

TO: All Design Section Staff
FROM: Bijan Khaleghi
DATE: October 29, 2021
SUBJECT: WSDOT Scour Design Policy - Revised

This design memorandum provides revisions to the WSDOT Scour Design Policy. Bridge Design Manual Sections 7.1.7 and 15.7.1 and Figures 8.1.9-1 through 8.1.9-3 shall be replaced in entirety with the following. **This design memorandum supersedes the October 19, 2021 WSDOT Scour design policy memorandum.**

BDM 7.1.7

7.1.7 *Scour Requirements*

Scour can affect the bridge structure, adjacent wall structures, and the bridge embankment. Per AASHTO, the bridge structure shall be designed for total scour. Total scour for the bridge structure does not consider any added scour countermeasures as explained in the New Structures section below. If scour countermeasures are designed following guidance from HEC 23, then walls and embankments benefit as explained in the following Section.

All bridge foundations shall be **designed for** scour regardless of bridge type, location, and usage. **Bridge foundations shall be designed by the bridge designers for scour considering the following** two conditions:

1. At Service and Strength Limit States: For the **scour design flood**, the streambed material above the total scour line shall be assumed to have been removed for design conditions. The design flood **is the worst-case scour for all floods up to and including Q100. The Hydraulics Office provides the total scour elevation corresponding to the scour design flood.**
2. At Extreme Limit States (Earthquake and Scour): **Two separate extreme cases shall be evaluated when verifying the stability of the bridge foundation.**
 - A. Extreme Case I – 50% of the total scour **design** flood depth plus seismic
 - B. Extreme Case II - 100% of the scour **check** flood depth

Excess reserve beyond that required for stability under these conditions is not necessary.

Unless otherwise specified, bridges shall be designed for the **total scour at the scour design flood and shall have top of footing locations based on total scour at the scour**

check flood. If there is lateral migration, then the determination of total scour during both the scour design flood and the scour check flood shall account for the migrated state.

Total scour is determined by the Hydraulics Office.

Where conditions dictate a need to construct the top of a **deep foundation** footing or cap at an elevation above the **total scour check flood**, the bridge designers shall address the scour potential of the design, based on the State Hydraulics Office analysis of the scour potential of the proposed geometry of the foundation element.

Figure 7.1.7-1 as well as the following subsections provide guidance on top of footing or pile/shaft cap elevations.

A. New Structures

Spread footings on soil or erodible rock shall be located by the bridge designers so that the **top of footing is below total scour depths determined for the scour check flood**. Spread footings on scour-resistant rock shall be **designed and constructed to maintain** the integrity of the supporting rock.

Deep foundations such as piles or shafts may be selected by the bridge designers to protect bridges from scour. **Interior piers may have the top of shaft or top of pile cap placed above the depth of total scour at the scour check flood if the foundation is designed for this condition**. For abutments without scour countermeasures designed per most recent version of HEC 23, the top of pile or shaft cap shall be below the total scour at the scour check flood. If an abutment has a scour countermeasure design meeting the most recent version of HEC 23 guidelines the top of pile or shaft cap may be placed above the depth of total scour at the scour check flood. The hydraulic and geotechnical recommendations shall account for the exposed cap and/or shaft or pile.

When fenders or other pier protection systems are used, the bridge designers shall address the effects of such systems on scour and collection of debris, based on State Hydraulics Office analysis of the hydraulic **and** scour effects of the proposed systems.

If stream migration risk is classified as anything other than “Low” in the Preliminary Hydraulic Design Report, then the foundation shall be designed for stream migration.

In cases where designing foundation for stream migration risk is classified as anything other than “Low” results in significant increase in construction time and costs, it is recommended to consider scour countermeasures as specified elsewhere in this memorandum.

Deviation in stream migration limits may be considered on a case-by-case basis with State Hydraulic Engineer’s approval. Such deviation requires an in-depth migration study and justification that there will be a significant reduction in construction time and cost associated with the revised foundation design.

When migrated scour conditions could uncover the shaft cap and expose the supporting shafts below, soil arching conditions behind the shafts shall be assumed,

requiring the full-depth earth pressures to be applied from behind the shafts and shaft cap as shown in Figure 7.1.7-2.

Lateral analysis of the shafts shall be determined using the forces from Figure 7.1.7-2 and ignoring all soil down to the scour depth. Axial capacity of the shafts shall be determined by ignoring the soil resistance above the scour depth.

B. Existing Structures

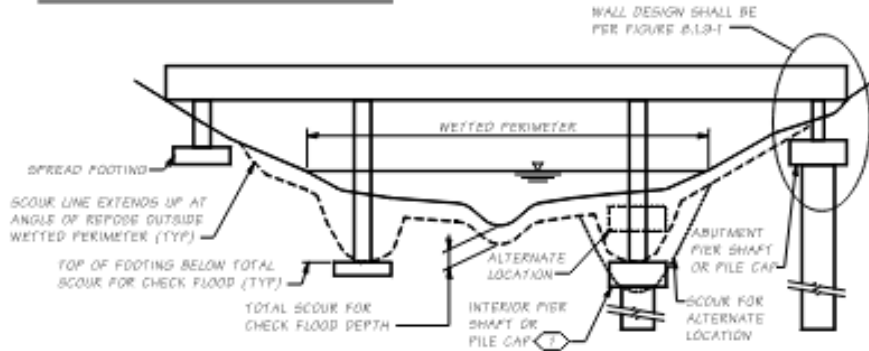
When scour conditions would uncover the spread footing, the Hydraulics Office shall be contacted, and a repair may be required.

C. Buried Structures

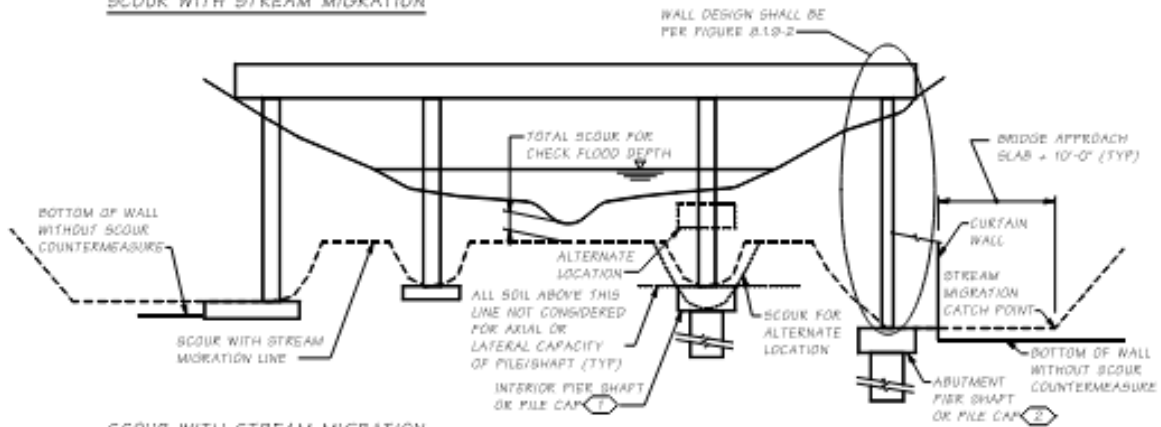
Three sided buried structures are supported by shallow or deep foundations, and therefore foundation guidance regarding scour shall follow that for New Structures above.

Four sided buried structures shall be positioned such that the bottom of the structure is located a minimum of 2 feet below total scour at the design flood.

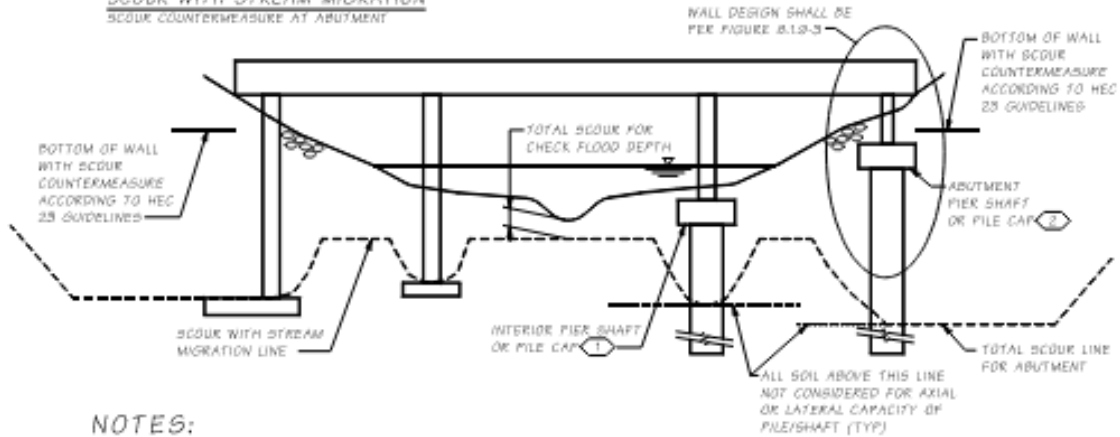
SCOUR WITHOUT STREAM MIGRATION



SCOUR WITH STREAM MIGRATION



SCOUR WITH STREAM MIGRATION
SCOUR COUNTERMEASURE AT ABUTMENT



NOTES:

- ① INTERIOR PIER SHAFT OR PILE CAP MAY BE LOCATED ABOVE STREAM MIGRATION OR SCOUR LINE AS LONG AS THE FOUNDATION IS DESIGNED FOR THIS CONDITION. BOTH HYDRAULIC AND GEOTECHNICAL RECOMMENDATIONS SHALL ACCOUNT FOR THE EXPOSED CAP AND/OR SHAFT OR PILE.
- ② ABUTMENT PIER SHAFT OR PILE CAP MAY BE LOCATED ABOVE STREAM MIGRATION LINE IF A SCOUR COUNTERMEASURE DESIGN HAS BEEN ADDED AT THE BRIDGE END AND THE FOUNDATION IS DESIGNED FOR THE HIGHER ELEVATION. BOTH HYDRAULIC AND GEOTECHNICAL RECOMMENDATIONS SHALL ACCOUNT FOR THE EXPOSED CAP AND/OR SHAFT OR PILE. EARTH PRESSURE ON ABUTMENT SHALL BE PER FIGURE 7.17-2.

Figure 7.1.7-1 Foundation Scour Effects

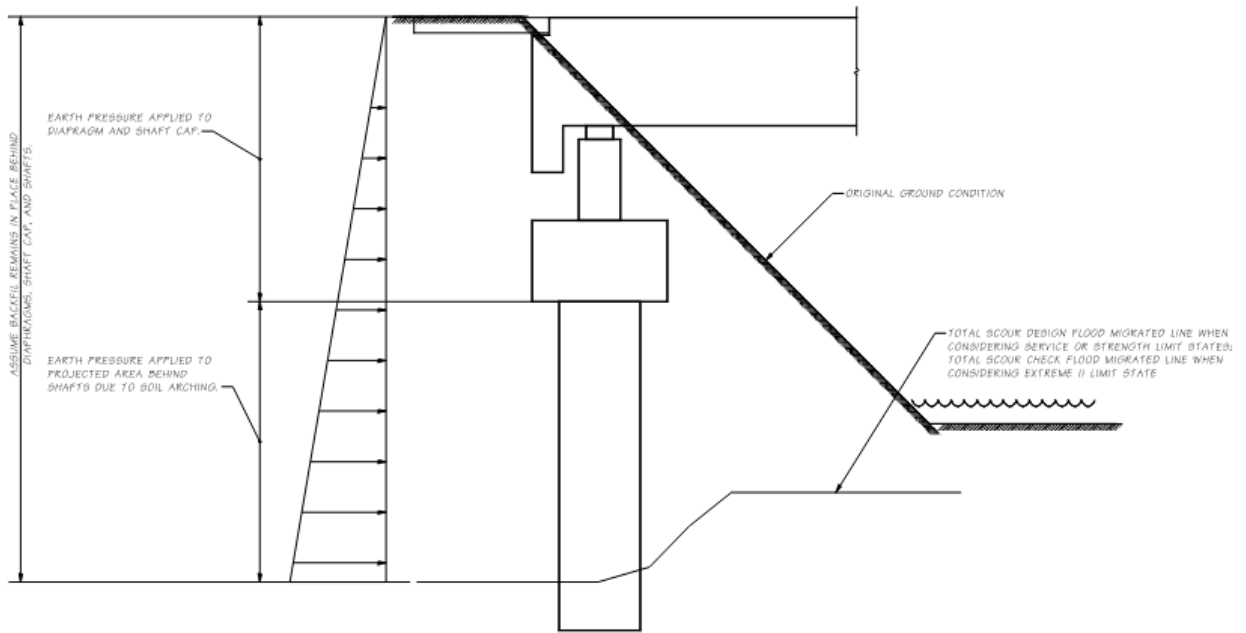


Figure 7.1.7-2 Scour Effects when the Shafts below a Shaft Cap are Exposed

BDM 15.7.1

15.7.1 *General Substructure Considerations*

A. Foundation Seals

The top of seal, if used, shall be no higher than the total scour at check flood.

B. Scour

Requirements from 7.1.7 shall be followed. The hydraulic engineer of record replaces the Hydraulic Office where mentioned.

C. Combination of Extreme Event Effects

1. Downdrag

Seismic soil liquefaction induced downdrag forces shall be included in the Extreme Event I limit state. Downdrag loads may be decoupled from the inertial and overstrength load effects.

2. Lateral Ground Displacement

Where lateral ground displacement (e.g. lateral spreading and lateral flow) is expected, the ground displacement may be decoupled from the inertial and overstrength load effects. See WSDOT *Geotechnical Design Manual* Sections 6.4.2.7 and 6.5.4 for additional guidance on combining loads when lateral ground displacement occurs.

3. Scour

The effects of local scour shall be combined with earthquake loading. At the Extreme Event I limit state, the design shall consider a scour depth equal to 50 percent of the design flood scour depth.

BDM Figures 8.1.9-1 through 8.1.9-3

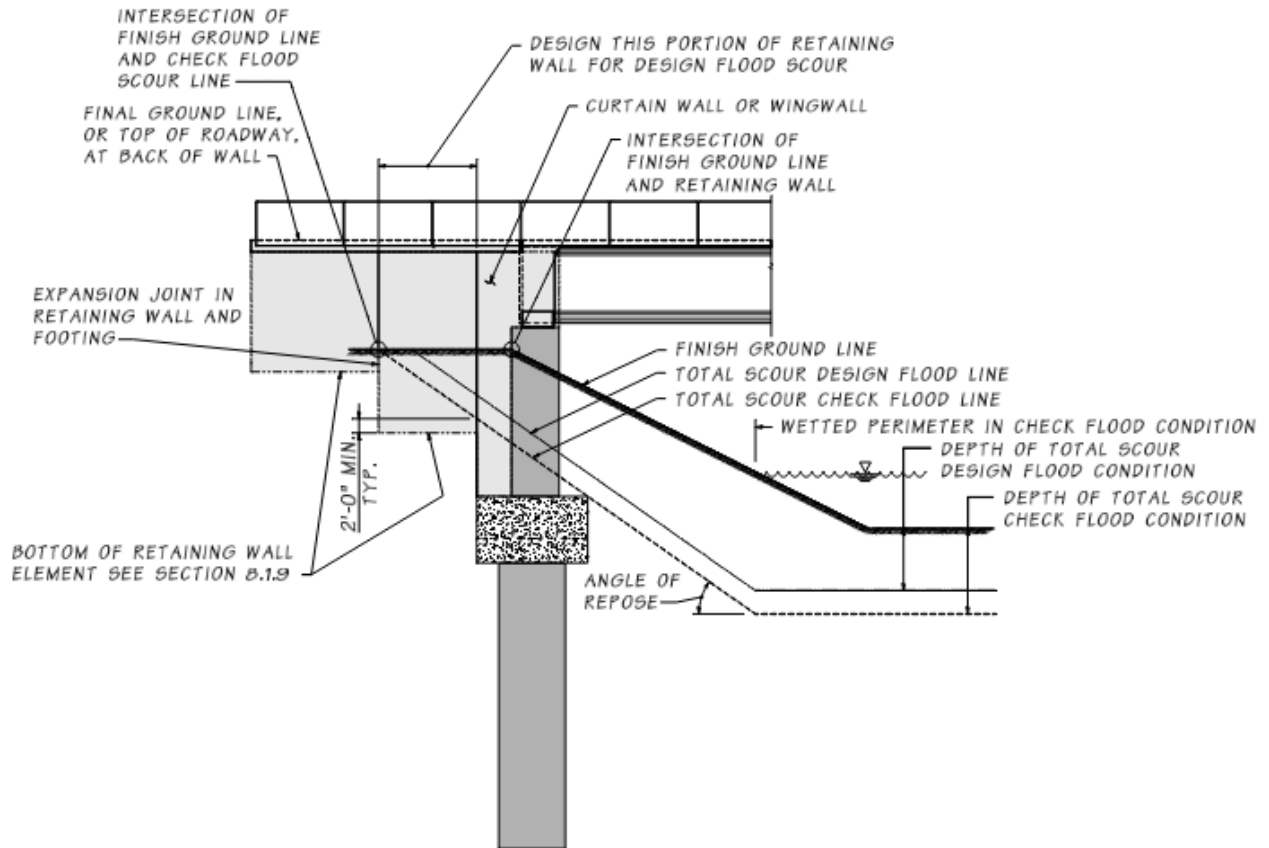


Figure 8.1.9-1 Scour without Stream Migration

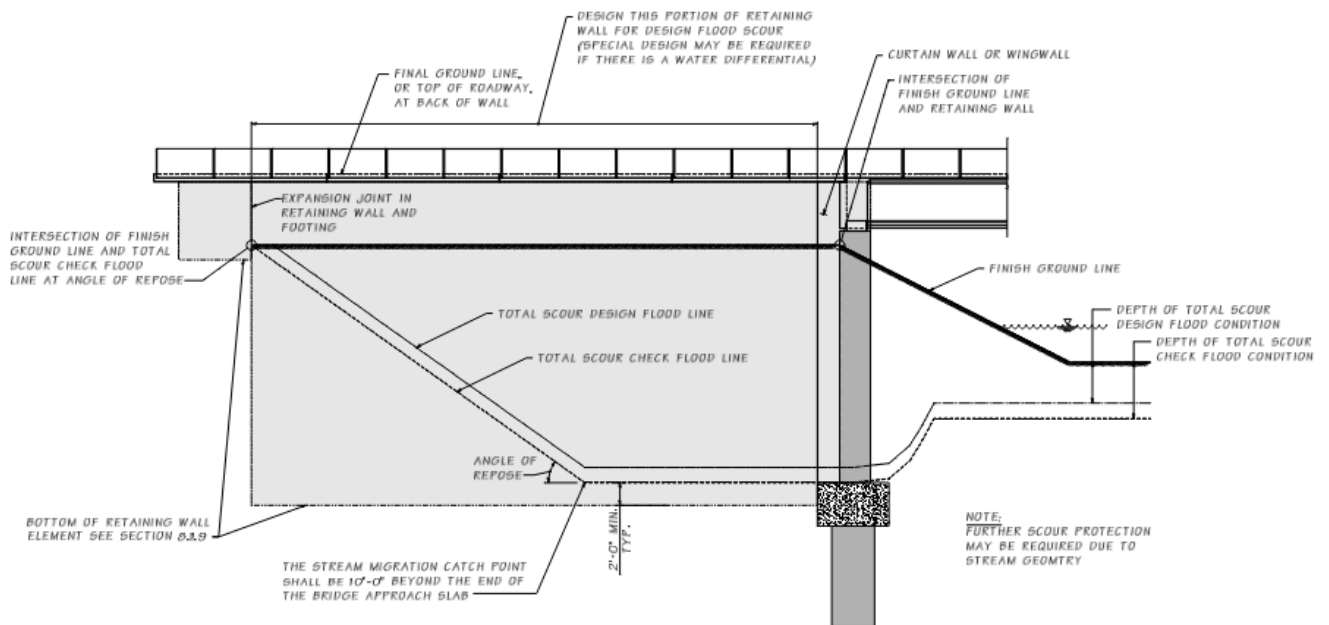


Figure 8.1.9-2 Scour with Stream Migration

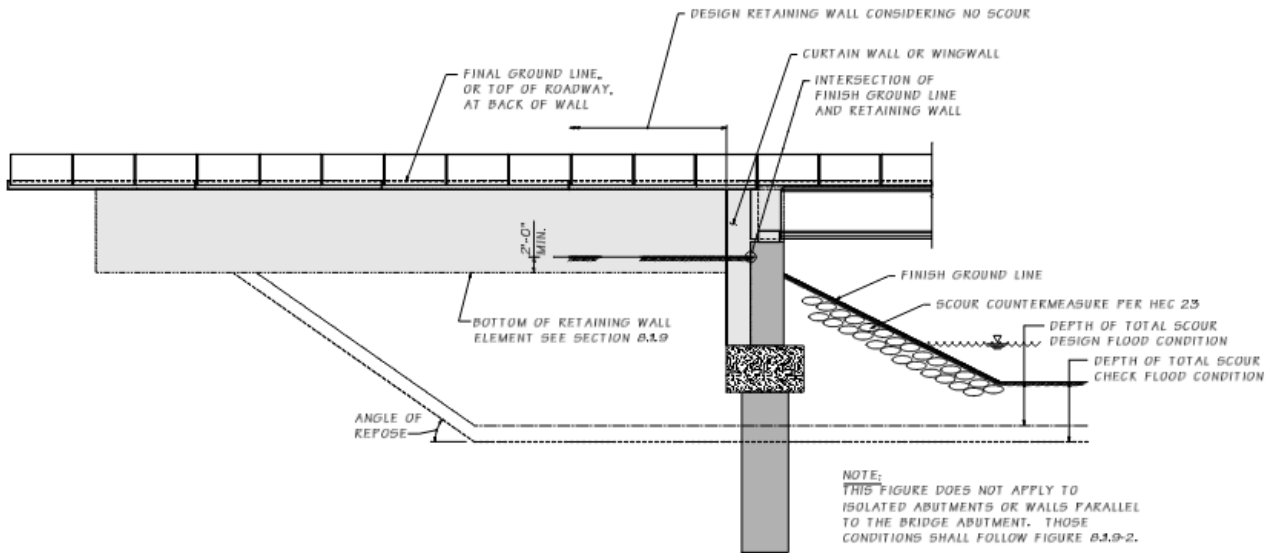


Figure 8.1.9-3 Scour with Stream Migration and Scour Countermeasures

Background:

Scour and migration are important aspects to be considered in bridge design. The placement of foundations and wall elements when considering scour and migration needed further clarification. The WSDOT Bridge Design Office, WSDOT Hydraulics Office, and WSDOT Geotechnical Office worked together to establish the information provided. This policy memorandum provides additional guidance for BDM Section 7.1.7 Scour Requirements and Section 15.7.1 General Substructure Considerations and BDM Figures 8.1.9-1 through 8.1.9-3.

If you have any questions regarding this policy memorandum, please contact Amy.Leland@wsdot.wa.gov at 360-705-7394 or Bijan.Khaleghi@wsdot.wa.gov at 360-705-7181.

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