

Scour Critical Bridges and Plans of Action

A bridge that is predicted to fail in a flood, or is already losing the soil under its foundations, cannot be left to the regular inspection cycle. This course explains what makes a bridge scour critical, how scour vulnerability is evaluated and coded, and how to write and maintain a Plan of Action (POA) that protects the public before, during and after floods. It draws on HEC-18, Evaluating Scour at Bridges, 5th Edition (FHWA-HIF-12-003, 2012), Chapter 10 and Appendix E; HEC-23, Bridge Scour and Stream Instability Countermeasures, 3rd Edition (FHWA-NHI-09-111, 2009), Chapters 1 through 3 and 9; the FHWA Recording and Coding Guide (FHWA-PD-96-001) Item 113 codes; and the current National Bridge Inspection Standards, 23 CFR 650.313(o). Section and table numbers are given so you can check each point. Scenario numbers that do not come from these documents are labeled illustrative.

Learning objectives

- Define scour critical
- Describe evaluation methods
- Write a plan of action
- Monitor and close bridges

Why scour critical bridges get special treatment

HEC-18 Section 10.1 opens with a blunt fact: roughly 500,000 bridges in the National Bridge Inventory cross waterways, and in any given year hundreds of them can be expected to see floods on the order of the 100-year flood or greater. It is not economically feasible to build every bridge to resist every conceivable flood, or to retrofit every existing bridge until it is invulnerable. Some risk has to be accepted. What cannot be accepted is unmanaged risk. Every bridge over water should be assessed so the owner knows which bridges are vulnerable and what prudent measures are needed.

HEC-18 Section 10.6.1 states that scour-related deficiencies are the leading cause of serious bridge failures and closures. The national scour evaluation program grew out of the April 1987 collapse of the New York State Thruway bridge over Schoharie Creek. FHWA Technical Advisory T5140.20 established the program in 1988, and T5140.23, Evaluating Scour at Bridges, superseded it in 1991. T5140.23 said a Plan of Action should be developed for each existing bridge found to be scour critical. In January 2005 the NBIS made that mandatory at 23 CFR 650.313(e)(3).

The current NBIS, published in 2022, carries the requirement forward in 23 CFR 650.313(o), Scour. The owner must perform a scour appraisal for all bridges over water, document the process and results in the bridge file, and re-appraise when scour conditions change. For bridges determined to be scour critical *or having unknown foundations*, the owner must prepare and document a scour POA for deploying countermeasures for known and potential deficiencies and to address safety concerns. The POA must address a schedule for repairing or installing physical and/or hydraulic countermeasures, and/or the use of monitoring as a countermeasure. The regulation says appraisal procedures should be consistent with HEC-18 and HEC-20, and POAs should be consistent with HEC-18 and HEC-23.

The scale is large. HEC-18 Table 2.2 shows the status of the scour evaluation program in 2011: of 493,473 bridges in the inventory, 23,034 (4.7 percent) were coded scour critical, 40,825 (8.3 percent) had unknown foundations, and 3,917 (0.8 percent) still needed evaluation. Each of those scour critical and unknown foundation bridges needs a POA. This course shows what goes into one.

This course builds on [BR-H01 Scour Fundamentals](#), which covers how scour depths are computed. Countermeasure design is covered in [BR-H03 Stream Stability and Scour Countermeasures](#), and diving inspection of submerged foundations in [BR-I09](#).

Defining scour critical

The Coding Guide (FHWA-PD-96-001, Item 113) defines a scour critical bridge as one with abutment or pier foundations rated as unstable due to (1) observed scour at the bridge site or (2) a scour potential determined from a scour evaluation study. HEC-18 Section 2.5.1 puts it more simply: a scour critical bridge is one predicted to fail from a certain magnitude flood, either from analysis or observation.

The two paths matter because they lead to very different urgency. A bridge can be scour critical because:

- **Calculation says so.** The computed total scour prism for the scour design flood undermines the footing or drops below pile tips, but the bridge shows no current distress. It is not presently at risk, but could be in a large enough flood.
- **Observation says so.** An inspection, perhaps an underwater inspection, finds a scour hole undermining a footing or exposed piles. The bridge has already lost support and may be at risk in the next moderate flood.

HEC-23 Section 2.1.3 uses exactly this contrast to explain why management strategies differ. The first bridge needs a plan; the second needs action now.

The determination is not a single engineer's calculation. Both T5140.23 and HEC-18 call for an interdisciplinary team of hydraulic, geotechnical and structural engineers. The hydraulic engineer computes the scour prism. The geotechnical engineer determines what foundation capacity remains with the soil in that prism removed. The structural engineer checks the substructure and superstructure response, including redundancy. HEC-23 Section 1.4 notes that once the total scour prism is plotted, all three disciplines must be involved in judging structural stability.

A bridge that passes this review is low risk. One that does not is scour critical, and the NBIS requires a POA.

Item 113 codes and what they trigger

Results of the scour evaluation have historically been coded in NBI Item 113, Scour Critical Bridges. The 1995 Coding Guide codes are quoted here because HEC-18 and HEC-23 are written around them. The Coding Guide says scour analyses shall be made by hydraulic, geotechnical and structural engineers.

Code	Meaning (Coding Guide, Item 113)
N	Bridge not over waterway.
U	Bridge with unknown foundation that has not been evaluated for scour. Since risk cannot be determined, flag for monitoring during flood events and, if appropriate, closure.
T	Bridge over tidal waters not evaluated for scour but considered low risk; monitored with regular inspections and appropriate underwater inspections. Unknown foundations in tidal waters are coded U.
9	Foundations, including piles, on dry land well above flood water elevations.
8	Foundations determined stable for assessed or calculated scour; calculated scour is above top of footing.
7	Countermeasures installed to correct a previously existing scour problem; bridge is no longer scour critical.
6	Scour calculation or evaluation has not been made.

5	Foundations stable for calculated scour; scour within limits of footing or piles.
4	Foundations stable for calculated scour; field review indicates action is required to protect exposed foundations from additional erosion and corrosion.
3	Scour critical; foundations unstable for calculated scour conditions (scour within limits of footing or piles, or below spread-footing base or pile tips).
2	Scour critical; field review indicates extensive scour has occurred at foundations. Immediate action is required to provide countermeasures.
1	Scour critical; field review indicates failure of piers or abutments is imminent. Bridge is closed to traffic.
0	Scour critical. Bridge has failed and is closed to traffic.

Codes 3, 2, 1 and 0 are scour critical. Code U requires a POA under the current NBIS as well. The Coding Guide also says that when Item 113 is rated 4 or below, the Item 60 Substructure rating may need to be revised to reflect actual scour damage. HEC-18 Section 10.3.2 adds that Item 60 should be consistent with Item 113 whenever Item 113 is 2 or below.

Two coding rules are often misunderstood:

- **Monitoring does not change the code.** HEC-18 Sections 2.5.1 and 10.4.1 and HEC-23 Section 1.5 all say that monitoring does not fix the scour problem and does not allow a scour critical bridge to be recoded to a non-scour-critical code. Monitoring can be an acceptable countermeasure by itself, but the bridge stays scour critical.
- **Properly designed countermeasures can change the code.** HEC-23 Section 2.1.3 explains that the 2001 Item 113 revisions let owners consider countermeasures when coding. Hydraulic or structural countermeasures that were selected and designed by the interdisciplinary team and properly installed can move a bridge from scour critical to low risk, which is code 7. Owners may also consider mitigation installed during or immediately after a flood, but then the POA must include specific instructions for monitoring those countermeasures.

Related condition items in the Coding Guide are Item 60 Substructure, Item 61 Channel and Channel Protection, Item 71 Waterway Adequacy, and Items 92 and 93 Critical Feature Inspection and date. HEC-18 Section 10.3.2 lists these six as the hydraulic and scour-related items. Under the SNBI the item numbers and some definitions change; see this course's flag.

Evaluation methods: screening, assessment and analysis

Not every bridge needs a full HEC-18 analysis. The national program, as described in HEC-18 Section 10.1, began by screening all bridges over water, setting priorities, and then evaluating them. By 2011 virtually all bridges had an initial screening and more than 90 percent had been evaluated.

The NBIS uses the word appraisal and points to HEC-18 and HEC-20. In practice, evaluation proceeds along the flow chart in HEC-23 Figure 1.1, which ties the three circulars together:

1. **HEC-20 block.** Data collection and site reconnaissance, stream classification, and stability evaluation. HEC-20 provides a six-step Level 1 qualitative analysis and an eight-step Level 2 quantitative analysis. In some cases this is enough to show the bridge is low risk.
2. **HEC-18 block.** More detailed hydrology and hydraulics, and the seven-step scour analysis, which yields long-term degradation, contraction scour and local scour, plotted as a total scour prism.
3. **Interdisciplinary stability check.** Structural and geotechnical engineers evaluate the foundation with the prism removed. For an existing bridge, stable means low risk with no further action; unstable means scour critical and a POA

is required.

4. **HEC-23 block.** If countermeasures can fix the problem at reasonable cost and acceptable environmental impact, they are selected and designed. If the problem is too severe, replacement or major rehabilitation may be needed.

A scour assessment can also be qualitative. HEC-18 Table 10.2, Assessing the Scour Potential at Bridges, is a checklist for inspectors covering upstream conditions, conditions at the bridge and downstream conditions. Items include bank stability, channel alignment, aggradation or degradation, floodplain flow patterns, evidence of overtopping, debris, exposed footings or piles, the condition of riprap, whether the superstructure is tied down, and whether simple spans or nonredundant designs make the bridge vulnerable to collapse if a foundation moves.

Because the evaluation compares a structure against a scour prism, foundation information is essential. HEC-18 Section 10.2 lists office review questions: has a scour evaluation been done, is the bridge scour critical, is there a POA, what do successive cross sections show, what is the foundation type, are footing and pile tip elevations known, and what are the subsurface soils. When those answers are unknown, the bridge falls into the unknown foundation category covered later in this course.

Two kinds of observed risk: lessons from three failures

HEC-18 Section 10.5 describes three U.S. bridge failures with loss of life since 1987 that illustrate why inspection and follow-up matter. They are worth knowing because each one maps to a POA element.

Schoharie Creek, New York, April 5, 1987. The I-90 bridge collapsed, killing 10 people. The NTSB found the probable cause was the failure to maintain adequate riprap around the piers, which led to severe erosion under the spread footings. Contributing were ambivalent plans and specifications, an inadequate inspection program, inadequate oversight, and lack of structural redundancy. The footings were 5 ft deep with their tops at the streambed. A 1979 consultant inspection found most of the riprap around the piers missing, but the 1986 inspection did not detect any riprap problem. HEC-18's lesson: riprap does not necessarily make a bridge safe from scour, and inspectors must recognize when riprap is missing and what that means.

Hatchie River, Tennessee, April 1, 1989. The northbound U.S. 51 bridge collapsed, killing eight. The NTSB cited northward migration of the main channel that the state failed to evaluate and correct, with lack of span redundancy contributing. Inspections had accurately recorded the channel migration and footing exposure. But inspectors did not have plans on site, misjudged the pile cap thickness, and thought 1 ft of pile was exposed when it was actually 3 ft. Channel profiles were not plotted over time, so the lateral migration was not recognized. A diver inspection was not done because the foundation was in less than the then-current 10 ft depth criterion. The flood at collapse was not large, but was overbank and long-lasting. HEC-18's lessons: take plans to the site, plot successive cross sections, inspect submerged elements that cannot be seen or felt, and communicate between inspectors, evaluators and decision makers.

Arroyo Pasajero, California, March 10, 1995. The two I-5 bridges over Los Gatos Creek collapsed, killing seven. Long-term degradation of about 10 ft, contraction scour, and local pier scour exposed the cast-in-place columns below the depth of their reinforcing steel. A web wall added by maintenance forces after a 1969 flood increased the effective pier width; with a 15 to 26 degree angle of attack this potentially increased local pier scour by a factor of 3.6 to 4.4. The drainage area had increased about 33 percent through a channel connecting two creeks, and regional subsidence had steepened the channel. HEC-18's lesson: inspection, maintenance, design and management must all communicate, and maintenance changes must be reported.

HEC-18 Section 10.5.5 summarizes: inspectors must have plans on site, must measure, plot and compare cross sections, and must document conditions upstream and downstream. Maintenance must tell others when it changes a bridge or channel.

Designers must tell inspectors what to look for. A POA is the document that makes these responsibilities explicit for each scour critical bridge.

The purpose and two core parts of a Plan of Action

HEC-18 Section 10.6.1 states the goal of a POA simply: to provide guidance for inspectors and engineers that can be implemented for scour critical bridges before, during and after flood events to protect the traveling public. HEC-23 Section 1.5 adds that the purpose is to minimize the potential for failure by prescribing site-specific actions to correct the scour problem.

T5140.23, as quoted in both circulars, identifies two primary components:

1. Instructions regarding the type and frequency of inspections to be made at the bridge.
2. A schedule for the timely design and construction of scour countermeasures.

HEC-18 stresses that a POA is much more than a schedule. Developing one requires considering bridge management and inspection strategies, evaluating countermeasure alternatives, developing a monitoring program (inspection type and frequency, instrumentation, flood monitoring), writing bridge closure instructions, planning detour routes, and arranging implementation and maintenance, including contacts, responsibilities, communications, coordination with other agencies and public notification.

The actions a POA can call for fall into the four countermeasure groups of HEC-23 Section 2.3: hydraulic countermeasures (river training and armoring), structural countermeasures (foundation strengthening and pier geometry modification), biotechnical countermeasures, and monitoring. A POA may combine them. For example, it may specify flood monitoring now and riprap installation in two construction seasons.

Management strategy: matching the response to the risk

HEC-23 Section 2.1.3 makes the point that while many bridges may be scour critical, the severity and risk to the public vary dramatically. The management strategy, meaning the urgency of the response, the type and frequency of inspection, redundancy in the plan, and money allocated to countermeasures including monitoring, can vary from one scour critical bridge to the next. Factors HEC-23 identifies include:

- **How the bridge became scour critical.** A bridge already undermined, found by inspection, is far more urgent than a bridge rated critical by 100-year-flood calculations that shows no distress.
- **Importance to the network.** High ADT, the only access to an area, access to a hospital or fire station, an evacuation route, or airport access can justify more resources. HEC-23 notes this may require a risk-based analysis.
- **Other plans for the bridge.** A bridge programmed for replacement soon might reasonably rely on monitoring until replacement. A newer bridge with many years of service left would probably need a structural or hydraulic countermeasure at substantially greater cost.

HEC-23 Section 3.2.6 describes a risk-based method (Pearson et al. 2000) to set the level of resources for a scour critical bridge with limited remaining life. Risk is defined as the cost of failure multiplied by the probability of failure. HEC-23 Equation 3.2 gives annual risk as $\text{Risk} = K \cdot P \cdot [(\text{rebuild cost}) + (\text{running cost}) + (\text{time cost})]$, where K is a risk adjustment factor based on foundation and span type (NBI Item 43) and P is the annual probability of failure, from Item 113 or from Items 26, 60, 61 and 71. Running and time costs reflect detour length and ADT. HEC-23 says maximizing the benefit/cost

ratio offers the soundest economic approach to choosing countermeasures, because it gives the greatest countermeasure benefit per dollar.

Illustrative example (numbers are not from HEC-23): two scour critical county bridges have similar foundations. Bridge A carries 400 vehicles per day with a 2-mile detour and is programmed for replacement in four years. Bridge B carries 9,000 vehicles per day, is the only route to a regional hospital, and has a 22-mile detour. Under the Equation 3.2 logic, Bridge B's running and time costs make its annual risk far higher, which justifies a designed countermeasure soon. Bridge A may be well served by a POA built around flood monitoring and closure until replacement.

Inspection strategy and when to start monitoring

HEC-23 Section 2.1.4 explains that the type and frequency of inspection in the POA should follow the management strategy. The POA must address when to begin inspection work, how often to visit during a flood, and when monitoring is no longer necessary.

Not every scour critical bridge needs extra inspection. If a bridge is unstable for the calculated condition but field inspection shows no evidence of scour, the requirements may be no more than the NBIS requires. HEC-23's example is a bridge rated critical by calculation that has relatively deep piles in erosion-resistant material and has stood many years with no sign of scour; it might be handled through the regular inspection cycle plus inspections after major floods.

When more frequent inspection is needed, the POA must define the trigger. HEC-23 discusses the options in practical terms:

- **Discharge.** Discharge defines the scour analysis (for example, the 100-year flood), but it is usually a poor trigger because inspectors often cannot determine discharge in the field unless a gage or forecast is available.
- **Stage.** Stage corresponding to a critical discharge is more workable, but it must be easy for crews to measure. A flood stage reading only works if a gage is at or near the bridge.
- **Distance below the rail or curb.** A critical water surface defined as a measured distance down from the guard rail or curb line lets an inspector tape the distance.
- **A painted line.** The most direct approach is a line marked on a pier or abutment that shows when monitoring should begin.
- **Rainfall or forecasts.** Basin-wide triggers can use rainfall; HEC-23's example is beginning monitoring of all scour critical bridges in a basin after 10 inches of rain in 24 hours. Instrumented watersheds can use GIS and flood forecasting to predict which bridges need monitoring and when.

Once flood monitoring is underway, the inspector must know exactly what constitutes a critical condition and what to do. HEC-23 says a scour critical water surface elevation should be defined in the POA for each pier or abutment to be monitored, along with who to call and what to do when it is reached, extending if necessary to emergency repairs and closure.

Many agencies use two levels, a scour alert or watch level that starts monitoring and a scour critical level that triggers closure. The FHWA template's monitoring section, described below, provides for both scour alert and scour critical trigger conditions.

Monitoring: visual, portable and fixed

HEC-18 Section 10.4.1 explains why monitoring is needed at all: during a flood, scour is generally not visible, and on the falling stage scour holes typically refill. Visual monitoring during a flood and inspection after it cannot fully establish that a bridge is safe. Instruments resolve that uncertainty.

HEC-23 Section 2.4.4 defines three types of monitoring:

- **Visual monitoring.** Regular inspections at the normal interval, with increased effort during high flows (flood watch). Inspectors look for debris accumulation, flow impinging on piers or abutments, embankment erosion, settlement or tilting, and displaced riprap.
- **Portable instrumentation.** Carried along a bridge and from bridge to bridge. HEC-18 Section 10.4.2 says portable devices suit occasional measurements during and after floods, or monitoring many bridges infrequently. They give readings at a point in time, not a time history. The two main categories are physical probes (sounding weights, extensible rods or poles) and sonar instruments, typically deployed from the deck by hand or with a truck-mounted boom or crane. Boats are usually unsafe in flood flows, but tethered kneeboards or remote-controlled boats carrying sonar have been used successfully.
- **Fixed instrumentation.** Attached to the structure or buried in the bed at locations of primary concern. HEC-18 Section 10.4.3 says fixed devices suit frequent or continuous monitoring and can report during a flood without anyone on site, often by telemetry. They record maximum scour even if the hole refills. Limitations are higher initial cost, measurement at one location, and potential damage from ice and debris.

HEC-18 lists the main categories of fixed instruments: sounding rods, sonars, buried or driven rods such as sliding magnetic collars, other buried devices such as float-out sensors, tilt sensors, and time domain reflectometers. HEC-23 Chapter 9 describes how they work:

- **Sonar** monitors mounted on a pier or abutment face measure distance to the bed from sound travel time. They can track both scour and refill.
- **Magnetic sliding collars** ride down a rod into the scour hole and record the maximum scour depth only.
- **Float-out devices** are radio transmitters buried at set depths. If scour reaches one, it floats up and transmits its identification number to a receiver on the bridge. HEC-23 notes they are easy to install in dry riverbeds, during riprap placement, or during construction of a new bridge.

HEC-18 also notes that monitoring devices are often used not to measure scour holes but to detect movement of countermeasures, such as riprap at a pier. If movement is detected, inspectors can be mobilized with portable instruments and the bridge closed if necessary.

Selection is site-specific. HEC-18 Section 10.4.4 lists the nature and location of the scour problem, access limits from the superstructure and substructure, desired monitoring frequency, and cost over the bridge's remaining life. HEC-18 recommends thinking of a toolbox of instruments. Monitoring devices are countermeasures, so like any countermeasure they must be inspected and maintained so they work when needed. A dead sonar battery during a flood is a POA failure.

Closure, reopening and detours

HEC-23 Section 2.1.5 covers closure instructions, which are among the most important parts of a POA because they are carried out under pressure.

- **Type of closure.** Responses range from load restrictions to lane closures to complete closure, depending on severity and risk.
- **Method of closure.** Barricades may be adequate in some cases. In others the risk may justify posting a law enforcement officer to make sure no one crosses.

- **Detour routes.** The POA should describe the detour in advance so traffic disruption is minimized. HEC-23 specifically says the scour vulnerability of bridges along the detour should be known and evaluated. A detour across another scour critical bridge in the same basin is not a detour.
- **Reopening.** HEC-23 observes that closing is often easier than reopening. Almost anyone who detects a problem, such as an inspector, police officer or owner, could decide to close a bridge. Deciding when it is safe to reopen may need more information and engineering analysis by the interdisciplinary team. The POA should identify the person authorized to reopen and the criteria for reopening or lifting restrictions.

Reopening criteria commonly include receding water below the trigger level, a post-flood inspection with soundings at the monitored elements, comparison with the previous cross sections, and engineering review of any new scour or movement. Because live-bed scour holes refill as the flood recedes, post-flood soundings may understate the maximum scour reached during the event. Fixed instruments that record maximum scour, or probing to find the base of loose infill, help here.

Countermeasure alternatives and the schedule

HEC-23 Section 2.1.6 says that developing a schedule for countermeasures first requires selecting the preferred alternative. Several alternatives are often appropriate. A comprehensive POA should give enough information that an independent reviewer could reach the same conclusion about the preferred alternative.

To compare alternatives, develop a conceptual design for each so engineering feasibility can be checked and preliminary costs estimated. The POA should present the alternatives and a narrative explaining why the preferred one was chosen, then a schedule for its timely design and construction. HEC-23 allows that more intense monitoring may be recommended to reduce risk until countermeasures are designed and built.

HEC-23 Section 3.2 lists factors for life-cycle cost comparisons, including availability of materials of the required size and weight, haul distance, site access, equipment, construction underwater versus in the dry, environmental permitting, threatened and endangered species, traffic control, labor rates, in-house versus contract construction, design life, and anticipated maintenance.

HEC-18 Section 2.5.2 and Table 2.3 set minimum scour countermeasure design flood frequencies one step above the scour design flood, because countermeasures must remain stable at floods larger than the scour design flood:

Hydraulic design flood	Scour design flood	Countermeasure design flood
Q10	Q25	Q50
Q25	Q50	Q100
Q50	Q100	Q200
Q100	Q200	Q500

If a smaller flood, such as an overtopping flood, causes greater stress, HEC-18 says it should be used as the countermeasure design flood. Countermeasure design itself is the subject of BR-H03.

The POA should also address emergency countermeasures. HEC-23 Section 2.1.7 suggests describing what riprap is adequate, local sources, and installation methods during a flood. Pre-identifying a quarry, stockpile and contractor can turn a night of improvisation into a planned response.

The FHWA POA Standard Template

FHWA developed a standard POA template, reproduced with instructions in HEC-23 Appendix B and summarized in HEC-18 Section 10.6.2. It contains the minimum information FHWA recommends. Owners can modify fields to use local terminology and add site-specific concerns. HEC-23 suggests the template also be considered for unknown foundation bridges. FHWA's NHI course 135085, Plan of Action for Scour Critical Bridges, provides training on the template with a riverine case study.

Section	Title	Content (HEC-18 Sec. 10.6.2)
1	General Information	Structure number, route carried, waterway crossed, year built, ADT, and similar data.
2	Responsibility for POA	POA author, responsible agency, and contact information.
3	Scour Vulnerability	Current Item 113 rating, description of the scour evaluation, summary of scour history.
4	Recommended Action(s)	Status of recommended actions: increased inspection frequency, monitoring devices, flood monitoring program, countermeasures.
5	NBIS Coding Information	Current and previous ratings for Items 60, 61, 71 and 113.
6	Monitoring Program	Monitoring procedures and contacts, including scour alert and scour critical trigger conditions and the actions required.
7	Countermeasure Recommendations	Prioritized alternatives, cost estimates, anticipated installation schedule, contacts.
8	Bridge Closure Plan	Conditions requiring closure, contacts, and conditions for reopening.
9	Detour Route	Detour description, other bridges on the detour, traffic control equipment and location, notification of other agencies and the media.
10	Attachments	Maps, photos, sketches, as-built drawings, scour calculations, preliminary countermeasure designs.

HEC-23 notes that much of this information can come from the state's bridge management system. A POA is only as useful as its contact list and triggers are current, which leads to maintenance of the plan.

Developing, implementing and maintaining the POA

HEC-23 Section 2.1.8 distinguishes development from implementation.

Development means the owner has held meetings with internal units (design, construction, inspection and maintenance, districts) and external entities (local officials, police, fire and others) to identify and document general information and responsibility, scour vulnerability, recommended countermeasures or alternatives, NBI coding, countermeasure selections with priority and cost, the closure plan, the detour route, and other supporting information.

Implementation means the POA has been distributed to those internal and external parties, and the owner has met with them to communicate the instructions, who is responsible, detour routes, when to close and reopen, countermeasure selection, and design and installation schedules. Responsible parties should understand their roles and receive periodic training, for example in closure and reopening procedures. Implementation includes setting how often the POA is reviewed and updated.

HEC-23 Section 2.1.7 adds a communications plan: who may speak to the media and what information to give. Closures and failures draw intense interest, and planning ahead reduces confusion.

Maintenance. HEC-18 Section 10.6.3 says a POA must be updated periodically and whenever warranted by changes to the bridge or waterway, such as channel changes, scour from a flood, or new countermeasures. Periodic updates are often administrative: revising countermeasure schedules or contact information. They are essential because a POA involves multi-agency coordination. Significant changes that lead to recoding Item 113 require updating the POA immediately, and inspections during or after floods usually reveal that need. HEC-18 also lists preparedness (planning, training, exercises, equipment) and supporting technologies (monitoring, communications, GIS and internet-based systems) as elements of POA maintenance, including changes within partner agencies such as state patrol, public works and utilities.

Illustrative practice: many owners review each POA annually before flood season, test fixed monitors and telemetry, confirm contacts by phone, and check that barricades for the closure plan are where the POA says they are.

Bridges with unknown foundations

HEC-18 Appendix E defines unknown foundations as those whose type (spread footing, piles, columns), dimensions, reinforcing or elevation are not known. They are coded U in Item 113. Because the foundation is unknown, scour vulnerability cannot be assessed by conventional procedures. HEC-18 Section 2.5.3 states that each of these bridges must have a POA, and recommends a risk-based approach to prioritize the effort. The 2022 NBIS, 23 CFR 650.313(o)(2), explicitly requires a scour POA for bridges with unknown foundations.

The FHWA memorandum of January 9, 2008, Technical Guidance for Bridges over Waterways with Unknown Foundations, as summarized in HEC-18 Appendix E, recommends that owners:

1. Screen all U-coded bridges to confirm they truly have unknown foundations. Mine historical records in district and local offices, and cross-reference construction dates with known-foundation bridges built in the same period, since historical practices were repetitive and simple.
2. For bridges confirmed unknown: prioritize by functional classification; establish foundation characteristics with reasonable accuracy using historical design practice, geology and subsurface conditions, standards and nearby bridges, and proven surface and subsurface nondestructive testing; then conduct a scour evaluation and consider recoding.
3. For bridges whose foundations become fully known: evaluate per HEC-18 and code Item 113 accordingly.

Appendix E explains that moving a bridge into the scour program on a risk-based foundation determination is the equivalent of recoding it to 6, scour evaluation not yet made, after which it is evaluated and recoded. The memorandum also said FHWA was contemplating treating any bridge still coded U after November 2010 as scour critical and subject to the POA requirement until countermeasures are installed or the bridge is replaced.

For a U bridge, the POA usually leans heavily on monitoring and closure because the capacity of the foundation cannot be computed. The Coding Guide's own description of code U says to flag the bridge for monitoring during floods and, if appropriate, closure.

Inspector duties and notification

Much of a POA is carried out by inspectors. HEC-18 Section 10.1 gives the two objectives of inspecting for scour: accurately record the present condition of the bridge and stream, and identify conditions that indicate potential scour or instability problems for review by others.

HEC-18 Section 10.3.7 calls measuring and plotting streambed elevations relative to the foundations perhaps the single most important part of inspecting for scour. Where rods, poles or sounding lines cannot measure the bed accurately, divers or scour

monitoring devices are needed. For submerged foundations the questions are the same as in shallow water: is the footing, pile cap or piling exposed or undermined, and has riprap been damaged, displaced or removed?

HEC-18 Section 10.3.8 requires a positive means of promptly communicating findings. Any condition the inspector considers an emergency or potentially hazardous should be reported immediately. Conditions that are not immediately hazardous but warrant action go to the interdisciplinary team. The current NBIS reinforces this with its critical findings procedures. Under 23 CFR 650.313, the critical findings an owner must address in a timely manner include, at a minimum, findings that warrant full or partial closure of any bridge, and findings that cause the Channel Condition Rating or Scour Condition Rating item in the NBI to be rated critical or worse. Those two NBI item names come from the current regulation and show how the SNBI carries scour into condition ratings.

Safety is part of the plan too. HEC-18 Section 10.3.1 warns that inspectors in fast water should be secured by a safety line with a boat available, because overtopped waders can drag a person under in seconds, and that work from the deck needs traffic warning. Flood monitoring at night in rain on a narrow bridge is dangerous, and a POA should account for that when choosing between portable and fixed instruments.

Worked scenario: writing a POA

This scenario is illustrative. The bridge, numbers and names are invented to show how the parts of a POA fit together.

Bridge. A three-span 1962 continuous steel girder bridge carries a state route with 6,500 ADT over a sand-bed river. The piers are on spread footings with bottoms 6 ft below the current streambed. The interdisciplinary team's HEC-18 analysis for the Q100 scour design flood gives 3 ft of long-term degradation, 2 ft of contraction scour and 9 ft of local pier scour at Pier 2. The total scour of 14 ft is below the footing base, so the bridge is coded 3, scour critical by calculation. Field inspection shows the bed at Pier 2 is about 1.5 ft lower than in the as-built plans, but the footing is not exposed.

Management strategy. The bridge is not programmed for replacement, carries moderate traffic, and the detour is 11 miles. The team concludes that monitoring is an interim measure only and a countermeasure is needed.

Monitoring program. Fixed sonar on the upstream face of Pier 2, with telemetry and an alert threshold. A scour alert line painted on Pier 2 at the stage that corresponds to the flow at which, per the hydraulic model, velocities at the pier exceed critical velocity for the bed. When water reaches the line, the district crew begins flood watch with hourly visual checks and sonar readings, plus probing at Pier 1 with a portable sonar from the deck. The scour critical trigger is bed elevation at Pier 2 reaching 2 ft above the footing base, or any visible settlement or tilt.

Closure plan. At the scour critical trigger, the district engineer closes the bridge with barricades staged at the maintenance yard, and state police are called to the east approach. The detour uses two bridges that were evaluated and are coded 8. Reopening requires soundings by the bridge inspection unit after water falls below the alert line and approval by the named district bridge engineer.

Countermeasures. Alternatives evaluated: riprap pier protection per HEC-23, articulating concrete blocks, and underpinning with micropiles. Riprap is preferred on cost and constructability, designed for the Q200 countermeasure design flood per HEC-18 Table 2.3, with a schedule of design this year, permits next spring, and construction in the following low-water season. Until then, the monitoring program stays in force.

After construction. If the riprap is designed by the team and properly installed, Item 113 can be recoded to 7. The POA is then revised to include inspection of the riprap after floods.

Summary

A scour critical bridge is one whose foundations are unstable for calculated scour or observed scour. Item 113 codes 3, 2, 1 and 0 identify scour critical bridges, and code U identifies unknown foundations. The NBIS, now at 23 CFR 650.313(o), requires a scour appraisal of every bridge over water, and a POA for every scour critical and unknown foundation bridge, consistent with HEC-18 and HEC-23.

The POA has two cores: inspection type and frequency, and a schedule for countermeasures. Around them sit the monitoring program with clear triggers, closure and reopening instructions, detours checked for their own scour risk, countermeasure alternatives with a reasoned choice, communications, and named responsibilities. Monitoring reduces risk but does not change the scour critical code. Properly designed and installed countermeasures can. A POA must be implemented, exercised and kept current, or it will fail when it is needed.

Office review checklist before inspecting a scour critical bridge

HEC-18 Section 10.2 recommends an office review of plans and previous reports before the field inspection. For a bridge with a POA, the review is also the time to check that the POA still matches reality. The HEC-18 questions, paraphrased, are:

1. Has an engineering scour evaluation been made, and is the bridge scour critical?
2. If it is scour critical, has a POA been developed?
3. What do streambed cross sections from successive inspections show: stable, degrading, aggrading or moving laterally?
Are there scour holes at piers and abutments?
4. What equipment is needed to measure bed elevations (rods, poles, sounding lines, sonar)?
5. Are there sketches or aerial photographs to show whether the channel is migrating or the flow direction is changing?
6. What foundation type was built, are footing and pile tip elevations known, and what are the subsurface soils?
7. Do special conditions need divers, boats or electronic gear for underwater work?
8. Are there special items to look at, such as damaged riprap, skewed approach flow, or past debris problems?

To these, a POA review adds practical checks: are the trigger elevations and painted lines still correct after any channel change, are the monitoring instruments working, are contacts current, and has the countermeasure schedule slipped? HEC-18 Section 10.3.2 notes that Items 92 and 93, Critical Feature Inspection and date, are used to alert inspectors to elements needing special attention, such as countermeasures or monitoring devices previously installed. Under the SNBI, use the corresponding special inspection data your agency has adopted.

The Hatchie River case in this course shows the cost of skipping this step. Its inspectors lacked plans in the field and its cross sections were never plotted together, so a migrating channel went unrecognized until the bridge fell.

Key takeaways

- Scour critical means foundations unstable for calculated or observed scour; Item 113 codes 3, 2, 1 and 0.
- 23 CFR 650.313(o) requires a scour appraisal for every bridge over water and a POA for scour critical and unknown foundation bridges.
- A POA's two core parts are inspection type and frequency, and a schedule for countermeasure design and construction.
- Monitoring can be a countermeasure but does not allow recoding out of scour critical; designed and installed countermeasures can (code 7).

- Define field-measurable triggers, such as a painted line or distance below the rail, plus a scour critical elevation per element.
- Closure plans need named reopen authority and detours whose bridges are not themselves scour critical.
- Use the FHWA 10-section POA template and update the POA immediately when Item 113 is recoded.

References

1. FHWA, HEC-23 Bridge Scour and Stream Instability Countermeasures, 3rd Edition, FHWA-NHI-09-111 and -112, 2009
2. FHWA, HEC-18 Evaluating Scour at Bridges, 5th Edition, FHWA-HIF-12-003, 2012
3. 23 CFR Part 650, Subpart C — National Bridge Inspection Standards (final rule published May 6, 2022)
4. FHWA, Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, FHWA-PD-96-001, December 1995, Item 113 – Scour Critical Bridges.
5. FHWA Technical Advisory T5140.23, Evaluating Scour at Bridges, October 28, 1991 (as summarized in HEC-18 Sec. 10.6.1 and HEC-23 Sec. 2.1.1).
6. FHWA Memorandum, Technical Guidance for Bridges over Waterways with Unknown Foundations, January 9, 2008 (as summarized in HEC-18 Appendix E).

Study text only; the final quiz is taken online. Verify all references against the edition your agency has adopted.