

INDIANA DEPARTMENT OF TRANSPORTATION
BRIDGE SCOUR EVALUATION PROCEDURES
FOR LOCAL PUBLIC AGENCIES

INTRODUCTION

Several catastrophic bridge failures resulting from scour led to the development and initiation of the national bridge scour evaluation program in 1988. That program required each state to develop procedures to ensure each bridge over a waterway, whether existing or under design, was evaluated as to its vulnerability to scour in order to determine the prudent measures to be taken for its protection. INDOT's initial approach to this program for existing bridges was published in 1995. The approach was recently reviewed and due to inadequacies and limitations in the program, INDOT determined those evaluations were no longer acceptable. In addition, documents for many of the scour evaluations conducted during the initial program are no longer maintained in each bridge's bridge file. Therefore, the primary purpose of these revised scour evaluation procedures is: (1) to apply a risk-based approach to scour evaluations and the development and implementation of Plans of Action (POAs); and (2) to ensure those efforts are properly documented in each bridge file. The result of this effort will be that each bridge will be assigned a Scour Critical Evaluation Rating (Item 113) based on the following bridge scour evaluation procedures. Those bridges identified as scour critical or coded as U (unknown foundation) will require a Plan of Action (POA) to be developed and implemented.

The expected outcome of this process is to determine an accurate scour rating for each bridge based on existing documents, field conditions, and engineer judgement, or determine what documents are needed for an accurate scour rating. This process is to be completed utilizing an appropriate combination of office and field reviews. It is anticipated that the office reviews would include review of the online bridge files from INDOT and interviews with County staff. It may also include review of historical bridge files not available online from INDOT. It is anticipated the field reviews would be accomplished concurrently during an NBIS routine bridge inspection. The "Scour Evaluator" is responsible for the overall scour evaluation and is required to sign the forms. The "Scour Evaluator" must be a Professional Engineer that is a certified NBIS Team Leader in Indiana. It is preferred that these scour evaluation procedures be conducted by a multi-disciplinary team knowledgeable in hydraulic, geotechnical, bridge design, and bridge inspection procedures.

INITIAL SCREENING PROCESS

Screen each bridge utilizing the INITIAL SCOUR SCREENING PROCEDURE FOR LOCAL PUBLIC AGENCIES form in **Appendix A**. Bridges with multiple foundations should analyze the worst case. Answer each question and assign NA or a Scour Critical Evaluation Rating (Item 113) per the form. Sign and date the form; then upload the completed form to INDOT's electronic bridge file. If the assigned Scour Critical Evaluation Rating (Item 113) from the INITIAL SCOUR SCREENING PROCEDURE FOR LOCAL PUBLIC AGENCIES equals N, 9, or 8; the INDOT Scour Evaluation Procedure is complete for that bridge. If the INITIAL SCOUR SCREENING PROCEDURE FOR LOCAL PUBLIC AGENCIES equals NA, the Scour Critical

Evaluation Rating (Item 113) can't be determined through the INITIAL SCREENING PROCESS and the bridge must be assessed or analyzed per the SCOUR ASSESSMENT/SCOUR ANALYSIS Procedures.

SCOUR ASSESSMENT/SCOUR ANALYSIS

Utilize the following guideline to determine whether the bridge will be assessed via the SCOUR ASSESSMENT PROCEDURE FOR LOCAL PUBLIC AGENCIES form in **Appendix B** or analyzed in accordance with Hydraulic Engineering Circular 18 (HEC-18) in order to assign a Scour Critical Evaluation Rating (Item 113). See **Appendix C** for HEC-18 guidance.

1. For bridges with **KNOWN** foundations, identify each bridge as either Moderate Risk or Low Risk. Moderate Risk Bridges are those that cross the rivers and streams identified on the map in **Appendix D** or identified by the Inspection Team Leader. Low Risk bridges are all other bridges.
 - a. Analyze each Moderate Risk Bridge by utilizing the procedures in HEC-18 in order to assign a Scour Critical Evaluation Rating (Item 113). Additional guidance is in **Appendix C**.
 - b. Assess or Analyze each Low Risk Bridge by either of the following methods:
 - i. Utilize the SCOUR ASSESSMENT PROCEDURE FOR LOCAL PUBLIC AGENCIES form in **Appendix B** in order to assign a Scour Critical Evaluation Rating (Item 113). Answer each question by circling the appropriate answer and, if applicable, assign a Scour Critical Evaluation Rating (Item 113) per the form. Sign and date the form; then upload the completed form to INDOT's electronic bridge file location. OR
 - ii. Utilize procedures in HEC-18 to assign a Scour Critical Evaluation Rating (Item 113).
2. For bridges with **UNKNOWN** foundations, identify each bridge as either Moderate Risk or Low Risk. Moderate Risk Bridges are those that cross the rivers and streams identified on the map in **Appendix D** or identified by the Inspection Team Leader. Low Risk bridges are all other bridges. Use one of the following methods.
 - a. Assign a Scour Critical Evaluation Rating (Item 113) = "U" and develop a POA, OR
 - b. Analyze each Moderate Risk Bridges by utilizing the procedures in HEC-18 in order to assign a Scour Critical Evaluation Rating (Item 113). Additional guidance is in **Appendix C**.
 - c. Foundations can be determined by either of the following methods:
 - i. Use NDE to determine foundation type, OR
 - ii. Infer foundation information based on similar bridges in county built in similar timeframe or year of construction (see FHWA guidance: <http://www.fhwa.dot.gov/unknownfoundations/>); if using inference, document the methodology used.
 - d. Assess or Analyze each Low Risk Bridge by either of the following methods:
 - i. Utilize the SCOUR ASSESSMENT PROCEDURE FOR LOCAL PUBLIC AGENCIES form in **Appendix B** in order to assign a Scour Critical Evaluation Rating (Item 113).

Answer each question by circling the appropriate answer and, if applicable, assign a Scour Critical Evaluation Rating (Item 113) per the form. Sign and date the form; then upload the completed form to INDOT's electronic bridge file location. OR

- ii. Utilize procedures in HEC-18 in order to assign a Scour Critical Evaluation Rating (Item 113). Additional guidance is in **Appendix C**.

Infer foundation information based on similar bridges in county built in similar timeframe or year of construction; if using inference, document the methodology used. The following assumptions can be used in lieu of inference:

1. If rock is near surface, spread footings can be assumed
2. If the top of the spread footing can be located for probing or other means, the bottom of the spread footing can assumed to be 3' lower than the top of the footing.
3. If the foundation is unknown, and the pile length cannot be reasonably assured, then treat the bridge as if it is supported on spread footing.

Bridges with Scour Critical Evaluation Rating (Item 113) = 0, 1, 2, or 3 are defined as Scour Critical. A Plan of Action (POA) is required to be developed and implemented for each bridge defined as Scour Critical or with a Scour Critical Evaluation Rating (Item 113) = U. Bridges not defined as Scour Critical are monitored for scour during routine inspections.

DEFINITIONS:

- **“No signs or history of scour”**: in performing the office and field reviews outlined in the INTRODUCTION, scour was not reported.
- **“Significant scour on Spread Footings”**: any portion of spread footing with more than 1' depth exposure.
- **“Significant Scour on Piles”**:
 - **End bent/ Abutment with spillslopes**: any exposure of piles deeper than 4' below cap.
 - **Vertical faced abutments**: any exposure of piles.
 - **Interior pile bent/ drilled shaft**: any exposure of piles deeper than 3' below normal channel bottom.
 - **Interior bent/pier with footing or mudsill**: any exposure of piles.
- **“Appropriately sized scour countermeasures”**: determination is based on existing study or an engineering judgement. The following should be considered:
 - If the current scour countermeasures are damaged, then they might not be appropriately sized.
 - Class I vs Class II or concrete underpin based on stream velocity.
 - Length of service.

- **“Stream banks unstable”:** A stream bank is considered unstable when it is susceptible to erosion (the process by which the land’s surface is worn away by actions of wind, water, ice, and gravity). If the bank is bare, or rills, gullies, or channels are forming, then the bank is considered unstable. Look for bank sloughing, undermining, evidence of lateral movement, or damage to bank stabilization measures. It is also important to look up and down the stream (approximately 200’) for side channels feeding into the main stream below the bridge for bank stability. Consider NBIS Item 61 as a mean to confirm stream stability conditions.

SCOUR RATINGS DURING FIELD REVIEWS

The most recent Scour Critical Evaluation Rating (Item 113) from FHWA memo can be found on the FHWA website: <http://www.fhwa.dot.gov/engineering/hydraulics/policymemo/revguide.cfm>

APPENDICES

A – Form - INITIAL SCOUR SCREENING PROCEDURE FOR LOCAL PUBLIC AGENCIES

B – Form - SCOUR ASSESSMENT PROCEDURE FOR LOCAL PUBLIC AGENCIES

C – Form - SCOUR ANALYSIS SUMMARY (HEC-18) FOR LOCAL PUBLIC AGENCIES

D - MAP OF MODERATE RISK BRIDGES FOR USE WITH SCOUR EVALUATION PROCESS FOR LOCAL PUBLIC AGENCIES

E – Flowchart – OVERALL BRIDGE SCOUR EVALUATION PROCEDURES FOR LOCAL PUBLIC AGENCIES

Appendix A

DRAFT - FORM

Indiana Department of Transportation
INITIAL SCOUR SCREENING PROCEDURE
FOR LOCAL PUBLIC AGENCIES

1. Is the bridge over a waterway? Yes/No
 - If No, complete the information at the bottom of this form and code Item 113 = "N"
 - If Yes, go to 2

2. Are all of the foundations on dry land well above flood water elevations or floodway? Yes/No
 - If Yes, complete the information at the bottom of this form and code Item 113 = "9"
 - If No **OR** Unknown, go to 3

3. Was the bridge designed and constructed to resist scour; and do plans show depth of foundation to be below the depth of Q100 scour (with sufficient length for friction piles)? Yes/No or Unknown
 - If Yes, complete the information at the bottom of this form and code 113 = "8"
 - If Unknown, **OR** the foundations are not below the Q100, go to 4

4. Are spread footings on erosion resistant rock or pile foundations of sufficient depth (20') below scour with no signs or history of scour**? Yes/No
 - If Yes, complete the information at the bottom of this form and code Item 113 = "8"
 - If No **OR** Unknown, go to 5

5. Is the bridge a single span bridge that meets all following criteria? Yes/No
 - i. Appropriately sized scour countermeasures in place**, AND
 - ii. Elevation of stream bottom above bottom of footing/pile cap, AND
 - iii. Does not have any signs or history of scour
 - If Yes, complete the information at the bottom of this form and code Item 113 = "8"
 - If No, go to 6

6. Is the bridge a 4-Sided Box Culvert or a Pipe Culvert with no signs or history of scour? Yes/No
 - If Yes, complete the information at the bottom of this form and code Item 113 = "8"
 - If No, go to 7

7. Is the bridge a single span concrete arch bridge with no signs or history of scour? Yes/No
 - If Yes, complete the information at the bottom of this form and code Item 113 = "8"
 - If No, complete the information at the bottom of this form, code "NA" on this form, and go to SCOUR ASSESSMENT PROCEDURES (Appendix B)

** See the "Definitions" section

To Be Completed by Scour Evaluator

Coding from INITIAL SCOUR SCREENING PROCEDURE: NA OR Item 113 = N, 9, 8

Coding by Scour Evaluator: NA OR Item 113 = N, 9, 8

Justification if different:

County:

County Bridge#:

NBI Bridge #

Screening performed by:

Signed:

Date:

Appendix B

DRAFT - FORM

Indiana Department of Transportation
SCOUR ASSESSMENT PROCEDURE
FOR LOCAL PUBLIC AGENCIES

1. CULVERTS

- a. Is the bridge a 4-Sided Box Culvert or a Pipe Culvert?
 - If Yes, go to 8.
 - If No, go to 2. Note: 3-sided culverts should be evaluated

2. HISTORICAL SCOUR PERFORMANCE:

- a. Has the bridge experienced a flood with a documented 100 yr. return interval which did not result in significant scour?
- b. Is the bridge >50 years old with no signs or history of scour and not on granular or soft soil?
Yes/No/Unknown
 - If the answer to a. **OR** b. is Yes, assign a rating of "8" to Scour Critical Evaluation Rating (Item 113).
 - If No **OR** Unknown, go to 3.

3. SCOUR COUNTERMEASURES:

- a. Are scour countermeasures in place, functioning properly, and have minor to no damage?
Yes/No/Unknown
 - If No **OR** Unknown, go to 4.
 - If Yes, go to 3.b.
- b. Are the scour countermeasures appropriately sized? **OR** has the bridge experienced a flood with a documented 50 yr. return interval with no damage to the installed countermeasures?
Yes/No/Unknown.
- c. If scour countermeasures are present, were they installed to correct a previously existing problem with scour? Yes/No/Unknown
 - If the answer to questions a. b. **AND** c. is Yes, and the answer to d. is Yes, assign a rating of "7" to Scour Critical Evaluation Rating (Item 113).
 - If the answer to questions a. b. **AND** c. is Yes, and the answer to d. is No, assign a rating of "8" to Scour Critical Evaluation Rating (Item 113).
 - If the answer to b., **OR** c. is No **OR** Unknown, go to 4.

4. GEOMORPHIC CONDITIONS AFFECTING SCOUR RESISTANCE:

- a. Is the stream bed degrading? Yes/No/Unknown
- b. Is the channel meandering? Yes/No/Unknown
- c. For natural streams, are there channel bends of greater than 30 degrees within 100 feet upstream of the bridge? Yes/No/Unknown

- d. Are the stream banks unstable? Yes/No/Unknown
- e. Are bridge substructure units skewed from the direction of flow? Yes/No/Unknown
- f. Do ice jams or debris block more than 10% of the flow cross section? Yes/No/Unknown
- If the answer to any of the above questions is Yes **OR** Unknown, go to 7.
- If the answer to all the above questions is No, go to 5.

5. SINGLE SPAN BRIDGE CONSIDERATIONS:

If the bridge is multiple-span, go to 6.

If the bridge is a single span and the Waterway Adequacy (NBI Item 71 \geq 5), answer the following questions. Otherwise, go to 6.

- a. Is the bridge supported by concrete abutments on piles? Yes/No/Unknown
- b. Is the bridge supported by timber abutment on piles? Yes/No/Unknown
- c. Is the bridge supported by end bent on piles with a spillslope at each end bent?
Yes/No/Unknown
- d. Is the bridge on concrete abutments and over a waterway labeled as a "Ditch" **OR** has a slope of less than 0.5 feet per mile? Yes/No/Unknown
- If the answer to any of the above four questions is Yes, assign a rating of "8" to Scour Critical Evaluation Rating (Item 113).
- If the answer to all of the four questions is No **OR** Unknown, go to 6.

6. REDUCED RISK BRIDGES:

- a. Is the bridge programmed for replacement or rehabilitation within 5 years **OR** installation of scour countermeasures within 2 years? Yes/No/Unknown
- b. Is the road classified as a "Rural Minor Collector or Local Road" (Item 26 - Functional Classification of Rural Minor Collector or Local) **AND** is the estimated average daily traffic (ADT) over the bridge less than 200? Yes/No
- If the answer to a. **OR** b. is Yes, and the bridge has no signs or history of significant scour, assign a rating of "5" to Scour Critical Evaluation Rating (Item 113).
- If the answer to a. **OR** b. is Yes, and the bridge has had signs or history of significant scour, go to 7.
- If the answer to a. and b. is No **OR** Unknown, go to 7.

7. FOUNDATION SCOUR RESISTANCE ASSESSMENT:

Use the following foundation and soil cases in assessing the Scour vulnerability by moving sequentially through the following procedure. Foundation types may be based on either known or inferred data as discussed in the SCOUR ASSESSMENT/SCOUR ANALYSIS section. Soil type may be based upon known geotechnical information, historical records, or professional judgment. Alternatively, at the discretion of the scour evaluation engineer(s), a scour critical analysis may be performed. If it is the opinion of the scour evaluation engineer(s) that the rating for a bridge derived from this procedure does not yield reasonable results, they may assign an alternate scour critical evaluation rating using sound engineering judgment. Such a rating must be clearly

documented in the NBIS bridge files and approved by the Bridge Program Manager. Assign a Scour Critical Evaluation Rating (Item 113) as indicated.

- a. If the bridge is supported on spread footings on:
 - 1) Rock, and
 - a) Footing socketed into rock, regardless of exposure: "8"
 - b) Footing not exposed: "8"
 - c) Top of footing exposed: "5"
 - d) Footing fully exposed with no rock degradation: "4"
 - e) Footing fully exposed with potential of rock degradation: "3"
 - f) Footing fully exposed with rock degradation and undermining: "2 or 1"
 - 2) Stiff clays/clay till ($Q_u \geq 1.5$ tsf), and :
 - a) No observed scour: "5"
 - b) Scour present, footing not exposed: "5"
 - c) Scour present, $< \frac{1}{2}$ of footing exposed, and determined stable: "4"
 - d) Scour present, $> \frac{1}{2}$ of footing exposed, and determined stable: "3"
 - e) Scour present, and $> \frac{1}{2}$ of footing exposed, 10% of area of footing undermined; scour adjacent to $>25\%$ of face of footing; or otherwise determined unstable: "2 or 1"
 - 3) Granular or soft soils ($Q_u < 1.5$ tsf)
 - a) No observed scour: "5"
 - b) Scour present, footing not exposed: "4"
 - c) Scour present, footing exposed: "3"
 - d) Scour present, any area of footing undermined; scour adjacent to $>10\%$ of face of footing; or otherwise determined unstable: "2 or 1"
- b. If the bridge is supported on pile foundations on:
 - 1) Any soil type; pile tips $\geq 40'$ below ground surface and piles not exposed by significant scour: "8".
 - 2) Socketed or driven into rock:
 - a) Piles not exposed by "significant" scour: "8"
 - b) Piles exposed by "significant" scour: "5"
 - 3) Pile tips on rock but not socketed or driven into rock:
 - a) Minor to no existing scour is present or has occurred previously:
 1. A 3-foot minimum thickness of cohesive soil in upper $\frac{1}{2}$ of embedded pile length: "8"
 2. No layers of cohesive soil in upper $\frac{1}{2}$ of embedded pile length: "5"
 - b) History of significant scour or erosion:
 1. A 3-foot minimum thickness of cohesive soil in upper $\frac{1}{2}$ of embedded pile length: "4"
 2. No layers of cohesive soil in upper $\frac{1}{2}$ of embedded pile length : "2"
 - 4) Friction piles in cohesive soils; min. 3-ft layer w/ $Q_u \geq 1.5$ tsf in upper $\frac{1}{2}$ of embedded pile length required, or else go to 5) below:

- a) Little or no existing scour is present or has occurred previously:
 - 1. Pile tips $\geq 15'$ deep: "8"
 - 2. Pile tips $< 15'$ deep: "5"
- b) History of significant scour or erosion:
 - 1. Pile tips $\geq 35'$ deep: "8"
 - 2. Pile tips $< 35'$ and $\geq 20'$ deep: "5"
 - 3. Pile tips $< 20'$ deep without significant scour present: "4"
 - 4. Pile tips $< 20'$ deep with significant scour present, or piles otherwise determined unstable: "2"
- 5) Friction piles in granular or soft soils:
 - a) Pile tips $\geq 20'$ below ground surface without significant scour present: "8"
 - b) Pile tips $\geq 20'$ below ground surface with significant scour present but considered stable: "5"
 - c) Pile tips $\geq 20'$ below ground surface with significant scour present but has the potential to be unstable: "4"
 - d) Pile tips $< 20'$ below ground surface without significant scour present: "4"
 - e) Pile tips $< 20'$ below ground surface with significant scour present, or piles otherwise determined unstable: "2"
- 6) If the foundation is unknown, and the pile length cannot be reasonably assured, then treat the bridge as if it is supported on spread footing.

8. CULVERTS:

- a. Is the stream bed degrading? Yes/No/Unknown
- b. Is the channel meandering? Yes/No/Unknown
- c. For natural streams, are there channel bends of greater than 30 degrees within 100 feet upstream of the bridge? Yes/No/Unknown
- d. Are the stream banks unstable? Yes/No/Unknown
- e. Are culvert substructure units skewed from the direction of flow? Yes/No/Unknown
- f. Do ice jams or debris block more than 10% of the flow cross section? Yes/No/Unknown
- If the answer to any of the a-f questions is Yes **OR** Unknown, then
 - Box culverts with significant scour between the ends of the box and the cut-off walls due to undermining of the wingwalls: "4"
 - Box culverts with signs of significant scour not due to undermining of the wingwalls: "2"
 - Pipe culverts with no sign of significant scour: "4"
 - Pipe culverts with signs of significant scour: "2"
- If the answer to all questions a-f is no, then:
 - Box culverts with significant scour between the ends of the box and the cut-off walls due to undermining of the wingwalls: "5"
 - Box culverts with signs of significant scour not due to undermining of the wingwalls: "3"
 - Pipe culverts with no sign of significant scour: "5"
 - Pipe culverts with signs of significant scour: "3"

To Be Completed by Scour Evaluator

Scour Critical Evaluation Rating (Item 113) from SCOUR ASSESSMENT PROCEDURE: 8, 7, 5, 4, 3, 2, 1

Scour Critical Evaluation Rating (Item 113) by Scour Evaluator: 8, 7, 5, 4, 3, 2, 1

Justification if different:

County:

County Bridge#:

NBI Bridge #

Foundation type:

Assessment performed by:

Signed:

Date:

Appendix C

Indiana Department of Transportation
SCOUR ANALYSIS SUMMARY (HEC-18)
FOR LOCAL PUBLIC AGENCIES

The scour analysis will be completed using HEC-RAS in accordance with HEC-18 and the INDOT Design Manual. Only Q100 will be used for the analysis. A summary of the scour parameters from the HEC-18 analysis will be uploaded to the bridge file (see below). A determination of the proper Coding for Item 113 will be made following the FHWA coding guide.

Scour Parameters

Q100 Discharge	=	cfs.
Elevation @ Q100	=	MSL
Velocity @ Q100	=	ft./sec.
Contraction Scour Depth	=	ft.
Total Scour Depth	=	ft.
Low Scour Elevation	=	MSL

To Be Completed by Scour Evaluator

Scour Critical Evaluation Rating (Item 113) from SCOUR ASSESSMENT PROCEDURE: 8, 7, 5, 4, 3, 2, 1

Scour Critical Evaluation Rating (Item 113) by Scour Evaluator: 8, 7, 5, 4, 3, 2, 1

Justification if different:

County:

County Bridge#:

NBI Bridge #

Foundation type:

Assessment performed by:

Signed:

Date:

Appendix D

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Indiana Department of Transportation
MAP OF MODERATE RISK BRIDGES FOR USE WITH
SCOUR EVALUATION PROCESS FOR LOCAL PUBLIC AGENCIES



Appendix E
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Flowchart
BRIDGE SCOUR EVALUATION PROCEDURES
FOR LOCAL PUBLIC AGENCIES

