NEW JERSEY DEPARTMENT OF TRANSPORTATION
MEMORANDUM

TO: Bridge Inspection Staff
Structural Evaluation

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DATE: May 2, 2008

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SUBJECT: Bridge Scour Countermeasures
Conceptual Design and Cost Estimates for Inspection Reports

In order to provide guidance for the conceptual design and cost of bridge scour countermeasures for use in generating bridge inspection reports and coding SI&A Items FI (Recommended Scour Countermeasure) and FJ (Scour Countermeasure Cost), the attached discussion document is provided. The document has been generated with consideration of the current state of practice for the design of scour countermeasures.

In brief, the following general rules should be used:

Recommended Scour Countermeasure Designs:

Short Single Span Bridges (<40'):

- Articulated Concrete Blocks—Preferred
- Gabions (rip-rap filled wire baskets)

Countermeasure extends from abutment to abutment

Longer Single Span Bridges (>40'):

- Articulated Concrete Blocks—Preferred
- Gabions (rip-rap filled wire baskets)
- Rip-Rap (may be used if excavation depth is not an issue)

Countermeasure extends out from substructure unit 2X the depth of 100 year storm flow (use a minimum of 10' for estimating)

Longer Multi-Span Bridges:

- Gabions (rip-rap filled wire baskets)—Can use if shallow depth water
- Concrete armoring units—Can use on shallow depth water
- Rip-Rap—Can use if deep depth water
- Steel Sheet Piling—Can use if adequate headroom exists to drive piles (preferred)
- Toskanes (A-Jacks)—Can use if deep depth water

Countermeasure extends out from substructure unit 2X the depth of 100 year storm flow (use a minimum of 10' for estimating)

Scour Countermeasure Cost:

Countermeasure Area <5,000 SF:
Countermeasure Area x $50/SF + $100K (site access cost)

Countermeasure Area >5,000 SF:
Countermeasure Area x $40/SF

Judgment must be exercised for the cost of countermeasures when the area approaches the transition of 5,000 SF since the cost does not immediately switch from $50 to $40/SF. It would also be appropriate to consider a site access cost where deemed necessary.

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Item FI – Recommended Scour Countermeasures

The NJDOT Coding Guide presents a list of possible scour countermeasure types in Item FK that could be used. In reality, however, all of the NJDOT projects completed or in design to date have utilized some form of revetment material. The materials most often used include:

Type	Code
Rock riprap	A
Wire enclosed riprap mattresses (Gabions)	B
Articulated Concrete Block System	D
Steel Sheet Piling	G
Concrete Armor Units (Toskanes)	H

The selection of the type of countermeasure will be based upon several factors including the size of the bridge as well as the characteristics of the stream. It will also be dependent on whether other work is required to be performed at the bridge. For example, if the superstructure is being replaced, the use of steel sheeting as a scour countermeasure in front of the abutments can minimize the extent of environmental disturbance. Final selection of the countermeasure type will be dependent on design requirements, as contained in HEC-23 as well as the manufacturer's recommendations.

Some projects are designed solely for the purpose of installing countermeasures. The following is a list of typical situations and the countermeasures that would typically be recommended:

- For short single or short two span structures (typically < 40 feet), the countermeasures will likely extend over the entire opening width between the two abutments. In this case, wire enclosed riprap or an articulated concrete block system are normally recommended. Typically the articulated block system has been favored, because it will normally have a thinner profile and reduce the environmental disturbance. However, for streams where there is a more significant velocity, wire enclosed riprap (gabions) may be necessary. Gabions would also be considered in locations where it may be difficult to obtain a relatively smooth surface for an articulated block mat. Stability issues result when the articulated concrete block system has individual units with a slight projection above the top surface of the mat.

- For longer single span structures (typically > 40 feet) where the abutments require protection, the same types of countermeasures (articulated concrete block and gabions) are recommended. Similar to the previous case, the articulated concrete block system is typically preferred, when it can be installed consistent with the manufacturer's recommendations. If excavation depth for the proper size and depth of stone is not an issue, it may be possible and cost effective to use riprap. In both of these situations, however, the countermeasures will typically extend out a distance of approximately two times the depth of the 100-year flow from the face of the abutment.

- For longer multi-span structures or structures where the pier alone needs to be protected, other factors need to be considered. Articulated concrete block mats generally have not

been used in these situations and would not be recommended. For shallow depth waterways, a gabion mattress or concrete armoring units can be evaluated. For deeper water depths, constructability appears to be an issue with the gabion mattress, so armoring units or riprap should be considered. If there is adequate headroom in these deeper water situations, steel sheeting may also be an adequate countermeasure solution. The current FHWA guidance on the use of riprap at piers is that for existing structures, when adequately designed, it can reduce the risk of failure. Providing the adequate size stone and required depth of the riprap is a constructability issue and potentially increases the extent of environmental disturbance. Little experience with the use of concrete armoring units is currently present in the State. However, the use of a product similar to Toskanes (known as A-Jacks) is being considered at several structures.

Item FJ – Scour Countermeasure Cost

To evaluate the approximate cost of the countermeasures, it is necessary to determine the type and approximate extent that is required. The discussion for Item FI gave some information for determining a conceptual recommended type of countermeasure. The extent is typically dependent on factors related to the bridge geometry and the waterway characteristics. In addition, specific types of revetment materials can have individual requirements related to their use and placement. HEC-23 or the manufacturer's requirements should be consulted for the design placement and determination of the extent and limit of the countermeasures. However, some general rules for estimating the required countermeasure limits are as follows:

- For an abutment, the revetment materials will typically extent out from its face twice the depth of the 100-year flow. This dimension should also be used to determine the placement limits for extending the countermeasure both upstream and downstream from the fascia of the bridge. For those structures with a Stage II In-depth evaluation, the depth of the 100-year flow will have been computed and will be noted within the report. For single span structures, when this dimension extends close to or beyond the centerline of the span the entire opening area should be protected. However, providing a center portion of the span with a natural streambed will minimize the environmental disturbance to the stream and is generally preferred where it can be accommodated.

- For a pier the revetment material will typically extend out from each face of the pier a dimension equal to twice the thickness of the pier. This dimension should also be used to determine the placement limits for extending the countermeasure both upstream and downstream from the fascia of the bridge.

In evaluating the installed costs for the installation of the countermeasures, there does not appear to be a consistent relationship between the area of the required countermeasures and their in-place cost. This is due to the costs for providing access to the site as well as other items, such as dewatering and cofferdams. These elements are still required at structures with smaller countermeasure areas and can be a significant factor in the total cost. At structures with larger countermeasure areas, however, these elements are not as significant a factor in the cost. In addition, for revetment countermeasures, material cost did not appear to have a significant

impact on the installed cost. For example, while stone riprap may be a less expensive material than gabions or articulated concrete block, it requires a thicker depth and more excavation. This acts to offset the savings in material cost. In lieu of a more detailed construction cost estimate, the following can be used to determine a preliminary construction cost for the scour countermeasures:

- For bridges with a countermeasure area of less than 5,000 square feet:

  Countermeasure Area x $50/SF + $100K

- For bridges with a countermeasure area greater than 5,000 square feet

  Countermeasure Area x $40/SF