A TECHNIQUE FOR PRELIMINARY APPRAISAL OF POTENTIAL AND OBSERVED SCOUR AS APPLIED TO STATE-MAINTAINED HIGHWAY BRIDGES IN MARYLAND

By Edward J. Doheny, Bernard M. Helinsky, and Ronald A. McGregor

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GLOSSARY

AGGRADATION. General and progressive buildup of a channel bed because of sediment deposition.

ALLUVIAL FAN. A landform shaped like a fan in plan view and deposited where a stream channel issues from a narrow valley of high slope onto a plain or broad valley of low slope.

ALLUVIUM. Unconsolidated material deposited by a stream in a stream channel, flood plain, alluvial fan, or delta.

APPROACH. Stream channel upstream from a bridge within two to three bridge lengths, or within two to three channel widths at the bridge.

ARMORING. (a) Natural process whereby an erosion-resistant layer of large sediment particles is formed on a channel bed because of removal of finer sediment particles by the flow; (b) placement of a covering on the channel bed, banks, or embankment slope to resist erosion.

AT BANK, (LEFT OR RIGHT). Channel bank location in reference to riprap placement. "At bank" refers to the bank area near bridge wingwalls and within one bridge-opening channel width upstream or downstream from the bridge.

BANK ANGLE. The acute angle of the side slope of a stream channel between which the flow is normally confined. Bank angles are measured in degrees above horizontal.

BANK EROSION. Removal of soil particles or a mass of soil particles from a channel bank.

BANK FAILURE. Sudden collapse of a channel bank due to erosion of bank material at the toe of the channel bank.

BANKFULL DISCHARGE. Minimum discharge that, on the average, completely fills a stream channel.

BANKFULL STAGE. Minimum stage that, on the average, completely fills a stream channel.

BANK HEIGHT. The vertical distance between the toe of a channel bank and the top of a channel bank.

BANKLINE. The alignment of the top of a channel bank with respect to the bridge. The bankline often coincides with the alignment of trees at the top of a channel bank.

BANK PROTECTION. Structure(s) placed on or near a channel bank to control bank erosion or to prevent failure.

BED MATERIAL. Material found on the bed of a stream channel.

BEDROCK. The solid rock that underlies unconsolidated materials. Bedrock depths range from surface exposure to several hundred feet below the ground surface.
BENT. A supporting structural member at the junction of connected bridge spans consisting of a pile, or a series of driven piles, with no apparent footing.
BLOWHOLE. An overwidened channel cross section just downstream from a constricted bridge opening. A blowhole is created by erosion of bed material and bank material under the bridge and just downstream from the bridge. This erosion is caused by expended flow energy that is created by increased flow velocities through the constricted bridge opening.
BOULDER. A fragment of rock whose diameter is in the range of 256 to 4,000 millimeters.
BRIDGE LENGTH. The total length of a bridge from top of left abutment to top of right abutment.

BRIDGE OPENING. The cross-sectional area beneath a bridge available for conveying water.
CHANNEL BANK. The side slopes of a stream channel between which the flow is normally confined.
CHANNEL BAR. An alluvial deposit of sand or gravel that lacks trees. Channel bars usually are present in a stream channel at the inside of a meander bend or downstream from an area of significant debris accumulation.
CHANNEL BED. The bottom of a stream channel bounded by channel banks.
CHANNEL DEPTH. The vertical distance from the water surface to the channel bed at any point along a stream-channel cross section.

CHANNEL DEPTH AT THALWEG. The channel depth at the lowest bed elevation along a cross section, excluding local scour holes, at the upstream side of a bridge opening.
CHANNEL PROCESS. Behavior of a stream channel with respect to migration, erosion, and sedimentation.
CHANNEL REACH. A segment of channel length that is arbitrarily bounded for purposes of study.
CHANNEL-STABILITY ASSESSMENT. An on-site field investigation of the hydraulics and geomorphology of a stream channel near a bridge.
CHANNEL WIDTH. The horizontal distance across a stream channel, normal to the flow, from top of channel bank to top of channel bank.

CLAY. Sediment with median grain-size diameters of 0.00024 to 0.00391 millimeter.
COBBLE. A fragment of rock whose median diameter is 64 to 256 millimeters.
CONFLUENCE. The junction of two or more stream channels.
CONSTRICTION. A natural or artificial section (bridge, channel reach, or dam) where the conveyance is less than the average conveyance of the channel reach.
CONTRACTION SCOUR. Erosion of a channel bed because of flow acceleration through a natural or artificial channel constriction.

CROSS SECTIONAL (CROSS SECTION). A section normal to the trend of flow in a stream channel.
DEBRIS BLOCKAGE. Fallen trees, brush, or trash that accumulate at or under a bridge opening and reduce conveyance of flow.
DEFLECTED-FLOW DEBRIS. Debris in the stream channel that redirects flow from its normal path toward piers or bents, abutments, or the channel banks.
DEGRADATION. A progressive lowering of a channel bed because of scour.
DIAGNOSTIC CHARACTERISTICS. Distinguishable physical traits of stream channels that are used to compose a potential-scour index or an observed-scour index.

FLOOD PLAIN. A flat, alluvial lowland that borders a stream channel and is subject to periodic inundation by floods.

FLUVIAL EROSION. Bank erosion that is characterized by particle by particle removal of bank material from otherwise stable channel banks.

GRAVEL. A fragment of rock whose median diameter is 2 to 64 millimeters.

GEOMORPHOLOGY. The branch of physiography and geology that deals with the form and evolution of the Earth's landscapes and the processes which change the elements of the landscapes.

HIGH-FLOW ANGLE OF APPROACH. The angle between the bank alignment at the bridge and the centerline of the flowpath of the stream channel at a bankfull stage.

HIGH-FLOW MEANDER-IMPACT POINT. The upstream or downstream location on a channel bank where bank erosion has been caused by the natural process of channel meandering at bankfull stage.

INVERT (PAVED). A channelized floor or bed, usually constructed of concrete or metal.

LATERAL EROSION. Erosion in which the removal of bank material is extended in a horizontal direction.

LEFT BANK. The left bank of a stream channel as viewed by a person looking in a downstream direction.

LOCAL SCOUR. Erosion, occurring around piers and abutments, that is caused by local disturbances in the flow, such as turbulence.

LOW FLOW. Normal stage and discharge of a stream.

LOW-FLOW MEANDER-IMPACT POINT. The upstream or downstream location on a channel bank where bank erosion has been caused by the natural process of channel meandering at low flow.

MASS WASTING. The downward movement of bank material due to the force of gravity. Mass wasting is characterized by block failure of bank material and is often caused by flow impacting on channel banks.

MAXIMUM SPAN LENGTH. The length of the longest horizontal opening between piers or abutments of a bridge.

MEANDER. Two consecutive curves in a stream channel, in the rough shape of an S.

MEANDER WAVELENGTH. The distance across a stream channel between corresponding points of successive meanders. A meander wavelength is estimated from channel-stability assessment data by (1) adding the distances between an upstream and downstream meander-impact point and the bridge width in between, and (2) multiplying the sum by two to complete a full wavelength cycle.

NUMERICAL-INDEX VALUE. The ranking value assigned to a specific diagnostic characteristic in the potential-scour index or the observed scour-index.

OBSERVED SCOUR. Contraction scour, local scour, or long-term channel degradation at a bridge that is readily observable.

OBSERVED-SCOUR INDEX. A listing of diagnostic characteristics and corresponding numerical-index values for observed scour.

OBSERVED-SCOUR RATING. The summation of numerical-index values for observed scour.

PIER. A supporting structural member at the junction of connected bridge spans. Piers have footings that are set on the channel bed or in the material underlying the channel bed.

POTENTIAL SCOUR. Scour that can occur because of geomorphic and hydraulic characteristics of a stream channel that have the potential to cause contraction scour, local scour, or long-term channel degradation at a bridge.

POTENTIAL-SCOUR INDEX. A listing of diagnostic characteristics and corresponding numerical-index values for potential scour.

POTENTIAL-SCOUR RATING. The summation of numerical-index values for potential scour.

RANGE FINDER. An instrument that is used in the field for measuring horizontal distances greater than 50 ft and less than 600 ft.

RANGE POLE. Four-foot lengths of graduated pole sections that can be combined and used in the field for measuring horizontal distances of less than 50 ft or vertical heights of 16 ft or less. Horizontal distances are usually measured with an 8-ft length of pole, by flipping the pole hand over hand.
RIGHT BANK. The right bank of a stream channel as viewed by a person looking in a downstream direction.
RIPRAP. A layer or facing of rock that is placed to protect a bridge, embankment, or channel bank from erosion.
SAND. Sediment in a channel bed with median grain-size diameters of 0.06256 to 2 millimeters.
SCOUR. Erosive action of running water that results in the excavation and transportation of materials from the bed and banks of stream channels.

SCOUR DEPTH. The vertical distance a channel bed is lowered below the ambient channel-bed elevation by scour.
SILT. Sediment in a channel bed with median grain-size diameters of 0.00391 to 0.06256 millimeter.
SKEW. The angle between the alignment of an abutment or pier and the bankfull flowpath of water approaching that abutment or pier.
SLUMP (SLUMPED). A slip or collapse of a channel bank (or riprap on a channel bank) caused by erosion at or near the toe of the channel bank.
SPILLTHROUGH ABUTMENT. A bridge abutment with a fill slope on the streamward side.

STABILITY (STABLE). A state of dynamic balance of a stream channel where no appreciable change in vertical or lateral aggradation or degradation occurs from year to year.
STAGE. Water-surface elevation of a stream with respect to a reference elevation.
STAGE OF CHANNEL EVOLUTION. The state of channel stability and channel processes based on the Simon (1989) channel-evolution model.
STREAM CHANNEL. The channel bed and channel banks that confine the surface flow of a stream.
TOE OF CHANNEL BANK. The part of a channel cross section where the channel bank terminates and the channel bed begins.

UNDERCLEARANCE AT THALWEG. The vertical distance between the base of the bridge deck or supporting beam and the water surface at the lowest elevation of the channel bed on the upstream side of the bridge opening, excluding the elevation of local scour holes.
UNDERCUT (UNDERCUTTING). The erosion of bank material or riprap from the toe of a channel bank.
UNWADEABLE STREAM CHANNEL. A stream channel that cannot be waded because of soft, uncohesive bed materials; channel depths greater than 4 ft; or high flow velocities.
VERTICAL ABUTMENT. A bridge abutment with a vertical face on the streamward side.
WADEABLE STREAM CHANNEL. A stream channel that can be waded using hipboots or chestwaders.
WOODY-VEGETATIVE COVER. Tree cover on the channel banks of the reach.

A TECHNIQUE FOR PRELIMINARY APPRAISAL OF POTENTIAL AND OBSERVED SCOUR AS APPLIED TO STATE-MAINTAINED HIGHWAY BRIDGES IN MARYLAND

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ABSTRACT

This report describes a technique for assessing potential scour and observed scour at highway bridges over waterways. The U.S. Geological Survey conducted channel-stability assessments at 876 State highway, U.S. highway, and Interstate highway bridges over waterways in the State of Maryland between May 1990 and April 1991. Conventional data-collection techniques were used in the field to obtain bridge data and stream-channel data for each bridge. A potential-scour index and observed-scour index were composed by assigning numerical-index values to specific diagnostic characteristics of the bridge and stream channel. Potential-scour ratings and observed-scour ratings for assessed bridges were obtained by summing numerical-index values that were assigned to each diagnostic characteristic in the potential-scour index and the observed-scour index.

The data and ratings have several potential applications: (1) screening of individual bridges or groups of bridges for potential scour or observed scour, (2) investigating relations among individual data variables, (3) investigating individual potential- or observed-scour diagnostic characteristics for bridges by physiographic province, (4) investigating multiple potential- or observed-scour diagnostic characteristics for bridges by physiographic province, and (5) investigating potential- or observed-scour diagnostic characteristics by county using a Geographic Information System analysis.

INTRODUCTION

Almost 500,000 bridges in the United States are built over waterways. Many of these bridges span **stream channels**[1] that are continually subjected to **scour** and **bank erosion** (Lagasse and others, 1991). Scour is the most common cause of bridge failure in the United States (Butch, 1991). The failures of the Schoharie Creek Bridge in New York State on April 5, 1987, and the Hatchie River Bridge in western Tennessee on April 1, 1989, brought the problem of scour at bridges in the United States to national attention.

The Maryland State Highway Administration (MDSHA), under a directive from the Federal Highway Administration (FHWA), has developed a program to assess the magnitude and distribution of **potential-scour** conditions and **observed-scour** conditions at highway bridges over waterways in Maryland. The U.S. Geological Survey (USGS), in cooperation with MDSHA, initiated a study in May 1990 to conduct **channel-stability assessments** at State highway, U.S. highway, and Interstate highway bridges over waterways in Maryland.

Bridge inspections by State personnel have previously dealt only with the physical characteristics of the bridge. Channel-stability assessments, as conducted by the USGS, deal with hydraulic and geomorphic relations between a bridge and the stream channel that can cause scour. The uniqueness of channel-stability assessments has emphasized a need for (1) documentation of field techniques for conducting channel-stability assessments, and (2) demonstration of how the collected data can be used to assess potential scour and observed scour at bridges over waterways.

Purpose and Scope

This report (1) describes conventional data-collection techniques for channel-stability assessments, (2) describes a rating system that is used to obtain **potential-scour ratings** and **observed-scour ratings** for bridges where channel-stability assessments are conducted, and (3) presents typical examples of applications of the channel-stability-assessment data and ratings for bridges in Maryland.

The information in this report is based on bridge data and stream-channel data that were collected during channel-stability assessments at 876 State highway, U.S. highway, and Interstate highway bridges over waterways in Maryland between May 1990 and April 1991. Bridge data and stream-channel data were collected and documented during each channel-stability assessment by use of a channel-stability-assessment form, conventional field equipment, and a set of conventional data-collection techniques.

A rating system was applied to selected data to assess potential scour and observed scour for each bridge. A **potential-scour index** and an **observed-scour index** were composed by assigning **numerical-index values** to **diagnostic characteristics** of the bridge and stream channel. Potential-scour ratings and observed-scour ratings for assessed bridges were obtained by summing the numerical-index values that were assigned to each diagnostic characteristic in the potential-scour index and the observed-scour index.

The data and ratings were used to demonstrate five specific applications: (1) screening of individual bridges or groups of bridges for potential scour or observed scour, (2) investigating relations among individual data variables, (3) investigating individual potential- or observed-scour diagnostic characteristics for bridges by physiographic province or province division, (4) investigating multiple potential- or observed-scour diagnostic

1. Words that are **bold** are found in the "Glossary" section of the report.

characteristics for bridges by physiographic province or province division, and (5) investigating potential- or observed-scour diagnostic characteristics by county by use of a Geographic Information System analysis.

Related Studies

The USGS initiated a program in 1988 to study scour at bridges in the State of Tennessee. Similar studies also were implemented by the USGS in the States of South Carolina (1990), Indiana (1991), and Massachusetts (1992). A scour-monitoring study based on **scour-depth** measurements at **piers** and abutments during storms was conducted at three bridges in Caroline, Carroll, and Garrett Counties, Maryland (Hayes, 1993).

General Limitations of Assessments

Channel-stability assessments were not conducted at bridges where boat usage or an underwater assessment was required because conventional data-collection techniques could not assure accurate data. Bridges that were constructed as box culverts or corrugated metal pipes were excluded from the channel-stability assessments because these bridges have paved **inverts**. The report does not include information for approximately 35 bridges that were being repaired or replaced during 1990 and 1991.

Channel-stability assessments were conducted assuming downgradient flow to a maximum of **bankfull discharge** and **bankfull stage**. This assumption may not represent the worst possible scour condition for all bridges.

Stream channels are dynamic with time. The next major hydrologic event could cause a transformation to a stream channel. Data collected during the channel-stability assessments are, therefore, only valid until the next major hydrologic event.

The contents of this report are based on the latest research pertaining to potential scour and observed scour at bridges. The contents of this report do not necessarily reflect the official views of FHWA or MDSHA.

Acknowledgments

The authors would like to thank Leonard N. Podell and Stanley R. Davis of the Maryland State Highway Administration for providing bridge inspection and inventory reports, and for planning assistance. Special thanks are extended to Bradley Bryan, U.S. Geological Survey, Tennessee District, for his assistance and training in channel-stability assessments and data-base operation and management. Special thanks are extended to the Maryland Department of Planning for providing 1990 land-use data.

DESCRIPTION OF STUDY AREA

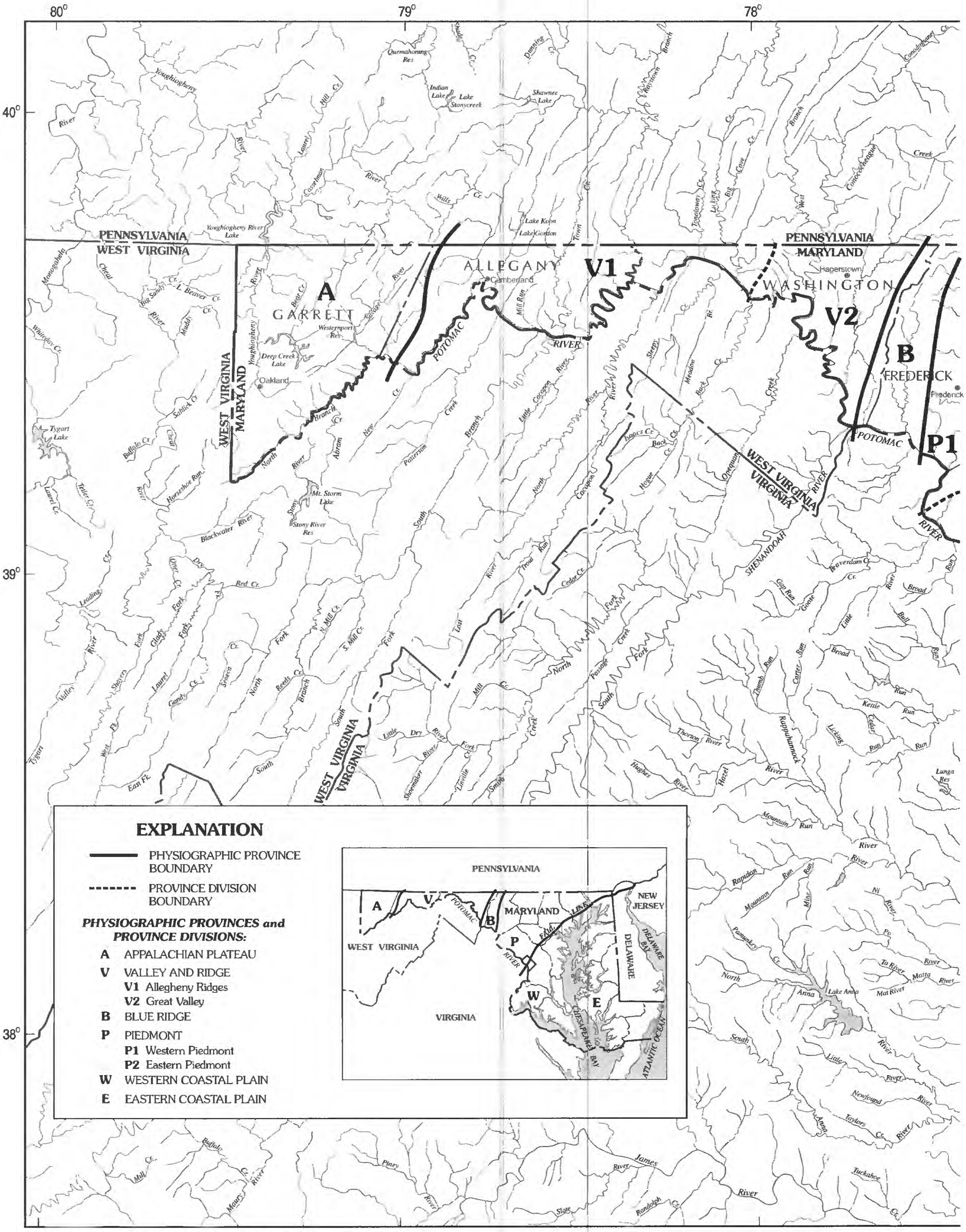
Channel-stability assessments were conducted statewide in Maryland on a county by county basis. For purposes of interpreting the channel-stability-assessment data, the study area was subdivided on the basis of physiographic province and divisions within the physiographic province.

Land use was described in the immediate vicinity of each bridge. The description was based on the predominant type of land use near each bridge, not throughout each drainage basin.

Physiography

Maryland extends across five physiographic provinces--the Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau. The general boundaries of these provinces and their subdivisions are shown in figure 1. The Coastal Plain Physiographic Province is divided into the Coastal Plain East and the Coastal Plain West divisions by the Chesapeake Bay. The Piedmont Physiographic Province is divided into the Piedmont Eastern and the Piedmont Western divisions by Parrs Ridge, which forms a drainage and geologic divide between the two province divisions (Volkes, 1957). The Valley and Ridge Physiographic Province is divided into the Great Valley division on the east and the Allegheny Ridges division on the west because of differences in topography and stream slope between the two province divisions.

Certain features within physiographic provinces and province divisions affect scour



BASE FROM U.S. GEOLOGICAL SURVEY, 1:500,000, 1979

Figure 1. Physiographic provinces and province divisions in Maryland.

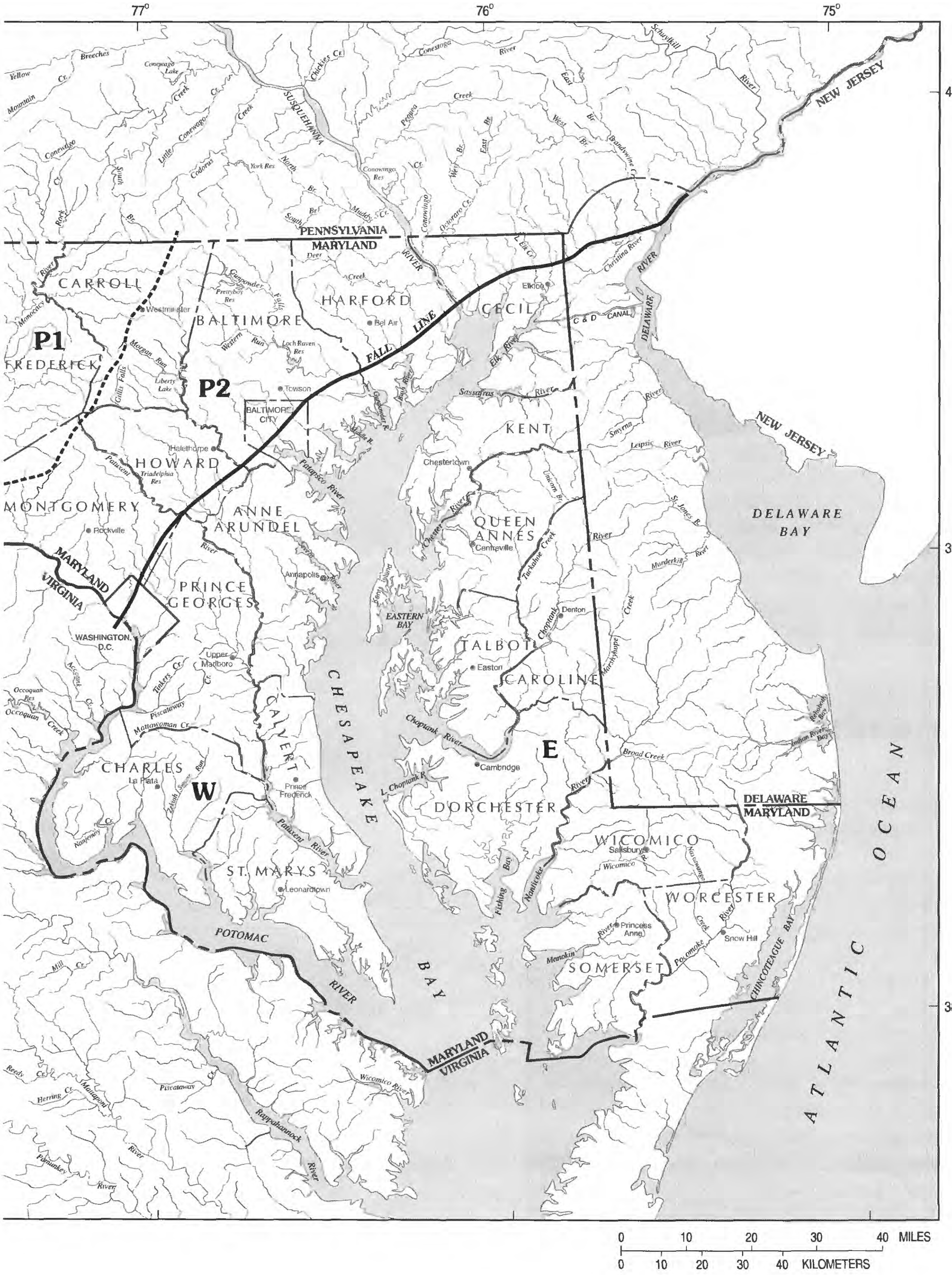


Figure 1. Physiographic provinces and province divisions in Maryland--Continued

differently. For example, the terrain of the Coastal Plain East division is flat. Most streams are lightly sloped, with alluvial **channel banks** and highly erodible **channel beds** of **sand.** While channel beds of sand are very susceptible to scour because of small particle sizes, they also are more likely to refill scour holes in moderate to **low flow** because of the lightly sloped streams (Doheny, 1993). In contrast, the Appalachian Plateau Physiographic Province is a broad upland with pronounced relief and rugged topography. Many streams are steep-sloped with rapids and waterfalls. Stream channels are incised, with channel banks composed of alluvial material, **gravel, cobbles, boulders,** and **bedrock.** Channel beds differ in erodibility and consist mainly of cobbles, boulders, and bedrock. Channel beds in the Appalachian Plateau Physiographic Province are more resistant to scour than channel beds of the Coastal Plain East Province division because of larger-sized **bed material.** However, scour can still occur because of the high velocities in the steep-sloped stream channels. A detailed description of the entire physiography of Maryland can be found in Volkes (1957).

Land Use

The type of land use near a bridge can affect the type and quantity of debris that is carried in a stream channel (Doheny, 1993). **Debris blockage** at a bridge can increase flow velocities through the bridge opening and cause **contraction scour** or **local scour** to occur. Types of land use that were used to describe each **channel reach** in the channel-stability assessments were (1) urban, (2) row crop, (3) pasture, (4) forest, and (5) wetland. Percentages of the types of land use by county for the State of Maryland (Thomas Masutia, Maryland Department of Planning, written commun., 1990) are summarized in table 1. Types of land use other than those mentioned above were grouped under the heading of "Other" in table 1 because they did not describe the channel reach at any of the 876 assessed bridges.

DATA REQUIREMENTS

Data requirements for conducting channel-stability assessments are shown in the channel-stability-assessment form (fig. 2). The channel-stability-assessment form serves as a fundamental data-collection mechanism in the field and contains information that describes the site location (bridge number, highway route number, stream name); the bridge (**bridge length, maximum span length, underclearance at thalweg,** pier and abutment characteristics); and the stream channel (hydraulics and **geomorphology**) (Simon and others, 1989). The channel-stability-assessment form used for Maryland bridges is based on the form that was used by the USGS for a comparable study conducted in western Tennessee in 1988.

Table 1. *Selected types of land use in Maryland, by county, 1990*

County	Land use, in percent					
	Urban	Row crop	Pasture	Forest	Wetlands	Other
Allegany	8.1	7.8	4.6	79.3	0.0	0.2
Anne Arundel	33.8	16.6	2.0	45.4	.8	1.4
Baltimore	32.9	24.1	4.6	35.5	.8	2.1
Calvert	16.5	20.6	1.7	57.3	3.3	.6
Caroline	5.5	57.2	2.0	32.3	1.6	1.4
Carroll	13.7	50.8	10.7	23.8	.1	.9
Cecil	11.6	44.0	2.6	39.9	1.1	.8
Charles	13.0	19.1	1.6	63.2	2.3	.8
Dorchester	2.3	29.6	.6	40.6	24.0	2.9
Frederick	8.8	51.5	8.2	30.7	0.0	.8
Garrett	5.4	17.2	6.4	69.1	.5	1.4
Harford	21.2	34.4	5.7	35.8	2.4	.5
Howard	26.3	27.7	6.9	36.8	.1	2.2
Kent	4.0	65.2	.7	26.9	2.4	.8
Montgomery	35.7	22.9	9.8	27.7	.1	3.8
Prince Georges	30.9	14.7	3.7	45.5	1.0	4.2
Queen Annes	5.8	62.4	1.1	28.4	1.8	.5
St. Marys	12.0	28.1	1.8	55.9	1.2	1.0
Somerset	3.3	24.2	1.8	42.3	27.7	.7
Talbot	6.7	61.1	2.1	26.6	3.2	.3
Washington	10.4	41.7	6.4	39.3	0.0	2.2
Wicomico	7.6	37.6	1.5	46.5	6.4	.4
Worcester	4.8	31.1	1.5	54.2	7.1	1.3

DATA-COLLECTION TECHNIQUES

During each channel-stability assessment, bridge data and stream-channel data are measured and observations are noted on the channel-stability-assessment form. Data are collected, in order, at the

CHANNEL- STABILITY-ASSESSMENT FORM

[Modified from Simon and others, 1989]

1) Date__________ Stream____________________Vicinity ________________ Inspector________________

Land use (vicinity of bridge) ____________, 1= Urban 2= Row crop 3= Pasture 4= Forest 5= Wetland

2) Location: Route No.__________County No. _________District No. _________ Bridge No.____________

Latitude _________ Longitude ___________

Physiographic province or province division___________

1= Appalachian Plateau
2= Allegheny Ridges
3= Blue Ridge
4= Piedmont Western
5= Piedmont Eastern
6= Coastal Plain West
7= Coastal Plain East
8= Great Valley

Sketch of Plan View

3) Bridge characteristics:

Total bridge length (I49)____ Maximum span length (I48)_____

Channel protection (I61) ____ (See FHWA codes)

Intermediate observation of local scour (I321)_________
(See MDSHA codes)

Waterway adequacy (I71) _______ (See FWHA codes)

Tentative scour potential rating,
intermediate observation (I113) ________
*(See FHWA codes, use **6** unless a severe scour condition exists that requires immediate MDSHA notification)*

ADT Factor________ (See MDSHA traffic codes)

Foundation ________ (See MDSHA foundation codes)

1= Spread footing on soil
2= Spread footing, subsurface base unknown
3= Unknown foundation
4= Pile foundation pile lengths unknown or <20 ft
6= Pile foundation pile lengths >20 ft or spread footings on rock

Number of overflow bridges: Left_________ Right___________

4) Flow conditions: Low flow __________ 0= No 1= Yes

Underclearance at thalweg_________ ft or 999 if >35 ft
Channel depth at thalweg _______ ft
Tidal ___________ 0= No 1=Yes

High flow angle of approach _________ degrees
(+= toward right bank, - = toward left bank)

Deflected-flow debris_________ 0= No 1= Yes

Impact point _________ ft, ________ 1= LB 2= RB
(+) = US, (-) = DS

Figure 2. Channel-stability-assessment form

Cause of deflection and effect on bridge:

Capacity of bridge opening, chance of overtopping (circle one):
4= Remote - greater than 100 years
3= Slight - 11 to 100 years
2= Occasional - 3 to 10 years
1= Frequent - less than 3 years

Capacity of channel (circle one): 1= Low 2= Moderate 3= High

Road overflow risk and resultant traffic delays (circle one):
3= Insignificant - minor inconvenience, highway passable in a matter of hours.
2= Significant - traffic delays up to several days.
1= Severe - long-term delays to traffic with resulting hardship.

5) Channel-bank conditions:

	Height from bed		Average angle		Vegetative cover (%)		Bank material		Bank erosion	
	1 LB	2 RB	1 LB	2 RB	1 LB	2 RB	1 LB	2 RB	1 LB	2 RB
1 U/S										
2 D/S										

Note: Vegetative cover: (consider zone from top of bank to the water)
Bank material 1= Silt/clay, 2= Sand, 3= Gravel/cobble, 4=Bedrock
Bank erosion: 0= None, 1= Mass wasting, 2= Fluvial erosion

6) Type of bed material (circle appropriate choice):
1= Sand, 2= Silt/clay, 3= Gravel, 4= Cobble/boulder, 5= Bedrock, 6=Alluvium (if can not tell)

Channel bed armored? 0= No 1= Yes
Estimated depth of gravel deposits_______ ft. (enter 999 if not observed)

7) Channel profile: (1) Upstream: 1= Pool 2= Riffle
(2) Downstream; 1= Pool 2= Riffle

Sketch of Cross Section-Upstream Side of Bridge Opening

Figure 2. Channel-stability-assessment form--Continued

8) Distance to confluence, if any: 0= No 1= Yes; (+)= US (-) DS

Comments

_________ ft 1= LB entry, 2= RB entry
_________ ft 1= LB entry, 2= RB entry
_________ ft 1= LB entry, 2= RB entry
_________ ft 1= LB entry, 2= RB entry

9) Piers: (Listed from left to right). Stop at first pier on flood plain past top of channel bank.

		shape	skew	1 2 3 4 5 6 7 8 9 (circle appropriate choice below)	Local scour	Exposure
B____	P________	__________	________	Loc:1fp, 1tb, lb, mcl, mcm, mcr, rb, rtb, rfp,	0 1 2	N F P
B____	P________	__________	________	Loc:1fp, 1tb, lb, mcl, mcm, mcr, rb, rtb, rfp,	0 1 2	N F P
B____	P________	__________	________	Loc:1fp, 1tb, lb, mcl, mcm, mcr, rb, rtb, rfp,	0 1 2	N F P
B____	P________	__________	________	Loc:1fp, 1tb, lb, mcl, mcm, mcr, rb, rtb, rfp,	0 1 2	N F P
B____	P________	__________	________	Loc:1fp, 1tb, lb, mcl, mcm, mcr, rb, rtb, rfp,	0 1 2	N F P
B____	P________	__________	________	Loc:1fp, 1tb, lb, mcl, mcm, mcr, rb, rtb, rfp,	0 1 2	N F P
B____	P________	__________	________	Loc:1fp, 1tb, lb, mcl, mcm, mcr, rb, rtb, rfp,	0 1 2	N F P
B____	P________	__________	________	Loc:1fp, 1tb, lb, mcl, mcm, mcr, rb, rtb, rfp,	0 1 2	N F P
B____	P________	__________	________	Loc:1fp, 1tb, lb, mcl, mcm, mcr, rb, rtb, rfp,	0 1 2	N F P

Notes: B= Bent (Driven Pile); check only if applicable.

Shape is a standard	Skew is based on high flow alignment	Local scour
1= Squared	(+) = skew to right	0 = None
2= Rounded	(-) = skew to left	1 = Observed
3= Pointed		2 = Undefinable
4= Square piles		
5= Round piles		
6= Pointed piles		

Piers: N = No exposure	F = Footing exposed	P = Piling exposed
Bents: N = Defaults	F = Moderate	P = Severe

lfp = Left flood plain	mcl = Main channel left	rb = Right bank
ltb = Left top of bank	mcm = Main channel middle	rtb = Right top of bank
lb = Left bank	mcr = Main channel right	rfp = Right flood plain

10) Abutments:

		1	2		3= Exposed piles	4 = Exposed footing
1 left; skew _______	Loc:0, +	_____ft, -	_____ft,	spillthrough or vertical.	1= Yes 0= No	1= Yes 0= No
2 right; skew _______	Loc:0, +	_____ft, -	_____ft,	spillthrough or vertical .	1= Yes 0= No	1= Yes 0= No

Notes: Skew is measured based on high-flow conditions
(+) = skew to right
(-) = skew to left

Loc: (+) indicates the abutment is set back from the channel bank;
(-) indicates the abutment is projected into the stream channel;
(0) indicates the abutment is even with the channel bank.

Figure 2. Channel-stability-assessment form--Continued

11) Debris blockage: Percent (%) of bridge opening blocked.

Horizontal:__________ to __________% Vertical:__________ to __________%

Type and size:_________ 1= Brush 2= Whole trees 3= Trash 4= All of others

Potential for debris (qualitative):________ 1= Low 2= Moderate 3= High

____

____

Obstructions (describe):____

____

Note: Left bank to right bank 0% = LB 100%= RB
Bed to top of bank 0% to 100 %
Take pictures, make notes.

12) Riprap on (circle appropriate choice):

1 = U/S rt bank:	0= Absent	1= Present	2= Good condition	3= Weathered to size smaller	4= Slumped
2 = U/S lf bank:	0= Absent	1= Present	2= Good condition	3= Weathered to size smaller	4= Slumped
3 = At rt bank:	0= Absent	1= Present	2= Good condition	3= Weathered to size smaller	4= Slumped
4 = At lf bank:	0= Absent	1= Present	2= Good condition	3= Weathered to size smaller	4= Slumped
5 = D/S rt bank:	0= Absent	1= Present	2= Good condition	3= Weathered to size smaller	4= Slumped
6 = D/S lf bank:	0= Absent	1= Present	2= Good condition	3= Weathered to size smaller	4= Slumped

RIPRAP CLASS_________

	Size of stone by weight	**Percent of total weight within the given size**		**Nominal size (165 lbs./cu.ft.)**
1= CLASS I:	150 lb		100	11"x11"x 11" or equivalent
	2 lb	not to exceed	10	9" spherical
2= CLASS II:	700 lb		100	19"x19"x19" or equivalent
	20 lb	not to exceed	10	16" spherical
3= CLASS III	2,000 lb		100	28"x28"x28" or equivalent
	40 lb	not to exceed	10	23" spherical

If slumped, where and why:____

____

7= Bed: 0= Absent 1= Present 2= Good condition 3= Weathered to size smaller 4= Moved

If moved, to what extent?____

RIPRAP CLASS_________ (See Classifications Above)

8= At rt abut:	0= Absent	1=Present	2= Good condition	3= Weathered to size smaller	4= Slumped
9= At lf abut:	0= Absent	1=Present	2= Good condition	3= Weathered to size smaller	4= Slumped

RIPRAP CLASS_________ (See Classifications Above)

If slumped, where and why:____

Figure 2. Channel-stability-assessment form--Continued

13) Average channel widths:

Upstream_________________, At bridge opening____________, Downstream_____________________

Blowhole_________________ 0= No 1= Yes _________ft downstream, _______ ft wide, _________ ft long.

14) Meander-impact points in vicinity of bridge:

	1 Low flow		2 High flow	
Straight:	0= No	1= Yes	0= No	1= Yes
	1= LB	2= RB	1= LB	2= RB
U/S (ft)	_______	________	_______	______
D/S (ft)	_______	________	_______	______
Meander wavelength	___________ ft		____________ ft	

Note: Entry will be LB or RB and distance from bridge. 0= impact at bridge.

15) Channel bar present:_____________ 0= No 1= Yes

___________ to ___________ % (0% =LB, 100% =RB)

Distance U/S (+) ______ ft or D/S (-) __________ ft. (Distance measured to mid-bar)

Width at mid bar_______ ft.

16) Alluvial fan or delta in vicinity of bridge: 0= No 1=Yes 2= Questionable

If "questionable." then describe:____

____

17) Stage of channel evolution (circle appropriate choice):

1= Undisturbed 2= New construction 3= Degradational 4= Degradation and bank failure
5= Aggradation or stable bed, with bank failure or bank erosion 6= Fully recovered

18)__________ Pictures taken, frames ____________ to ____________ on roll______________.

Film roll no.	Picture no.	Description

Place other sketches as needed on back.

19) General condition of bridge decking, superstructure and substructure, qualitative, (Refer to I60 as a guide, report serious conditions to MDSHA):____
____

Figure 2. Channel-stability-assessment form--Continued

following locations: (1) On the bridge deck, (2) under the bridge deck, and (3) upstream and downstream from the bridge deck.

The following six pieces of field equipment are needed for collection of bridge data and stream-channel data during channel-stability assessments: (1) A calibrated **range finder**, (2) a magnetic compass with an integral inclinometer or a 180-degree protractor, (3) two or more 8-ft graduated **range poles**, (4) a 5- to 10-lb weighted leadline or 5-lb weighted 150-ft fiberglass tape measure, (5) a waterproof or conventional 35-millimeter camera, and (6) hipboots or chestwaders.

On the Bridge Deck

The alignment of the stream channel at the bridge is observed from the bridge deck. The **high-flow angle of approach** is measured by facing upstream and turning an angle, using a compass or protractor, from the existing **bankline** at the bridge to the centerline of the approaching flow. Flow directed toward the **right bank** is assigned a positive high-flow angle of approach (+), and flow directed toward the **left bank** is assigned a negative high-flow angle of approach (-) (figs. 3 and 4). No high-flow angle of approach is assigned if there are no channel **meanders** near the bridge and flow passes through the **bridge opening** without impacting either channel bank near the bridge.

Photographs are taken from the bridge deck to indicate the alignment of the stream channel near the bridge. At least two perspectives are photographed at each bridge--(1) Looking upstream at the centerline of the stream channel from the upstream side of the bridge deck, and (2) looking downstream at the centerline of the stream channel from the downstream side of the bridge deck. Additional photographs are taken, if needed, to show the entire stream channel upstream and downstream from the bridge.

A plan-view sketch is drawn based on an upstream to downstream perspective. The plan-view sketch shows the alignment of the stream channel at the bridge and the location of piers or **bents,** debris blockage, **channel bars,** and **riprap.** An example of a plan-view sketch for Big Pipe

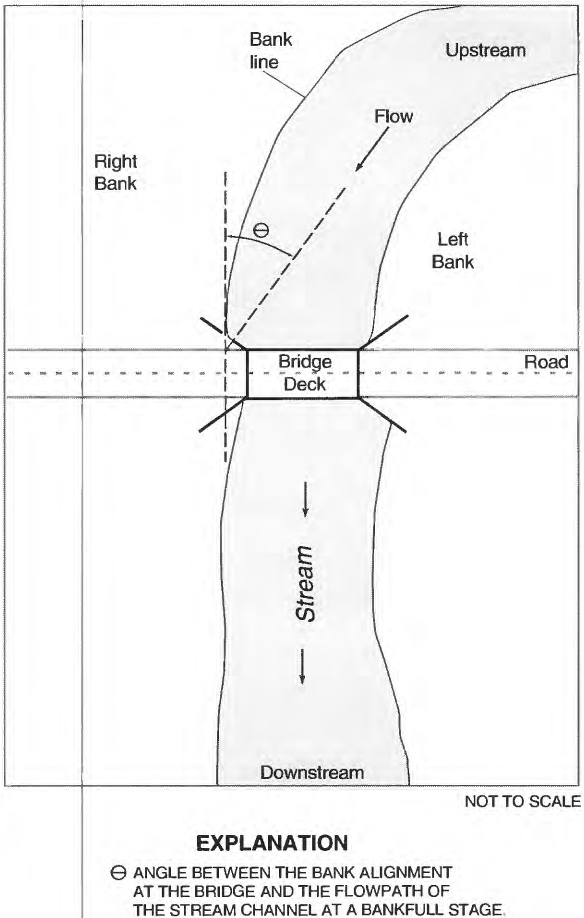


Figure 3. Plan view of positive high-flow angle of approach.

Creek at MD-77 (State Route 77 in Maryland), Carroll County, Md., is shown in figure 5.

An assessment of land use in the channel reach is made from the bridge deck by observing the channel banks and **flood plains** in the channel reach. If land use on the upstream and downstream sides of the bridge differs from each other, the upstream type of land use is used to describe the channel reach because the upstream type of land use influences runoff characteristics at the **approach** to a bridge.

A weighted leadline, weighted tape measure, or range pole is used at bridges over **unwadeable stream channels** to measure the **channel depth at thalweg** and the underclearance at thalweg on the upstream side of the bridge opening. The selected

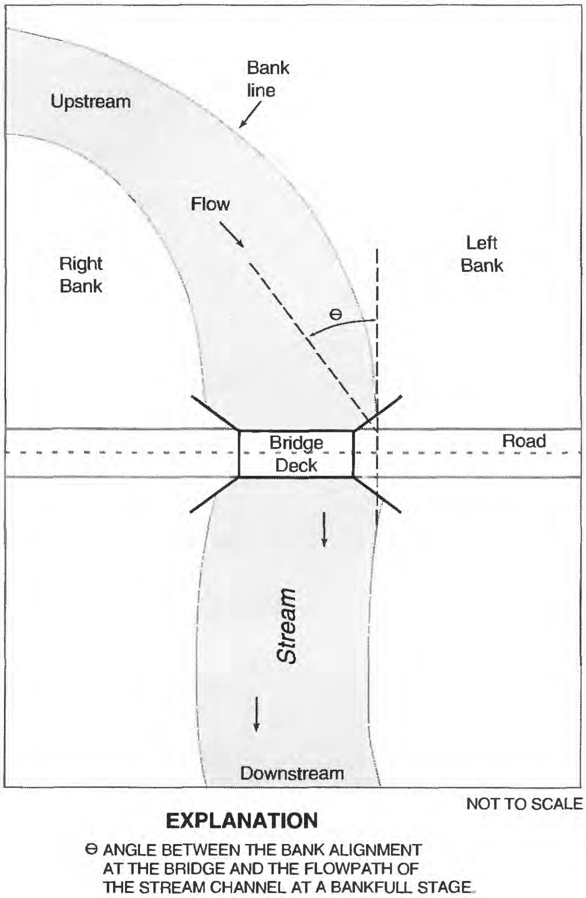


Figure 4. Plan view of negative high-flow angle of approach.

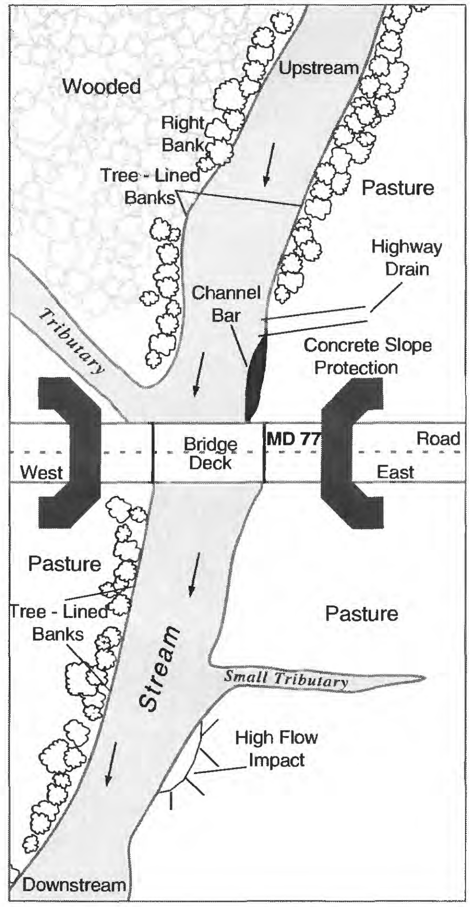


Figure 5. Plan view of Big Pipe Creek at Route MD-77, Carroll County, Maryland.

measuring instrument is lowered from the bridge deck. The **channel depth** is measured in various places until the channel depth at thalweg is located. The distance between the water surface and the base of the bridge deck or support beam is then measured at this location. If the underclearance at thalweg exceeds the length of a 16-ft range pole, then the underclearance at thalweg is measured with a weighted leadline or weighted tape measure from the bridge deck even if the stream channel can be waded.

A weighted leadline, weighted tape measure, or range pole also is used at bridges over unwadeable stream channels to determine local scour, abutment-footing exposures, and pier-footing exposures. The selected measuring instrument is lowered from the bridge deck. The channel depth is measured while the instrument is gradually moved closer to the pier or abutment. An increase in channel depth as the instrument is moved closer to the pier or abutment indicates the presence of local scour. The presence or absence of abutment-footing exposures and pier-footing exposures is determined by lowering the instrument and striking the channel bed near the pier or abutment. An abrupt change in the surface that the instrument is striking can indicate a footing exposure if (1) it is accompanied by a decrease in channel depth near the pier or abutment, and (2) a constant channel depth is maintained after the change in striking surface.

Abutment **skew** and pier skew for bridges over unwadeable stream channels are measured by facing upstream and turning an angle with a compass or protractor from the line of the abutment or pier alignment to the bankfull flowpath approaching the abutment or pier (fig. 6). The direction of abutment skew or pier skew is assigned by (1) facing upstream, and (2) noting the direction the flow would push the abutment or pier if it could move. If an abutment or pier is skewed to the right, then the skew is assigned a positive value (+). If an abutment or pier is skewed to the left, then the skew is assigned a negative value (-).

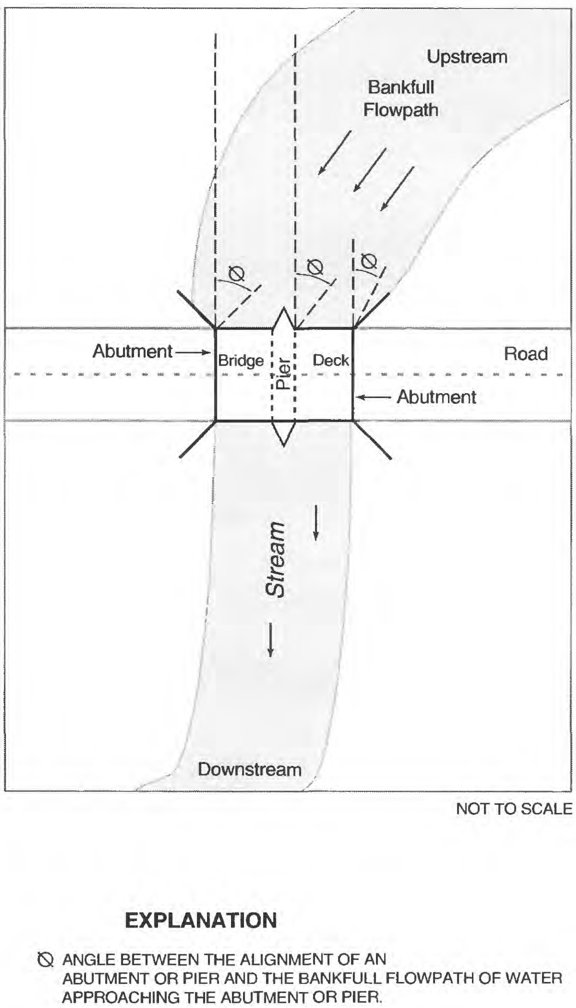


Figure 6. Plan view of abutment skew and pier skew.

Under the Bridge Deck

For bridges located over **wadeable stream channels**, abutment skew and pier skew are measured from the stream channel and under the bridge by (1) standing next to each abutment and pier on the upstream side of the bridge and facing upstream, and (2) turning an angle from the line of the abutment or pier alignment to the bankfull flowpath approaching the abutment or pier. If the stream channel is wadeable, the presence or absence of abutment-footing exposures and pier-footing exposures is observed or checked by prodding near the base of the footings with a range pole. The underclearance at thalweg and the channel depth at thalweg are measured from under the bridge if (1) the stream channel is wadeable, and (2) the underclearance at thalweg can be measured with a range pole of length ranging from 8 to 16 ft.

A range finder, range pole, or weighted-tape measure is used to measure the horizontal and vertical dimensions of any debris blockage at the upstream side of the bridge. Percentages of debris blockage are calculated according to the **cross-sectional** location of the debris blockage at the upstream side of the bridge opening (fig. 7).

The **channel width** on the upstream side of the bridge opening is measured. A range finder is used for stream channels greater than 50 ft in width and a range pole is used for stream channels less than 50 ft in width.

The channel bed under the bridge and near the bridge is observed to determine the type of bed material in the channel bed. If the bed material in the stream channel is substantially mixed, a conservative estimate is made of the predominant type of bed material. The presence or absence of riprap in the channel bed is noted.

A range finder or range pole is used to measure the abutment locations with respect to the channel banks. Abutment locations for **vertical abutments** and **spillthrough abutments** are measured as the distance between the base of the abutment and the location of the channel bank (figs. 8 and 9). A positive abutment location indicates an abutment that is set back from the top of the channel bank at a bankfull **stage**. A zero or negative abutment location indicates an abutment that is in contact with flow and a greater risk for scour than an abutment with a positive location.

Debris blockage: Location of blockage in the bridge opening, percent of opening blocked.
Horizontal: 35% to 65% Vertical: 0% to 40%.

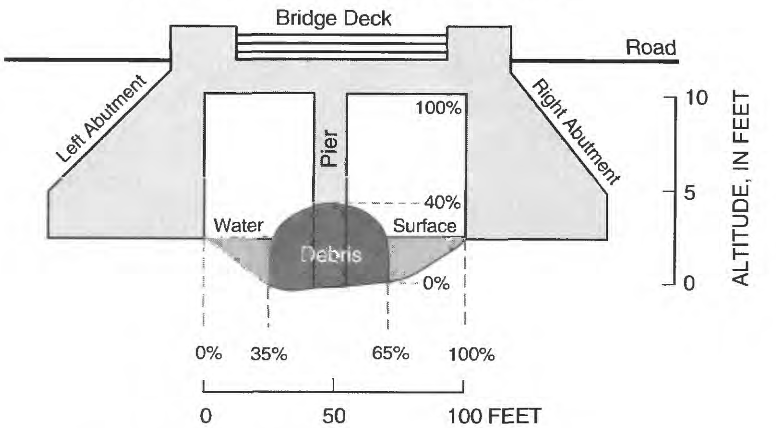


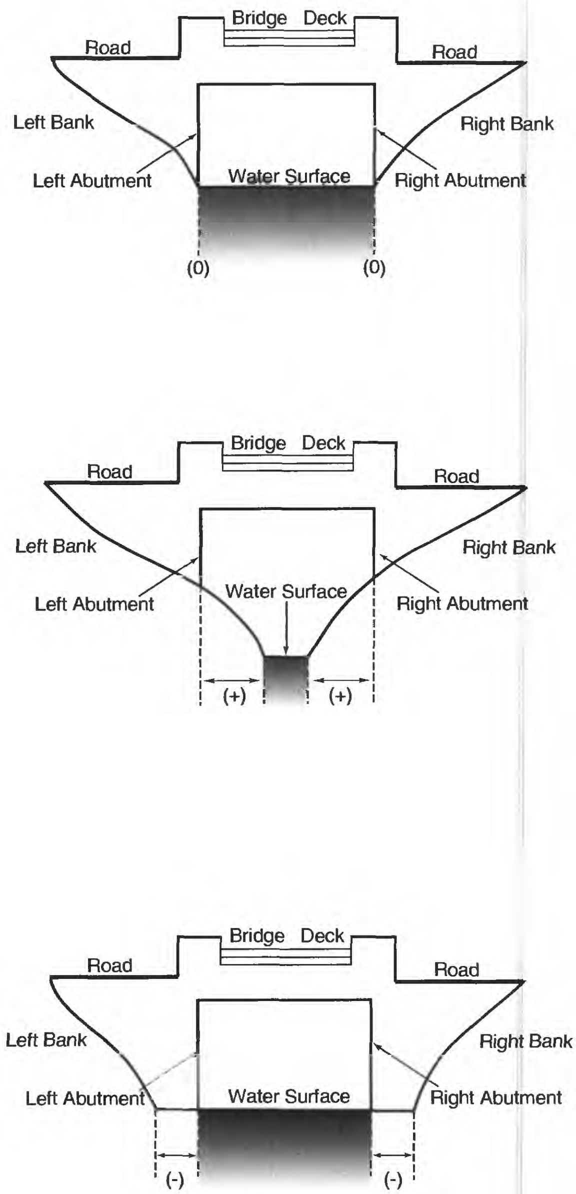
Figure 7. Cross section showing debris blockage at upstream side of bridge opening.

Upstream and Downstream from Bridge

The channel reach used for measurement of stream-channel data ranges from two to three bridge lengths upstream and downstream from the bridge (fig. 10). In the situation where bridges are wider than the stream channel, the channel reach is defined as two to three channel widths at the bridge opening, upstream and downstream from the bridge.

Average **bank heights** and **bank angles** for the channel reach are measured using a range pole and compass with inclinometer. Bank heights are measured by (1) placing the range pole at the **toe of the channel bank**, and (2) measuring the vertical distance from the toe of the channel bank to the top of the channel bank. Measurements of bank heights and bank angles are made at two or three locations along each channel bank and the average values are noted on the channel-stability-assessment form. Average bank angles are measured by (1) laying the range pole along the slope of the channel bank, (2) placing the inclinometer on top of the range pole, and (3) reading the bank angle from the inclinometer. Measurements are made at two or three locations along each channel bank and the average values are noted on the channel-stability-assessment form.

Woody-vegetative-cover percentages are estimated for each channel bank in the channel reach. The woody-vegetative-cover percentages are based on the surface area of tree cover from the edge of water to the top of the channel bank (fig. 11). Only trees are considered as woody-vegetative cover because they have extensive root systems that provide lateral **stability** to channel banks from erosion. Grass, weeds, brush, and bushes are not

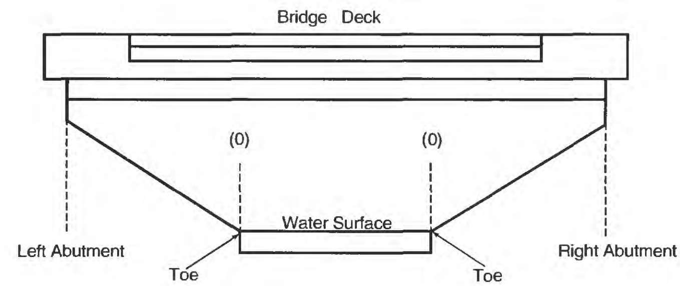


Zero location (0): All or nearly all of the abutment face is contacted by the flow from the upstream to the downstream end of the abutment. The width of the channel upstream from the bridge is equal to that of the bridge opening and is aligned with the abutments.

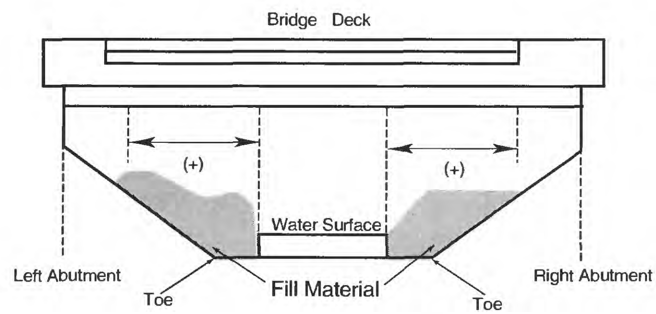
Positive location (+): A natural bank or a deposition of fill material exists between the channel and the abutment, from the upstream to the downstream end of the abutment. The width of the channel upstream from the bridge is usually less than the bridge opening and channel banks are aligned with the abutments.

Negative location (-): The horizontal difference in location between the channel bank at the edge of water at the upstream end of the abutment, and the horizontally projected axis of the abutment. Channel banks upstream from the bridge are widened to envelope wingwalls.

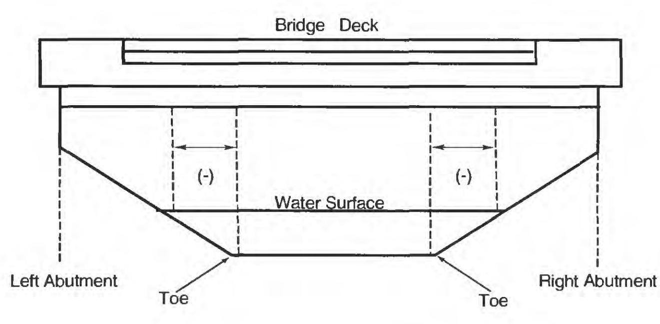
Figure 8. Cross sections showing locations of vertical abutments.



Zero location (0): All or nearly all of the abutment toe is contacted by the flow from the upstream to the downstream end of the abutment.

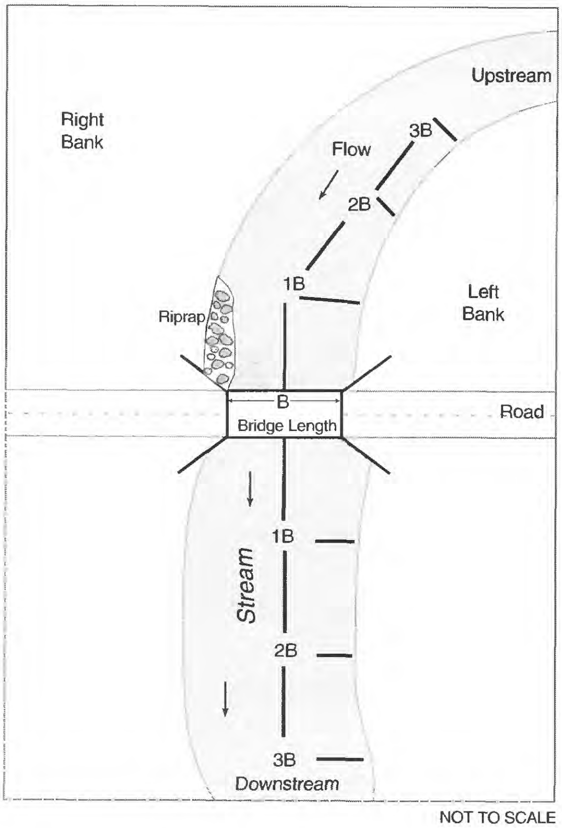


Positive location (+): A natural bank or a deposition of fill material exists between the channel and toe of the abutment from the upstream to the downstream end of the abutment.



Negative location (-): The horizontal difference in location between the toe of the abutment and the edge of water that is located at a point along the slope of the abutment.

Figure 9. Cross sections showing locations of spillthrough abutments.



EXPLANATION

B BRIDGE LENGTH FROM ABUTMENT TO ABUTMENT (or channel width at the bridge opening if the bridge is larger than the channel width at the bridge opening).

1B ONE BRIDGE LENGTH

2B TWO BRIDGE LENGTHS

3B THREE BRIDGE LENGTHS

Figure 10. Plan view of typical channel reach (1B to 3B) for measurement of stream-channel data during a channel-stability assessment.

included in the estimation of woody-vegetative-cover percentages because they do not have root systems that provide lateral stability to channel banks from erosion. Trees that have fallen into the stream channel are not considered in the estimation of woody-vegetative-cover percentages because their root systems are no longer protecting the channel bank from erosion.

The channel banks in the channel reach are observed to determine the type of bank material and the type of bank erosion on each channel bank. Channel banks protected by stable riprap are considered nonerosive. Alluvial channel banks are characterized with **mass wasting, fluvial erosion,** or no erosion depending on the magnitude of the bank angles and the extent of **undercutting** and block failure of the channel banks. The presence or absence of riprap is noted for each channel bank in the channel reach. The location, size, and condition of any riprap are observed and noted.

Average channel widths are measured using a range finder for distances of 50 ft or greater, or with a range pole for distances less than 50 ft. The downstream channel is observed for the presence of a **blowhole** (fig. 12). If a blowhole is present on the downstream side of the bridge, the length and maximum width of the blowhole are measured with a range finder or range pole. Also measured is the distance from the downstream side of the bridge deck to the point where the blowhole begins to overwiden the stream channel.

Confluences in the channel reach are located by (1) noting the channel bank where the confluence enters (left bank or right bank), and (2) measuring the distance from the confluence to the bridge deck with a range finder or range pole. This distance is coded as a positive distance for a confluence located upstream from the bridge, or a negative distance for a confluence located downstream from the bridge.

Deflected-flow debris in the stream channel is characterized by (1) noting the channel bank that is impacted by the flow deflection, and (2) measuring the distance from the impact point to the bridge deck with a range finder or range pole. This distance is coded as a positive distance for deflected-flow debris impacting a channel bank upstream from the bridge, or a negative distance for deflected-flow debris impacting a channel bank downstream from the bridge.

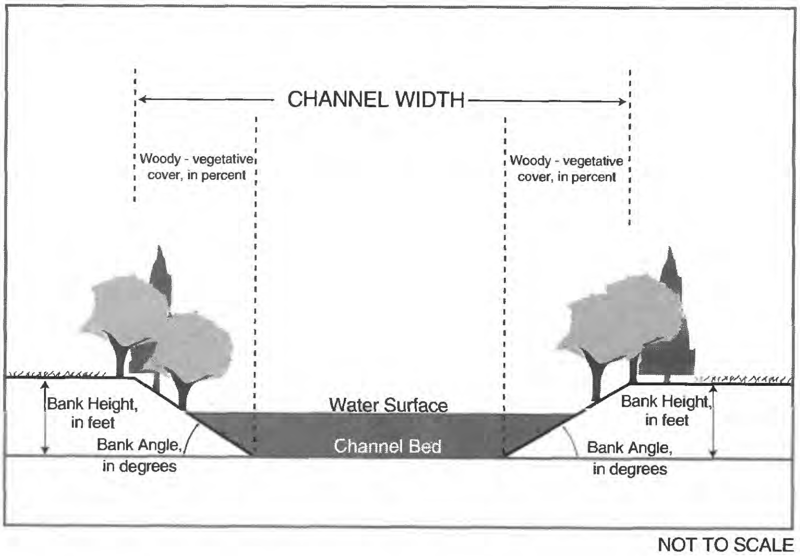


Figure 11. Typical channel-bank conditions with woody-vegetative (tree) cover.

An **alluvial fan** or delta near the bridge is noted on the channel-stability-assessment form. The alluvial fan can be described in detail on the channel-stability-assessment form if deemed necessary.

Low-flow meander-impact points and **high-flow meander-impact points** are located using a range finder or range pole. The location of a meander-impact point is determined by (1) noting whether the meander-impact point is located upstream or downstream from the bridge, (2) noting whether the meander-impact point is located on the left bank or the right bank, and (3) measuring the distance from the location where the meander-impact point contacts the channel bank to the bridge. High-flow meander-impact points are measured more qualitatively than low-flow meander-impact points because channel-stability assessments are conducted during low-flow conditions. Indications of high-flow meander-impact points in a stream channel include a high-flow angle of approach, undercutting and mass wasting of channel banks, and **slumped** riprap. The meander-impact points that are located closest to the upstream side or downstream side of the bridge are noted on the channel-stability-assessment form. **Meander wavelengths** are calculated on the basis of the location of low-flow meander-impact points and high-flow meander-impact points.

A channel bar in the stream channel is located using a range finder or range pole. The width of the channel bar at mid-bar is measured. The distance from mid-bar to the front of the bridge deck is

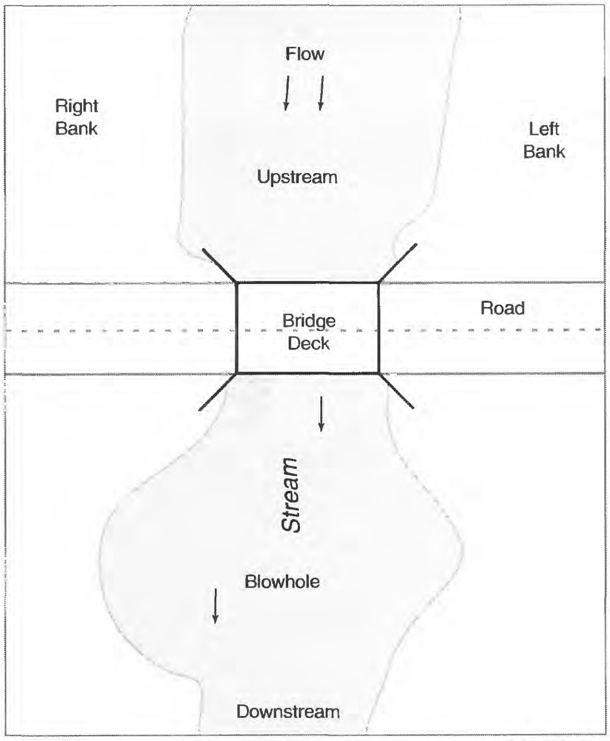


Figure 12. Plan view of a blowhole at a bridge.

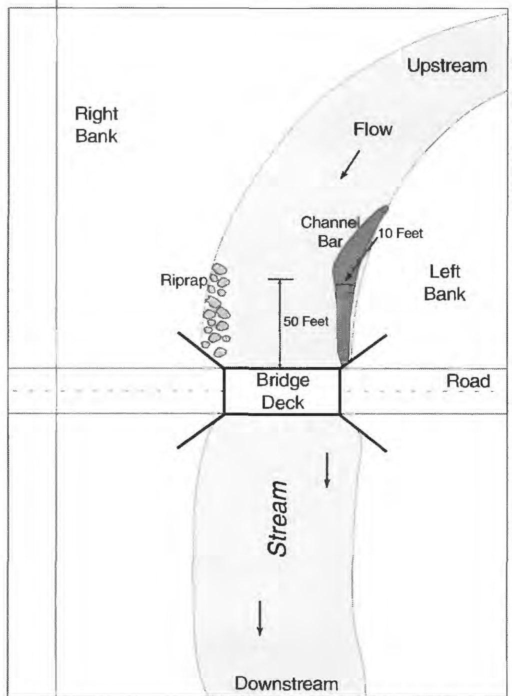


Figure 13. Plan view showing the location of a channel bar near a bridge. (Distance to mid-bar = 50 feet upstream, width at mid-bar = 10 feet)

measured (fig. 13). The location of the channel bar with respect to the channel banks is measured, and percentages are calculated on the basis of the cross-sectional position of the channel bar in the stream channel (fig. 14). The channel-stability-assessment form allows for only one channel bar. If more than one channel bar is present in the stream channel, the channel bar upstream from the bridge or underneath the bridge is measured because channel bars in these locations can direct flow toward piers and abutments. If no channel bars are located upstream from the bridge or under the bridge, then a channel bar downstream from the bridge is measured.

The alignment of the bridge and stream channel is photographed while standing in the stream channel. Two perspectives of the bridge are photographed--(1) looking downstream at the bridge from the centerline of the channel, at a minimum of one bridge length in distance upstream from the bridge; and (2) looking upstream at the bridge from the centerline of the channel, at a minimum of one bridge length in distance downstream from the bridge. Photographs are taken from either of the channel banks or from the right or left edge of the water when the stream channel is unwadeable. Additional photographs are taken, if needed, to show the entire bridge and stream channel from the two perspectives.

A **stage of channel evolution** is assigned to the stream channel at the conclusion of the channel-stability assessment (fig. 15 and table 2). The stage of channel evolution is based on all collected data contributing to stream-channel mobility and observations made during the channel-stability assessment. For example, a stream channel that is heavily riprapped on all channel banks with no bank

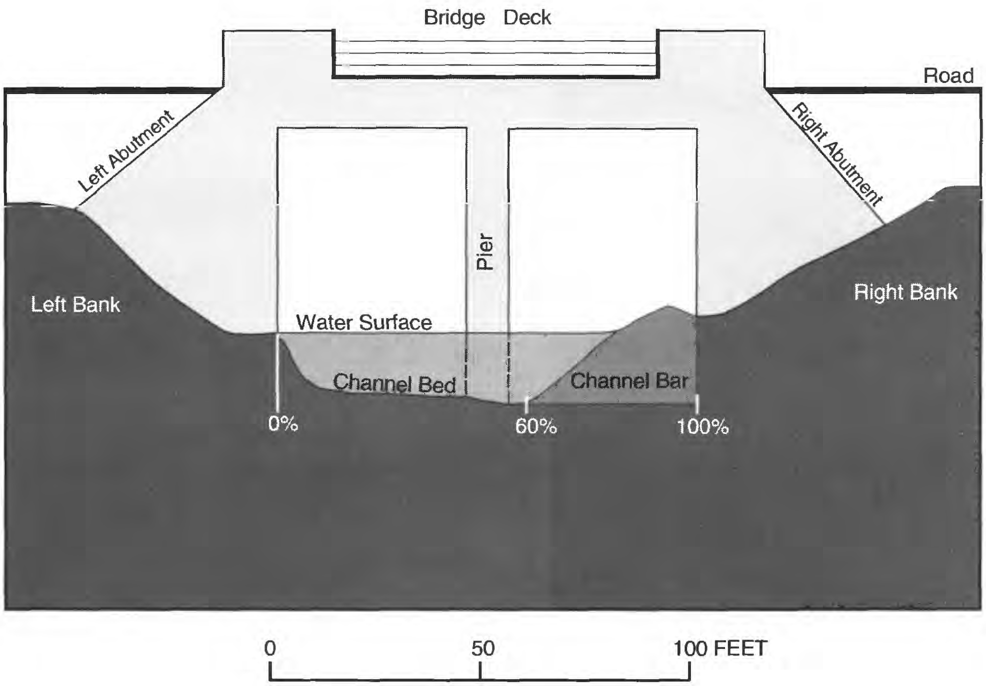


Figure 14. Cross section showing the location of a channel bar location near a bridge. (The bar occupies 60 to 100 percent of the bridge opening horizontally.)

erosion is assigned a stage II (new construction). A detailed description of all stages of channel evolution can be found in Simon (1989).

Completion of the channel-stability-assessment form for a typical bridge requires approximately 1 1/2 to 2 hours. The amount of time that is required depends on (1) the size of the bridge being assessed, and (2) the width and depth of the stream channel being assessed.

Quality Assurance

Quality assurance for channel-stability assessments consists of training for project personnel, followup training for project personnel, and ongoing project supervision by the project chief. Quality assurance procedures are discussed below.

Training. Training initially consists of (1) a theoretical discussion of scour concepts, (2) explanation of the channel-stability-assessment form and data-collection techniques, (3) discussion and demonstration of equipment calibration and use, and (4) discussion of safety considerations. Channel-stability assessments are then conducted at preselected bridges, with project personnel working together in a group. Discussions of channel-stability-assessment data are conducted at each bridge. Data-collection techniques are demonstrated at each bridge.

Channel-stability assessments are then conducted individually at a common bridge. Selected channel-stability-assessment data are discussed at the completion of each channel-stability assessment. Training of project personnel is completed with discussion of questions about channel-stability-assessment data and data-collection techniques.

Followup Training: Followup training for project personnel is conducted by the project chief. Channel-stability assessments are conducted individually at selected bridges by the project chief

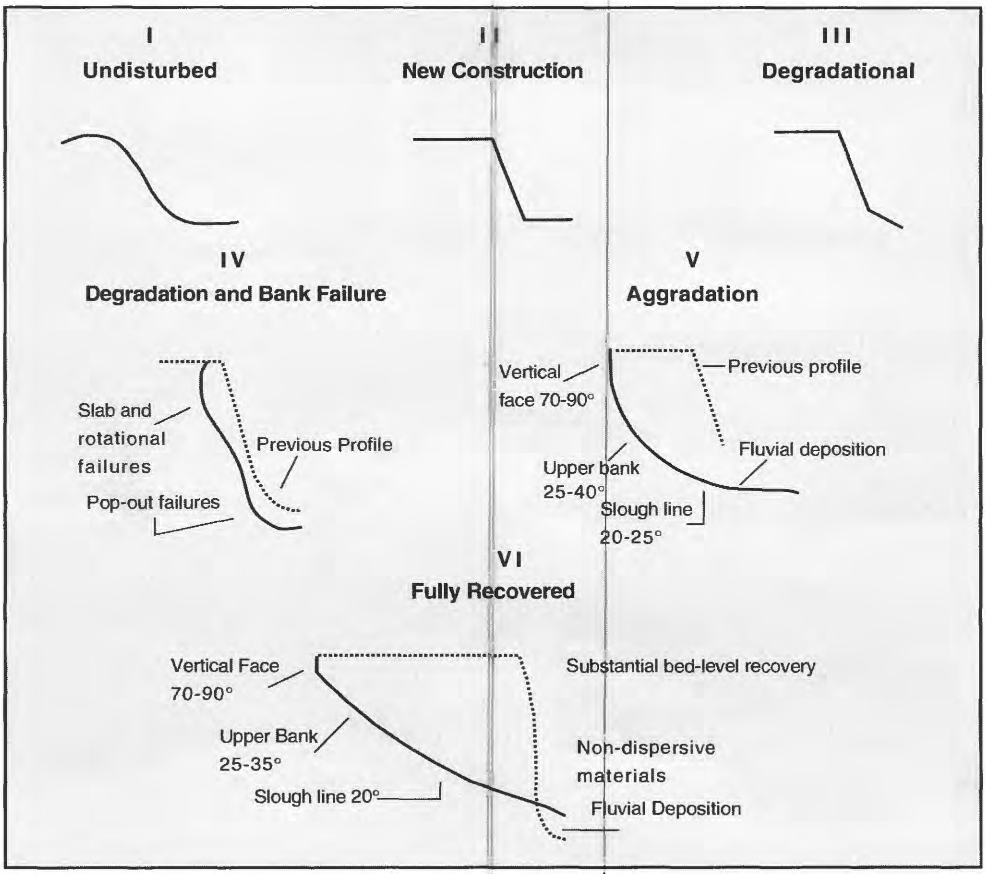


Figure 15. Stages of channel evolution. (Modified From Simon, 1989, fig. 5)

and project personnel. Channel-stability-assessment data are compared and discussed. Followup training is conducted until familiarity and consistency with channel-stability assessments and data-collection techniques is assured.

Project Supervision: The project chief will discuss weekly field activities with all project personnel. Any problems or site anomalies are discussed. If there are problems or site anomalies that cannot be understood or resolved, the project chief may accompany the site assessor to the bridge to resolve the problem. The project chief also may conduct a repeat channel-stability assessment on occasion at a bridge chosen at random to check data collected by project personnel.

TECHNIQUE FOR APPRAISAL OF POTENTIAL AND OBSERVED SCOUR

Data collected during channel-stability assessments are used to obtain an appraisal of potential scour and observed scour. All data are checked for technical accuracy and entered into a data base. Diagnostic characteristics of the bridge and stream channel are assigned numerical-index values that are used to assess ongoing **channel processes** and scour at bridges (Simon and others, 1989). A potential-scour index and an observed-scour index composed of diagnostic characteristics and numerical-index values are used to obtain a potential-scour rating and an observed-scour rating for each bridge. The potential-scour rating and observed-scour rating for each bridge are obtained by summing the numerical-index values that are assigned to each diagnostic characteristic in the potential-scour index and observed-scour index.

Table 2. *Stages of channel evolution*

[From Simon, 1989, table VII]; --, not applicable]

No.	Stage name	Dominant processes: Fluvial	Dominant processes: Hillslope	Characteristic forms	Geotechnical evidence
1	Undisturbed	Sediment transport-mild aggradation; basal erosion on outside bends, deposition on inside bends.	--	Stable, alternate channel bars; convex top-bank shape; flow line high relative to top bank; channel straight or meandering.	Vegetated banks to flow line
2	New construction	--	--	Trapezoidal cross section; linear bank surfaces; flow line lower relative to top bank.	Removal of vegetation
3	Degradational	Degradation; basal erosion on banks.	Pop-out failures.	Heightening and steepening of banks; alternate bars eroded; flow line lower relative to top bank.	Riparian vegetation, high flow line and may lean towards channel.
4	Degradation and bank failure.	Degradation; basal erosion on banks.	Slab, rotational and pop-out failures.	Large scallops and bank retreat; vertical-face and upper-bank surfaces; failure blocks on upper bank; some reduction in bank angles; flow line very low relative to top of channel bank.	Tilted and fallen riparian vegetation.
5	Aggradation or stable bed, with bank failure or bank erosion	Aggradation; development of meandering thalweg; initial deposition of alternate bars; reworking of failed material on lower banks.	Slab, rotational and pop-out failures; low-angle slides of previously failed material.	Large scallops and bank retreat; vertical face, upper bank, and slough line; flattening of bank angles; flow line low relative to top bank; development of new flood plain.	Tilted and fallen riparian vegetation; re-establishing vegetation on slough line; deposition of material above root collars of slough-line vegetation.
6	Fully recovered	Aggradation; further development of meandering thalweg; further deposition of alternate bars; reworking of failed material; some basal erosion on outside bends deposition on flood plain and bank surfaces.	Low-angle slides; some pop-out failures near flow line.	Stable, alternate channel bars; convex-short vertical face, on top bank; flattening of bank angles; development of new flood plain; flow line high relative to top bank.	Re-establishing vegetation extends up slough line and upper bank; deposition of material above root collars of slough-line and upper-bank vegetation; some vegetation establishing on bars.

Quality Assurance

Channel-stability assessments are checked for technical accuracy prior to entry into the data base and development of potential-scour ratings and observed-scour ratings. Channel-stability assessments are checked by use of (1) bridge-inventory information provided by the cooperator, (2) photographs of the bridge and stream channel that are taken during each channel-stability assessment, and (3) the plan-view sketch of the bridge and stream channel that is drawn during each channel-stability assessment.

Stream name, highway route number, bridge number, bridge length, and maximum span length are checked against bridge-inventory information provided by the cooperator. The physiographic province or province division where the bridge is located is checked by use of a map that shows physiographic province boundaries and province divisions.

The magnitude and direction of the high-flow angle of approach are checked against the channel alignment shown in the plan-view sketch and photographs. The channel-stability assessment is then checked to ensure that abutment skews, pier or bent skew, low-flow meander-impact points, and high-flow meander-impact points coincide with the direction of the high-flow angle of approach shown in the plan-view sketch and photographs.

Bank angles for the stream channel are checked against corresponding types of bank erosion on the respective channel banks. If mass wasting is coded as the type of erosion on a given channel bank, the corresponding bank angle is checked to ensure that the magnitude of the bank angle is greater than 45 degrees. The bridge-deck photographs and instream photographs are also used to verify types of erosion on the respective channel banks.

The magnitude and direction of pier or bent skews are checked against the magnitude and direction of the high-flow angle of approach to ensure (1) the pier or bent skew is of similar magnitude as the high-flow angle of approach, and (2) the pier or bent skew is opposite in sign to the high-flow angle of approach because skew is measured looking upstream rather than looking downstream. Piers or bents located on a flood plain are checked to ensure that a skew of zero is assigned because they are not contacted by the flow at a bankfull discharge.

Abutment locations and skews are checked using the plan-view sketch and the photographs. Abutment locations are checked to ensure that (1) abutments that protrude into the stream channel are assigned negative locations, (2) abutments set back from the tops of the channel banks are assigned positive locations, and (3) abutments located along the channel bank are assigned a location of zero. Abutment skews are checked using the same method described for pier skews. Abutments located on a flood plain are checked to ensure that a skew of zero is assigned because they are not contacted by the flow at a bankfull discharge.

Debris blockage at the bridge opening is checked using the instream photographs of the bridge. The instream photographs are used to confirm the location percentages of the debris blockage and the type of debris present.

The presence of a blowhole is confirmed by use of the plan-view sketch and photographs taken of the channel downstream from the bridge opening. If a blowhole is present, the channel widths measured during the channel-stability assessment are checked to ensure that the average channel width at the bridge is smaller than the average channel widths upstream and downstream from the bridge.

The presence and location of a channel bar are verified by use of the plan-view sketch and photographs. The bridge-deck photographs and instream photographs are used to confirm the presence or absence of a channel bar in the stream channel. The upstream or downstream location and cross-sectional position of the channel bar are checked against the locations shown in the plan-view sketch. All percentage calculations are checked for mathematical correctness.

The stage of channel evolution is checked by use of coded stream-channel data and photographs taken during the channel-stability assessment. All data variables contributing to stream-channel mobility are checked and verified to ensure that the proper stage of channel evolution has been selected. These data variables include the bank angles of the stream channel, channel widths, the types of bank erosion, riprap location and condition, channel-bar presence and location, and debris blockage at the bridge opening.

Development of Scour Indexes

Scour indexes are developed by assigning numerical values to specific diagnostic characteristics of the bridge and stream channel. The scour indexes consist of a potential-scour index and an observed-scour index. Data collected during channel-stability assessments are used with the scour indexes to obtain potential-scour ratings and observed-scour ratings.

Potential-Scour Index

Thirteen diagnostic characteristics in the potential-scour index (fig. 16) are used to calculate a potential-scour rating for a bridge. The 13 diagnostic characteristics and the rating system that comprise the potential-scour index are discussed below.

The numerical-index value for "type of bed material" is a function of erodibility. Bedrock is the least erodible bed material under consideration. A channel bed consisting of bedrock is, therefore, assigned a maximum numerical-index value of 5. Cobbles and boulders are slightly more erodible than bedrock. A channel bed consisting of cobbles or boulders is, therefore, assigned a numerical-index value of 4.5. Erodibility continues to increase, respectively, for gravel, sand, unknown **alluvium**, and **silt** or **clay**. The numerical-index values for these bed materials, therefore, decrease from 4 to 1, respectively.

"Protected channel bed" refers to natural or manmade **armoring** in the channel bed that can reduce channel-bed erodibility. The numerical-index value for a protected channel bed is a function of channel-bed erodibility and channel-bank erodibility. A protected channel bed is assigned a maximum numerical-index value of 4. An unprotected channel bed is more erodible than a protected channel bed. An unprotected channel bed is, therefore, assigned a numerical-index value of 3. Natural or manmade **bank protection** on the channel banks with an unprotected channel bed can cause additional stream energy to be directed at the channel bed. An unprotected channel bed with one protected channel bank is, therefore, assigned a numerical-index value of 2. The more bank protection that is present with an unprotected channel bed, the greater the possibility is that additional stream energy will be directed at the channel bed. An unprotected channel bed with two protected channel banks is, therefore, assigned a numerical-index value of 1.

"Stage of channel evolution" refers to the state of stream-channel stability. Numerical-index values for stage of channel evolution are based on six stages of stream-channel stability that are defined in the Simon (1989) channel-evolution model. Stage I (undisturbed) stream channels and Stage VI (fully recovered) stream channels are described by **aggradation** of the channel bed with little or no erosion of channel banks. Because aggradation of the channel bed provides additional cover for abutment footings and pier footings, Stage I and Stage VI stream channels are assigned a maximum numerical-index value of 5. Stage II (new construction) stream channels are described by uneroded channel banks that can be composed of unerodible material. The channel bed can be composed of erodible bed material. Stage II stream channels are, therefore, assigned a numerical-index value of 4. Stage V (aggradation or stable bed, with **bank failure** or bank erosion) stream channels are described by erodible bed material and erodible channel banks. The channel bed can be stable or aggrading slightly. Because the potential exists for scour on the channel bed and channel banks, a numerical-index value of 3 is assigned to Stage V

POTENTIAL-SCOUR INDEX

[Modified from Simon and others, 1989. Diagnostic characteristics and numerical-index values for calculation of potential-scour rating. Potential-scour rating equals sum of assigned numerical-index values]

1) Type of bed material					
Bedrock	Cobble boulder	Gravel	Sand	Unknown alluvium	Silt/ clay
5	4.5	4	3	2	1
2) Protected channel bed					
			(With protected channel banks)		
Yes	No		1 Channel bank	2 Channel banks	
4	3		2	1	
3) Stage of channel evolution					
I	II	III	IV	V	VI
5	4	2	1	3	5
4) Percent of channel constriction at the bridge					
0-5	6-25	26-50	51-75	76-100	
5	4	3	2	1	
5) Number of piers or bents in stream channel					
0	1-2	3 or more			
3	2	1			
6) Percent of debris blockage [horizontal (6), vertical (7), total (8)]					
0-5	6-25	26-50	51-75	76-100	
5	4	3	2	1 (values are divided by 3)	
9) Bank erosion for left bank and right bank					
None	Fluvial	Mass wasting			
3	2	1			
10) Location of high-flow meander impact point from bridge (in feet)					
>100	51-100	26-50	0-25		
4	3	2	1		
11) Skew for each pier or bent (default value = 14)					
No	Yes				
0	-1				
12) Mass wasting at left or right bank pier or bent					
No	Yes				
4	1				
13) High-flow angle of approach (in degrees)					
0-10	11-25	26-40	41-60	61-90	
4	3.5	3	2	1	

Figure 16. Form for potential-scour index.

stream channels. Stage III (degradational) stream channels are described by erodible bed material and erodible bank material. **Degradation** of a channel bed can cause abutment-footing exposures and pier-footing exposures. Stage III stream channels are, therefore, assigned a numerical-index value of 2. Stage IV (degradation and bank failure) stream channels are described by erodible bed material and erodible channel banks. The channel bed can be degraded and scoured. The channel banks can be subjected to **lateral erosion** or mass wasting. Because degradation of the channel bed and lateral erosion of the channel banks occur simultaneously, Stage IV stream channels are assigned a numerical-index value of 1.

"Percent of channel **constriction** at the bridge" refers to a calculation of percentage of reduction in channel width between the approach and the bridge opening. Contraction scour can result from flow acceleration at a channel constriction. Increased channel constriction results in increased flow velocity through a bridge opening and greater potential for contraction scour. The potential for contraction scour is minimal when there is no constriction of the channel or up to 5 percent of constriction. A maximum numerical-index value of 5 is, therefore, assigned for this condition. As percentages of channel constriction at the bridge increase within the ranges specified in figure 16, numerical-index values decrease from 5 to 1.

"Number of piers or bents in stream channel" refers to the number of piers or bents that are contacted by the flow at a bankfull or lower stage. A large number of piers or bents in the stream channel can increase the potential for local scour. The numerical-index value for piers or bents in the stream channel decreases for increasing numbers of piers or bents in the stream channel. A maximum numerical-index value of 3 is assigned for bridges with no piers or bents in the stream channel. The potential for local scour is greater for bridges with one or two piers or bents in the stream channel than for bridges with no piers or bents in the stream channel. A numerical-index value of 2 is, therefore, assigned. A minimum numerical-index value of 1 is assigned for bridges with three or more piers or bents in the stream channel. Minimization of the numerical-index value for bridges with three or more piers or bents in the stream channel is done to avoid overemphasis of piers or bents on the potential-scour rating, and to eliminate bias in reducing potential-scour ratings for multiple-span bridges over large waterways.

"Percent of horizontal, vertical, and total debris blockage" refers to debris blockage at the bridge opening that contributes to channel constriction and increases in flow velocity through the bridge opening. Increased flow velocity through a bridge opening can lead to rapid scouring of bed material. Increasing percentages of horizontal, vertical, and total debris blockage, within the ranges specified in figure 16, result in numerical-index values that decrease from 5 to 1 for debris blockage in each direction. Because the total numerical-index value for debris blockage has three components, a composite numerical-index value for debris blockage is needed before summation into the potential-scour rating. A composite numerical-index value for debris blockage is obtained by dividing the numerical-index values for horizontal, vertical, and total debris blockage by three and summing them.

"Bank erosion for left bank and right bank" refers to no erosion, fluvial erosion, or mass wasting. The left bank and right bank of the stream channel are each assigned a numerical-index value that is based on the most unstable type of bank erosion taking place on the channel bank upstream or downstream from the bridge. No erosion on a channel bank near a bridge is the most stable condition because the channel bank is not subjected to lateral erosion. A channel bank with no erosion is, therefore, assigned a maximum numerical-index value of 3. Fluvial erosion on a channel bank near a bridge indicates greater erodibility than a channel bank with no erosion. A channel bank with fluvial erosion is, therefore, assigned a numerical-index value of 2. Mass wasting on a channel bank near a bridge indicates lateral instability of the channel bank and can lead to failure of a pier or abutment located on the channel bank. A channel bank with mass wasting near the bridge is, therefore, assigned a numerical-index value of 1.

"High-flow meander-impact point from bridge" refers to a location on a channel bank or at the bridge where bankfull flow impacts the channel bank or the bridge because of a meander in the stream channel. A numerical-index value is assigned on the basis of the high-flow meander-impact point that is located closest to the bridge, because rises in stream stage often create a greater risk for a high-flow meander-impact point to be located at the bridge. As the location of the high-flow meander-impact point from the bridge decreases within the ranges specified in figure 16, the assigned numerical-index value decreases from 4 to 1.

"Skew for each pier or bent" refers to the angle of skew that is assigned to each pier or bent in a channel-stability assessment. A numerical-index value of 14 is initially assigned as a maximum value. This represents a numerical-index value of 1 for each of the 14 piers or bents that can be coded on the channel-stability-assessment form. The numerical-index value is reduced by 1 for each pier or bent that has a skew assigned to it. The numerical-index value is not reduced for piers or bents with a skew of 0 or for piers or bents that do not exist.

"Mass wasting at left or right bank pier or bent" refers to mass wasting on a channel bank where a pier or bent is located. Mass wasting on a channel bank indicates lateral instability of the channel bank. Mass wasting can cause a pier or bent that is located on a channel bank to be undermined. A numerical-index value of 4 is assigned to the left bank and right bank if (1) no piers or bents are located on the channel banks, or (2) a pier or bent is located on either or both channel banks with no mass wasting occurring. The numerical-index value is reduced to 1 for a channel bank where mass wasting occurs and a pier or bent is located.

"High-flow angle of approach" refers to the bankfull alignment of flow in the stream channel at the bridge. A high-flow angle of approach indicates a potential for scour on one side of a stream channel. Flow directed toward a channel bank can undercut channel banks and cause abutment-footing exposures and pier-footing exposures. A numerical-index value is assigned on the basis of the magnitude of the high-flow angle of approach that is measured during a channel-stability assessment. As the magnitude of the high-flow angle of approach increases within the ranges in figure 16, the numerical-index value decreases from 4 to 1.

Observed-Scour Index

Five diagnostic characteristics in the observed-scour index (fig. 17) are used to calculate an observed-scour rating for a bridge. The five diagnostic characteristics and the rating system that comprise the observed-scour index are discussed below.

"Observed scour at each pier or bent, and abutment" refers to the degree of scour observed at piers or bents, and abutments. The numerical-index value for observed scour at each pier or bent, and abutment is a function of observed-scour conditions at each pier or bent, and abutment.

Abutment scour is rated according to increasing degree of severity. A maximum numerical-index value of 4 is assigned when no scour is observed at an abutment. A numerical-index value of 2 is assigned when an abutment-footing exposure is observed.

Exposure of piles below an abutment footing is rated separately from an abutment footing exposure. If no piles are exposed below an abutment footing, a maximum numerical-index value of 4 is assigned. A minimum numerical-index value of 1 is assigned when pile exposures are observed below an abutment footing.

The channel-stability-assessment form allows coding for a maximum of 14 piers or bents. A maximum numerical-index value of 4 is initially assigned to each of the 14 piers or bents in the observed-scour index to establish a maximum value of 56. Bridges with 0 to 14 piers or bents can then be compared. The numerical-index values for

OBSERVED-SCOUR INDEX

[Modified from Simon and others 1989. Diagnostic characteristics and numerical-index values for calculation of observed-scour rating. Observed-scour rating equals sum of assigned numerical-index values]

1) Observed scour at each pier or bent, and abutment

If pier:	None	Observed	Footing exposed	Piles exposed
	4	3	2	1
If bent:	None	Observed	Moderate	Severe
	4	3	2	1
If abutment:	None	Footing exposed	Piles exposed	
	4	2	1	

2) Failed riprap at bridge

Left		Right	
No	Yes	No	Yes
2	1	2	1

3) Bed riprap moved?

No	Yes
2	1

4) Blowhole observed?

No	Yes
4	1

5) Mass wasting at left or right bank pier or bent

No	Yes
4	1

Figure 17. Form for observed-scour index.

existing piers or bents are reduced or remain constant based on observed-scour conditions at each pier or bent.

Observed scour at each pier is rated according to increasing degree of severity. A maximum numerical-index value of 4 is assigned to a pier when no scour is observed. A numerical-index value of 3 is assigned to a pier when scour is observed. A numerical-index value of 2 is assigned to a pier when a footing exposure is observed. A minimum numerical-index value of 1 is assigned to a pier when pile exposures are observed.

Observed scour at each bent is rated according to increasing degree of severity. A maximum numerical-index value of 4 is assigned to a bent when no scour is observed. Numerical-index values decrease from 3 to 1 depending on whether the observed scour is (1) minor (0- to 1-ft scour depth), (2) moderate (1- to 3-ft scour depth), or (3) severe (3-ft or greater scour depths).

"Failed riprap at bridge" refers to slumped or undercut riprap **at the left bank** or **at the right bank**. A numerical-index value is assigned for the left and right bank on the basis of riprap stability at each channel bank. A numerical-index value of 2 is assigned for each channel bank if (1) no riprap is present at either channel bank, or (2) riprap that is not slumped or undercut is present at either or both channel banks. A numerical-index value of 1 is assigned for the channel bank where slumping or undercutting of riprap exists.

"Bed riprap moved" refers to riprap in the channel bed that has been moved by the flow. A numerical-index value is assigned on the basis of bed-riprap mobility. A numerical-index value of 2 is assigned if (1) no riprap is present on the channel bed, or (2) riprap that has not been moved by the flow is present on the channel bed. The numerical-index value is reduced to 1 if riprap on the channel bed has been moved by the flow.

"Blowhole observed" refers to an overwidened and deepened channel cross section immediately downstream from a constricted bridge opening. A numerical-index value is assigned on the basis of the presence or absence of a blowhole on the downstream side of a bridge. A numerical-index value of 4 is assigned when a blowhole is not observed on the downstream side of a bridge. A numerical-index value of 1 is assigned when a blowhole is observed on the downstream side of a bridge.

"Mass wasting at left or right bank pier or bent" refers to mass wasting on a channel bank where a pier or bent is located. Mass wasting on a channel bank indicates lateral instability of the channel bank. Mass wasting can cause a pier or bent that is located on a channel bank to be undermined. A numerical-index value of 4 is assigned to the left bank and right bank if (1) no piers or bents are located on the channel banks, or (2) a pier or bent is located on either or both channel banks with no mass wasting occurring. The numerical-index value is reduced to 1 for a channel bank where mass wasting occurs and a pier or bent is located.

Limitations of Data and Ratings

Data that are presented and interpreted in this report are based on bridge and stream-channel conditions that existed in Maryland during 1990-91. Bridges that have been repaired or replaced since 1991 are not accounted for in this report.

No provisions are made on the channel-stability-assessment form to specifically assess tidal reaches. The determination of scour in tidal situations has not been studied sufficiently to permit inclusion in this document (Richardson and others, 1991). All channel-stability assessments for bridges in tidal reaches are conducted assuming downgradient flow.

At the request of MDSHA, qualitative codes (I61, I321, I71, I113, ADT Factor, Foundation, and I60) are included on the channel-stability-assessment form as ancillary information for the use of MDSHA. These codes are not used in the calculation of the potential-scour ratings and observed-scour ratings.

Foundation codes provided by MDSHA do not give pile lengths. The only foundation codes that are used for Maryland bridges are, therefore, (1) spread footings on soil, (2) pile foundations with unknown lengths, or (3) unknown foundations. Bridges with driven piles at the base of the abutments and spread footings at the base of the piers are assigned a foundation code for the more scour-susceptible condition of spread footings on soil.

Bridges with spillthrough abutments are characterized with abutment-footing exposure when the toe of the slope protection is exposed or undermined. Although the abutment may still be protected from scour, exposing or undermining at the toe of slope protection can lead to failure of the slope protection and scour at the abutment footing.

The channel-stability-assessment form allows for coding of a maximum of 14 piers or bents. This is the maximum allowable number of piers or bents that the rating programs can consider. Bridges with greater than 14 piers or bents cannot be rated for potential scour or observed scour without modification to the rating programs. No modifications were made to the rating programs to allow for coding of greater than 14 piers for Maryland bridges.

Alluvium is coded as the predominant type of bed material in the channel bed if the bed material is unknown. This can occur when the stream channel is unwadeable and the bed material cannot be seen through the water.

The numerical-index values from the potential-scour index and observed-scour index have no physical meaning. The potential-scour ratings and observed-scour ratings that are calculated from the respective indexes have no physical meaning either.

Potential-scour ratings range in value from a minimum of 12 to a maximum of 63, with a larger number indicating fewer potential-scour conditions. Observed-scour ratings range in value from a minimum of 24 to a maximum of 90, with a larger number indicating fewer observed-scour conditions. This approach is a modification of the original prototype that was developed and used by the USGS Tennessee District.

The potential-scour ratings and observed-scour ratings are a screening tool for prioritizing possible scour problems at bridges. The bridge owner must determine the ultimate risk of bridge failure after also consulting hydraulic and hydrologic data, site plans, and geotechnical information.

POTENTIAL APPLICATIONS OF DATA

The channel-stability-assessment data, potential-scour ratings, and observed-scour ratings have several potential applications. These include (1) screening of individual bridges or bridges by county for potential scour or observed scour, (2) investigating relations between specific data variables, (3) investigating individual potential- or observed-scour diagnostic characteristics for bridges by physiographic province or province division, (4) investigating multiple potential- or observed-scour diagnostic characteristics for bridges by physiographic province or province division, and (5) investigating potential- or observed-scour diagnostic characteristics by county using a Geographic Information System (GIS) analysis.

Screening of Bridges for Potential or Observed Scour

The scour data base can be used to (1) store, sort, and retrieve channel-stability-assessment data, and (2) generate a two-page site report of the channel-stability assessment, potential-scour rating, and observed-scour rating for any or all bridges in the scour data base. Bridges can be screened using the applications of the scour data base. Screening involves (1) investigating potential-scour ratings or observed-scour ratings to determine which diagnostic characteristics are reducing the rating, or (2) investigating channel-stability-assessment data, diagnostic characteristics, potential-scour ratings, or observed-scour ratings for groups of bridges in relation to one another.

Two-page site reports based on the channel-stability-assessment form are generated using the scour data base. The report is a computerized version of the channel-stability-assessment form without sketches, comments, and photographic information. An example of a site report based on a channel-stability assessment for bridge 6015, Big Pipe Creek at MD-77 (Maryland State Route 77), Carroll County, Md., is shown in figure 18.

Reports of potential-scour rating are generated by use of the scour data base. Each report lists the numerical-index value that is assigned to each diagnostic characteristic in the potential-scour index, and the potential-scour rating for the bridge. An example of a report for a potential-scour rating for bridge 6015, Big Pipe Creek at MD-77, Carroll County, Md., is shown in figure 19. The report indicates a potential-scour rating of 48 out of a maximum potential-scour rating of 63. The numerical-index values that are assigned to the potential-scour diagnostic characteristics are, therefore, indicating some potential for scour at bridge 6015, based on the channel-stability-assessment data collected at bridge 6015. Diagnostic characteristics that contribute to the reduced potential-scour rating for bridge 6015 are (1) type of bed material, (2) protected channel bed, (3) stage of channel evolution, (4) number of piers or bents in the stream channel, (5) bank erosion at left bank and right bank, (6) high-flow meander impact point from bridge, (7) skew for each pier or bent, and (8) high-flow angle of approach. For example, figure 19 indicates that the type of bed material is assigned a numerical-index value of 4 for bridge 6015. Figure 18 indicates that the type of bed material for bridge 6015 is coded as a 3, which is the code for gravel in item 6 of the channel-stability-assessment form (fig. 2). Use of this information along with item 1 (type of bed material) of the potential-scour index (fig. 16) indicates that the numerical-index value for gravel is 4 out of a

CHANNEL-STABILITY ASSESSMENT FOR BRIDGE 6015

[Modified from Simon and others, 1989. Diagnostic characteristics and numerical-index values for calculation of observed-scour rating. Observed-scour rating equals sum of assigned numerical-index values]

BRIDGE NUMBER:6015
DATE: 11/1/1990
VICINITY: DETOUR
ROUTE: 77:

STREAM: Big Pipe Creek
INSPECTOR: B. M. Helinsky
COUNTY: 6

LAND USE:3
PHYSIOGRAPHIC
PROVINCE/DIVISION: 4
DISTRICT: 7

TOTAL BRIDGE LENGTH: 194 FT
CHANNEL PROTECTION: 8
NUMBER OF OVERFLOW BRIDGES: L= 0
UNDERCLEARANCE AT THALWEG: 20 FT
CHANNEL DEPTH AT THALWEG: 2.0 FT

MAXIMUM SPAN LENGHT: 74 FT
WATERWAY ADEQUACY: 9
R= O
TIDAL: 0

LOWFLOW= 1

HIGH FLOW ANGLE OF APPROACH: 35 DEGREES
DEFLECTED FLOW: 0
LOCAL SCOUR: 8
FOUNDATION: 1
CHANNEL CAPACITY: 2

IMPACT POINT: 0
TENTATIVE SCOUR POTENTIAL: 6
CAPACITY OF BRIDGE OPENING: 3
ROAD OVERFLOW RISK: 3

ADT FACTOR: 3

BANK CONDITIONS

LOCATION	HEIGHT FROM BED (FT)		BANK ANGLE (DEG)		VEGETATIVE COVER (%)		BANK MATERIAL		BANK EROSION	
	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB
Upstream	8.5	8.5	60	60	80	85	1	1	2	2
Downstream	7.0	6.0	35	35	80	85	1	1	2	2

TYPE OF BED MATERIAL: 3
CHANNEL BED ARMORED: 0
ESTIMATED DEPTH OF GRAVEL DEPOSITS: 999.0
CHANNEL PROFILE: UPSTREAM = 1 DOWNSTREAM = 2

CONFLUENCE 1:1 40 FT ENTRY=1
CONFLUENCE 2:1 30 FT ENTRY=2
CONFLUENCE 3:1 -275 FT ENTRY=1
CONFLUENCE 4:0 0 FT ENTRY=0

PIER BENTS:	NUMBER	SHAPE	SKEW	LOCATION	LOCAL SCOUR	EXPSOURE
0	1	3	-35	4	1	0
0	1	3	-35	6	1	1
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

Figure 18. Site report of channel-stability assessment for bridge 6015, Big Pipe Creek at MD-77, Carroll County, Maryland

ABUTMENT CONDITIONS:

BANK	SKEW	LOCATION (FT)	TYPE	EXPOSED PILES	EXPOSED FOOTING
Left	-35	0	1	0	0
Right	0	12	1	0	0

DEBRIS BLOCKAGE: 0		RIPRAP ON:	CONDITION
PERCENT OF OPENING BLOCKED:		1-US RT BANK = 0	0
HORIZONTAL 0 TO 0		2-US LF BANK = 0	0
VERTICAL 0 TO 0		3-AT RT BANK = 1	2
		4-AT LF BANK = 1	2
POTENTIAL FOR DEBRIS: 2		5-DS RT BANK = 0	0
		6-DS LF BANK = 0	0
CHANNEL WIDTH UPSTREAM:	85 FT	7-BED = 0	0
CHANNEL WIDTH-BRIDGE OPENING	130 FT	8-AT RT ABUT = 1	2
CHANNEL WIDTH DOWNSTREAM	100 FT	9-AT LF ABUT = 1	2

BLOWHOLE: 0
0 FT = DOWNSTREAM
0 FT = WIDE,
0 FT = LONG

RIPRAP CLASSES:
BANK = 3
BED = 0
ABUTMENT = 3

MEANDER IMPACT POINTS:

LOCATION	LOW FLOW BANK	LOW FLOW DISTANCE (FT)	HIGH FLOW BANK	HIGH FLOW DISTANCE (FT)
UPSTREAM	2	0	2	0
DOWNSTREAM	0	0	1	275

LOW FLOW WAVELENGTH = 0 FT
HIGH FLOW WAVELENGTH = 550 FT

CHANNEL BAR LOCATION: 1
0 TO 12% (0% = LB, 100% = RB)
DISTANCE = 30 FT WIDTH AT MID BAR = 16 FT

ALLUVIAL FAN OR DELTA: 0
STAGE OF CHANNEL EVOLUTION: 5
GENERAL CONDITION OF SUBSTRUCTURE: 8

Figure 18. Site report of channel-stability assessment for bridge 6015, Big Pipe Creek at MD-77, Carroll County, Maryland--Continued

POTENTIAL-SCOUR RATING FOR BRIDGE 6015

[Modified from Simon and others, 1989. Diagnostic characteristics and numerical-index values for calculation of potential-scour rating. Potential-scour rating equals sum of assigned numerical-index values]

BRIDGE NUMBER: 6015 STREAM: BIG PIPE CREEK
COUNTY: CARROLL ROUTE: 77
PHYSIOGRAPHIC PROVINCE OR PROVINCE DIVISION: 4

Diagnostic characteristics	Numerical index value
TYPE OF BED MATERIAL:	4.00
PROTECTED CHANNEL BED:	1.00
STAGE OF CHANNEL EVOLUTION:	3.00
PERCENT OF CHANNEL CONSTRICTION AT THE BRIDGE:	5.00
NUMBER OF PIERS OR BENTS IN STREAM CHANNEL:	2.00
PERCENT OF HORIZONTAL DEBRIS BLOCKAGE:	1.67
PERCENT OF VERTICAL DEBRIS BLOCKAGE:	1.67
PERCENT OF TOTAL DEBRIS BLOCKAGE:	1.66
BANK EROSION FOR LEFT BANK:	2.00
BANK EROSION FOR RIGHT BANK:	2.00
HIGH-FLOW MEANDER IMPACT POINT:	1.00
SKEW FOR EACH PIER OR BENT:	12.00
MASS WASTING AT LEFT BANK PIER OR BENT:	4.00
MASS WASTING AT RIGHT BANK PIER OR BENT:	4.00
HIGH-FLOW ANGLE OF APPROACH	3.00
POTENTIAL-SCOUR RATING:	48.00

Figure 19. Report of potential-scour rating for bridge 6015, Big Pipe Creek at MD-77, Carroll County, Maryland.

maximum of 5, since gravel is more erodible than cobbles, boulders, or bedrock. Numerical-index values from all other potential-scour diagnostic characteristics for bridge 6015 can be confirmed using the same procedure.

Reports of observed-scour rating are generated by use of the scour data base. Each report lists the numerical-index value that is assigned to each diagnostic characteristic in the observed-scour index, and the observed-scour rating for the bridge. An example of a report for observed-scour rating for bridge 6015, Big Pipe Creek at MD-77, Carroll County, Md., is shown in figure 20. The report indicates an observed-scour rating of 87 out of a maximum observed-scour rating of 90. The numerical-index values that are assigned to the observed-scour diagnostic characteristics are, therefore, indicating some observed scour at bridge 6015 based on the channel-stability-assessment data collected at bridge 6015. The diagnostic characteristic that contributes to the reduced observed-scour rating for bridge 6015 is observed scour at pier 1 and at pier 2. For example, figure 20 indicates that observed scour at pier 1 is assigned a numerical-index value of 3 for bridge 6015. Figure 18 indicates that local scour for pier 1 is coded as a 1, and exposure for pier 1 is coded as a 0. This is the code for local scour at a pier with no footing exposure in item 9 of the channel-stability-assessment form (fig. 2). Use of this information along with item 1 (Observed scour at each pier, bent, and abutment) of the observed-scour index (fig. 17) indicates that the numerical-index value for local scour at a pier with no footing exposure is 3 out of a maximum of 4. This is because local scour at a pier is more serious than no scour at all. Numerical-index values from the additional pier and all other observed-scour diagnostic characteristics for bridge 6015 can be confirmed using the same procedure.

OBSERVED-SCOUR RATING FOR BRIDGE 6015

[Modified from Simon and others, 1989. Diagnostic characteristics and numerical-index values for calculation of observed-scour rating. Observed-scour rating equals sum of assigned numerical-index values]

BRIDGE NUMBER: 6015 STREAM: BIG PIPE CREEK
COUNTY: CARROLL ROUTE: 77
PHYSIOGRAPHIC PROVINCE OR PROVINCE DIVISION: 4

Diagnostic characteristics	Numerical index value
OBSERVED SCOUR AT PIER 1 OR BENT 1:	3.00
OBSERVED SCOUR AT PIER 2 OR BENT 2:	2.00
OBSERVED SCOUR AT PIER 3 OR BENT 3:	4.00
OBSERVED SCOUR AT PIER 4 OR BENT 4:	4.00
OBSERVED SCOUR AT PIER 5 OR BENT 5:	4.00
OBSERVED SCOUR AT PIER 6 OR BENT 6:	4.00
OBSERVED SCOUR AT PIER 7 OR BENT 7:	4.00
OBSERVED SCOUR AT PIER 8 OR BENT 8:	4.00
OBSERVED SCOUR AT PIER 9 OR BENT 9:	4.00
OBSERVED SCOUR AT PIER 10 OR BENT 10:	4.00
OBSERVED SCOUR AT PIER 11 OR BENT 11:	4.00
OBSERVED SCOUR AT PIER 12 OR BENT 12:	4.00
OBSERVED SCOUR AT PIER 13 OR BENT 13:	4.00
OBSERVED SCOUR AT PIER 14 OR BENT 14:	4.00
LEFT ABUTMENT-EXPOSED PILES:	4.00
RIGHT ABUTMENT-EXPOSED PILES:	4.00
LEFT ABUTMENT-EXPOSED FOOTING:	4.00
RIGHT ABUTMENT-EXPOSED FOOTING:	4.00
FAILED RIPRAP AT LEFT BANK:	2.00
FAILED RIPRAP AT RIGHT BANK:	2.00
BED RIPRAP MOVED:	2.00
BLOWHOLE OBSERVED:	4.00
MASS WASTING AT LEFT BANK PIER OR BENT:	4.00
MASS WASTING AT RIGHT BANK PIER OR BENT:	4.00
OBSERVED-SCOUR RATING:	87.00

Figure 20. Report of observed-scour rating for bridge 6015, Big Pipe Creek at MD-77, Carroll County, Maryland.

Bridges can also be screened by county using selected channel-stability-assessment data, diagnostic characteristics, potential-scour ratings, or observed-scour ratings. Data tables of any user-selected data variables or ratings can be assembled to aid in comparing the data or ratings for a particular county. Table 3 shows selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for Carroll County, Md. If, for example, it is desired to conduct more detailed scour studies at five bridges in Carroll County with the smallest potential-scour ratings, bridges 6039, 6026, 6050, 6024, and 6025 are selected from table 3 with potential-scour ratings of 45.51, 46.01, 47.01, 47.33, and 47.33, respectively. If, for example, it is desired to conduct more detailed scour studies at the bridges in Carroll County with the largest magnitude of high-flow angle of approach, bridges 6006, 6025, 6026, 6032-1, and 6032-2 are chosen with a magnitude of positive (+) or minus (-) 40 degrees.

Table 3. *Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained bridges over waterways in Carroll County, Maryland, 1990-91*

[There is no tidal flow; N = north; S = South]

Bridge no.	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach
6001	Liberty Reservoir	26	960	Spread footing	Piedmont Eastern	Forest
6002	Liberty Reservoir	26	1,681	Spread footing	Piedmont Eastern	Forest
6005	West Branch	852	20	Spread footing	Piedmont Eastern	Urban
6006	Little Pipe Creek	852	50	Spread footing	Piedmont Western	Pasture
6007	Dickerson Run	31	30	Spread footing	Piedmont Western	Pasture
6008	Sam Creek	31	38	Spread footing	Piedmont Western	Pasture
6012	Sam Creek	75	80	Spread footing	Piedmont Western	Pasture
6013	Little Pipe Creek	75	36	Spread footing	Piedmont Western	Urban
6015	Big Pipe Creek	77	194	Spread footing	Piedmont Western	Pasture
6016	Meadow Branch	84	52	Spread footing	Piedmont Western	Pasture
6018	Branch of Gunpowder Falls	86	20	Spread footing	Piedmont Eastern	Pasture
6019	Gunpowder Falls	86	44	Spread footing	Piedmont Eastern	Pasture
6020	North Branch Patapsco River	91	172	Spread footing	Piedmont Eastern	Forest
6024	Piney Creek	140	59	Spread footing	Piedmont Western	Pasture
6025	Big Pipe Creek	832	116	Spread footing	Piedmont Western	Pasture
6026	Bear Branch	832	25	Spread footing	Piedmont Western	Pasture
6028	Tuckers Branch	97	62	Pile	Piedmont Western	Pasture
6029	South Branch Patapsco River	97	110	Spread footing	Piedmont Eastern	Forest
6031	Big Pipe Creek	97	70	Spread footing	Piedmont Western	Forest
6032-1	Branch of West Branch	140 N	307	Spread footing	Piedmont Western	Urban
6032-2	Branch of West Branch	140 S	307	Spread footing	Piedmont Western	Urban
6033	Piney Creek	194	82	Spread footing	Piedmont Western	Pasture
6035	Big Pipe Creek	194	200	Spread footing	Piedmont Western	Pasture
6036	East Branch	482	30	Spread footing	Piedmont Eastern	Pasture
6038	Big Pipe Creek	496	40	Spread footing	Piedmont Eastern	Pasture
6039	Branch of Big Pipe Creek	496	20	Spread footing	Piedmont Western	Pasture
6040	Bear Branch	496	20	Spread footing	Piedmont Western	Forest
6042	Talbot Branch	850	20	Spread footing	Piedmont Western	Pasture
6049	Liberty Reservoir	32	580	Spread footing	Piedmont Eastern	Forest
6050	Morgan Run	97	115	Spread footing	Piedmont Eastern	Forest
6051	Little Pipe Creek	75	115	Pile	Piedmont Western	Pasture
6056	Big Pipe Creek	140	120	Spread footing	Piedmont Western	Forest
6058	Little Pipe Creek	County Road	105	Spread footing	Piedmont Western	Pasture

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0= No 1= Yes)	Debris blockage present (0= No 1= Yes)	Pier-footing exposure (0= No 1= Yes)	Abutment-footing exposure (0= No 1= Yes)	Potential-scour rating	Observed scour rating	Bridge no.
Gravel	0	0	0	0	0	55.01	90.00	6001
Gravel	0	0	0	1	0	56.01	86.00	6002
Gravel	-25	1	0	0	1	51.51	86.00	6005
Gravel	-40	1	0	1	1	49.01	85.00	6006
Gravel	30	1	0	0	1	52.01	86.00	6007
Bedrock	0	1	0	0	0	55.01	90.00	6008
Gravel	0	1	1	0	0	52.33	89.00	6012
Gravel	0	0	0	0	1	54.01	86.00	6013
Gravel	35	1	0	1	0	48.00	87.00	6015
Gravel	10	1	0	0	0	51.01	89.00	6016
Gravel	0	1	0	0	1	51.01	88.00	6018
Gravel	-15	1	0	1	1	48.51	85.00	6019
Gravel	30	1	0	0	1	48.01	85.00	6020
Gravel	-30	1	1	1	1	47.33	84.00	6024
Gravel	40	1	1	1	1	47.33	86.00	6025
Gravel	40	1	0	0	1	46.01	85.00	6026
Cobble/boulder	30	1	0	0	1	51.51	86.00	6028
Cobble/boulder	30	1	1	0	1	47.50	85.00	6029
Gravel	25	1	0	0	0	52.51	89.00	6031
Gravel	-40	1	1	0	0	48.33	90.00	6032-1
Gravel	-40	1	0	0	0	51.01	90.00	6032-2
Gravel	-20	1	0	1	1	50.51	86.00	6033
Gravel	0	1	1	1	0	50.33	86.00	6035
Gravel	-25	1	0	0	1	49.51	86.00	6036
Gravel	20	1	0	0	1	49.51	87.00	6038
Gravel	20	1	0	0	1	45.51	86.00	6039
Gravel	25	1	0	0	0	52.51	90.00	6040
Gravel	15	1	0	0	1	51.51	88.00	6042
Gravel	0	0	0	0	0	54.01	90.00	6049
Gravel	35	1	0	0	0	47.01	88.00	6050
Gravel	5	0	0	0	0	49.01	89.00	6051
Cobble/boulder	0	1	0	1	1	54.51	83.00	6056
Silt/clay	10	1	1	1	0	50.33	86.00	6058

A table of selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for all bridges in the Maryland scour data base by county is given in the appendix. A copy of the complete scour data base is on file in the USGS Maryland District office.

Relations Among Data Variables

Channel-stability-assessment data can be used to investigate relations among any user-specified data variables. Selected data retrievals are made from the data base to determine specific relations among data variables. The following examples are excerpted from Doheny (1993).

Relations can be investigated between land use near the bridge and debris blockage at the bridge opening for bridges in the Maryland scour data base. Debris blockage at a bridge opening can increase flow velocity through the bridge and lead to contraction scour and local scour. The type of land use in the channel reach upstream from the bridge can affect the type and amount of debris that a stream channel carries. Table 4 shows the relation between land use near a bridge and the number of bridges with debris blockage at the bridge opening.

Table 4. *Number of bridges where the bridge opening is blocked by debris, by type of land use near the bridge*

[From Doheny, 1993]

Type of land use	Number of bridges	Number of bridges with debris blockage	Percent of bridges with debris blockage
Urban	157	23	14.6
Row crop	50	3	6.0
Pasture	163	35	21.5
Forest	462	58	12.6
Wetland	44	1	2.3
Total	876	120	13.7

Pasture land use resulted in the largest percentage of bridges with debris blockage when compared to other types of land use. Many bridges with nearby pasture land use have cattle gates mounted against the bridge openings that collect debris. Forest land use resulted in the largest number of bridges with debris blockage because of the abundance of woody vegetation. Urban land use resulted in a large number of bridges with debris blockage because large amounts of runoff carried trees, brush, and trash into stream channels. Row crop and wetland land use resulted in the smallest numbers and percentages of bridges with debris blockage because of small amounts of woody vegetation in the upstream channel reach.

Another example of relations among data variables for bridges in the Maryland scour data base is the relation between the high-flow angle of approach and observed pier-footing exposures. The cumulative number of bridges with one or more pier-footing exposures for increasing magnitude of high-flow angle of approach is shown in figure 21. The number of bridges with one or more pier-footing exposures increases as the high-flow angle of approach increases. The largest increase is for bridges with high-flow angles of approach in the range of 10 to 30 degrees.

Individual Problem Analysis

Channel-stability-assessment data can be used to screen individual potential- or observed-scour diagnostic characteristics by physiographic province or province division. This type of analysis can provide insight into (1) whether or not a diagnostic characteristic is contributing to reduction of potential- or observed-scour ratings for bridges in a physiographic province or province division, and (2) which bridges are being subjected to the diagnostic characteristic in question. For example, a selected data retrieval can be made from the Maryland scour data base to determine how many bridges in the Piedmont Western Province division have a high-flow angle of approach exceeding 10 degrees. Figure 22 indicates that 17 of 74 bridges in the Piedmont Western Province division have a high-flow angle of approach exceeding 10 degrees. Another example could be to determine how many bridges in the Great Valley Province division have one or more pier footings exposed. Figure 23 indicates that 14 of 43 bridges in the Great Valley Province division have one or more pier footings exposed. The scour data base also allows a user to generate a summary report showing all bridge numbers for any selected

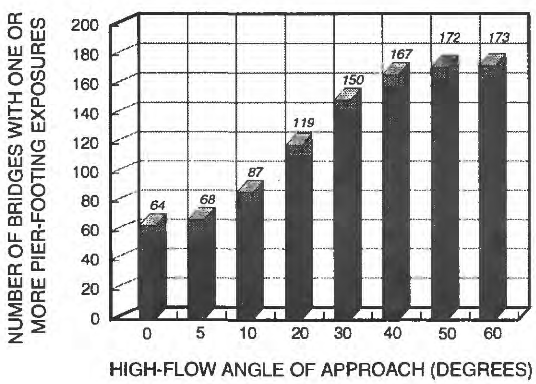


Figure 21. Cumulative number of bridges with one or more pier-footing exposures for increasing magnitude of high-flow angle of approach

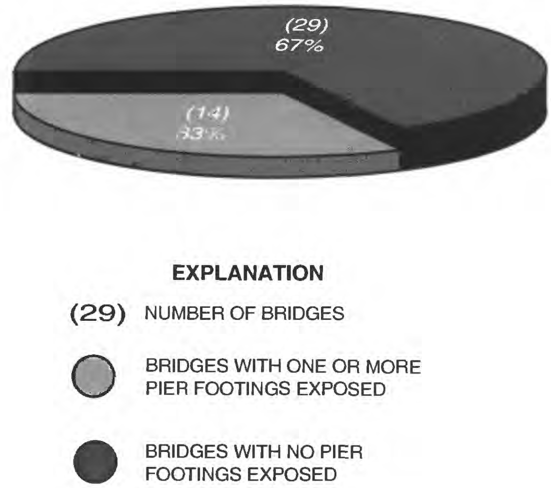


Figure 23. Pier-footing exposures for bridges in the Great Valley Province division.

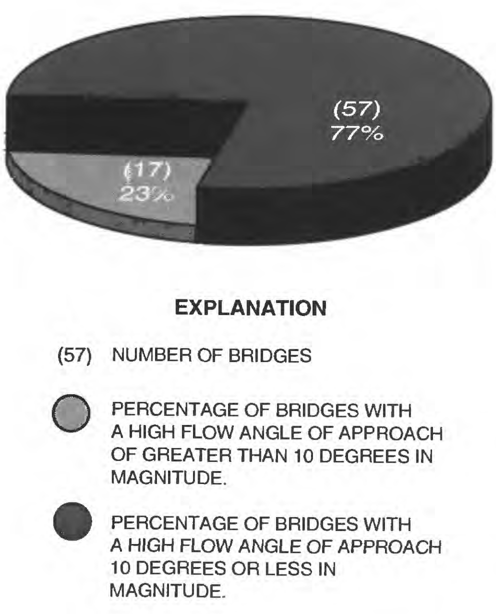


Figure 22. High-flow angle of approach of greater or less than 10 degrees in magnitude for bridges in the Piedmont Western Province division.

data retrieval in order of descending potential-scour rating. Table 5 shows a summary report for bridges in the Piedmont Western Province division where the high-flow angle of approach exceeds 10 degrees.

Multiple Problem Analysis

Channel-stability-assessment data can be used to screen multiple potential- and observed-scour diagnostic characteristics by physiographic province or province division. This type of analysis can provide insight into which potential- and observed-scour diagnostic characteristics are most significant in reduction of potential- or observed-scour ratings for bridges in a physiographic province or province division. For example, two selected data retrievals can be made from the Maryland scour data base to determine (1) how many bridges in the Blue Ridge Physiographic Province have a high-flow angle of approach greater than 10 degrees, and (2) how many bridges in the Blue Ridge Physiographic Province have a channel constriction at the bridge greater than 5 percent. Figure 24 shows that nearly twice as many bridges in the Blue Ridge Physiographic Province

Table 5. *Bridges in the Piedmont Western Province division where the high-flow angle of approach exceeds 10 degrees*

[I = Interstate Route; US = United States Route]

Bridge No.	Stream	County	Route	Potential scour rating	Observed scour rating
10021	Bush Creek	Frederick	I-70	53.51	90.00
10047	Bennett Creek	Frederick	75	52.51	90.00
6031	Big Pipe Creek	Carroll	97	52.51	89.00
6040	Bear Branch	Carroll	496	52.51	90.00
10056	Double Pipe Creek	Frederick	77	52.01	88.00
15053	Little Bennett Creek	Montgomery	355	52.01	86.00
6007	Dickerson Run	Carroll	31	52.01	86.00
6028	Tuckers Branch	Carroll	97	51.51	86.00
6042	Talbot Branch	Carroll	850	51.51	88.00
10034	Rock Creek	Frederick	US-40	51.01	86.00
10036	Carroll Creek	Frederick	144	50.66	85.00
10014	Tuscarora Creek	Frederick	28	50.51	84.00
15036-3	Little Bennett Creek	Montgomery	I-270	50.01	88.00
6015	Big Pipe Creek	Carroll	77	48.00	87.00
6025	Big Pipe Creek	Carroll	832	47.33	86.00
6026	Bear Branch	Carroll	832	46.01	85.00
6039	Branch of Big Pipe Creek	Carroll	496	45.51	86.00
Average values of ratings				50.54	87.06

have a channel constriction at the bridge greater than 5 percent. Therefore, channel constriction is causing a reduction in potential-scour ratings for more bridges than is the high-flow angle of approach in the Blue Ridge Physiographic Province.

This analysis can be expanded to include additional diagnostic characteristics for the Blue Ridge Physiographic Province. For example, selected data retrievals can be made from the Maryland scour data base to determine (1) how many bridges have debris blockage at the bridge opening, (2) how many bridges have a high-flow meander impact point less than 100 ft from the bridge, and (3) how many bridges have one or more skewed piers or bents. Combining these results with those shown in figure 24 allows for an analysis with five diagnostic characteristics (fig. 25). The most common characteristic of the five diagnostic characteristics for the Blue Ridge Physiographic Province is a high-flow meander-impact point less

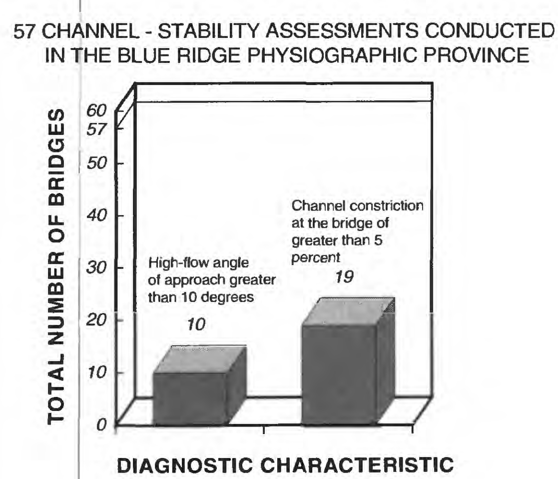


Figure 24. Number of bridges with two selected potential-scour diagnostic characteristics in the Blue Ridge Physiographic Province.

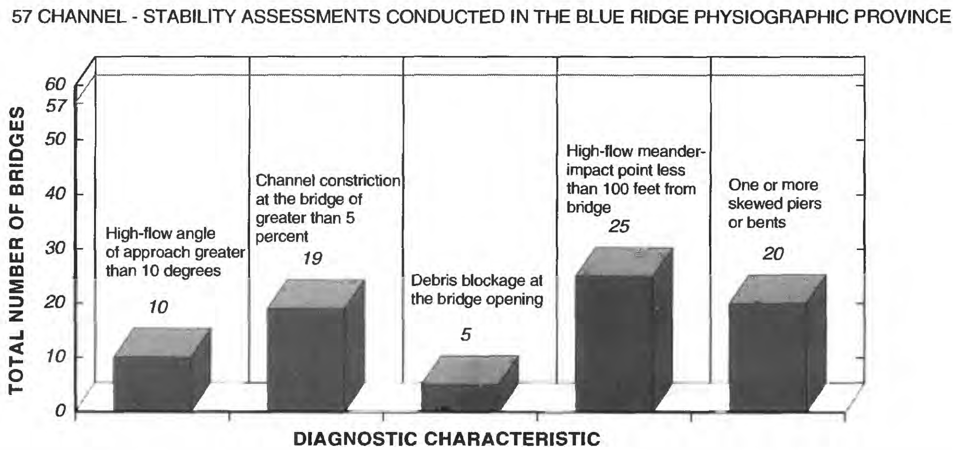


Figure 25. Number of bridges with five selected potential-scour diagnostic characteristics in the Blue Ridge Physiographic Province.

than 100 ft from the bridge as indicated in figure 25. Therefore, this diagnostic characteristic is causing a reduction in potential-scour ratings for more bridges than any other diagnostic characteristic compared in this example. Debris blockage at the bridge opening is the least common of the five diagnostic characteristics compared in figure 25 and is causing a reduction in potential-scour ratings for less bridges than any diagnostic characteristic compared in this example.

If an equivalent analysis is performed for another physiographic province or province division, then the results can be compared. The results of an analysis of the same diagnostic characteristics as the two previous examples for the Great Valley Province division are shown in figures 26 and 27. Comparing figure 24 to figure 26 indicates that channel constriction is causing a reduction in potential-scour ratings for more bridges than is the high-flow angle of approach in both the Blue Ridge Physiographic Province and the Great Valley Province division. However, channel constriction is affecting nearly twice as many bridges than is the high-flow angle of approach in the Blue Ridge Physiographic Province. Channel constriction is affecting only slightly more bridges than is the high-flow

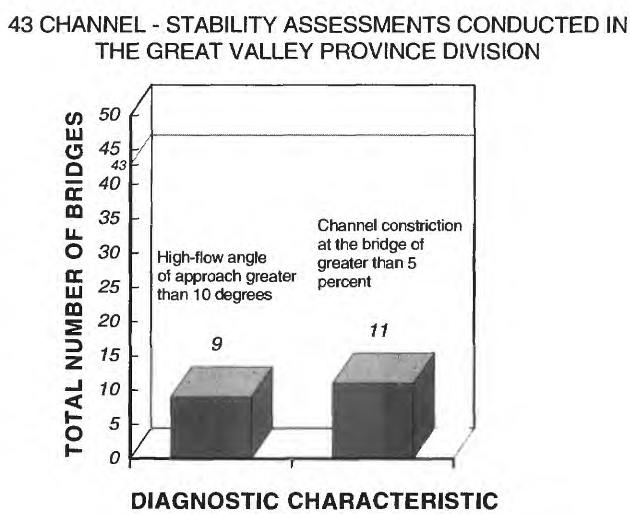


Figure 26. Number of bridges with two selected potential-scour diagnostic characteristics in the Great Valley Province division.

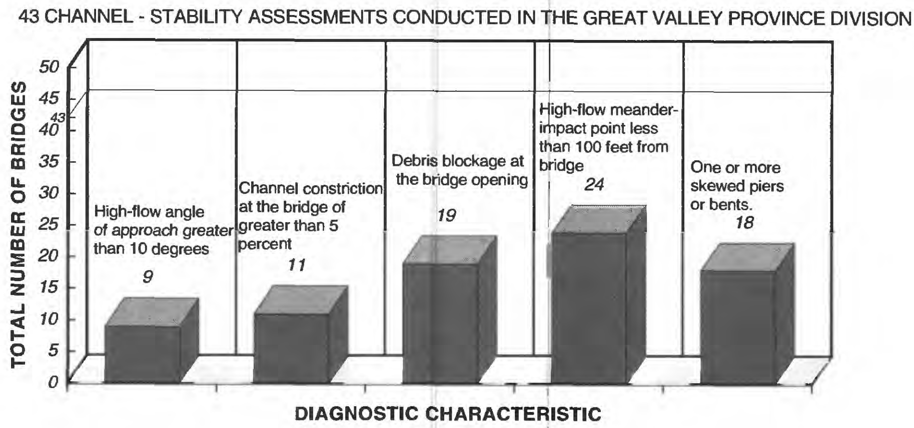


Figure 27. Number of bridges with five selected potential-scour diagnostic characteristics in the Great Valley Province division.

angle of approach in the Great Valley Province division. Channel constriction is also affecting a larger percentage of bridges in the Blue Ridge Physiographic Province than in the Great Valley Province division. The high-flow angle of approach is affecting a larger percentage of bridges in the Great Valley Province division than in the Blue Ridge Physiographic Province.

Comparing figure 25 to figure 27 indicates that a high-flow meander-impact point less than 100 ft from the bridge is causing a reduction in potential-scour ratings for more bridges than any of the other diagnostic characteristics for both the Blue Ridge Physiographic Province and the Great Valley Province division. However, the percentage of affected bridges is larger for the Great Valley Province division than for the Blue Ridge Physiographic Province because there are less bridges present in the Great Valley Province division than in the Blue Ridge Physiographic Province. Also, debris blockage at the bridge opening affects significantly more bridges in the Great Valley Province division than in the Blue Ridge Physiographic Province. One or more skewed piers or bents affects slightly more bridges in the Blue Ridge Physiographic Province than in the Great Valley Province division. However, the percentage of affected bridges is larger for the Great Valley Province division.

Multiple problem analysis can be used for any user-specified combination of potential- or observed-scour diagnostic characteristics and physiographic provinces or province divisions. A summary report similar to table 5 can be generated for any selected data retrieval made during a multiple problem analysis.

Geographic Information System Analysis

Potential- or observed-scour diagnostic characteristics can be investigated by use of a Geographic Information System (GIS) analysis. The Maryland scour data base was interfaced with GIS. This allows a user to generate maps showing the location of bridges with a specified potential- or observed-scour diagnostic characteristic or rating. The maps can be generated by physiographic province or province division, by county, or statewide.

A GIS analysis can be used to investigate geographic patterns of potential- or observed-scour diagnostic characteristics or ratings. For example, the location of all bridges where channel-stability assessments were conducted and those having debris blockage at the bridge opening in Carroll County, Md., can be shown on a map that is generated with GIS (fig. 28). All bridges with debris blockage have their location labeled with a black diamond. All bridges with no debris blockage at the bridge opening have their location labeled with a small circle. Figure 28 shows that seven bridges in Carroll County have debris blockage at the bridge opening. All except two of these bridges are located in the northwestern part of the county. Further investigation could determine the possible reasons why this pattern may exist. Channel-stability-assessment data for bridges in this location of the county could be investigated using selected data retrievals from the scour data base. An analysis independent of those described in this report could be necessary.

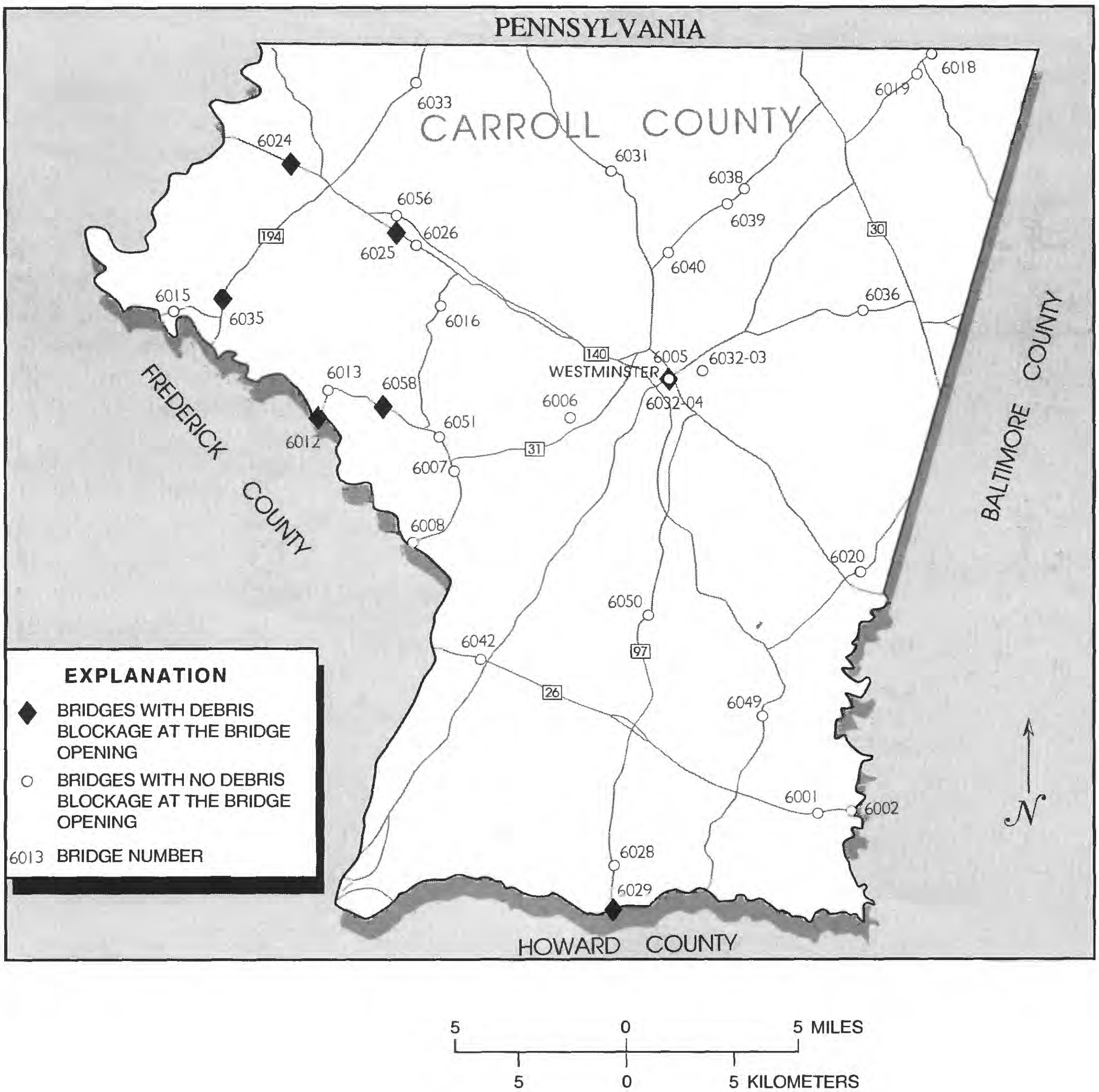


Figure 28. Bridge locations where channel-stability assessments were conducted to determine where debris blockage occurred at the bridge openings, Carroll County, Maryland.

SUMMARY

Scour is the leading cause of bridge failure in the United States. Previous bridge inspections in Maryland have dealt exclusively with the physical characteristics of the bridge, instead of the hydraulic and geomorphic relations between a bridge and stream channel that can cause scour.

Channel-stability assessments, as conducted by the U.S. Geological Survey, describe the physical characteristics of a bridge as well as the hydraulic characteristics and geomorphology of the stream channel. The unique nature of channel-stability assessments has emphasized a need for (1) documentation of field techniques for conducting channel-stability assessments, and (2) demonstration of how the collected data can be used to assess potential scour and observed scour at bridges over waterways.

Conventional data-collection techniques were used to conduct channel-stability assessments at 876 State highway, U.S. highway, and Interstate highway bridges over waterways in the State of Maryland between May 1990 and April 1991. A potential-scour index and observed-scour index were composed by assigning numerical-index values to specific diagnostic characteristics of the bridge and stream channel. Potential-scour ratings and observed-scour ratings for assessed bridges were obtained by summing the numerical-index values that were assigned to each diagnostic characteristic in the potential-scour index and the observed-scour index.

The data and ratings have several potential applications. These include (1) screening of individual bridges or groups of bridges for potential scour or observed scour, (2) investigating relations among individual data variables, (3) investigating individual potential- or observed-scour diagnostic characteristics for bridges by physiographic province or province division, (4) investigating multiple potential- or observed-scour diagnostic characteristics for bridges by physiographic province or province division, and (5) investigating potential- or observed-scour diagnostic characteristics by county by Geographic Information System analysis.

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APPENDIX

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = Business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
1001	Allegany	Braddock Run	36	57	Spread footing	Allegheny Ridges	Urban	0
1002	Allegany	Braddock Run	831	31	Spread footing	Allegheny Ridges	Urban	0
1003	Allegany	Jennings Run	831	62	Spread footing	Allegheny Ridges	Urban	0
1004	Allegany	Jennings Run	36	76	Spread footing	Allegheny Ridges	Urban	0
1006	Allegany	Jennings Run	36	54	Spread footing	Appalachian Plateau	Forest	0
1007	Allegany	Jennings Run	36	56	Spread footing	Appalachian Plateau	Forest	0
1008	Allegany	Jennings Run	36	44	Spread footing	Appalachian Plateau	Forest	0
1010	Allegany	Neff Run	36	22	Spread footing	Appalachian Plateau	Forest	0
1011	Allegany	Elk Lick Run	36	25	Pile	Appalachian Plateau	Forest	0
1012	Allegany	Georges Creek	36	84	Spread footing	Appalachian Plateau	Forest	0
1013	Allegany	Georges Creek	36	102	Spread footing	Appalachian Plateau	Forest	0
1014	Allegany	Georges Creek	36	96	Spread footing	Appalachian Plateau	Forest	0
1016	Allegany	Georges Creek	939	68	Spread footing	Appalachian Plateau	Forest	0
1017	Allegany	Georges Creek	939	88	Spread footing	Appalachian Plateau	Forest	0
1018	Allegany	Butcher Run	939	24	Spread footing	Appalachian Plateau	Forest	0
1019	Allegany	Georges Creek	939	110	Spread footing	Appalachian Plateau	Forest	0
1020	Allegany	Moores Run	939	32	Spread footing	Appalachian Plateau	Forest	0
1022	Allegany	Branch of Georges Creek	937	20	Spread footing	Appalachian Plateau	Urban	0
1023	Allegany	North Branch Potomac River	937	405	Spread footing	Appalachian Plateau	Urban	0
1028	Allegany	Wills Creek	AltUS40	193	Spread footing	Allegheny Ridges	Forest	0
1033	Allegany	Flintstone Creek	144	46	Spread footing	Allegheny Ridges	Forest	0
1034	Allegany	Town Creek	US40/48	195	Spread footing	Allegheny Ridges	Forest	0
1035	Allegany	Town Creek	144	71	Spread footing	Allegheny Ridges	Forest	0
1036	Allegany	Fifteen Mile Creek	AltUS40	66	Spread footing	Allegheny Ridges	Forest	0
1037	Allegany	Snib Hollow Run	AltUS40	28	Spread footing	Allegheny Ridges	Forest	0
1042	Allegany	North Branch	47	44	Spread footing	Appalachian Plateau	Forest	0
1043	Allegany	North Branch	47	40	Spread footing	Appalachian Plateau	Forest	0
1044	Allegany	Evitts Creek	51	147	Spread footing	Allegheny Ridges	Forest	0
1046	Allegany	Sawpit Run	51	40	Spread footing	Allegheny Ridges	Forest	0
1047	Allegany	Town Creek	51	204	Spread footing	Allegheny Ridges	Forest	0
1048	Allegany	C & O Canal	51	89	Spread footing	Allegheny Ridges	Forest	0
1049	Allegany	Potomac River	51	444	Spread footing	Allegheny Ridges	Forest	0
1051	Allegany	Branch of Warrior Run	53	22	Spread footing	Allegheny Ridges	Forest	0
1055	Allegany	Georges Creek	825	73	Spread footing	Appalachian Plateau	Urban	0
1056	Allegany	Pea Vine Run	US-220	27	Spread footing	Allegheny Ridges	Forest	0
1057	Allegany	Warrior Run	US-220	24	Spread footing	Allegheny Ridges	Urban	0
1061	Allegany	Warrior Run	636	30	Spread footing	Allegheny Ridges	Urban	0
1062	Allegany	Deep Hollow Run	US-220	17	Spread footing	Allegheny Ridges	Forest	0
1064	Allegany	Sideling Hill Creek	780D	85	Spread footing	Allegheny Ridges	Forest	0
1066	Allegany	North Branch Potomac River	932	312	Spread footing	Allegheny Ridges	Urban	0
1068	Allegany	Branch of Wills Creek	35	20	Spread footing	Allegheny Ridges	Urban	0
1070	Allegany	Branch of North Branch	47	20	Pile	Appalachian Plateau	Forest	0
1071	Allegany	Mill Run	51	20	Spread footing	Allegheny Ridges	Pasture	0
1072	Allegany	Warrior Run	636	20	Spread footing	Allegheny Ridges	Forest	0
1073	Allegany	Mill Run	US-220	20	Spread footing	Allegheny Ridges	Forest	0
1074	Allegany	Mill Run	US-220	20	Spread footing	Allegheny Ridges	Forest	0
1075	Allegany	Mill Run	US-220	10	Spread footing	Allegheny Ridges	Forest	0
1076	Allegany	Toms Hollow Run	US-220	22	Spread footing	Allegheny Ridges	Forest	0
1078	Allegany	North Branch	36	64	Spread footing	Appalachian Plateau	Forest	0
1079	Allegany	Jennings Run	36	52	Spread footing	Appalachian Plateau	Forest	0
1080	Allegany	Jennings Run	36	59	Spread footing	Appalachian Plateau	Forest	0
1082	Allegany	Georges Creek	135	94	Spread footing	Appalachian Plateau	Urban	0
1087	Allegany	Fifteen Mile Creek	US40/48	202	Spread footing	Allegheny Ridges	Forest	0
1091	Allegany	Evitts Creek	144	127	Spread footing	Allegheny Ridges	Forest	0
1096	Allegany	Wills Creek	US40/48	150	Spread footing	Allegheny Ridges	Urban	0
1098	Allegany	Potomac River	956	472	Spread footing	Allegheny Ridges	Pasture	0
1118	Allegany	Georges Creek	US40/48	34	Spread footing	Appalachian Plateau	Urban	0
1121	Allegany	Georges Creek	36	188	Spread footing	Appalachian Plateau	Urban	0
1126	Allegany	Georges Creek	36	160	Spread footing	Appalachian Plateau	Forest	0
1127	Allegany	Neff Run	36	30	Unknown	Appalachian Plateau	Forest	0
1132	Allegany	Fifteen Mile Creek	US40/48	329	Spread footing	Allegheny Ridges	Forest	0
2001	Anne Arundel	Patapsco River	I-695	1,358	Pile	Coastal Plain West	Forest	1
2006	Anne Arundel	Sawmill Creek	2	34	Pile	Coastal Plain West	Urban	0
2007	Anne Arundel	Marley Creek	2	32	Spread footing	Coastal Plain West	Forest	0
2011-1	Anne Arundel	Patapsco River	295 N	348	Pile	Coastal Plain West	Forest	1
2011-2	Anne Arundel	Patapsco River	295 S	348	Pile	Coastal Plain West	Forest	1

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Cobble/Boulder	0	1	1	0	0	55.83	90.00	1001
Cobble/Boulder	0	1	0	0	1	56.51	86.00	1002
Cobble/Boulder	0	1	0	0	1	53.01	88.00	1003
Cobble/Boulder	40	1	0	0	0	51.51	90.00	1004
Cobble/Boulder	0	1	1	0	0	53.16	90.00	1006
Cobble/Boulder	0	1	0	0	1	57.51	88.00	1007
Cobble/Boulder	-45	1	0	1	1	50.51	84.00	1008
Cobble/Boulder	-20	1	0	0	1	51.01	88.00	1010
Cobble/Boulder	30	1	1	0	1	48.16	87.00	1011
Cobble/Boulder	0	1	0	1	1	53.51	86.00	1012
Cobble/Boulder	-25	1	0	1	1	51.01	84.00	1013
Cobble/Boulder	0	1	1	1	1	54.50	84.00	1014
Cobble/Boulder	0	1	0	0	0	55.51	90.00	1016
Cobble/Boulder	0	1	0	1	1	56.51	86.00	1017
Cobble/Boulder	20	1	0	0	1	52.01	86.00	1018
Cobble/Boulder	0	1	0	1	1	54.51	86.00	1019
Cobble/Boulder	20	1	0	0	1	51.01	86.00	1020
Cobble/Boulder	20	1	0	0	1	54.01	86.00	1022
Cobble/Boulder	-50	0	0	0	0	51.51	89.00	1023
Bedrock	0	1	0	1	0	61.01	86.00	1028
Bedrock	-5	1	0	0	1	50.01	87.00	1033
Bedrock	-40	1	0	0	0	49.01	90.00	1034
Bedrock	0	1	0	0	1	56.01	88.00	1035
Bedrock	0	1	0	0	0	58.01	90.00	1036
Cobble/Boulder	50	1	0	0	0	50.51	90.00	1037
Cobble/Boulder	0	1	0	1	1	53.51	86.00	1042
Cobble/Boulder	0	1	0	1	1	55.51	84.00	1043
Cobble/Boulder	-30	1	0	0	0	48.51	90.00	1044
Cobble/Boulder	35	1	0	0	1	51.51	88.00	1046
Cobble/Boulder	0	1	0	1	0	56.51	88.00	1047
Alluvium	0	0	0	0	0	59.01	90.00	1048
Cobble/Boulder	-30	1	0	1	0	51.51	84.00	1049
Cobble/Boulder	0	1	0	0	1	51.51	88.00	1051
Cobble/Boulder	0	1	0	0	0	57.51	90.00	1055
Cobble/Boulder	-20	1	0	0	1	52.01	88.00	1056
Cobble/Boulder	-20	1	1	1	1	47.33	86.00	1057
Cobble/Boulder	0	1	0	0	1	56.51	86.00	1061
Gravel	30	1	0	0	0	48.01	89.00	1062
Cobble/Boulder	0	1	0	0	0	53.51	90.00	1064
Cobble/Boulder	-50	1	1	0	1	51.83	85.00	1066
Cobble/Boulder	-15	1	1	0	0	57.01	90.00	1068
Cobble/Boulder	0	1	0	0	0	55.51	90.00	1070
Gravel	-30	1	0	0	1	52.01	88.00	1071
Cobble/Boulder	-20	1	0	0	1	52.01	88.00	1072
Cobble/Boulder	20	1	0	0	1	51.01	88.00	1073
Gravel	-40	1	0	0	1	52.01	88.00	1074
Cobble/Boulder	45	1	0	0	1	48.51	88.00	1075
Cobble/Boulder	-35	1	0	0	0	49.51	89.00	1076
Cobble/Boulder	0	1	0	0	1	55.51	88.00	1078
Bedrock	0	0	0	0	0	56.01	90.00	1079
Cobble/Boulder	0	0	0	0	0	57.51	90.00	1080
Cobble/Boulder	0	1	0	0	1	57.51	88.00	1082
Gravel	15	1	0	0	0	49.51	90.00	1087
Gravel	0	1	1	0	0	55.33	90.00	1091
Bedrock	0	1	0	0	0	62.01	90.00	1096
Alluvium	0	0	1	0	0	53.00	88.00	1098
Cobble/Boulder	0	1	0	0	0	53.51	90.00	1118
Cobble/Boulder	15	1	1	0	0	52.01	90.00	1121
Cobble/Boulder	-20	1	0	0	0	50.01	90.00	1126
Cobble/Boulder	0	1	0	0	0	56.51	90.00	1127
Gravel	-10	1	0	0	0	53.01	90.00	1132
Sand	0	0	1	1	0	49.66	84.00	2001
Sand	15	1	0	0	0	52.51	90.00	2006
Sand	-10	1	0	0	0	56.01	90.00	2007
Sand	0	1	0	1	0	52.01	82.00	2011-1
Sand	0	1	0	1	0	52.01	84.00	2011-2

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
2018-1	Anne Arundel	Stony Run	295 N	400	Spread footing	Coastal Plain West	Forest	0
2018-2	Anne Arundel	Stony Run	295 S	405	Spread footing	Coastal Plain West	Forest	0
2026-3	Anne Arundel	Patuxent River	US-50 E	229	Pile	Coastal Plain West	Forest	0
2026-4	Anne Arundel	Patuxent River	US-50 W	229	Pile	Coastal Plain West	Forest	0
2030	Anne Arundel	South River	US-50	198	Pile	Coastal Plain West	Forest	1
2035-3	Anne Arundel	Weems Creek	US-50 E	280	Pile	Coastal Plain West	Forest	1
2035-4	Anne Arundel	Weems Creek	US-50 W	280	Pile	Coastal Plain West	Forest	1
2042	Anne Arundel	Weems Creek	70	734	Pile	Coastal Plain West	Urban	1
2043	Anne Arundel	College Creek	70	928	Pile	Coastal Plain West	Urban	1
2044	Anne Arundel	Severn Run	170	31	Spread footing	Coastal Plain West	Forest	0
2045	Anne Arundel	Stony Creek	173	885	Pile	Coastal Plain West	Urban	1
2046	Anne Arundel	Rock Creek	173	40	Spread footing	Coastal Plain West	Urban	1
2049	Anne Arundel	Branch of Deep Run	176	22	Spread footing	Coastal Plain West	Urban	0
2050	Anne Arundel	Piny Run	176	28	Spread footing	Coastal Plain West	Forest	0
2052	Anne Arundel	Mill Creek	179	64	Pile	Coastal Plain West	Forest	1
2053	Anne Arundel	Spa Creek	181	832	Pile	Coastal Plain West	Urban	1
2054	Anne Arundel	Patuxent River	214	200	Pile	Coastal Plain West	Forest	1
2066	Anne Arundel	Severn Run	3	41	Pile	Coastal Plain West	Forest	0
2067	Anne Arundel	Galloway Creek	4	40	Spread footing	Coastal Plain West	Forest	0
2068	Anne Arundel	Branch of Herring Bay	423	40	Pile	Coastal Plain West	Wetland	1
2071	Anne Arundel	College Creek	450	478	Pile	Coastal Plain West	Urban	1
2072	Anne Arundel	Bacon Ridge Branch	450	36	Pile	Coastal Plain West	Forest	1
2074	Anne Arundel	Marley Creek	648	200	Pile	Coastal Plain West	Urban	1
2077	Anne Arundel	Patapsco River	167A	298	Pile	Coastal Plain West	Forest	1
2079	Anne Arundel	Rockhold Creek	258	450	Pile	Coastal Plain West	Pasture	1
2081	Anne Arundel	Weems Creek	436	356	Pile	Coastal Plain West	Urban	1
2109-1	Anne Arundel	Furnace Creek	10 N	145	Pile	Coastal Plain West	Urban	1
2109-2	Anne Arundel	Furnace Creek	10 S	145	Pile	Coastal Plain West	Urban	1
2126	Anne Arundel	Tracys Creek	256	518	Pile	Coastal Plain West	Wetland	1
2127	Anne Arundel	Rockhold Creek	256	249	Pile	Coastal Plain West	Urban	1
2167	Anne Arundel	Stony Run	176	20	Spread footing	Coastal Plain West	Urban	0
2169-1	Anne Arundel	Marley Creek	10 N	212	Pile	Coastal Plain West	Urban	1
2169-2	Anne Arundel	Marley Creek	10 S	212	Pile	Coastal Plain West	Urban	1
3001	Baltimore	Little Gunpowder Falls	US-1	68	Spread footing	Piedmont Eastern	Forest	0
3002	Baltimore	Branch of Gunpowder Falls	US-1	20	Spread footing	Piedmont Eastern	Pasture	0
3003	Baltimore	Gunpowder Falls	US-1	108	Spread footing	Piedmont Eastern	Forest	0
3006	Baltimore	East Branch Herbert Run	644	543	Spread footing	Piedmont Eastern	Urban	0
3007	Baltimore	Herbert Run	US-1	65	Pile	Piedmont Eastern	Urban	0
3010	Baltimore	Patapsco River	US-1	200	Pile	Piedmont Eastern	Forest	0
3011	Baltimore	Herbert Run	Alt US1	534	Spread footing	Piedmont Eastern	Forest	0
3012	Baltimore	Little Gunpowder Falls	7	90	Spread footing	Piedmont Eastern	Forest	0
3013	Baltimore	Gunpowder Falls	7	232	Pile	Piedmont Eastern	Forest	0
3019	Baltimore	Georges Run	25	40	Spread footing	Piedmont Eastern	Pasture	0
3020	Baltimore	Black Rock Run	25	22	Spread footing	Piedmont Eastern	Forest	0
3023	Baltimore	Western Run	25	80	Spread footing	Piedmont Eastern	Pasture	0
3024	Baltimore	Beaverdam Run	25	26	Spread footing	Piedmont Eastern	Forest	0
3027	Baltimore	Jones Falls	25	50	Spread footing	Piedmont Eastern	Forest	0
3028	Baltimore	Jones Falls	25	58	Spread footing	Piedmont Eastern	Forest	0
3029	Baltimore	Jones Falls	25	1,000	Spread footing	Piedmont Eastern	Urban	0
3030	Baltimore	Gwynns Falls	26	161	Spread footing	Piedmont Eastern	Urban	0
3032	Baltimore	Gwynns Falls	37	130	Spread footing	Piedmont Eastern	Forest	0
3034-3	Baltimore	Little Gunpowder Falls	US-40 E	90	Pile	Coastal Plain West	Forest	0
3034-4	Baltimore	Little Gunpowder Falls	US-40 W	90	Pile	Coastal Plain West	Forest	0
3035-3	Baltimore	Gunpowder Falls	US-40 E	193	Pile	Coastal Plain West	Forest	1
3035-4	Baltimore	Gunpowder Falls	US-40 W	193	Pile	Coastal Plain West	Forest	1
3036	Baltimore	Honeygo Run	US-40	26	Pile	Coastal Plain West	Urban	0
3037	Baltimore	Whitemarsh Run	US-40	28	Spread footing	Coastal Plain West	Urban	0
3039	Baltimore	Stemmers Run	US-40	36	Spread footing	Coastal Plain West	Urban	0
3040	Baltimore	Redhouse Creek	US-40	36	Pile	Coastal Plain West	Urban	0
3042	Baltimore	Western Run	45	90	Spread footing	Piedmont Eastern	Forest	0
3045	Baltimore	Indian Run	88	24	Spread footing	Piedmont Eastern	Forest	0
3047	Baltimore	Little Falls	45	42	Spread footing	Piedmont Eastern	Forest	0
3048	Baltimore	Gunpowder Falls	45	64	Spread footing	Piedmont Eastern	Forest	0
3051-1	Baltimore	Jones Falls	I-83 N	281	Pile	Piedmont Eastern	Forest	0
3051-2	Baltimore	Jones Falls	I-83 S	281	Pile	Piedmont Eastern	Forest	0

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Gravel	15	1	0	0	0	45.51	90.00	2018-1
Gravel	5	0	0	0	0	50.01	90.00	2018-2
Silt/Clay	-10	0	0	0	0	51.01	90.00	2026-3
Silt/Clay	-10	0	0	0	0	51.01	90.00	2026-4
Silt/Clay	0	0	0	1	0	53.01	86.00	2030
Cobble/Boulder	-15	0	0	0	0	54.01	90.00	2035-3
Cobble/Boulder	-15	0	0	0	0	54.01	90.00	2035-4
Alluvium	0	0	0	1	0	51.01	78.00	2042
Alluvium	0	0	0	0	0	53.01	90.00	2043
Silt/Clay	0	1	0	0	0	54.01	90.00	2044
Sand	0	0	0	0	0	52.01	90.00	2045
Alluvium	0	0	0	0	0	50.01	89.00	2046
Gravel	-20	0	0	0	1	51.51	86.00	2049
Gravel	20	1	0	0	0	51.51	90.00	2050
Alluvium	25	0	0	1	0	45.51	88.00	2052
Alluvium	0	0	0	0	1	53.01	75.00	2053
Alluvium	0	0	0	0	0	55.01	90.00	2054
Sand	0	0	0	0	0	54.01	90.00	2066
Sand	35	0	0	0	0	46.01	90.00	2067
Sand	-25	1	0	0	0	50.51	90.00	2068
Alluvium	0	0	0	0	0	51.01	90.00	2071
Silt/Clay	0	0	0	0	0	50.01	90.00	2072
Sand	0	0	0	0	0	48.01	90.00	2074
Sand	-10	1	1	0	1	49.00	86.00	2077
Alluvium	0	0	0	0	0	53.01	90.00	2079
Sand	15	0	0	0	1	30.51	88.00	2081
Silt/Clay	0	0	0	0	0	47.01	90.00	2109-1
Silt/Clay	0	0	0	0	0	47.01	90.00	2109-2
Sand	30	0	0	0	0	43.01	90.00	2126
Sand	30	0	0	0	1	46.01	88.00	2127
Gravel	0	0	0	0	0	56.01	90.00	2167
Sand	0	0	0	0	0	49.01	90.00	2169-1
Sand	0	0	0	0	0	49.01	90.00	2169-2
Cobble/Boulder	-35	1	0	0	1	53.51	88.00	3001
Cobble/Boulder	0	1	0	0	0	57.51	90.00	3002
Cobble/Boulder	20	1	0	1	0	48.01	88.00	3003
Bedrock	15	0	0	0	0	48.51	90.00	3006
Sand	20	1	0	0	0	48.51	90.00	3007
Gravel	10	1	1	1	0	52.33	88.00	3010
Gravel	15	1	0	0	0	49.51	90.00	3011
Cobble/Boulder	-20	1	0	0	0	50.01	90.00	3012
Cobble/Boulder	0	1	0	0	0	53.51	90.00	3013
Gravel	50	1	0	0	1	48.01	85.00	3019
Bedrock	25	1	0	0	0	50.51	90.00	3020
Gravel	-95	1	0	0	1	50.01	88.00	3023
Gravel	40	1	0	0	1	50.01	86.00	3024
Gravel	0	1	0	1	1	52.01	84.00	3027
Gravel	0	1	1	1	1	48.33	84.00	3028
Cobble/Boulder	0	0	0	0	0	47.51	87.00	3029
Cobble/Boulder	0	1	0	0	1	52.51	88.00	3030
Cobble/Boulder	0	0	0	0	0	50.51	87.00	3032
Sand	20	1	1	0	0	47.17	89.00	3034-3
Sand	20	1	1	0	0	48.17	90.00	3034-4
Gravel	-20	1	1	1	1	51.51	84.00	3035-3
Gravel	-20	1	1	1	1	49.51	84.00	3035-4
Sand	-10	1	0	0	1	53.01	86.00	3036
Gravel	-40	1	0	0	0	50.01	87.00	3037
Gravel	20	1	0	0	1	50.51	88.00	3039
Gravel	10	1	0	0	1	53.01	88.00	3040
Gravel	0	1	0	0	0	57.01	90.00	3042
Gravel	0	1	0	1	1	55.01	84.00	3045
Cobble/Boulder	0	1	0	0	0	52.51	90.00	3047
Gravel	0	0	0	0	1	53.01	88.00	3048
Gravel	20	0	0	0	0	52.51	90.00	3051-1
Gravel	20	0	0	0	0	47.51	90.00	3051-2

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
3052	Baltimore	Piney Run	I-83	292	Pile	Piedmont Eastern	Forest	0
3057	Baltimore	Western Run	I-83	202	Spread footing	Piedmont Eastern	Forest	0
3065	Baltimore	Patapsco River	125	680	Pile	Piedmont Eastern	Forest	0
3066	Baltimore	Brice Run	125	45	Spread footing	Piedmont Eastern	Forest	0
3067	Baltimore	Gwynns Falls	126	82	Spread footing	Piedmont Eastern	Urban	0
3068	Baltimore	Piney Run	128	52	Spread footing	Piedmont Eastern	Pasture	0
3069	Baltimore	McGill Run	128	24	Spread footing	Piedmont Eastern	Pasture	0
3070	Baltimore	Slade Run	128	25	Pile	Piedmont Eastern	Pasture	0
3072	Baltimore	North Branch	129	30	Spread footing	Piedmont Eastern	Forest	0
3074	Baltimore	North Branch	130	30	Spread footing	Piedmont Eastern	Forest	0
3077	Baltimore	Slaughterhouse Branch	133	20	Spread footing	Piedmont Eastern	Forest	0
3080	Baltimore	Peggys Run	137	20	Spread footing	Piedmont Eastern	Pasture	0
3083	Baltimore	North Branch Patapsco River	140	201	Spread footing	Piedmont Eastern	Forest	0
3084	Baltimore	Gwynns Falls	140	72	Pile	Piedmont Eastern	Urban	0
3086	Baltimore	Patapsco River	144	201	Spread footing	Piedmont Eastern	Urban	0
3087	Baltimore	Greene Branch	145	42	Spread footing	Piedmont Eastern	Pasture	0
3088	Baltimore	Greene Branch	145	27	Spread footing	Piedmont Eastern	Pasture	0
3089	Baltimore	Little Gunpowder Falls	146	61	Spread footing	Piedmont Eastern	Pasture	0
3090	Baltimore	Little Gunpowder Falls	147	56	Spread footing	Piedmont Eastern	Forest	0
3091	Baltimore	Haystack Branch	147	32	Spread footing	Piedmont Eastern	Pasture	0
3092	Baltimore	Long Green Creek	147	37	Spread footing	Piedmont Eastern	Forest	0
3093	Baltimore	Branch of Long Green Creek	147	27	Spread footing	Piedmont Eastern	Pasture	0
3094	Baltimore	Gunpowder Falls	147	110	Spread footing	Piedmont Eastern	Forest	0
3096-3	Baltimore	Middle River	150 E	100	Pile	Coastal Plain West	Urban	1
3096-4	Baltimore	Middle River	150 W	100	Pile	Coastal Plain West	Urban	1
3097	Baltimore	Back River	150	1,500	Pile	Coastal Plain West	Urban	1
3100	Baltimore	Little Gunpowder Falls	165	61	Spread footing	Piedmont Eastern	Forest	0
3105	Baltimore	Little Falls	463	36	Spread footing	Piedmont Eastern	Forest	0
3107	Baltimore	Jones Falls	746	50	Spread footing	Piedmont Eastern	Urban	0
3109	Baltimore	Patapsco River	US-40	180	Spread footing	Piedmont Eastern	Forest	0
3144-5	Baltimore	Gwynns Falls	I-695 NW	122	Pile	Piedmont Eastern	Forest	0
3144-6	Baltimore	Gwynns Falls	I-695 SE	122	Pile	Piedmont Eastern	Forest	0
3152	Baltimore	Jones Falls	I-695	141	Pile	Piedmont Eastern	Urban	0
3153	Baltimore	Jones Falls	I-695	299	Pile	Piedmont Eastern	Urban	0
3211-1	Baltimore	Little Falls	I-83 N	285	Spread footing	Piedmont Eastern	Forest	0
3211-2	Baltimore	Little Falls	I-83 S	285	Spread footing	Piedmont Eastern	Forest	0
3215-1	Baltimore	Gunpowder Falls	I-83 N	354	Spread footing	Piedmont Eastern	Forest	0
3215-2	Baltimore	Gunpowder Falls	I-83 S	405	Spread footing	Piedmont Eastern	Forest	0
3229-3	Baltimore	Patapsco River	I-70 E	780	Spread footing	Piedmont Eastern	Forest	0
3229-4	Baltimore	Patapsco River	I-70 W	714	Spread footing	Piedmont Eastern	Forest	0
3237	Baltimore	Moores Branch	Acc. Rd	68	Pile	Piedmont Eastern	Forest	0
3238-5	Baltimore	Back River	695 NW	2,151	Pile	Coastal Plain West	Urban	1
3238-6	Baltimore	Back River	695 SE	2,151	Pile	Coastal Plain West	Urban	1
3243-1	Baltimore	Patapsco River	I-95 N	810	Spread footing	Piedmont Eastern	Forest	0
3243-2	Baltimore	Patapsco River	I-95 S	920	Spread footing	Piedmont Eastern	Forest	0
3270	Baltimore	Stemmers Run	702	146	Pile	Coastal Plain West	Urban	1
3271-3	Baltimore	Stemmers Run	702 E	512	Pile	Coastal Plain West	Urban	1
3271-4	Baltimore	Stemmers Run	702 W	538	Pile	Coastal Plain West	Urban	1
3274	Baltimore	Gwynns Falls	Co-Rd	63	Pile	Piedmont Eastern	Forest	0
3278	Baltimore	Black Rock Run	25	18	Spread footing	Piedmont Eastern	Pasture	0
3281	Baltimore	Stemmers Run	695	270	Pile	Coastal Plain West	Urban	1
3282	Baltimore	Stemmers Run	695	1,406	Spread footing	Coastal Plain West	Urban	1
3298	Baltimore	Loch Raven Reservoir	146	1,150	Spread footing	Piedmont Eastern	Urban	0
3306	Baltimore	Overshot Run	146	22	Spread footing	Piedmont Eastern	Pasture	0
3308	Baltimore	Branch of Gwynns Falls	I-795	743	Pile	Piedmont Eastern	Forest	0
3312	Baltimore	Gwynns Falls	I-795	126	Pile	Piedmont Eastern	Forest	0
3313	Baltimore	Gwynns Falls	I-795	125	Pile	Piedmont Eastern	Forest	0
3314-1	Baltimore	Gwynns Falls	I-795 N	566	Spread footing	Piedmont Eastern	Forest	0
3314-2	Baltimore	Gwynns Falls	I-795 S	518	Spread footing	Piedmont Eastern	Forest	0
3319-1	Baltimore	Gwynns Falls	I-795 N	493	Pile	Piedmont Eastern	Urban	0
3319-2	Baltimore	Gwynns Falls	I-795 S	493	Pile	Piedmont Eastern	Urban	0
3319-C	Baltimore	Gwynns Falls	I-795	493	Unknown	Piedmont Eastern	Urban	0
3331	Baltimore	Gwynns Falls	940	957	Spread footing	Piedmont Eastern	Urban	0
4002	Calvert	Hunting Creek	2/4	100	Pile	Coastal Plain West	Wetland	0
4003	Calvert	Hunting Creek	2/4	98	Pile	Coastal Plain West	Forest	1
4005	Calvert	The Narrows	2	20	Pile	Coastal Plain West	Urban	1

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Cobble/Boulder	25	1	0	0	0	53.01	90.00	3052
Gravel	25	1	0	0	0	46.51	87.00	3057
Gravel	10	1	1	0	0	52.67	90.00	3065
Gravel	30	1	1	0	1	50.33	86.00	3066
Cobble/Boulder	5	1	1	0	0	51.16	90.00	3067
Gravel	-75	1	0	0	0	50.01	89.00	3068
Gravel	10	0	0	1	0	51.01	88.00	3069
Gravel	-35	0	0	0	0	51.01	89.00	3070
Gravel	20	1	1	1	0	47.83	88.00	3072
Cobble/Boulder	0	0	0	0	1	53.51	86.00	3074
Gravel	10	1	0	0	0	46.01	90.00	3077
Gravel	10	1	0	0	1	51.01	88.00	3080
Silt/Clay	-45	0	0	0	0	44.01	90.00	3083
Cobble/Boulder	0	1	0	0	0	53.51	90.00	3084
Cobble/Boulder	-20	1	1	1	0	50.33	86.00	3086
Gravel	0	1	0	0	0	54.01	89.00	3087
Gravel	5	1	0	0	0	55.01	90.00	3088
Gravel	0	1	0	0	0	56.01	90.00	3089
Gravel	0	1	0	0	0	56.01	90.00	3090
Cobble/Boulder	50	1	0	0	1	51.51	85.00	3091
Cobble/Boulder	0	0	0	0	1	55.51	86.00	3092
Cobble/Boulder	-30	1	0	0	1	52.51	88.00	3093
Cobble/Boulder	-5	1	0	1	0	53.51	88.00	3094
Alluvium	-20	0	0	0	0	45.51	88.00	3096-3
Alluvium	-20	0	0	0	0	45.51	88.00	3096-4
Alluvium	0	0	0	0	0	50.01	90.00	3097
Cobble/Boulder	10	1	0	0	1	53.51	86.00	3100
Gravel	10	1	0	1	1	46.01	83.00	3105
Cobble/Boulder	0	0	0	0	1	51.51	86.00	3107
Gravel	-45	1	0	0	0	50.01	89.00	3109
Gravel	0	1	0	0	1	57.01	85.00	3144-5
Gravel	0	1	0	0	1	57.01	85.00	3144-6
Gravel	0	1	1	0	0	54.67	89.00	3152
Gravel	0	1	0	0	0	54.01	90.00	3153
Gravel	-15	1	0	1	1	50.51	82.00	3211-1
Gravel	-40	1	0	1	1	44.01	79.00	3211-2
Gravel	0	1	0	0	0	57.01	90.00	3215-1
Gravel	0	1	0	0	0	56.01	90.00	3215-2
Gravel	30	1	0	0	0	52.01	90.00	3229-3
Gravel	-30	1	0	0	0	49.01	90.00	3229-4
Gravel	10	1	0	0	0	41.01	83.00	3237
Alluvium	30	0	0	0	0	41.01	90.00	3238-5
Alluvium	30	0	0	0	0	41.01	89.00	3238-6
Gravel	-15	1	0	0	0	51.51	90.00	3243-1
Gravel	-15	1	0	0	0	51.51	90.00	3243-2
Gravel	-10	0	0	0	0	52.01	89.00	3270
Gravel	0	1	0	0	0	52.01	90.00	3271-3
Gravel	15	1	0	0	0	50.51	90.00	3271-4
Gravel	20	1	0	0	0	50.51	90.00	3274
Gravel	0	1	0	0	1	54.01	88.00	3278
Sand	5	1	0	1	0	50.01	86.00	3281
Gravel	10	1	0	0	0	55.01	90.00	3282
Alluvium	0	0	0	0	0	53.01	80.00	3298
Gravel	35	1	1	0	1	47.33	85.00	3306
Gravel	30	1	0	0	0	53.01	88.00	3308
Gravel	0	1	1	0	1	54.99	86.00	3312
Gravel	0	1	1	1	1	54.33	84.00	3313
Cobble/Boulder	50	1	0	0	0	47.51	90.00	3314-1
Cobble/Boulder	50	0	0	0	0	46.51	90.00	3314-2
Gravel	-20	1	0	0	0	48.51	90.00	3319-1
Gravel	0	1	0	0	0	52.01	90.00	3319-2
Gravel	-20	1	0	0	0	48.51	90.00	3319-C
Gravel	-15	1	0	0	0	50.51	89.00	3331
Silt/Clay	0	0	0	0	0	48.01	90.00	4002
Alluvium	0	1	0	0	0	51.01	90.00	4003
Alluvium	0	0	0	0	0	54.01	90.00	4005

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
4011	Calvert	Fishing Creek	261	117	Pile	Coastal Plain West	Urban	1
4014	Calvert	Chew Creek	262	20	Pile	Coastal Plain West	Forest	0
4015	Calvert	Hunting Creek	263	30	Pile	Coastal Plain West	Forest	1
4016	Calvert	Plum Point Creek	263	20	Pile	Coastal Plain West	Forest	1
4017-1	Calvert	Lyons Creek	4 N	72	Unknown	Coastal Plain West	Forest	0
4017-2	Calvert	Lyons Creek	4 S	83	Pile	Coastal Plain West	Forest	0
4018-1	Calvert	Hall Creek	4 N	120	Pile	Coastal Plain West	Forest	0
4018-2	Calvert	Hall Creek	4 S	62	Pile	Coastal Plain West	Forest	0
4020	Calvert	Governor Run	509	20	Pile	Coastal Plain West	Forest	0
4023	Calvert	Battle Creek	506	21	Pile	Coastal Plain West	Wetland	1
5001	Caroline	Mill Creek	16	50	Pile	Coastal Plain East	Row Crop	1
5002	Caroline	Choptank River	287	198	Spread footing	Coastal Plain East	Wetland	0
5003	Caroline	Long Marsh Ditch	313	70	Pile	Coastal Plain East	Row Crop	0
5005	Caroline	Choptank River	313	258	Pile	Coastal Plain East	Forest	1
5008	Caroline	Watt Creek	404	196	Pile	Coastal Plain East	Forest	1
5009	Caroline	Faulkner Branch	313	60	Pile	Coastal Plain East	Forest	1
5011	Caroline	Choptank River	314	193	Pile	Coastal Plain East	Urban	1
5012	Caroline	Tuckahoe Creek	328	909	Pile	Coastal Plain East	Forest	1
5015	Caroline	Tuckahoe Creek	404	164	Pile	Coastal Plain East	Forest	1
5016	Caroline	Choptank River	404 BUS	740	Pile	Coastal Plain East	Forest	1
5017	Caroline	Tuckahoe Creek	404	97	Spread footing	Coastal Plain East	Forest	1
5018	Caroline	Long Marsh Ditch	304	78	Spread footing	Coastal Plain East	Row Crop	0
5019	Caroline	Forge Branch	480	55	Pile	Coastal Plain East	Forest	1
5022	Caroline	Marshyhope Creek	313	270	Pile	Coastal Plain East	Urban	1
5026	Caroline	Choptank River	404	1,100	Pile	Coastal Plain East	Forest	1
5030	Caroline	Marshyhope Creek	306	205	Pile	Coastal Plain East	Urban	1
6001	Carroll	Liberty Reservoir	26	960	Spread footing	Piedmont Eastern	Forest	0
6002	Carroll	Liberty Reservoir	26	1,681	Spread footing	Piedmont Eastern	Forest	0
6005	Carroll	West Branch	852	20	Spread footing	Piedmont Eastern	Urban	0
6006	Carroll	Little Pipe Creek	852	50	Spread footing	Piedmont Western	Pasture	0
6007	Carroll	Dickerson Run	31	30	Spread footing	Piedmont Western	Pasture	0
6008	Carroll	Sams Creek	31	38	Spread footing	Piedmont Western	Pasture	0
6012	Carroll	Sams Creek	75	80	Spread footing	Piedmont Western	Pasture	0
6013	Carroll	Little Pipe Creek	75	36	Spread footing	Piedmont Western	Urban	0
6015	Carroll	Big Pipe Creek	77	194	Spread footing	Piedmont Western	Pasture	0
6016	Carroll	Meadow Branch	84	52	Spread footing	Piedmont Western	Pasture	0
6018	Carroll	Branch of Gunpowder Falls	86	20	Spread footing	Piedmont Eastern	Pasture	0
6019	Carroll	Gunpowder Falls	86	44	Spread footing	Piedmont Eastern	Pasture	0
6020	Carroll	North Branch Patapsco River	91	172	Spread footing	Piedmont Eastern	Forest	0
6024	Carroll	Piney Creek	140	59	Spread footing	Piedmont Western	Pasture	0
6025	Carroll	Big Pipe Creek	832	116	Spread footing	Piedmont Western	Pasture	0
6026	Carroll	Bear Branch	832	25	Spread footing	Piedmont Western	Pasture	0
6028	Carroll	Tuckers Branch	97	62	Pile	Piedmont Western	Pasture	0
6029	Carroll	South Branch Patapsco River	97	110	Spread footing	Piedmont Eastern	Forest	0
6031	Carroll	Big Pipe Creek	97	70	Spread footing	Piedmont Western	Forest	0
6032-1	Carroll	Branch of West Branch	140 N	307	Spread footing	Piedmont Western	Urban	0
6032-2	Carroll	Branch of West Branch	140 S	307	Spread footing	Piedmont Western	Urban	0
6033	Carroll	Piney Creek	194	82	Spread footing	Piedmont Western	Pasture	0
6035	Carroll	Big Pipe Creek	194	200	Spread footing	Piedmont Western	Pasture	0
6036	Carroll	East Branch	482	30	Spread footing	Piedmont Eastern	Pasture	0
6038	Carroll	Big Pipe Creek	496	40	Spread footing	Piedmont Eastern	Pasture	0
6039	Carroll	Branch of Big Pipe Creek	496	20	Spread footing	Piedmont Western	Pasture	0
6040	Carroll	Bear Branch	496	20	Spread footing	Piedmont Western	Forest	0
6042	Carroll	Talbot Branch	850	20	Spread footing	Piedmont Western	Pasture	0
6049	Carroll	Liberty Reservoir	32	580	Spread footing	Piedmont Eastern	Forest	0
6050	Carroll	Morgan Run	97	115	Spread footing	Piedmont Eastern	Forest	0
6051	Carroll	Little Pipe Creek	75	115	Pile	Piedmont Western	Pasture	0
6056	Carroll	Big Pipe Creek	140	120	Spread footing	Piedmont Western	Forest	0
6058	Carroll	Little Pipe Creek	Cnty Rd	105	Spread footing	Piedmont Western	Pasture	0
7003	Cecil	Octoraro Creek	US-1	200	Spread footing	Piedmont Eastern	Forest	0
7004	Cecil	Branch of Octoraro Creek	US-1	24	Spread footing	Piedmont Eastern	Pasture	0
7007	Cecil	Principio Creek	7	68	Spread footing	Piedmont Eastern	Forest	0
7008	Cecil	Stony Run	7	56	Spread footing	Coastal Plain East	Forest	0
7009	Cecil	Northeast Creek	7	114	Spread footing	Piedmont Eastern	Forest	0
7012	Cecil	Big Elk Creek	7	102	Spread footing	Coastal Plain East	Pasture	0

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Alluvium	0	0	0	0	0	56.01	90.00	4011
Sand	60	1	0	0	0	51.01	90.00	4014
Alluvium	-20	1	0	0	1	50.51	88.00	4015
Alluvium	0	0	0	0	1	55.01	88.00	4016
Sand	-20	1	1	1	0	48.84	88.00	4017-1
Sand	0	0	0	0	0	53.01	90.00	4017-2
Silt/Clay	0	1	0	0	0	53.01	90.00	4018-1
Silt/Clay	0	1	0	0	0	53.01	90.00	4018-2
Sand	15	1	0	0	0	52.51	90.00	4020
Alluvium	0	0	0	0	0	51.01	90.00	4023
Sand	0	0	0	0	1	50.01	86.00	5001
Sand	-25	1	0	1	0	47.51	86.00	5002
Sand	0	1	0	0	0	58.01	89.00	5003
Sand	0	0	0	1	0	54.01	87.00	5005
Sand	0	0	0	0	0	51.01	90.00	5008
Gravel	0	1	0	0	0	55.01	90.00	5009
Sand	-30	0	0	1	0	48.01	85.00	5011
Sand	25	1	0	0	0	39.51	90.00	5012
Sand	-10	0	0	0	0	44.01	87.00	5015
Sand	25	0	0	0	0	51.51	90.00	5016
Sand	-20	1	0	1	1	45.51	82.00	5017
Sand	20	1	0	0	0	49.51	89.00	5018
Sand	5	0	0	0	0	56.01	90.00	5019
Sand	0	0	0	0	0	41.01	84.00	5022
Sand	0	0	0	0	0	45.01	86.00	5026
Gravel	-10	0	0	1	0	50.01	84.00	5030
Gravel	0	0	0	0	0	55.01	90.00	6001
Gravel	0	0	0	1	0	56.01	86.00	6002
Gravel	-25	1	0	0	1	51.51	86.00	6005
Gravel	-40	1	0	1	1	49.01	85.00	6006
Gravel	30	1	0	0	1	52.01	86.00	6007
Bedrock	0	1	0	0	0	55.01	90.00	6008
Gravel	0	1	1	0	0	52.33	89.00	6012
Gravel	0	0	0	0	1	54.01	86.00	6013
Gravel	35	1	0	1	0	48.00	87.00	6015
Gravel	10	1	0	0	0	51.01	89.00	6016
Gravel	0	1	0	0	1	51.01	88.00	6018
Gravel	-15	1	0	1	1	48.51	85.00	6019
Gravel	30	1	0	0	1	48.01	85.00	6020
Gravel	-30	1	1	1	1	47.33	84.00	6024
Gravel	40	1	1	1	1	47.33	86.00	6025
Gravel	40	1	0	0	1	46.01	85.00	6026
Cobble/Boulder	30	1	0	0	1	51.51	86.00	6028
Cobble/Boulder	30	1	1	0	1	47.50	85.00	6029
Gravel	25	1	0	0	0	52.51	89.00	6031
Gravel	-40	1	1	0	0	48.33	90.00	6032-1
Gravel	-40	1	0	0	0	51.01	90.00	6032-2
Gravel	-20	1	0	1	1	50.51	86.00	6033
Gravel	0	1	1	1	0	50.33	86.00	6035
Gravel	-25	1	0	0	1	49.51	86.00	6036
Gravel	20	1	0	0	1	49.51	87.00	6038
Gravel	20	1	0	0	1	45.51	86.00	6039
Gravel	25	1	0	0	0	52.51	90.00	6040
Gravel	15	1	0	0	1	51.51	88.00	6042
Gravel	0	0	0	0	0	54.01	90.00	6049
Gravel	35	1	0	0	0	47.01	88.00	6050
Gravel	5	0	0	0	0	49.01	89.00	6051
Cobble/Boulder	0	1	0	1	1	54.51	83.00	6056
Silt/Clay	10	1	1	1	0	50.33	86.00	6058
Cobble/Boulder	0	1	1	0	1	57.83	85.00	7003
Gravel	-25	1	0	0	1	51.51	88.00	7004
Bedrock	50	1	1	0	1	49.66	88.00	7007
Gravel	25	1	1	1	1	46.83	84.00	7008
Gravel	30	1	0	1	0	48.01	88.00	7009
Gravel	20	1	1	1	0	48.50	87.00	7012

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
7014	Cecil	Principio Creek	US-40	60	Spread footing	Piedmont Eastern	Forest	0
7016-3	Cecil	Northeast Creek	US-40 E	133	Spread footing	Coastal Plain East	Forest	0
7016-4	Cecil	Northeast Creek	US-40 W	133	Spread footing	Coastal Plain East	Forest	0
7017-3	Cecil	Little North East Creek	US-40 E	110	Spread footing	Coastal Plain East	Forest	0
7017-4	Cecil	Little North East Creek	US-40 W	110	Spread footing	Coastal Plain East	Forest	0
7018-3	Cecil	Little Elk Creek	US-40 E	300	Pile	Coastal Plain East	Pasture	0
7018-4	Cecil	Little Elk Creek	US-40 W	300	Pile	Coastal Plain East	Pasture	0
7021-3	Cecil	Big Elk Creek	US-40 E	389	Pile	Coastal Plain East	Urban	1
7021-4	Cecil	Big Elk Creek	US-40 W	389	Pile	Coastal Plain East	Urban	1
7025	Cecil	Bohemia River	213	1,175	Pile	Coastal Plain East	Pasture	1
7026	Cecil	Octoraro Creek	222	162	Spread footing	Piedmont Eastern	Forest	0
7027	Cecil	Rock Run	222	36	Spread footing	Piedmont Eastern	Urban	0
7030	Cecil	Branch of Northeast River	267	20	Spread footing	Coastal Plain East	Forest	0
7034	Cecil	Northeast Creek	272	83	Spread footing	Piedmont Eastern	Pasture	0
7037	Cecil	Northeast Creek	272	126	Pile	Coastal Plain East	Urban	0
7040	Cecil	Northeast Creek	273	74	Spread footing	Piedmont Eastern	Pasture	0
7041	Cecil	Little Northeast Creek	273	26	Spread footing	Piedmont Eastern	Pasture	0
7042	Cecil	Little Elk Creek	273	86	Spread footing	Piedmont Eastern	Pasture	0
7043	Cecil	Little Elk Creek	279	115	Pile	Coastal Plain East	Forest	0
7044	Cecil	Big Elk Creek	273	166	Spread footing	Piedmont Eastern	Forest	0
7045	Cecil	Big Elk Creek	277	156	Pile	Piedmont Eastern	Forest	0
7046	Cecil	Branch of Big Elk Creek	316	25	Spread footing	Coastal Plain East	Forest	0
7047	Cecil	Branch of Big Elk Creek	316	25	Spread footing	Coastal Plain East	Forest	0
7048	Cecil	Big Elk Creek	279	143	Spread footing	Coastal Plain East	Forest	0
7052	Cecil	Big Elk Creek	213	121	Pile	Coastal Plain East	Urban	1
7053	Cecil	Back Creek	286	20	Spread footing	Coastal Plain East	Wetland	1
7055	Cecil	Little Elk Creek	545	95	Spread footing	Piedmont Eastern	Forest	0
7056	Cecil	Branch of Little Elk Creek	545	20	Spread footing	Piedmont Eastern	Forest	0
7058	Cecil	Love Run	591	21	Spread footing	Piedmont Eastern	Forest	0
7060	Cecil	Big Elk Creek	281	212	Pile	Coastal Plain East	Forest	0
7063	Cecil	Northeast Creek	272	106	Spread footing	Coastal Plain East	Urban	0
8001	Charles	Picowaxen Creek	257	20	Spread footing	Coastal Plain West	Forest	1
8002-1	Charles	Zekiah Swamp	5 N	70	Pile	Coastal Plain West	Forest	0
8002-2	Charles	Zekiah Swamp	5 S	64	Pile	Coastal Plain West	Forest	0
8003-1	Charles	Zekiah Swamp	5 N	34	Pile	Coastal Plain West	Forest	0
8003-2	Charles	Zekiah Swamp	5 S	32	Pile	Coastal Plain West	Forest	0
8005	Charles	Zekiah Swamp	6	20	Pile	Coastal Plain West	Wetland	0
8006	Charles	Zekiah Swamp	6	67	Pile	Coastal Plain West	Wetland	0
8007	Charles	Zekiah Swamp	6	190	Pile	Coastal Plain West	Wetland	0
8009	Charles	Port Tobacco Creek	6	100	Pile	Coastal Plain West	Wetland	1
8013	Charles	Wards Run	6	60	Pile	Coastal Plain West	Wetland	1
8015	Charles	Nanjemoy Creek	6	67	Spread footing	Coastal Plain West	Forest	0
8018	Charles	Reeder Run	224	46	Spread footing	Coastal Plain West	Forest	0
8019	Charles	Branch of Thomas Cut	224	35	Pile	Coastal Plain West	Forest	1
8020	Charles	Thomas Cut	224	35	Pile	Coastal Plain West	Wetland	1
8022	Charles	Mattawoman Creek	225	180	Pile	Coastal Plain West	Forest	1
8024	Charles	Branch of Mattawoman Creek	225	35	Pile	Coastal Plain West	Forest	0
8025	Charles	Port Tobacco Creek	225	50	Spread footing	Coastal Plain West	Pasture	0
8028	Charles	Mattawoman Creek	227	93	Spread footing	Coastal Plain West	Forest	0
8029	Charles	Pages Swamp	227	21	Spread footing	Coastal Plain West	Forest	0
8032	Charles	Gilbert Run	231	20	Pile	Coastal Plain West	Forest	0
8036	Charles	Wicomico River	234	34	Pile	Coastal Plain West	Wetland	1
8037	Charles	Wicomico River	234	190	Pile	Coastal Plain West	Wetland	1
8038	Charles	Neale Sound	254	560	Pile	Coastal Plain West	Urban	1
8042	Charles	Branch of Wards Run	425	40	Pile	Coastal Plain West	Forest	0
8043	Charles	Branch of Hill Top Fork	425	52	Pile	Coastal Plain West	Forest	0
8045	Charles	Piney Branch	488	30	Pile	Coastal Plain West	Forest	0
8046	Charles	Kerrick Swamp	488	36	Pile	Coastal Plain West	Forest	0
8047	Charles	Gilbert Swamp Run	234	123	Pile	Coastal Plain West	Wetland	0
9001	Dorchester	Marshyhope Creek	14	340	Pile	Coastal Plain East	Forest	1
9002	Dorchester	Cabin Creek	16	54	Pile	Coastal Plain East	Row Crop	1
9003	Dorchester	Parsons Creek	16	175	Pile	Coastal Plain East	Wetland	1
9006	Dorchester	Chicamacomico River	US-50	120	Pile	Coastal Plain East	Wetland	1
9008	Dorchester	Cambridge Creek	795	274	Pile	Coastal Plain East	Urban	1
9010	Dorchester	Blackwater River	335	194	Pile	Coastal Plain East	Wetland	1
9011	Dorchester	Wallace Creek	335	19	Spread footing	Coastal Plain East	Wetland	1

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Gravel	0	1	1	0	0	50.66	90.00	7014
Gravel	0	1	1	1	0	52.67	86.00	7016-3
Gravel	0	1	1	1	0	52.33	87.00	7016-4
Gravel	-20	1	0	1	0	47.51	88.00	7017-3
Gravel	-30	1	1	1	0	45.33	87.00	7017-4
Gravel	-20	1	1	1	0	48.50	88.00	7018-3
Gravel	40	1	1	1	0	41.00	79.00	7018-4
Gravel	0	1	0	1	0	56.01	88.00	7021-3
Gravel	10	1	0	1	0	56.01	88.00	7021-4
Sand	0	0	0	0	0	49.01	90.00	7025
Gravel	10	1	0	1	0	52.01	88.00	7026
Gravel	-10	1	1	1	1	51.00	84.00	7027
Gravel	-40	1	0	0	0	53.01	90.00	7030
Silt/Clay	0	1	0	0	0	53.01	90.00	7034
Gravel	0	0	1	0	0	54.33	89.00	7037
Gravel	20	1	0	0	0	51.51	89.00	7040
Gravel	-25	1	1	0	1	51.49	88.00	7041
Gravel	10	1	1	0	1	49.33	84.00	7042
Gravel	0	1	0	0	0	50.01	89.00	7043
Gravel	0	1	0	0	0	54.01	89.00	7044
Cobble/Boulder	20	1	0	0	1	52.01	87.00	7045
Gravel	-50	1	1	0	1	46.33	86.00	7046
Gravel	40	1	1	0	1	49.33	86.00	7047
Sand	0	1	0	0	1	50.01	86.00	7048
Sand	10	0	0	1	0	49.01	88.00	7052
Alluvium	0	0	0	0	1	54.01	86.00	7053
Gravel	-25	1	0	0	1	50.51	87.00	7055
Gravel	-15	1	0	0	1	50.51	88.00	7056
Cobble/Boulder	0	0	0	0	1	54.51	86.00	7058
Gravel	-30	1	1	0	0	48.33	89.00	7060
Gravel	0	0	0	0	0	55.01	89.00	7063
Gravel	-15	0	0	1	1	51.51	84.00	8001
Alluvium	0	0	0	0	1	54.01	85.00	8002-1
Alluvium	0	0	0	0	1	54.01	85.00	8002-2
Alluvium	0	0	0	0	1	55.01	86.00	8003-1
Alluvium	0	0	0	0	1	54.01	86.00	8003-2
Alluvium	0	0	0	0	0	55.01	90.00	8005
Alluvium	0	0	0	0	0	55.01	90.00	8006
Alluvium	0	0	0	0	0	52.01	90.00	8007
Alluvium	0	0	0	0	0	48.01	90.00	8009
Alluvium	0	0	0	0	0	52.01	90.00	8013
Alluvium	-15	0	0	1	0	51.51	86.00	8015
Gravel	0	1	0	0	0	57.01	90.00	8018
Alluvium	0	0	0	0	0	51.01	90.00	8019
Alluvium	0	0	1	0	0	47.67	90.00	8020
Alluvium	0	0	0	0	0	52.01	88.00	8022
Gravel	-15	1	0	0	0	53.51	90.00	8024
Gravel	0	1	0	0	0	56.01	90.00	8025
Gravel	0	1	0	1	1	55.01	82.00	8028
Gravel	0	0	1	0	0	54.33	90.00	8029
Gravel	0	0	0	0	1	57.01	88.00	8032
Silt/Clay	0	0	0	0	1	50.01	86.00	8036
Gravel	0	0	0	1	1	52.01	86.00	8037
Sand	30	0	0	1	0	38.01	85.00	8038
Gravel	0	0	0	0	0	57.01	90.00	8042
Silt/Clay	0	1	0	0	0	52.01	84.00	8043
Gravel	0	1	0	0	0	57.01	90.00	8045
Alluvium	20	1	0	0	1	49.51	88.00	8046
Gravel	30	1	0	0	0	53.01	89.00	8047
Sand	25	0	0	0	1	41.51	86.00	9001
Sand	-15	0	0	0	0	47.51	90.00	9002
Silt/Clay	15	0	0	0	0	47.51	90.00	9003
Sand	-40	1	0	0	0	44.01	90.00	9006
Alluvium	0	0	0	1	0	54.01	86.00	9008
Sand	0	0	0	0	0	52.01	87.00	9010
Sand	-15	0	0	0	1	50.51	86.00	9011

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
9012	Dorchester	Branch of Honga River	335	120	Pile	Coastal Plain East	Wetland	1
9013	Dorchester	Great Marsh Creek	335	200	Pile	Coastal Plain East	Wetland	1
9015	Dorchester	Marshyhope Creek	392	365	Pile	Coastal Plain East	Forest	1
9016	Dorchester	Warwick River	14	374	Pile	Coastal Plain East	Row Crop	1
9018	Dorchester	Birch Dam Creek	335	108	Pile	Coastal Plain East	Row Crop	1
9019	Dorchester	Chicamacomico River	US-50	102	Pile	Coastal Plain East	Wetland	1
10001	Frederick	Flat Run	US-15 B	50	Spread footing	Blue Ridge	Pasture	0
10002	Frederick	Toms Creek	US-15 B	80	Spread footing	Blue Ridge	Forest	0
10003	Frederick	Little Owens Creek	US-15	40	Spread footing	Blue Ridge	Pasture	0
10004	Frederick	Owens Creek	US-15	63	Unknown	Blue Ridge	Forest	0
10006	Frederick	High Run	806	20	Spread footing	Blue Ridge	Forest	0
10007	Frederick	Little Hunting Creek	806	30	Spread footing	Blue Ridge	Forest	0
10010	Frederick	Tuscarora Creek	US-15	69	Spread footing	Piedmont Western	Pasture	0
10012	Frederick	Ballenger Creek	85	60	Spread footing	Piedmont Western	Pasture	0
10013	Frederick	Branch of Monocacy River	85	23	Spread footing	Piedmont Western	Urban	0
10014	Frederick	Tuscarora Creek	28	46	Spread footing	Piedmont Western	Pasture	0
10015	Frederick	Branch Into Potomac River	28	20	Spread footing	Piedmont Western	Pasture	0
10016	Frederick	Branch Into Potomac River	28	40	Spread footing	Piedmont Western	Pasture	0
10017	Frederick	Potomac River	US-15	1,320	Spread footing	Blue Ridge	Forest	0
10018	Frederick	Catoctin Creek	17	140	Spread footing	Blue Ridge	Forest	0
10019	Frederick	Middle Creek	17	50	Spread footing	Blue Ridge	Pasture	0
10021	Frederick	Bush Creek	I-70	35	Spread footing	Piedmont Western	Pasture	0
10024	Frederick	Potomac River	17	2,500	Spread footing	Blue Ridge	Forest	0
10025	Frederick	Monocacy River	26	320	Spread footing	Piedmont Western	Pasture	0
10026	Frederick	Israel Creek	26	86	Spread footing	Piedmont Western	Pasture	0
10027	Frederick	Dollyhyde Creek	26	21	Spread footing	Piedmont Western	Pasture	0
10029	Frederick	Monocacy River	28	435	Spread footing	Piedmont Western	Forest	0
10030	Frederick	Catoctin Creek	US-40	50	Spread footing	Blue Ridge	Pasture	0
10031	Frederick	West Branch-Middle Creek	US-40	116	Spread footing	Blue Ridge	Pasture	0
10032	Frederick	Little Catoctin Creek	US-40	38	Spread footing	Blue Ridge	Pasture	0
10033	Frederick	*Little Catoctin Creek	US-40	30	Spread footing	Blue Ridge	Row Crop	0
10034	Frederick	Rock Creek	US-40	36	Spread footing	Piedmont Western	Forest	0
10036	Frederick	Carroll Creek	144	50	Spread footing	Piedmont Western	Urban	0
10037	Frederick	Carroll Creek	144	40	Pile	Piedmont Western	Urban	0
10038-3	Frederick	Monocacy River	144 E	520	Spread footing	Piedmont Western	Pasture	0
10040	Frederick	Catoctin Creek	AltUS40	85	Spread footing	Blue Ridge	Pasture	0
10041	Frederick	Beaver Dam Creek	75	20	Spread footing	Piedmont Western	Pasture	0
10042	Frederick	Linganore Creek	75	119	Spread footing	Piedmont Western	Pasture	0
10043	Frederick	Bens Branch	874	102	Spread footing	Piedmont Western	Forest	0
10044	Frederick	Bush Creek	75	82	Spread footing	Piedmont Western	Pasture	0
10045	Frederick	Fahrmey Branch	75	34	Spread footing	Piedmont Western	Pasture	0
10046	Frederick	Branch of Bennett Creek	75	40	Spread footing	Piedmont Western	Pasture	0
10047	Frederick	Bennett Creek	75	70	Spread footing	Piedmont Western	Pasture	0
10049	Frederick	Branch of Hunting Creek	77	27	Spread footing	Blue Ridge	Forest	0
10052	Frederick	Hunting Creek	77	66	Spread footing	Blue Ridge	Forest	0
10053	Frederick	Owens Creek	77	114	Spread footing	Piedmont Western	Pasture	0
10054	Frederick	Beaver Creek	77	56	Spread footing	Piedmont Western	Forest	0
10055	Frederick	Monocacy River	77	218	Spread footing	Piedmont Western	Pasture	0
10056	Frederick	Double Pipe Creek	77	210	Spread footing	Piedmont Western	Pasture	0
10057	Frederick	Ballenger Creek	381	40	Spread footing	Piedmont Western	Pasture	0
10058	Frederick	Little Catoctin Creek	79	30	Spread footing	Blue Ridge	Pasture	0
10059	Frederick	Monocacy River	80	495	Spread footing	Piedmont Western	Pasture	0
10060	Frederick	Branch of Friends Creek	550	32	Spread footing	Blue Ridge	Forest	0
10061	Frederick	Owens Creek	550	60	Spread footing	Blue Ridge	Forest	0
10062	Frederick	Flat Run	140	48	Spread footing	Blue Ridge	Urban	0
10063	Frederick	Middle Creek	140	70	Spread footing	Piedmont Western	Pasture	0
10065	Frederick	Monocacy River	140	156	Spread footing	Piedmont Western	Pasture	0
10067	Frederick	Middle Creek	17	80	Spread footing	Blue Ridge	Forest	0
10068	Frederick	Middle Creek	17	24	Spread footing	Blue Ridge	Pasture	0
10069	Frederick	Middle Creek	17	98	Spread footing	Blue Ridge	Pasture	0
10070	Frederick	Middle Creek	17	66	Spread footing	Blue Ridge	Pasture	0
10071	Frederick	Middle Creek	17	68	Spread footing	Blue Ridge	Forest	0
10072	Frederick	Little Pipe Creek	194	130	Spread footing	Piedmont Western	Pasture	0
10075	Frederick	Monocacy River	I-270	508	Spread footing	Piedmont Western	Pasture	0
10079-3	Frederick	Bennett Creek	I-270 E	75	Spread footing	Piedmont Western	Forest	0
10079-4	Frederick	Bennett Creek	I-270 W	75	Spread footing	Piedmont Western	Forest	0

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Sand	-30	0	0	0	0	48.01	90.00	9012
Sand	-30	0	0	0	0	47.01	90.00	9013
Sand	40	0	0	0	0	37.01	90.00	9015
Sand	0	0	0	0	0	52.01	90.00	9016
Sand	-40	0	0	0	0	47.01	90.00	9018
Sand	0	1	0	0	0	55.01	90.00	9019
Bedrock	0	0	0	0	1	61.01	86.00	10001
Bedrock	0	1	0	0	0	56.01	90.00	10002
Gravel	35	1	0	0	0	51.01	90.00	10003
Cobble/Boulder	15	1	0	0	0	53.01	90.00	10004
Cobble/Boulder	10	1	0	0	1	51.51	86.00	10006
Cobble/Boulder	0	1	0	0	1	54.51	86.00	10007
Gravel	5	1	0	0	0	56.01	90.00	10010
Cobble/Boulder	0	1	0	0	1	54.51	88.00	10012
Gravel	0	1	0	0	1	54.01	88.00	10013
Gravel	15	1	0	1	1	50.51	84.00	10014
Gravel	0	1	0	0	1	54.01	86.00	10015
Gravel	0	1	0	0	0	55.01	90.00	10016
Bedrock	0	0	1	1	0	57.01	78.00	10017
Gravel	0	1	0	0	0	55.01	90.00	10018
Gravel	-20	1	0	0	1	50.51	88.00	10019
Gravel	15	1	0	0	0	53.51	90.00	10021
Cobble/Boulder	0	0	0	1	0	56.51	81.00	10024
Gravel	10	1	1	0	0	52.33	90.00	10025
Gravel	-15	1	1	1	1	50.83	86.00	10026
Gravel	-15	1	0	0	0	51.51	90.00	10027
Gravel	5	1	1	1	0	54.00	87.00	10029
Gravel	-40	1	0	0	1	47.01	86.00	10030
Gravel	15	1	1	0	0	49.83	89.00	10031
Gravel	-30	1	0	0	0	47.01	90.00	10032
Gravel	-15	1	0	0	0	51.51	90.00	10033
Gravel	40	1	0	0	1	51.01	86.00	10034
Gravel	30	1	1	0	1	50.66	85.00	10036
Gravel	0	1	0	0	1	54.01	88.00	10037
Gravel	0	0	1	1	0	53.67	88.00	10038-3
Gravel	0	1	0	0	1	55.01	88.00	10040
Gravel	-25	0	0	0	1	52.51	86.00	10041
Gravel	10	1	0	0	0	49.01	87.00	10042
Gravel	0	1	0	0	1	54.01	88.00	10043
Gravel	0	1	0	0	0	55.01	90.00	10044
Gravel	-20	1	0	0	1	49.51	88.00	10045
Gravel	-15	1	0	0	1	48.51	85.00	10046
Gravel	25	1	0	0	0	52.51	90.00	10047
Cobble/Boulder	-20	1	0	0	1	54.01	88.00	10049
Cobble/Boulder	10	1	0	0	1	55.51	86.00	10052
Bedrock	0	1	1	0	0	57.33	89.00	10053
Gravel	10	0	0	1	1	51.01	86.00	10054
Bedrock	0	1	0	0	0	55.01	89.00	10055
Cobble/Boulder	15	1	0	0	0	52.01	88.00	10056
Gravel	-30	1	0	1	1	49.01	84.00	10057
Gravel	-30	1	0	0	1	49.01	88.00	10058
Gravel	0	0	0	0	0	53.01	87.00	10059
Gravel	0	1	0	0	0	57.01	90.00	10060
Cobble/Boulder	20	1	0	1	1	51.01	84.00	10061
Bedrock	0	1	0	1	1	58.01	84.00	10062
Gravel	0	1	1	1	1	54.33	84.00	10063
Bedrock	-20	1	0	1	0	52.51	86.00	10065
Cobble/Boulder	-15	1	0	1	1	48.01	86.00	10067
Gravel	0	1	0	0	1	56.01	88.00	10068
Cobble/Boulder	0	1	0	1	1	51.51	84.00	10069
Gravel	15	1	1	1	0	49.83	87.00	10070
Gravel	40	1	0	0	1	48.01	87.00	10071
Gravel	-10	1	1	0	0	50.33	90.00	10072
Gravel	-10	1	0	0	0	50.01	89.00	10075
Gravel	0	1	0	0	0	55.01	90.00	10079-3
Gravel	0	1	0	0	0	56.01	90.00	10079-4

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
10081	Frederick	Little Catoctin Creek	180	23	Spread footing	Blue Ridge	Pasture	0
10082	Frederick	Catoctin Creek	180	198	Spread footing	Blue Ridge	Forest	0
10083	Frederick	Ballenger Creek	180	28	Spread footing	Piedmont Western	Pasture	0
10085	Frederick	Monocacy River	355	308	Spread footing	Piedmont Western	Pasture	0
10086	Frederick	Bennett Creek	355	60	Spread footing	Piedmont Western	Pasture	0
10087	Frederick	Catoctin Creek	383	206	Unknown	Blue Ridge	Forest	0
10088	Frederick	Branch Into Potomac River	478	24	Spread footing	Blue Ridge	Urban	0
10089	Frederick	Branch Into Potomac River	478	25	Spread footing	Blue Ridge	Forest	0
10090	Frederick	Little Catoctin Creek	464	41	Spread footing	Blue Ridge	Forest	0
10091	Frederick	Catoctin Creek	464	302	Spread footing	Blue Ridge	Forest	0
10092	Frederick	Branch of Catoctin Creek	464	20	Spread footing	Blue Ridge	Forest	0
10093	Frederick	Monocacy River	550	420	Spread footing	Piedmont Western	Pasture	0
10094	Frederick	Israel Creek	550	66	Spread footing	Piedmont Western	Pasture	0
10095	Frederick	Branch of Israel Creek	550	20	Spread footing	Piedmont Western	Forest	0
10109	Frederick	Hunting Creek	US-15	267	Spread footing	Blue Ridge	Forest	0
10111	Frederick	Fishing Creek	US-15	64	Spread footing	Piedmont Western	Forest	0
10112	Frederick	Catoctin Creek	US-340	410	Spread footing	Blue Ridge	Forest	0
10124	Frederick	Toms Creek	US-15	104	Spread footing	Blue Ridge	Forest	0
10125	Frederick	Flat Run	US-15	104	Spread footing	Blue Ridge	Pasture	0
10129-3	Frederick	Little Catoctin Creek	I-70 E	330	Spread footing	Blue Ridge	Pasture	0
10129-4	Frederick	Little Catoctin Creek	I-70 W	330	Spread footing	Blue Ridge	Pasture	0
10130-3	Frederick	Catoctin Creek	I-70 E	182	Spread footing	Blue Ridge	Forest	0
10130-4	Frederick	Catoctin Creek	I-70 W	182	Spread footing	Blue Ridge	Forest	0
10133-3	Frederick	Grindstone Run	I-70 E	202	Spread footing	Blue Ridge	Forest	0
10133-4	Frederick	Grindstone Run	I-70 W	250	Spread footing	Blue Ridge	Forest	0
10135	Frederick	Grindstone Run	I-70	34	Unknown	Blue Ridge	Pasture	0
10158	Frederick	Fishing Creek	US-15	66	Spread footing	Piedmont Western	Pasture	0
10159	Frederick	Tuscarora Creek	US-15	69	Spread footing	Piedmont Western	Pasture	0
10160	Frederick	Bush Creek	I-70	659	Spread footing	Piedmont Western	Forest	0
10162	Frederick	Long Branch	144	26	Spread footing	Piedmont Western	Urban	0
10164	Frederick	Catoctin Creek	17	50	Spread footing	Blue Ridge	Pasture	0
10165	Frederick	Toms Creek	US-15	104	Spread footing	Blue Ridge	Forest	0
10166	Frederick	Flat Run	US-15	100	Spread footing	Blue Ridge	Pasture	0
10170	Frederick	Little Owens Creek	US-15	42	Spread footing	Blue Ridge	Pasture	0
10172	Frederick	Haines Branch	75	20	Pile	Piedmont Western	Pasture	0
10173	Frederick	Owens Creek	806A	92	Pile	Blue Ridge	Forest	0
10176	Frederick	Catoctin Creek	17	84	Spread footing	Blue Ridge	Pasture	0
10177	Frederick	Little Catoctin Creek	17	60	Spread footing	Blue Ridge	Pasture	0
10178	Frederick	Potomac River Tributary	180	21	Spread footing	Blue Ridge	Urban	0
10179	Frederick	Hunting Creek	US-15	266	Spread footing	Blue Ridge	Forest	0
10180	Frederick	Hunting Creek	US-15	60	Spread footing	Blue Ridge	Forest	0
10183-3	Frederick	Monocacy River	I-70 E	575	Spread footing	Piedmont Western	Pasture	0
10183-4	Frederick	Monocacy River	I-70 W	575	Spread footing	Piedmont Western	Pasture	0
11001	Garrett	Potomac River	38	304	Spread footing	Appalachian Plateau	Forest	0
11002	Garrett	Youghiogheny River	39	116	Spread footing	Appalachian Plateau	Forest	0
11003	Garrett	Little Youghiogheny River	39	51	Spread footing	Appalachian Plateau	Urban	0
11006	Garrett	Big Shade Run	AltUS40	28	Spread footing	Appalachian Plateau	Forest	0
11007	Garrett	Casselman River	AltUS40	133	Spread footing	Appalachian Plateau	Forest	0
11009	Garrett	Glade Run	42	26	Spread footing	Appalachian Plateau	Forest	0
11010	Garrett	Buffalo Run	42	40	Spread footing	Appalachian Plateau	Forest	0
11011	Garrett	Youghiogheny River	828	155	Spread footing	Appalachian Plateau	Forest	0
11013	Garrett	Potomac River	US-50	336	Spread footing	Appalachian Plateau	Forest	0
11014	Garrett	Little Youghiogheny River	135	104	Spread footing	Appalachian Plateau	Pasture	0
11015-3	Garrett	Youghiogheny River	US-48 E	497	Spread footing	Appalachian Plateau	Forest	0
11015-4	Garrett	Youghiogheny River	US-48 W	497	Spread footing	Appalachian Plateau	Forest	0
11018	Garrett	Savage River	135	120	Spread footing	Appalachian Plateau	Forest	0
11021	Garrett	Deep Creek Lake	US-219	680	Spread footing	Appalachian Plateau	Forest	0
11023	Garrett	Cherry Creek	US-219	44	Spread footing	Appalachian Plateau	Pasture	0
11024	Garrett	Youghiogheny River	US-219	23	Spread footing	Appalachian Plateau	Pasture	0
11025	Garrett	Branch of Casselman River	495	60	Spread footing	Appalachian Plateau	Forest	0
11029	Garrett	Nydegger Run	560	27	Spread footing	Appalachian Plateau	Pasture	0
11034	Garrett	Crabtree Creek	495	23	Spread footing	Appalachian Plateau	Pasture	0
11035	Garrett	Youghiogheny River	US-219	224	Spread footing	Appalachian Plateau	Pasture	0
11036	Garrett	Little Youghiogheny River	135	32	Spread footing	Appalachian Plateau	Forest	0
11037	Garrett	Bear Creek	US-219	274	Spread footing	Appalachian Plateau	Forest	0
11038-3	Garrett	Bear Creek	US-48 E	750	Pile	Appalachian Plateau	Forest	0

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Gravel	-25	1	0	0	1	48.51	86.00	10081
Gravel	0	1	0	1	0	55.01	87.00	10082
Gravel	-60	1	1	1	1	45.33	84.00	10083
Gravel	0	1	1	1	0	53.66	88.00	10085
Bedrock	-20	1	1	1	1	49.16	86.00	10086
Gravel	0	1	0	1	0	50.01	88.00	10087
Cobble/Boulder	5	1	0	0	1	52.16	84.00	10088
Cobble/Boulder	-30	1	0	0	1	49.51	86.00	10089
Gravel	-40	1	0	0	1	50.01	86.00	10090
Cobble/Boulder	-5	0	0	0	0	53.51	90.00	10091
Gravel	5	1	0	0	1	54.01	86.00	10092
Gravel	0	1	0	0	0	49.01	87.00	10093
Gravel	-10	1	0	1	1	50.01	84.00	10094
Gravel	-10	1	0	0	0	54.01	90.00	10095
Cobble/Boulder	0	1	0	0	0	58.51	90.00	10109
Cobble/Boulder	0	1	1	0	0	53.83	90.00	10111
Gravel	-20	1	0	0	0	51.51	88.00	10112
Gravel	-5	1	0	1	0	49.01	87.00	10124
Gravel	-40	1	0	1	1	48.01	83.00	10125
Cobble/Boulder	0	1	0	0	0	54.51	90.00	10129-3
Gravel	0	1	0	0	0	56.01	90.00	10129-4
Gravel	0	1	0	0	1	51.01	85.00	10130-3
Gravel	-15	1	0	0	1	45.51	83.00	10130-4
Gravel	0	1	0	0	1	53.01	88.00	10133-3
Gravel	0	1	0	0	1	54.01	88.00	10133-4
Gravel	-20	1	0	0	0	50.51	90.00	10135
Cobble/Boulder	0	1	0	0	0	54.51	90.00	10158
Gravel	0	1	0	0	0	56.01	90.00	10159
Gravel	-10	1	0	0	0	53.01	90.00	10160
Gravel	0	1	0	0	0	57.01	90.00	10162
Gravel	30	1	1	0	0	44.33	90.00	10164
Gravel	0	1	0	0	0	52.01	88.00	10165
Gravel	0	1	0	0	0	55.01	89.00	10166
Gravel	0	1	0	0	0	57.01	90.00	10170
Gravel	-10	1	0	0	1	52.01	86.00	10172
Cobble/Boulder	10	1	0	0	0	55.51	90.00	10173
Gravel	0	1	0	1	1	56.01	86.00	10176
Gravel	25	1	1	1	0	49.83	88.00	10177
Gravel	60	1	0	0	1	50.01	86.00	10178
Cobble/Boulder	10	1	0	0	0	54.51	90.00	10179
Cobble/Boulder	0	1	0	0	0	55.51	90.00	10180
Gravel	0	0	0	0	0	56.01	90.00	10183-3
Gravel	0	0	0	0	0	55.01	90.00	10183-4
Cobble/Boulder	0	1	0	1	0	52.51	82.00	11001
Gravel	0	1	0	0	0	54.01	89.00	11002
Gravel	0	1	0	0	1	54.01	86.00	11003
Cobble/Boulder	-10	1	0	0	0	58.51	90.00	11006
Cobble/Boulder	0	1	0	0	1	57.51	88.00	11007
Cobble/Boulder	0	0	0	0	1	55.51	86.00	11009
Cobble/Boulder	-20	1	0	0	0	56.01	90.00	11010
Cobble/Boulder	0	0	0	0	0	53.51	86.00	11011
Cobble/Boulder	-30	0	0	0	0	51.51	89.00	11013
Gravel	0	1	0	0	0	56.01	90.00	11014
Cobble/Boulder	0	1	0	0	0	55.51	89.00	11015-3
Cobble/Boulder	0	1	0	0	0	55.51	89.00	11015-4
Cobble/Boulder	0	1	1	0	1	53.50	88.00	11018
Alluvium	0	0	0	0	0	56.01	90.00	11021
Alluvium	50	1	0	1	1	46.01	84.00	11023
Alluvium	20	1	0	0	1	50.51	86.00	11024
Cobble/Boulder	0	1	0	1	1	55.51	84.00	11025
Cobble/Boulder	0	0	0	0	1	57.51	86.00	11029
Gravel	50	1	0	0	1	50.01	85.00	11034
Sand	0	0	0	0	0	54.01	90.00	11035
Gravel	-10	1	0	0	1	54.01	88.00	11036
Bedrock	15	1	0	0	1	56.51	88.00	11037
Cobble/Boulder	0	0	0	0	0	56.51	90.00	11038-3

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
11038-4	Garrett	Bear Creek	US-48 W	750	Pile	Appalachian Plateau	Forest	0
11053-3	Garrett	Casselman River	US-48 E	320	Pile	Appalachian Plateau	Forest	0
11053-4	Garrett	Casselman River	US-48 W	326	Pile	Appalachian Plateau	Forest	0
11054	Garrett	Youghiogheny River	42	560	Spread footing	Appalachian Plateau	Forest	0
12002	Harford	Deer Creek	US-1	128	Spread footing	Piedmont Eastern	Forest	0
12004	Harford	Winters Run	Alt US1	54	Spread footing	Piedmont Eastern	Pasture	0
12008	Harford	Grays Run	7	28	Spread footing	Coastal Plain West	Forest	0
12009	Harford	James Run	7	56	Spread footing	Coastal Plain West	Forest	0
12010	Harford	Bynum Run	7	60	Spread footing	Coastal Plain West	Pasture	0
12011	Harford	Winters Run	7	126	Pile	Coastal Plain West	Forest	0
12013	Harford	Swan Creek	132	36	Spread footing	Piedmont Eastern	Forest	0
12014	Harford	Deer Creek	23	88	Spread footing	Piedmont Eastern	Forest	0
12016	Harford	Deer Creek	24	123	Spread footing	Piedmont Eastern	Pasture	0
12017	Harford	Kellog Branch	24	21	Spread footing	Piedmont Eastern	Forest	0
12018	Harford	Stirrup Run	24	36	Spread footing	Piedmont Eastern	Forest	0
12019	Harford	Winters Run	755	108	Pile	Coastal Plain West	Forest	1
12022	Harford	Swan Creek	US-40	40	Spread footing	Piedmont Eastern	Forest	0
12024	Harford	Cranberry Run	US-40	27	Pile	Coastal Plain West	Forest	0
12025	Harford	Church Creek	US-40	35	Pile	Coastal Plain West	Wetland	1
12026	Harford	Bush River	US-40	106	Pile	Coastal Plain West	Wetland	1
12027	Harford	Branch of Winters Run	US-40	50	Spread footing	Coastal Plain West	Wetland	1
12028	Harford	Winters Run	US-40	128	Pile	Coastal Plain West	Forest	1
12029	Harford	Island Branch	136	33	Spread footing	Piedmont Eastern	Pasture	0
12030	Harford	Big Branch	136	30	Spread footing	Piedmont Eastern	Pasture	0
12031	Harford	Falling Branch	136	38	Spread footing	Piedmont Eastern	Pasture	0
12032	Harford	Broad Creek	136	102	Spread footing	Piedmont Eastern	Pasture	0
12033	Harford	Deer Creek	136	100	Spread footing	Piedmont Eastern	Pasture	0
12034	Harford	James Run	136	28	Spread footing	Piedmont Eastern	Forest	0
12039	Harford	Cranberry Run	159	37	Spread footing	Coastal Plain West	Forest	0
12040	Harford	Deer Creek	161	261	Spread footing	Piedmont Eastern	Pasture	0
12042	Harford	Winters Run	24	195	Pile	Coastal Plain West	Forest	1
12043	Harford	Deer Creek	165	80	Spread footing	Piedmont Eastern	Pasture	0
12044	Harford	Little Deer Creek	165	40	Spread footing	Piedmont Eastern	Pasture	0
12045	Harford	West Branch	165	32	Spread footing	Piedmont Eastern	Pasture	0
12046	Harford	Branch of West Branch	165	20	Spread footing	Piedmont Eastern	Pasture	0
12047	Harford	Carsin Run	462	60	Pile	Piedmont Eastern	Urban	0
12049	Harford	Deer Creek	543	100	Spread footing	Piedmont Eastern	Pasture	0
12050	Harford	Branch of Bynum Run	543	21	Spread footing	Piedmont Eastern	Pasture	0
12052	Harford	Broad Creek	623	378	Spread footing	Piedmont Eastern	Forest	0
12054	Harford	Broad Creek	624	24	Spread footing	Piedmont Eastern	Pasture	0
12055	Harford	Branch of Broad Creek	624	20	Spread footing	Piedmont Eastern	Pasture	0
12057	Harford	Broad Creek	646	63	Spread footing	Piedmont Eastern	Pasture	0
12063	Harford	East Branch Winters Run	23	295	Spread footing	Piedmont Eastern	Forest	0
12065	Harford	Winters Run	US-1	128	Spread footing	Piedmont Eastern	Forest	0
13002	Howard	Bealmear Branch	US-1	36	Spread footing	Piedmont Eastern	Forest	0
13003	Howard	Deep Run	US-1	22	Spread footing	Piedmont Eastern	Forest	0
13004	Howard	Dorsey Run	US-1	37	Spread footing	Piedmont Eastern	Forest	0
13005	Howard	Crones Run	US-1	21	Spread footing	Piedmont Eastern	Forest	0
13007-1	Howard	Little Patuxent River	US-1 N	212	Spread footing	Piedmont Eastern	Urban	0
13007-2	Howard	Little Patuxent River	US-1 S	98	Spread footing	Piedmont Eastern	Urban	0
13009	Howard	Hammond Branch	US-1	30	Spread footing	Piedmont Eastern	Urban	0
13012-1	Howard	Little Patuxent River	US-29 N	75	Spread footing	Piedmont Eastern	Urban	0
13012-2	Howard	Little Patuxent River	US-29 S	75	Spread footing	Piedmont Eastern	Urban	0
13013-1	Howard	Middle Patuxent River	US-29 N	130	Spread footing	Piedmont Eastern	Forest	0
13013-2	Howard	Middle Patuxent River	US-29 S	140	Spread footing	Piedmont Eastern	Forest	0
13016-3	Howard	Little Patuxent River	108 E	102	Pile	Piedmont Eastern	Forest	0
13016-4	Howard	Little Patuxent River	108 W	102	Pile	Piedmont Eastern	Forest	0
13017	Howard	Middle Patuxent River	108	138	Spread footing	Piedmont Eastern	Forest	0
13018	Howard	South Branch Patapsco River	851	148	Spread footing	Piedmont Eastern	Forest	0
13021	Howard	Terrapin Branch	32	30	Spread footing	Piedmont Eastern	Pasture	0
13022	Howard	Middle Patuxent River	32	66	Spread footing	Piedmont Eastern	Pasture	0
13024	Howard	*Middle Patuxent River	32	22	Spread footing	Piedmont Eastern	Pasture	0
13025	Howard	*Middle Patuxent River	32	22	Spread footing	Piedmont Eastern	Pasture	0
13026	Howard	Middle Patuxent River	32	79	Spread footing	Piedmont Eastern	Forest	0
13032	Howard	Little Patuxent River	US-40	36	Spread footing	Piedmont Eastern	Urban	0
13036	Howard	Cabin Branch	94	22	Spread footing	Piedmont Eastern	Forest	0

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Cobble/Boulder	0	0	0	0	0	56.51	90.00	11038-4
Cobble/Boulder	-20	1	0	0	0	49.01	90.00	11053-3
Cobble/Boulder	-20	1	0	0	0	49.01	90.00	11053-4
Cobble/Boulder	-20	0	0	0	0	51.01	90.00	11054
Gravel	40	1	0	1	0	51.01	88.00	12002
Gravel	30	1	0	0	1	50.01	85.00	12004
Gravel	-10	1	0	0	1	50.66	84.00	12008
Gravel	15	1	1	0	0	47.49	89.00	12009
Gravel	45	1	1	1	1	42.99	83.00	12010
Gravel	20	1	0	1	1	50.51	83.00	12011
Cobble/Boulder	50	1	0	0	1	46.51	83.00	12013
Gravel	-15	1	0	0	0	53.51	90.00	12014
Cobble/Boulder	20	1	0	0	1	56.01	88.00	12016
Cobble/Boulder	20	1	0	0	1	51.01	86.00	12017
Gravel	-10	1	0	0	1	54.01	86.00	12018
Silt/Clay	-20	0	0	0	0	46.51	90.00	12019
Bedrock	60	1	0	0	1	50.01	86.00	12022
Silt/Clay	-5	1	0	0	1	50.01	86.00	12024
Alluvium	20	0	0	0	0	50.51	90.00	12025
Alluvium	-10	1	0	1	1	50.01	86.00	12026
Alluvium	0	0	0	1	1	55.01	78.00	12027
Alluvium	-5	0	0	0	0	54.01	89.00	12028
Gravel	-20	0	0	0	0	53.51	90.00	12029
Cobble/Boulder	-50	1	0	0	1	48.51	86.00	12030
Cobble/Boulder	10	1	0	0	1	57.51	86.00	12031
Cobble/Boulder	10	1	1	0	0	51.83	90.00	12032
Cobble/Boulder	-10	1	0	0	1	51.51	88.00	12033
Cobble/Boulder	20	1	0	0	1	49.01	85.00	12034
Gravel	-10	1	1	0	0	52.67	89.00	12039
Cobble/Boulder	-50	1	0	1	0	53.51	88.00	12040
Alluvium	-10	0	0	0	0	51.01	89.00	12042
Cobble/Boulder	-15	1	0	0	1	50.01	88.00	12043
Gravel	55	1	0	0	0	48.01	88.00	12044
Cobble/Boulder	20	1	0	0	1	52.01	86.00	12045
Cobble/Boulder	-15	1	0	0	1	51.01	88.00	12046
Gravel	-15	1	1	0	0	52.49	90.00	12047
Cobble/Boulder	0	1	0	0	0	57.51	90.00	12049
Gravel	-15	1	0	0	1	52.51	87.00	12050
Alluvium	45	0	0	0	0	47.01	89.00	12052
Gravel	-20	1	0	0	1	52.51	86.00	12054
Gravel	-35	1	0	0	1	52.01	86.00	12055
Cobble/Boulder	-60	1	0	0	0	48.51	89.00	12057
Gravel	10	1	0	0	0	52.01	90.00	12063
Gravel	-50	1	1	0	1	47.34	81.00	12065
Gravel	-50	1	1	0	1	48.66	88.00	13002
Gravel	-30	1	1	0	1	50.33	86.00	13003
Gravel	0	0	0	0	0	57.01	90.00	13004
Gravel	0	1	0	0	0	57.01	90.00	13005
Gravel	0	0	0	0	0	54.01	90.00	13007-1
Sand	0	0	0	0	0	54.01	88.00	13007-2
Gravel	15	1	0	0	1	53.51	86.00	13009
Gravel	-20	1	0	0	0	52.51	90.00	13012-1
Gravel	-20	1	0	0	0	54.51	90.00	13012-2
Gravel	0	1	0	0	0	54.01	89.00	13013-1
Gravel	45	1	0	0	1	42.01	84.00	13013-2
Gravel	20	1	0	0	0	53.51	90.00	13016-3
Gravel	20	1	0	0	0	50.51	90.00	13016-4
Gravel	20	1	1	0	0	47.16	89.00	13017
Cobble/Boulder	0	0	0	0	0	57.51	90.00	13018
Gravel	20	1	0	0	1	49.51	88.00	13021
Gravel	-25	1	1	0	1	45.50	87.00	13022
Gravel	10	1	0	0	1	52.01	86.00	13024
Gravel	40	1	0	0	1	50.01	87.00	13025
Gravel	0	1	0	0	1	56.01	85.00	13026
Gravel	0	1	0	0	0	55.01	90.00	13032
Gravel	-50	0	0	0	1	47.01	86.00	13036

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
13037	Howard	Cattail Creek	97	40	Spread footing	Piedmont Eastern	Forest	0
13038	Howard	Patuxent River	97	86	Spread footing	Piedmont Eastern	Forest	0
13041	Howard	Deep Run	176	38	Pile	Piedmont Eastern	Forest	0
13044	Howard	Patuxent River	216	260	Spread footing	Piedmont Eastern	Forest	0
13046	Howard	South Branch Patapsco River	32	294	Spread footing	Piedmont Eastern	Forest	0
13047	Howard	Patuxent River	94	55	Spread footing	Piedmont Eastern	Forest	0
13056-1	Howard	Middle Patuxent River	I-95 N	249	Spread footing	Piedmont Eastern	Forest	0
13056-2	Howard	Middle Patuxent River	I-95 S	249	Spread footing	Piedmont Eastern	Forest	0
13072-1	Howard	Little Patuxent River	I-95 N	285	Spread footing	Piedmont Eastern	Forest	0
13072-2	Howard	Little Patuxent River	I-95 S	391	Spread footing	Piedmont Eastern	Forest	0
13078	Howard	Little Patuxent River	175	124	Spread footing	Piedmont Eastern	Forest	0
13079	Howard	Little Patuxent River	175	144	Spread footing	Piedmont Eastern	Urban	0
13087	Howard	Little Patuxent River	175	132	Spread footing	Piedmont Eastern	Urban	0
13104	Howard	South Branch Patapsco River	Park Rd	28	Pile	Piedmont Eastern	Forest	0
13105	Howard	Little Patuxent River	Cd@32	438	Spread footing	Piedmont Eastern	Forest	0
13106	Howard	Little Patuxent River	Cd@32	438	Spread footing	Piedmont Eastern	Forest	0
13114	Howard	Middle Patuxent River	32	465	Spread footing	Piedmont Eastern	Forest	0
14001	Kent	Shipyard Creek	20	22	Spread footing	Coastal Plain East	Row Crop	1
14004-1	Kent	Sassafras River	US-301 N	123	Pile	Coastal Plain East	Forest	1
14004-2	Kent	Sassafras River	US-301 S	123	Pile	Coastal Plain East	Forest	1
14006	Kent	Sassafras River	213	746	Pile	Coastal Plain East	Urban	1
14009	Kent	Radcliff Creek	289	114	Pile	Coastal Plain East	Wetland	1
14013	Kent	Chester River	290	369	Pile	Coastal Plain East	Row Crop	1
14014	Kent	Mills Branch	291	39	Pile	Coastal Plain East	Forest	0
14015	Kent	Cypress Branch	291	54	Pile	Coastal Plain East	Forest	0
14016	Kent	Sassafras River	299	40	Pile	Coastal Plain East	Row Crop	1
14017	Kent	Branch of Sassafras River	299	31	Pile	Coastal Plain East	Row Crop	1
14018	Kent	Jacobs Creek	299	60	Pile	Coastal Plain East	Row Crop	1
14019	Kent	Swan Creek	445	21	Pile	Coastal Plain East	Row Crop	1
14020	Kent	Swan Creek	445	20	Pile	Coastal Plain East	Wetland	1
14021	Kent	Branch of East Fork	446	20	Spread footing	Coastal Plain East	Row Crop	0
14021-A	Kent	Branch of East Fork	446	12	Unknown	Coastal Plain East	Row Crop	0
14022	Kent	Morgan Creek	291	194	Pile	Coastal Plain East	Wetland	1
14023	Kent	Grays Inn Creek	674	26	Pile	Coastal Plain East	Forest	1
15001	Montgomery	Little Monocacy River	28	36	Spread footing	Piedmont Eastern	Forest	0
15002	Montgomery	Seneca Creek	28	92	Spread footing	Piedmont Eastern	Forest	0
15004	Montgomery	Branch of Watts Branch	28	33	Spread footing	Piedmont Eastern	Urban	0
15007	Montgomery	Muddy Branch	190	47	Spread footing	Piedmont Eastern	Forest	0
15008	Montgomery	Patuxent River	108	85	Spread footing	Piedmont Eastern	Forest	0
15009	Montgomery	Northwest Branch	US-29	45	Spread footing	Piedmont Eastern	Forest	0
15010	Montgomery	Sligo Creek	US-29	20	Spread footing	Piedmont Eastern	Urban	0
15011	Montgomery	Hawlings River	97	30	Spread footing	Piedmont Eastern	Forest	0
15012	Montgomery	Reddy Branch	97	24	Spread footing	Piedmont Eastern	Forest	0
15014	Montgomery	Dry Seneca Creek	107	36	Spread footing	Piedmont Eastern	Forest	0
15016	Montgomery	North Branch Rock Creek	115	30	Spread footing	Piedmont Eastern	Forest	0
15017	Montgomery	Hawlings River	650	40	Spread footing	Piedmont Eastern	Forest	0
15018	Montgomery	Bucklodge Branch	117	28	Spread footing	Piedmont Eastern	Pasture	0
15020	Montgomery	Great Seneca Creek	118	80	Spread footing	Piedmont Eastern	Forest	0
15021	Montgomery	Little Seneca Lake	121	530	Spread footing	Piedmont Eastern	Urban	0
15022	Montgomery	Great Seneca Creek	124	40	Spread footing	Piedmont Eastern	Pasture	0
15023	Montgomery	Branch of Northwest Branch	182	26	Spread footing	Piedmont Eastern	Forest	0
15024	Montgomery	Branch of Northwest Branch	182	20	Spread footing	Piedmont Eastern	Forest	0
15025	Montgomery	Branch of Northwest Branch	182	51	Spread footing	Piedmont Eastern	Urban	0
15027	Montgomery	Cabin John Creek	190	90	Pile	Piedmont Eastern	Forest	0
15029	Montgomery	Cabin John Creek	191	31	Spread footing	Piedmont Eastern	Forest	0
15030	Montgomery	Rock Creek	185	171	Spread footing	Piedmont Eastern	Forest	0
15032	Montgomery	Sligo Creek	193	22	Spread footing	Piedmont Eastern	Forest	0
15033	Montgomery	Sligo Creek	195	220	Spread footing	Piedmont Eastern	Urban	0
15034	Montgomery	Patuxent River	US-29	448	Pile	Piedmont Eastern	Forest	0
15036-3	Montgomery	Little Bennett Creek	I-270 E	161	Spread footing	Piedmont Western	Forest	0
15036-4	Montgomery	Little Bennett Creek	I-270 W	161	Spread footing	Piedmont Western	Forest	0
15043	Montgomery	Great Seneca Creek	I-270	227	Spread footing	Piedmont Eastern	Forest	0
15051	Montgomery	Sligo Creek	320	43	Spread footing	Piedmont Eastern	Forest	0
15053	Montgomery	Little Bennett Creek	355	40	Spread footing	Piedmont Western	Forest	0
15054	Montgomery	Little Seneca Creek	355	25	Spread footing	Piedmont Eastern	Forest	0

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Gravel	10	1	0	0	1	49.01	87.00	13037
Gravel	30	1	1	1	1	47.00	84.00	13038
Gravel	0	1	0	0	0	55.01	90.00	13041
Gravel	-20	1	1	0	1	44.51	83.00	13044
Cobble/Boulder	5	0	0	0	0	57.51	84.00	13046
Gravel	35	1	0	0	0	49.01	90.00	13047
Gravel	-5	1	0	0	0	54.01	90.00	13056-1
Gravel	-25	1	0	0	1	50.51	88.00	13056-2
Cobble/Boulder	0	1	0	0	0	55.51	90.00	13072-1
Cobble/Boulder	25	1	0	0	0	52.01	90.00	13072-2
Gravel	0	1	0	0	0	55.01	90.00	13078
Gravel	-25	1	0	0	0	49.51	89.00	13079
Gravel	-20	1	0	0	0	50.51	90.00	13087
Cobble/Boulder	-40	1	0	0	0	48.51	90.00	13104
Gravel	-40	1	0	0	0	47.01	90.00	13105
Gravel	0	1	0	0	0	53.01	90.00	13106
Gravel	25	1	0	0	0	50.51	90.00	13114
Gravel	5	1	0	0	0	57.01	90.00	14001
Sand	-10	1	0	0	0	47.01	90.00	14004-1
Sand	0	1	0	0	0	49.01	87.00	14004-2
Alluvium	0	0	0	0	0	50.01	90.00	14006
Gravel	0	0	0	0	0	56.01	90.00	14009
Alluvium	30	0	0	0	0	37.01	90.00	14013
Sand	-20	1	0	0	1	51.51	88.00	14014
Sand	50	1	0	1	1	48.01	86.00	14015
Sand	15	1	0	0	1	49.51	88.00	14016
Gravel	50	1	0	0	1	50.01	86.00	14017
Sand	0	0	0	0	0	53.01	89.00	14018
Sand	-10	1	0	0	1	54.01	88.00	14019
Sand	-15	1	0	0	1	51.51	88.00	14020
Gravel	5	1	0	0	0	54.01	90.00	14021
Gravel	-30	1	0	0	0	49.01	90.00	14021-A
Alluvium	20	0	0	0	0	51.51	90.00	14022
Sand	0	1	0	1	1	49.01	86.00	14023
Gravel	-15	0	0	0	1	53.51	86.00	15001
Gravel	15	1	0	1	0	51.51	88.00	15002
Gravel	-20	0	0	0	0	48.51	90.00	15004
Gravel	-25	0	0	0	0	52.51	90.00	15007
Gravel	10	0	0	0	0	57.01	90.00	15008
Cobble/Boulder	20	1	0	0	0	51.01	90.00	15009
Cobble/Boulder	-10	0	0	0	1	52.51	86.00	15010
Cobble/Boulder	-20	0	0	0	1	52.01	86.00	15011
Gravel	0	1	0	0	1	55.01	86.00	15012
Cobble/Boulder	0	0	0	0	0	57.51	90.00	15014
Cobble/Boulder	-25	1	0	0	0	52.01	90.00	15016
Gravel	40	0	0	0	1	53.01	86.00	15017
Gravel	30	1	0	1	1	47.01	84.00	15018
Gravel	-10	0	0	1	1	55.01	84.00	15020
Alluvium	0	0	0	0	0	50.01	90.00	15021
Gravel	-40	0	0	0	0	48.01	88.00	15022
Gravel	45	1	0	0	1	49.01	86.00	15023
Gravel	-15	1	0	0	0	52.51	90.00	15024
Gravel	40	1	0	0	0	48.01	90.00	15025
Cobble/Boulder	10	0	0	0	0	52.51	90.00	15027
Gravel	40	1	0	0	1	50.01	86.00	15029
Gravel	20	1	0	0	0	49.51	89.00	15030
Gravel	-20	1	1	0	1	49.83	86.00	15032
Cobble/Boulder	-10	0	0	0	0	54.51	90.00	15033
Gravel	0	0	0	0	0	54.01	90.00	15034
Bedrock	35	1	0	1	0	50.01	88.00	15036-3
Bedrock	0	0	0	0	0	56.01	90.00	15036-4
Gravel	-30	0	0	0	0	48.01	90.00	15043
Cobble/Boulder	-30	1	1	0	1	48.83	85.00	15051
Gravel	40	1	0	0	1	52.01	86.00	15053
Gravel	-40	0	0	0	1	53.01	86.00	15054

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
15055	Montgomery	Great Seneca Creek	355	94	Spread footing	Piedmont Eastern	Forest	0
15057	Montgomery	Little Falls Branch	396	29	Spread footing	Piedmont Eastern	Forest	0
15059	Montgomery	Rock Creek	410	195	Pile	Piedmont Eastern	Urban	0
15060	Montgomery	Branch of Rock Creek	410	24	Spread footing	Piedmont Eastern	Urban	0
15062	Montgomery	Rock Creek	547	48	Spread footing	Piedmont Eastern	Forest	0
15063	Montgomery	Rock Creek	586	96	Spread footing	Piedmont Eastern	Forest	0
15065	Montgomery	Branch of Northwest Branch	28	28	Spread footing	Piedmont Eastern	Forest	0
15070	Montgomery	*Little Monocacy River	109	20	Spread footing	Piedmont Eastern	Pasture	0
15074	Montgomery	Goshen Branch	124	20	Spread footing	Piedmont Eastern	Forest	0
15076-1	Montgomery	Paint Branch	US-29 N	360	Spread footing	Piedmont Eastern	Forest	0
15076-2	Montgomery	Paint Branch	US-29 S	360	Spread footing	Piedmont Eastern	Forest	0
15085	Montgomery	Cabin John Creek	I-495	285	Spread footing	Piedmont Eastern	Forest	0
15086	Montgomery	Cabin John Creek	I-495	250	Spread footing	Piedmont Eastern	Forest	0
15087	Montgomery	Cabin John Creek	I-495	269	Spread footing	Piedmont Eastern	Forest	0
15092-3	Montgomery	Rock Creek	28 E	315	Spread footing	Piedmont Eastern	Forest	0
15092-4	Montgomery	Rock Creek	28 W	315	Spread footing	Piedmont Eastern	Forest	0
15093	Montgomery	Great Seneca Creek	117	104	Spread footing	Piedmont Eastern	Forest	0
15095	Montgomery	Little Seneca Creek	117	54	Spread footing	Piedmont Eastern	Forest	0
15099	Montgomery	Little Bennett Creek	109	60	Spread footing	Piedmont Western	Forest	0
15100	Montgomery	Potomac River	I-495	1,399	Spread footing	Piedmont Eastern	Forest	0
15107	Montgomery	Cabin John Creek	I-495	285	Spread footing	Piedmont Eastern	Forest	0
15108	Montgomery	Cabin John Creek	I-495	350	Pile	Piedmont Eastern	Forest	0
15126-5	Montgomery	Rock Creek	I-495 NW	346	Pile	Piedmont Eastern	Forest	0
15126-6	Montgomery	Rock Creek	I-495 SE	374	Pile	Piedmont Eastern	Forest	0
15137	Montgomery	Northwest Branch	I-495	500	Spread footing	Piedmont Eastern	Forest	0
16001	Prince Georges	Patuxent River	US-1	215	Pile	Coastal Plain West	Urban	0
16002	Prince Georges	Patuxent River	US-1	191	Pile	Coastal Plain West	Urban	0
16004	Prince Georges	Paint Branch	US-1	160	Spread footing	Coastal Plain West	Urban	0
16005-1	Prince Georges	Northwest Branch	US-1 N	69	Spread footing	Coastal Plain West	Urban	0
16005-2	Prince Georges	Northwest Branch	US-1 S	73	Spread footing	Coastal Plain West	Urban	0
16007-1	Prince Georges	Northwest Branch	AltUS1 N	270	Pile	Coastal Plain West	Urban	1
16007-2	Prince Georges	Northwest Branch	AltUS1 S	299	Pile	Coastal Plain West	Urban	0
16008	Prince Georges	Anacostia River	AltUS1	270	Pile	Coastal Plain West	Urban	1
16009	Prince Georges	Federal Springs Branch	725	34	Spread footing	Coastal Plain West	Urban	0
16011	Prince Georges	Patuxent River	4	200	Pile	Coastal Plain West	Urban	1
16013	Prince Georges	Piscataway Creek	5	91	Pile	Coastal Plain West	Forest	0
16016	Prince Georges	Folly Branch	450	20	Spread footing	Coastal Plain West	Forest	0
16018	Prince Georges	Northwest Branch	193	130	Pile	Coastal Plain West	Urban	0
16019	Prince Georges	Paint Branch	193	114	Unknown	Coastal Plain West	Forest	0
16021	Prince Georges	Horsepen Branch	197	36	Spread footing	Coastal Plain West	Forest	0
16032	Prince Georges	Collington Branch	202	62	Spread footing	Coastal Plain West	Urban	0
16034	Prince Georges	Northwest Branch	208	90	Spread footing	Coastal Plain West	Urban	0
16035	Prince Georges	Carey Branch	210	28	Spread footing	Coastal Plain West	Urban	0
16036	Prince Georges	Henson Branch	210	64	Pile	Coastal Plain West	Forest	0
16037	Prince Georges	Piscataway Creek	210	174	Unknown	Coastal Plain West	Forest	0
16038	Prince Georges	Indian Creek	212	44	Pile	Coastal Plain West	Urban	0
16041	Prince Georges	Paint Branch	212	38	Spread footing	Coastal Plain West	Forest	0
16042	Prince Georges	Northwest Branch	212	36	Spread footing	Coastal Plain West	Urban	0
16043	Prince Georges	Sligo Creek	212	67	Spread footing	Coastal Plain West	Urban	0
16048	Prince Georges	Collington Branch	978	32	Spread footing	Coastal Plain West	Urban	0
16052	Prince Georges	Piscataway Creek	223	114	Pile	Coastal Plain West	Forest	0
16053-1	Prince Georges	Patuxent River	3 N	267	Pile	Coastal Plain West	Forest	0
16053-2	Prince Georges	Patuxent River	3 S	263	Pile	Coastal Plain West	Forest	0
16054-1	Prince Georges	Western Branch	US-301 N	136	Pile	Coastal Plain West	Forest	0
16054-2	Prince Georges	Western Branch	US-301 S	136	Pile	Coastal Plain West	Forest	0
16057-1	Prince Georges	Timothy Branch	US-301 N	35	Pile	Coastal Plain West	Forest	0
16057-2	Prince Georges	Timothy Branch	US-301 S	35	Pile	Coastal Plain West	Forest	0
16060	Prince Georges	Swanson Creek	381	40	Spread footing	Coastal Plain West	Forest	0
16061	Prince Georges	Charles Branch	382	44	Pile	Coastal Plain West	Forest	0
16062	Prince Georges	Mataponi Creek	382	40	Pile	Coastal Plain West	Forest	0
16063	Prince Georges	Rock Branch	382	40	Spread footing	Coastal Plain West	Wetland	0
16065	Prince Georges	Northwest Branch	320	56	Spread footing	Coastal Plain West	Urban	0
16066	Prince Georges	Swanson Creek	382	20	Pile	Coastal Plain West	Forest	0
16067	Prince Georges	Sligo Creek	410	40	Spread footing	Coastal Plain West	Urban	0
16068	Prince Georges	Northwest Branch	410	130	Pile	Coastal Plain West	Forest	0
16069	Prince Georges	Branch of Anacostia River	412	90	Spread footing	Coastal Plain West	Urban	0

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Gravel	15	1	0	1	1	53.51	82.00	15055
Cobble/Boulder	-10	0	0	0	0	50.51	90.00	15057
Gravel	-10	0	0	0	0	53.01	90.00	15059
Gravel	0	0	0	0	1	53.01	86.00	15060
Gravel	10	1	0	0	1	54.01	88.00	15062
Gravel	0	0	0	0	0	54.01	90.00	15063
Cobble/Boulder	-15	1	0	0	1	54.01	86.00	15065
Gravel	0	1	0	0	1	56.01	86.00	15070
Gravel	35	0	1	1	1	46.33	84.00	15074
Gravel	0	1	0	0	0	55.01	90.00	15076-1
Gravel	30	1	0	0	0	51.01	90.00	15076-2
Cobble/Boulder	10	0	0	0	0	55.51	90.00	15085
Cobble/Boulder	0	0	0	0	0	56.51	90.00	15086
Cobble/Boulder	-10	0	0	0	0	54.51	90.00	15087
Gravel	0	0	0	0	0	54.01	90.00	15092-3
Gravel	-20	1	0	0	0	49.51	90.00	15092-4
Cobble/Boulder	0	0	0	0	0	52.51	88.00	15093
Gravel	-10	0	1	1	1	52.33	84.00	15095
Bedrock	-45	1	0	0	1	52.01	86.00	15099
Alluvium	-10	0	0	1	0	48.01	87.00	15100
Gravel	5	1	1	0	0	51.33	89.00	15107
Gravel	0	0	0	0	0	53.01	90.00	15108
Gravel	-30	0	0	0	0	50.01	90.00	15126-5
Gravel	-30	0	0	0	0	50.01	90.00	15126-6
Cobble/Boulder	-15	1	0	0	0	50.01	90.00	15137
Sand	-20	1	0	0	0	50.51	89.00	16001
Gravel	-20	0	0	0	0	49.51	89.00	16002
Gravel	10	1	0	0	0	53.01	90.00	16004
Gravel	0	0	0	0	0	59.01	90.00	16005-1
Gravel	-20	0	0	0	0	56.51	90.00	16005-2
Gravel	0	1	0	0	0	55.01	90.00	16007-1
Gravel	0	1	0	0	0	55.01	90.00	16007-2
Sand	-35	1	0	0	0	47.01	90.00	16008
Gravel	-10	1	0	0	0	54.01	90.00	16009
Silt/Clay	15	0	0	0	0	52.51	90.00	16011
Gravel	-15	1	0	0	0	51.51	90.00	16013
Alluvium	0	0	0	0	1	51.01	86.00	16016
Sand	30	1	0	0	0	48.01	90.00	16018
Gravel	30	1	0	0	0	49.01	90.00	16019
Gravel	0	1	0	0	0	53.01	90.00	16021
Silt/Clay	-20	0	0	1	1	48.51	86.00	16032
Gravel	20	1	0	1	1	53.51	84.00	16034
Gravel	40	1	1	1	1	48.33	86.00	16035
Gravel	-30	1	0	0	0	51.01	90.00	16036
Gravel	-20	0	0	0	0	51.51	89.00	16037
Alluvium	-10	0	0	0	0	49.01	90.00	16038
Cobble/Boulder	30	1	0	0	1	51.51	86.00	16041
Cobble/Boulder	0	0	0	0	1	54.51	88.00	16042
Bedrock	0	0	0	0	0	58.01	90.00	16043
Silt/Clay	-5	0	0	0	0	52.01	90.00	16048
Gravel	-30	0	0	0	0	50.01	90.00	16052
Alluvium	30	0	0	1	0	47.01	80.00	16053-1
Alluvium	30	0	0	1	0	47.01	80.00	16053-2
Silt/Clay	0	0	0	0	0	51.01	90.00	16054-1
Silt/Clay	0	0	0	0	0	51.01	90.00	16054-2
Gravel	-10	0	0	0	0	57.01	90.00	16057-1
Gravel	-10	0	0	0	0	57.01	90.00	16057-2
Sand	-30	1	0	1	0	50.01	88.00	16060
Sand	-30	1	0	0	1	50.01	88.00	16061
Gravel	-10	1	0	1	1	50.01	86.00	16062
Alluvium	0	0	0	0	0	50.01	90.00	16063
Cobble/Boulder	15	0	0	0	1	53.01	88.00	16065
Gravel	-40	1	0	0	0	53.01	90.00	16066
Cobble/Boulder	-30	1	0	0	0	49.51	90.00	16067
Gravel	20	1	1	0	0	49.17	90.00	16068
Gravel	15	0	0	1	0	50.51	88.00	16069

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
16072	Prince Georges	Indian Creek	434	63	Spread footing	Coastal Plain West	Urban	0
16073	Prince Georges	Northwest Branch	500	86	Spread footing	Coastal Plain West	Urban	0
16078-3	Prince Georges	Patuxent River	198 E	700	Pile	Coastal Plain West	Forest	0
16078-4	Prince Georges	Patuxent River	198 W	700	Pile	Coastal Plain West	Forest	0
16079	Prince Georges	Northwest Branch	650	50	Spread footing	Coastal Plain West	Urban	0
16080	Prince Georges	Sligo Creek	650	60	Spread footing	Coastal Plain West	Urban	0
16083	Prince Georges	Cattail Branch	704	20	Spread footing	Coastal Plain West	Urban	0
16090-3	Prince Georges	Folly Branch	US-50 E	81	Pile	Coastal Plain West	Wetland	0
16090-4	Prince Georges	Folly Branch	US-50 W	81	Pile	Coastal Plain West	Wetland	0
16095	Prince Georges	Patuxent River	4	243	Pile	Coastal Plain West	Forest	1
16100-3	Prince Georges	Western Branch	4 E	241	Pile	Coastal Plain West	Urban	1
16100-4	Prince Georges	Western Branch	4 W	241	Pile	Coastal Plain West	Urban	1
16109	Prince Georges	Western Branch	717	40	Spread footing	Coastal Plain West	Urban	0
16111	Prince Georges	Beaverdam Creek	201	84	Spread footing	Coastal Plain West	Forest	0
16125	Prince Georges	Paint Branch	I-95	197	Spread footing	Coastal Plain West	Forest	0
16176	Prince Georges	Paint Branch	I-95	0	Spread footing	Coastal Plain West	Forest	0
16188	Prince Georges	Northeast Branch	410	148	Pile	Coastal Plain West	Urban	0
16196	Prince Georges	Piscataway Creek	5	107	Pile	Coastal Plain West	Forest	0
16197-1	Prince Georges	Patuxent River	I-95 N	510	Spread footing	Piedmont Eastern	Forest	0
16197-2	Prince Georges	Patuxent River	I-95 S	510	Spread footing	Piedmont Eastern	Forest	0
16215	Prince Georges	Piscataway Creek	210	206	Pile	Coastal Plain West	Forest	0
17001	Queen Annes	Cox Creek	18	32	Pile	Coastal Plain East	Wetland	1
17002	Queen Annes	Branch of Reed Creek	18	19	Spread footing	Coastal Plain East	Forest	1
17003	Queen Annes	Beaverdam Ditch	19	35	Spread footing	Coastal Plain East	Row Crop	0
17004	Queen Annes	Cox Creek	US-50	62	Pile	Coastal Plain East	Wetland	1
17005-3	Queen Annes	Piney Creek	US-50 E	40	Pile	Coastal Plain East	Forest	1
17005-4	Queen Annes	Piney Creek	US-50 W	40	Pile	Coastal Plain East	Forest	1
17012-1	Queen Annes	Red Lion Branch	US-301 N	87	Pile	Coastal Plain East	Row Crop	1
17012-2	Queen Annes	Red Lion Branch	US-301 S	87	Pile	Coastal Plain East	Row Crop	1
17013-1	Queen Annes	Unicorn Branch	US-301 N	147	Pile	Coastal Plain East	Forest	1
17013-2	Queen Annes	Unicorn Branch	US-301 S	147	Pile	Coastal Plain East	Forest	1
17014-1	Queen Annes	Chester River	US-301 N	210	Pile	Coastal Plain East	Forest	1
17014-2	Queen Annes	Chester River	US-301 S	215	Pile	Coastal Plain East	Forest	1
17016	Queen Annes	Browns Branch	213	32	Spread footing	Coastal Plain East	Forest	1
17017	Queen Annes	Southeast Creek	19A	59	Spread footing	Coastal Plain East	Forest	1
17018	Queen Annes	Granny Finley Branch	213	30	Pile	Coastal Plain East	Forest	0
17019	Queen Annes	Three Bridle Branch	213	66	Pile	Coastal Plain East	Forest	1
17020	Queen Annes	Gravel Run	213	20	Pile	Coastal Plain East	Urban	0
17021	Queen Annes	Old Mill Stream Branch	213	32	Pile	Coastal Plain East	Forest	1
17023	Queen Annes	Red Lion Branch	290	36	Spread footing	Coastal Plain East	Forest	1
17024	Queen Annes	Red Lion Branch	300	45	Spread footing	Coastal Plain East	Row Crop	1
17025	Queen Annes	Unicorn Branch	300	54	Pile	Coastal Plain East	Row Crop	0
17026	Queen Annes	Andover Branch	300	20	Spread footing	Coastal Plain East	Row Crop	0
17027	Queen Annes	Andover Branch	300	32	Spread footing	Coastal Plain East	Pasture	0
17028	Queen Annes	Branch of Red Lion Branch	302	26	Pile	Coastal Plain East	Row Crop	1
17029	Queen Annes	Corsica River	304	90	Pile	Coastal Plain East	Row Crop	1
17030	Queen Annes	Chester River	313	177	Pile	Coastal Plain East	Forest	1
17032	Queen Annes	Norwich Creek	404	99	Pile	Coastal Plain East	Row Crop	0
17033	Queen Annes	Southeast Creek	405	32	Spread footing	Coastal Plain East	Row Crop	0
17034	Queen Annes	German Branch	405	32	Spread footing	Coastal Plain East	Row Crop	0
17035	Queen Annes	Branch of Wye River	456	28	Spread footing	Coastal Plain East	Forest	1
17036	Queen Annes	Blockston Branch	481	32	Spread footing	Coastal Plain East	Row Crop	1
17038	Queen Annes	Red Lion Branch	544	83	Pile	Coastal Plain East	Forest	1
17039	Queen Annes	Branch of Wye River	662	32	Spread footing	Coastal Plain East	Forest	1
17040	Queen Annes	Wye Narrows	Co.Rd.	702	Pile	Coastal Plain East	Pasture	1
17042	Queen Annes	German Branch	304	45	Spread footing	Coastal Plain East	Row Crop	0
17045	Queen Annes	Pearl Creek	544	24	Unknown	Coastal Plain East	Forest	0
18001	St. Marys	Clement Creek	5	20	Pile	Coastal Plain West	Forest	0
18002	St. Marys	Mcintosh Run	5	85	Spread footing	Coastal Plain West	Forest	1
18005	St. Marys	Moldier Run	5	30	Pile	Coastal Plain West	Forest	0
18006	St. Marys	St. Marys River	5	74	Pile	Coastal Plain West	Urban	0
18007	St. Marys	Hilton Run	5	32	Pile	Coastal Plain West	Forest	1
18008	St. Marys	Eastern Branch	5	37	Pile	Coastal Plain West	Pasture	1
18009	St. Marys	Branch of St. Marys River	5	22	Pile	Coastal Plain West	Urban	1
18010	St. Marys	Church Creek	5	22	Pile	Coastal Plain West	Forest	1
18012	St. Marys	Swamp Creek	6	20	Pile	Coastal Plain West	Forest	1
18013	St. Marys	Persimmon Creek	6	20	Pile	Coastal Plain West	Forest	1

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Gravel	10	1	0	0	0	52.01	90.00	16072
Sand	25	1	1	0	0	47.16	90.00	16073
Sand	-15	1	0	0	0	50.51	90.00	16078-3
Sand	-30	1	0	0	0	45.01	90.00	16078-4
Cobble/Boulder	30	0	0	0	0	51.51	90.00	16079
Cobble/Boulder	-45	1	0	0	1	50.51	86.00	16080
Gravel	-15	0	0	0	0	52.51	90.00	16083
Alluvium	0	0	0	0	0	48.01	90.00	16090-3
Alluvium	0	0	0	0	0	48.01	90.00	16090-4
Silt/Clay	0	0	0	0	1	52.01	85.00	16095
Silt/Clay	0	0	0	0	0	54.01	90.00	16100-3
Silt/Clay	10	0	0	0	0	52.01	90.00	16100-4
Silt/Clay	25	0	0	0	0	50.51	90.00	16109
Sand	0	0	1	0	0	54.33	90.00	16111
Cobble/Boulder	-10	1	0	0	0	54.51	90.00	16125
Gravel	0	1	0	0	0	57.01	90.00	16176
Gravel	10	0	1	0	0	51.33	88.00	16188
Gravel	-15	1	0	0	0	48.51	90.00	16196
Cobble/Boulder	-15	0	0	0	0	54.01	90.00	16197-1
Cobble/Boulder	-15	0	0	0	0	54.01	90.00	16197-2
Gravel	-20	0	0	0	0	49.51	90.00	16215
Sand	0	0	0	1	1	51.01	84.00	17001
Sand	-15	1	0	0	0	52.51	90.00	17002
Sand	0	1	0	0	0	55.01	90.00	17003
Sand	0	0	0	0	0	52.01	90.00	17004
Sand	0	0	0	0	0	52.01	90.00	17005-3
Sand	0	0	0	0	0	56.01	90.00	17005-4
Sand	0	1	0	0	1	52.01	85.00	17012-1
Sand	0	1	0	0	1	53.01	85.00	17012-2
Sand	0	1	0	0	0	51.01	88.00	17013-1
Sand	0	1	0	0	0	53.01	89.00	17013-2
Sand	20	0	0	1	1	43.51	84.00	17014-1
Sand	0	0	0	1	1	52.01	84.00	17014-2
Sand	-5	0	0	0	1	55.01	87.00	17016
Sand	0	1	0	1	1	49.01	79.00	17017
Gravel	0	0	0	1	1	55.01	86.00	17018
Gravel	0	0	0	1	1	56.01	84.00	17019
Gravel	-10	0	0	0	0	53.01	90.00	17020
Gravel	25	0	1	0	0	48.83	89.00	17021
Sand	0	1	0	0	1	51.01	87.00	17023
Sand	-40	1	0	1	0	52.01	86.00	17024
Sand	-15	1	0	0	0	49.51	90.00	17025
Sand	5	1	0	0	1	53.01	86.00	17026
Sand	-30	1	0	1	1	47.01	86.00	17027
Sand	0	0	0	0	0	55.01	89.00	17028
Alluvium	30	0	0	0	0	43.01	89.00	17029
Sand	30	1	0	1	0	45.01	86.00	17030
Gravel	0	1	0	0	0	52.01	90.00	17032
Gravel	-15	1	0	0	0	52.51	90.00	17033
Gravel	-10	1	0	1	1	54.01	84.00	17034
Sand	30	1	0	1	1	49.01	86.00	17035
Sand	-40	0	0	1	1	50.01	86.00	17036
Sand	0	1	0	0	0	52.01	89.00	17038
Gravel	0	0	0	1	1	54.01	84.00	17039
Sand	45	0	0	0	0	34.01	90.00	17040
Sand	0	0	0	1	1	55.01	82.00	17042
Gravel	15	1	1	0	1	49.51	86.00	17045
Sand	10	0	0	0	1	53.01	86.00	18001
Gravel	-25	1	0	0	0	48.51	88.00	18002
Gravel	0	1	0	0	0	57.01	90.00	18005
Gravel	-15	1	1	1	1	50.83	86.00	18006
Gravel	0	0	0	0	0	57.01	90.00	18007
Gravel	10	0	0	0	1	57.01	88.00	18008
Sand	0	0	0	0	0	52.01	90.00	18009
Silt/Clay	0	0	0	0	0	53.01	90.00	18010
Sand	30	0	0	0	0	55.01	90.00	18012
Alluvium	0	0	0	0	0	55.01	90.00	18013

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
18015	St. Marys	Chaptico Creek	234	91	Pile	Coastal Plain West	Forest	1
18016	St. Marys	Clement Creek	234	108	Pile	Coastal Plain West	Forest	1
18017	St. Marys	Nelsons Run	238	20	Spread footing	Coastal Plain West	Pasture	1
18018	St. Marys	Burroughs Run	238	24	Pile	Coastal Plain West	Forest	1
18019	St. Marys	Locust Run	242	30	Pile	Coastal Plain West	Forest	0
18020	St. Marys	Clement Creek	242	90	Pile	Coastal Plain West	Forest	0
18022	St. Marys	Tomakokin Creek	242	27	Pile	Coastal Plain West	Forest	0
18023	St. Marys	Moldier Run	244	39	Spread footing	Coastal Plain West	Forest	1
18024	St. Marys	Poplar Hill Creek	244	21	Pile	Coastal Plain West	Forest	1
18026	St. Marys	St. Georges Creek	249	400	Pile	Coastal Plain West	Forest	1
18027	St. Marys	Tomakokin Creek	470	25	Pile	Coastal Plain West	Forest	1
18029	St. Marys	St. Marys River	471	44	Pile	Coastal Plain West	Forest	0
18033	St. Marys	Kingston Creek	4	270	Pile	Coastal Plain West	Forest	1
19001	Somerset	Passerdyke Creek	US-13	21	Pile	Coastal Plain East	Row Crop	0
19002	Somerset	Manokin River	675	20	Pile	Coastal Plain East	Row Crop	1
19003-1	Somerset	Kings Creek	US-13 N	40	Pile	Coastal Plain East	Wetland	1
19003-2	Somerset	Kings Creek	US-13 S	40	Pile	Coastal Plain East	Wetland	1
19005	Somerset	Monie Creek	362	41	Pile	Coastal Plain East	Row Crop	1
19007	Somerset	South Branch Rock Creek	363	75	Pile	Coastal Plain East	Wetland	1
19008	Somerset	East Branch Rock Creek	363	65	Pile	Coastal Plain East	Wetland	1
19009	Somerset	Manokin River	363	82	Pile	Coastal Plain East	Urban	1
19010	Somerset	Dividing Creek	364	47	Pile	Coastal Plain East	Forest	1
19011	Somerset	Big Annemessex River	413	58	Pile	Coastal Plain East	Wetland	1
19012-1	Somerset	Manokin River	US-13 N	80	Pile	Coastal Plain East	Urban	1
19012-2	Somerset	Manokin River	US-13 S	82	Pile	Coastal Plain East	Urban	1
19013	Somerset	Little Annemessex River	460	119	Pile	Coastal Plain East	Forest	1
19014-1	Somerset	Jones Creek	US-13 N	20	Pile	Coastal Plain East	Row Crop	0
19016-1	Somerset	Back Creek	US-13 N	23	Pile	Coastal Plain East	Forest	0
19017	Somerset	Rehobeth Branch	667	64	Pile	Coastal Plain East	Row Crop	1
19018	Somerset	Marumsco Creek	667	61	Pile	Coastal Plain East	Row Crop	1
19019	Somerset	Dames Quarter Creek	363	60	Pile	Coastal Plain East	Wetland	1
20001	Talbot	Knapps Narrows	33	100	Pile	Coastal Plain East	Row Crop	1
20002	Talbot	Oak Creek	33	430	Pile	Coastal Plain East	Row Crop	1
20004-3	Talbot	North Branch Skipton Creek	US-50 E	78	Pile	Coastal Plain East	Forest	1
20004-4	Talbot	North Branch Skipton Creek	US-50 W	78	Pile	Coastal Plain East	Forest	1
20005-3	Talbot	South Branch Skipton Creek	US-50 E	93	Pile	Coastal Plain East	Forest	1
20005-4	Talbot	South Branch Skipton Creek	US-50 W	93	Pile	Coastal Plain East	Forest	1
20010	Talbot	Norwich Creek	303	36	Spread footing	Coastal Plain East	Forest	1
20012	Talbot	Branch of Tuckahoe Creek	303	20	Spread footing	Coastal Plain East	Row Crop	1
20013	Talbot	Wootenaux Creek	328	37	Pile	Coastal Plain East	Row Crop	0
20016	Talbot	Peachblossom Creek	333	500	Pile	Coastal Plain East	Row Crop	1
20017	Talbot	Trippe Creek	333	350	Pile	Coastal Plain East	Row Crop	1
20018	Talbot	Miles River	370	1,276	Pile	Coastal Plain East	Row Crop	1
20020	Talbot	Mill Creek	662	25	Spread footing	Coastal Plain East	Forest	0
20021	Talbot	Branch of Skipton Creek	662	26	Unknown	Coastal Plain East	Forest	1
20022	Talbot	Potts Mill Creek	662	32	Spread footing	Coastal Plain East	Row Crop	1
20023	Talbot	Choptank River	331	841	Pile	Coastal Plain East	Wetland	1
20024	Talbot	Norwich Creek	309	102	Pile	Coastal Plain East	Forest	0
20030	Talbot	Branch of Tuckahoe Creek	303	18	Spread footing	Coastal Plain East	Forest	1
21001	Washington	Potomac River	US-11	1,697	Spread footing	Great Valley	Urban	0
21003	Washington	Antietam Creek	34	240	Spread footing	Great Valley	Pasture	0
21004	Washington	Little Antietam Creek	845	50	Spread footing	Great Valley	Forest	0
21005	Washington	Beaver Creek	34	24	Spread footing	Great Valley	Pasture	0
21008	Washington	Tonoloway Creek	144	43	Spread footing	Allegheny Ridges	Urban	0
21009	Washington	Great Tonoloway Creek	144	299	Spread footing	Allegheny Ridges	Forest	0
21010	Washington	Licking Creek	US-40	300	Spread footing	Allegheny Ridges	Pasture	0
21011	Washington	Little Conococheague Creek	US-40	30	Spread footing	Great Valley	Pasture	0
21012	Washington	Conococheague Creek	US-40	370	Spread footing	Great Valley	Pasture	0
21013	Washington	Branch of Antietam Creek	US-40	31	Spread footing	Great Valley	Urban	0
21014-3	Washington	Antietam Creek	US-40 E	222	Spread footing	Great Valley	Urban	0
21014-4	Washington	Antietam Creek	US-40 W	140	Spread footing	Great Valley	Urban	0
21015	Washington	Landis Spring Branch	US-40	32	Spread footing	Great Valley	Pasture	0
21016	Washington	Beaver Creek	US-40	84	Spread footing	Great Valley	Pasture	0
21017	Washington	Little Beaver Creek	US-40	23	Spread footing	Great Valley	Forest	0
21018	Washington	Antietam Creek	AltUS40	119	Spread footing	Great Valley	Urban	0
21019	Washington	Landis Spring Branch	AltUS40	21	Spread footing	Great Valley	Pasture	0

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Alluvium	0	0	0	0	0	54.01	90.00	18015
Alluvium	0	0	0	0	0	54.01	90.00	18016
Alluvium	0	1	0	0	0	55.01	90.00	18017
Alluvium	0	0	0	0	1	55.01	88.00	18018
Gravel	0	0	0	0	0	56.01	90.00	18019
Gravel	0	0	0	0	0	55.01	90.00	18020
Gravel	0	1	0	0	0	57.01	90.00	18022
Gravel	-10	1	0	1	1	55.01	84.00	18023
Gravel	0	0	0	0	0	57.01	90.00	18024
Sand	0	0	0	0	0	51.01	87.00	18026
Silt/Clay	-50	1	0	0	0	49.01	90.00	18027
Gravel	-40	0	1	1	1	51.67	85.00	18029
Silt/Clay	0	0	0	0	0	53.01	90.00	18033
Sand	0	0	0	0	0	49.01	89.00	19001
Sand	-40	0	0	1	1	45.01	84.00	19002
Sand	0	0	0	0	1	55.01	86.00	19003-1
Sand	0	0	0	0	1	55.01	86.00	19003-2
Sand	0	0	0	0	0	52.01	90.00	19005
Sand	0	0	0	0	0	47.01	90.00	19007
Sand	40	0	0	0	0	43.01	90.00	19008
Sand	0	0	0	0	0	53.01	90.00	19009
Sand	35	0	0	0	0	49.01	89.00	19010
Sand	15	0	0	0	0	51.51	90.00	19011
Sand	-30	0	0	0	0	50.01	90.00	19012-1
Sand	0	0	0	0	0	53.01	90.00	19012-2
Sand	0	0	0	0	0	48.01	87.00	19013
Sand	0	1	0	1	1	54.01	84.00	19014-1
Sand	10	0	1	1	1	47.99	84.00	19016-1
Sand	30	0	0	0	0	47.01	87.00	19017
Sand	-5	0	0	0	0	53.01	90.00	19018
Sand	0	0	0	0	0	54.01	90.00	19019
Alluvium	0	0	0	0	0	50.01	90.00	20001
Sand	25	0	0	0	0	36.51	84.00	20002
Sand	-20	0	0	0	0	45.51	90.00	20004-3
Sand	0	0	0	0	0	53.01	90.00	20004-4
Sand	15	0	0	0	0	47.51	89.00	20005-3
Sand	0	0	0	0	0	53.01	90.00	20005-4
Sand	-30	1	0	1	1	51.01	84.00	20010
Sand	-35	1	0	0	1	49.01	86.00	20012
Sand	-15	1	0	0	0	49.51	90.00	20013
Sand	30	0	0	0	0	35.01	90.00	20016
Sand	30	0	0	0	0	35.01	90.00	20017
Sand	-20	0	0	0	0	35.51	90.00	20018
Sand	30	1	0	0	0	49.01	90.00	20020
Sand	-55	1	0	0	0	49.01	89.00	20021
Sand	-30	1	0	1	1	44.01	84.00	20022
Alluvium	30	0	0	0	0	39.01	90.00	20023
Sand	0	0	0	0	0	53.01	89.00	20024
Sand	50	0	0	0	1	49.01	86.00	20030
Cobble/Boulder	-40	0	1	1	0	41.83	78.00	21001
Cobble/Boulder	0	1	0	1	0	50.51	87.00	21003
Cobble/Boulder	0	0	0	0	1	51.51	86.00	21004
Cobble/Boulder	-45	1	0	0	1	49.51	86.00	21005
Cobble/Boulder	-45	1	0	0	1	47.51	88.00	21008
Cobble/Boulder	-25	0	0	1	0	50.01	86.00	21009
Cobble/Boulder	30	1	0	1	0	45.51	86.00	21010
Gravel	-20	1	0	0	1	47.51	88.00	21011
Cobble/Boulder	0	0	1	1	0	50.83	87.00	21012
Gravel	20	1	1	0	1	47.83	88.00	21013
Silt/Clay	0	1	1	0	0	48.66	90.00	21014-3
Silt/Clay	0	1	1	1	0	48.66	86.00	21014-4
Silt/Clay	0	1	0	0	0	52.01	90.00	21015
Gravel	0	1	0	0	1	53.01	87.00	21016
Gravel	20	1	1	0	1	46.83	86.00	21017
Cobble/Boulder	0	1	0	1	0	52.51	86.00	21018
Gravel	65	1	0	0	1	48.01	85.00	21019

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
21020	Washington	Beaver Creek	AltUS40	60	Spread footing	Great Valley	Pasture	0
21021	Washington	Beaver Creek	AltUS40	27	Spread footing	Great Valley	Pasture	1
21022	Washington	Green Springs Run	56	21	Spread footing	Great Valley	Pasture	0
21023	Washington	Little Conococheague Creek	56	50	Spread footing	Great Valley	Pasture	0
21024	Washington	Marsh Run	60	20	Spread footing	Great Valley	Row Crop	0
21025	Washington	Antietam Creek	60	230	Spread footing	Great Valley	Pasture	0
21026	Washington	Little Antietam Creek	62	78	Spread footing	Great Valley	Forest	0
21028	Washington	Antietam Creek	64	100	Spread footing	Great Valley	Row Crop	0
21032	Washington	Beaver Creek	66	20	Spread footing	Great Valley	Pasture	0
21034	Washington	Israel Creek	US-340	339	Spread footing	Blue Ridge	Forest	0
21036	Washington	Conococheague Creek	68	166	Spread footing	Great Valley	Urban	0
21038	Washington	Antietam Creek	68	133	Spread footing	Great Valley	Pasture	0
21039	Washington	Beaver Creek	68	38	Spread footing	Great Valley	Forest	0
21041	Washington	Potomac River	US-340	2,242	Spread footing	Blue Ridge	Forest	0
21042	Washington	Conococheague Creek	494	266	Spread footing	Great Valley	Row Crop	0
21043	Washington	Potomac River	US-522	2,582	Spread footing	Allegheny Ridges	Forest	0
21045	Washington	Beaver Creek	66	23	Spread footing	Great Valley	Pasture	0
21047	Washington	Little Antietam Creek	858	21	Spread footing	Great Valley	Pasture	0
21049	Washington	Beaver Creek	844	23	Spread footing	Great Valley	Forest	0
21050	Washington	Little Antietam Creek	34	128	Spread footing	Great Valley	Pasture	0
21078-1	Washington	Potomac River	I-81 N	1,177	Spread footing	Great Valley	Urban	0
21078-2	Washington	Potomac River	I-81 S	1,177	Spread footing	Great Valley	Urban	0
21092-3	Washington	Great Tonoloway Creek	I-70 E	403	Spread footing	Allegheny Ridges	Forest	0
21092-4	Washington	Great Tonoloway Creek	I-70 W	482	Spread footing	Allegheny Ridges	Forest	0
21094-3	Washington	Licking Creek	I-70 E	384	Pile	Allegheny Ridges	Forest	0
21094-4	Washington	Licking Creek	I-70 W	374	Pile	Allegheny Ridges	Forest	0
21106-3	Washington	Conococheague Creek	I-70 E	360	Spread footing	Great Valley	Forest	0
21106-4	Washington	Conococheague Creek	I-70 W	360	Spread footing	Great Valley	Forest	0
21120-3	Washington	Antietam Creek	I-70 E	234	Spread footing	Great Valley	Row Crop	0
21120-4	Washington	Antietam Creek	I-70 W	234	Spread footing	Great Valley	Row Crop	0
21127-3	Washington	Beaver Creek	I-70 E	194	Spread footing	Great Valley	Pasture	0
21127-4	Washington	Beaver Creek	I-70 W	194	Spread footing	Great Valley	Pasture	0
21128	Washington	Beaver Creek	I-70	154	Spread footing	Great Valley	Pasture	0
21129	Washington	Beaver Creek	I-70	182	Spread footing	Great Valley	Pasture	0
21130	Washington	Beaver Creek	66	54	Pile	Great Valley	Pasture	0
21147-3	Washington	Sideling Hill Creek	US-48 E	520	Spread footing	Allegheny Ridges	Forest	0
21147-4	Washington	Sideling Hill Creek	US-48 W	520	Spread footing	Allegheny Ridges	Forest	0
21153	Washington	Conococheague Creek	Co Rd	570	Spread footing	Great Valley	Pasture	0
22001-3	Wicomico	Pocomoke River	US-50 E	97	Pile	Coastal Plain East	Forest	0
22001-4	Wicomico	Pocomoke River	US-50 W	97	Pile	Coastal Plain East	Forest	0
22002-1	Wicomico	Leonard Pond Run	US-13 N	78	Spread footing	Coastal Plain East	Urban	0
22002-2	Wicomico	Leonard Pond Run	US-13 S	78	Pile	Coastal Plain East	Urban	0
22004	Wicomico	East Branch Wicomico River	US-13	42	Pile	Coastal Plain East	Urban	1
22005-1	Wicomico	Tonytank Pond	US-13B N	240	Pile	Coastal Plain East	Urban	0
22005-2	Wicomico	Tonytank Pond	US-13B S	240	Pile	Coastal Plain East	Urban	0
22008-3	Wicomico	Barren Creek	US-50 E	75	Pile	Coastal Plain East	Forest	1
22008-4	Wicomico	Barren Creek	US-50 W	75	Pile	Coastal Plain East	Forest	1
22009	Wicomico	Wicomico River	991	40	Pile	Coastal Plain East	Urban	1
22010	Wicomico	Burnt Mill Branch	346	32	Pile	Coastal Plain East	Forest	0
22011	Wicomico	Pocomoke River	346	102	Pile	Coastal Plain East	Forest	0
22014	Wicomico	Quantico Creek	347	20	Pile	Coastal Plain East	Wetland	1
22015	Wicomico	Windsor Creek	349	21	Pile	Coastal Plain East	Wetland	1
22016	Wicomico	Nassawango Creek	350	20	Spread footing	Coastal Plain East	Forest	0
22017	Wicomico	Green Hill Creek	352	40	Spread footing	Coastal Plain East	Wetland	1
22018	Wicomico	Burnt Mill Branch	353	20	Pile	Coastal Plain East	Forest	0
22019	Wicomico	Adkins Pond	354	20	Pile	Coastal Plain East	Row Crop	0
22020	Wicomico	Adkins Pond	354	60	Pile	Coastal Plain East	Row Crop	0
22022	Wicomico	Mockingbird Creek	54	20	Pile	Coastal Plain East	Row Crop	0
22025	Wicomico	Aydelotte Branch	353	40	Pile	Coastal Plain East	Forest	0
22028	Wicomico	Wicomico River	US-50	121	Pile	Coastal Plain East	Urban	1
22029	Wicomico	Wetipquin Creek	Ent Rd	28	Pile	Coastal Plain East	Wetland	1
22036-1	Wicomico	Parker Pond	US-13 N	62	Pile	Coastal Plain East	Forest	0
22036-2	Wicomico	Parker Pond	US-13 S	62	Pile	Coastal Plain East	Forest	0
22045	Wicomico	Nanticoke River	313	1,381	Pile	Coastal Plain East	Forest	1
23001	Worcester	Nassawango Creek	12	72	Pile	Coastal Plain East	Forest	0
23002	Worcester	Pocomoke River	12	92	Pile	Coastal Plain East	Forest	1

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Gravel	0	1	0	1	1	50.01	85.00	21020
Gravel	20	1	0	0	1	49.51	86.00	21021
Gravel	-15	1	0	0	1	49.51	88.00	21022
Gravel	-20	1	1	0	1	51.16	88.00	21023
Cobble/Boulder	50	1	0	0	0	47.51	90.00	21024
Cobble/Boulder	0	0	1	0	0	50.83	89.00	21025
Gravel	0	1	1	1	0	48.33	86.00	21026
Cobble/Boulder	-25	1	1	1	1	48.67	84.00	21028
Gravel	-20	1	0	0	1	46.51	85.00	21032
Cobble/Boulder	-20	1	0	0	0	40.01	84.00	21034
Gravel	0	1	1	1	1	49.00	79.00	21036
Gravel	-30	1	0	1	1	47.01	84.00	21038
Cobble/Boulder	65	0	0	0	1	49.51	86.00	21039
Bedrock	0	0	0	1	0	47.01	74.00	21041
Cobble/Boulder	0	0	1	1	0	55.50	88.00	21042
Gravel	-30	1	0	0	0	47.01	88.00	21043
Gravel	10	1	1	0	1	49.00	86.00	21045
Cobble/Boulder	45	1	1	0	1	42.83	86.00	21047
Gravel	-10	1	0	0	1	53.01	88.00	21049
Gravel	0	1	0	0	0	50.01	88.00	21050
Cobble/Boulder	10	0	0	0	0	49.51	90.00	21078-1
Cobble/Boulder	10	0	1	0	0	49.17	90.00	21078-2
Cobble/Boulder	0	0	0	0	0	56.51	90.00	21092-3
Cobble/Boulder	20	1	0	0	0	48.01	87.00	21092-4
Cobble/Boulder	0	0	0	0	0	55.51	89.00	21094-3
Cobble/Boulder	-45	0	0	0	0	53.51	89.00	21094-4
Cobble/Boulder	0	1	0	1	1	53.51	86.00	21106-3
Cobble/Boulder	-30	1	1	1	1	44.83	79.00	21106-4
Cobble/Boulder	20	0	0	0	0	52.01	89.00	21120-3
Cobble/Boulder	30	0	1	0	0	48.17	88.00	21120-4
Gravel	0	1	0	0	0	55.01	90.00	21127-3
Gravel	-10	1	1	0	0	50.33	90.00	21127-4
Gravel	15	1	0	0	0	50.51	90.00	21128
Gravel	0	1	0	0	0	55.01	90.00	21129
Gravel	0	1	1	1	0	54.00	88.00	21130
Gravel	0	1	0	1	0	45.01	80.00	21147-3
Gravel	0	0	0	1	0	53.01	86.00	21147-4
Cobble/Boulder	-15	0	0	0	0	52.01	90.00	21153
Sand	0	0	0	0	0	57.01	90.00	22001-3
Sand	0	0	0	0	0	57.01	88.00	22001-4
Alluvium	40	0	0	0	0	45.01	90.00	22002-1
Alluvium	0	0	0	0	0	54.01	88.00	22002-2
Alluvium	30	0	0	0	0	50.01	90.00	22004
Alluvium	0	0	0	0	0	55.01	86.00	22005-1
Alluvium	0	0	0	0	0	53.01	86.00	22005-2
Alluvium	0	1	0	0	0	53.01	90.00	22008-3
Alluvium	30	1	0	0	0	48.01	90.00	22008-4
Alluvium	35	0	0	0	1	47.01	88.00	22009
Sand	0	0	1	0	0	47.66	90.00	22010
Sand	25	1	0	0	0	51.51	88.00	22011
Alluvium	-25	0	0	0	1	45.51	86.00	22014
Alluvium	-10	0	0	0	0	50.01	90.00	22015
Sand	0	0	0	0	1	56.01	86.00	22016
Alluvium	-55	0	0	0	1	46.01	86.00	22017
Sand	0	0	0	0	0	52.01	90.00	22018
Alluvium	0	0	0	0	0	51.01	90.00	22019
Alluvium	0	0	0	0	1	48.01	85.00	22020
Sand	15	1	0	0	0	49.51	90.00	22022
Sand	10	0	0	0	0	52.01	90.00	22025
Alluvium	0	0	0	1	0	52.01	86.00	22028
Alluvium	-10	0	0	0	0	52.01	90.00	22029
Sand	-25	0	0	0	0	48.51	90.00	22036-1
Sand	0	0	0	0	0	56.01	90.00	22036-2
Sand	0	0	0	0	0	54.01	90.00	22045
Sand	-40	0	0	1	1	50.01	81.00	23001
Alluvium	30	0	0	1	0	46.01	88.00	23002

Appendix: Selected channel-stability-assessment data, potential-scour ratings, and observed-scour ratings for State-maintained highway bridges over waterways in Maryland, 1990-91--Continued

[* = Branch of; N = north; S = south; E = east; W = west; NW = northwest; SE = southeast; B = business; Alt = alternate]

Bridge No.	County	Stream	Route	Bridge length (feet)	Type of bridge foundation	Physiographic province or division	Land use in reach	Tidal flow (0 = No 1 = Yes)
23004	Worcester	Pocomoke River	675	235	Pile	Coastal Plain East	Urban	1
23005-1	Worcester	Wagram Creek	US-13 N	82	Pile	Coastal Plain East	Forest	0
23005-2	Worcester	Wagram Creek	US-13 S	82	Pile	Coastal Plain East	Forest	0
23006-3	Worcester	Herring Creek	US-50 E	84	Pile	Coastal Plain East	Forest	1
23006-4	Worcester	Herring Creek	US-50 W	84	Pile	Coastal Plain East	Forest	1
23008	Worcester	Purnell Branch	394	66	Pile	Coastal Plain East	Forest	1
23010	Worcester	Pilchard Creek	US-113	20	Pile	Coastal Plain East	Forest	1
23011	Worcester	Tilghman Race	354	28	Pile	Coastal Plain East	Forest	1
23012	Worcester	Pattys Branch	365	43	Pile	Coastal Plain East	Forest	1
23013	Worcester	Buntings Branch	367	50	Pile	Coastal Plain East	Forest	1
23014	Worcester	Libertytown Branch	374	20	Spread footing	Coastal Plain East	Row Crop	1
23015	Worcester	Ayer Creek	376	66	Pile	Coastal Plain East	Forest	1
23016-1	Worcester	Pocomoke River	US-13 N	1,823	Unknown	Coastal Plain East	Urban	1
23016-2	Worcester	Pocomoke River	US-13 S	1,823	Unknown	Coastal Plain East	Urban	1
23017	Worcester	Pocomoke River	374	120	Pile	Coastal Plain East	Forest	1
23023-1	Worcester	Corkers Creek	US-113 N	32	Pile	Coastal Plain East	Forest	1
23023-2	Worcester	Corkers Creek	US-113 S	18	Spread footing	Coastal Plain East	Forest	1
23024	Worcester	Bachelors Branch	US-113	30	Pile	Coastal Plain East	Forest	1
23027	Worcester	Pilchard Creek	US-113	33	Pile	Coastal Plain East	Forest	1
23029	Worcester	Purnell Branch	US-113	69	Pile	Coastal Plain East	Forest	1

Type of bed material	High-flow angle of approach (degrees)	Channel bar present (0 = No 1 = Yes)	Debris blockage present (0 = No 1 = Yes)	Pier-footing exposure (0 = No 1 = Yes)	Abutment-footing exposure (0 = No 1 = Yes)	Potential-scour rating	Observed-scour rating	Bridge No.
Alluvium	-20	0	0	0	0	47.51	87.00	23004
Sand	-40	1	0	0	0	45.01	89.00	23005-1
Sand	-40	1	0	0	0	47.01	89.00	23005-2
Sand	-30	0	0	0	0	46.01	90.00	23006-3
Sand	0	0	0	0	0	55.01	90.00	23006-4
Sand	-30	0	0	0	0	46.01	88.00	23008
Sand	-20	0	0	0	1	49.51	86.00	23010
Sand	-10	0	0	0	1	52.01	86.00	23011
Sand	-15	0	0	0	0	47.51	88.00	23012
Sand	0	1	0	1	1	49.01	86.00	23013
Sand	0	0	0	0	0	52.01	90.00	23014
Alluvium	10	0	0	0	0	43.01	90.00	23015
Alluvium	25	0	0	1	0	44.51	76.00	23016-1
Alluvium	25	0	0	1	0	44.51	76.00	23016-2
Sand	0	0	1	0	0	55.33	90.00	23017
Sand	0	0	0	0	1	49.01	84.00	23023-1
Sand	0	0	0	0	1	52.01	86.00	23023-2
Sand	20	0	0	0	1	47.51	84.00	23024
Sand	-20	0	0	0	1	47.51	84.00	23027
Sand	25	0	0	0	0	46.51	89.00	23029