



# Section 2

TxDOT Scour Evaluation & Scour Coding

Ryan Eaves

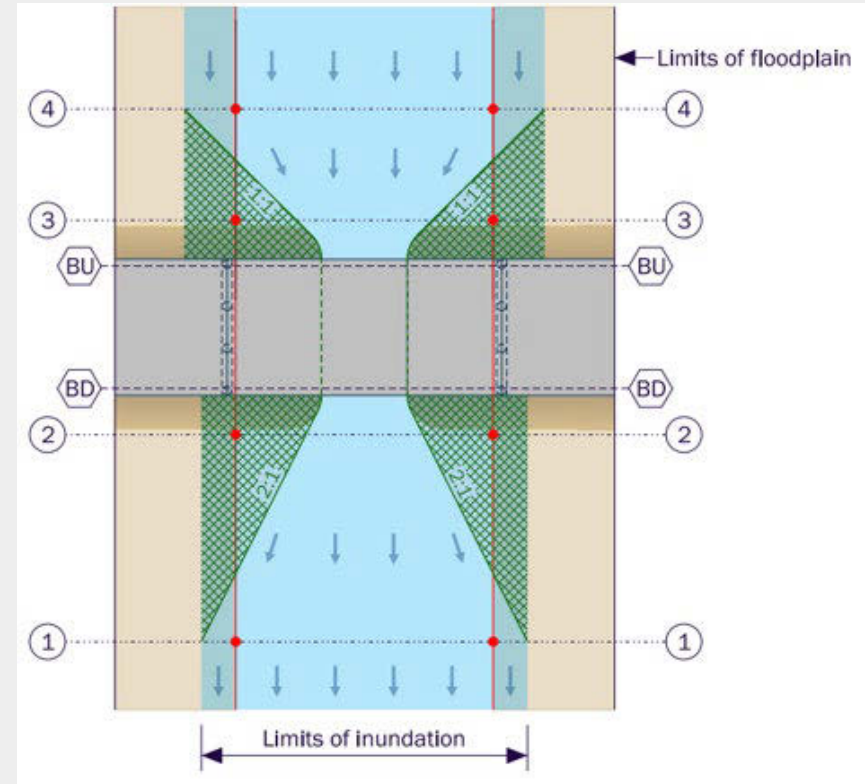


<b>1</b>	What is Scour?	3-5
<b>2</b>	TxDOT Scour Program Requirements	6-15
<b>3</b>	Item 113 - Scour Coding	16-33
<b>4</b>	Evaluation Examples	34-40
<b>5</b>	Scour Critical Structures	41-43
<b>6</b>	Countermeasure Design and Evaluation	44-48
<b>7</b>	SNBI	49-51

# Scour at Bridges



- Erosion of streambed or bank material due to flowing water
  - Contraction scour
    - Constricting the channel at a bridge opening
  - Pier Scour
    - Obstructions to flow in the channel



- Loss of axial and lateral capacity
- Substructure slenderness concerns



- Erosion around abutments
- Slope failures
- Undermining rigid structures



# Scour Program Goals



- Predict and evaluate the effect of scour on bridges
- Track scour progression over time



## Scour Evaluation Guide

Revised July 2023

<https://ftp.txdot.gov/pub/txdot-info/library/pubs/bus/bridge/scour-guide.pdf>



## Scour Analysis Guide

September 2023

<https://ftp.txdot.gov/pub/txdot-info/des/guides/scour-guide.pdf>



- Scour Evaluations are required for all bridges over waterways
  - Scour Summary Sheet (Form 2605)
  - Accompanying scour evaluation
- Bridge Class Culvert
  - Scour Summary Sheet (Form 2606)

Scour Summary Sheet for Span Bridges (Form 2605, Rev. 03/24, Page 1 of 2)

DISTRICT:  COUNTY:  NBIF:

FEATURE CARRIED:  FEATURE CROSSED:  CSJ:

**Recommended Scour Coding(s)**

NBI CODINGS		
Item	Description	Coding
Item 113	Scour Critical Bridges	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Item 113.1	Scour Plans of Action	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Item 113.2	Unknown Foundations	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

SNBI CODINGS		
Item	Description	Coding
B.C.11	Scour Condition (Observed Scour Only)	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
B.AP.03	Scour Vulnerability	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
B.AP.04	Scour Plan of Action	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
B.AP.03.1	Unknown Foundations	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

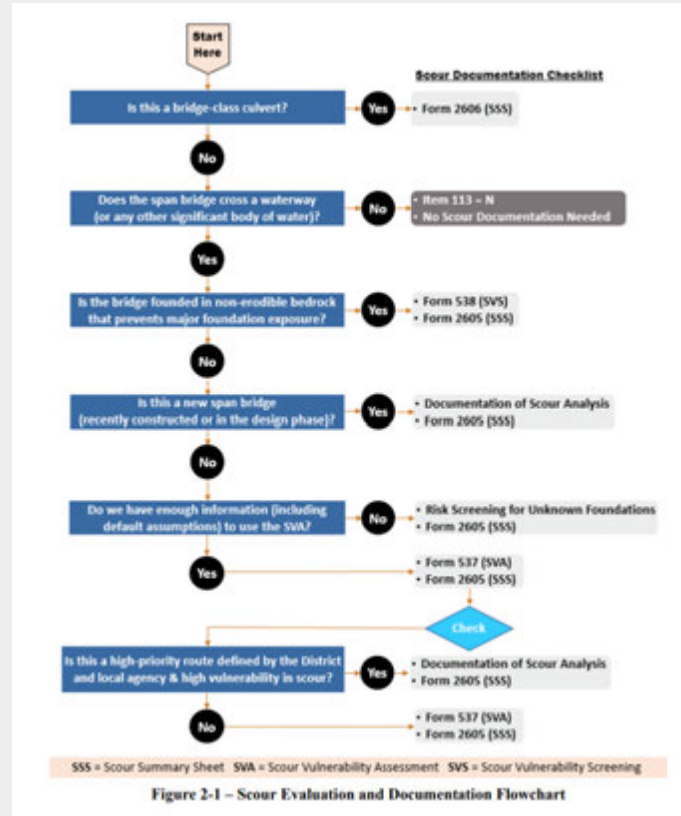
Engineer of Record for the Recommended Scour Coding(s):

Date of Recommendation:

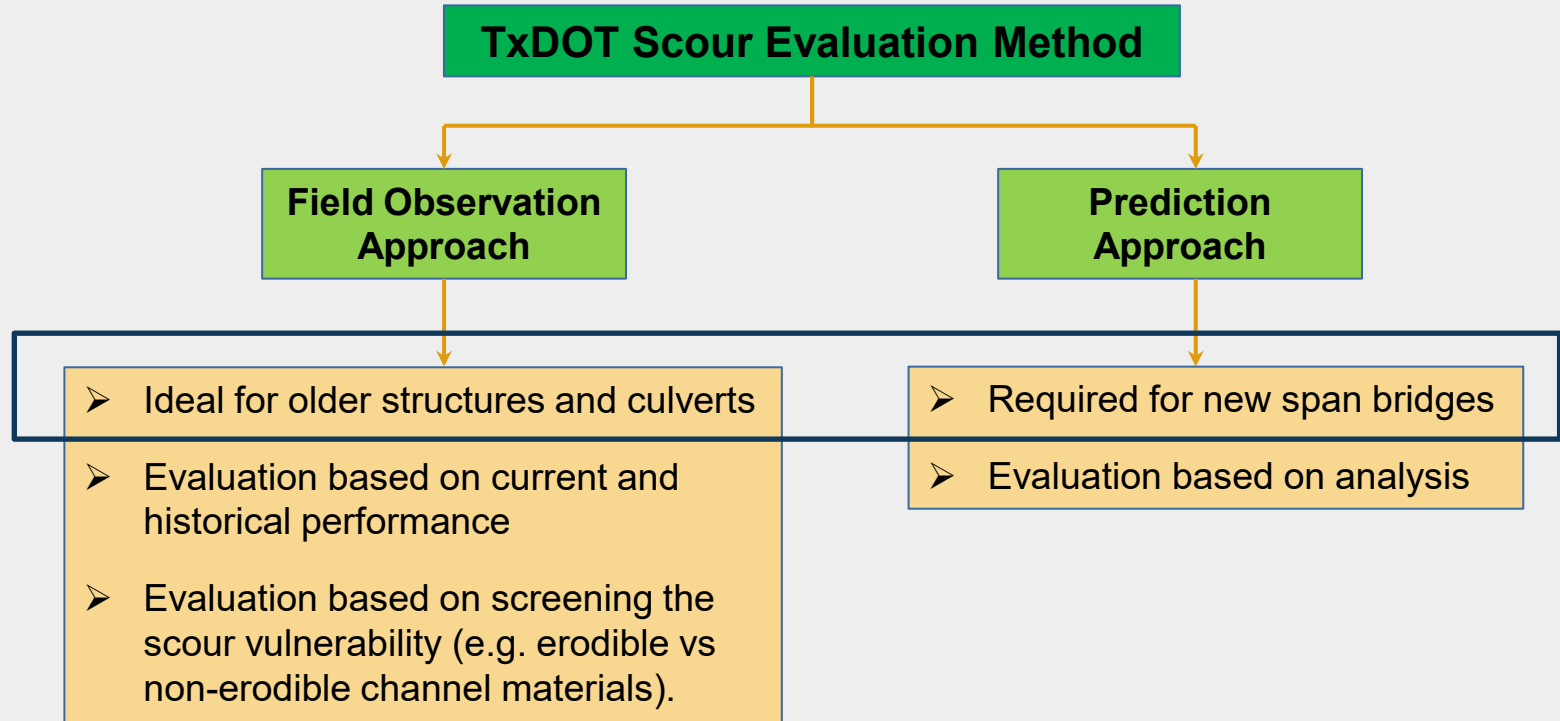
Seal, Signature, and Date



Figure 2-1 Scour Evaluation Guide







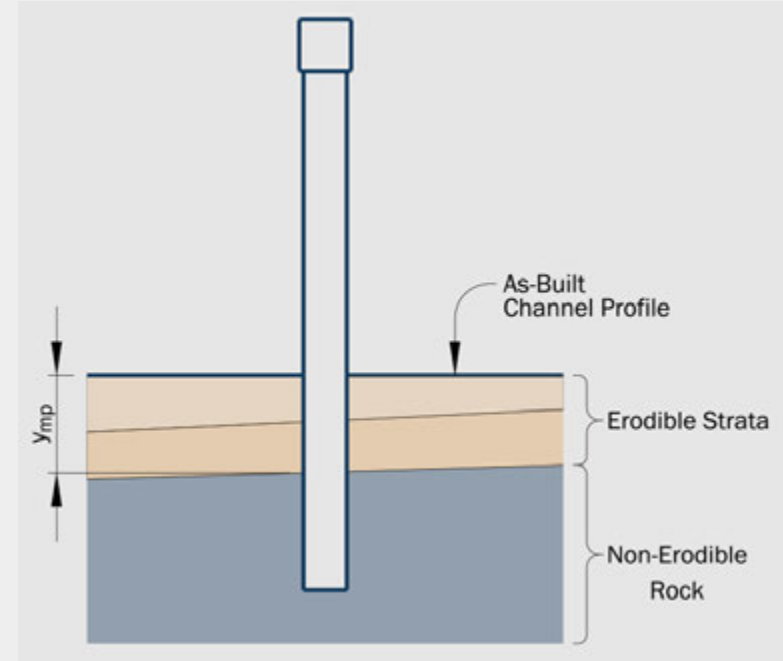


- Scour Evaluation Methods
  - Screening
    - Identify low-risk structures
  - Assessment
    - Detailed evaluation based on scour history
  - Analysis
    - Detailed analytical evaluation based on hydraulic analysis

- Evaluation based on Screening
- SVS Form 538
  - Bridges found in non erodible strata
  - Evaluate at maximum possible scour depth

**Table 4-1 – Channel Materials and Scour Vulnerability**

Material	Sub-Category	TCP Values or Equivalent Strength Data	Scour Vulnerability
Rock	Hard (granite, limestone, shale)	< 4 in./100 blows	Non-Erodible
	Soft (shale, sandstone)	< 12 in./100 blows	Mildly Erodible
Clay	Hard (redbed, shaley clays, very stiff clays)	< 12 in./100 blows	Mildly Erodible
	Soft to Medium	> 12 in./100 blows	Erodible
Sand	All	All	Very Erodible





## Scour Vulnerability Assessment (SVA - Form 537)

- Sum of Risk Factor to identify Scour Vulnerability Class

	Channel Material Score
+	Channel Condition Score
+	Scour History Score
+	Channel Migration History Score
<hr/>	
	Total Score

Total Score = Sum of Risk Factor Scores =

Scour Vulnerability Class (Check One):

Normal (Total Score < 3)  Enhanced (Total Score >= 3)



**Table 8-1 – SVA Scoring Criteria for Channel Material**

Channel Material	Score
Competent, Hard Rock	-3
Soft Rock or Hard Clay	-1
Fractured or Weathered Rock	1
Soft to Medium Clay	2
Sand	3

**Table 8-2 – SVA Scoring Criteria for Channel Condition**

NBI Item 61 Coding or SNBI Item B.C.09 Coding	Score
8 – 9	-1
6 – 7	1
5	3
≤ 4	5

**Table 8-3 – SVA Scoring Criteria for Scour History**

Foundation Exposure from $y_{sh}$	Score
Minimal	-2
Moderate	1
Major	4

**Table 8-4 – SVA Scoring Criteria for Channel Migration History**

Foundation Exposure from $y_{max}$	Score
No History of Channel Migration	0
Channel migration has occurred, but the shift has not impacted adjacent bents or abutments.	1
Channel migration has occurred, and the shift has impacted adjacent bents or abutments.	2



- Analytical Scour Evaluation with calculated scour depths
  - High risk structures
  - Structures highly vulnerable to scour

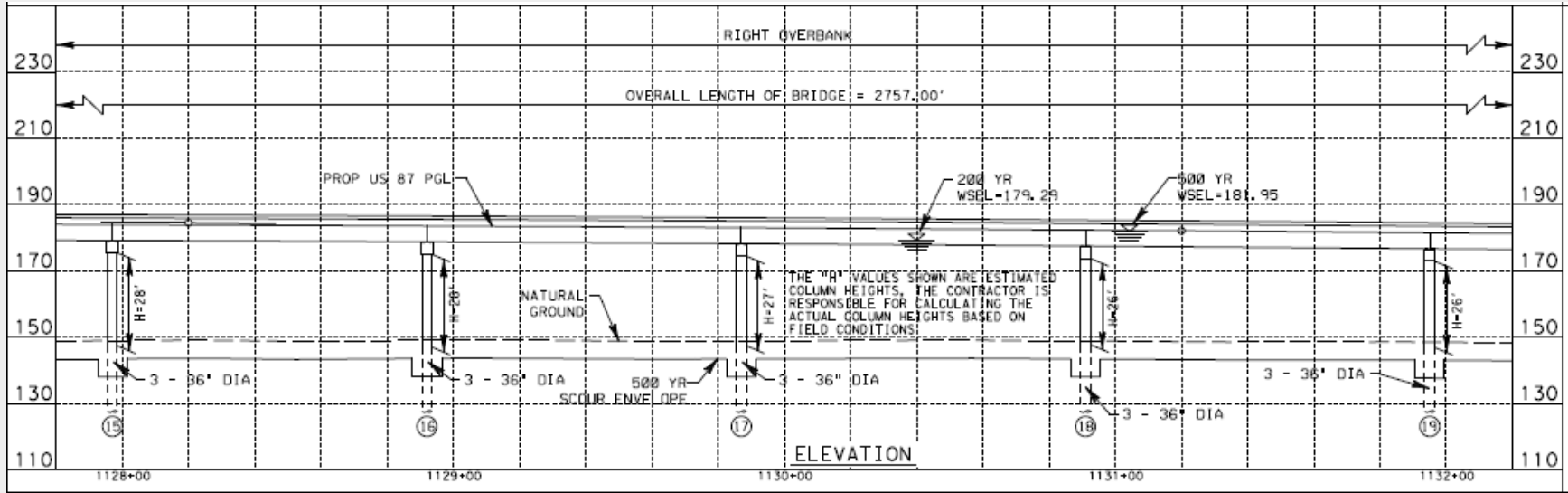


## Scour Analysis Guide

September 2023



- Scour Analysis based on hydraulic and hydrologic analysis **required** for all bridges
- Bridges designed to resist damage resulting from the scour design flood





- Scour Evaluations are required for bridge class culverts
  - Scour Summary sheet for Culverts (Form 2606)
  - Form 2606 also serves as scour evaluation

**Form 2606**  
(Rev. 02/24)  
Page 1 of 1

DISTRICT:       FEATURE CARRIED:   
COUNTY:       FEATURE CROSSED:   
NBI#:       CSJ:

Engineer of Record for the Recommended Scour Coding(s):

Date of Recommendation:

NBI Coding		
Item	Description	Coding
113	Scour Critical Bridges	<input type="text"/>
113.1	Scour Plans of Action	<input type="text"/>

SNBI Coding		
Item	Description	Coding
B.C.10	Channel Protection Condition Rating	<input type="text"/>
B.C.11	Scour Condition Rating	<input type="text"/>
B.AP.03	Scour Vulnerability	<input type="text"/>
B.AP.04	Scour Plan of Action	<input type="text"/>

Seal, Signature, and Date





# TxDOT Coding Guide for Item 113

NBI Item 113 - Scour Critical Bridge

Item 113.1 - Scour Plan of Action

Item 113.2 – Unknown Foundations



<u>Code</u>	<u>Description for Span Bridges</u>
N	Bridge is not over a waterway.
U	Unknown foundation and lacking scour evaluation and/or documentation.
T	Over tidal waters and lacking scour evaluation and/or documentation.
7	Previously observed scour has been remediated: countermeasures have been installed and are performing well.
6	Lacking scour evaluation and/or documentation.



<u>Code</u>	<u>Description for Span Bridges</u>
9	All foundation components, including piles or shafts, are above flood waters.
8	The <b>calculated scour depth</b> would cause <b>minimal foundation exposure</b> . The <b>observed scour depth</b> has caused <b>minimal foundation exposure</b> .
5	The <b>calculated scour depth</b> would cause <b>moderate foundation exposure</b> . The <b>observed scour</b> causes <b>minimal foundation exposure</b> .
4	The <b>observed scour depth</b> has caused <b>moderate foundation exposure</b> . The <b>calculated scour depth</b> would cause <b>minimal or moderate foundation exposure</b> . Action is required to address the observed scour.



<u>Code</u>	<u>Description for Span Bridges</u>
3	The <b>calculated scour depth</b> would cause <b>major foundation exposure</b> . The <b>observed scour</b> has caused <b>minimal or moderate foundation exposure</b> . A Bridge Scour Plan of Action (Form 2604) is required.
2	<b>Observed scour</b> has caused <b>major foundation exposure</b> . <b>Immediate action is required to remediate the observed scour</b> . A Bridge Scour Plan of Action (Form 2624) is required.
1	<b>Observed scour</b> exceeds the <b>maximum allowable scour depth</b> . <b>Failure is imminent and the bridge is closed to traffic</b> . A Bridge Scour Plan of Action (Form 2609) is required.
0	Failure has occurred and the bridge is closed to traffic.



**Table 5-1 – Basis of Item 113 Coding for Span Bridges Without Designed and Functioning Scour Countermeasures**

Foundation Exposure	Calculated or Assessed Scour Depth (From Scour Analysis)	Observed Scour Depth (From Inspection Record)
Minor	8	8
Moderate	5	4
Major	4	2 <sup>(1)</sup>
Extreme	3 <sup>(2)</sup>	1 <sup>(1)</sup>

Notes: (1) If Major or Extreme foundation exposure is observed, verify the coding with scour assessment (see Section 3.4). Consult Geotechnical Branch at [scour@txdot.gov](mailto:scour@txdot.gov) regarding structural scour assessment, recommending repairs and countermeasures, and scour documentation.

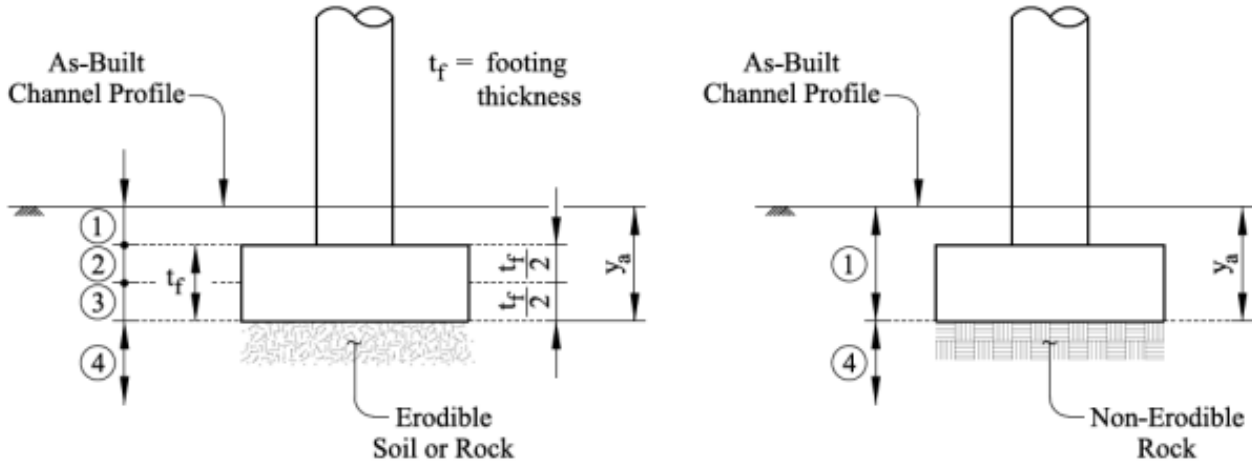
(2) When observed scour depths are not consistent with calculated scour depths, this indicates a need to re-evaluate scour vulnerability (e.g., Forms 537 or 538) and /or methods of scour analyses.



Figure 8-1 Scour Evaluation Guide

- ① Minor Foundation Exposure
- ② Moderate Foundation Exposure
- ③ Major Foundation Exposure
- ④ Extreme Foundation Exposure

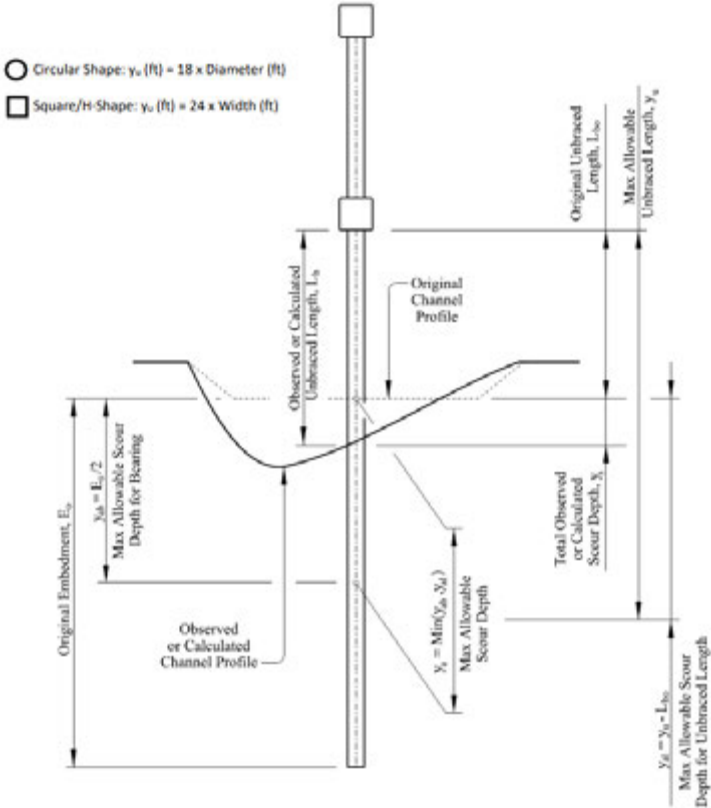
$y_a$  = Max Allowable Scour Depth (Refer to Ch. 2 in the Scour Evaluation Guide)



# Maximum Allowable Scour

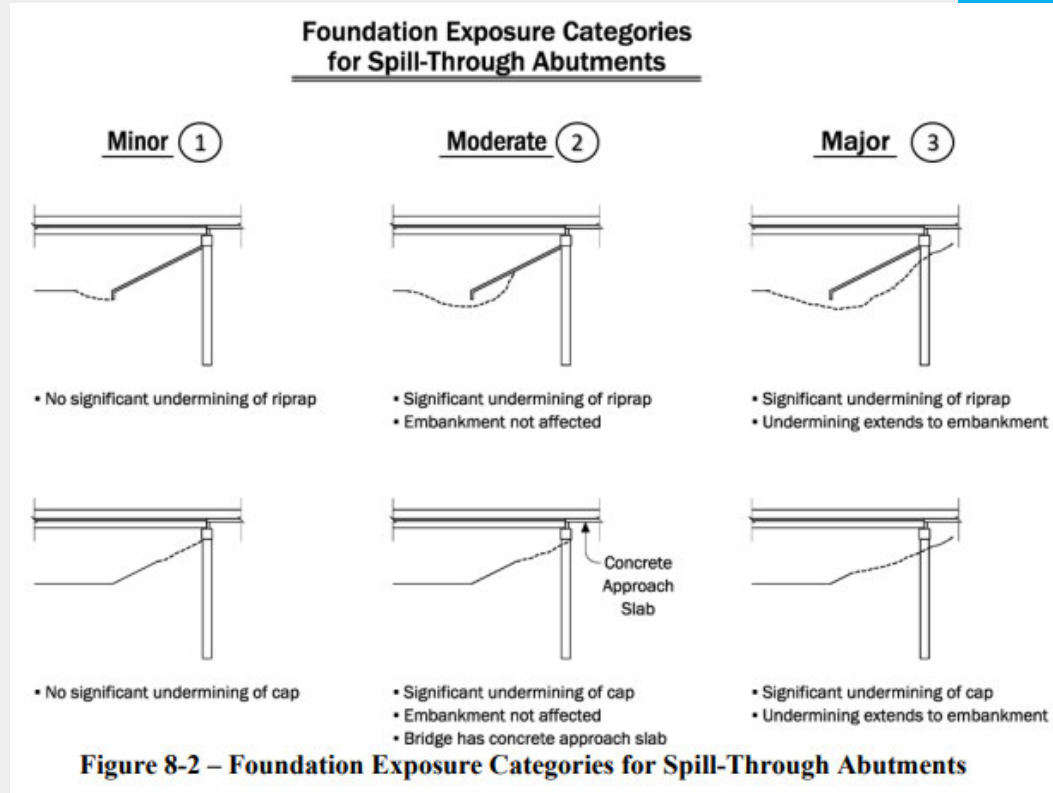


Figure 3-2 Scour Evaluation Guide











**Table 8-5 – SVA Scour Coding Table**

<b>Current Scour Condition</b>  Refer to Figures 8-1 and 8-2 for Definitions of Foundation Exposure Categories	<b>Recommended Scour Coding</b>			
	Scour Vulnerability Class			
	Normal	Enhanced	Normal	Enhanced
	Item 113		SNBI Item B.C.11 & (Item B.AP.03)	
Countermeasures Installed & Functioning	8	8	4 to 9 (B)	4 to 9 (B)
Minor Foundation Exposure	8	5	6, 7, 8, 9 (A)	6 or 7 (A)
Moderate Foundation Exposure	4	3	4, 5, 6 (A)	4, 5, 6 (C or D)
Major Foundation Exposure	2	2	2 or 3 (C or D)	2 (C or D)
Bridge Closed	1	1	1 (C or D)	1 (C or D)
Bridge Failed	0	0	0	0



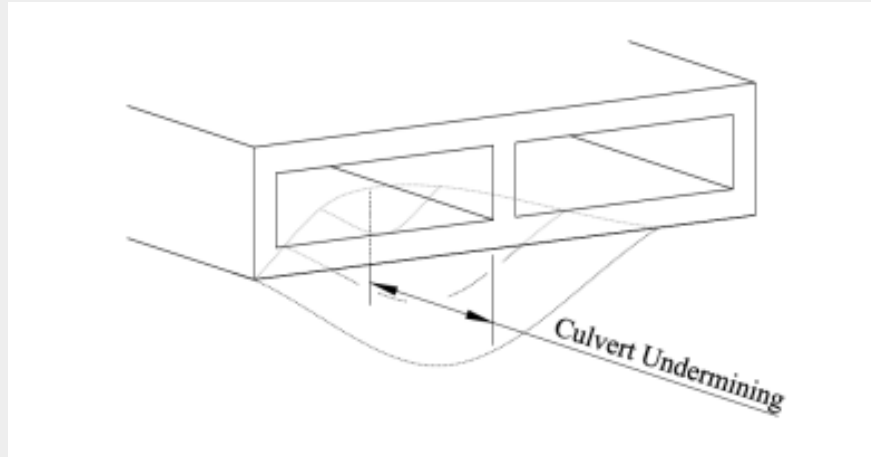
<u>Code</u>	<u>Description for Span Bridges</u>
N	Bridge is not over a waterway.
8	Refer to the table and figure in Appendix A
7	Previously observed scour has been remediated: countermeasures have been installed and are performing well.
6	Lacking scour evaluation and/or documentation.



<u>Code</u>	<u>Description for Span Bridges</u>
4	Refer to the table and figures in Appendix A
2	Refer to the table and figures in Appendix A. A Bridge Scour Plan of Action (Form 2624) is required.
1	Failure is imminent and the culvert is closed to traffic. A Bridge Scour Plan of Action (Form 2609) is required.
0	Failure has occurred and the culvert is closed to traffic.

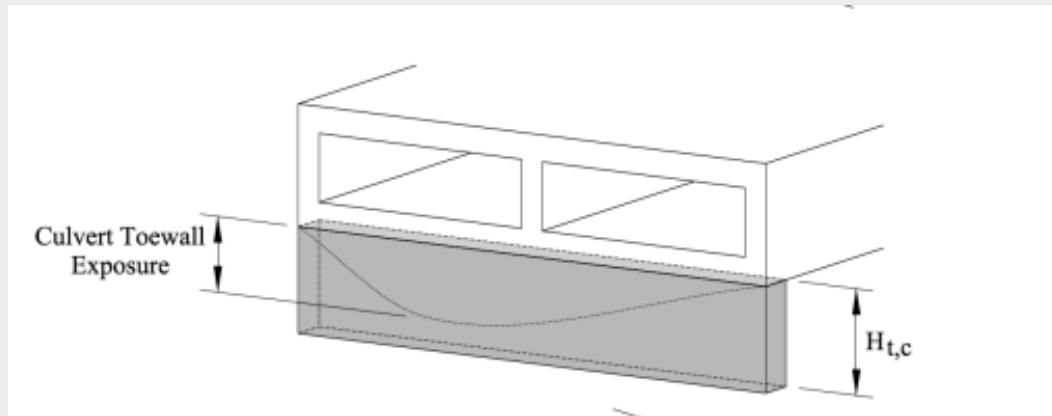


Item 113 Coding	Exposure and/or Undermining Category	<i>Choose the Most Critical Mechanism</i>			
		Culvert/Pipe Undermining	Culvert/Pipe Toewall Exposure	Apron Undermining	Apron Toewall Exposure
8	Minimal	< 1 ft.	$< \frac{1}{3} H_{t,c}$	$< \frac{1}{5} L_a$	$\leq H_{t,a}$
4	Moderate	1 – 3 ft.	$\leq H_{t,c}$	$\frac{1}{5} L_a - \frac{3}{5} L_a$	$> H_{t,a}$
2	Major	> 3 ft.	$> H_{t,c}$	$> \frac{3}{5} L_a$	-



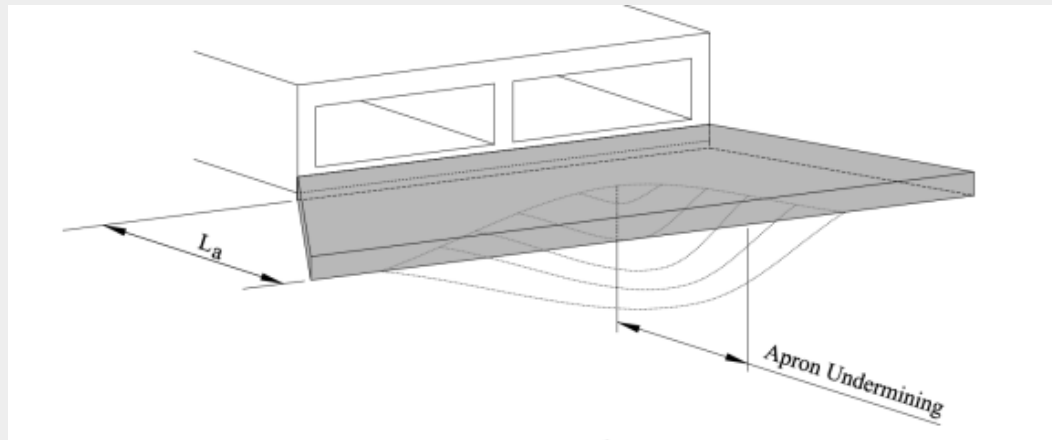


Item 113 Coding	Exposure and/or Undermining Category	<i>Choose the Most Critical Mechanism</i>			
		Culvert/Pipe Undermining	Culvert/Pipe Toewall Exposure	Apron Undermining	Apron Toewall Exposure
8	Minimal	< 1 ft.	$< \frac{1}{3} H_{t,c}$	$< \frac{1}{5} L_a$	$\leq H_{t,a}$
4	Moderate	1 – 3 ft.	$\leq H_{t,c}$	$\frac{1}{5} L_a - \frac{3}{5} L_a$	$> H_{t,a}$
2	Major	> 3 ft.	$> H_{t,c}$	$> \frac{3}{5} L_a$	-



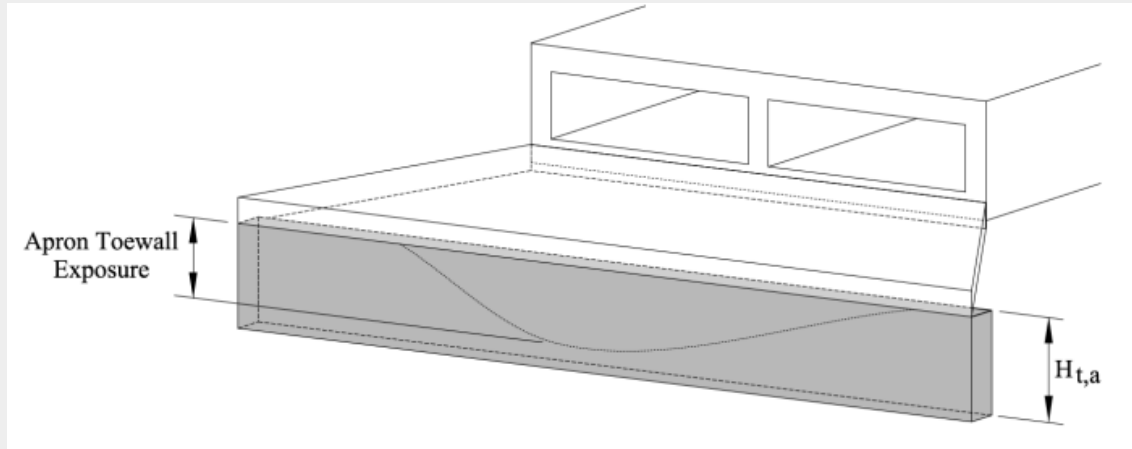


Item 113 Coding	Exposure and/or Undermining Category	<i>Choose the Most Critical Mechanism</i>			
		Culvert/Pipe Undermining	Culvert/Pipe Toewall Exposure	Apron Undermining	Apron Toewall Exposure
8	Minimal	< 1 ft.	< $\frac{1}{3} H_{t,c}$	< $\frac{1}{5} L_a$	$\leq H_{t,a}$
4	Moderate	1 – 3 ft.	$\leq H_{t,c}$	$\frac{1}{5} L_a - \frac{3}{5} L_a$	$> H_{t,a}$
2	Major	> 3 ft.	$> H_{t,c}$	$> \frac{3}{5} L_a$	-





Item 113 Coding	Exposure and/or Undermining Category	Choose the Most Critical Mechanism			
		Culvert/Pipe Undermining	Culvert/Pipe Toewall Exposure	Apron Undermining	Apron Toewall Exposure
8	Minimal	< 1 ft.	< $\frac{1}{3} H_{t,c}$	< $\frac{1}{5} L_a$	$\leq H_{t,a}$
4	Moderate	1 – 3 ft.	$\leq H_{t,c}$	$\frac{1}{5} L_a - \frac{3}{5} L_a$	$> H_{t,a}$
2	Major	> 3 ft.	$> H_{t,c}$	$> \frac{3}{5} L_a$	-







- Maximum Allowable Scour
  - Based on Foundation and Structural Capacity
- Compared to Evaluated Scour
  - Observed Scour
    - SVA Vulnerability Category
  - Or Calculated Scour

**Table 8-5 – SVA Scour Coding Table**

Current Scour Condition  Refer to Figures 8-1 and 8-2 for Definitions of Foundation Exposure Categories	Recommended Scour Coding			
	Scour Vulnerability Class			
	Normal	Enhanced	Normal	Enhanced
	Item 113		SNBI Item B.C.11 & (Item B.AP.03)	
Countermeasures Installed & Functioning	8	8	4 to 9 (B)	4 to 9 (B)
Minor Foundation Exposure	8	5	6, 7, 8, 9 (A)	6 or 7 (A)
Moderate Foundation Exposure	4	3	4, 5, 6 (A)	4, 5, 6 (C or D)
Major Foundation Exposure	2	2	2 or 3 (C or D)	2 (C or D)
Bridge Closed	1	1	1 (C or D)	1 (C or D)
Bridge Failed	0	0	0	0

**Table 5-1 – Basis of Item 113 Coding for Span Bridges Without Designed and Functioning Scour Countermeasures**

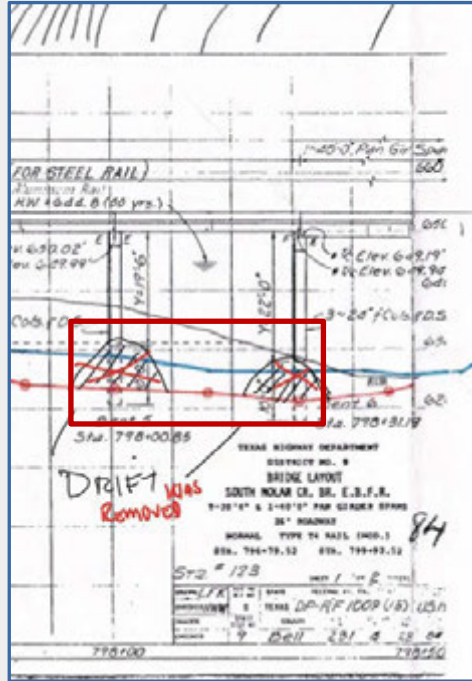
Foundation Exposure	Calculated or Assessed Scour Depth (From Scour Analysis)	Observed Scour Depth (From Inspection Record)
Minor	8	8
Moderate	5	4
Major	4	2 <sup>(1)</sup>
Extreme	3 <sup>(2)</sup>	1 <sup>(1)</sup>

Notes: (1) If Major or Extreme foundation exposure is observed, verify the coding with scour assessment (see Section 3.4). Consult Geotechnical Branch at [scour@txdot.gov](mailto:scour@txdot.gov) regarding structural scour assessment, recommending repairs and countermeasures, and scour documentation.

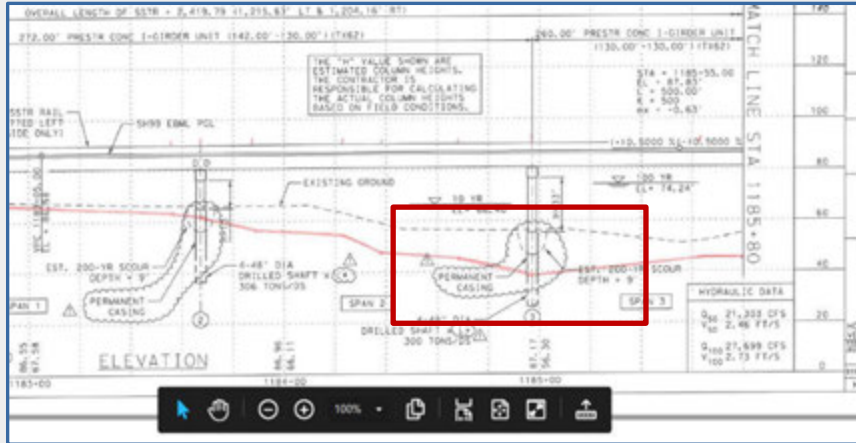
(2) When observed scour depths are not consistent with calculated scour depths, this indicates a need to re-evaluate scour vulnerability (e.g., Forms 537 or 538) and /or methods of scour analyses.



PHOTO 10  
Description 10\_Bent 5 drilled shafts are exposed 3 ft high (Looking South)



SCOUR DEPTHS		
<input checked="" type="checkbox"/>	Scour depths are measured from the as-built channel profile.	
<input type="checkbox"/>	Scour depths are measured from: _____	
Abutment or Bent #	Bent #5	Bent #6
Yab	8.6'	8.5'
Yal	19.6'	17.8'
Max Allowable Scour Depth <sup>1</sup>	8.6'	8.5'
Max Possible Scour Depth <sup>2</sup>	6.1'	6.3'
Calculated Contraction Scour	-	-
Calculated Pier Scour	-	-
Total Calculated Scour Depth	-	-
Observed Scour Depth	5.7'	5.8'



## Latest Inspection Channel Profile

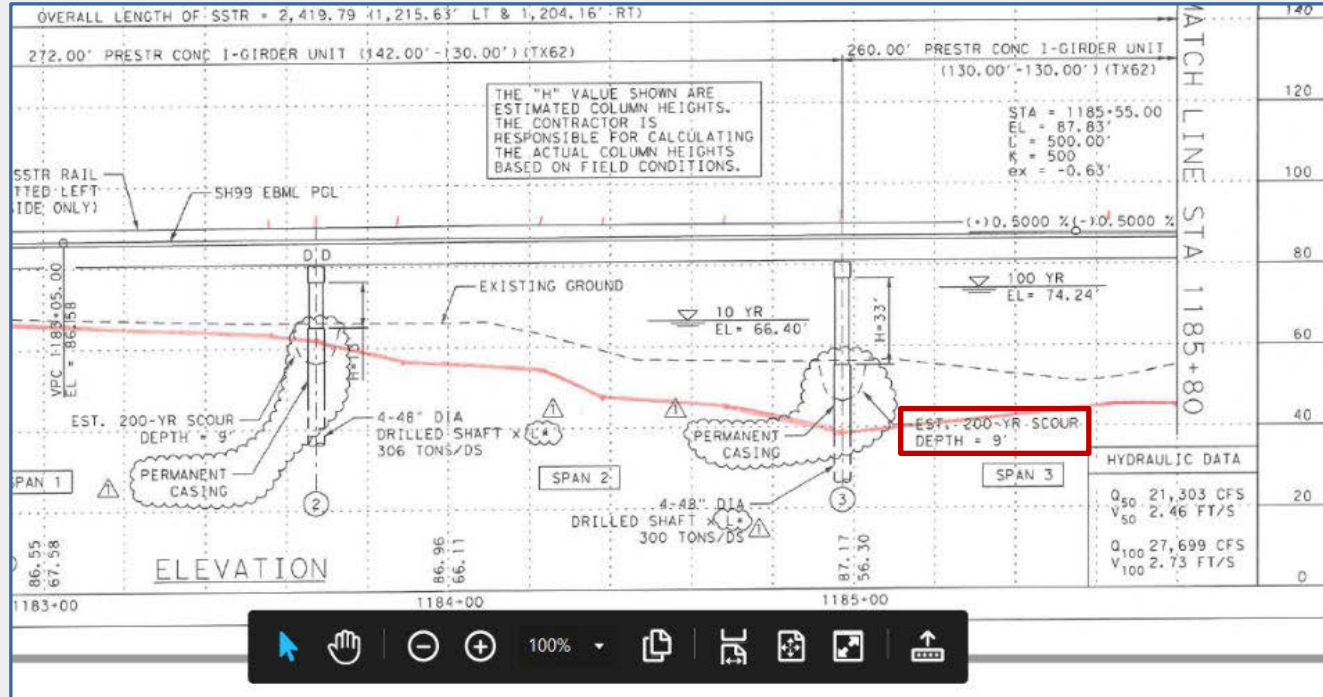
- As-built survey at Center Line, Inspection measured Downstream

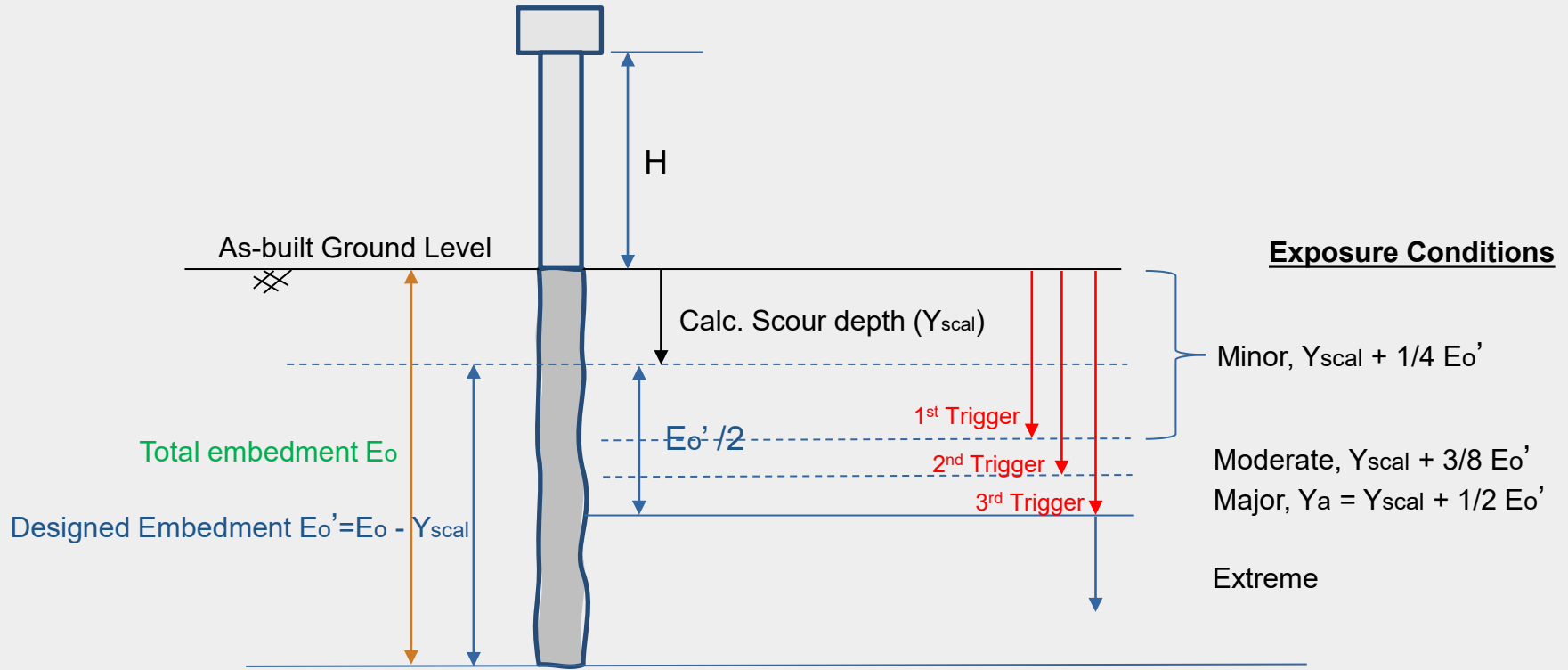


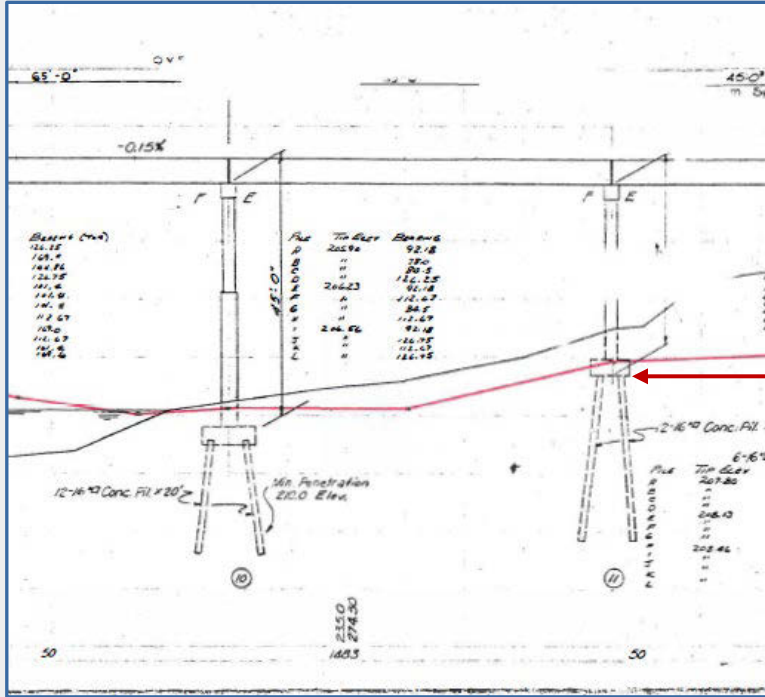
Latest Inspection Photo:  
New bridge with no Scour

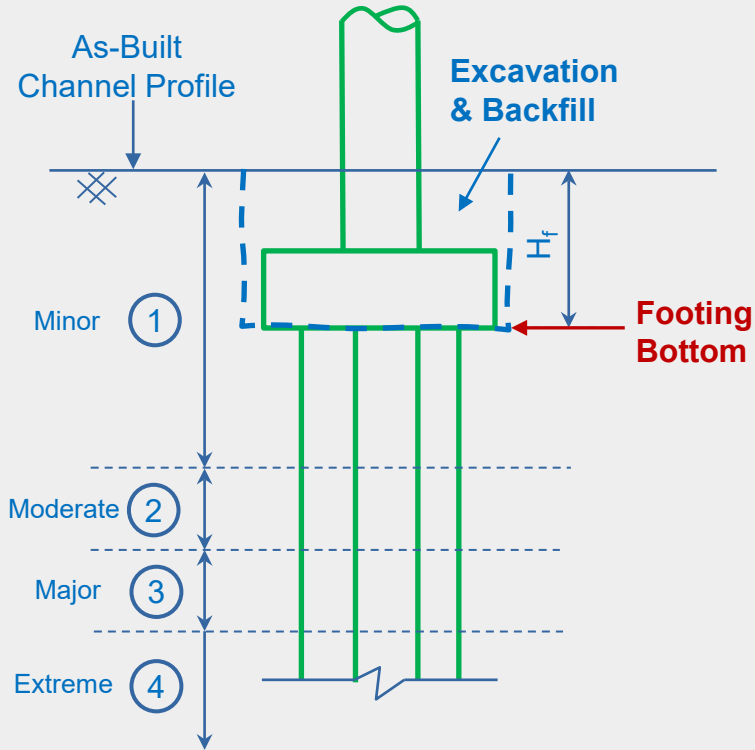


- Scour depth assumed in design









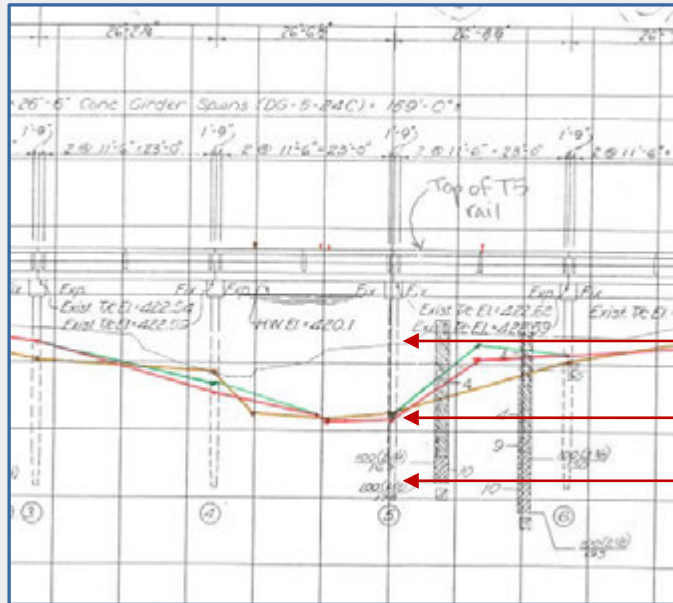
## As Built Channel Profile At or Above the Bottom of Footing.

- Scour above bottom of footing is considered minor exposure.
- Original Embedment ( $E_0$ ) of foundation or  $Y_a$  (Both  $Y_{al}$  and  $Y_{ab}$ ) should count from the bottom of footing to the tip of piling/DS.

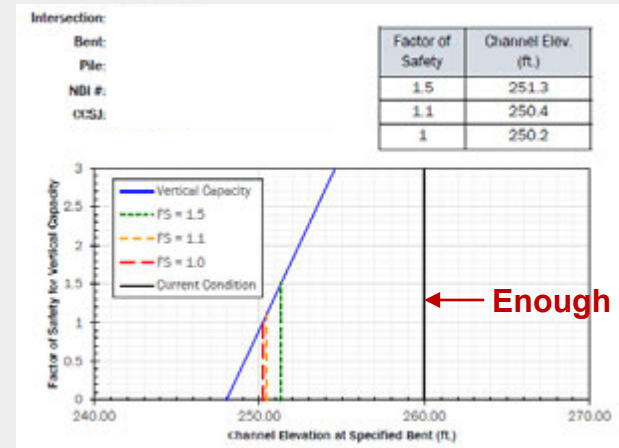
# Evaluation Examples



- In-depth capacity analysis
  - Scour critical bridges



BENT NO.	6	DATE DRIVEN	7-9-62	PILE SIZE	15" Sq.	DESIGN LOAD	33 Tons
A	37	37.00		20.42	.050	100 ✓	
B	37	37.00		20.20	.000	150 ✓	
C	37	37.00		20.40	.050	100 ✓	
D	37	35.86	1.14	19.13	.000	150 ✓	
E		35.51	16.48				





- Classification for a bridge that is unstable or may become unstable, as determined by a scour appraisal
  - Observed scour depth in the “Major” scour category
  - Calculated scour depth in the “Extreme” scour category





- Item 113 coded as a 3, 2 or 1
  - Coding of 3
    - Often used when calculated scour exceeds the maximum allowable scour depth
    - POA Form 2604 is required
  - Coding of 2
    - Major foundation exposure from observed scour depth
    - Immediate action required to remediate
    - POA Form 2624 is required
    - Bridge Division should be notified in [Scour@txdot.gov](mailto:Scour@txdot.gov)



- Coding of 1
  - Extreme foundation exposure from observed scour depth
  - Failure is imminent and bridge is closed to traffic
  - POA form 2609 is required
  - Contact Bridge Division Immediately
  
- Scour Critical Structures
  - Require action plans from the bridge owner



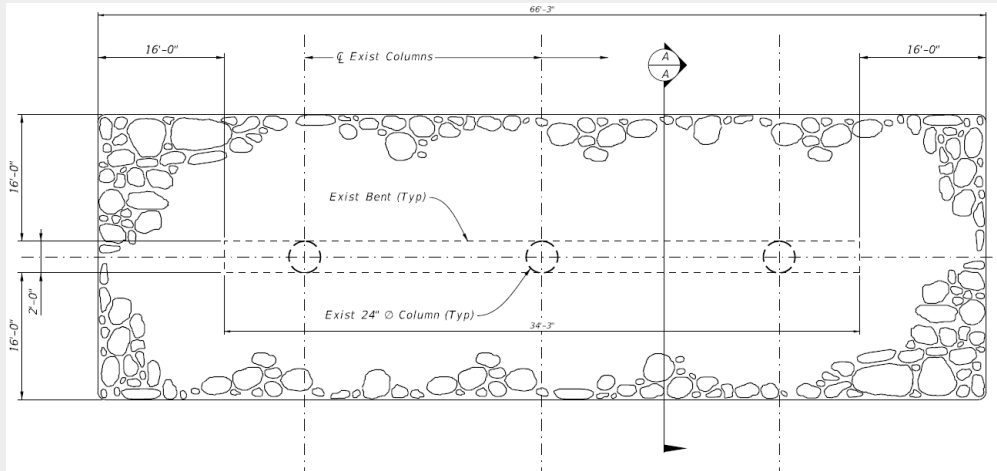
- Measures to improve or control stream stability and scour vulnerability
  - Revetment/Armoring
  - Foundation Underpinning
  - River Training Structures

Hydraulic Engineering Circular No. 23

**Bridge Scour and Stream Instability  
Countermeasures: Experience,  
Selection, and Design Guidance-Third  
Edition**



- Designed Countermeasure
  - Detail sheet including fully detailed plan in assetwise
  - Calculations in accordance with design in HEC 23 and based on calculated hydraulic data (flow velocity) at the bridge



- Not-Designed Countermeasure
  - Countermeasure may not be able to handle common flows
  - Countermeasures can have a negative effect on structure if effects are not evaluated
  - May not fully arrest the scour





- Countermeasures and Item 113
  - Designed Countermeasures to address calculated scour risk
    - Can be coded to 8 if design documentation included in Assetwise
  - Designed Countermeasures to address observed scour
    - Coding can be increased if design documentation included in assetwise
  - Non-Designed Countermeasures
    - No immediate coding change
    - Functionality must be verified by future inspections, then coded to 7
  
- Functionality of all countermeasures should be verified at inspection
  - Coding should be adjusted if countermeasures not intact





<b>Scour Condition Rating</b>	
<u>Format</u> AN (1)	<u>Frequency</u> EI
<u>Item ID</u> B.C.11	
Specification	
<p>Report the scour condition that represents the observed or measured scour using one of the following codes. The entire code description must be satisfied for the code to apply.</p>	
Code	Condition Description
N	Bridge does not cross over water.
9	No scour.
8	Insignificant scour.
7	Some minor scour.
6	Widespread minor or isolated moderate scour.
5	Moderate scour; strength and stability of the bridge are not affected.
4	Widespread moderate or isolated major scour; strength and/or stability of the bridge is affected.
3	Major scour; strength and/or stability of the bridge is seriously affected. Condition typically necessitates more frequent monitoring, load restrictions, and/or corrective actions.
2	Major scour; strength and/or stability of the bridge is severely compromised. Condition typically necessitates frequent monitoring, significant load restrictions, and/or corrective actions to keep the bridge open.
1	Bridge is closed to traffic due to scour condition. Channel rehabilitation may return the bridge to service.
0	Bridge is closed due to scour condition, and is beyond corrective action. Bridge replacement is needed to restore service.

**SNBI Coding Item B.AP.03 – Scour Vulnerability**

<u>Code</u>	<u>Descriptions for Span Bridges and Bridge Class Culvert</u>
0	Scour appraisal has not been completed.
A	Scour appraisal completed. Bridge determined to be stable for scour.
B	Scour appraisal completed. Bridge determined to be stable for scour, dependent upon designed, and functioning countermeasures.
C	Scour appraisal completed. Bridge could become unstable for scour. Temporary (not designed) countermeasure installed to mitigate scour. Bridge is scour critical.
D	Scour appraisal completed. Bridge is, or may become, unstable for scour. Bridge is scour critical.
E	Scour appraisal has not been completed. Temporary (not designed) countermeasure installed to mitigate scour.
U	Scour appraisal has not been completed due to unknown foundations



<b>Scour Plan of Action</b>									
<u>Format</u> AN (1)	<u>Frequency</u> I								
<u>Item ID</u> B.AP.04									
Specification	Commentary								
<p>Report whether the bridge has a scour plan of action (POA) implemented using one of the following codes.</p> <table border="0"> <tr> <td style="padding-right: 10px;"><u>Code</u></td> <td><u>Description</u></td> </tr> <tr> <td>0</td> <td>A scour POA is not required.</td> </tr> <tr> <td>N</td> <td>A scour POA is required, but not implemented.</td> </tr> <tr> <td>Y</td> <td>A scour POA is required and implemented.</td> </tr> </table> <p>Do not report this item if the bridge does not cross over a waterway as indicated in Item B.F.01 (<i>Feature Type</i>).</p>	<u>Code</u>	<u>Description</u>	0	A scour POA is not required.	N	A scour POA is required, but not implemented.	Y	A scour POA is required and implemented.	<p>The NBIS requires a scour POA for bridges over water that are determined to be scour critical or have unknown foundations.</p> <p>More information on scour POA can be found at the FHWA Hydraulics Engineering website: <a href="http://www.fhwa.dot.gov/engineering/hydraulics/bridgehyd/poa.cfm">http://www.fhwa.dot.gov/engineering/hydraulics/bridgehyd/poa.cfm</a>.</p> <p>Use code 0 if a bridge was considered scour critical, but now has designed, installed, and fully functional scour countermeasures.</p> <p>A scour POA is a document that addresses, based on risk, a schedule for repair or installation of scour countermeasures, and/or the monitoring, inspection, closing, and opening a bridge to traffic during and after flood events to protect the traveling public.</p>
<u>Code</u>	<u>Description</u>								
0	A scour POA is not required.								
N	A scour POA is required, but not implemented.								
Y	A scour POA is required and implemented.								