

I-40 HERNANDO DESOTO BRIDGE EMERGENCY REPAIR AND INSPECTION



After Action Report

November 10, 2021

PREPARED FOR:
Arkansas' U.S. Congressional Delegation
Governor Asa Hutchinson
Arkansas State Legislature
Arkansas State Highway Commission

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HERNANDO DESOTO BRIDGE

EMERGENCY REPAIR AND INSPECTION

After Action Report

Introduction

On May 11, 2021 – a partially fractured tie girder was discovered on the Interstate 40 Mississippi River Bridge between West Memphis and Memphis. This bridge is also known as the Hernando DeSoto Bridge (Bridge).

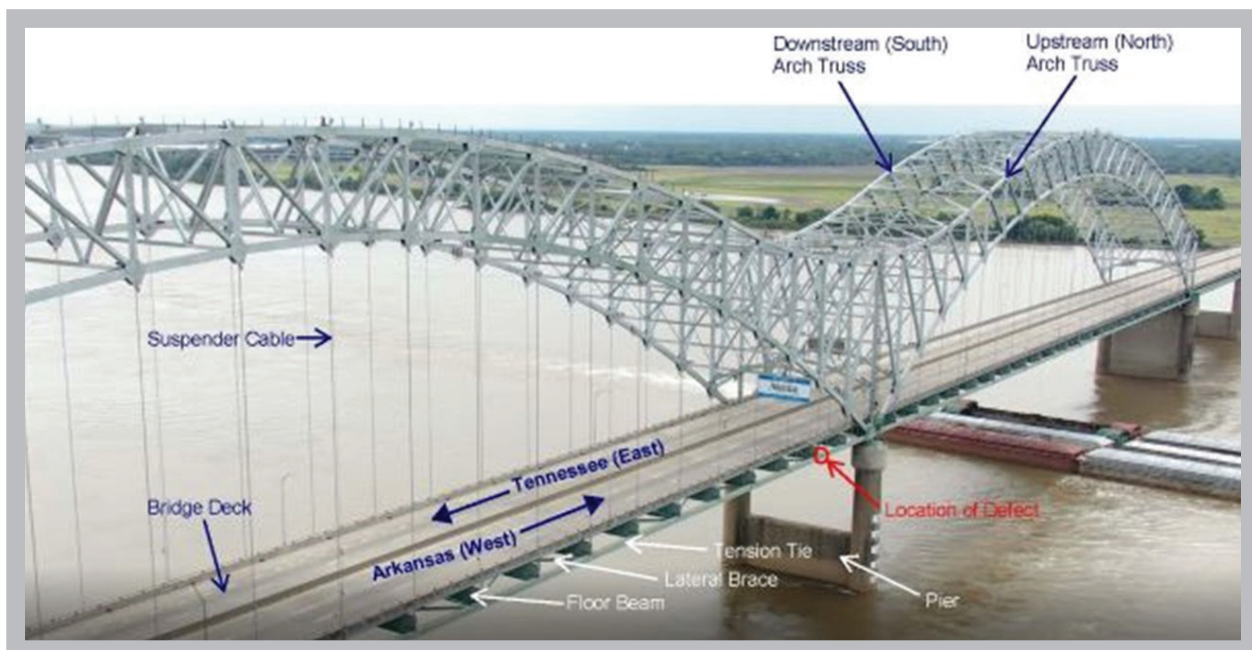
The fracture was discovered by Arkansas Department of Transportation's (ARDOT) consultant bridge inspector – Michael Baker International (MBI). MBI was conducting a routine inspection of the trusses and by chance noticed the fracture. MBI took immediate action and closed the Bridge.

Within 24 hours, an emergency repair team began to be assembled to design and construct the repairs. The team members were Arkansas and Tennessee Departments of Transportation, Arkansas and Tennessee Federal Highway Administration Offices, engineering consultants from MBI and HNTB, and Kiewit Corp.

Simultaneously, ARDOT hired engineering consultant, HNTB, to conduct a full hands-on inspection of the lower portion of the two tied arch spans. No additional major repairs were identified as needed from this inspection. ARDOT also contracted with HNTB to conduct a specialized inspection using ultrasound technology to inspect approximately 500 welds along the tie girders for hidden anomalies not visible by the naked eye. Seventeen welds had anomalies that resulted in additional steel plating that was added to the repair contract with Kiewit.

Upon completion of the repairs and inspections, the eastbound lanes of the Bridge were reopened to traffic on July 31, 2021. Westbound lanes were reopened on August 2, 2021.

The cost of the routine and specialized consultant inspections and the repairs is approximately \$10 million.



ARDOT's Bridge Inspection Program



ARDOT Internal Investigation

After the discovery of the fracture on May 11, 2021, the initial internal investigation verified that the crack was visible in 2019 and 2020. This resulted in the May 17, 2021 termination of the inspector responsible for inspecting this portion of the structure for at least the past 2 years.

ARDOT's Human Resources Division continued a review of the personnel involved in the Bridge's inspection beginning in 2014, as well as a review of ARDOT's overall Heavy Bridge Maintenance Inspection Program (HBM Program) policies and procedures. ARDOT's investigator was given full authority and reported directly to the Director. The results of the investigation are as follows:

- It was verified that the crack was visible at least as early as 2016.
- FHWA and ARDOT fracture critical inspection procedures require arms-length or direct eyesight of this portion of the Bridge.
- ARDOT Heavy Bridge Maintenance staff and the Human Resources investigator physically verified that the equipment used to inspect the Bridge provided adequate access to do a hands on inspection at the location of the fracture.
- The terminated inspector was directly responsible for inspecting that portion of the Bridge in 2016, 2017, 2019 and 2020.

- Management's failure to adequately act on reports by employees concerned with the terminated inspector's job performance perpetuated a culture where team members did not feel they had the authority or support to question a lead inspector's procedures or thoroughness.
- The bridge inspector responsible for this portion of the Bridge in 2018 was trained by the terminated inspector. It was his first time to be responsible for inspecting this portion of the bridge. There was a lack of adequate management and organization during the inspection. The inspector has been verbally counseled and will receive additional training.
- The HBM Program lacked adequate internal controls related to several components of administration and organization including:
 - Failure to enforce documented procedures for rotating inspection teams. The assigned "lead" inspector was rotated and recorded in the system, but the same inspector was allowed to inspect the same arch spans each time in 2016, 2017, 2019, and 2020.
 - Quality Assurance/Quality Control procedures are not well established for Heavy Bridge Maintenance inspections.
 - The ARDOT Bridge Inspection Manual outlines overarching fracture critical inspection procedures, but there are no formal documented detailed plans for the Bridge to ensure consistency.
 - Documented internal procedures were not followed to allow employees a means to provide management with feedback on the HBM Program.
 - Inspection reports on the Bridge lacked adequate detail to identify who was responsible for what portion of an inspection and/or what date a specific element was inspected.

Federal Highway Administration Bridge Inspection Program Assessment

The Arkansas Division of the Federal Highway Administration has general oversight of ARDOT's Bridge Inspection Program and conducts annual compliance reviews. ARDOT has never been found non-compliant – which simply means that anytime FHWA has made recommendations to improve our program, we have implemented the recommendations to their satisfaction.

At the request of ARDOT, the Federal Highway Administration (FHWA) performed a Bridge Inspection Program Assessment. The purpose of the assessment was to review ARDOT's policies, procedures, and standard operating practices used to administer the requirements of the National Bridge Inspection Standards (NBIS), identify improvement opportunities, and highlight commendable practices.

This report documents the 18 improvement opportunity recommendations and 18 commendable practices resulting from the assessment performed by an FHWA team (Team).

The improvement opportunity recommendations include the following areas:

- Quality Control (QC) and Quality Assurance (QA)
- Inspection Procedures
- Load Rating Procedures
- Scour Appraisals
- Inspection Resources

Several commendable practices in ARDOT's bridge inspection program were identified during the assessment. These practices should be supported to ensure continued success.

The Executive Summary is included as **Appendix A** of this report. The full *Bridge Inspection Program Assessment Arkansas Department of Transportation Final Report* can be viewed at: <https://www.ardot.gov/wp-content/uploads/2021/11/FHWA-Assessment-ARDOT-Bridge-Program.pdf>.

Fracture Investigation

As part of the repair project, portions of the steel tie girder immediately adjacent to the fracture were removed in order to perform a forensic investigation. Wiss, Janney, Elstner Associates, Inc. (WJE) was retained to complete the forensic investigation on the fractured specimen.

The fracture discovered on May 11th by Michael Baker International, occurred in a welded splice between two plates in the tie girder of the bridge. Upon closer examination of the specimen it was discovered that the initial fracture formed in an area of the weld where two weld repairs had been performed during fabrication. The weld repairs were more susceptible to cracking because of the type of steel and the welding method used in the fabrication of this bridge in the 1970s. In all likelihood the cracking in the weld occurred within hours of its completion but was not detected by any post-weld repair fabrication testing and remained unchanged for a number of years.

In the 1980s, the potential for cracking in welds was identified at a national level because of defects found in other similar bridges, and in 1982 an Ultrasonic Testing inspection of the Hernando de Soto tie girder welds was performed. The defects at this weld location went undetected.

The fracture report described how the crack propagated in three phases from the cracking of the weld repairs to the eventual fracture that was discovered in May of 2021. The initial fracture occurred on the interior face of the box where it was not visible by conventional inspection. The second phase of crack propagation fractured through the remaining thickness and was later identified in the 2019 drone video. The third fracture event propagated up the remaining web,

across the top flange, and arrested in the flange to web weld of the tie girder. It is likely the existing weld cracks became unstable as a result of a unique combination of low temperatures, increasing tie girder stress, and the effects of live loads to which the bridge had not been previously subjected.

Given the 48-year service life of this structure, the fact that the subject fracture occurred in three separate phases over several years, the recent inspection efforts to identify welding defects, and no evidence of observed fatigue crack growth during this study, it is highly unlikely that a similar fracture will occur. However, it is prudent to continue arms-length fracture critical inspections with a focus on identifying any new visible cracks at these welds. Given that all other anomalies investigated originated on the inside surface of the tie girder, ultrasonic testing should be performed on a periodic basis.

Prior to returning the bridge to service, ARDOT had approximately 500 similar welds along the tie girders tested using ultrasound technology to detect any hidden anomalies not visible by the naked eye. As a result, multiple welds had anomalies that resulted in additional steel plating that was added to the repair contract with Kiewit.

The *Fracture Investigation* report can be viewed at: <https://www.ardot.gov/wp-content/uploads/2021/11/Fracture-Investigation-I-40-MS-Rvr-Bridge.pdf>

Office of Inspector General Investigation

Because of the serious nature and the risk to the road user, ARDOT asked the US DOT Office of Inspector General (OIG) to determine if this negligence constitutes a criminal action. The OIG has conducted interviews of employees responsible for ARDOT's Bridge Inspection Program. Data and reports have been submitted as requested. We are waiting for the results of the investigation. This After Action Report will be updated upon receipt of the Final OIG Report.

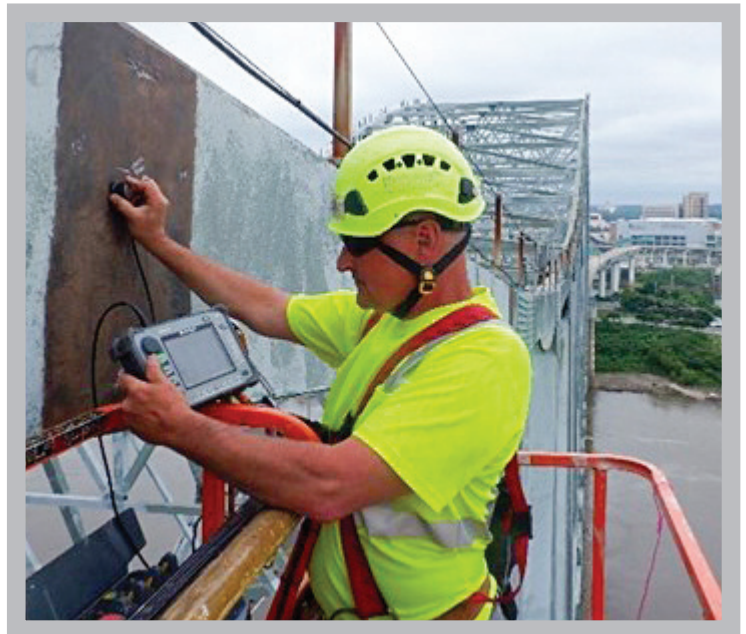
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- FHWA Assessment ARDOT Bridge Program
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- Fracture Investigation I-40 Mississippi River Bridge
<https://www.ardot.gov/wp-content/uploads/2021/11/Fracture-Investigation-I-40-MS-Rvr-Bridge.pdf>
- ARDOT Bridge Inspection Manual - 2020 Edition
<https://www.ardot.gov/wp-content/uploads/2021/11/ARDOT-Bridge-Inspection-Manual-2020-Edition.pdf>
- Federal Highway Administration (FHWA) Bridge Inspectors Reference Manual (BIRM)
www.fhwa.dot.gov/bridge/nbis/pubs/nhi12049.pdf

Conclusion

Based on the findings of ARDOT's Internal Investigation, FHWA's Assessment and WJE's Fracture Investigation the following changes/enhancements to strengthen and improve ARDOT's Bridge Inspection Program (Program) have been or will be implemented:

- Place the Heavy Bridge Maintenance (HBM) Section under new management
- Reorganize the Program
- Create a Bridge Inspection Oversight/Policy Committee and a Bridge Inspection Technical Subcommittee to provide additional leadership and accountability for the Program. The Bridge Inspection Manager will report to these Committees semi-annually. The members of both Committees will be primarily Professional Engineers.
- Add additional personnel to strengthen the Program
- Each Complex/Heavy Bridge inspection shall have on-site supervision by a Professional Engineer
- Fracture Critical Bridges and its members shall not be inspected by the same inspector consecutively
- Organize and provide Community of Practice sessions for Bridge Inspection personnel annually
- Solicit consultants to identify any new technologies available to strengthen ARDOT's program, to provide quality assurance and quality control until all the above changes have been implemented, and to provide additional training for our inspectors
- Implement FHWA Recommendations as listed in the Bridge Inspection Program Assessment (Appendix A)
- Ultrasonic Testing of the I-40 Bridge welds to be performed periodically as recommended by FHWA, TDOT and ARDOT staff



Additional Facts

- The I-40 bridge agreement between Arkansas and Tennessee is that ARDOT is responsible for routine and special bridge inspections and TDOT is responsible for contract maintenance and repairs. Our states share the cost equally.
- The bridge is 48 years old and carries 41,000 vehicles per day with about 30 percent being trucks.
- ARDOT is responsible for inspecting 12,782 structures.
 - 7,365 of these structures are state owned.
 - In 2020 ARDOT performed 10,384 inspections.
- Structures are typically inspected every 2 years.
- Fracture Critical Members (FCM) are inspected annually.
 - 765 bridges have FCMs. That includes the Hernando DeSoto Bridge.
- The Federal Highway Administration has general oversight of our program and conducts annual compliance reviews. The Department has consistently maintained program compliance. In many ways ARDOT's Bridge Inspection Program exceeds the minimum requirements to maintain compliance:
 - Structures with reduced load postings are inspected annually – (bi-annual required)
 - Structures in poor condition are inspected annually – (bi-annual required)
 - Inspectors use non-destructive Ultrasonic testing methods to inspect pins in pin and hanger details every two years – (not required)
- In 2017, ARDOT improved the Bridge Inspection Program by adding a statewide bridge inspection team to perform quality assurance inspections, review reports and supplement the District Inspection Teams when needed.
- In 2019, a third statewide inspection team was added to increase the number of quality assurance inspections that could be accomplished.
- In 2020, drones were added to enhance the program. At this time, ARDOT has purchased 13 drones. We have 16 certified drone pilots. We are actively deploying this technology.
- In 2021, a multi-beam sonar survey system was added to enhance underwater subsurface details.
- Since the fracture was discovered in 2021, a fourth statewide inspection team has been added.
- A fracture critical member (FCM) is "a steel member in tension, or with a tension element, whose failure would probably cause a portion of or the entire bridge to collapse." Bridges that contain FCMs are defined as fracture critical (FC) bridges.
- Quality Control is alternating inspection teams on bridge inspections. Quality Assurance is reinspecting a random sample periodically by management.



FEDERAL HIGHWAY ADMINISTRATION FINAL REPORT

APPENDIX A

BRIDGE INSPECTION PROGRAM ASSESSMENT
ARKANSAS DEPARTMENT OF TRANSPORTATION
FINAL REPORT



BY

FEDERAL HIGHWAY ADMINISTRATION

October 18, 2021



U.S. Department of Transportation
Federal Highway Administration

EXECUTIVE SUMMARY

This Bridge Inspection Program Assessment was performed by the Federal Highway Administration (FHWA) at the request of the Arkansas Department of Transportation (ARDOT). The purpose of the assessment was to review ARDOT's policies, procedures, and standard operating practices used to administer the requirements of the National Bridge Inspection Standards (NBIS), identify improvement opportunities, and highlight commendable practices.

This report documents the improvement opportunity recommendations and commendable practices resulting from the assessment performed by an FHWA team (Team). The Team included Larry O'Donnell and Anwar Ahmad from the Resource Center, Tom Drda from the Office of Bridges and Structures, and Scott Stotlemeyer from the Missouri Division.

ARDOT's policies, procedures, and standard operating practices for bridge inspection are administered by qualified and conscientious personnel dedicated to the delivery and quality improvement of their program.

The Team identified improvement opportunities to enhance quality and improve the effectiveness in performing and managing bridge inspections and follow-up actions. These improvement opportunities are grouped into the following broad categories: Quality Control (QC) and Quality Assurance (QA), Inspection Procedures, Load Rating Procedures, Scour Appraisals, and Inspection Resources. The prioritized improvement opportunity recommendations are summarized as follows and discussed further in the report. Some of the improvement opportunity recommendations are interrelated and should not be treated as mutually exclusive.

Quality Control and Quality Assurance

Recommendation 1. Document and implement updates to QC and QA procedures that include the following.

- Independent QC review of inspection and load rating documentation by qualified personnel other than just the inspection team members or load rater.
- QC procedures for a qualified engineer on site during inspections of major and complex bridges.
- More robust QC inspection review procedures performed by the District Construction Engineers (DCEs) and District Maintenance Engineers (DMEs), and additional review of district QC practices by Heavy Bridge Maintenance (HBM).
- QA procedures for review of statewide inspection teams.
- Core training curriculum and certifications needed for inspection personnel based on inspection types and bridge complexity.
- Periodic training/meetings for bridge inspection personnel (HBM, load rating, bridge management, DCEs and DMEs, and district inspection and maintenance staff) to discuss as a group: bridge

inspection issues, results of QC and QA reviews, requirements, expectations, useful practices, and changes in policies or procedures.

- QC and QA procedures for InspectX data (i.e., Structure Inventory and Appraisal (SI&A) data and supporting bridge record/file data).

Inspection Procedures

Recommendation 2. Enhance inspection procedures for bridges with fracture critical members (FCMs), bridges with underwater members, and major and complex bridges. Include details in the procedures as described in the FHWA Bridge Inspector's Reference Manual (BIRM) and American Association of State Highway and Transportation Officials (AASHTO) Manual for Bridge Evaluation (MBE).

Recommendation 3. Evaluate all bridges over water and determine which bridges have members requiring an NBIS underwater inspection (UWI).

Recommendation 4. Update InspectX data management system to maintain more complete bridge records and implement a standard file naming convention for inclusion of supporting files that includes a brief description and a more meaningful date in the filename, to facilitate access by all users.

Recommendation 5. Involve select representatives from HBM staff, DCEs, DMEs, and inspectors in development and implementation of proposed changes to procedures and policies. Include clearer communication protocols between HBM, DCEs, DMEs, and inspectors regarding policy, procedure guidance, and direction.

Recommendation 6. Evaluate and adjust priority definitions for maintenance needs in terms of expected and achievable completion time frames.

Recommendation 7. Report the actual ARDOT Bridge Inspection Manual (BIM) required NBIS inspection types to be performed and their associated inspection frequency to the FHWA National Bridge Inventory (NBI).

Recommendation 8. Develop and implement improved procedures to clearly indicate FCM inspection findings from Routine inspection findings, to facilitate access by all InspectX users, when results of the inspection types are combined in the same report.

Recommendation 9. Routinely communicate the importance of the bridge inspection program requirements, expectations, and procedure updates to local agency bridge owners. Establish recurring presentations at Municipal League meetings or other common meetings regularly attended by local agency bridge owners.

Load Rating Procedures

Recommendation 10. Ensure load ratings for all bridges are done adequately and appropriately. Consider having consultant professional engineering services available to perform load ratings on major, complex, and other bridges as needed.

Recommendation 11. Ensure all legal vehicular loads are adequately addressed by ARDOT load rating models.

Recommendation 12. Update and implement reporting protocols to ensure load ratings and required load postings are completed timely and adequately for all bridges.

Recommendation 13. Consistently utilize a load rating summary sheet for each bridge identifying the controlling members, primary member conditions, assumptions, and posting requirements, when applicable, and have it readily available in the InspectX Files tab to facilitate access by all users.

Recommendation 14. Develop and implement procedures for engineering personnel to perform inspections to capture and document the necessary information for performing a load rating or structural review when there is a change in condition to primary load carrying members, which may impact load capacity, or develop and periodically deliver training to inspectors on inspection documentation required for a load rating or structural review.

Scour Appraisals

Recommendation 15. Ensure that all bridges over water have a documented scour appraisal in InspectX to facilitate access by all users.

- Form a multi-disciplinary scour appraisal team to update scour appraisals when warranted, and review and update scour plans of action (POA), when applicable, to indicate storm events, stream elevations, or flows that trigger scour monitoring.
- More clearly indicate the responsibility for implementing the scour POAs and performing the scour monitoring.
- Update and implement a more consistent process for documenting scour monitoring.

Inspection Resources

Recommendation 16. Develop and implement a process for use of on-call professional engineering consultant contracts for inspection program support. Evaluate bridge inspectors' workload with addition of major overhead sign structures and high mast lighting inspections by district bridge inspection teams and consider consultant services for the inspection of highway tunnels, especially complex tunnels, in place of district bridge inspection teams.

Recommendation 17. Establish inspection program performance measures that indicate accomplishments and develop reports and tools to assess program needs.

Recommendation 18. Conduct a facilitated organizational structure study of staffing needs, roles, and responsibilities, and make necessary realignments of staff responsibilities.

Several commendable practices that are efficient and effective in ARDOT's bridge inspection program were identified during the assessment. These practices should be supported to ensure continued success. These commendable practices are summarized as follows.

Commendable Practice 1. Researching, adopting, and integrating technologies to supplement safety inspection activities such as unmanned aerial system (i.e., drones), micro-drilling of timber, and underwater side-scan sonar.

Commendable Practice 2. The ARDOT bridge inspection program includes knowledgeable, experienced, and qualified staff that administer ARDOT's bridge inspection program.

Commendable Practice 3. Availability of multiple under-bridge inspection access equipment trucks (UBIT) in each district and Central Office that can be shared as needed.

Commendable Practice 4. Field inspection resource support (i.e., equipment and personnel) provided by HBM to districts and districts to HBM.

Commendable Practice 5. Load posting certification process for local agencies, and local agency posting support provided by the districts. Local owners can secure load posting materials from ARDOT at a reduced cost if program procedures are followed. Notably, District 3 that prepares the documents for the locals and hand carries the documents to them for their signature.

Commendable Practice 6. DCEs and DMEs are required to be licensed professional engineers (PE), with successful completion of comprehensive bridge inspection training, and provide support to district bridge inspectors as needed.

Commendable Practice 7. QA inspections performed by statewide inspection crews for bridges inspected by the districts.

Commendable Practice 8. Rotation of district inspection teams for Routine inspections so a bridge is not regularly inspected by the same inspection team.

Commendable Practice 9. Use of an automated load permitting and routing system.

Commendable Practice 10. Intent to maintain all inspection and inventory records electronically in the InspectX data management system.

Commendable Practice 11. Tracking bridge maintenance needs in the InspectX data management system.

Commendable Practice 12. Bridge maintenance crews have the skills and abilities to maintain and repair bridges and replace small structures.

Commendable Practice 13. Ability of maintenance personnel to react quickly for emergency repairs.

Commendable Practice 14. Inspectors are recruited through the State's bridge maintenance and construction programs.

Commendable Practice 15. Utilization of enthusiastic, dedicated, and skillful bridge inspection personnel willing to perform difficult tasks.

Commendable Practice 16. ARDOT has been maintaining the inventory, and performing inspections, load ratings, and scour appraisals for bridges on state, city, and county public highway systems since 1979. Having one entity (i.e., ARDOT) perform these functions of the bridge inspection program promotes uniformity and consistency throughout the program.

Commendable Practice 17. NBIS Form IIIB Guidelines for detailing the vertical and horizontal clearances for highways or railroads that pass under the bridge. These values are used to code National Bridge Inventory (NBI) Items 54 – Minimum Vertical Underclearance, 55 – Minimum Lateral Underclearance on Right, 56 – Minimum Lateral Underclearance on Left, and 69 – Underclearances Vertical and Horizontal.

Commendable Practice 18. Bridge Scour Plan of Action – Event Monitoring Form.

