



DISTRICT DEPARTMENT OF TRANSPORTATION

**BRIDGE INSPECTION MANUAL
OF
PROCEDURES**

**for
DISTRICT OF COLUMBIA
DEPARTMENT OF TRANSPORTATION**

June 2012

BRIDGE INSPECTION MANUAL OF PROCEDURES

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BRIDGE INSPECTION MANUAL
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1.0 GENERAL

1.1 Introduction

This manual has been prepared to assist the District of Columbia Department of Transportation (DDOT) and its Consultants in the inventory, inspection, appraisal and load rating of bridges under the District's jurisdiction. The program detailed in this manual will help implement the National Bridge Inspection Standards as issued by the Federal Highway Administration.

The National Bridge Inspection Standards are set forth in the Code of Federal Regulations, 23 CFR 650C, a copy of which is provided in Appendix A. The Standards require bridges to be inventoried, inspected and appraised in accordance with the *Manual for Bridge Evaluation* published by the American Association of State Highway and Transportation Officials (AASHTO).

The AASHTO manual, together with this manual, establishes the DDOT procedures and policies for determining the physical condition and maintenance needs of the bridges in the District of Columbia.

1.2 Objectives

1. Ensure the prompt discovery of any deterioration or structural damage that could become hazardous to the traveling public or that could become more costly to repair if corrective measures are not undertaken.
2. Maintain an up-to-date inventory which indicates the condition of all bridges on public roadways.
3. Maintain service records from which to appraise the relative value of various types of construction and repair.
4. Determine the extent of minor deterioration requiring routine maintenance and repair work as the basis for planning bridge maintenance programs.
5. Determine the extent of major deterioration requiring rehabilitation or replacement as the basis for planning bridge replacement and rehabilitation programs.
6. Establish guidelines for load rating and posting of bridges.

1.3 Definitions

1. A bridge is defined as a structure including supports, erected over a depression or an obstruction, such as water, highway or railway, and having a track or passageway for carrying traffic or other moving loads and having an opening measured along the center of the roadway, track or passageway, of 20 feet or more between undercopings of abutments or backwalls, or spring lines of arches, or extreme ends of openings for multiple boxes; or having an inside diameter of 20 feet or greater in the case of pipes.
2. A culvert is defined as a small structure under the roadway, usually for drainage. The term culvert is usually limited to buried structures where the clear span or spans between supports is less than about 20 feet. However, a special class of culverts with clear spans up to about 40 feet has evolved from corrugated metal pipe culverts. If the span measured along the center of the roadway is more than 20 feet, then this type of culvert qualifies for bridge classification.
3. A tunnel is defined as a structure that carries a roadway through a topographical barrier. Although a tunnel is not a bridge, the structural portions shall be inspected until a separate program is established for tunnels.
4. Complex bridges are defined as structures with unusual characteristics or components such as suspension, cable-stayed and movable bridges.

1.4 Qualifications of Bridge Inspection Personnel

A Program Manager must, at a minimum:

1. Be a registered professional engineer, or have 10 years bridge inspection experience; and
2. Successfully complete a Federal Highway Administration (FHWA) approved comprehensive bridge inspection training course.

There are five ways to qualify as a Team Leader. A Team Leader must, at a minimum:

1. Have the qualifications specified for a Project Manager; or
2. Have five years bridge inspection experience and have successfully completed an FHWA approved comprehensive bridge inspection training course; or
3. Be certified as a Level III or IV Bridge Safety Inspector under the National Society of Professional Engineer's program for National Certification in Engineering Technologies (NICET) and have successfully completed an FHWA approved comprehensive bridge inspection training course; or
4. Have all of the following:
 - A bachelors degree in engineering from a college or university accredited by or determined as substantially equivalent by the Accreditation Board for Engineering and Technology;

- Successfully passed the National Council of Examiners for Engineering and Surveying Fundamentals of Engineering examination;
 - Two years of bridge inspection experience; and
 - Successfully completed an FHWA approved comprehensive bridge inspection training course or;
5. Have all of the following:
- An associate's degree in engineering or engineering technology from a college or university accredited by or determined as substantially equivalent by the Accreditation Board for Engineering and Technology;
 - Four years of bridge inspection experience; and
 - Successfully completed an FHWA approved comprehensive bridge inspection training course.

The individual charged with the overall responsibility for load rating bridges must be a registered professional engineer.

An underwater bridge inspection diver must complete an FHWA approved comprehensive bridge inspection training course or other FHWA approved underwater diver bridge inspection training course.

1.5 Frequency of Inspections

The portions of each bridge are to be inspected at regular intervals, not to exceed 24 months, in accordance with Section 4.3 of the AASHTO manual.

Certain types or groups of bridges will require inspection at less than 24 month intervals. The depth and frequency to which bridges are to be inspected will depend on such factors as age, traffic characteristics, state of maintenance and known deficiencies. The evaluation of these factors will be the responsibility of the individual in charge of the inspection program.

The maximum inspection interval may be increased for certain types or groups of bridges where past inspection reports and favorable experience and analysis justifies the increased interval of inspection. If the Consultant believes that a bridge can be inspected greater than the required 24 months, a detailed proposal shall be submitted to the DDOT Bridge Inspection Manager for approval. If DDOT agrees, a request shall be submitted to the FHWA for approval.

1.6 Bridge File

DDOT will maintain a bridge file for each structure under their jurisdiction. The bridge files (records) will be in accordance with Section 2 of the AASHTO manual and include, but not limited to, construction, rehabilitation, inventory, inspection and load rating data.

1.7 Routine Handling of Bridge Inspection Findings

For bridges maintained by DDOT, the Bridge Inspection Supervisor prepares reports summarizing bridge deterioration found in the District. The Bridge Inspector's maintenance recommendations form (described in Section 2) illustrates a typical format for such reports. Another typical format is a series of memoranda each covering the bridges in one Maintenance

Section. With the memo format, each bridge showing deterioration would be listed and followed by a brief description of the deterioration. Regardless of the format employed, photographs and sketches shall be included in the reports if it would otherwise be difficult to describe deterioration. The reports shall be forwarded to the Engineer responsible for bridge maintenance, who uses them as the basis for bridge maintenance, rehabilitation and replacement.

1.8 Letters of Concern

When a structural deficiency or condition is noted that does not require immediate attention, but may need to be addressed prior to submission of the inspection report, that could develop into something serious or may need to be monitored, a Letter of Concern (LOC) shall be prepared and forwarded to DDOT Supervisors so they are aware of the condition. If an LOC was previously submitted for the previous cycle report and the condition has not been addressed, a new LOC shall be provided noting the condition and any changes that may have developed. The conditions reported are typically given Priority E or 1 in the **Maintenance and Repair/Rehabilitation Recommendations** section of the report. Conditions coded as Priority 2 may require an LOC. The LOC shall be emailed to DDOT as soon as practical.

1.9 Emergency Handling of Bridge Inspection Findings

Upon discovery of critical conditions posing immediate danger to the traveling public, the Bridge Inspector shall immediately notify the DDOT Supervisors with recommendations for load posting, closing the bridge and/or repairs, who will then assess the situation. If warranted, DDOT will take emergency action to eliminate the danger. All verbal contact with DDOT regarding critical bridge conditions shall be followed as soon as practical with written notification of the bridge inspection findings. A Critical Finding Report Form, as shown in Appendix C, shall be completed for reporting emergency conditions. Such notification shall be sent by email.

The Consultant shall notify the District's Project Manager and Maintenance Engineer immediately whenever a potentially perilous or hazardous condition is observed. Written notification shall be provided within 24 hours. Examples of such situation could include:

- Distress in primary members to the point where there is doubt that the members can safely carry the loads for which they are subjected and partial or complete failure of the bridge is a possibility.
- Scour at or under the pier of a stream bridge is such that significant movement is likely which could cause the bridge to collapse.
- Abutment movement or distress which is so excessive that there is a clear possibility that it may not be capable of supporting the superstructure and partial or complete failure is a possibility.
- Suspected cracks in pin or hangers of two girder/truss bridges.
- Missing weight restriction signs.
- Any situation where the structural integrity of the bridge is such that its safety is in question.
- Any condition that is a significant hazard to public safety.

1.10 Load Rating and Load Posting

All bridges including those of questionable load-carrying capacity should receive a structural analysis as discussed in Section 3. If a bridge has been analyzed previously, the calculations should be reviewed and revised if necessary to reflect current conditions. When analysis indicates that a bridge cannot safely carry the legal load, suitable posting loads should be calculated and if the bridge already has load restriction signs, these should be evaluated for adequacy.

2.0 INSPECTION PROCEDURES

2.1 Introduction

2.1.1 General

Bridge inspection is the use of techniques to determine the condition of a bridge, with the user of these techniques being the Bridge Inspector. Good bridge inspection consists of five steps:

1. Planning of the inspection to ensure that attention is given to each bridge component in accordance with its importance,
2. Preparation according to the inspection plan,
3. Careful and systematic observations,
4. Complete and accurate recording of significant observations,
5. Assessment of observations to determine condition ratings.

2.1.2 References

1. AASHTO. 2011. *Manual for Bridge Evaluation (MBE)*
2. AASHTO. 2012. *AASHTO LRFD Bridge Design Specifications, Sixth Edition*
3. AASHTO. 1998. *Movable Bridge Inspection, Evaluation and Maintenance Manual*
4. FHWA. 1986. *Inspection of Fracture-Critical Bridge Members*
5. FHWA. 2012. *Bridge Inspector's Reference Manual (BIRM)*
6. FHWA. 1986. *Culvert Inspection Manual*
7. U. S. Government. 2004. *National Bridge Inspection Standards, (NBIS) Code of Federal Regulations*
8. FHWA. 1995. *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges*
9. FHWA. 1988. Technical Advisory T5140.21 – *Revisions to the NBIS*
10. FHWA. 1991. Technical Advisory T5140.23 – *Evaluating Scour at Bridges*
11. FHWA. 2001. HEC 18 – *Evaluating Scour at Bridges, Fourth Edition*
12. FHWA. 2001. HEC 20 – *Stream Stability at Highway Structures, Third Edition*
13. FHWA. 2009. HEC 23 – *Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance, Third Edition*
14. AASHTO. 2011. *Guide Manual for Bridge Element Inspection*
15. FHWA. 2005. *Inspection and Maintenance of Ancillary Highway Structures*
16. FHWA. 2009. *Manual on Uniform Traffic Control Devices*

2.1.3 Recording Field Information

Unless otherwise indicated, the Bridge Inspector shall record both National Bridge Inspection (NBI) ratings as described in the Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges and the AASHTO Guide Manual for Bridge Element Inspection. Scour and underwater evaluation, as well as, fracture-critical inspection reports shall be included when necessary. The forms or references to be used are described in the following sections.

2.2 Routine Condition Ratings

2.2.1 General

Routine field inspections for the District Department of Transportation will be made in-depth. The inspection report shall consist of the following parts. A sample Routine inspection report with the prescribed order of respective forms or parts is shown in Appendix D.

- Bridge Inventory Cover Sheet (2.2.2.1)
- Bridge Inspection Summary Report (2.2.2.2)
- Bridge Location Map (2.2.2.3)
- Bridge Plans (2.2.2.4)
- Bridge Inspection Summary Form – PONTIS and NBI Ratings (2.2.2.5)
- Bridge Inspection Report–PONTIS (2.2.2.6)
- Bridge Inspection Report–NBI Ratings (2.2.2.7)
- Bridge Appraisal Worksheet (2.2.2.8)
- Stream Bed Cross Section (2.2.2.9)
- Bridge Maintenance and Repair/Rehabilitation Recommendations (2.2.2.10)
- Load Rating Summary Form (2.2.2.11)
- Photograph Summary Sheet (2.2.2.12)
- Structure Inventory and Appraisal Sheet (SI&A) (2.2.2.13)

The inspection report furnished for the previous cycle inspection is retained in the bridge folder as an inspection history source data package. Copies of the previous inspection report will be provided to the inspector when performing the new field inspections.

Several forms have been developed in order to comply with the Federal guidelines and to furnish additional information on maintenance needs and posting requirements. Electronic files of all current bridge inspection forms have been furnished to the Inspector. The guidelines for using the forms and worksheets to complete the inspection report are as follows. The forms shall be modified and saved electronically for printing and later reference. Submission of a hard copy of field inspection reports and a .pdf copy is to be 60 days after completion of field inspection with 90 days as the maximum limit.

2.2.2 Routine Inspection Forms

2.2.2.1 Bridge Inventory Cover Sheet

This sheet has been developed to provide a general idea of the type of bridge to be inspected and its importance.

- A. INSPECTION CYCLE. Enter 24 months (unless the bridge is placed on other cycle).
- B. INSPECTION DATE. Enter month, day and year (e.g. 09/26/2011)
- C. INSPECTION TYPE. Indicate the type of inspection (e.g., Routine, Supplemental, Interim, Special). A Routine inspection is the inspection carried during the regular bridge inspection cycle. Supplemental is an inspection type to perform follow-up information on conditions or data after a previous Routine inspection. This is generally caused by access problems (need of snoopers) or temporary high water. Interim inspections are normally requested by maintenance forces, office staff or other agencies. Special inspections are performed to inspect specified structural elements in more detail. The request could originate from the following situations: impact damage, extreme deteriorated conditions, design problems, excessive deflections, fire damage, observations from private citizens, maintenance personnel or government authorities. Special inspections are one time inspections.
- D. BRIDGE NO. Enter the DDOT bridge number.
- E. HIGHWAY. Enter the name of the highway carried by the structure.
- F. OVER. Enter the name of the feature crossed by the structure.
- G. MILEPOST. Indicate to tenth of a mile the location of the structure to the nearest State System road.
- H. ADT (% Truck). Enter the current average daily traffic and the corresponding truck percentage.
- I. DESCRIPTION. Give a brief description of the structure. When space permits give number of spans, type floor, type beams and type substructure (e.g., three-span concrete deck bridge on prestressed I-beams, intermediate concrete piers, and concrete abutments).
- J. CLEAR WIDTH BETWEEN CURBS. Enter from the bridge inventory the clear width between curbs in feet (Verify in the field if necessary).

- K. APPROACH ROADWAY WIDTH EXCLUDING SHOULDER. Enter from the bridge inventory the width in feet of the approach roadway. Do not include shoulders.
- L. TYPE OF DECK AND SURFACING. Enter the deck material and the type of wearing surface.
- M. NUMBER OF SPANS. Enter the number of spans.
- N. PRESENT POSTING. Enter posting recommendation from the inventory. If no posting was recommended enter NONE.
- O. SUFFICIENCY RATING. Enter the sufficiency rating of the structure generated from the previous cycle inspection data and provided by DDOT on the preprinted SI&A form and enter the month and year of the previous inspection.
- P. DATE BUILT. Enter the original construction date of the bridge.
- Q. DATE OF MAJOR REHABILITATION. Enter the last date the structure was subject to a major rehabilitation.

PHOTOGRAPH. Attach a new 4" x 6" photograph taken at the time the inspection is made. If the bridge is posted the photo should show the posting sign. The date and bridge number should be imprinted in the photograph. Check the direction the photograph was taken.

2.2.2.2 Bridge Inspection Summary Report

This form provides general information regarding the inspection including the organization that performed the inspection, the name of the project manager, date of inspection and whether the structure is redundant/non-redundant or fracture-critical. The form also indicates if a pin and hanger ultrasonic inspection and/or underwater inspection was performed during the cycle, whether the bridge is weight posted, if a load rating is recommended and the date of the last load rating, if there are recommended maintenance repairs/rehabilitation items, there was a Letter of Concern prepared and if there are follow-up requirements. This form is signed and sealed by the project manager.

2.2.2.3 Bridge Location Map

Provide an 8-1/2" x 11" sheet with the detailed location of the bridge. In the case of multiple structures (ramps, overpasses) the location map should clearly indicate the structure to be inspected.

2.2.2.4 Bridge Plans

Typically existing plan and elevation sheets, a cross section sheet, framing plans and other details as appropriate shall be provided from the previous inspection report or added. If the bridge was rehabilitated or replaced, update the drawing sheets accordingly. Plans for medium to large bridges shall be 11" x 17" in size. Type the following information on a structure drawing sheet: the bridge span length(s), clear roadway widths, out-to-out superstructure widths, and the minimum vertical underclearance (as field measured). If existing plans or sketches for the bridge inspected are not available, include a sheet stating, "**Existing Plans are not Available**", in their place in the report. Plans shall be considered unavailable if after one request of DDOT they are not located. The above structure data shall be included on this sheet.

2.2.2.5 Bridge Inspection Summary Form – PONTIS and NBI Ratings

This sheet is comprised of the element level inspection data and the NBI condition rating summaries for deck, superstructure, substructure, channel and culverts, if applicable. The 2011 AASHTO Guide Manual for Bridge Element Inspection shall be used as the reference for the recording the element data. The NBI condition ratings are taken from the Bridge Inspection Report – NBI Ratings Form (see Section 2.2.2.7) and summary descriptions are provided. At the bottom of this form information on the special equipment used, the number of man-hours used (to the nearest hour) for the team inspection and report, inspection date and initials of the inspectors are given similar to that presented at the bottom of the NBI Ratings form.

2.2.2.6 Bridge Inspection Report – PONTIS

This form is used to describe the condition of the components rated on the Bridge Inspection Report – NBI Ratings sheet (see Section 2.2.2.7). All components with a rating of 6 or below must be clearly documented in this form. Each comment must be referenced to an element number from the AASHTO Guide Manual for Bridge Element Inspection. Entries do not need to be in sequence as shown in the Bridge Inspection Report – NBI Ratings Sheet. Enough information must be provided to justify the rating given and to provide a clear understanding of the condition state for the evaluation by the appraiser. Documentation must be given to explain why the condition rating has changed for a particular element from the previous inspection. Numbering of spans and bents follows a North-South or East-West direction unless otherwise noted in the plans. In the General portion of the report, minimum vertical and horizontal underclearances shall be provided for the traveled roadways in both directions for divided highways and the minimum underclearances for two-way undivided traffic. If the minimum vertical underclearance

for the structure, above the traveled roadway or shoulder is 13'-6" or less, clearance posting shall be recommended with an assigned Priority Code of 1 unless there is a severe hazard and a Priority Code E is justified. Minimum vertical and horizontal underclearances shall be provided at any railway tracks. The location of the minimum vertical and horizontal underclearances shall be shown on elevation drawing or sketches of the structure. All organizations and/or persons contracted to gain access to the site or for safety purposes shall be identified and contact phone numbers provided in the General portion of the report (Railroads, NPS, Coast Guard, Harbor Patrol, etc.).

Should the bridge contain fracture-critical details as described in Section 2.4.3, the members shall receive a close hands-on inspection and their condition identified and described on this form. The fracture-critical report cover sheet, included in Appendix C, shall be completed, signed by the project manager and provided at the end of this form.

This form should include detailed information on the traffic safety features. The bridge rail type, the approach guide rail transitions, the approach guide rail and the approach guide rail ends must be identified as either non-existent, obsolete, non-standard or standard. In each case explain your choice.

Information is also needed on speed limit signs on the route. If there is a speed limit sign, indicate the limiting mph. If not, estimate the usual speed of traveling (mph). If there is a yellow speed warning sign approaching the bridge it should be noted and the posted speed limit recorded. The inspector needs to evaluate if the route speed limit or the usual speed limit should be lowered due to roadway alignment and estimate the reduction in mph. Indicate if the lowering of the traveling speed is due to horizontal alignment, vertical alignment or both.

Information on the overflowing frequency and expected traffic delays due to flood should be included. The flooding frequency can be divided in four periods: 0-3 years, 3-10 years, 11-100 years and >100 years. For each period indicate if the deck, the approaches or both get flooded. The delays due to flood should be classified in the following three categories: several hours, several days or several weeks.

A thorough condition documentation using sketches, tables and/or photographs is requested. The use of digital color photographs with the bridge number and inspection date imprinted is recommended. Color photos have proven to be most descriptive showing conditions on and around the structure and will also reduce the amount of field time that would otherwise be required for sketches and written documentation. All photographs and sketches must be referenced in the Bridge Inspection Report. Photographs should be preceded by a

photo-log sheet that will list the title of the photograph and indicate the location and direction the photograph was taken. All general and specific defect photographs should have a title giving a brief description of what each photo is showing (e.g., Spall at the East Face of the Cap on Bent 3).

Photographs shall be generally included in the following order:

- *General* – Elevation views of the bridge, approach photos (looking towards and away from the bridge) and photos looking upstream and downstream of the bridge.
- *Deck* – Deck joints, typical deck condition, typical parapet condition, typical guide rail or fence photos, typical deck drains, typical deck soffit and any photos depicting deterioration of the deck.
- *Superstructure* – Typical superstructure photos, typical bearings and any photos depicting deterioration of the superstructure
- *Substructure* – Typical substructure photos including wingwall elevations and any photos depicting deterioration of the substructure.
- *Miscellaneous* – Stream channel, slope protection, utility photos or posting signs.

Include photos of bank erosion conditions upstream, downstream and under the structure. Photos can vary in size to fit two photos on a sheet, but generally no less than 3-1/2" x 5".

2.2.2.7 Bridge Inspection Report – NBI Ratings

Listed below are guidelines and comments covering the items on this form.

- A. **Bridge Number** – Enter the DDOT number assigned to the bridge being inspected (e.g., 0036, 1011 and 1303A).
- B. **Name** – Indicate the name used to identify the bridge (e.g., K Street Bridge, South Capitol Street (NB), Potomac River Freeway [Ramps 1 and 4]).
- C. **Over** – Indicate the name of the feature being crossed.
- D. **SI&A Item 58, Deck** – Identify the type of material used for decking. The general condition rating (dark boxes) for this item should be a condition evaluation that reflects on all spans in the structure and not necessarily one span having

the worst condition rating. The condition rating of elements listed under deck such as (wearing surface, joints, curbs, railing, etc.) should not control the overall SI&A deck rating (e.g., a wearing surface at its worst condition may reduce the overall rating of a deck at the most to a 6, fair condition).

- D.1 **Wearing Surface** – Rate only the existing condition of the wearing surface.
 - D.2 **Joints** – Show the number of each type used in the structure and apply a condition grade for each type that best reflects on the entire structure. If in doubt about the type of joint provide photos and additional description that will facilitate its identification in the office.
 - D.3 **Drainage System** – Rate the condition of the deck drainage system.
 - D.4 **Curbs, Sidewalks, Parapets, Median Barriers and Delineations** – Rate only their existing condition.
 - D.5 **Railings** – Identify the type of material used for the railing, the type of railing and rate only its existing condition (the fact that a railing does not meet current standards should not have a bearing on the condition rating). When the type of railing cannot be identified provide photos for further identification (it will be needed for the appraisal of the bridge safety features).
 - D.6 **Railing Protective Coating** – Rate the existing condition of the railing protective coating. If not existent rate N.
 - D.7 **Soffit** - Rate the condition of the deck soffit. This element will primarily control the overall deck rating, especially for reinforced concrete decks.
- E. **SI&A Item 59, Superstructure** – Listed elements are used for evaluating the condition rating for SI&A Item 59. Secondary members and bearings should not control the overall SI&A rating of Item 59. Only in extreme situations will secondary members and bearings affect the overall SI&A rating.
- E.1 **Main Members** – Select the material type and rate the existing conditions of the main superstructure element (e.g., girders, beams, spandrel bents, cables on cable support bridges). Different spans may have different main members and material types.

- E.2 **Floor Systems** – Rate the existing condition of the members conforming the floor system. Under a separate item rate the condition of the corresponding connections.
 - E.3 **Secondary Members** – Rate the existing conditions of secondary members such as intermediate diaphragms or cross bracings.
 - E.4 **Machinery (Movable Spans)** – The rating shown should be the overall rating resulting from a special inspection and using a form for movable spans.
 - E.5 **Bearings** – Determine if the bearing was initially intended to be fixed or expansion and report the existing condition in the appropriate box. Indicate the type of bearing being inspected (e. g., sliding, rocker, roller). Bearings will not influence the superstructure condition rating except in extreme situations.
 - E.6 **Steel Protective Coating** – If there are steel members, rate the condition of the protective coating system. Otherwise rate as N.
 - E.7 **Pin and Hanger Assemblies** – If there are pin and hanger assemblies, rate the overall conditions of visible components including pins, bushings and hanger plates. Include alignment of components, affects of corrosion product and condition of paint protection. Include condition of auxiliary support systems, if present.
- F. **SI&A Item 60, Substructure** – Listed elements are used for evaluating the condition rating for SI&A Item 60. All these items except for backwalls, wingwalls, collision protection system and steel protective coating can significantly affect the overall evaluation of SI&A Item 60. Scour conditions should be thoroughly investigated and detailed in the report (refer to FHWA Technical Advisory T5140.23 and HEC 18). Scour conditions affecting the overall condition of the substructure (SI&A Item 113 is 4 or less) will affect the overall condition rating for SI&A Item 60.
- F.1 **Above Ground Substructure Elements** – Rate the existing conditions of all visible substructure elements above the ground level.
 - F.2 **Below Ground Substructure Elements (Footing, Piles, Piers)** – If possible rate the existing condition of below ground substructure footings, sills, piles, piers. Make a best judgment rating on unseen below ground

items and state either "not visible" or "unable to inspect". Request an underwater inspection for substructures that cannot be evaluated below waterline to the ground line.

G. SI&A Item 61, Channel and Channel Protection –

Conditions to be rated under this SI&A Item are associated with the flow of water through the bridge. Drift along the channel and/or under the structure should be considered when making the evaluation. The definition and rating scales used for this SI&A Item are found on Page 40 of the Recording and Coding Guide.

G.1 Channel Banks – Rate the existing condition of the channel banks. Slope erosion caused by roadway drainage should not be rated under this group of elements but as slope protection, riprap, drainage under abutment or slope protection under approaches. If slope erosion is caused by channel flow then the condition should affect both elements, the abutment slope protection and the channel banks, and will have an impact on SI&A Item 61.

G.2 Channel Bed – The existing condition of the channel bed including any scour effects should be rated under this element.

G.3 Waterway Opening – Rate the existing condition of the waterway opening at the bridge site. Drift under the structure should be considered when making this evaluation.

G.4 Riprap, Toe Walls, Aprons, Dikes Jetties – The existing condition of these elements should also be evaluated. However they should not have a significant effect on the overall rating of SI&A Item 61.

H. SI&A Item 62, Culverts – The present form has been developed for structures other than culverts. Therefore, in this form the corresponding rating code for SI&A Item 62 must be N. If a culvert structure is being inspected then use the Culvert Inspection Form (to be developed).

I. Approaches – The existing condition should be rated according to the general SI&A conditions ratings. The rating code should include among others the effects of settlement, rippling, stability, roughness, broken surfacing. The elements listed under this Item will have a condition rating but there will not be an overall rating for the approaches.

- I.1 **Embankments** – Rate the existing condition of the embankments and embankment retaining walls.
- I.2 **Slope Protection** – This refers to the existing condition of the embankment or the cut slopes.
- I.3 **Roadway** – Rate the existing condition of the pavement structures right before and after the bridge structure.
- I.4 **Relief Joints** – Rate the existing condition of any joints provided to accommodate pavement deformations.
- I.5 **Approach Slabs** – This element will furnish a condition rating only for structures with a design approach slab to the bridge.
- I.6 **Drainage** – Rate the existing condition of the approach roadway drainage.
- I.7 **Guide Rail** – Identify the type of material used for the guide rail, the type of guide rail and rate only its existing condition (the fact that the guide rail does not meet current standards should not have a bearing on the condition rating). When the type of guide rail cannot be identified provide photos for further identification (include transition and ends). The information will be needed for the appraisal of safety features.
- I.8 **Delineation** – Rate the existing condition of delineators used in the approach roadway.
- I.9 **Sight Distance** – Rate the sight distance condition for the bridge.
- J. **Miscellaneous** – Miscellaneous items rated are any bridge SIGNS (specify the type being rated, e.g., posting sign, warning sign), existing ILLUMINATION, WARNING DEVICES, UTILITY LINES on or under the bridge. In the case of utilities identify the type of utility when recognizable and give details by sketches or photographs on how it is attached to the structure.
- K. **Special Equipment Used** – List any non-routine means of access to the bridge such as snoopers, bucket trucks, climbing gear, scaffolding, rigging, etc.
- L. **No. Hours** – Enter the total Inspection Team man-hours and report preparation time (to the nearest one hour). Field time should include travel. If other help is needed such as

flagman and rigging personnel, enter their total man-hours and specify the type of help.

M. **Inspection Date** – Enter the date the field inspection was completed.

N. **Inspected By** – The report is considered a legal document and must be initialed and signed by the Team Leader. The Supervising Engineer (which could also be the Team Leader) needs to sign and seal the Bridge Inspection Report and Summary Report Form.

2.2.2.8 Bridge Appraisal Worksheet

This worksheet is provided to aid the appraiser in documenting the appraisal values required for the following SI&A items:

SI&A ITEM 67: "Structural Evaluation"

SI&A ITEM 68: "Deck Geometry"

SI&A ITEM 69: "Underclearances"

SI&A ITEM 70: "Bridge Posting"

SI&A ITEM 71: "Waterway Adequacy"

SI&A ITEM 72: "Approach Roadway Alignment"

Also, provided in the worksheet is space to discuss and rate the different components of the Traffic Safety Features (SI&A Item 36).

2.2.2.9 Soundings/Stream Bed Cross Section

Soundings shall be obtained for all bridges over waterways to develop a stream bed cross section at the upstream side of the bridge. Whenever there is a difference in bed elevation of two feet or more from the upstream side to the downstream side, a sketch of the stream bed cross section at the downstream side of the bridge should also be included. The stream bed cross section should reflect the entire bed elevation profile of the structure and include any significant changes in the bed profiles from previous inspections. Structures over large bodies of water or fast currents need special equipment to obtain the bed profiles. Make the request for the special equipment on the "Bridge Inspection Record" form.

2.2.2.10 Bridge Maintenance and Repair/Rehabilitation Recommendations

This form should be a new submittal for each inspection and included in each report even when no recommendations for maintenance and repairs are needed.

Enter the Bridge number (BRIDGE No.), the highway name (HIGHWAY), the inspector's name (INSPECTOR), and the date the form was completed (DATE). The form consists of four columns: The first column is to enter the name and element number for which

recommendations are being made (see Bridge Inspection Record and Summary Form for element descriptions). If an element number is not available, enter the name of the component or item. The second column is to describe the recommended maintenance or repair action. The third column is to provide a photograph, if available, of the deficiency and the fourth column is to indicate a priority code (PC) for the recommended action.

Quantities shall be provided for all maintenance and repair/rehabilitation recommendations (i.e., LF, SF, CF, EA, etc.) so that DDOT can plan for the magnitude of the work.

2.2.2.11 Load Rating Summary Form

This form is used by DDOT to provide a summary of all the inventory and operating rating calculations and the recommended posting actions for their in-house bridge ratings. This form is signed and sealed by the Engineer making the posting recommendations. Enter the bridge number (BRIDGE No.) and the highway name (FACILITY CARRIED). In the table provided, the bridge member being rated and the corresponding inventory and operating HS loadings are entered. At the bottom of the table the controlling load ratings are summarized.

Below the table, the calculated posting corresponding to the critical load rating and the bridge member controlling the load posting are entered and the existing posting and the recommended posting are indicated. If these two are different, the reason for the posting change is entered.

Finally, as already indicated, the form is signed, dated and sealed by the Engineer responsible for the posting recommendations.

2.2.2.12 Photograph Summary Sheet

This photograph summary sheet or photo-log has been developed to aid in the identification and sorting of the photographs taken during the inspection. Inspectors need to enter the bridge number (BRIDGE No.) and the highway name (HIGHWAY). Provide the photo number (PHOTO No.) used in the report and a brief description of the picture (DESCRIPTION). Finally date the sheet (DATE).

2.2.2.13 Structure Inventory and Appraisal Sheet (SI&A)

A printout of the latest structure inventory and appraisal sheet must be included in the report package. The SI&A sheet will be provided by DDOT from the PONTIS database. Any bridge data changes must be clearly marked on this sheet. In most cases the changes will be due to new condition and appraisal ratings, and a new date of inspection.

2.3 Scour and Underwater Evaluations

2.3.1 General

The following criteria are intended to provide guidance in determining whether or not the underwater inspection of a given bridge is advisable, and if so, how often should an underwater inspection be performed and what underwater inspection techniques should be used. Nevertheless, no set of criteria can be all inclusive and eliminate the need to exercise engineering judgment. It is therefore, important that the Bridge Inspection Supervisor or Bridge Inspector not only use these criteria, but also study the available references to become thoroughly familiar with the uses and limitations of underwater inspection techniques.

There are three categories of underwater investigations that may be appropriate for a given bridge. The categories are channel profile measurements, scour investigations and underwater inspections. Specific criteria for each category are discussed in the following sections.

2.3.2 Scour Evaluation

The FHWA Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges requires all bridges over stream crossings to be rated for Item 113, Scour Critical Bridges. FHWA Technical Advisory T5140.23, HEC 18 – Evaluating Scour at Bridges and HEC 20 – Stream Stability at Highway Structures provide guidance on developing and implementing a scour evaluation program.

The process provides for a screening investigation that will allow first to group bridges over stream crossings as scour susceptible or non-scour susceptible and to assess the scour potential of scour susceptible bridges. The information collected should in most cases serve as the basis for the rating of Item 113 of the Structure Inventory and Appraisal/National Bridge Inventory. For those few cases where the information collected does not lead to a conclusive Item 113 rating a detailed scour analyses must be undertaken. A scour analysis shall be made by hydraulic/geotechnical/structural engineers.

2.3.2.1 General Recommendations for Rating Item 113

- If the bridge has failed and is closed due to scour than rate as 0.
- If the bridge is closed and failure due to scour is imminent then rate as 1.
- If footing base is exposed and a prompt action is required to protect the bridge from scour, then rate as 2.
- If scour holes have formed to depths near spread footing base and the underlying material is erodible soil or rock (RQD less than 50) then rate as 2.
- If there are exposed piles requiring protection then rate as 4.
- If the bridge is a culvert with a paved invert then rate as 8. Culverts and pipes, even with minor scour, will generally be

rated as 8. Scour requiring some corrective action but not critical should be rated as 4.

- If scour holes have formed to depths near spread footing base and the underlying material is fair to good quality rock then rate as 6 (scour countermeasures and monitoring may be necessary).
- If the foundation is unknown and the risk of damage due to scour is low then rate as 6; if the risk of damage is considered severe than rate as 3. If subsequent subsurface investigations and detailed scour analyses show the bridge to be scour critical (provide scour countermeasures). Otherwise, rate as 6 (scour countermeasures can be deferred).

2.3.3 Channel Profile Measurements

All bridges over waterways, except box culverts and other bridges with lined channels, should have a channel profile sheet which is updated as appropriate by re-measuring the channel profile. Design plans will usually show the channel profile as it existed at the time of construction.

If portions of the channel are submerged, then appropriate underwater inspection techniques should be used to take channel profile measurements. If water currents and channel depths are moderate, then the Bridge Inspector would ordinarily take measurements with a drop line just as if the channel were dry. However, if there are significant currents or extreme depths, then a sounding rod or electronic depth finder should be used. See Section 2.3.5 for further discussion of underwater inspection techniques.

There are two criteria for the frequency of channel profile measurements. First and foremost is channel activity, i.e., changes in the channel depth or width, or shifts in the channel's position within the flood plane. If there are no indications of significant activity, then there is no need to re-measure the channel profile. The second criterion is whether or not channel activity endangers one or more of the substructure elements. The second criterion depends on the magnitude of the channel activity, as well as, the type of substructure element affected.

For instance, even though a channel is shifting significantly, there might not be a potential to endanger concrete piling embedded 25 feet below the channel bed elevation. If this is true, then channel profile measurements would not be warranted more frequently than every 60 months as recommended in Table 2.3.1.

All bridges over waterways should have a sketch of the stream bed cross sections along the upstream and downstream fascia.

Table 2.3.1: Criteria for Channel Profile Measurement

CRITERIA	RECOMMENDED FREQUENCY
The channel is active and channel activity currently endangers one or more substructure elements.	Every 24 months, plus or minus six months.
The channel is active and continued channel activity may endanger one or more substructure elements even though none are currently endangered.	Every 48 months, plus or minus 12 months or during an underwater inspection.
The channel is active but the magnitude of channel activity has little potential to cause substructure problems or the channel is not active.	Every 60 months, plus or minus 24 months or during an underwater inspection.

For bridges not in the underwater program, the channel cross sections shall be determined by taking drop line readings along each fascia of the bridge. The stream bed cross sections should reflect the entire bed elevation profile of the structure and include any significant changes in the bed profiles from previous inspections. If readings were taken during a previous inspection, then new readings should be taken at the same locations from the same reference point on the bridge. If previous readings are not available, then readings should be taken starting adjacent to the beginning abutment and proceeding at spacings less or equal to 10 feet to the end abutment. An additional reading should be taken in front of each intermediate pier.

The readings shall be recorded on a sketch which clearly locates each sounding point, and identifies the reference used for the readings. Acceptable reference points are the top of the railing or parapet, and the top of the deck. If the top of railing or parapet is used as the reference point, the dimension from the top of the railing to the sidewalk or top of the deck should be recorded so that the reference is not lost in the case the railing is replaced. Refer to the Bridge Inspector's Reference Manual (BIRM), Section 13.2.6 for an example of channel profiles.

The drop line method does not work well for bridges over large bodies of water or fast currents (e.g., bridges over the Potomac River or over the Anacostia River). These bridges will need special equipment to obtain the bed profile. Since these bridges are inspected in detail throughout an underwater inspection program, no attempt should be made during routine NBI inspections to obtain the bed elevation profile. However, it should be noted in the "Bridge Inspection Record" form, the need for special equipment and any observed problems due to scour or erosion. There could be some bridges not over the Potomac River or Anacostia River where the drop line method will not work. In those cases, the consultant shall propose a method to obtain the stream bed profiles and submit the estimate cost to the DDOT Project Manager for approval.

If local scour greater than two feet deep (measure from the original stream bed profile) is observed adjacent to any portion of a substructure, or if the channel bottom cannot be seen adjacent to any portion of the substructure, then a channel profile shall be provided for the entire length of the substructure unit.

The readings should be taken immediately next to the footing or approximately one foot beyond the face of abutment or pier if the footings are not exposed. The readings should be taken at five foot spacings or less along each face of pier or abutment. Additional readings shall be taken at five foot intervals for 30 feet upstream and downstream along a projected centerline of any substructure where channel profile readings are required. Acceptable reference points are the top of footing, the bridge seat and the top of pier. In addition, when erosion or scour is observed, a sketch should be provided documenting the location and the three dimensions of the limits of bed material loss.

2.3.4 Scour Investigations

Scour investigations should be performed if there is a potential for substructure problems such as the undermining of a spread footing or the exposure of steel or timber piling. When investigating scour, if portions of the substructure are submerged, then appropriate underwater inspection techniques should be used. If plans are available, scour measurements can be correlated with the substructure configuration to determine whether a spread footing is being undermined or whether piling are being exposed by scour. Depending on stream depth and velocity, the Bridge Inspector would ordinarily work from a boat and take scour measurements with a drop line, sounding rod or electronic depth finder. When plans are not available, ordinary techniques may not indicate undermining or exposure of piling. In this case, the use of divers may be warranted, especially for major bridges when there is a high potential for scour. See Section 2.3.5 for further discussion of underwater inspection techniques.

There are two criteria for the frequency of scour investigation. First is the potential for scour, which is judged by the stream velocity at flood state and by the characteristics of the channel bed material. If there is no potential for significant scour, as for bridges over lakes or rocky channels, then there is no need to investigate scour.

The second criteria is the potential for substructure problems caused by scour. The three substructure problems that may be caused by scour are as follows:

1. Undermining. If the substructure does not extend below the depth of anticipated scour, then scour may undermine the substructure.
2. Piling deterioration. If steel or timber piling could be exposed by scour, then the piling may be subject to deterioration. In fresh water, piling deterioration is most likely to be critical if piling are exposed within a few feet of the water surface at low water. In salt or brackish water, piling deterioration may be critical if piling are exposed anywhere between the water surface and the mud line.
3. Instability. If scour removes channel or embankment material from one side of a pier or abutment, then lateral pressure from material on the other side may cause substructure instability.

When a scour investigation is warranted, the recommended frequency of scour investigation should be determined from Table 2.3.2. For instance, if the potential exists for scour to expose steel piling which are presently encased in concrete to a depth one foot below the mud line in a salt water bay, then the recommended frequency of scour investigations would be every 60 months as determined from Table 2.3.2.

Table 2.3.2: Criteria for Scour Investigations

CRITERIA	RECOMMENDED FREQUENCY
Scour endangers one or more substructure elements.	Every 24 months, plus or minus six months.
Scour may endanger one or more substructure elements even though none are currently endangered.	Every 60 months, plus or minus 12 months
Significant scour is possible or present but has little potential to cause substructure problems.	Every 96 months, plus or minus 24 months.
The channel and stream characteristics make significant scour unlikely	Whenever significant scour becomes possible.

2.3.5 Underwater Inspections

Underwater inspection of bridge structural elements will be performed on regular intervals not-to-exceed 60 months.

Certain underwater structural elements may require inspection at less than 60 month intervals. The level and frequency to which these members are inspected should consider such factors as construction material, environment, age, scour characteristics, condition rating from past inspections and known deficiencies.

Certain underwater structural elements may be inspected at greater than 60 month intervals, but not exceeding 72 months. Written FHWA approval is required for greater than 60 month intervals. This may be appropriate when past inspection findings and analysis justifies the increased inspection interval.

Other factors that can prompt an underwater inspection at less than 60 month intervals are:

1. When above water inspection indicates that serious problems exist below water.
2. When submerged portions of the substructure are susceptible to deterioration that may not be evident through a visual inspection of areas near the waterline at low tide or periods of low water. In salt, brackish or corrosive waters, underwater portions of the substructure are susceptible to hidden deterioration when there is a change in the type, configuration or

protection of material in the area from the splash zone to the mud line. In fresh or noncorrosive waters, susceptibility is generally limited to bridges where material changes occur near the low water level.

3. When plans are not available and there is possibly a material change as described in the preceding paragraph.

If an examination of submerged portions of the substructure is warranted, then the use of a diver is generally recommended. Section 2.3.6 for further discussion of underwater inspection techniques.

2.3.6 Underwater Inspection Procedures

2.3.6.1 Diving Inspection Intensity Levels

Originating in the offshore diving industry, and adopted by the United States Navy, the designation of standard levels of inspection has gained acceptance. Three diving inspection intensity levels have evolved as follows:

- Level I: Visual, tactile inspection
- Level II: Detailed inspection with partial cleaning
- Level III: Highly detailed inspection with nondestructive testing

Routine underwater inspections normally include a 100 percent Level I inspection and a 10 percent Level II inspection, but it may include a Level II and Level III inspection to determine the structural condition of any submerged portion of the substructure with certainty.

Level I inspection consists of a close visual inspection at arm's length with minimal cleaning to remove marine growth. Although the Level I inspection is referred to as a "swim-by" inspection, it must be detailed enough to detect obvious major damage or deterioration. A Level I inspection is normally conducted over the total 100% exterior surface of each underwater element, involving a visual and tactile inspection with limited probing of the substructure and adjacent streambed. The results of the Level I inspection provide a general overview of the substructure condition and verification of the as-built drawings. The Level I inspection can also indicate the need for Level II or Level III inspections and aid in determining the extent and selecting the location of more detailed inspections.

Level II inspection is a detailed inspection that requires that portions of the structure be cleaned of marine growth. It is intended to detect and identify damaged and deteriorated areas that may be hidden by surface growth. A Level II inspection is typically performed on at least 10% of all underwater elements. In some cases, cleaning is time consuming and should be restricted to critical areas of the structure. The thoroughness of cleaning should be governed by what is necessary to determine the condition of the underlying

material. Removal of all growth is generally not needed. Generally, the critical areas are near the low waterline, near the mud line, and midway between the low waterline and the mud line. On pile structures, horizontal bands, approximately 6 to 12 inches in height, should be cleaned at designated locations:

- Rectangular piles – the cleaning should include at least three sides
- Octagonal piles – at least six sides
- Round piles – at least three-fourths of the perimeter
- H-piles – at least the outside faces of the flanges and one side of the web

On large elements, such as pier and abutments, areas at least one square foot in size should be cleaned at three or more levels on each face of the element. Deficient areas should be measured, and the extent and severity of the damage documented.

A Level III inspection is a highly detailed inspection of a critical structure or structural element, or a member where extensive repair or possible replacement is contemplated. The purpose of this type of inspection is to detect hidden or interior damage and loss in cross-sectional area. This level of inspection includes extensive cleaning, detailed measurements and selected nondestructive and partially destructive testing techniques such as ultrasonics, sample coring or boring, physical material sampling and in-situ hardness testing. The use of testing techniques is generally limited to key structural areas, areas that are suspect, or areas that may be representative of the entire bridge element in question.

The appropriate level of inspection will depend on such factors as age, construction material, type of design, stream bed material, presence of corrosion pollution, depth and velocity of flood flows, maintenance history and numerous other factors. Refer to Section 13.3.2 in the BIRM for additional information on underwater inspection procedures.

2.3.6.2 Sounding Techniques

1. Sounding rod. A typical sounding rod is a 15 or 20 foot graduated pole that can be folded up or taken apart like a fishing pole. A sounding rod is suitable for channel profile measurements and scour investigations in shallow water.
2. Drop line. A typical drop line consists of a weight secured to the end of a 50 foot tape measure. A drop line is suitable for channel profile measurements and scour investigations in shallow or moderately deep water. However, high stream velocities will cause the drop line to drift downstream making it difficult to take good measurements.

3. Electronic depth finder. The typical electronic depth finder is a portable, battery-operated, 10 lb unit called a fish finder or fathometer. An electronic depth finder is suitable for channel profile measurements and scour investigations in deep water and faster moving streams.

2.3.6.3 Use of Divers

The use of divers is generally recommended for underwater inspections and may be advisable for scour investigations when plans are not available to correlate with soundings. In order to effectively use the time spent underwater, a diver must know what to look for and must be able to evaluate the significance of what is observed. For this reason, DDOT policy is that divers meet the qualifications of an Inspection Team Leader or be directly supervised at the site by a qualified P. E.

2.3.6.4 Underwater Photography and Video Equipment

Cameras come with a variety of lens and flash units. In some cases, visibility is limited and the camera must be placed close to the subject. Wide-angle lenses are, therefore, most often used. Suspended particles often dilute the light reaching the subject and can reflect light back into the lens. When visibility is very low, clear water boxes can be used. The boxes are constructed of clear plastic and can be filled with clean water. By placing the box against the subject area, the dirty water is displaced and the camera shot can be taken through the clear water.

Video equipment is available either as self-contained, submersible units or as submersible cameras having cable connection to the surface monitor and controls. The latter type allows a surface operator to direct shooting while the diver concentrates on aligning the camera only. The operator can view the monitor, control the lighting and focusing and communicate with the diver to obtain an optimum image. Since a sound track is linked to the communication equipment, a running commentary can also be obtained.

An extension of the video camera is a remotely operated vehicle (ROV), where the diver is eliminated and the camera is mounted on a surface controlled propulsion system. Its effectiveness diminishes substantially in stream velocities greater than 1.5 knots and is limited by cloudy water, inability to determine the exact orientation and position of the camera, and control sensitivity. Also important to note is that an ROV cannot typically perform cleaning operations prior to photos being taken.

2.3.6.5 Cofferdams

The use of a cofferdam permits a thorough substructure examination, but the expense involved make the use of a cofferdam unjustifiable

except in hazardous situations or where qualified divers are not available. Numerous types of cofferdam systems are available making it possible to construct a cofferdam for practically any situation. However, if a cofferdam is to be used, the design must be checked by an Engineer. When considering the use of a cofferdam, recognize that the cost will increase tremendously as the water depth increases.

2.3.7 Bridges in the Underwater Inspection Program

The bridges listed in Appendix E have been identified by DDOT personnel as requiring specialized underwater inspection (i.e., divers and sounding equipment).

2.3.8 References for Scour and Underwater Inspection

The following references shall be utilized for scour and underwater inspections:

1. FHWA Bridge Inspector's Reference Manual (BIRM), Section 13
2. FHWA, Technical Advisory T5140.23
3. AASHTO Manual for Bridge Evaluation, Section 4.2.6

2.4 **Fracture-Critical Inspections**

2.4.1 General

The Bridge Inspection Consultant shall create and maintain a list of bridges that require fracture-critical inspections. The list may be established as inspections proceed. The list shall include a location and copy of the specific fracture-critical details and the frequency at which they are inspected. The list shall be provided to DDOT periodically and whenever updates are made. A close visual inspection should be made of all fracture-critical details during each routine inspection.

A fracture-critical bridge member (FCM) is a steel bridge or span member in which a single fracture could cause the bridge or span to collapse. When bridge Engineers talk about fracture and fracture-critical bridge members, they are talking about the failure of a steel member by cracking. Generally speaking, a fracture in an existing bridge or span will begin with a small crack which grows slowly over a period of years until it reaches its critical size. The critical size may be one-eighth of an inch or it may be several inches long depending on the type of steel, the stress in the steel and the temperature of the steel. Whatever the critical size, once a crack reaches that size, it grows instantaneously across the remainder of the cross sectional element. This instantaneous crack growth is what Bridge Engineers call a fracture.

A fracture is not always catastrophic, but in situations where only a few separate steel elements are available to carry the load, a single undetected crack in one element could result in a catastrophic fracture that causes the bridge to collapse. The problem of where, when and how to look for that one insidious little crack is best approached in a systematic manner by means of a fracture control plan.

2.4.2 Fracture Control Plan for Existing Bridges

The purpose of a fracture control plan for existing bridges is to economically minimize the possibility of a catastrophic fracture by increasing the level of inspection in proportion to the potential for catastrophic fracture. The following factors increase the potential for catastrophic fracture:

1. Low redundancy of bending or tension members
2. Structural details that cause high stress concentrations
3. High design stresses
4. Low standards of fabrication and construction
5. High volumes of truck traffic
6. Heavy overloads
7. Low temperature
8. Deterioration or damage at critical details

When there is a high potential for catastrophic fracture, considerable resources and technical expertise should be brought to bear on the problem of detecting cracks before they reach critical size. A good fracture control plan will minimize the possibility of a catastrophic fracture by rationally allocating the resources and technical expertise available for bridge inspection.

The following steps are recommended for developing a fracture control plan for existing bridges:

1. Identify all fracture-critical bridge members
2. Identify the critical areas of these members
3. Identify the critical details within these areas.
4. Evaluate the critical details by considering design, fabrication and construction practices, as well as, detail geometry
5. Evaluate service conditions by considering truck traffic, overloads and existing deterioration or drainage
6. Allocate available resources and technical expertise according to the potential for catastrophic fracture as determined in Steps 4 and 5.

Steps 1, 2 and 3 are accomplished as explained below in Section 2.4.3 and in Section 10 of the Bridge Inspector's Reference Manual (BIRM). The AASHTO Manual for Bridge Evaluation, Sections 6 and 7 provide guidance for Steps 4 and 5.

2.4.3 Fracture-Critical Details

Fracture-critical details are the structural details that cause stress concentrations within the critical areas of fracture critical members. The critical areas of fracture-critical members are the high tension areas where only a few separate steel elements are available to carry the load.

The following examples describe how to identify the fracture-critical members and fracture critical areas of bridges.

Two-Girder Systems. Steel bridges or spans with only two main girders are fracture-critical. However, for DDOT there is one exception: the riveted plate girder bridge is not considered fracture-critical because of internal redundancy. Each of the critical areas of a riveted plate girder, i.e., the flanges, consists of several angles and plates all of which must fracture before the flange fails. Aside from the riveted plate girder bridge, steel bridges or spans with only two main girders will have a fracture-critical area on each girder at the lower flange in the mid-span region of each span and at the upper flange in the region over each continuous support. The upper flanges near the end supports do not constitute fracture-critical areas.

Box Girder Bridges, Single Box Design. The single box design of a steel box girder is a fracture-critical bridge. The bottom plate is welded to two or sometimes three web plates each of which has a flange plate welded to its upper edge. The upper flange plates will be fracture-critical areas in the regions over each continuous support except where the plans show a substantial amount of additional reinforcing steel parallel to the flanges. In this case, the additional reinforcing steel provides a high degree of redundancy that guards against a sudden catastrophic fracture.

Steel Caps. Where supports cannot be located directly under the bridge, bridge designers may use a steel box beam cap to span between widely spaced columns. The superstructure is then supported in the mid-span region of the cap. In these cases, there is one fracture-critical area at the lower flange in the mid-span region.

Truss Bridges. When a truss bridge has only two main trusses it may contain fracture-critical members. The fracture-critical member would be single-element tension member such as an eyebar or I-beam tension member. Built-up, riveted tension members are not considered fracture-critical, neither are tension members consisting of multiple separate steel elements. Each fracture-critical tension member would count as one fracture-critical area.

Suspension Bridges. The main suspension cables and suspenders are not considered fracture-critical if they consist of multi-strand cables. However, on older suspension bridges, eyebars or threaded rods may be used for the main suspension cables. Each of these members is fracture-critical unless it consists of more than two eyebars or threaded rods.

Suspended Span Bridges, Two-Girder Bridges. The same criteria apply that were discussed for two-girder systems. In addition, pin and hanger assemblies which may support a two-girder, suspended span are considered fracture-critical. If auxiliary support systems (catcher beams) are in place at pin and hanger assemblies, these are considered fracture-critical details.

Once the critical areas have been identified, the critical details are identified by referring to Table 6.6.1.2.3-1 of the 2010 AASHTO "LRFD Bridge Design Specifications" Fifth Edition. The AASHTO Specifications identify structural details and assign each detail to a category which indicates its relative severity. Category "A" details are the best details because they can withstand repeated

loading better than the other details which become progressively worse for Categories B, C and so on. Categories E and E' are the worst details

2.4.4 Evaluation of Fracture-Critical Bridges

The following procedures provide specific guidance for determining when a detailed inspection of a fracture-critical bridge is needed. The Bridge Inspector should follow these procedures to evaluate all fracture-critical bridges in the District. When evaluating fracture-critical bridges, consider the following factors:

Stress Category of Critical Details. Each change in cross section within the critical areas should be identified and assigned a stress category in accordance with Table 6.6.1.2.3-1 of the AASHTO LRFD Specification referenced herein. Refer to the AASHTO Specification for special cases and further explanation of the stress categories. In general, the inspector should be concerned with Category E details or worse. However, the inspector may use discretion in including certain details in lower categories.

Stress Range. The representative stress range is found in accordance with the AASHTO LRFD Specification referenced herein. The location of the stress and the loading that produces it should be noted, and the stress calculations should be made part of the permanent record of the bridge.

Equivalent Daily Fatigue Loading. This is the number of times that the representative live load stress is produced in the critical area. In the absence of load monitoring, this number is merely an estimate of the number of fully loaded trucks that cross the bridge each day in the critical lane.

Estimated Fatigue Life Remaining. After determining the live load stress range and the most severe stress category for the critical details, the remaining fatigue life of the bridge can be determined using the AASHTO LRFD Specification referenced herein.

Inspection Frequency. All FCMs are to be inspected at intervals not-to-exceed 24 months. Certain FCMs may require inspection at less than 24 months depending on the age of the bridge, equivalent daily fatigue cycles, remaining estimated fatigue life, condition of the fracture-critical members and the stress category of the member.

2.4.5 Fracture-Critical Inspection Techniques

Inspection Techniques. A Fracture-Critical Inspection consists of an intense close visual inspection of FCMs or fatigue-sensitive details for fatigue cracks. The inspection could include special cleaning or the use of nondestructive testing methods. This type of inspection shall be conducted based on findings from a routine inspection or at predetermined intervals. A close visual inspection requires that the critical details be cleaned free of cracked paint, rust and debris. The ideal time for a close visual inspection is during a painting job immediately after the steel has been blast cleaned. The worst time is immediately after painting because the fresh paint will hide any cracks that might exist. Several years after painting, a close visual inspection without the

removal of paint should reveal cracks that have grown since painting. Cracked paint at critical details must be removed to determine if the steel is cracked beneath the paint.

The inspection is generally limited to the close visual inspection. If this inspection reveals cracks or suspected cracks, then additional nondestructive testing methods such as ultrasonic, dye penetrant, magnetic particle or other methods may be required depending on the circumstances. Ultrasonic inspection of pins in pin and hanger systems shall be performed to detect internal defects in these components.

2.4.6 Fracture-Critical Inspection Report

2.4.6.1 General Guidelines

The fracture-critical report should include at least the following:

- Fracture-Critical cover sheet (see Appendix C)
- Inspection Findings (narrative style)
- Summary and Conclusions
- Sketches and Photographs

2.4.6.2 Fracture-Critical Cover Sheet

The cover sheet shown Appendix C is divided into four parts:

1. General information
2. Equipment used
3. Inspection team/inspection date
4. Repairs needed

General Information: Under General Information, type the bridge number, bridge name, facility carried, feature crossed, ADT, percent truck in ADT and ADT date.

Equipment Used: Check all applicable equipment. If the special equipment used is not listed, fill in the blank spaces provided. More than one box can be checked.

Inspection Team/Inspection Date: Write in the names of the inspectors, the reviewer of the report and the date of the inspection.

Repairs Needed: Check all that applies. If no repairs are needed, check the "NONE" box; if there are deficiencies needing immediate attention to preserve the life of the bridge, check the "URGENT" box; if the repairs needed can be performed during a normal maintenance schedule, check the "PROGRAMMED" box. More than one box can be checked.

2.4.6.3 Inspection Findings

In this section include a detailed narrative which provides insight regarding the condition of the fracture-critical elements inspected. Sketches and photographs should be included and properly referenced in the text. Minor deficiencies or defects should be reported since they might evolve into critical deficiencies or defects. Fracture-critical elements with no notable problems should also be described in the report. This will help document that the member was inspected. Any defect found should be clearly identified. When possible, at least the type of defect, location and cause should be part of the narrative.

2.4.6.4 Summary and Recommendations

This is the final product of the Fracture-Critical Inspection Report. The summary should include a listing of deficiencies and the urgency of repairs. Recommendations should focus on reducing the risk of failure. The FCM report should be included with the routine inspection report.

2.4.6.5 Sketches and Photographs

The sketches and photographs can be included in an appendix or within the text. They serve to enhance and clarify the inspection report. Pictures can be taken not only of defects but also of members without defects to illustrate the current condition of the fracture-critical element. Always include in the photo a ruler or any other object that will provide an idea of the scale depicted. If close-up photos are taken, an overall picture shall also be included.

2.5 Inspection of Complex Bridges

Complex or special bridges are cable-supported structures such as suspension and cable-stayed bridges and movable bridges. The components of these structures, inspection procedures and overview of common defects are included in Section 16 of the Bridge Inspector's Reference Manual (BIRM). Although additional inspector training and experience beyond the qualifications as outlined in Section 1.4 of this document are not required for complex bridges, due to the specialized nature of these bridges or structures, the inspection supervisor or project manager should be very familiar with these type of bridges.

There are primarily three categories of movable bridges. There are swing bridges, bascule bridges and vertical lift bridges. Other than defects common to all types of bridges fatigue of structural members can be a problem with movable bridges due to reversal or fluctuation of stresses during opening and closing cycles. Members and connections subject to stress variations should be closely inspected for fatigue damage. Another important consideration for the inspection of movable bridges is safety. This includes inspector safety, public safety and navigation safety when operating the bridges.

2.6 Safety Inspections of Railroad-Owned Bridges

In addition to the NBIS inspection of bridges and tunnels in the District, DDOT is responsible for performing safety inspections of railroad-owned bridges crossing over all public highways in the District. The intent of these examinations is to perform a cursory inspection of the underside of the structures and supports, and the traffic safety features to determine if there are deficiencies at the structures that could affect the safe passage of vehicles or pedestrians below. These deficiencies could include deck underside concrete spalls or incipient concrete spalls, severe section loss in members, loose connection fasteners, extreme lean of bearings, traffic impact damage and lack of proper signs and/or hazard markers or the damage of such items. Detailed vertical underclearances are also obtained during each inspection in both directions of traffic at curblines, mid-span or at other high points in the roadway below to establish the minimum underclearance and the need for posting.

The safety inspections are performed at 24 month intervals. The inspection is performed from the ground, sidewalk or roadway below and could utilize a ladder. A report is prepared similar to the NBIS Inspection Report; however, it does not include all the forms of an NBIS Inspection Report. A sample Safety Inspection Report is included in Appendix D with the prescribed order of the respective forms or parts. The following sheets, sketches or forms are included in a Safety Inspection Report:

Bridge Inventory Cover Sheet

Bridge Inspection Summary

Bridge Location Map

Sketch of Vertical Underclearances – A plan view of all obtained underclearances

Bridge Inspection Report–PONTIS – This form contains an abbreviated narrative of the structure condition and observed deficiencies

Bridge Appraisal Worksheet – This form generally only contains the ADT, if known, on the roadway below the structure and the minimum vertical and horizontal under clearances

Bridge Maintenance and Repair/Rehabilitation Recommendations

Photograph Summary Sheet

3.0 STRUCTURAL ANALYSIS AND LOAD RATING

Perform or update the safe load carrying capacity of each bridge in accordance with the AASHTO manual. Evaluate load ratings at inventory and operating levels using the AASHTO HS configuration.

Use conventional methods of analysis unless more complex and refined methods are specified or warranted and specifically directed by the District.

Identify the structural components or members that govern the ratings. Define any section losses and/or deficiencies on these members. Include a table of stresses and a rating summary in the report.

All computations are to be in accordance with current AASHTO Specifications. Update existing computations accordingly. The rating calculations shall consider and reflect the structural condition of the bridge elements including section loss, steel cracks, loss of connections damaged or misalignment of members. The Consultant shall include a narrative report describing how any of these deficiencies were incorporated into the load rating calculations.

Calculate the load ratings, use data available from inspection files and reports, supplemental field information and testing data. When no data or drawings (or sketches) are available, calculate load ratings based on field measurements of components and material destructive testing, if needed. Post or restrict the bridge in accordance with the AASHTO manual or in accordance with the District law where the maximum unrestricted legal loads or State routine permits loads exceed the allowed under the operating rating or equivalent rating factor.

Perform a structural analysis of the substructure only if its structural adequacy is in question or it is at risk due to scour as a result of the field inspection findings or its unusual component makeup.

Provide emergency retrofit schemes, as directed, for any critical conditions uncovered. Final results should be summarized on a Load Rating form similar to that described in Section 2.2.2.11.

4.0 QUALITY CONTROL/QUALITY ASSURANCE

Assure systematic Quality Control (QC) and Quality Assurance (QA) procedures are used to maintain a high degree of accuracy and consistency in the inspection program. Include periodic field review of inspection teams, periodic review of bridge inspection refresher training for program managers and team leaders and independent review of inspection reports and computations. For additional information on this topic refer to Section 1.3 of the FHWA Bridge Inspector's Reference Manual (BIRM).

APPENDIX A

CODE OF FEDERAL REGULATIONS 23 – HIGHWAYS – PART 650

APPENDIX B
LIST OF BRIDGES FOR ROUTINE INSPECTIONS

APPENDIX C
CRITICAL FINDING REPORT FORM
FRACTURE-CRITICAL INSPECTION REPORT COVER FORM

Fracture-Critical Inspection

BRIDGE NO.: _____	HIGHWAY: _____	INSPECTION
	OVER: _____	DATE: _____
DESCRIPTION _____		
PRESENT POSTING: _____		
SUFFICIENCY RATING: _____		
YEAR BUILT: _____		
DATES OF MAJOR REHABILITATION: _____		
NUMBER OF SPANS: _____		
CLEAR WIDTH BETWEEN CURBS: _____		
APPROACH ROADWAY WIDTH INCLUDING SHOULDERS: _____		
TYPE OF DECK AND SURFACING: _____		
MILEPOST: _____		
ADT (% TRUCK): _____		
YEAR ADT: _____		

EQUIPMENT USED: _____

FRACTURE CRITICAL TYPE:	_____ TWO GIRDER SYSTEM	_____ PIN & LINK ASSEMBLY
	_____ CROSS GIRDER SYSTEM	_____ SUSPENDED SPANS
	_____ HANGER ROD SYSTEM	_____ SWING SPAN
	_____ CURVED STEEL BOX GIRDER	_____ BASCULE SPAN

INSPECTION TEAM LEADER: _____
INSPECTION TEAM MEMBERS: _____

REVIEWED BY: _____

REPAIRS NEEDED: _____ NONE _____ PROGRAMMED _____ URGENT
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APPENDIX D

SAMPLE ROUTINE AND SAFETY INSPECTION REPORTS

APPENDIX E

BRIDGES IN UNDERWATER INSPECTION PROGRAM

BRIDGES IN DDOT UNDERWATER INSPECTION PROGRAM

BRIDGE NO.	LOCATION
0001	Chain Bridge over Potomac River, N. W.
0007	Francis Scott Key Memorial Bridge over Potomac River, S.W.
0052	Benning Road Bridge over Anacostia River, N. E.
0053	South Capitol Street Bridge over Anacostia River, S. E. (Frederick Douglas Memorial Bridge)
0054	Pennsylvania Avenue Bridge over Anacostia River, S. E. (John Philip Sousa Memorial Bridge)
0076	New York Avenue Bridge over Anacostia River, N. E.
0077	Benning Road Bridge over Kingman Lake, N. E.
0169-1	Center Highway Bridge over Potomac River, S. W. (Rochambeau Memorial Bridge)
0170-1	Northbound 14 th Street Bridge over Potomac River, S. W. (Arland D. Williams Memorial Bridge)
0171-2	14 th Street Bridge over Tidal Basin Outlet, S. W.
0233	East Capitol Street Bridge over Anacostia River, N. E.
1026	Anacostia Freeway Bridge over Oxon Run Bay, S. W.
1113	Southwest Freeway Bridge over Washington Channel, S. W. (Francis Case Memorial Bridge)
1133	Southbound 14 th Street Bridge over Potomac River, S. W. (George Mason Memorial Bridge)
1200	Theodore Roosevelt Memorial Bridge over Potomac River, N. W. (including Little River Crossing)
1415	11 th Street Bridge over Anacostia River, S. E.
1416	Eastbound I-695 over Anacostia River, S. E.
1417	Westbound I-695 over Anacostia River, S. E.