NCHRP

Web-Only Document 148:

Debris Photographic Archive and Supplemental Materials for *NCHRP Report 653*

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Appendices to Contractor's Final Report for NCHRP Project 24-26
Submitted September 2009

National Cooperative Highway Research Program
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

ACKNOWLEDGMENT

This work was sponsored by the American Association of State Highway and Transportation Officials (AASHTO), in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program (NCHRP), which is administered by the Transportation Research Board (TRB) of the National Academies.

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www.national-academies.org

Contents

This document contains Appendices A through C from the contractor's final report on NCHRP Project 24-26. The main body of the final report, including Appendix D, has been published as *NCHRP Report 653: Effects of Debris on Bridge Pier Scour* and can be read or purchased at the TRB website (www.trb.org).

APPENDIX A

Debris Photographic Archive

To access the debris photographic archive, go to the TRB website (www.trb.org), select Projects from the navigation banner and Find a Project from the pulldown menu, select NCHRP from the Program pulldown menu and type “24-26” for the Project Number, then click submit. There will be a link to an ISO image that will allow you to burn a copy of the archive to a CD for your use.

The debris photo archive is organized by State and then subdivided by Stream in both the file folders and the accompanying directory. As an introduction to the photo archive, four example sites have been selected and are described below. To follow along with the examples, open the folder named Debris at Bridges Photo Archive, navigate to the designated State and then to the given Stream. In the folder for the given Stream you will find a PowerPoint™ and other various media files. If the media files are photographs, they are also contained within the PowerPoint™ file. Additional detailed the information regarding the examples can be found in the Excel™ file called *DebrisPhotoArchive.xls*. Open the file and then using the tabs at the bottom of the workbook navigate to the "Examples" tab.

These four examples are intended not only to provide an entrée for the user into the debris photo archive, but also to illustrate how additional relevant data can be obtained for any site(s) of interest. By following the examples the user will find links to the National Bridge Inventory (NBI), Google Earth™, and Terraserver. The NBI provides data on the location of the bridge its structural and hydraulic characteristics and condition, and a wealth of additional information on the crossing, waterway, scour status, and countermeasures. Google Earth™ and Terraserver provide access to watershed and hydraulic characteristics, and Terraserver offers access to both current and historic aerial photography. The examples also make use of the DOT's or bridge owner's bridge files as an additional source of relevant data. Thus, a user can readily develop an extensive data base on any site in the archive.

Arroyo Grande Creek, California

Photographs of US Highway 101 over the Arroyo Grande Creek in the Central and South Coast Region of California were submitted by Kevin Flora of Caltrans. Using the location, structure number and stream name provided by Caltrans, the bridge was found in the NBI and the inventory route, latitude, longitude, year built, structure length, maximum span length, number of spans in main unit, skew angle, channel protection and water way adequacy rating, waterway inspection requirement, and scour critical and substructure ratings were obtained.

In the "Arroyo Grande, CA" folder in the Debris Photo Archive there are eleven photos. These same eleven photos are in the PowerPoint file "Flora-CalTrans-ArroyoGrandeCk.ppt." The first several photographs show a triangular/conical shaped debris mass at multiple piers. Additional photographs in the folder show debris clean up efforts, various views of the debris mass, and scour and undermining at one of the bents. See the bottom left corner of the PowerPoint slides for notes provided by Caltrans.

Pack River, Idaho

State Highway 200 over the Pack River is a steel girder bridge located in Bonner County, Idaho. Ayres Associates staff were on site for a field visit during a time of high flow. During this site visit, videos were taken from two viewpoints and are included in the "Pack River, ID" folder. In the videos, floating debris is seen flowing along the thalweg of the river, through the bridge section, and on occasion colliding with a pier skewed approximately 30-60 degrees to the flow.

Additional information, such as scour ratings and bridge details is included in the accompanying Excel™ spreadsheet. If a user were interested in gathering further information about this site, for example understanding more about the watershed contributing debris to the flow, a program such as Google Earth™, or similar, could be consulted. **Figures A.1 and A.2** show images obtained by entering the latitude and longitude for S.H. 200 over the Pack River, found in the accompanying Excel™ spreadsheet into the program. When aerial images are examined, a user is able to see that upstream of the bridge the channel is highly meandering, unstable and subject to frequent cutoffs.

Figure A.1. Aerial view of State Highway 200 over the Pack River.

Figure A.2. Aerial view of State Highway 200 over the Pack River.

Chariton River, Missouri

Photos of State Route 129 over the Chariton River were provided by John Holmes of Missouri Department of Transportation (MODOT). The bridge was built in 1949 and has been subject to debris problems for many years. Included in the archive are views of the bridge from upstream and downstream, the channel from upstream and downstream and the abutments. Of particular interest though are the historical pictures from 1976 and 1999 of debris rafts caught on a pier. The debris rafts tend to be triangular in shape and comprised of mostly small brush and branches with a few larger logs.

Further information about this site was gathered from the NBI and input into the accompanying spreadsheet. A user could compile more information by collecting aerial photographs from varying years and compare differences. Aerial photographs are available from numerous sources. **Figures A.3** and **A.4** show aerial imagery from 1995 collected from TerraServer-USA.NET Web Service and a 2005 image collected from Google Earth™. Observable in Figures A.3 and A.4 are changes in forest cover, represented by the dark areas, especially on the meandering tributary on the right of the picture. This tributary joins the Chariton River just upstream of the State Route 129 Bridge.

Figure A.3. Aerial view of State Highway 129 over the Chariton River taken in 1995.

Figure A.4. Aerial view of State Highway 129 over the Chariton River taken in 2005.

San Antonio River, Texas

Photographs of the San Antonio River over County Road 117 were provided by Jon Kilgore of Texas Department of Transportation (TXDOT). Shown in the pictures is a small bridge with a significant amount of woody vegetation that leans into the channel on the stream banks. The bridge opening had caught a significant amount of debris that spans the entire channel (**Figure A.5**). Unique to this photo set is the visible evidence of damage caused to the structure, potentially from debris. Delaminating of the concrete and spalling can be seen underneath the upstream side of the bridge, see **Figure A.6**.

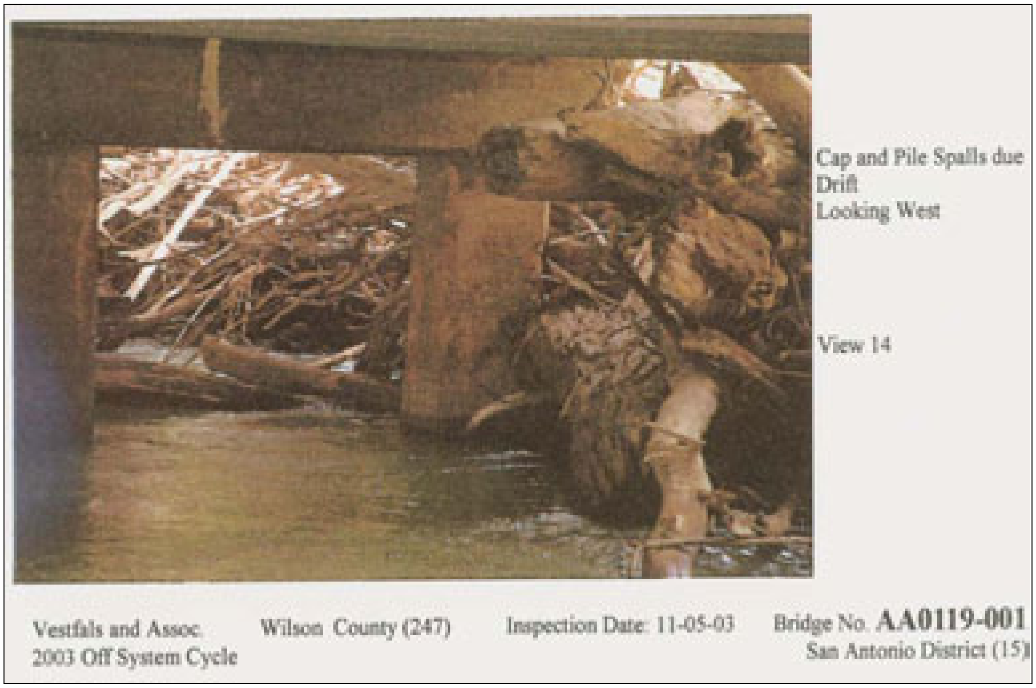


Figure A.5. Photo shows debris build up and spalls looking West on the Wilson County CR 117 Bridge.

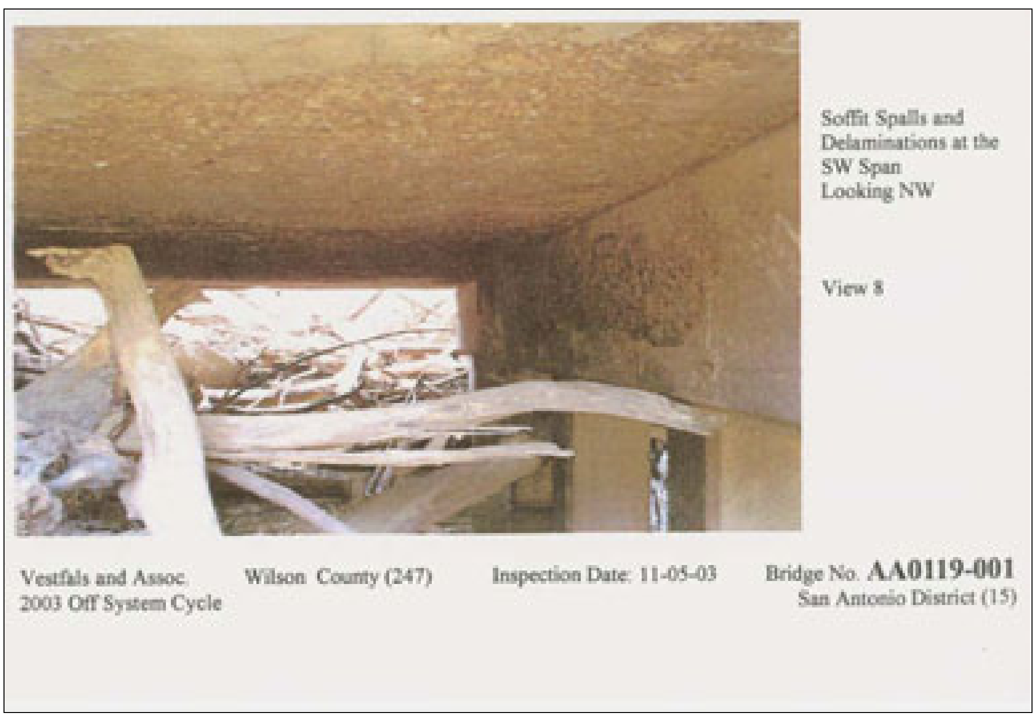


Figure A.6. Photo shows soffit spalls and delaminating at the SW span looking NW on the Wilson County CR 117 Bridge.

APPENDIX B

Survey of Practitioners

Instructions for Viewing NCHRP 24-26 Questionnaire Responses Databases

To access the database, go to the TRB website (www.trb.org), select Projects from the navigation banner and Find a Project from the pulldown menu, select NCHRP from the Program pulldown menu and type "24-26" for the Project Number, then click submit. There will be a link to an ISO image that will allow you to burn a copy of the archive to a CD for your use.

To view the database you must have Microsoft Access installed on your computer (see below for an alternative to Microsoft Access).

- Place CD in drive and open CD drive file system using Explorer to view CD contents

- Double click on the file NCHRP 24-26/Access icon.

- A box will appear stating the database is read-only. Click OK in the box to gain access to the database.

A switchboard screen will appear allowing the user to easily navigate between common actions within the database. Though the user has the ability to enter all objects within the database, i.e., tables, forms, queries and reports, the best way to view survey data is through the forms. Forms show each record in an easily readable format with all information associated with that record visible or available in one workbook. The form is also used for data entry purposes. The form makes viewing the data relatively easy whereas the tables can be difficult to view and follow.

- To open the form containing results from the survey using the switchboard click on the Edit Existing Survey button from the list of options in the switchboard window.

- To open a background object click on the specific object you'd like to view from the list of objects along the left hand side of the database window. Then click the open button on the left hand side immediately above the Objects list. The object you've selected will now open for viewing.

A table serves primarily as the 'storage container' for the data. A table shows the data in its entirety. Each line of the table is an individual record. The columns of a table are the fields of information associated with each record. As previously mentioned, the best way to view the data is by using the form object.

Navigating within a form:

- To move from record to record either scroll your mouse wheel or click on the arrows located at the lower left hand corner of the screen.

- To move up or down on a page use the arrows or the location bar along the right hand side of the window.

- To move from side-to-side on a page, use the arrows or location bar along the bottom right hand side of the window.

Specific instructions for the NCHRP Project 24-26 Questionnaire form are:

- The form appears very much like the questionnaire that was distributed.

- After opening the form, maximize it within the Access window and move the position bar on the right side of the window to the top – this will allow the tabs to appear that allow you to move between the Questionnaire sections.

- To view a specific part of the questionnaire – select the appropriate tab below the questionnaire heading.

- Often the answer to a question exceeds the visible space of the answer box on the screen. To view the entire answer, use the right and left arrows on your keyboard.

No special procedure is required to close either the form or table object; simply click on the x in the upper right hand corner – no save is necessary.

National Cooperative Highway Research Program

NCHRP Project 24-26

Debris Accumulation at Bridges and its Effect on Scour

Contact Information:

Your name: ____

Your agency: ____

Address: ____

____

____

Phone: ____

Fax: ____

Email: ____

This questionnaire is NOT designed for interactive email reply. Please respond before February 18, 2005, using one of the following methods:

1. **Print out questionnaire, fill out by hand, and fax or mail to the address below.**
2. **Save questionnaire to a file, fill out responses and email as an attachment.**

Please return completed questionnaire to:

Mr. Paul E. Clopper, PE
Co-Principal Investigator, NCHRP Project 24-26
Ayres Associates Inc
3665 JFK Parkway, Bldg. 2, Suite 200
Fort Collins, Colorado 80525

Phone: (970) 223-5556
Fax: (970) 223-5578
Email: clopperp@AyresAssociates.com

Please check here if you do not have the time to fully complete the enclosed questionnaire, but would like to receive a call from the research team to discuss any items further. Thank you.

<u>Problem Statement</u>:

Drift (floating debris) often collects at bridges. Usually, drift accumulation is a result of a flood or storm event; however, drift accumulation can be a more gradual process that results from natural watershed and river processes.

The result of drift accumulation at or near bridges typically reduces waterway flow capacity, increases lateral forces on bridge structural elements, and increases the potential for scour at piers, abutments, and approach embankments.

The objectives of NCHRP Project 24-26 are to develop (a) guidelines for predicting the size and geometry of debris accumulations at bridge piers and (b) methods for quantifying scour at bridge piers resulting from debris accumulation. The research team requests your input in answering the following questions regarding your experience and insight with respect to debris accumulation at bridges.

<u>Note</u>: Where a numerical score is requested, please provide a rating from 5 (severe or chronic problem) to 0 (no problem). ***The same numerical score may be applied to any or all items listed under each topical heading. If your state has more than one distinct physiographic region, please fill out one questionnaire for each region.***

> ***Describe the physiographic region corresponding to your response (e.g., Piedmont, Coastal Plain, Central Valley, High Plains, Mountain, etc.):***
>
> ____

1. <u>SOURCE AREAS THAT PRODUCE DRIFT AND DEBRIS</u>:

This topic involves identifying the potential source areas that can produce debris problems at bridges in your region.

Please rate the following items: (**5** = Severe); (**4** = Moderate to severe); (**3** = Moderate); (**2** = Low to moderate); (**1**= Low); (**0** = Not a problem / not applicable).

<u>Source Areas That Produce Debris</u>	**<u>Score Each Item</u> (0 to 5)**
a. Unstable banks of streams and rivers	____________
b. Landslides in the watershed and tributaries	____________
c. Watershed land use and management	____________
d. Other (describe): ____________________	____________

2. BRIDGE CHARACTERISTICS:

This section develops information on the type of bridge structural elements that typically exhibit the most problems with debris accumulations in your region.

Please rate the following items in terms of how common it is for debris to accumulate on the various structural elements listed: (**5** = Very common); (**4** = Common); (**3** = Moderate); (**2** = Uncommon); (**1**= Rare); (**0** = Never / not applicable).

Bridge Structural Element	Score Each Item (0 to 5)
a. Drilled shaft piers	____________________
b. Pile bents	____________________
c. Pile bent with cross bracing	____________________
d. Pile cap / pile group	____________________
e. Wall-type pier	____________________
f. Pier skewed to flow direction	____________________
g. Other (describe): ____________________	____________________

3. DEBRIS ACCUMULATION:

This topic has to do with the physical characteristics of debris accumulation on bridge structural elements.

Please rate the following items: (**5** = Severe); (**4** = Moderate to severe); (**3** = Moderate); (**2** = Low to moderate); (**1**= Low); (**0** = Not a problem / not applicable).

Typical or "Chronic" Types of Debris Accumulation	Score Each Item (0 to 5)
a. Accumulation of debris "cluster" at a single pier	__________________
b. Accumulation of debris "raft" that spans two or more piers	__________________
c. Accumulation of debris on superstructure (deck/railing)	__________________
d. Accumulation that spans from pier to bank (or abutment)	__________________
e. Submerged debris	__________________
f. Floating debris	__________________
g. Other (describe): ____________________	__________________

4. **SCOUR AT BRIDGES:**

This topic asks you to provide your opinion regarding the specific effects of debris accumulation that results in erosion and scour at bridges in your region:

Please rate the following items: (**5** = Severe); (**4** = Moderate to severe); (**3** = Moderate); (**2** = Low to moderate); (**1**= Low); (**0** = Not a problem / not applicable).

Typical Location of Debris-Induced Scour	Score Each Item (0 to 5)
a. Local scour at one or more piers	______________
b. Local scour at abutment(s)	______________
c. Contraction scour caused by waterway constriction	______________
d. Overtopping of approach embankments due to flow blockage	______________
e. Flow redirection creates general streambank instability	______________
f. Other (describe): ________________	______________

5. **MAINTENANCE:**

This topic seeks information regarding the typical cost spent in your state on maintenance activities related to clearing debris accumulations, or repairing damage to bridges caused by debris.

Please estimate the percentage of your total annual highway maintenance budget spent on the following activities:

Maintenance or Repair Activity	Percent of Budget
a. Clearing debris accumulations from bridges	________________
b. Repairing damage caused by debris	________________
c. Other (describe): ________________	________________

6. <u>DEBRIS CHARACTERISTICS</u>:

This section develops information on the type and nature of debris that forms accumulations at bridges in your region.

Please rate the following items: (**5** = Very common); (**4** = Common); (**3** = Moderate); (**2** = Uncommon); (**1**= Rare); (**0** = Never / not applicable).

Note: The term "key log" refers to that element of the debris that would typically initiate the process of further debris accumulation.

Description of Debris	**Score Each Item (0 to 5)**
a. Key log less than 25 feet in length	____________________
b. Key log greater than 25 feet and less than 75 feet	____________________
c. Key log greater than 75 feet	____________________
d. Primarily shrubs and bushes	____________________
e. Construction debris or other manmade material	____________________
f. Other (describe): ____________________	____________________

7. <u>KNOWN PROBLEM SITES:</u>

Please identify two or three sites in your region that have known and recurring (chronic) problems with debris accumulation. Please include photos, debris-related repair or maintenance reports, or other information if available.

(Example: State Route 601, Bridge #6126 over Blackwood Creek, approx. 1.5 miles north of the Town of Wheaton, Sansone County, Nebraska)

Site No.	Location	Additional information provided? (Y/N)
1		
2		
3		

Would you recommend that any of the above-listed sites be considered as a potential field study site, where debris accumulation can be measured and documented as part of NCHRP Project 24-26? <u>If you answer yes, you or your designated representative will be contacted for further information by a member of the project team</u>.

I recommend one or more sites listed above as a potential field study site:

______ YES

______ NO

If "Yes," designated representative: ______________________________
Name

____
Telephone Number

Thank you for your assistance.

Table B.1. List of Respondents.		
State	Name	Agency
Alaska	Mark Miles	Alaska DOT
Arizona	Steven D. Puzas	Arizona DOT Safford District
Arkansas	Brooks Booher	Arkansas State Highway and Transportation Department
Arkansas	Jaysson Funkhouser	USGS
California	Cathy Avila	Avila and Associates Consulting Engineers, Inc.
California	Kevin Flora	Caltrans
California	Kevin Flora	Caltrans
California	Kevin Flora	Caltrans
California	Kevin Flora	Caltrans
California	Kevin Flora	Caltrans
California	Kevin Flora	Caltrans
Connecticut	Michael E. Hogan	Connecticut Department of Transportation
Florida	Jose A. Quintana	Florida Department of Transportation
Florida	Juan Santandreu	FDOT District 6
Florida	William Watts	Florida DOT, District Two
Hawaii	Curtis Matsuda	Hawaii Department of Transportation, Highways Division
Iowa	Tim Dunlay	Iowa Dept. of Transportation, Office of Bridges & Structures
Kansas	Bradford M. Rognlie	Kansas DOT, State Bridge Office, Bureau of Design
Louisiana	Steven C. Lee	Louisiana Department of Transportation
Minnesota	Larry Cooper	MnDOT
Minnesota	Dave Davidson	MnDOT, District 1
Minnesota	Duane Hill	MnDOT
Minnesota	Dennis Iverson	MnDOT, Rochester District
Minnesota	Doug Larson	MnDOT
Minnesota	Seth Yliniemi	MnDOT, District 4
Mississippi	Bridge Design	Mississippi DOT
Missouri	Ken Foster	MoDOT
Montana	Russell Brewer	Montana Department of Transportation
Nebraska	Jisa	Nebraska Department of Roads
Nevada	Chris Miller	Nevada Department of Transportation
Nevada	Dean Mosher	Nevada DOT
New Jersey	James Lane	New Jersey Department of Transportation
New Mexico	Scott Waltemeyer	US Geological Survey Water & Science Center
New Mexico	Scott D. Waltemeyer	US Geological Survey Water & Science Center
New Mexico	Scott Waltemeyer	US Geological Survey Water & Science Center
New York	Jerry Butch	U.S. Geological Survey
New York	Jerry Butch	U.S. Geological Survey
New York	Jerry Butch	U.S. Geological Survey
New York	Jerry Butch	U.S. Geological Survey
New York	Jerry Butch	U.S. Geological Survey
New York	Jerry Butch	U.S. Geological Survey
North Dakota	Clifford Scott	North Dakota Department of Transportation
Ohio	Gregory L. Baird	Ohio Department of Transportation
Ohio	Brandon Callett	Ohio Department of Transportation, District 8

Table B.1. List of Respondents.		
State	Name	Agency
Ohio	John Coen	Ohio Department of Transportation
Ohio	Steve L. Reichenbach	Ohio Department of Transportation, District One
Ohio	Robert Taylor	ODOT District 6
Oregon	Bill Long	City of Portland, Bureau of Maintenance
Oregon	Michael Pulzone	Oregon Dept. of Transportation
Pennsylvania	Peggy Johnson	Penn State University, Dept. of Civil Engineering
Pennsylvania	Peggy Johnson	Penn State University, Dept. of Civil Engineering
Puerto Rico	Luis G. Santos	Puerto Rico Highway and Transportation Authority
Puerto Rico	Luis G. Santos	Puerto Rico Highway and Transportation Authority
Tennessee	Bradley Bryan	USGS
Tennessee	Bradley Bryan	USGS
Tennessee	Bradley Bryan	USGS
Tennessee	Jon Zirkle	Tennessee DOT, Hydraulics Section, Inspection & Repair Section
Texas	Michael W. Alford	TxDOT
Texas	Rocky Armendariz	Tx DOT
Texas	Jimmy Bridges	TxDOT
Texas	Jerry Conner	TxDOT
Texas	Randy Duke	Tx DOT
Texas	Michael Heise	TxDOT
Texas	Tim Hertel	TxDOT, Wichita Falls
Texas	Jeff Howell	TxDOT
Texas	J.B. Hutchinson	TxDOT
Texas	Jon H. Kilgore	TxDot San Antonio District
Texas	Blane Laywell	Tx-DOT Milam County Maintenance
Texas	Paul Montgomery	TxDOT, District 11
Texas	Ted Moore	TxDOT
Texas	David W. Morris	TxDOT
Texas	Carl L. O'neill	TxDOT
Texas	Michael T. Schneider	TxDOT
Texas	H. Carl Schroeder	TxDOT Grimes Co. Maintenance
Texas	Anthony Villarreal	TXDOT
Texas	Arthur L. Waguespack	TxDOT
Texas	Bobby Wells	TxDOT
Texas	Dennis W. Wilde	TxDOT
Utah	Tim Ularich	Utah Department of Transportation
Vermont	Gary Schelley	VT. Agency of Transportation
Virginia	Bruce Mcfadden	VDOT
Virginia	Marvin Jack Meredith	VA. Dept. of Transportation – VDOT
Virginia	T.W. Overton	VDOT
Virginia	Miles Pierce	VDOT
Wisconsin	Allan Bjorklund	Wisconsin DOT - District 8
Wisconsin	Brock Gehrig	Wisconsin Department of Transportation
Wisconsin	Dale Weber	Wisconsin Department of Transportation - District 3
Wyoming	Gregg C. Frederick	Wyoming Department of Transportation

APPENDIX C

Field Pilot Study Report

CHRONOLOGICAL TRIP SUMMARY:

EFFECTS OF DEBRIS ON BRIDGE-PIER SCOUR ON FOUR BRIDGES IN SOUTH-EASTERN KANSAS APRIL 25-28, 2005

NCHRP 24-26

April 25 (Monday)

Travel from Fort Collins, Colorado to Parsons, Kansas. On route to Parsons, team stopped to observe bridges US-400 over the Neosho River and US-400 over the Verdigris River. Arrived in Parsons, met with Mr. Brad Rognlie, bridge squad leader for KDOT who coordinated KDOT support.

Table C.1 presents stream flow conditions for April 25-27 from USGS stream gage stations located on or near the four observed bridges.

Table C.1. Stream Flow Information From USGS Gages.

Route	Crossing	USGS Stream Gage Number	Distance of Gage from Bridge (mi)	Nearby Town to Gage	Average Gage Height April 25-27 (ft)	Average Ppt April 25-27 (in)	Average Discharge April 25-27 (cfs)
US 400	Neosho River	07183500	Gage located at bridge	Parsons, KS	8.6	0.004	1317
US 400	Verdigris River	07170500	Approximately 20 miles downstream of bridge	Independence, KS	3.0	0.0	251
RS 807	Elk River	07169800	Approximately 10 miles upstream of bridge	Elk Falls, KS	2.9	0.003	35.6
K 166	Neosho River	07185000	Approximately 15 miles downstream of bridge	Commerce, OK	3.7	0.005	1585

April 26 (Tuesday)

Travel to Chetopa, Kansas.

K-166 crossing over the Neosho River (see Attachment 1)

Bridge No. 50-085 is a 46-foot wide, 2-lane highway bridge, with a shoulder and sidewalk on both sides, carrying highway K-166 over the Neosho River. Main Street Chetopa, Kansas, population 1300, is located immediately west of the bridge (**Figure 1.1**). KDOT personnel provided traffic control. KDOT closed one lane of traffic to allow the articulated arm truck to park adjacent to the edge of the bridge above the debris pile.

Observations:

- Five reinforce concrete piers and two concrete abutments support the bridge, from east to west, Piers #1, 2, and 3 are located in the channel.

- The upstream channel was split approaching the bridge. A large island lies directly upstream of Pier #2. The majority of the flow was contained in the wider right channel (**Figure 1.2**).

- Debris build up was heavy on the upstream nose of Pier #3, located in the larger channel (**Figure 1.3**).

- A spill dam was located approximately 200 feet downstream of the bridge (**Figure 1.4**).

- Debris on the main channel pier was approximately 12 feet high and extended 25 feet upstream of the pier. On the left, debris was reaching toward the island in the center of the channel, approximately 8 feet from the island.

- On Pier #1, located in the narrower channel, the debris was compromised primarily of three main logs, about 1 foot in diameter each, and small twig build up (**Figure 1.5**).

- Streambanks upstream of the bridge were vertical with approximately 3-6 feet of exposed soil visible. Numerous large trees were observed leaning into the channel (**Figure 1.6**).

Equipment used:

- Fully instrumented, articulated arm truck for monitoring scour at bridges. Articulated arm truck for scour monitoring was developed for NCHRP 21-07 Project. The truck has a telescoping articulated arm, which can be positioned over the side of a bridge deck to determine surface characteristics of a debris pier. The truck is a 1-ton, dual wheeled, Ford F-450 with a Palfinger articulating knuckle boom telescoping crane mounted on the bed and chassis. The crane is operated from the flat bed of the truck and is able to take direct measurements from a water level just below the bridge deck downward to about 30 feet. The crane can be articulated to allow positioning around the perimeter of the debris pile (see **Figures 1.7 and 1.8**).

- Instrumentation to monitor the position of the crane in space. The position of the crane in space is monitored by resistance sensors that measure movement of the crane. Sensors monitor the length and vertical angle of the telescoping arm, and the azimuth of the crane rotation. This data is transferred by a wireless modem to a data logger and laptop located on the truck (**Figure 1.9**). The raw data is processed by software on the computer and displayed in real-time for the user.

- An acoustic stage sensor was used to measure the distance to the water surface. The sensor was mounted to a boom that extended perpendicular to the truck and out over the water surface (**Figure 1.10**).

- For underwater measurements of debris, a separate streamlined head was built to house a side-pointing wireless sonar. Instead of the sonar mounted to point straight down, the side looking head allows the transducer to be mounted to look horizontally under the debris pile. The side looking head is attached to the articulating arm and positioned around the pile in the same manner as the downward pointing sonar (**Figure 1.11**).

- A laptop computer, with two serial ports, was used to process the data from each logger, sent as serial data strings (**Figure 1.12**). Knowing the rotation of the crane and the rotator, the deflection angles of the crane arm and rotator, and the extension of the crane arm allowed for geometric calculation the position in space of the end of the rotator relative to the center pivot of the crane where it was mounted to the truck.

- Computer software for sonar measurements with the crane allows point measurements or continuous recording. Computer software necessary to process data coming from the transducer and position sensors was developed in-house by Ayres Associates. The user can select from two data collection modes. Point Data collects one data point at a specific location; Continuous Recording collects data at one-second intervals continuously as the articulating arm is moved around the debris pile.

- Wireless sonar in a sounding weight, 35 lb and 75 lb sounding weights could be lowered over the bridge deck using the articulating arm and a cable winch. The sounding weights have been modified to house wireless sonar that transmits the sonar data back to software on the truck. The sounding weights are used in applications where the bridge deck is too high for the articulating arm to reach the water.

- The hydrographic survey boat was used for documenting geomorphic conditions, such as bank stability, debris source areas, overall channel type, and flow patterns. The boat was a 16-foot flat bottom Jon Boat with a 50-hp jet drive outboard motor (**Figure 1.13**). The jet motor is very maneuverable and allows the boat to be operated in shallow water without risk of damaging a standard prop. The boat and motor can be operated in less than 1 foot of water.

- Tape, digital camera, and video.

Railroad Bridge crossing the Neosho River (see Attachment 2)

A steel railroad bridge crossing the Neosho River was located close to the Chetopa boat launch (**Figures 2.1 and 2.2)**. Four piers were located in the channel with some degree of debris build up on each pier. The perimeters of the debris piles were mapped on two easily accessible piers using the boat and transducer (see **Figures 2.3 and 2.4**).

<u>April 27 (Wednesday)</u>

Travel to Oak Valley, Kansas.

RS-807 crossing the Elk River (see Attachment 3)

Bridge No. 25-450 is a continuous concrete slab structure, 266 feet in length and approximately 30 feet in width. This is a county bridge providing local access, located just outside of Oak Valley, KS (**Figure 3.1**). Primary land use upstream was agriculture; an approximately 30-foot buffer zone was observed between the river and agricultural fields (**Figure 3.2**).

- Five piers span the width of the channel; only two piers were located in the flow at the time of observation (**Figure 3.3**).

- The two piers located in the flow had pier wall extensions protruding upstream and skewed to the flow (**Figure 3.4**).

- Per conversation with a local land owner:
  - Current debris pile was typical and of average size for this bridge
  - In the past, debris has been observed within 10 feet of the bridge deck
  - Last year KDOT crews removed debris from upstream of bridge with backhoe and placed the debris immediately downstream on right bank (**Figure 3.5**)
  - Debris clusters of similar size can be observed along the banks of the Elk River for several miles downstream

- Large key log, approximately 5-6 feet in diameter at root wad, initially thought to have come from left bank immediately upstream of the bridge (**Figure 3.6**). Evidence of loss of large tree and slope failure could be seen on left bank (**Figure 3.7**). Pictures of left bank provided by KDOT taken July 2004 did not show a tree of similar size on banks.

- Debris buildup is much more significant on left wing wall due to the bulk of the key log being located on the left.

- Channel appears to widen at the bridge: upstream width was approximately 25 feet less than at bridge.

- Riprap located on left riverbank extending 12 feet up and downstream of bridge, average diameter of riprap was approximately 3 feet. Roughly, 30 feet upstream exposed roots are visible on the bank; slope is steep but not vertical. Further upstream, banks were barely visible due to a large number of trees leaning over the channel (**Figure 3.8**).

- Immediately downstream of riprap, banks slope mildly toward channel. Slope increases with distance from bridge. Channel is relatively straight downstream of the bridge until about 1/2 mile downstream where the channel turns right. The outside bank of the bend had approximately 15-20 foot vertical wall.

- On right bank agriculture fields come all the way up to the channels, banks provide an approximate 25-foot buffer.

- A utility line runs along the downstream deck of the bridge.

- Observed tree species included cottonwood, ash, birch, oak and around 6-9 unidentified species. Bank vegetation was composed of grasses, trees and weeds.

- Downstream of bridge flow depth was estimated to be 1-3 feet. Flow depth was estimated to increase under the bridge centerline to over 5 feet.

Equipment used:

- A standard surveyors wheel with a mechanical counter was used to measure the length and width of the bridge.

- Fully instrumented articulating arm truck was utilized in conjunction with the wireless sonar in the sounding weight, the streamline probe with wireless sonar, and the computer software for data collection.

- A Leica total station with data logger was used to measure horizontal and vertical angles of the debris pile from the bank. The total station displays a digital readout of the angles from the instrument to the points being surveyed. The total station was also used to take electronic distance measurements (EDM) of the bridge deck and adjacent bank line (**Figure 3.9**).

- Tape, digital camera, and video.

- A method of recording data around the debris pile and taking topographical shots on the actual debris pile was developed for this study. In this application, a chain of known length was attached to the end of the articulated arm, and was positioned at locations on and around the pile to take measurements and provide an above water map of the debris pile (**Figure 3.10**). The known length of the chain was added as a "rod height" to the vertical position. This method may be used when the bridge deck is too high above the water for the transducer to be in the water, or to take topographical data of the pile.

- Another method that was developed for the field study used the same chain method as described above, but a prism cluster was hung from the chain. The prism could be shot with a total station at each position and the debris pile would be mapped using the total station and data logger for positioning of the end of the chain. This provided another relatively accurate method of mapping the debris pile in relation to the bridge. No positioning sensors software on the truck were required for this method.

US-400 over Verdigris River (see Attachment 4)

Bridge No. 63-081 is a 46-foot wide, two-lane highway bridge, with a shoulder on both sides, carrying highway U.S.-400 over the Verdigris River (see **Figure 4.1** for a location map of the bridge).

- One pier is located in the center of the channel. Large debris pile established on nose of pier (**Figure 4.2)**.

- Upstream of bridge, banks show signs of erosion, large trees leaning into channel (**Figure 4.3**).

- Evidence upstream of pier of rotational bank failure and loss of tree.

- Large key log on left of pile with root wad oriented downstream.

- Riprap, approximately 1 foot in average diameter, located on both banks in the bridge cross section.

- Large riprap 3-4 feet average diameter located on upper bank, surrounding abutment.

- Vegetation wrapped on small shrubs is evidence of high water, approximately 10 feet above current water level.

- Green vegetation was established on debris pile.

Equipment used:

- A Leica total station with data logger was used to measure horizontal and vertical angles of the debris pile from the bank (**Figures 4.4 and 4.5**).

- The Interphase Twinscope™, used as a hand held measurement system, not attached to boom, was tested. The Twinscope™ is a continuously scanning sonar that displays a 90 degree underwater view in front of the sonar. The Twinscope™ is designed to be mounted to the hull of a boat and has been used successfully in ocean applications. The application of this instrumentation for this project would be to lower it into the water and point it in the direction of the debris pile to get underwater view of the debris pile shape (see **Figures 4.6 and 4.7**). The results were inconclusive. Echos, scatter, and interference in a shallow water environment render the interpretation of results speculative, at best.

- A Laser Atlanta laser range finder was used to measure distance, height, and width of objects (**Figure 4.8**). The range finder gives accurate distances of an object up to 2,000 feet without a prism. It also has a built in inclinometer to measure vertical angles.

- Tape, digital camera, and video.

US-400 over Neosho River (see Attachment 5)

Bridge No. 50-065 is a 45-foot wide, two-lane highway bridge, with a shoulder on both sides, carrying highway U.S.-400 over the Neosho River. **Figures 5.1 and 5.2** show a location map and aerial photo of the bridge.

The following observations were made:

- Banks were steep at the bridge on both sides of the channel, approximately 20 vertical feet. At the bridge, the banks were vegetated with grass and brush. Upstream channel was forested and trees leaned into the channel (**Figure 5.3**).

- Two concrete piers were in channel at the time of observation. Heavy debris had collected on the left pier and extended onto the left bank (**Figures 5.4 and 5.5**).

- Large key log, approximately 2 feet in diameter stretched from the pier to the bank (**Figure 5.6**). The debris pile was approximately 12 feet tall and 20 feet from the bridge deck (**Figure 5.7**) with the bulk of the pile extending 40 upstream.

- Debris extended upstream on left bank approximately 60 feet from the bridge (**Figure 5.8**).

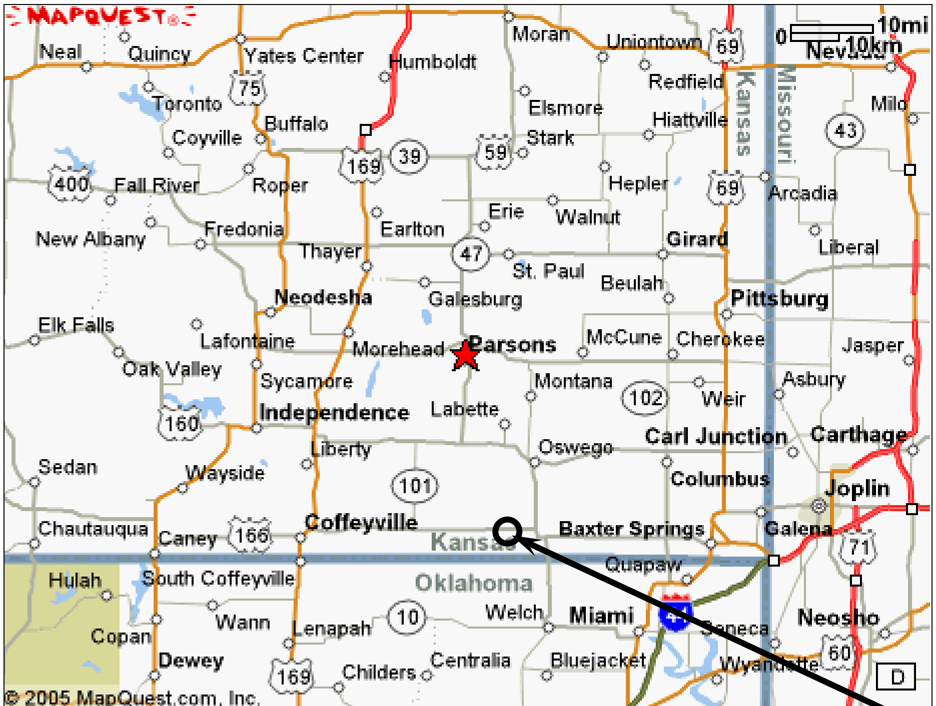
Equipment used:

- Leica total station with data logger was used to measure horizontal and vertical angles of the debris pile from the bank.

- Tape, digital camera, and video.

Attachment 1

Bridge No. 50-085, on US-166 over the Neosho River
Chetopa, Kansas



US-166 crossing over Neosho River

Figure 1.1. Location map.

Figure 1.2. Aerial view.

Figure 1.3. Debris buildup at Pier #3.

Figure 1.4. Spillway downstream of the bridge.

Figure 1.5. Debris at Pier #2. Note the island between Piers #2 and #3.

Figure 1.6. Steep upstream banks and leaning trees.

Figure 1.7. Articulating arm truck.

Figure 1.8. Articulating arm truck with crane extended to take measurements.

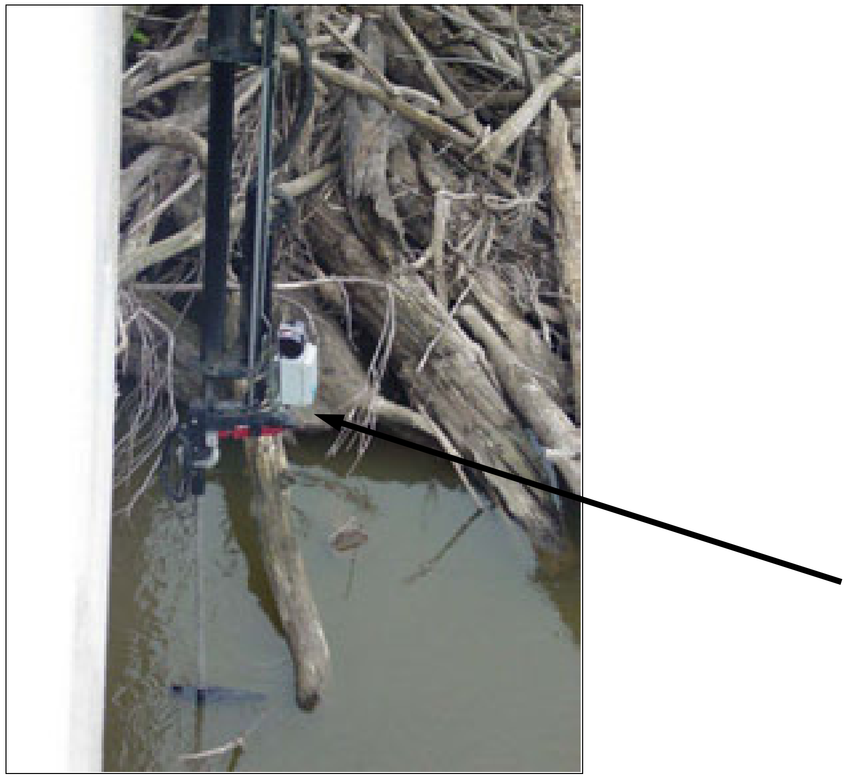


Figure 1.9. Resistance sensor and wireless modem located on the end of the crane.

Figure 1.10. Acoustic stage sensor on boom.

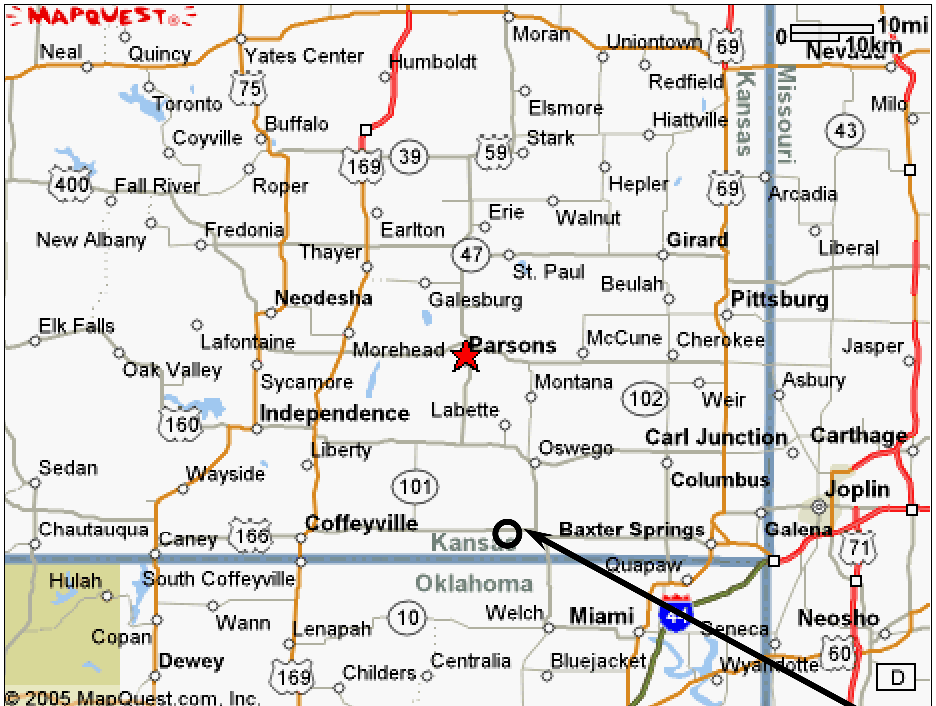
Figure 1.11. Streamline probe to position wireless sonar.

Figure 1.12. Laptop located on articulating arm truck.

Figure 1.13. Hydrographic survey boat.

Attachment 2

Railroad Bridge over the Neosho River
Chetopa, Kansas



Railroad bridge crossing over Neosho River

Figure 2.1. Location map.

Figure 2.2. Aerial view of Railroad Bridge.

Figure 2.3. Railroad Bridge adjacent to the boat launch.

Figure 2.4. Debris at Railroad Bridge pier.

Attachment 3

Bridge No. 25-450 on RS-807 over the Elk River
Oak Valley, Kansas

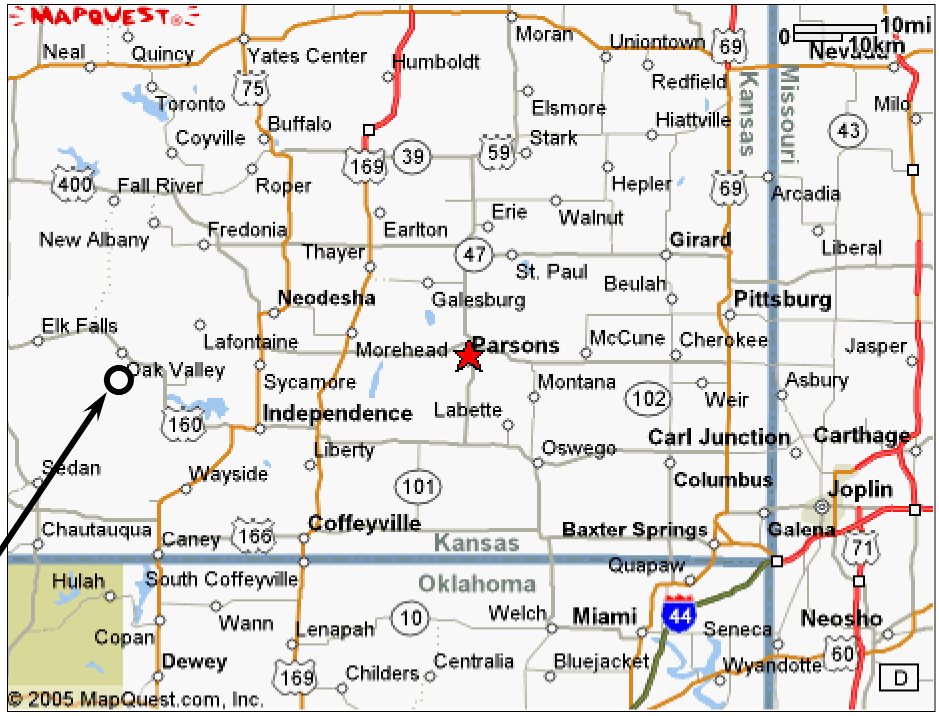


Figure 3.1. Location map.

RS-807 crossing over Elk River

Figure 3.2. Aerial view.

Figure 3.3. Two piers in channel with heavy debris.

Figure 3.4. Extension walls, skewed to flow.

Figure 3.5. Debris removed from piers the previous year and placed downstream of bridge.

Figure 3.6. Key log on left extension pier.

Figure 3.7. Evidence of loss of trees and slope failure on left bank.

Figure 3.8. Looking upstream from the bridge deck.

Figure 3.9. Using the Leica total station with data logger.

Figure 3.10. Using the chain and steel ball extension to obtain elevations of the debris pile.

Attachment 4

Bridge No. 63-081, on US-400 over the Verdigris River
Near Neodesha, Kansas

Figure 4.1 Location map.

No aerial photo available, most recent photo was taken in 1991, bridge was constructed in 1995.

Figure 4.2. Looking downstream toward the bridge.

Figure 4.3. Looking upstream from below the bridge deck. Note the riprap on the banks and the trees leaning into the channel.

Figure 4.4. Surveying the edge of the debris pile.

Figure 4.5. Surveying the debris pile with the total station.

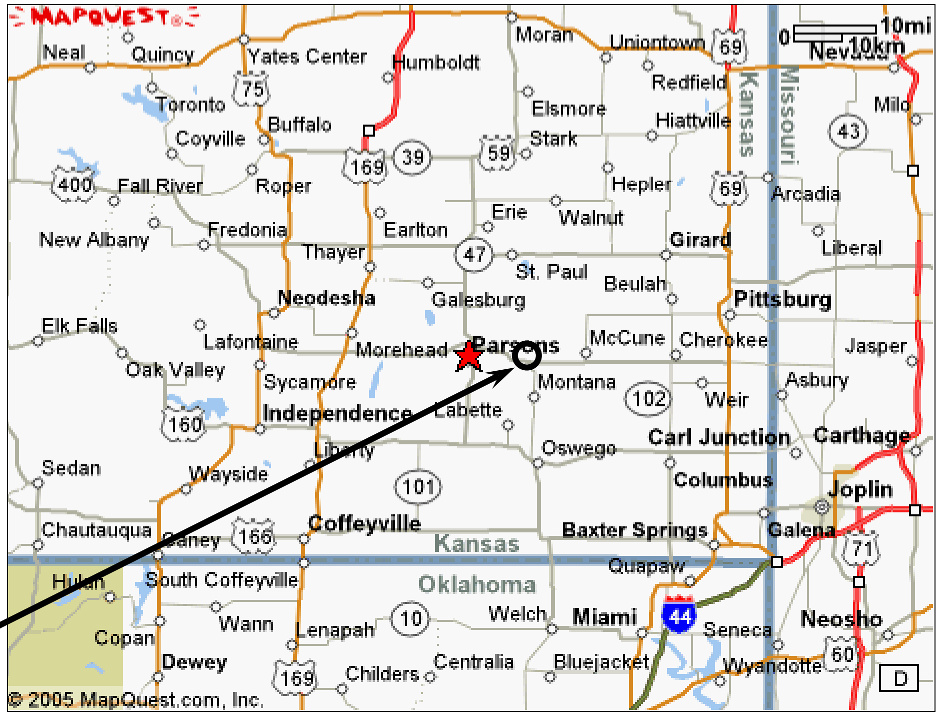
Figure 4.6. Using the Twinscope to map the underwater configuration of the debris pile.

Figure 4.7. Twinscope screen.

Figure 4.8. Using the laser range finder.

Attachment 5

Bridge No. 50-065, on US-400 over the Neosho River
Near Parsons, Kansas



US-400 crossing over Neosho River

Figure 5.1. Location map.

Figure 5.2. Aerial view.

Figure 5.3. Looking upstream from debris pile. Note the eroding banks and trees leaning into the channel.

Figure 5.4. Looking upstream at debris pile.

Figure 5.5. Looking downstream at debris pile.

Figure 5.6. Large key log in debris pile.

Figure 5.7. Measuring the water surface from the bridge deck.

Figure 5.8. View of debris pile from bridge deck.