Recommended changes to BDDM Section 1.1.2.2
Jan Six, August, 2009

I also recommend moving this item (3) on "Scour Evaluation" to section 1.1.3 ("Foundation and Hydraulic Considerations"). It doesn't really seem applicable under the "Bridge Length" section. Better yet, put this in a new "Hydraulics" Section in the BDDM and consolidate all other Hydraulics recommendations there (as appropriate).

1.1.2.2 Bridge Length

(3) Scour Evaluation and Design - The Hydraulics Report will present the results of the scour analysis. The scour analysis shall include analysis on possible long term changes in the channel bottom elevation due to either aggradation or degradation, possible shifts in channel alignment, contraction scour and local pier scour. Abutment scour and the potential for "washout" conditions are also evaluated. Scour depths are calculated for both the 100-year (design/base flood) and 500-year (check flood) events. However, if the incipient roadway-overtopping flood can occur, it is usually the worst case for scour because it will usually create the worst scour conditions at the bridge site (greatest flow contraction and highest stream velocity). Therefore, scour depths are calculated depending on the recurrence interval for the overtopping flood. See Chapter 10 of the ODOT Hydraulics Manual for a description of these specific conditions and criteria. The *Hydraulics Report* will provide the scour elevations for each of these conditions.

Scour at Bridge Abutments
In addition to scour caused by contraction, channel degradation and local pier scour, the potential for scour at the bridge abutments must be considered at all waterway crossings. Abutment scour, lateral stream migration (channel changes) or overtopping of the approach embankment could all result in partial or complete removal of approach fill material and severely destabilize the abutment foundation and the bridge. A "washout" condition could occur under any of these conditions where the approach embankment supporting the abutment foundation is completely scoured out. Each of these three conditions should be evaluated as described below:

- Abutment Scour: ODOT policy states that abutment scour calculations are not required if abutment and approach fill slopes in the waterway are protected with a properly designed revetment protection system, such as a riprap blanket with a toe trench extending down to the maximum scour elevation. Revetment methods are discussed in the ODOT Hydraulics Manual, Chapter 10, and in the FHWA Highway Engineering Circular No. 18 (HEC-18). The revetment protection must be capable of withstanding the velocities and flow associated with the check flood event. With this level of protection, the scour prism is reduced to just the contraction scour, scour from degradation and local pier scour (if applicable) for use in scour design of the structure.

  For abutments and bridge fill slopes in contact with stream flow or wave action and not protected with permanent revetment measures, abutment scour is calculated (if hydraulic and site conditions are appropriate). Abutment scour could lead to destabilization of the bridge end slope and loss of embankment material supporting the bridge foundation and abutment. If this condition is possible, then the potential for a full washout condition should be considered for both the 100 and 500 year flood events.

- Roadway Overtopping: Overtopping of the approach fill near the bridge end may also result in a washout condition (ref. HEC-18, Section 7.6 and AASHTO Section 2.6.4.5). This condition should be considered in cases where the overtopping is located in the

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<#>$Q_{100} < Q_{overtopping} < Q_{500}$: The 100-year flood and the overtopping flood scour depths are analyzed¶
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<#>$Q_{overtopping} < Q_{100}$: Only the overtopping flood scour depth is analyzed¶

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For the 100-year flood (or overtopping flood if it is more frequent), the stability of the bridge design should be checked to provide a minimum geotechnical resistance factor of 0.70 (Factor of Safety of approximately 2.0). For the 500-year flood (or overtopping flood if it controls) the bridge stability should be checked with a geotechnical resistance factor of 1.0. The *Hydraulics Report* will give the scour elevations for each of these conditions or for the overtopping flood if applicable. ¶
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Only the scour due to long term stream bed degradation is included in the seismic design of the bridge (Extreme Event Limit I).¶

proximity of the bridge end and a breeched embankment could result in the scour and removal of fill material supporting the bridge abutment foundation. Properly designed slope protection and revetment may provide sufficient mitigation against the potential for a washout condition depending upon site conditions. However, each overtopping case is unique and should be carefully evaluated for the potential of a “washout” condition. If a “washout” condition is considered feasible, the amount of embankment material that could be removed, and the scour depths, are to be determined by the hydraulic designer.

- Lateral Stream Migration: The potential for lateral streambed migration (channel changes) should be evaluated for possible detrimental affects leading to erosion and/or scour of the bridge approach fills. For unprotected, or even well protected, abutment slopes, if there is a possibility that the stream channel could shift towards the abutment such that the revetment might not be relied upon for permanent protection, then the condition of a full or partial washout of the abutment fill material should be assessed. The potential and likelihood for stream channel migration and the resulting affects, is determined by the hydraulic designer who should also determine whether protective measures such as channel guides, stream bank stabilization techniques or other measures could be employed to mitigate this potential. The hydraulic design and any stream bank stabilization measures must demonstrate that the channel won't migrate towards the abutment such that it could cause a destabilization of the slope and a potential "washout" design condition.

Under a washout condition, all foundation support (vertical and lateral) provided by the embankment material beneath the abutment should be neglected down to the scour elevation associated with both the design flood (base flood) and check flood events (excluding local pier scour). The foundation should be capable of supporting the bridge loads under both of these design conditions as described in the AASHTO LRFD Bridge Design Specifications.

Abutment scour conditions which could result in partial or complete washout of the material supporting the abutment foundations may occur at one or both of the bridge abutments depending on the site conditions. For sites with potential washout conditions, the bridge should be investigated for the washout condition that would produce the worst case unbalanced loading in the structure, provided that case is feasible. This is often the case for strutted abutments where the passive resistance of the abutment backfill material is crucial to the stability of the structure and a washout condition behind only one abutment could lead to unbalanced loads and failure of the bridge.

For washout conditions at abutments supported on deep foundations, debris loads on the end bent piles or shafts are not included in this analysis.

Scour Design
For scour depths associated with the design flood, (typ. 100-year flood or overtopping flood if it is more frequent), the bridge design should be checked at both the Service and Strength Limit States (per AASHTO Article 3.7.5). For scour depths associated with the check flood, (500-year flood or overtopping flood if it controls), the bridge should provide adequate foundation resistance to support the unfactored Strength Limit State loads (per AASHTO Article 10.5.5.3.2).

Only the scour due to long term stream bed degradation is included in the seismic design of the bridge (Extreme Event Limit State I).

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