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Database Program for Highway Bridge-Scour Data

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ABSTRACT

A database management program was developed for the storage, retrieval, and display of scour data of highway bridges. The program is currently being used by the Louisiana Department of Transportation and Development (LA DOTD) to streamline the process of data entry and retrieval, and to detect scour and stream instability at any particular bridge. The quick analysis of the data has led LA DOTD to timely decision making with regard to remediation of scour critical locations.

The program tabulates and plots bridge information, pier data, and river cross-sections at the survey locations. It displays survey maps and soil boring data. The analysis of the scour data is performed using plots of the cross-sections, longitudinal sections and contour lines of the scour data. The history of the scour at any specific location is also plotted in time plots.

The compiled and plotted data from the program can be utilized in determining local scour at the piers and contraction scour at the bridge, analyzing the long-term changes in elevations, and in evaluating site conditions and soil properties for scour repair.

The use of the program by the LA DOTD replaced the tedious work of manual and visual retrieval and display of the monitored scour data. A case study of implementing the program to retrieve the scour data and evaluate scour potential of one of the bridges is presented.

INTRODUCTION

Field monitoring of scour at bridges that are susceptible to scour damage in Louisiana has been carried out since 1970's. LA DOTD monitors approximately one hundred and thirty bridges at a frequency of one to several times per year. Traditionally, in order to evaluate bridge scour, survey data had to be located, retrieved from central files, copied, and then manually plotted and analyzed. A database management program was developed in order to provide the means of retrieving the tremendous amount of scour data, plotting cross, and analyzing the changes in scour depth with time at any selected location near the bridge.

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The paper presents the development of the database program, its use, and provides recommendations for the implementation of database systems for monitoring bridge scours.

DESCRIPTION OF THE BRIDGE-SCOUR DATABASE

The design of the database program was based on the LA DOTD need to electronically access the statewide fathometer data of all its surveyed bridges. The database was designed to provide the following capabilities:

- Electronic storage and retrieval of the bridge scour data, pier properties, hydrographic, and fathometer data collected since 1970.
- Graphical display and prints of the riverbed elevations, longitudinal sections, and cross sections at any selected location and survey date.
- Provide the main parameters required for proper prediction and repair of scour; such as bridge geometry, water levels, site characteristics, pier types and elevations, and soil properties from borings at pier locations.

The database was designed using Microsoft ACCESS software. Figure 1 shows the database tables and structure. A data management program was developed in Microsoft Visual Basic as a user front-end and it is connected remotely to the database in the server. The architecture implemented in the program consisted of two-tier client-server connection that enabled multi-users to access the database through the server. The program in the client side allowed sending queries, using Structured Query Language (SQL) commands, to retrieve the data from the server and to display the tables and graphs on the user's terminal.

a. Display of Bridge Information and Survey data

The first step in using the program is to select the bridge to analyze. The selection of the bridge is done using one or a combination of several indices such as bridge number, state project number, river name, route, parish name; or alternatively, by clicking on the screen on the selected district in the state map. Figure 2 shows the data search form.

The program displays the bridge information and pier data in a tabulated form. A typical bridge information data form is shown in figure 3. It also displays bridge plan and the locations of data collection (Figure 4).

The magnitude of scour depth primarily depends on site conditions, the hydraulic parameters at the bridge reach, and the properties of the bed material (1). Bed-material properties and soil classification at the locations of the soil borings were retrieved from construction drawings and are displayed in the 'Soil Boring' folder of the database. Figure 5 shows a schematic of the bridge structure and soil boring data.

b. Data Entry and Maintenance

Although the database is accessed through the LA DOTD Local Area Network (LAN), only the survey-section personnel can add or modify the data in the database. Data is added and edited in separate forms that are designed for easy and systematic data entry. The data entry consists mainly of: (i) Bridge Information, type, location, and geometry; (ii) Pier data, foundations types, their elevations, and coordinates; (iii) Fathometer data and coordinates. Figure 6 shows the pier data form. Data entry also includes scanned graphs and drawings of the bridge plans and soil borings. Figure 6 shows the data entry form for the Pier data.

USE OF THE DATABASE TO MONITOR BRIDGE SCOUR

Cross-section plots are one of the main functions that provide the user with the changes in scour depth at any location. The database includes the fathometer data at various locations at the approach sections. The user can plot the cross-sections at various locations at a specific survey date; or alternatively, plot the sections at various survey dates for the same location.

Figure 7 shows riverbed cross sections of a sample bridge at an upstream location near the pier for several survey dates. The distance from the baseline of the bridge is plotted in the x-axis. Plots of cross-sections at consecutive survey dates can be utilized in identifying local scour behind the piers. Pier local scour can be computed as the maximum vertical distance between an ambient bed elevation (an estimate of natural bed elevation without the pier in place) and the lowest elevation measured in the scour hole (2). The plots at two consecutive dates in figure 7 showed a change in the elevation near the middle pier. A detail plot at this location in Figure 8 shows a drop of an about 4 ft in the elevation at this location.

Long-term evaluation of the changes in riverbed scour at any location can also be performed using the time plots. Figure 9 shows historical change of riverbed elevation for the location plotted in figure 8. The figure shows the drop of elevation at the last survey dates.

The contours of the riverbed elevations at any selected survey date are also plotted from the data collected from various upstream and downstream locations. Although it is generally difficult to treat scour components separately, the changes in the contour elevations at two consecutive dates (commonly before and after flooding) provide means of evaluating overall scour components at the site. Figure 10 shows a sample of a contour plot of a bridge.

The database program also provides longitudinal cross sections of the riverbed elevations from field measurements. These plots define the changes of elevations at any selected survey date of along the water streamlines. References 3 and 4 provide more details about the capabilities and use of the database program.

CONCLUSIONS

The database scour program was developed to facilitate data retrieval and management of scour in Louisiana bridges. It provided the major parameters needed for an initial evaluation of scour potential from field data (e.g. riverbed elevations, water levels, bridge properties, pier types and elevations, and soil properties at the piers).

The evaluation of field scour data and developing a database for its management and analysis has been recognized as necessary to evaluate potential scour. For this purpose, a national Bridge Scour Data Management System (BSDMS) was developed to provide a description and analysis of the data required to assess scour process at a site (5). The database scour program for Louisiana bridges presents a model system that can be implemented for quick and comprehensive site assessment of and to provide most of the scour parameters needed for the implementation of the BSDMS.

Future development of the database systems can be achieved by including data needed for the estimation of scour values (e.g. hydraulic flood data, flow velocity, pier sizes and shapes, variations of water temperatures, and sediment gradations and properties). Ultimately, with the addition of these parameters, the output can be implemented in the theoretical analysis of scour management systems.

ACKNOWLEDGEMENT

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5. Landers, M., and Mueller, D., “Channel Scour at Bridges in the United States”, Federal Highway Administration, Report FHWA-RD-95-184, 1995.

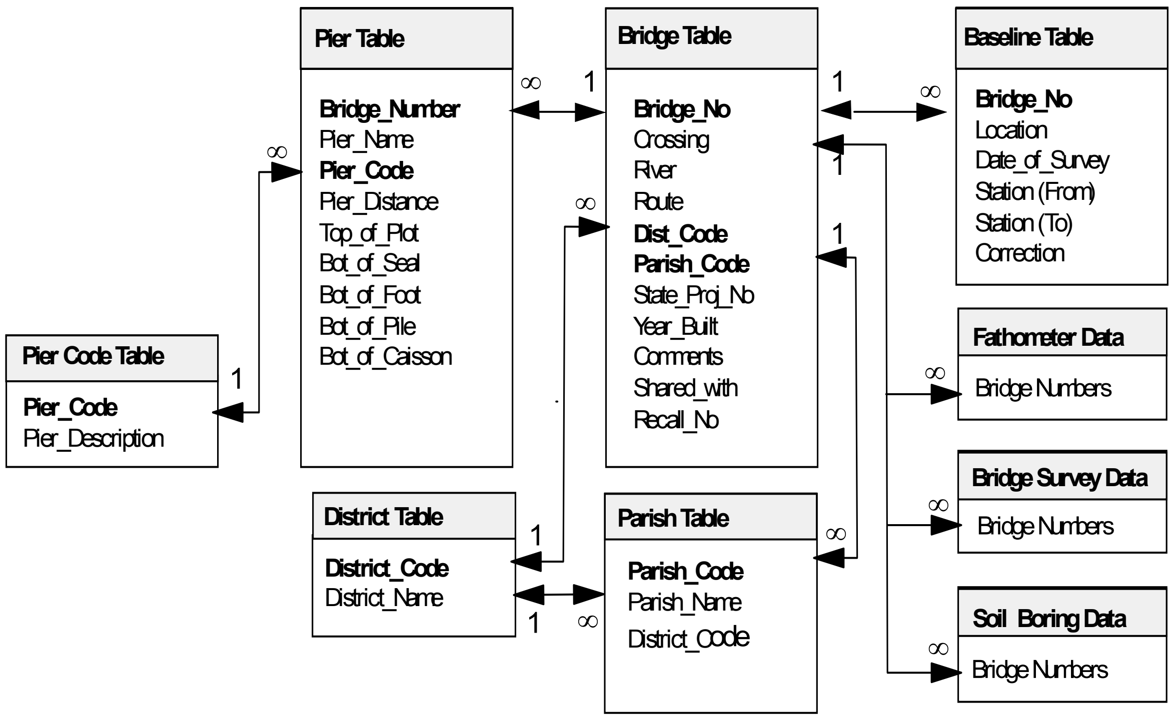

Figure 1. Data types and structure of the database

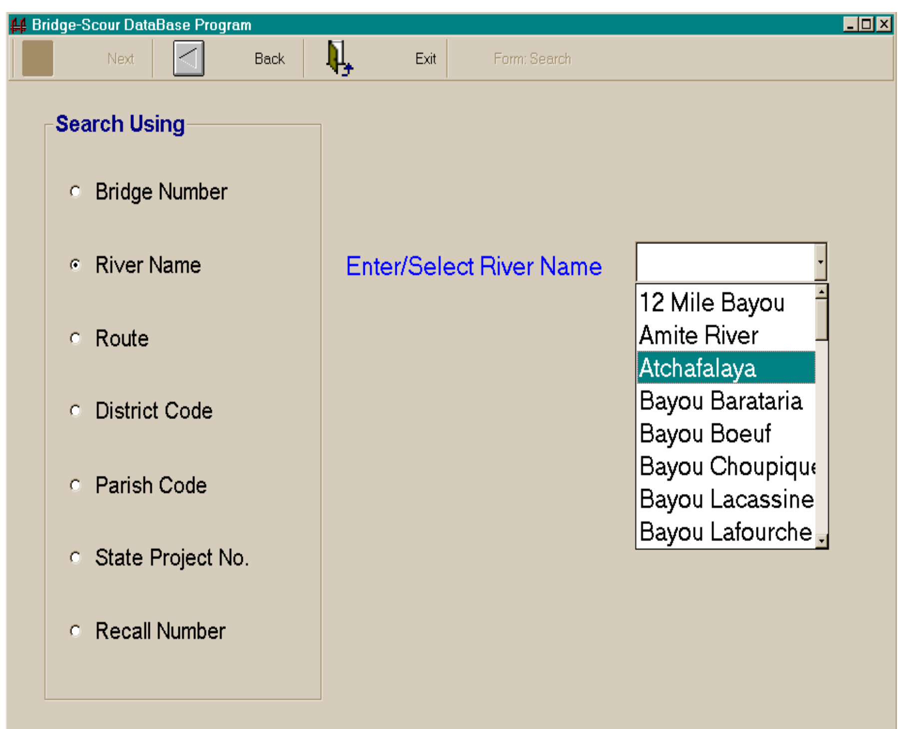

Figure 2. Use of Search Form to select a bridge using several search routines

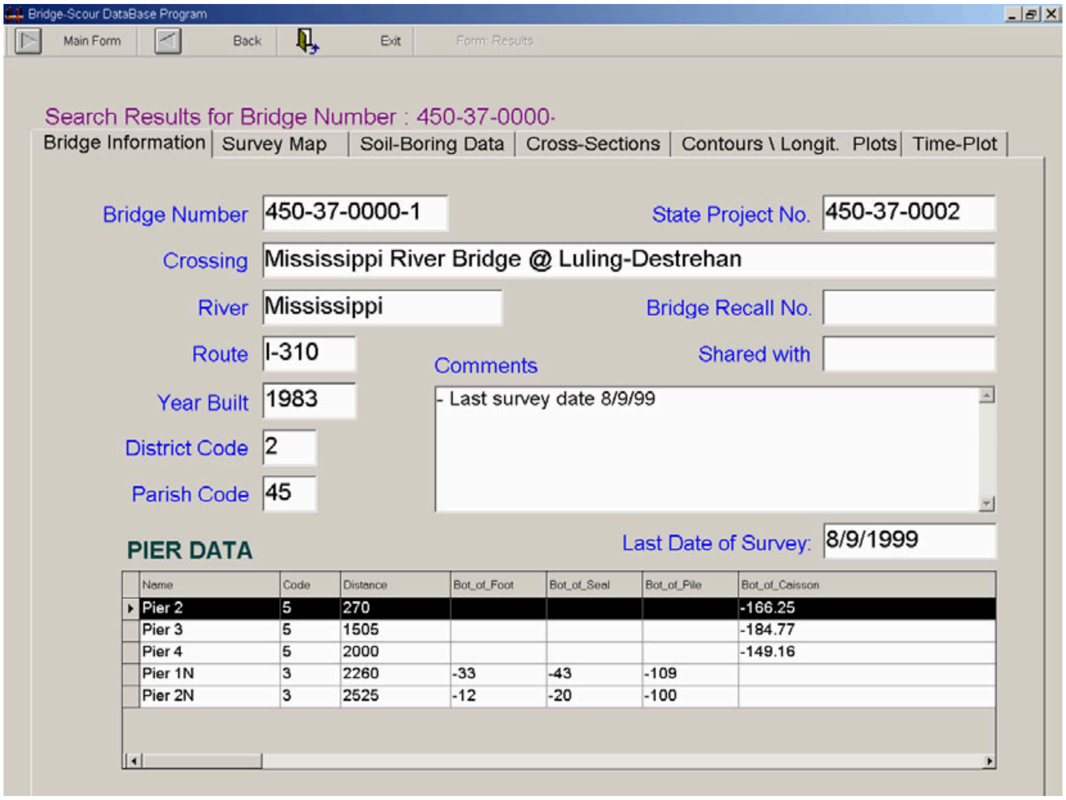

Figure 3. Bridge and pier data are shown in the Bridge Information Folder

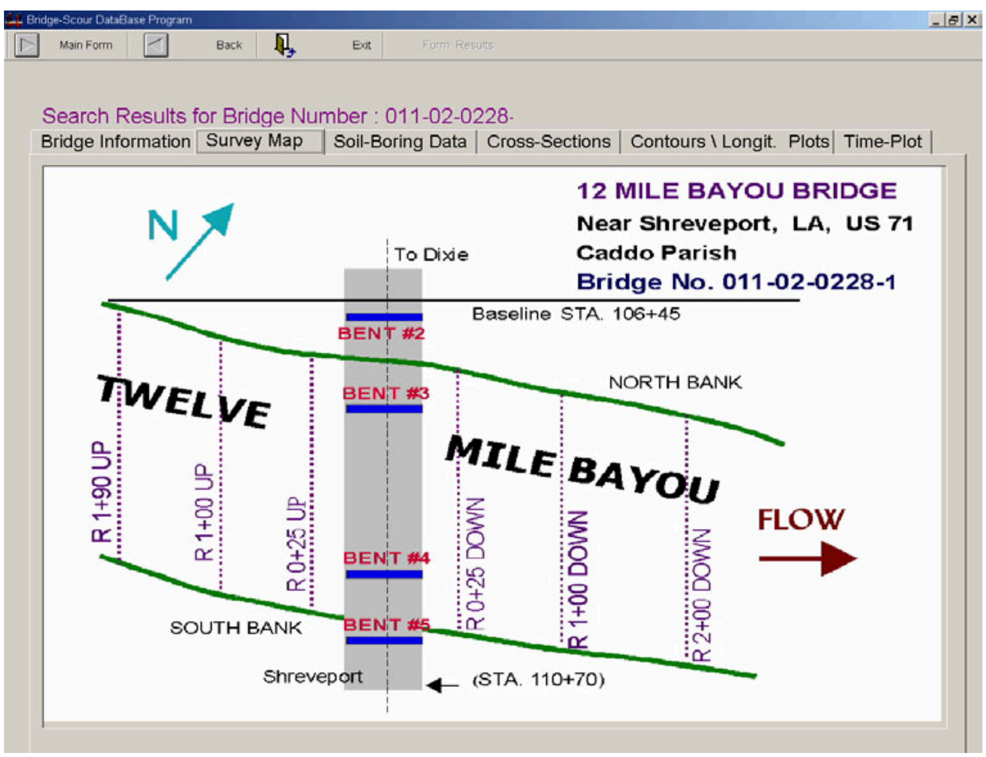

Figure 4. Survey map showing the locations of fathometer data-collection.

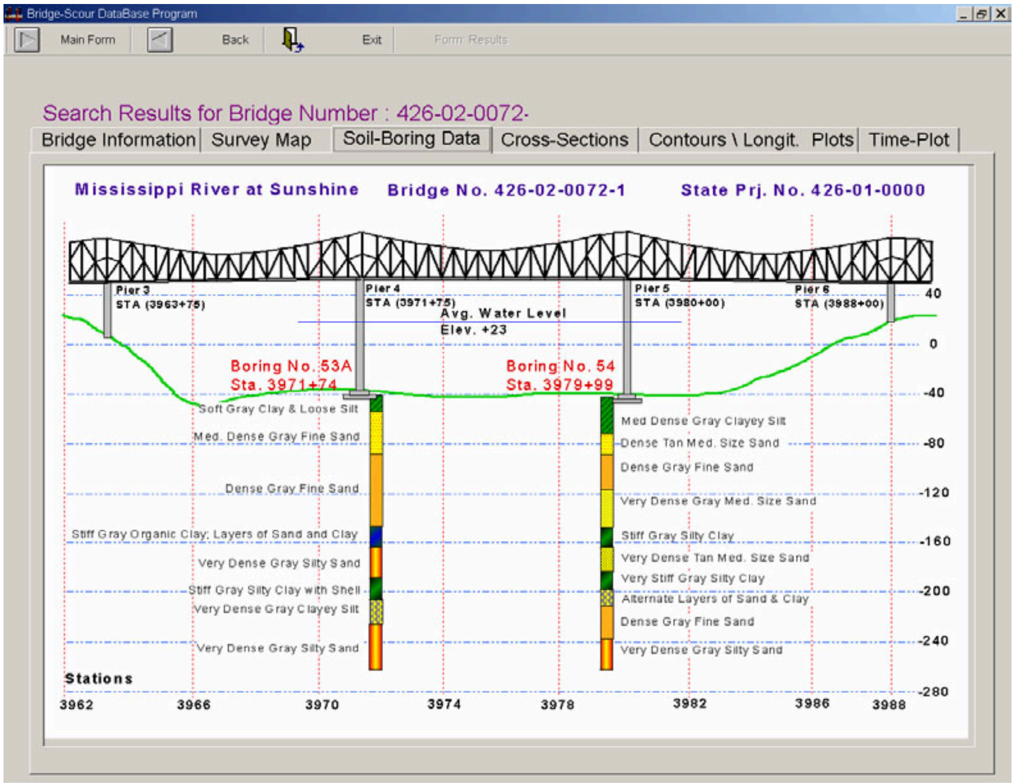

Figure 5. Schematic of the bridge structure showing soil boring locations and data

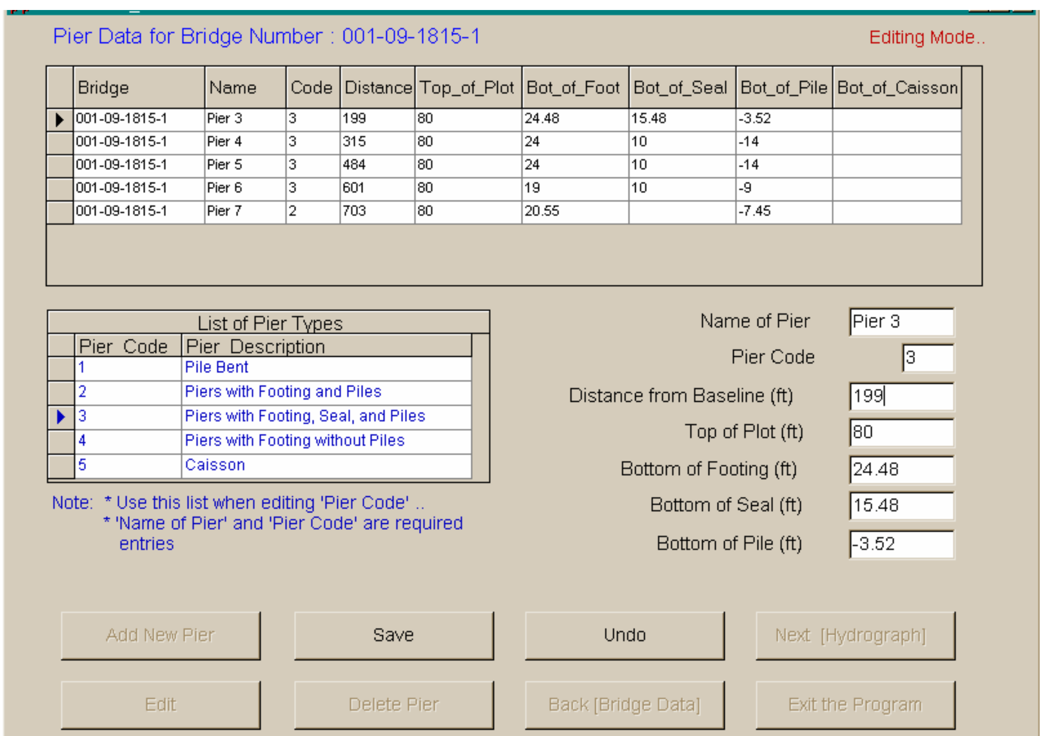

Figure 6. Data entry form of Pier data and elevations

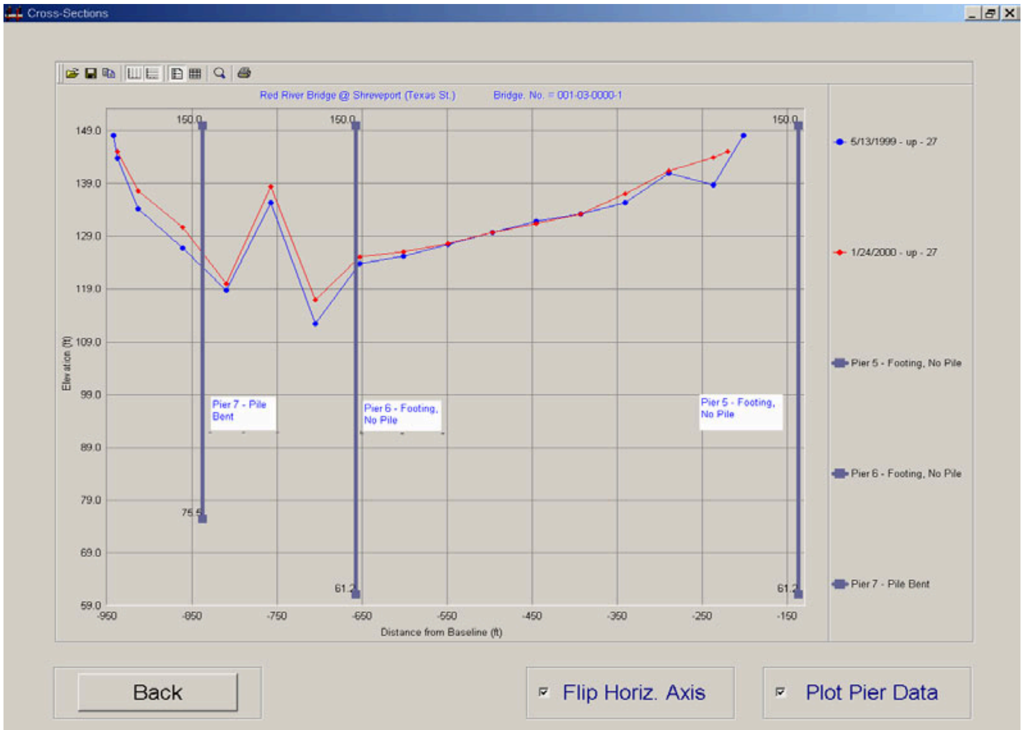

Figure 7 Cross-section plots for several dates at bridge downstream

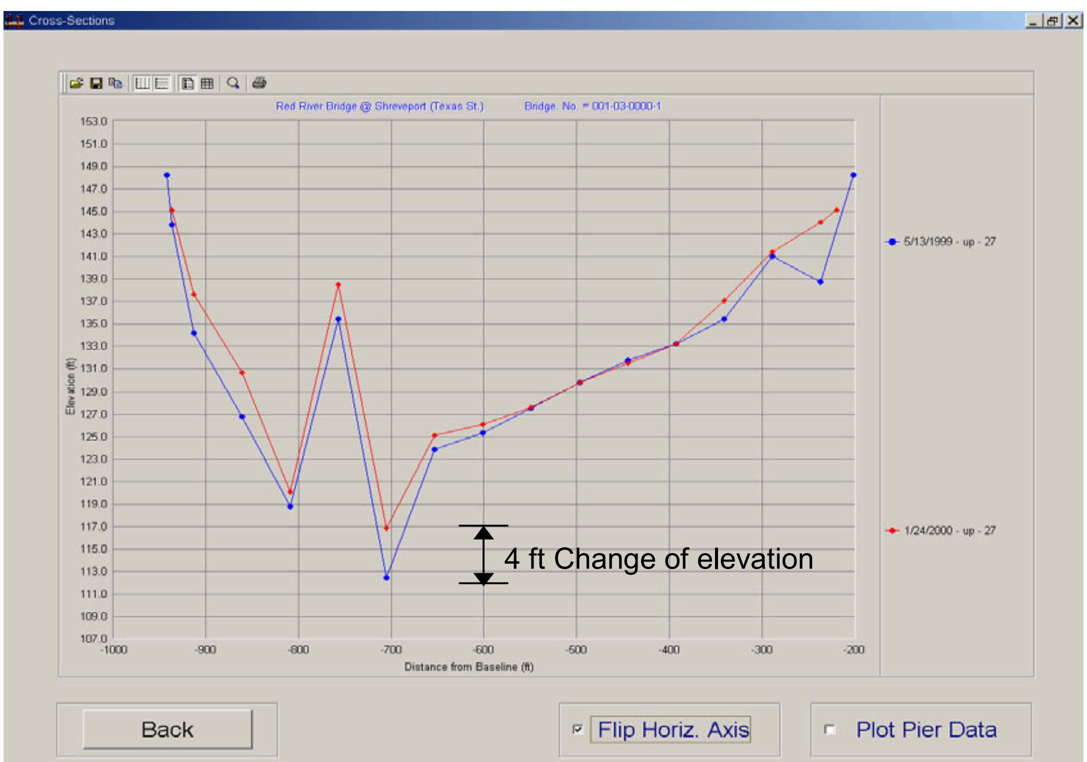

Figure 8. Detail of Figure 7 showing elevation changes at two consecutive fathometer readings

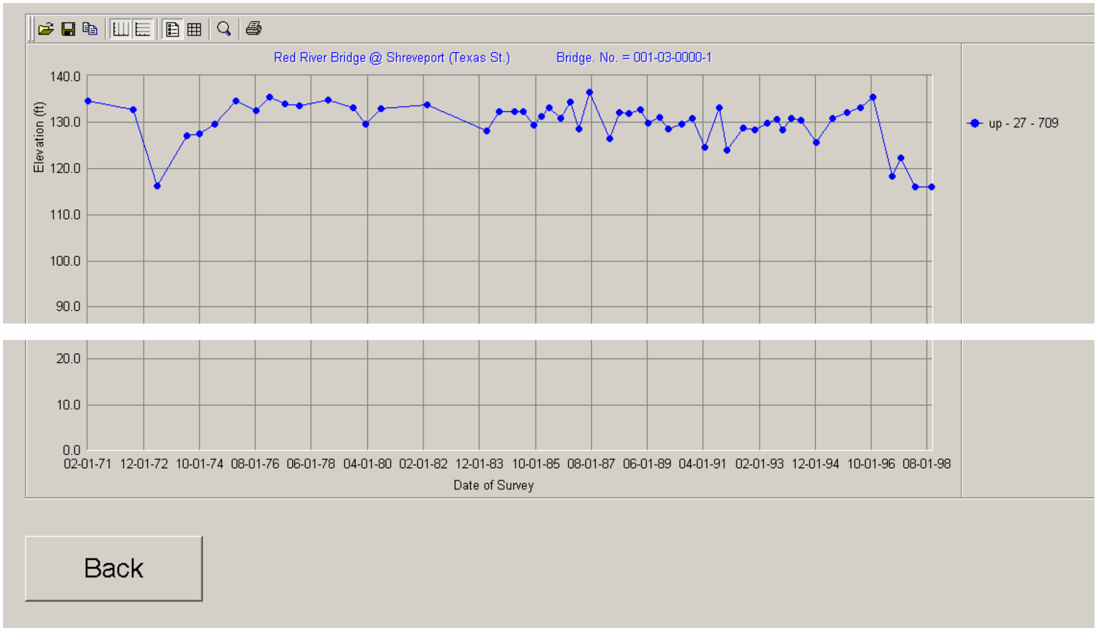

Figure 9. Tine plot showing the change of elevations near the pier at location shown in figure 8

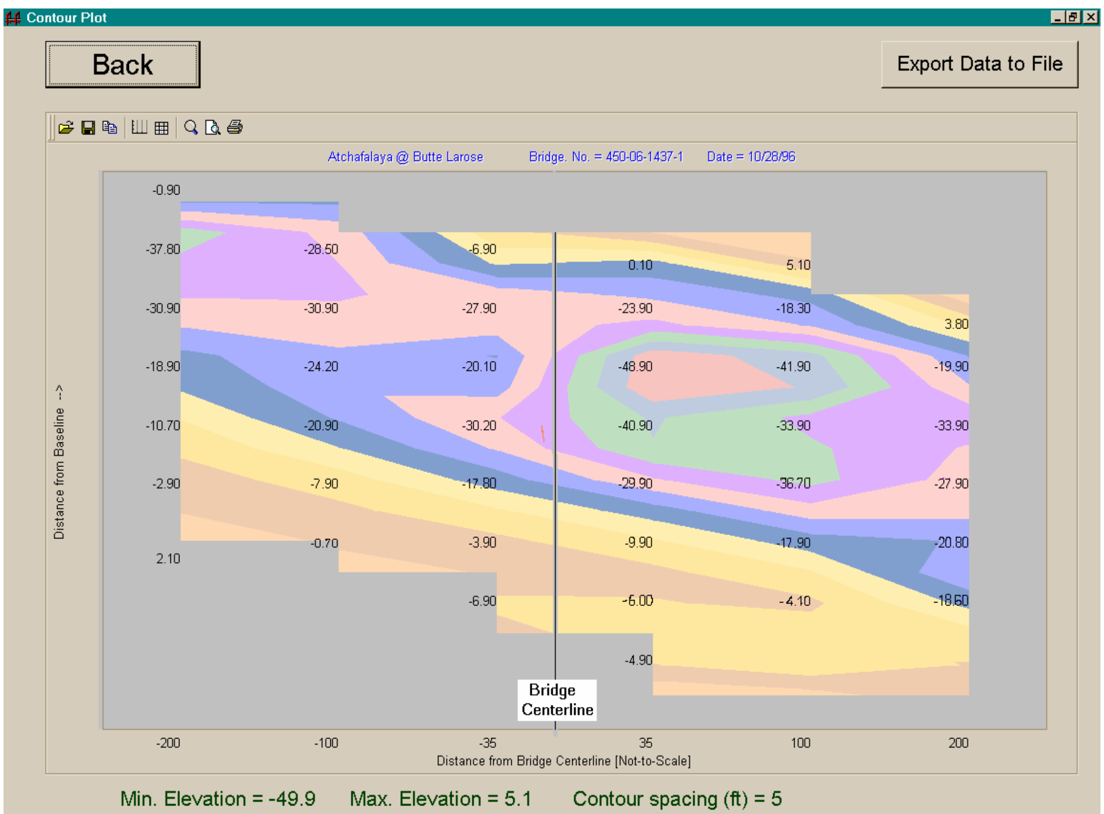

Figure 10. View of contour plot in the database program