CHAPTER 6

SCOUR

6.01 Purpose

The National Bridge Inspection Standards (NBIS) require each state to identify bridges that are scour critical, and to prepare a plan of action to monitor known and potential deficiencies in accordance with the plan. This process may be divided into two overall categories; the proper coding of Item 113, and managing bridges for scour vulnerability. Coding of Item 113 is determined through one or more analyses to determine whether the structure is susceptible to scour, and may be infrequently updated when conditions contrary to the assigned value are observed or scour countermeasures are installed. The managing of scour critical bridges is a recurrent effort that must be completed throughout the life of the structure. This chapter describes the minimum requirements and monitoring processes that must be adhered to for NBIS compliance. For additional information review Chapter 13 of the FHWA *Bridge Inspector's Reference Manual* (BIRM).

6.02 Responsibilities

Responsibility for coding Item 113 does not follow identical processes for MDOT and local agency owned bridges. For MDOT owned bridges, the coding determination is a collaborative effort performed between the Bureau of Development Hydraulics Unit and the Region Bridge Engineer (bridge owner). For local agency owned bridges, the bridge owner is responsible for performing the coding. Additional information regarding this practice is described in Coding and Managing Bridges for Scour Vulnerability .

The bridge owner is also responsible for ensuring that each bridge over water has a scour vulnerability evaluation in the bridge file. If the evaluation indicates that the bridge is scour critical, then the bridge owner shall be responsible for creating and maintaining an up-to-date Scour Plan of Action (POA) until the bridge is replaced or other measures are installed. Ensuring consistent monitoring in accordance with the POA is also the responsibility of the bridge owner.

The bridge owner shall ensure that the POA is reviewed during flood events and determine whether monitoring is required. When monitoring is necessary, and the work will be performed by an individual other than the bridge owner, the POA must be assigned in MiB^{RIDG}E. This will allow for the inspector to document the findings for the High Flow Event or Scour Action Inspection Report that is added within the POA.

6.02.01 FHWA Metric #18 Inspection Procedures – Scour Critical Bridges

In compliance with NBIS, the bridge owner shall ensure that all bridges over water have the following;

- Evaluation of scour vulnerability
- POA prepared and implemented to evaluate known and potential deficiencies
- Methods and procedures to monitor scour critical bridges in accordance with the POA
- Stream bed cross-sections

On an annual basis, FHWA reviews the entire Michigan bridge inventory and compiles a list of structures where Item 113 is coded 3 or less, U, 6, or null and provides MDOT with an Assessment Reporting Tool (ART) report. The results are then reviewed by MDOT and a response is provided for each of the identified deficiencies. The majority of the defects identified are related to bridges that were constructed within the previous 90 or 180 days that the report was generated, but when monitoring is not documented within MiB^{RIDG}E each individual agency must be contacted for an explanation so a formal response may be provided.

In addition to the ART reports generated from the database query, FHWA also performs intermediate or in-depth assessments during randomly selected file and field reviews to verify that scour monitoring occurred in accordance with the POA. All scour critical bridges located over a watercourse that experienced flooding during the previous year should have a High Flow Event and/or Scour Action Inspection Report to document that monitoring and follow-up occurred.

In order to maintain FHWA compliance, bridge owners must continue to update inventory coding, develop a comprehensive POA, and perform documented monitoring as-needed. Failure to abide by the FHWA requirements may result in a non-compliance finding and jeopardize the disbursement of funding to the state and/or individual agencies involved.

6.03 Scour Analysis

All bridges over water require an assessment of the scour vulnerability to be performed. This evaluation may have occurred prior to construction depending on the year of design. During 1992 requirements were incorporated in the American Association of State Highway and Transportation Officials (AASHTO) *Standard Specifications for Highway Bridges* manual for hydraulic studies to be completed during the preliminary design phase to ensure that the bridge could withstand the effects of scour. Structures built before or during the timeframe that the standard was developed were not required to be evaluated for scour during the design phase.

The minimum documentation that must be in the bridge file includes a completed Level One analysis, or for new structures designed under the specification, plan drawings which denote the depth of anticipated scour. When the results of the Level One analysis indicate that stream instability or scour problems exist then a Level Two analysis or refined hydraulic analysis should be performed. If further analysis is not completed the POA must be developed in a manner that will mitigate any safety concerns during a flood or high flow event. Bridge owners must refer to the MDOT Drainage Manual for Michigan specific guidelines for scour evaluations. This information can be stored electronically in the MiB^{RIDG}E web application under the Inventory & Appraisal tab in the “Waterway Data” section (see Figures 6.03.01 and 6.03.02).

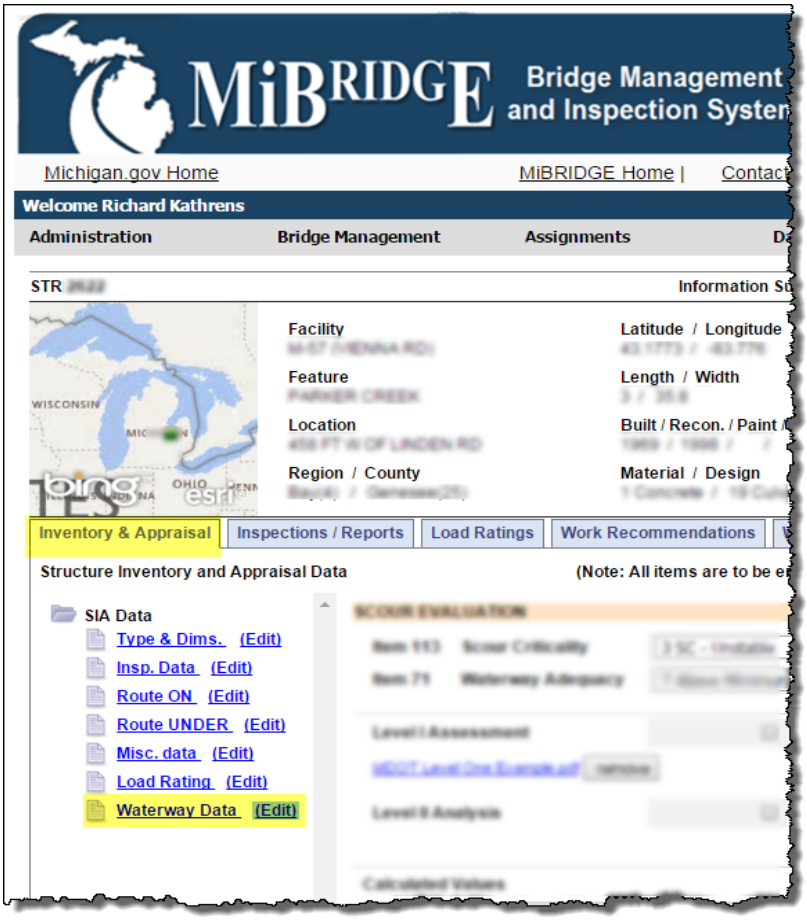


Figure 6.03.01 Waterway Information (MiB[RIDG]E)

Under the Scour Evaluation Section, Item 113 Scour Criticality can be entered or edited. The source of determining the final value of Item 113 should be entered and includes the following choices:

- **Observed:** Scour Criticality determined as a result of a field inspection. Typically, when the observed condition is the source of Item 113 field conditions are more severe than what was determined by the Assessed or Calculated values. Item 113 cannot be coded solely on the observed condition and an assessed worksheet or calculated value must be in the file for comparison of the observed conditions.

- **Assessed:** Scour Criticality determined by completion of the MDOT Level One Scour Analysis Worksheet. Unless a calculated scour analysis is completed, all bridges over water should have the Level One Worksheet completed and uploaded to MiB[RIDG]E.

- **Calculated:** Scour Criticality determined by a completed detailed hydraulic analysis or MDOT Level Two Scour Worksheet

SCOUR EVALUATION

Item 113	Scour Criticality	3 SC - Unstable	Source of Item 113	Assessed
Item 71	Waterway Adequacy	7 Above Minimum		
Level I Assessment		Yes		
Level II Analysis		Yes		

Document Date	Document Name	Document Type
03/07/2016	MDOT Level Two Example.pdf	Level II
03/07/2016	MDOT Level One Example.pdf	Level I

Calculated Values

Scour Analysis Frequency	25 Year	50 Year	100 Year	500 Year	Comments
Anticipated Surface Elevation (ft)	581.75	585.63	600.21	602.3	
Distance Below Bottom Chord (ft)	5.0	4.5	0.0	0.0	Pressure Flow at the 100 Year
Anticipated Flow (cubic ft/sec)	150.0	180.0	200.5	225.24	
Anticipated Pressure Flow (Y/N)	N	N	Y	Y	

Figure 6.03.02 Scour Evaluation Information (MiB[RIDG]E)

The Substructure Information section located in the Waterway Data area of the MiB[RIDG]E Inventory & Appraisal Tab allows the collection of data that can be used to assist with evaluating the structure in regards to scour (see Figure 6.03.03). The substructure table is automatically generated for structures with ten or less spans. If the structure has more than ten spans the table can be manually created. This table is available for all structures over water and will be used on the scour plan of action for scour critical structures. The data for Normally in Water and Normal Water Depth refer to the typical or normal conditions generally found at the structure. If values have been calculated for the 100 year storm event then a comparison can be made to determine if the substructure units are in water during this event. This information may assist field investigations during flood events to help determine the potential of the flood event through comparison of previously calculated values. The determination of the footing type, depths, and soil types can be also be documented, whether this information is known or not.

SUBSTRUCTURE INFORMATION

Foundation	Normally in Water	Normal Water Depth (ft)	In Water (100 Yr)	Footing Type	Depth Known	Soil Type
Abutment A	N	N/A	N	A Spread Ftg Soil	Y	Non Cohesive
Abutment B	N	N/A	N	B Footing Timber Piles	Y	Non Cohesive
Pier 1	Y	5.1	Y	C Footing Steel H Piles	Y	Cohesive
Pier 2	Y	8.2	Y	H Curtain Wall	Y	Cohesive
Pier 3	Y	18.6	Y	I Spread Footing Rock	Y	Rock
Pier 4	Y	24.3	Y	M Gravity Steel H Piles	N	Rock
Pier 5	Y	12.2	Y	Q Gravity on Rock	N	Unknown
Pier 6	Y	3.5	Y	U Unknown	N	Unknown

Figure 6.03.03 Substructure Information (MiB[RIDG]E)

6.04 Examining Scour during Routine NBI Inspections

Scour inspections during regularly scheduled NBI inspections consist of inspecting the entire channel within the vicinity of the structure for aggradation, degradation, general scour, and local scour. Defects should be recorded on the Bridge/Culvert Safety Inspection Report (BSIR/CSIR) under the Scour Inspection (BISR #17 / CSIR #3) item during the routine inspection (see Figures 6.04.01 and 6.04.02). The NBI ratings for the condition of the Abutment (BSIR #13), Piers (BSIR #14), or Culvert (CSIR #1) may be impacted by severity of the scour observed.

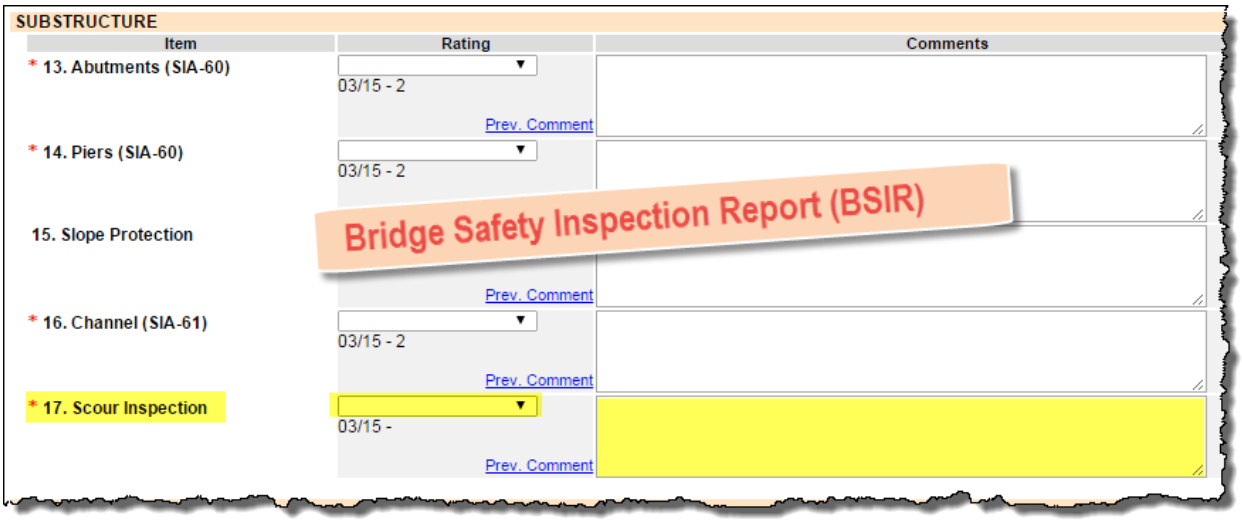


Figure 6.04.01 BSIR Scour Inspection

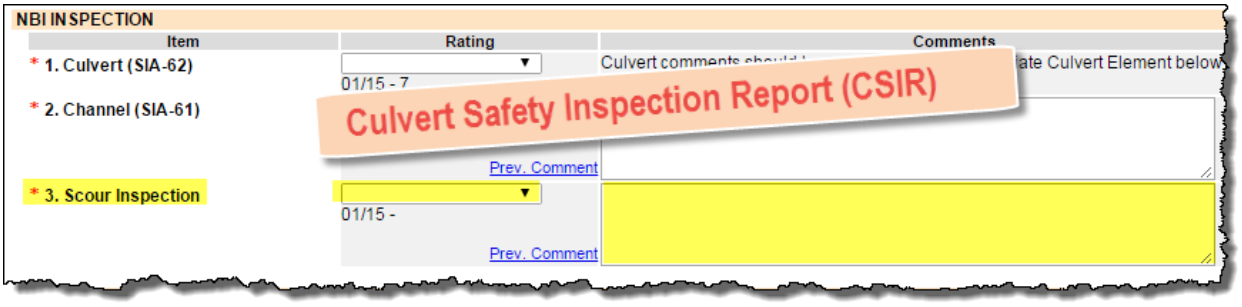


Figure 6.04.02 CSIR Scour Inspection

Since aggradation and degradation usually occur over a significant period of time verification is usually accomplished through periodic recording of stream bed cross-sections to determine overall changes in channel elevations. These types of scour may be caused by naturally occurring environmental changes, or from human induced modifications upstream or downstream from the bridge. For example, increased deforestation and agricultural land use upstream of the structure may lead to additional sediment laden runoff being deposited into the channel leading to aggradation.

General and local scour may occur suddenly through flow increases during, or immediately following, abnormal precipitation or catastrophic events such as a dam failure. Examination of the channel and

substructure units for scour must occur during each regularly scheduled routine NBI inspection for all bridges over waterways. The evaluation may consist of visual observations to detect changes in the channel for bridges without substructure units in the waterway. For this condition the channel should be inspected for steep eroding banks, tension cracking, sloughing, meandering bends, and active undercutting.

When piers or abutments have submerged surfaces in less than 10 feet of water the wade and probe or boat and probe methods must be employed. Probing is important to detect whether the footing is exposed, undermined, or whether live-bed scour has caused loose sediment to refill the void. Where water depths exceed 10 feet an underwater diving inspection must be scheduled at intervals that do not exceed 60 months. When the results of the underwater diving inspection indicate that active scour is present that may potentially threaten stability, the frequency of underwater diving inspections should be increased (See Guidelines for Bridge Inspection Frequencies for more details). Additionally, efforts should be made during the routine inspection to detect changes through the performance of depth soundings to detect scour. The POA should also be tailored for these structures to ensure monitoring is performed during high flow events.

When scour countermeasures have been installed they must be inspected for deterioration and effectiveness. Improperly placed or inadequately sized materials will become unstable and may not offer the protection desired. Document scour or defects identified for any kind of scour countermeasure under the Scour Inspection (BISR #17 / CSIR #3) item during the routine inspection, and on the Scour Action Inspection Report within the POA following an event that triggered monitoring. The NBI ratings for the condition of the Abutment (BSIR #13), Piers (BSIR #14), or Culvert (CSIR #1) may be impacted by severity of the scour observed. The NBI Rating for Item 113, Scour Criticality, may also be impacted by the condition of the scour countermeasures especially when Item 113 is coded 7 indicating that countermeasures have been installed to mitigate an existing scour problem.

Riprap should be angular interlocking stone or in unique situations can include fieldstone. Plain riprap should have a minimum size of approximately 8 to 12 inches and heavy riprap 12 to 24 inches. The protected area should be well graded. Signs of displaced stones, slumping, disintegration, and exposed or damaged geotextile filter can limit the effectiveness of the countermeasure.

Channel armoring should be well keyed to prevent washouts from occurring. Inspect surfaces for cracking and bowing. Where weep holes have been installed to equalize pressure verify that they are clean and functioning adequately. Sound any areas where undermining is suspected to determine if fill is missing from underneath.

Articulating concrete blocks (ACB) are preformed units which either interlock, are held together by cables, or both to form a continuous blanket or block matrix. ACB should be placed flat or sloped uniformly. Review the entire surface for missing or severely damaged blocks. Individual blocks that are misaligned and have raised edges can have a severe impact to the stability of the mat during high flows. Inspect the individual sections for overturning, uplift, cracking, and exposed or damaged geotextile fabric.

Gabion mattresses are basket or compartmented rectangular containers made of wire mesh filled with cobbles or other rock. Gabions should be inspected for movement and separation. The wire should be checked for abrasion and corrosion to ensure it is suitable to retain the rock. Inspect individual sections for undermining or sagging.

Grout filled bags are fabric bags that have been filled with grout to provide scour protection. Grout filled bags should be inspected to ensure that they are keyed in along each edge. Sound any areas where undermining is suspected to determine if fill is missing from underneath.

Sheet piling that has been installed as a scour countermeasure should be inspected for corrosion or section loss that could affect performance. Inspect the alignment for signs of tilting caused by inadequate toe, scour, or deteriorated tie-back anchors.

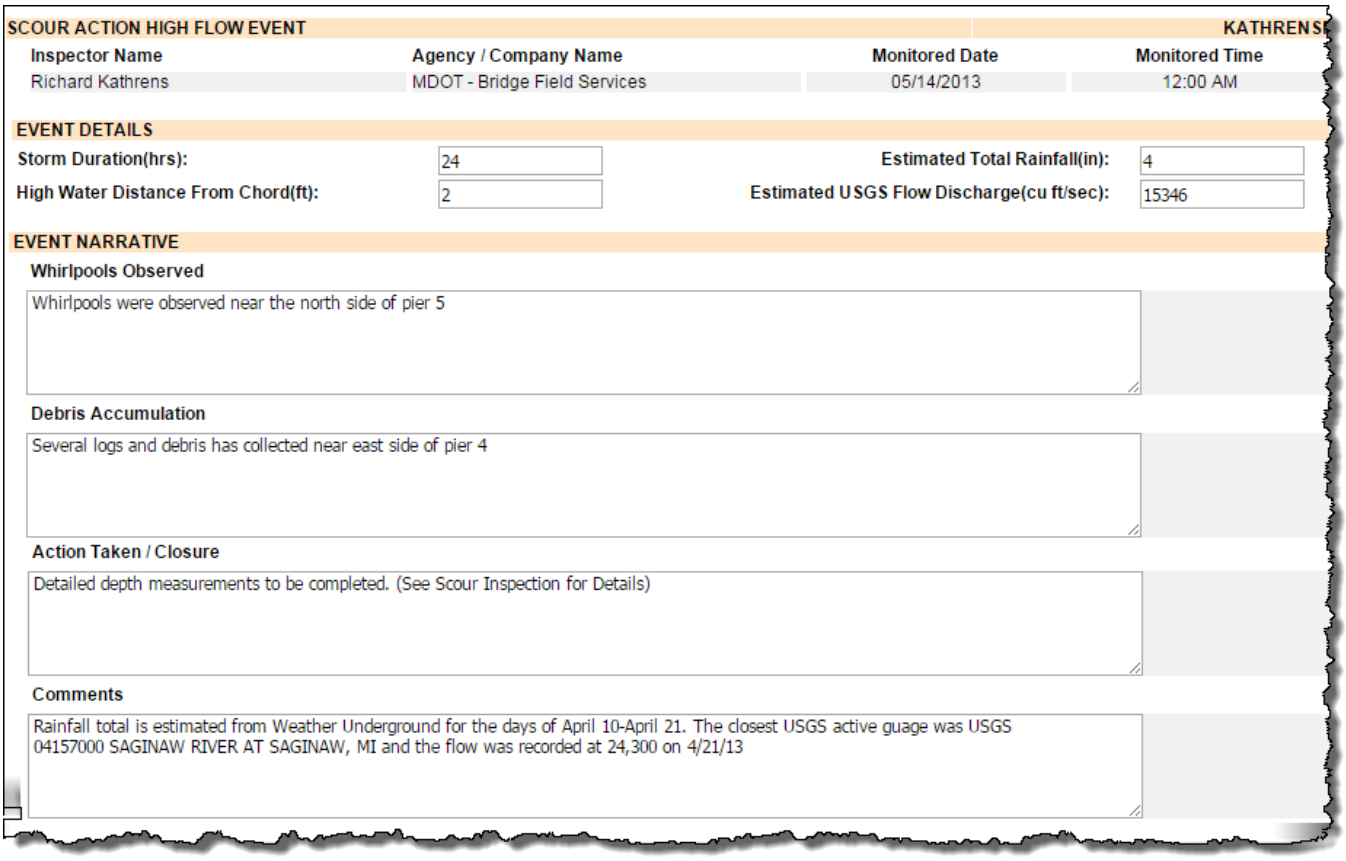
6.05 Scour Protection Examination during Michigan Bridge Element Inspections

Element level information shall be collected during each inspection where scour protection is employed using the Michigan Bridge Element Inspection Manual. The team leader shall document the scour protection that is visible and use Condition State Table 10 to determine the relative effectiveness of the materials. Scour Protection that have been identified on the previous Underwater Diving Inspection Report shall also be entered on the Michigan Element Inspection Report with quantities based according to the information described in the report. The overall goal of collecting scour protection information is to determine the amount deployed at each site and to render an overall judgment relating to its effectiveness and stability.

6.06 Scour Critical Bridge – High Flow Events

It is often too dangerous to perform a scour inspection using probing or underwater diving techniques during or immediately following a storm event when the water elevation and flow levels are high. However, the site should still be safe to monitor from the deck surface if overtopping of the bridge has not occurred. The bridge owner or an inspection team leader should review the effects of the increased water velocities and look for signs that adversely affect the structure. Repetitive site visitations should be scheduled as-needed until a scour inspection may be performed once water levels return to near normal.

Field reviews should be documented on the High Flow Event Report, which may be accessed within each bridge-specific POA. This is the only method to verify that that monitoring occurred. Fields within the High Flow Event Report include information for the storm duration, total rainfall, freeboard, and estimated flow rate. Additionally, the inspector may note observations including whirlpools, debris accumulation, and describe any actions that were taken. When settlement, pressure flow, or other conditions warrant closure of the structure the bridge owner shall be immediately notified and MDOT Bridge Field Services shall be contacted as described in Chapter 10, Critical Findings.



SCOUR ACTION HIGH FLOW EVENT — KATHRENS

Inspector Name	Agency / Company Name	Monitored Date	Monitored Time
Richard Kathrens	MDOT - Bridge Field Services	05/14/2013	12:00 AM

EVENT DETAILS

Storm Duration(hrs):	24	Estimated Total Rainfall(in):	4
High Water Distance From Chord(ft):	2	Estimated USGS Flow Discharge(cu ft/sec):	15346

EVENT NARRATIVE

Whirlpools Observed

Whirlpools were observed near the north side of pier 5

Debris Accumulation

Several logs and debris has collected near east side of pier 4

Action Taken / Closure

Detailed depth measurements to be completed. (See Scour Inspection for Details)

Comments

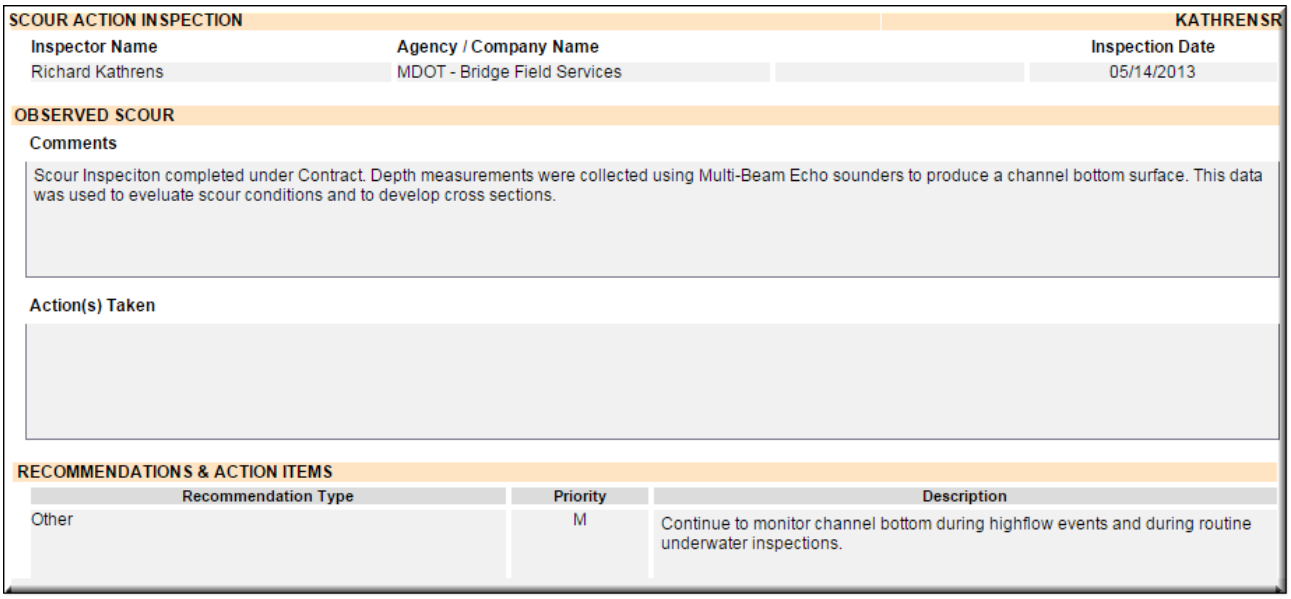
Rainfall total is estimated from Weather Underground for the days of April 10-April 21. The closest USGS active guage was USGS 04157000 SAGINAW RIVER AT SAGINAW, MI and the flow was recorded at 24,300 on 4/21/13

Figure 6.06.01 High Flow Event Monitoring (MiB^{RIDG}E)

6.07 Scour Critical Bridge – Scour Inspections

Once conditions are safe to access the waterway following a high flow event, a Scour Action Inspection should be performed to record any contraction or local scour that occurred during the flooding. At a minimum, this should include probing around all substructure units that were submerged to determine if changes in the streambed or footing exposure occurred. Where water depths exceed 10 feet and depth soundings indicate that scouring occurred it is highly recommended to enlist a qualified diving inspector or perform a detailed bathymetric survey to determine the extent of damage. When previously unrecorded footing exposure or undermining is identified the bridge owner should be notified immediately.

When unscheduled scour inspections are performed independent of the routine inspection data collected should be entered in MiB^{RIDG}E on the Scour Action Inspection form (see Figure 6.07.01)



SCOUR ACTION INSPECTION — KATHRENSR

Inspector Name	Agency / Company Name	Inspection Date
Richard Kathrens	MDOT - Bridge Field Services	05/14/2013

OBSERVED SCOUR

Comments

Scour Inspeciton completed under Contract. Depth measurements were collected using Multi-Beam Echo sounders to produce a channel bottom surface. This data was used to eveluate scour conditions and to develop cross sections.

Action(s) Taken

RECOMMENDATIONS & ACTION ITEMS

Recommendation Type	Priority	Description
Other	M	Continue to monitor channel bottom during highflow events and during routine underwater inspections.

Figure 6.07.01 Intermediate Scour Action Inspection Report (MiB[RIDG]E)

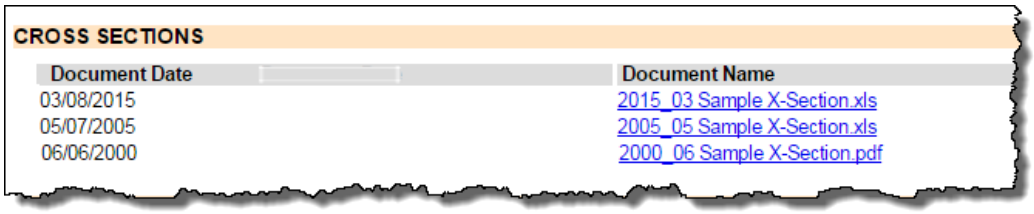
6.08 Stream Bed Cross-Sections

All NBI structures over water including culverts require a minimum of one stream bed cross section to be in the bridge file. The only exception to this rule is side by side culvert pipes. If the individual pipe diameter is less than 12 feet a cross section is not required. Four sided box culverts should have cross sections recorded beyond the apron. The offset distance from the edge of the apron should be referenced for both upstream and downstream measurements.

Scour critical bridges with active erosion or observed scour should have cross sections recorded every two years or after a flood event where the scour POA was reviewed and monitoring occurred. For scour critical bridges without active erosion or observed scour the cross sections should be performed every four years or after a flood event where the scour POA was reviewed and monitoring occurred.

Bridges with minor observed scour or erosion must have a minimum of one cross section in the file; including additional cross sections as changes in the channel are observed and every 60 months for locations requiring underwater diving. These recommendations are also provided in the MDOT *Guidelines for Bridge Inspection Frequencies* and reiterated in Chapter 5 for the inspection team leader.

The Cross Sections located in the Waterway Data area of the MiB[RIDG]E Inventory & Appraisal Tab allows the electronic data collection of current and previous stream bed cross section information. This information can be uploaded in either excel (.xls) or adobe (.pdf) format (see Figure 6.08.01).


CROSS SECTIONS

Document Date	Document Name
03/08/2015	2015_03 Sample X-Section.xls
05/07/2005	2005_05 Sample X-Section.xls
06/06/2000	2000_06 Sample X-Section.pdf

Figure 6.08.01 Cross Section (MiB[RIDG]E)

6.09 Scour Plan of Action

The Scour POA is required for all bridges where Item 113 is coded ≤ 3 or U (Unknown Foundation). In addition, structures that are owned by MDOT and have Item 113 coded 7 will also have a POA developed. Additional guidance for structures with unknown types of foundations may be found in FHWA's Memorandum HIBT-20 "Frequently Asked Questions – Bridges Over Waterways with Unknown Foundation". The MDOT POA form has been developed in MIB[RIDG]E (www.Michigan.gov/BridgeInspect) and all scour critical bridges shall have valid information entered into the database using the web-based application. The bridge owner may assign rights for the form to be updated by any active registered user when changes or monitoring are necessary.

The standard Information Summary and Current Status header displayed for other reports also appears for the Scour POA. The information within this section provides several key characteristics including location, dimensions, and design type, among other inventory and appraisal data. The scour evaluation code for Item 113 is also displayed which should be verified prior to creating or modifying an existing POA (see Figure 6.09.01). If the coding is incorrect the team leader may correct the value based according to the Level 1 analysis, information obtained on the plans, or field observations if the bridge owner concurs.

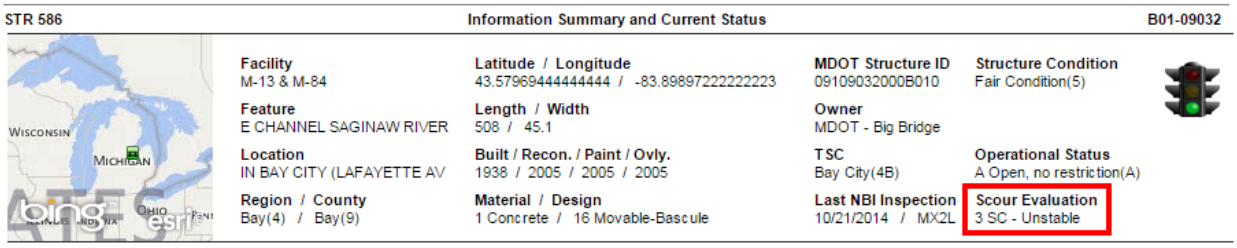


Figure 6.09.01 Information Summary and Current Status

Once the bridge owner or individual assigned with creating or modifying the POA selects the Scour Action Plan folder on the left navigation column and selects "Add New" or "Edit" they may begin adding detailed information. For POAs where editing occurs their name, organization, and the date will automatically populate once the form is saved. Unless a note or description is provided elsewhere on the form, the person identified is ultimately responsible for preparing the POA. When information is added to the form on behalf of another person or organization it should be noted in the Scour Evaluation Report – Executive Summary field. The Executive Summary field is also for general or specific information that summarizes the completed evaluation (see Figure 6.09.02).

PLAN OF ACTION AUTHORS KATHRENSR

Name	Agency	Phone	Email	Last Modified Date
.TEST LA .Bridge Owner	Saginaw County	517-322-5715	kathrensr@michigan.gov	03/07/2016
.TEST Consultant .Bridge Engineer	Consultant A	517-322-6092	kathrensr@michigan.gov	03/07/2016
.TEST MDOT .Hydraulics	MDOT Hydraulics	517-322-5717	kathrensr@michigan.gov	03/07/2016

SCOUR VULNERABILITY

Item 113	Scour Criticality	3	Source of Item 113	Calculated
Item 71	Waterway Adequacy	5		
Level I Assessment		Y	09/29/2015	
Level II Analysis		Y	09/29/2015	

Executive Summary Scour Evaluation

Scour calculations were performed on the 100 and 500 year events in 1990. Bridge abutments are set back from the river so there is no calculated abutment scour. Estimated scour at pier 1 is 5' +/- (EL 572'), pier 2 is 35' +/- (EL 520'), pier 3 is 36' +/- (EL 517), pier 4 is 17' +/- (EL 510), and 6' +/- (EL 570') at pier 5 in the 100 year event. Estimated scour at pier 1 is 6' +/- (EL 571'), pier 2 and 3 are 38' +/- (EL 514'), pier 4 is 18' +/- (EL 509'), and 6' +/- (EL 570') at pier 5 in the 500 year event. The bottom of footing for Pier 1 is 565, piers 2-3 is 546', pier 4 is 548' and pier 5 is 560'.

Figure 6.09.02 Information Summary and Current Status

The scour vulnerability information is populated with information from the Inventory and Appraisal – Waterway Data section (see Figures 6.03.02 and 6.03.03). This includes a summary of the calculated scour analysis and the general information regarding foundation type and soil for each substructure unit (see Figure 6.09.03). During the analysis this information should be reviewed in the structural drawings and boring logs of the as-built plans. Location of substructure units that will have submerged surfaces during a 100 year storm event should be indicated in the appropriate column and the foundation type field, depth and soil type should be updated. This information is duplicated from the Waterway Data screens. The Executive Summary Scour Evaluation field provides an overview of the calculations that were completed by a hydraulics engineer. The bridge owner or team leader who prepares the POA should summarize the hydraulic analysis at each substructure unit located in water during the 100 year and 500 year events.

Calculated Values

Scour Analysis Frequency	25 Year	50 Year	100 Year	500 Year	Comments
Anticipated Surface Elevation (ft)	0.0	584.6	585.1	0.0	
Distance Below Bottom Chord (ft)	0.0	11.6	11.1	0.0	
Anticipated Flow (cubic ft/sec)	0.0	66220.0	73740.0	0.0	
Anticipated Pressure Flow (Y/N)	N	N	N	N	

Substructure Information

Foundation	Normally in Water	Normal Water Depth (ft)	In Water (100 Yr)	Footing Type	Depth Known	Soil Type
Abutment A	N	N/A	N	A Spread Ftg Soil	Y	Cohesive
Abutment B	N	N/A	N	B Footing Timber Piles	Y	Non Cohesive
Pier 1	N	N/A	N	D Footing Stl Tube Piles	N	Rock
Pier 2	Y	15.0	Y	K Gravity on Soil	N	Unknown
Pier 3	Y	20.0	Y	I Spread Footing Rock	Y	Cohesive
Pier 4	Y	22.0	Y	G Caissons	Y	Rock
Pier 5	N	N/A	N	F Pile Bents	N	Unknown
Pier 6	N	N/A	N	E Footing on Tremie	N	Non Cohesive

Figure 6.09.03 Scour Analysis Event Frequency and Foundation Information

Within the Scour Analysis Event Frequency section the user may enter the anticipated surface elevation, distance below bottom chord, and anticipated flow for 25 year, 50 year, and 100 year events. This area

provides those monitoring the structure during flooding reference data for the amount of freeboard, if any, during each event. The information for this section is derived from a combination of the soil borings, as-built drawings, and hydraulic analysis.

The FHWA defines three types of countermeasures including monitoring, structural, and hydraulic which should be considered for each scour critical bridge. It is important to note on the POA the types of countermeasures that are feasible for the structure. All scour critical structures will require some type of monitoring and most structures will require structure/hydraulic countermeasures to help protect the structure due to scour conditions. Commentary should be provided to discuss the feasibility of installing structural/hydraulic countermeasures along with an estimate of cost (see Figure 6.09.04).

There are some cases where it is not feasible to install structural or hydraulic countermeasures. In these cases the scour action plan should indicate that only monitoring is required. The "Only Monitoring" box should be selected only if there are no other feasible countermeasures.

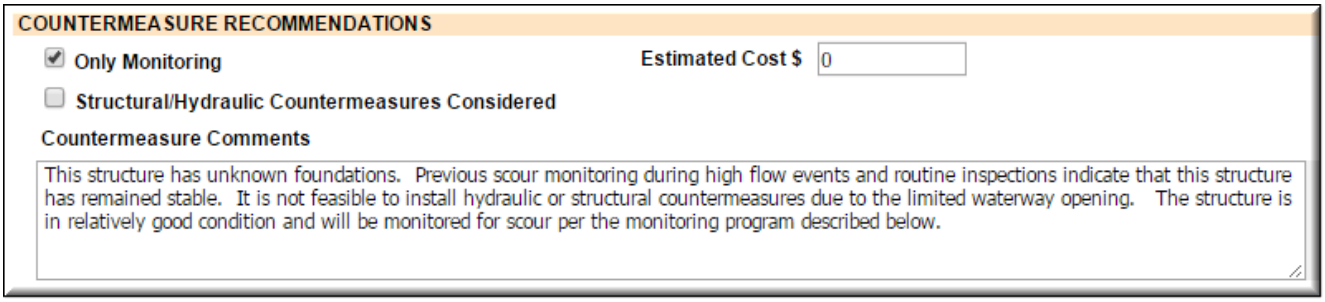


Figure 6.09.04 Types of Feasible Countermeasures

Commentary regarding the most vulnerable locations and where monitoring should commence will allow for efficient response and aid personnel responding to the site during inclement weather conditions. This information should be included in the Monitoring Program section of the POA (see Figure 6.09.05). A brief description of the monitoring recommendations can be summarized in the comment field.

Detailed monitoring activities can be added in this section. These are generally split into inspection activities and/or flood monitoring. The inspection activities include Routine, Special, Underwater, and Stream Bed Cross Sections where recommended intervals to complete scour inspections can be added. All scour critical structures will have scour inspections completed during routine and/or underwater inspections.

MONITORING PROGRAM

Recommended Monitoring Requirements

Monitoring of this structures is mainly focused on the main channel near Piers 4 and 5. Flow rates can be obtained from the USGS monitor just down stream of the structure. These piers have been protected with rip rap along the shipping channel and depth measurements should be completed during and after the flood events to help verify the stability of the rip rap.

(Check all that are recommended)

Type	Frequency/ Amount	Comments
☑ Regular Inspection	24.0	Continue to wade and probe during routine inspections.
☐ Other Special Inspection		
☑ Underwater Inspection	60.0	
☑ Stream Bed Cross Sections	24.0	Update Stream Bed Cross Sections every 24 Months and after High Flow Events
☐ Monitoring Devices (Fixed, Sonar, etc.)		
Flood Monitoring - Initiate monitoring when any of the following occur		
☐ NOAA Flood Warning (This includes both Flash Flood and Flood Warnings)		
Flow Information		
☐ Discharge (cfs)		
☐ Rainfall (in/hr)		
☑ WS Elevation (ft)	5.0	Measured from Top of Rail, Near Pier 3, North Side of Bridge
☐ Pressure Flow		
☐ Debris Accumulation		

Figure 6.09.05 Monitoring Program

The decision of when monitoring begins should be determined by a culmination of information including previously recorded scour data, the degree of flooding, existing hydraulic or structural countermeasures, and additional bridge specific factors. Most scour critical structures will require some type of flood monitoring to assist with determining the stability of the channel bottom. Determining the appropriate time and method to initiate the flood monitoring will help with scheduling the appropriate resources and reduce the risk to the public.

The Monitoring Program section of the POA template also has several predefined triggers listed which encompass minimum conditions to begin the flood monitoring process. These are recommendations to make the bridge owner aware of circumstances which may require field observations to begin. The bridge owner shall ultimately determine when monitoring must occur during a flood event.

There may be cases where the appropriate level of documentation and data collection has occurred to determine that the structure is stable for flood events and scour can safely be monitored during routine inspections. In this case there may not be a need for flood monitoring to occur for every flood event. This information and justification must be documented in the monitoring requirements comment field.

Specific details in regard to what needs to be monitored can be documented in the “Items to Watch During Monitoring” area (see Figure 6.09.06). A brief summary of the overall issues to be aware of during monitoring can be discussed in the comment field provided. There is also an automated table generated based on the number of spans where specific details can be added per substructure unit.

Items to Watch During Monitoring

The dolphins on Pier 3 show some settlement and loose chains and collision damage. Upstream dolphin at Pier 2 appears to have been struck and has 2 broken piles and 80% of total section remaining. Pier 3 footing is exposed up to ten feet at the upstream corner channel side. Pier 2 footing is exposed up to 6ft. (2005)

Foundation	Items to Watch
Abutment A	N/A
Abutment B	N/A
Pier 1	Water will reach the Pier at the 100yr event, Monitor for
Pier 2	Use depth finder along south side during flood event to verify channel depth (see notes in file)
Pier 3	This pier has rip rap along the north side.
Pier 4	Excessive Debris accumulate around this pier during a flood, Monitor for wirlpools
Pier 5	
Pier 6	

Figure 6.09.06 Monitoring Plan Items to Watch

The conditions to evaluate bridge closure, and a contact person to initiate the process, must be identified on the POA. Several predefined circumstances that frequently cause closure have been identified on the template. In addition, the bridge owner's name and contact information must be listed for re-opening the bridge after inspection (see Figure 6.09.07).

BRIDGE CLOSURE PLAN

Conditions To Consider Bridge Closure

- ☐ Water Surface Elevation 0 ft
- ☐ Overtopping of Road or Structure
- ☐ Pressure Flow
- ☑ High Debris Accumulation
- ☑ Observed Structure Movement/Settlement
- ☐ Loss of Scour Countermeasures

Contacts Responsible for BRIDGE CLOSURE

Name	Title	Agency	Work Phone	Cell Phone
Lead Worker	Maintenance	City Village	800-321-8585	800-989-7474
Bridge Owner	Bridge Engineer	Some Agency	555-555-5555	777-777-7777

Contacts Responsible for OPENING Bridge

Name	Title	Agency	Work Phone	Cell Phone
Bridge Owner	Bridge Engineer	Some Agency	555-555-5555	777-777-7777

Figure 6.09.07 Conditions for Bridge Closure and Contact Information for Closing/Opening

Potential detours that may be used if closure of the bridge is necessary should also be provided. Any bridges along the detour route should be identified along with information that includes load restrictions and the scour criticality rating. This will aid bridge maintenance crews or vendors during the installation of appropriate signing once closure is recommended (see Figure 6.09.08).

Detour Route

Possible Detour Route(Max 1000 chars allowed):

M13 North to M-25 to M-84

Bridges/Culverts on Detour Route

Detour Strc#	Facility Carried/Feature Intersected	Load Limitations	Scour Rating	Remove
646	SAGINAW RI & MECHELEN DR		3	remove
669	US-10		N	remove
719	DUTCH CREEK		U	remove
645	M-13 CONN SB		N	remove
747	SAGINAW RIVER AND MCRR		3	remove

Figure 6.09.08 Detour Route Information

To assist with creating the detour route the structures within a five mile radius can be displayed and mapped along with the structures on the detour route selected. (See Figure 6.09.09).

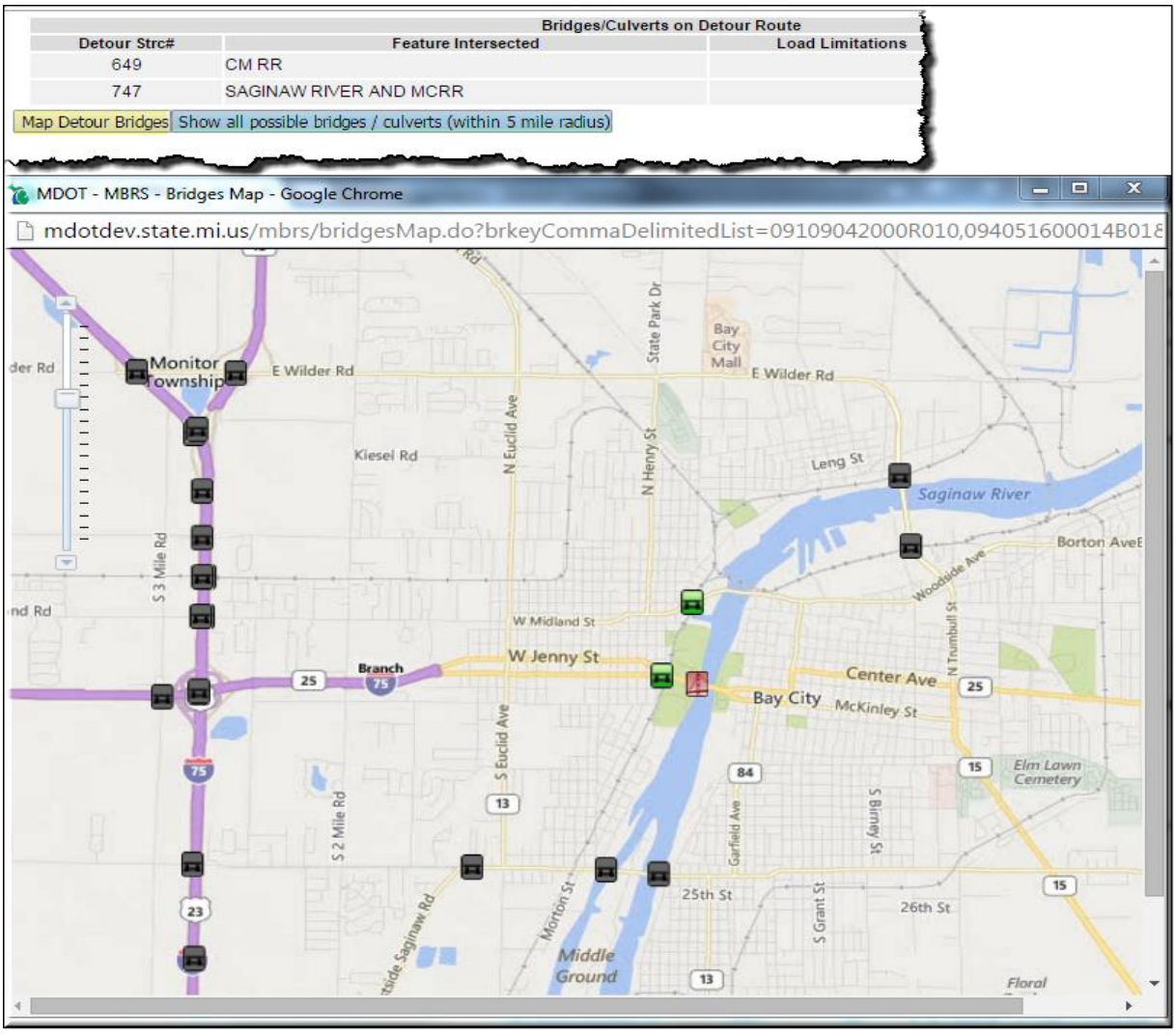
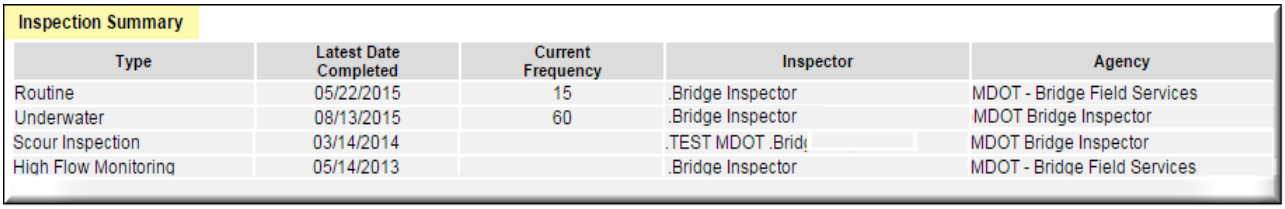


Figure 6.09.09 Detour Mapping Information

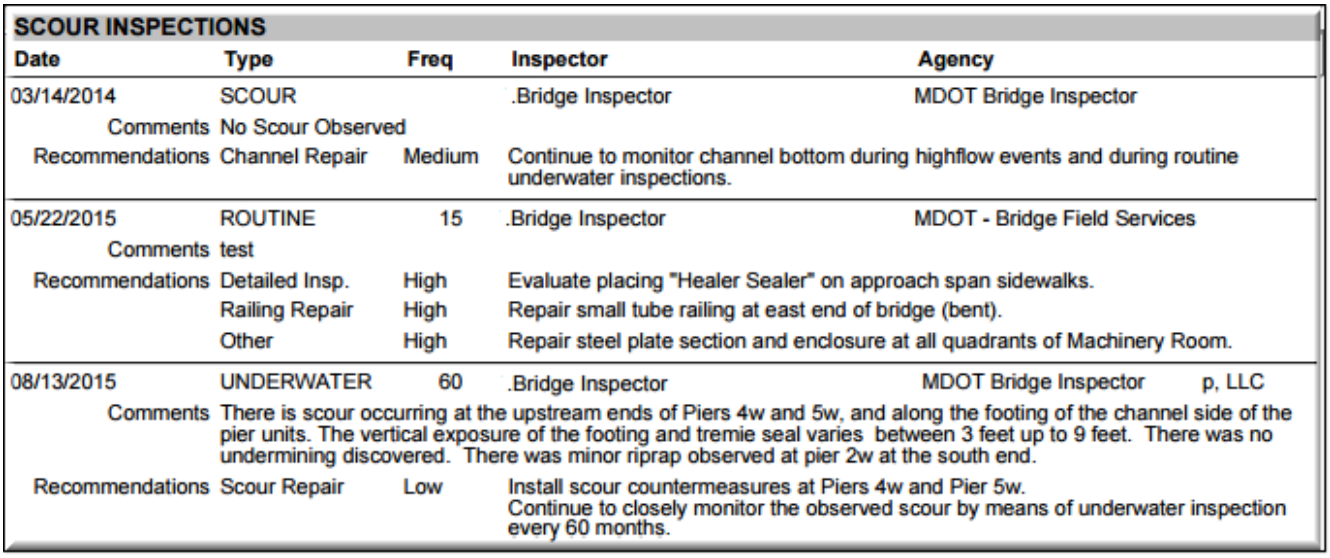
A brief summary of all the inspections that have occurred in regards to scour is automatically tabulated on the POA and summarized on the printed version (see Figures 6.09.10 and 6.09.11). This information is collected as a result of the field work performed during the Routine, Underwater, Intermediate Scour Inspection, and High Flow Monitoring inspections. The information is useful to determine the last time the structure was evaluated for scour and whether there were any significant findings.



Inspection Summary

Type	Latest Date Completed	Current Frequency	Inspector	Agency
Routine	05/22/2015	15	.Bridge Inspector	MDOT - Bridge Field Services
Underwater	08/13/2015	60	.Bridge Inspector	MDOT Bridge Inspector
Scour Inspection	03/14/2014		.TEST MDOT .Brid	MDOT Bridge Inspector
High Flow Monitoring	05/14/2013		.Bridge Inspector	MDOT - Bridge Field Services

Figure 6.09.10 Scour Inspection Summary (MiB[RIDG]E)



SCOUR INSPECTIONS

Date	Type	Freq	Inspector	Agency
03/14/2014	SCOUR		.Bridge Inspector	MDOT Bridge Inspector
Comments	No Scour Observed			
Recommendations	Channel Repair	Medium	Continue to monitor channel bottom during highflow events and during routine underwater inspections.	
05/22/2015	ROUTINE	15	.Bridge Inspector	MDOT - Bridge Field Services
Comments	test			
Recommendations	Detailed Insp.	High	Evaluate placing "Healer Sealer" on approach span sidewalks.	
	Railing Repair	High	Repair small tube railing at east end of bridge (bent).	
	Other	High	Repair steel plate section and enclosure at all quadrants of Machinery Room.	
08/13/2015	UNDERWATER	60	.Bridge Inspector	MDOT Bridge Inspector p, LLC
Comments	There is scour occurring at the upstream ends of Piers 4w and 5w, and along the footing of the channel side of the pier units. The vertical exposure of the footing and tremie seal varies between 3 feet up to 9 feet. There was no undermining discovered. There was minor riprap observed at pier 2w at the south end.			
Recommendations	Scour Repair	Low	Install scour countermeasures at Piers 4w and Pier 5w. Continue to closely monitor the observed scour by means of underwater inspection every 60 months.	

Figure 6.09.11 Scour Inspection Summary (Printed Report)