Scour – Level 1 & 2 Evaluations, Plans of Action and Countermeasures

March 10, 2009
Big Rapids, MI
Scour – Level 1 & 2 Evaluations, Plans of Action and Countermeasures

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MORNING SESSION
Moderator: Chris Gilbertson, P.E.-Michigan Technological University

8:30  Check in
9:00  Opening Remarks
      John Kiefer, P.E.-Michigan’s Local Technical Assistance Program
      Chris Gilbertson, P.E.-Michigan Technological University
9:05  FHWA-Bridge Scour Program
      Cynthia Nurmi, P.E., Hydraulic Engineer
      Federal Highway Administration
9:35  FHWA-Scour and Plans of Action-NBIS Compliance
      Jon Nekritz, P.E., Division Bridge Engineer
      Federal Highway Administration
9:45  MDOT-Hydraulic Evaluation Requirements
      Dave Juntunen, P.E., Engineer of Bridge Operations
      Michigan Department of Transportation
10:30 Break
10:45 Level 1 Evaluation
      Patricia Schriner, P.E., President
      Taiga Engineering, LLC
11:15 Level 2 Evaluation
      Brian Barkdoll, P.E., PhD., Department of Civil and Environmental Engineering
      Michigan Technological University
12:00 Lunch

AFTERNOON SESSION

1:00  Countermeasure Calculations and Design
      Brian Barkdoll, P.E., PhD., Department of Civil and Environmental Engineering
      Michigan Technological University
1:30  Scour Critical Bridge-Plans of Action
      Dave Juntunen, P.E., Engineer of Bridge Operations
      Michigan Department of Transportation
      Nate VanDrunen, Grand Region Bridge Engineer
      Michigan Department of Transportation
2:00 Break

(continued on next page)
Agenda (continued)

2:15 Quality Assurance  
   Richard Smith, P.E., Bridge Inspection Program Manager  
   Michigan Department of Transportation

2:30 Case Studies  
   Nate VanDrunen, Grand Region Bridge Engineer  
   Michigan Department of Transportation

3:05 Permitting  
   Jerry Fulcher, P.E., Chief-Transportation and Flood Hazard Unit  
   Michigan Department of Environmental Quality

3:30 Question/Answer  
   Panel & Audience

4:00 Adjourn
About the Presenters

**Cynthia Nurmi, P.E.**  
Federal Highway Administration

Cynthia has worked at the FHWA Resource Center since 1999. She has led the development of the FHWA POA template and webtraining. She has assisted Divisions and States around the country by reviewing POAs and providing technical assistance and training. Cynthia also is on the Unknown Foundations Team and has led several efforts on this topic, such as the Unknown Foundations Summit and the Unknown Foundations Synthesis.

Prior to working at FHWA, Cynthia worked at the Federal Energy Regulatory Commission in the Dam Safety Branch. She also worked at the Metropolitan Atlanta Rapid Transit Authority in the Conceptual Design Section.

Cynthia graduated from the Georgia Institute of Technology with a BSCE and MSCE. Cynthia is a licensed professional engineer in Georgia.

**Jon Nekritz, P.E.**  
Federal Highway Administration-Michigan Division

Jon Nekritz is the Bridge Engineer in the Federal Highway Administration’s Michigan Division office in Lansing. He has over 30 years with FHWA, including assignments in bridge design and inspection, and has held the positions of Division Bridge Engineer in the FHWA New Mexico Division and Assistant Region Bridge Engineer in the old FHWA Region 5 office. He has been in his current position for over 15 years. Mr. Nekritz has a B.S. Degree in Civil Engineering from the University of Maryland and is a licensed Professional Engineer.

**Dave Juntunen, P.E.**  
Michigan Department of Transportation

Dave has worked for MDOT for 22 years as a bridge designer, structural research engineer, and bridge operations engineer.

**Patricia Schriner, P.E.**  
Taiga Engineering, LLC.

Patricia Schriner has 16 years of experience in hydraulics and scour. She worked in the MDOT Hydraulics Unit for 12 years, including 7 years as the unit’s supervisor. She is now the owner of Taiga Engineering, which provides consulting engineering services in hydraulics, scour, storm sewer design, and other areas of water resources engineering. Patricia has B.S. and M.S. Degrees in Civil Engineering from Michigan Technological University and is a licensed professional engineer.

**Brian Barkdoll, P.E., PhD.**  
Michigan Technological University

Dr. Barkdoll has degrees from the Universities, of Akron, Cincinnati and Iowa. He has spent 4 years as an engineer for the U.S. Peace Corps in Nepal. Dr. Barkdoll's teaching interests include fluid mechanics, hydraulics, hydrology, sediment transport, contaminant transport, and water collection and distribution. His research interests are in sedimentation, scour, oxygen transfer, clay permeability, vortices, acoustics, stream restoration, dams and reservoirs, intakes, water distribution systems, international development, and environmental sustainability.

Dr. Barkdoll is a member of the ASCE Sedimentation Committee and the Environmental Hydraulics Committee. He has won the Daniel W. Mead Award for Younger Members of the American Society of Civil Engineers and the Chi Epsilon...
About the Presenters

James M. Robbins Excellence-in-Teaching Award for the S.W. District. He has published over 35 technical papers and given over 25 seminars at international conferences.

Dr. Barkdoll has been involved in over $1.3M of research and is a member of 8 professional societies. He regularly reviews technical papers and proposals to 10 journals and funding organizations.

Dr. Barkdoll is a Diplomate of the Academy of Water Resources Engineers (D.WRE). He is the past Chair of the Sedimentation Technical Committee of the American Society of Civil Engineers.

**Nate VanDrunen, P.E.**
Michigan Department of Transportation

Nate VanDrunen is a 1998 graduate of Calvin College with a degree in Engineering. He worked at URS Corporation from 1997 to 2005 with the majority of his experience in bridge construction, bridge scoping and bridge design.

He began at MDOT in 2005 and currently works at MDOT as a bridge engineer in the Grand Region. His main responsibilities include managing the bridge inspection program, assisting with the development of the 5-year bridge program, performing bridge scoping and assisting with bridge maintenance projects and issues.

**Richard Smith, P.E.**
Michigan Department of Transportation

Richard Smith has been with the MDOT Bridge Inspection Program since 1999. He has worked at MDOT for nearly 20 years and has 18 years of experience in the private sector with industrial and consulting firms.

**Jerry Fulcher, P.E.**
Michigan Department of Environmental Quality

Current supervisor of the Transportation and Flood Hazard Unit in DEQ which reviews permit applications submitted by Public Transportation Agencies for projects that impact a lake, stream/drain, or wetland. A registered Professional Engineer with a B.S. Degree in Civil Engineering from Michigan Technological University. 29 years of experience with the DNR/DEQ.
FHWA-Scour Bridge Program

Cynthia Nurmi, P.E., Hydraulic Engineer
Federal Highway Administration
Phone:(404)562-3908
Email:Cynthia.Nurmi@fhwa.dot.gov

Presentation Summary

Why Do We Need A Scour Program?

► Floods damage roadways and bridges
► Hydraulic Issues cause the greatest percentage of bridge failures

History of FHWA Bridge Scour Program

► Scour research since 1940’s
► Scour guidance since 1970’s
► Formalization of Program
  • 1988
    - T 5140.20 issued
    - NBIS incorporated Item 113
  • T 5140.23
    - Interdisciplinary Team
    - New Bridges
      Required designing for scour for 100 year and superflood
    - Existing Bridges
      Required evaluation of scour potential at existing bridges
    - POAs
      Recommended development of actions to address scour potential of scour critical bridges
      Monitoring
      Countermeasures
  • Bridge Inspection
    - Training for scour and stream stability issues
Deadlines

- 1997 Scour Evaluations to be completed for existing bridges
- POA recommended for scour critical bridges

Revision of Regulations

- 23CFR650.313(e)
  - Evaluate for Scour
  - Monitor for Known and Potential Deficiencies
  - Address Critical Findings

Funding

- Bridge funds may be used for inspections (monitoring) and evaluations
- SAFETELU – scour countermeasures can be paid for with bridge funds

Current Status of FHWA Bridge Scour Program

January 4, 2008, Memorandum

- Completion Dates for scour evaluations and POAs

Technical Guidance

- HEC 18
- HEC 20
- HEC 23
- HEC 25
- POA Template

Training

- NHI 135046
- NHI 135047
- NHI 135048
- NHI 135082
- NHI 135085

POAs

Monitor

- Who, What, Where, When

Address Critical Findings

- Types of countermeasures

Implementation

- Maintenance
- Training
Future of FHWA Bridge Scour Program

► Technical Guidance
  • HEC 23 update

► Training
  • NHI 135047 update

► Research
  • Turner Fairbank Lab
  • NCHRP

► Unknown Foundations
  • January 9, 2008, Memo
    - Evaluate by November 2010
    - POAs if not Evaluated
  • Team developing guidance
    - future website

For More Information

FHWA Publications:

FHWA POA Template:
http://www.fhwa.dot.gov/engineering/hydraulics/bridgehyd/poaform.cfm

FHWA Training:
http://www.fhwa.dot.gov/engineering/hydraulics/training.cfm

POA Web-Training:
https://admin.na3.acrobat.com/_a55098539/n135085seminar/

FHWA and NCHRP Research:
http://www.fhwa.dot.gov/engineering/hydraulics/research/summary.cfm

Regulations:
http://www.access.gpo.gov/nara/cfr/waisidx_01/23cfr650_01.html

Michigan’s Local Technical Assistance Program
www.MichiganLTAP.org
FHWA-Scour and Plans of Action-NBIS Compliance

Jon Nekritz, P.E., Division Bridge Engineer Phone:(517)702-1837
Federal Highway Administration-Michigan Division Email:jon.nekritz@fhwa.dot.gov

Presentation Summary

January 4, 2008 FHWA Washington Headquarters memorandum

► National status of scour evaluations and POA development and implementation

► Requested FHWA Divisions to verify status and take specific action to ensure compliance with NBIS scour/POA requirements

► Recommended target dates:
  • Scour evaluations complete – all bridges – November 2008
  • Implement POAs – state bridges: April 2009; non-state bridges: April 2010

► FHWA progress reporting requirements
  Link to memo:
  http://www.fhwa.dot.gov/engineering/hydraulics/policymemo/20080104.cfm

2/14/2008 FHWA Michigan Division Letter to MDOT

► Michigan status of scour evaluation completion and POA development and implementation as of January 2008
  • Over 2,100 not evaluated; >525 scour critical - POAs not developed

► Michigan non-compliance with scour/POA provisions of NBIS

► Requested MDOT to provide schedule for completing scour evaluations and developing & implementing POAs

► Recommended Jan 4 memo target dates for completion
3/20/2008 response from MDOT

- Expressed support of national scour evaluation and POA effort
- MDOT working with CRAM & MML, issuing guidance, and developing MBIS POA form
- Proposed completion dates for MDOT bridges
  - Scour evaluations – Dec 31, 2009
  - Develop & implement POAs – Dec 31, 2010
- Proposed targets for local agency bridges
  - Scour evaluations – Dec 31, 2009
  - Develop & implement POAs – Dec 31, 2010

4/16/2008 FHWA Michigan Division letter to MDOT in response

- Accepted dates presented in 3/20/09 letter, but as completion dates
  - Completion dates apply to MDOT, local agency, & other agency bridges
- Acceptance is conditioned on:
  - Additional time only based on substantial effort underway; requires FHWA concurrence
  - Significant incremental progress being made
- Letter covers how progress will be tracked

**FOR MORE INFORMATION**

FHWA Reporting Requirements Memo:
http://www.fhwa.dot.gov/engineering/hydraulics/policymemo/20080104.cfm

Michigan’s Local Technical Assistance Program
www.MichiganLTAP.org
February 14, 2008

Mr. Kirk T. Steudle, Director
Michigan Department of Transportation (B450)
Lansing, Michigan

Dear Mr. Steudle:

National Bridge Inspection Standards
Scour Evaluations and Plans of Action for Scour Critical Bridges

Attached is a January 4, 2008, memorandum from our Washington Headquarters office that provides specific direction to the Federal Highway Administration (FHWA) Division offices to ensure that the National Bridge Inspection Standards (NBIS) scour evaluation and Plans of Action (POA) requirements (23 CFR 650.313(e) and 23 CFR 650.313(e)(3)) are met by the States.

Scour is by far the most common cause of the failure of highway bridges. The NBIS defines scour as the erosion of streambed or bank material due to flowing water; often considered as being localized around piers and abutments of bridges. A scour critical bridge is a bridge that has been determined to be unstable for the observed or evaluated scour condition. After long being FHWA Policy and AASHTO guidance, the evaluation of bridges for scour vulnerability and the development and implementation of POAs for those bridges that are evaluated to be scour critical are requirements of the NBIS, revised effective January 13, 2005.

The FHWA Michigan Division has worked closely with the Michigan Department of Transportation (MDOT) to have highway bridges over waterways in Michigan evaluated for scour vulnerability and, more recently, to develop procedures for developing and implementing scour critical bridge POAs. Much progress has been made by your staff in these efforts. However, significant work remains to be done, particularly for the scour evaluation of local agency highway bridges, and for the development and implementation of POAs for all Michigan scour critical highway bridges.

The following table provides an up-to-date count of Michigan highway bridges over waterways that have had evaluations completed, have unknown foundations (making evaluations difficult), and that still require scour evaluations (updated as of January 2008 from data supplied by the MDOT Bridge Operations Unit).
Additionally, the following table provides an up-to-date count of Michigan highway bridges that have been evaluated to be scour critical, and therefore require the development and implementation of POAs (updated as of January 2008 from data supplied by the MDOT Bridge Operations Unit). Note that at least some of the bridges still requiring evaluation in the table above should be expected to be scour critical and will add to the numbers below, and that a small number of scour critical MDOT bridges (< 25) have already had POAs developed:

<table>
<thead>
<tr>
<th>Highway Bridges over Waterways</th>
<th>Scour Evaluation Complete</th>
<th>Unknown Foundations</th>
<th>Scour Evaluation Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDOT owned bridges</td>
<td>1,331</td>
<td>106</td>
<td>91</td>
</tr>
<tr>
<td>County owned bridges</td>
<td>3,233</td>
<td>553</td>
<td>1,769</td>
</tr>
<tr>
<td>City owned bridges</td>
<td>410</td>
<td>28</td>
<td>267</td>
</tr>
<tr>
<td>Other owned bridges</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>6,984</strong></td>
<td><strong>685</strong></td>
<td><strong>2,161</strong></td>
</tr>
</tbody>
</table>

Summarizing the tables above: (1) there are currently over 2,100 highway bridges that have not yet had scour evaluations performed, and (2) at least 525 highway bridges that have already been determined to be scour critical and have not had POAs developed and implemented. Based on this current status, we have determined that Michigan is not in compliance with the requirements of 23 CFR 650.313(e) and 23 CFR 650.313(e)(3).

In order to avoid the possible suspension of Federal-aid highway funds, we are requesting that MDOT provide the Michigan Division with the following information:

1. A schedule for completing the scour evaluation of all bridges over waterways within the State, including local agency and other owner bridges. We strongly recommend a target date of November 30, 2008, for completing these evaluations, regardless of ownership.

2. A schedule for completing the development and implementation of POAs for all bridges identified as scour critical. We strongly recommend target dates as follow:
   a. State owned bridges: November 30, 2008, for completion of POA development and April 30, 2009, for completion of POA implementation.
   b. Local agency and other owner bridges: November 30, 2009, for completion of POA development, and April 30, 2010, for completion of POA implementation.
The requested schedules should include outlines and descriptions of actions to be taken by MDOT to meet the target dates. Proposed target dates that are later than those recommended will be evaluated for acceptability based on the provided justification. We would appreciate the requested information be provided by Monday, March 10, 2008.

Additionally, we request that MDOT provide regular status reports to the Michigan Division on the progress made towards developing and implementing POAs. The attachment contains specific requirements for status reports; however, we would like to work out tracking and reporting details by working directly with your staff.

We are looking forward to working with you and your staff to restore Michigan’s substantial compliance with the NBIS and, therefore, avoid the suspension of Federal-aid highway funds. If you have any questions, please contact Jon Nekritz, Michigan Division Bridge Engineer, at 517-702-1837.

Sincerely,

Original signed by:

James J. Steele
Division Administrator

Attachment

cc: Larry Tibbits, MDOT, Bureau of Highways Operations (B450)
   John Friend, MDOT, Bureau of Highway Delivery (B235)
   John Polasek, MDOT, Bureau of Highway Development (B450)
   David Juntunen, MDOT, C&T (E020)
   Kristin Schaster, MDOT, Design (B220)
   Mark Harrison, MDOT, Design (B220)

Profile No. S-97906
March 20, 2008

Mr. James J. Steele
Division Administrator
Federal Highway Administrator
315 West Allegan, Room 201
Lansing, Michigan 48933

Dear Mr. Steele:

National Bridge Inspection Standards (NBIS)
Scour Evaluations and Plans of Action for Scour Critical Bridges

This is in response to your letter of February 14, 2008, and the accompanying January 4, 2008, FHWA office memorandum. We are supportive of the national effort to evaluate all bridges over waterways for scour, and develop action plans by which these bridges can best be managed.

The Michigan Department of Transportation (MDOT) is taking the following actions for all of our scour critical bridges:

1. MDOT has a Scour Critical Bridge Committee, which serves as Michigan’s interdisciplinary team for evaluating scour issues. The objective of this committee is to develop state policy and procedures to manage Michigan’s scour critical bridges.

2. MDOT’s Drainage Manual (Appendix 6D) provides guidance for performing scour evaluations. The Drainage Manual is available on MDOT’s Web site at:

   http://www.michigan.gov/stormwatermgmt/0,1607,7-205--93193--,00.html

3. The Michigan Bridge Reporting System (MBRS) provides a special report that shows all bridges over waterways that need evaluation for scour, scour critical bridges, bridges with unknown foundations and bridge owners. MBRS can be accessed on MDOT’s Web site at:

   http://www.michigan.gov/mdot/0,1607,7-151-9625_24768_39613--,00.html

4. MDOT will work with all bridge owners to review and clean-up the scour critical bridge fields in the bridge database. For example, some agencies may have done the evaluation, but did not update the bridge database appropriately.
Mr. James J. Steele  
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5. We are working with the County Road Association of Michigan (CRAM) and the Michigan Municipalities League (MML) to raise awareness of this issue, and to develop a plan by which all local agency bridge owners can comply with NBIS requirements.

6. The department issues Bridge Advisories (BAs) to provide guidance and share information on bridge safety, bridge inspection, bridge management, and bridge load rating issues to MDOT, local agencies, and contractors working for the agencies. MDOT will use BAs to provide guidance to MDOT staff and local agency bridge owners on management of scour critical bridges. BAs are available on MDOT's Web site at:

http://www.michigan.gov/mdot/0,1607,7-151-9625_24368_49104----,00.html

7. MDOT’s Scour Critical Bridge Committee is developing a form and process for all Michigan bridge owners to use for managing their scour critical bridges during a flood event and for asset management. The Plan of Action (POA) form will be available on the internet-based Michigan Bridge Inspection System by this spring. All bridge owners will need to complete a POA for their scour critical bridges.

Evaluating bridges for scour can be an extensive and costly activity. It takes considerable time and effort to do the needed preliminary investigation, stream survey, collection of hydraulic data, geotechnical review, and finally complete the scour calculations. This procedure is well defined and suitable for bridges on the National Highway System (NHS); however, determining the appropriate level of effort that should be done on non-NHS bridges on low volume routes is much less clear. We welcome FHWA assistance and guidance, especially as it relates to developing consistent policy among the states as to what level of detail scour evaluations should be done for low volume non-NHS bridges, and how to code Item 113 when bridge piers and abutments receive counter measures.

We have developed a plan to complete the scour evaluation of all our bridges, approximately 90 structures, by December 31, 2009. We will develop and implement POAs for all of our scour critical bridges by December 31, 2010.

MDOT will work with local agency bridge owners, through CRAM and MML, and directly with bridge owners, to develop plans to complete their scour evaluations and POAs. Michigan has approximately 71 of 83 counties with one or more scour evaluations to do, and a majority of these have less than 20 evaluations to do. Eleven counties have between 20 and 50 evaluations, eight counties have between 50 and 100 evaluations, and four counties have over 100 scour evaluations to do. There are 119 cities with one or more scour evaluations that need to be done; twelve agencies have between 5 and 10 scour evaluations, and only two cities have over 10. We believe the majority of local agency bridge owners will be able to meet MDOT’s proposed targets for completing scour evaluations (December 31, 2009), and developing and implementing POAs (December 31, 2010). Some of the counties with a large number of bridges may need more time. If an agency cannot meet MDOT’s proposed target completion dates, they may
Mr. James J. Steele  
Page 3  
March 20, 2008  

request an alternate completion date. This request must be in writing and include a justification for the alternate completion date. Agencies that have not completed their scour evaluations by the agreed upon dates will be held in non-compliance for federal-aid highway funds.

We are also willing to meet with your staff to provide regular status reports on the progress made in completing scour evaluations and developing and implementing POAs.

If you have any questions, please contact me or John C. Friend, Engineer of Delivery, at 517-335-1697.

Sincerely

[Signature]

Kirk T. Steudle  
Director
March 20, 2008. Your letter was in response to our
February 14, 2008, letter in which we notified you of our determination that Michigan is not in
compliance with the requirements of 23 CFR 650.313(e) and 23 CFR 650.313(e)(3).

Your letter lists the actions being taken by the Michigan Department of Transportation (MDOT)
to comply with the NBIS scour requirements. We commend MDOT for taking these actions and
strongly encourage that these actions continue to completion.

Your letter also mentions that the level of effort required for scour evaluation of non-National
Highway System (NHS) bridges on low volume routes is not clear. In this regard, we believe
that the available guidance for performing scour evaluations allows states sufficient flexibility in
determining what level of effort should be applied to individual bridges. However, we can
provide expert assistance to discuss this issue further.

We have reviewed the dates presented in your letter for completion of scour evaluations,
December 31, 2009, and development and implementation of Plans of Action (POA), December 31,
2010, while not meeting our recommended targets, are acceptable with the following conditions:

- The completion dates presented in your letter apply to all NBIS bridges in Michigan,
  including MDOT, local agency, and other owner bridges.

- Local agencies are not allowed additional time for completion of these tasks at this time.
  Your letter states that local agencies may request alternate completion dates. We believe
any future extension should only be considered within a short timeframe of the completion date, should only be based on evidence of substantial effort having already been made, and we ask that you consult us and get our agreement before any future extensions are granted.

- Regular status reports are provided to FHWA. Details of this reporting will be worked out with the MDOT Scour Committee. We note that a meeting of this committee is scheduled for May 7, 2008.

- Significant incremental progress in completing scour evaluations and development and implementation of POAs is made.

- National Bridge Inventory (NBI) Item 113 – Scour Critical Bridges is used to track progress in completing scour evaluations.

- MDOT implements a process for tracking of POA development and implementation progress. We believe that the internet-based POA form currently being implemented as part of MDOT’s MBIS would allow for this tracking and, therefore, strongly recommend that MDOT require all bridge owners to use this form. The form may require minor modification to enable tracking of POA development and implementation progress.

We believe these conditions fit well within the actions described in your letter and are looking forward to working with you and your staff to restore Michigan’s substantial compliance with the NBIS. If you have any questions, please contact Jon Nekritz, Michigan Division Bridge Engineer, at 917-702-1937.

Sincerely,

Original signed by: Thomas J. Fudal

James J. Steele
Division Administrator

cc: Larry Tibbits, MDOT, Bureau of Highway Operations (B450)
   John Friend, MDOT, Bureau of Highway Delivery (B235)
   John Polasek, MDOT, Bureau of Highway Development (B450)
   David Juntunen, MDOT, C&T (E020)
   Kristin Schuster, MDOT, Design (B220)
   Mark Harrison, MDOT, Design (B220)
MDOT-Hydraulic Evaluation Requirements

David Juntunen, P.E., Bridge Operations Engineer
Michigan Department of Transportation
Phone: (517)322-5688
Email:juntunend@michigan.gov

Presentation Summary

FHWA Letter of Non-compliance

July 7 Letter, MDOT to Local Agencies

► All state highway bridges owners must:
  • Complete scour evaluations for their highway bridges over streams or rivers.
  • For bridges that have been identified as being scour critical, the bridge owner must “prepare a plan of action to monitor known and potential deficiencies and to address critical findings.”

Identify Bridges Needing Scour Evaluations

► State Numbers
  • MDOT
    - Needing Scour Evaluations - 58
    - Scour Critical -
    - Unknown Foundations -
  • Counties
    - Needing scour evaluations – 1567
    - Scour Critical – 157
    - Unknown foundations - 571
  • Cities and Townships
    - Needing scour evaluations – 290
    - Scour Critical – 21
    - Unknown foundations - 29
Michigan Bridge Reporting System

- Agencies can access Michigan’s bridge database and review a report showing your bridges with scour needs through MDOT’s Michigan Bridge Reporting System. MBRS can be found by going to MDOT’s website at http://www.michigan.gov/mdot. Select “doing business” from the left hand menu, then select “Bridge Operations”, then select “Bridge Management”, then select “Michigan Bridge Reporting System.” You will be asked for your user ID and password. Note: your user ID and password for MBRS is the same one used for the Michigan Bridge Inspection System (MBIS). If you do not have a users ID and password, please call Ron Hafner, Michigan Department of Transportation, Bridge Management Unit, Phone 517-322-6058. Once in MBRS select “Scour Critical Structures” from the left hand menu. To see your bridges needing to be evaluated for scour, select “Not Yet Evaluated (Item 113 = 6)” from the drop down list for Display Criteria. To see your bridges that are currently listed as scour critical and needing POA’s, select “Scour Critical (Item 113 = 0-3)” from the drop down list.

Understanding Item 113

- The MBRS report is created using Structural Inventory and Appraisal (S I & A) Item 113 of the FHWA’s Recording and Coding Guide for Structure Inventory and Appraisal of the Nation’s Bridges (Report No. FHWA-PD-96-001). The coding guide can be found at the following website: http://www.fhwa.dot.gov/BRIDGE/mtguide.pdf

MDOT Bridge Advisories

- BA 2006-01 - Scour Inspection during Flood Events
- BA 2008-04 - NBIS Scour Evaluations and Plans of Action for Scour Critical Bridges
- BA 2008-06 - Evaluating Culverts for Scour
Data Base clean-up

- Year Built – There are several hundred bridges built within the last 10-15 years that likely were analyzed for scour during design and built on deep foundations.

**FOR MORE INFORMATION**

Michigan Bridge Reporting System
http://www.michigan.gov/mdot

FHWA’s Recording and Coding Guide for Structure Inventory and Appraisal of the Nation’s Bridges

Michigan’s Local Technical Assistance Program
www.MichiganLTAP.org
Presentation Summary

Purpose of a Level 1 Scour Evaluation

- It is an initial assessment of the bridge’s scour susceptibility.
- It is a qualitative assessment; no calculations are done.
- Use the results to determine the bridge’s NBIS Item 113 code and whether it needs a Level 2 analysis.
- A Level 1 Scour Evaluation should be done on every existing bridge.

What is involved in a Level 1 evaluation?

- MDOT developed a Level 1 Scour Worksheet (attached). The worksheet includes:
  - Office Review
    - Previous bridge inspection reports
    - Original construction plans
    - Soil borings
    - Maintenance records
  - Field Review
    - Fill out as much of the worksheet as possible in the field
    - Look upstream and downstream to evaluate stream stability
    - Take several photographs, particularly if there’s riprap
    - Take cross sections at the upstream and downstream faces

Conclusions from Level 1 Evaluation

- Give the bridge an Item 113 code.
- Does the bridge need a Level 2 Analysis?
  - If you already know that the bridge is critical or not critical, it does not need a Level 2 Analysis. A Level 2 Analysis will give you an estimated scour depth, so it is only required if you aren’t sure if the bridge is scour critical. Give the bridge an Item 113 Code of “6” until the Level 2 Analysis is complete.
Follow up

- FHWA recommends taking follow-up cross sections every 2 years during the bridge inspection. You can use the spreadsheet to compare these to previous cross sections.

- If a bridge is determined to be scour critical, a Plan of Action must be written and implemented.

References

- HEC-18, “Evaluating Scour at Bridges”
- HEC-20, “Stream Stability at Highway Structures”
- HEC-23, “Bridge Scour and Stream Stability Countermeasures”

All of the above are available at FHWA’s website: www.fhwa.dot.gov/engineering/hydraulics/scourtech

Forms

- Level 1 and Level 2 Scour Analysis Worksheets are in the MDOT Drainage Manual, which is available at MDOT’s website: www.michigan.gov/mdot
  Go to Maps and Publications, and then Manuals and Guides.

- The Cross Section Spreadsheet is available on the MDOT Bridge Operations website: www.michigan.gov/mdot
  Go to Doing Business, then Bridge Operations, then Forms & Reports.

FOR MORE INFORMATION

FHWA’s Website
www.fhwa.dot.gov/engineering/hydraulics/scourtech

MDOT’s Website
www.michigan.gov/mdot

Michigan’s Local Technical Assistance Program
www.MichiganLTAP.org
MICHIGAN DEPARTMENT OF TRANSPORTATION
LEVEL ONE SCOUR ANALYSIS WORKSHEET

Date: ________ By: __________ Structure No: ______ Control Section: __________

Job No: ______ Route: __________ Watercourse: ____________________________

All references are to HEC-20, 3rd Edition.

Data Collection

___ Plans
___ Bridge Inspection Reports (Maintenance Division)
___ Underwater Inspection Reports (Maintenance Division)
___ Review existing items 60, 61, 71, 92, 93, and 113 of the NBIS
___ Review available construction, design, and maintenance files for repair and maintenance work done on structure

Field Investigation

Date: ______________________

___ Channel bottom width approximately one bridge span upstream = _______ feet

___ Overbank and channel Manning's roughness coefficients

___________ Left ____________ Channel _____________ Right

___ Is there sufficient riprap? Abutments __________ Piers ____________

___ Photographs

___ Cross sections at upstream and downstream faces of bridge

Comments:

Stream Characteristics

___ Complete the attached Figure 2.6 from HEC-20.

Comments:

Land Use: Identify the existing and past land use of the upstream watershed:

<table>
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<th>Urban Area</th>
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<td>Undeveloped Land</td>
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1 of 2
**Lateral Stability:** Refer to HEC-20, Section 2.3.9 on Channel Boundaries and Vegetation for channel bank stability. Comment:

**Vertical Stability:**
- streambed elevation change from as-built plans? Yes ____ No ____
- exposed pier footings (degradation)? Yes ____ No ____
- exposed abutment footings (degradation)? Yes ____ No ____
- channel bank caving in (degradation)? Yes ____ No ____
- eroding floodplain (aggradation)? Yes ____ No ____
- crossing at confluence or tributaries? Yes ____ No ____
- bridge sites upstream and downstream? Yes ____ No ____
- grade or hydraulic controls, i.e. dams, weirs, diversions? Yes ____ No ____
- foundation on rock? Yes ____ No ____
- channel armoring potential? Yes ____ No ____

Comments:

**Stream Stability:** Make a qualitative assessment of the overall stream stability by referring to the above information and Figure 2.6 and Table 3.2 from HEC-20 (attach copies of figures).

Stable____, Unstable____, Degrading____, Aggrading____

Comments:

**RECOMMENDED NBIS ITEM 113 CODE**

**LEVEL TWO ANALYSIS NEEDED:** YES____ NO____
channel is elevated through deposition and becomes part of the floodplain. Also, the stream channel is lengthened and the slope is further reduced. The upstream streambed is filled in and average flood elevations are increased. As the stream works across the stream valley, deposition causes the total floodplain to raise in elevation. Hence, even old streams are far from static. Old rivers meander, and they are affected by changes in sea level, influenced by movements of the earth’s crust, changed by delta formations or glaciation, and subject to modifications due to climatological changes and as a consequence of man’s development.

2.3.7 Natural Levees

Natural levees form during floods as the stream stage exceeds bankfull conditions. Sediment is then deposited on the floodplain due to the reduced velocity and transporting capacity of the flood in these overbank areas. The natural levees formed near the stream are rather steep because coarse material drops out quickly as the overbank velocity is smaller than the stream velocity. Farther from the stream, the gradients are flatter and finer materials drop out. Swamp areas are found beyond the levees.

Classification based on natural levees is illustrated in Figure 2.6. Streams with well-developed natural levees tend to be of constant width and have low rates of lateral migration. Well-developed levees usually occur along the lower courses of streams or where the floodplain is submerged for several weeks or months a year. If the levee is breached, the stream course may change through the breach. Areas between natural levees and the valley sides may drain, but slowly. Streams tributary to streams with well-developed natural levees may flow approximately parallel with the larger stream for long distances before entering the larger stream.

2.3.8 Apparent Incision

The apparent incision of a stream channel is judged from the height of its banks at normal stage relative to its width. For a stream whose width is about 30 m (100 ft), bank heights in the range of 1.8 to 3.0 m (6 to 10 ft) are about average, and higher banks indicate probable incision. For a stream whose width is about 300 m (1,000 ft), bank heights in the range of 3.0 to 5.0 m (10-15 ft) are about average, and higher banks indicate probable incision. Incised streams tend to be fixed in position and are not likely to bypass a bridge or to shift in alignment at a bridge. Lateral erosion rates are likely to be slow, except for western arroyos with high, vertical, and clearly unstable banks.

2.3.9 Channel Boundaries and Vegetation

Although no precise definitions can be given for alluvial, semi-alluvial, or non-alluvial streams, some distinction with regard to the erosional resistance of the earth material in channel boundaries is needed. In geology, bedrock is distinguished from alluvium and other surficial materials mainly on the basis of age, rather than on resistance to erosion. A compact alluvial clay is likely to be more resistant than a weakly cemented sandstone that is much older. Nevertheless, the term “bedrock” does carry a connotation of greater resistance to erosion, and it is used here in that sense. An alluvial channel is in alluvium, a non-alluvial channel is in bedrock or in very large material (cobbles and boulders) that do not move except at very large flows, and a semi-alluvial channel has both bedrock and alluvium in its boundaries. The bedrock of non-alluvial channels may be wholly or partly covered with sediment at low stages, but is likely to be exposed by scour during floods.

2.11
Most highway stream crossings are over alluvial streams which are susceptible to more hydraulic problems than non-alluvial streams. However, the security of a foundation in bedrock depends on the quality of the bedrock\(^{(1)}\) and the care with which foundation is set. Serious problems and failures have developed at bridges with foundations on shale, sandstone, limestone, glacial till, and other erodible rock. The New York State Thruway Schoharie Creek bridge failure is a catastrophic example of such a failure. Bed material at the bridge site was highly cemented glacial till which scoured, undermining spread footings.\(^{(3)}\)

Changes in channel geometry with time are particularly significant during periods when alluvial channels are subjected to high flows, and few changes occur during relatively dry periods. Erosive forces during high-flow periods may have a capacity as much as 100 times greater than those forces acting during periods of intermediate and low-flow rates. When considering the stability of alluvial streams, in most instances it can be shown that approximately 90 percent of all changes occur during that small percentage of the time when the flow equals or exceeds dominant discharge. A discussion of dominant discharge may be found in Hydraulic Design Series No. 6, but the bankfull flow condition is recommended for use where a detailed analysis of dominant discharge is not feasible.\(^{(13)}\)

The most significant property of materials of which channel boundaries are comprised is particle size. It is the most readily measured property, and, in general, represents a sufficiently complete description of the sediment particle for many practical purposes. Other properties such as shape and fall velocity tend to vary with size in a roughly predictable manner.

In general, sediments have been classified into boulders, cobbles, gravel, sands, silts, and clays on the basis of their nominal or sieve diameters. The size range in each general class is given in Table 2.1. Note that even when the English system of units is used, sand size particles and smaller are typically described in millimeters. Noncohesive material generally consists of silt (0.004 - 0.062 mm), sand (0.062 - 2.0 mm), gravel (2.0 - 64 mm), or cobble (64 - 250 mm).

The appearance of the streambank is a good indication of relative stability. A field inspection of a channel will help to identify characteristics which are associated with erosion rates:

- Unstable banks with moderate to high erosion rates usually have slopes which exceed 30 percent, and a cover of woody vegetation is rarely present. At a bend, the point bar opposite an unstable cut bank is likely to be bare at normal stage, but it may be covered with annual vegetation and low woody vegetation, especially willows. Where very rapid erosion is occurring, the bank may have irregular indentations. Fissures, which represent the boundaries of actual or potential slump blocks along the bank line indicate the potential for very rapid bank erosion.

- Unstable banks with slow to moderate erosion rates may be partly reshaped to a stable slope. The degree of instability is difficult to assess, and reliance is placed mainly on vegetation. The reshaping of a bank typically begins with the accumulation of slumped material at the base such that a slope is formed, and progresses by smoothing of the slope and the establishment of vegetation.
### Table 2.1. Sediment Grade Scale.

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<th>Size</th>
<th>Approximate Sieve Mesh Openings (per inch)</th>
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<td>Millimeters</td>
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<td>4-2</td>
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- Eroding banks are a source of debris when trees fall as they are undermined. Therefore, debris can be a sign of unstable banks and of great concern due to potential blockage of bridge openings.

- Stable banks with very slow erosion rates tend to be graded to a smooth slope of less than about 30 percent. Mature trees on a graded bank slope are convincing evidence of bank stability. In most regions of the United States, the upper parts of stable banks are vegetated, but the lower part may be bare at normal stage, depending on bank height and flow regime of the stream. Where banks are low, dense vegetation may extend to the water's edge at normal stage. Where banks are high, occasional slumps may occur on even the most stable graded banks. Shallow mountain streams that transport coarse bed sediment tend to have stable banks.

2.13
Active bank erosion can be recognized by falling or fallen vegetation along the bank line, cracks along the bank surface, slump blocks, deflected flow patterns adjacent to the bank line, live vegetation in the flow, increased turbidity, fresh vertical faces, newly formed bars immediately downstream of the eroding area, and, in some locations, a deep scour pool adjacent to the toe of the bank. These indications of active bank erosion can be noted in the field and on stereoscopic pairs of aerial photographs. Color infrared photography is particularly useful in detecting most of the indicators listed above, especially differences in turbidity. Figure 2.8 illustrates some of the features which indicate that a bank line is actively eroding.

Figure 2.8. Active bank erosion illustrated by vertical cut banks, slump blocks, and falling vegetation.

Bank Materials. Resistance of a streambank to erosion is closely related to several characteristics of the bank material. Bank material deposited in the stream can be broadly classified as cohesive, noncohesive, and composite. Typical bank failure surfaces of various materials are shown in Figure 2.9 and are described as follows.\(^{11}\)

- Noncohesive bank material tends to be removed grain by grain from the bank. The rate of particle removal, and particle movement, and hence the rate of bank erosion, is affected by factors such as particle size, bank slope, the direction and magnitude of the velocity adjacent to the bank, turbulent velocity fluctuations, the magnitude of and fluctuations in the shear stress exerted on the banks, seepage force, piping, and wave forces. Figure 2.9(a) illustrates failure of banks of noncohesive material from flow slides resulting from a loss of shear strength because of saturation, and failure from sloughing resulting from the removal of materials in the lower portion of the bank.
Figure 2.9. Typical bank failure surfaces: (a) noncohesive, (b) cohesive, and (c) composite (after Brown).\(^\text{[17]}\)
- Cohesive material is more resistant to surface erosion and has low permeability, which reduces the effects of seepage, piping, frost heaving, and subsurface flow on the stability of the banks. However, when undercut and/or saturated, such banks are more likely to fail due to mass wasting processes. Failure mechanisms for cohesive banks are illustrated in Figure 2.9(b).

- Composite or stratified banks consist of layers of materials of various sizes, permeability, and cohesion. The layers of noncohesive material are subject to surface erosion, but may be partly protected by adjacent layers of cohesive material. This type of bank is also vulnerable to erosion and sliding as a consequence of subsurface flows and piping. Typical failure modes are illustrated in Figure 2.9(c).

**Piping.** Piping is a phenomenon common to alluvial streambanks. With stratified banks, flow is induced in more permeable layers by changes in stream stage and by waves. If flow through the permeable lenses is capable of dislodging and transporting particles, the material is slowly removed, forming "pipes" which undermine portions of the bank. Without this foundation material to support the overlying layers, a block of bank material drops down and results in the development of tension cracks as sketched in Figure 2.9(c). These cracks allow surface flows to enter, further reducing the stability of the affected block of bank material. Bank erosion may continue on a grain-by-grain basis or the block of bank material may ultimately slide downward and outward into the channel, with bank failure resulting from a combination of seepage forces, piping, and mass wasting.

**Mass Wasting.** Local mass wasting is another form of bank failure. If a bank becomes saturated and possibly undercut by flowing water, blocks of the bank may slump or slide into the channel. Mass wasting may be caused or aggravated by the construction of homes on river banks, operation of equipment adjacent to the banks, added gravitational force resulting from tree growth, location of roads that cause unfavorable drainage conditions, agricultural uses on adjacent floodplain, saturation of banks by leach fields from septic tanks, and increased infiltration of water into the floodplain as a result of changing land-use practices.

Various forces are involved in mass wasting. Landslides, the downslope movement of earth and organic materials, result from an imbalance of forces. These forces are associated with the downslope gravity component of the slope mass. Resisting these downslope forces are the shear strength of the materials and any contribution from vegetation via root strength or engineered slope reinforcement activities. When the toe of a slope is removed, as by a stream, the slope materials may move downward into the void in order to establish a new equilibrium. Often, this equilibrium is a slope configuration with less than original surface gradient. The toe of the failed mass then provides a new buttress against further movements. Erosion of the toe of the slope then begins the process over again.

**Bank Erosion and Failure.** The erosion, instability, and/or retreat of a stream bank is dependent on the processes responsible for the erosion of material from the bank and the mechanisms of failure resulting from the instability created by those processes. Bank retreat is often a combination of these processes and mechanisms operating at various timescales. While the detailed analysis of bank stability is, primarily, a geotechnical problem (see for example, FHWA publications on soil slope stability), insight on the relationship between stream channel degradation and bank failure, for example, can be important to the hydraulic engineer concerned with bank instability. The processes responsible for bank erosion and bank failure mechanisms are discussed in more detail in Appendix B.
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Scour - Level 1 & 2 Evaluations, Plans of Action and Countermeasures
www.MichiganLTAP.org
### Level One Evaluation

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<th>READING ELEVATION</th>
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<tr>
<td>80</td>
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<td></td>
</tr>
</tbody>
</table>
Item 113 - Scour Critical Bridges

Use a single-digit code as indicated below to identify the current status of the bridge regarding its vulnerability to scour. Evaluations shall be made by hydraulic/geotechnical/structural engineers. Guidance on conducting a scour evaluation is included in the FHWA Technical Advisory T 5140.23 titled, "Evaluating Scour at Bridges." Detailed engineering guidance is provided in the Hydraulic Engineering Circular 18 titled "Evaluating Scour at Bridges." Whenever a rating factor of 2 or below is determined for this item, the rating factor for Item 60 -- Substructure and other affected items (i.e., load ratings, superstructure rating) should be revised to be consistent with the severity of observed scour and resultant damage to the bridge. A plan of action should be developed for each scour critical bridge (see FHWA Technical Advisory T 5140.23, HEC 18 and HEC 23). A scour critical bridge is one with abutment or pier foundation rated as unstable due to (1) observed scour at the bridge site (rating factor of 2, 1, or 0) or (2) a scour potential as determined from a scour evaluation study (rating factor of 3). It is assumed that the coding of this item has been based on an engineering evaluation, which includes consultation of the NBIS field inspection findings.

Code  Description

N  Bridge not over waterway.

U  Bridge with "unknown" foundation that has not been evaluated for scour. Until risk can be determined, a plan of action should be developed and implemented to reduce the risk to users from a bridge failure during and immediately after a flood event (see HEC 23).

T  Bridge over "tidal" waters that has not been evaluated for scour, but considered low risk. Bridge will be monitored with regular inspection cycle and with appropriate underwater inspections until an evaluation is performed ("Unknown" foundations in "tidal" waters should be coded U.)

9  Bridge foundations (including piles) on dry land well above flood water elevations.

8  Bridge foundations determined to be stable for the assessed or calculated scour condition. Scour is determined to be above top of footing (Example A) by assessment (i.e., bridge foundations are on rock formations that have been determined to resist scour within the service life of the bridge), by calculation or by installation of properly designed countermeasures (see HEC 23).

7  Countermeasures have been installed to mitigate an existing problem with scour and to reduce the risk of bridge failure during a flood event. Instructions contained in a plan of action
Level One Evaluation

have been implemented to reduce the risk to users from a bridge failure during or immediately after a flood event.

6 Scour calculation/evaluation has not been made. (Use only to describe case where bridge has not yet been evaluated for scour potential.)

5 Bridge foundations determined to be stable for assessed or calculated scour condition. Scour is determined to be within the limits of footing or piles (Example B) by assessment (i.e., bridge foundations are on rock formations that have been determined to resist scour within the service life of the bridge), by calculations or by installation of properly designed countermeasures (see HEC 23).

4 Bridge foundations determined to be stable for assessed or calculated scour conditions; field review indicates action is required to protect exposed foundations (see HEC 23).

3 Bridge is scour critical; bridge foundations determined to be unstable for assessed or calculated scour conditions:
   - Scour within limits of footing or piles. (Example B)
   - Scour below spread-footing base or pile tips. (Example C)

2 Bridge is scour critical; field review indicates that extensive scour has occurred at bridge foundations, which are determined to be unstable by:
   - a comparison of calculated scour and observed scour during the bridge inspection, or
   - an engineering evaluation of the observed scour condition reported by the bridge inspector in Item 60.

1 Bridge is scour critical; field review indicates that failure of piers/abutments is imminent. Bridge is closed to traffic. Failure is imminent based on:
   - a comparison of calculated and observed scour during the bridge inspection, or
   - an engineering evaluation of the observed scour condition reported by the bridge inspector in Item 60.

0 Bridge is scour critical. Bridge has failed and is closed to traffic.

EXAMPLES:  

<table>
<thead>
<tr>
<th>SCOUR TYPE</th>
<th>ACTION NEEDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Above top of footing</td>
<td>None - indicate rating of 8 for this item</td>
</tr>
<tr>
<td>B. Within limits of footing or piles</td>
<td>Conduct foundation structural analysis</td>
</tr>
<tr>
<td>C. Below pile tips or spread-footing base</td>
<td>Provide for monitoring and scour countermeasures as necessary</td>
</tr>
</tbody>
</table>

SPREAD FOOTING (NOT FOUND IN ROCK)
PILE FOOTING

++++++++++++++++++++++++++++++++++ - Calculated scour depth
Level One Evaluation

<table>
<thead>
<tr>
<th>STREAM SIZE (Sect 2.3.2)</th>
<th>Small [&lt; 30 m (100 ft.) wide]</th>
<th>Medium [30-160 m (100-500 ft.)]</th>
<th>Wide [&gt; 160 m (500 ft.)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLOW HABIT (Sect 2.3.3)</td>
<td>Ephemeral</td>
<td>(Intermittent)</td>
<td>Perennial</td>
</tr>
<tr>
<td>BED MATERIAL (Sect 2.3.4)</td>
<td>Silt-Clay</td>
<td>Silt</td>
<td>Sand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gravel</td>
<td>Cobble or Boulder</td>
</tr>
<tr>
<td>VALLEY SETTING (Sect 2.3.5)</td>
<td>No valley, alluvial fan</td>
<td>Low relief valley [&lt; 30 m (100 ft.) deep]</td>
<td>Moderate relief [30-300 m (100-1000 ft.) deep]</td>
</tr>
<tr>
<td>FLOODPLAINS (Sect 2.3.6)</td>
<td>Little or none (&lt; 2 x channel width)</td>
<td>Narrow (2-10 x channel width)</td>
<td>Wide (&gt; 10 x channel width)</td>
</tr>
<tr>
<td>NATURAL LEVEES (Sect 2.3.7)</td>
<td>Little or none</td>
<td>Mainly on concave</td>
<td>Well developed on both banks</td>
</tr>
<tr>
<td>APPARENT INCISION (Sect 2.3.8)</td>
<td>Not Incised</td>
<td>Probably Incised</td>
<td></td>
</tr>
<tr>
<td>CHANNEL BOUNDARIES (Sect 2.3.9)</td>
<td>Alluvial</td>
<td>Semi-alluvial</td>
<td>Non-alluvial</td>
</tr>
<tr>
<td>TREE COVER ON BANKS (Sect 2.3.9)</td>
<td>&lt; 50 percent of bankline</td>
<td>50-90 percent of bankline</td>
<td>&gt; 90 percent of bankline</td>
</tr>
<tr>
<td>SINUOSITY (Sect 2.3.10)</td>
<td>Straight Sinuosity (1-1.05)</td>
<td>Sinuous (1.06-1.23)</td>
<td>Meandering (1.25-2.0)</td>
</tr>
<tr>
<td>BRAIDED STREAMS (Sect 2.3.11)</td>
<td>Not braided (&lt;5 percent)</td>
<td>Locally braided (2-35 percent)</td>
<td>Generally braided (&gt;35 percent)</td>
</tr>
<tr>
<td>ANABRANCHED STREAMS (Sect 2.3.12)</td>
<td>Not anabranch (&lt;5 percent)</td>
<td>Locally anabranch (2-35 percent)</td>
<td>Generally anabranch (&gt;35 percent)</td>
</tr>
<tr>
<td>VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS (Sect 2.3.13)</td>
<td>Narrow point bars</td>
<td>Wider at bends</td>
<td>Random variation</td>
</tr>
</tbody>
</table>

Figure 2.6. Geomorphic factors that affect stream stability (adapted from Brice and Blodgett).}^{10}
<table>
<thead>
<tr>
<th>Table 3.2. Interpretation of Observed Data (after Keefer et al.).(^{(26)})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observed Condition</strong></td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Alluvial Fan(^1)</td>
</tr>
<tr>
<td>Upstream</td>
</tr>
<tr>
<td>Downstream</td>
</tr>
<tr>
<td>Dam and Reservoir</td>
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<tr>
<td>Upstream</td>
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<tr>
<td>Downstream</td>
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<tr>
<td>River Form</td>
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<td>Meandering</td>
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<tr>
<td>Straight</td>
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<tr>
<td>Braided</td>
</tr>
<tr>
<td>Bank Erosion</td>
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<tr>
<td>Vegetated Banks</td>
</tr>
<tr>
<td>Head Cuts</td>
</tr>
<tr>
<td>Diversion</td>
</tr>
<tr>
<td>Clear water diversion</td>
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<tr>
<td>Overloaded sediment</td>
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<tr>
<td>Channel Straightened</td>
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<tr>
<td>Deforest Watershed</td>
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<tr>
<td>Drought Period</td>
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<tr>
<td>Wet Period</td>
</tr>
<tr>
<td>Bed Material Size</td>
</tr>
<tr>
<td>Increase</td>
</tr>
<tr>
<td>Decrease</td>
</tr>
</tbody>
</table>

\(^1\)The observed condition refers to location of the bridge on the alluvial fan, i.e., on the upstream or downstream portion of the fan.
BRIDGE CROSS SECTION SPREADSHEET

INSTRUCTIONS

The purpose of this spreadsheet is to provide bridge cross sections for comparison over a period of time. The cross sections will provide long-term data on local scour and streambed degradation/degradation, and the spreadsheet will provide this data in a consistent format. The instructions for using the spreadsheet are as follows:

1. The spreadsheet is divided in two sections: A PREVIOUS CROSS SECTION and A CURRENT CROSS SECTION. If available, MDOT will provide information on the previous cross section taken at the structure for comparison purposes.

2. The benchmark elevation and the reference elevation are not necessarily the same thing. The engineer taking the measurements will pick the location of the benchmark. It should be a fixed elevation at the bridge, for example, the top of abutment. If the actual elevation is not available, an assumed elevation (typically 100) may be used. Since this is for comparison purposes, it must be described in enough detail so that the measurements can be repeated at any time in the future. If the A PREVIOUS CROSS SECTION information is filled out, use the same benchmark as previously used.

The reference elevation is the elevation that the "READING" will be subtracted from. This could be the benchmark elevation, but if the bridge is on a slope or camber, one reference that can be used is the water surface elevation. In this case, the distance from the benchmark to the water must be measured to obtain the elevation of the water, and the water surface elevation is entered as the A REFERENCE ELEVATION on the spreadsheet. The spreadsheet automatically subtracts the readings at each station from the reference elevation, so the reference elevation must be entered in cell H23 (Upstream face) or cell H59 (Downstream face) to make the automatic calculation work.

3. Stationing is always from left to right looking downstream. Station 0 is the left abutment. The minimum number of station points for the channel bottom is dependent on the width of the watercourse. If the watercourse is less than 20 feet in width, a minimum of 5 station points, one every 4 feet, is required. For widths equal to or greater than 20 feet but less than 50 feet, 5 to 10 equally spaced station points are required. For widths equal to or greater than 50 feet, 10 to 20 equally spaced station points (5 or 10 foot intervals) are required in the channel.

In addition to these points, the location of piers must be indicated by the stationing. For example, 25 and 28 with a description as Pier 1 indicates a 3 foot wide pier starting at station 25. Readings should be taken as close as possible to both sides of the pier or in front of the pier. Since scour holes typically occur at piers, it is important to take these readings.

4. The spreadsheet automatically graphs the cross-sections on the second and third pages of the spreadsheet. It will also graph the cross-section taken at the previous bridge inspection for comparison. For this reason, the cross-section points must be taken at the same locations that are shown in column A under A STATION. If there is no previous information, take points as directed in Item 2 above and enter the station points in column A.

5. Check the graphs to make sure that the cross-sections look reasonable and make any corrections necessary while at the site.

6. Submit a disk with the Excel file labeled with the control section and bridge number. For example, B01 of 06071 would be labeled 06071b01. Also submit hard copies of the data and graphs.

7. Any questions may be directed to Chris Botwin, Hydraulics Hydrology Unit, 313-335-1919.
Level 2 Evaluation

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Michigan Technological University

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Email:barkdoll@mtu.edu

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Presentation Summary

All material summarized from “Evaluating Scour at Bridges” HEC 18, FHA, Publ # FHWA HI-96-031

7 Steps for Total Bridge Scour

► 1: Determine scour analysis variables
  • Find design Q (worst-case scenario) 500-yr Q or special angle, etc.
  • Any future changes to river?
  • Calculate water surface profiles (step method, HEC-2, WSPRO, etc.)
  • Get geology, sediment size, cross-sections, planform, watershed data, similar bridge scour, energy gradeline slope, flooding history, location wrt other bridges or tributaries, meander history, erosion history, sand mining, etc.)

► 2: Analyze long-term bed elevation change
  • Find trend of aggradation/degradation using either past data,
  • Site evidence,
  • worst-case, or
  • software.

► 3: Evaluate scour analysis method
  • Get fixed-bed hydraulic data
  • Assess profile and planform changes
  • Adjust fixed-bed hydraulics for profile and planform changes
  • Compute contraction (discussed later)
  • Compute local scour (discussed later)
  • Get total scour by adding long-term degradation+contraction scour+local scour

► 4: Compute contraction scour magnitude

► 5: Compute local pier scour magnitude
  • Determine if clear water or live bed by incipient motion equation
  • Adjust for pier nose shape
Level 2 Evaluation

- Find angle of attack correction
- Adjust for bedform shape (ripples or dunes)
- Adjust for armoring (layer of larger stones on bed surface)
- Special cases
  - Very wide piers
  - Exposed footings and/or piles
  - Pile caps in flow
  - Multiple columns skewed to flow
  - Pressure flow scour deck over-topping
  - Debris

► 6: Compute local abutment scour magnitude
- Many kinds exist
- Adjust for different setbacks (in main channel, back on floodplain)
- Adjust for shape (spill-through, vertical face, wingwall)
- Adjust for angle to flow

► 7: Plot and evaluate total scour
- Plot bed degradation elevation
- Subtract contraction scour and local scour (include local scour width as well=2depth)
- Is scour depth reasonable?
- Avoid overlapping scour holes
- Consider scour protection rather than a foundation deeper than the scour (can you count on it?)
- Evaluate cost, safety, environmental effects, ice, and debris.
- Re-Evaluation of Design
  - Waterway width OK? (Leave as is?)
  - Are scour holes overlapping?
  - Relief bridges on floodplain needed?
  - Abutments properly aligned?
  - Can crossing location be changed?
  - Can you train the flow at bridge?
  - Is 2-D numerical model or physical model study needed?

FOR MORE INFORMATION

Michigan’s Local Technical Assistance Program

www.MichiganLTAP.org
Countermeasure Calculations and Design

Brian Barkdoll, P.E., PhD.
Department of Environmental Engineering
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Email:barkdoll@mtu.edu

Presentation Summary


Selecting a countermeasure

depends on Erosion Mechanism, Stream Characteristics, Construction and Maintenance Requirements, Vandalism, Costs

► Countermeasures for Meander Migration
   include bank revetments, spurs, retardance structures, longitudinal dikes, vane dikes, bulkheads, channel relocations, and a carefully planned cutoff

► Countermeasures for Channel Braiding and Anabranching
   include dikes constructed from the margins of the braided zone to the channel over which the bridge is constructed, guide banks at bridge abutments (Design Guideline 10) in combination with revetment on highway fill slopes (Design Guideline 12), riprap on highway fill slopes only, and spurs (Design Guideline 9) arranged in the stream channels to constrict flow.

► Countermeasures for Degredation
   include Check-dams or drop structures, Combinations of bulkheads and riprap revetment, deeper foundations at piers and pile bents, Jacketing piers with steel casings or sheet piles, adequate setback of abutments from slumping banks, Rock-and-wire mattresses, Longitudinal stone dikes placed at the toe of channel banks, tiebacks to the banks to prevent outflanking.

► Countermeasures to Control Aggradation
   include Alteration or replacement of a bridge, Maintenance programs, spurs or dikes with flexible revetment have, A debris basin and controlled sand and gravel mining.
Countermeasure Calculations and Design

- **Countermeasure to control Contraction scour**
  include longer bridges, relief bridges on the floodplain, superstructures at elevations above flood stages of extreme events, and a crest vertical profile on approach roadways to provide for overtopping during floods exceeding the design flood event.

- **Monitoring**
  is very important to catch problems before they get dangerous.

**Bendway Wiers/ Stream Barbs**
- **Flow goes over to redirect flow**
- **Made of stones, grout bags, or logs**
- **Must design:**
  height, angle, length, location, spacing, key length, top width, # of wiers

**Rock Riprap at Piers and Abutments**
- **Does help, but must be monitored**
- **Must design:**
  rock size, extent of mattress, and underlying Geotextile filter size

**Spurs**
- **Flow goes around to re-direct flow**
- **Must design:**
  type of spur, extent of spur field, length, orientation, permeability, Height, depth of keying into bank, spacing, shape, and protection with riprap

**Guidebanks**
- **For use when embankments encroach on floodplain**
- **Must design:**
  orientation, length, height, shape, size, riprap protection, downstream extent
Additional Countermeasures

- Soil cement (where rock not available)
- Wire-enclosed riprap mattress (Gabions)
- Articulated concrete blocks
- Grout-filled mattress
- Concrete Armor Units
- Grout-filled bags
- Check dams for grade control
- Revetments for bank stabilization

Various NCHRP reports published on bridge scour

New version of HEC 23

coming out soon with new material on biotechnology as countermeasures

For More Information

“Bridge Scour and Stream Instability Countermeasures, Experience, Selection, and Design Guidance”


Michigan’s Local Technical Assistance Program

www.MichiganLTAP.org
Presentation Summary

Scour Action Plans in the Michigan Bridge Inspection System (MBIS)

Agencies can access the MBIS to create and update Scour Critical Bridge Action Plans by going to MDOT’s website at http://www.michigan.gov/mdot. Select “doing business” from the left hand menu, then select “Bridge Operations”, then select “Michigan Bridge Inspection System.” You will be asked for your user ID and password. If you do not have a users ID and password, please call Ron Hafner, Michigan Department of Transportation, Bridge Management Unit, Phone 517-322-6058. Once in MBIS select “Special Reports” from the top tab. Select “Scour Action Plan” and then “Get Special Inspections.” A list of your scour critical bridges will be shown. Select either “Structure #” or “MDOT Structure ID” to show the scour action plan form.

Filling out the Scour Action Plan form

Discuss “smart form”
which is pre-filled information from the bridge data base, such as bridge identification, structure location, and latest bridge safety inspection report and Pontis inspection data.

Identifying watershed

Section 1 – Scour Vulnerability Rating

Abutment and pier information
Scour Critical Bridge-Plan of Action (Part 1)

- Observed Scour
- Executive summary of Scour analysis report.
- Scour Analysis Event Frequency

► Section 2 – Bridge inspection Coding Information
  - Pontis Smart flags
  - Bridge safety inspection Report (BSIR)

► Section 3 – Countermeasure Condition and Recommendation
  - Existing countermeasures
  - Inspector recommendations

► Section 4 – Monitoring Plans
  - River cross section elevations
  - Items to watch
  - Monitoring devices
  - Responsible agency

► Section 5 – Bridge Closure
  - Conditions to Evaluate for bridge closure
  - Contact people for bridge closure
  - Re-opening after inspection

► Section 6 – Detour route
  - Possible detour route
  - Bridges on detour route

► Section 7 – Documentation of high flow event

Future development

FOR MORE INFORMATION

MDOT’s Website
www.michigan.gov/mdot

MDOT’s Bridge Operations Website
http://www.michigan.gov/mdot/0,1607,7-151-9625_24768—,00.html

Michigan’s Local Technical Assistance Program
www.MichiganLTAP.org
Scour Critical Bridge-Plan of Action (Part 2)

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Presentation Summary
Quality Assurance

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Presentation Summary

QUALITY
...pursuit of perfection...

Why do it?

► All human endeavor is intrinsically not perfect.
► Required by the regulations
► Aging network, compounded by a lack of maintenance, means more structures with less of a safety factor.
► “Continuous Improvement” for safety
► Program consistency and uniformity.

QA/QC vs Audit

► Not intended to duplicate the FHWA oversight role.
► Intended to provide validation of good work and provide advice where improvement is possible.
► Review process is known to all... no surprises.
► Reviewers assume a desire for professional improvement and mutual respect.

Definition of Quality Control

► QC from 23-CFR-650...
  “Procedures that are intended to maintain the quality of the bridge inspection unit and load rating at or above a specific level.”

Definition of Quality Assurance

► QA from 23-CFR-650
  “The use of sampling and other measures to assure the adequacy of the quality control procedures in order to verify or measure the quality level of the entire bridge inspection and load rating program.”
Quality Assurance

Fundamental Parameters

- The QA/QC program cannot take so much time and effort that it detracts from the inspection work
- The program must be clear and transparent to the outside observer, evaluations must be:
  - Unbiased and not hiding deficiencies
  - QA/QC efforts must be effective in ensuring the program is keeping the bridges from becoming unsafe AND
  - serious efforts are made to correct deficiencies

Quality Assurance by MDOT

- Done under contract by MDOT
- Majority of QA’s done in a day or less.
- Very structured process.
  - Standardized meeting agendas
  - Standardized evaluation forms / checklists
- Review will cover reports and field check.
- Feedback Form
- Cycle through all agencies (MDOT & LA’s) once every 10 years.

Quality Control

- Done at the inspection unit level by independent QTL.
  - Keep a copy of the credentials in the file.
- Review 10% of the network of the completed inspections in a given season.
- File review (all documents).
  - Review network data files (MBRS)
- Field verify ratings.
- Communication of findings.

Good QC practices

- Chose a variety of structure types, materials, and condition.
- QC reviewer to sign / initial and date reports that have been reviewed. File in bridge file.
- Maintain a QC file with list of structures reviewed and communication of findings.
- Check ratings vs. comments and if they are in alignment with the guidelines.
- Check the condition vs the inspection frequency.

File review

- Review at least 10% of the network.
- MBRS can assist with overall reviews.
- Review all documents.
  - Insp. Reports
  - Load Rating
  - Scour Evals
  - Pictures
  - Plans

Field review

- Check ratings with condition of bridge.
- Check comments with rating and condition.
- Frequency of inspection.
- General compliance with FC, scour, UW, and other inspection factors.
- Be aware of “Compliancy due to Familiarity”.
- Look for consistent errors which show up from bridge to bridge.

QC by Your Consultant

- If you do inspection under contract with a consultant, they need to do QC.
- The requirements are the same.
- Now a condition of pre-qualification.
- Contract template has the QC requirements.
- Request MBRS outputs for QC.
Quality Assurance

Summary

- QA reviews by MDOT are not audits and we attempt to take the stress out of the reviews and use the review for technical exchange.
- Keep the process tight and efficient.
- Feedback.

FOR MORE INFORMATION (MORE INFO - HEAD)

Michigan’s Local Technical Assistance Program
www.MichiganLTAP.org
Case Studies

Nate VanDrunen, P.E., Grand Region Bridge Engineer Phone:(616)451-4884
Michigan Department of Transportation Email:vandrunenm@michigan.gov

Presentation Summary
Case Studies
Scour Protection

While scour protection may be necessary to ensure the structural safety of the bridge there are a couple of environmental statutes administered by the Michigan Department of Environmental Quality, Land and Water Management Division that must be met.

- **Part 301, Inland Lakes and Streams, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).** Permits are needed under Part 301 for the following:
  - Dredge or fill the bottomland.
  - Construct, enlarge, extend, remove or place a structure on bottomland.
  - Create, enlarge, or diminish an inland lake or stream.
  - Structurally interfere with the natural flow of an inland lake or stream.

- **Definition of a stream-** “…a river, stream, or creek which may or may not be serving as a drain…or any other body of water that has definite banks, a bed, and visible evidence of a continued flow or continued occurrence of water….“
A stream has the following criteria:

- Definite Banks
- A Bed
- Visible evidence of a continued flow or occurrence of water

NOT a Stream:

- No Definite Banks
- No Bed
- Visible evidence of occurrence of water but not of continued flow
Permits are required for fill placed below the ordinary high water mark - The line between upland and bottomland that persists through successive changes in water levels, below which the presence and action of the water is so common or recurrent that the character of the land is marked distinctly from the upland vegetation.

“The department shall issue a permit if it finds that the structure or project will not adversely affect the public trust or riparian rights … the department shall consider the possible effects of the proposed action upon the inland lake or stream … and the uses of all such waters, including uses for recreation, fish and wildlife, aesthetics, local government, agriculture, commerce, and industry.”

Primary concerns under Part 301 when using riprap/articulating block
- Narrowing of stream channel
- Loss of stream habitat, organism’s are washed away
Part 31, Floodplain Regulatory Authority, Water Resources Protection, of the NREPA. A Permit is required under Part 31 for the following activities:

- Any Occupation,
- Any Filling,
- Any Grade Changes within the floodplain of a river

Part 31 applies to streams/drains with a drainage area of 2 square miles or more. Evaluate for a range of flows up to and including the 100-year (1% chance) flow.

- Project shall not cause a harmful interference which is defined as causing an increased stage or change in direction of flow that causes, or is likely to cause:
  - Damage to property
  - A threat to life
  - A threat of personal injury
  - Pollution, impairment, or destruction of water or other natural resources.

- A Hydraulic Analysis may be needed if there is a reduction in flow area.

- DEQ/DNR prefers a natural channel bottom when ever possible allows.

- Riprap can be used- avoid lining the entire channel bottom if possible.
Tri-lock maybe ok in certain instances, depends on the quality of the stream, try to minimize the amount so that it does not cover the entire stream bottom- acts similar to concrete in that organisms are washed away.

No concrete lined channels, grouting of riprap etc

Minimize Impacts

- You can place riprap/articulating block in scoured out areas to match the original stream invert.
- You can bury the riprap/articulating block so that it matches the existing stream elevation. Fill in the voids of the block with gravel.
- Leave part of the natural stream channel in place
- Place rock over top of the trilock to enhance resource values.
- Go to a larger structure size so the velocities are reduced and the amount of protection is therefore reduced or eliminated.
- Consider using cross vanes that direct the flow to the center of the stream and away from the abutment.

References


For More Information

DEQ-LWMD Application Form:
www.michigan.gov/jointpermit

Staff Contacts, FAQs, Samples:
www.michigan.gov/deqtransformationreview

Michigan’s Local Technical Assistance Program:
www.MichiganLTAP.org

DEQ Transportation Review:
www.michigan.gov/deqtransformationreview