

# Chapter 5      *Load Rating and Scour*

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## 5-1      **General**

The National Bridge Inspection Standards (NBIS) requires a load rating be calculated for each reportable bridge\* as well as a scour evaluation for any reportable structure over water. Temporary structures that will be in service for more than 90 days shall be load rated as well as assessed for scour.

The load rating calculations and scour evaluations are a permanent part of the bridge file and are to be updated when the condition of the bridge changes. All load rating calculations and new and updated Scour analysis shall be stamped, signed, and dated by a registered professional engineer.

## 5-2      **Bridge Load Rating**

Load rating of structures shall be completed per *Bridge Design Manual (BDM)* Chapter 13 and the AASHTO Manual for Bridge Evaluation (MBE). See BDM Section 13.4 for summary sheets and information included in the Load Rating Report. See the appendix in the MBE for examples of load rating different types of structures. Newly discovered or transfer of ownership of bridges shall have load ratings completed and data entered into the inventory within 90 days.

### 5-2.1      **General Load Rating and Re-Rating Guidelines**

- The Load rating of new structures shall be completed within 90 days of opening the structure to the traveling public in the anticipated final configuration.
- The ratings of existing bridges shall be re-examined when the “Revise Rating Flag” is turned on. The condition of identified bridge elements shall be reviewed and the load ratings shall be updated if needed. In cases where the capacity of a member is reduced significantly, such as impact damage to a girder with loss of reinforcing or damage to steel members, ratings shall be updated within 30 days. In other cases such as increase in dead load, a preliminary assessment can be made based on the increase in dead load, condition of the structure and existing ratings. If in the Load Rating Engineer’s judgment, the ratings will not be affected significantly, and will not require a need to post or lower the load restriction on the bridge, ratings should be updated within 12 months, however, the decision and findings shall still be documented in the Load Rating File.

Load ratings of structures shall be reviewed and updated as necessary. Factors to be reviewed to assess the need for updating the rating should be changes in the design code or changes in the load rating criteria as well as the criteria listed in [Section 5-2.2](#) below or updates to load rating models due to software upgrades.

#### 5-2.1.A      **Load Posting Review Period**

Load rating of a structure can be an iterative process due to the assumptions and simplifications made during the calculation phase. WSDOT has developed a load posting review period to address this concern. Bridges that pose a safety concern and require immediate posting will be exempt from this process.

1. Initial load rating completed, and load posting is recommended. This may be a complete stamped and signed load rating package.
2. Load rating is reviewed by the owner. Assumptions and simplifications in the calculations are considered. Load rater and owner discuss possible mitigations:
  - a. Refined calculations, including advanced modeling, or assumptions.
  - b. Material testing, field measurements, nondestructive testing, or other techniques to verify material properties or conditions followed by refined calculations.
  - c. Third party QC/QA of the load rating or new load rating completed.
  - d. No refinements or investigation recommended.
3. If the bridge poses a safety risk while mitigations are explored or if the process will likely take more than 60 days, the bridge shall be posted within 30 days. Each structure will be tracked throughout this process with updates provided to FHWA monthly.
4. Updated or new load rating is reviewed by the owner.
5. If bridge requires posting, FHWA is notified and 30-day timeline to have signage in place begins.
  - a. If repair or strengthening is required, the bridge shall be posted until the work is complete and the load rating is updated.

### **5-2.2 Bridge Load Rating Revision Criteria**

WSBIS Item 2688, Revise Rating should be coded as “Y” when one or more of the following items apply:

1. The Superstructure or Cross-beams/ Floor-beams Elements' State condition changes from either Condition State 1, 2 or 3 to Condition State 4, or Superstructure or Substructure Condition Code is reduced to 4 or less.
2. If the approach condition to the structure causes severe impact to the bridge, call for a high priority repair to fix the approaches so the transition onto the structure is smooth.
3. If the deck has potholes on the surface or at the joints, call for a high priority repair to patch the potholes in the deck at the joints.
4. The thickness of the overlay has increased.
5. The railing is replaced with a heavier traffic barrier.
6. New utilities such as water main or sewer line have been installed on the structure.
7. The number of striped lanes has increased on 2 line superstructure members such as trusses or 2-line girder bridge, and box girder bridges.
8. Damaged or deficient structural elements have been repaired/ replaced, such as replacement of timber caps or girders or replacement or repair of damaged girders due to high load hits or other deterioration.

When a deficiency is observed in the field such as rot pockets in timber or section loss in a steel member, the inspector should provide the following items to assist in providing accurate rating factors:

1. The description "shell thickness" shall state whether the thickness is all around the member or on one side and whether it is full depth and location.
2. Section loss in steel members shall include, if possible, the remaining section thickness, location of the section loss and required dimensions.

Provide a sketch of the deficient member and show deterioration as stated above and provide the dimensions of the deteriorated area. It is of great importance to provide as accurate information as possible instead of estimates. Posting or restricting a bridge is greatly dependent on this information. When trying to figure what information should be provided, inspectors should ask the question, can an engineer calculate accurate capacity of the element/member in question?

The load rating group shall write a comment under "Note 11" addressing the "Revise Rating" flag. The comments should state whether the ratings were updated based on the Inspector's findings or that no need for updating the rating with the reasoning.

### 5-2.3 **Bridges With Unknown Structural Components**

For concrete and masonry bridges with no design plans, and when the necessary reinforcing details are unknown and cannot be measured, load capacity ratings may be determined based on field inspection by a qualified bridge inspector followed by evaluation by a qualified engineer. Such a bridge does not need to be posted for load restrictions if it has been carrying normal traffic for an appreciable period of time and shows no sign of distress; Reference the AASHTO *Manual for Bridge Evaluation* (MBE) second edition, Sections 6.1.4 and 6A.8.1. General rating guidelines for these structures are:

- Inventory rating shall be equal to the design truck at the time the bridge was constructed. Operating rating shall be equal to the inventory rating multiplied by 1.667.
- Legal trucks rating factors shall be equal to 1 when the Superstructure, Substructure, or culvert NBI code is equal or greater than 5. Restriction of permit loads shall be assessed.
- Posting or restricting of a bridge shall be assessed when NBI code of the superstructure, substructure or culvert is 4 or less or when there are signs of structural distress.

The Load Rating Methods WB1551 and WB1554 shall be coded as "0", Administrative.

Full documentation for an administrative rating shall be placed in the bridge load rating file.

The table below shows typical design loads and the era they were utilized. The information in the table is based on State bridge inventory and it is dependent on the class of highway.

	Design Load in Tons	Design Era
H-10	10	Early 1900- mid 20's
H-15	15	Mid 1910's-Mid 1960's
H-20	20	Mid 1910's-1920's
HS-15	27	Mid 1940's-Late 60's
HS-20	36	Mid-1940's- Early 2000's

\*Administrative ratings imply ratings based on Field evaluation and Documented Engineering Judgment.

## 5-2.4 Data Management

The WSBS database shall be updated within 30 days from the completion and approval of a load rating of a structure.

## 5-2.5 Posting Requirements

Posting of a structure shall occur when the Operating rating factor for any of the legal loads is less than 1 based on the Load Factor or Allowable Stress Methods or the rating factor for any of the legal loads is less than 1 based on the Load and Resistance Factor Method. Legal loads in the State consist of the three AASHTO legal trucks, Type 3 (Single Unit), Type 3S2 (Truck-Semi Trailer) and Type 3-3 (Truck Trailer), the SUV's (SU4, SU5, SU6 and SU7). Emergency Vehicles EV2 and EV3 are also considered legal loads on the Interstate and within one road mile from the interstate per FHWA Memo dated November 3, 2016.

Agencies generally post a bridge between the Inventory Rating and the Operating Rating using the Load Factor Method and Allowable Stress Methods. The minimum permissible posting value is three tons at inventory or operating levels. Bridges not capable of carrying a minimum gross live load of three tons shall be closed. Follow the MBE for calculating the posting limits.

In general, posting of a structure, when warranted, shall occur as soon as possible but not to exceed 30 days. In instances where the load carrying capacity of a bridge is significantly reduced, such as by impact to the structure, posting or closing of the bridge shall occur as soon as it is determined it is not safe to carry legal vehicular loads.

The procedures for notification of postings for reportable structures to FHWA is as follows:

1. When it is determined that a bridge requires posting, notification as indicated below is required within 5 business days.
  - a. WSDOT Bridge Load Rating Engineer shall notify the WSDOT Bridge Preservation Engineer.
  - b. Local Agencies shall notify the WSDOT Local Programs Bridge Engineer.
2. The WSDOT Bridge Preservation Engineer or WSDOT Local Programs Bridge Engineer will notify the FHWA Division Bridge Engineer within 48 hours of notification as described above.
3. Bridges subject to this notification process will be tracked in a database maintained by WSDOT Bridge Preservation Office for state-owned structures and WSDOT Local Programs for local agency-owned structures.
4. An update will be provided to FHWA Division Bridge Engineer every two weeks.

For State structures, a posting memo from the Statewide Program Manager would be addressed to the Region Administrator; the Bridge and Structures Engineer, FHWA Bridge Engineer, Region Maintenance and Operation Engineer, Region Traffic Engineer, State Traffic Engineer, and Commercial Vehicle Services. The posting memos would state that the Restricted List on Commercial Vehicles website will be updated within thirty days from the date the posting memo is sent. It would also request that the region email the Risk Reduction Engineer when posting signs have been placed and include photos of the posting. At the thirty day point, if the region doesn't respond to the memo, the Risk reduction Engineer will contact the region and request a status update and follow up after fifteen days thereafter. After sixty days, if the posting signs haven't been installed, the issue would be elevated to

upper management. To track the postings, a spreadsheet shall be developed which shows the bridge Number, Structure Id, Date Load rating was completed, Date memo sent to region, and date the posting was implemented, and it shall be maintained by the Risk reduction group.

When possible, additional tests such as concrete strength or steel yield strength shall be performed to validate the assumption in the load rating analysis, hence mitigate the need for posting or restriction of the bridge. Strengthening or repair of an element should also be considered to eliminate the need for posting or restriction.

Load Posting Signs for structures where needed, shall follow the Manual on Uniform Traffic Control Devices (MUTCD) and WSDOT *Sign Fabrication Manual* M 55-05. See Exhibit 5-1 through Exhibit 5-3 for additional signage information.

All bridges requiring load posting shall have posting signs at the bridge and additional advance posting signs, when practicable, in advance of the nearest intersecting roads, ramps or a wide point in the road where a driver can detour or turn around.

Exhibit 5-1 AASHTO Legal Trucks Posting

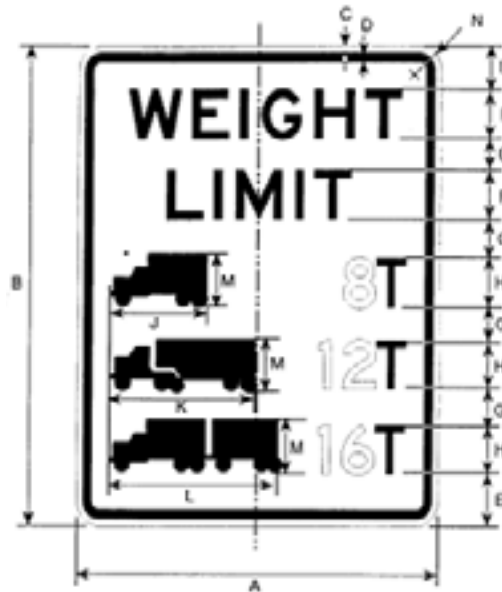


Exhibit 5-2 Emergency Vehicles Posting

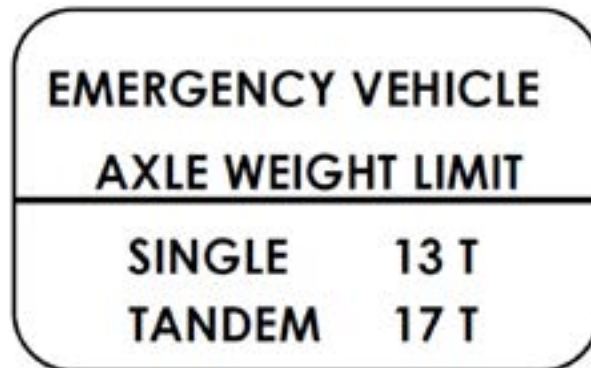
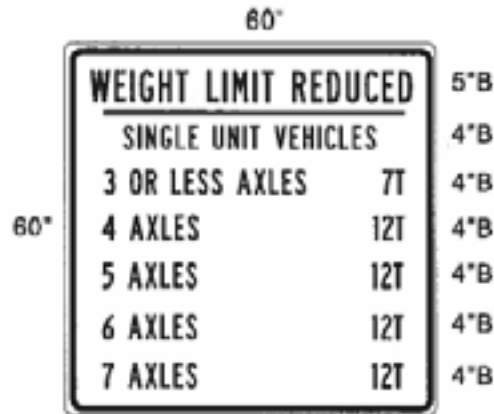
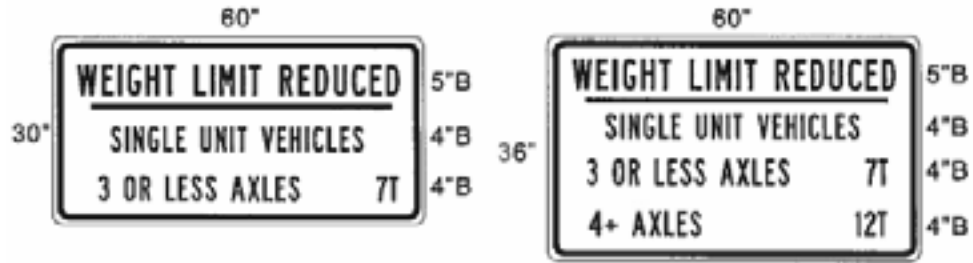


Exhibit 5-3 SUV Posting Signs



7/8" Border, 5/8" Margin, Corner Radius 2-1/4"

COLORS

LEGEND & BORDER - BLACK (NON-REFL)  
BACKGROUND - WHITE (REFL)

## 5-2.6 Overload Permits

Overweight loads traveling over state or local agency roads are required to obtain permits/ approval from the state, county, or city maintaining those roadways. No permit loads shall be allowed over posted bridges. The first step in evaluating a permit is to determine if the configuration meets RCW 46.44 for maximum gross weight, load per axle, or axle group (E-Snoopi) is a tool on WSDOT Commercial Vehicle website is used to calculate axle weight per RCW). The second step is to evaluate the structures on the traveled route. This can be accomplished in two methods.

The first method, which is more precise for a specific structure, is to model the permit load moving on the bridge and calculating its load rating factor. A single lane distribution factor can be used in the model, which means that no other trucks are permitted in the adjacent lanes. A rating factor equal to or above 1 means the permit truck can safely travel over the particular structure. Permit loads that have unusual configuration or have more than 4 tires per axle shall be evaluated using this method.

The second method is more general and the engineer shall be extremely cautious when applying it to ensure that the permit load is enveloped by one of the typical rated trucks. The method calculates the maximum weight per axle allowed over a bridge and is dependent on the load rating factors for the particular structure, as follows:

- **Truck Type SA**

**Definition:** Construction Equipment Tires (a.k.a., Super Single Axle) (RCW 46.44.091(3))

**Range:** Up to 45,000 lbs. per axle.

**Criteria:** Using the Load Rating Factor for the Overload 1 Truck (a.k.a., OL1), which has a dual axle weighing 43,000 lbs., the equation is  $45,000 \text{ lbs.} \times \text{Rating Factor} \times 43/45$  rounded to the nearest 500 lbs.

- **Collection Truck (RCW 46.44.041) Restriction List Truck Type S/A**

**Definition:** Two-axle trucks where the rear drive axle is the item in question on non-interstate routes only.

**Range:** Up to 26,000 lbs. on rear axle.

**Criteria:** Using the Load Rating Factor for the AASHTO1 Truck (a.k.a., Type 3), which has a dual axle weighing 34,000 lbs., the equation is  $26,000 \text{ lbs.} \times \text{Rating Factor} \times 34/34$  rounded to the nearest 500 lbs.

- **Truck Type T/D**

**Definition:** Three-axle trucks where the rear tandem drive axles are the item in question on non-interstate routes only.

**Range:** Up to 42,000 lbs. on rear dual.

**Criteria:** Using the Load Rating Factor for the AASHTO1 Truck (a.k.a., Type 3), which has a dual axle weighing 34,000 lbs., the equation is  $42,000 \text{ lbs.} \times \text{Rating Factor} \times 34/42$  rounded to the nearest 500 lbs.

- **Tow Truck (RCW 46.44.015) Restriction List**

**Truck Type:** Tow truck with tandem (dual) drive axles.

**Definition:** Three axle tow truck with tandem drive axles towing a variety of vehicles.

**Range:** Up to 48,000 lbs. on drive dual axles.

**Criteria:** Using the Load Rating Factor for the AASHTO2 Truck (a.k.a., Type 3S2), which has dual weighing 31,000 lbs., the equation is **48,000 lbs.\* Rating Factor\* 31/48** rounded to the nearest 500 lbs.

- **Truck Type CL8**

**Definition:** Class 8 Short Hitch five-axle combination (three-axle tractor with a two-axle trailer).

**Range:** Up to 21,500 lbs. per axle in dual group and 20,000 to 22,000 for a single axle.

**Criteria:** Use the Load Rating Factor for the OL1 Truck based on single lane distribution factor. The equation is **22,000 lbs.\* Rating Factor** rounded to the nearest 500 lbs.

- **Truck Type BL**

**Definition:** Big load six plus axle combination and three to four axle single units.

**Range:** Up to 22,000 lbs. per axle in dual and tridem groups and up to 22,000 lbs. for a single axle.

**Criteria:** Use the Load Rating Factor for the OL2 Truck based on a single lane distribution factor. The equation is **22,000 lbs.\* Rating Factor\* Modifying Factor (MF)\*** rounded to the nearest 500 lbs. In some instances engineering judgment may be used in establishing restrictions on a structure.

\*Modifying Factor (MF) is 1.15 if Superstructure or Substructure Condition is 6 or above; 1.10 for Condition of 5 and 1 for 4 or less. The MF is applicable to concrete and steel members. For timber members the MF is 1.

For permits traveling over State routes, WSDOT can request the weighing of a permit load at any time, however, here are typical triggers:

- Analysis shows that the load is close to overstressing one or more bridges.
- Multiple load requests: 10 or more loads in the 200-300 thousand pound range.
- 5 or more loads over 300 thousand pounds.
- Any load over 500,000 pounds.

**Commentary:** *The SA load is assumed to act as a tandem axle due to the size of the tire. The occurrence of these permitted loads are occasional, hence, the OL1 was used to envelope these vehicles due to the lower Live Load Factor instead of the Type 3S2 which was previously used.*

*The MF multiplier applied to the BL is used since the OL2 is an envelope truck and is not permitted in the State. The Engineer shall use the MF with extreme caution and it shall not be applied to every permit load.*



### 5-3 Scour Appraisal

All reportable structures spanning waterways are required by the NBIS/SNBI to have a scour appraisal to identify the susceptibility to erosion of streambed material and the degree to which it affects foundation stability. The documentation should include pertinent information that supports the conclusions of the appraisal such as: as-built foundation details, current condition of the foundation, a stream bed cross section profile, stream flow rates, scour calculations, etc. A scour appraisal starts with a qualitative assessment using a rational approach following engineering judgement. The qualitative assessment is a screening tool to determine the susceptibility of a structure to scour. Based on the assessment, initial scour (1680/113/SNBI BAP03), waterway adequacy (1662/72), and channel protection (1677/61) codes are determined. If a scour code (1680/113/SNBI BAP03) cannot be determined using the qualitative approach, a quantitative analysis shall be conducted and the NBI 1680 (113) scour code set to '3' and SNBI BAP03 set to 'D', Scour Critical, in the interim.

Qualitative assessments and quantitative analyses are to be performed by the BPO Scour Engineer, a hydraulics engineer, a professional engineer with knowledge of hydraulics engineering, or any subject matter expert (SME) deemed appropriate by the bridge owner. Reports will be dated and signed by the person conducting the evaluation. Reports written by engineers outside of the bridge owner agency shall also be stamped by the engineer conducting the evaluation. Bridge owners take responsibility for the content of the reports done by their designated SME.

Quantitative analyses shall include calculated scour depths based on the effects of the flood event that causes the worst predicted scour (design flood). The scour elevations are compared to the structure foundations and a determination of stability is made from which the scour code is set. When a quantitative analysis determines a bridge is scour critical, additional analysis is required to help establish monitoring triggers. The additional analysis shall determine, as a minimum (items 1, 2, and 3):

1. The flow at which the structure becomes scour critical (based on structural analysis or to the bottom of the spread footing or to within 10' of the average pile tip elevation),
2. The estimated water surface elevation (WSEL) at the structure that coincides with the flow which causes the bridge to become scour critical (see 1. above),
3. The flow and WSEL at the structure where scour depths start to become a concern (close to scour critical elevations). This level is to be set by the bridge owner or Structural Engineer based on structural stability. But, in the lack of structural analysis, can be taken as scour to the top of spread footings or to within 15 feet of the shallowest pile tip.
4. Quantitative analyses may also include recommendations for the design of countermeasures that will protect the structure from the scour potential and to prevent channel migration to protect the piers, abutments, and approach roadways.

**NOTE (Discussion on scour critical and scour concern depths):** The scour critical depth is the precise scour elevation that triggers the decision of whether the bridge is or is not scour critical. The scour analysis may show that the design flood scour elevation is well below the scour critical depth. Further analysis shall determine what event takes the scour depth to the brink of becoming scour critical. Scour concern depth is the scour elevation that the bridge owner sets. Above this elevation, scour is of no concern. Below this level, the bridge owner starts to raise concern. This is the depth that periodic monitoring should start to ensure safety to the travelling public.

As the bridge foundation condition changes and/or the stream bed characteristics change, the scour criticality may have to be reanalyzed. Scour appraisals shall be reviewed as necessary.

Upon determining that a bridge is scour critical, the agency needs to develop a written plan of action (POA) to manage the structure (see 5-3.2 Action Plans for Scour Critical Bridges). For additional information, see FHWA HEC 18 Evaluating Scour at Bridges.

Scour evaluations of new bridges completed during the design phase that are provided to the Scour Engineer shall be used to complete an appraisal and entered into the data inventory within 90 days of the structure being open to traffic. Newly discovered or transfer of ownership bridges shall have scour appraisal completed and entered into inventory within 12 months.

### 5-3.1 **Determining Susceptibility to Scour**

Each bridge's susceptibility to scour damage must be determined to be either:

1. Stable for calculated scour conditions (NBI 1680/113 scour code 8, 7, 5, 4/SNBI BAP03 code A. Or code B in the case of an engineered repaired scour critical bridge).
2. Scour critical (NBI 1680/113 scour code 3, 2, 1, 0/SNBI BAP03 code C if temporary countermeasures are in place or D if no countermeasures are placed).
3. Scour risk cannot be determined due to unknown foundations (scour code U for NBI and SNBI)
4. Structures that have not had an appraisal made (NBI 1680/113 scour 6/SNBI BAP03 code 0) must have an appraisal complete before the next submittal to NBI.
5. Structures over tidal water that have not been evaluated for scour but considered low risk are coded T in NBI (NBI 1680/113 scour code 5 (SNBI BAP03 code A) for WSDOT owned bridges). If the tidal structure is considered high risk, the scour code shall be NBI 1680/113 code 6 (SNBI BAP03 code 0) and an appraisal shall be completed before the next submittal to NBI. If the tidal structure has unknown foundations, it shall be coded U. Scour NBI 1680/113 code 'T' is not used by WSDOT.
6. Structures over waterways with foundations on dry land well above floodwaters and channel migration to the piers is not likely in the life of the bridge (NBI 1680/113 scour code 9/SNBI BAP03 code A).

See FHWA coding guide revision at [www.fhwa.dot.gov/engineering/hydraulics/policymemo/revguide.cfm](http://www.fhwa.dot.gov/engineering/hydraulics/policymemo/revguide.cfm).

The results of the scour appraisal are to be recorded by the scour engineer in the Scour Summary Sheet (See Section 5-4) and to be placed in the scour files. Upon completion of all scour appraisals, there should not be any bridges with an NBI 1680/113 code "6" (SNBI BAP03 code 0). The completed scour appraisals, information required to do the appraisals, and the best mitigation option for the bridge are to be incorporated into the bridge scour file located at W:\Data\Bridge\RiskReduction\Scour\SCOUR FILES.

**Table 5-1** Default Maximum Soundings Frequency

<b>NBI/SNBI Code</b>	<b>Soundings Max. Frequency (months)</b>
2/D	12
3/C or D	24
U/U	24
4/ no SNBI equivalent	24
5/A	72
7/B	72
8/A	72

The soundings frequency for state bridges are determined by the Scour Engineer as needed based on field and/or historic observations as well as scour appraisals. In the absence of further guidance by the Scour Engineer, Table 5-1 (Default Maximum Soundings Frequency) shall govern. The list of bridges that require soundings for State bridges is created by the Scour Engineer and provided to the Information Group within BPO no later than December 31<sup>st</sup> of each year to be added to Bridge Works.

### **5-3.2 Action Plans for Scour Critical Bridges**

For each bridge that has been determined to be scour critical SNBI BAP 03 equals C, D, or U, SNBI BAP 04 should equal N or Y. A Scour Plan of Action (POA) shall be developed to identify the appropriate measures necessary to monitor and/or to make the bridge less vulnerable to damage or failure due to scour. The POA is to provide specific direction as to essential actions required at the site for region field staff and inspectors to observe and take the appropriate action without further communication. It should have details of whom to contact after a bridge has been closed due to scour. The action to be taken must be documented in the POA in sufficient detail that is easy to follow and thorough enough that field personnel can make appropriate decisions without higher approval.

Region field staff inspecting the condition of structures and elements susceptible to scour must have the authority to close a bridge and must know how to conduct an emergency closure. They must have the necessary equipment with them to take this action at the time of the determination without leaving the bridge or calling for assistance.

The two primary components of the POA are instructions regarding the frequency of inspections to be made at the bridge, and a schedule for the timely design and construction of scour countermeasures (see Section 5-4 for WSDOT and FHWA POA templates). The POA should have defined triggering events that initiate a flood scour inspection and actions to be performed. Triggering events are defined during the scour evaluation and should have the ability to be monitored 24/7. The POA's for WSDOT are updated by the Scour Engineer as needed when condition changes warrant it. Current POAs are available on BEIS with changes made in real time.

The POA should include:

- Physical site identification (bridge, route, stream, etc.); features that are vulnerable (approach roadway, pier/s, pier orientation/beginning of bridge)
- Hydrologic and Hydraulic Characteristics (water surface elevation as appropriate).
- Party responsible for decision on closure/reopen.
- Responsible party contact information.
- Trigger mechanisms for closure and opening. On-site water surface elevation marked on piers or abutments such that field crews can observe them from riverbank.
- Communication to public (detour signage, law enforcement, press, etc.)
- Records of mitigation in place (quarry spall, weirs, mats, barbs, etc.) with photo and original dimensions for future examination and reference. This information to be made available to inspectors and region field staff to utilize during inspections and flood events.

**Monitoring** – It is important that all scour critical bridges be monitored during and after flood events. The POA should include specific instructions to bridge inspectors or maintenance workers on what to look for, at what locations, and methods of inspection to use. Guidance should also be included as to when a bridge should be closed to traffic. Agencies should also develop and inform appropriate personnel of bridge closure procedures. The intensity of the monitoring effort is related to the risk of the scour hazard, as determined from the scour evaluation. Some of the items to consider when developing the monitoring plan include:

- Amount of existing rotational movement or settlement of substructure units
- Degree of streambed degradation, aggradation, or lateral movement
- Recommended procedures and equipment for taking measurements of streambed elevations (rods, probes, weights, portable sonic equipment, etc.)
- Instructions for inspecting existing countermeasures such as riprap, dikes, barbs, mats, etc.
- Guidance on maximum permissible scour depths, flood flows, water surface elevations, etc. beyond which the bridge should be closed to traffic.
- Instructions for checking the operation of fixed scour monitoring devices.
- Reporting procedures for conditions that warrant bridge closure. Establish the chain of command with authority to close bridges.
- Forms and procedures for documenting inspection results and instructions regarding follow-up actions when necessary.

**Temporary Countermeasures** – Temporary countermeasures provide a degree of protection for scour critical bridges. They may prevent damage for most flows, but are sacrificial, low-cost treatments that help ensure the safety of a bridge during normal flood events. Use of such measures may postpone the need to close a bridge during high flows. Temporary countermeasures, such as riprap, should not be viewed as an alternative to monitoring, but rather as a supplement.

**Permanent Countermeasures** – Permanent countermeasures are engineered to make a bridge safe from damage due to scour. A variety of methods exist including channel improvements, structural strengthening or underpinning, drop structures, relief bridges or constructing additional spans. These types of fixes would eliminate the bridge from being “scour critical,” but are more costly. Agencies prioritize permanent countermeasures to address the most critical needs as funds permit.

### 5-3.3 Recording Bridge Scour Information

The completed bridge scour appraisal shall include the resulting WSBIS 1680 scour code (SNBI BAP 03 code), the information required to do the appraisals, and the written action plan to mitigate scour risk if appropriate. The appraisal is to be incorporated into the permanent bridge scour file for the bridge. Any changes to bridge inventory data should be accomplished within 90 days after the appraisal or field review are complete. The scour monitoring information or schedule should be communicated to all affected parties.

Fields that relate to bridge hydraulics and/or scour are:

- Waterway Adequacy Appraisal- WSBIS 1662 (NBI Item 71) and SNBI BAP 02 (Overtopping Likelihood)
- Substructure Condition - WSBIS 1676 (NBI Item 60)
- Channel Protection - WSBIS 1677 (NBI Item 61), SNBI BC 09 (Channel Condition) and BC 10 (Channel Protection Condition)
- Pier/Abutment Protection – WSBIS 1679 (NBI Item 111)
- Scour – WSBIS 1680 (NBI Item 113) and SNBI BAP03 (Scour Vulnerability Appraisal)

#### 5-3.3.A Scour Monitoring Report (SNBI BIE 01)

Whenever a scour POA triggering event occurs, a Scour Monitoring Report (BIE 01 = 9) shall be entered into WSBIS. These inspections may have multiple site visits for the same event. In such cases, the first day the inspection is conducted is the start date. The last day the bridge is inspected for the event is the end date of the inspection.

#### 5-3.3.B Transitioning from NBI to SNBI

When transitioning from NBI to SNBI, use Table 5-2 (Scour Critical to Scour Vulnerability Translation) to set initial codes. All codes should be reviewed for accuracy.

Table 5-2 NBI Scour Critical to SNBI Scour Vulnerability Translation

Scour Critical Code NBI 1680/113	Scour Vulnerability Appraisal SNBI BAP03	Scour Condition SNBI BC11 (suggested)	Comments
9	A	8	Bridge is not likely to ever have its substructure exposed to channel flow
8	A	7 or better	
7	B	5 or better	Bridge has engineered repairs to protect the foundations from destabilizing scour.
6	0	TBD	Bridge needs a scour appraisal completed
5	A	5 or better	
4	A	5 or less	Not scour critical but has active pier/abutment scour
3	D	3 or better	Scour Critical. Code D until a review determines countermeasures in place warrants a code of C
2	D	2 or 3	BC11 could be 3 if the bridge has not been restricted or posted due to scour.
1	D	1	Imminent failure of the foundations due to scour – Bridge is closed
0	D	0	Bridge has failed due to scour and is closed.
U	U	3 or better	Unknown foundations, treat as if it is scour critical
T	See 5-3.1 5	5 or better	No equivalent in SNBI
N	NULL	N	Not used in SNBI

### 5-3.4 Scour Analysis

The procedure for analyzing stream stability and scour shall be per HEC Publications (see Exhibit 5-4) which could involve the following three levels of analysis:

- **Level 1** – Application of simple geomorphic concepts and other qualitative analyses.
- **Level 2** – Application of basic hydrologic, hydraulic and sediment transport engineering concepts.
- **Level 3** – Application of mathematical or physical modeling studies.

**Data Needs for Level 1 Qualitative and Other Geomorphic Analyses** – The data required for a qualitative assessment include maps, aerial photographs, notes, and photographs from field inspections, historic channel profile data, information on human activities, changes in stream hydrology and hydraulics over time, stream gage data, bridge foundation plans, and geotechnical studies.

A flowchart of the typical steps in qualitative geomorphic analyses is provided in Exhibit 5-5.

The six steps are generally applicable to most stream stability problems. As shown in the figure, the qualitative evaluation leads to a conclusion regarding the need for more detailed (Level 2) analysis or a decision to complete a screening or evaluation based on the Level 1 analysis. A Level 1 qualitative analysis is a prerequisite for a Level 2 engineering analysis for bridge design or rehabilitation.

Exhibit 5-4 Scour and Stream Stability Analysis

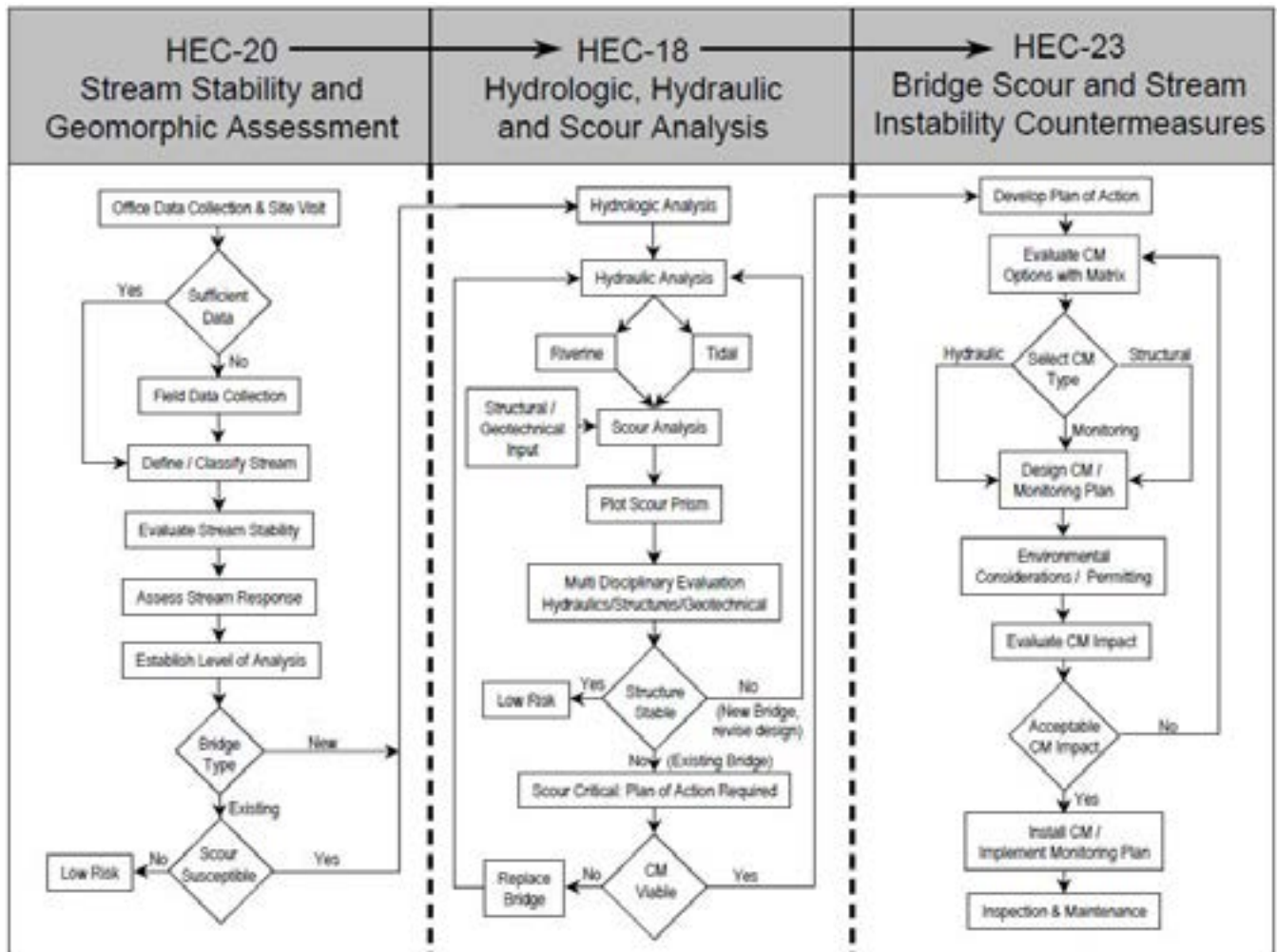
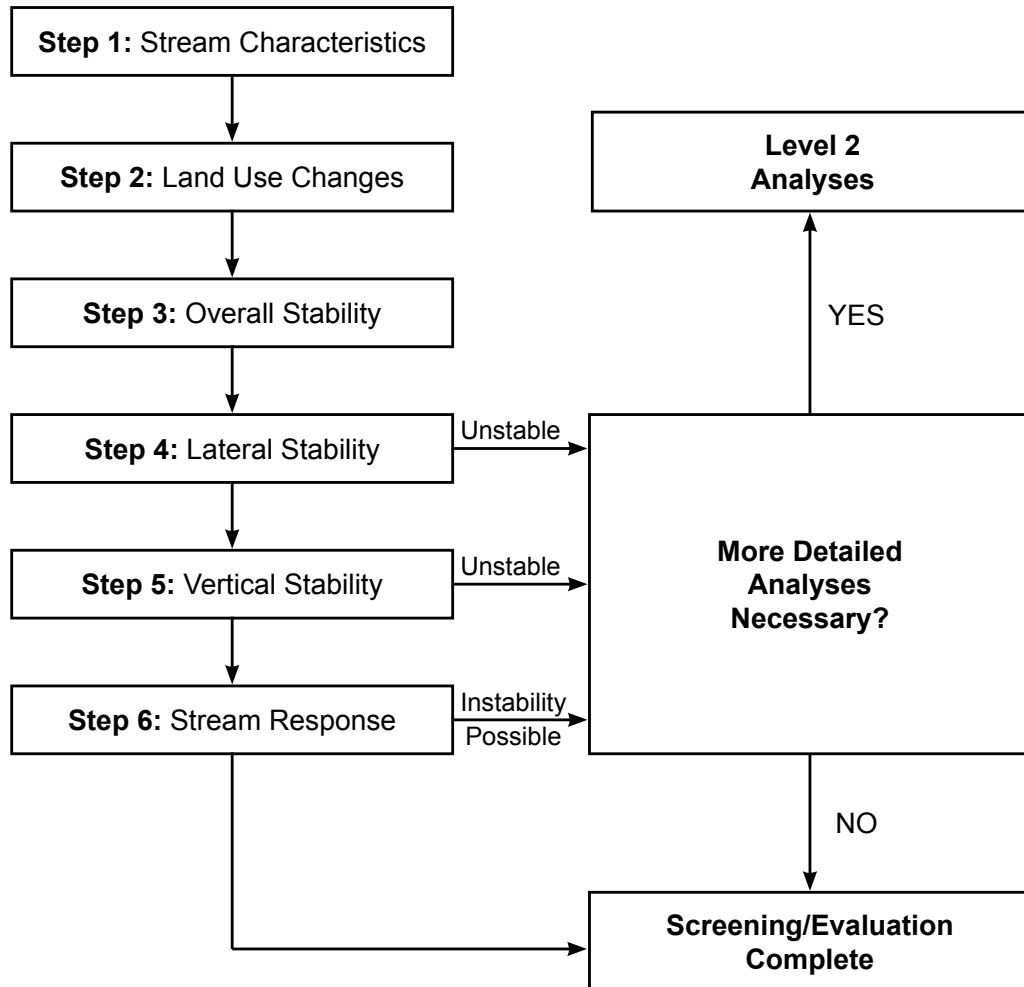


Exhibit 5-5 Level 1 Analysis

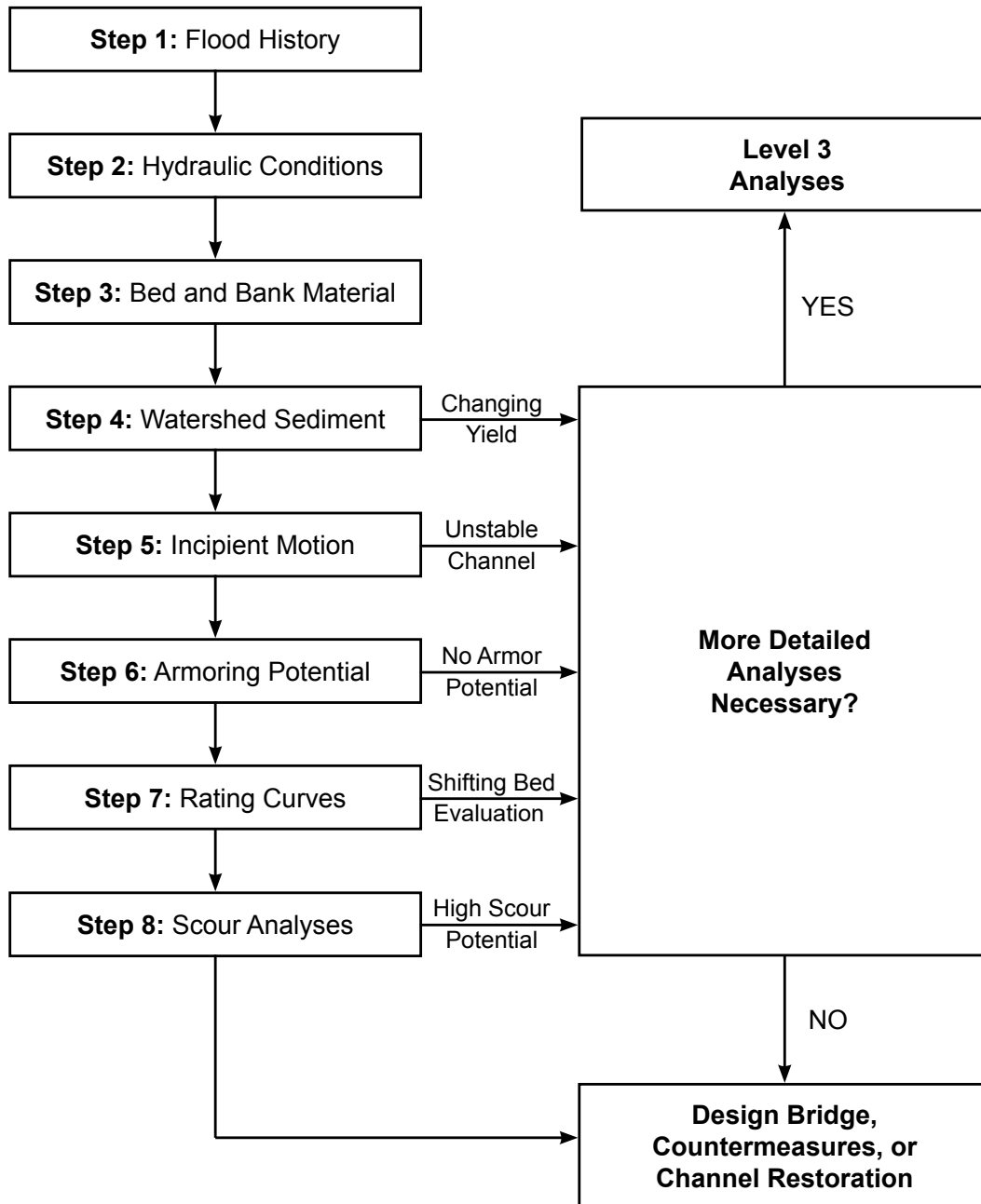


**Data Needs for Level 2 Basic Engineering Analyses** – Data requirements for basic hydrologic, hydraulic and sediment transport engineering analyses are dependent on the types of analyses that must be completed. Hydrologic data needs include dominant discharge (or bank full flow), flow duration curves, and flow frequency curves. Hydraulic data needs include: cross sections, channel and bank roughness estimates, channel alignment, and other data for computing channel hydraulics, up to and including water surface profile calculations. Analysis of basic sediment transport conditions requires information on land use, soils, geologic conditions, watershed and channel conditions, and available measured sediment transport rates (e.g., from USGS gauging stations).

More detailed quantitative analyses require data on the properties of bed and bank materials and field data on bedload and suspended-load transport rates. Properties of bed and bank materials that are important to a study of sediment transport include size, shape, fall velocity, cohesion, density, and angle of repose.

Level 3 analyses are performed by a professional engineer with hydraulic expertise or bridge owner designated subject matter expert (SME) (see Exhibit 5-6).

Exhibit 5-6 Level 2 Analysis



## Appendices

- [Appendix 5-A](#) WSDOT Scour Summary Sheet
- [Appendix 5-B](#) WSDOT Plan of Action Template
- [Appendix 5-C](#) Instructions for Completing WSDOT Plan of Action
- [Appendix 5-D](#) FHWA Plan of Action Template
- [Appendix 5-E](#) Instructions for Completing FHWA Plan of Action



# Appendix 5-A

# WSDOT Scour Summary Sheet

SCOUR SUMMARY SHEET							
<b>Bridge Number:</b>							
<b>Waterway</b>							
<b>Scour Code</b>							
<b>Owner</b>							
<b>SID</b>		Place PE Stamp Here					
<b>Analyzed By:</b>							
<b>Date of Analysis:</b>							
<b>Q100 (cfs)</b>		<b>Q100 Water Surface Elev. (ft.)</b>					
<b>Q500 (cfs)</b>		<b>Q500 Water Surface Elev. (ft.)</b>					
<b>V100 (ft./sec)</b>		<b>V500 (ft./sec)</b>					
<b>Angle of Attack</b>		<b>Thalweg Elevation</b>					
<b>Superstructure Low Point (pt. obstructs water flow) Elev. (ft.)</b>							
<b>Q When High Water Touches Bottom of Bridge if less than Q500 (cfs)</b>							
Scour Analysis							
Pier Number	Bottom of Foundation Elev. (ft.)	Calculated Scour Elev. (ft.)	Monitor (UW, R, F)	Inspection Frequency			
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
<b>Mitigation</b>		<b>In Place and Functioning (Y/N)</b>					
<b>Description of Mitigation</b>							
<b>Comments</b>							
<b>Frequencies:</b>							
<u>Type of Inspection</u>		<u>Frequency (years)</u>		<u>Year Frequency Established</u>			
Stream Cross Section from U/S Rail							
Underwater							
Fathometric							

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**SCOUR CRITICAL BRIDGE - PLAN OF ACTION**

Structure ID	Brg No	Bridge Name
Region	Route	Mile Post
Owner	Last Inspection Date	
Waterway	Brg Length	Main Span
		Appr Spans

Foundations: Date POA Modified:  
 Subsurface soil information:  Non-Cohesive  Cohesive  Rock Modified By:  
Title:

Does the bridge provide service to emergency facilities and/or an evacuation route?   N/A

**SCOUR VULNERABILITY**

**NBIS coding :**

Scour Code NBIS	Item 113 WS 680
Substructure NBIS	Item 60 WS 676
Channel Protection	Item 60 WS 677
Waterway Adequacy	Item 71 WS 662

Source of Scour Rating  Observed  Assessment  Calculated

Scour Evaluation Summary:

9 Note:

361 Note:

677 Note:

680 Note:

**Scour Critical Elements:**

**RECOMMENDED ACTION(S)**

a. Flood Monitoring Program	<input type="checkbox"/> Yes <u>Recommended</u> <input type="checkbox"/> No	<input type="checkbox"/> Yes <u>Implemented</u> <input type="checkbox"/> No
b. Hydraulic/Structural Countermeasures	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No

**MONITORING PROGRAM**

Regular Inspection Program  w/ cross sections

Items to Watch:

Underwater Inspection Program

Items to Watch:

Flood Monitoring Program  Visual Inspection

Flood monitoring required during event:

Flood monitoring event defined by (check all that apply):

Discharge  Stage

Elevation measured from

Flood warning system:

Frequency of flood monitoring:

Post-flood monitoring required:  within

Frequency of post-flood monitoring:

Criteria for termination of flood monitoring:

Agency and Department responsible for monitoring:

Contact  
Number

**COUNTERMEASURE RECOMMENDATIONS**

Countermeasure  
implementation  
project type:

Contact person:

Target design completion date:

Target construction completion date:

Countermeasures  
already completed:

**BRIDGE CLOSURE PLAN**

Scour monitoring criteria for consideration of bridge closure:

Agency and department responsible for closure:

Closure contact name:

Criteria for reopening the bridge:

Person responsible for Re-opening bridge after inspection:

**DETOUR ROUTE**

Detour route description ( route number, from/to, distance from bridge, etc.) :

Bridges on Detour Route:

Traffic control equipment (detour signing and barriers) and locations(s):

News release, other public notice (include authorized person(s), information to be provided and limitations):

Scour Files (From BEIST)

# **Appendix 5-C      *Instructions for Completing WSDOT Plan of Action***

## **SECTION 1: General Information**

- The general bridge information is usually available via BEISt or from Bridge Works.
- Subsurface soil information is available from boring logs or site visits.
- Included under this section is whether the bridge provides service to emergency services or is a part of an evacuation route.
- POA updates (date, person, and title) provided here.

## **SECTION 2: Scour Vulnerability**

- NBI codes 1680, 1676, 1677, and 1682 obtained from most recent bridge inspection report via a query.
- Source of scour rating (observed, assessment, or calculated) defined.
- The Scour Evaluation Summary lists pier foundation elevations and calculated scour elevations when available.
- The bridge inspection notes 9, 361, 1677, and 1680 are obtained from the most recent bridge inspection report via a query.
- The scour critical bridge elements are listed in this section.

## **SECTION 3: Recommended Actions**

- Check boxes determine whether a flood monitoring program and hydraulic/structural countermeasures have been recommended and/or implemented.

## **SECTION 4: Monitoring Program**

- Regular and underwater inspection programs items to watch as well as cross sections included (under regular inspections).
- Flood monitoring program and visual inspection (during the flood) check boxes listed in this section.
- Flood monitoring required during the event checkbox. Provided with region input.
- Flood monitoring definition checkboxes listed (discharge, stage, elevation measured from, flood warning system).
- Flood elevations tied to bridge structure when possible.
- Specific USGS river gauge listed.
- Flood monitoring and post flood monitoring frequencies listed. These frequencies are provided by the regions.
- Criteria for flood monitoring termination stated.
- Agency, department responsible for flood monitoring along with contact information listed.

**SECTION 5: Countermeasure Recommendations**

- Countermeasure implementation project type as well as targeted design and construction completion dates provided. A list of completed scour countermeasures is included here.
- Scour engineer contact information listed here.

**SECTION 6: Bridge Closure Plan**

- Scour monitoring criteria (flood elevations, debris piles, obvious bridge distress) listed for consideration of bridge closure.
- Agency, department, closure contact information listed here.
- Criteria for reopening bridge, person responsible for reopening bridge (BPO engineer) contact information listed.

**SECTION 7: Detour Route**

- Detour route description (route number, distance from bridge) provided by regions.
- Bridges on detour route along with any load or geometric restrictions provided by regions.
- Traffic control equipment (signing and barriers) and locations provided by region maintenance.
- News releases, other public notices including authorized persons provided by region public relations.

**SECTION 8: Scour files**

- Electronic scour file locations listed.

<b>SCOUR CRITICAL BRIDGE - PLAN OF ACTION</b>		
<b>1. GENERAL INFORMATION</b>		
Structure number: _____	City, County, State: _____	Waterway: _____
Structure name: _____	State highway or facility carried: _____	Owner: _____
Year built: _____	Year rebuilt: _____	Bridge replacement plans (if scheduled): _____ Anticipated opening date: _____
Structure type: <input type="checkbox"/> Bridge <input type="checkbox"/> Culvert		
Structure size and description: _____		
Foundations: <input type="checkbox"/> Known, type: _____    Depth: _____ <input type="checkbox"/> Unknown		
Subsurface soil information ( <i>check all that apply</i> ): <input type="checkbox"/> Non-cohesive <input type="checkbox"/> Cohesive <input type="checkbox"/> Rock		
Bridge ADT: _____	Year/ADT: _____	% Trucks: _____
Does the bridge provide service to emergency facilities and/or an evacuation route (Y/N)? _____ If so, describe: _____		
<b>2. RESPONSIBILITY FOR POA</b>		
Author(s) of POA (name, title, agency/organization, telephone, pager, email): _____ Date: _____		
Concurrences on POA (name, title, agency/organization, telephone, pager, email): _____		
POA updated by (name, title, agency, organization): _____ Date of update: _____ Items update: _____		
POA to be updated every _____ months by (name, title, agency/organization): _____ Date of next update: _____		
<b>3. SCOUR VULNERABILITY</b>		
a. Current Item 113 Code: <input type="checkbox"/> 3 <input type="checkbox"/> 2 <input type="checkbox"/> 1                      Other: _____		
b. Source of Scour Critical Code: <input type="checkbox"/> Observed <input type="checkbox"/> Assessment <input type="checkbox"/> Calculated                      Other: _____		
c. Scour Evaluation Summary: _____		
d. Scour History: _____		





**Flood Monitoring Program**  
 Type:  Visual inspection  
 Instrument (*check all that apply*):  
 Portable  Geophysical  Sonar  Other: \_\_\_\_\_  
 Flood monitoring required:  Yes  No  
 Flood monitoring event defined by (*check all that apply*):  
 Discharge \_\_\_\_\_  Stage \_\_\_\_\_  
 Elev. measured from \_\_\_\_\_  Rainfall \_\_\_\_\_ (in/mm) per \_\_\_\_\_ (hour)  
 Flood forecasting information: \_\_\_\_\_  
 Flood warning system: \_\_\_\_\_  
 Frequency of flood monitoring:  1 hr.  3 hrs.  6 hrs.  Other: \_\_\_\_\_  
 Post-flood monitoring required:  No  Yes, within \_\_\_\_\_ days  
 Frequency of post-flood monitoring:  Daily  Weekly  Monthly  Other: \_\_\_\_\_  
 Criteria for termination of flood monitoring: \_\_\_\_\_  
 Criteria for termination of post-flood monitoring: \_\_\_\_\_  
 Scour alert elevation(s) for each pier/abutment: \_\_\_\_\_  
 Scour critical elevation(s) for each pier/abutment: \_\_\_\_\_

*Note: Additional details for action(s) required may be included in Section 8.*  
 Action(s) required if scour alert elevation detected (*include notification and closure procedures*): \_\_\_\_\_  
 Action(s) required if scour critical elevation detected (*include notification and closure procedures*): \_\_\_\_\_

**Agency and department responsible for monitoring:** \_\_\_\_\_

**Contact person (*include name, title, telephone, pager, e-mail*):** \_\_\_\_\_

**7. COUNTERMEASURE RECOMMENDATIONS**

*Prioritize alternatives below. Include information on any hydraulic, structural or monitoring countermeasures.*

**Only monitoring required (see Section 6 and Section 10 – Attachment F)**  
 Estimated cost \$ \_\_\_\_\_

**Structural/hydraulic countermeasures considered (see Section 10, Attachment F):**

<u>Priority Ranking</u>	<u>Estimated cost</u>
(1) _____	\$ _____
(2) _____	\$ _____
(3) _____	\$ _____
(4) _____	\$ _____
(5) _____	\$ _____

**Basis for the selection of the preferred scour countermeasure:** \_\_\_\_\_

**Countermeasure implementation project type:**  
 Proposed Construction Project  Maintenance Project  
 Programmed Construction - Project Lead Agency:  
 Bridge Bureau  Road Design  Other \_\_\_\_\_

**Agency and department responsible for countermeasure program (if different from Section 6 contact for monitoring):** \_\_\_\_\_

Contact person (include name, title, telephone, pager, e-mail): \_\_\_\_\_

Target design completion date: \_\_\_\_\_

Target construction completion date: \_\_\_\_\_

Countermeasures already completed: \_\_\_\_\_

**8. BRIDGE CLOSURE PLAN**

**Scour monitoring criteria for consideration of bridge closure:**

- Water surface elevation reaches \_\_\_\_\_ at \_\_\_\_\_
- Overtopping road or structure
- Scour measurement results / Monitoring device (See Section 6)
- Observed structure movement / Settlement
- Discharge: \_\_\_\_\_ cfs/cms
- Flood forecast: \_\_\_\_\_
- Other:  Debris accumulation  Movement of riprap/other armor protection  
 Loss of road embankment

Emergency repair plans (include source(s), contact(s), cost, installation directions): \_\_\_\_\_

Agency and department responsible for closure: \_\_\_\_\_

Contact persons (name, title, agency/organization, telephone, pager, email): \_\_\_\_\_

Criteria for re-opening the bridge: \_\_\_\_\_

Agency and person responsible for re-opening the bridge after inspection: \_\_\_\_\_

**9. DETOUR ROUTE**

**Detour route description** (route number, from/to, distance from bridge, etc.) - Include map in Section 10, Attachment E.

**Bridges on Detour Route:**

Bridge Number	Waterway	Sufficiency Rating/ Load Limitations	Item 113 Code

Traffic control equipment (detour signing and barriers) and location(s): \_\_\_\_\_

Additional considerations or critical issues (susceptibility to overtopping, limited waterway adequacy, lane restrictions, etc.) : \_\_\_\_\_

News release, other public notice (include authorized person(s), information to be provided and limitations): \_\_\_\_\_

#### 10. ATTACHMENTS

Please indicate which materials are being submitted with this POA:

- Attachment A: Boring logs and/or other subsurface information
- Attachment B: Cross sections from current and previous inspection reports
- Attachment C: Bridge elevation showing existing streambed, foundation depth(s) and observed and/or calculated scour depths
- Attachment D: Plan view showing location of scour holes, debris, etc.
- Attachment E: Map showing detour route(s)
- Attachment F: Supporting documentation, calculations, estimates and conceptual designs for scour countermeasures.
- Attachment G: Photos
- Attachment H: Other information: \_\_\_\_\_

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# **Appendix 5-E      Instructions for Completing FHWA Plan of Action**

The existing bridge management system in your state will provide much of the information required to fill out this template.

**Note:** All blocks in this template will expand automatically to allow as much space as you require. All fields can be modified to accommodate local terminology, as desired. Where check boxes are provided, they can be checked by double-clicking on the box and selecting the “checked” option. If you include additional attachments, please indicate this in Section 10.

## **Section 1**

**Foundations** – It is recommended that substructure depths be shown in the bridge elevation, Attachment C (see Section 10). The minimum depth should be reported in Section 1 as a worst-case condition.

**Subsurface Soil Information** – If conditions vary with depth and/or between substructure units, this should be noted and included in Attachments A and/or C (see Section 10).

### **Sections 1, 2, 3, and 4**

These sections are intended as an executive summary for the reviewer/manager who may not need the details of Sections 5 through 10, and show:

- **Section 1** – General information
- **Section 2** – Who prepared the POA
- **Section 3** – The source of the problem
- **Section 4** – What actions are recommended and their status

## **Section 3**

Reasons why the bridge has been rated scour critical for Item 113:

### **Scour Critical**

- Aggressive stream or tidal waterway (high velocity, steep slope, deep flow).
- Actively degrading channel.
- Bed material is easily eroded.
- Large angle of attack (> 10°).
- Significant overbank or floodplain flow (floodplain >50 m or 150 feet wide).
- Possibility of bridge overtopping (potential for pressure flow through bridge).
- Evidence of scour and/or degradation.
- Evidence of structural damage due to scour.
- Foundations are spread footings on erodible soil, shallow piles, or embedment unknown.
- Exposed footing in erodible material.
- Exposed piles with unknown or insufficient embedment.
- Loss of abutment and/or pier protection.
- No countermeasures or countermeasures in poor condition.
- Needs countermeasures immediately.

### Unknown Foundations

- No record of foundation type (spread footing vs. piles).
- Depth of foundation or pile embedment unknown.
- Condition of foundation or pile embedment unknown.
- Subsurface soil strata not documented.

## Section 5

This section highlights recent changes in the scour/hydraulics coding items as an indication of potential problems or adverse trends. See FHWA Policy Memorandum on Revision of Coding Guide, Item 113 - Scour Critical Bridges dated April 27, 2001, for details on Items 113 and 60 which can be found at [www.fhwa.dot.gov/engineering/hydraulics/policymemo/revguide.cfm](http://www.fhwa.dot.gov/engineering/hydraulics/policymemo/revguide.cfm).

## Section 6

Multiple individuals responsible for various monitoring activities may be listed, as appropriate.

## Section 7

Guidance on the selection and design of scour countermeasures may be found in FHWA Hydraulic Engineering Circular No. 23, Bridge Scour and Stream Instability Countermeasures, Second Edition, 2001. To facilitate the selection of alternative scour countermeasures, a matrix describing the various countermeasures and their attributes is presented in this circular and can be found at <http://isddc.dot.gov/olpfiles/fhwa/010592.pdf>.

## Section 8

Standard closure and reopening procedures, if available, may be appended to the POA (see Section 10, Attachment H).

## Section 9

In some situations, public transportation (e.g., bus routes) may be of importance to the public, and therefore could be included in the POA (see Section 10, Attachment).