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U.S. Geological Survey

Software User's Guide for Determining the Pennsylvania Scour Critical Indicator Code and Streambed Scour Assessment Rating for Roadway Bridges

by Mark F. Henneberg and Jeffrey L. Strause

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CONVERSION FACTOR AND ABBREVIATION

Multiply	By	To obtain
foot (ft)	0.3048	meter

Software User's Guide for Determining the Pennsylvania Scour Critical Bridge Indicator Code and Streambed Scour Assessment Rating for Roadway Bridges

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ABSTRACT

This report presents the instructions required to use the Scour Critical Bridge Indicator (SCBI) Code and Scour Assessment Rating (SAR) calculator developed by the Pennsylvania Department of Transportation (PennDOT) and the U.S. Geological Survey to identify Pennsylvania bridges with excessive scour conditions or a high potential for scour. Use of the calculator will enable PennDOT bridge personnel to quickly calculate these scour indices if site conditions change, new bridges are constructed, or new information needs to be included. Both indices are calculated for a bridge simultaneously because they must be used together to be interpreted accurately. The SCBI Code and SAR calculator program is run by a World Wide Web browser from a remote computer. The user can 1) add additional scenarios for bridges in the SCBI Code and SAR calculator database or 2) enter data for new bridges and run the program to calculate the SCBI Code and calculate the SAR. The calculator program allows the user to print the results and to save multiple scenarios for a bridge.

INTRODUCTION

The Scour Critical Bridge Indicator (SCBI) Code and Scour Assessment Rating (SAR) use algorithms to rate bridge sites for observed and potential streambed scour on the basis of U.S. Geological Survey (USGS) field observations and (or) existing Pennsylvania Department of Transportation (PennDOT) data (Cinotto and White, 2000, p. 24).

In 1993, PennDOT initiated a cooperative project with USGS to assess approximately 13,800 bridges for streambed scour. USGS personnel completed scour assessments at all sites by November 2000. Scour conditions documented during USGS assessments in Pennsylvania are limited to a one-time visit; yet, scour is a dynamic process and conditions can change frequently. PennDOT needs to incorporate the effects of changing site conditions in the SCBI Code and SAR and to determine new values with updated bridge-site data. It is anticipated that PennDOT also will use the Web-based calculator to determine SCBI Code and SAR values for new bridges and other bridges that may not have been included in the original USGS/PennDOT investigation, hereafter termed USGS/PennDOT Bridge Scour Project.

The SCBI Code was developed by PennDOT and the SAR by PennDOT and USGS as a means to identify Pennsylvania bridges with excessive scour conditions or a high potential for scour. The two indices are considerably different and must be used together to be interpreted accurately. Whereas the SCBI Code primarily is directed to satisfy the 1988 Federal Highway Administration (FHWA) mandate, the SCBI Code and SAR are designed to work in conjunction with each other (Cinotto and White, 2000, p. 24); (Federal Highway Administration, 1988, 1991).

The Web-based approach taken with the SCBI Code and SAR calculator requires a permanent network location to host the program. For additional information about SCBI Code and SAR calculator or to inquire about access to the calculator, contact: Charles E. Carey, P.E., Bridge Quality Assurance Division, Pennsylvania Department of Transportation, P.O. Box 3560, Harrisburg, PA 17105-3560 (telephone 717-787-7284).

Purpose and Scope

This report provides instructions for using the Web-based SCBI Code and SAR calculator developed by USGS in cooperation with PennDOT. Included in this report are the contributing factors and algorithms for the two scour indices and a user's guide for the Web-based SCBI Code and SAR calculator. Various hydraulic, hydrologic, and structural data components are used by the calculator. The user can use new and current data to determine the indices. This report is intended to serve as a guide for use of the Web-based SCBI Code and SAR calculator by PennDOT bridge engineers and inspection personnel.

Scour Critical Bridge Indicator Code

The SCBI Code indicates the vulnerability of the bridge to future scour. The SCBI Code is based on the FHWA code (NBI Item 113) (Federal Highway Administration, 1989) and PennDOT's interpretation of the FHWA Code (Bryan Spangler, Pennsylvania Department of Transportation, written commun., 1999). The SCBI Code contains a whole number between 9 and 2. Each code number has one or more cases. Codes and cases are not a straightforward numeric sequence, they describe a specific type of site condition only; for example, a code 6 is not necessarily better or worse than a code 5 (Cinotto and White, 2000, p. 24).

The SCBI Code and SAR calculator uses various factors from the field or office scour evaluations to determine the SCBI Code for individual **subunits**[1] and the bridge. The data fields that must be complete to determine the SCBI Code for each substructure unit, hereafter termed a bridge subunit, are found in table 1.

Table 1. Scour Critical Bridge Indicator Code and Scour Assessment Rating data components

[PennDOT BMS, Pennsylvania Department of Transportation Bridge Management System]

Scour Critical Bridge Indicator Code	Scour Assessment Rating
Subunit type	Subunit type
Subunit foundation type	Subunit foundation type
Scour condition (PennDOT BMS Entry W11A.2)	Scour condition (PennDOT BMS Entry W11A.2)
Evidence of movement	Change since last inspection (PennDOT BMS Entry W11A.1)
Wingwall presence and condition	Under-bridge streambed material OR streambed material near the subunit (PennDOT BMS Entry W07)
Under-bridge streambed material	Countermeasure presence, location, and condition
Trapping potential	Evidence of movement
Debris potential	Structural configuration and material (PennDOT BMS entry C05A)
Debris vertical and horizontal location	
Evidence of pressure flow	

The complete original procedures for determining the SCBI Code can be found in Cinotto and White (2000). The SCBI Code algorithm used by the Web-based SCBI Code and SAR calculator was modified from Cinotto and White (2000) to eliminate the comparisons of USGS and PennDOT data. The modified algorithm can be found in appendix C of this report.

Scour Assessment Rating

The SAR is composed of component values for each bridge subunit and selected site conditions that are combined to provide an overall bridge rating from 0 to 100. It was designed by PennDOT and USGS to incorporate all factors that could lead to **hydraulic** failure at a bridge site. The SAR indicates the observed scour condition of a bridge site and generally can be interpreted as 100 to 80 = good, 79 to 51 = average, 50 to 20 = potential problems, and 19 to 0 = poor; however, all bridge-site data must be reviewed before making this interpretation (Cinotto and White, 2000, p. 24).

[1] Words presented in **bold** type are defined in Appendix A of this report.

The calculator uses various factors determined during field or office scour evaluations to compute the SAR for individual subunits and the bridge. Factors noted as PennDOT Bridge Management System (**BMS**) entries are described in PennDOT (1993). The data fields that must be complete to determine the SAR for a bridge subunit are found in table 1.

The complete original procedures for rating a subunit and a bridge can be found in Cinotto and White (2000), including the stipulation that the SAR be assigned a value of 999 for a bridge where the data noted above are incomplete or missing. The SAR algorithm used by the Web-based calculator was modified from Cinotto and White (2000) to eliminate comparisons of USGS and PennDOT data. The modified algorithm can be found in appendix D of this report.

Previous Investigations

Cinotto and White (2000) describe procedures for the assessments by USGS of streambed scour at nearly 13,800 bridges in Pennsylvania during 1994-2000. Procedures were included for field-view and office-review assessments along with the rationale and procedure for calculating the SCBI Code and SAR. The instructions in this report expand on procedures for calculation of the SCBI Code and SAR presented in Cinotto and White (2000) and also use selected data from the PennDOT BMS (Pennsylvania Department of Transportation, 1993).

Acknowledgments

The authors thank Bryan Spangler, P.E., and Charles Carey, P.E., of PennDOT for providing information and technical advice. Many USGS staff also contributed to this report. Kevin J. Breen and Kirk E. White have provided leadership and invaluable assistance throughout the course of the project. Peter J. Cinotto and Raymond G. Davis, Jr., helped test and review the Web-based calculator.

WHEN TO USE THE SCOUR CRITICAL BRIDGE INDICATOR (SCBI) CODE AND SCOUR ASSESSMENT RATING (SAR) CALCULATOR

This Web-based calculator was developed to determine the SCBI Code and SAR values for four different situations. The calculator allows PennDOT bridge-inspection personnel to determine the SAR and SCBI Code when:

- review of bridge records identify previously undetermined or unknown PennDOT historical data or revised USGS field data needed to calculate the SCBI Code and SAR
- site conditions change and the original SCBI Code and SAR values no longer reflect current site conditions
- new scenarios are developed
- new bridges are constructed or other bridges are identified for calculation of the SCBI Code and SAR

Review of Bridge Record Data

A population of bridges are present that have not had the SCBI Code or SAR calculated because data components required for the calculations could not be determined. Review of available bridge records has provided the needed data components for many of these bridges. The SCBI Code and SAR calculator allows PennDOT bridge personnel to quickly calculate scour values for these bridges.

Revisions to Field Data Resulting From Changes in the Stream Channel or Site Conditions

Many variables can change at bridge sites. However, only specific variables will have any affect on the SCBI Code or SAR. These variables may change as review of bridge files uncovers previously unknown data or as a result of changes in the site conditions since the original assessment. All the data fields that can be entered or changed with the SCBI Code and SAR calculator affect the SCBI Code or the SAR.

Scenario Testing

The SCBI Code and SAR calculator can be used to test and save multiple scenarios for each bridge. For example, if a bridge has an **advanced scour** condition at a **pier** and the PennDOT personnel responsible for the structure plan to add countermeasures, such as backfilling the scour hole and adding **riprap** to the area, the district bridge personnel can see how these changes will affect the code and rating before starting the job. An additional use can be developing scenarios for bridges with insufficient data for complete USGS/PennDOT Bridge Scour Project field-view or office review assessments. As previously unavailable data are found, scenarios can be developed to accommodate these bridges.

New Structures or Other Bridges Identified for Calculation of the SCBI Code and SAR

Any bridge structure not assessed previously by USGS is considered a "new" structure in the calculator. This includes bridges less than 20 ft in length, bridges built after 1983, or culverts. These structures were not part of the USGS/PennDOT Bridge Scour Project.

GUIDE FOR USING THE SCBI CODE AND SAR CALCULATOR

The remaining sections of this report describe the procedures used to operate the calculator. The calculator has two main pages, a bridge-selection page and an SCBI Code and SAR calculations page. The user's guide section is broken down by page and data component. Figures illustrate the values available for individual data components. The procedures also can be viewed online by reading the information files.

System Requirements

Using a Web-based approach for the SCBI Code and SAR calculator results in few requirements on the user's PC. These requirements are:

- Screen resolution of at least 1024 × 768 pixels
- Either Microsoft Internet Explorer version 5.0 or later, or Netscape Navigator version 6.0 or later
- A connection to the PennDOT computer network

Bridge-Selection Page

The bridge-selection page (fig. 1) is the initial user interface to the Web-based calculator. The two options are 1) retrieve data for existing bridges (those bridges already in the database for the USGS/PennDOT Bridge Scour Project), and 2) launch the data-entry routine for new bridges (bridges not in the USGS/PennDOT Bridge Scour Project database).

To select an existing bridge, choose a county first by clicking on the "Change County" dropdown list box, select the county number of the desired bridge, and click on "Refresh." The page will regenerate with an updated bridge list (in the format bridge number - serial number XXXXXXXXXXXXXX- YYYYY) for the county selected in the existing bridge number dropdown list box. Click on the "Select Existing Bridge Number" dropdown list box, select the desired bridge, and click on the "Go" button. The SCBI Code and SAR calculations page will load with either the USGS/PennDOT Bridge Scour Project assessment data or the initial saved scenario for bridges not assessed by USGS.

To create a new bridge in the USGS/PennDOT scour calculator database and run it through the calculator, click on the "Enter Data for New Bridge Number" button. This action will load the SCBI Code and SAR Calculations page with empty fields for all the SCBI Code and SAR components. Select the desired values as described in the SCBI Code and SAR Calculations Page section of this report. Either calculate the SCBI Code and SAR by clicking the "Calculate" button or save the new scenario for the new bridge. Enter a new bridge number in the empty field and click on the "Save New Scenario" button. Because the new bridge does not have USGS assessment data, the scenarios will begin with number 2. Scenario number 1 always is USGS assessment data.

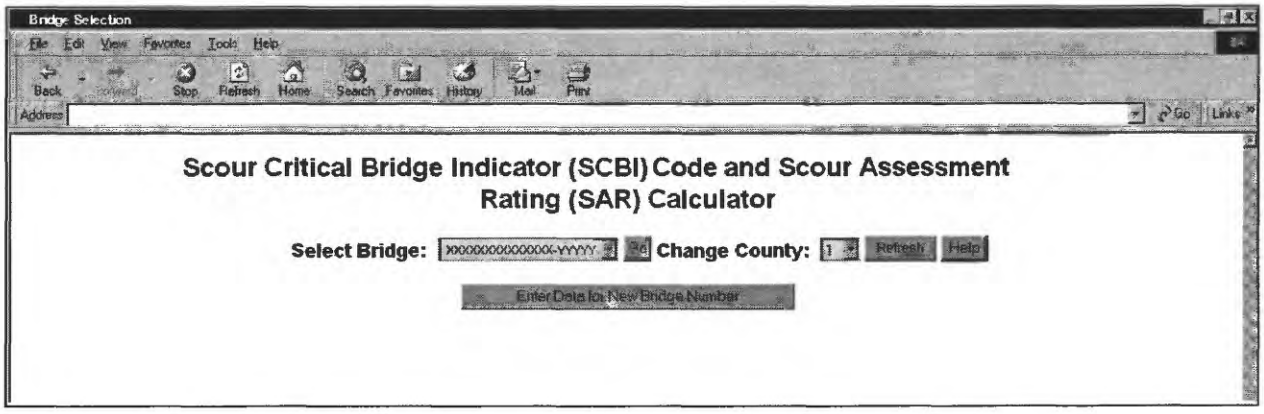


Figure 1. Example display of bridge-selection page for the Scour Critical Bridge Indicator Code and Scour Assessment Rating calculator.

SCBI Code and SAR Calculations Page

Various navigation features of the calculations page allow the user to move easily to different calculator features (fig. 2). The top button functions (Save New Scenario, Reformat for Print, and Calculate) are discussed later in this report. The main navigation function on this page is the "Return to Bridge Selection page" link. Clicking on this link will display the Bridge-Selection page. The browser's navigation toolbar also may be used to navigate forward or back.

The Comments field may be used to store any text comments pertinent to an individual scenario. Each saved scenario will save the present comments with the data values. Comments may be up to 255 characters long.

Entering and Editing Data

The calculator has been designed to minimize data-entry errors by using dropdown list boxes wherever possible. Care still must be taken to insure the correct values are selected from the list box. The following section will address data entry for specific components of the calculator.

Abutment Data

The **abutment** data section consists of six data fields. The fields include values for abutment type, abutment foundation type, scour condition, movement, change since last inspection, and **streambed material** near the subunit. Abutment data must be chosen from the dropdown list box. Abutment data must be complete for both **near** (**NAB**) and **far** (**FAB**) abutments. Click on the dropdown arrow and select the desired abutment data from the list. Any values other than what appear in the dropdown list box will not be accepted by the calculator, except for streambed material. Some early USGS assessments did not have the W07 field included in the assessment, so a null value is acceptable. The calculator will use the underbridge bed material for these bridges as noted in the algorithms (see Appendixes). Note that there are selections of P7 and P8 as well as C7 and C8 in the W07 list. The values P7 and C7 are identical, as are P8 and C8. USGS continued to use the "P" values when PennDOT started using the "C" values. Both values are treated the same by the calculator, but the user only should use the "C" values because this is what PennDOT currently (2001) uses. The available selections are listed in figure 3.

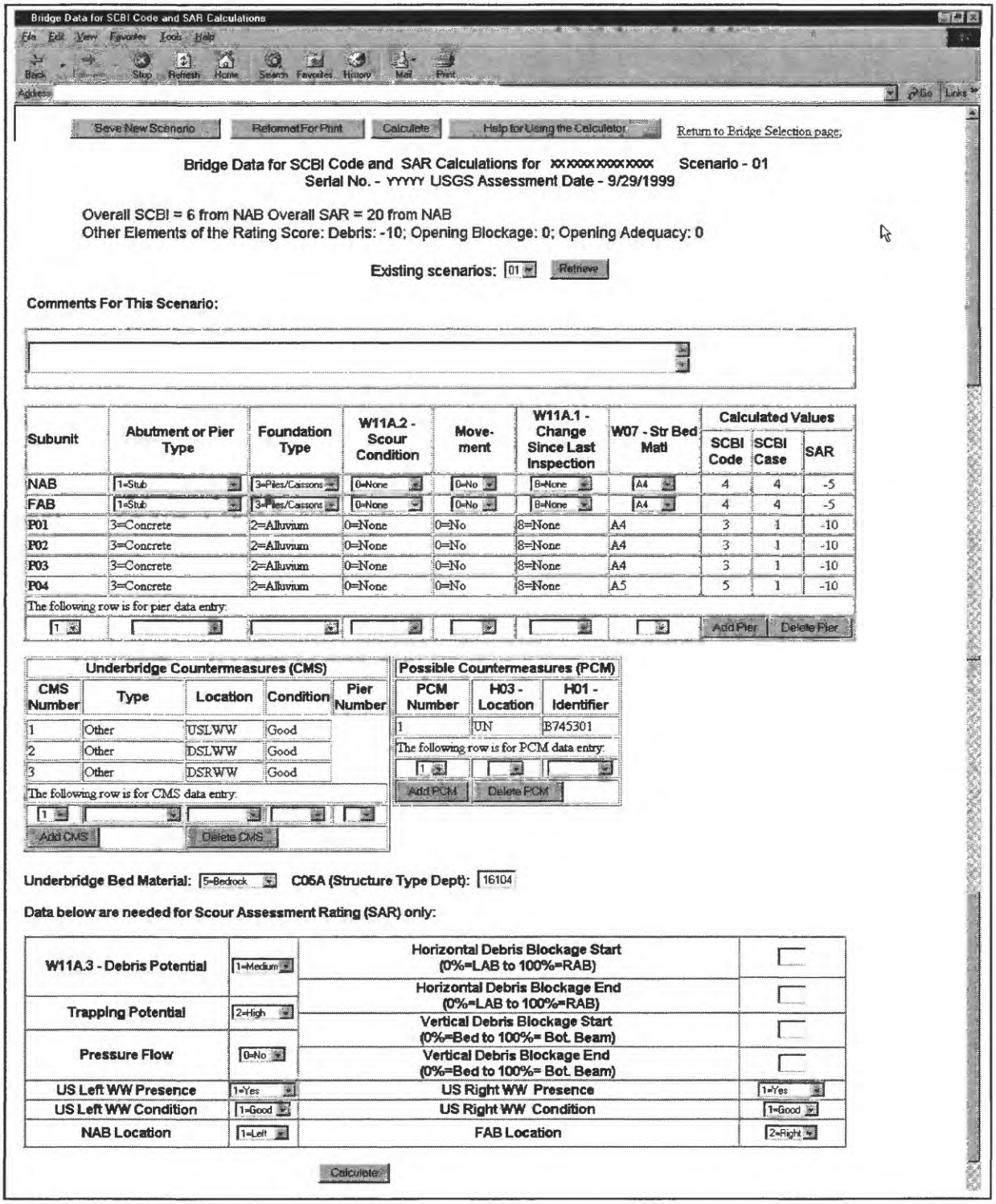


Figure 2. Example display of Scour Critical Bridge Indicator Code and Scour Assessment Rating calculations page.

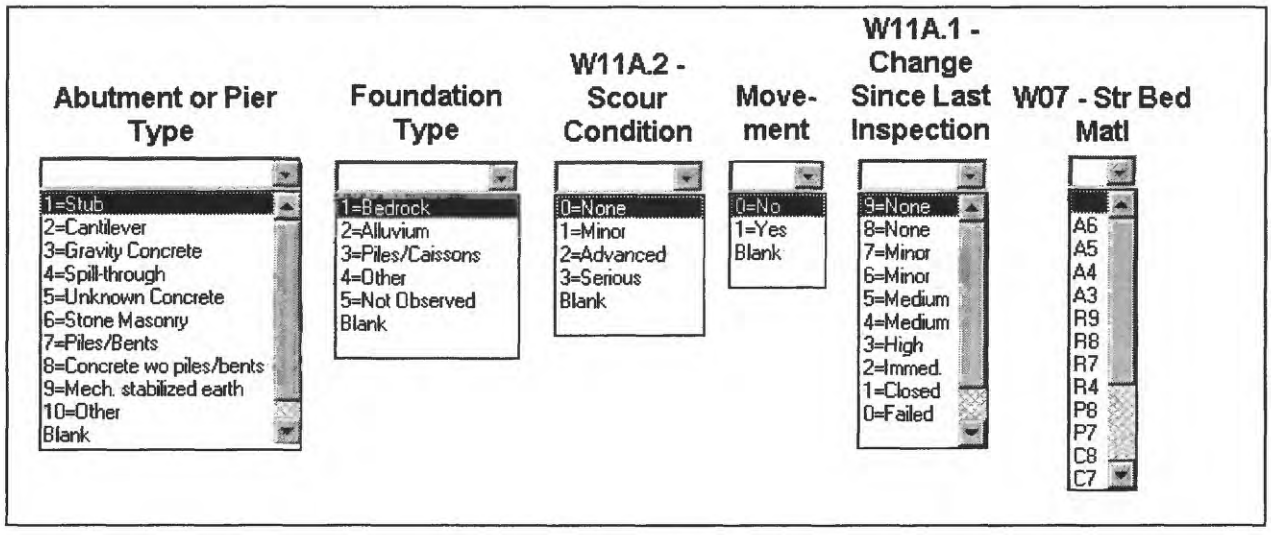


Figure 3. Abutment data values for the Scour Critical Bridge Indicator Code and Scour Assessment Rating calculator.

Pier Data

The pier data section consists of seven data fields. The fields include values for pier number, pier type, pier foundation type, scour condition, movement, change since last inspection, and streambed material near the subunit. Pier data may be entered following procedures similar to those used for abutment data. Select the appropriate value from the dropdown list for the field. Repeat for the next field until all the data are entered. Click on the "Add Pier" button. The page will regenerate and the abutments/pier section will reflect the new pier data. Pier data cannot be edited in the same manner as the abutment type data fields even though the display is similar. The entire record for the pier must be deleted. A new pier then can be created using the original pier number and added to the abutment/pier table. Up to 99 piers can be entered for a bridge. Note that there are selections of P7 and P8 as well as C7 and C8 in the W07 list. The values P7 and C7 are identical, as are P8 and C8. USGS continued to use the "P" values when PennDOT started using the "C" values. Both values are treated the same by the calculator, but the user only should use the "C" values because this is what PennDOT currently uses. The available selections are shown in figure 4.

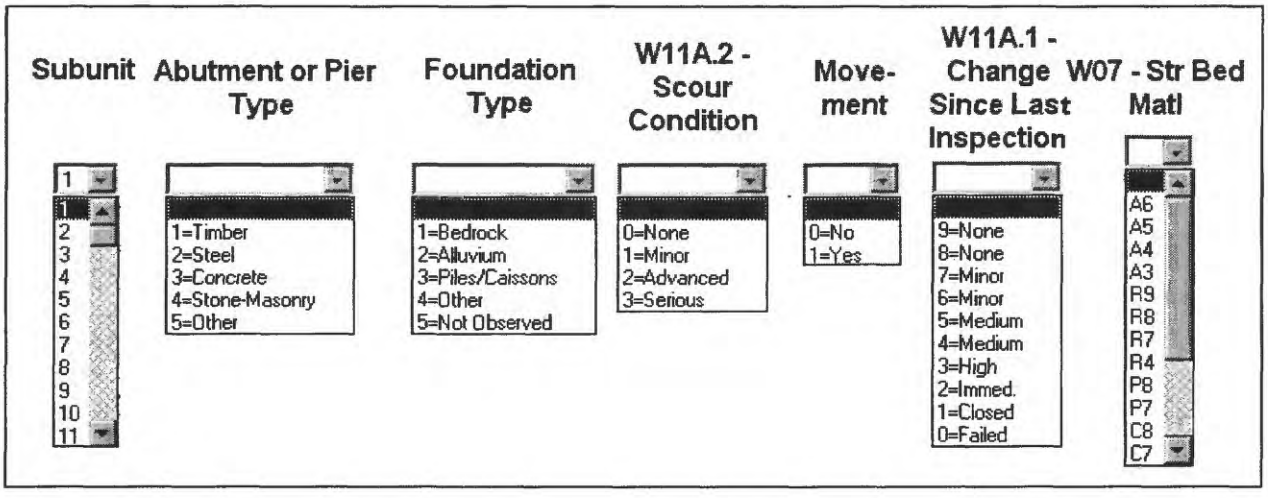


Figure 4. Pier data values for the Scour Critical Bridge Indicator Code and Scour Assessment Rating calculator.

Underbridge Countermeasures

The underbridge **countermeasures** section contains five data fields. The fields include countermeasure number, type, location, condition, and pier number (if applicable). The fields can be entered and edited by following procedures similar to those used to add or edit a pier. Select the appropriate value for the field from the dropdown list box and move to the next field. When all the fields are complete, click "Add CMS" and the page will be regenerated with the updated countermeasures table. Up to 99 underbridge countermeasures can be entered for a bridge. Multiple countermeasures may be created for a subunit, but each countermeasure must be entered individually. Note that the pier number field must remain blank if the countermeasure is not at a pier. The countermeasure records cannot be edited individually. To edit a record, delete the incorrect record and create a new countermeasure record with the original countermeasure number and correct values. The pier number dropdown list box is for countermeasures with a "4 = Pier" for the location value. Each countermeasure at a pier must be associated with the specific pier it is intended to protect. The available selections are shown in figure 5.

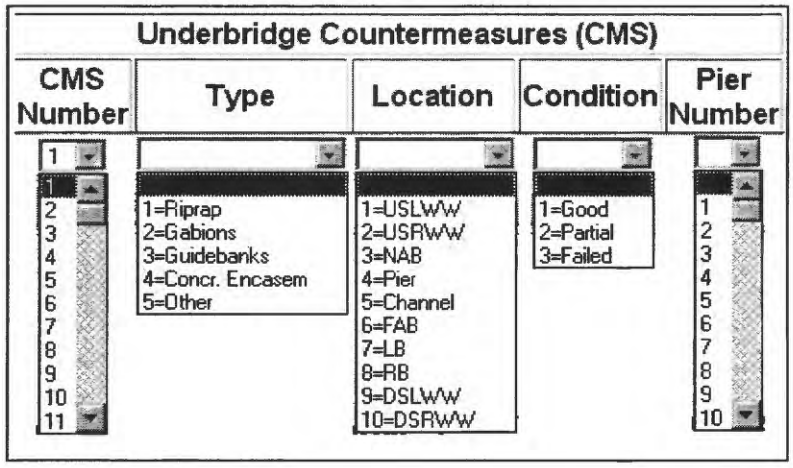


Figure 5. Underbridge countermeasure data values for the Scour Critical Bridge Indicator Code and Scour Assessment Rating calculator.

Possible Countermeasures

The possible countermeasures section contains three data fields. The fields include countermeasure number, location, and identifier. The fields can be entered and edited by following procedures similar to those used to add or edit underbridge countermeasures. Select the appropriate value for the field from the dropdown list box and move to the next field. When all the fields are complete, click "Add PCM" and the page will be regenerated with the updated possible countermeasures table. Up to 99 possible countermeasures can be entered for a bridge. The possible countermeasure records cannot be edited individually. To edit a record, delete the incorrect record and create a new possible countermeasure record with the original possible countermeasure number and correct values. The selections available are listed in figure 6.

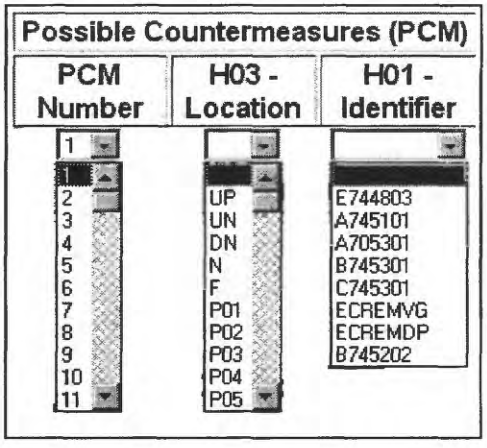


Figure 6. Possible countermeasure data types for the Scour Critical Bridge Indicator Code and Scour Assessment Rating calculator.

SAR Components

The SAR components section of the calculator contains 13 data fields. All these fields only are used in determining the SAR and have no affect on the SCBI Code. Nine of the fields can be edited by clicking on the dropdown list box and making a selection (figs. 7 and 8). The remaining four fields are for debris blockage dimensions and are in percentages (fig. 9). The horizontal debris blockage begins at the **left abutment (LAB)** with 0 percent and ends at the **right abutment (RAB)** with 100 percent. The vertical debris blockage begins at the streambed with 0 percent and ends at the bottom beam with 100 percent. A bridge with a debris pile that extends from 30 percent to 55 percent horizontally and from 15 percent to 30 percent vertically is shown in figure 9. If there is no debris present, the debris fields may remain blank. The selections for the nine selectable data fields are listed in figures 7 and 8.

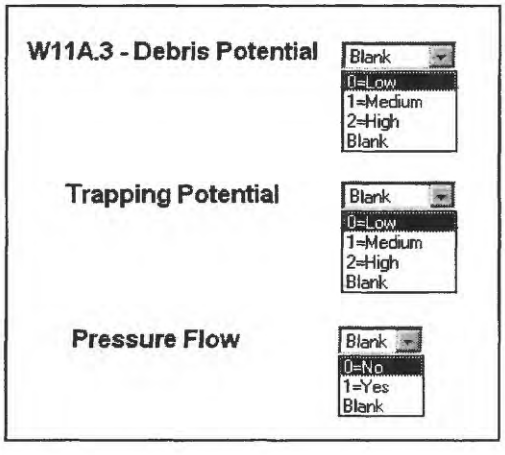


Figure 7. Scour Assessment Rating-only component data types for the Scour Critical Bridge Indicator Code and Scour Assessment Rating calculator.

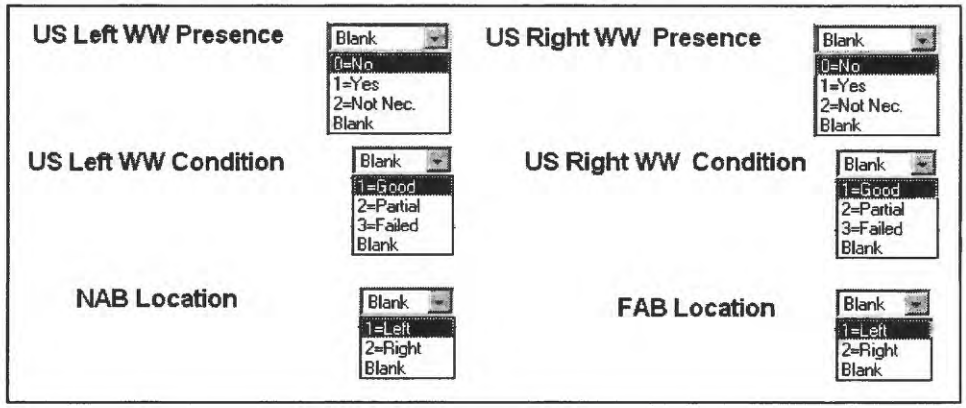


Figure 8. Wingwall data types for the Scour Critical Bridge Indicator Code and Scour Assessment Rating calculator.

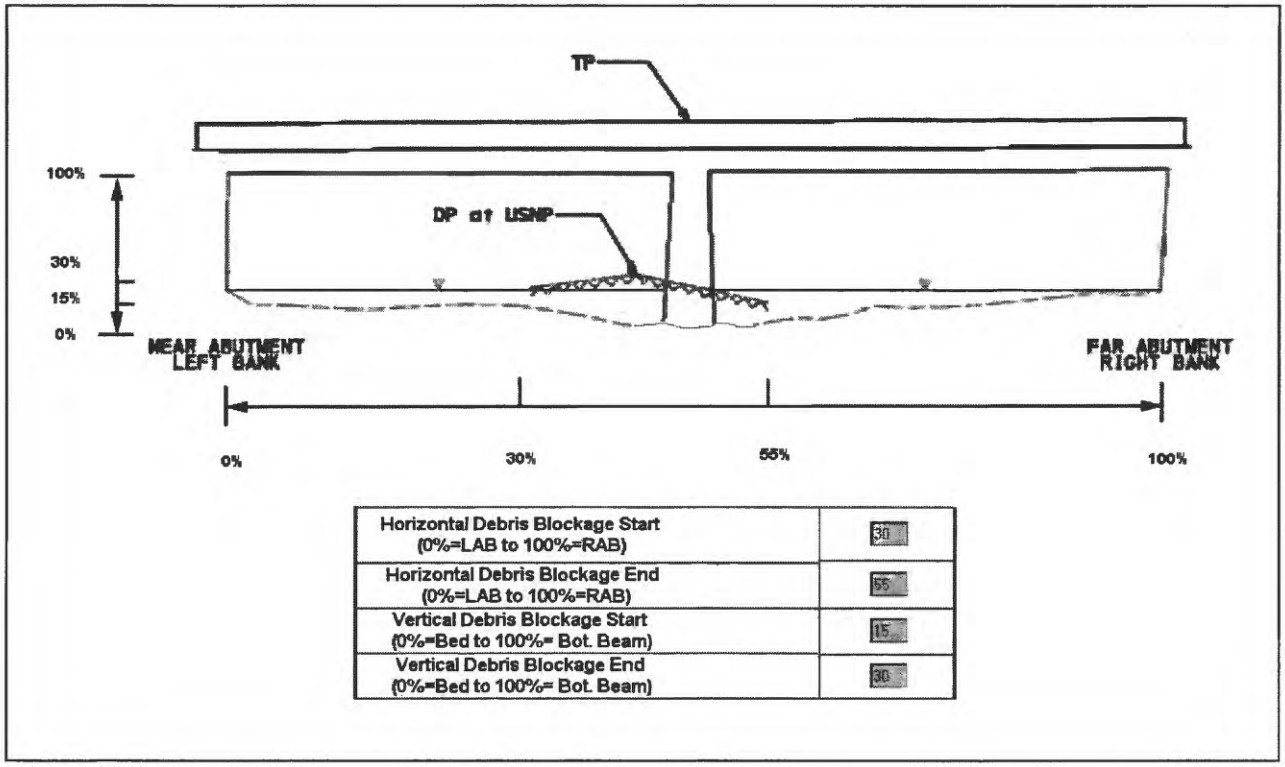


Figure 9. Debris blockage schematic and corresponding data-entry values for the Scour Critical Bridge Indicator Code and Scour Assessment Rating calculator.

Structure Type and Bed Material

The final two data components used by the calculator are the Structural Configuration and Material (C05A) and Underbridge Bed Material fields. The C05A component is a 5-digit field designating the structure type and materials used in construction. This component affects bridges that score with an SCBI Code 8, because an SCBI Code of 8 indicates culverts or bridges founded on competent bedrock. The underbridge bed material is a field completed during USGS scour assessments. For some bridges assessed prior to 1996, no W07 was completed. The underbridge streambed material was used to compute the SCBI Code and SAR for these bridges, and it is not needed for new bridges or new scenarios. The structure type and bed material data entry fields can be found in figure 10.

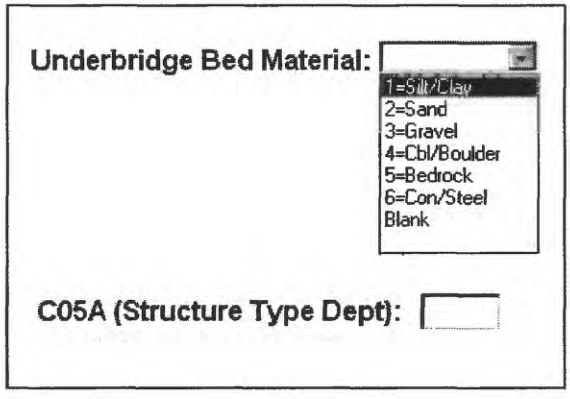


Figure 10. Underbridge bed material and structure type for the Scour Critical Bridge Indicator Code and Scour Assessment Rating calculator.

Calculating the SCBI Code and SAR

To calculate the SCBI Code and SAR for a bridge, click on the "Calculate" button at the top or bottom of the page. The Web page will regenerate and the SCBI Code and SAR will be displayed in red if the calculations were completed. If any data were missing or incorrect, a warning message will be displayed identifying the field that needs to be edited.

The calculator has been designed to provide error checking for most input variables before calculations can be performed. The SCBI Code and SAR will be determined only for bridges with complete and legitimate data sets. If a data set is missing data or an incorrect value has been entered for a variable, a warning message will be displayed at the top of the page and the calculations will not be completed. The identified field must be rectified before attempting to run the calculations again. Special situations may arise where the user wishes to enter a bridge with only one abutment. The calculator will not save a scenario with only one abutment. To enable saving a bridge with only one abutment, enter identical values into the missing abutment data fields, creating two identical abutments. This action will allow the calculator to save the scenario and it will not affect the algorithms.

Saving and Deleting Scenarios

The database for the calculator is designed to store up to 99 individual scenarios for each bridge number. If the bridge was assessed previously by USGS, scenario number 1 always will display USGS data. Saving a scenario is a two-step process. The first step is to verify all the information to be included with the scenario is on the SCBI Code and SAR Calculations page. Then click on the "Save New Scenario" button. The scenario will be saved to the database and auto-numbered by the calculator. The scenario number will appear in the "Existing Scenarios" dropdown list box and will append the bridge number in the title.

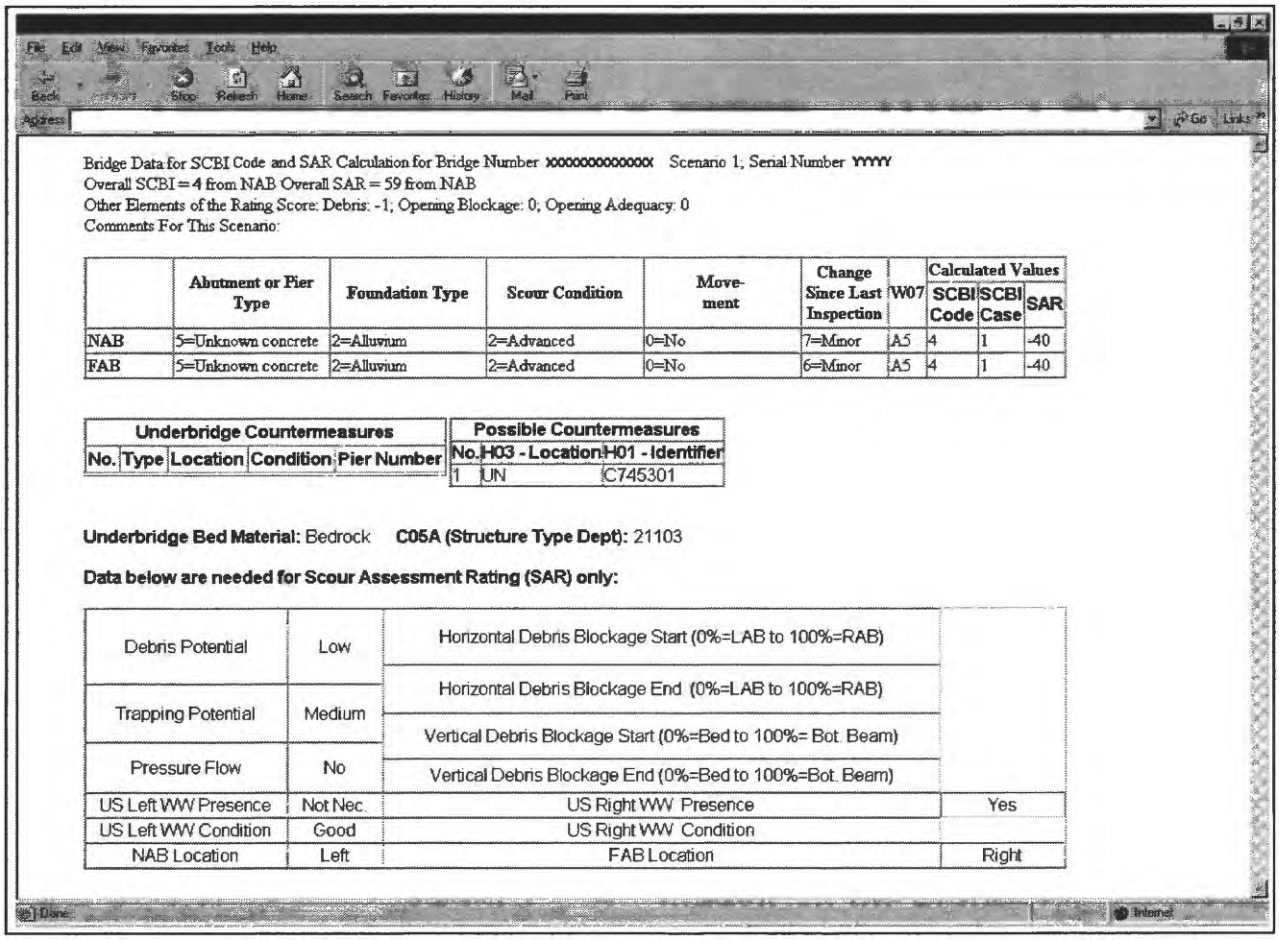
To delete an existing scenario, select the bridge that has the scenario to be deleted. Scenario number 1 will load by default. Select the scenario to be deleted from the "Scenario Number" dropdown list box and click on the "Retrieve" button. The calculator will display the selected scenario. Click on the "Delete" button to delete the selected scenario from the SCBI Code and SAR database. After a scenario is deleted, the calculator will return to scenario number 1 for the selected bridge.

Retrieving a Saved Scenario

To retrieve a saved scenario, the SCBI Code and SAR calculations page must be loaded first. This action will load the USGS data by default for bridges assessed under the USGS/PennDOT Bridge Scour Project. For bridges not assessed under the USGS/PennDOT Bridge Scour Program, it will load scenario number 2. Click on the "Existing Scenarios" dropdown list box and select the scenario number to be retrieved. Click on "Retrieve" for the calculator to load the selected scenario.

Printing Results

Printing the results produced by the calculator is a two-step process. The first step is to select the "Reformat For Print" button on the SCBI Code and SAR calculations page of the calculator. After the calculator generates the printer-friendly version, click on the print button of the browser's navigation toolbar, or click on File, click on Print, click on OK. An example of the reformatted page is shown in figure 11. Click on the "Back" button of the browser's navigation toolbar to return to the SCBI Code and SAR calculations page.



Bridge Data for SCBI Code and SAR Calculation for Bridge Number xxxxxxxxxxxxx Scenario 1, Serial Number yyyy
Overall SCBI = 4 from NAB Overall SAR = 59 from NAB
Other Elements of the Rating Score: Debris: -1; Opening Blockage: 0; Opening Adequacy: 0
Comments For This Scenario:

	Abutment or Pier Type	Foundation Type	Scour Condition	Move-ment	Change Since Last Inspection	W07	Calculated Values SCBI Code	SCBI Case	SAR
NAB	5=Unknown concrete	2=Alluvium	2=Advanced	0=No	7=Minor	A5	4	1	-40
FAB	5=Unknown concrete	2=Alluvium	2=Advanced	0=No	6=Minor	A5	4	1	-40

Underbridge Countermeasures					Possible Countermeasures		
No.	Type	Location	Condition	Pier Number	No.	H03 - Location	H01 - Identifier
					1	UN	C745301

Underbridge Bed Material: Bedrock **C05A (Structure Type Dept):** 21103

Data below are needed for Scour Assessment Rating (SAR) only:

Debris Potential	Low	Horizontal Debris Blockage Start (0%=LAB to 100%=RAB)	
Trapping Potential	Medium	Horizontal Debris Blockage End (0%=LAB to 100%=RAB)	
Pressure Flow	No	Vertical Debris Blockage Start (0%=Bed to 100%= Bot. Beam)	
US Left WW Presence	Not Nec.	Vertical Debris Blockage End (0%=Bed to 100%=Bot. Beam)	
US Left WW Condition	Good	US Right WW Presence	Yes
NAB Location	Left	US Right WW Condition	
		FAB Location	Right

Figure 11. Reformatted printer-friendly page for Scour Critical Bridge Indicator Code and Scour Assessment Rating calculator.

REFERENCES CITED

Cinotto, P.J., and White, K.E., 2000, Procedures for scour assessments at bridges in Pennsylvania: U.S. Geological Survey Open-File Report 00-64, 210 p.

Federal Highway Administration, 1988, Scour at bridges: Federal Highway Administration Technical Advisory 5140.20, 132 p.

_____1989, Recording and coding guide for the structure inventory and appraisal of the nation's bridges: Federal Highway Administration Report FHWA-ED-89-044, 115 p.

_____1991, Evaluating scour at bridges: Federal Highway Administration Technical Advisory 5140.23, 4 p.

Pennsylvania Department of Transportation, 1993, Bureau of Design, Bridge management system (BMS), coding manual, office version: Pennsylvania Department of Transportation Publication 100A, 123 p.

APPENDIXES

Appendix A—Data Entry Item Definitions and Abbreviations

The terms in this glossary were compiled from many sources. Some definitions have been modified and may not be the only valid ones for these terms. Many of the definitions have been taken directly from Cinotto and White (2000).

A3 – Highly erodible alluvium material predominantly composed of very small particles: clays, silts, and (or) fine sands. High potential for scour.

A4 – Alluvium consisting of a mixture of fine particles with some larger aggregate. Some cobbles and an occasional boulder may be present. Scour is present or has occurred in the past.

A5 – Stable naturally armored streambed composed of cobbles, boulders, gravel, with some fine material that has not shown signs of scour over a long time period (years). Potential for scour under high velocities is present.

A6 – Stable streambed material predominantly consisting of larger native cobbles and boulders (not riprap) with small amounts of fine material filling voids. Little scour potential, even during high flows.

A705301 – Streambed paving repair or replace.

A745101 – Abutment slopewall repair or replace.

ABUTMENT – A structure that supports the end of a bridge.

ADVANCED SCOUR – Scour that has occurred to such an extent that the footing of a bridge substructure is exposed to very slightly undermined (Pennsylvania Department of Transportation, 1993, p. 118).

ALLUVIUM – Waterborne materials deposited by running water, including clay, silt, sand, gravel, and (or) cobbles (Pennsylvania Department of Transportation, 1993, p. 117).

B745202 – Apron or cutoff wall repair or replace.

B745301 – Rock protection.

BED MATERIAL – The material that composes the channel bed from the toe of one bank to the toe of the other.

BENT – A framework transverse to the length of a structure usually designed to carry lateral as well as vertical loads.

BRIDGE MANAGEMENT SYSTEM (BMS) – A PennDOT-designed database that computes need estimates and rankings and stores structure inventory, inspection, and appraisal data.

C7 – Paved streambed with concrete, gabions, or masonry units in good condition. Minor problems may be present, but protection against scour is adequate. Synonymous with P7.

C8 – Paved streambed with concrete, gabions, or masonry units in good condition and adequate to resist scour. Synonymous with P8.

C745301 – Scour hole backfill.

CANTILEVER ABUTMENT – A structural member, as a wall, that projects beyond a fulcrum and is supported by a balancing member or a downward force behind the fulcrum.

Appendix A—Data Entry Item Definitions and Abbreviations—Continued

C05A – Structure type (configuration and material used) for approach span as assigned by PennDOT (abbreviated as "Dept").

COUNTERMEASURE – An object or objects specifically placed to prevent or repair damage from erosion.

DEBRIS POTENTIAL – See Cinotto and White (2000, p. 54).

DN – Downstream.

DSLWW – Downstream left wingwall.

DSRWW – Downstream right wingwall.

E744803 – Footing underpinning.

ECREMVG – Vegetation or debris removal.

ECREMDP – Sediment deposition removal.

ENCASEMENT – A covering of concrete placed to repair damage from erosion or protect bridge substructure units from erosion.

F – Far abutment.

FAB – Far abutment.

FAILED – When describing a countermeasure, the countermeasure is no longer present or is completely ineffective.

FAR – The northern or easternmost side of a bridge structure (generally) as the bridge structure relates to the trend of the roadway crossing the structure.

FOOTING – The supporting base of a substructure unit, as for a bridge pier or abutment, also known as "footer."

GABION – A wire basket filled with stone of specified size.

GOOD – When used to describe a countermeasure, the countermeasure is performing as intended.

GRAVITY CONCRETE ABUTMENT – A concrete abutment type that supports the superstructure and retains the approach roadway fill through its own mass.

HYDRAULIC – Relating to the static and dynamic behavior of fluids.

HYDROLOGIC – Relating to the properties, distribution, and effects of water in the atmosphere, on the Earth's surface, and in soil and rocks.

LAB – Left abutment. Abutment on the left bank.

LB – Left bank. Streambank on the observer's left-hand site as observer stands on the bridge or in the stream facing downstream.

MECHANICALLY STABILIZED EARTH – A method of construction that uses straps or wire mesh placed as a part of the backfill to anchor the face of prefabricated wall panels; also known as mechanically stabilized panels.

Appendix A—Data Entry Item Definitions and Abbreviations—Continued

MINOR SCOUR – Scour that has occurred to such an extent that the streambed may exhibit slight holes or depressions; footing of the bridge substructure not exposed (Pennsylvania Department of Transportation, 1993, p. 118).

N – Near abutment.

NAB – Near abutment.

NEAR – The southern or westernmost side of a bridge structure (generally) as the bridge structure relates to the trend of the roadway crossing the structure.

PARTIAL – When used to describe a countermeasure, the countermeasure is present but not performing as intended.

PIER – An intermediate support for the adjacent ends of two bridge spans.

PILE – A long and slender member usually of timber, steel, or reinforced concrete, driven or drilled into the ground to carry a vertical load, resist a lateral force, water, or earth pressure.

PRESSURE FLOW – The flow that occurs when the stream stage exceeds the clearance of the bridge opening.

P7 – Paved streambed with concrete, gabions, or masonry units in good condition. Minor problems may be present, but protection against scour is adequate. Synonymous with C7.

P8 – Paved streambed with concrete, gabions, or masonry units in good condition and adequate to resist scour. Synonymous with C8.

R4 – Highly erodible rock with on-going scour that could advance in a high flow event. Rock may be highly weathered, faulted, and (or) soft.

R7 – Erodible rock that may have some minor scour, but there is little risk that could cause failure during high flows.

R8 – Erodible rock with no signs of scour. Rock may be faulted, weathered, and (or) soft.

R9 – Non-erodible rock with no signs of scour. Rock may be faulted, weathered, and (or) soft.

RAB – Right abutment. Abutment on the right bank.

RB – Right bank. Streambank on the observer's right-hand side as observer stands on the bridge or in the stream facing downstream.

RIPRAP – Unconsolidated rock that is sized to resist substantial movement from stream or other erosive processes and placed in a location so as to protect that location from erosive processes.

SERIOUS SCOUR – Scour that has occurred to such an extent that the bridge substructure has been significantly undermined (Pennsylvania Department of Transportation, 1993, p. 118).

SPILL-THROUGH ABUTMENT – Type classification given to a bridge abutment constructed to slope outwards from the stream channel to the bottom of the bridge deck.

STONE-MASONRY – Type classification given to a bridge-substructure unit constructed of stonework.

STREAMBED MATERIAL – See W07.

Appendix A—Data Entry Item Definitions and Abbreviations—Continued

STUB ABUTMENT – Type classification given to a concrete bridge abutment when a shallow abutment is set back from the stream and has a sloping earthen or reinforced bank leading from the stream to the abutment.

SUBUNIT – Bridge substructure unit, such as a pier.

TRAPPING POTENTIAL – See Cinotto and White (2000, p. 54).

UN – Under bridge.

UNKNOWN CONCRETE – Type classification given to a bridge-substructure unit when personnel cannot determine information over and above visually noting the use of concrete construction material.

UP – Upstream.

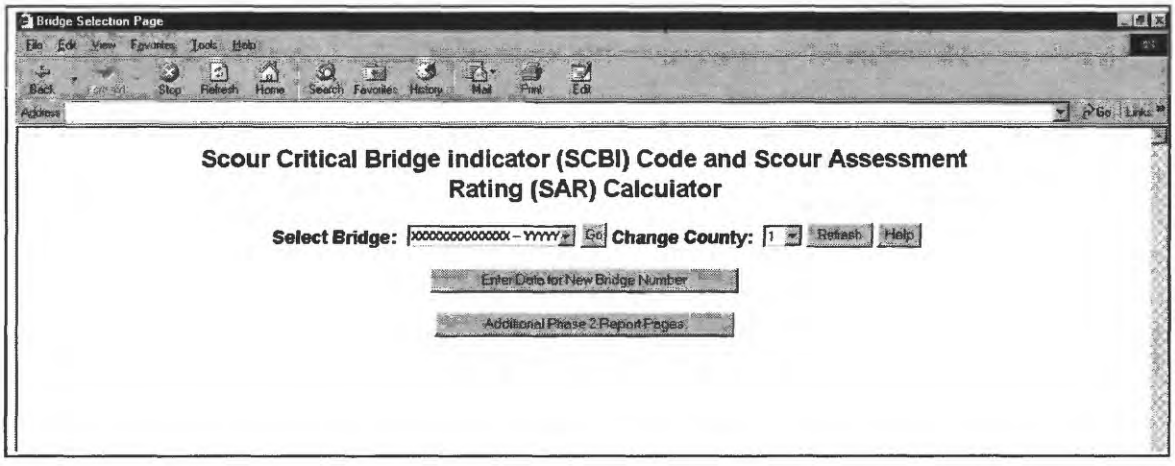
USLWW – Upstream left wingwall.

USRWW – Upstream right wingwall.

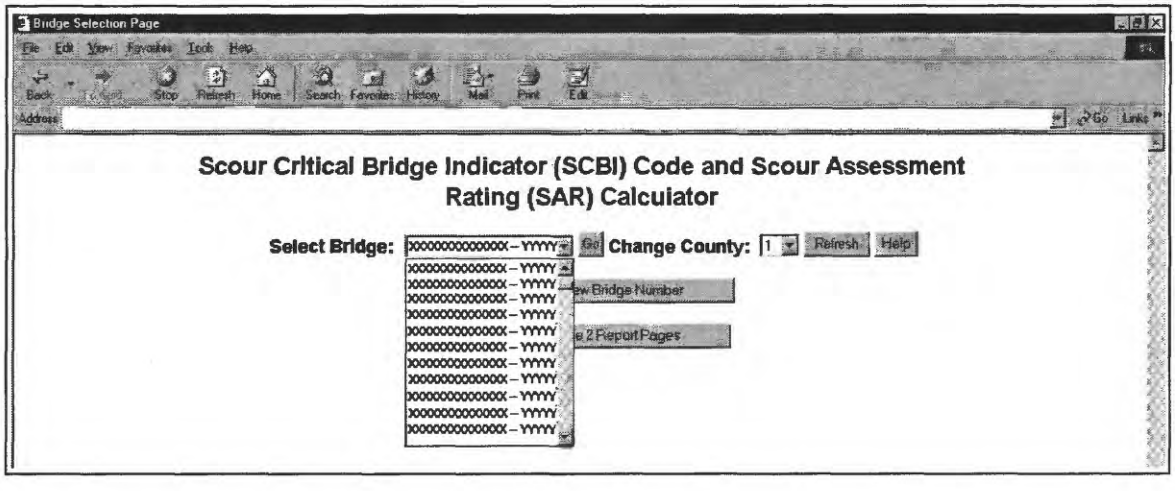
W07 – Indicates the type of streambed material near subunit correlated with its potential for scour by use of an alphanumeric entry; for example, A4 or P7.

WINGWALL – A structure attached to the side of a bridge abutment and so placed as to protect the material behind the bridge abutment from the erosive processes of a stream.

Appendix B—Scour Critical Bridge Indicator and Scour Assessment Rating Calculation Example

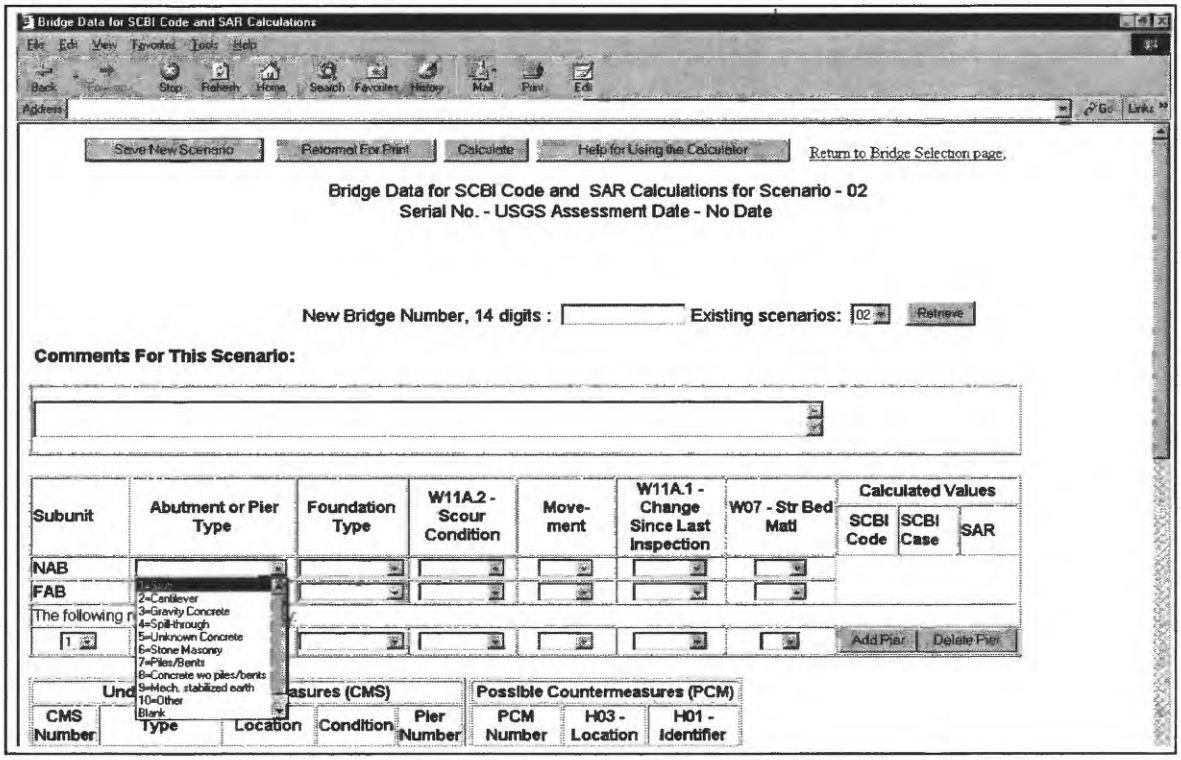


- Select County and click "Refresh" button.

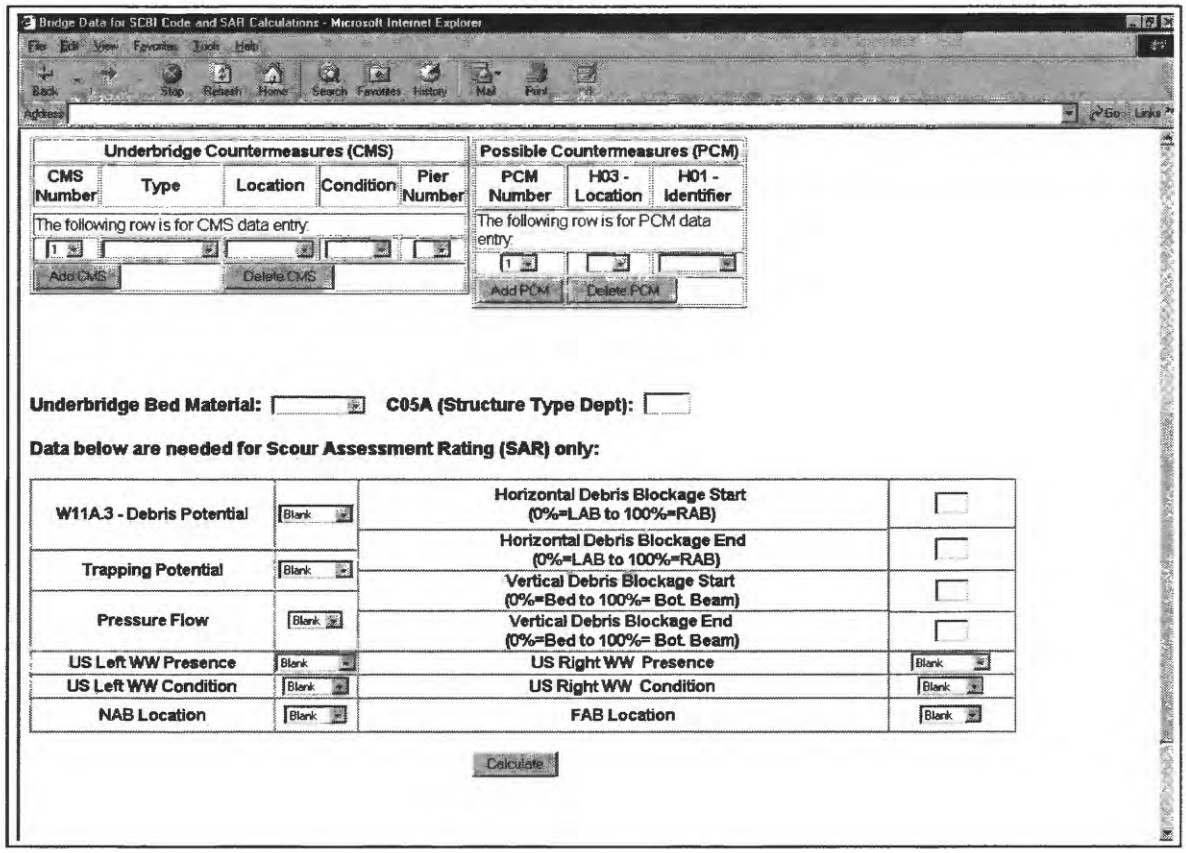


- Select Bridge and click "Go" button.
- The calculator will advance to the SCBI Code and SAR Calculations page.
- The calculator will load scenario 01, the original USGS assessment data, if available.
- Make selections or revisions for Abutment type, Foundation type, and others until all fields are complete.

Appendix B—Scour Critical Bridge Indicator and Scour Assessment Rating Calculation Example—Continued

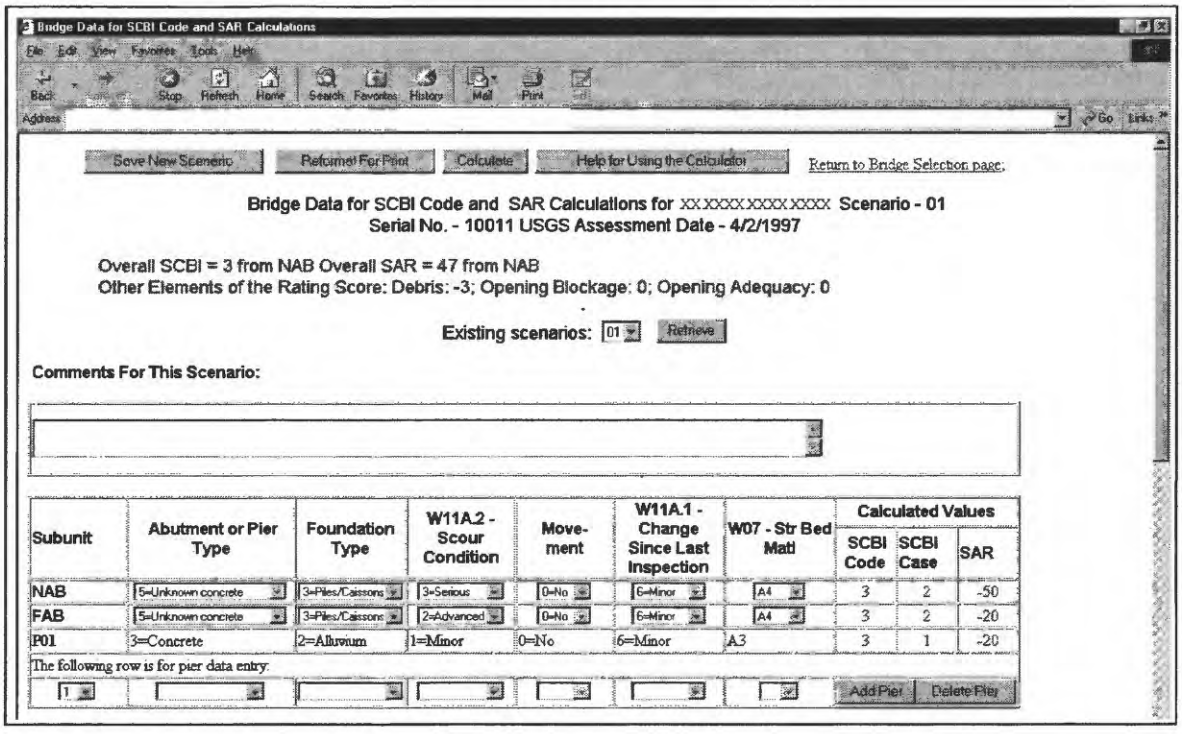


- Top of SCBI Code and SAR Calculations page.



- Bottom of SCBI Code and SAR Calculations page.
- When all fields have been completed, click on "Calculate" button.

Appendix B—Scour Critical Bridge Indicator and Scour Assessment Rating Calculation Example—Continued



Bridge Data for SCBI Code and SAR Calculations

Save New Scenario | Reformat For Print | Calculate | Help for Using the Calculator | Return to Bridge Selection page.

Bridge Data for SCBI Code and SAR Calculations for XX.XXXX.XXXX.XXXX Scenario - 01
Serial No. - 10011 USGS Assessment Date - 4/2/1997

Overall SCBI = 3 from NAB Overall SAR = 47 from NAB
Other Elements of the Rating Score: Debris: -3; Opening Blockage: 0; Opening Adequacy: 0

Existing scenarios: 01 Retrieve

Comments For This Scenario:

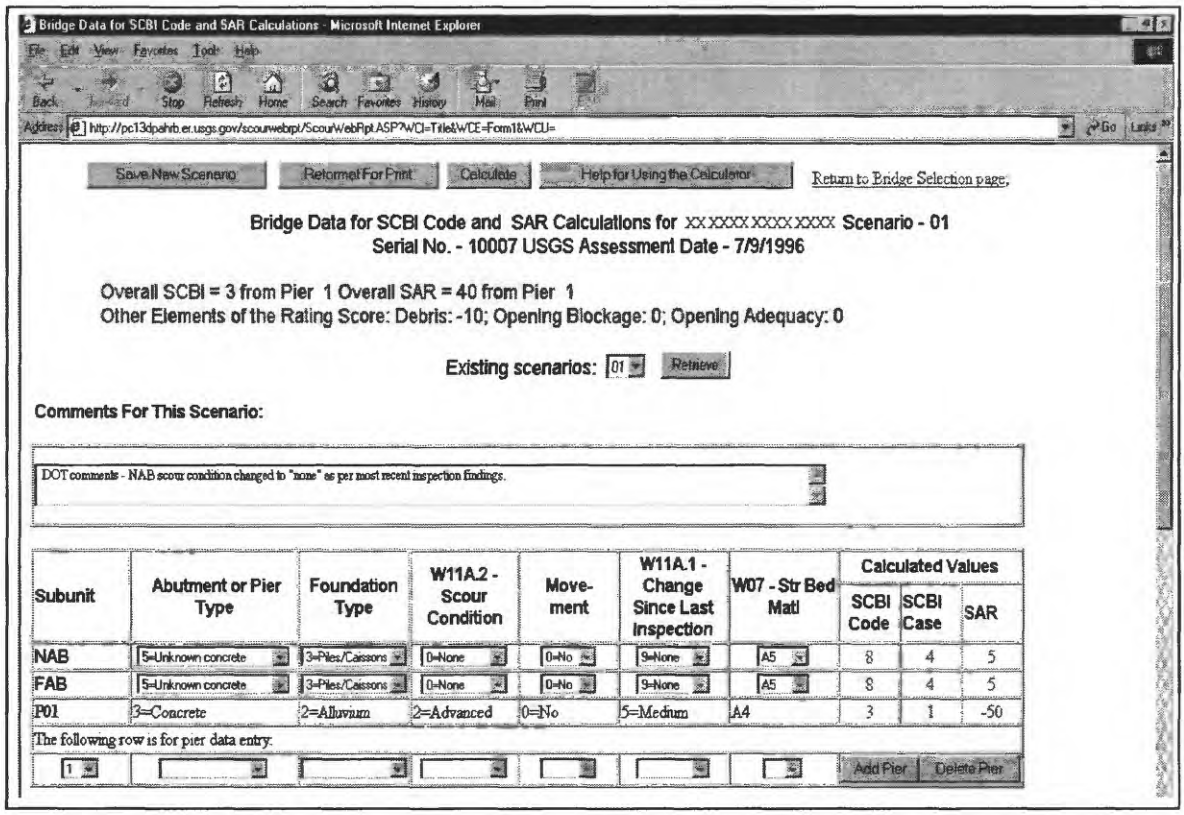
Subunit	Abutment or Pier Type	Foundation Type	W11A.2 - Scour Condition	Move-ment	W11A.1 - Change Since Last Inspection	W07 - Str Bed Matl	Calculated Values		
							SCBI Code	SCBI Case	SAR
NAB	5=Unknown concrete	3=Piles/Caissons	3=Serious	0=No	6=Minor	A4	3	2	-50
FAB	5=Unknown concrete	3=Piles/Caissons	2=Advanced	0=No	6=Minor	A4	3	2	-20
P01	3=Concrete	2=Alluvium	1=Minor	0=No	6=Minor	A3	3	1	-20

The following row is for pier data entry:

1 | Add Pier | Delete Pier

- SCBI Code and SAR Calculation results.
- Please note that results are displayed at the top of page and to the right of the abutment and pier data fields. Results are displayed on the screen in red.

Appendix B—Scour Critical Bridge Indicator and Scour Assessment Rating Calculation Example—Continued



- Enter any pertinent comments into the "Comments For This Scenario" box and click on "Save New Scenario" button if you wish to retain all the data fields on the screen.
- Click on the "Return to Bridge Selection page" to begin with another bridge or create a new one.

Appendix C—Algorithm for Web-Based SCBI Code

The following is based on appendix F in Cinotto and White (2000). There are some differences in the algorithm used for the Web-based SCBI Code and SAR calculator from the original approach used by the USGS/PennDOT Bridge Scour Project that the user should be aware of before interpreting any results produced by the SCBI Code and SAR calculator. Those differences are outlined in the algorithm presented here.

The main difference between the USGS/PennDOT Bridge Scour Project approach and the Web-based SCBI Code and SAR calculator approach is the initial comparison of USGS and PennDOT BMS data for subunit type and subunit foundation type. This comparison has been completed for all the bridges assessed by USGS and the resulting SCBI Code subunit and subunit foundation type values will be loaded by default for scenario number 1 (the USGS assessment). This comparison will not be completed for new bridges or for new scenarios of existing bridges. The user must enter values for subunit type and subunit foundation type or the application will return an error message and the calculations will not be completed. In the past, these subunits would have received a rating of code 6 case 1. This program will not return this value because a null subunit or subunit foundation type is considered invalid for new bridges and new scenarios. A value of code 6 case 1 will be returned for USGS assessment data that meet the original criteria.

One other difference is that the flagging of final results, as presented in Cinotto and White (2000), will not be completed by the SCBI Code and SAR calculator. This results because USGS and BMS values for subunit and subunit foundation types are not compared. A code 6 case 3 is a legitimate value for bridges that meet the criteria listed in tables C1 and C2.

The final difference between the two algorithms is related to bridges with multiple piers. Code 6 case 2 describes subunits where pier type and (or) foundation type could not be identified to a specific pier. This situation should not occur when using the Web-based application.

Table C1. Incompatible combinations of abutment types and foundation types in the Scour Critical Bridge Indicator Code (from Cinotto and White, 2000, p. 127)

[w/o, without]

Abutment type	Abutment foundation type
Stub	Alluvium
Stub	Not observed
Piles / bents	Bedrock
Piles / bents	Alluvium
Piles / bents	Not observed
Concrete w/o piles / bents	Piles / caissons
Other	Bedrock
Other	Alluvium
Other	Piles / caissons
Other	Not observed

Table C2. Incompatible combinations of pier types and foundation types in the Scour Critical Bridge Indicator Code (from Cinotto and White, 2000, p. 127)

Pier type	Pier foundation type
Steel	Bedrock
Steel	Alluvium
Steel	Not observed
Other	Bedrock
Other	Alluvium
Other	Piles / caissons
Other	Not observed

Appendix C—Algorithm for Web-Based SCBI Code—Continued

One final consideration must be made when coding a bridge. The subunits and the bridge are coded following different orders. These different orders are to insure that problem bridges receive the worst code possible, facilitating prioritization of bridges with excessive scour conditions.

A subunit may meet the criteria for more than one code; however, it receives the code closest to the top of the ordered list below (Cinotto and White, 2000).

Code 6, cases 1-3

Code 2

Code 8

Code 7

Code 5

Code 4

Code 3

Code 6, case 4

Because the subunits are components of the overall structure code, the overall bridge structure receives the code equal to the code for the subunit rated closest to the top of the ordered list below (Cinotto and White, 2000).

Code 6

Code 2

Code 3

Code 4

Code 5

Code 7

Code 8

Appendix C—Algorithm for Web-Based SCBI Code—Continued

CODE 9

The SCBI Code and SAR Calculator does not score the SCBI Code as this value.

Appendix C—Algorithm for Web-Based SCBI Code—Continued

CODE 8

Code 8 indicates bridges classified as culverts by PennDOT or subunits founded on competent bedrock.

CASE 1

Criteria

1. BMS C05A (digits 4 and 5) = 31, 33, 34, 35
2. scour condition = 0, 1, 2, 3
3. movement = 0
4. change since last inspection = 4, 5, 6, 7, 8, 9

CASE 2

Criteria

1. abutment foundation type = 1
2. abutment type = 1, 2, 3, 4, 5, 6

OR

1. pier foundation type = 1
2. pier type = 1, 3, 4

AND

3. scour condition = 0, 1, 2
4. movement = 0
5. change since last inspection = 4, 5, 6, 7, 8, 9
6. streambed material near the subunit = A3, A4, A5, A6, R7, R8, R9, P7, P8, C7, C8

If 5. not available, subunit coded based on criteria 1 - 5 above only.

CASE 3

Criteria

1. abutment foundation type = 5
2. abutment type = 2, 3, 4, 5, 6

OR

1. pier foundation type = 5
2. pier type = 1, 3, 4

AND

3. scour condition = 0, 1, 2
4. movement = 0
5. change since last inspection = 4, 5, 6, 7, 8, 9
6. under-the-bridge primary bed material = 5

CASE 4

Criteria

1. abutment foundation type = 3
2. abutment type = 1, 2, 3, 4, 5, 6, 7

OR

1. pier foundation type = 3
2. pier type = 1, 2, 3, 4

AND

3. scour condition = 0, 1
4. movement = 0
5. change since last inspection = 7, 8, 9

6A. streambed material near the subunit = A5, A6

If 6A. not available, use 6 B.:

6B. under-the-bridge primary bed material = 4

Appendix C—Algorithm for Web-Based SCBI Code—Continued

CODE 7

Code 7 indicates subunits that are adequately protected by countermeasures.

CASE 1

Criteria

1. all under-the-bridge countermeasures at the subunit = 1
2. scour condition = 0, 1, 2
3. movement = 0
4. change since last inspection = 4, 5, 6, 7, 8, 9

CASE 2

Criteria

1. none of the listed possible countermeasures are recommended at the subunit OR under the bridge:

Possible countermeasures	Location
Footing underpinning	[at subunit]
Abutment slopewall (repair/replace)	[at subunit]
Streambed paving (repair/replace)	UN
Rock protection	UN
Scour hole (backfill)	UN
Apron/cutoff was (repair/replace)	Inlet/Outlet

2. scour condition = 0, 1, 2
3. movement = 0
4. change since last inspection = 4, 5, 6, 7, 8, 9

5A. streambed material near the subunit = P7, P8, C7, C8

If 5A not available, use 5B.:

5B. under-the-bridge primary bed material = 6

Appendix C—Algorithm for Web-Based SCBI Code—Continued

CODE 6

CASE 1

Criteria

For subunits for which BMS data for subunit type or subunit foundation type is blank, not determined, other, or BMS C05A (digits 4 and 5) do not equal 31, 33, 34, or 35

CASE 2

Criteria

For piers for which BMS data for pier type and/or pier foundation type could not be identified to a specific pier

CASE 3

Criteria

For subunits for which BMS data and USGS data for subunit type and subunit foundation type are incompatible.

CASE 4

Criteria

For subunits that do not meet any case criteria for assigning codes 2-5, 7-8, code 6 case 1.

Appendix C—Algorithm for Web-Based SCBI Code—Continued

CODE 5

Code 5 indicates subunits in contact with streambed material consisting predominantly of cobbles and boulders, and show little or no evidence of streambed instability.

CASE 1

Criteria

1. abutment foundation type = 2, 5
2. abutment type = 2, 3, 4, 5

OR

1. pier foundation type = 2, 5
2. pier type = 3

AND

3. scour condition = 0, 1
4. movement = 0
5. change since last inspection = 7, 8, 9

6A. streambed material near the subunit = A5, A6, R7, R8

If 6A. not available, use 6B.:

6B. under-the-bridge primary bed material = 4, 5

CASE 2

Criteria

1. abutment foundation type = 1
2. abutment type = 1, 2, 3, 4, 5

OR

1. pier foundation type = 1
2. pier type = 3

AND

3. scour condition = 0, 1
4. movement = 0
5. change since last inspection = 7, 8, 9
6. streambed material near the subunit = R4

If 6. not available, criteria for this case cannot be met

CASE 3

Criteria

1. abutment foundation type = 3
2. abutment type = 1, 2, 3, 4, 5, 7

OR

1. pier foundation type = 3
2. pier type = 2, 3

AND

3. scour condition = 0, 1, 2
4. movement = 0
5. change since last inspection = 7, 8, 9

6A. streambed material near the subunit = A5, A6

If 6A. not available, use 6B.:

6B. under-the-bridge primary bed material = 4

Appendix C—Algorithm for Web-Based SCBI Code—Continued

CODE 4

Code 4 indicates subunits in contact with streambed material consisting predominantly of cobbles and boulders, and show some evidence of streambed instability.

CASE 1

Criteria

1. abutment foundation type = 2, 5
2. abutment type = 2, 3, 5

OR

1. pier foundation type = 2, 4, 5
2. pier type = 3

AND

3. scour condition = 0, 1, 2
4. movement = 0
5. change since last inspection = 4, 5, 6, 7, 8, 9

6A. streambed material near the subunit = A5, A6, R7, R8

If 6A. not available, use 6B.:

6B. under-the-bridge primary bed material = 4, 5

CASE 2

Criteria

1. abutment foundation type = 1
2. abutment type = 1, 2, 3, 4, 5

OR

1. pier foundation type = 1
2. pier type = 3

AND

3. scour condition = 0, 1, 2
4. movement = 0
5. change since last inspection = 4, 5, 6, 7, 8, 9
6. streambed material near the subunit = R4

If 6. not available, criteria for this case cannot be met

CASE 3

Criteria

1. abutment foundation type = 3
2. abutment type = 1, 2, 3, 4, 5, 7

OR

1. pier foundation type = 3
2. pier type = 2, 3

AND

3. scour condition = 0, 1, 2, 3
4. movement = 0
5. change since last inspection = 4, 5, 6, 7, 8, 9

6A. streambed material near the subunit = A5, A6

If 6A. not available, use 6B.:

6B. under-the-bridge primary bed material = 4

Appendix C—Algorithm for Web-Based SCBI Code—Continued

CODE 4—Continued

CASE 4

Criteria

1. abutment foundation type = 3
2. abutment type = 1, 2, 3, 4, 5, 7

OR

1. pier foundation type = 3
2. pier type = 2, 3

AND

3. scour condition = 0, 1, 2, 3
4. movement = 0
5. change since last inspection = 7, 8, 9

6A. streambed material near the subunit = A3, A4

If 6A. not available, use 6B.:

6B. under-the-bridge primary bed material = 1, 2, 3

CASE 5

Criteria

1. abutment type = 9
2. scour condition = 0
3. movement = 0

CASE 6

Criteria

1. abutment foundation type = 2, 5
2. abutment type = 6

OR

1. pier foundation type = 2, 5
2. pier type = 1, 4

AND

3. scour condition = 0, 1
4. movement = 0
5. change since last inspection = 7, 8, 9

6A. streambed material near the subunit = A5, A6, R7, R8

If 6A not available, use 6B.:

6B. under-the-bridge primary bed material = 4

CASE 7

Criteria

1. abutment foundation type = 1
2. abutment type = 6

OR

1. pier foundation type = 1
2. pier type = 1, 4

AND

3. scour condition = 0, 1, 2
4. movement = 0
5. change since last inspection = 7, 8, 9
6. streambed material near the subunit = R4

If 6. not available, criteria for this case cannot be met

Appendix C—Algorithm for Web-Based SCBI Code—Continued

CODE 4—Continued

CASE 8

Criteria

1. abutment foundation type = 3
2. abutment type = 6

OR

1. pier foundation type = 3
2. pier type = 1, 4

AND

3. scour condition = 0, 1, 2
4. movement = 0
5. change since last inspection = 4, 5, 6, 7, 8, 9

6A. streambed material near the subunit = A5, A6

If 6A. not available, use 6B.:

6B. under-the-bridge primary bed material = 4

CASE 9

Criteria

1. abutment foundation type = 3
2. abutment type = 6

OR

1. pier foundation type = 3
2. pier type = 1, 4

AND

3. scour condition = 0, 1, 2
4. movement = 0
5. change since last inspection = 7, 8, 9

6A. streambed material near the subunit = A3, A4

If 6A. not available, use 6B.:

6B. under-the-bridge primary bed material = 1, 2, 3

Appendix C—Algorithm for Web-Based SCBI Code—Continued

CODE 3

Code 3 indicates subunits in contact with streambed material consisting predominantly of erodible, fine material.

CASE 1

Criteria

1. abutment foundation type = 2, 5
2. abutment type = 2, 3, 4, 5

OR

1. pier foundation type = 2, 5
2. pier type = 3

AND

3. scour condition = 0, 1, 2
4. movement = 0
5. change since last inspection = 4, 5, 6, 7, 8, 9

6A. streambed material near the subunit = A3, A4, R4

If 6A. not available, use 6B.:

6B. under-the-bridge primary bed material = 1, 2, 3

CASE 2

Criteria

1. abutment foundation type = 3
2. abutment type = 1, 2, 3, 4, 5, 7

OR

1. pier foundation type = 3
2. pier type = 2, 3

AND

3. scour condition = 0, 1, 2, 3
4. movement = 0
5. change since last inspection = 4, 5, 6, 7, 8, 9

6A. streambed material near the subunit = A3, A4

If 6A. not available, use 6B.:

6B. under-the-bridge primary bed material = 1, 2, 3

CASE 3

Criteria

1. abutment type = 9
2. scour condition = 1
3. movement = 0
4. change since last inspection = 4, 5, 6, 7, 8,

CASE 4

Criteria

1. abutment foundation type = 2, 5
2. abutment type = 6

OR

1. pier foundation type = 2, 5
2. pier type = 1, 4

AND

3. scour condition = 0, 1, 2
4. movement = 0

Appendix C—Algorithm for Web-Based SCBI Code—Continued

CODE 3—Continued

5. change since last inspection = 4, 5, 6, 7, 8, 9
6A. streambed material near the subunit = A3, A4, A5, A6, R4
If 6A. not available, use 6B.:
6B. under-the-bridge primary bed material = 1, 2, 3, 4

CASE 5

Criteria

1. abutment foundation type = 1
2. abutment type = 6

OR

1. pier foundation type = 1
2. pier type = 1, 4

AND

3. scour condition = 0, 1, 2
4. movement = 0
5. change since last inspection = 4, 5, 6, 7, 8, 9
6. streambed material near the subunit = R4

If 6. not available, criteria for case cannot be met

CASE 6

Criteria

1. abutment foundation type = 1
2. abutment type = 1, 2, 3, 4, 5

OR

1. pier foundation type = 1
2. pier type = 3

AND

3. scour condition = 3
4. movement = 0
5. change since last inspection = 4, 5, 6, 7, 8, 9

CASE 7

Criteria

1. abutment foundation type = 3
2. abutment type = 6

OR

1. pier foundation type = 3
2. pier type = 1, 4

AND

3. scour condition = 0, 1, 2
4. movement = 0
5. change since last inspection = 4, 5, 6, 7, 8, 9
6A. streambed material near the subunit = A3, A4
If 6A. not available, use 6B.:
6B. under-the-bridge primary bed material = 1, 2, 3

Appendix C—Algorithm for Web-Based SCBI Code—Continued

CODE 2

Code 2 indicates subunits having critical site conditions related to scour, such as movement of the subunit, significant change since last inspection, or scour condition for foundation that potentially threatens bridge structure.

CASE 1

Criteria

1. abutment type = 9
2. scour condition = 2, 3

CASE 2

Criteria

1. movement = 1

CASE 3

Criteria

1. abutment foundation type = 2, 4, 5
2. abutment type = 2, 3, 4, 5

OR

1. pier foundation type = 1, 2, 4, 5
2. pier type = 3

AND

3. scour condition = 3

CASE 4

Criteria

1. abutment type = 6

OR

1. pier type = 1, 4

AND

2. scour condition = 3

CASE 5

Criteria

1. abutment type = 8

CASE 7

Criteria

1. change since last inspection = 3

Appendix D—Algorithm for Web-Based SAR

The following is based on appendix H in Cinotto and White (2000). There are some differences in the algorithm used for the Web-based SCBI Code and SAR Calculator from the original approach used by the USGS/PennDOT Bridge Scour Project that the user should be aware of before interpreting any results produced by the SCBI Code and SAR calculator. Those differences are presented below.

The main difference between the USGS/PennDOT Bridge Scour Project's approach and the Web-based SCBI Code and SAR calculator approach is the initial comparison of USGS and PennDOT BMS data for subunit type and subunit foundation type. This comparison has been completed for all the bridges assessed by USGS and the resulting SAR subunit and subunit foundation type values will be loaded by default for scenario number 1 (the USGS assessment). This comparison will not be completed for new bridges or for new scenarios of existing bridges. The user must enter values for subunit type and subunit foundation type or the Web-based SCBI Code and SAR calculator will return an error message and the calculations will not be completed. In the past, these subunits would have received an SAR of 999. This program will not return this value because a null subunit or subunit foundation type is considered invalid for new bridges and new scenarios. An SAR value of 999 will be returned for USGS assessment data that meet the original criteria.

The other difference is that the flagging of final results as presented in Cinotto and While (2000) will not be completed by the application. This is because USGS and BMS values for subunit and subunit foundation types are not compared. A 999 is a legitimate value for bridges that meet the criteria listed in table D1.

Table D1. Incompatible combinations of abutment types and foundation types in the Scour Assessment Rating (from Cinotto and White, 2000, p.176)

[w/o, without]

Abutment type	Abutment foundation type
Stub	Alluvium
Stub	Not observed
Piles / bents	Bedrock
Concrete w/o piles / bents	Piles / caissons

Appendix D—Algorithm for Web-Based SAR—Continued

SCOUR ASSESSMENT RATING CRITERIA FOR SITES WHERE SCOUR ASSESSMENTS ARE BASED ON FIELD OBSERVATIONS AND AVAILABLE DATA

Bridge ID:_____

I. ABUTMENTS	NEAR	FAR
A. Scour Condition At Abutments:		
1. Movement		
a. Foundation Type:		
1) Alluvium, Other, Not Observed		
a) Abutment Type:		
(1) Piles/Bents, Spill-through (-75)	_____	_____
(2) Cantilever, Gravity, Unknown Concrete, Concrete w/o piles/bents (-75)	_____	_____
(3) Stone Masonry, Mechanically Stabilized, Other (-90)	_____	_____
1) Piles/Caissons		
a) Abutment Type:		
(1) Piles/Bents, Stub, Spill-through (-75)	_____	_____
(2) Cantilever, Gravity, Unknown Concrete (-75)	_____	_____
(3) Stone Masonry, Mechanically Stabilized, Other (-80)	_____	_____
1) Bedrock		
a) Abutment Type:		
(1) Cantilever, Gravity, Spill-through, Unknown Concrete, Stub (-75)	_____	_____
(2) Stone Masonry, Concrete w/o piles/bents Mechanically Stabilized, Other(-75)	_____	_____
2. Serious scour		
a. Foundation Type:		
1) Alluvium, Other, Not Observed		
a) Abutment Type:		
(1) Piles/Bents, Spill-through (-40)	_____	_____
(2) Cantilever, Gravity, Unknown Concrete, Concrete w/o piles/bents (-60)	_____	_____
(3) Stone Masonry, Mechanically Stabilized, Other (-85)	_____	_____

Appendix D—Algorithm for Web-Based SAR—Continued

I. ABUTMENTS—Continued	NEAR	FAR
2) Piles/Caissons		
a) Abutment Type:		
(1) Piles/Bents, Stub, Spill-through (-40	_____	_____
(2) Cantilever, Gravity, Unknown Concrete (-50)	_____	_____
(3) Stone Masonry, Mechanically Stabilized, Other (-75)	_____	_____
3) Bedrock		
a) Abutment Type:		
(1) Cantilever, Gravity, Spill-through, Unknown Concrete, Stub (-60)	_____	_____
(2) Stone Masonry, Concrete w/o piles/bents, Mechanically Stabilized, Other(-75)	_____	_____
3. Advanced scour		
a. Wingwall condition = Good or wingwall not necessary		
1) Foundation Type:		
a) Alluvium, Other, Not Observed		
(1) Abutment Type:		
(a) Piles/Bents,Spill-through (-20)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete, Concrete w/o piles/bents (-40)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-70)	_____	_____
b) Piles/Caissons		
(1) Abutment Type:		
(a) Piles/Bents, Stub, Spill-through (-20)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete (-20)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-50)	_____	_____
c) Bedrock		
(1) Abutment Type:		
(a) Cantilever, Gravity, Spill-through, Unknown Concrete, Stub (-10)	_____	_____
(b) Stone Masonry, Concrete w/o piles/bents, Mechanically Stabilized, Other (-15)	_____	_____
b. Wingwall condition = Partial or no wingwall but one is needed		
1) Foundation Type:		

Appendix D—Algorithm for Web-Based SAR—Continued

I. ABUTMENTS—Continued	NEAR	FAR
a) Alluvium, Other, Not Observed		
(1) Abutment Type:		
(a) Piles/Bents, Spill-through (-40)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete, Concrete w/o piles/bents (-50)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-75)	_____	_____
b) Piles/Caissons		
(1) Abutment Type:		
(a) Piles/Bents, Stub, Spill-through (-40)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete (-40)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-60)	_____	_____
c) Bedrock		
(1) Abutment Type:		
(a) Cantilever, Gravity, Spill-through, Unknown Concrete, Stub (-30)	_____	_____
(b) Stone Masonry, Concrete w/o pile/bents Mechanically Stabilized, Other (-35)	_____	_____
c. Wingwall condition = Failed		
1) Foundation Type:		
a) Alluvium, Other, Not Observed		
(1) Abutment Type:		
(a) Piles/Bents, Spill-through (-55)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete, Concrete w/o piles/bents (-65)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-80)	_____	_____
b) Piles/Caissons		
(1) Abutment Type:		
(a) Piles/Bents, Stub, Spill-through (-55)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete (-55)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-70)	_____	_____
c) Bedrock		
(1) Abutment Type:		

Appendix D—Algorithm for Web-Based SAR—Continued

I. ABUTMENTS—Continued	NEAR	FAR
(a) Cantilever, Gravity, Spill-through Unknown Concrete, Stub (-50)	_____	_____
(b) Stone Masonry, Concrete w/o pile/bents Mechanically Stabilized, Other (-55)	_____	_____
4. Minor scour		
a. Wingwall condition = Good or wingwall not necessary		
1) Foundation Type:		
a) Alluvium, Other, Not Observed		
(1) Abutment Type:		
(a) Piles/Bents, Spill-through (-5)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete, Concrete w/o piles/bents (-15)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-35)	_____	_____
b) Piles/Caissons		
(1) Abutment Type:		
(a) Piles/Bents, Stub, Spill-through (-5)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete (-10)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-30)	_____	_____
c) Bedrock		
(1) Abutment Type:		
(a) Cantilever, Gravity, Spill-through Unknown Concrete, Stub (0)	_____	_____
(b) Stone Masonry, Concrete w/o piles/bents Mechanically Stabilized, Other (-5)	_____	_____
b. Wingwall condition = Partial or no wingwall but one is needed		
1) Foundation Type:		
a) Alluvium, Other, Not Observed		
(1) Abutment Type:		
(a) Piles/Bents, Spill-through (-30)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete, Concrete w/o piles/bents (-40)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-55)	_____	_____

Appendix D—Algorithm for Web-Based SAR—Continued

I. ABUTMENTS—Continued	NEAR	FAR
b) Piles/Caissons		
(1) Abutment Type:		
(a) Piles/Bents, Stub, Spill-through (-30)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete (-35)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-50)	_____	_____
c) Bedrock		
(1) Abutment Type:		
(a) Cantilever, Gravity, Spill-through, Unknown Concrete, Stub (-25)	_____	_____
(b) Stone Masonry, Concrete w/o piles/bents, Mechanically Stabilized, Other (-30)	_____	_____
c. Wingwall condition = Failed		
1) Foundation Type:		
a) Alluvium, Other, Not Observed		
(1) Abutment Type:		
(a) Piles/Bents, Spill-through (-40)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete, Concrete w/o pile/bents (-60)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-65)	_____	_____
b) Piles/Caissons		
(1) Abutment Type:		
(a) Piles/Bents, Stub, Spill-through (-40)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete (-45)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-60)	_____	_____
c) Bedrock		
(1) Abutment Type:		
(a) Cantilever, Gravity, Spill-through, Unknown Concrete, Stub (-30)	_____	_____
(b) Stone Masonry, Concrete w/o pile/bents, Mechanically Stabilized, Other (-35)	_____	_____
5. No scour		
a. Wingwall condition = Good or wingwall not necessary		
1) Foundation Type:		

Appendix D—Algorithm for Web-Based SAR—Continued

I. ABUTMENTS—Continued	NEAR	FAR
a) Alluvium, Other, Not Observed		
(1) Abutment Type:		
(a) Piles/Bents, Spill-through (-5)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete, Concrete w/o piles/bents (-10)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-25)	_____	_____
b) Piles/Caissons		
(1) Abutment Type:		
(a) Piles/Bents, Stub, Spill-through (-5)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete (-5)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-20)	_____	_____
c) Bedrock		
(1) Abutment Type:		
(a) Cantilever, Gravity, Spill-through Unknown Concrete, Stub (0)	_____	_____
(b) Stone Masonry, Concrete w/o piles/bents, Mechanically Stabilized, Other (-5)	_____	_____
b. Wingwall condition = Partial or no wingwall but one is needed		
1) Foundation Type:		
a) Alluvium, Other, Not Observed		
(1) Abutment Type:		
(a) Piles/Bents, Spill-through (-25)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete, Concrete w/o piles/bents (-35)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-45)	_____	_____
b) Piles/Caissons		
(1) Abutment Type:		
(a) Piles/Bents, Stub, Spill-through (-25)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete (-35)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-45)	_____	_____
c) Bedrock		
(1) Abutment Type:		

Appendix D—Algorithm for Web-Based SAR—Continued

I. ABUTMENTS—Continued	NEAR	FAR
(a) Cantilever, Gravity, Spill-through, Unknown Concrete, Stub (-20)	_____	_____
(b) Stone Masonry, Concrete w/o piles/bents, Mechanically Stabilized, Other (-25)	_____	_____
c. Wingwall condition = Failed		
1) Foundation Type:		
a) Alluvium, Other, Not Observed		
(1) Abutment Type:		
(a) Piles/Bents, Spill-through (-35)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete, Concrete w/o piles/bents (-50)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-60)	_____	_____
b) Piles/Caissons		
(1) Abutment Type:		
(a) Piles/Bents, Stub, Spill-through (-35)	_____	_____
(b) Cantilever, Gravity, Unknown Concrete (-40)	_____	_____
(c) Stone Masonry, Mechanically Stabilized, Other (-55)	_____	_____
c) Bedrock		
(1) Abutment Type:		
(a) Cantilever, Gravity, Spill-through, Unknown Concrete, Stub (-25)	_____	_____
(b) Stone Masonry, Concrete w/o piles/bents, Mechanically Stabilized, Other (-30)	_____	_____
B. Has every countermeasure, located at an abutment, received a condition rating of Good?		
(Under bridge bed material = 6 [Con/Steel] will count as a good countermeasure)		
1. YES (+10)	_____	_____
2. NO (0)	_____	_____
TOTAL SCORE		

Appendix D—Algorithm for Web-Based SAR—Continued

II. PIERS	P01	P02	P03	P04
A. Scour Condition At Piers				
6. Movement:				
a. Pier foundation Type:				
1) Alluvium, Other, Not Observed				
a) Pier Type:				
(1) Steel, Concrete (-85)	____	____	____	____
(2) Timber, Stone Masonry, Other (-85)	____	____	____	____
2) Piles/Caissons				
a) Pier Type:				
(1) Steel, Concrete (-85)	____	____	____	____
(2) Timber, Stone Masonry, Other (-85)	____	____	____	____
3) Bedrock				
a) Pier Type:				
(1) Steel, Concrete (-80)	____	____	____	____
(2) Timber, Stone Masonry, Other (-85)	____	____	____	____
7. Serious scour				
a. Pier foundation Type:				
1) Alluvium, Other, Not Observed				
a) Pier Type:				
(1) Steel, Concrete (-70)	____	____	____	____
(2) Timber, Stone Masonry, Other (-85)	____	____	____	____
2) Piles/Caissons				
a) Pier Type:				
(1) Steel, Concrete (-65)	____	____	____	____
(2) Timber, Stone Masonry, Other (-75)	____	____	____	____
3) Bedrock				
a) Pier Type:				
(1) Steel, Concrete (-65)	____	____	____	____
(2) Timber, Stone Masonry, Other (-75)	____	____	____	____
8. Advanced scour				
a. Pier foundation Type:				

Appendix D—Algorithm for Web-Based SAR—Continued

II. PIERS—Continued	P01	P02	P03	P04
1) Alluvium, Other, Not Observed				
a) Pier Type:				
(1) Steel, Concrete (-50)	____	____	____	____
(2) Timber, Stone Masonry, Other (-70)	____	____	____	____
2) Piles/Caissons				
a) Pier Type:				
(1) Steel, Concrete (-25)	____	____	____	____
(2) Timber, Stone Masonry, Other (-50)	____	____	____	____
3) Bedrock				
a) Pier Type:				
(1) Steel, Concrete (-15)	____	____	____	____
(2) Timber, Stone Masonry, Other (-20)	____	____	____	____
9. Minor scour				
a. Pier foundation Type:				
1) Alluvium, Other, Not Observed				
a) Pier Type:				
(1) Steel, Concrete (-20)	____	____	____	____
(2) Timber, Stone Masonry, Other (-30)	____	____	____	____
2) Piles/Caissons				
a) Pier Type:				
(1) Steel, Concrete (-10)	____	____	____	____
(2) Timber, Stone Masonry, Other (-20)	____	____	____	____
(3) Bedrock				
a) Pier Type:				
(1) Steel, Concrete (0)	____	____	____	____
(2) Timber, Stone Masonry, Other (0)	____	____	____	____
10. No scour				
a. Pier foundation Type:				
1) Alluvium, Other, Not Observed				
a) Pier Type:				
(1) Steel, Concrete (-10)	____	____	____	____

Appendix D—Algorithm for Web-Based SAR—Continued

II. PIERS—Continued	P01	P02	P03	P04
(2) Timber, Stone Masonry, Other (-15)	____	____	____	____
2) Piles/Caissons				
a) Pier Type:				
(1) Steel, Concrete (-5)	____	____	____	____
(2) Timber, Stone Masonry, Other (-10)	____	____	____	____
(3) Bedrock				
(a) Pier Type:				
(1) Steel, Concrete (0)	____	____	____	____
(2) Timber, Stone Masonry, Other (-5)	____	____	____	____
B. Has every countermeasure, located at a pier, received a condition rating of Good?				
(Under bridge bed material = 6 [Con/Steel] will count as a good countermeasure)				
1. YES (+10)	____	____	____	____
2. NO (0)	____	____	____	____
TOTAL SCORE				

USGS Debris Potential Not Available (1995 field season only)

IIIa. Debris Potential (Item 3 of W11-A):

1. High or present (-12)	____
2. Medium (-7)	____
3. Minor (-3)	____
4. None (0)	____

Appendix D—Algorithm for Web-Based SAR—Continued

USGS Debris Potential Available (All field seasons except 1995)

IIIb. USGS Debris/Trapping Potential:

1. Debris = Low, Trapping = Low (0) _____
2. Debris = Low, Trapping = Med. or vice versa (-1) _____
3. Debris = Low, Trapping = High or vice versa (-3) _____
4. Debris = Med., Trapping = Med. (-7) _____
5. Debris = Med., Trapping = High or vice versa (-10) _____
6. Debris = High, Trapping = High (-15) _____

TOTAL SCORE

IV. OPENING BLOCKAGE UNDER BRIDGE

A. Percent of opening blockage:

1. Blockage is < or = 5% (0) _____
2. 5%< Blockage < 21% (-10) _____
3. 20%< Blockage <40% (-20) _____
4. Blockage is > 40% (-50) _____

TOTAL SCORE

V. OPENING ADEQUACY

A. History/Evidence of pressure flow?

1. YES: (-20)
2. No (0) _____

TOTAL SCORE