What is scour and how does it affect WSDOT bridges?

Scour is the removal of soil from around bridge piers and abutments. Flowing water transports soils from around bridge piers and abutments and moves it down stream, leaving the bridge foundations exposed and in some cases undermined. Undermined bridge foundations can compromise the integrity of the structure and in some cases cause collapse.

Scour is the leading cause of bridge failures in Washington State and nationwide. Of the 70 documented bridge failures in Washington State history, 43 were due to scour.

What steps does WSDOT take to ensure that its bridges are safe and haven’t been damaged by scour?

WSDOT has approximately 1,583 vehicular bridges and culverts over 20-feet in length that span over water. 262 of these bridges are considered “scour critical” which means there is potential for the bridge to be damaged by scour. WSDOT’s efforts to ensure that these bridges are safe and haven’t been damaged by scour fall in to two categories, monitoring and response.

Monitoring for Scour Damage

WSDOT performs routine inspections of its bridges at least once every two years. In some cases where there are specific concerns, bridge inspections are more frequent. During these inspections, the bridge inspectors observe conditions at the bridge piers and abutments as well as the waterway upstream and downstream of the bridge. Bridge scour conditions are recorded in the bridge inspection report. If significant scour is observed, the bridge inspector will call for a repair.

Where conditions are difficult to evaluate due to water depth or other conditions, the WSDOT Dive Team will perform an underwater inspection of bridge elements. Divers performing the underwater inspection are able to gather detailed information about scour conditions. Once again, if significant scour is observed, the bridge inspector will call for a repair.

All WSDOT scour critical bridges are monitored by WSDOT staff during flood events. The monitoring is conducted in accordance with a “Scour Plan of Action”, which is a documented plan that has been prepared ahead of time. The plan of action includes a summary of the scour vulnerabilities and guidance for actions to be taken during flood events. Actions include monitoring bridges during and after flood events as well as closing bridges if conditions exceed a pre-determined threshold or if scour damage is suspected.
Responding to Scour Damage

If scour damage has occurred that compromises the integrity of a bridge, the bridge is closed to traffic until repairs are made.

If scour has occurred but the damage does not compromise the integrity of the bridge, WSDOT will take action to repair the damage. Some repairs are completed by WSDOT Maintenance crews while others are completed under contract. Who completes the repair depends on several factors including what part of the State the bridge is located in, the nature of the repair, and the anticipated cost of the repair.

How were WSDOT Bridge Scour Mitigation Measures completed in the past and how is it done today?

In years past, the majority of bridge scour repairs were completed by WSDOT maintenance crews. Repairs were completed quickly and efficiently at a relatively low cost. WSDOT maintenance crews were able to install and maintain scour countermeasures that significantly reduced the risk of scour damage to WSDOT bridge.

Today, the efforts required to obtain permits for bridge scour repairs preclude WSDOT maintenance crews from completing bridge scour repairs in many parts of the State. WSDOT maintenance crews in these areas don’t have the staff or funding that would be required to obtain the necessary permits. So, most bridge scour repair projects are completed through the Bridge Scour Mitigation Program.

What does the WSDOT Bridge Scour Mitigation Program do?

The WSDOT Bridge Scour Mitigation Program addresses only the worst bridge scour deficiencies by designing, permitting, and constructing bridge scour repairs under contract.

What does it take to complete a WSDOT Bridge Scour Mitigation Project today?

There are several steps necessary to complete bridge scour repairs in today’s world. The steps are:

- **Identify Needs** – Bridge inspection data is reviewed to identify bridges that have a bridge scour repair need.
- **Prioritize Needs** – Once the list of needs is determined, the details of each case are reviewed and prioritized against each other on a statewide basis.
- **Program and Fund Projects** – The funds that are available for bridge scour repairs are assigned to the top bridge scour needs. Usually only three or four bridge scour repair projects are programmed each biennium.
- **Design Repair** – WSDOT staff including bridge engineers, hydraulic engineers, and environmental staff work together to design the repair and appropriate mitigation.
- **Obtain Permits** – WSDOT staff work to obtain permits from the appropriate entities to construct the repair. This process usually takes about 2-years.
- **Construction** – The project is advertised and awarded to the Contractor with the lowest bid. Construction of most scour repairs typically takes less than a month.

What are the major challenges of completing WSDOT Bridge Scour Mitigation Projects?

Completing bridge scour mitigation projects is challenging. One of the major challenges is in identifying and addressing scour needs before they jeopardize a bridge. Bridge scour is dynamic and conditions can change rapidly. There are many variables that affect the rate at which bridge scour happens. Two of the primary variables are soil type and water velocity. Some soils are more susceptible to scour than others. Loose unconsolidated soil is easily carried away while hard bedrock layers are generally not susceptible to scour. Also, high flow velocities scour away soils faster than lower velocities. A major cause of higher velocities near bridge piers is due to the accumulation of wood debris that floats down the river and gets hung up on the bridge. This wood debris can constrict the channel and cause localized areas of high velocity flow that scours away supporting soils.

A second challenge is in permitting bridge scour projects. In order to construct a scour repair, WSDOT must obtain permits from many entities including, The Washington State Department of Fish and Wildlife, Washington State Department of Ecology, The US Corps of Engineers, Native American Tribes, Local Jurisdictions, and land owners. Meeting the requirements of each entity is often very challenging, time consuming, and often results in added costs in construction, due to added constraints and required mitigation.

A third challenge is in addressing all of the high priority scour needs with available funds. Because the process to complete scour repairs is expensive and lengthy (2-years minimum), WSDOT can only address a few scour repairs each biennium. This means WSDOT often reacts to only the worst needs through emergency scour repair projects.
How many bridge scour projects has WSDOT completed by contract in the past 10-years and at what cost?

In the past 10-years, WSDOT has completed 13 bridge scour repair projects (17-bridges) by contract, at a total cost of $12 million.

<table>
<thead>
<tr>
<th>Bridge Scour Repair Projects Completed in the Past 10-Years</th>
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<tbody>
<tr>
<td><strong>Project</strong></td>
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<tr>
<td>SR 522/Snohomish River Bridge Scour Repair</td>
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<tr>
<td>SR 8/Middles Fork Wildcat Creek Scour Repair</td>
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<tr>
<td>US 101/Sol Duc River Bridge Scour Repair</td>
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<td>US 101 Humptulips River Bridge Scour Repair</td>
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<td>SR 9/Pilchuck Creek Bridge Scour Repair</td>
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<td>SR9 and SR 20/Thunder and Coal Creek Bridges Scour Repair</td>
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<tr>
<td>US 12/Touchet River Bridge at Touchet Scour Repair</td>
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<tr>
<td>SR 508/Tilton River Bridge Scour Repair (Emergency)</td>
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<tr>
<td>SR 202/Tokul Creek Bridge Scour Repair (Emergency)</td>
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<tr>
<td>SR 410/White River Bridge Scour Repair</td>
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<tr>
<td>US 97 Et Al/Yakima and Benton County Bridges Scour Repairs</td>
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<tr>
<td>SR 108/Wildcat Creek Bridge Scour Repair</td>
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</tbody>
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$12,071,249

**CURRENT WORK:**

**Examples of Recent WSDOT Bridge Scour Mitigation Projects**

**Case Study: Humptulips River Bridge (101/150)**

Bridge No. 101/150 carries US 101 traffic over the Humptulips River in Grays Harbor County. The bridge consists of three concrete approach spans to the South, a steel ‘through truss’ main span, and a single concrete approach span at the North end. When the bridge was originally constructed, the Humptulips River was centered under the 260-foot main span. However, over time the course of the river has changed, and the channel has shifted to the South at the bridge. With this shift, the flow of the river became directed straight at Pier No.4. The material around Pier No. 4 was being removed by scour action at a rapid rate. Because Pier No. 4 is founded on a shallow spread footing, WSDOT felt it was necessary to take immediate action to protect the pier. In 2006 an emergency scour repair was completed. The emergency repair focused only on armoring Pier No. 4 to ensure that it could make it through the winter high flows.

In November 2006, just weeks after the emergency repair was completed, the repair was tested by severe flooding. The newly installed repair performed well and provided the necessary protection.

For the next year and a half WSDOT worked to design and permit the permanent repair. The permanent repair added to the emergency repair. Elements that were added included upstream barbs designed to direct the river back under the main span, as well as mitigation elements intended to offset the impacts of the scour repair. In 2008, the remaining repair elements were constructed.

**Case Study: Tilton River Bridge (508/32)**

Bridge 508/32 carries SR 508 over the Tilton River near Morton, Washington. Following a flood event in the area, WSDOT staff suspected that a void may have formed under the footing at Pier No. 3. The WSDOT dive team was called to the site to investigate, as this area was in deep water. The dive team found that soils had been scoured out from under the West half of the footing. Traffic on the bridge was immediately reduced to one lane... keeping traffic on the East half of the bridge.

Under an emergency contract, WSDOT’s contractor began working to repair the damage. The repair consisted of filling the void under the footing with concrete and also removing the above water portion of an adjacent rock that was causing the scour. Work began in early June and was completed by the end of July 2009.
FUTURE WORK: What are the current top bridge scour mitigation needs?

As discussed above, WSDOT’s bridge inspectors are continually inspecting bridges, with each bridge being inspected at least once every two years. Given the dynamic nature of scour, bridge scour needs and priorities can change rapidly. Currently the top three bridge scour repair needs are:

**Chehalis River Bridge (Bridge No. 101/115)**

Bridge No. 101/115 carries US 101 traffic over the Chehalis River Bridge in Aberdeen Washington. Scour action has removed soils from around and below the Pier 14 pile cap. The void is approximately 7.5-feet high and has exposed (16) untreated timber piles. Based on recent experience with the nearby Simpson Avenue Bridge, WSDOT is concerned that the exposed timber piles could be damaged by marine borers, which are small bugs that bore in to and eat wood. Repair of this bridge scour need will likely consist of filling the void under the pile cap with concrete and placing riprap around the pier. This repair is estimated to cost approximately $3.5 million.

**Union Slough Bridge (Bridge No. 529/15E)**

Bridge No. 529/15E carries southbound SR529 traffic over Union Slough near Everett. Scour action has removed soils from around several of the bridge’s pile cap foundations. The scour has caused voids to form under the pile caps at Piers 8 and 9. The voids under these piers leave many untreated timber piles exposed. Similar to the Chehalis River Bridge, WSDOT is concerned that the exposed timber piles could be damaged by marine borers. Repair of this bridge scour need will likely consist of filling the void under the pile caps with concrete and placing riprap over exposed pile caps. This repair is estimated to cost approximately $2.5 million.

**South Fork Skykomish River Bridge (Bridge No. 2/119)**

Bridge No. 2/119 carries US 2 traffic over the South Fork of the Skykomish River near the town of Skykomish Washington. Scour action has removed soils from around the pile cap at Pier 3. The scour has caused a void under the pile cap that is approximately 3.5-feet tall and exposes (18) untreated timber piles. Because the piles are in fresh water, marine borers are not a concern. However, being exposed, the timber piles are vulnerable to damage by debris moving down the river and decay. Repair of this bridge scour need will likely consist of filling the void under the pile cap with concrete. This repair is estimated to cost approximately $1.1 million.

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