

Final Report

FHWA/IN/JTRP-2000/9

Utilizing GIS Technology to Improve INDOT Pavement Friction Data Management and Distribution

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16. Abstract <p>Pavement friction condition provides an important parameter in selecting highway rehabilitation and maintenance projects. The Research Division of Indiana Department of Transportation has been conducting annual pavement friction testing on the Indiana highway network. Due to the large amount of data accumulated, an efficient system is in demand for data management. In this project, we developed a computer program that constitutes an integrated system for friction data management and distribution. In the developed system, database technology was utilized for data storage and organization; networking technology was utilized for real-time data distribution; geographic information systems (GIS) technology as well as computer graphics are used for data presentation and analysis.</p> <p>The new friction data management and distribution system can be characterized as having the following features:</p> <ol style="list-style-type: none"> 1. A user-friendly graphic interface. Users retrieve and analyze data through the graphic user interface (GUI). The interface is designed in such an intuitive way that minimal training is required for a user to work with the program. GIS technology was utilized in the form of an embedded map component in the user interface. The GIS component provides a powerful analytical tool by revealing data patterns that are not easily identifiable through other methods. 2. Behind the scenes database management. Database access and management is handled by the computer program "behind the scenes" so that no prior knowledge of database or computer programming is required from users. 3. Real-time data distribution. Friction data are automatically updated through the INDOT-wide area network to allow access of the most current data. The program is designed in a way to minimize network traffic. 					
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INDOT Research

TECHNICAL *Summary*

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Final Report

Utilizing GIS Technology to Improve INDOT Pavement Friction Data Management and Distribution

Introduction

Pavement friction condition plays an important role in roadway management. The Research Division of Indiana Department of Transportation (INDOT) has been conducting annual pavement friction testing on the Indiana highway network. The large amount data accumulated present a challenge for efficient and effective data management and distribution. Currently, friction data is distributed yearly in the form of written reports and computer disks that contain Microsoft Access database files. Several problems are associated with this form of data distributions. First of all, information retrieval is inconvenient. The users need to search through the written report or execute a query within the Microsoft Access program to find out any desired information. Due to the length of the written report, finding information has proven to be a cumbersome and time-consuming task. On the other hand, dealing

with Microsoft Access data requires working knowledge of the Microsoft Access program and an understanding of the database structure. Secondly, in the current form of data distribution, there exists a gap between the time when data is collected and the time when data is make available to the users.

In this project, we seek to improve the quality of INDOT friction data management and distribution by addressing the aforementioned problems. Specifically, we try to achieve the following goals: 1). To develop an intuitive and efficient tool for accessing, displaying and analyzing friction data. 2). To utilize geographic information system (GIS) technology for friction data analysis. 3). To develop a method that enables timely distribution of friction data by taking advantage of the newly established INDOT wide area network.

Findings and Implementations

In this project, a computer program was developed that integrates the friction database, a graphic user interface, network, and the GIS technology for friction data management and distribution.

All friction data are consolidated into one single database, allowing users to retrieve and make comparisons among current and historical data. The graphic user

interface (GUI) provides an easy and intuitive way for users to retrieve and analyze data from the database. The GIS technology was utilized in the form of an embedded map in the graphic user interface. The map component provides a powerful tool for data presentation and analysis, by revealing patterns that can not be easily identified with other methods. Network

technology was utilized to provide real-time distribution of the friction data.

The primary users of the computer program will be INDOT district and Roadway Management engineers. However, the program is designed in such a way that virtually anyone is capable of using it with minimal training. No previous knowledge of database, GIS or computer programming is

necessary for a user to run the program. The computer program can be installed on user's computer from a shared drive in the INDOT wide area network. Installation CD is also available if needed. Once the program is installed, the friction data are automatically updated every time a user runs the program. No user intervention is necessary for data updates.

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Problem Statement

The Indiana Department of Transportation Research Division conducts pavement friction testing for inventory, research and other special purposes. Pavement friction data is used by the districts and INDOT Roadway Management Division as an important consideration in selecting highway rehabilitation and maintenance projects. Currently, the friction data is distributed yearly in the form of written reports and computer disks that contain Microsoft Access data files. Several problems are associated with this form of data distributions:

1. Access of the friction data is inconvenient. The users need to search through the written report or execute a query within the Microsoft Access program to find out the desired information. Each report is typically several hundred pages long. The task of searching information through the report is usually cumbersome and time consuming. On the other hand, dealing with Microsoft Access data requires working knowledge of the Microsoft Access program and an understanding of the database structures.

2. Related and useful information of testing sites, such as historical friction data can not be directly obtained from the data reports.

3. In the current form of friction data distribution, there exists a gap between the time when friction data is collected and the time when the data is made available to the users.

Project Objectives

In the current project, we seek to address the aforementioned problems and to improve the quality of friction data management and distribution. Specifically, we try to achieve the following goals:

1. To provide an efficient and intuitive method for accessing, displaying and analyzing friction data.
2. To enhance the efficiency of friction data management by utilizing geographic information system (GIS) technology.
3. To distribute friction data in a timely manner by taking advantage of the newly established INDOT wide area network.

Project Activities

The major task of the project involves the development of a computer program (Friction Data Query Program) that integrates the friction database, a graphic user interface, and the use of GIS and network technology for friction data management and distribution.

The Friction Data Query Program was developed using the Microsoft Visual Basic 6.0 programming language. The program can be logically viewed as having a front-end portion and a back-end portion. The front end consists mainly of the graphic user interface (GUI). The GUI portion of the program presents information to the users, allowing data to be received, displayed and edited. The back end portion of the program handles the bulk of

the computation task, allowing data to be stored, retrieved, and manipulated. GIS technology was utilized in the form of an embedded map in the user interface. The software package MapObjects LT from ESRI Inc was used to provide the embedded GIS component.

All friction data are consolidated into one single database, allowing users to retrieve and make comparisons among current and historical data. The graphic user interface provides an easy and intuitive way for users to retrieve and analyze data from the database. The GIS component in the user interface provides a powerful tool for data presentation and analysis, by revealing patterns that can not be easily identified with other methods.

Detailed description of the Friction Data Query program can be found in the attached user manual.

Implementation

The primary users of the Friction Data Query program will be district and Roadway Management engineers. However, the program is designed in such a way that virtually anyone can use it with minimal training. No previous knowledge of database, GIS or computer programming is necessary for a user to run the program. The Friction Data Query program can be installed on user's computer from a shared drive in the INDOT wide area network. Once the program is installed, the friction data are automatically updated every time a user runs the program.

User Manual
For the Friction Data Query Program

Last modified: October 1999

Overview of the Friction Data Query Program:

Every year, the INDOT Research Division conducts friction testing on Indiana highways, including all interstate, state, and U.S. routes within the Indiana boundary. At least one test is taken at each reference post location of a given road. The measured friction number, along with information about the time and location of test, are recorded. All information is stored in a Microsoft Access database. The Friction Data Query Program is a computer program that provides an intuitive way for users to access and analyze the friction data stored in the Microsoft Access database.

The query program can be logically divided into two parts, a front end and a back end. The front end consists mainly of the graphic user interface (GUI). The GUI portion of the program presents information to the users, allowing data to be received, displayed and edited. The back end portion of the program handles the bulk of the computation task, allowing data to be stored, retrieved, and manipulated. The query program was developed using the Microsoft Visual Basic programming language. Embedded GIS technology was utilized so that a map component is included in the user interface. Friction data can be retrieved and displayed either in the map or in a tabular form.

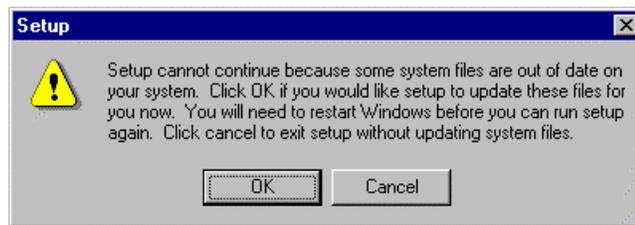
Installation of the Friction Data Query Program:

The Friction Data Query program is distributed through installation CD or through the INDOT wide-area network.

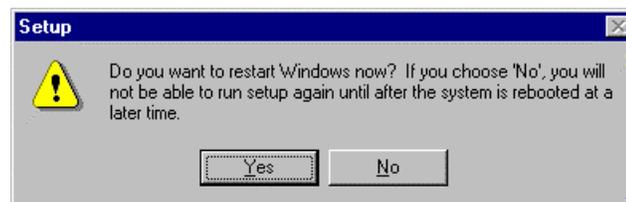
To install the program using the CD-ROM, insert the installation disk into the CD-ROM drive, open the CD-ROM folder on the user's computer, double click the setup.exe icon, and then follow the on-screen instruction.

To install the program from the INDOT network, open the **DIV.RESEARCH** folder in the **Y** drive, then open the **Friction Data Query** folder. Double click **setup.exe** (or **setup**), then follow the on-screen instruction.

In some cases during the setup process, depending on the configurations of the user's computer, certain system files may need to be updated. Before the setup program updates the system files, a message pops up, as shown below:



After the user selects OK, another messages window pops up, as shown below:



Once the user selects **Yes**, the computer will reboot. The user should then restart the installation process and follow the on-screen instruction.

Running the Friction Data Query Program

To start the program, click **Start** on the left corner of the task bar, highlight **Program**, and then select **Friction Data Query**.

Detailed Description of the Friction Data Query Program:

1. The user interface of the program:

Users interact with the query program through the graphic user interface (GUI).

Figure 1 shows the initial GUI at program startup.

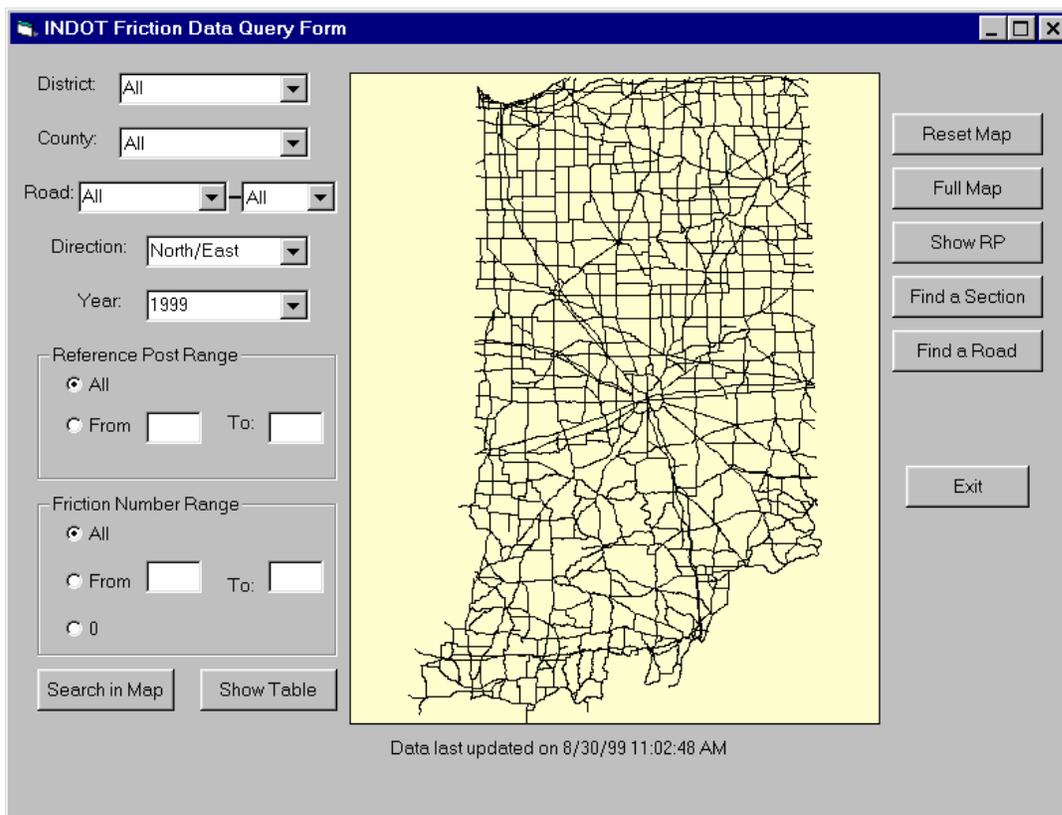


Figure 1. The graphic user interface of the Friction Data Query Program

The left portion of the GUI contains interactive components that allow a user to specify the friction data of his/her interest and submit the request. The middle portion of

the GUI is a map component that displays the Indiana roadways. The map is also capable of displaying all the road reference post by using reference post tags, as shown in Figure 2. The friction data are displayed in the map through the reference post tags with different colors. The right portion of the GUI contains several command buttons that allow the map to be manipulated. It also contains an **Exit** button, which terminates the program when being clicked.

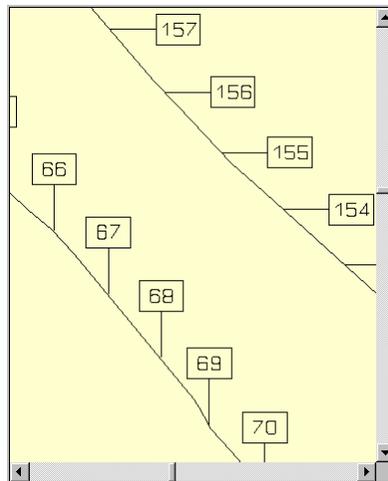


Figure 2. Example of road segments with reference post tags attached

(Road segments shown are US-52 between RP66-70, I-65 between RP157-RP154)

2. Individual component of the graphic user interface:

2.1.



The *District* list box is used to limit the search of friction data to a specific district of user's interest. When the down-arrow in the list box is clicked, the names of all six

INDOT districts are displayed (as shown in Figure 3). A user can select a specific district by highlighting the name. If a user is interested in data of all districts or is not sure about which district to choose, he/she can highlight **All**.

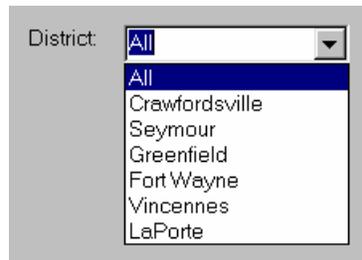


Figure 3. The *District* list box with districts names

2.2.



The *County* list box is used to limit the search of friction data to a specific county of interest. When the down arrow in the list box is pressed, a series of available county names appear in a drop-down list, as shown in Figure 4. If **All** is selected in the *District* list box, then the names of all Indiana counties are displayed in the county list. Otherwise, only county names within the specified district are displayed.

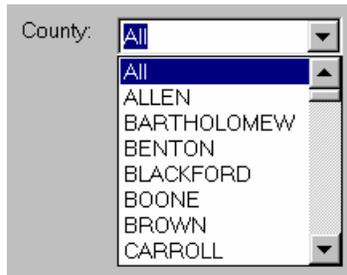


Figure 4. The *County* list box displays the names of Indiana counties

2.3.



Two list boxes are used to define a road of interest. The list box on the left side allows a user to select the road type, i.e. Interstate, State or U.S. route, as shown in Figure 5. The list box on the right side allows a user to choose the road number, as shown in Figure 6. When a specific road type is selected from the road type list, only existing road numbers of the corresponding road type are displayed in the road number box. To specify a road, *e.g.* interstate 65, a user should first select **Interstate** from the list on the left and then select **65** from the list on the right. If a user is interested in friction data of all interstate roads, he/she needs to select “Interstate” from the list on the left and **All** from the list on the right.

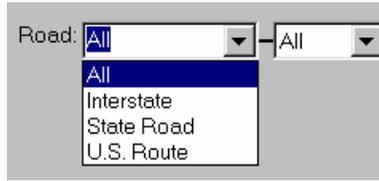


Figure 5. The list box displays road types

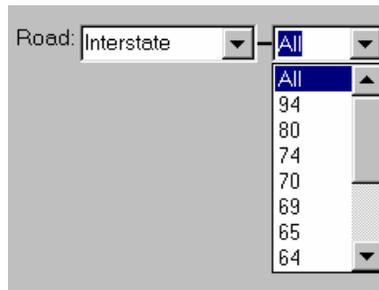


Figure 6. The list box displays existing road numbers of a specific road type

2.4.



The *Direction* list box is used to specify the road direction. There are three items in the drop down list: **North/East**, **South/West**, **All**, as shown in Figure 7. If searching results are to be shown in tabular form, all three items can be selected in the *Direction* list box. However, if results are to be shown in the map, only **North/East** or **South/West** can be selected. This is due to the fact that a road is represented as a single line in the map and that a reference post location on either side of a road is represented by the same reference post tag. Therefore, friction data can only be displayed one direction at a time on the map.

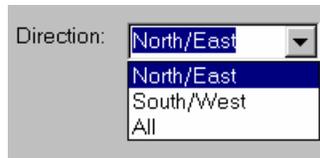
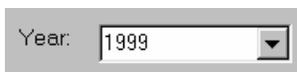


Figure 7. The *Direction* list box

2.5.



The *Year* list box is used to select the testing year of interest. The list box displays the years in descending order, starting from the current year and down to 1996, as shown in Figure 8. If results are to be shown in the map, only one single year data can be displayed at a time. However, if results are to be shown in tabular form, a user can select **All** in the list and then the data retrieved are not limited to one specific year.

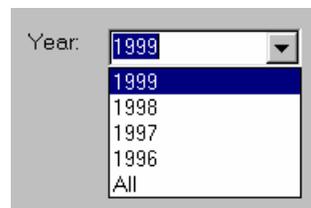
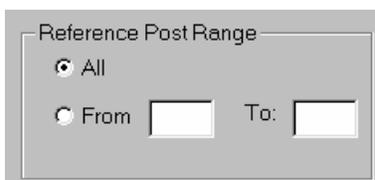


Figure 8. The *Year* list box

2.6.

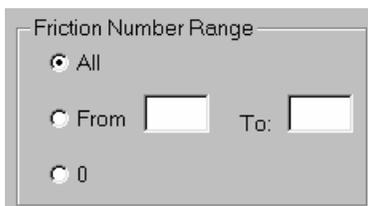


The *Reference Post Range* box is used to specify road segments of interest. Within the box, a user can select **All** for an entire road or select a segment of a road by specifying the starting and ending reference posts (Figure 9).

A dialog box titled "Reference Post Range" with a light gray background. It contains three radio button options: "All", "From", and "To". The "From" option is selected, and it is followed by a text input field containing the number "100". The "To:" option is followed by a text input field containing the number "110".

Figure 9. Selection of a road segment

2.7.

A dialog box titled "Friction Number Range" with a light gray background. It contains three radio button options: "All", "From", and "0". The "All" option is selected. The "From" option is followed by an empty text input field, and the "To:" option is followed by another empty text input field.

The *Friction Number Range* box is used to specify the data of interest with respect to the value of friction numbers. A user can select **All** to retrieve data with a full range of friction numbers. A user can also select a range of friction numbers by specifying the lower bound and higher bound of the range (Figure 10). When **0** is selected (Figure 11), road sections with no available test records are highlighted in the map.

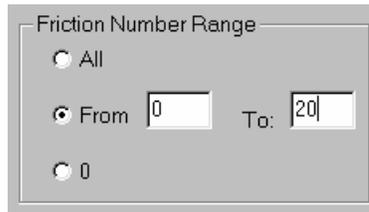


Figure 10. The *Friction Number Range* box.

(When a friction number range is selected, only records with friction number values between the specified range are retrieved.)

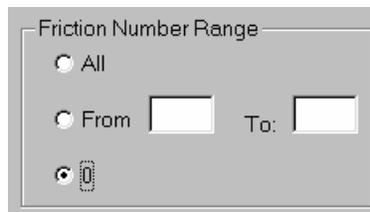


Figure 11. The *Friction Number Range* box.

(When **0** is selected, road segments with no testing records are displayed in the map)

2.8.



When this button is clicked, a query is sent to the friction database. Data (records) that match user's specifications (testing time, location, friction number ranges, etc) are retrieved from the database. These records are then displayed in the map through the reference post tags, with different colors of the tags denoting different ranges of friction number values. Figure 12 shows an example of such map display. In this example, the user specification is to show the friction data collected in 1998 on all Indiana roads. When the **Search in Map** button was hit, the results are shown in the map. By default, records with

friction number values under 20 are shown in red; those with friction number values between 20 and 30 are shown in blue; while those with friction numbers above 30 are shown in green.

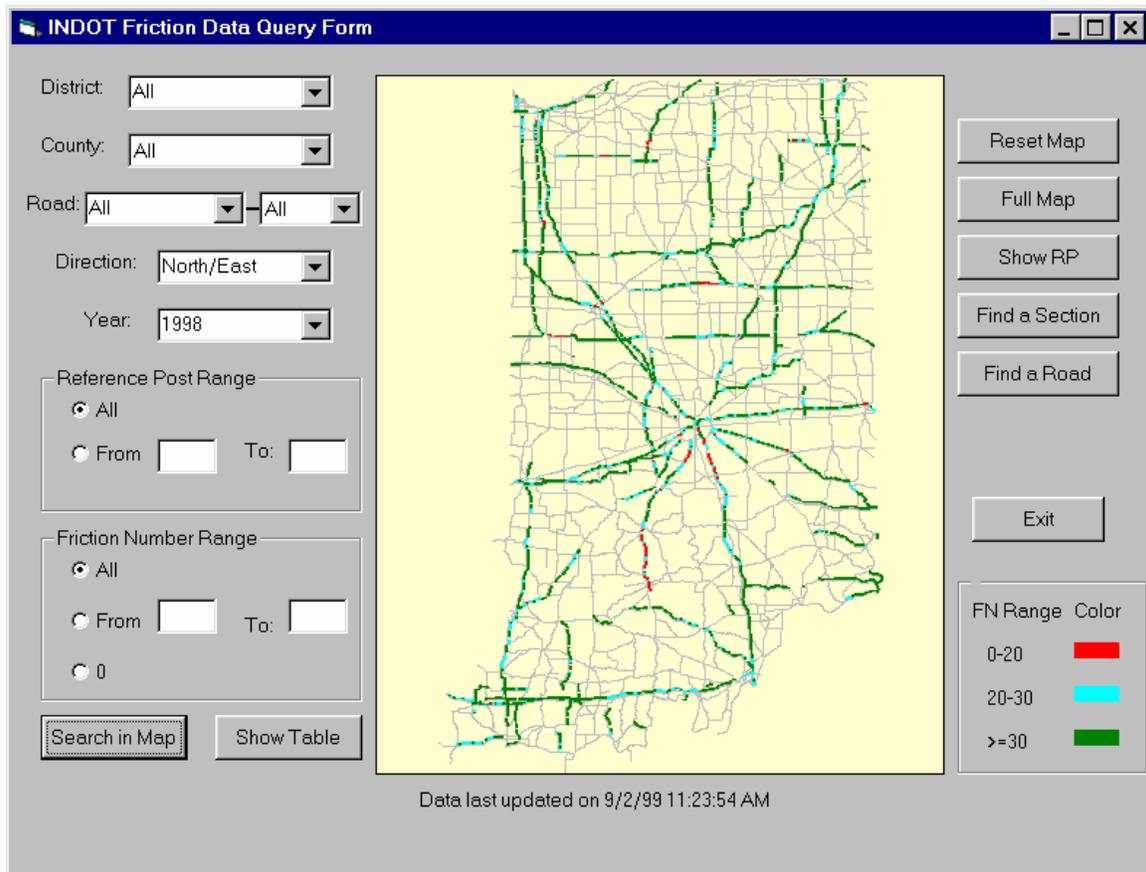


Figure 12. Example of query results displayed in the map component

To expand a certain part of a map display, place the mouse cursor in one corner of the desired region, press the left mouse button and drag the mouse. When the cursor reaches the opposite corner of the region, release the button. The selected area is zoomed and displayed in the map. An example of a zoomed portion of a map is shown in Figure

13. The map content in Figure 13, which is an expanded portion of the map shown in Figure 12, displays a segment of a road with low friction numbers. To identify the name of the road, place the mouse cursor on any part of the road line and click the right mouse button. As a result, the name of the road is displayed in a pop-up window. Unfortunately, at this time the road names can not be directly labeled in the map due to the limitation of the software used. To move the map content around in an expanded mode, place the mouse cursor in the center of the map, use the left button to drag the map content while pressing the Shift key on the keyboard.

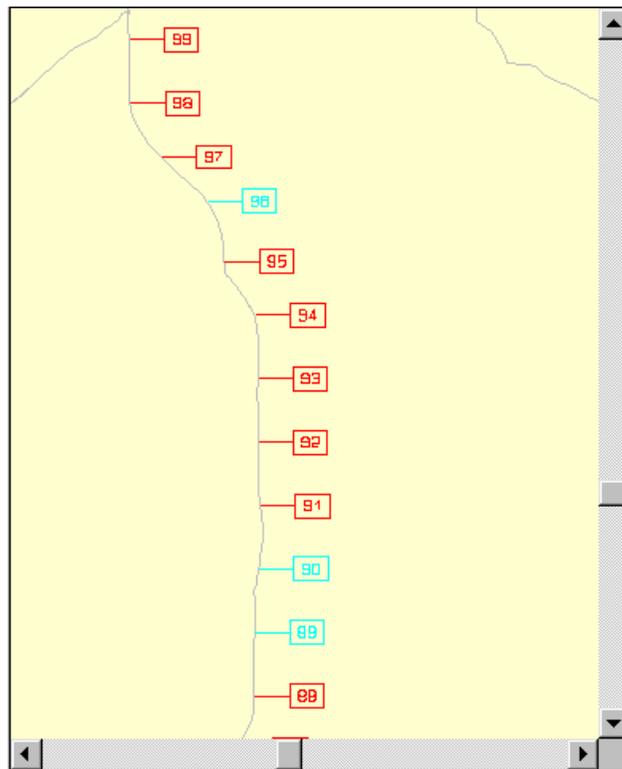


Figure 13. An expanded part of a map

2.9.



When this button is clicked, a query is submitted to the friction database, all records that meet user's specifications are displayed in a table, shown in a separate window.

A typical output window is shown in Figure 14.

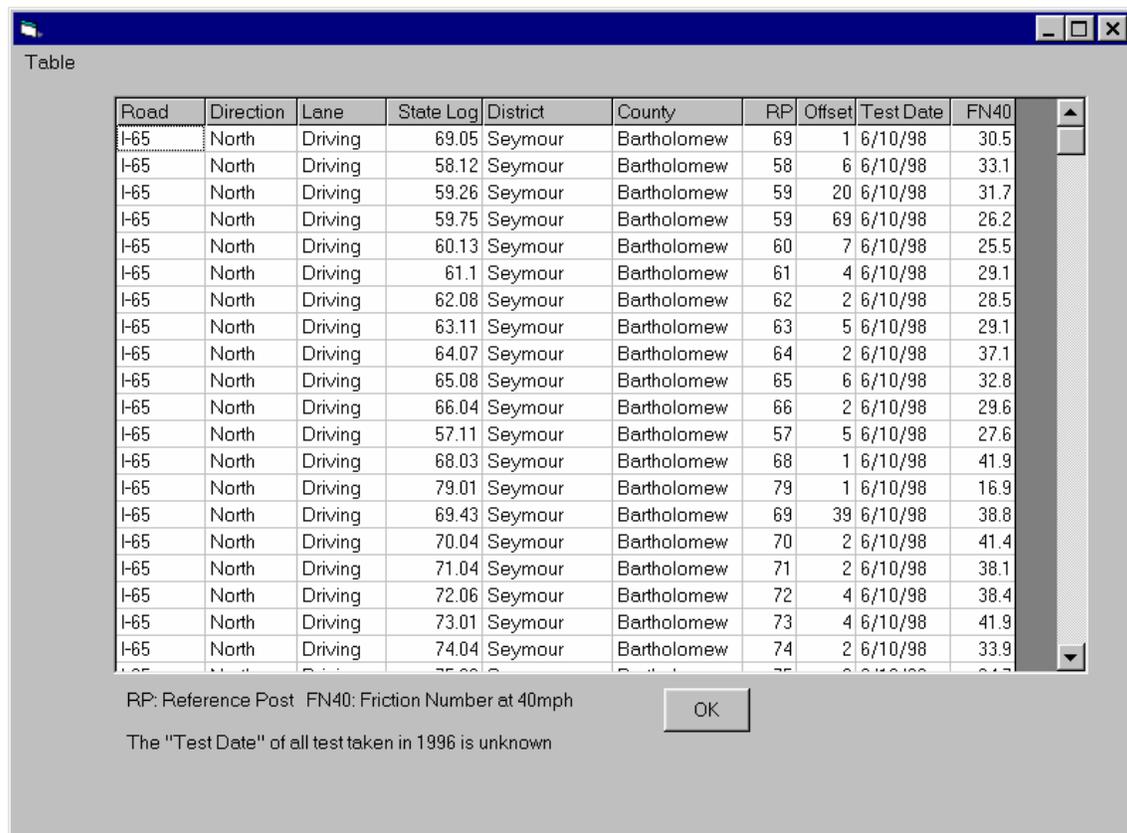


Figure 14. The output window contains a table that displays user-requested friction data

The main part of the output window is a grid table, which displays the data retrieved from the friction database. The displayed information includes location of test

(road, direction, lane, state log, district, county, reference post, reference post offset), time of test, as well as the friction number measured at 40mph driving speed (friction numbers measured at speed other than 40mph are converted according to a speed-friction number correlation equation).

The content of a table can be saved into a text file so that it can be imported into other programs such as Microsoft Excel. To save the content of a table, click the **Table** menu on the upper left corner of the output window, then select **Save** from the pull-down list.

To print out the content of a table, click the **Table** menu; then select **Print** from the pull-down list. A pop-up window then appears that provides users with different options for printing. The pop-up window is shown in Figure 15.

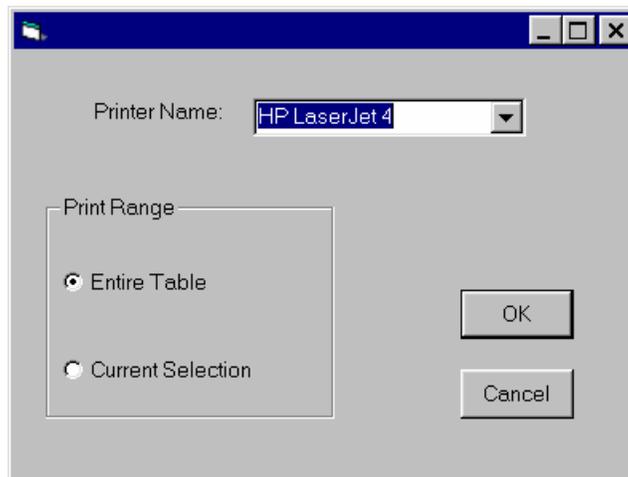


Figure 15. The pop-up window contains options for printing

The user can select a destination printer from a list of printers available to the user's computer. The user can also choose to print the entire table or to print a selected part

of the table. To print certain part of a table, use the mouse cursor to highlight the desired part, then select <Print> from the <Table> menu. In the pop-up window, select “current selection” from the “Print Range” box, and then click the OK button.

The content of a table can be sorted according to a specific column. To sort a table, go to the **Table** menu, select **Sort** from the pull-down list. A small box will appear in the center of the table, as shown in Figure 16. The user can then select the sort column and the sort order (ascending or descending).

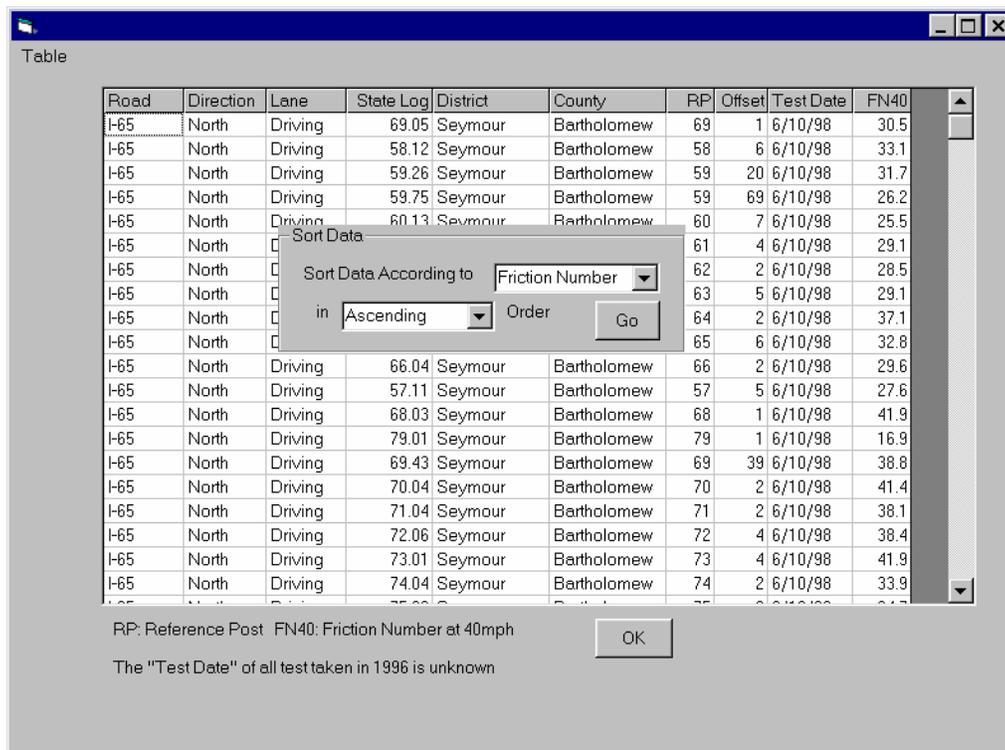


Figure 16. The *Sort Data* box allows users to specify the sort column and order

2.10.



When this button is clicked, any map display resulted from a search is cleared.

2.11.



When this button is clicked, the full content of the map is shown if the map was in an expanded mode.

2.12.



When this button is clicked, all roads in the map are labeled with reference post tags.

2.13.



When this button is clicked, a window pops up (as shown in Figure 17). A user should enter the name of the road and desired reference post range, then press the **OK** button. As a result, the specified road segment along with the corresponding reference post tags is shown in the map.

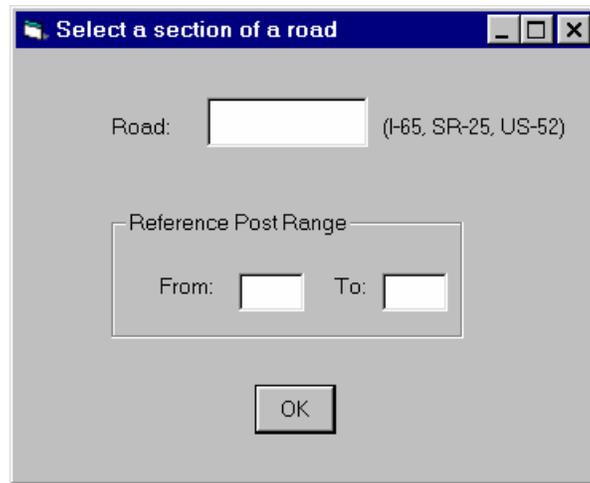


Figure 17. The *Select a section of the road* window allows a user to enter a road name and a reference post range

4.2.14.



When this button is clicked, the user is prompted to enter a road name. As a result, the specified road is shown in the map, highlighted in red.