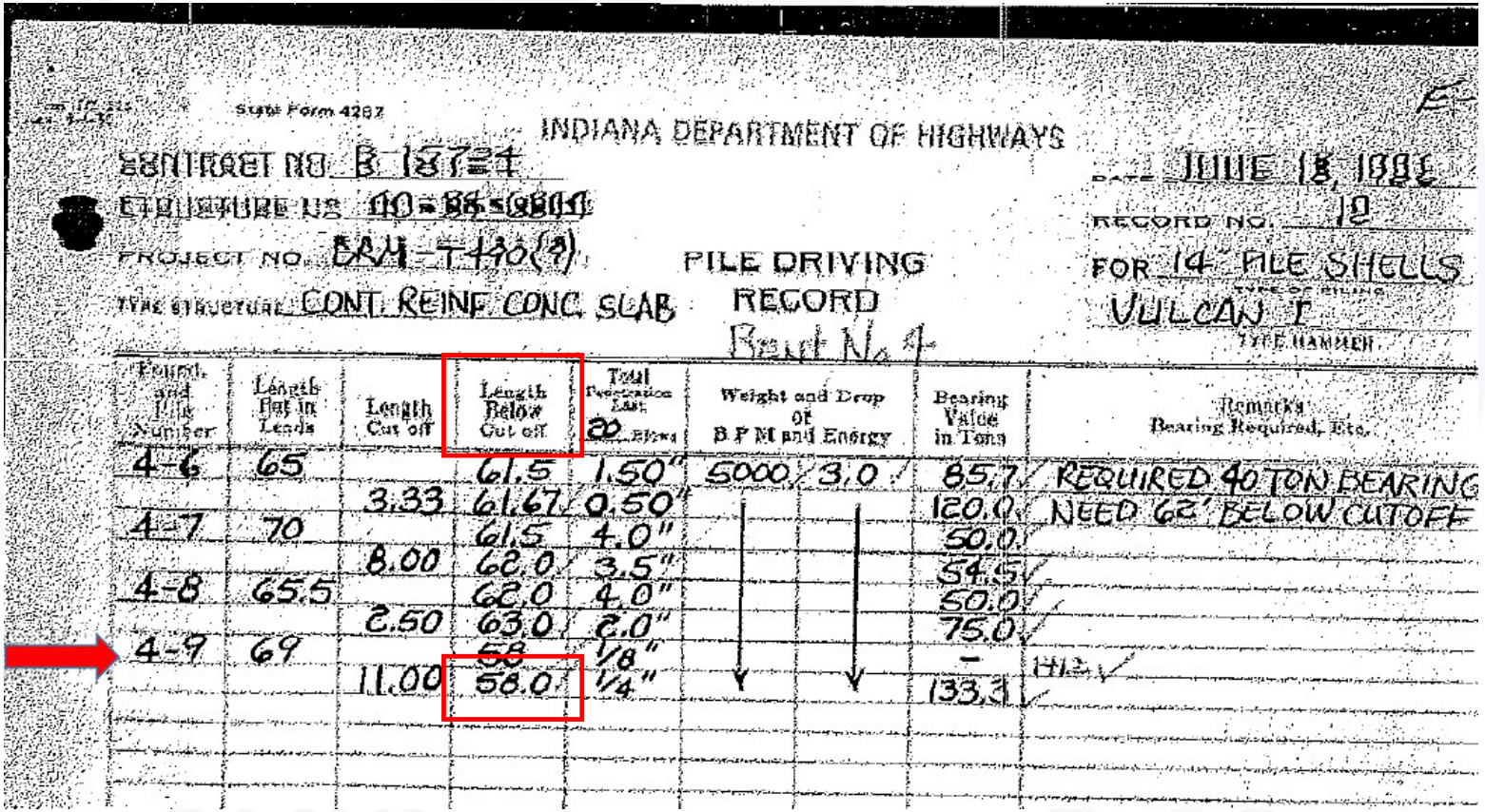
- Bottom of Footing Elevation
  - Should be located on the existing bridge plans



NextLevel INDIANA

Scour Memo Part A

- Low Pile Elevation: Source #1- Pile Driving Records
  - The pile tip elevation of the shortest (shallowest) pile for each pier or bent



State Form 4282

INDIANA DEPARTMENT OF HIGHWAYS

CONTRACT NO. B-18724

STRUCTURE NO. 10-86-5(8811)

PROJECT NO. BRM-T-490(2)

THE STRUCTURE CONT. REINF. CONC. SLAB

PILE DRIVING RECORD

Bent No. 4

JUNE 18, 1962

RECORD NO. 12

FOR 14" PILE SHELLS

TYPE OF DRIVING: VULCAN I

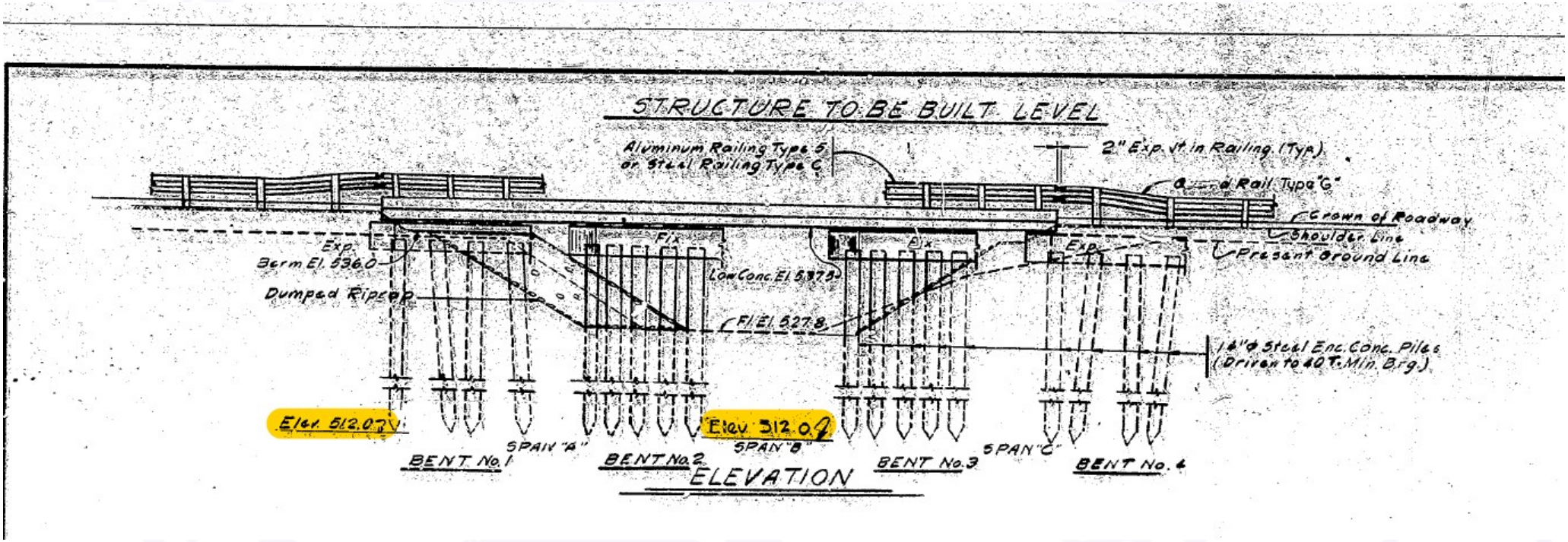
TYPE HAMMER

Pound and Pile Number	Length Flat in Leads	Length Cut off	Length Below Cut off	Total Penetration Last 20 Blows	Weight and Drop of B.P.M and Energy	Bearing Value in Tons	Remarks Bearing Required, Etc.
4-6	65		61.5	1.50"	5000 / 3.0	85.7	REQUIRED 40 TON BEARING
		3.33	61.67	0.50"		120.0	NEED 62' BELOW CUTOFF
4-7	70		61.5	4.0"		50.0	
		8.00	62.0	3.5"		54.5	
4-8	65.5		62.0	4.0"		50.0	
		2.50	63.0	2.0"		75.0	
4-9	69		58	1/8"		-	H12
		11.00	58.0	1/4"		133.3	

NextLevel INDIANA

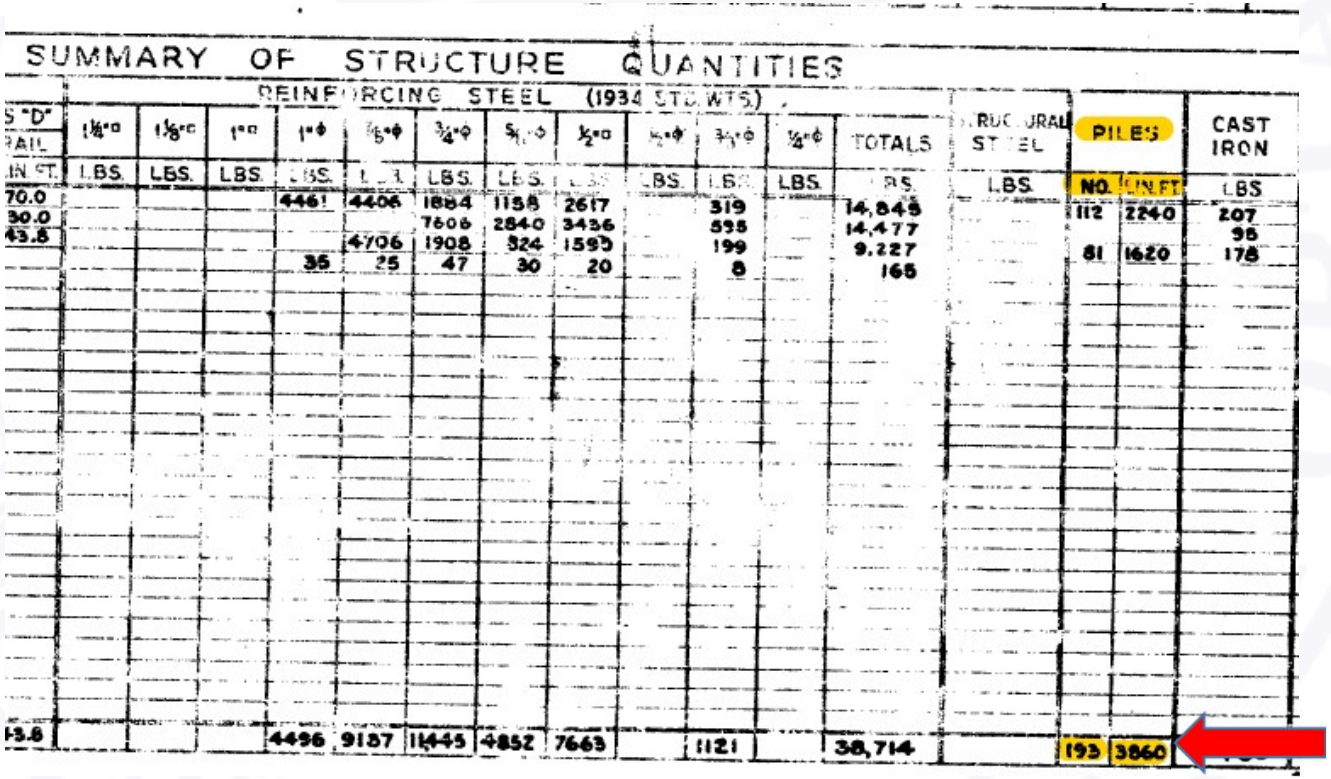
Scour Memo Part A

- Low Pile Elevation: Source #2- Existing plans
  - The pile tip elevation of the shortest pile for each pier or bent



Scour Memo Part A

- Low Pile Elevation: Source #3- Quantities table estimates
  - The pile tip elevation of the shortest pile for each pier or bent
    - Example: **3860/193 = 20 ft** average pile length from the Quantities table



SUMMARY OF STRUCTURE QUANTITIES

REINFORCING STEEL (1934 STD. WTS.)															
"D" RAIL IN FT.	1¼"□ LBS.	1⅛"□ LBS.	1"□ LBS.	1"φ LBS.	⅞"φ L.B.	¾"φ LBS.	⅝"φ LBS.	½"□ L.B.S.	½"φ LBS.	⅜"φ LB.	½"φ LBS.	TOTALS LBS.	STRUCTURAL STEEL LBS.	PILES NO.	PILES LIN.FT.	CAST IRON LBS
70.0				4461	4406	1884	1158	2617		319		14,845		112	2240	207
30.0						7606	2840	3436		535		14,477				96
43.8					4706	1908	324	1593		199		9,227				
				35	25	47	30	20		8		165		81	1620	178
13.8				4496	9187	11445	4852	7663		1121		38,714		193	3860	

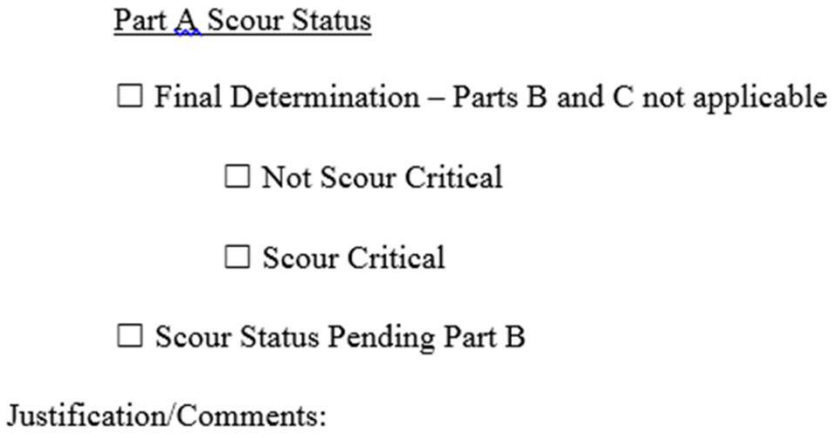
Scour Memo Part A

- Bridge Foundation Data Summary
  - Example table and data sources reference

	Location (as identified on bridge plans)				
	Bent 1	Pier 2	Pier 3	Pier 4	Source
Bottom of Footing El. (ft., NAVD)	697.35	664.39	667.72	669.29	existing bridge plans
Low Pile Elevation	692.93		661.47	660.46	Pile Driving records, plans, quantity estimates
Q_{100} Low Scour Elevation (ft., NAVD)	667.80	667.80	667.80	667.80	HEC-RAS model results
Exposed Pile Length (feet)	n/a	n/a	0.0	1.49	[Bottom of Footing Elev - Q100 Low Scour Elevation]
Length of Pile Still Buried	n/a	n/a	6.33	7.34	[Q100 Low Scour Elevation - Low Pile Elevation]
D_{50} of Soil used in Scour Analysis (mm)	0.01	0.01	0.01		if not known use 0.01 mm to be conservative
# of Rows of Piles*	1	0	2	2	existing bridge plans

Scour Determination

- Part A ends with Scour Status determination
  - Final Determination:
    - Not Scour Critical
    - Scour Critical
  - Pending Part B
    - Forward to INDOT Bridge (structural) to determine the scour critical status
    - Foundation configuration (piles, no piles, etc.) along with low scour elevation is used to determine scour recommendation by hydraulics



Part A Scour Status

☐ Final Determination – Parts B and C not applicable

☐ Not Scour Critical

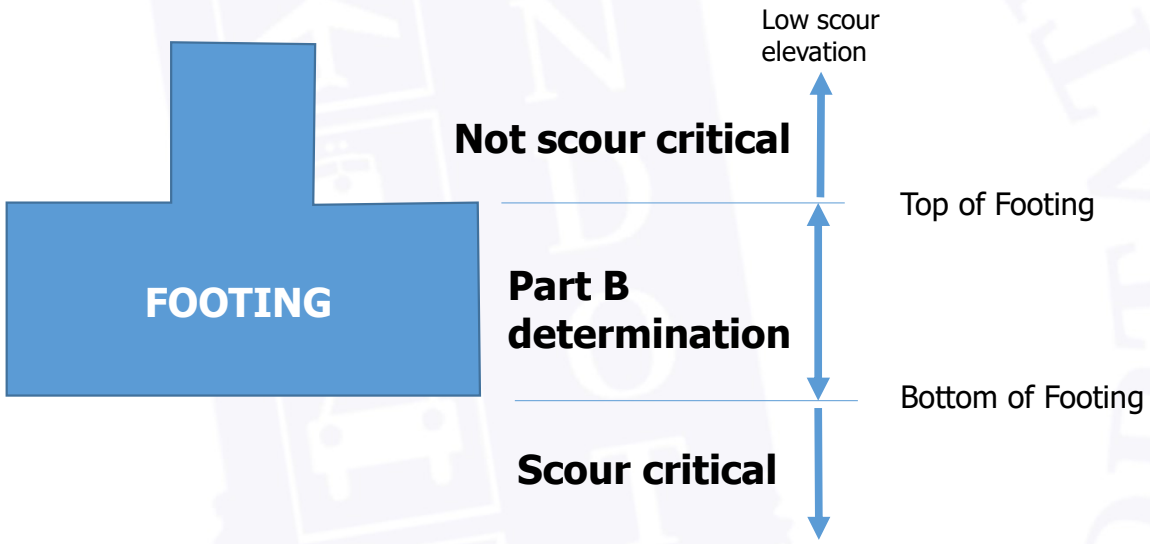
☐ Scour Critical

☐ Scour Status Pending Part B

Justification/Comments:

Scour Determination

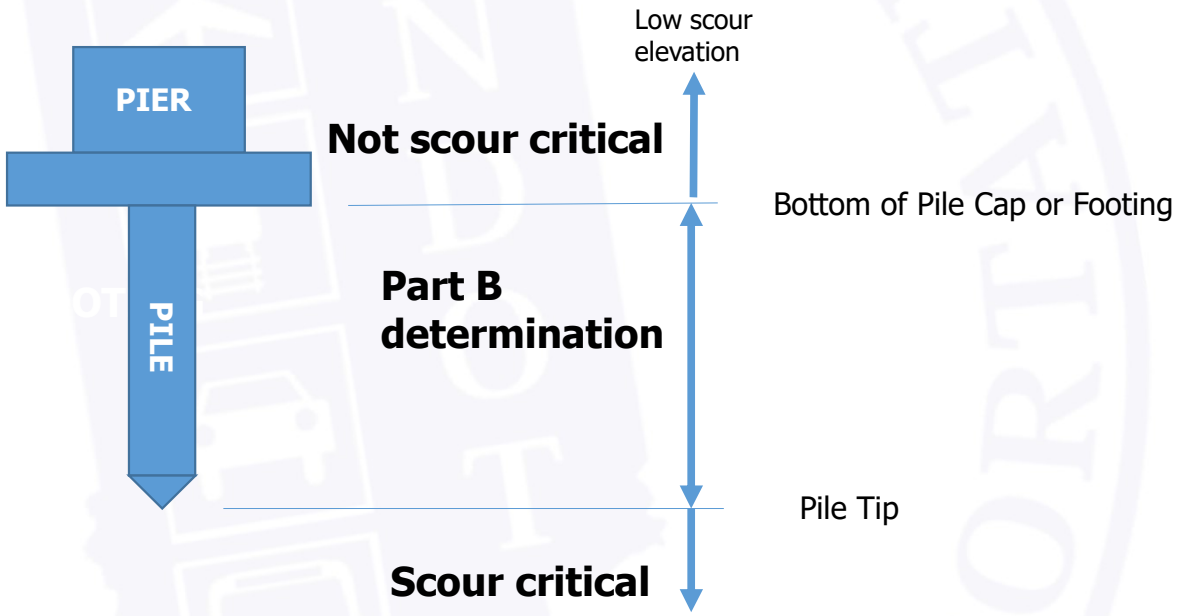
- Bridge with piers on footings, with no piles



- Not scour critical – top of footing is not exposed at low scour elevation
- Scour critical – low scour elevation is below bottom of footing
- Scour Status pending Part B – low scour elevation is along the footing

Scour Determination

- Bridge with piers on piles



- Not scour critical – piles are not exposed at low scour elevation
- Scour critical – low scour elevation is below bottom of footing
- Scour Status pending Part B – piles are exposed at low scour elevation
  - "10 feet of pile is still embedded" rule is SUPERSEDED

Scour Determination

- Part A ends with Scour Status determination
  - Final Determination:
    - Not Scour Critical
    - Scour Critical
  - Pending Part B
- Justification/Comments
  - State the reason why a particular Part A Scour Status was selected
    - Example: Scour critical due the low scour elevation being lower than the pile tips
  - Give any additional information that might be useful for INDOT Bridge to make a determination
    - Example: Riprap already in place
  - Provide as a separate files: the existing bridge plans and pile driving records if available
    - The existing bridge plans
    - Pile driving records if available
    - Inspection Reports if applicable

Scour Determination

- Narrative
  - Provide a Narrative as needed
  - Leave first paragraph as it is
  - Document unknown information or estimated information
  - Provide scour countermeasures even if it is unknown whether the bridge will be scour critical

Provided Narrative as needed...

Part A of this scour letter is provided by the Hydraulics Section and identifies the low scour elevation from the hydraulic analysis and makes recommendations for scour mitigation measures. The information from Part A may be used by the Bridge Section and the Engineer of Record to make the Bridge Scour Critical Determination in Parts B and C of this letter, unless the final determination is made by the Hydraulics Engineer and noted as such in Part A. The stamp and signature provided by the INDOT Hydraulics Section is for the information provided in Part A.

If the bridge is determined to be scour critical the following measures are recommended:

Identify Scour Mitigation Measures…

Scour Countermeasures

- Based on IDM Figures 203-2D, & 203-3B

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

Note: If clear-zone or other issues prohibit the use of the required erosion-protection method, the Office of Hydraulics should be contacted for additional instructions.

STREAM VELOCITY FOR EROSION PROTECTION

Figure 203-2D

Type	Minimum Thickness	
	Abutment	Pier
Revetment	1.5 ft	2.0 ft
Class 1	2.0 ft	3.0 ft
Class 2	2.5 ft	4.0 ft

Riprap-Lay Thickness

Note: The thickness is measured such that the top is at the ground elevation.

Substructure Type	Lay Width
Sloping Abutment	The cone is covered top to toe, a square toe trench is placed below the riprap, based on lay thickness.
Vertical Abutment	2 times the water depth or a minimum of 10 ft
Pier	2 times the pier width or a minimum of 6 ft. The lay width is from the outside wall of the pier, all the way around.

Riprap-Lay Width

Note: For an oversized-box or three-sided structure, see the INDOT *Standard Drawings*.

RIPRAP SCOUR PROTECTION

Figure 203-3B

NextLevel INDIANA

Questions

1. A bridge with footers on piles is analyzed for scour. The low scour elevation is below the footer, exposing the pile 8ft. But the pile is still embedded over 10 ft. What is the scour determination?
    1. Scour critical
    2. Not scour critical
    3. Scour Critical, Part B
2. What are the three sources of pile tip elevations?
    1. Pile driving records, existing plans, quantity tables
    2. Existing plans, inspection reports, HEC-RAS tables
    3. Pile driving records, sediment cores, quantity reports
3. How is low scour elevation calculated?
    - Contraction Scour + Pier Scour
    - Abutment + Pier Scour – Low Flow Line
    - Flowline Elevation – Total Scour

NextLevel INDIANA

Questions???

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Hydraulics Website: http://in.gov/indot/3595.htm