



# Creating Useful Scour Documentation

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## What is scour

FHWA "Scour is the result of the erosive action of flowing water, excavating and carrying away material from the bed and banks of streams and from around the piers and abutments of bridges."



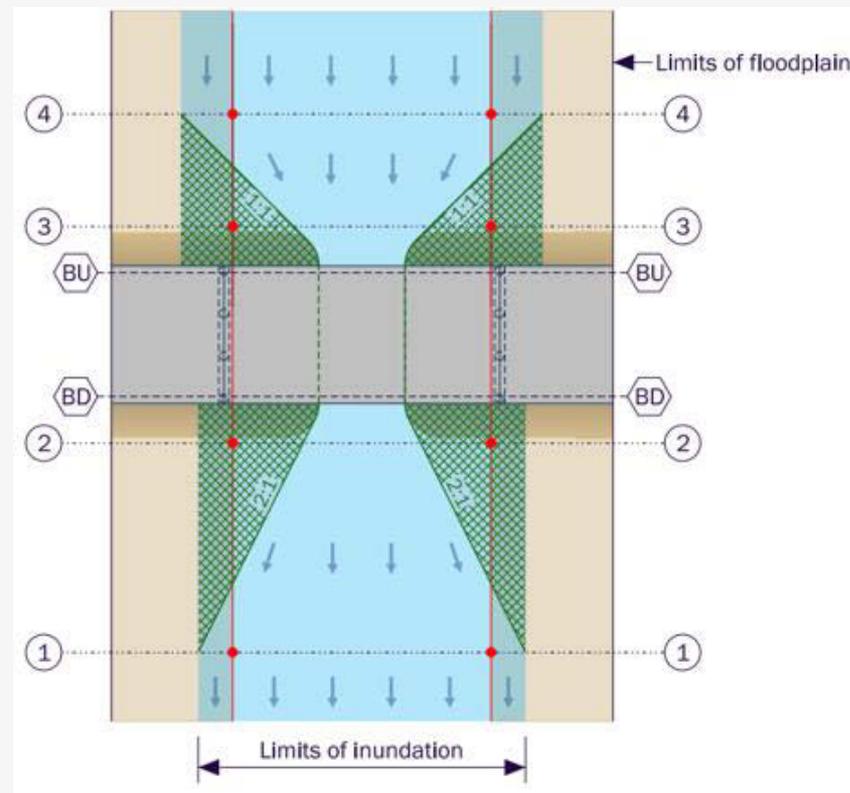
## More things to consider

- Different materials scour at different rates, however ultimate scour depth can be similar across soil types.
- Maximum scour often occurs during peak floods and may take several floods.
- Scour holes can refill, hiding damage.



## 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



## The Leading Cause of Bridge Failures

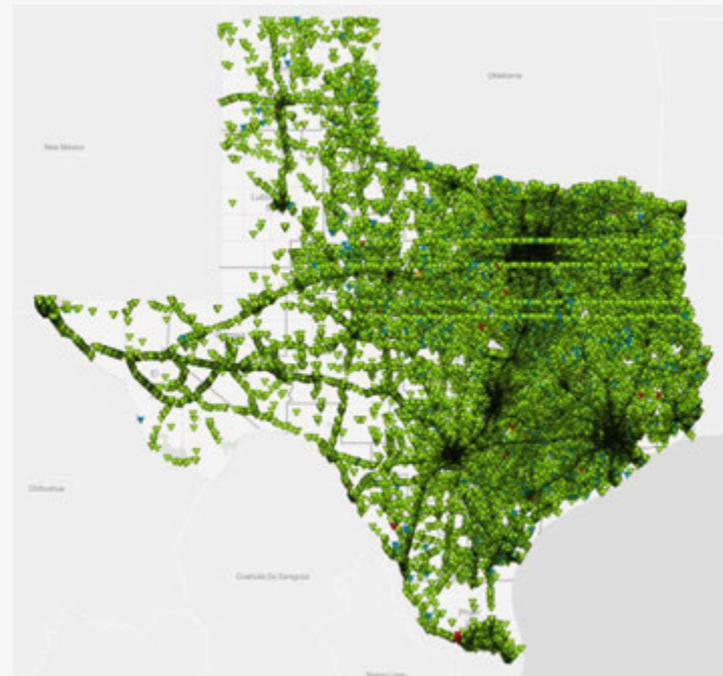
Scour is the primary cause of bridge collapses during floods.

- 1987 floods: 17 bridges destroyed in NY and New England.
- 1985 floods: 73 bridges failed across PA, VA, and WV.
- 1993 Mississippi flood: 23 bridge failures.
- 1994 Georgia storm: Over 500 bridges damaged



## TxDOT bridge inventory

- 58,923 total bridges
  - 46,464 bridges over water (79%)
    - Of these:
      - 21,346 bridge class culverts (36%)
      - ~1% scour critical

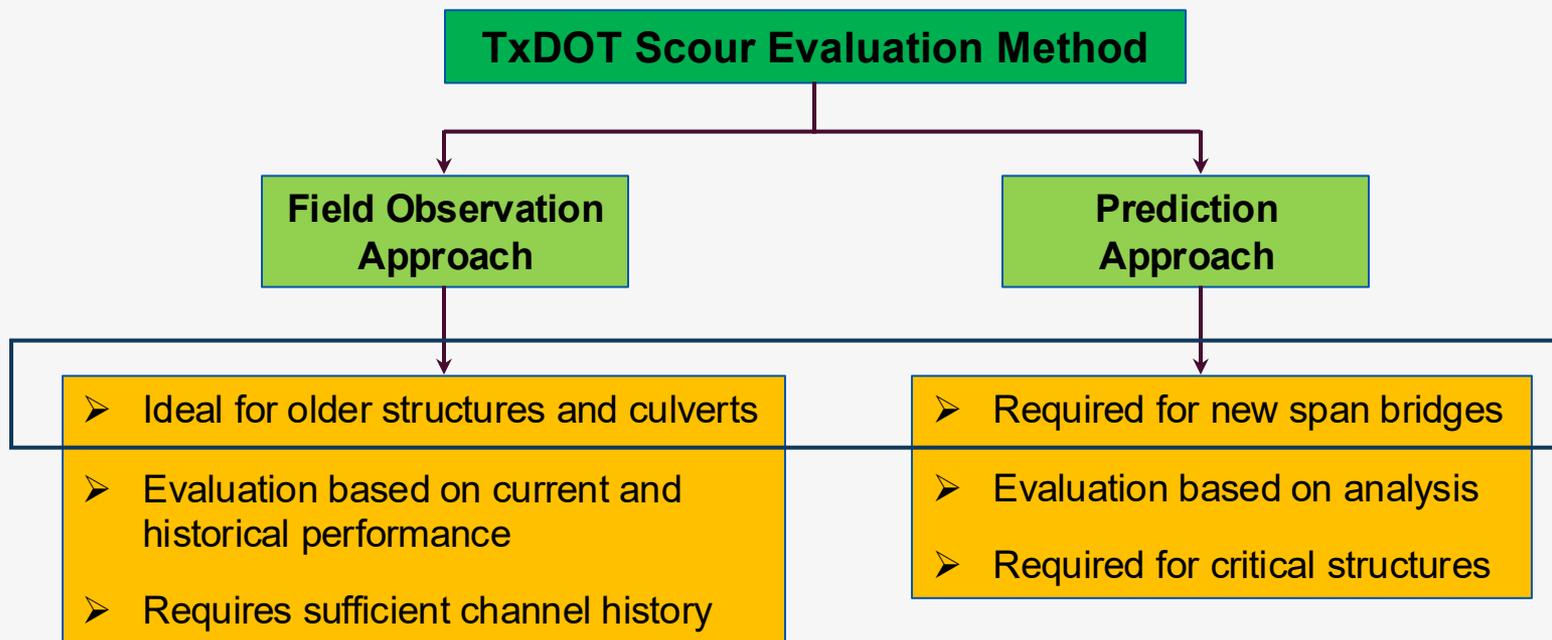


## Objectives of scour evaluation program

- Minimizing future flood damage requires greater focus on developing and applying improved procedures for designing and inspecting bridges for scour.

## Importance of Scour Evaluation

- Scour documentation
  - Rapid evaluation in flood response
  - Prioritization of structures for replacement
  - Identify structures requiring repair
- Supports cost-effective maintenance and rehabilitation strategies.
- Helps prevent bridge collapse and loss of life.
- FHWA mandates evaluation of scour for all bridges over waterways.



## Scour Documentation

Scour Summary Sheet supported by

- Scour analysis
- Scour screening evaluation
- Scour vulnerability assessment
- Risk assessment for unknown foundations
- Plan of action for scour critical structures
- In depth capacity analysis
- Plan of action follow up

## Scour Summary Sheet Contents

- Bridge information
- Engineer's seal and signature
- Countermeasure condition
- Maximum allowable scour depth
- Observed scour depth
- Trigger elevation (for reevaluation)
- Description for future action

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 2	Abut 1
$y_{ab}$ <input checked="" type="checkbox"/> or $y_{ar}$ <input type="checkbox"/>	15	
$y_{al}$	25	
Max Allowable Scour Depth <sup>1</sup> , $y_a$	15 (Elev. 200)	
Max Possible Scour Depth <sup>2</sup>		See Trigger
Calculated Contraction Scour	5	
Calculated Pier Scour	2.5	
Total Calculated Scour Depth	7.5	
Observed Scour Depth	10 (Elev. 195)	See below
Notes: (1) Min ( $y_{ar}$ or $y_{ab}$ or $y_{al}$ ). (2) ONLY applicable if a non-erodible stratum is present.		
Abutment Protection Condition: None or Minor <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Major <input type="checkbox"/> B.C.05		

Form 2605  
(Rev. 03/24)  
Page 3 of 3

### TRIGGER ELEVATION & FUTURE ACTION

Refer to Chapter 10 of the Scour Evaluation Guide.

Current scour at abutment exposed toe wall of CRR. Considered moderate exposure condition.

Re-evaluation will be needed:

- When scour exposed the bottom of abutment cap
- When scour at Bent 2 exceeded 13 feet (Elev. 198')

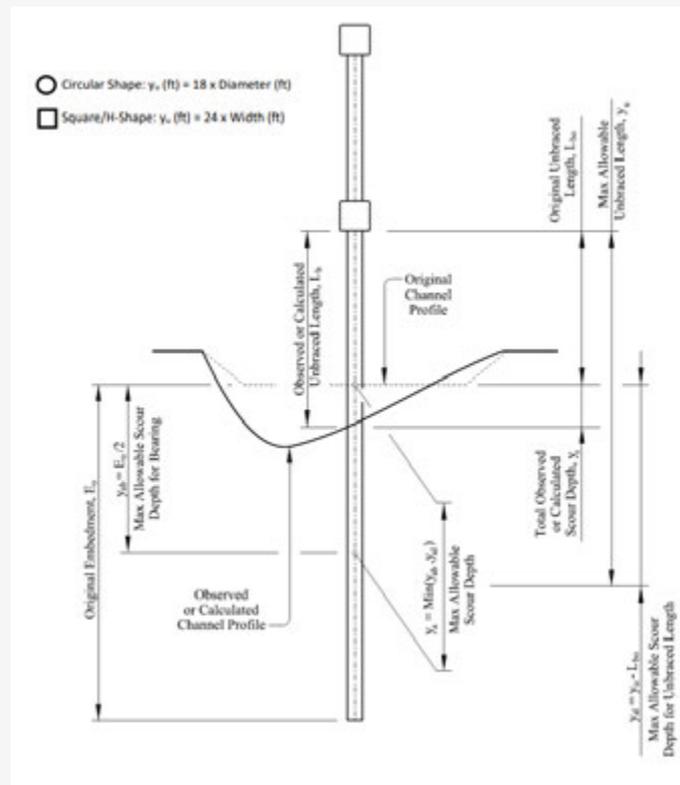
## Maximum Allowable Scour – Span Bridges

- Amount of scour that can occur before a bridge foundation becomes unstable due to:
  - Bearing capacity
  - Lateral support
  - Rotational stiffness
  - Other applicable failure modes

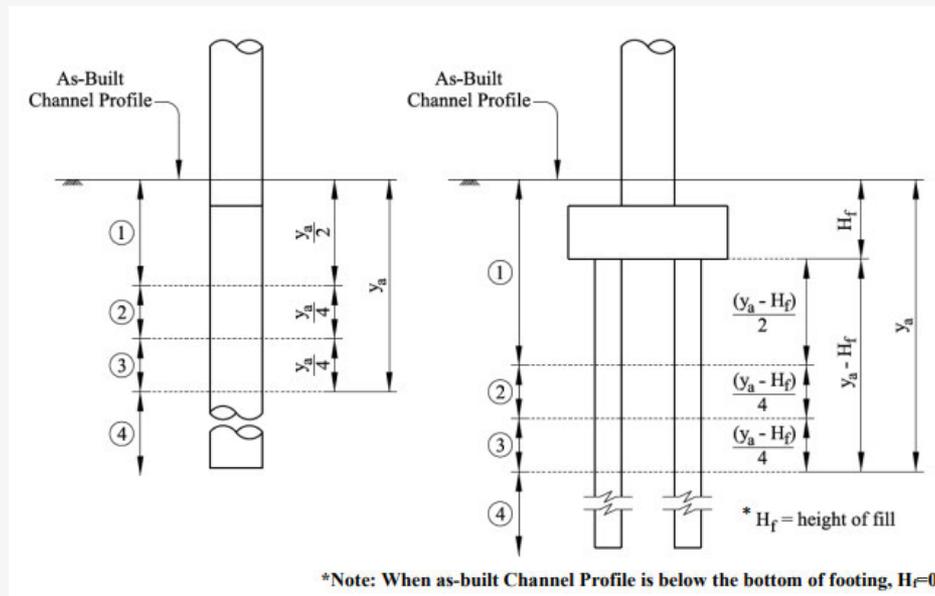


## Maximum Allowable Scour – Deep Foundations

- Geotechnical capacity assumptions
  - Factor of safety of 2 from original embedment
  - Uniform material along full length of element
  - End-bearing neglected
  - No disregard depth from original channel profile

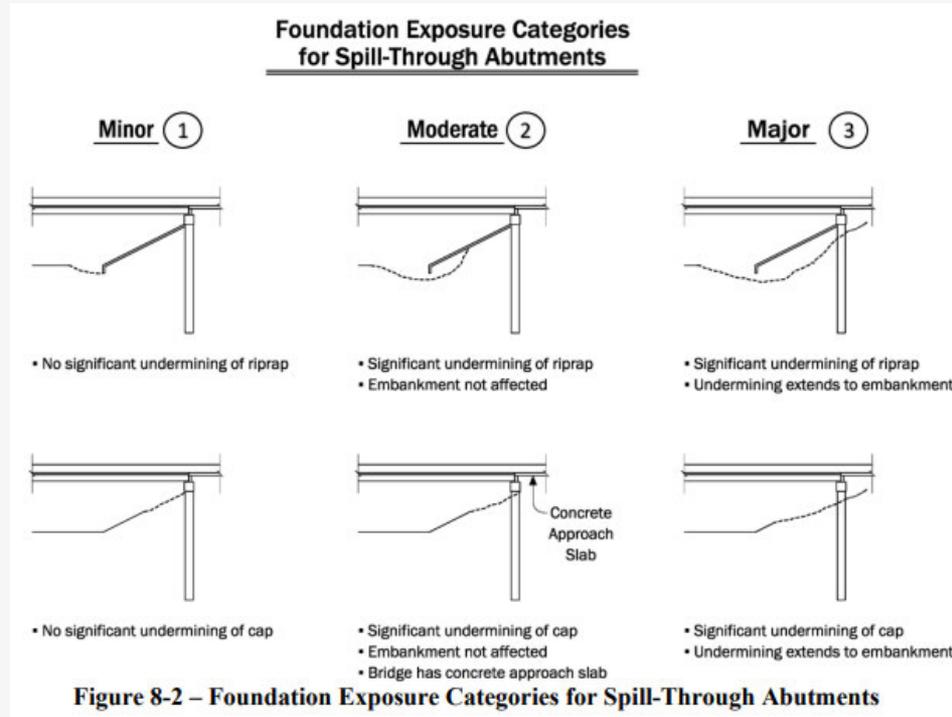


# Exposure Categories - Deep Foundations



- 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)

# Exposure Categories - Abutments



## Exposure Categories - Abutments



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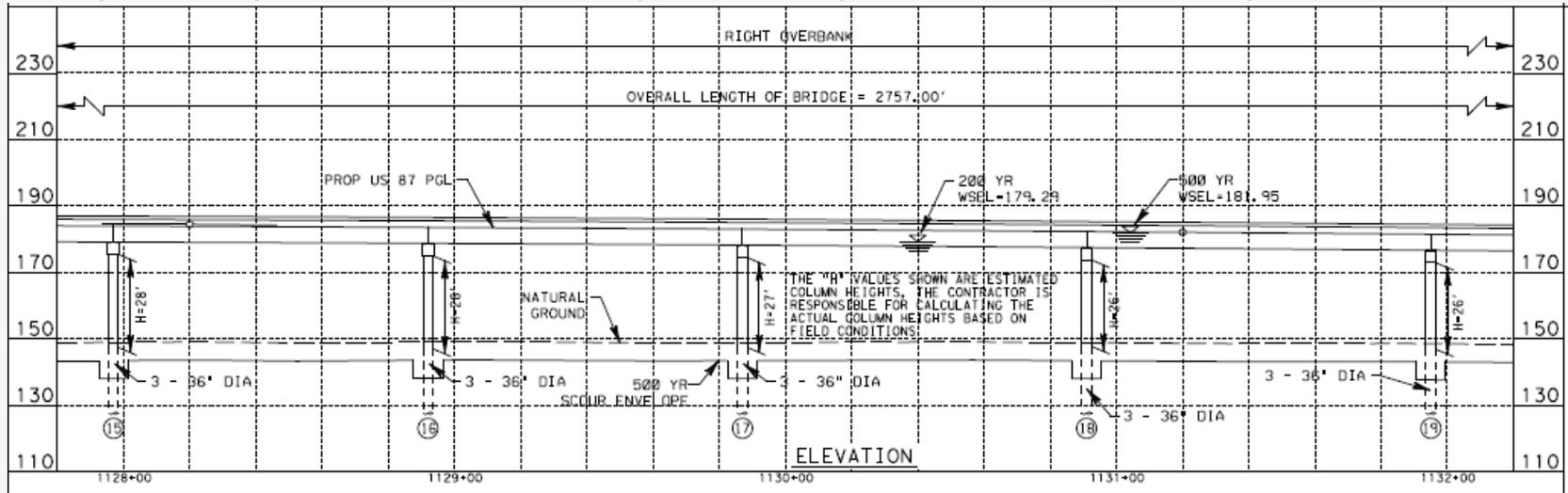


## Scour Analysis Methods

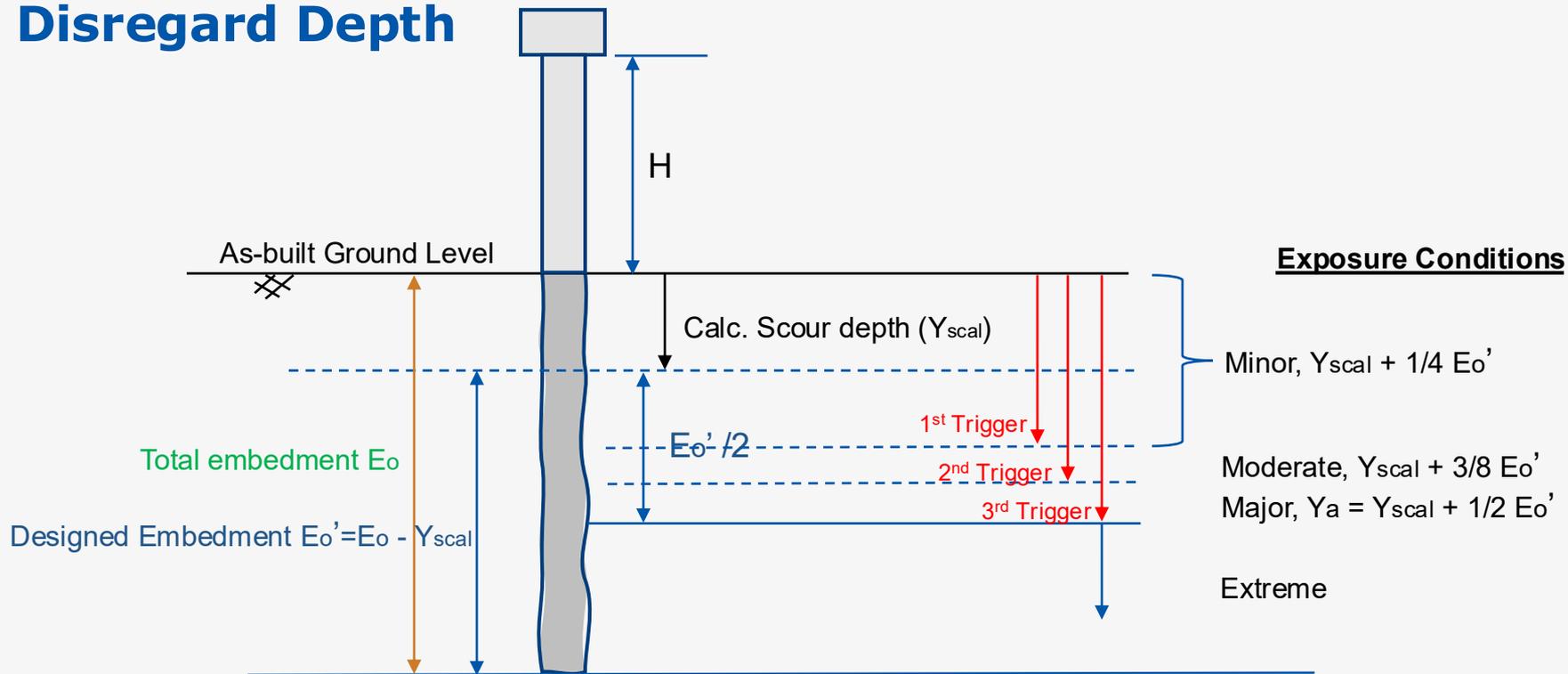
- Contraction Scour
  - Traditional HEC-18 method
    - Sandy Soils
  - SRICOS method
    - Clay and soft rock
  - Pressure method
    - Water above bridge low chord
- Pier Scour
  - Traditional HEC-18 method
    - Sandy Soils
  - SRICOS method
    - Clay and soft rock
  - Annandale's Erodibility Index method
    - Fractured/jointed rock

## New Structures

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



# Disregard Depth



## Plan of Action Contents

- Bridge information
- Engineer's seal and signature
- Current scour and channel coding
- Scour vulnerability rating
- Monitoring plan
- Countermeasure recommendations

## Plan of Action

Required for scour critical bridges

- Monitoring program considered as scour countermeasure only if specific details are provided (e.g., flood elevation or precipitation)

Other Monitoring Program

Type:  Visual  Other:

Flood Monitoring Required:  Yes  No

Trigger Conditions for Flood Monitoring:

Discharge:

Stage:

Other:

# NOAA ATLAS 14

NOAA ATLAS 14 data can be used for the precipitation estimate

PDF tabular | **IT graphical** | Supplementary information | [Print page](#)

**POD-based precipitation frequency estimates with 90% confidence intervals (in inches)<sup>1</sup>**

Duration	Average recurrence interval (years)									
	1	2	3	5	10	25	50	100	200	500
1-min	0.378 (0.284-0.495)	0.644 (0.361-0.985)	0.930 (0.424-0.732)	0.946 (0.405-0.855)	0.768 (0.527-1.04)	0.643 (0.455-1.16)	0.542 (0.355-1.25)	0.463 (0.281-1.05)	0.403 (0.241-0.71)	0.322 (0.173-0.48)
5-min	0.607 (0.408-0.922)	0.774 (0.549-0.941)	0.894 (0.651-1.16)	1.24 (0.788-1.35)	1.38 (0.888-0.98)	1.24 (0.801-1.82)	1.12 (0.625-1.1)	1.03 (0.52-1.1)	0.92 (0.38-0.92)	0.83 (0.32-0.92)
15-min	0.753 (0.579-0.985)	0.883 (0.679-1.16)	1.10 (0.845-1.42)	1.25 (0.869-1.75)	1.52 (1.02-2.01)	1.69 (1.26-2.06)	1.86 (1.28-2.06)	2.03 (1.46-2.37)	2.25 (1.62-2.39)	2.49 (1.82-2.69)
30-min	0.88 (0.704-1.37)	0.99 (0.824-1.38)	1.16 (1.16-1.82)	1.25 (1.12-2.35)	1.47 (1.02-2.02)	1.69 (1.43-2.1)	1.86 (1.75-3.42)	2.03 (1.88-3.04)	2.25 (1.88-3.04)	2.49 (2.08-3.04)
60-min	0.92 (0.71-1.78)	1.08 (0.72-2.08)	1.38 (1.16-2.08)	1.47 (1.16-2.08)	1.75 (1.46-2.08)	1.86 (1.46-2.08)	2.03 (1.86-3.04)	2.25 (2.08-3.04)	2.49 (2.08-3.04)	2.78 (2.19-3.42)
2-hr	1.69 (1.22-2.08)	1.81 (1.47-2.47)	2.49 (1.88-3.14)	2.65 (2.14-3.7)	3.41 (2.49-3.98)	3.55 (2.74-3.98)	4.36 (2.88-4.96)	4.77 (3.28-4.96)	5.43 (3.58-4.96)	5.94 (3.78-4.96)
3-hr	1.75 (1.34-2.37)	2.31 (1.62-2.7)	2.69 (2.08-3.42)	3.59 (2.42-4.16)	3.88 (2.88-4.96)	4.39 (3.48-4.96)	4.95 (3.48-4.96)	5.54 (3.78-4.96)	6.28 (4.16-4.96)	7.04 (4.16-4.96)
6-hr	2.02 (1.57-2.85)	2.68 (1.92-3.15)	3.18 (2.48-4.97)	3.79 (2.81-4.97)	4.67 (3.48-4.96)	5.38 (3.87-7.26)	6.11 (4.28-4.96)	6.92 (4.79-7.26)	8.08 (5.32-7.26)	9.01 (5.78-7.26)
12-hr	2.38 (1.63-2.85)	2.88 (2.24-3.98)	3.29 (2.88-4.42)	4.08 (3.44-5.78)	4.95 (3.75-7.26)	5.51 (4.44-5.78)	6.28 (5.18-7.26)	7.23 (5.78-7.26)	8.28 (6.78-7.26)	9.9 (7.78-7.26)
24-hr	2.79 (1.7-4.81)	3.33 (2.64-4.96)	4.27 (3.38-5.16)	5.12 (4.02-5.16)	6.38 (4.82-5.16)	7.43 (5.11-5.16)	8.57 (6.82-5.16)	9.85 (7.88-5.16)	11.7 (9.18-5.16)	13.2 (8.58-5.16)
3-day	3.12 (2.48-3.81)	3.83 (3.03-4.97)	4.89 (3.88-4.97)	6.04 (4.61-7.36)	7.29 (5.58-9.34)	8.42 (6.22-11.8)	9.79 (6.88-11.8)	11.2 (7.78-11.8)	13.3 (8.82-11.8)	15.6 (9.83-11.8)
5-day	3.41 (2.74-4.76)	4.18 (3.18-4.96)	5.39 (4.28-4.96)	6.52 (5.02-7.36)	7.82 (6.08-8.58)	9.34 (7.02-11.8)	10.9 (8.28-11.8)	12.9 (9.18-11.8)	14.2 (10.18-11.8)	16.8 (10.18-11.8)
6-day	3.62 (2.88-4.48)	4.49 (3.53-5.16)	5.85 (4.53-4.96)	6.88 (5.31-4.96)	8.24 (6.35-9.34)	9.52 (7.18-11.8)	10.9 (7.88-11.8)	12.5 (8.77-11.8)	14.8 (9.77-11.8)	16.6 (10.8-11.8)
7-day	4.05 (3.1-4.81)	4.92 (3.88-4.96)	6.29 (4.95-7.43)	7.46 (5.88-7.43)	8.97 (6.82-11.8)	10.5 (7.88-11.8)	12.0 (8.58-11.8)	13.8 (9.82-11.8)	15.8 (10.18-11.8)	17.7 (11.24-11.8)
10-day	4.41 (3.38-5.16)	5.34 (4.38-4.96)	6.81 (5.38-6.28)	8.08 (6.38-8.58)	9.88 (7.88-11.8)	11.3 (8.58-11.8)	12.8 (9.34-11.8)	14.5 (10.2-11.8)	16.7 (11.2-11.8)	18.9 (12.3-11.8)
29-day	5.62 (4.53-6.88)	6.57 (5.45-7.88)	8.29 (6.88-8.58)	9.71 (7.88-11.8)	11.7 (9.18-11.8)	13.7 (10.18-11.8)	15.7 (11.2-11.8)	18.2 (12.3-11.8)	20.4 (13.2-11.8)	23.4 (15.2-11.8)
30-day	6.45 (5.32-7.78)	7.58 (6.38-7.43)	9.48 (7.88-11.8)	11.0 (9.18-11.8)	13.1 (10.18-11.8)	14.8 (11.2-11.8)	16.2 (12.3-11.8)	17.8 (13.2-11.8)	20.1 (14.2-11.8)	21.9 (15.2-11.8)
60-day	7.75 (6.43-7.78)	9.62 (7.88-11.8)	11.2 (9.18-11.8)	13.0 (10.18-11.8)	15.2 (11.2-11.8)	16.8 (12.3-11.8)	18.5 (13.2-11.8)	20.2 (14.2-11.8)	22.0 (15.2-11.8)	24.2 (16.2-11.8)
90-day	8.91 (7.42-9.68)	10.3 (8.58-11.8)	12.7 (10.18-11.8)	14.5 (11.2-11.8)	17.4 (13.2-11.8)	19.8 (14.2-11.8)	22.3 (15.2-11.8)	24.7 (16.2-11.8)	27.1 (17.2-11.8)	29.2 (18.2-11.8)

<sup>1</sup> Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parentheses are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates for a given duration and average recurrence interval will be greater than the upper bound or less than the lower bound is 5%. Estimates of upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

Other Monitoring Program

Type:  Visual  Other:

Flood Monitoring Required:  Yes  No

Trigger Conditions for Flood Monitoring:  Discharge:

Stage: 2 yr 24 hr precipitation 3.0 inch

Other:

## Example



## Example (cont.)



## Example (cont.)

FOUNDATION DETAILS	
<input type="checkbox"/>	The foundation is protected by a non-erodible stratum. (Describe below.) Majority of DS is embedded in clays. Drilled-and-underreamed portion embedded in shale (range elev. 288 to 290'). <small>Refer to Chapter 7 of the TxDOT Scour Evaluation Guide.</small>
<input type="checkbox"/>	The foundation is supported by unknown foundations. (List any assumptions below.) Since drilled-and-underreamed shafts were used and they were founded in shale, assumed end bearing has been considered as a major component of the bearing capacity. <small>Refer to Chapter 6 of the TxDOT Scour Evaluation Guide.</small>
INSPECTION DETAILS	
Date of Most Recent Inspection:	<input type="text"/>
<input type="checkbox"/>	Scour countermeasures have been installed and are performing well. (Describe below.) Condition of gabion baskets is still good (with a few baskets broken). Continue to monitor the gabion performance.

SCOUR DEPTHS					
<input checked="" type="checkbox"/>	Scour depths are measured from the as-built channel profile.				
<input checked="" type="checkbox"/>	Scour depths are measured from: <input type="text" value="Yal measured from nearest tie-beam (which vary)"/>				
Abutment or Bent #	4	5	6	7	
Y <sub>ab</sub> <input checked="" type="checkbox"/> or Y <sub>ar</sub> <input type="checkbox"/>	26' (elev 296)*	20' (elev 296)*	28' (elev 296)*	34' (elev 296)*	
Y <sub>al</sub>	34'	29'	34'	36'	
Max Allowable Scour Depth <sup>1</sup> , y <sub>a</sub>	26' (elev 296)*	20' (elev 296)*	28' (elev 296)*	34' (elev 296)*	
Max Possible Scour Depth <sup>2</sup>					
Calculated Contraction Scour					
Calculated Pier Scour					
Total Calculated Scour Depth					
Observed Scour Depth	0.0	0.0	9.7	2.0	

Notes: (1) Max Allowable Scour Depth is based on the maximum possible scour depth.

## Case Study (Cont.)

### TRIGGER ELEVATION & FUTURE ACTION

Refer to Chapter 10 of the Scour Evaluation Guide.

\*See calculation for deepening Yab based on end bearing and the strata of shale.  
 Channel seems stable at elev 316' (or no vertical scour further), and has sign of later migration southward.  
 Trigger for Bents 4 to 7: when observed scour reach elev. 296'.

#### Justification by calculation.

Design load from as-built - For 24' roadway, 30.4 tons per shaft.

Design load	24'	30.4	4.79	5875	590	6560
Rating	2	600	600	600	600	600

#### GENERAL NOTES:

Design: H-15-44 Loading (Two lanes) in accordance with 2011 & 1949 Specifications as amended by T.H.D. Supplement No. 1.  
 All concrete shall be Class 4. Chamfer all exposed corners, except as noted.  
 Dimensions relating to reinforcing steel are to centers of bars.  
 Average calculated per 100 sq ft: Roadway=278 tons, 24' Roadway=30.4 tons, 27' Roadway=33.0 tons.  
 Street forms as per included form detail sheet shall be used.  
 Re-bars to the 18" x 18" bents are to be placed per instructions with 20' spacing 153-417 before being placed to the reinforcing men.

TEXAS HIGHWAY DEPARTMENT  
**30'-0" CONCRETE SLAB  
 AND GIRDER SPAN**  
 21', 24', & 27' ROADWAYS - NO CURBS  
 H-15 LOADING CG-1!

Sheet of 4	1	2	3	4
1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35
36	37	38	39	40
41	42	43	44	45
46	47	48	49	50
51	52	53	54	55
56	57	58	59	60
61	62	63	64	65
66	67	68	69	70
71	72	73	74	75
76	77	78	79	80
81	82	83	84	85
86	87	88	89	90
91	92	93	94	95
96	97	98	99	100

## Example (cont.)

Conservatively assumed the Shale is softer than 100 blows/12", see below Fig 5-2 in 2020 TxDOT Geotechnical Manual.

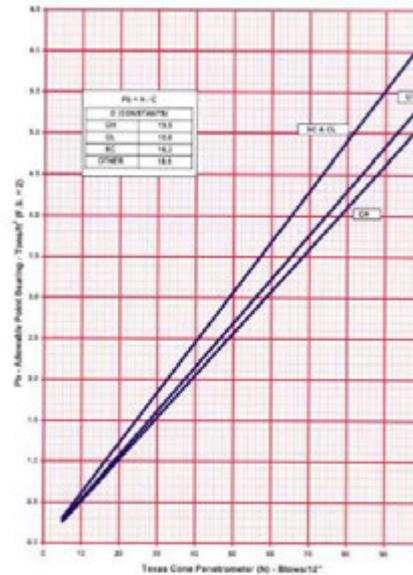


Figure 5-2. Allowable Point Bearing (TCP Values Softer than 100 Blows/12 in.)

Allowable end bearing = 5.37 tsf

Conservatively neglect the contribution of underreamed flares, I take DS diameter = 24" or (2').

End bearing =  $5.37 \times \pi \times 2^2 / 4 = 17$  tons.

17 tons x 2 (F.S.) = 34 tons

When scour reach elev 292' (about 1 to 2D above the tip) for Bents 4 to 7, F.S. for vertical capacity = 34 tons/30 tons = 1.1.

Therefore, recommended scour rating for  $Y_{AS}$  ONLY:

Item 113 = 4 for now

Item 113 = 3 when scour reach 296' (the top of shale layer)

Item 113 = 2 when scour reach 292' (re-evaluate scour impact for the bridge).

Item 113 = 1 when scour reach 290' or when the top of underream exposed.

## Conclusion

Once again,

- Scour documentation
  - Rapid evaluation in flood response
  - Prioritization of structures for replacement
  - Identify structures requiring repair
- Supports cost-effective maintenance and rehabilitation strategies.

# Thank you!

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