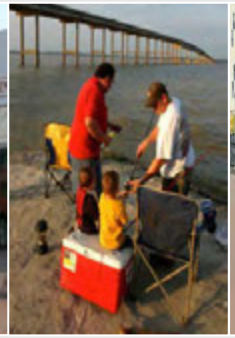
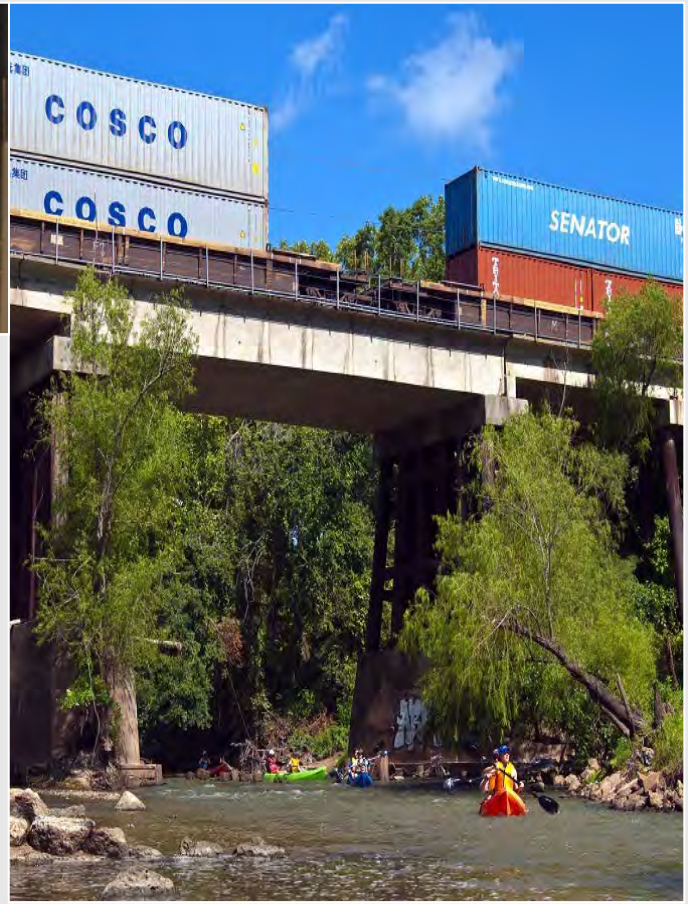
TEXAS DEPARTMENT OF TRANSPORTATION





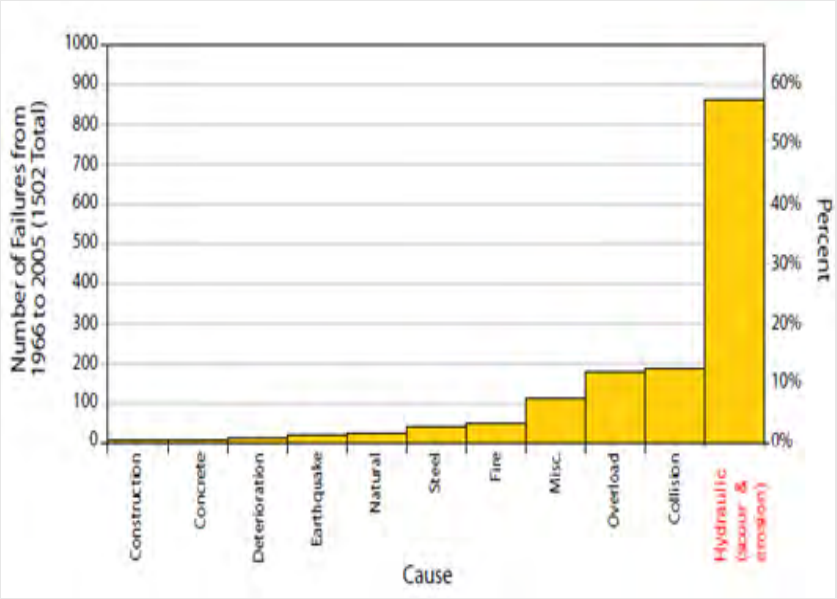
SCOUR: EVALUATION AND RIPRAP

John G. Delphia, P.E.
TxDOT Bridge Division Geotechnical Branch

IMPORTANCE OF SCOUR

- **The most common cause of bridge failures is from floods scouring bed material from around bridge foundations** (from pg 1-1, *Evaluating Scour at Bridges- 5th Edition*, FHWA 2012)

- **There is a need to ensure public safety and minimize the adverse effects resulting from bridge failures/closures**



Scour Program

http://www.timesunion.com/local/article/30-years-ago-Bridge-collapse-kills-10-11045976.php#photo-12655627

https://dspace.library.colostate.edu/bitstream/handle/10217/86173/Lesson02.pdf?sequence=11&isAllowed=y

- **1991 – The FHWA initiated a Scour Evaluation Program.**
- **<u>The program required state DOT's to evaluate all existing structures for scour vulnerability</u>.**
- **<u>All subsequent new bridge designs are required to include a scour evaluation</u>.**

PURPOSE OF PERFORMING A SCOUR ANALYSIS

To ensure that a bridge can withstand the effects of scour without failing.

PURPOSE OF CODING A BRIDGE FOR SCOUR

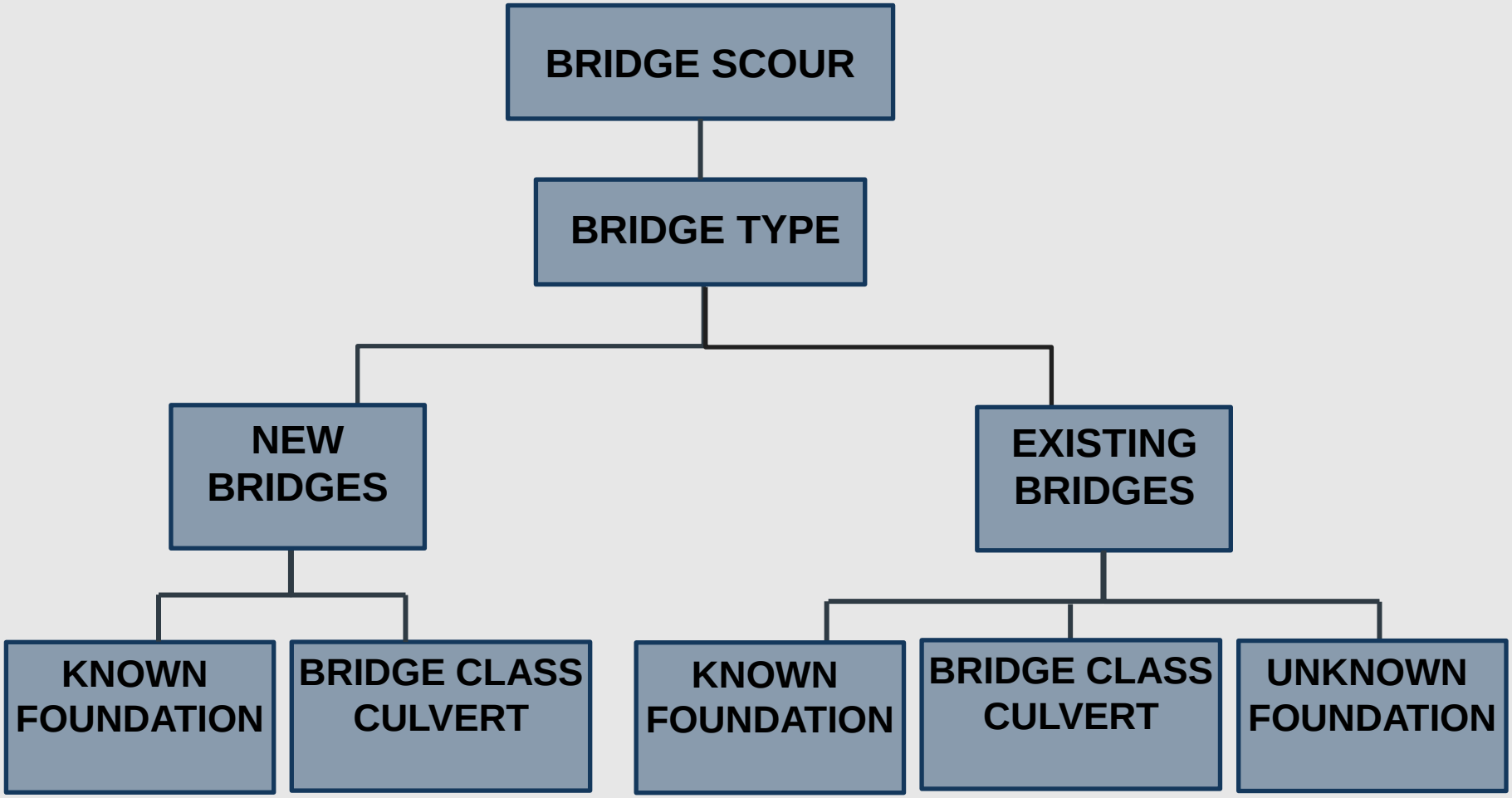
To identify the current status of the bridge regarding its vulnerability to scour

PURPOSE OF DOCUMENTATION OF SCOUR FOR BRIDGES

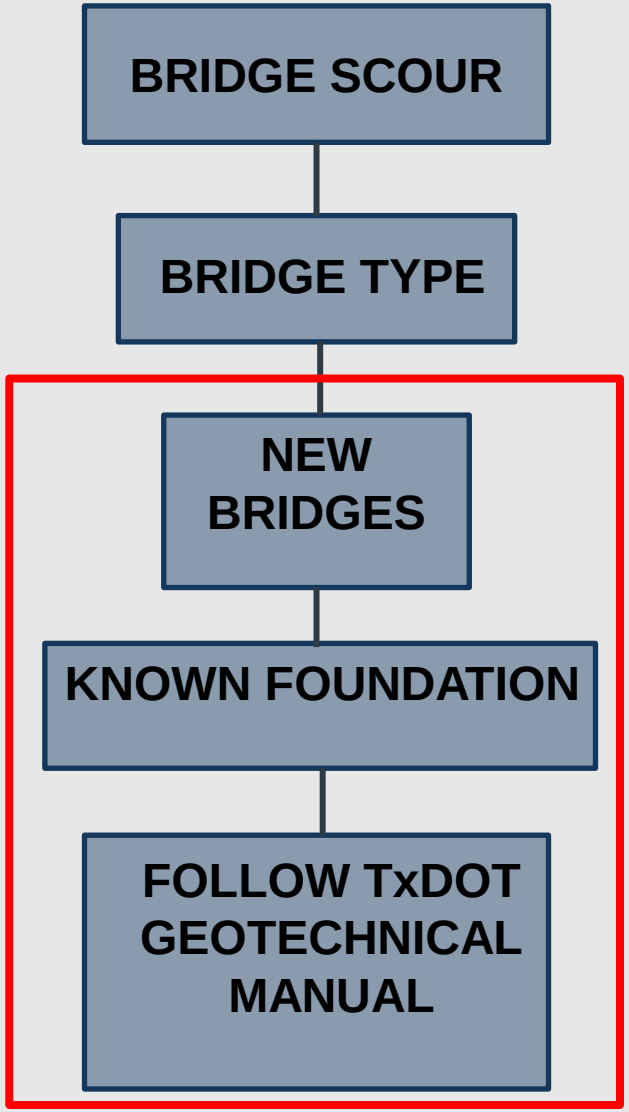
To document the current status of the bridge regarding its vulnerability to scour and to indicate what to do during /after flooding events

SCOUR EVALUATION PROCEDURES

BRIDGE SCOUR EVALUATION PROCEDURES



BRIDGE SCOUR EVALUATION PROCEDURES: New Bridges



BRIDGE SCOUR EVALUATION PROCEDURES: New Bridges

Geotechnical Manual

Texas Department of Transportation

December 2012

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BRIDGE SCOUR EVALUATION PROCEDURES: New Bridges

TxDOT GEOTECHNICAL MANUAL – 2012 SCOUR ANALYSIS METHODS

	CONTRACTION SCOUR	PIER SCOUR
ROCK NEAR THE SURFACE	MATERIAL SUSCEPTIBILITY TABLE ANNANDALE'S ERODIBILITY INDEX METHOD	
COHESIONLESS SOILS (sands, gravels)	HEC-18 EQ.	FROEHLICH'S EQ. HEC-18 EQ. FLORIDA DOT PIER SCOUR EQN.
COHESIVE SOILS (clay)	HEC-18 EQ. D50 LIMIT = 6.56 X 10^{-3} in.	HEC-18 EQ. WITH CLAY REDUCTION FACTOR
	SRICOS METHOD ANNANDALE'S ERODIBILITY INDEX METHOD	
LAYERED SOIL	- CONDUCT SCOUR ANALYSIS LAYER BY LAYER - SRICOS METHOD - ANNADALE'S ERODIBILITY INDEX METHOD	

BRIDGE SCOUR EVALUATION PROCEDURES: Cohesionless Soil

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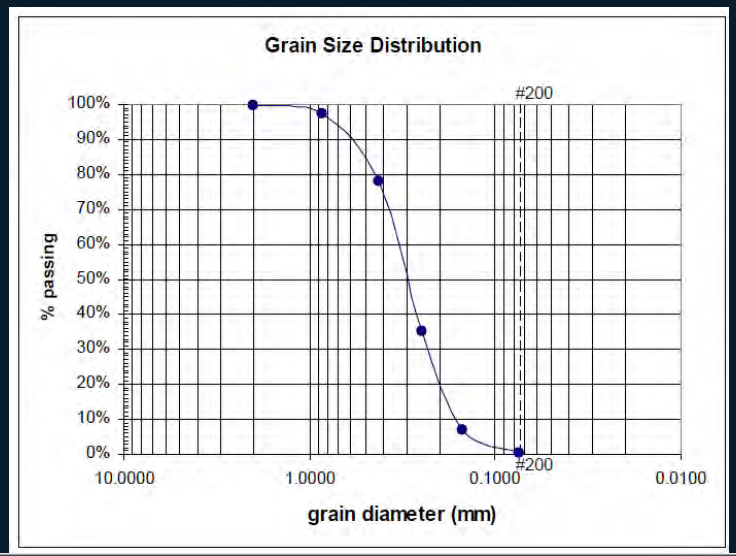
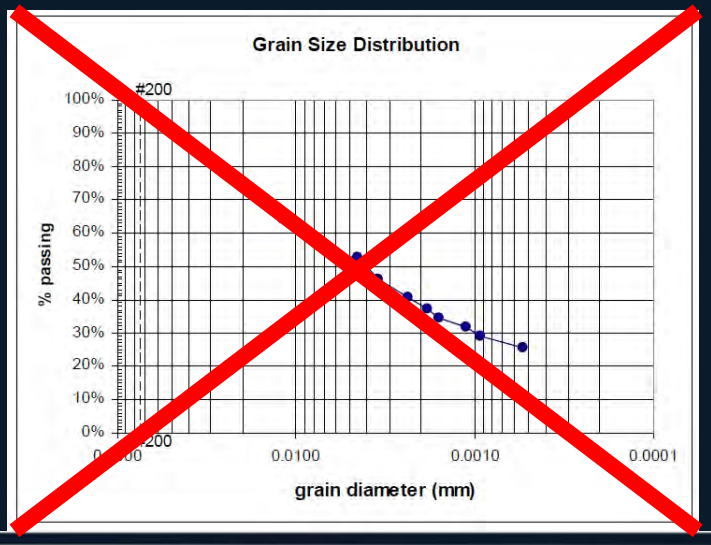
D50 and D95
ONLY USEFUL FOR COHESIONLESS SOILS

Critical Velocity Equation

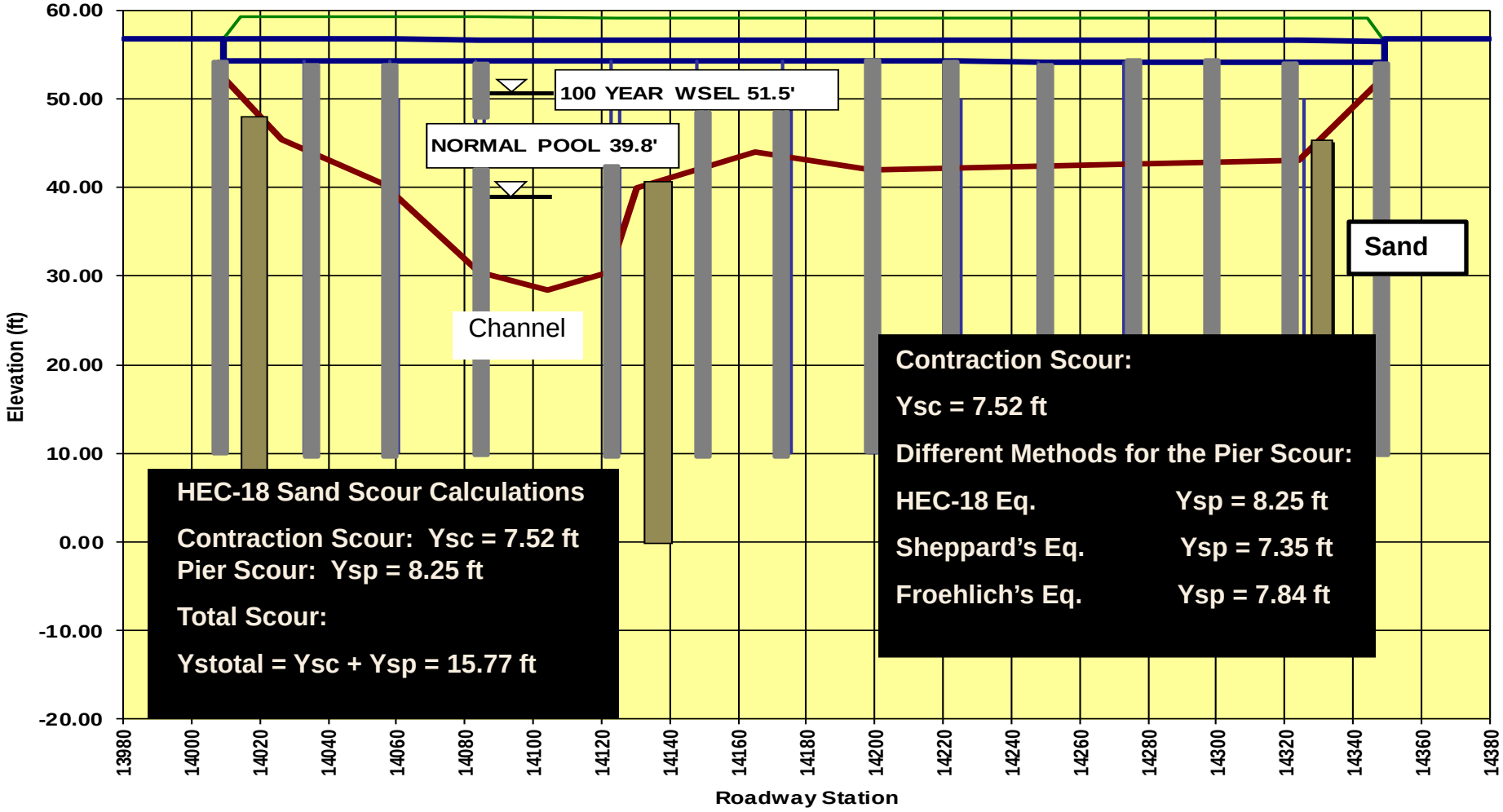
$Vc = K_u\, y^{1/6}\, D_{50}^{1/3}$ $K_u = 11.17$(English)

(threshold velocity for material size $\leq$ D50)





UNIFORM SAND PROFILE



HEC-18 Sand Scour Calculations

Contraction Scour: Ysc = 7.52 ft
Pier Scour: Ysp = 8.25 ft

Total Scour:

Ystotal = Ysc + Ysp = 15.77 ft

Contraction Scour:

Ysc = 7.52 ft

Different Methods for the Pier Scour:

HEC-18 Eq.	Ysp = 8.25 ft
Sheppard's Eq.	Ysp = 7.35 ft
Froehlich's Eq.	Ysp = 7.84 ft

BRIDGE SCOUR EVALUATION PROCEDURES: Cohesive Soil

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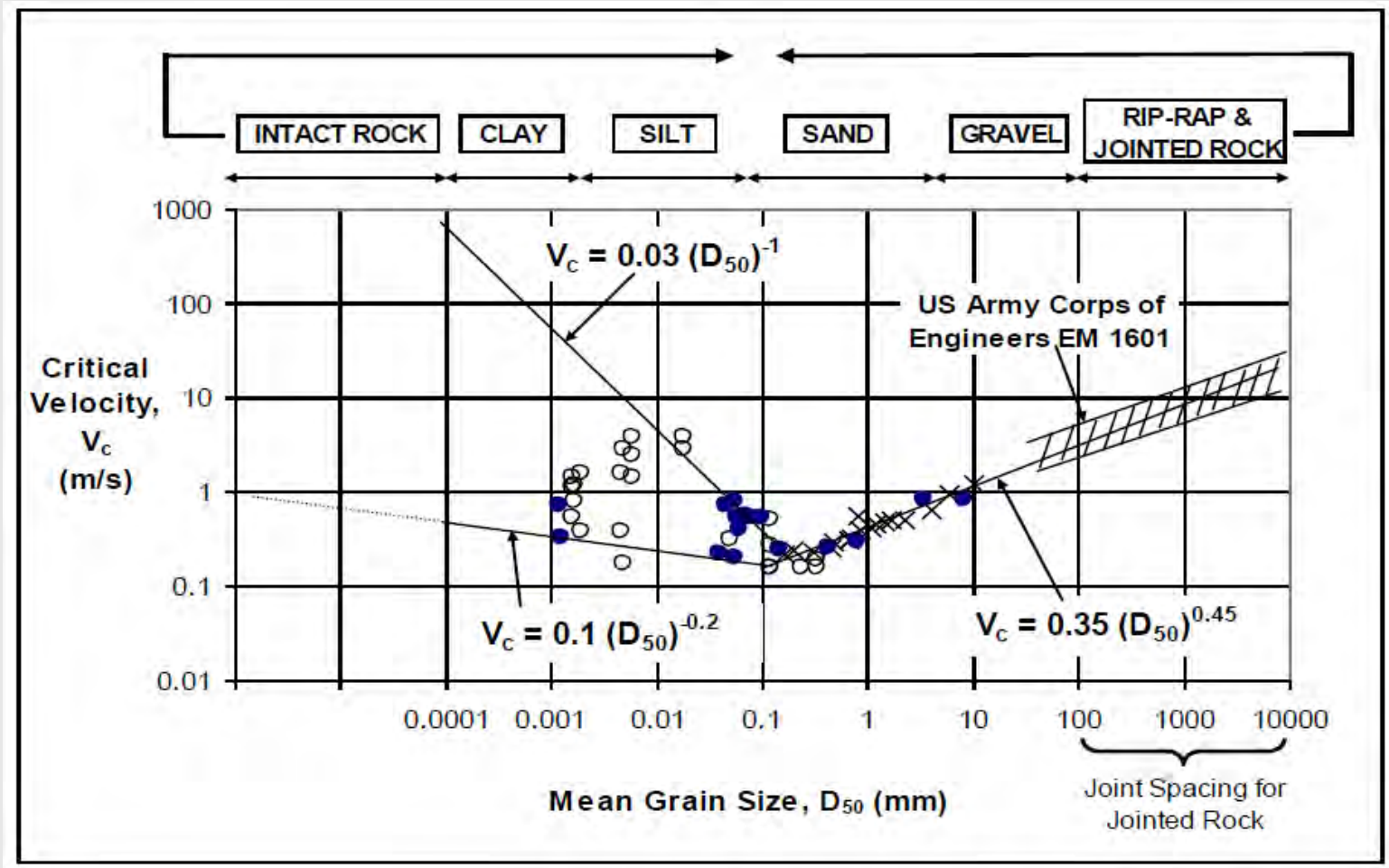
D50 and D95 - ONLY USEFUL FOR COHESIONLESS SOILS



DEFAULT VALUE FOR D50 and D95 FOR CLAY & SILT IS 0.2 mm or 6.56×10^{-4} ft

SRICOS METHOD

PIER SCOUR

Re = Vd/ν

$\tau_{max} = K_w K_{sp} K_{sh} K_a\ 0.0094 \rho V^2 \{1/\log(Re) - 1/10\}$

Z_{ri}

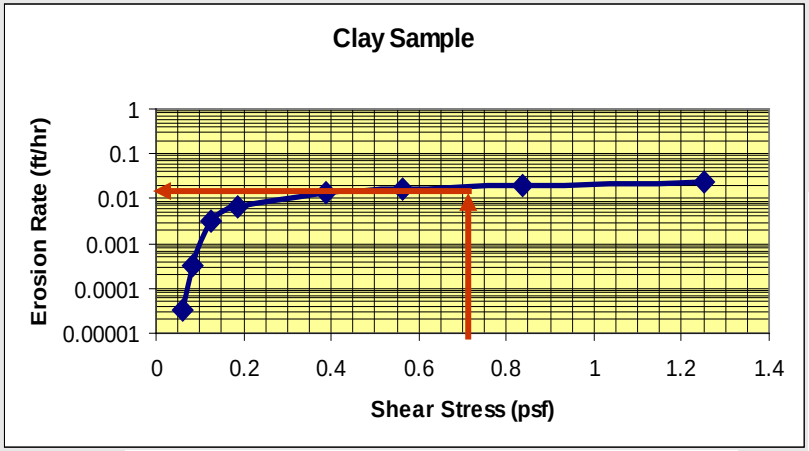
$Z_{max} = 0.18 Re^{0.635}$

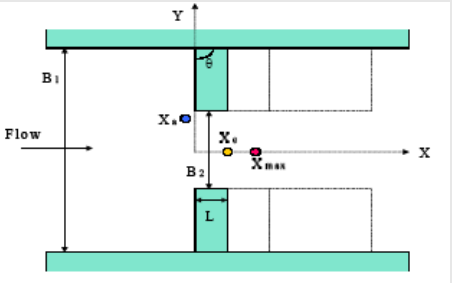
$Z_t = t / (1/ Z_{ri} + t / Z)$

$$k_w = \frac{\tau_{max}}{\tau_{max}(deep)} = 1 + 16 e^{-\frac{4H}{B}}$$

$$k_a = \frac{\tau_{max}}{\tau_{max}(0\deg)} = 1 + 1.5\left(\frac{\alpha}{90}\right)^{0.57} \qquad k_{sh} = 1.15 + 7 e^{-4\frac{L}{B}}$$

$$k_{sp} = \frac{\tau_{max}}{\tau_{max}(\text{single})} = 1 + 5 e^{-1.1\frac{S}{B}}.$$





CONTRACTION SCOUR

$R_h = A/P$

$\tau_{max} = K_R K_L K_W K_\theta\ \rho g\ n^2 V^2 R_h^{-1/3}$

Z_{ri}

$Z_{max} = K_\theta K_L x 1.90\{1.49 V_{HEC}(g\ H1)^{-1/2} - (\tau_c/\rho)^{1/2}(g\ n\ H_1)^{-1/3}\}\ H_1$

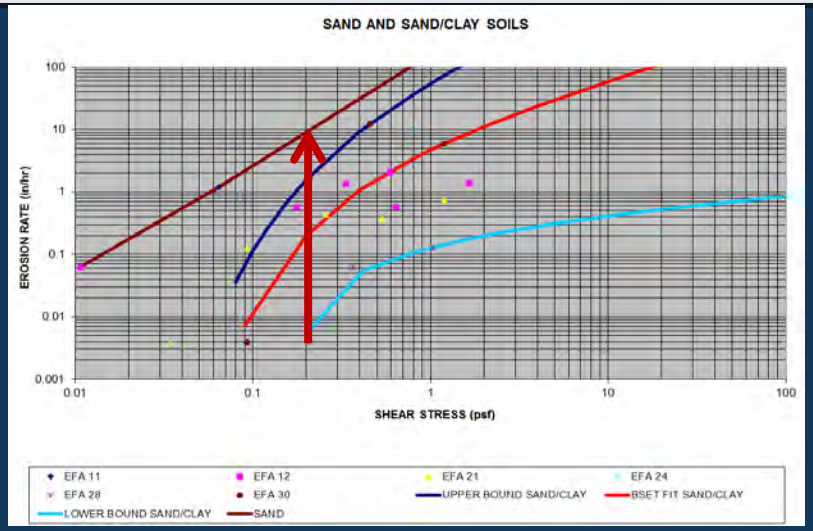
$Z_t = t / (1/ Z_{ri} + t / Z)$

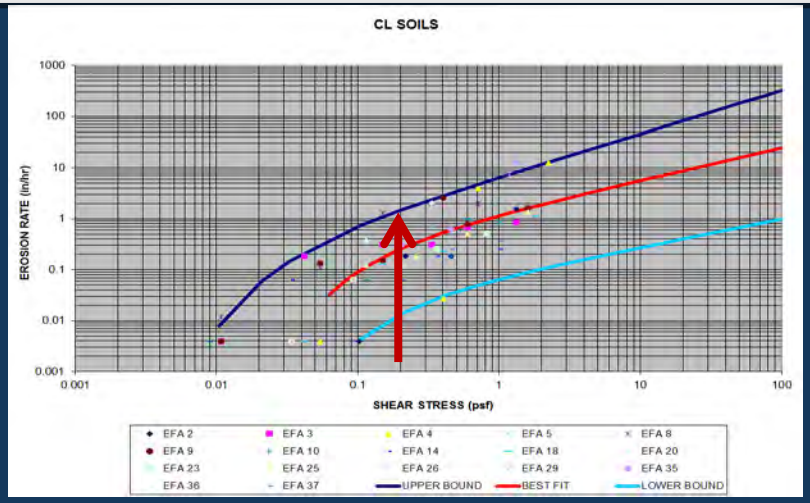
$$k_{c-L} = \begin{cases} 1 & , for \quad k_{c-L} \geq 0.35 \\ 0.77 + 1.36\left(\frac{L}{B_1 - B_2}\right) - 1.98\left(\frac{L}{B_1 - B_2}\right)^2 & , for \quad k_{c-L} < 0.35 \end{cases}$$

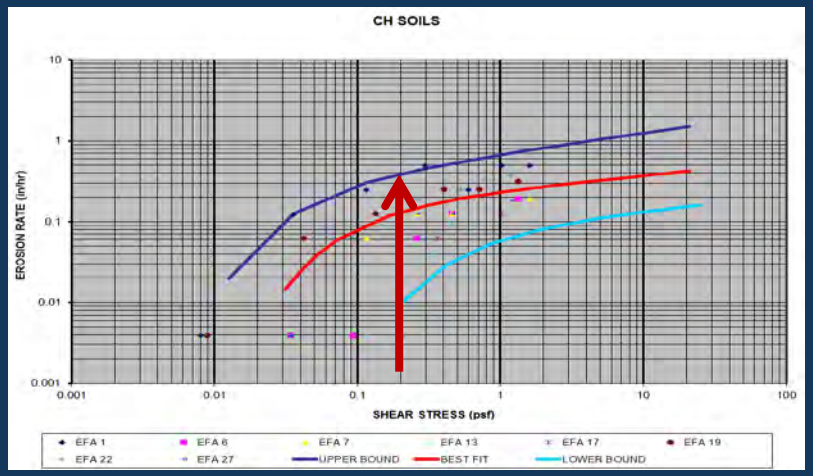
$$k_R = 0.62 + 0.38\left(\frac{B_1}{B_2}\right)^{1.75}$$

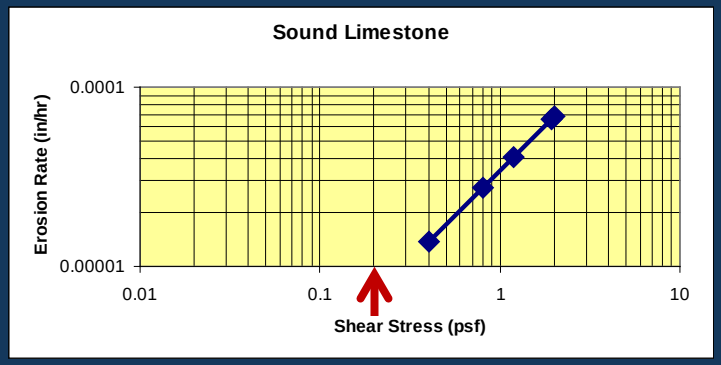
$$k_\theta = 1 + 0.9\left(\frac{\theta}{90}\right)^{1.5}$$

Scour Rate in Cohesive Soils (SRICOS) METHOD

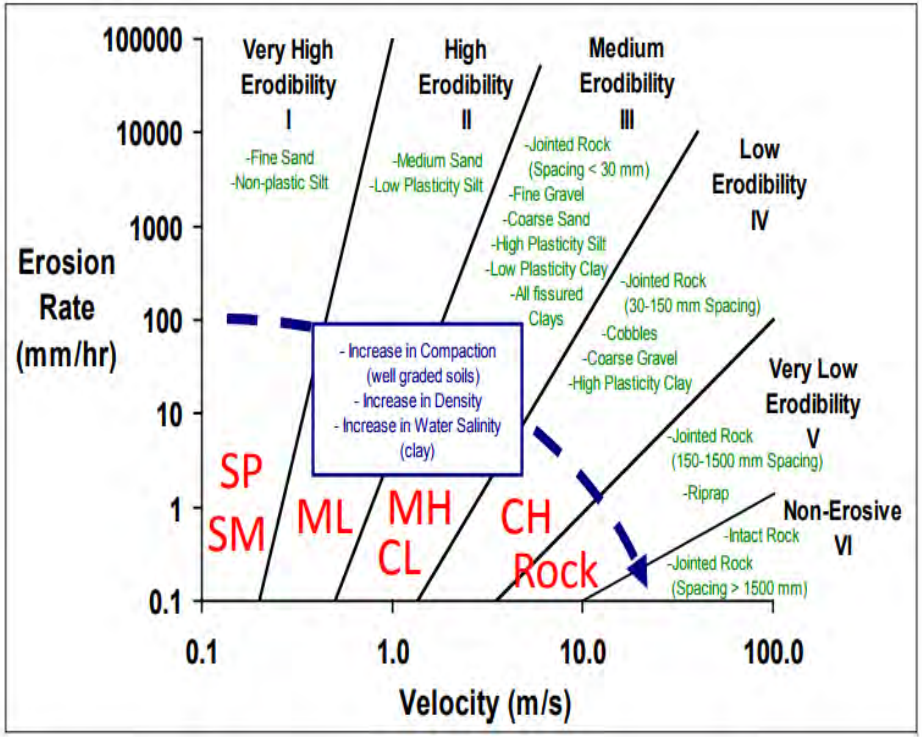


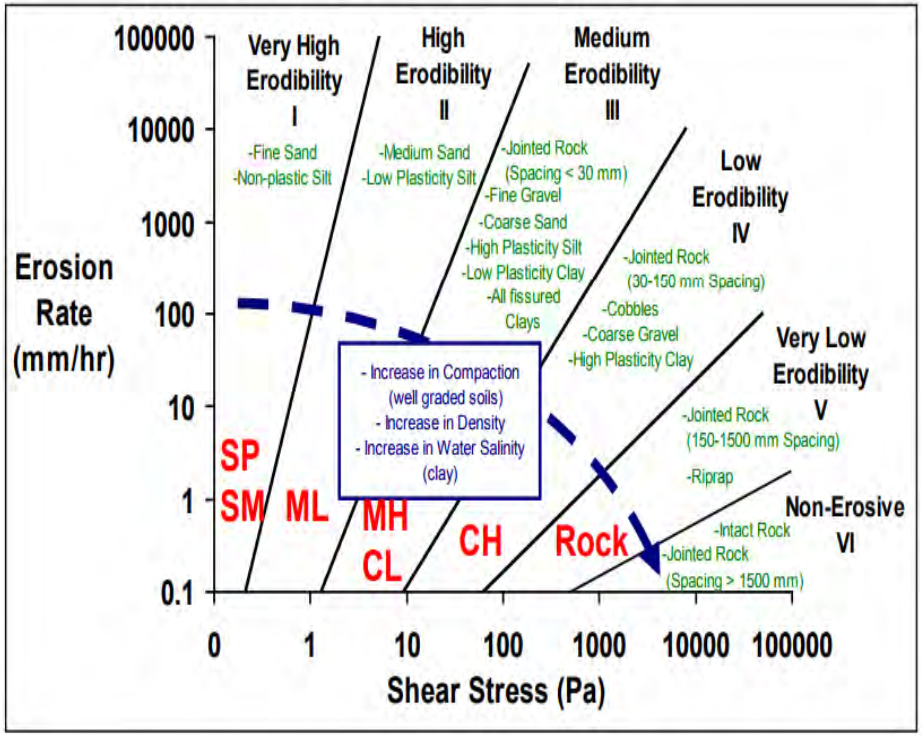






BRIDGE SCOUR EVALUATION PROCEDURES: Cohesive Soil





From HEC-18 Manual

NCHRP Project 24-43

"Relationship between Erodibility and Properties of Soils"

Objective: To determine relationships between erodibility and geotechnical properties that can be used as cost-effective means to assess site-specific, surficial erosion resistance of cohesive and cohesionless materials.

Example for Cohesive Soils:

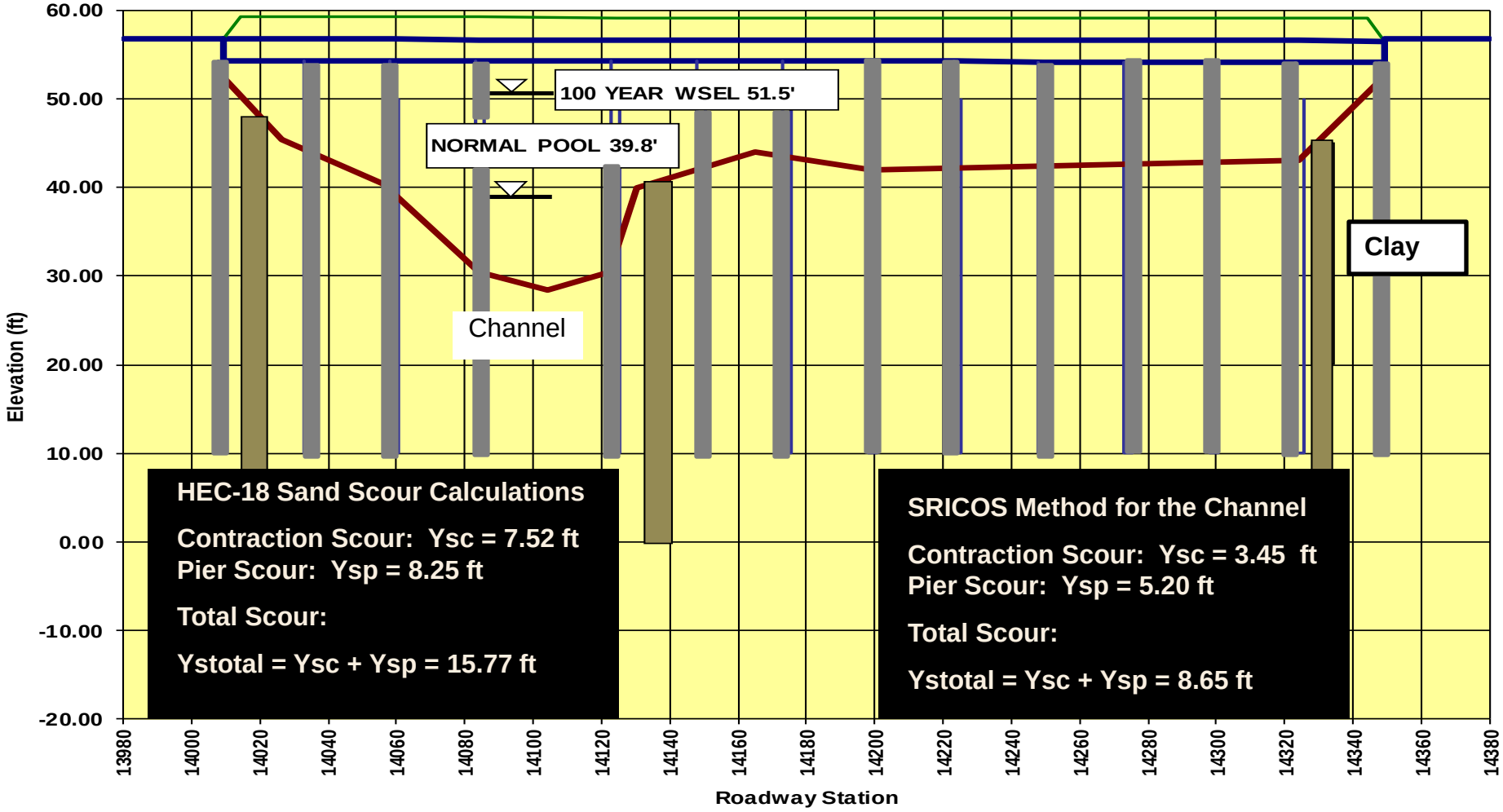
Erosion Rate = $\alpha_d C_1 (\tau_b - \tau_c)^{1.8}$

$$C_1 = \alpha_d (q_u)^{-1.0} PI^{-1.1}$$

$$\tau_c = \alpha_d \left(\frac{w}{F}\right)^{-2.0} PI^{1.3} q_u^{0.4}$$

q_u = Unconfined compressive strength, lbf/ft^2 (Pa).
PI = Plasticity index, dimensionless ratio.
α_d = Unit conversion constant, 14.2 in U.S. customary units and 680 in S.I.

UNIFORM CLAY PROFILE



BRIDGE SCOUR EVALUATION PROCEDURES: Cohesive Soil

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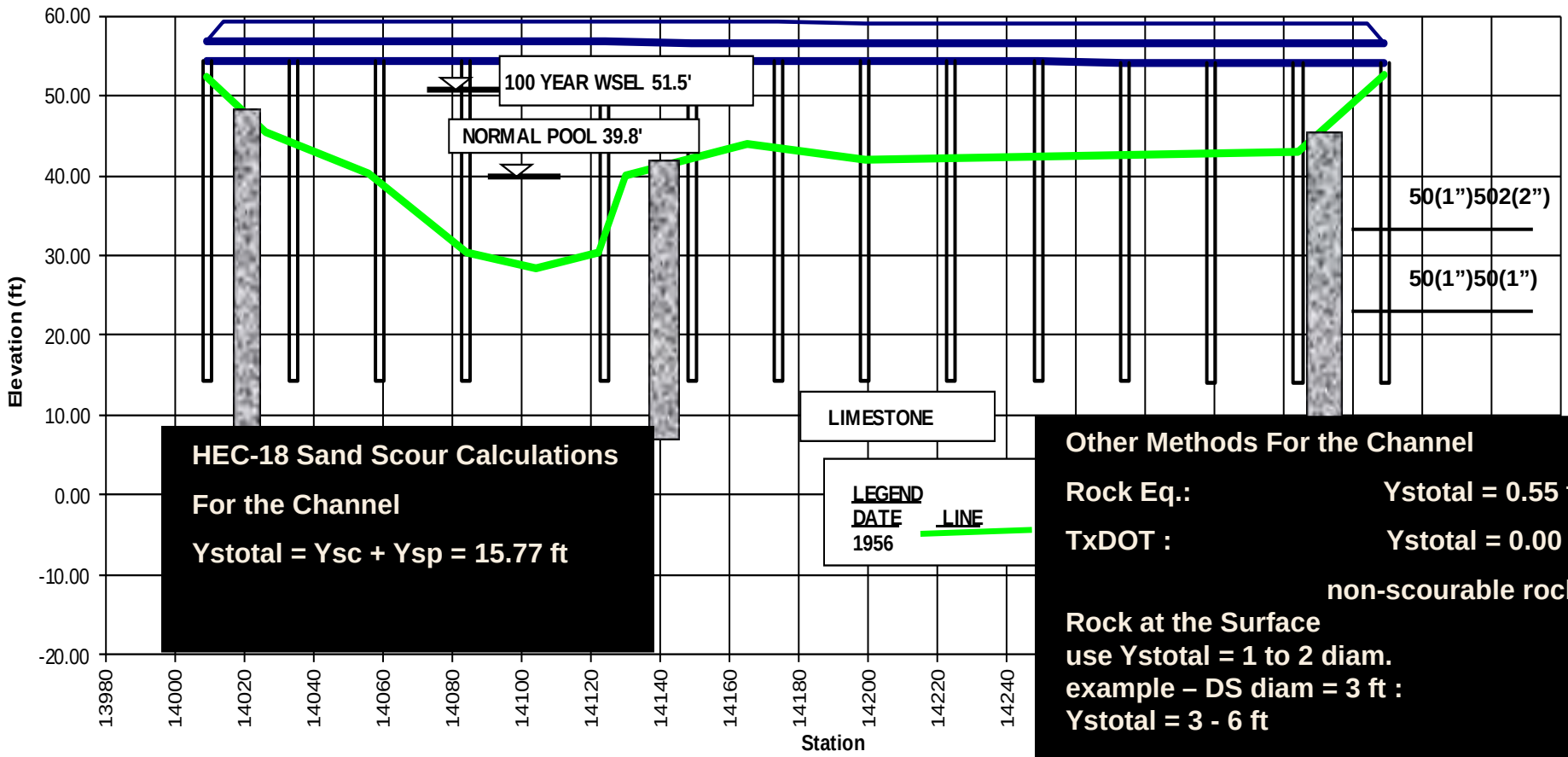
ROCK AT OR NEAR THE SURFACE

Material Susceptibility to Scour			
Material	**Subtype**	**Texas Cone Penetrometer**	**Susceptibility**
Rock	Hard (Granite, Limestone, Shale)	< 4”/100 blows	Not susceptible
	Soft (Shale)	< 12”/100 blows	Mildly susceptible, but not considered over time span of one flood event
Clays	Hard (Redbed, Shaley Clays, Very Stiff Clays)	< 12”/ 100 blows	Mildly susceptible, but not considered over time span of one flood event
	Soft to Medium	> 12”/ 100 blows	Susceptible to scour at a moderate rate
Sands	All	All	Very susceptible

ROCK PROFILE



HEC-18 Sand Scour Calculations

For the Channel

Ystotal = Ysc + Ysp = 15.77 ft

Other Methods For the Channel

Rock Eq.: Ystotal = 0.55 ft

TxDOT : Ystotal = 0.00 ft

non-scourable rock

Rock at the Surface
use Ystotal = 1 to 2 diam.
example – DS diam = 3 ft :
Ystotal = 3 - 6 ft

BRIDGE SCOUR EVALUATION PROCEDURES: Rock

Wetting and drying cycles make Clay and Shale susceptible to scour

Highly weathered and fractured rock can be susceptible to scour

https://www.slideshare.net/Vyankyo/river-erosion-and-its-associated-fetures

PROGRAMS AVAILABLE TO EVALUATE SCOUR:

Cohesionless Soil:

- HEC-RAS contains the HEC-18 sand contraction and pier scour equations, as well as Froehlich's equation

- Florida DOT has a spreadsheet available to calculate pier scour (http://www.fdot.gov/roadway/Drainage/Florida-Scour-Manual-Training-Course.shtm)

- FHWA Hydraulic Toolbox (https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm)

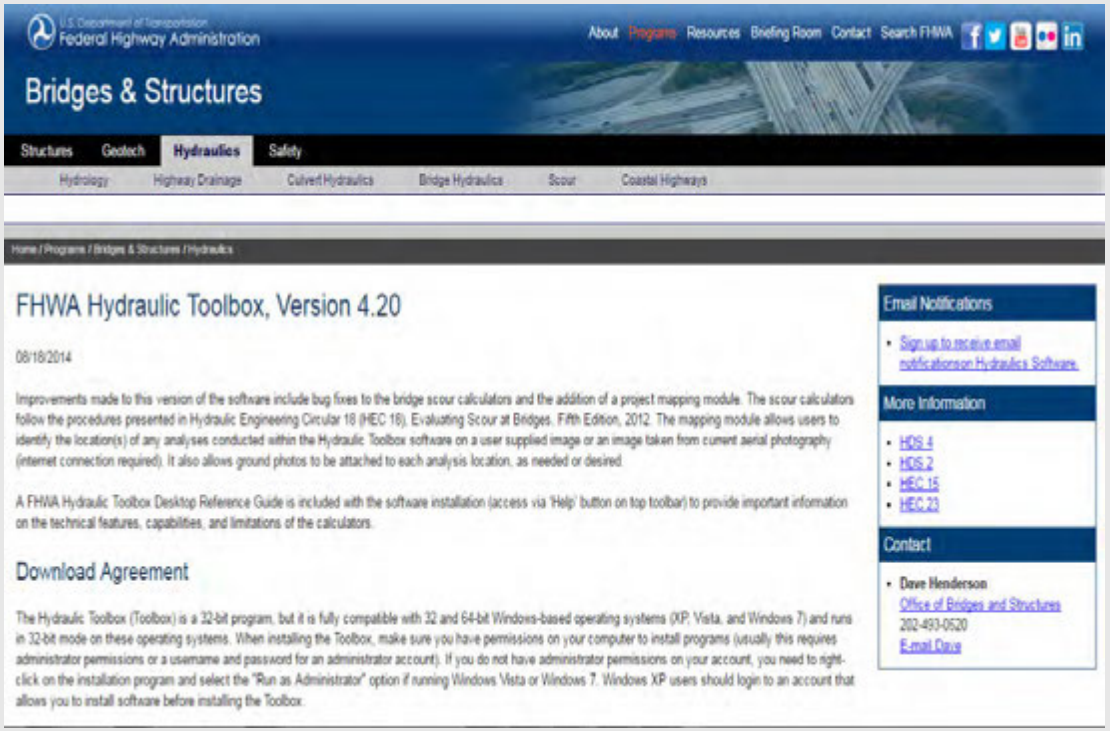
Cohesive Soil:

- HEC-RAS contains the HEC-18 sand contraction and pier scour equations. Reduce pier scour by multiplier.

- FHWA Hydraulic Toolbox – contains the SRICOS pier scour equation

- SRICOS-EFA Program – can be downloaded from Texas A&M (https://ceprofs.civil.tamu.edu/briaud/research_wip.html#sricos_proj)

FHWA HYDRAULIC TOOLBOX



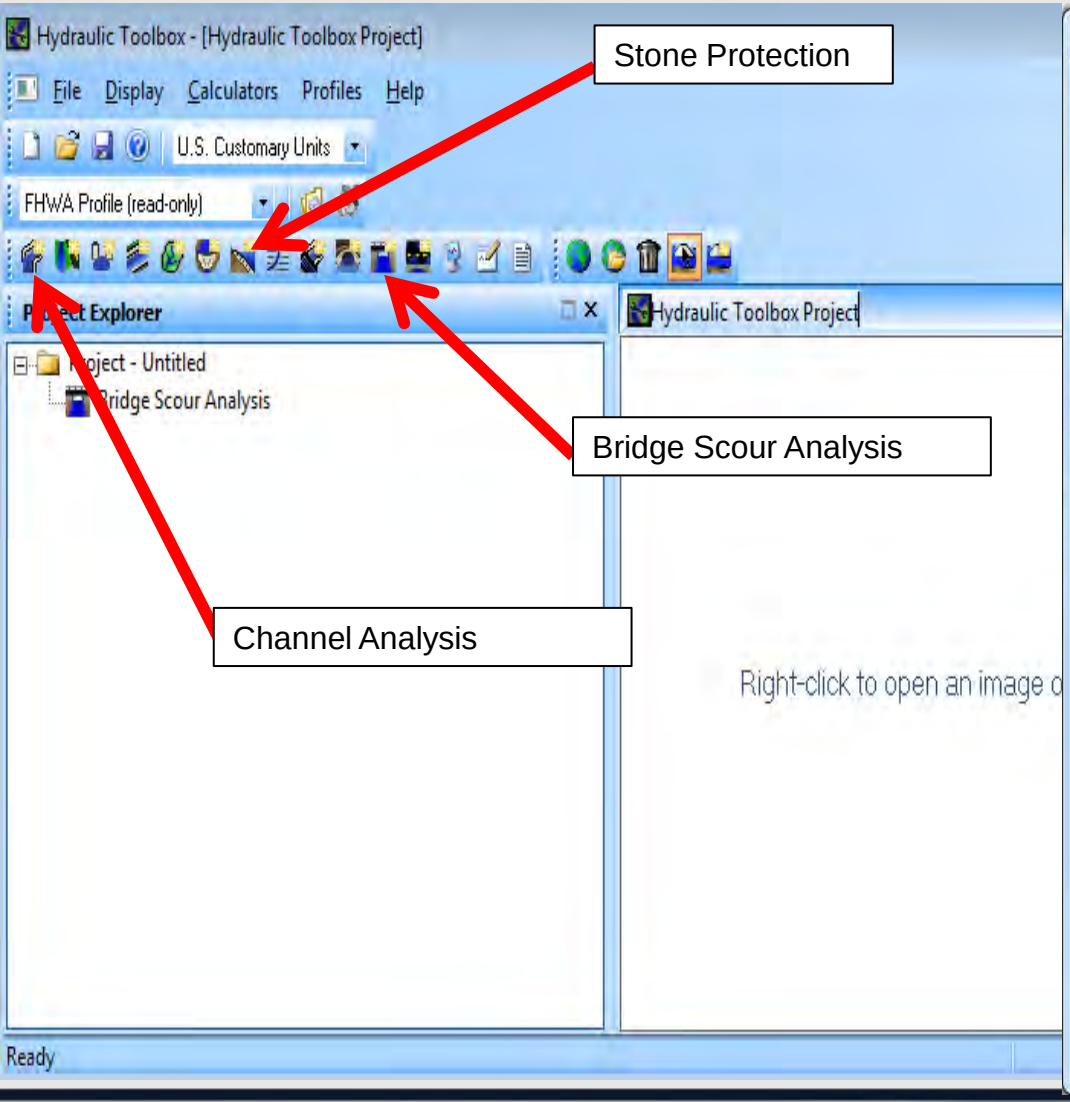
https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm

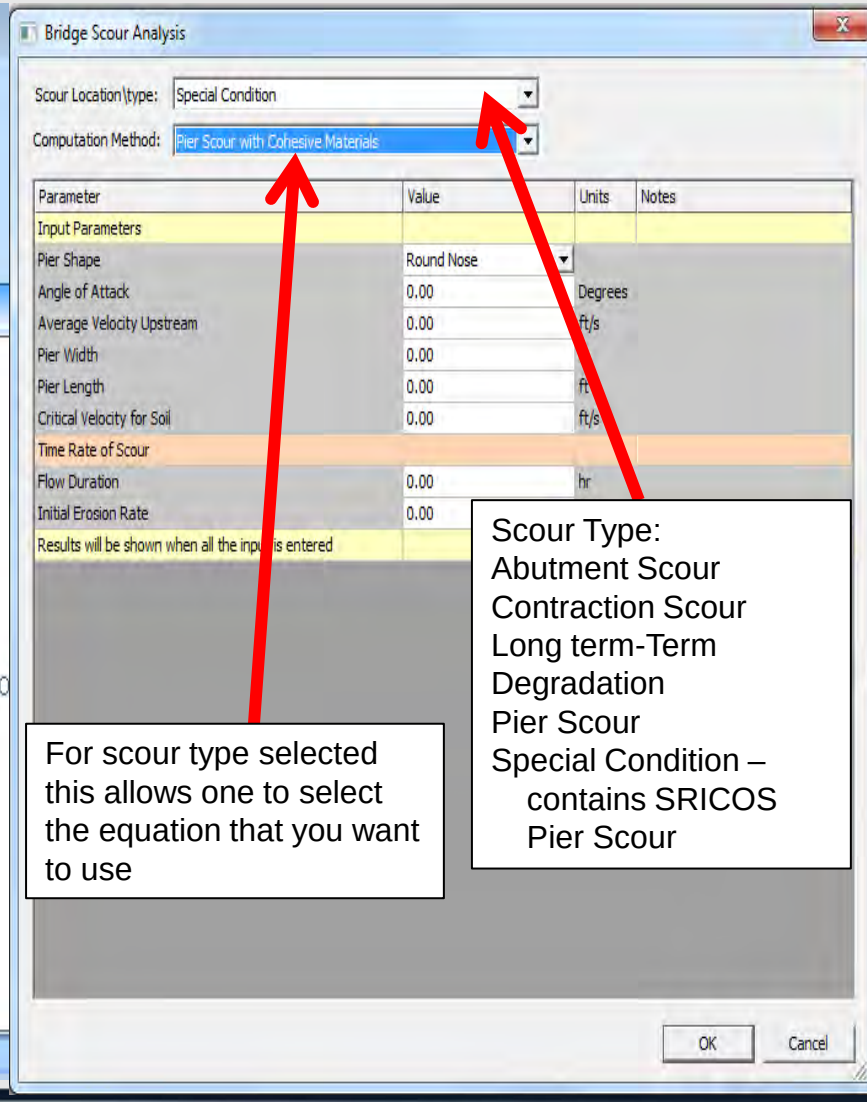
FHWA HYDRAULIC TOOLBOX

- Contains HEC-18 Sand Equations and various pier scour equations, such as: a) Florida DOT; b)SRICOS; c) Complex pier scour; d) Coarse Bed (i.e. large gravel)

- Also contains contraction scour and abutment scour equations, as well as stone protection calculations for D50 and a channel analysis calculations.

FHWA HYDRAULIC TOOLBOX





IF THE SCOUR PREDICTIONS ARE EXCESSIVE

- Verify Hydrology/Hydraulics

  (see TxDOT Research Project 0-6654 Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment)

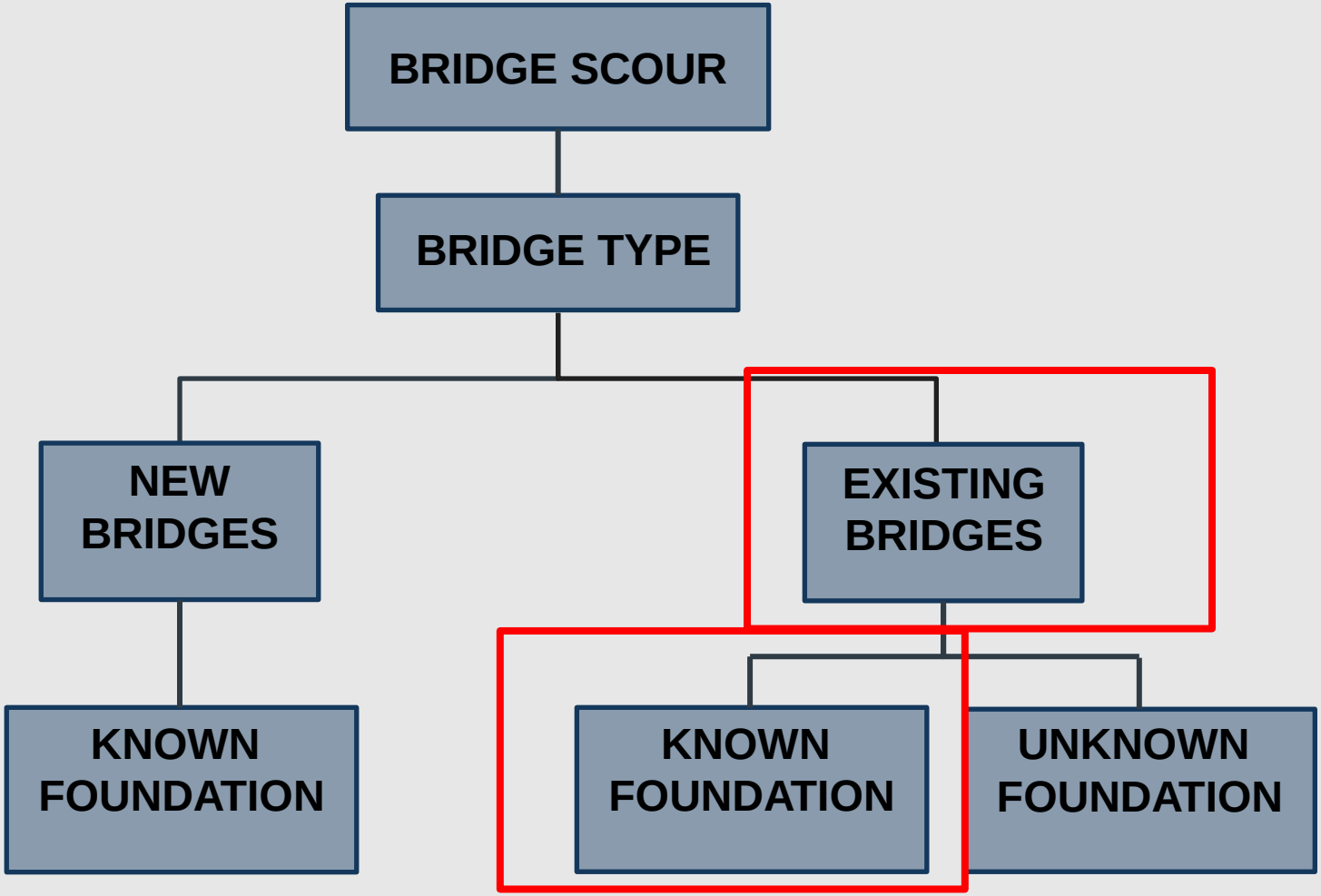
- Check the HEC-RAS model

  Some Items to Check:

  - Make sure the geometry is correct.
  - Make sure that you have checked the expansion and contraction coefficients for the sections around the bridge. The default values are too low to capture the energy loss.
  - Make sure that you have used the ineffective flow conditions for the sections adjacent to the bridge and have used them appropriately.
  - You may have to adjust the Manning's n values for the internal bridge cross sections.

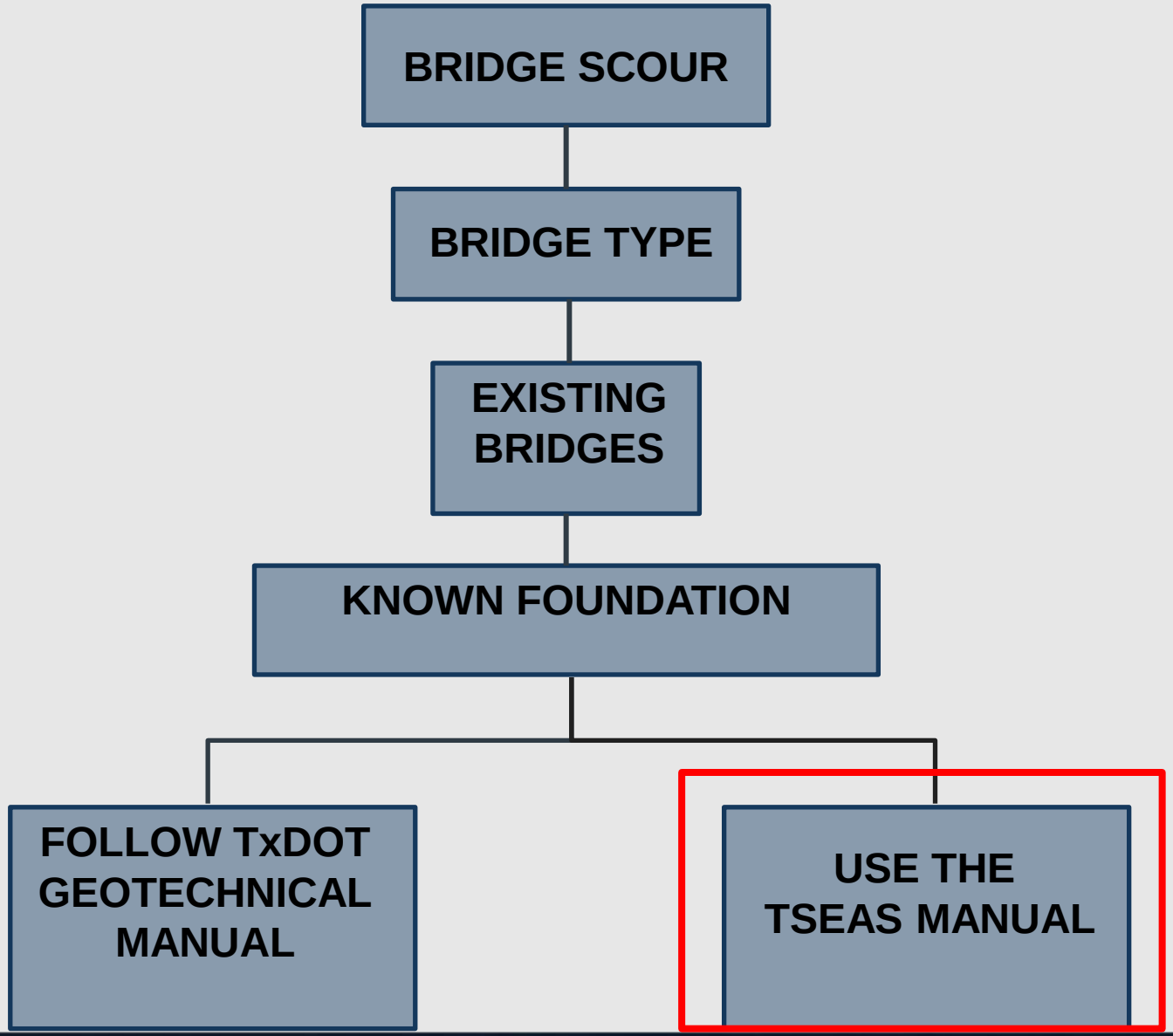
- Compare historic data of cross section changes at the bridge with the scour predictions

BRIDGE SCOUR EVALUATION PROCEDURES: Existing Bridges



SCOUR EVALUATION PROCEDURES FOR EXISTING BRIDGES

BRIDGE SCOUR EVALUATION PROCEDURES: Existing Bridges



BRIDGE SCOUR EVALUATION PROCEDURES: Existing Bridges

Texas Department of Transportation

Texas Secondary

Evaluation And

Analysis For Scour

(TSEAS)

for

Texas Bridge Scour Program

Prepared By

The Division of Bridges and Structures

Hydraulics Section

September 1993

The TSEAS Manual is used as a screening process to evaluate existing bridges and to determine the maximum allowable scour depth.

TSEAS Manual includes both an observational scour analysis and an "engineering" scour analysis.

http://ftp.dot.state.tx.us/pub/txdot-info/brg/geotechnical/tseas.pdf

BRIDGE SCOUR EVALUATION PROCEDURES: Existing Bridges

CRITICAL ROUTES = Evacuation Roadways; Emergency System Roadways; High AADT Roadways; School Routes with no Alternative Paths

TSEAS Manual

KNOWN FOUNDATION

Existing Structures

Concise Analysis

<u>Not to be used on bridges</u>:
- On Interstates
- On Critical Routes

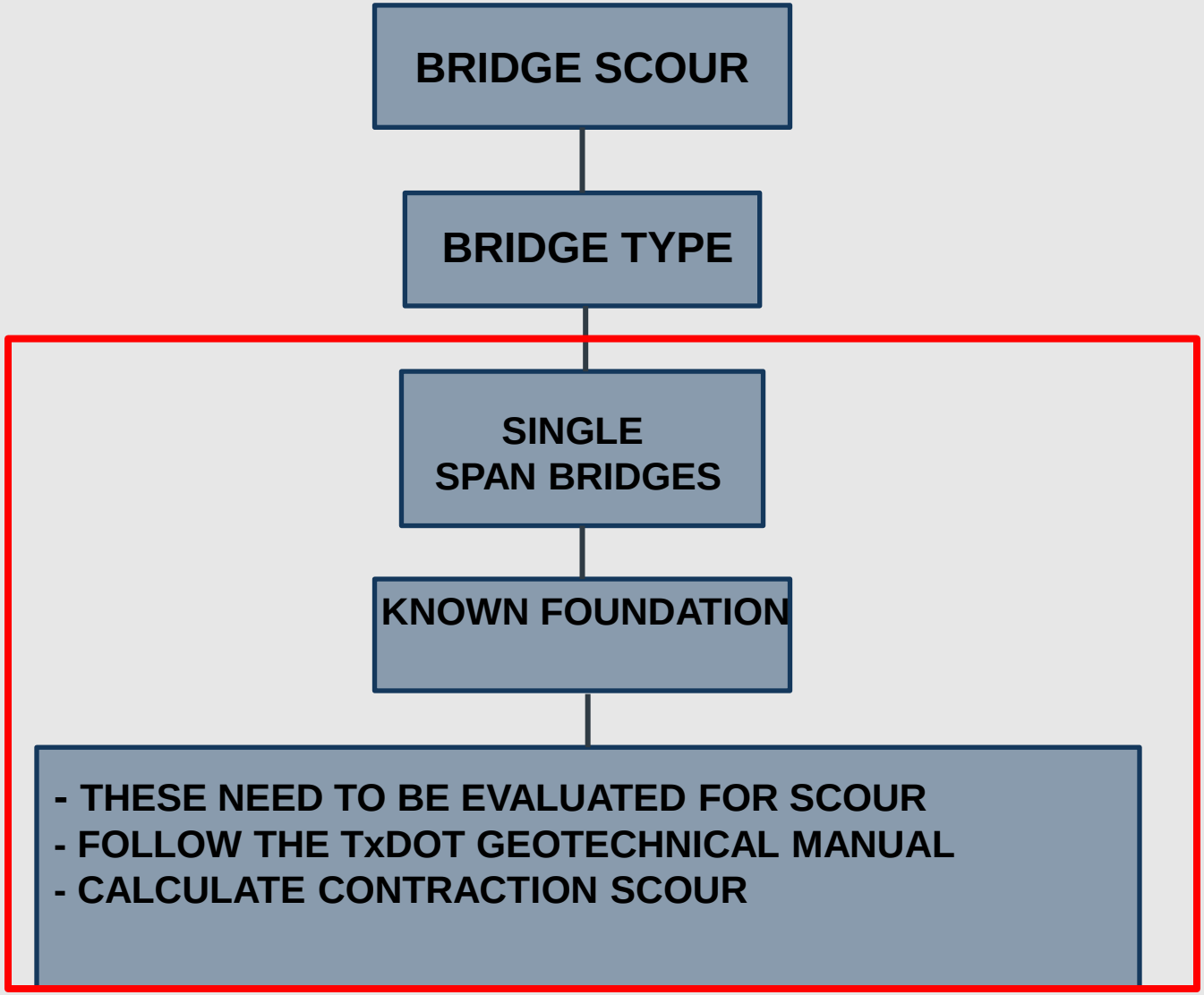
This is a simplified scour analysis that estimates allowable scour and pier scour, but only determines if contraction scour is a problem.

Secondary Screening

<u>ONLY USED</u> on Low Volume Off-System Bridges

This observation method includes a qualitative evaluation of the stability of the scour at the bridge.

BRIDGE SCOUR EVALUATION PROCEDURES: Single Span Bridges



SINGLE SPAN BRIDGE – January 2013

View looking downstream – north/northwest

Bridge was opened to traffic in 2007

View looking upstream - south

Undermining of the riprap – southwest corner

View looking west - southwest

SINGLE SPAN BRIDGE – October 2013

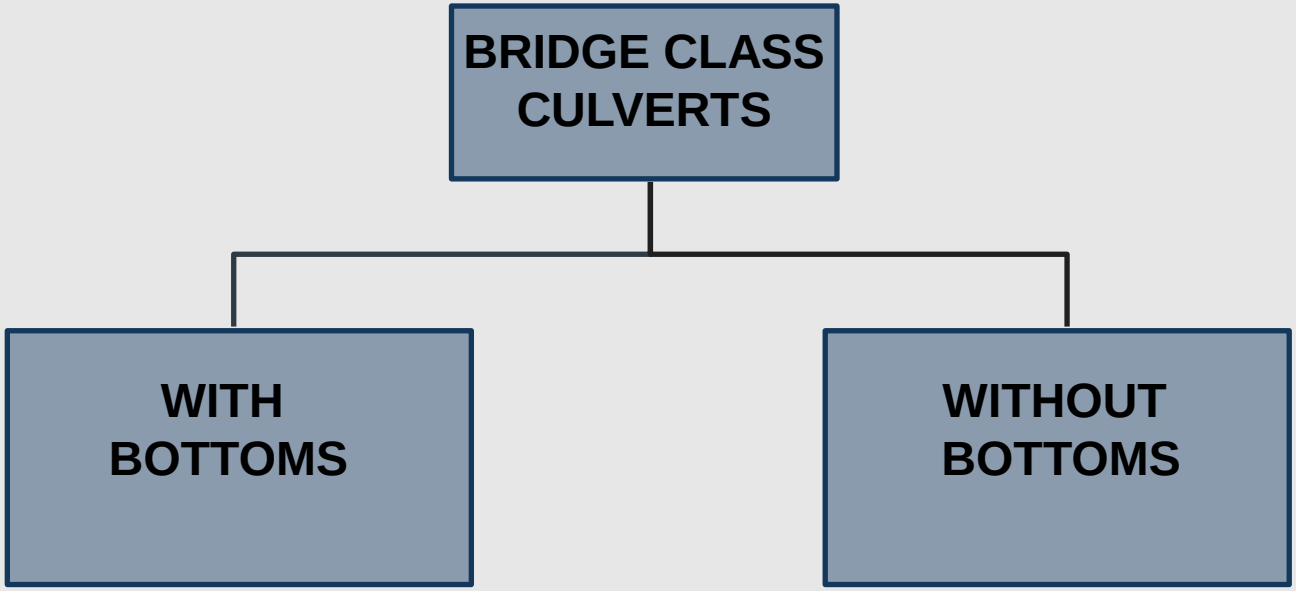
View looking upstream - south

View looking west - northwest

View looking east

View looking north under the west abutment

WHAT ABOUT BRIDGE CLASS CULVERTS?



BRIDGE CLASS CULVERTS – WITH BOTTOMS

March, 2008

- Guidelines were sent to each District on how to evaluate bridge class culverts for scour
- Districts can perform the evaluations

Scour Evaluation and Coding of Culverts March 2008

Questions have been raised regarding the appropriate coding of Item 113 (Scour Critical Bridges) in the Bridge Inspection Database for culverts. Please utilize the following criteria for coding culverts.

Concrete Box Culverts: Since typical concrete box culverts have integral bottom slabs which serve as the foundation for the box, they are not susceptible to scour in the traditional sense. Culverts typically do not fail in a catastrophic mode, but rather distort and deflect if foundation support is lost beneath the bottom slab. Loss of support is usually the result of water piping underneath the bottom slab, or a head cut undermining the downstream portion of the culvert floor. Neither of these mechanisms are predicted by the HEC-18 scour analysis.

The following criteria should be used for determining the coding of Item 113 for box culvert structures:

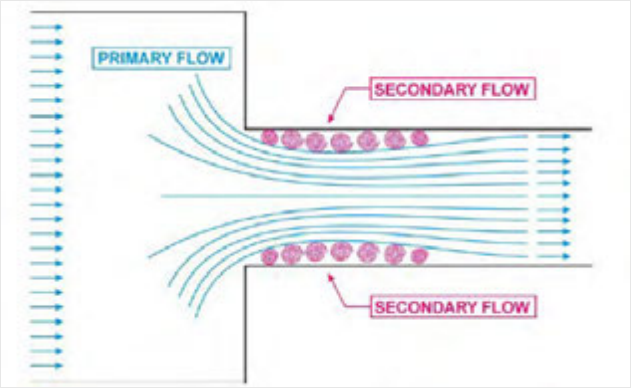
- In the absence of specific observed erosion, piping, or scour as described below, culverts should be coded "8".
- Where erosion, piping, or scour have occurred and exposed more than half of the toewall depth, a code of "4" should be assigned.
- Where erosion, piping, or scour have exposed the entire toewall and are beginning to undermine the bottom slab of the culvert, a code of "3" should be assigned.
- Where erosion, piping or scour have caused a significant portion of the bottom slab to be undermined with accompanying cracks, distress and distortion, a code of "2" should be assigned.

Pipe Culverts: Pipe culverts are similar to box culverts in that they have continuous support along the bottom of the structure.

The following criteria should be used for determining the coding of Item 113 for pipe culvert structures:

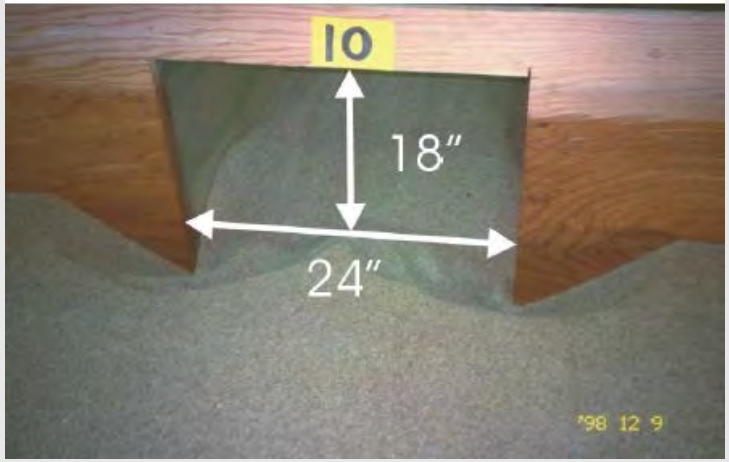
- In the absence of specific observed erosion, piping, or scour as described below, culverts should be coded "8".
- Where erosion, piping, or scour have occurred and exposed more than half of the toewall depth (where present) or undermined less than 1' of the pipe end, a code of "4" should be assigned.
- Where erosion, piping, or scour have exposed the entire toewall (where present) and have undermined more than 1' of the pipe end without observed distress, a code of "3" should be assigned.
- Where erosion, piping, or scour have exposed the entire toewall (where present) and have undermined more than 1' of the pipe end with accompanying cracks, distress and distortion, a code of "2" should be assigned.

BRIDGE CLASS CULVERTS – WITHOUT BOTTOMS

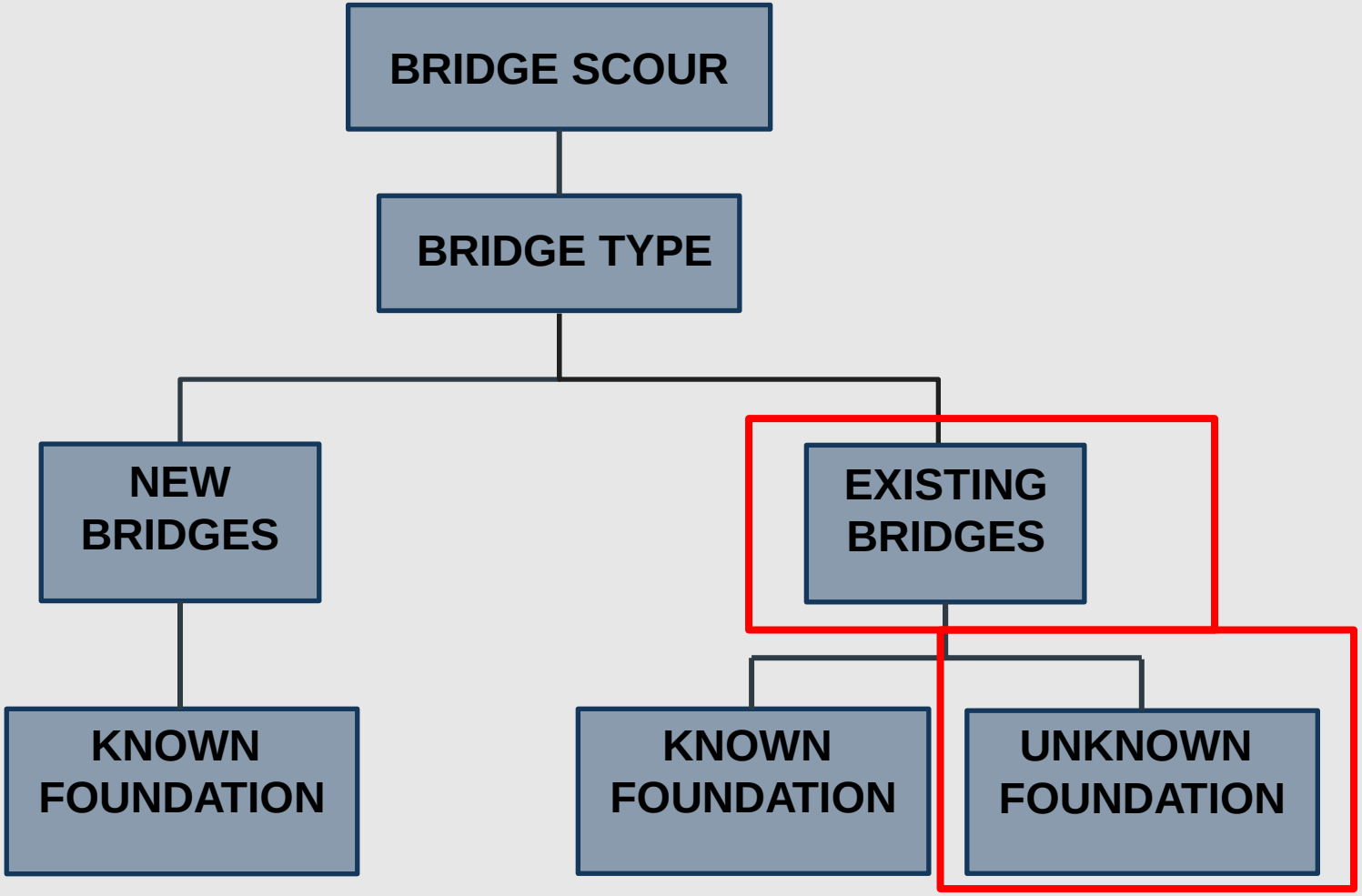


Need to be analyzed for scour using on of the methods outlined in the TxDOT Geotechnical Manual – Chapter 5 Section 5 Scour or using the FHWA Manual - Bottomless Culvert Scour Study: Phase II Laboratory Report.

If these are used the spread footing foundations should be supported on drilled shafts.



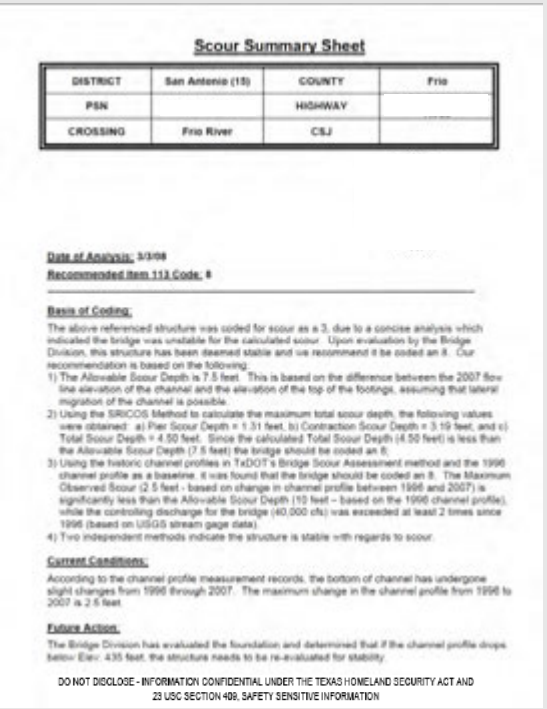
BRIDGE SCOUR EVALUATION PROCEDURES: Bridges with Unknown Foundations



GEOTECHNICAL BRANCH WILL ANALYZE BRIDGES WITH UNKNOWN FOUNDATIONS

SCOUR DOCUMENTATION

SCOUR SUMMARY SHEETS



Scour Summary Sheet

DISTRICT	San Antonio (15)	COUNTY	Frio
PSN		HIGHWAY	
CROSSING	Frio River	CSJ	

Date of Analysis: 3/3/08
Recommended Item 113 Code: 8

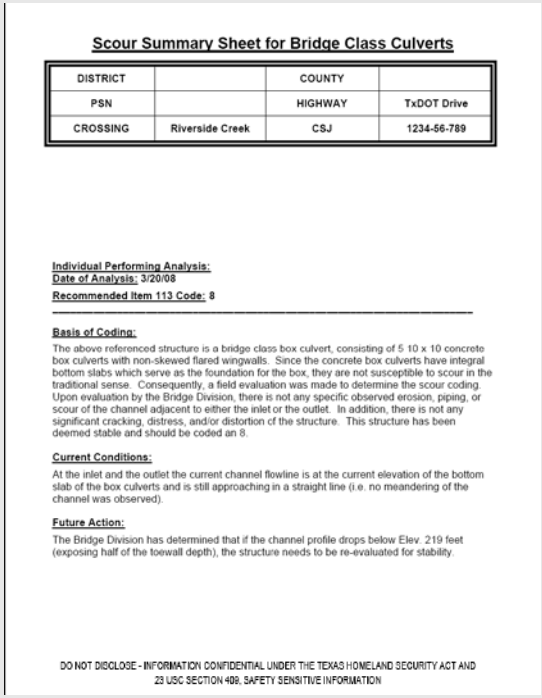
Basis of Coding:
The above referenced structure was coded for scour as a 3, due to a concise analysis which indicated the bridge was unstable for the calculated scour. Upon evaluation by the Bridge Division, this structure has been deemed stable and we recommend it be coded an 8. Our recommendation is based on the following:
1) The Allowable Scour Depth is 7.5 feet. This is based on the difference between the 2007 flow line elevation of the channel and the elevation of the top of the footings, assuming that lateral migration of the channel is possible.
2) Using the SRICOS Method to calculate the maximum total scour depth, the following values were obtained: a) Pier Scour Depth = 1.31 feet, b) Contraction Scour Depth = 3.19 feet, and c) Total Scour Depth = 4.50 feet. Since the calculated Total Scour Depth (4.50 feet) is less than the Allowable Scour Depth (7.5 feet) the bridge should be coded an 8.
3) Using the historic channel profiles in TxDOT's Bridge Scour Assessment method and the 1996 channel profile as a baseline, it was found that the bridge should be coded an 8. The Maximum Observed Scour (2.5 feet - based on change in channel profile between 1996 and 2007) is significantly less than the Allowable Scour Depth (10 feet – based on the 1996 channel profile), while the controlling discharge for the bridge (40,000 cfs) was exceeded at least 2 times since 1996 (based on USGS stream gage data).
4) Two independent methods indicate the structure is stable with regards to scour.

Current Conditions:
According to the channel profile measurement records, the bottom of channel has undergone slight changes from 1996 through 2007. The maximum change in the channel profile from 1996 to 2007 is 2.5 feet.

Future Action:
The Bridge Division has evaluated the foundation and determined that if the channel profile drops below Elev. 435 feet, the structure needs to be re-evaluated for stability.

DO NOT DISCLOSE - INFORMATION CONFIDENTIAL UNDER THE TEXAS HOMELAND SECURITY ACT AND 23 USC SECTION 409, SAFETY SENSITIVE INFORMATION

- **Scour Summary Sheets were developed for bridges with known foundations and bridge class culverts**
- **Guidelines for completing them and examples were sent out to the Districts in March 2008**
- **These are to be used to document the initial coding of bridges for scour and any changes in the coding of existing structures.**
- **To be placed in the Bridge Inspection Folder and in InspectTech.**



Scour Summary Sheet for Bridge Class Culverts

DISTRICT		COUNTY	
PSN		HIGHWAY	TxDOT Drive
CROSSING	Riverside Creek	CSJ	1234-56-789

Individual Performing Analysis:
Date of Analysis: 3/20/08
Recommended Item 113 Code: 8

Basis of Coding:
The above referenced structure is a bridge class box culvert, consisting of 5 10 x 10 concrete box culverts with non-skewed flared wingwalls. Since the concrete box culverts have integral bottom slabs which serve as the foundation for the box, they are not susceptible to scour in the traditional sense. Consequently, a field evaluation was made to determine the scour coding. Upon evaluation by the Bridge Division, there is not any specific observed erosion, piping, or scour of the channel adjacent to either the inlet or the outlet. In addition, there is not any significant cracking, distress, and/or distortion of the structure. This structure has been deemed stable and should be coded an 8.

Current Conditions:
At the inlet and the outlet the current channel flowline is at the current elevation of the bottom slab of the box culverts and is still approaching in a straight line (i.e. no meandering of the channel was observed).

Future Action:
The Bridge Division has determined that if the channel profile drops below Elev. 219 feet (exposing half of the toewall depth), the structure needs to be re-evaluated for stability.

DO NOT DISCLOSE - INFORMATION CONFIDENTIAL UNDER THE TEXAS HOMELAND SECURITY ACT AND 23 USC SECTION 409, SAFETY SENSITIVE INFORMATION

BRIDGE SCOUR DOCUMENTATION

Scour Summary Sheet

DISTRICT	San Antonio (15)	COUNTY	Frio
PSN		HIGHWAY	
CROSSING	Frio River	CSJ	

Date of Analysis: 3/3/08

Recommended Item 113 Code: 8

Basis of Coding:

The above referenced structure was coded for scour as a 3, due to a concise analysis which indicated the bridge was unstable for the calculated scour. Upon evaluation by the Bridge Division, this structure has been deemed stable and we recommend it be coded an 8. Our recommendation is based on the following:

1) The Allowable Scour Depth is 7.5 feet. This is based on the difference between the 2007 flow line elevation of the channel and the elevation of the top of the footings, assuming that lateral migration of the channel is possible.
2) Using the SRICOS Method to calculate the maximum total scour depth, the following values were obtained: a) Pier Scour Depth = 1.31 feet, b) Contraction Scour Depth = 3.19 feet, and c) Total Scour Depth = 4.50 feet. Since the calculated Total Scour Depth (4.50 feet) is less than the Allowable Scour Depth (7.5 feet) the bridge should be coded an 8;
3) Using the historic channel profiles in TxDOT's Bridge Scour Assessment method and the 1996 channel profile as a baseline, it was found that the bridge should be coded an 8. The Maximum Observed Scour (2.5 feet - based on change in channel profile between 1996 and 2007) is significantly less than the Allowable Scour Depth (10 feet – based on the 1996 channel profile), while the controlling discharge for the bridge (40,000 cfs) was exceeded at least 2 times since 1996 (based on USGS stream gage data).
4) Two independent methods indicate the structure is stable with regards to scour.

Current Conditions:

According to the channel profile measurement records, the bottom of channel has undergone slight changes from 1996 through 2007. The maximum change in the channel profile from 1996 to 2007 is 2.5 feet.

Future Action:

The Bridge Division has evaluated the foundation and determined that if the channel profile drops below Elev. 435 feet, the structure needs to be re-evaluated for stability.

DO NOT DISCLOSE - INFORMATION CONFIDENTIAL UNDER THE TEXAS HOMELAND SECURITY ACT AND 23 USC SECTION 409, SAFETY SENSITIVE INFORMATION

Recommended coding

Signed/Sealed document to be placed in the Bridge Inspection Folder/InspectTech

Basis of Coding describes the:

1) Current coding;

2) Updated coding;

3) The reason for updating the coding

Current Conditions describes the most recent channel conditions

Future Action describes a change in channel profile that would be considered significant enough to warrant an additional evaluation

BRIDGE SCOUR DOCUMENTATION

Scour Summary Sheet for Bridge Class Culverts

DISTRICT		COUNTY	
PSN		HIGHWAY	TxDOT Drive
CROSSING	Riverside Creek	CSJ	1234-56-789

Individual Performing Analysis:
Date of Analysis: 3/20/08
Recommended Item 113 Code: 8

Basis of Coding:

The above referenced structure is a bridge class box culvert, consisting of 5 10 x 10 concrete box culverts with non-skewed flared wingwalls. Since the concrete box culverts have integral bottom slabs which serve as the foundation for the box, they are not susceptible to scour in the traditional sense. Consequently, a field evaluation was made to determine the scour coding. Upon evaluation by the Bridge Division, there is not any specific observed erosion, piping, or scour of the channel adjacent to either the inlet or the outlet. In addition, there is not any significant cracking, distress, and/or distortion of the structure. This structure has been deemed stable and should be coded an 8.

Current Conditions:

At the inlet and the outlet the current channel flowline is at the current elevation of the bottom slab of the box culverts and is still approaching in a straight line (i.e. no meandering of the channel was observed).

Future Action:

The Bridge Division has determined that if the channel profile drops below Elev. 219 feet (exposing half of the toewall depth), the structure needs to be re-evaluated for stability.

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Signed/Sealed document to be placed in the Bridge Inspection Folder/InspectTech

Indicate the appropriate Item 113 code for the bridge based on the evaluation.

Describe/document the method(s) used to evaluate the bridge for scour.

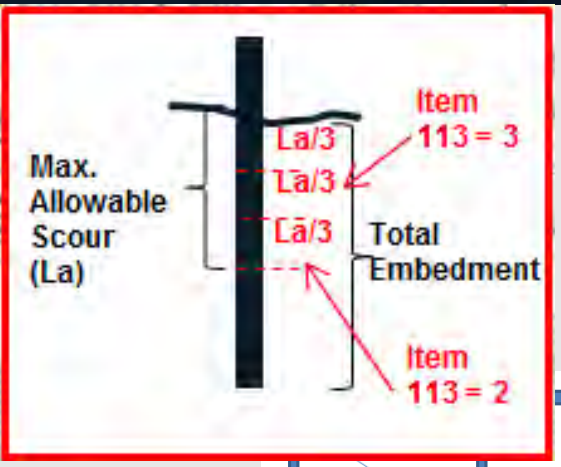
Describe/document the current conditions of the scour at the bridge.

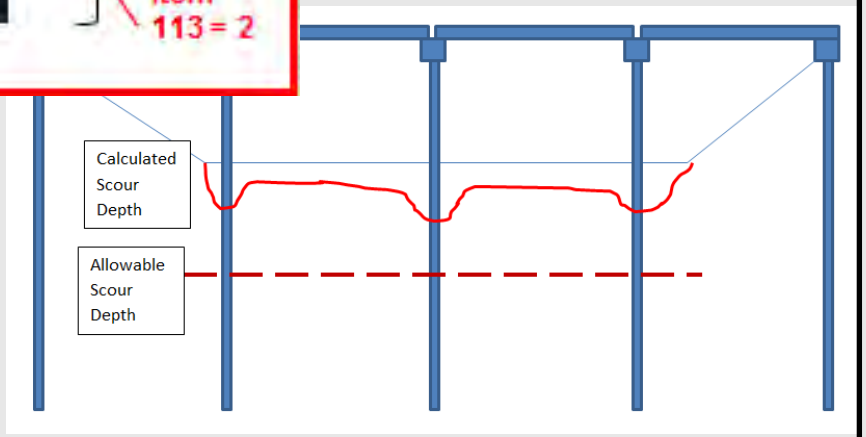
Describe/document the elevation that the scour depth can reach prior to the bridge having to be re-evaluated.

GUIDANCE FOR FUTURE ACTION

USE OF MAXIMUM ALLOWABLE SCOUR DEPTH AND GUIDELINE LIMITS ON WHEN TO CODE A BRIDGE A 3, 2, OR 1 IN ITEM 113

BRIDGE SCOUR DOCUMENTATION





WORKSHEET # 1

ALLOWABLE SCOUR DEPTH

BENT NUMBER: #3

LOCATION:

1	Elevation of natural ground at base of pier	459 ft
2	Elevation of bottom pier/drill shaft	423 ft
3	Depth of Embedment	36 ft
4	Top of Column Elevation	466 ft
5	Total length of column	7 ft
	Enter ds - drilled shaft, pt - trestle pile, phs - h/square pile	ds
	or ptb - timber pile	
6	Diameter of column/drill shaft or pile (inches)	30 in
7	Maximum Allowable scour depth based on Bearing	0.5*36 = 18 ft
	Allowable unsupported factor - ft/in of dia.	1.5
	Unsupported Column Length =	30*1.5 = 45 ft
9	Maximum Allowable scour depth: Lateral Stability =	45 – 7 = 38 ft
10	Max. Allow. Scour Depth=	18 ft

Maximum Scour Depth is controlled by Bearing, not Lateral Stability

Use the guidelines for

- **Max. Allow. Scour Depth/3 = 18/3 = 6 ft**
- **Max. Allow. Scour Depth*(2/3) = 18*(2/3) = 12 ft**

Bridge should be coded a 3 when the scour level is:

6 ft ≤ Scour Depth ≤ 12 ft

Bridge should be coded a 2 when the scour level is:

12 ft ≤ Scour Depth ≤ 18 ft

DOCUMENTATION

ALL SCOUR CODINGS NEED TO BE WELL DOCUMENTED, WITH THE DOCUMENTATION PLACED IN THE BRIDGE INSPECTION FOLDER AND IN InspectTech

SCOUR COUNTERMEASURES

SCOUR COUNTERMEASURES

RIGID

Impermeable

Does NOT conform to changes in the supporting surface

FLEXIBLE

Permeable

Conforms to changes in the supporting surface

SCOUR COUNTERMEASURES

RIGID

CONCRETE RIPRAP

GROUTED STONE PROTECTION

SCOUR COUNTERMEASURES: Rigid

Rigid Protection Visible Problems

- Undermined
- Voided
- Settled
- Cracked

SCOUR COUNTERMEASURES

FLEXIBLE

STONE PROTECTION

INTERLOCKING ARTICULATED CONCRETE BLOCKS

GABIONS

GABION MATTRESS

CONCRETE ARMOR UNITS

SCOUR COUNTERMEASURES

SCOUR COUNTERMEASURES: Flexible

The Geotechnical Branch recommends the use of flexible countermeasures, when applicable

ADVANTAGES

- Design is adaptable
- Construction is not complicated and does not require specialty equipment
- Has a natural appearance
- Failures are easily identified and can be fixed
- Easily inspected and repaired
- Rough surface
- Adjusts to distortions and local displacement of the foundation soil
- Movements can occur without complete failure and protection is still functional

DISADVANTAGES

- No standard – must be designed
- May be hard to obtain in some parts of Texas
- Near vertical gabions can be difficult to repair

SCOUR COUNTERMEASURES: Flexible - STONE PROTECTION

- In the 2014 Specification for Item 432 Riprap, is the size equal to the thickness?
  No.
- Why?
- In the **2004 Specification** the size was equal to the thickness, but some installations have had problems.
- In the **2014 Specification** the size is not equal to the thickness.
- Nearly all design methods for stone protection state that the thickness should be the larger of: 1) the largest size particle allowed (Dmax); or 2) twice the D50 size.
- Typically, the thickness is governed by 2 x D50, so a simple estimate of the thickness is 1.5 x size.
- Example, assume an 18 inch size, then from Table 2 the largest size is Dmax = 19.04” and D50 = 11.10” – 14.21”. Now Dmax = 19.04” < 2 x D50 = 2 x 11.10 – 2 x 14.21 = 22.20 – 28.42”. The 2 x D50 is the larger of the two values, so it would control the thickness.
- In the **2014 Specification Book** the size is listed and the thickness must be determined. This allows the engineer to select whatever thickness meets the need of the job.

Stone Protection (Size)
Thickness = XX

SUMMARY

- Scour at bridges is complex, but an evaluation of it is required to ensure the bridge is stable and the traveling public is safe
- Documenting the scour conditions indicates the current status of the bridge regarding its vulnerability to scour and what to do during flooding events
- Scour countermeasures are often required to prevent future scour and having the bridge become scour critical
- Flexible countermeasures are recommended and often required to stabilize conditions at the bridge

QUESTIONS?

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