OFFICE OF BRIDGE DEVELOPMENT
MANUAL FOR HYDROLOGIC AND HYDRAULIC DESIGN

CHAPTER 11, EVALUATING SCOUR AT BRIDGES

APPENDIX E

GUIDELINE FOR OBTAINING SOIL SAMPLES IN STREAMS AND ON FLOOD PLAINS

BRIDGE DEVELOPMENT

This Chapter is currently being rewritten to be consistent with the guidelines set forth in Chapter 14

FEBRUARY 2003

CHAPTER 11, APPENDIX E

GUIDELINE FOR OBTAINING SOIL SAMPLES IN STREAMS AND ON FLOOD PLAINS FOR EVALUATING SCOUR AT BRIDGES

INTRODUCTION

The SHA Interdisciplinary Scour Team has developed this guideline to:

- explain the extent of soils information needed for a bridge scour evaluation,
- provide guidance on how to obtain the soil samples, and
- set forth the roles of the scour team members in conducting the soil sampling program.

The Office of Bridge Development uses the Maryland SHA Bridge Scour Program (ABSCOUR) as the primary tool for evaluating scour at bridges. This program requires certain information on surface and subsurface soils in the stream channel and on the flood plain. Estimated scour depths are usually dependent on the characteristics of these soils, so appropriate samples need to be collected and accurately measured. To accomplish this task, a scour team is formed to prepare and conduct a soil-sampling plan. The challenge to the scour team is to obtain the information needed for the scour evaluation in a reasonable and cost-effective manner.

INTERDISCIPLINARY SCOUR TEAM

Normally, the members of the interdisciplinary scour team will include representatives from Structures H&H, the Bridge Division and the Office of Materials and Technology, Geotechnologic Explorations:

- The Structures H&H member develops and coordinates the soil sampling plan. In addition, he or she conducts a preliminary reconnaissance and scour assessment of the bridge site and provides detailed information on the location of each sample to be taken.
- The Geotechnical Engineer assists in the development of the soil-sampling plan and makes arrangements to collect, test and evaluate the samples.
- The Bridge Project Engineer provides information regarding the structure, design schedules and proposed locations of borings for foundation analysis and design.

CONSULTANT SCOUR STUDIES

Consultants preparing scour reports for SHA bridges or for Federally financed county bridges submit a soil-sampling plan to the SHA similar to the one presented in this guideline. The consultant initiates an early coordination meeting with Structures H&H to present the conceptual plan for conduct of the work. The conceptual plan includes the names of the consultant's interdisciplinary scour team, a schedule for the conduct of the work, and an outline for the completion of Hydrology, Geomorphology, Hydraulic, Soil-Sampling and Scour Reports. Arrangements are made at the early coordination meeting for follow-up meetings to review progress of the work. Decisions are made regarding the soil-sampling plan and who is to do the work. The soil-sampling plan is incorporated in the scour report.

PRELIMINARY SCOUR ASSESSMENT

The Structures H&H Engineer conducts a preliminary scour assessment and reconnaissance of the bridge crossing. Consideration is given to the timing of the soil sampling effort, whenever feasible, to obtain surface stream samples during the summer or fall when stream flow is at a minimum.

The Engineer uses information obtained from this initial visit to make rough estimates of the scour at bridge piers and abutments. If scour depths are excessive, this "heads up" signal is evaluated to decide if proposed locations of piers or abutments should be changed.

The following objectives are accomplished with the preliminary scour assessment and reconnaissance of the bridge crossing:

- pebble counts of the bed load in the stream channel,
- a plan for obtaining sub-pavement samples,
- visual observations of the characteristics of the flood plain soils, vegetation and other features,
- locations where additional samples are needed over and beyond the six sites in Table 1.
- one or more sketches providing complete information to the Geotechs on the location of each flood plain and channel bed sample to be taken.
- photographs and sketches depicting the relationship of the proposed or existing bridge with the stream and its flood plain.

Using information from available reports (Hydrology, Geomorphology and HEC-RAS studies) the Engineer completes the ABSCOUR computations and discusses the results with the Bridge Project Engineer.

Next, the Structures H&H Engineer, in consultation with the Bridge and Geotechnical Engineers, prepares a preliminary soil sampling program. This information is set forth on the Soil Sampling Plan Worksheet (Appendix A).

THE SOIL SAMPLING PLAN AND SCHEDULE

The SHA ABSCOUR program requires soils information at the locations set forth in Table 1.

TABLE 1
Locations of Soil Samples for Scour Evaluations (See Figure 1)

Channel Location	Left Flood Plain	Channel	Right Flood Plain
Approach cross-section	1	2	3
Bridge cross-section	4	5	6

The Structures H&H Engineer determines the location of these sites for the bridge project and works with the Geotechs in developing the sampling plan. . Other samples, in addition to the six locations noted above, are included as needed, particularly if the stream under consideration is not stable.   These other sample locations may include point bars, channel banks, and additional upstream or downstream cross-sections.

The H&H Engineer provides detailed information and sketches to the Geotechnical Engineer regarding the location of each surface sample site. Particular attention is given to ways and means of collecting the sub-pavement samples in the stream bed.

The Geotechnical Engineer arranges for notification of property owners for permission to work on their property.

Sample locations 4, 5 and 6 typically include both surface soil samples and soil borings. The worksheet in Appendix A serves as a convenient means to outline the sampling plan.

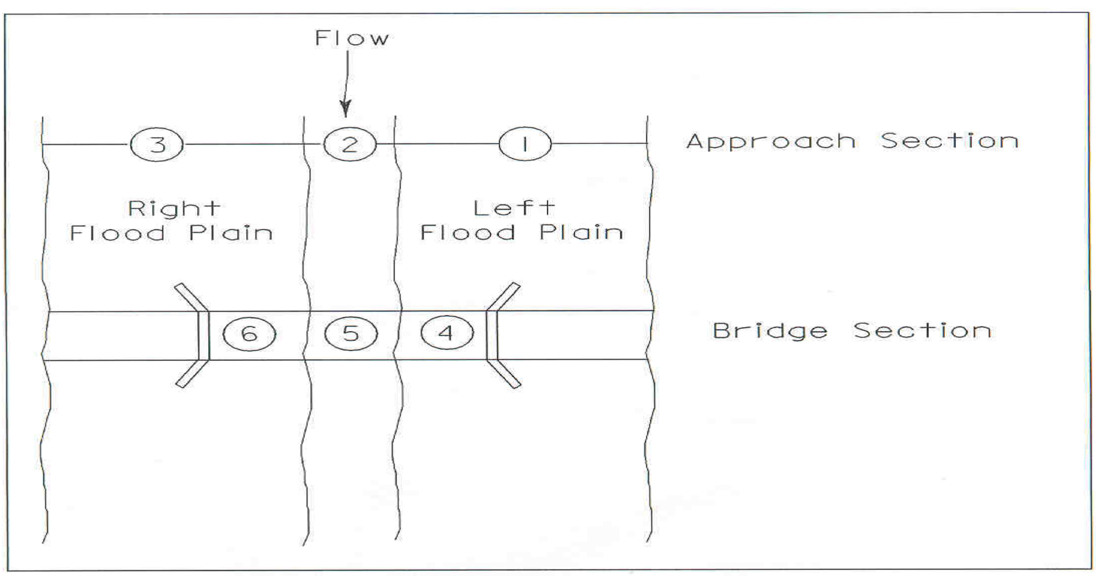

FIGURE I

Locations of Soil Samples for Scour Evaluation

(# denote Sample Locations)

PROCEDURES FOR OBTAINING SAMPLES

The Geotechnical Engineer makes arrangements to collect the following samples.

1. The Approach cross-section

Please refer to Figure 1 and note that sample locations 1 and 3 are on the flood plain at the approach section, upstream of the bridge. In many cases, the flood plain soils are fairly uniform so that one sample at each location will be adequate. The Structures H&H Engineer determines the number of samples required as a part of the preliminary scour assessment and provides a sketch depicting the location of each sample.

For non-cohesive soils, a sample pit with a depth of about 12 inches is dug at the selected sample sites. If the soil is relatively uniform, take one sample from the each pit. If the soil consists of layers of significantly different materials, sample each layer.

The Soils Lab runs a sieve analysis on the bagged samples to determine the particle size distribution and D50 size. Fill in all required information on the tag for each soil sample. Note the location of each sample and plot the locations on maps for inclusion in the scour report.

For cohesive soils, Shelby tube samples can be taken and tests run in the EFA apparatus to measure directly the critical velocity of the soils. If it is not practical to get a Shelby tube sample of the surface soils, other sampling techniques can be used to provide an estimate of the soil's ability to resist erosion. Soils are classified as 1) low resistance to erosion, 2) average resistance to erosion or 3) high resistance to erosion. This classification is based on the Geotechnical Engineer's best judgment of the evaluation of the results of the soil tests. Table 2 provides guidance as to how to use this information in the ABSCOUR analysis. Neill's use of the term competent velocity is equivalent to SHA's use of the term critical velocity

Table 2
Tentative Guide to Competent Velocities for Erosion of Cohesive Material
(From Neill's Guide to Bridge Hydraulics, 1973)

FLOW DEPTH Ft.	COMPETENT MEAN VELOCITIES (ft/sec) *		
	LOW RESISTANCE TO EROSION	AVERAGE RESISTANCE TO EROSION	HIGH RESISTANCE TO EROSION
5	1.9	3.4	5.9
10	2.1	3.9	6.6
20	2.3	4.3	7.4

Recommendations:
Classify very soft or soft soils (loads< 500 psf) as low resistance

Classify medium stiff to stiff soils (loads 500 to 2000 psf) as average resistance
Classify very stiff to hard soils (loads> 2000 psf) as high resistance

The flood plain samples are used to decide if the soil has the strength to resist the estimated flood plain velocities. A vital consideration in this regard is the characteristics of the flood plain vegetation. If the vegetation is very thick and deep rooted, it is likely to protect the underlying soil and keep it from being eroded by the flow on the flood plain. In general, overbank flows have low velocities and shallow depths which do not have the strength to erode thick vegetative covers. Use the information collected on the flood plain and in the channel at the approach section to decide whether scour at the bridge will be live bed or clear water scour. Note the characteristics of the flood plain vegetation on the Appendix A Worksheet.

Use two different sampling techniques for the stream channel:

- Sample the "pavement" or surface layer of stones using the pebble count method. In most cases the Structures H&H Engineer makes the pebble counts during the reconnaissance visit.
- Sample the "sub-pavement" or layer below the surface layer of stones to a depth of 6" to 12" to obtain adequate material to make a sieve analysis. This is accomplished with an open-ended cylinder or, for deeper water, some sort of casing arrangement. Sampling in water deeper than about two feet will present problems. Bed material can vary significantly over the channel width, particularly at bends. Consider taking samples at several locations in the channel cross-section to obtain a representative sample. Sub-pavement sampling requires a joint effort between the Structures H&H Engineer and the Geotechnical Engineer to select the right time of year, pick appropriate sample locations and obtain the right equipment to accomplish the work.

- Measure the thickness of the surface layer of stones. If this pavement is very thin, consisting of only a few layers of "armoring" stones, do not rely on the layer for protection of the stream bed. For such cases, use the D50 size of the sub-pavement. Conversely, if the pavement layer is thick, say 6 inches or more, it is usually reasonable (depending on the stream characteristics) to use the D50 size of the pavement in the scour calculations to determine live-bed or clear water scour.

Special sampling equipment may be needed (wet suit, casing, etc,) if the water in the channel is more than about two feet deep. For very deep streams where the channel bottom is not accessible, it may be necessary to obtain samples from bars. These considerations are evaluated and taken into account by the Structures H&H Engineer when preparing the soil-sampling plan.

2. The Bridge cross-section

Surface Samples

Designate the soil sample locations at the bridge as numbers 4, 5 and 6 (Figure 1). If the bridge spans only the channel, sample locations 4 and 6 do not exist.

Take the surface soil samples at locations 4, 5 and 6 in a manner similar to that described for the approach section. Judgment is needed in selecting sample sites at an existing bridge, because it is common for scour to have occurred under the bridge. In such cases, the scour holes may have filled back in with silt. This silt is easily erodible and is probably not representative of the stream bed at this location. For such cases, determine the bed load material under the silt. Give consideration to obtaining a more representative sample of the stream bed upstream or downstream of the bridge.

The Structures H&H Engineer selects and prepares sketches of the location of all surface samples.

Borings

Soil or rock borings are typically designated at each pier and abutment by the Bridge Engineer for use in the foundation analysis. These borings may also serve as valuable information for the scour evaluation; however, in some cases the foundation borings will not be representative of the flood plain. The Structures H&H Engineer is interested in the soils in front of the abutment whereas the Bridge Engineer may designate the location of the foundation boring well behind the abutment and possibly out of the flood plain. To address this issue, the Structures H&H Engineer reviews the location of the proposed foundation borings with the Bridge Engineer. If necessary, especially for the clear water scour condition, an additional boring of flood plain soils in front of the abutment is taken. For purposes of scour evaluation, extend the borings at least 15 feet below stream bed for small bridges. For major streams, the potential scour at piers or abutments is much greater and the minimum depth of borings for scour is decided on a case by case basis. A minimum of one boring is to be obtained for each sample location in Figure 1 (Locations 4, 5 and 6), except as provided for below.)

The H&H Engineer should plan to be present at the bridge site when borings are taken to review the boring plan with the drilling crew. (Please note that surface sampling can also be accomplished during the visit of the Structures H&H Engineer).

The abutment borings serve to provide additional information about sub surface soils at locations 4 and 6 in Figure 1. The pier borings, depending on the configuration of the bridge, may provide information for locations 4, 5 and 6.

In some cases, there may be a need to obtain additional borings beyond that needed for the foundation analysis. Typical examples include:

- If there are no piers in the channel, take at least one boring in the stream channel. (Note: for small bridges, the abutment borings may indicate that subsurface conditions are consistent at each abutment. Therefore, a third channel boring may not be needed.) Generally, consider drilling the channel boring to the same depth as the abutment borings. This information is used by the Geotech to prepare a profile or cross-section of the subsurface soils at the bridge.

- For purposes of the foundation analysis, a core size of 1 3/8 inch internal diameter is normally specified. If the subsurface material is coarse gravel or cobbles, however, the small core diameter will be inadequate to obtain a reasonable estimation of the D50 size of the material. In this case additional subsurface exploration techniques are used to obtain the particle size distribution of the underlying material.

The subsurface exploration serves to provide an overview of the types of materials at the bridge. It will also indicate whether the subsoils tend to be homogeneous, or whether there are subsurface layers with different properties such as sand, gravel, clay, or rock.

If the subsurface material consists of cohesive soils, samples can be obtained with Shelby tubes and tested in the EFA Apparatus to obtain the critical shear strength of the material. The Structures H&H Engineer in consultation with the Bridge and Geotechnical Engineers determines if Shelby tube samples are needed for the sampling plan. SHA is in the beginning stages of use of the EFA Apparatus; therefore, the number of requests for the conduct of critical shear strength tests may need to be limited.

If the subsurface material is rock, determine the properties of the rock with respect to its resistance to scour. As a minimum, determine the RQD of the rock and request the opinion of the SHA Geologist as to its resistance to scour. If the potential for scour in the rock is significant, the Interdisciplinary Scour Team should evaluate the competency of the rock and decide if additional information (analysis using the erodibility index method, etc.) is necessary.

If the subsurface material is sand, one or two samples are adequate unless there is a *significant change* in the makeup of the material. (from fine sand to medium sand; from very coarse sand to very fine gravel, etc.). Additional samples are taken as necessary for layered materials (See below). Sieve analyses should be run on these samples and the D50 size reported for each sample taken. The depths and elevations of the samples should be included in the soil boring report.

If the subsurface material is gravel or cobbles, the standard 1 3/8-inch core will not be wide enough to obtain a representative sample for a determination of the D50 particle size. For such cases, it may be feasible to use an oversize split spoon sampler or an auger to obtain the sample size required to get a representative particle size distribution and D50 of the material.

In some cases, it may be feasible to obtain a representative sample of the coarse material subsoils by getting the auger sample from the flood plain near the stream bank. If the sample must be taken in the streambed, it may be feasible to set a casing down into the mud line, and then auger inside the casing to keep the sample from being washed away when it is extracted. The ground elevation of each boring needs to be determined so that the boring log can be correlated with the stream bed elevation and the bridge foundations. When it becomes difficult for the drilling crew to establish accurate ground elevations, a minimum requirement is to tie in the ground at the boring location to a bridge feature (low steel elevation, bridge deck elevation, etc.) and to document the measurements on the boring log)

Arrangements for sampling coarse bed materials are made by the drilling crew. The crew should be familiar with the procedures to be used and the equipment needed to take samples of coarse bed materials. All necessary equipment should be brought to the project site. Planning for such eventualities should be a part of the Soil Sampling Plan.

After obtaining the completed boring logs, the Geotechnical Engineer plots the subsurface profile of the soils under the bridge. This plot includes, as appropriate, the elevations of the flood plains, the channel bed, pier and abutment footings and pile tip elevations, when available. The Structures H&H Engineer will provide this information.

APPENDIX E-1

SOIL SAMPLING PLAN FOR EVALUATING SCOUR AT BRIDGES

PRELIMINARY PLAN (STRUCTURES H&H ENGINEER) _______
FINAL SOIL-SAMPLING PLAN (GEOTECHNICAL ENGINEER) _______

PROJECT NUMBER ____________________________________ DATE__________

Interdisciplinary Scour Team:

Office of Bridge Development
Structures H&H ______________________________________
Bridge Project Engineer ________________________________
Geotechnologic Explorations Unit ______________________________

RESPONSIBILITY FOR OBTAINING SAMPLES

1. Pebble Counts: Structures H&H
2. Locating all other samples: Structures H&H
3. Taking all other samples: Geotechnical Engineer with assistance from Structures H&H Engineer (Sub-pavement samples, etc.)

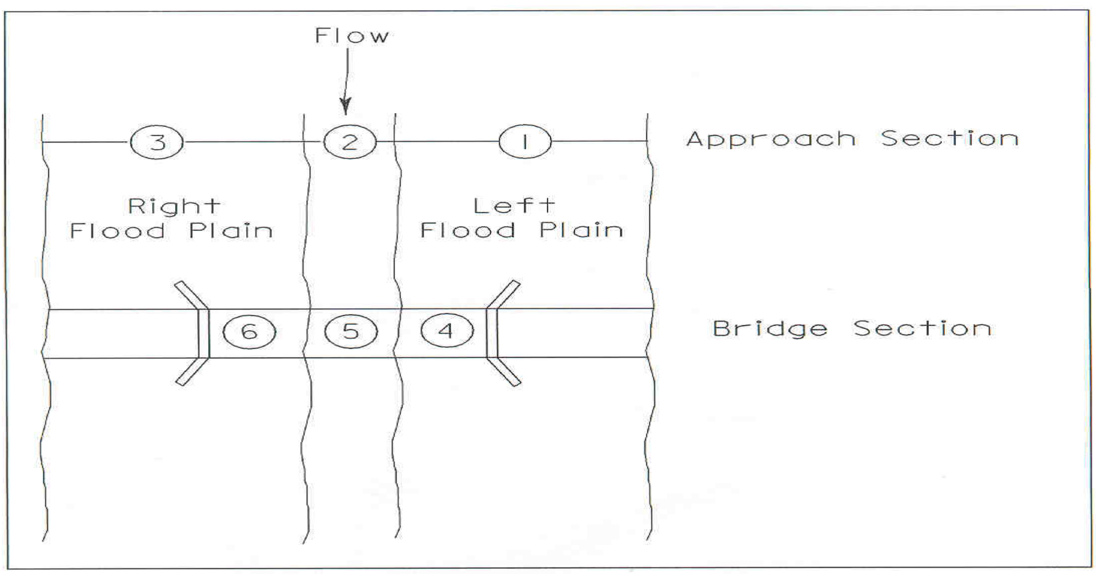

FIGURE I

Locations of Soil Samples for Scour Evaluation

(# denote Sample Locations)

SAMPLE LOCATION SITES

Upstream distance to Approach Section from Bridge ________________________

Provide sketch(s) of locations of all sample sites
Soil Samples – document the soil sample identification numbers and locations (bag samples and borings) on Figure 1

Locations of additional sample sites (Describe, identify and note on sketch)

____
____
____
____
____

DATA COLLECTION PLAN AT SOIL SAMPLE SITES

	Left Flood Plain	Channel	Right Flood Plain
	APPROACH CROSS-SECTION		
Sample Number (Figure 1)	**1**	**2**	**3**
Granular Soils			
D50- top layer			
D50 – 2nd layer			
D-50 – 3rd layer			
Cohesive Soils			
Erodibility Classification – Sample #1			
Erodibility Classification– Sample #2			
Pavement D50 from Pebble Counts			
Thickness of Pavement			
Sub-pavement D50			
Cohesive Soils			
Erodibility Classification – Sample #1			
Erodibility Classification– Sample #2			
Description of Flood Plain; Estimated Manning's "n" values			

	BRIDGE CROSS-SECTION SURFACE SOIL SAMPLES		
Sample Number (Figure 1)	**4**	**5**	**6**
Granular Soils			
D50- top layer			
D50 – 2nd layer			
D-50 – 3rd layer			
Cohesive Soils			
Erodibility Classification – Sample #1			
Erodibility Classification– Sample #2			
	Left Flood Plain	Channel	Right Flood Plain
Pavement D50 from Pebble Counts			
Thickness of Pavement			
Sub-pavement D50			
Cohesive Soils			
Erodibility Classification – Sample #1			
Erodibility Classification– Sample #2			
	BRIDGE CROSS-SECTION SUB-SURFACE SOIL SAMPLES		
PROVIDE THE FOLLOWING INFORMATION FOR EACH BORING			
Sample Number (Figure 1)	**4**	**5**	**6**
Boring Number and Location (Plot on Figure 1)			
D50 , depth and elevation of each granular soil sample taken from the boring			
Depth, elevation and critical shear stress for each cohesive soil sample (Shelby tube)			
Need for further testing (erodibility index, etc.)			
All descriptive information for rock Cores including RQD			
Elevation of bottom of existing or proposed footing			
Estimated elevation of pile tips			
Use the boring data to plot a cross-section or profile of the subsurface soils under the bridge.			