

Monitoring Scour Critical Bridges During Floods For Local Bridge Owners

Presented by



SAFETY FIRST

**DO NOT ENDANGER YOURSELF OR OTHERS
WHILE MONITORING BRIDGES**

DO NOT ENTER FLOOD WATERS

**FLOOD WATERS INCLUDE BOTH STANDING
AND FLOWING WATER**

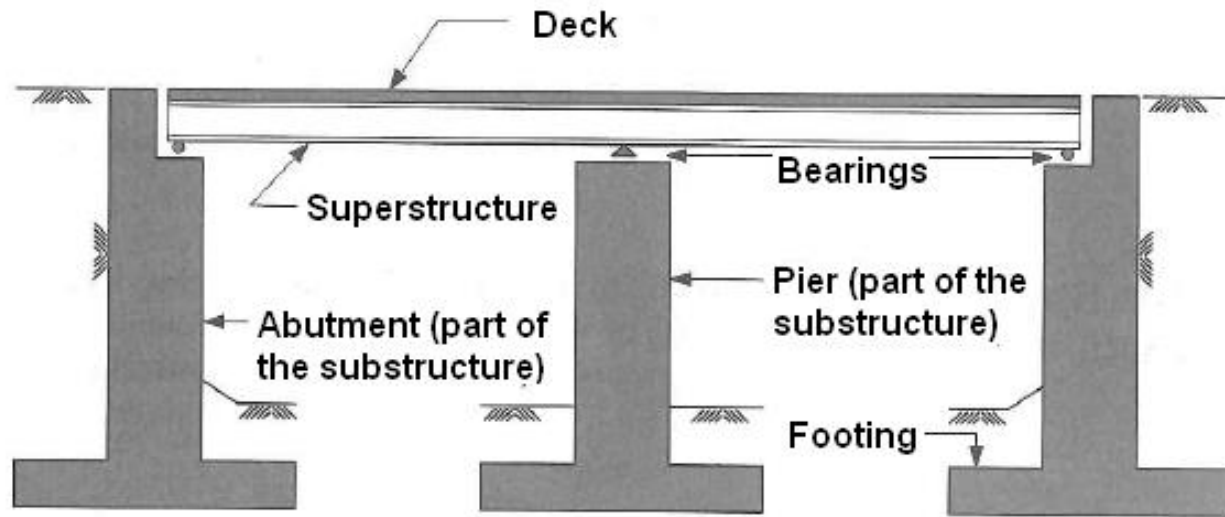
Topics

- Safety First
- What are the Parts of a Bridge?
- What is Scour?
- Scour – Minor, Advanced and Serious
- What is a Scour Critical Bridge?
- What are the Scour Critical Categories?
- Why is Monitoring Necessary?
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Topics

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What are the Parts of a Bridge?



Deck = the part of a bridge that provides a surface for cars and pedestrians.

Superstructure = the part of a bridge that supports traffic and transfers load to the bridge substructure below. Superstructure includes the beams or girders, railings, sidewalks, and bearings.

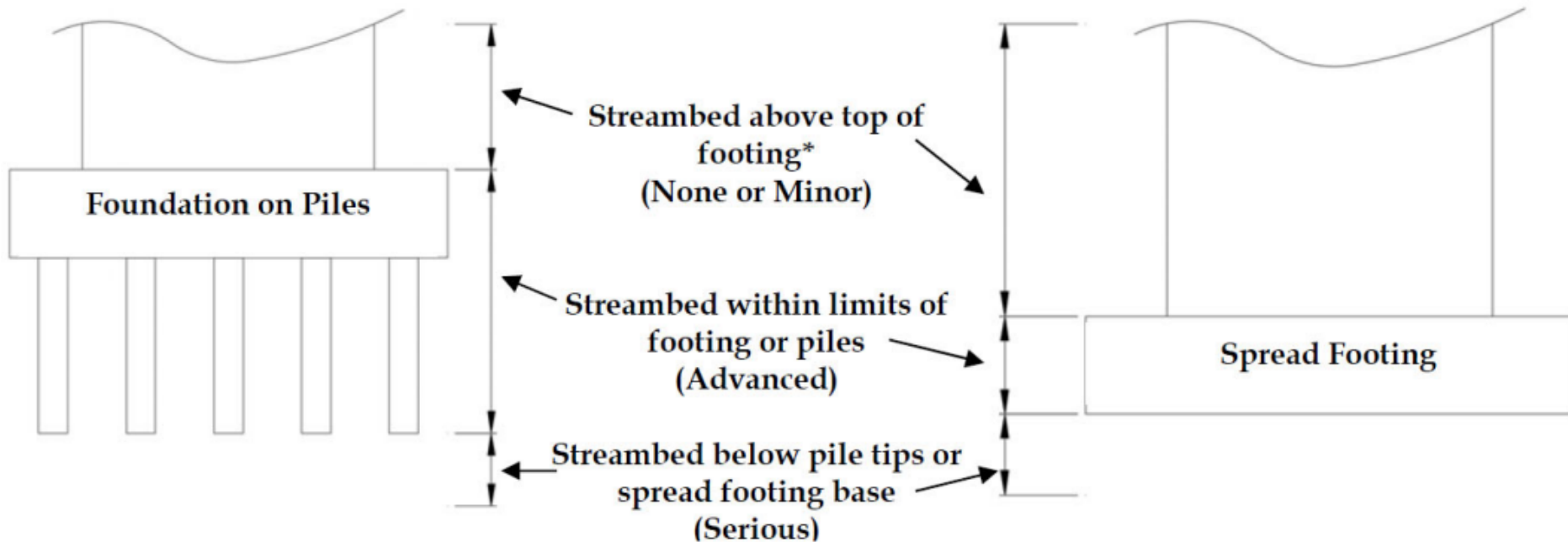
Substructure = the part of a bridge that supports the superstructure and transfers load to the bridge foundation. Substructure includes the abutments, piers, wingwalls, and footings.

Picture Source: FHWA NHI 03-001 Bridge Inspector's Reference Manual

What is Scour?

- Scour is streambed erosion caused by flowing water.
- Scour caused by floodwaters can remove large amounts of foundation material from under the footings of a bridge.
- Scour can make the bridge unstable and dangerous for people to cross.

Scour – Minor, Advanced and Serious



What is a Scour Critical Bridge?

- A scour critical bridge is at risk of becoming unstable at its footings if scour becomes serious during a flood.
- A scour critical bridge requires a written scour plan of action which includes monitoring when triggered by flooding events.

What is a Scour Critical Bridge?

- Many bridges are not scour critical and therefore are not categorized.
- **Bridges which are not categorized do NOT need to be monitored during floods.**
- However, nearly all bridges which cross waterways have some vulnerability to scour damage or washout caused by flood waters.

What are the Scour Critical Categories?

- **Category A** = Serious scour and undermining has occurred; any additional scour could cause the bridge to become unstable
- Footing is at high risk of becoming unstable due to potential for scour
- Presents significant safety hazard under high water conditions

What are the Scour Critical Categories?

- **Category B** = Advanced scour has occurred; moderate amounts of new scour could cause the bridge to become unstable
- Footing at moderate risk of becoming unstable due to potential for scour
- Presents moderate safety hazard under high water conditions

What are the Scour Critical Categories?

- **Category C** = Minor scour has occurred; significant amounts of new scour could cause the bridge to become unstable
- Footing at lower risk of becoming unstable due to potential for scour
- Presents lower safety hazard under high water conditions

Why is Monitoring Necessary?

- For public safety
- Required by federal statute
 - Code of Federal Regulations; Chapter 23 Highways – Section 650.313(3)(3); 2005 National Bridge Inspection Standards (NBIS)
 - “Bridges that are scour critical. Prepare a plan of action to monitor known and potential deficiencies and to address critical findings. **Monitor bridges that are scour critical in accordance with the plan.**”
- The NBIS applies to bridges greater than 20 feet in span length

What is “Monitoring” a Bridge?

- During flood events, visit and observe scour critical bridges to ensure that they remain structurally safe.
- This process is called a monitoring visit and it helps ensure the safety of the traveling public.
- A bridge monitoring log is used to record each monitoring visit.
- The monitoring log for each scour critical bridge is available for download from PennDOT’s Local Scour Critical Bridge Website.

What is “Monitoring” a Bridge?

- In addition to recording monitoring activities, the log helps the bridge owner decide whether the bridge should remain open or should be closed.
- At each monitoring visit, observe specific aspects of the condition of the bridge and its surroundings and record findings on a scour critical bridge monitoring log.
- Bridge closure depends on the conditions observed at the bridge, approach roadway and waterway channel.

What is “Monitoring” a Bridge?

Flood Conditions to Observe Record and Respond

- Bridge
 - Pressure flow
 - Water overtopping the bridge
 - Alignment, settlement or tilt damage
- Approach Roadway
 - Settlement damage
 - Embankment erosion damage
- Waterway Channel
 - Significant Debris Build-up

What is “Monitoring” a Bridge?

- Use the monitoring log to record visible distress by circling either Yes (Y) or No (N) to identify whether conditions for closure exist at the bridge.
- Bridge closure should be strongly considered whenever a Y is circled on the monitoring log.
- Detailed descriptions of bridge closure conditions and the bridge closure plan are provided on the front of the monitoring log.
- Photographs of bridge closure conditions are at the end of this presentation

SCOUR CRITICAL BRIDGE - PLAN OF ACTION



1. General Information					
Structure ID Number (5A01): 01019401400000		District, County, Place (5A04):(5A05):(5A06): 08; 01 - Adams; 01/221 - UNION		Inspection Date (7A01): 11/17/2020	
BRKEY (5A03): 124		Length (5B18): 70	Facility Carried (5A08): PA 194; SR 0194	Feature Intersected (5A07): SOUTH BR OF CONEWAGO	
Year Built (5A15): 1956	Year Rebuilt (5A16): 0		Structure Type (6A26-29): 21103 RC T BEAM		
Number of Spans: Appr (5B14): 0		Main (5B11): 2	5A10 Lat: 39.765453	5A11 Long: 77.026847	
Bridge ADT (5C10): 12,095	Bridge ADTT (6C27): 899	ADT Year (5C11): 2021	BPN (6A19): 3 - Non-NHS/ADT > 2000		
Substructure (1A02): 5		Channel (1A05): 5	Waterway Adequacy (1A06): 8		

2. Scour Information						
SCBI (4A08): 3		Source of SCBI Code (IU03): 0		Minimum Obs. Scour Rating (IN03): 4		SCBI Category: B
7A01 Inspection Date	5D02 Structure Unit	IN13 Foundation Type	IN03 Observed Scour Rating	IU27 SCBI CODE	IN18 Water Depth	IN24 Underwater Inspection Notes:
11/17/2020	FAB	P - Researched/unknown	4	3	0.6	Ponded water is along stem to 2' deep - 2' + - of soft silty material is under the water - no footing was detected this inspection.
11/17/2020	P01	P - Researched/unknown	4	3	0.6	Rock placed @ right nose - footing not detected - minor scour beyond rock - ponded water on far side of pier
11/17/2020	NAB	P - Researched/unknown	4	3	0.8	Rock has been placed along the entire footing and wing areas - no footings are visible or probable. In front of the placed rock the water depth is to 2'-6'.

3. Monitoring Program (During Event)

Monitor Category B bridges at a minimum of twelve (12) hour intervals. Bridge Watch and Scour Critical Bridge Maps may be used as a means for locating these bridges.

The Scour POA for Category B bridges includes a need for monitoring these bridges in flooded areas whenever possible, especially those bridges located on the Interstates and the National Highway System (NHS). The recommended frequency for monitoring is once every 12 hours. Note that a minimum of 2 visits are required and monitoring is no longer needed after the bridge is closed. Monitoring of a bridge may be discontinued when the water level is at least two feet below the bridge load carrying members and after it has been clearly observed that the flood waters are receding, i.e., at the time of the visit to the bridge, the water level is now lower than that observed at the previous visit.

Local owned bridges: The local owner is responsible for flood monitoring and shall coordinate with PennDOT's local bridge coordinator to determine the bridges requiring monitoring.

Note: Bridge deck above roadway approaches; slight chance of overtopping roadway approaches

4. Post-Flood (After Event)

A post-flood damage inspection is to be performed after each significant flood event that is experienced in the watershed where this bridge is located. As a guide, the 50 year recurrence interval storm event may be used as a trigger for the need for inspection. If the bridge has been closed due to overtopping of the approach roadway or bridge, or due to pressure flow, then the bridge must be inspected for scour damage before being re-opened to traffic.

Local bridge owners shall coordinate with PennDOT's local bridge coordinator to coordinate the post-flood inspection effort.



Scour Critical Bridge Monitoring Log

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File Scour Critical Bridge monitoring logs with other bridge inspection records at the municipality

Monitoring logs are subject to review by the Federal Highway Administration (FHWA)

Struct ID: 02711333172722

02/113 - PENN HILLS

Date: ___ / ___ / ___

BRKEY: 2179

PLUM CREEK UPPER BRANCH

UNIVERSAL RD

			Bridge		Roadway		Channel
Monitoring Personnel	Time	AM or PM	Pressure Flow	Alignment / Settlement / Tilt	Settlement	Embankment Erosion	Debris Buildup
		A / P	Y / N	Y / N	Y / N	Y / N	Y / N
Remarks:							
		A / P	Y / N	Y / N	Y / N	Y / N	Y / N
Remarks:							
		A / P	Y / N	Y / N	Y / N	Y / N	Y / N
Remarks:							

Who can Monitor Bridges?

- **You do NOT need to be an engineer or bridge inspector in order to monitor scour critical bridges.**
- PennDOT uses road maintenance crews to monitor scour critical bridges on state highways.
- Familiarization with these scour monitoring procedures should be completed prior to flood events.

Who can Monitor Bridges?

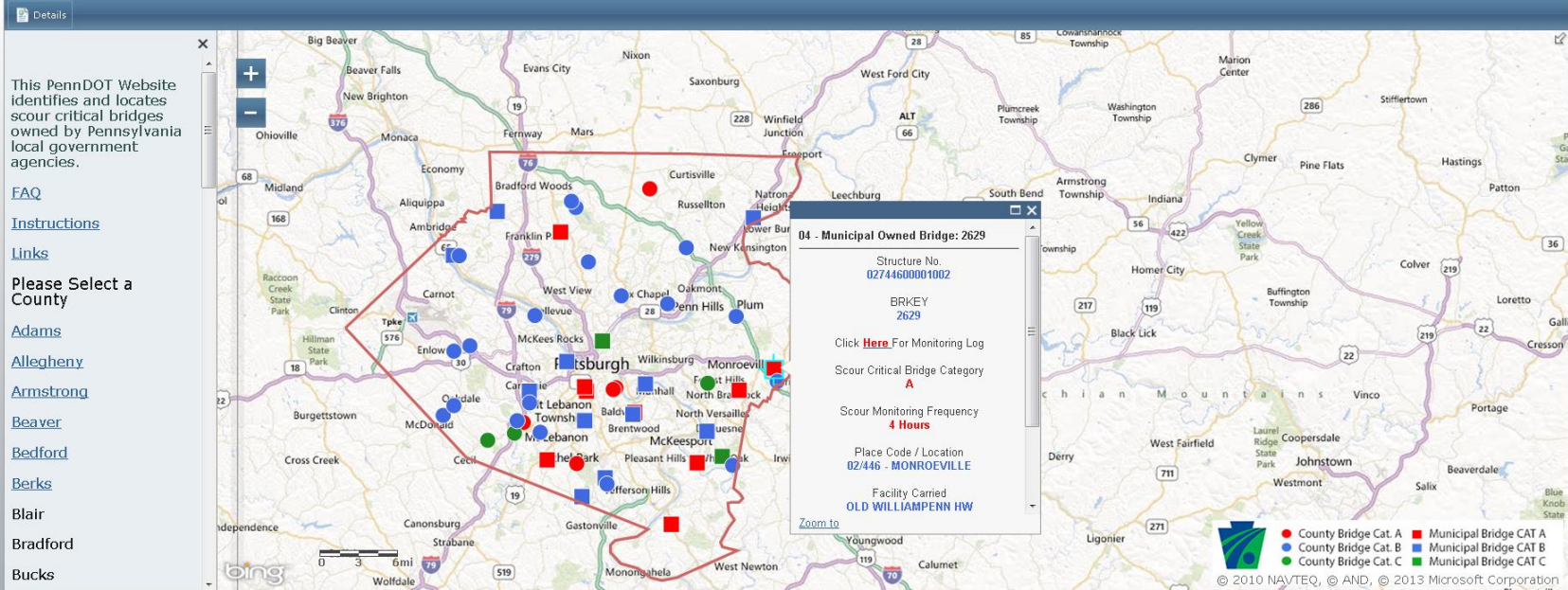
Municipal employees and local volunteers can monitor scour critical bridges including:

- Road masters
- Road crews
- Emergency management personnel
- Fire police

Monitoring personnel for locally-owned bridges will vary depending upon each local government organization.

Local Scour Critical Bridges Map

Allegheny County Local Scour Critical Bridges



Local Scour Critical Bridges Map

Online Scour Critical Bridges Map

- Choose your county from the list on the left pane.
- Click on a bridge (marker is red, blue, or green based on its scour category) to get a pop-up box with information about the bridge.
- Click on the hyperlink: “Click **Here** For Monitoring Log” in the pop-up box to download/print a scour critical bridge monitoring log
- Complete the monitoring log at each visit during flood events. The log serves as a record and must be kept on file.

Monitoring Priority and Frequency

Category A

- Monitor once flooding begins
- Required monitoring frequency is at least once every 4 hours.
 - If a Category A bridge experiences pressure flow or debris build-up but must remain open, then the bridge must be monitored continuously until flood waters recede and then inspected by qualified personnel.
- Record monitoring visits on Scour Critical Bridge Monitoring Log.

Monitoring Priority and Frequency

Category B

- Monitor as resources allow once flooding begins.
- If necessary, provide higher priority for monitoring activities on Category A bridges.
- Required monitoring frequency is at least once every 12 hours.
 - If a Category B bridge experiences pressure flow or debris build-up but must remain open, then the bridge must be monitored continuously until flood waters recede and then inspected by qualified personnel.
- Record monitoring visits on Scour Critical Bridge Monitoring Log.

Monitoring Priority and Frequency

Category C

- Monitor as resources allow once flooding begins.
- If necessary, provide higher priority for monitoring activities on Category A & B bridges.
- Required monitoring frequency is at least once every 24 hours.
 - If a Category C bridge experiences pressure flow or debris build-up but must remain open, then the bridge must be monitored continuously until flood waters recede and then inspected by qualified personnel.
- Record monitoring visits on Scour Critical Bridge Monitoring Log.

Flood Alert Definitions

The National Weather Service Flood Alerts

- **Flood Warning:** informs the public that high flow or overflow along larger streams in which there is a serious threat to life or property is in progress, imminent, or highly likely
- **Flood Watch:** informs the public that there is a threat of flooding, but the occurrence is neither certain nor imminent
- **Flood Advisory:** highlights conditions that are less serious than a watch

Flood Alert Definitions

The National Weather Service Flash Flood Alerts

- **Flash Flood Warning:** informs the public that a rapid and extreme water level rise in streams due to intense rainfall is in progress, imminent, or highly likely
- **Flash Flood Watch:** conditions are favorable for a rapid and extreme water level rise in streams due to intense rainfall, but the occurrence is neither certain nor imminent


Flood Alert Information Websites

National Weather Service Website

- <http://alerts.weather.gov/cap/pa.php?x=1> to see a listing of statewide alerts.
- <http://alerts.weather.gov/cap/pa.php?x=3> to select a specific county within Pennsylvania and click on the desired link.

Flood Alert Information Websites

PennDOT Website

- <http://www.dot.state.pa.us/>
- Then click on the  link from the home page
- Then click on the Travel Conditions link in the upper left and select Weather Alerts on the pull down menu
- Then select a county to view

Flood Alert Information Websites

Commonwealth of Pennsylvania Alert System

- Provides direct weather updates
- The updates are sent by either e-mail or cell phone via text/SMS messages.
- These updates can be received by visiting the AlertPA's website at:
<https://public.coderedweb.com/CNE/en-US/BF5CCF5B2AB3> and registering as a new user.
- After registering the user has full control over what alerts to receive and where to receive them.

Flood Alert Information Websites

The National Weather Service's Advanced Hydrologic Prediction Service

- Provides river observations and river forecasts of a number of rivers and other waterways at:
<http://water.weather.gov/ahps2/index.php?wfo=ctp>
- Click on the desired river or waterway icon
- The river flood and action stages will be shown

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Before a Flood

- Identify individuals who will monitor bridges.
- Individuals responsible to monitor bridges need to review this presentation prior to monitoring bridges.
- Identify bridges within the municipality or county which are scour critical and require monitoring.
- PennDOT's website and bridges are updated monthly.

Before a Flood

- Download and print monitoring logs at:
<http://padotgis.maps.arcgis.com/apps/OnePane/basicviewer/index.html?appid=62ad3e7559684662a8c965281ea686ca>
- Determine bridge closure methods.
- Pre-plan bridge monitoring assignments and a plan to communicate bridge closures that occur during flooding events.

During a Flood

- When stream water levels rise significantly, begin monitoring visits for Category A bridges.
- A **Flood Warning** issued by the National Weather Service should trigger bridge monitoring (flood warnings are often preceded by flood advisories or flood watches)
- As flood conditions worsen, or continue over a long period of time, then begin monitoring Category B and Category C bridges.

During a Flood

- Monitor Category A, B, and C bridges for signs of distress or damage and record observations on scour critical bridge flood monitoring log
- Continue to make monitoring visits while water level is rising.
- Monitor bridges a minimum of two times. This is necessary to determine if the water level is rising or receding.
- Once it is confirmed that the water level is receding, then monitoring may be discontinued.

During a Flood

- Close the bridge if necessary for public safety. Follow the directions on the scour critical bridge flood monitoring log to find out if conditions at the bridge make this step necessary.
 - Bridge
 - Pressure flow
 - Water overtopping the bridge
 - Alignment, settlement or tilt distress/damage
 - Approach Roadway
 - Settlement distress/damage
 - Embankment erosion distress/damage
 - Waterway Channel
 - Significant debris build-up

Closing a Bridge

- In order to re-route emergency response vehicles after a bridge has been closed, immediately notify appropriate law enforcement, local emergency responders, and county emergency communications center using a non-emergency phone number or pre-established alternate communications.
- Avoid directly calling 911 unless there is an actual emergency.
- Notify PennDOT Municipal Services or PennDOT bridge inspection personnel of bridge closures whenever possible.



This is a photograph of **pressure flow**. The water is flowing against the bridge superstructure. Water levels may continue to rise and flow over the bridge; this is called “overtopping”.



This top photograph shows **settlement** distress in the roadway due to **tilt** damage of the abutment.

This bottom photograph shows the **tilt** damage of the abutment on the left-hand side causing the **settlement** distress of the roadway in the top photograph.





This top photograph shows **settlement** damage in the abutment due to scour taking away the earth underneath the abutment.

This bottom photograph shows the same **settlement** damage, and its effect of distress on the roadway above the bridge.





This is a photograph of extreme **settlement** damage in the abutment on the left-hand side of the photo.



This is a photograph of **settlement** damage in the stone masonry pier and some collapsing in the arch.



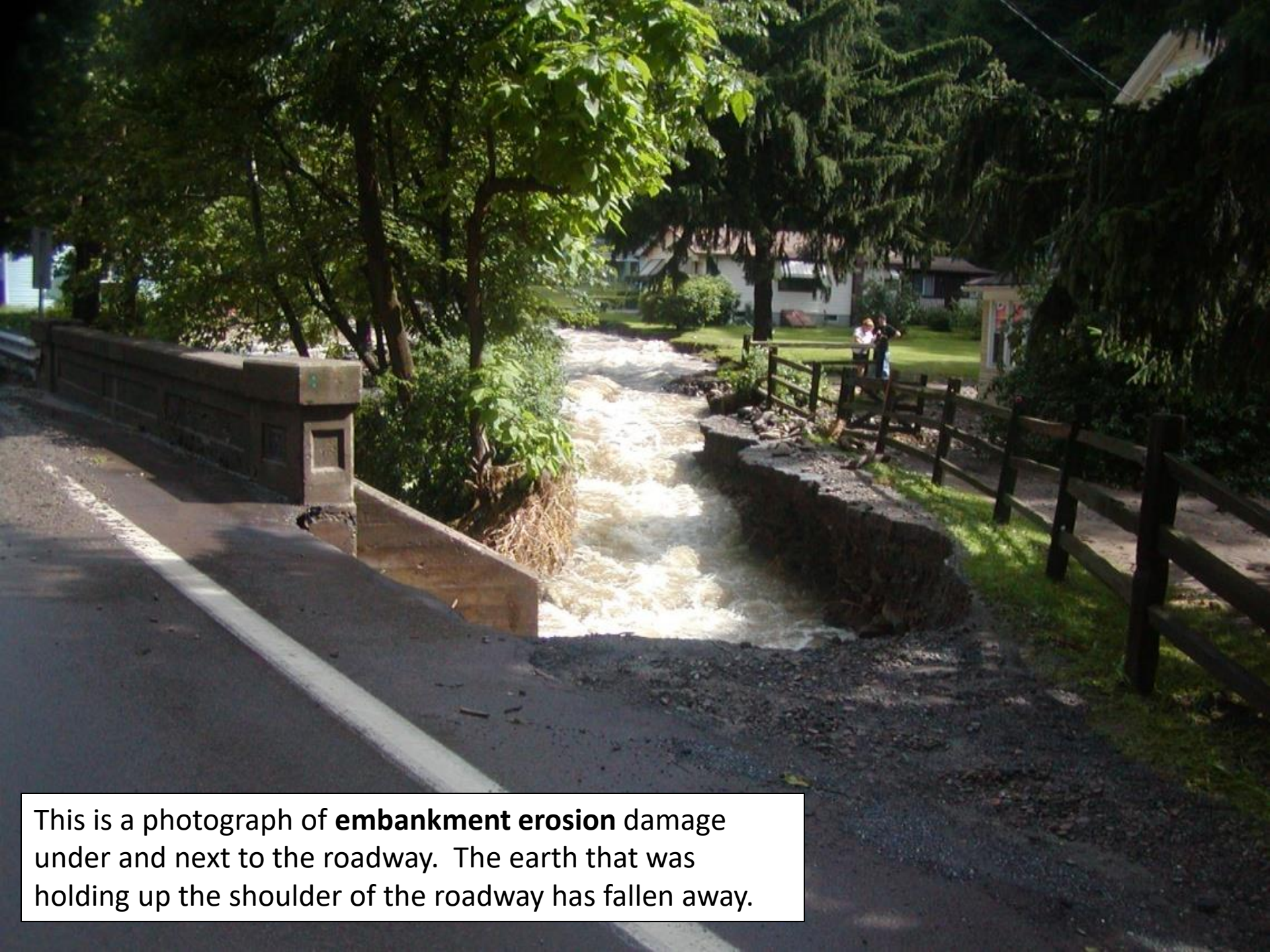
This is a photograph of **settlement** damage in the approach fill behind the abutments, viewed from the roadway above the bridge.



This is a photograph of extreme **settlement** damage in the roadway, causing a hole in the roadway behind the bridge abutments.



This is a photograph of **embankment erosion** damage. The shoulder of the roadway has fallen away and part of the masonry bridge has collapsed into the stream channel.



This is a photograph of **embankment erosion** damage under and next to the roadway. The earth that was holding up the shoulder of the roadway has fallen away.



This is a photograph of severe **debris buildup**, in this case a pile of tree branches, caught against the bridge that is blocking more than 25% of the span opening.

After a Flood

- Completed monitoring logs for each bridge that was monitored are to be placed in the bridge file maintained by the owner.
- These records may be subject to audit at a later date as required by FHWA.
- Bridges that are closed must receive a post-flood damage inspection performed by a qualified bridge safety inspector and a professional engineer approves that the bridge is safe for traffic.

After a Flood

- **All Category A, B and C bridges that have been closed from pressure flow, overtopping, debris build-up or from damage must be inspected PRIOR to re-opening. Category D bridges must also be inspected for damage after closure; however, the inspection can occur after the bridge is re-opened to traffic.**
- **All flood-damaged bridges (including settlement, tilt, misalignment, erosion or bridge washout) MUST REMAIN closed until inspected.**

After a Flood

- Depending on the severity of the storm, some or all Category A, B, C, or D bridges may require a post-flood damage inspection after water recedes to normal levels even if the bridge was not closed; this may include bridges that were not closed during monitoring.
- This determination will be made by PennDOT. PennDOT bridge personnel will notify local bridge inspection engineers.

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