Research Report
KTC-05-03/SPR 227-01-1F

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KENTUCKY GEOTECHNICAL DATABASE

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Research Report KTC-05-03/SPR227-01-1F

Kentucky Geotechnical Database

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in cooperation with the
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16. Abstract

Development of a comprehensive dynamic, geotechnical database is described. Computer software selected to program the client/server application in windows' environment, components and structure of the geotechnical database, and primary factors considered in constructing the database are discussed. Oracle®8i, PowerBuilder®8, and Map Object® software were used to construct the database, build graphical user interfaces (GUI), and embed roadway maps, respectively. Any number of users may use the database simultaneously. Twelve highway district offices and several central offices of the Kentucky Transportation Cabinet are connected to the database. Data may be entered and retrieved dynamically in the client/server structure.

This report is the fourth of four, recently completed, research studies. It summarizes all studies and describes the integration of major components of the database. Components include rock slope, landslide, and soil and rock engineering data. The first two studies, conducted in the mid 1990's, focused on potential rock slope hazards and the development of a rock slope management system. The rock slope component of the database provides procedures for gathering field data and rating the hazardous conditions of rock slopes. About 2100 of about 10,000 observed rock slopes were classified as potentially hazardous and rated numerically using the Oregon DOT's Rock Slope Hazard Rating System. The third research study and report, which was published in 2003, focused on landslides. The landslide database provides programmed procedures for gathering field data, rating the severity of a landslide, and describes a management system. About 1,400 landslides were identified and rated using a simple system devised by the University of Kentucky Transportation Center and the Kentucky Transportation Cabinet. Latitudes and longitudes of rock slope and landslide sites were determined using Global Positioning System equipment (sub-meter accuracy). Attributes, including JPEG-format photographs and latitudes and longitudes, of rated rock slope and landslide sites are stored in the comprehensive database. A priority list of hazardous rock slopes and landslides can be generated rapidly.

The main focus of the fourth, and current, study focused on soil and rock engineering data generated during geotechnical investigations and testing. This report dealt more with developing specific database features, simplifying data entry schemes, and expanding retrieval capabilities and flexibilities. A large amount of additional soil and rock geotechnical engineering data was entered during the current study. Information in this report is presented in three parts: rock slopes, landslides, soil and rock engineering data, which reflects the historical accumulation of these components under separate studies. Several schemes for retrieving data and generating reports are described.

Secondary components of the database include statistical analyzers and engineering applications for performing "on-line" analysis of data, developing correlations between different soil parameters, and performing engineering analysis and designs. Procedures for entering historical soil and rock engineering data have been developed and programmed. Issues concerning database security, engineering units, and storing and displaying maps, graphics, and photographs are discussed. The database contains procedures for dynamically overlaying the locations of landslides, rock slopes, and borings onto embedded roadway and digitized geological maps. Strategies and illustrations of graphical user interfaces for data entry and retrieval are described.

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FOREWORD

Each year the Kentucky Transportation Cabinet (KyTC) spends considerable funds developing plans for proposed transportation facilities and also remedial maintenance plans for failure situations. Gathering geotechnical engineering information represents a major investment in time and money and plays a vital role in the development of transportation plans. Geotechnical engineering information is essential in developing economical plans and is the first type of information needed in planning new facilities. Regardless of whether geotechncial investigations and laboratory testing are performed in-house or by geotechnical consultants, this work involves considerable costs. Although large investments of money and time have been made in past investigations, fast retrieval of existing geotechnical information is difficult when it exists only in paper form. Hence, the ideal of developing a system that could store and rapidly extract geotechnical information served as the guiding principle in development of the Kentucky Geotechnical Database. Development of a "user-friendly" system that could be made accessible to a large number of users was considered vital.

The Kentucky Geotechnical Database will serve many purposes and uses. Not only will it provide a means of retrieving soil and rock data rapidly, but also it provides systems for managing landslide and rock slope problems. Geotechnical data will be useful in planning transportation facilities. Although the need to perform geotechnical field investigations will continue, reliable soil and rock data at a study site can reduce the amount of fieldwork and laboratory testing required, especially in reconstruction projects in urban areas where roadways are heavily traveled. Using soil and rock data–information that has already been bought--will represent large savings in the future. Knowledge provided by the database of landslide-prone geological areas will be vital to planners in avoiding past mistakes. Database information of geological areas where numerous highway rock slope problems exists can aid engineers in designing safer rock slopes and avoiding past mistakes. The data will also be useful in research studies, examining seismic-prone areas of the state, and providing vital data for the economical development of Kentucky. The twelve highway district offices and key central offices of the Kentucky Transportation Cabinet are connected to the database by the client-server structure. The database provides a good system for managing the geotechnical highway assets of Kentucky.

However, the client-server structure and design are being mimicked in building a dynamic web site so that the Internet can be used to access the database worldwide in the future. Consequently, transportation and local planners and future potential investors can readily access soil and rock, landslide, and rock slope information of Kentucky sites.

The talents, contributions, and support of many individuals and agencies were required in the development of the comprehensive geotechnical database described herein. Earlier works published in 1962 and 1966 by Dr. Robert C. Deen, former Director of the University of Kentucky Transportation Center (UKTC), served as forerunners to development of the soil portion of the database. Soil engineering test data generated during that period in collaboration with the Soil Conservation Service (U.S Department of Agriculture) has been included in the current database. Dwight Spradling, former associate research engineer at UKTC, first proposed a computerized soils data system for Kentucky in 1972. He provided many details for the system he proposed. The authors wish to dedicate this report to Dr. Deen and Mr. Spradling for their vision in seeing the need of a Kentucky soil database.

Bill Pfalzer, former research engineer at UKTC and a former Transportation Engineer of KyTC, developed much of the original structure of the soil portion of the database in the seventies and the rock portions in the nineties. The soil engineering data at this early stage was contained in a D-base format. In this current study, Mr. Pfalzer served as liaison between the Kentucky Transportation Cabinet and the Geotechnology Section of the University of Kentucky Transportation Center. By providing this valuable link on a daily and weekly basis, he insured that the needs of KyTC were met. He also provided a large portion of the content for most of the site level data entry screens since personnel of KyTC performed most of the data entry, other than the rock slope and landslides data entries. He also developed the "Simple Search GUI screen." With new emphasis on boring and sample level data entry, he supervised this data entry and designed data entry screens for attributes, project type (except MSE walls), borings,

RQD percent recovery, soil and rock samples, and soil and rock properties (except resilient modulus), and revision of some landslide graphical user interfaces.

The senior author (program manager and chief research engineer of the Geotechnology Section at UKTC), Tony L. Beckham, Research Geologist and report author, and Liecheng Sun, Research Senior and report author, revived the concept of building a soil and rock geotechnical database. However, the concept was transformed into building a comprehensive geotechnical database that would also include rock slope and landslide data. The senior author was instrumental in selecting the Oracle and PowerBuilder software and provided overall management of the various facets of the database development, and made numerous structural suggestions. Liecheng Sun and Mikhail Slepak, former research engineer at UKTC, performed evaluations of the selected software, as well as other software, to confirm the selection. Mikhail Slepak programmed initial portions of the database software. However, most portions of the database were written by Liecheng Sun. He was able to transform drawn-on-paper ideas of his own and the other authors into reality on the computer screen. His style created very attractive and user-friendly graphical user interfaces. He invented an array of ideas pertaining to data entry, data manipulation, and data retrieval schemes. He also programmed algorithms into the program for transforming latitude and longitude into state plane coordinates and vice versa. He also developed techniques using Map Object® for embedding roadway maps and geological Quadrangles. Those techniques provided means of dynamically overlaying landslide, rock slope, and boring locations onto embedded maps.

Tony Beckham was closely involved with and responsible for the collection of all rock slope and landslide data. With the able assistance of Barry Butcher, former research investigator at UKTC, Beckham supervised student teams who gathered much of the field data concerning rock slopes and landslides. This included the measurements of slopes, developing rock hazardous ratings, and GPS determinations of latitude and longitude. He and Mikhail Slepak developed the rock slope graphical user interfaces. He supervised rock slope and landslide data entry, and portions of soil and rock data entry. His careful eye for detail helped insure accurate data entry.

Finally, the idea of including sections for statistical analysers and engineering applications originated from the senior author. By making available statistical analyzers in the database, the user may analyze a selected set of data on screen without having to download the data. Although the section containing engineering applications is in an infant state, software (and theory) developed and programmed by the senior author, Liecheng Sun, and Mikhail Slepak for performing stability analysis of reinforced and unreinforced slopes, walls, and the bearing capacity analyses of reinforced layered foundations has been included in the database. Other software developed by Bixain Ni, former research engineer, analyses the stability of landslides where (drilled-in) railroad steel rails are used as a restraining structure. Also included in the applications section are resilient modulus data and mathematical models invented by the senior author, Bixain Ni, and Liecheng Sun (and others) for analyzing resilient modulus data. By including software and analysers, users can perform many tasks on line. Tony Beckham supervised all resilient modulus equipment setup and testing.

Henry Mathis, former Branch Manager of the Geotechnical Branch, the Kentucky Transportation Cabinet, worked for several years promoting the concept of building a landslide and rock slope database. His foresight and promotion were very valuable in making the development of the database a reality. The authors wish to acknowledge the sponsorship and support provided by the Federal Highway Administration and the Kentucky Transportation Cabinet. The support provided by Bill Broyles, Branch Manager of the Geotechnical Branch of KyTC, Marcie Mathews, Research Coordinator for KyTC, and Mr. Paul Toussaint, director of UKTC, are recognized.

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EXECUTIVE SUMMARY

The Kentucky Geotechnical Database is a comprehensive, large, and broadly ranging Oracle® database system for managing geotechnical information. The database has been developed over a period of several years, as a joint effort of the Kentucky Transportation Cabinet and the University of Kentucky Transportation Center. This fourth report provides a discussion of work performed on the database during this study and describes various features of the database as they relate to three past database studies, each of which contributed significantly to continuing development of the database. Through the course of the current study, PowerBuilder® software was used to construct graphical user interfaces (GUIs), which simplify data entry and retrieval.

The first and second of the four studies, conducted in the early nineties, addressed potential rockfall hazards that occur on roadways maintained by the Kentucky Transportation Cabinet. In the first study, preliminarily ratings were performed at about 5,270 rock-cut sites using the Oregon DOT Rockfall Hazard Rating System (RHRS). One hundred and eighty-one of those slopes were rated “A,” which indicated that, visually, the rock slopes were potentially hazardous. Another 1,264 of the 5,270 rock-cut slopes were given a rating of “B,” which indicated that the rock slopes could be potentially hazardous, but the rater was not certain. In the first study, numerical ratings of the 181 rock slopes were performed using the rock slope hazardous rating system (RHRS) devised by the Oregon Department of Transportation. The Federal Highway Administration (FHWA) and ten other states sponsored the development of the numerical rating system. The RHRS method numerically evaluates nine components of a rock slope and adjacent roadway. This study recommended that all rock slopes on major highways under the jurisdiction of the Kentucky Transportation Cabinet be evaluated. It was recommended that the RHR system be used statewide as a means to manage rockfall sites. Summing numerical results of the nine components yields a total score or hazardous rock slope rating. Those data were published in a report in 1996.

During the period 1996 to 2003, hundreds of additional sites were added to the database information and a total of 2,100 (initially rated “A” and “B”) were rated numerically using the RHR system. A total of about 10,000 rock cut slopes were given preliminary ratings. A slope rating of “A” was considered very hazardous while a “B” rating was uncertain as to the hazardous nature of the slope. As judged by the reviewer, many slopes were rated “C,” which indicated that they did not pose any hazard. Moreover, in this second study, a rock slope management system was built in a client/server application to provide the means to conveniently add all data to the geotechinical database. All data was deposited on a server of the Cabinet in a central location so that all personnel would have access to the data. Highway personnel could interact with this component of the database from any location in the state. Data could be entered and retrieved at all Highway District offices and key central offices of the Cabinet.

The third study dealt with highway landslides that occur on roadways maintained by the Kentucky Transportation Cabinet. In that study, about 1,400 slides were categorized as A) Very Serious, B) Serious, C) Moderate and D) Minor. A landslide database management system was built in a client-server application and composes the second major portion of the database. Attributes, JPEG-format photographs (embedded in the Oracle database), and GPS locations of the 1,400 highway landslides are contained in the Kentucky Geotechnical Database. A description of this work was published in 2003 and portions of that study are summarized herein. The database facilitated this work, as well as, providing a powerful tool for managing the data and simplifying both storage and retrieval.

The fourth, and current study, dealt more with development of specific database features, and particularly graphical user interfaces (GUI) screens, which make the database user friendly. This report summarizes and describes the major components of the comprehensive geotechnical database. As a part of this work, a series of landslide GUIs, to facilitate evaluating the cost and performance of individual landslides throughout the state, were developed. These GUI screens, as well as many other aspects of the database in general, were discussed in a landslide report published in February 2003. Similarly, GUI screens were developed to facilitate storage of the rock slope data. These screens were not shown in the original report on rockfall (1996), because they had not yet been developed. However, they are presented in this report. The first project-type of GUI for rock slopes gives total score, preliminary class, the date the rock slope was evaluated, and by whom, and any related comments. The next-to-last rock slope GUI is a summary page, ideal as a printed record, while intervening GUIs record the various components used to evaluate rockfall hazard. Photos of these potentially hazardous rock slopes are stored in the last rock slope GUI.

Also, as a part of the current study, input screens to facilitate the input of borings and sample level data were developed, and a great deal of additional data were entered. Although most available sites had been entered prior to the initiation of this study, the entry of borings and samples was just getting a good start when this project began. During the 15 months prior to the initiation of this study the number of borings had increased from 332 to 3652. Then during the course of this project, the number of borings further increased to 20,388. The number of tested soil samples also increased impressively during the course of this project, from 4873 to 24,561, while the number of described rock core samples increased from 1205 to 11,536. Although the addition of real boring data was partly intended to populate the database for users, another main intent was to provide data so that various GUI screens and retrieval screens could be tested.

Information in this report is presented in three sections (rockfall, landslides, and soil and rock engineering data) that reflect the historical accumulation of these components under separate studies conducted by the Kentucky Transportation Center, as well as separately by the Department of Transportation (the entry of "other" sites such as bridges, culverts and roadways). The database, however, is actually more unified than might appear from this structure. Where differences remain, efforts are currently underway to structure all types of sites in a similar manner whenever possible. A subsequent Users Guide for the Kentucky Geotechnical Database, which will emphasize a more unified structure, is anticipated. Some major technical components of the database are described. These include entity relationship for the database, listings of all database tables and names, and a data dictionary of all parameters used in the database. In development of the database, the general guiding philosophy was that transportation facilities are assets and the database should be in manner to provide management of those assets. Although the current database has been developed as a client/server system, it is recommended that this application be replicated and developed for the Internet, as a means to advance the use and accessibility of the geotechnical database.

INTRODUCTION

Background

In planning, reconstructing, or maintaining, highways, knowledge of the occurrences and types of rock falls and landslides and engineering properties of soils and rocks in an area are essential to optimize design and minimize costs. From past experience, the cost of excavating and placing soil and rock is some ninety percent of the total cost of constructing a new highway in mountainous country. In flat to rolling terrain, the cost is some fifty percent of the total cost. Performance of a highway is directly related to types of soil and rock located in the highway corridor. Slope geometry selected for embankments and cuts in mountainous country largely affect both initial and future maintenance costs. Stabilities of embankment slopes and rock cuts are dependent on strength properties and weathering characteristics of the geological (rock and soil) units. Strengths of compacted soils and rocks greatly control the slope angles of embankments. Both cut and embankment slope angles dictate right-of-way requirements. Engineering properties of the materials used in the embankment subgrade have a large affect on the performance of pavement. Excessive settlement, failure of the embankment, or a weak subgrade can cause premature failure of the pavement. Uneven pavements can cause traffic safety problems. Consequently, in planning highway facilities, first-hand knowledge of geotechnical information characterizing soil and rock units within the project area, during the design phase, is invaluable. Moreover, knowledge of past performance of soil and geological units in rock cut slopes and embankments can aid in reducing failures. The number of embankment and cut-slope failures in a region alerts the designer of potential design problems. In reconstruction of existing roadways, geotechnical drilling to determine foundation conditions and to retrieve soil and rock specimens for testing will be extremely difficult, dangerous, and costly as traffic volumes increase. Hence, the collection of soil and rock engineering and "capturing' geotechnical data as it is generated will be extremely important.

The maintenance of highway rock slopes and the correction of landslides were identified by engineers of the Kentucky Transportation Cabinet as major engineering problems that involve considerable expenditures (millions of dollars) of funds each year. The importance of storing geotechnical engineering soil and rock data developed during geotechnical investigations was also recognized as a valuable tool in planning new transportation facilities and in the repairing rock slopes and landslides. The Federal Highway Administration (FHWA) has strongly suggested to all states that rock slope and landslide inventories be developed so cost estimates and, eventually, remedial plans may be developed. Such information could be used to inform the United States Congress for potential funding and to create a program similar to the Bridge Replacement Program. This report and the inventories of rock slopes and landslides on Kentucky's highways and described herein are in response to the suggestion by FHWA, Hopkins, et al (1988), Mathis[1], and Lutton (1977). The report represents an attempt to define the scope of highway rock slope and embankment problems in Kentucky on major routes. The Kentucky Geotechnical Database described herein provides the means of defining actual

[1] Private communication, former geotechnical engineer and Branch Manager of the Geotechnical Branch, Division of Materials, Kentucky Transportation Cabinet, Frankfort, Kentucky.

numbers of potentially hazardous rock slopes and landslides on highways under the jurisdiction of the Kentucky Transportation Cabinet. These efforts represent the first major step toward initiating a managed effort toward developing engineering corrections of rock slope and landslide problems in Kentucky. To develop an effective management plan requires identifying and developing information of rock slope and landslide sites where future corrections and reconstruction may be needed to improve safety and maintain or increase traffic capacities.

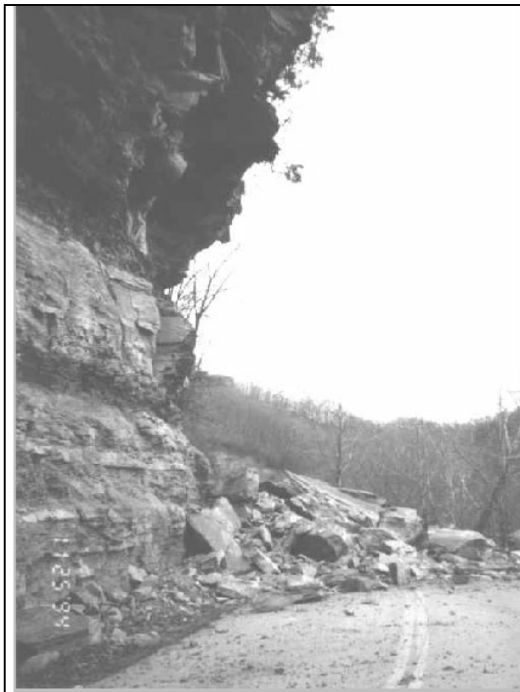


Figure 1. Massive rock fall on KY 1098 in Breathitt County

Figure 2. Highway embankment failure on KY 847 in Owsley County.

Most highways in Kentucky are more than four decades old, and as they continue to age, highway cut slopes and embankments deteriorate and occasionally collapse with dramatic impact to the highway, as illustrated in Figures 1 and 2. Highway rock slopes exposed to rain and snow, many cycles of freezing and thawing, extreme differences in temperature, and natural chemical reactions, weather over time and frequently produce rock falls that are hazards to the traveling public (Hopkins, Beckham, and Puckett 1996, Hopkins and Gilpin 1981, and Hopkins and Deen 1983). Rock slope repairs have been costly and extensive in Kentucky. For instance, emergency funding to repair the slope in Figure 1 was about $250,000. Numerous examples of rock slopes that have required costly repairs have been described elsewhere (Hopkins, Beckham, and Puckett 1996) and herein.

As noted by Bjerrum (1967), Skempton (1964), and Hopkins, et al. (1975, 1988), many factors cause landslides. Well-known landslide causes include erosion of the toe of embankments, which removes support, the gradual intrusion of water into the embankment which increases forces tending to move the embankment down slope, a lowering of available shear strength to resist the pull of gravity, and rapid drawdown of streams which occurs during flooding as floodwaters recede (Hopkins et al, 1975 and Hopkins, 1988). Embankments constructed more than four decades ago were oftentimes built at steep slope angles. Steep slopes promote the gradual reduction in shear strength available to resist failure and cause instability.

In many instances, past shale compaction specifications were inadequate to prevent excessive embankment settlement and instability, as illustrated in Figure 3 (Hopkins and Gilpin 1981; Hopkins and Deen 1983; Hopkins 1988 et al.; and Hopkins and Beckham 1998, 2000). Because of poor compaction of shales, numerous embankment landslides developed on Interstate 75 (Lexington, Kentucky to Cincinnati, Ohio) and Interstate 71 (Louisville, Kentucky to Cincinnati, Ohio). Because the shales in the geologic units (Kope and Fairview) appear very firm, and rock-like, when initially excavated, they were compacted in thick lifts (36 inches), which created large voids in the embankment. As water intruded into the embankment, the shales degraded into soil and caused large settlements and finally instability. More than 200 million dollars has been spent over the past four decades repairing the embankments on these intervals of I 75 and I 71. The repairs averaged about 2 million dollars per mile. Berms were used to repair most of the embankments.

Figure 3. Example of large embankment settlement on I 75 about two decades after construction in Northern Kentucky *(After Hopkins and Beckham, 1997, 1998).*

Shale specifications developed in the past two decades (Hopkins and Beckham 1998) specified using 12-inch lifts and breaking the shales down into soil-like materials using extra heavy compactors. This technique has been used extensively in recent years. For example, the new shale specifications were used to compact the embankments of the Alexandria-Ashland highway (built in the mid-eighties and now identified as Ky 9) in Northern Kentucky. Embankments on this highway were constructed with the same type of shales (Kope Formation), or shales of a similar nature (Crab Orchard), that were used to construct the I-71 and I-75 embankments. Embankment failures on Ky 9 (AA) are almost non-existent. If the behavior of embankments on Ky 9 had followed the behavior of I 75 and I 71 embankments, then repair costs would have exceeded 150 million dollars. Adoption and application of the changed shale compaction specifications have saved the Cabinet millions of dollars. Long-term observations of embankments constructed using the changed shale compaction specifications have shown excellent performance. The embankments have generally been very stable and settlements are very small (Hopkins and Beckham, 1998).

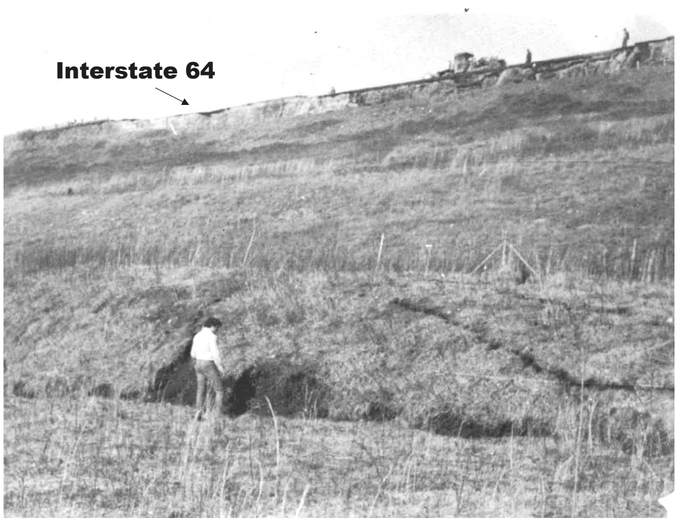


Figure 4. Large embankment failure on I 64 near Owingsville, Kentucky and MP 118, 1973.

Embankment landslides and cut slope failures in soils and rock in Kentucky have been extensive and expensive. Although weak embankment materials have frequently been involved in creating the failure, many landslides occurred because the embankments were constructed on weak foundation soils and clayey shales. Failure often occurs between overlying soil and underlying shale. For example, the massive embankment failure shown in Figure 4 occurred in 1973 near Owingsville, Kentucky about four years after construction (Hopkins 1973). This failure occurred because of

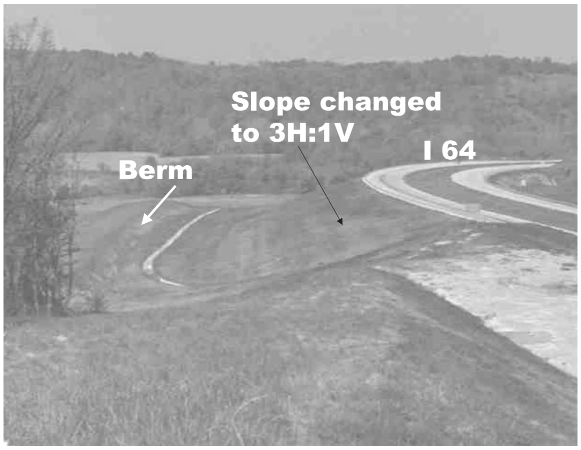


Figure 5. View of berm used to repair I-64 embankment failure (after Hopkins 1973).

a gradual water table rise into the embankment, which was composed of weak, weathered residual clayey shales and soil. When failure occurred two lanes of Interstate 64 were destroyed. Fortunately, the large movements of the slide were monitored with slope inclinometers and fatalities were avoided after the failure. A large berm and decreased slope angle, Figure 5, was used to repair the embankment failure at a cost $430,000. Today, this cost would be more than 1.5 million dollars.

Some of the more expensive embankment failures have occurred in bridge approach embankments (Hopkins 1973; Hopkins and Yoder 1973). For instance, in 1969 the eastern and western embankments of the twin bridges on the Bluegrass Parkway spanning Chaplin River, shown in Figures 6 and 7, were failing and moving toward the concrete abutments and piers. Movements were so severe that the concrete abutments developed large cracks and the real danger existed that the large bridge approach embankments would completely collapse and drop all end spans of the twin bridges into the river. Such action would have closed the parkway for months. Causes of the

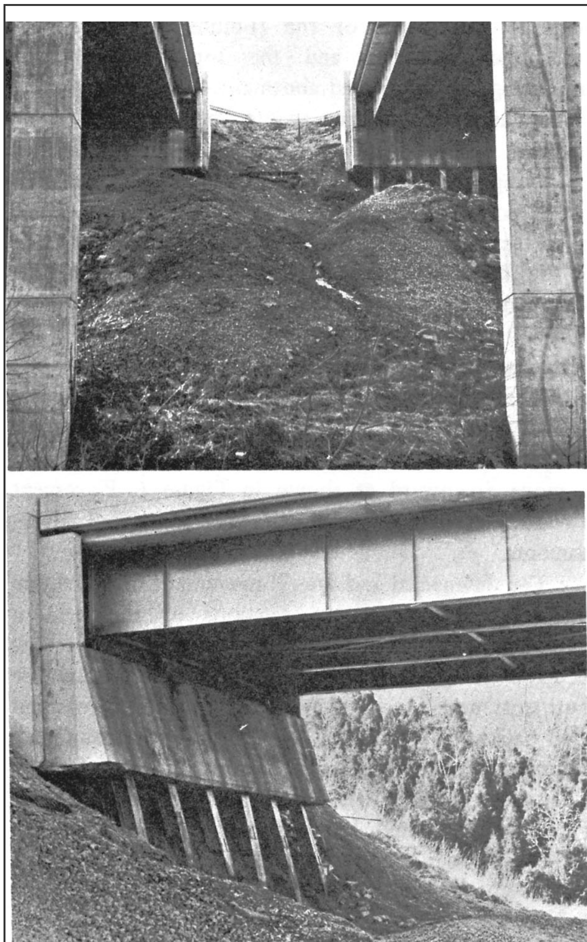


Figure 6. Views of western embankment slope failure and exposed abutment piling on the Bluegrass Parkway across Chaplin River (after Hopkins 1973).

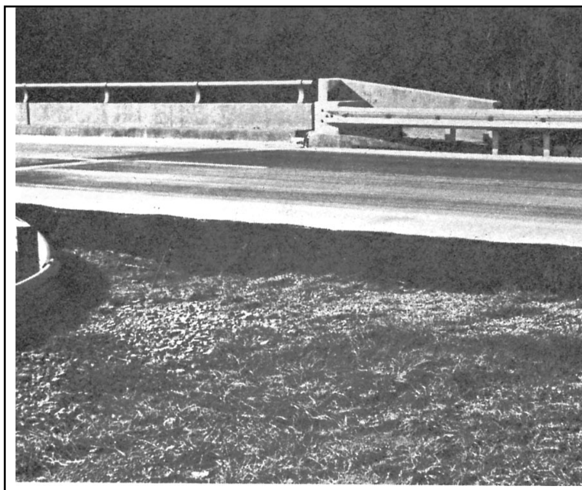


Figure 7. View of the heavily patched eastern bridge approach caused by large settlements and movements of the abutments toward the river (After Hopkins and Yoder 1973).

failures were ingress of water into the embankments, weak clayey shale foundations, rapid drawdown, toe erosion, and very steep slopes (1.5 horizontal to 1 vertical). The ends of the bridges were lengthened and the embankment slopes decreased to about 3 horizontal to one vertical. Cost of repairs was 1.5 million dollars. Today, this repair job would be several million dollars because of inflation.

Another bridge approach embankment failure, which occurred in 1983, is shown in Figure 8. This two-lane bridge carries U. S. 68 across Licking River in Nicholas County. The 120-foot bridge approach embankment was moving rapidly and threatened to close the highway. Highway closure would have caused a several-mile detour. Consequently, government officials did not allow decreasing the slope of the embankment and lengthening the bridge. Moreover, this bridge-lengthening solution was estimated to exceed 3 million dollars. Causes of this failure were ingress of the water table into the embankment, weak clayey shale and soils, rapid drawdown, and toe erosion. A rock shear key and berm were designed (Figure 8) and used to repair the moving embankment at a cost of 750,000 dollars (Hopkins 1983). Slope inclinometer readings showed that the embankment essentially ceased movement about 2 years after construction of the shear key and berm.

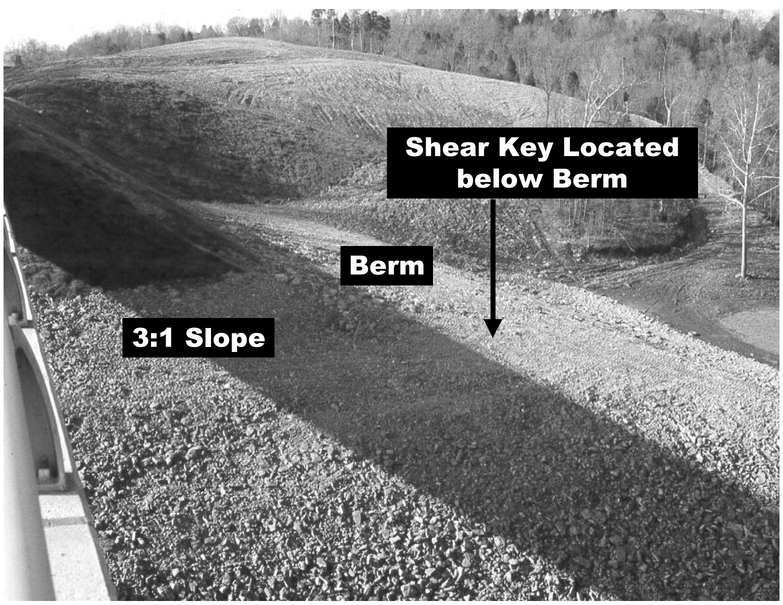


Figure 8. View of the construction of a shear key and berm to halt movement of the failing southern bridge approach embankment on U.S. 68 across Licking River in Nicholas County, Kentucky.

Through research, many of the past inadequacies have been addressed and improved design and construction standards that emerged are used today in constructing new, or reconstructing older, highways. This has aided in mitigating the occurrence of landslides and rock falls on new highways. However, only when new construction, or reconstruction, occurs can new design and construction techniques address the problems of aging embankments and rock slopes. Older highways, which suffer from deterioration or inadequate design and construction standards, will continue to present maintenance problems.

The need for compiling the engineering properties of Kentucky soils was initially recognized by Deen in earlier studies (1962; 1966). In those studies, the engineering properties of soil series mapped by the Soil Conservation Service were determined and compiled as chapters in several of their reports. Later, Spraldling (1976) described and proposed the development a computerized soils data system for Kentucky. Pfalzer (1980) and Pfalzer and Hensley (1981) developed input and retrieval guides for a Kentucky soils data system. These earlier works served as forerunners to development of the soil and rock geotechnical engineering database described herein.

Objectives

Major objectives of this study were to continue development of a comprehensive client/server geotechnical database and further enhance database features that would allow the management of massive amounts of geotechnical information, while at the same time allows an unlimited number of users access to the data simultaneously from diverse locations. The computer program was developed in a windows format and as a client/server application. The Geotechnical database contains four major components: landslides, rock slopes, structures, and soil and rock information. Secondary components include engineering and statistical applications. A major focus of this report is to describe the development of the soil and rock and structures portions of the database. Although the rock slope and landslide potions were performed in separate studies, distinctive aspects of those components of the database are described herein. The database currently resides on a server of the Kentucky Transportation Cabinet. The twelve highway district offices and key central offices are connected in a client/server structure. Data can flow from the district and central offices to the Cabinet's server and vice versa.

Another aim of this study was to develop tools that would facilitate with ease the entering, manipulation, and retrieval of geotechnical data. To make the database a useful tool to the Kentucky Transportation Cabinet in its day-to-day operation, and as a third objective, a large amount of additional "historical" geotechnical data was entered into the database. Also, by populating the database, routines for entering, manipulating, and retrieving data could be evaluated and checked.

The many capabilities of the Oracle® database, which resides on a server of the Kentucky Transportation Cabinet, do an excellent job of handling massive amounts of data and making the data readily available to widely separate users. To a large extent, the second objective was achieved by developing numerous graphical users interfaces (GUI), which greatly simplified data entry, manipulation, and retrieval and created a user-friendly database. All graphical user interfaces were created using PowerBuilder® software and they are illustrated and discussed in the body of this report. In particular, the "Data Window" feature of that software was especially useful in creating graphical user interfaces. Data entry, particularly at the boring and sample levels, increased dramatically during the study period, and met, or exceeded, the goals of the third objective.

Finally, a fourth objective was the development of mechanisms, with a great degree of utility, for handling all data pertaining to potentially hazardous rock slopes and landslide. Graphical user interfaces were developed to house the results of rock slope inventory rating information, which had been accumulated in work that was performed prior to the current study. Data entry graphical user interfaces were also developed for landslides. Attributes, photographs and the latitudes and longitudes of all hazardous rock slopes and landslides are contained in the database. Latitudes and longitudes of all landslide and rock slope sites were obtained using Global Positioning System (GPS) equipment—sub-meter accuracy. All of the graphical user interfaces are illustrated and discussed in detail in the main body of the report. Information in the database is used in the development of the Cabinet's six-year plan.

Scope of Report

Data within the Kentucky Geotechnical Database is entered on three hierarchical levels. The highest level is “sites.” A site may be a bridge, culvert, section of roadway, interchange, landslide, rock slope, or bridge approach, for example. Each site may contain borings (stored on the second hierarchical level) and each boring may include a number of soil and/or rock samples (constituting the third hierarchical level).

Although all sites are created equal within the database, the layout of this report still reflects the historical development of the database in somewhat discrete sections. Personnel of the Kentucky Transportation Cabinet entered into the database site information pertaining to most bridge, culvert, wall (until some very recent work) and roadway sections. Concurrently, with much of that work, a research study of potentially hazardous rock slope sites was conducted by the University Kentucky Transportation Center. Later, a major effort to enter geotechnical data at the borings’ and samples’ level was initiated. This work pertained almost exclusively to those sites entered by the Transportation Cabinet (bridges, culverts, walls and roadways). Meanwhile, a second major research study performed by the University of Kentucky Transportation Center focused on landslides. Results of those research efforts pertaining to both rock slopes and landslides were stored in the database. Development of data entry and retrieval graphical user interfaces proceeded simultaneously.

The next section of the report deals with the geographical location of sites. Although sites may be identified by highway milepost and verbal descriptions, the database allows locating both sites and borings by geographic position (state plane coordinates or/and latitude and longitude) and insures that a site has a unique location since milepost and roadway number may change. This applies to all types of sites, but rock slopes and many landslides, in particular, were located by GPS (Geographic Positioning System) equipment. Many of the older borings and structure/roadway sites were located in the office, using mapping and plotting procedures of lesser accuracy. GPS methods used for locating sites and borings and the structure of those portions of the database that allow entry and display of this information are discussed.

Following the section on geographical location, a threefold format is used and includes descriptions of rock slopes, landslides, and the structures and roadway data obtained from record plans and reports of the Kentucky Transportation Cabinet and other sources. Rock slopes are discussed first, and not only the GUI screens and aspects very specific to the database are presented, but also how this information was generated, how the rating system works, and how the results should be interpreted and used by the Transportation Cabinet. A similar section on landslides follows. The next section deals with other sites. Many of these structure/roadway sites are the ones that include attached borings and sample level data, (though such data might also be entered for landslide and rock slope sites) and, consequently, it is within this section that data pertaining to borings and samples are discussed.

The next section is a discussion of engineering applications that make the database far more than just a storage repository for massive amounts of data. Here the data can be analyzed and designs performed “on-line.” For example, the percentage of CBR test results that are less than any desired value, for any given site, county, or statewide, can be plotted. There is a program for the design of asphalt pavements with varying base courses and soil types. Resilient modulus data of soils and aggregates are presented and can be analyzed (modeled mathematically) on-line. There is a program for designing landslide corrections using driven railroad rails. Within this program one may assume a conventional soil backfill, or if necessary a lightweight material such

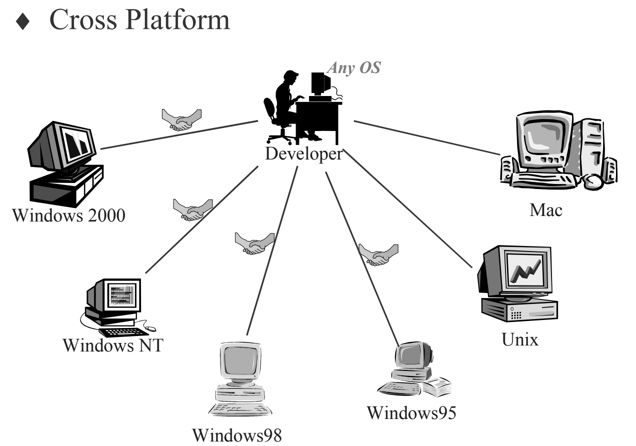


Figure 9. Cross platform capabilities of PowerBuilder® Software.

as geofoam. A program for analyzing and designing the stability of walls and slopes reinforced with geotextiles or unreinforced is presented. This program also includes a method of determining the bearing capacity of reinforced or unreinforced layered soils. Although the above examples illustrate the flexibility and great utility that these engineering applications already have, the potential for future development of such applications remains great.

The next section deals with database security, while the final section deals with retrieval capabilities within the database. A wide variety of lists can be generated with great ease. This list may be at the site level, or alternatively at the borings or samples level. These have already proven to be of considerable value in assisting personnel of the Geotechnical Branch of the Kentucky Transportation Cabinet in performing various tasks.

DEVELOPMENT TOOLS

Where wide interest in stored information may exist, numerous users may want to access the data at the same time. Hence, the database software must contain a feature to permit this type of accessibility. In anticipating this need, the Kentucky geotechnical database was constructed using Oracle®8i (and 9i) database software (Aronoff et al, 1997; Devraj, 2000; and Gruber, 2000). PowerBuilder® software (Sybase, 1999a, b, c), a product of SYBASE®, was used to build graphical user interfaces (GUIs). This software is an object-oriented, development tool that allows the user to build powerful, multi-tier applications that can run on multiple platforms and interact with various databases, as illustrated in Figure 9. It provides the necessary tools to develop client/server applications and provides strong support for development in Data Windows and graphical user interface environment. The Data window, Figure 10, is a powerful tool for building graphical user interfaces.

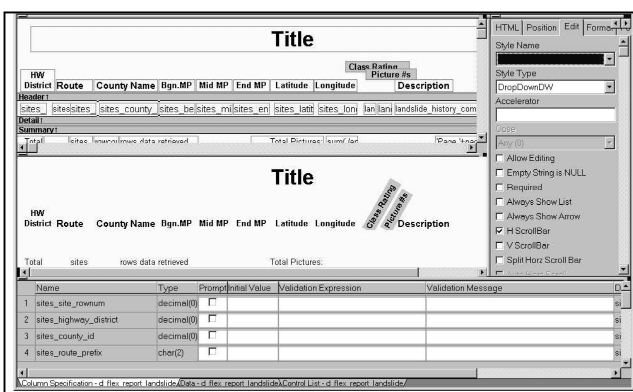


Figure 10. Data Window of PowerBuilder® 8.0.

The database can accommodate any number of "user hits" at essentially the same time. One example of the usefulness of this feature is illustrated in Figure 11. In this example, personnel located at district offices and geotechnical personnel in the central office can view the same data and photographs at the same time and discuss (by telephone) attributes of the site. Hence, this feature provides a quick means of assessing a situation before traveling to the site.

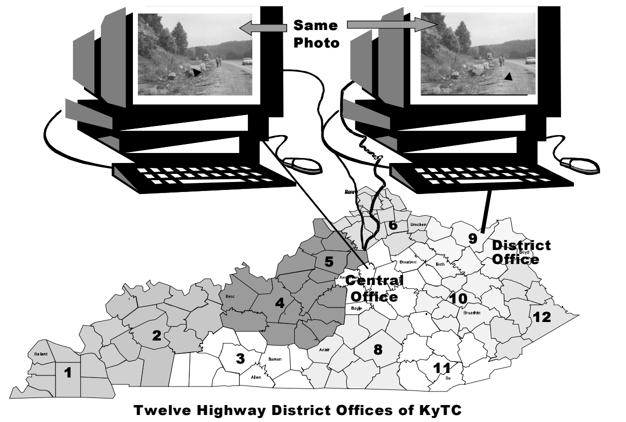


Figure 11. View of the same site photo by personnel at the same time at different locations.

By using MapObjects® software (ESRI, 1999a, b)--a Geographical Information System (GIS) product of the Environmental Systems Research Institute, Inc. (ESRI®)--and locations from GPS equipment, data site distribution can be viewed on different types of Kentucky maps. MapObjects® consists of a set of mapping software components that allows maps to be included with user applications. It comprises an ActiveX control (OCX) called the Map control and a set of over forty-five ActiveX Automation objects. Programs built with MapObjects® will display a map with multiple GIS map layers, such as roads, landslides, rock fall sites, geotechnical borings, streams, and boundaries. Features can be selected with an SQL expression and real-time or time-series data can be displayed dynamically. Embedding MapObjects® in PowerBuilder® applications provides both powerful map and data processing functions, which were instrumental in developing a successful application. Digitized 7.5-minute geologic quadrangles, produced by the Kentucky Geological Survey, can be stored on a local computer, and displayed with the databases. Other embedded maps include county roadway maps. Electronic photographs are stored as a JPEG (Joint Photographic Experts Group) file.

LOCATION OF SITES

Conventional Schemes of Locating Sites

The essential meaning of the prefix "geo" refers to specific properties of the planet earth and location is one of those properties. In the early development of the geotechnical database, it was recognized that the ability to physically locate the various geotechnical sites and data entries of associated attributes in the database was of paramount importance. Lack of a means of identifying the exact location on the earth of a boring or other highway feature would limit the usefulness of geotechnical data in the database. Moreover, it was also realized that the ability to view these locations in relation to each other was also valuable. Each variable and its assigned properties had to be assigned a position on the earth to allow comparison to like variables. Physically locating a site in the field using conventional schemes, such as surveying, is very difficult and time consuming.

For example, when a highway project is initially constructed, station numbers are used to identify the different locations of the boreholes, embankments, slopes, culverts, bridges, and other essential features of the project. During construction, stakes driven into the ground at fixed intervals, or station numbers, of length, identifies locations of the various features of the project. Hence, if a particular soil boring shown on a plan at a certain station number needs to be identified in the field, then that particular hole could be located physically by finding the stake with the proper station number. Unfortunately, station numbers (stakes) are destroyed during and after construction and do not provide a means of identifying a particular location after construction. The stakes are only used during construction and are temporary because they are made of wood and rot after some time. Moreover, the station numbers of numerous past highway projects are frequently not tied to a fixed and accurate point on the earth. To locate a highway feature after construction using standard surveying techniques would be too costly and generally impractical.

Consequently, a system evolved for identifying locations of highway features in the field by assigning a particular location to a county name, the highway (route) number, and the mile point. Using this conventional system, which is only approximate, allows engineers to physically locate in a fairly reasonable manner a highway feature in the field. It also allows a rough estimate of comparison of locations from a map. Because this system continues to be used today by operation engineers and others, this method of identifying and referring to a location of a highway feature was retained in building the geotechnical database.

Although identifying a location by county number, route number, and milepost has provided a fair means of identifying a highway feature in the field, this system is oftentimes inaccurate for a number of reasons. First, odometers on different vehicles are not accurate to the tenth of a mile. Although different vehicles may start at the same location, they may yield different locations because the odometers may measure distances slightly different. Secondly, reconstruction of new highways in Kentucky very often results in a change in mile points. Generally, reconstruction tends to shorten an old road and change existing mile points. Sometimes the highway route number itself changes, as illustrated in Figure 12, and the locations become virtually useless. The conventional system that is widely used for defining a location by county number, route number, and mile point is not unique because the identifiers of that location are subject to change in the future. Because of the nature of these possible errors, a system was needed to provide a unique means of identifying highway sites, or features. Some geotechnical data such as borings could not be referenced to the mile point system and were lost.

Figure 12. After reconstruction, US 23 in Johnson and Floyd Counties was renumbered KY 321 in the mid-nineties.

Application of the Global Positioning System (GPS) for Locating Sites

To overcome difficulties associated with the mile point system and conventional surveying, and beginning in 1998, Global Positioning System (GPS) equipment was acquired and used to locate hazardous rock fall sites and landslides along Kentucky's highways. The GPS system provides an excellent way of identifying a highway feature by latitude and longitude, which are unique

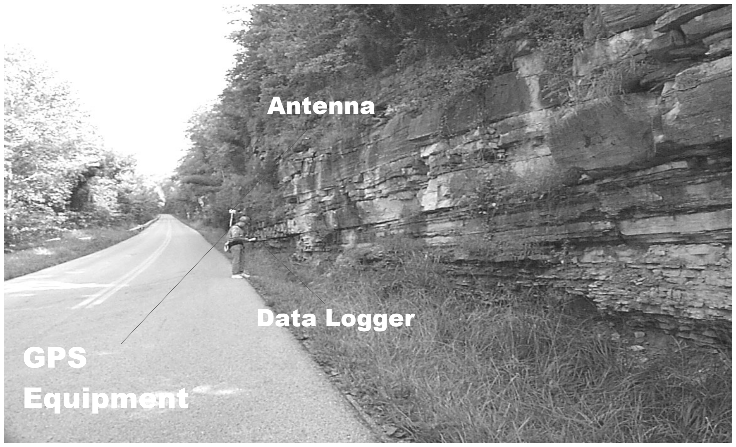


Figure 13. Portable GPS pack by Trimble®.

numbers. This equipment produces accurate coordinates that do not change as the arterial highway system changes in Kentucky.

The unit first used to locate sites in Kentucky was Trimble's ProXR mapping grade system. This unit provides a location accuracy of one-meter (or sub-meter) horizontal and six meters vertical. The unit is portable and can be carried as a pack (Figure 13), or mobile mounted in a vehicle, as shown in Figures 14 and 15, respectively. Set-up time is about five minutes and requires no permanent changes to the vehicle. The self-contained system consists of an antenna (Figure 14), receiver, and data logger (Figures 15). The Trimble ProXR antenna also allows real-time correction in the field with the use of a built-in radio antenna that receives signals from near-by beacons transmitting fixed correct coordinates. The unit also features multi-path rejection technology. As a pack unit, the ProXR is very concise. However, the large weight of the unit discouraged the use of the pack as a common practice. As a mobile mount, it can be separated for ease of use. The antenna uses a magnetic mount that holds fast to the top of any vehicle. While this system eliminated the problems with the mile point system, some minor problems arose, such as the weight problem and time required to learn the use of the system.

The Global Positioning System operates by producing a pseudo random code and comparing it with the same code embedded in a radio signal transmitted by satellites orbiting the earth. In theory, these codes are produced at the same time. The time difference from the instant the receiver produced the code and the instant the code was received from the satellite is used to calculate distance. Signals from at least four satellites are needed to produce three-dimensional positions. There are 24 satellites that make up a constellation in a non-geosynchronous orbit 12,600 miles above the earth. These satellites, called space vehicles by the GPS, are in constant contact with each other and continually upgrade the receiver's clock using onboard atomic clocks accurate to one ten millionth of a second.


Figure 14. The Trimble® ProXR, vehicular-mounted antenna.

A signal from the first satellite locates the position to a point on a sphere. A signal from the second satellite places the position at the intersection of two spheres. The signal from the third satellite narrows the position to one of two points made by a third intersecting sphere. The forth satellite locates the true point three dimensionally as the fourth sphere intersects the first three at the point. This process is known as satellite trilateration and is one of five principles of

Figure 15. Data logger.

operation along with satellite ranging, accurate timing, satellite positioning, and correcting errors.

The calculations behind satellite ranging assume the signals travel at a constant speed--the speed of light. Because this is only a constant in a vacuum, errors are inherent and must be corrected. Upon striking the earth's atmosphere, the signal from the satellite must pass through the "D layer" of the atmosphere. When solar rays charge the atmosphere, the radio signal is absorbed. It also passes the troposphere, which creates lag as well. The department of defense does correct clock and orbital errors having to do with timing and positioning. Multipath interference occurs when the signal is reflected off other objects such as buildings before reaching the receiver. The antenna on the ProXR detects and rejects such signals using advanced signal processing.

Essentially, three methods are available for obtaining data using the ProXR. The first method consists of simply recording the position read in the field onto a data sheet. The second method requires logging a number of positions into a file (rover file), downloading these into a desktop computer program, and comparing them with positions (base files) taken by another receiver over a known point. If they are close enough together, they should "see" the same constellation of satellites and record the same error allowing the correction to be applied to your new field point. This is called "Differential Correction." The third method actually does this correction in the field by receiving a low-power AM signal from a nearby beacon. This is termed "Real Time Differential Correction."

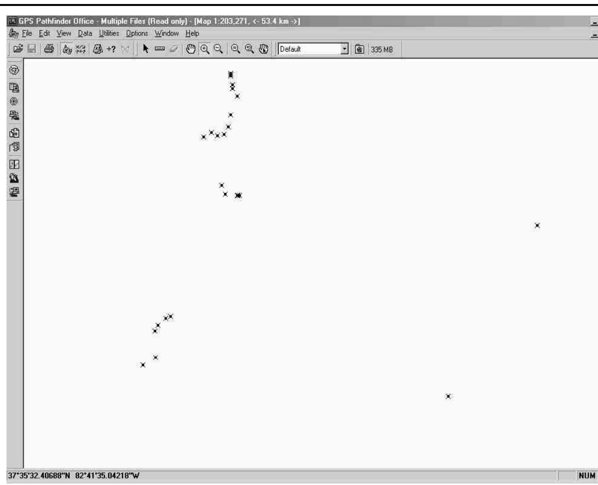


Figure 16. Plot of mapped positions**.**

All rock fall and landslide sites have been located using the mapping-grade GPS equipment. This technology has also been used to map and define some highways, including bridges and culverts. This system provides a way to link the two methods of locating these structures together. Using a "data dictionary" in the data logger's software, all the location data including, county, route and mile point can be entered and saved with the position record. The data logger is also able to record the date and time and name of the person using the equipment. Also it keeps an embedded record of what satellites it used to calculate the positions and the condition of the signal. These two items are termed an ephemeris and almanac. Upon returning to the office, all data are "dumped" (via serial port connection) into the desktop processing software where it is corrected, if needed, and all points are processed and averaged to give the most accurate location. The data can also be viewed or exported to a number of formats.

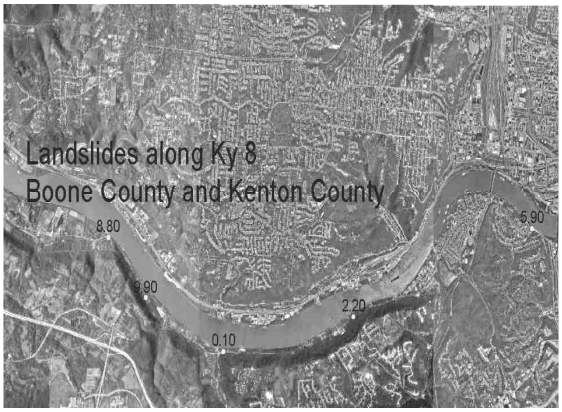


Figure 17. Locations of landslides superimposed on an aerial photograph along KY 9 in Boone and Kenton Counties, Kentucky.

The ProXR allows "real-time correction," as well as differential correction. The receiver monitors for any beacon signal. The handheld data-logging unit stores all data taken by the receiver in a "Rover-File". The unit is self-contained in an airtight hard-shell case, as shown in Figure 15. The Pathfinder software program is included with the unit and is used to process, view, and export positions taken by the ProXR. It also allows the manipulation of datum, projection, and units of display and is capable of plotting directly to a printer, as shown Figure 16.

After all data are corrected and ready for use, it is exported to an ASCII format and printed. At this point, all data concerning the site are available, as well as the site position. This printout is used by the person(s) inputting the site information into the geotechnical databank. After all positions are entered and stored on the databank, this printout is placed in a binder with the original field data sheets for future reference. The digital file is placed in a file according to highway district and backed up to a CD regularly along with the corrected data logged files. Exporting it to a GIS format and opening the data using a GIS program, such as ArcGIS, can make further use of the data. Using the measured field positions, the locations of rock fall, or landslide, sites can be placed on aerial photographs to obtain a better view of where the sites are in relation to their physical environment. From this information, picture files can be created and placed with a specific site in the data bank. Viewing the sites on an aerial photograph may provide users an insight as to the cause of a problem or give a view of terrain that must be negotiated to get to a particular site.

To illustrate, the latitude and longitude of several landslide areas along KY route 9 have been plotted on an aerial photograph, figure 17, or an ortho-photo quarter quandrangle, of a particular stretch of the Ohio River. Apparently, the landslides are occurring in the bends of the river at this location that are most susceptible to erosion along the base of the embankments and natural slopes. Natural slopes in this area are composed of residual soils that were derived from the Kope Geological Formation. These soils and the Kope shales were used to construct the embankments of KY 9. The clayey shales of the Kope Formation have been involved in numerous landslides of this area. As support of the slopes is lost, the embankments and natural slopes gradual "creep" down slope. Eventually, as the erosion and creep continue, and with the occurrence of rapid drawdown during flooding, the slopes fail. Viewing landslides in this manner can aid in determining the major causes of landslides in certain regions.

Conversion Between State Plane Coordinate System (SPCS) and Geodetic Position Latitude/Longitude

Terms and Definitions (Mitchell and Simmons 1977)

As with any plane-rectangular coordinate system, a projection employed in establishing a State coordinate system may be represented by two sets of parallel straight lines that are intersected by other parallel lines at right angles. The network thus formed is termed a grid. One set of these lines is parallel to the plane of a meridian passing approximately through the center of the area shown on the grid, and the grid line corresponding to that meridian is the Axis of Y of the grid. It is also termed the central meridian of the grid. Forming right angles with the Axis of Y and to the south of the area shown on the grid is the Axis of X. The point of intersection of these axes is the origin of coordinates. The position of a point represented on the grid can be defined by stating two distances, termed coordinates.

One of these distances, known as the x-coordinate, gives the position in an east-and-west direction. The other distance, known as the y-coordinate, gives the position in a north-and-south direction. The x-coordinates increase in size, numerically, from west to east; the y-coordinates increase in size from south to north. *All x-coordinates is an area represented on a State grid are made positive by assigning the origin the coordinates: x = 0 plus a large constant*. For any point, then, the x-coordinate equals the value of x adopted for the origin, plus or minus the distance of the point east or west from the central meridian (Axis of Y); and the y-coordinate equals the perpendicular distance to the point from the Axis of X. The linear unit of the State coordinate systems is the foot (equal to 12 inches) and it is defined by the equivalence: 1 international meter = 39.37 inches exactly.

The linear distance between two points on a State coordinate system, as obtained by computation or scaled from the grid, is termed the grid length of the line connecting those points. The angle between a line on the grid and the Axis of Y, reckoned clockwise from the south through 360º, is the grid azimuth of the line. The computations involved in obtaining a grid length and a grid azimuth from grid coordinates performed by means of the formulas of plane trigonometry.

Geodetic and Plane-Coordinate Positions (Mitchell and Simmons 1977)

For more than a century, the United States Coast and Geodetic survey has engaged in geodetic operations, which determined the geodetic positions – the latitudes and longitudes – of thousands of monument points distributed throughout the country. These latitudes and longitudes are on an ideal figure – a spheroid of reference, which closely approaches the sea-level surface of the Earth. By mathematical processes, the positions of the grid lines of a State coordinate system are determined with respect to the meridians and parallels on the spheroid of reference. A point that is defined by stating its latitude and longitude on the spheroid of reference may also be defined by stating its x- and y-coordinates on a State grid. If either position is known, the other can be derived by formal mathematical computation. So too with lengths and azimuths: the geodetic length and azimuths between two positions can be transformed into grid length and azimuth by mathematical operation. Or the process may be reversed when grid values are known and geodetic values are desired.

In general, any survey computations involving the use of geodetic position data can also be accomplished with the corresponding grid data; but with this difference: results obtained with geodetic data are exact, but they require the use of involved and tedious spherical formulas and special tables. On the other hand, results obtained with grid data are not exact, since they involve certain allowances that must be made in the transfer of survey data from the curved surface of the Earth (spheroid) to the plane surface of a State coordinate system; but the computations with the data are quite simple, being made with the ordinary formulas of plane surveying; and with the State coordinate systems, exact correlation of grid values and geodetic values is readily obtained by simple mathematical procedures.

State Grid Zones (Mitchell and Simmons 1977)
One of the important characteristics of the State coordinate systems is the small number of separate grids required to cover a State; or, to put it differently, the large area that is served by a single origin and reference meridian. Since the geodetic data determined by the national control survey - the latitudes and longitudes of points, and the lengths and azimuths of lines - are sea-level data, it follows that surveys which are to be adjusted to stations of the national survey must first be reduced to a sea-level base. And as the State coordinate systems are developed directly from geodetic values, the use of those systems requires the further reduction of the sea-level values to grid values.

In reducing a ground-level length to its corresponding grid length on a State coordinate system, the two processes involved – reduction to sea level and thence to the grid – may, for most land surveys, be performed in a single operation, employing a factor which is a combination of the sea-level and scale factors.

SPCS 27 Background (Stem 1989)
The State Plane Coordinate System of 1927 (SPCS 27) was designed in the 1930s by the U.S. Coast and Geodetic Survey (predecessor of the National Ocean Service) to enable surveyors, mapmakers, and engineers to connect their land or engineering surveys to a common reference system, the North American Datum of 1927. The following criteria were applied in the design of the State Plane Coordinate System of 1927:

- Use of conformal mapping projection.
- Restricting the maximum distortion to less than one part in 10,000.
- Covering an entire State with as few zones of a projection as possible.
- Defining boundaries of projection zones as an aggregation of counties.

It is impossible to map a curved Earth on a flat map using plane coordinates without distorting angles, azimuths, distances, or area. It is possible to design a map such that some of the four remain undistorted by selecting an appropriate "map projection." A map projection in which angles on the curved Earth are preserved after being projected to a plane is called a "conformal" projection. Three conformal map projections were used in designing the original State plane coordinate system: the Lambert conformal conic projection, the transverse Mercator projection, and the oblique Mercator projection. The Lambert projection was used for States that are long in the east-west direction (e.g., Kentucky, Tennessee, North Carolina), or for States that prefer to be divided into several zones of east-west extent. The transverse Mercator projection was used for States (or zones within States) that are long in the north-south direction (e.g., Vermont and Indiana), and the oblique Mercator was used in one zone of Alaska when neither of these two was appropriate. These same map projections are also often custom designed to provide a coordinate system for a local or regional project.

Land survey distance measurements in the 1930s were typically made with a steel tape, or something less precise. Accuracy rarely exceeded one part in 10,000. Therefore, the designers of SPCS 27 concluded that a maximum systematic distance scale distortion attributed to the projection of 1:10,000 could be absorbed in the computations without adverse impact on the survey. If distances were more accurate than 1:10,000, or if the systematic scale distortion could not be tolerated, the effect of scale distortion could be eliminated by computing and applying an appropriate grid scale factor correction. Admittedly, the one in 10,000 limit was set at an arbitrary level, but it worked well for its intended purpose and was not restrictive on the quality of the survey when grid scale factor was computed and applied.

To keep the scale distortion at less than one part in 10,000 when designing the SPCS 27, some States required multiple projection "zones." Thus some States have only one State plane coordinate zone, some have two or three zones, and the State of Alaska has 10 zones that incorporate all three projections. With the exception of Alaska, the zone boundaries in each State followed county boundaries. There was usually sufficient overlap from one zone to another to accommodate projects or surveys that crossed zone boundaries and still limit the scale distortion to 1:10,000. In more recent years, survey accuracy usually exceeds 1:10,000. More surveyors became accustomed to correcting distance observations for projection scale distortion by applying the grid scale factor correction. When the correction is used, zone boundaries become less important, as projects may extend farther into an adjacent zone.

Requirement for SPCS 83 and SPCS 27 (Stem 1989)

The necessity for the State Plane Coordinate System of 1983 (SPCS 83) arose from the establishment of the North American Datum of 1983 (NAD 83). When NAD 27 was readjusted and redefined by the National Geodetic Survey, a project that began in 1975 and finished in 1986, SPCS 27 became obsolete. NAD 83 produced new geodetic coordinates for all horizontal control points in the National Geodetic Reference System (NGRS). The project was undertaken because NAD 27 values could no longer provide the quality of horizontal control required by surveyors and engineers without regional recomputations (least squares adjustments) to repair the existing network. NAD 83 supplied the following improvements:

- One hundred and fifty years of geodetic observations (approximately 1.8 million) were adjusted simultaneously, eliminating error propagation, which occurs when projects must be mathematically assembled on a "piecemeal" basis.
- The precise transcontinental traverse, satellite triangulation, Doppler position, baselines established by electronic distance measurements (EDM), and baselines established by very long baseline interferometry (VLBI), improved the internal consistency of the network.
- A new figure of the Earth, the Geodetic Reference System of 1980 (GRS 80), which approximates the Earth's true size and shape, supplied a better fit than the Clarke 1866 spheroid, the reference surface used with NAD 27.
- The origin or the datum was moved from station MEADES RANCH in Kansas to the Earth's center of mass, for compatibility with satellite systems.

Not only will the published geodetic position of each control point change, but also the State plane coordinates will change for the following reasons:

- The plane coordinates are mathematically derived (using "mapping equations") from geodetic coordinates.
- The new figure of the Earth, the GRS 80 ellipsoid, has different values for the semi major axis "a" and flattening "f" (and eccentricity "e" and semi minor axis "b"). These ellipsoidal parameters are often embedded in the mapping equations and their change produces different plane coordinates.

- The mapping equations are accurate to the millimeter, whereas previous equations promulgated by NGS were derivatives of logarithmic calculations with generally accepted approximations.
- The States have defined the defining constants of several zones.
- The numeric grid value of the origin of each zone has been significantly changed to make the coordinates appear clearly different.
- The State plane coordinates for all points published on NAD 83 by NGS will be in metric units.
- The NPCS 83 uses the Gauss-Kruger form of the transverse Mercator projection, whereas the SPCS 27 used the Gauss-Schreiber form of the equations.

SPCS 83 Design (Stem 1989)

In the mid-1970s NGS considered several alternatives to SPCS 83. Some geodesists advocated retaining the design of the existing State plane coordinate system (projection type, boundaries, and defining constants) and others believed that a system based on a single projection type should be adopted. The single projection proponents contended that the present SPCS was cumbersome, since three projections involving 127 zones were employed.

Studies were instituted to decide whether a single system would meet the principal requirements better than SPCS 27 and the transverse Mercator projection with zone of 2º in width. Throughout these studies, three dominant factors for retaining the SPCS 27 design were evident: SPCS had been accepted by legislative action in 37 States. The grids had been in use for more than 40 years and most surveyors and engineers were familiar with the definition and procedures involved in using them. Except for academic and puristic considerations the philosophy of SPCS 27 was fundamentally sound. With availability of electronic calculators and computers, little merit was found in reducing the number of zones or projection type. There was merit in minimizing the number of changes to SPCS legislation. For these reasons a decision was made to retain the basic design philosophy of SPCS 27 in SPCS 83.

The above decision was expanded to enable NGS to also publish UTM coordinates for those users who preferred that system. Both grids are now fully supported by NGS for surveying and mapping purposes. It is recognized that requirements will arise when additional projections may be required, and there is no reason to limit use to only the SPCS 83 and UTM system.

Polynomial Formulas and Coefficients for the Lambert Projection (Stem 1989)

Conversion of coordinates from NAD 83 geodetic positions to SPCS 83 plane coordinate positions, and vice versa, can be greatly simplified for the Lambert projection using precomputed zone constants obtained by polynomial curve fitting. NGS developed the Lambert "polynomial coefficient" approach as an alternative to the rigorous mapping equations. For many zones the solution of the textbook mapping equations for the Lambert projection requires the use of more than 10 significant digits to obtain millimeter accuracy, and in light of the programmable calculators generally in use by surveyors/engineers, an alternative approach was warranted. The mapping equations of the transverse Mercator projection do not present the same numerical problem, as does the Lambert projection. Therefore, 10 significant digits are adequate. For the polynomial coefficient method of the Lambert projection, 10 significant digits will produce millimeter accuracy in all zones.

Given the precomputed polynomial coefficients, the conversion process by this method reduces to the solution of simple algebraic equations, requiring no exponential or logarithmic functions. It is therefore very efficient for hand calculators and small computers. In addition, the conversion is not too difficult to apply manually without the aid of programming. For this reason, the polynomial coefficient approach has also been listed as a manual approach in table form. When programmed, this approach may be more efficient than mapping equations.

The fundamental polynomial equations of this method are

$$u = L_1\,\Delta\phi + L_2\,\Delta\phi^2 + L_3\,\Delta\phi^3 + L_4\,\Delta\phi^4 + L_5\,\Delta\phi^5 \qquad \text{(forward conversion)} \qquad (1)$$

$$\Delta\phi = \phi - \phi_0 = G_1\,u + G_2\,u^2 + G_3\,u^3 + G_4\,u^4 + G_5\,u^5 \qquad \text{(inverse conversion)} \qquad (2)$$

From the equations and Figure 18, "u" is a distance on the mapping radius "R" between the central parallel and a given point. The determination of "u" in meters on a plane by a polynomial, given point (ϕ, λ) in the forward conversion, and the determination by a polynomial of $\Delta\phi$ in radians on the ellipsoid given point (N, E) in the inverse conversion, is the unique aspect of this method. The L_i coefficients perform the functions: (1) computing the length of the meridian arc between ϕ and ϕ_0, and (2) converting that length to (R_0 – R) which is its equivalent on the mapping radius. The coefficients, G_I, serve the same two-stage process, but in reverse. The polynomial coefficients of these equations, L_i and G_i, were separately determined by a least squares curve-fitting program that also provided information as to the accuracy of the fit. Ten data points were used for Lambert zones that provided 0.5 mm coordinate accuracy in the conversion. Kentucky zones required only four coefficients for each forward and inverse conversion, four L's and four G's.

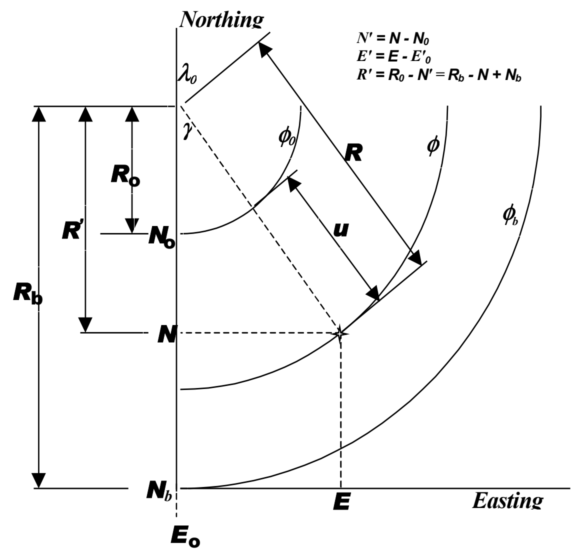


Figure 18. Variables used in coordinate conversions.

Direct Conversion Computation for SPCS 83(Stem 1989)

The computation starts with the geodetic position of a point (ϕ, λ), and computes the Lambert grid coordinates (N, E), convergence angle (γ), and grid scale factor (κ).

$$\Delta\phi = \phi - \phi_0 \qquad (\Delta\phi \text{ in decimal degrees}) \qquad (3)$$

$$u = L_1\,\Delta\phi + L_2\,\Delta\phi^2 + L_3\,\Delta\phi^3 + L_4\,\Delta\phi^4 + L_5\,\Delta\phi^5 \qquad (4)$$

In Kentucky, only four L's are required. After changing to nested form, the above formula becomes

$$u = \Delta\phi\,(L_1 + \Delta\phi\,(L_2 + \Delta\phi\,(L_3 + L_4\,\Delta\phi)))$$
$$R = R_0 - u$$

$\gamma = (\lambda_0 - \lambda) \sin(\phi_0)$ convergence angle
$E' = R \sin \gamma$
$N' = u + E' \tan(\gamma/2)$
$E = E' + E_0$ easting
$N = N' + N_0$ northing
$\kappa = F_1 + F_2 u^2 + F_3 u^3$ grid scale factor

Inverse Conversion Computation for SPCS 83 (Stem 1989)
The computation starts with the Lambert coordinates (N, E) from which are computed the geodetic coordinates (ϕ, λ), convergence angle (γ), and grid scale factor (κ).

$N' = N - N_0$
$E' = E - E_0$
$R' = R_0 - N'$
$\gamma = \tan^{-1}(E'/R')$ convergence angle
$\lambda = \lambda_0 - \gamma/\sin(\phi_0)$ longitude
$u = N' - E' \tan(\gamma/2)$
$\Delta\phi = \phi - \phi_0 = G_1 u + G_2 u^2 + G_3 u^3 + G_4 u^4 + G_5 u^5$ ($\Delta\phi$ in decimal degrees)

In Kentucky, only four G's are required. After changing to nested form, the above formula becomes

$\Delta\phi = u (G_1 + u (G_2 + u (G_3 + G_4 u)))$
$\phi = \phi_0 + \Delta\phi$ latitude
$\kappa = F_1 + F_2 u^2 + F_3 u^3$ grid scale factor in Figure 13 and formulas,

where

ϕ Parallel of geodetic latitude, positive north
ϕ_0 Central parallel, the latitude of the true projection origin
ϕ_b Latitude of the grid origin
λ Meridian of geodetic longitude, positive west
λ_0 Central meridian, longitude of the true and grid origin
κ Grid scale factor at a general point
γ Convergence angle
N Northing coordinate
N_b The northing value for ϕ_b at the central meridian (the grid origin). Sometimes identified as the false northing
N_0 Northing value at the intersection of the central meridian with the central parallel (the true projection origin)
E Easting coordinate
E_0 The easting value at the central meridian λ_0. Sometimes identified as the false easting

R Mapping radius at latitude ϕ
R_b Mapping radius at latitude ϕ_b
R_0 Mapping radius at latitude ϕ_0
L_i Coefficients used in the forward conversion process
G_i Coefficients used in the inverse conversion process
F_i Coefficients used for grid scale factor

Constants for Lambert Projection in SPCS 83(Stem 1989)

In the Kentucky North, Zone # 1601, numerical values are as follows:

ϕ_0 = 38.4672539691
λ_0 = 84.25
E_0 = 500000.
N_0 = 107362.4795
R_0 = 8037943.9917
L_1 = 111001.1272
L_2 = 9.49969
L_3 = 5.63960
L_4 = 0.019624
G_1 = 9.008917501E-06
G_2 = -6.94594E-15
G_3 = -3.71303E-20
G_4 = -1.0140E-27
F_1 = 0.999962079530
F_2 = 1.23109E-14
F_3 = 5.03E-22

In the Kentucky South, Zone # 1602, numerical values are as follows:

ϕ_0 = 37.3341456532
λ_0 = 84.75
E_0 = 500000.
N_0 = 611064.2249
R_0 = 8372015.2303
L_1 = 110977.8556
L_2 = 9.40195
L_3 = 5.64201
L_4 = 0.018759
G_1 = 9.010806634E-06
G_2 = -6.87874E-15
G_3 = -3.71775E-20
G_4 = -9.7208E-28
F_1 = 0.999945401603
F_2 = 1.23142E-14
F_3 = 4.82E-22

Direct Conversion Computation for SPCS 27 (Claire 1968)
The computation starts with the geodetic position of point (ϕ, λ), and computes the Lambert grid coordinates (x, y), convergence angle (θ), and grid scale factor (κ).

$$s = 101.2794065\ (60\ (L_7 - \phi') + L_8 - \phi'' + (1052.893882 - (4.483344 - 0.023520 \cos^2\phi) \cos^2\phi) \sin\phi \cos\phi)$$

where ϕ' is in degrees and minutes of ϕ expressed in whole minutes, ϕ'' is the remainder of ϕ in seconds, and

$$R = L_3 + sL_5 (1 + (s/10^8)^2 (L_9 - (s/10^8) L_{10} + (s/10^8)^2 L_{11}))$$
$$\theta = L_6 (L_2 - \lambda) \qquad \text{(}\theta\text{ and }\lambda\text{ are in seconds, }\theta\text{ is convergence)}$$
$$x = L_1 + R \sin\theta$$
$$y = L_4 - R + 2R \sin^2(\theta/2)$$
$$\kappa = L_6R(1 - 0.0067686580 \sin^2\phi)^{1/2}/(20925832.16 \cos\phi). \qquad \text{(Scale factor)}$$

Inverse Conversion Computation for SPCS 27 (Claire 1968)
The computation starts with the Lambert coordinates (x, y) from which are computed the geodetic coordinates (ϕ, λ).

$$\theta = \arctan((x - L_1) / (L_4 - y))$$
$$\lambda = L_2 - \theta / L_6 (\theta \text{ and } \lambda \text{ are in seconds})$$
$$R = (L_4 - y) / \cos\theta$$
$$s_1 = (L_4 - L_3 - y + 2 R \sin^2(\theta / 2)) / L_5$$
$$s_2 = s1 / (1 + (s_1 / 10^8)^2 L_9 - (s_1 / 10^8)^3 L_{10} + (s_1 / 10^8)^4 L_{11})$$
$$s_3 = s1 / (1 + (s_2 / 10^8)^2 L_9 - (s_2 / 10^8)^3 L_{10} + (s_2 / 10^8)^4 L_{11})$$
$$s = s1 / (1 + (s_3 / 10^8)^2 L_9 - (s_3 / 10^8)^3 L_{10} + (s_3 / 10^8)^4 L_{11})$$
$$\omega' = L_7 - 600 \qquad \text{(degrees and minutes of }\omega\text{ in whole minutes)}$$
$$\omega'' = 36000 + L8 - 0.009873675553\ s \text{(remainder of }\omega\text{ in seconds)}$$
$$\omega = \omega' + \omega''$$
$$\phi' = L_7 - 600 \qquad \text{(degrees and minutes of }\phi\text{ in whole minutes)}$$
$$\phi'' = \omega'' + (1047.546710 + (6.192760 + 0.050912 \cos^2\omega) \cos^2\omega) \sin\omega \cos\omega$$
(remainder of ω in seconds)
$$\phi = \phi' + \phi''$$

Constants for Lambert Projection in SPCS 27 Claire 1968)
In the Kentucky North, Zone # 1601, values are as follows:

L_1 = 2,000,000.000
L_2 = 303,300.00
L_3 = 26,371,820.68
L_4 = 26,724,051.82
L_5 = 0.999962081
L_6 = 0.6220672671
L_7 = 2299

L_8 = 30.63364
L_9 = 3.81202
L_{10} = 3.62113
L_{11} = 0

In the Kentucky South, Zone # 1602, values are as follows:

L_1 = 2,000,000.000
L_2 = 328,700.00
L_3 = 27,467,860.75
L_4 = 27,832,235.64
L_5 = 0.9999453808
L_6 = 0.6064623718
L_7 = 2231
L_8 = 36.57874
L_9 = 3.81301
L_{10} = 3.47771
L_{11} = 0.00

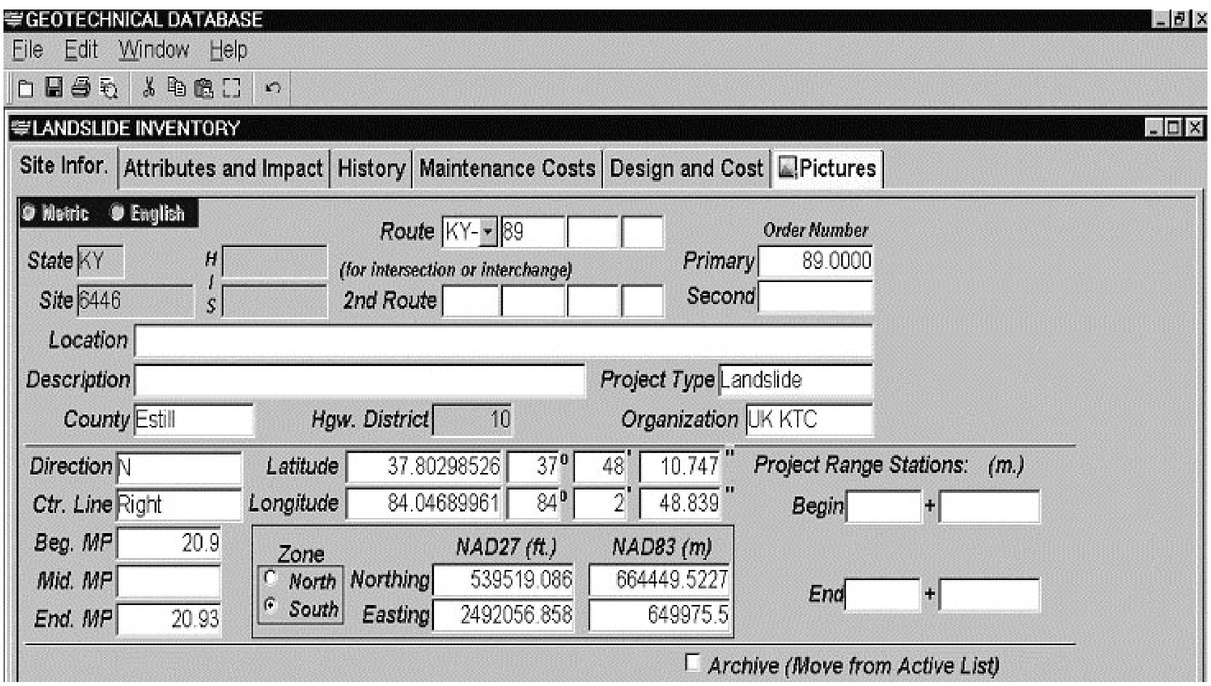


Figure 19. Display of coordinates in different coordinate systems.

Coordinates of Sites Stored and Displayed in the Geotechnical Database

To facilitate data entry into the geotechnical database, data pertaining to any selected coordinate system may be entered. Those systems include SPCS 27, SPCS 83, degree-minute-second Latitude/Longitude, or decimal Latitude/Longitude. Once data is entered into a selected coordinate system, algorithms, described previously, in the geotechnical database automatically convert the entered data into the coordinates of the other coordinate systems and automatically display on the screen all coordinates for all coordinate systems. For example, other coordinate systems will automatically convert to other system's coordinates by corresponding formulas, as described in the previous sections, only decimal Latitude/Longitude data will be saved to the database. When the existing decimal Latitude/Longitude data are retrieved, the coordinates of the other three systems are calculated and displayed on the screen, as shown in Figure 19.

GENERAL DATABASE STRUCTURE

The main objective of a database application is to devise a system for entering, retrieving, and analyzing data, effectively and efficiently. To achieve these aims, many categories were created within the geotechnical database. To use them effectively, the different categories not only have to be isolated individually, but they also have to be linked together in the database. For this purpose, and to create a hierarchy that is logical, flexible, and easy to understand, the database was divided into several levels to accomplish a "tree-like" design and linked using primary and foreign keys (Aronoff et al, 1997). A primary key is a column or set of columns that uniquely identifies each row in a table. A foreign key is a column or set of columns that contains primary key values from another table. Each item in the column or columns must correspond to an item in the other table. There are natural and relational connections among those geotechnical data by location. Based on location, data are divided into different levels. Location/site is the highest-level datum. Any geotechnical datum has that information. Below that level are different project categories, more detail and lower level data such as holes, sample, and properties. Using this relational structure, storage requirements of the database are minimized.

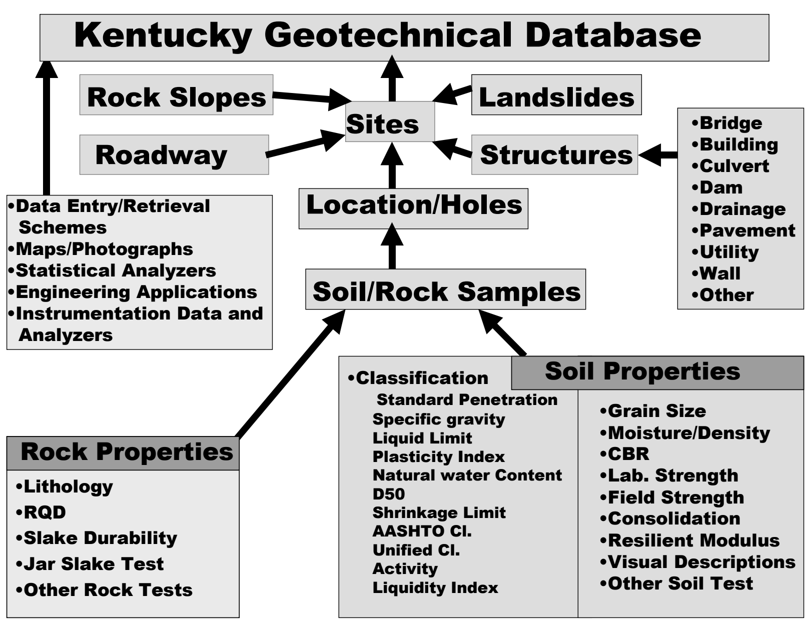


Figure 20. Structure of the Kentucky Geotechnical Database.

The "tree-like" structure and datum relationships of different components of the Kentucky Geotechnical Database are illustrated in Figure 20. The data are partitioned into five major categories:

1. Rock Slope Database
2. Landslide Database
3. Roadway Database

4. Structures Database
5. Soil and Rock Engineering Database

Structures include bridges, buildings, culverts, dam, drainage, pavement, utility, wall, and other types of structures identified in the future. Test properties of soils include classification, grain size, moisture-density relations, CBR, field and laboratory strengths, consolidation, resilient modulus, and visual description. Test results entered in the classification category include specific gravity, liquid limit, plasticity index, natural water content, D_{50}, shrinkage limit, AASHTO soil classification, unified soil classification, soil activity, and soil liquidity index. Test properties of rocks include lithology, rock quality designation (RQD), slake-durability, jar slake test, visual descriptions, and unconfined compressive strength. Other components of the database include data entry and retrieval schemes, analytical and design applications, statistical analyzers, and electronic photographs and maps. All terms and tables used in the database are defined in **Appendix A** and in the "help" section of the database program.

DETAILED DESCRIPTION OF ROCK SLOPE MANAGEMENT SYSTEM

A general overview and brief descriptions of major components of the geotechnical database are given below. A detailed discussion of the rock slope database and management system is presented after this section. Detailed descriptions of the landslide database management system are presented in a companion report.

Main Menu

The main menu of the geotechnical database is shown in Figure 21. When "Add a New Project" is clicked, the graphical user interface illustrated in Figure 22 appears. The user may add a rock fall or landslide site, or any other type of site. Other types of highway sites include roadway, bridge, building, culvert, dam, drainage, pavement, wall, and "other." The GUI screen shown in Figure 23 appears when "Site" on the menu is clicked. The site screen contains an array of data entry slots for any array of site data. This includes such information as route number, station numbers, intersecting routes, verbal description, mileposts, values of latitude and longitude, or NAD 27, or NAD 83, coordinates and other information as shown in the figure.

As shown in Figure 22, the site menu also contains special data entry GUI screens for rock fall and landslide sites. Screens for these types of sites, as well as full discussions on the inventories of rock slope and landslide sites in Kentucky are described in more detail in following sections.

Rock Slope Data and Management System

Effective management of rock slope problems requires a system that will help identify potentially hazardous sites where rock fall may occur. Also, the system should be simple and clearly identify important parameters that largely control rockfall potential of a cut slope. A rock fall hazard rating system (RHRS), developed by the Oregon Department of Transportation for the Federal Highway Administration, met the conditions cited above. Details are given elsewhere (Pierson and Vickle 1993; Pierson 1993). The rating system provides a rather simple and uniform means of identifying potentially dangerous rock fall slopes and a method for developing a priority list of sites where protective measures, or repairs, may be needed.

When using the RHRS approach, rock slopes are initially classified, visually, for the potential of falling rocks entering the roadway. Rock slopes assigned to classification, “A,” have high potential for falling rocks entering the roadway, as illustrated by the slope in Figure 24. A “B” classification indicates a moderate chance for rocks entering the roadway. Figure 25 is a view of a typical “B” slope. Slopes with a low chance of falling rocks entering the roadway are classified as “C”, as illustrated in Figure 26. A large number of slopes on a selected route can be surveyed quickly by merely driving the route and assigning each slope to one of the three categories. Historical information can be used in the preliminary classification. RHRS is a proactive way to address problematic rock slopes and is a very useful tool to assist in allocation of funds to repair hazardous rock cuts (Pierson and Vickle, 1993).

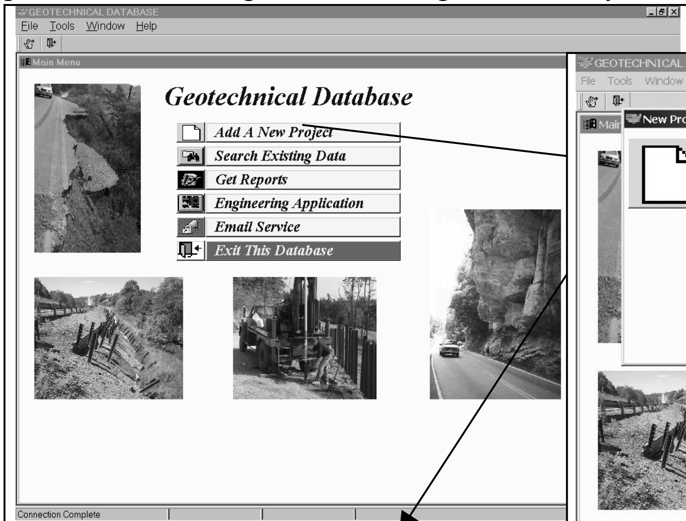


Figure 21. Main menu of geotechnical database.

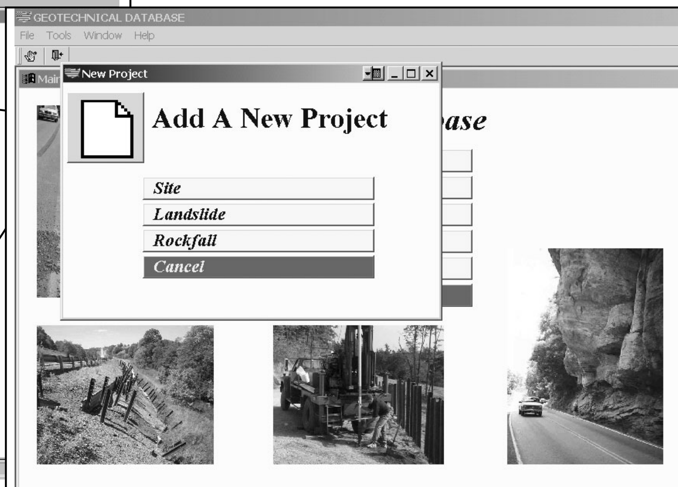


Figure 22. Menu for adding site information.

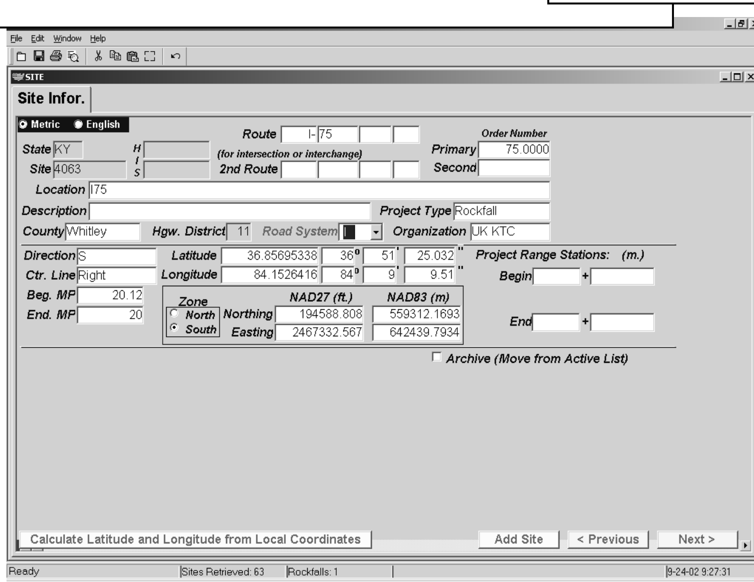


Figure 23. GUI screen for entering site information.

After obtaining preliminary ratings, slopes that were assigned (subjectively) to A and B categories are rated numerically using the RHRS approach. Detailed numerical ratings of rock slopes are based on 12 categories, or attributes. These include slope height, ditch effectiveness, average vehicle risk, percent of decision sight distance, roadway width, geologic character (Case 1--rock jointing and friction between joints or Case 2--differential erosion features and

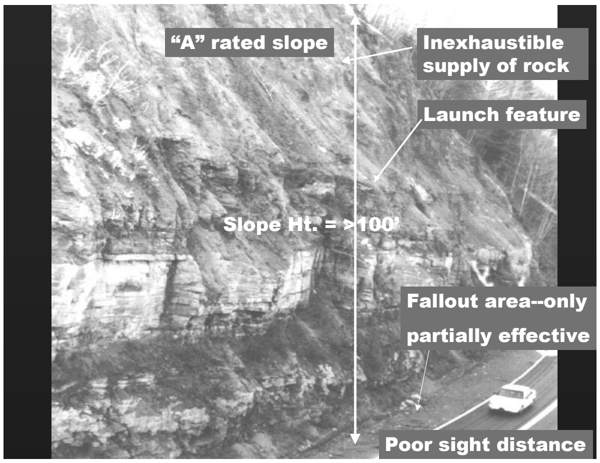


Figure 24. Example of an "A" rated slope.

Figure 25. Example of a "B" rated slope.

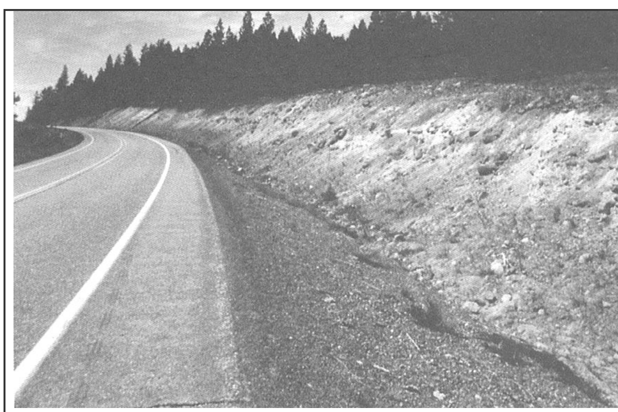


Figure 26. Example of a "C" rated slope (After Pierson and Vickle 1993).

differential erosion rates), block size or volume, climate, and rock fall history. The system provides a good means of assessing the risk associated with a site. Scoring graphs, based on an exponential scoring system, have been established for each category.

All components of the RHRS approach have been programmed into the Kentucky Geotechnical Database using Graphical User Interface (GUI) screens. In cases involving scores between set points, the program provides the range of scores that can be entered and controls allowable values the user can enter. Total score is automatically tabulated after the user has entered all data for all parameters. Spaces are available to enter comments relative to each category or the rock fall site. Any comments entered are displayed on printed reports. Preliminary surveys of about 10,000 rock slopes on interstates, parkways, primary routes, and some secondary routes in Kentucky were surveyed. Approximately 2,086 rock slopes assigned to categories, "A" or "B," were rated numerically (9). Latitude and longitude of each site were obtained using GPS equipment. Also, photographs of each site were obtained. All data, including electronic photographs have been stored in the database.

A rock slope is considered a site in the database. Site information includes county, route, mile point and station if known. Space is also available to enter location and description comments. Rock slope data for slopes is entered to the database by use of graphical user interface screens. A site screen is shown in Figure 23. This example shows a slope on Interstate 75 in Whitley County, from MP 20.0 to 20.12. Global Positioning System (GPS) coordinates can be entered as decimal degrees, degrees- minutes- seconds, or in State Plane coordinates format. When coordinates are entered in one format, the others are automatically calculated. GPS coordinates are used to display sites on electronic maps embedded in the program.

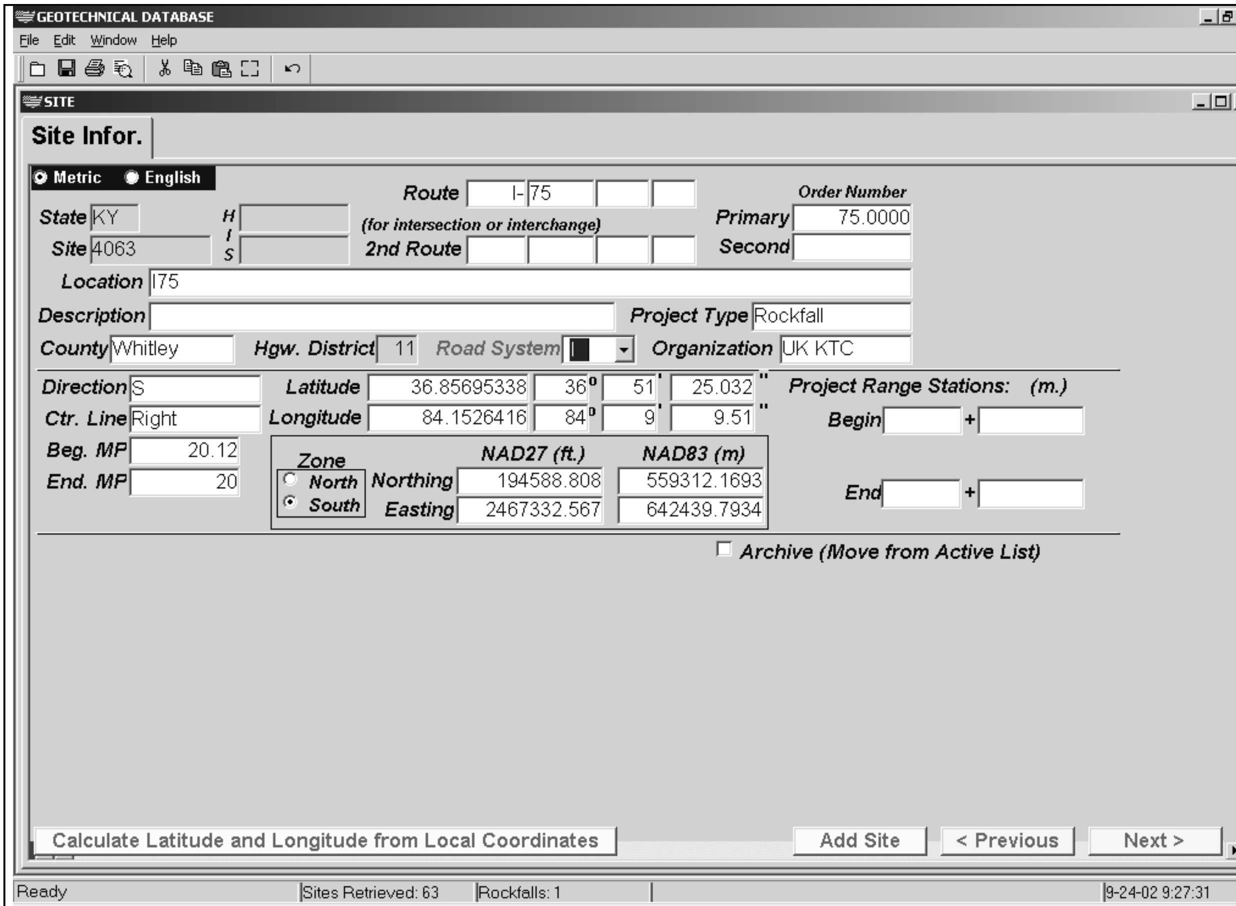


Figure 27. GUI screen for entering site information.

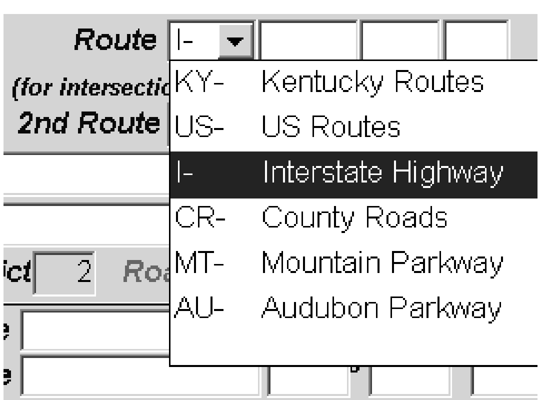


Figure 28. Dropdown list for entering route prefix.

Detailed Explanation of Graphical User Interfaces for Entering Rock Slope Data

Site GUI screen

The **Site Screen**, as illustrated in Figure 27, contains information about the physical location of a particular rock slope site. State is automatically entered. The same screen, Figure 27, is used in the landslide inventory, roadway, structure, and soil/rock modules of the Kentucky Geotechnical Database.

Route can be selected by entering the route number in the center box after **Route** (that is, 75). A prefix can be selected from a drop down list in the first box (for example, I for Interstate, Figure 28). Clicking the mouse in the blank box and using the down arrow button to make a selection activates the drop down list. The first letter of the selection can also be typed and the appropriate selection appears. For example, typing **K** in the box will enter **KY** for route prefix and **U** would

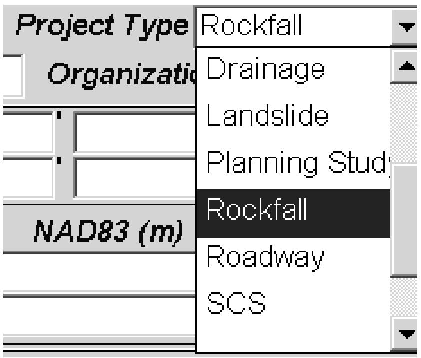


Figure 29. Dropdown list for entering the type of project.

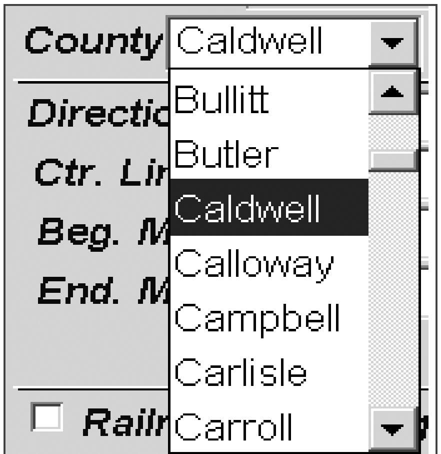


Figure 30. Dropdown list for entering the county name.

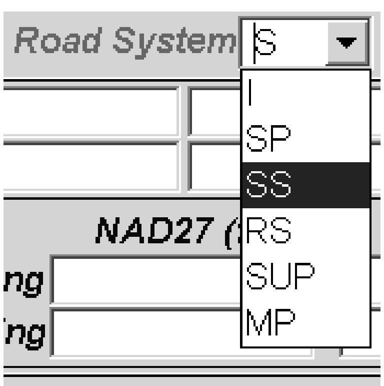


Figure 31. Dropdown list for entering the type of road system.

enter **US**. Selecting the prefix from the drop down list and entering the Route Number in the next box enters route. A suffix can also be entered when applicable. A Route suffix can be added by clicking the mouse in the blank box and using the button to make a selection or the first letter of the selection can also be typed and the appropriate selection appears. For example, typing **W** in the box will enter W for Route Suffix.

Site number is unique and is automatically assigned by algorithms stored in the database program. The term, **2nd Route,** is reserved for intersections of roadways. It is not used in the *Rock fall* module of the database.

Order Number, Primary, and **Secondary** apply to roadways within the county and are automatically assigned by a Database Administrator (DBA). The **Location** and **Description** fields are for entering additional information, which are preferable but not required.

Project Type is selected by using the drop down list, Figure 29, or the first letter of the **Project Type** can be typed in the adjacent box or be selected from a drop down list box. It is always **Rock fall** when using the *Rock fall* module of the database.

Clicking the mouse in the blank box and using the drop down list, Figure 30, a **County** selection may be made, or the first letter of the **County** can be entered. The first **County,** in alphabetically order, will appear. The user may scroll down to the desired County. Typing **C** in the box will go to Caldwell County. If Carroll County is needed, then the user scrolls down to find Carroll or the user types C and scrolls down from Caldwell. The **Hgw. District** automatically assigns the appropriate Highway District number when County is entered. The type of **Road System** is selected from a drop down list, Figure 31**.** For example**, SS** means the "state secondary" system**.**

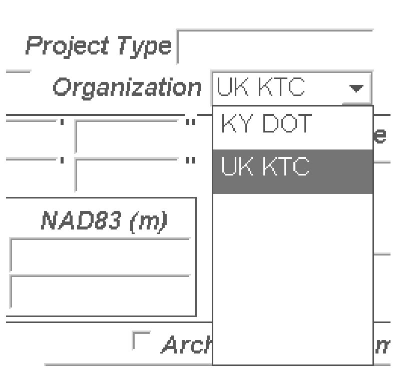


Figure 32. Dropdown list for entering organization.

Organization is selected by using the drop down list, Figure 32, to make a selection, or the first letter of the **Organization** entering the information can be typed in the adjacent box. For example, typing **U** would return UKTC, which means the University of

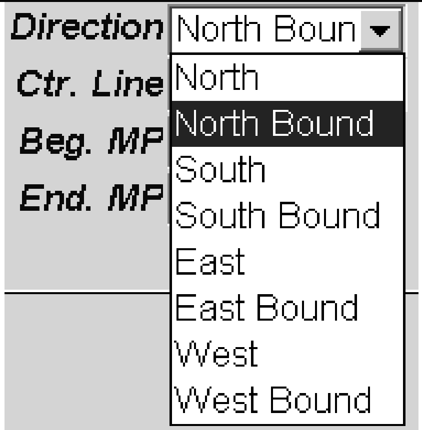


Figure 33. Dropdown list for entering the route direction adjacent to the rock slope.

Kentucky Transportation Center entered this rock fall site. Selecting **K** means the Kentucky Transportation Cabinet entered the site information. In structuring the database, allowance has been made for geotechnical consultants to enter data in the future.

Dir. refers to lane direction the slope is adjacent to. The direction can be typed or selected from a drop down list box, Figure 33, Ctr**. Line** is the offset direction (**Right or Left**) from the centerline of the roadway. The offset direction can be typed or selected from a drop down list box.

Beg. MP, Mid MP, or **End MP** refers to the beginning, middle, and ending mile point of the slope being rated, respectively. Only the **Beg. MP** and **End MP** are used in the *Rock fall* module of the database.

Latitude and **Longitude** are entered as decimal degrees or **Degrees (°) Minutes (') and Seconds (")**. If **Latitude** and **Longitud**e are entered in decimal degrees (up to 8 decimal places) they are automatically converted to **Degrees, Minutes and Seconds**, and vice versa. The decimal place must be typed in when **Longitude** is entered in Decimal Degrees (i.e. 84.50000000). The decimal is automatically entered for **Latitude** (i.e. 34.50000).

State Plane Coordinates are automatically calculated when **Latitude** and **Longitude** are entered. They are displayed in two North American Datum (NAD) methods: **Northing** and **Easting, NAD 27 (Ft)**, feet and **NAD 83, (m)** meters and (**Ft**) feet. **North** and **South Zone** are also selected. **State Plane Coordinates** can also be entered and L**atitude** and **Longitude** will be calculated as decimal, degrees and degree, minutes, and seconds.

Project Range Stations can be entered as **Begin** (Beginning) and **End** (Ending) stations if known. Stations can be entered in English or Metric formats. Stations can be entered to the hundredth of a foot or meter.

Rock Slope GIU for Numerical Scoring

The **Total Score** screen, Figure 34, is used to record the Date, Class of Slope, typically A or B if it is rated, person or persons who performed the rating, and any comments. The numerical RHRS score is calculated by clicking the **Compute Total Score** tab after all rock fall parameters have been entered. Rock slope parameters and other data are arranged near the top of the total score GUI screen in the form of tabs. These tabs have been labeled **Site Infor., Total Score, Traffic, Geometry, Geologic Character, Climate/rock fall History, Mitigation Cost, Report, and picture.** Clicking any one of these labeled tabs causes a GUI screen to appear for entering data pertaining to that tab.

Date: The rating date is entered in this field, as shown in Figure 34. **Rated by**: Enter the name or initials of the person(s) rating the slope.

Class: Enter the preliminary classification of the slope **A, B**, or **C** by typing or using the drop down list, Figure 35, to make a selection. **Comments**: Any comments can be entered here. This example is recording the roll number and picture numbers from developed prints from the site. Any comment entered appears on the report screen. **Compute Total Score**: After entering all information and scores, return to this page and click "**Compute Total Score."** The **Total Score** of the numerically rated rock slope assigned to the site will be computed.

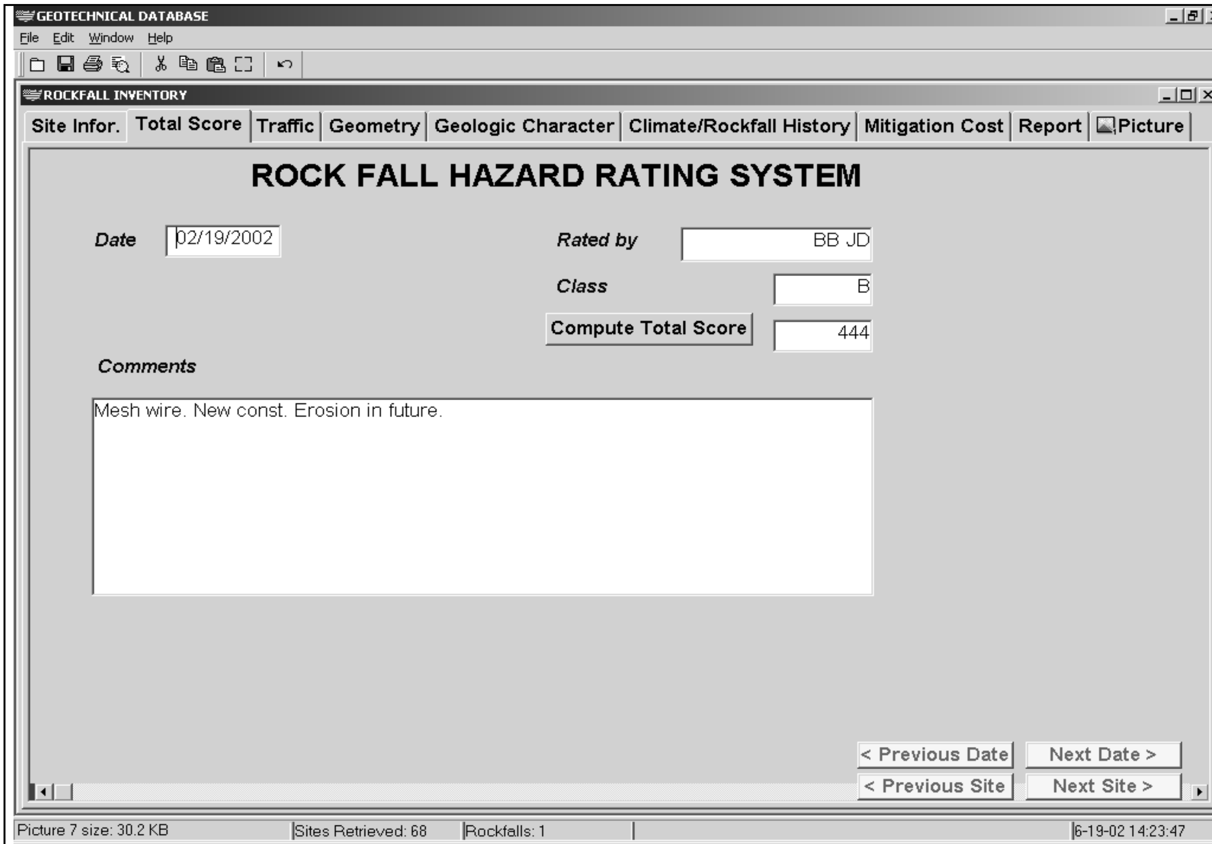


Figure 34. Rock slope total score GUI screen for recording rock slope data.

When the tab labeled "**Traffic**" (Figure 34) is clicked using the mouse, the **Traffic Information** screen (Figure 36) appears. This screen is used to calculate Average Vehicle Risk and Percent of Decision Sight Distance scores. The Average Vehicle Risk score determines "the risk associated with the percentage of time a vehicle is in the rock fall section" (Pierson and Vickle, 1993). It is automatically calculated when the speed limit, which can be typed or selected from a drop down list, slope length, and Average Annual Daily Traffic (AADT) obtained from the Kentucky Transportation Cabinet (KYTC) are entered. The algorithm for calculating average vehicle risk is:

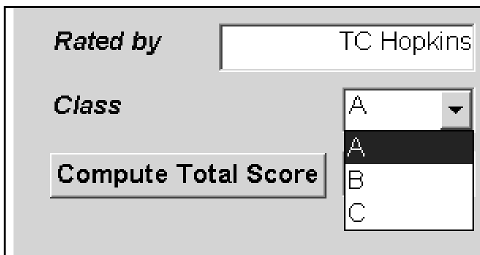


Figure 35. Dropdown list for entering the preliminary rating of the rock slope.

$$AVR = \frac{\frac{ADT(cars/day)}{24 hours/day} \; x \; Slope \; Length \; (miles) \; x \; 100\%}{Posted \; Speed \; Limit \; (miles \; per \; hour)} \quad (5)$$

where

ADT is equal to the average daily traffic.

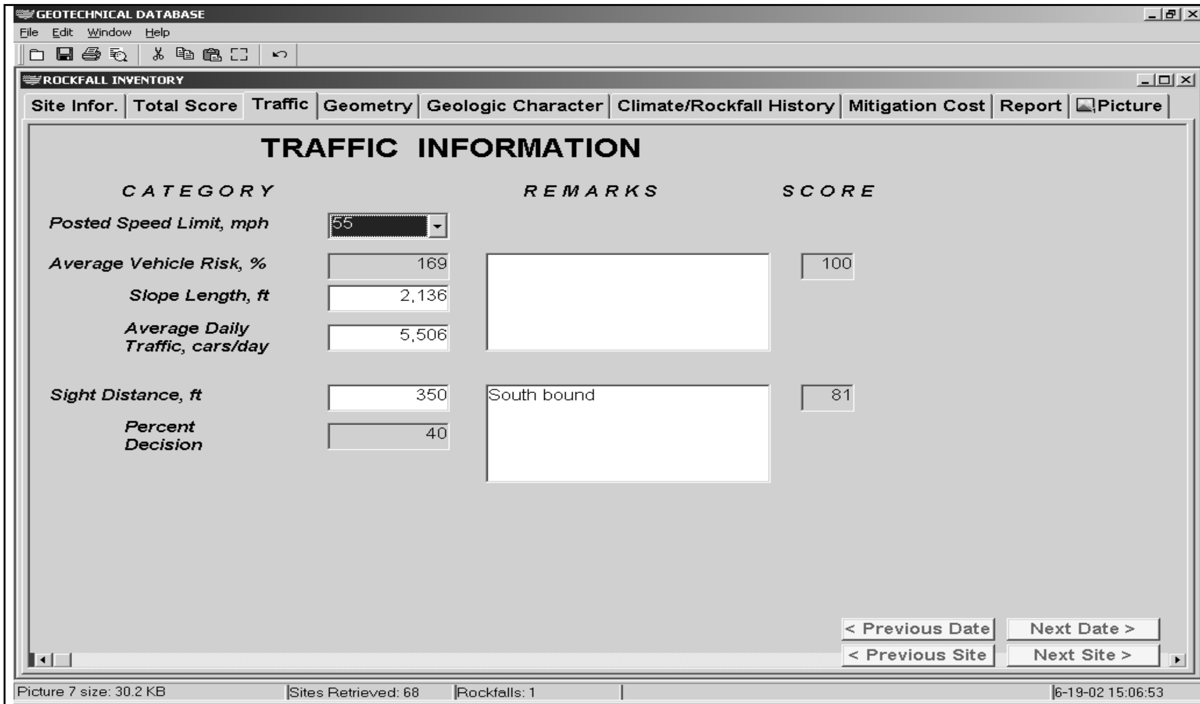


Figure 36. GUI traffic information screen for scoring the average vehicle risk and sight distance.

The **Posted Speed Limit** is normally obtained from the posted speed limit on roadway signs, Figure 37, near the site. The relationship between the AVR category score and percent of time a vehicle is in the rock slope section is shown in Figure 38. When the rating is 100 percent a vehicle can be expected to be present in the slope section 100 percent of the time. If the calculated percent is greater than 100 percent, then more than one vehicle is present in the section at any given time. **"The Percent of Decision Sight Distance,"** PDSD, compares the amount of sight distance available through a rock slope section to the low amount (Figure 39) prescribed by AASHTO (Pierson and Vickle 1993), or

$$\text{PDSD} = \frac{AST}{DSD} x \quad 100\% \tag{6}$$

where

AST = Actual sight distance and

DSD = Decision sight distance.

The category score is shown in Figure 40 as a function of percent decision sight distance.

After entering values for posted speed limit, horizontal slope length, ADT, and sight distance, the program automatically computes average vehicle risk and percent decision sight distance. Based on computed values of average vehicle risk and percent decision sight distance, category scores are computed for these two parameters.

Clicking the tab in Figure 34, identified as **"Geometry,"** causes the geometry GUI screen to appear, as shown in Figure 41. This screen is used to enter data pertaining to the *Slope Height, Ditch Effectiveness, and Roadway Width.* The **Slope Height** score is based on the principal that the taller a slope is the greater the likelihood for falling rocks to enter the roadway. The

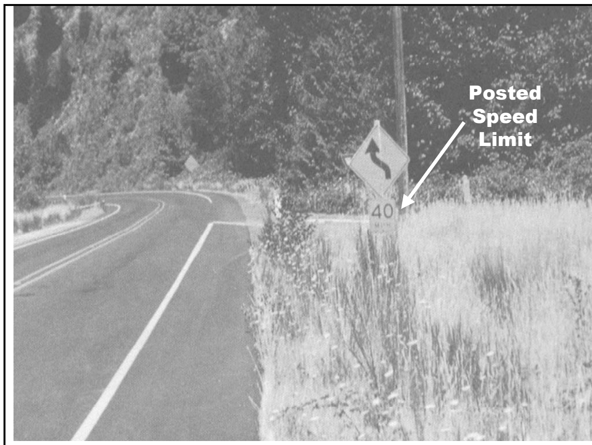


Figure 37. Posted speed limit sign.

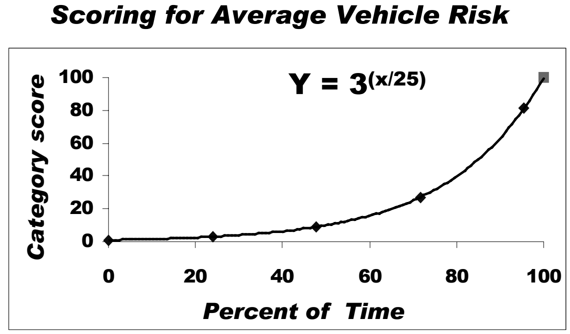


Figure 38. Category score as a function of the percent of time a vehicle is in the measured rock slope section.

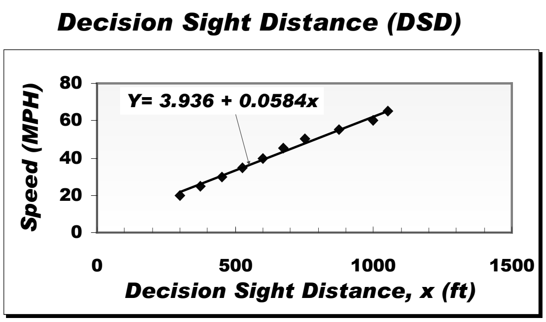


Figure 39. Speed of vehicle as a function of decision sight distance.

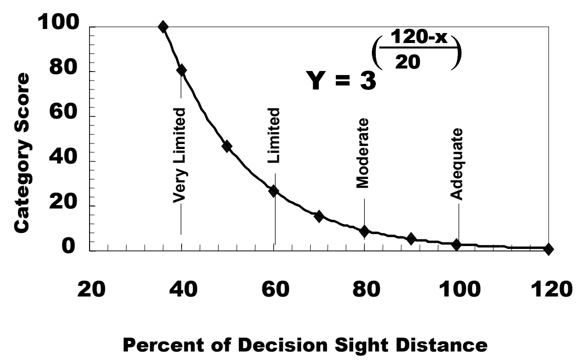


Figure 40. Category score as a function of percent of decision sight distance.

relationship of the category score and slope height is shown in Figure 42. Two situations oftentimes encountered are depicted in Figures 43 and 44. In the first case, height of slope involves only the height of the cut slope. In the second situation, Figure 44, height of slope includes height of the cut slope and height of the natural slope situated above the cut slope.

Slope height may be entered directly (Figure 41), or an approximate value may be determined by measuring two angles, " and $, using a hand held instrument (inclinometer), as illustrated in Figures 45, 46, and 47. Using an inclinometer, angles, $ (Figure 46), and " (Figure 47) may be measured from the horizontal to the same point at the top of the slope. A distance, X, between the points where the two angles were obtained is determined, and a height of instrument (HI) is measured. **Slope Height, SH,** is determined by:

$$SH = \frac{(\sin\alpha \sin\beta)X}{\sin(\alpha - \beta)} + HI \qquad (7)$$

In the computer program, when parameters, ", $, X, and HI are entered into the GUI screen shown in Figure 41, slope height and the slope height category score are automatically calculated.

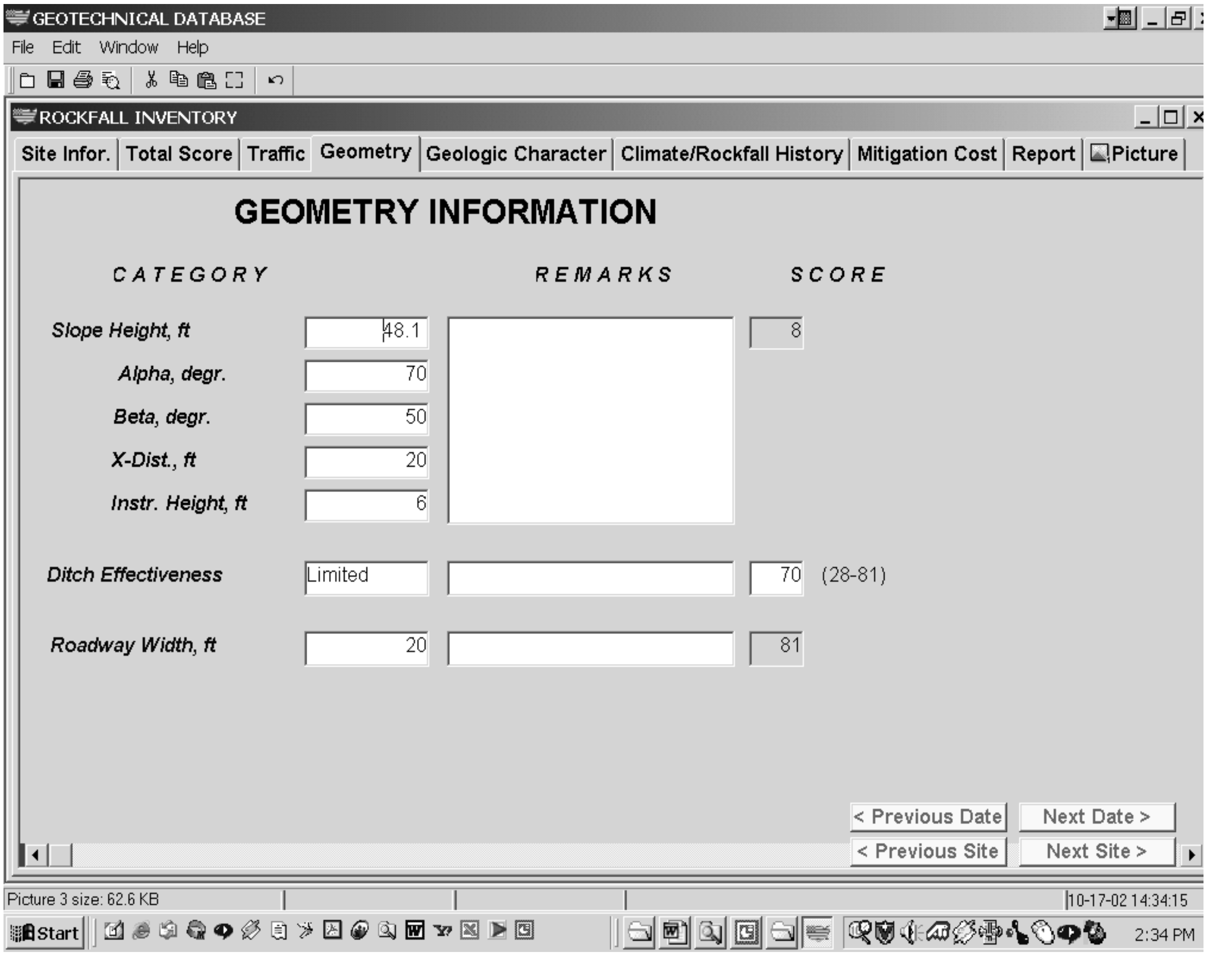


Figure 41. GUI screen for entering the geometry of a rock slope.

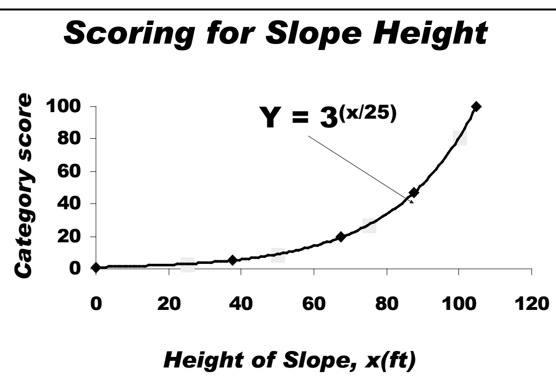


Figure 42. Category score as a function of height of slope.

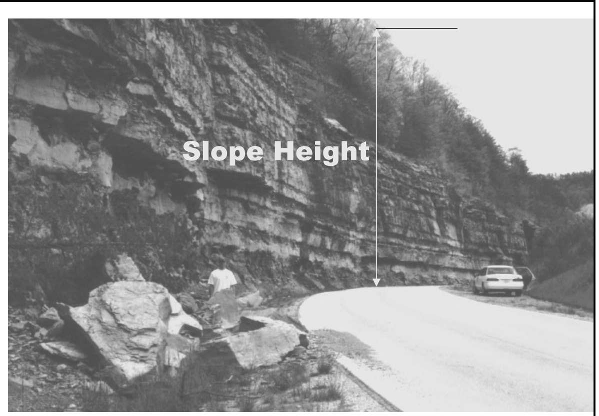


Figure 43. Vertical height of cut slope.

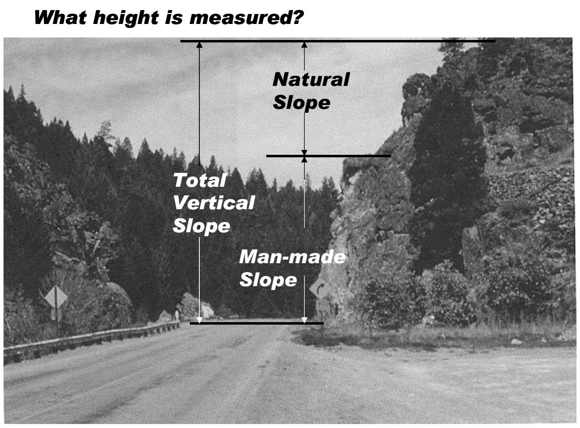


Figure 44. Height of slope includes the height of the cut slope and the height of the natural slope.

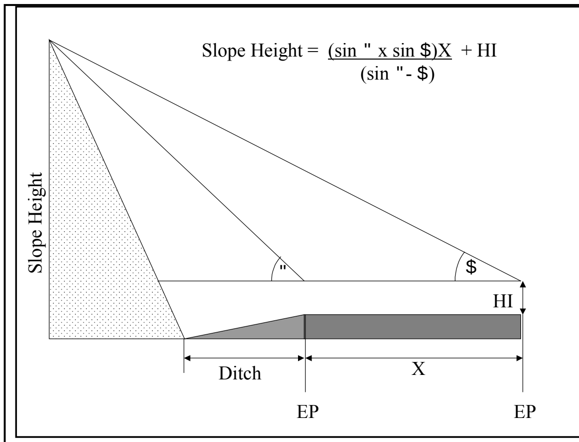


Figure 45. An approximate method of determining the slope height from geometrical relationships.

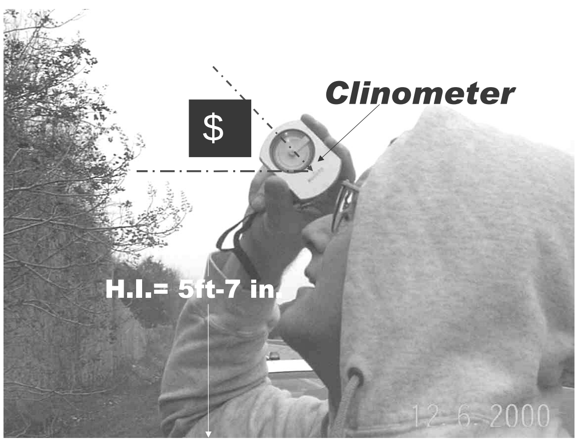


Figure 46. Clinometer used for measuring angles and illustration of the measurement of the angle, $.

Figure 47. Measurement of the angle, ".

Ditch Effectiveness is an estimated measure of the ability of the ditch, or distance between base of the slope and edge of pavement, to contain or prevent any falling rock from reaching the paved roadway. Although such parameters as slope height or average vehicle risk are fairly objective in assigning numerical values, judging effectiveness of the width of a ditch is subjective. Generally, as the width of the area between toe of slope and edge of pavement increases, the **Ditch Effectiveness** score decreases. Two extreme examples of ditch effectiveness, where low and high scores were assigned numerical values of zero and 100 points, respectively, are illustrated in Figures 48 and 49.

In judging effectiveness of the ditch area to contain rock fall, the user must try to anticipate the quantity of rock fall that may occur and how the quantity of material will "fit" in the ditch, or whether it will spill over onto the roadway, or whether it will completely breakdown on impact

Figure 48. The ditch effectiveness of this example was assigned a low score because of the larger space between the toe of the slope and the edge of the pavement.

Figure 50. Wide fallout area.

Figure 51. Failure of part of this large volume of material spilled onto the roadway at the I 75 site.

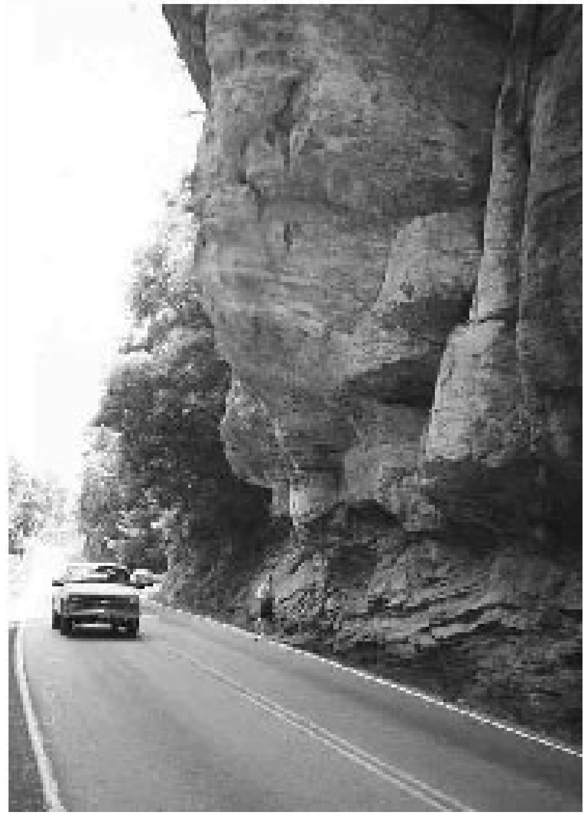
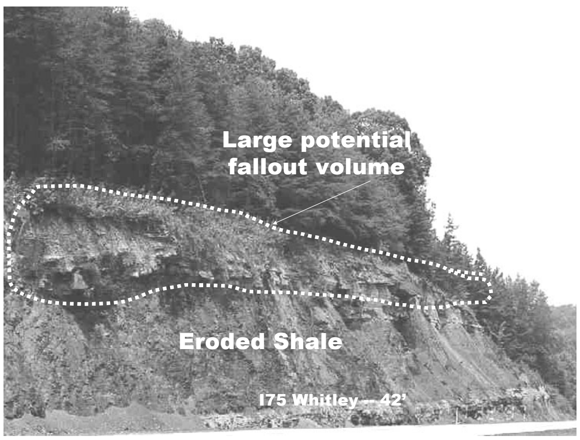


Figure 49. The ditch at this site is ineffective in retaining rock fall and preventing spillage onto the roadway.

into tiny rock fragments. Although the ditch, or the area between the toe of the slope and edge of pavement may be quite large, rock fall may in some situations enter the roadway. For example, the site at a location on I-75, Figure 50, appears to have more than adequate room to prevent rock fall spillage onto the interstate. However, as shown in Figure 51, rock fall and debris filled the ditch area (bottom right in photo) and spilled onto the roadway (the photo was obtained after rock fall and debris had been removed from the roadway). Another view of the slope in Figure 52 reveals that a large volume of hard material was situated above an eroded shale unit.

In assigning numerical values to this category, benchmark points (arbitrarily selected as 3, 9, 27, and 81) are associated with descriptions. Scoring this category requires judgment of the rater. According to Pierson and Vickle (1993), this association is as follows:

- 3 points—Good catchment: all, or nearly all falling rocks, are retained in the catch ditch (see example in Figure 48).
- 9 points—Moderate catchment: falling rocks occasionally reach the roadway
- 27 points—Limited catchment: falling rocks frequently reach the roadway.
- 81 points –No catchment: no ditch, or the ditch is ineffective, and all, or nearly all, of the falling rocks reach the roadway (see Figure 49).



Figurec 52. Potential rock fall and debris at a site on I 75.

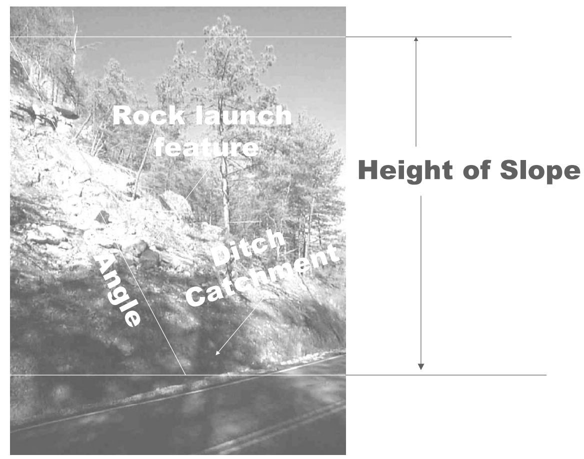


Figure 53. Some factors to consider in assessing ditch catchment.

Pierson and Vickle (1993) note that the rater should consider the following factors in evaluating the ditch catchment:

- slope height and angle (See Figure 53)
- ditch width, depth, and shape (see Figure 54)
- anticipated block size and quantity of rock fall (see Figures 52 and 53)
- slope irregularities that could serve to create a rock fall launching feature (see Figure 52 and 53).

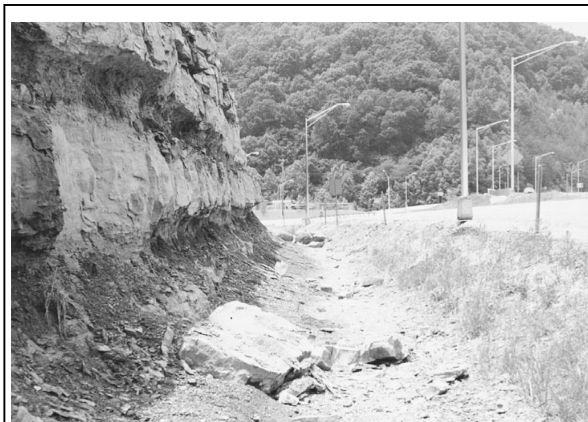


Figure 54. Ditch containing good catchment and designed according to the Ritchie ditch criteria.

Roadway Width is scored based on the assumption that the wider the roadway the more room a driver possesses to avoid rock debris that has reached the roadway, including paved shoulders. The measured portion of the roadway width includes the paved shoulders. Category score as a function of roadway width is shown in Figure 55. This category is a measurement of the available maneuvering room, or width of roadway, that allows a driver to miss a rock(s) in the roadway.

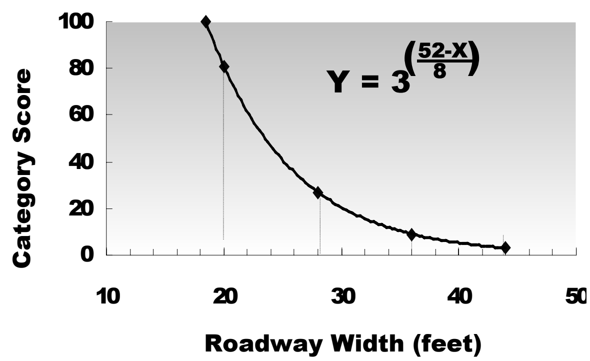


Figure 55. Category score as a function of roadway width.

After clicking the tab, identified as **Geologic Character** in Figure 34, the GUI screen in Figure 56 appears. The **Geologic Character** screen is used to rate the structural conditions, joints, and bedding planes and differential erosional features and rates, visible on the slope. Joints are fissures in the rock mass. Bedding planes are the interface between different rock layers. The structural condition of joints and bedding planes are considered to be discontinuous if they are more than 10 feet in length. Joint orientation score is based on the relationship between the angles of the joints and the highway. The score is higher if the orientation of the joints or bedding planes would cause falling rocks to be projected toward the road.

Two cases of **Geologic Character** are considered**:**

1) **Joints and their Orientation to the roadway, and,**
2) **Differential Erosion Features and Rates**

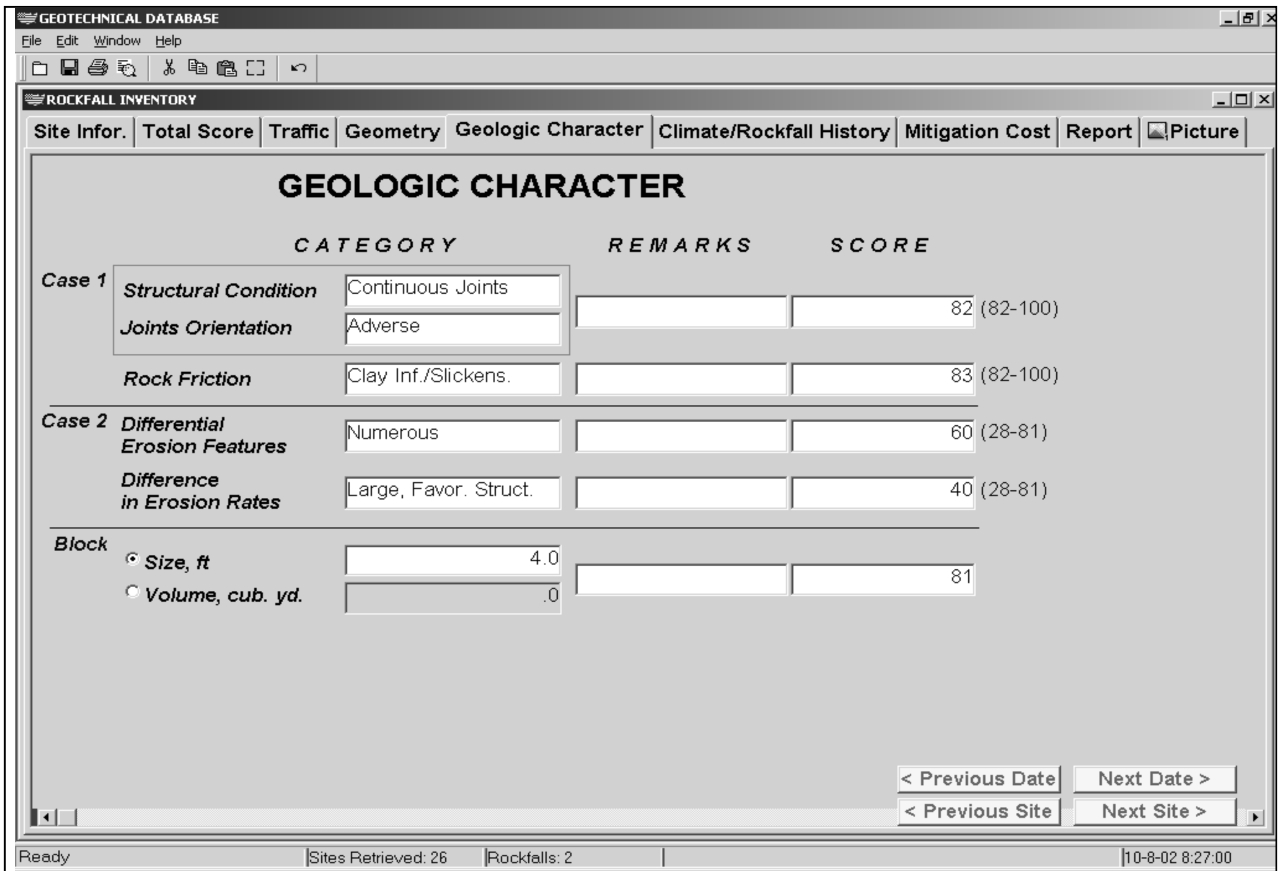


Figure 56. GUI screen for entering geology information and potential rockfall block size and volume.

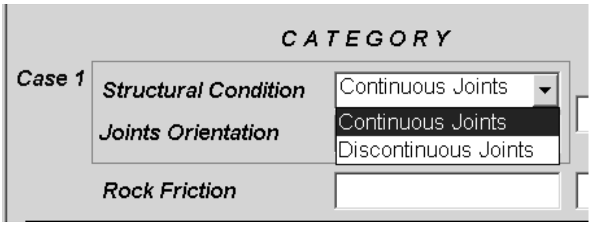


Figure 57. Dropdown list for selecting joint type.

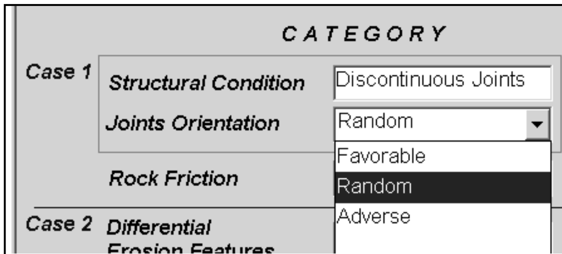


Figure 58. If discontinuous joint is selected, then the user must specify whether the joint orientation is **Favorable, Random**, or **Adverse**.

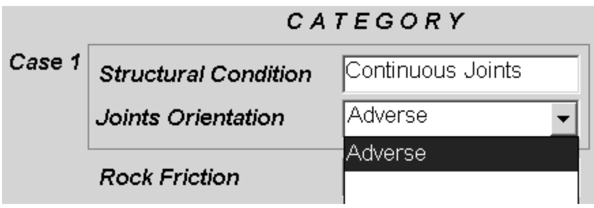


Figure 59. When the joints orientation is identified as continuous, the condition is identified as **Adverse** in the dropdown feature.

Figure 60. Continuous joints are rated as an adverse condition (usually in sedimentary units, joints are greater than 10 feet).

Case 1

Structural Condition: Select **Continuous Joints or Discontinuous Joints** from the drop down list (Figure 57) or type the first letter of the selection. Joints are **Continuous** if 10 feet or larger in length. **Joint Orientation**: If joint orientation is **Discontinuous,** then the user must select **Favorable, Random** or **Adverse** from the drop down list, as shown in Figure 58 (Note: If the category, **Continuous Joints,** is selected, **Joint Orientation** must be **Adverse,** as shown in Figure 59 and illustrated in Figures 60 and 61**).**

The S**tructural Condition**, case 1, is scored as follows:

If **Discontinuous Joints** and **Favorable Orientation** are selected, then a corresponding **SCORE** ranging from 0 to 9 is entered if **Discontinuous Joints** and **Random Orientation** are selected enter a corresponding **SCORE** from 10 to 27.
If **Discontinuous Joints** and **Adverse Orientation** are selected enter a corresponding **SCORE** from 28 to 81.
If **Continuous Joints** and **Adverse Orientation** are selected enter a corresponding **SCORE** from 82 to 100.

Rock Friction: Select **Rough, Planar Undulating or Clay infilled Slickensided** from the drop down list, as shown in Figure 62. **Rock Friction** is scored as follows:

If **Rough** is selected, then enter a corresponding **SCORE** ranging from 0 to 9.
If **Undulating** is selected, then enter a corresponding **SCORE** ranging from 10 to 27.

Figure 61. Another example of continuous joints and an adverse condition—tilted layers.

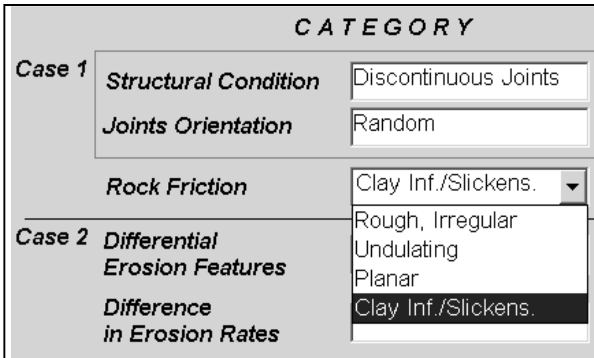


Figure 62. Dropdown list for rock friction.

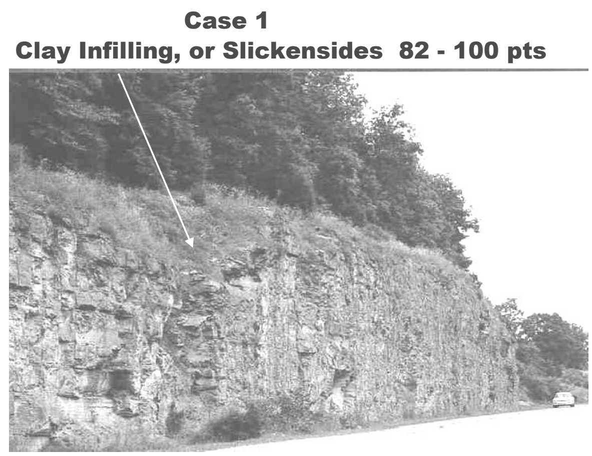


Figure 63. An example where the rock friction was described as clay infilling, or slickenside.

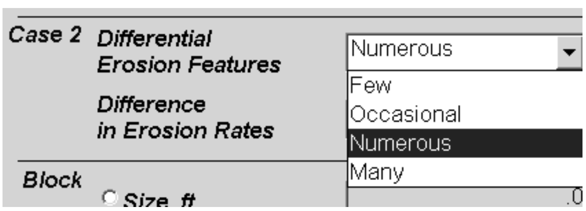


Figure 64. Dropdown list for differential erosion features.

If **Planar** and **Adverse Orientation** is selected, then enter a corresponding **SCORE** ranging from 28 to 81.

If **Clay Infilling/Slickenslide** (see Figure 63 for an example**)** is selected, then enter a corresponding **SCORE** ranging from 82 to 100.

Numerical ratings of the structural condition, Case 2-- **Differential Erosion Features and Rate—**are scored in the GUI screen shown in Figure 56. **Differential Erosion Features** are selected as **Few, Occasional, Many, or Major** from the drop down list in Figure 64, or type the first letter of the selection. **SCORE** Differential Erosion Features as follows**:**

If **Differential Erosion Features Few** is selected, enter a corresponding **SCORE** ranging from 0 to 9.

If **Differential Erosion Features Occasional** is selected, enter a corresponding **SCORE** ranging from 10 to 27.

If **Differential Erosion Features Many** is selected, enter a corresponding **SCORE** from 28 to 81.

If **Differential Erosion Features Major** is selected enter, a corresponding **SCORE** from 82 to 100.

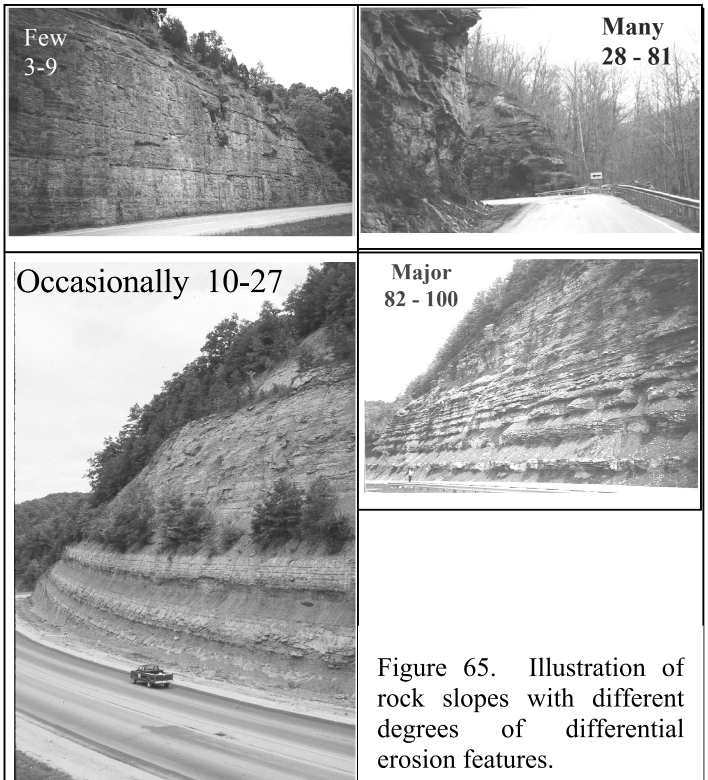


Figure 65. Illustration of rock slopes with different degrees of differential erosion features.

Examples of rock slopes containing different differential erosion features are illustrated in Figure 65.

Differential Erosion Rates are selected as **Small, Moderate, Large, or Extreme** from the drop down list, as shown in Figure 66, and are scored as follows:

If **Differential Erosion Rates Small** is selected, then a corresponding **SCORE** ranging from 0 to 9 is entered
If **Differential Erosion Rates Few** is selected, then a corresponding **SCORE** ranging from 10 to 27 is entered
If **Differential Erosion Rates Large** is selected, then a corresponding **SCORE** ranging fm 28 to 81is entered
If **Differential Erosion Rates Extreme is** selected, then a corresponding **SCORE** ranging from 82 to 100 is entered.

Examples of rock slopes with different erosion rates are illustrated in Figure 67.

Block: This category describes the material falling from the rock slope. If **Size** of the block is the deciding factor in determining the type of material falling, click the **Size** button and enter the largest dimension in feet of rock (Figure 56). The category score is simply a function of the size of the block, as illustrated in Figure 68. If **Volume**, as illustrated in Figure 69, is the

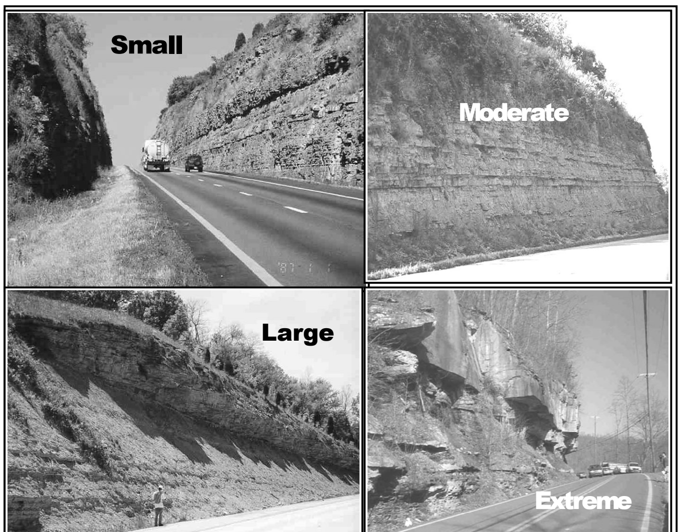


Figure 67. Rock slopes with different degrees of differential erosion rates.

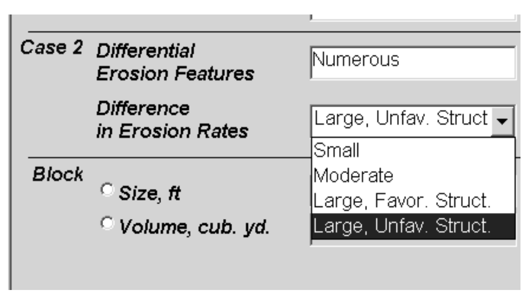


Figure 66. Dropdown list for describing the difference in erosion rate.

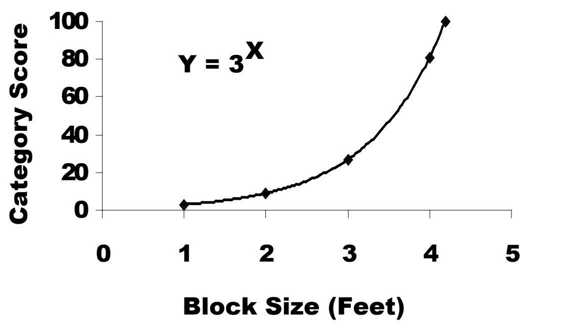


Figure 68. Category score as function of block size.

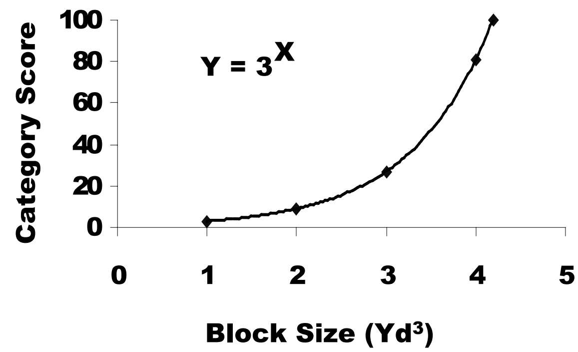


Figure 70. Category score as function of volume of fallen rock.

Figure 69. Illustration of rock fall volume.

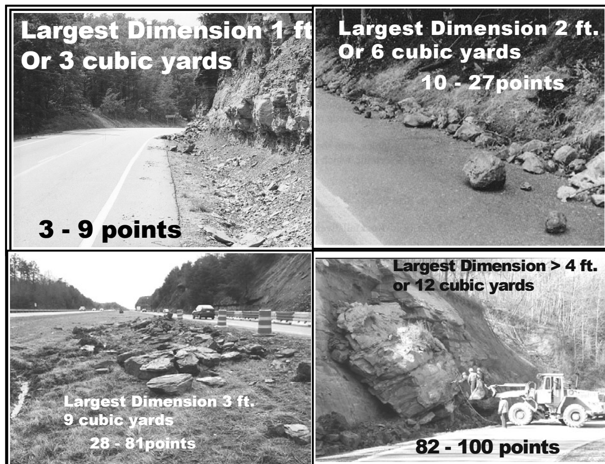


Figure 71. Category scores for example rock slopes with different block/volume dimensions.

determining factor, such as a pile of rocks instead of a few or several scattered individual rocks, click the **Volume** button and enter the approximate volume of material in cubic yards, which has fallen, or has the potential to fall. The **SCORE** will be automatically entered based upon volume.

The relationship of category score and volume of material is shown in figure 70. Rock slope scoring examples with different block or volume dimensions are depicted in figure 71.

By clicking the tab, identified as **CLIMATE/ROCKFALL HISTORY,** in Figure 34, a GUI screen for scoring the climate and the rock fall history is enabled, as shown in Figure 72. C**limate:** RHRS was developed by the Oregon Department of Transportation. Oregon has many different climatic conditions. The scoring conditions were based on Oregon's climate. Climatic conditions are described elsewhere (Pearson and Vickle 1993).

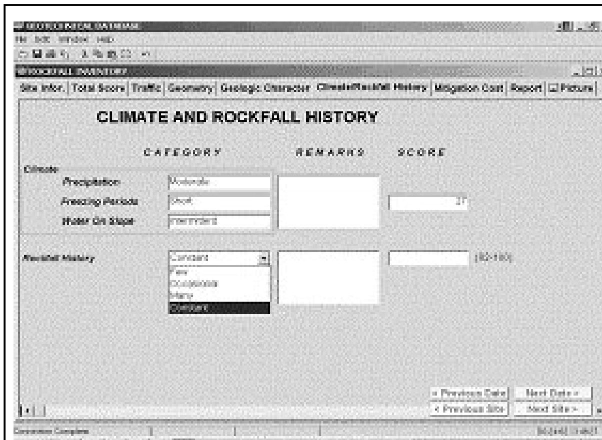


Figure 72. GUI screen for entering climate/ rockfall history data.

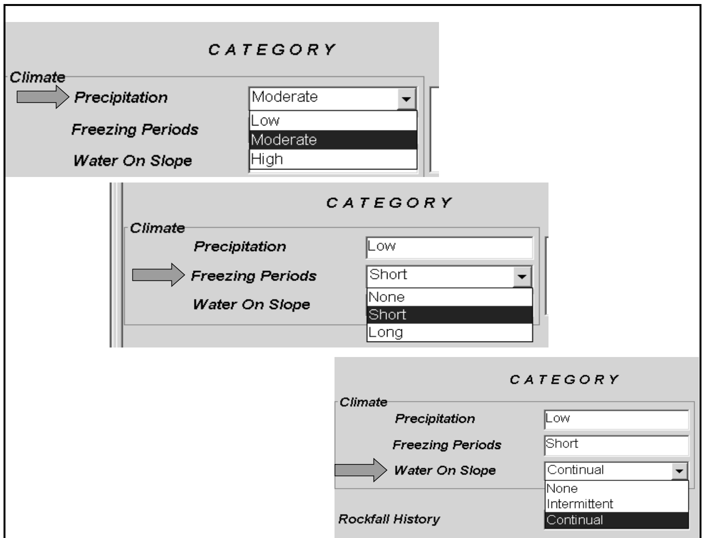


Figure 73. Dropdown lists for describing precipitation, freezing periods, and water on the rock slope.

Climate score is based on the amount of precipitation, free-thaw cycles and water on the slope. Typically a score of 27 is used for Kentucky because Kentucky's precipitation and freeze thaw periods are fairly uniform statewide. The score may **be changed if the rater is** supplied information concerning the slope, such as the amount of water present.

Precipitation: This parameter is selected from a dropdown list, Figure 73. The user may describe the precipitation as **Low, Moderate, or High** from the drop down list or type the first letter of the selection. **Freezing Periods**: select **None, Short,** or **Long** from the drop down list, Figure 73, or type the first letter of the selection. **Water on Slopes**: select **None, Intermittent**, or **Continual** from the drop down list, Figure 73, to make a selection or type the first letter of the selection.

CLIMATE is scored as follows**:**

If **Precipitation, Low to Moderate,** and **Freezing Periods, None, and Water on Slope, None,** are selected enter a corresponding **SCORE** from 0 to 9.
If **Precipitation, Moderate,** and **Freezing Periods, Short, and Water on Slope, Intermittent** are selected enter a corresponding **SCORE** from 10 to 27.
If **Precipitation, High** and **Freezing Periods, Long, and Water on Slope, Continual** are selected enter a corresponding **SCORE** from 28 to 81.
If **Precipitation, High,** and **Freezing Periods, Long, and Water on Slope, Continual** are selected enter a corresponding **SCORE** from 82 to 100.

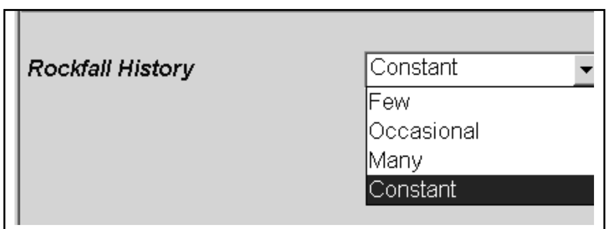


Figure 74. Dropdown list for selecting description of rockfall activity at a site.

Because the temperature and rainfall across Kentucky is fairly uniform, a **SCORE** of 27 is suggested for all rock slopes rated in Kentucky.

Rock fall History: This parameter is scored by selecting **Few, Occasional, Moderate,** or **Many** from the drop down list, as shown in Figure 74. The best source of rock fall History is County and District Transportation Cabinet, Operations Personnel. The category **SCORE** is assigned as follows:

If **Few** is selected enter a corresponding **SCORE** from 0 to 9.
If **Occasional** is selected, enter a corresponding **SCORE** from10 to 27.
If **Moderate** is selected, enter a corresponding **SCORE** from 28 to 81.
If **Many** is selected, enter a corresponding **SCORE** from 82 to 100.

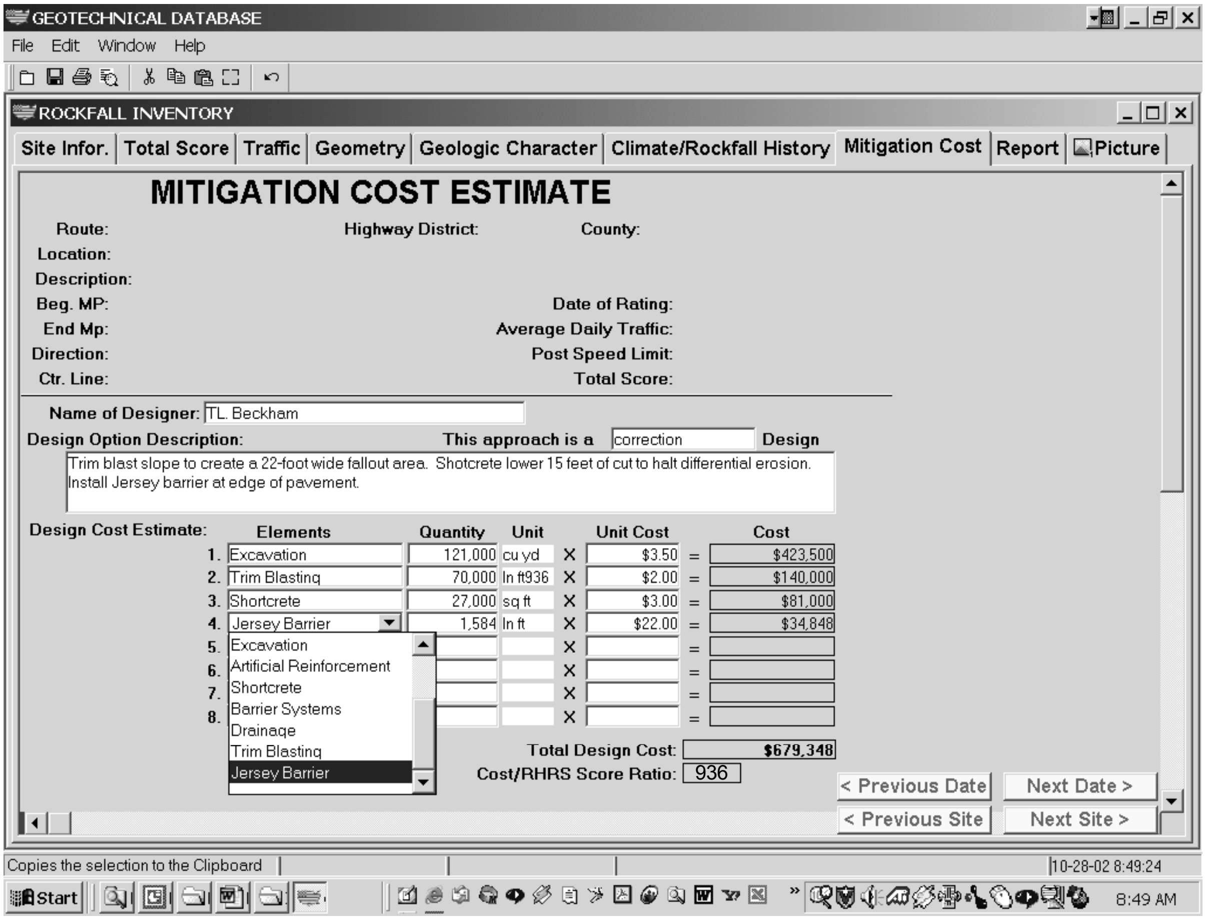


Figure 75. GUI screen for entering estimated remedial methods and costs for correction, or hazard reduction, plan.

As shown in Figure 75, the **Mitigation Cost Estimate** screen can be used to estimate the cost for repairing a rock slope and compute a cost/RHRS score ratio. Total Design Cost is calculated by selecting elements to be used in the repair from a drop down list and entering the quantity and unit cost for each element. A **Cost/RHRS** ratio is then determined.

When the **Report Screen** (Figure 75) is selected a written report, summarizing all of the attributes and key information of a rated slope, is displayed, as shown in Figure 76.

Visual Features of Database –Electronic Photographs and Map displays

The visual function is an extremely important feature for users. Colored photographs of rock slope and landslide sites can provide valuable visual information. Clicking the mouse on the “**PICTURE**” tab shown in Figure 75 may access this feature. The GUI screen that appears and an example of a series of photographs of an example rock slope are illustrated in Figure 77. By double clicking the computer mouse on one of the smaller photographs, an enlarged view of the site is obtained, as shown in Figure 78. Attributes can be viewed in photographs that are not necessarily evident in narrative descriptions, or if they could be described, the descriptions would have to be lengthy. Technically, handling visual data in a database is much more difficult than handling text data because visual data is much greater in size than text data. Because of the size issue, data transmitting speed, processing time, and storage space requirements are primary factors that must be considered. In the early development of the database, photographs were stored as a Bitmap file (a product of Microsoft). The file size was 2.5 Megabytes (Mb). By

ROCKFALL HAZARD RATING SYSTEM 10/8/2002 10:24:20

Total Score: *504* Preliminary Class Rating: *B*
Rating Agency: *UK KTC* Rated by: *BB, JD*
Rating Date: *2/19/2001*
Route No. --- Primary: *US23* Route No. --- Secondary:
Beginning Mp: *13.85* Ending Mp: *14.1*
Direction: *N* Centerline: *Left*
Latitude: *38.42328761* Longitude: *82.60180163*
County: *Boyd* Highway District: *9*

Slope Score: *17* Actual Height of Slope, ft: *64*
Remarks:

Ditch Effetiveness Score: *25* Ditch Effectiveness: *Moderate*

Average Vehicle Risk Score: *100* Percent of Time: *273.38* Posted Speed Limit, mph: *55*
Average Daily Traffic, cars/day: *10,935*
Slope Length, ft:
Remarks:

AASHTO Decision Site:

Distance Score: *15* Actual Sight Distance, ft.: *620*
Percent of Low Design Value: *71*
Remarks:

Width Score: *47* Actual Width, ft: *24*
Remarks:

Geologic Condition-Case 1: Fracture:
A. Structural Condition Score: *82* Joint Orientation: *Adverse*
B. Rock Friction Score: *83* Rock Friction: *Clay Inf./Slickens.*
Geologic Condition-Case 2: Remarks:
A. Differential Erosion Feature: *60*
B. Erosion Rate Difference: *40* Rate: *Large, Favor. Struct.*

Block Size/Quantity Score: *81* Block Size, ft: *4.0*
Quantity of Mareriai, ft^3: *.0*
Remarks:

Climate/Water on Slope Score: *27* Precipitation: *Moderate*
Presence of Water on Slope: *Intermittent*
Remarks:

Rockfall History Score: *27* Fall Occurrence: *Occasional*
Additional Remarks: Remarks: *6 Year Plan:D-1997*
Roll# 8093; pictures 19-21 *R-2000, U-2001*
Roadway Report R-42-2000 issued with design reccomendations *C-2002*
Geotechnical Report R-42-2000

Figure 76. Rock slope report.

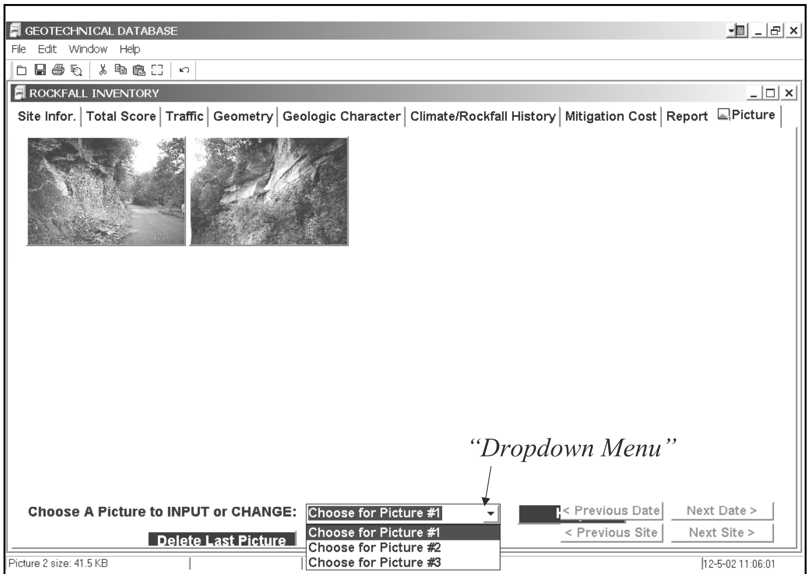


Figure 77. GUI screen displaying different photographs of a site.

saving the electronic file photographs in a JPEG format, the file size was reduced to 44 Kilobytes (Kb) and reduced space requirements. The reduction was made feasible by algorithms developed by the authors. Unique algorithms were written to store the photographs in the Oracle database.

Electronic images are entered using the function entitled "**Choose A Picture to INPUT or CHANGE,**" as shown in Figure 79. To enter a picture, select from a dropdown menu (bottom of Figure 77) "***Choose for Picture # n*** *(where*

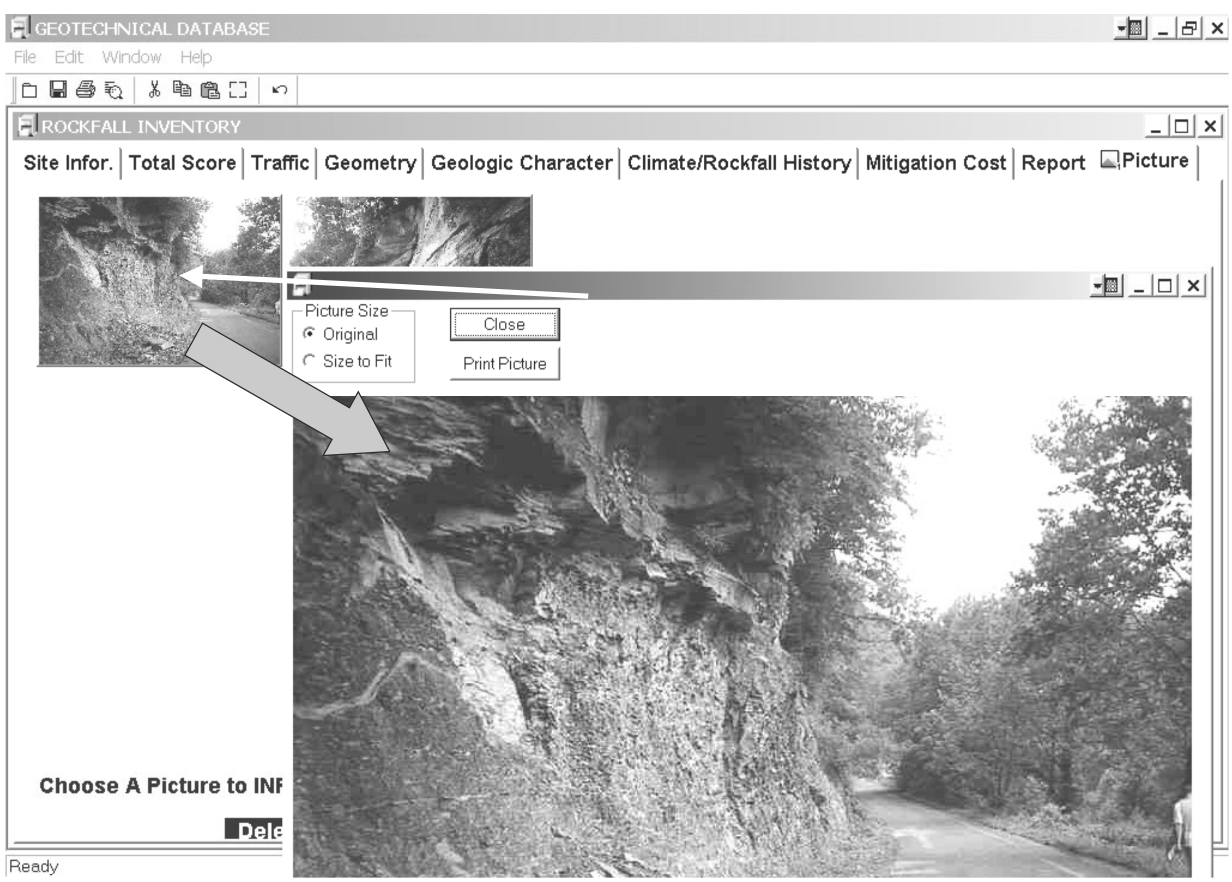


Figure 78. Larger view of photograph after clicking the mouse on the smaller photograph.

n = 1, 2, 3, 4….).” If n is less than or equal to the existing picture number you will need to change the number to the next larger number to enter a new picture. A box will appear in the upper left hand corner of the screen. Select the drive and directory the electronic images are stored in. Click the mouse on the name of the image to be stored. The image will appear. Adjust the size of the image if necessary to view the entire picture. Images are usually 100% or larger. Reducing the image to about 50 % will allow a full view of the picture. The name of the image will appear in the ***Select any File in the Directory to Open It* screen.** Click on **Open** and the image will appear on the screen. A **Save Picture** button will appear on the picture input screen**.** Click **Save Picture** and image will be saved to the database. Repeat the process (except *Choose for Picture # 2, 3, 4…*) to install up to twelve (12) pictures per site. The image will be saved as Picture #1. Currently, all images stored in the database are in a *.jpg format reduced to 22% of their original capacity to conserve storage space. Clicking on the button -- **Delete Last Picture** (Figure 79)- deletes the last picture. Pictures must be deleted from last to first. For example, if four pictures are stored and the second image needs to be deleted, then picture numbers four and three would have to be deleted first. Picture associated with the site can be viewed in a slide or thumbnail format. Double clicking on any slide will enlarge the picture to full screen size and return a screen (Figure 78), which allows the user to “Size to Fit” and “Print Picture” option.

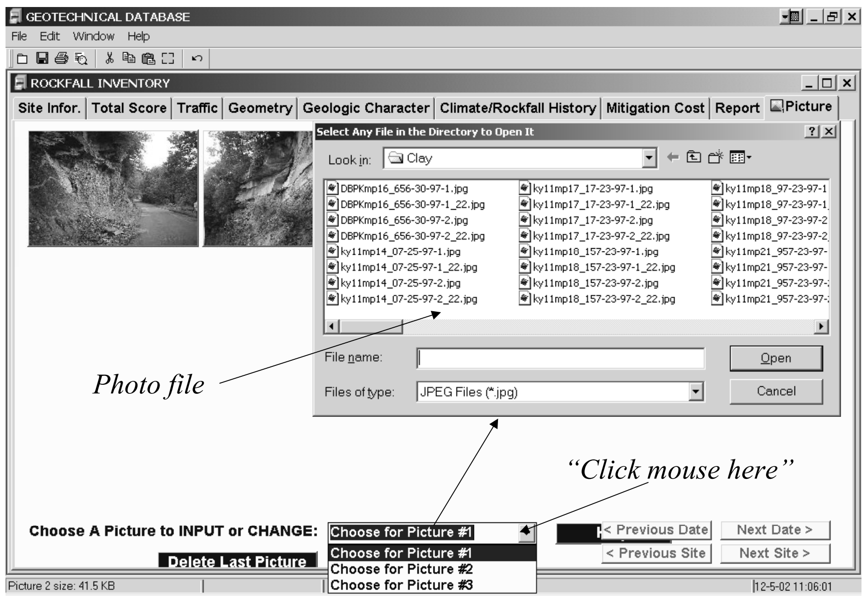


Figure 79. Entering and deleting photographs.

Currently, there are about 5,200 photographs (of landslide and rock slope sites) in the Kentucky Geotechnical database. Other visual images embedded in the database include 120 county maps showing major highway routes of Kentucky. By using MapObject® software, processing speed for displaying maps is extremely fast, and maps can be displayed almost instantly. Moreover, locations and distributions of hazardous rock slopes and landslides, as illustrated in figure 80, can be displayed on roadways of the embedded maps, since latitude and longitude of each site were obtained using GPS equipment. A zoom feature (Figure 80) is included for enlarging viewing areas for details.

The user can click on a hole location and a plot of the boring showing soil classification (as function of depth or elevation) is graphical displayed. Merely pointing and clicking the mouse can identify any roadway on the map. When a rock slope location on the map is clicked, the user is switched to detailed information, and visa versa. A limited number of digitized geological

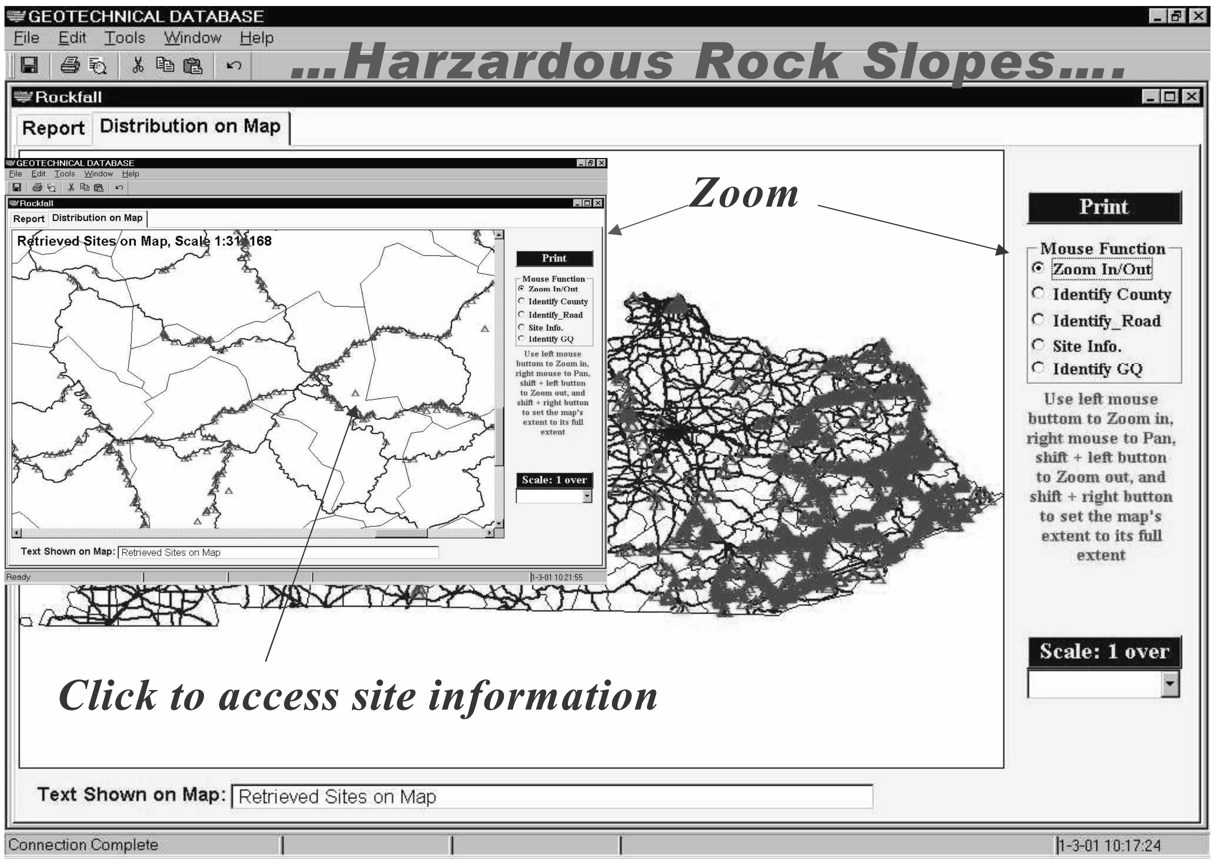


Figure 80. Map displaying locations of rock slope sites that were rated numerically using the Oregon DOT/FHWA method and illustrating zoom features.

quadrangles have been embedded in the database (the Kentucky Geological Survey has a program to digitize all geological quadrangles of Kentucky).

General Characteristics of Rock Slopes in Kentucky

In the Oregon DOT and FHWA rock slope hazardous rating system, rock slopes are initially assigned to three categories. If the slope is considered very hazardous, than it is given a preliminary rating of "A". If the reviewer is not sure regarding the hazardous nature of the rock slope, or the rater feels that the slope may pose some hazard, then the rock slope is rated as "B". When it is obvious that the slope poses no danger, the rock slope is assigned to the "C" category. In the second phase, the "A" slopes are numerically rated first and, after this task has been completed, the "B" slopes are numerically rated. The preliminary rating is very subjective in nature and depends mainly on the feelings of the rater regarding the potential for rock fall to reach the roadway. As a means of analyzing the subjectivity of the RHRS approach, the numerical scores of the "A" slopes and "B" slopes were analyzed statistically.

Distribution of RHRS scores of the slopes rated "A" is shown in Figure 81. The mean RHRS score for this group of slopes was about 478. In 67 percent of the time, the rater's score lies between values of 388 and 568. In 95 percent of the cases, the score ranges from 298 to 658. The mean score of slopes rated "B" was 321, as shown in Figure 82, which was less than the

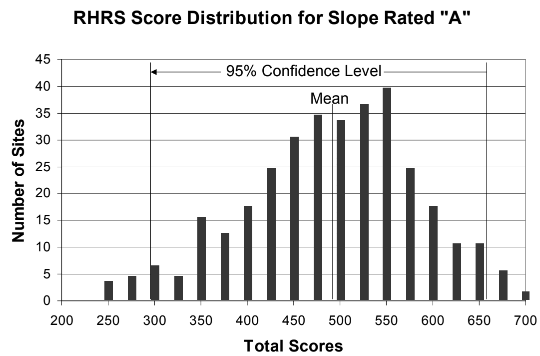


Figure 81. Histogram of RHRS scores of slopes rated preliminarily as an "A" slope.

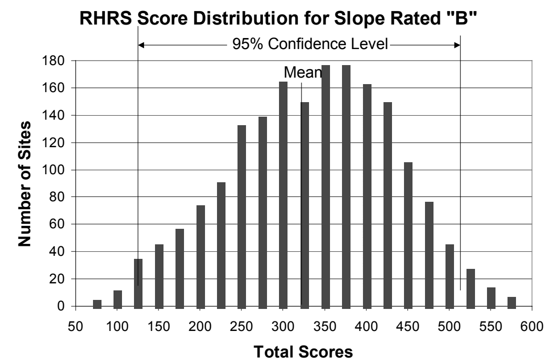


Figure 82. Histogram of RHRS scores of slopes rated preliminarily as a "B" slope.

mean value of the "A" slopes. In 67 percent of the "B" cases, the rater's score occurred between values of 224 and 418. In 95 percent of the cases, the rater's score fell in a range of 127 to 515. Generally, numerically scores of the "B" slopes were lower than the "A" slopes. Consequently, the preliminary classification and placement of a rock slope into a subjective category appears to be a very reasonable approach.

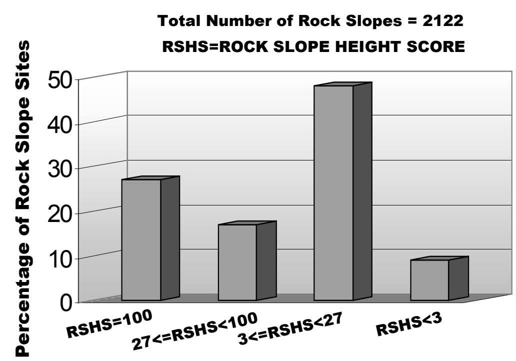


Figure 83. Distribution of rock slope height scores.

As illustrated in Figure 83, about 26 percent (about 1 slope in 4) of the rated highway rock slopes received a rock slope height score (RSHS) of 100 or greater. About 560 rock slopes scored 100. Heights of this category of slopes ranged from about 100 to 368 feet. Distribution of the number of rock slope sites as a function of height of rock slopes scoring 100 is shown in Figure 84. As the height of slope increases, the cost of mitigating, or repairing a rock slope increases. From a future remedial and cost standpoint this may be a significant number. A histogram of RHRS scores when the slope height score is equal to 100 is shown in Figure 85. The mean RHRS score is 410. In 67 percent

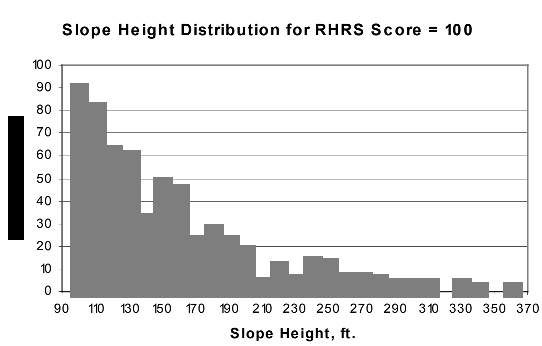


Figure 84. Number of rock slope sites that were scored 100 as a function of slope height.

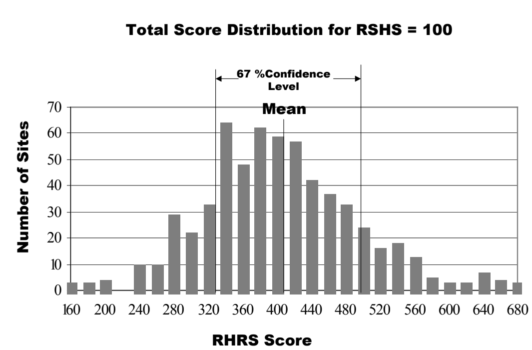


Figure 85. Histogram of RHRS scores when the rock slope height score (RSHS) is equal to 100.

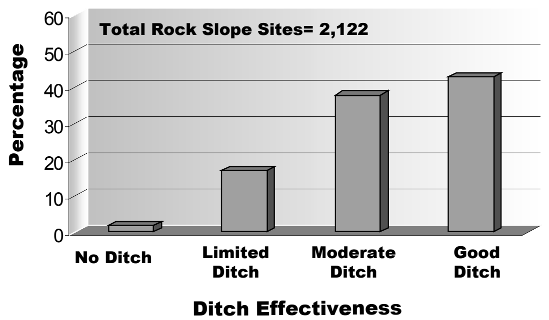


Figure 86. Different categories of ditch effectiveness expressed as a percentage of total sites.

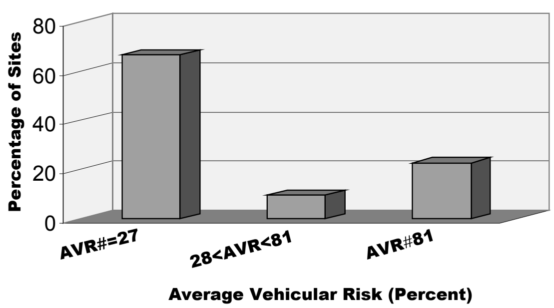


Figure 87. Distribution of AVR scores for rock slopes in Kentucky.

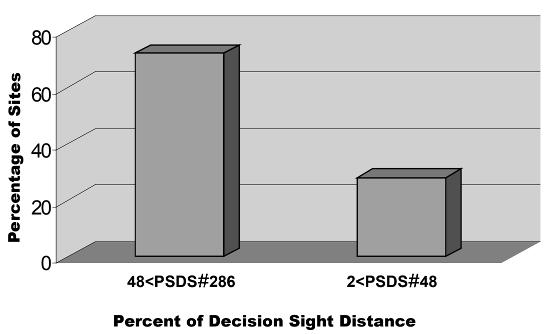


Figure 88. Percentages of decision sight distance of surveyed slopes.

of the cases, the RHRS score ranges from 329 to 491. As shown in Figure 83, in 17 percent of the total observed cases, the rock slope score was less than, or equal to 27 and less than 100. Some 57 percent of the rated slopes were scored less than 27.

To prevent rock fall from entering the highway, it is essential to have sufficient space between the toe of the slope and the edge of pavement, or to have a ditch of sufficient size, to contain the rock fall. As shown in Figure 86, the ditch effectiveness of about 43 percent of the surveyed slopes were rated as “Good.” At 38 percent of the sites, the ditch effectiveness was rated as “Moderate”. In about 19 percent of the cases, the ditch effectiveness was rated as “No Ditch” or “limited”. In about 40 percent of the cases, the effectiveness of the ditch was rated “good” while in 60 percent of the cases the ditch effectiveness was rated “no ditch” to “Moderate”.

The Average Vehicle Risk score determines “the risk associated with the percentage of time a vehicle is in the rockfall section” (Pierson, Van Vickle, 1993). As the value of AVR increases, the risk increases, or the chance that a vehicle may be hit by falling rock increases. As shown in Figure 87, the average vehicular risk, AVR, score of about 67 percent of the rock slopes in the survey was less than or equal to 27. However, the AVR score of about 23 percent of the slopes (about 1 in 4) was greater than or equal to 81.

Another significant parameter in the RHRS system is the percent of decision sight distance. This parameter compares (in percent) the actual sight distance available to a driver to the decision sight decision (prescribed by AASHTO) necessary to avoid hitting an object in the roadway. The larger the value the better opportunity the driver has to avoid an object in the roadway. The percent of decision sight distance at 28 percent of the sites, Figure 88, could be described as limited to very limited, that is, the sites have limited sight distance.

In the RHRS system, the geology of a rock slope is scored in two different ways. The rock joints are scored (case1) and the erosion of the rock formations is scored (case 2). The largest score of the two cases is used in the total RHRS score. As shown in Figure 89, the rock jointing case prevailed in 67 percent of the cases. In Figure 90, distributions of different types of jointing are compared. In 57 percent of the jointing cases, the joint was described as "discontinuous adverse." When the erosion rate score controlled, the erosion rate was described as "large and

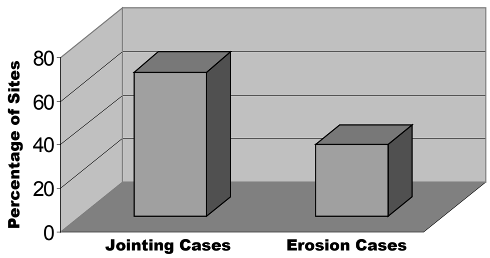


Figure 89. Comparison of the rock jointing scores and erosion scores.

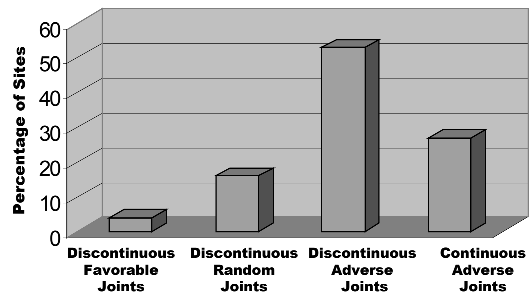


Figure 90. Distribution of different types of jointing.

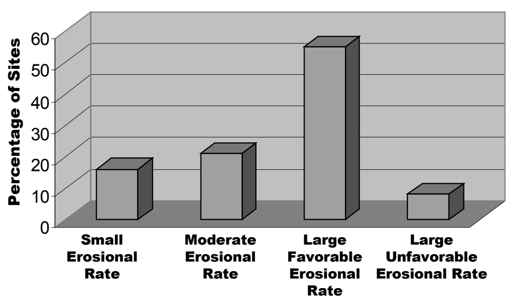


Figure 91. Distribution of different types of erosional rates.

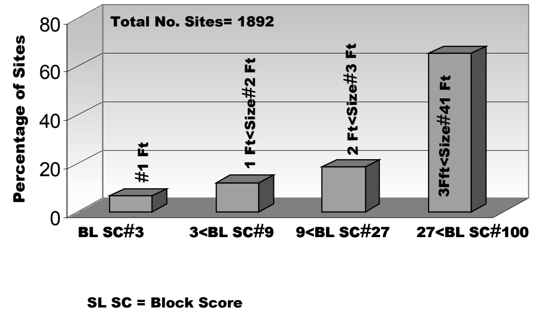


Figure 92. Block sizes and corresponding block scores.

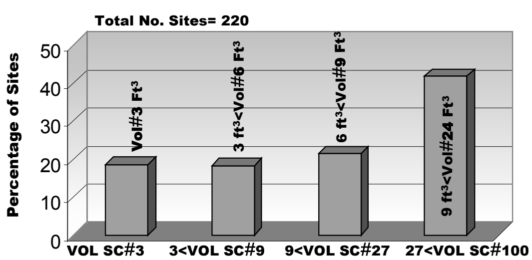


Figure 93. Volume sizes and corresponding rock fall volume scores.

favorable" in 53 percent of the cases, as shown in Figure 91.

The size of rock, or the volume of rock fall, that could reach the highway represents a significant danger to the traveling public. Generally, as the rock size, or volume, increases, the danger to motorist increases. The larger the size, or the volume of falling material, the greater opportunity for the falling rock to fill the ditch, or catchment area, and spill onto the highway. In about 60 percent of the observed cases, Figure 92, the block size was large and ranged from about 3 ft to 41 feet. In about 40 percent of the cases where the size of volume controlled the scoring, the size of volume ranged from about 9 to 24 ft^3, as shown in Figure 93. A description of the frequency of rock fall at the surveyed sites is shown in Figure 94. At about 18 percent of the sites (or about 1 in 5), the rock fall history was described as "Constant" or "Many Falls." As shown in Figure 95, when the total RHRS score is large, the rock fall history score is likely to be large.

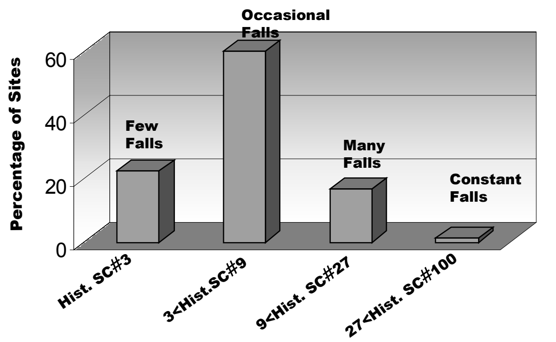


Figure 94. Characterization of frequency of rock fall at the surveyed sites

Roadway width is another important parameter in the defining the rock fall character of a roadway system. As the width of highway increases, vehicular maneuverability increases and the chances of avoiding rock fall on the highway improve. This condition on the roadway network in Kentucky is examined in Figure 91. In about 38 percent of the cases, the roadway score was greater than or equal to 27. Roadway width ranged from 15 to 28 feet. In those cases, the roadway width did not offer much maneuverability.

RHRS Score versus Actual Rock Fall Experience

About 8 percent of the rock slopes in the survey scored 500 or greater, based on the ODOT/FHWA Rock Hazardous Rating System, as shown in Figure 97. The RHRS score of twenty-five of those slopes ranged from 604 to 689. In all of those cases, the rock fall was described as “Many” and “Frequency.” The RHRS score of about 149 rock slopes ranged from a value equal to or greater than 500 and less than 600. The RHRS score of about 1 in 12 sites was equal to or greater than 500. Past experience, although limited, indicate that slopes that are scored more than 500 will probably involve considerable remedial, or mitigation, costs.

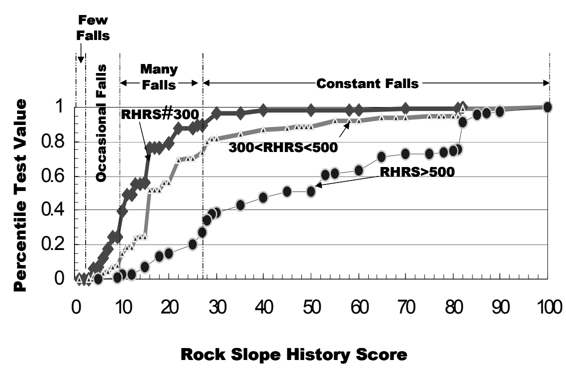


Figure 95. Rock slope history score compared to total RHRS score.

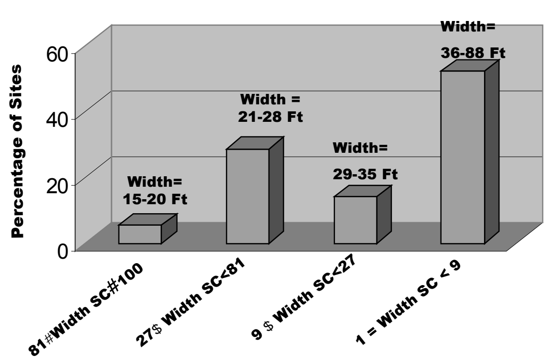


Figure 96. Roadway scores of sites surveyed in Kentucky.

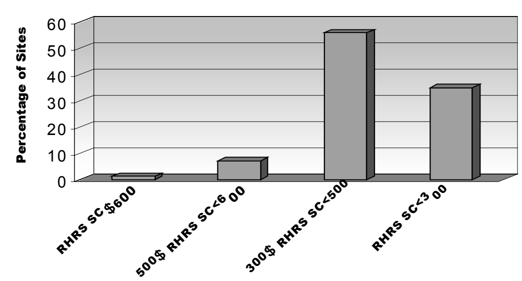


Figure 97. RHRS scores of rock slopes surveyed in Kentucky.

A very limited amount of experience is available that for relates the ODOT/FHWA RHRS score and rock fall history. However, a sampling of some of the rock slopes that received very high scores is described briefly below. In four rock slope cases that received the highest

Figure 98. Large boulders at the base of a rock slope on Ramp A of KY 56 in Webster County—RHRS score equal to 689.

numerical scores in Kentucky, catastrophic, or severe, failure occurred at three of the sites shortly after the numerical ratings were performed. One site, which received one of the highest RHRS scores (689), is shown in Figure 98. Large rocks are shown at the base of the slope. Rock fall at this site scored "Many." Repairs cost about $400,000.

Another site (before failure) that was scored 664 is shown in Figure 99. A view of this site after failure was shown in Figure 1. A view of the slope after emergency repairs were made is shown in Figure 100. The Colorado rock fall simulation computer program (Pfeiffer and Bowen 1989; Pfeiffer 1993) was used to develop the emergency design. About $250,000 was spent in repairing this slope. The slope after repairs was scored 351.

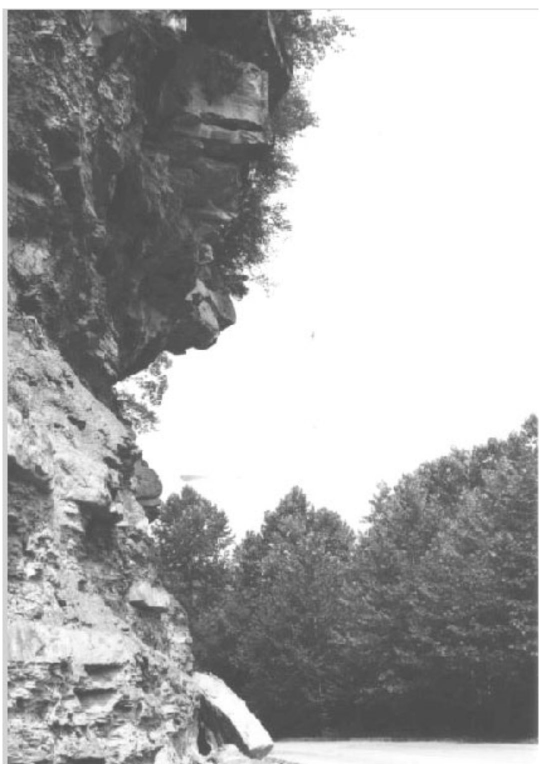


Figure 99. View of rock slope on KY 1098, MP 0.25 to 0.3, in Breathitt County before catastrophic failure.

Figure 100. View of rock slope on KY 1098 in Breathitt County after emergency repairs—RHRS score equal to 662.

A third slope where major rock fall has occurred is shown in Figures 101 and 102. This site was scored 662. Numerous rock falls have occurred at this site as evident from the large scars that are visible on the pavement and reports.

Rock fall at the highest-rated sites has occurred often and "many" times. Size of the rock fall varies from fragments to "car size boulders." For instance, at one site where the RHRS score was 604, Figure 103, on KY 931 in Letcher County, the rock fall was described in that manner. A major fall occurred on January 27, 2002 and forced the closing of the route until January 30, 2002.

Figure 101. Rock slope on KY 80, MP 5.82 to 6.03, in Pike County.

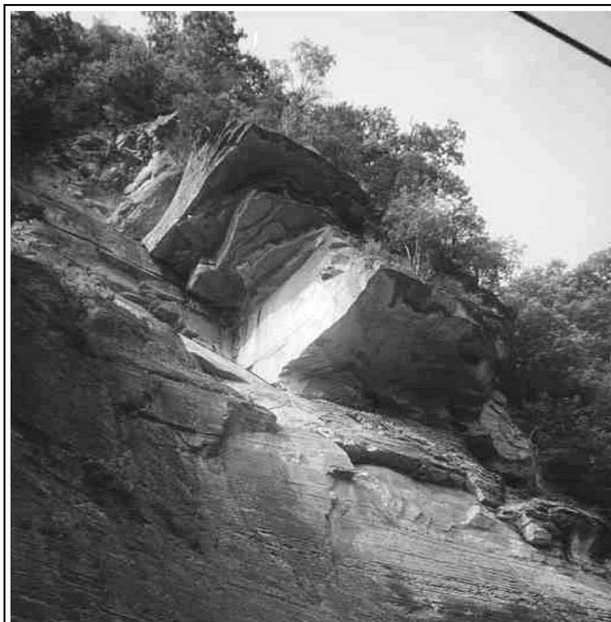


Figure 102. Overhanging rock at a slope on KY 80, MP 5.82 to 6.03, in Pike County.

The rock fall history of rock slopes scoring in the range of 500 to 600 was described as Many" to "Constant," as illustrated in Figure 104. For slopes scoring 300 to 500, the rock fall history was described essentially as "Occasional" to "Many," as shown in Figure 95. When the RHRS score was less than 300, the rock fall history was described mainly "Few" to "Occasional," as shown in figure 95.

In the cases cited above, the rock fall and failures are oftentimes related to high values of RHRS. However, one failure occurred in Kentucky that involved a moderate RHRS score of 337. This rock fall occurred on Interstate 75 at MP 20-20.15 in Whitley County. A view of the site, before failure, is shown in Figure 100. On November 11, 2000, massive rock fall occurred, filling the catchment area and spilling onto the southbound lanes. A southbound tractor-trailer struck an approximate 3- to 4- ton boulder and was destroyed in a single vehicle accident. The driver was injured but recovered. Crews were brought in to reconstruct slope the next day. A view of the site the following afternoon is shown in Figures 45, 46, and 47. As shown in Figure 105, talus piles had accumulated at the base of the rock slope. The failure occurred as the result of weathering of shale in the lower part of the slope and the removal of support of the sandstone cap. The talus piles at the base of the slope helped deflect the rock fall onto the southbound lanes. Because this slope was located in a long tangent (Figure 51) of highway, had a favorable sight distance, and a wide fall out zone, the RHRS score of the slope was scored lower than in many cases where those factors were unfavorable. However, the large potential overhanging mass still posed a real rock fall danger because it was massive enough to fill the catchment area and spill onto the highway. Cases of this type should be analyzed using the Colorado rock fall computer simulation program. This example illustrates that the numerical rating of slopes poses a challenge and requires skillful raters. The rater must try to visualize these types of situations. Also, this type of problem aids in gaining experience in using the rating system and points to the need to relate actual experience to the RHRS system.

Figure 103. Site where the rock fall was described as "car size boulders"—RHRS score equal to 604.

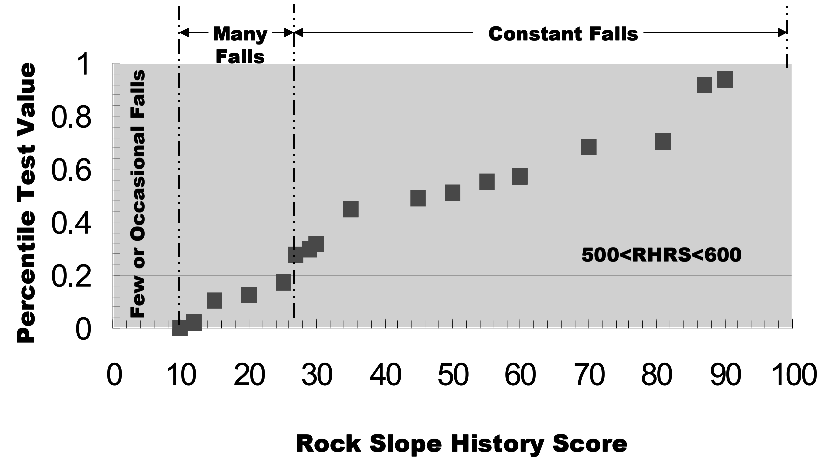


Figure 104. Rock slope history scores of slopes with RHRS scores ranging from 500 to 600.

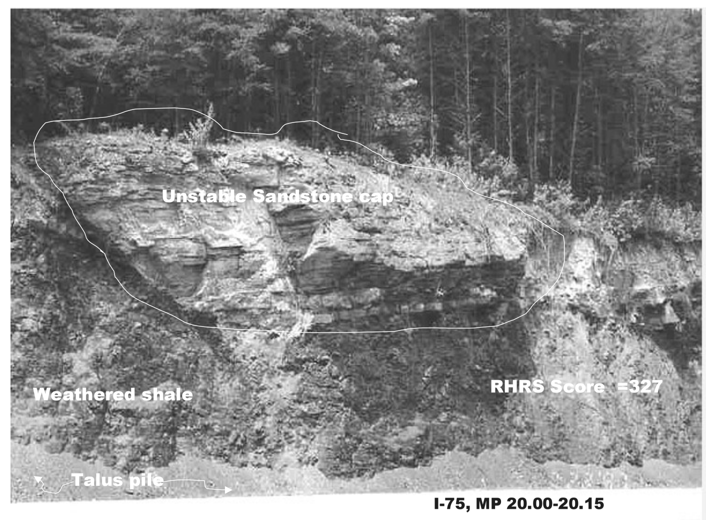


Figure 105. View of the I 75 site at MP 20.00-20.15 in Whitley County before failure.

DESCRIPTION OF LANDSLIDE DATABASE AND MANAGEMENT SYSTEM

The landslide data module of the database contains an inventory of landslides that are occurring, or that have occurred, on Kentucky highway routes. The database contains approximately 1400 landslides inventoried by the University of Kentucky Transportation Center and data for about 1,400 landslides imported from a database maintained by the Kentucky Transportation Cabinet. Landslide sites can be sorted according to district, county, route number, and mile point.

Figure 106. Past maintenance activities at a landslide site on US 68 in Mason County included driven rails that failed to arrest movements.

Landslide inventory data was collected using a data format used by the Kentucky Transportation Cabinet with minor modifications. This form was devised from guidelines originally proposed by Hopkins, et al (1988). Information collected for each landslide includes project, site, maintenance history, and severity rating. Project data includes county, route, milepost, and latitude and longitude. Site information includes the type of slide (embankment or cut slope), height of embankment or cut, length of slide, and a general description of the site. Maintenance data includes average annual daily traffic, maintenance expenditures, and past types of maintenance activities, as illustrated in Figure 106.

Landslide Severity Categories and Data Entry GUI Screens

Landslides are categorized by the following severity descriptions:

- A Very Serious—failure has occurred, or is imminent, road is closed, one lane condition exists, buildings in danger, or a major safety concern exists.
- B Serious—landslide is moving rapidly requiring constant maintenance (daily, weekly, monthly, etc.).
- C Moderate—some movements, breaks in pavement (occurrence over several years).
- D Minor-- slope failures affecting slope only, slight, or no, movements at the present time.

Site location and landslide attributes are entered using GUI screens similar to those used for rock fall sites. Additional screens are available for entering maintenance activities, and costs, and information relating to utilities, adjacent properties, and other factors. This format allows easy review of maintenance costs and activities at landslide sites. The main landslide GUI data entry screen is depicted in Figure 107.

When "Landslide" is clicked in the "Add a New Project" submenu (Figure 22), the landslide GUI screen shown in Figure 107 appears. This Graphical user interface screen contains tabs for retrieving other landslide data entry GUI screens. The tabs are identified as Site Information, Attributes and Impact, History, Maintenance Costs, Design and Cost, and Pictures. By clicking

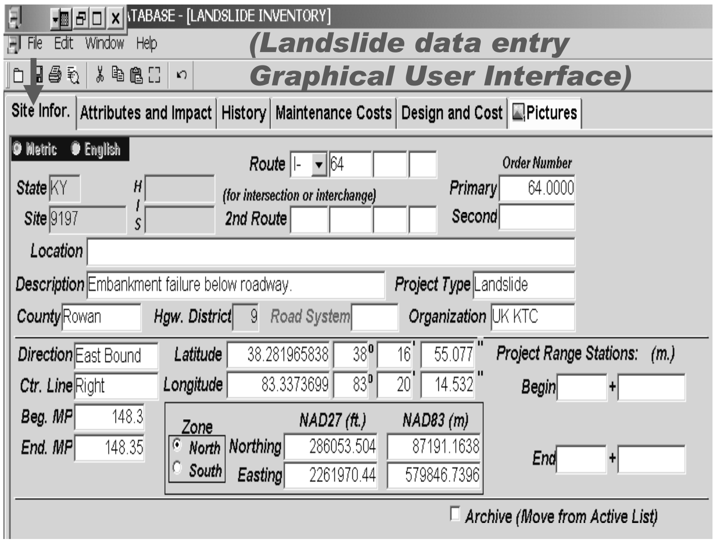


Figure 107. Graphical user interface for entering landslide site information and tabs for retrieving other landslide data entry graphical user interfaces (GUI).

the Site Tab, the GUI screen shown previously in Figure 23 appears. The site screen for landslides was described previously.

When the tab identified as "Attributes and Impact" is clicked, the GUI screen in Figure 108 appears. Values of height and length of the landslide can be entered on this GUI screen. The status of the landslide may be noted using a dropdown list. Choices include failing, monitoring failing slope, design in development, under construction, and corrected. The user may use a dropdown list of "Contributing Factors" to estimate those factors that may be contributing to the landslide movements or failure. Some choices include surface drainage, broken drainage structure, blocked drainage structure, ponded water, and other factors such as toe erosion and flooding (rapid draw down). The GUI screen has a dropdown list for noting the type of structures that may be affected by the landslide. Information regarding damaged utilities and utilities that are present but not affected by the landslide may be entered. Using a drop down listing, the user may specify the type of adjacent properties that may be present. Some choices include agriculture land, commercial, industrial, park, railroad, residential, and wooded area. The AADT (average annual daily traffic) may be posted.

By clicking the "History" tab, the GUI screen shown in Figure 109 appears. A continuous record of the history of the landslide may be maintained. Additional lines may be added by "right clicking" the mouse. Information includes the person examining the slide, date, and comments. A GUI screen for maintaining maintenance costs and the actions performed are shown in Figure 110. A dropdown list of activities is provided so that the user does not have to manually type the action performed. Data entry GUI screen for maintaining remedial design and construction costs of a landslide is shown in Figure 111. Views of the landslide may be obtained by clicking the tab "Pictures." The "Pictures" GUI screen for viewing and entering photographs is shown in Figure 112. By double clicking on a selected photograph, the user may enlarge the small photograph for better viewing (Figure 113).

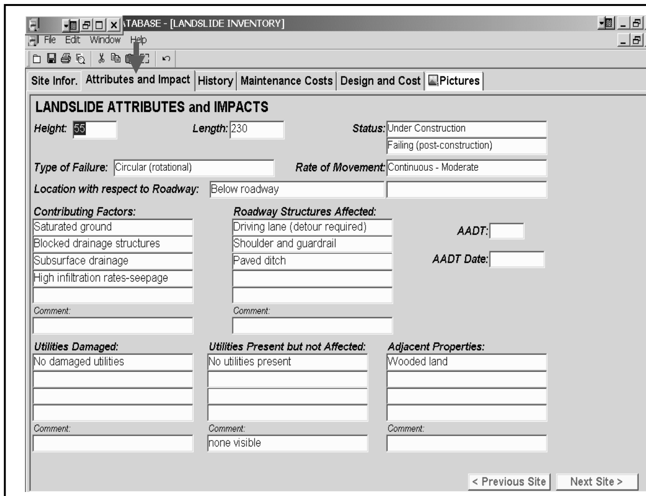


Figure 108. GUI screen for entering attributes and impact information pertaining to the landslide.

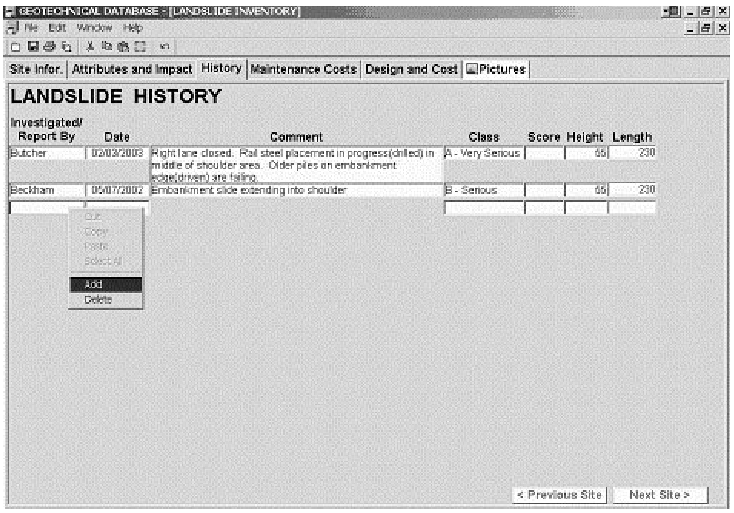


Figure 109. Data entry GUI screen for maintaining a history of the landslide.

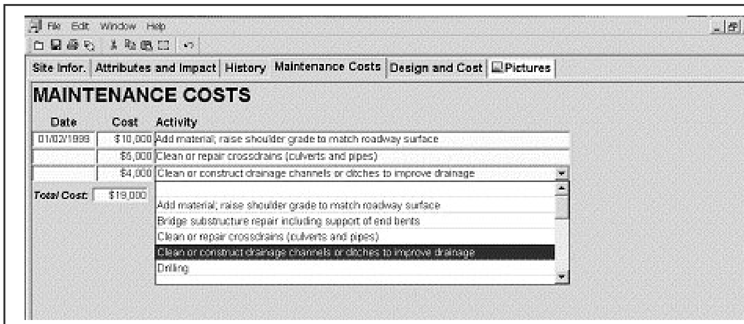


Figure 110. Data entry GUI screen for maintaining maintenance costs and actions performed.

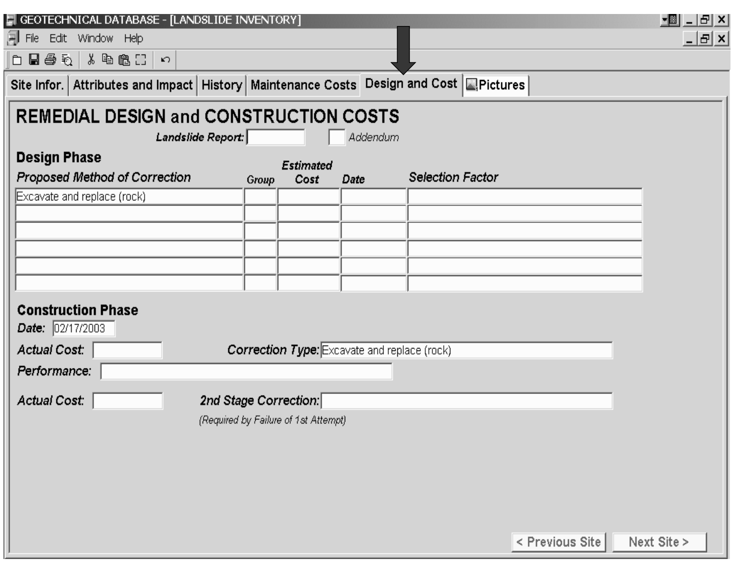


Figure 111. Data entry GUI screen for maintaining remedial design and construction costs of a landslide.

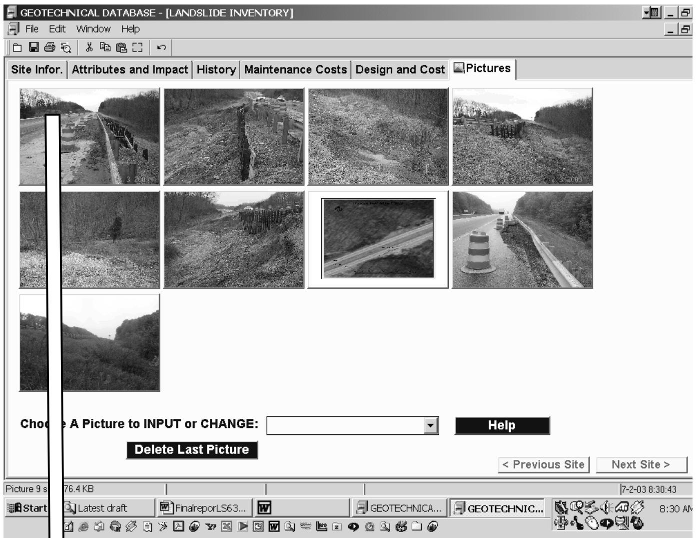


Figure 112. Views of a selected landslide.

Figure 113. An enlarged view of one of the views of the selected landslide.

Some General Features of Highway Landslides in Kentucky

Highway Landslide Severity Ratings
The total number of landslides identified by the University of Kentucky Transportation Center (UKTC) at the time of this report is about 1,400. Location and identification of many of those landslides were obtained from listings obtained from the Cabinet's Highway District Offices. The Kentucky Transportation Cabinet listed another 851 landslides in their archives. Information pertaining to those landslides was very limited and mainly consisted of a route number, county name, milepost number, and an indication of whether the landslide had been repaired. Efforts were made to eliminate duplication of landslides in the Cabinet's database and the database of landslides compiled by UKTC. Site visits to several of the landslides listed by the Cabinet were made. According to records supplied by the Kentucky Transportation Cabinet, 587 of the 851 landslides, or about 70 percent, had been repaired.

About 250 of the 1,347 (18 percent) landslides compiled by UKTC reportedly were repaired. The status of each of the repaired landslides is indicated in the UKTC database. However, it is not always known precisely for each repaired landslide if the repair has been successful.

Severity ratings of landslides compiled by the Geotechnology Section of the University of Kentucky Transportation Center at completion of this report are shown in Figure 114. The majority (57 percent) of highway landslides were assigned to the "C" category, which was described as "moderate movements, breaks in the pavement (occurrence over several years)." Generally, many highway embankments and foundations in Kentucky consist of clayey materials that tend to strain very slowly and prolong the time to complete collapse of the embankment. About 24 percent of the landslides were rated "B," that is, "the landslide is moving rapidly and requires constant maintenance (daily, weekly, monthly, etc.)." Approximately, 14 percent of the landslides were identified as "D," or minor slope failures affecting slope only. Highway

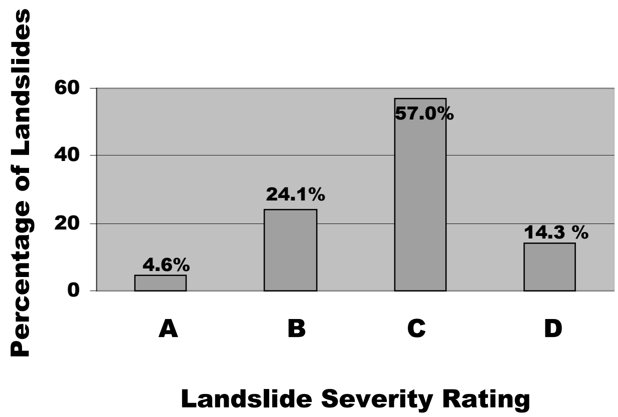


Figure 114. Severity ratings of highway landslides in Kentucky.

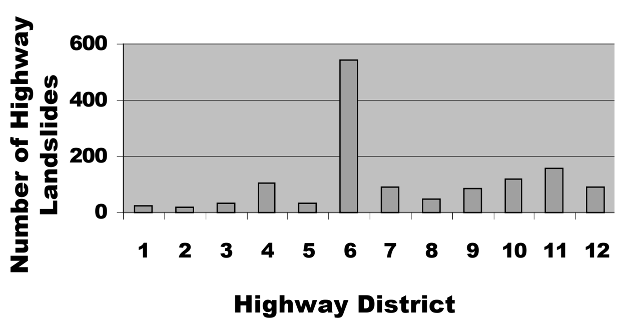


Figure 115. Number of landslides identified in each highway district of the Kentucky Transportation Cabinet.

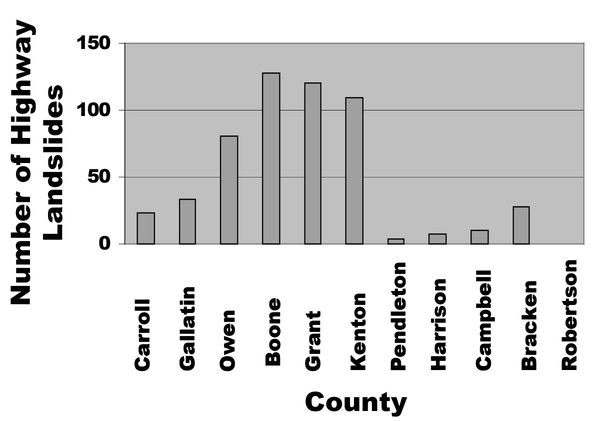


Figure 116. Number of landslides in the counties of Highway District 6.

landslides identified as "A," and described as "road is closed, one lane condition exists, buildings in danger, or safety concern," comprised about 4.6 percent of surveyed landslides.

Distribution of Highway Landslides

The number of highway landslides identified in each Highway District of the Kentucky Transportation Cabinet is shown in Figure 115. Kentucky's twelve highway districts are shown in Figure 11. Approximately 40 percent of the landslides (545) identified in the study are concentrated in district 6. This district is located in Northern Kentucky. A large portion of the district is situated in the Kope Geologic unit. Approximately 70 to 80 percent of this unit is composed of highly plastic clayey shale and about 20 to 30 percent limestone. The clayey shale of this unit slakes rapidly and breaks down when exposed to water. This action and the low shear strength of the shale have caused numerous major highway landslides in the area. Slopes in this area tend to weather rapidly and become very steep. Also, the hard and soft materials of the geological unit have caused major embankment compaction problems making it difficult to achieve good compaction. These conditions and the many streams (creating rapid drawdown and toe erosion) in the area create conditions conducive to landslides. A major portion (about 80 percent) of highway landslides, Figure 116, are concentrated in four counties of district 6, which are Boone, Grant, Kenton, and Owen. Bedrock in these counties is mainly Kope and Fairview. A map of district 6 showing the concentration of landslides is shown in Figure 117. In Bracken County, about 28 highway landslides occurred along State Route 8, which passes along the Ohio River.

As shown in Figure 118, about 77 highway landslides were identified (or

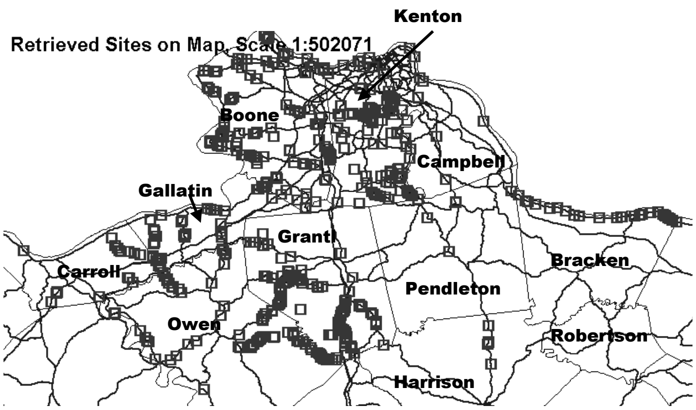


Figure 117. Locations of about 545 highway landslides in District 6.

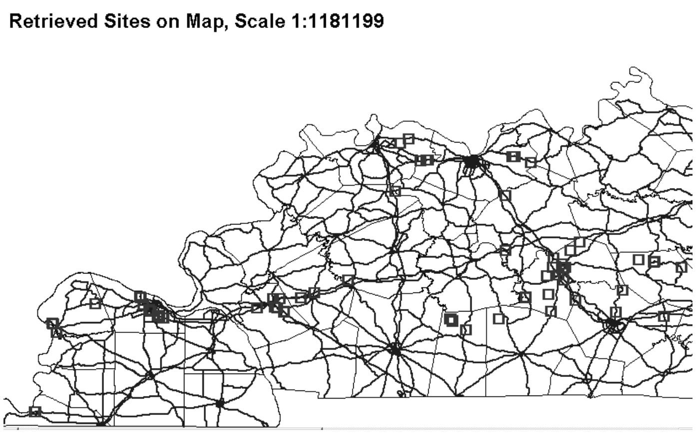


Figure 118. Locations of 77 highway landslides in Highway Districts 1, 2, and 3 of Western Kentucky.

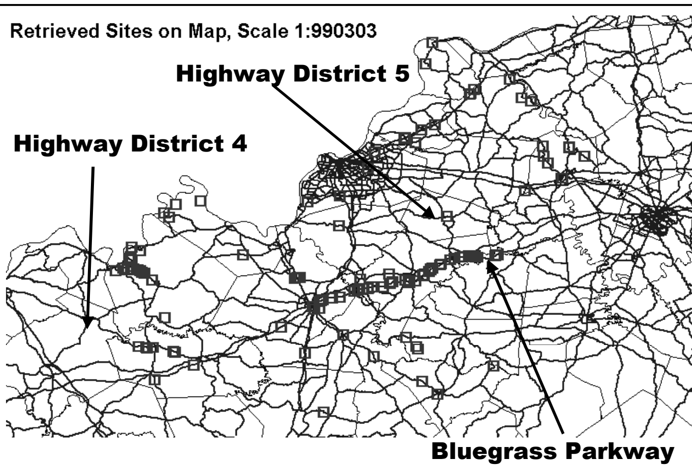


Figure 119. Highway landslides in Districts 4 and 5 in North Central Kentucky.

reported) in Highway Districts 1, 2, and 3 of Western Kentucky. Thirteen of those sites occurred on the Western Kentucky Parkway. One hundred and thirty-seven 137 landslides were identified in Districts 4 and 5 in Western Kentucky (Figure 119). Thither of those sites were located on the Bluegrass Parkway. Approximately 140 sites were identified in Highway Districts 7 and 8, Figure 120 Locations of about 450 landslides in Districts 9, 10 11, and 12 are shown in Figure 121.

The occurrences of landslides in different physiographical regions of Kentucky were examined. The different physiographical regions of Kentucky are depicted in Figure 122. These include the Mississippi Embayment and Illinois Basin (Western Kentucky Coal Field) of western Kentucky. Geology of the Mississippi Embayment is composed of Quaternary and Tertiary deposits. The Western Coal Field is primarily Pennsylvanian age. Geologic age of a large area occupying the lower western-central portion of the state is primarily Mississippian. The eastern portion of the state is the referred to as the Appalachian Basin (Eastern Kentucky Coal Field) which is mainly Pennsylvanian age. The upper north- central part of the state is Ordovician and is referred to as the Bluegrass Physiographical Region. The Knobs Region forms a ring around the Bluegrass Region. Geological units of this area are predominately Silurian and Devonian.

As shown in Figure 123, only 17 highway landslides were identified in the Mississippi Embayment area. Her, local relief is not great, and soil

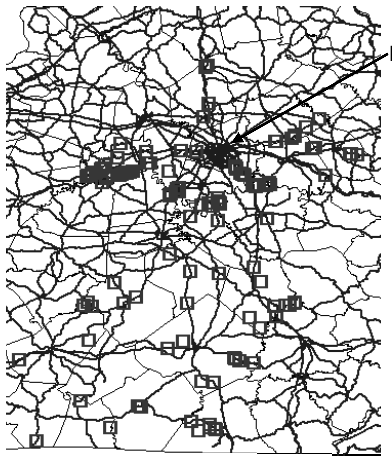


Figure 120. Highway landslides in Districts 7 and 8 in South Central Kentucky.

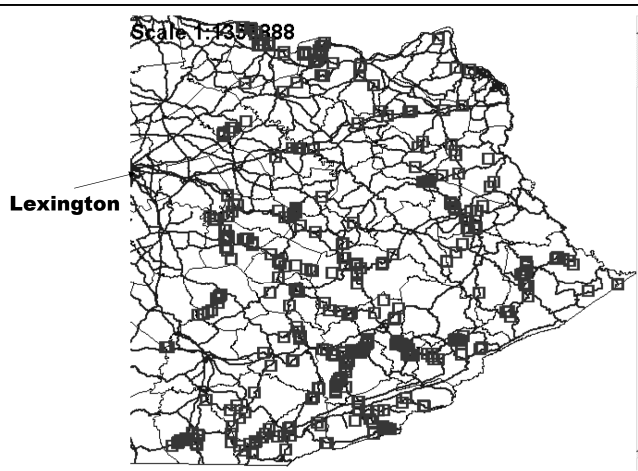


Figure 121 Highway landslides (about 450 sites) in Eastern Kentucky, Highway Districts 9, 10, 11, and 12.

units in this region contain large portions of sand and gravel with silt and some clay. Based on the Unified Soil Classification System, the soils are classified usually as CL-ML, ML, ML-Cl, GL-GM, SM, and SW-SM. These types of soils tend to have good shear strengths, which helps maintain good slope stability.

Highway landslides occurring in the Western Kentucky Coal Field are shown in Figure 124. Only about 41 highway landslides were observed in this region of the state. Rock units in this region consist of sandstone, shale, and coal. Soils in the region predominately are classified as clays-CL and some CH. Sandstones in the region used in road construction to form embankments have aided in maintaining slope stability. However, the shales tend to cause instability in some cases.

About 107 landslides were identified in the Mississippian Plateau Region of the state, as shown in Figure 122 and 125. Rock units in this area consist of shale, limestone, and sandstone. The soils are predominately clays and have low shear strengths, which oftentimes leads to slope instability.

Highway landslides in the Eastern Coalfield are shown in Figure 126. Approximately 347 highway landslides were identified and located in the Eastern Kentucky Coal Field. Rock units in this region consist of shale, sandstone, and coal and are of Pennsylvanian Age. Typically, soils in this region are classified as clays (CL and some CH) and silty clays (ML-CL). The large number of landslides in this region can be attributed to many factors, such as large embankments with steep slopes, and many streams located at the toes of the embankments that have caused rapid down and erosion of the toe of embankments. Another factor causing instability is the "damming" effect caused by side hill embankments that cause a gradual rise of the phreatic surface within the embankment. With a gradual rise in the water table, pore pressures in the embankments increase causing a decrease in effective stresses. This decreases the shear strength available to resist driving forces (Hopkins et al.1975, 1988)

Highway landslides occurring in the Knobs region, which forms a ring of small hills around the Bluegrass Physiographic Region is depicted in Figure 127. Although this Region is much

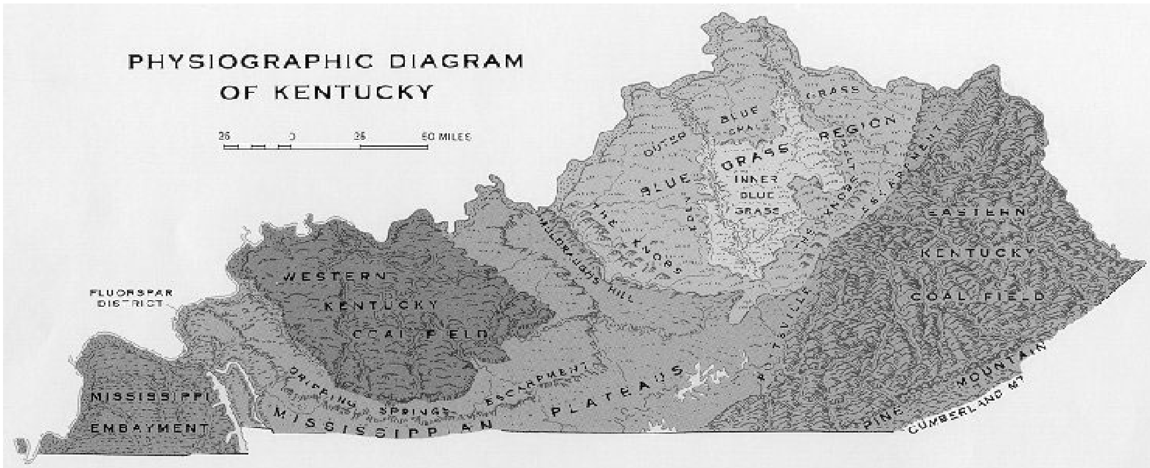


Figure 122. Physiographical Regions of Kentucky (Map obtained from the Kentucky Geological Survey).

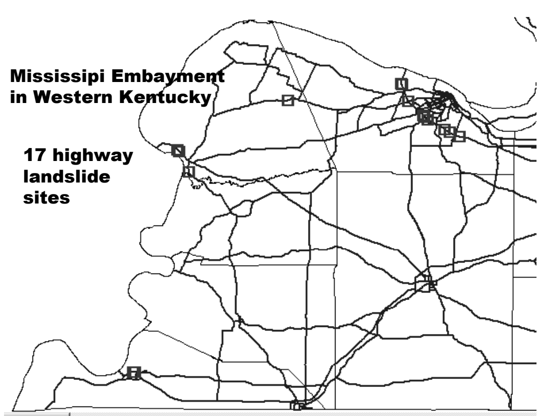


Figure 123. Highway landslides in the Mississippi Embayment area of Kentucky.

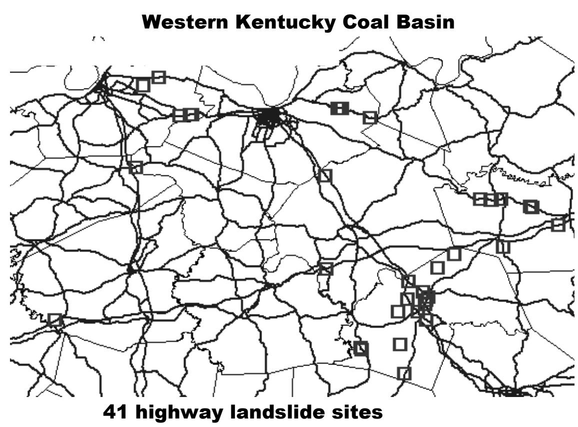


Figure 124. Highway landslides in the Western Coal Field.

smaller than other physiographic regions of the state, numerous landslides have occurred in the Knobs Region. Factors cited above are typically of the causes of the numerous failures (107) identified in this region. Weak shales of the Crab Orchard Geological Unit have been involved in many of the failures.

Numerous highway landslides have occurred in the Bluegrass Physiographic Region, Figure 128. Approximately 50 percent of highway landslides in Kentucky occur in this region —about 654. The majority of the landslides in the northern portion of the physiographical region mainly occur in four counties –Boone, Grant, Kenton, and Owen. Numerous landslides occur in roadways that were built through and with weak shales of the Kope Geological Unit (Ordovician Age).

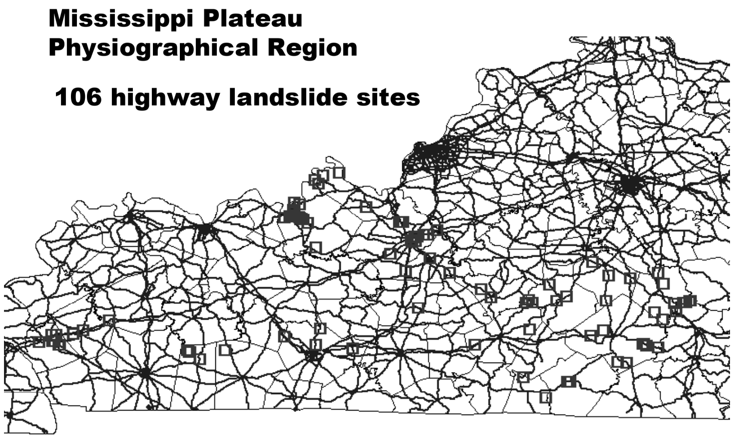


Figure 125. Highway landslides in the Mississippian Plateau Region.

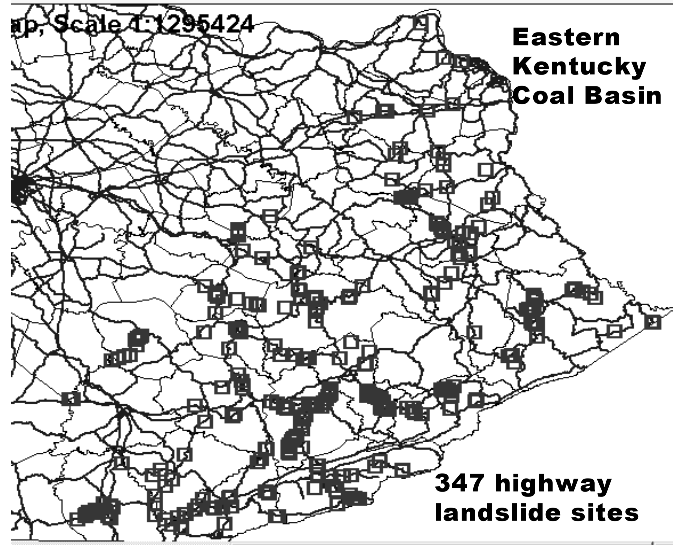


Figure 126. Highway landslides in the Eastern Kentucky Coal Field.

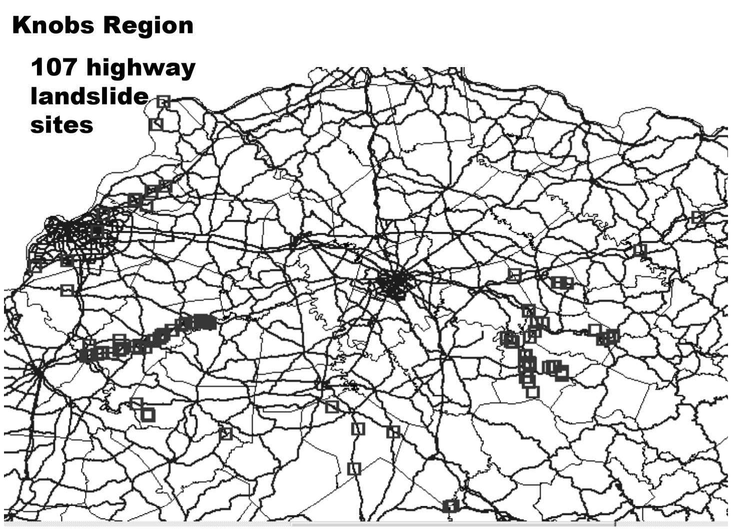


Figure 127. Highway landslide sites in the Knobs Region.

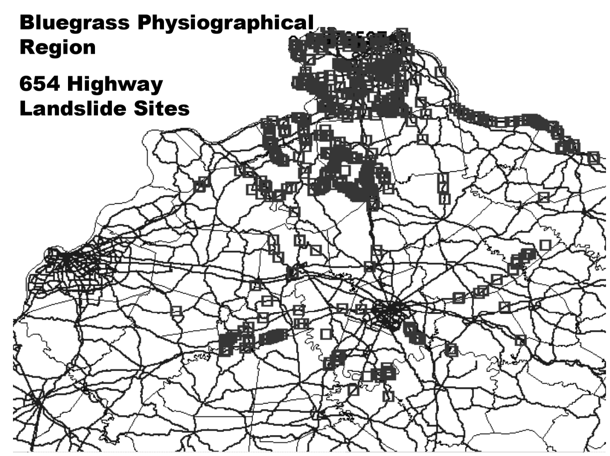


Figure 128. Highway landslides in the Bluegrass Physiographical Region.

This unit contains approximately 20-30 percent limestone and about 70 to 80 percent shale. Shales of Kope slake rapidly when exposed to water and breakdown into very weak soils. A major problem in constructing embankments of shale-limestone mixtures is the difficulty in achieving proper compaction because of a failure in breaking down the hard limestone-soft shale mixture. Lack of good compaction has caused numerous failures on Interstates 71 and 75 that pass through this region. Because shale-limestone mixtures were loosely compacted, large voids remained in the embankments. As the phreatic surface gradual rose in the embankments, the soft shales degraded into soil particles causing large settlements and eventually instability (Hopkins and Beckham 1998). Many embankments in this region are side hill-fill situations. Depth to bedrock in this area is very shallow and usually measures only a few feet. Typically, a very weak layer of weathered shale/soil exists near the top of the rock unit. Shear surfaces of the embankment failures often pass through the weak layers.

General heights of the observed landslides in Kentucky are shown in Figure 129. The height of about 19 percent, or 1 of 5, of the landslides was approximately equal to or greater than 51 feet. This is very significant because the remedial cost to repair those large highway failures can cost upwards of several hundreds of thousands of dollars. Distribution of the lengths of the landslides is shown in Figure 130. Lengths of about 45 percent of the landslides were 200 feet or less. About 33 percent of the landslides had lengths greater than 300 feet, but less than or equal to 500 feet. Lengths of about 22 percent of the landslides were greater than 500 feet. Total length of all landslides was 423,030 feet, or 80 miles.

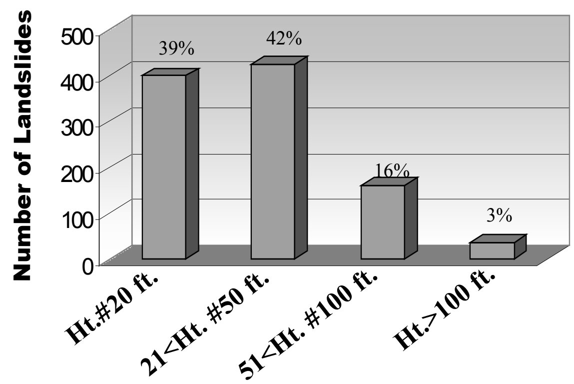


Figure 129. Number of landslides in different height categories.

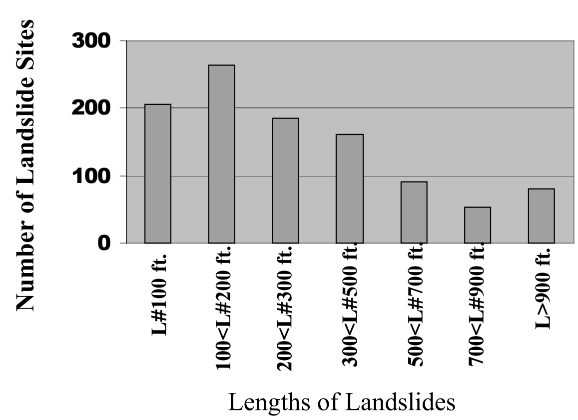


Figure 130. Number of landslides in specific length categories.

Based on information collected during the survey of landslide sites in Kentucky, railroad steel tracks have been used often in an attempt to halt movement of the landslide by forming a retaining wall structure. Sometimes the soil behind the retaining structure is excavated and backfilled with rock. Some type of cribbing, such as railroad wooden ties, or concrete panels, may be used to prevent spillage of the rock through the railroad steel tracks. Frequently, holes are drilled through the embankment and several feet into bedrock. By inserting the steel rails into bedrock, a cantilever structure is created.

Remedial measures had been attempted at about 282 landslide sites (of 1448 sites) based on the data compiled by UKTC. At about 180 of those sites, a railroad steel retaining structure was used. At about 175 sites of the 180 sites, based on notes and comments in the database, the railroad steel tracks had been placed in drilled holes into bedrock. At five sites, the railroad steel had been driven. At approximately 37 percent of the sites, the embankment height was less than or equal to about 20 feet while, at about 63 percent of the sites, the embankment height was greater than about 20 feet. Status of the repaired landslides is not precisely known and this information needs to be collected in the future.

SITES, ATTRIBUTES, BORINGS, AND SAMPLES

Types of Sites, Site Number, and Site Coordinates

Each site within the database is associated with a unique site number, and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created initially, the site number shown on the entry screen is valid for this new site. Copying an existing site to create a new site can be performed but the site number displayed is that of the existing site. To determine the site number of the new site requires closing and saving the entered data and then retrieving the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service), utility, planning study, or wall. With the current structure there can be sites within sites. For example, RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as side roads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. Station numbers assigned by the Kentucky Transportation Cabinet define the beginning and end of an RW-Mainline site.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service. Creation of a site requires data entry into the site level graphical user interface (GUI) illustrated previously in Figures 21, 22, and 23, and again, for the current discussion, in Figure 131.

Geographical coordinates of a site may consist of latitude and longitude or state plane coordinates. If state plane coordinates are known, the database automatically calculates the latitude and longitude and vice versa using algorithms that have been built into the database. At the time the site is created, the user may assign “identifier’ coordinates to the site. For a mainline roadway segment, the coordinates may be the beginning of the project or the center of the project if the user so chooses. If the user does not enter coordinates on the site screen for a roadway segment, then the program automatically assigns the coordinates of the first boring, provided borings are associated with the site. In the cases of landslides or rock slopes (or cuttings), the location coordinates are generally obtained using GPS equipment near the center (as judged by field personnel) of the rock slope or landslide. The "identifier" coordinates merely give an approximate location of the site. However, when sampling sites, or borings, are located within a site more exact geographical coordinates may be assigned. The manner of entering those coordinates is described below.

Creating and Subsequently Retrieving a New Site

After entering all desired site information (noting that certain fields such as county, route, and project type are essential), the site is saved. At the time a newly created site is closed (saved), the database automatically creates a site number, but this number is not known until the site is subsequently retrieved. Subsequent retrieval, of course, is necessary to view or change site level data or to add data in attached, lower level folders (attributes, borings or samples). The initial search, when site number is still unknown, will be simpler (that is fewer sites will be retrieved), if characteristics such as county, or route, are specified. By clicking within the box labeled **"County,"** on the Simple Search Screen (as shown in Figure 132), a county may be selected from the alphabetical list. This box, due to space constraints, displays only a small portion of the list, and the user may scroll down to highlight the desired county. A search, with only county specified, will yield all sites in that county. This would likely be a relatively large number of sites, and finding the new site could be difficult. Along with county, however, the user might also enter **"route number."** In this case the route number is "1718". The KY prefix is not required (or even accepted) so the numbers should always be used alone. Now the list of retrieved sites will be smaller, since only sites in that county and on that route will be listed. If the list is still long enough to make it difficult to find the new site, project type could also be

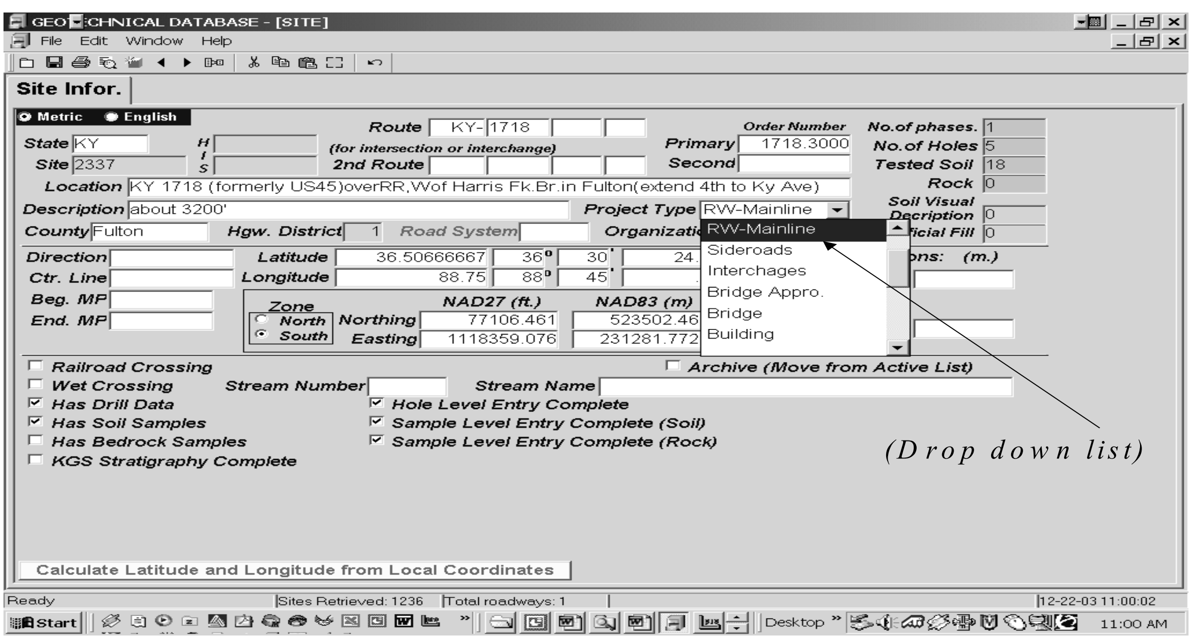


Figure 131. GUI for creating a site.

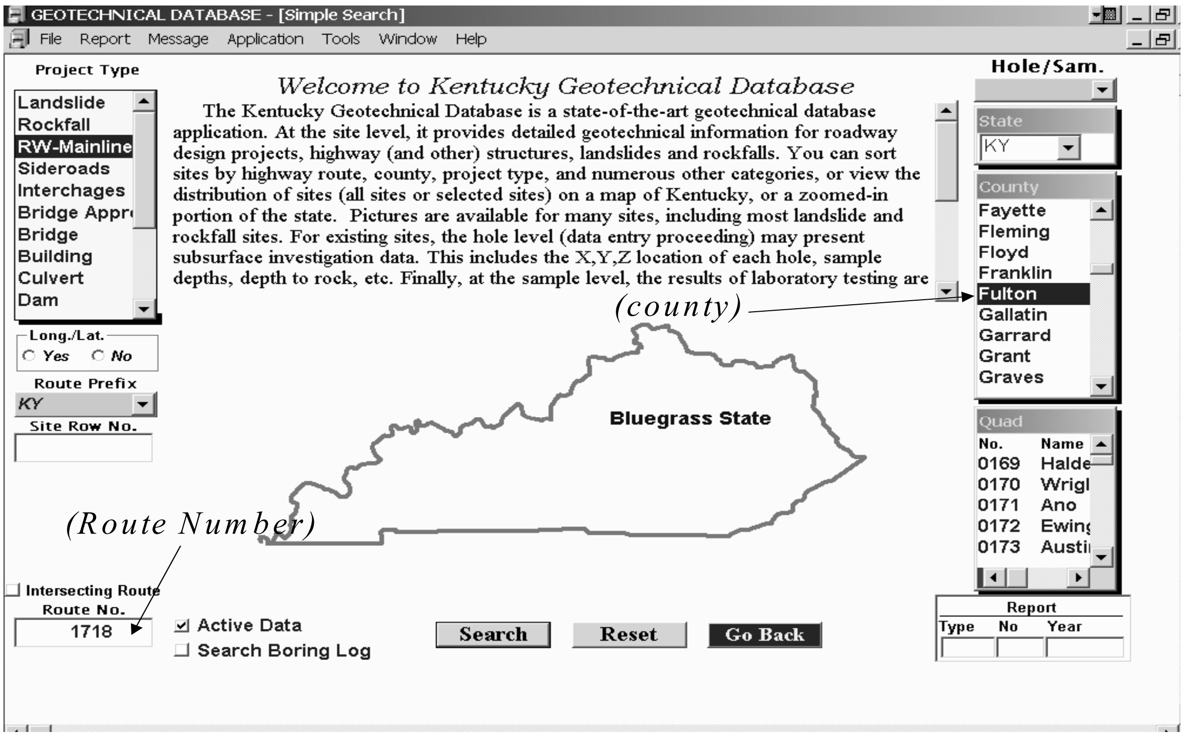


Figure 132. Search GUI.

specified, along with county and route. This demonstrates how the number of sites retrieved can be progressively reduced by use of appropriate selection criteria.

Site Level Data Entry GUI Screen

Even when appropriate selection criteria are fully utilized, it is possible that retrievals will yield more than a single site, and the user will have to find a newly created site from among all sites remaining in the list. When the desired site from the **"sites list"** (the left portion of the screen in Figure 133) is located, and highlighted, double clicking with the mouse will open the site data entry GUI screen, as shown in Figure 131. Data may now be changed or added, and at this time the unique site number may be noted and used in subsequent retrievals. In a list of selected sites, even if the "site list" consists of only a single site, the screen actually is divided into two parts. The site list appears on the left, while the section to the right shows the attributes, borings and samples folders (possibly empty) that are attached to the highlighted site. A greater percentage of the site list portion of the screen can be viewed by sliding the dividing panel to the right. A full view of the site list is shown in Figure 134. Site-level data entered by the user include highway district, county, beginning and ending mileposts, beginning and ending station numbers, project type, geographic coordinates, and a descriptive location. Other data, such as number of holes, number samples, and number of work phases, are shown on the site screen, based upon data input at different levels, but these cannot be entered or altered from the site screen. A full view of the right side of the screen (in Figure 133) is shown in Figure 135. This GUI contains some site information.

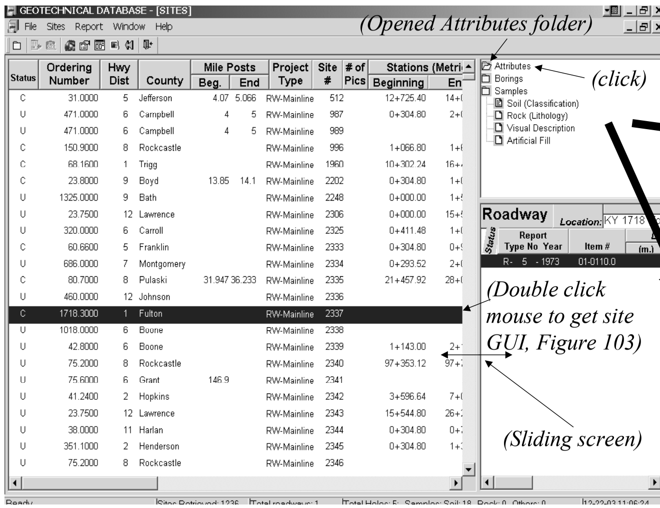


Figure 133. GUI showing retrieved site list (left) and attributes, borings or samples associated with one particular (selected) site (right).

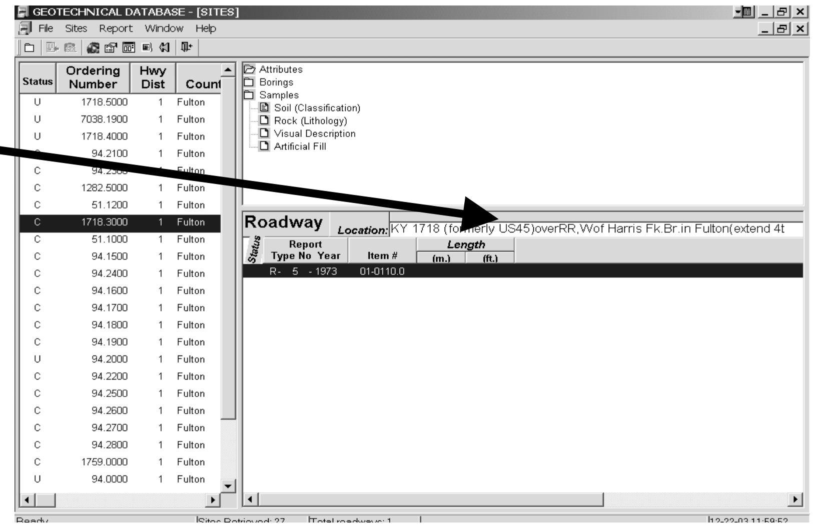


Figure 135. The top right portion of this GUI allows the user to select attributes, borings or samples (or even a particular type of sample) associated with the selected site (highlighted at left). The lower right portion of this GUI than provides details of the item selected, such as individual borings or samples.

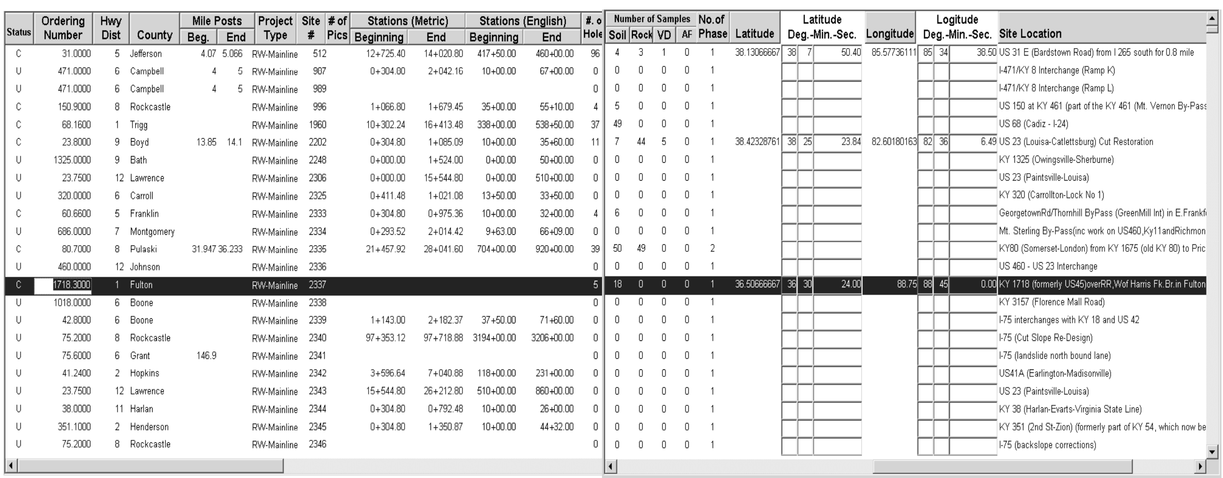


Figure 134. Full display of site list. The particular sites included in the list depend on which selection criteria were used in making the retrieval.

Attributes GUI (Workphase Portion)

While double clicking on a specific site from the site list will open the site-level data entry GUI for that site, single clicking will only activate (highlight) that site. Opening the **"Attributes"** folder (by double clicking at the right–hand top of the sites list screen) will yield the GUI shown in Figure 136, for the site that has been selected (highlighted). The upper portion of this GUI is used to enter **"work phase"** data.

The value of the geotechnical database derives in part from the fact that sites where geotechnical investigations are performed may eventually become the focus of additional study. Consider, for example, a bridge constructed in the mid 1970's. A geotechnical investigation was performed, and the results of drilling and lab testing were entered into the database. The date of drilling, who performed the drilling, who the bridge designer was, and who performed the laboratory testing are among the data entered. The item number, the English (as opposed to Metric) units that were used, and the vertical control datum (sea level or assumed, for example) were also entered.

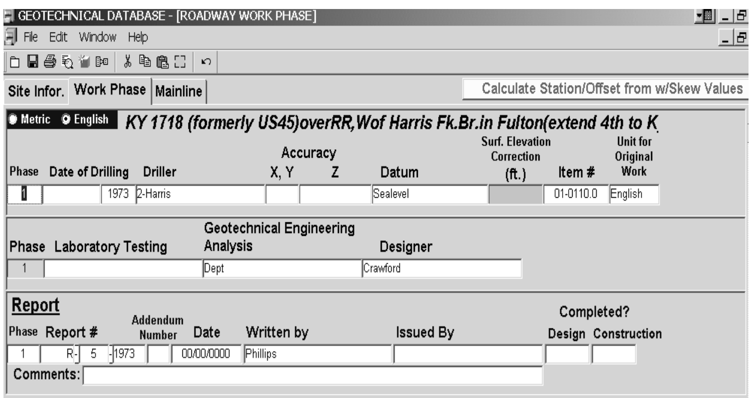


Figure 136. GUI for entering work phase/ report data.

Now, some thirty years later, a new bridge, wider than the original to accommodate increased traffic volume, is required. The new bridge is to be constructed at essentially the same location as the existing bridge. In some situations of this type, information obtained from the original geotechnical investigation could be adequate for developing plans for the new structure, saving both time and money. In other cases, however, additional drilling will be required. Since the location of the bridge has not changed, it is logical to consider it to be the same site. However, much of the information previously recorded will have changed. It is unlikely that the organization and individuals performing the new drilling will be the same as those who performed these jobs years earlier. The same is true of the bridge designer, and the new job may even be designed in Metric units as opposed to the English units of the older design. To accommodate these changes, the database format allows that when a new phase of work is identified, any or all of these fields can change. The bridge designer for the structure built in the 1970's (that is the Phase 1 bridge designer) is retained in the records, but the bridge designer for the new (Phase 2) bridge is also shown.

It may also be advantageous to assign different phases of work on the same general project. During design it may be discovered that additional information beyond that provided by the original geotechnical investigation is required. Thus, many months, or even a couple of years after the original investigation a drill crew is sent out for additional borings and samples. It is convenient, then, to identify the original work as phase 1, and the additional work as phase 2. A different crew than those who performed phase 1 drilling could easily perform phase 2 drilling. However, by identifying the work as different phases, this and other changes are easily accommodated.

Attributes GUI (Report Portion)

The lower portion of the Attributes Screen is used to enter information relating to geotechnical reports published by KyTC's Geotechnical Branch. Since 1973, most reports issued by the Geotechnical Branch have been assigned numbers, to facilitate tracking them. The format is X-#-Y, where X indicates the type of report, Y is the year in which it was published, and # is a sequential numbering of reports of the specified type issued during any given year. In paper files, year was historically, and commonly even now, reported with two digits (79 means 1979 while 02 means 2002). Of course it is always recorded with four digits in the database. Report types include R (roadway), S (structure), L (landslide) C (construction) and M (maintenance). Structure (S) reports include bridges, culverts and walls. On occasion they could also include buildings (salt domes, rest area facilities, or other buildings).

The Geotechnical Branch of the Kentucky Transportation Cabinet has also issued RSD (rock slope design) reports to facilitate construction of highway cuts in rock. Generally, drilling results and rock core logs presented in RSD reports are also presented, along with a good deal of additional information, in a roadway report for the same project. In these cases, which apply to over 90 percent of the RSD reports, it is unnecessary to enter RSD report data in the database. If all data from the roadway report were entered, then data in the RSD report would be redundant (but since the roadway report includes data not presented in the RSD report, the reverse would not be true). There are cases where a RSD report is issued for a project, but no roadway report is ever issued. When we find an RSD report that has no accompanying roadway report, meaning data presented in the RSD report are not duplicated elsewhere, this information should be input into the database. Since there are only a few of these (the exact or even approximate number is unknown) and also because the 3-character RSD designation is a problem in a database structure that allows only one character to specify report type, we have developed an alternate recording scheme. We record them as R (roadway) reports with #'s beginning with 900. The highest number used for regular roadway reports, to date, is 63, so a number 900 or above indicates that the data was actually issued as an RSD report rather than as a regular roadway report.

Prior to 1973, no numbers were assigned to reports. Some of these reports are still available in hard-copy project files, however, and as time permits some of these reports have been entered. To facilitate cataloguing, these reports are assigned a report number (the lowest unused number, for the particular type of report, for the appropriate year). Often, geotechnical reports prepared by geotechnical consultants are issued by the Geotechnical Branch, and assigned a number at the time they are issued. In numerous other cases, however, they were not assigned numbers. When such data are entered into the database, these consultant reports are also given newly assigned report numbers.

Information entered in the **"report"** portion of the attributes GUI includes report type (roadway, structure, landslide, etc.), report number and year, date of report, and whether publications are original reports or addenda, and report author.

It is not uncommon that once a geotechnical report has been issued, it becomes necessary to issue corrections (revisions) by means of an addendum. Errors within the original report may be discovered. The roadway alignment may change. The number of spans, or the location of bridge piers may change. Addenda, as required, are logged into the database using the **addendum number field** in the *Reports* section of the ***Attributes screen***. In this coding, a "0" is entered to indicate the original report, while a "1" refers to the first addendum, a "2" to the second addendum, et cetera. The date on the first line is the date that the original report was issued, while the date in the second line is the date the first addendum was issued, et cetera.

For sites for which one or more addenda have been issued, the **Comments field** (associated with "Report" on the Attributes screen) should be utilized to indicate why the addendum was required. Comments relating to the addendum should also indicate whether additional drilling/lab testing was performed, as it would then be necessary to enter this additional data into the database. As examples, "Comments related to the original report might read,

"Roadway alignment revised from Sta 421+73 to end of project," or

"Allowable bearing values reported for Pier 1 were in error."

Similarly, comments relating to a report addendum might read,

"Includes additional drilling and lab testing related to alignment change," or

"Provides revised foundation recommendations for Pier 1; no new drilling or lab testing."

Project-Type GUIs

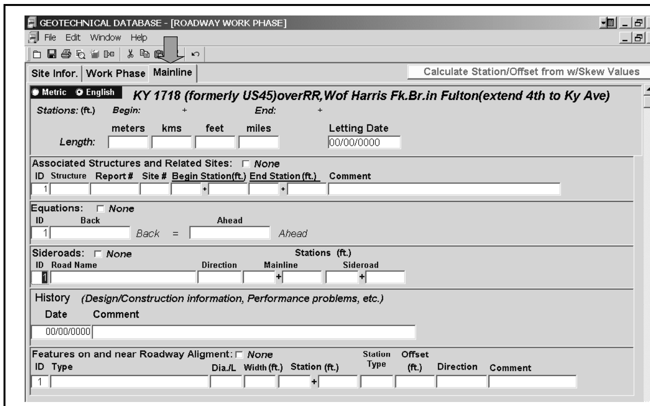


Figure 137. GUI for entering and viewing roadway/mainline site-level data.

Once the attributes screen (workphase/report) is opened, there will likely be an associated "Project-type" GUI. Continuing with a preceding example, the project type is **"roadway/mainline"** and if the tab is clicked, then the project-type GUI shown in Figure 137 appears. Data that may be entered on this screen includes associated structures, equations, side roads, project history, and related features, such as sinkholes or ponds which occur along the roadway alignment, and whose locations can be designated by station and offset. However, the various *Project-type* GUI's included in the database differ from one type of project to the next. From the example just given, it may be noted that information that may be entered applies well to roadway projects, but would not apply to other types of projects. If the project were a bridge, pertinent data would include length and width of the bridge, number of spans, individual span lengths, and the type of foundation (end bearing or point bearing piles, spread footings, drilled shafts, etc.) used at each substructure element (end bents, abutments and piers). These characteristics would not apply to culverts, roadways, or indeed to any other project type. This uniqueness extends throughout the system, as each type of project requires its own unique set of input parameters. To accommodate this, separate GUIs have been developed for each project type (note that, to date, there are a few project types, such as dams and utilities, for which project-type GUIs have not yet been developed). For some project types, specifically landslides and rockfall, an entire series of Project-type GUIs have been developed, as has been discussed previously. Figures 138 through 143 are illustrations of various other project-type data entry GUIs. Respectively, these are for roadway mainline, roadway side road, interchange, bridge approach, bridge, culvert and wall.

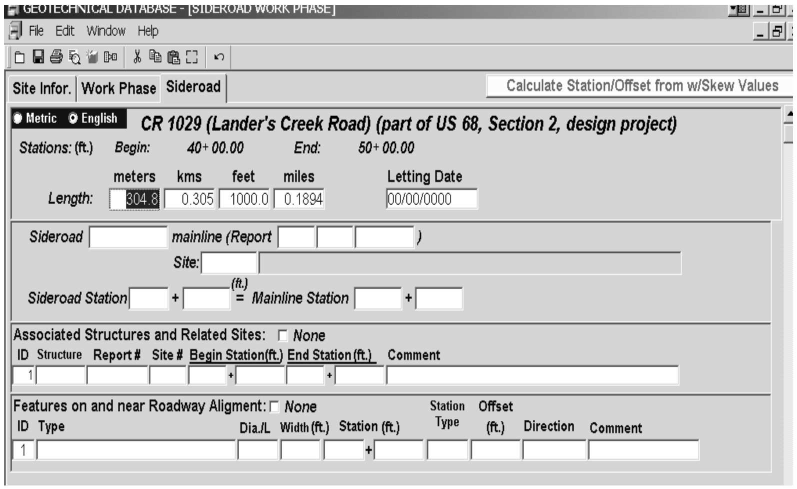


Figure 138. Sideroad GUI.

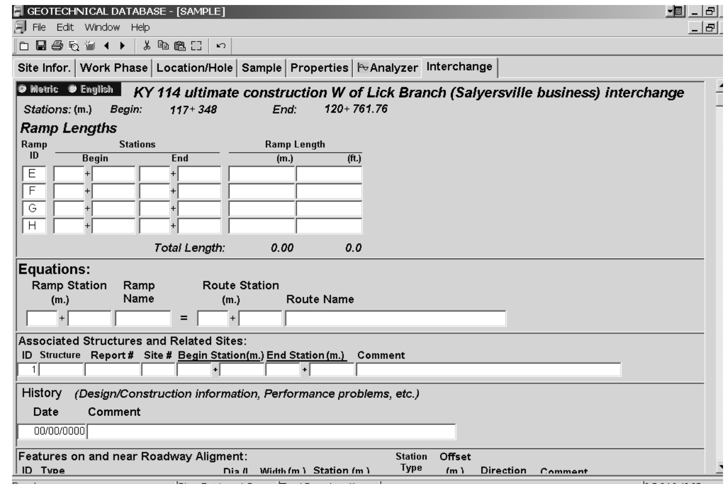


Figure 139. Interchange GUI.

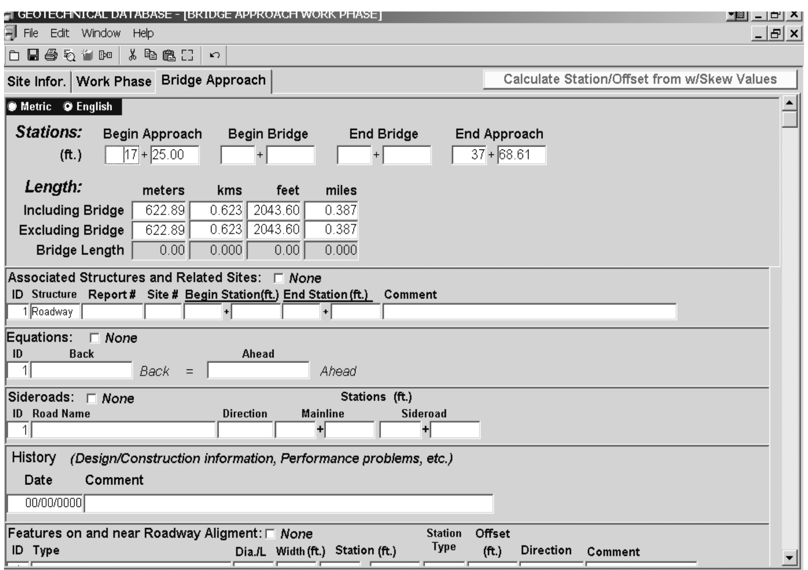


Figure 140. Bridge Approach GUI.

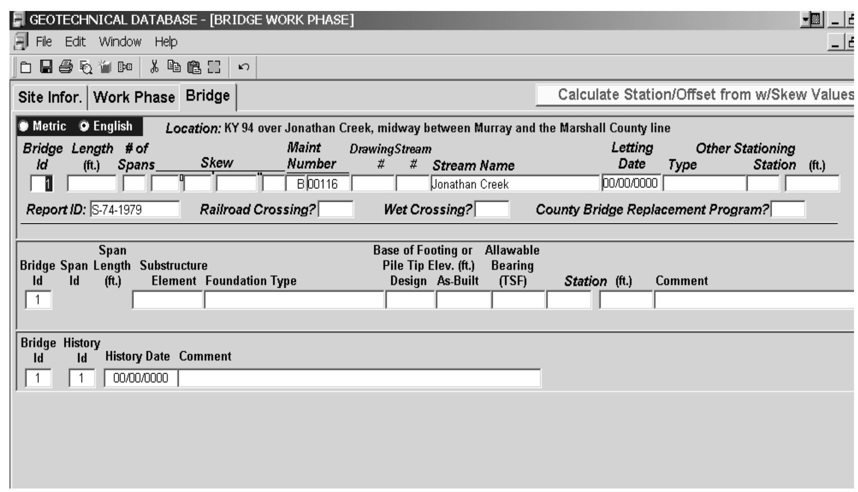


Figure 141. Bridge GUI.

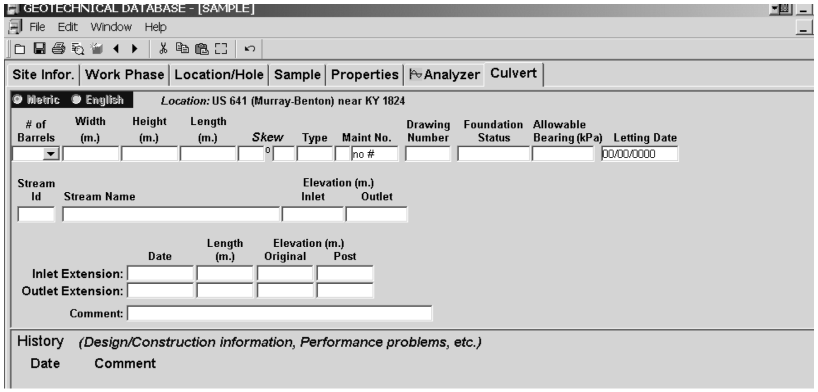


Figure 142. Culvert GUI.

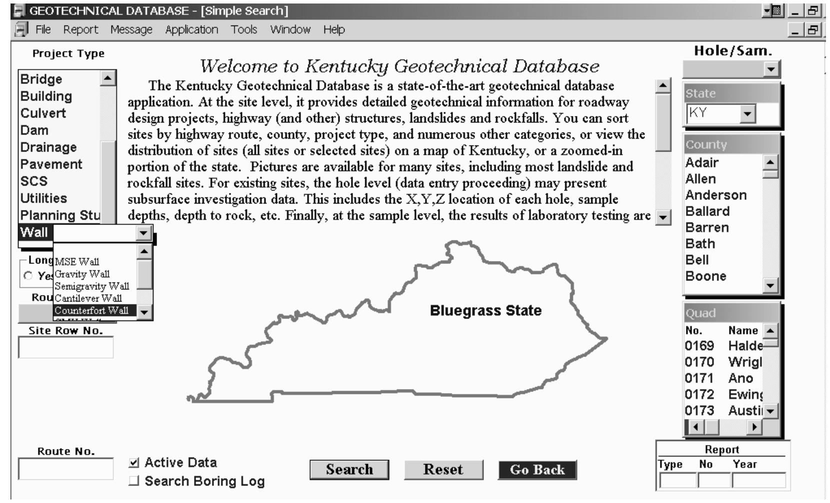


Figure 144. Accessing wall data.

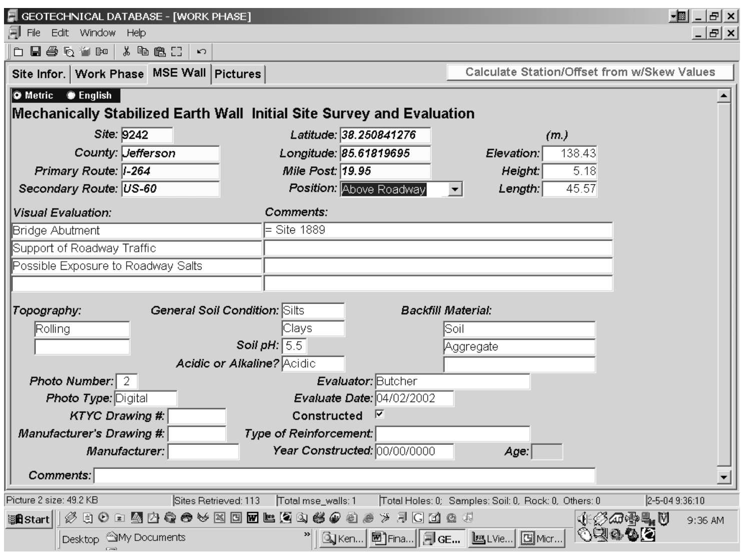


Figure 143. GUI for storing data for mechanical stabilized (MSE) walls.

Figure 145. Views of stored (embedded) photographs of a typical MSE wall.

A number of project-type graphical user interfaces are under construction, and will later be included in the database. These include buildings, dams, drainage structures, utilities and pavements. Also, the walls project-type GUI was originally designed for MSE (Mechanically Stabilized Earth) walls. The format of this GUI may be broadened slightly, to allow it to serve for all types of walls. This could be advantageous since many input values such as wall length, wall height, roadway above or below wall, etc., will apply to all walls regardless of type. Alternatively, the differences between wall types may seem too great (for example MSE walls are the same width at the top as at the bottom while gravity walls have a wide base, and thin upward). In this case, a series of wall graphical user interfaces, one for each type of wall, may be constructed. These wall types include gravity, semigravity, cantilever, conterfort, CMU, noise, and crib.

Access to the different wall types can be obtained by selecting from the menu shown in Figure 144. By highlighting and clicking "MSE" (under **Wall**), a GUI for a mechanically stabilized wall appears, as illustrated in Figure 144. This GUI contains tabs identified as "Site Info," "Work Phase," "**MSE Wall** (GUI is illustrated in the figure), and "Picture." By clicking "**Picture**" in Figure 143, views of the MSE wall appear, as shown in Figure 145.

Borings/Locations Data Entry GUIs

The database currently allows users to distinguish between various types of borings and other (non-boring) data collection locations. The boring types indicate the types of samples taken, if any. If only soil samples were obtained, then the boring type is **"Soil Test Sample Boring" (**abbreviated in the borings list as **S)**. If only rock samples were obtained, then the boring is labeled **"Rock Core" (R)**. If both soil and rock samples were obtained, it is labeled **"Soil Test Sample Boring with Rock Core" (SR)**. Borings are labeled "**Soundings** " (X) when no samples are obtained or "**Soil Visual Description**" (V) when the color and texture are described of penetrated materials brought to the surface by a flight of augers.

There are other classifications that are fairly self-explanatory. One is **"Soil Visual description with Rock Core" (VR)**. Soft rock may be angered, rather than cored. In this case, no rock sample is actually obtained, but the driller has described the penetrated rock interval, which can therefore, be entered as a "rock sample." This yields two additional boring types **"Soil Samples with Angered Rock" (SA)** and **"Soil Visual Description with Angered Rock" (VA)**. Finally, soundings are sometimes used along roadway profiles to allow better definition of the extent of sinkholes. Although these are regular soundings in the manner in which they are obtained, they would typically have surface elevations lower than the general ground surface between sinkholes. Use of such soundings to construct profiles could, therefore, be misleading unless the purpose of these soundings was known. The database consequently uses the category **"Soundings for Sinkhole Definition" (XS).**

In addition to those, there are two data collection locations which are not borings, but which are input on the same hierarchical level as borings. One of these is **"Rock Outcrop" (RO)** in which there are no samples. Only the elevation of the bedrock surface (which is exposed at the ground surface) is indicated. The other is **"Open-face Log" (OF)**, which is the description of a vertical section of bedrock exposed in a roadway cut, or in a naturally occurring, steep hillside or cliff-face exposure. These will include one or more rock samples defined based upon exposed intervals of the rock sequence.

A single borings level data entry GUI is used for all types of borings, and also for rock outcrop locations, which, although it has no samples or depths, still has a surface elevation and geographic coordinates. The data entry GUI for borings is shown in Figure 146. A different data entry GUI is used for Open Face Logs, as illustrated in Figure 147. Borings/Locations are stored in a folder attached to each site. By clicking the **"Borings"** folder in the top right portion of the site list screen, Figure 148, and provided any information has been entered, a split screen appears and displays boring information. The left portion of the split screen is the site list, and is like that shown in Figure 133 or 148. The right portion lists all borings associated with the selected site, and one example when fully revealed is shown in Figure 149. Information includes hole number, type of boring, station number and offset, surface elevation, depth to bedrock, RDZ, number of samples, USGS Quadrangle number, and work phase.

If a highlighted boring is doubled clicked to open the GUI (Figure 146), this screen will contain a series of tabs labeled site information, work phase, **location/hole**, (an active screen, shown first by default), maps/pictures, and project type (in this particular figure, a roadway). Clicking any of the other tabs would make another GUI appear, but many of these GUI's, accessed at the borings/locations level are view-only. To change data at the site level, the user would have to close the boring and open the site screen from the sites list. The same thing applies to workphase/report. Still it is often convenient to be able to see these higher-level screens from within borings.

By pointing the mouse pointer anywhere in the lower right-hand screen (Figure 148) labeled "Borings" and right clicking allows the user to add a new Location/Hole (Figure 146). At this level the user can define any number of holes or sampling locations. Any hole can also be deleted at this point. Geographical coordinates (state plane or latitude and longitude) of each hole or sampling location may be added at this point.

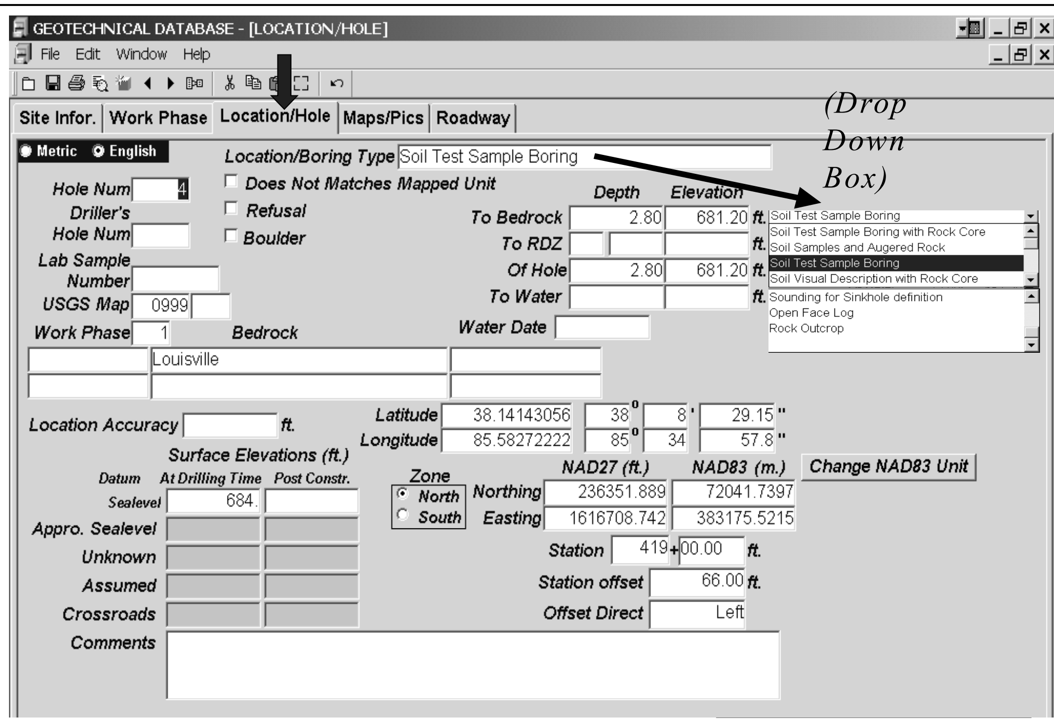


Figure 146. GUI for entering and viewing boring data.

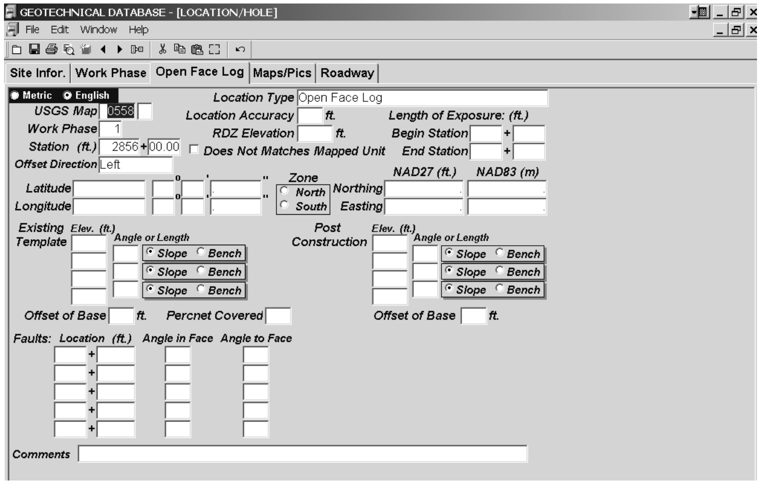


Figure 147. Data entry screen for open face log.

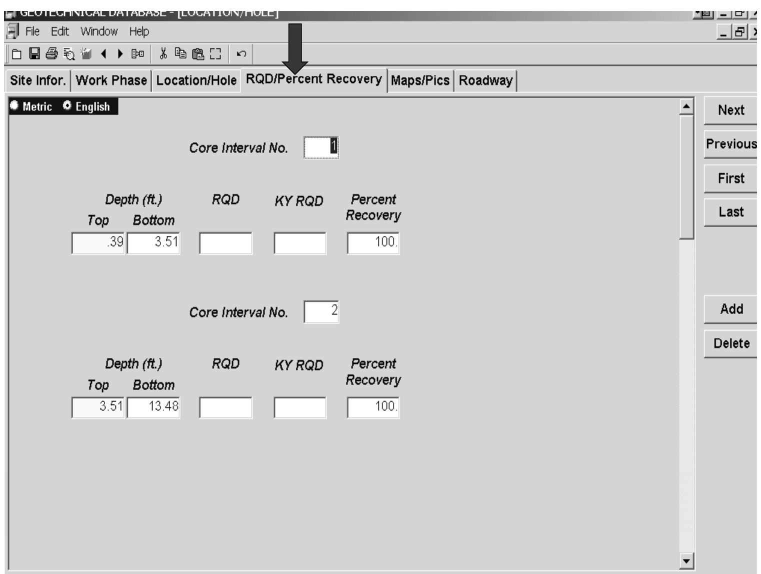


Figure 150. GUI for entering RQD/Percent Recovery data.

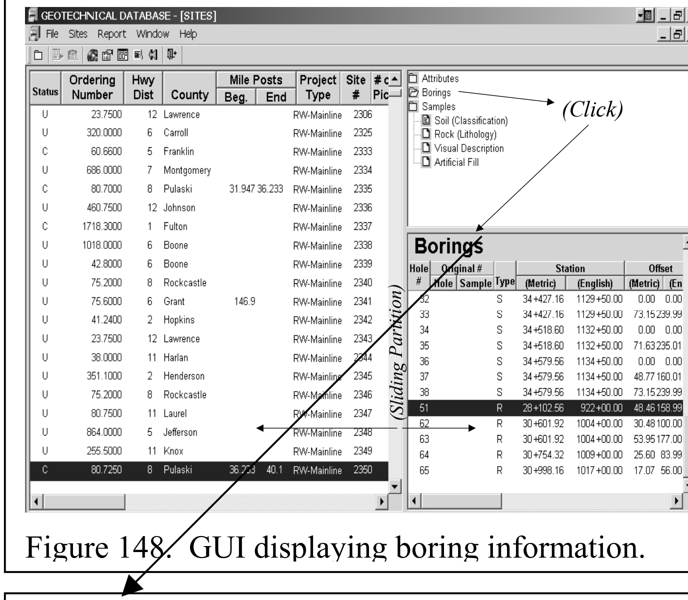


Figure 148. GUI displaying boring information.

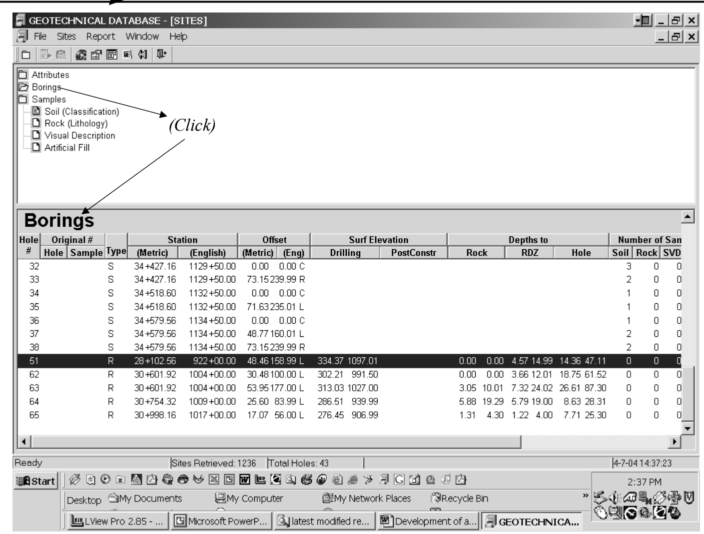


Figure 149. GUI for viewing the boring list or selecting (by double-clicking) an individual boring to enter new or revise existing data

Borings that contain rock cores (R, SR, and VR), include an "**RQD/Percent Recovery**" GUI as shown in Figure 150. They include data related to core runs made by the drillers (that is the extent of a full core barrel of sampled rock [defined by top and bottom elevations] extracted from a boring as part of the normal drilling process. These core runs have no predetermined relationship to rock samples subsequently defined by the geologists, based on change in lithology. Thus a five or ten foot core run could be two, three, or more samples, plus a portion of the next one, or it might be only a portion of a single sample. Since core runs are unrelated to samples, this information requires its own separate logging defined by elevations, which are recorded and stored at the boring level, while those elevations that define samples are distinctly different.

In some situations, where geographical coordinates are not used, the field survey of a project may be based on assumed coordinates of a geographical marker, or "Bench Mark," or geodetic marker. In this case "local" coordinates, or assumed coordinates, are assigned to all stations, borings and geotechnical sites within a project. In this situation, a reference boring, or reference feature, may be located "visually" on a quadrangle and latitude and longitude of the reference feature noted. Although this may not be highly accurate and may be several feet in error, it does provide some means of locating approximately the latitude and longitude of the reference boring. As a means of facilitating and obtaining approximately the latitudes and longitudes of other borings, or sampling locations, the GUI shown in Figure 151 was developed. If the latitude and longitude (or state plane coordinates) of the reference feature, or boring, are known accurately, or if it they are estimated from a quadrangle, then latitudes and longitudes of other borings may

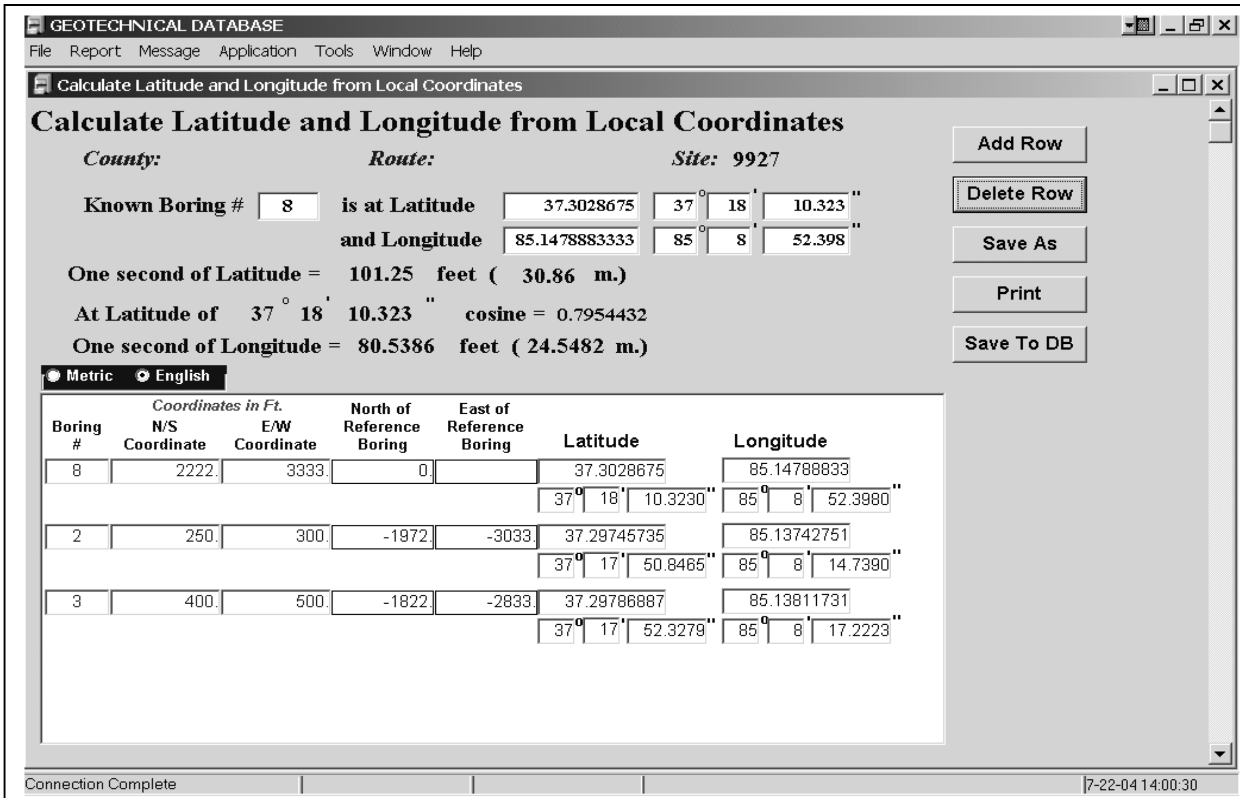


Figure 151. Adding and converting state plane coordinates to latitudes and longitudes of sampling locations of defined sites.

be calculated. This screen can be opened from the site information GUI in Figure 131. When the "**Calculate Latitude and Longitude from Local Coordinates**" button near the bottom of the figure is clicked, the GUI shown in Figure 151 appears. Or the latitude and longitude of only one hole may be known from GPS readings. If the state plane coordinates of other holes are known, then the latitudes and longitudes of the other holes may be computed. When the coordinates of other holes within a site are computed, as illustrated in Figure 151, using the reference hole (number 8 in the example), and saved to the Database ("DB"), the latitude and longitudes of the various holes of the site are automatically recorded in the proper boxes shown in Figure 146. If the latitude and longitude of the reference hole are known accurately (from GPS measurements), then all calculated latitudes and longitudes of the other holes are accurate.

Sample Types and Sampling Methods

Sample numbering procedures are illustrated in Figure 152. Holes 1 and 2 in this figure illustrate how soil samples are numbered consecutively despite gaps in the sampling record. Holes 3 and 4 illustrate how sample depths and depth to bedrock indicate whether the tested material is soil or rock.

Types of sample and sampling methods are sufficiently related that it is advantageous to discuss them together. There are only four types of samples, currently in the geotechnical database, while there are 18 different sampling methods that might be selected. Sample types are **tested soil samples**, **rock samples**, **visual description samples** and **artificial fill samples.** Whenever any sample is created (that is, entered into the database as a new entry), the first requirement, prior to entering any other data, is to designate the type of sample. This is necessary because different sample types have slightly different data input GUIs. All other boldface entries presented here are sampling methods.

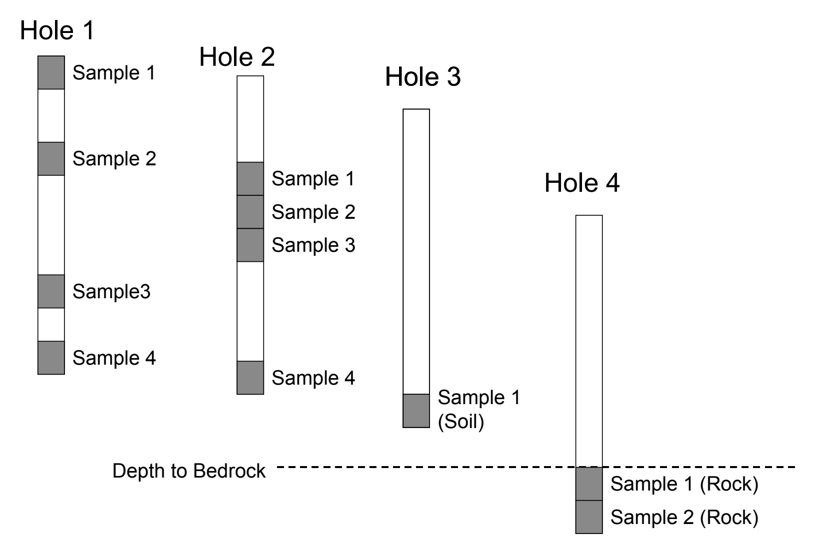


Figure 152. Sample numbering procedures.

Graphical user interfaces for samples are created by first clicking the "**Samples"** button located in the top right-hand screen of Figure 153. After this action, the "**All Samples"** screen appears in the lower right-hand corner of that figure. This action brings up all types of samples (if they exist and have previously been entered). By pointing the mouse in any portion of that screen and right clicking the mouse, a prompt is obtained asking the user to either "add" or "delete" a sample. Prior to creating sample GUIs the user must create a **Location/Hole** GUI (Figure 146). Otherwise the program will not allow the creation of a sample GUI.

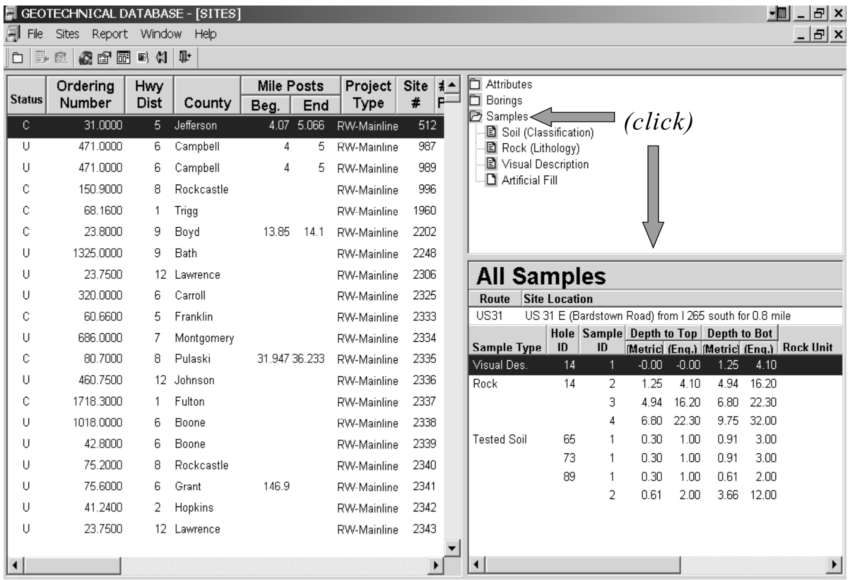


Figure 153. GUI displaying sample information.

Soil samples are retrieved in the same manner as borings. Left clicking on the samples folder (lower right-hand portion of Figure 153) will retrieve all samples for the highlighted site in the left-hand portion of Figure 153. Alternatively, the user can retrieve only tested soil samples (or at least all those with classification data) by highlighting a site in the left-hand portion of the screen in Figure 154 (or in Figure 153), opening the “Soil (Classification)” folder in the top right portion of Figure 154, and left clicking on a highlighted line. In a similar fashion, the user may retrieve only “Rock (Lithology)” samples (Figure 155), “Visual Description “ samples (Figure 156), or “Artificial Fill” samples (Figure 157). The heading for different categories in the sample list varies according to the type of sample retrieved.

The principal data entry GUI for “Tested Soil” is shown in Figure 158. A complete listing for “Rock Unit” is shown in Appendix D while a complete listing of “Stratigraphic Control” is shown in a drop down box in Figure 159[2]. Data entry sample graphical user interfaces for artificial fill and rock samples are shown in Figures 160 and 161, respectively. The two selections, however, have different attached “Properties” graphical user interfaces.

Except in the case of artificial fill (see below), any soil sample where laboratory testing was performed (beyond a simple natural moisture content) is classified as a tested soil sample (Figure 158). The sampling method may be **SPT (***Standard Penetration Test***) with blowcounts**, **Shelby Tube**, or **Auger (jar or bag) sample**, but regardless, some testing must be performed. Otherwise, even if a Shelby Tube were obtained, without testing it should be listed as a visual description sample, or not entered at all if there was not even a visual description. By indicating that a particular sample is “Tested Soil” the input screens will include attached (soil) “Properties,” available as nine sub-folders (screens) that allow the input of available test results. Visual description samples do not have most of these associated GUIs. The full range of the number of choices regarding sampling method is displayed in the drop down box in the right-hand portion of Figure 158.

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[2] One of the authors, Bill Pfalzer, collaborated with the Kentucky Geological Survey in developing the list of rock units for the drop down listing for Kentucky.

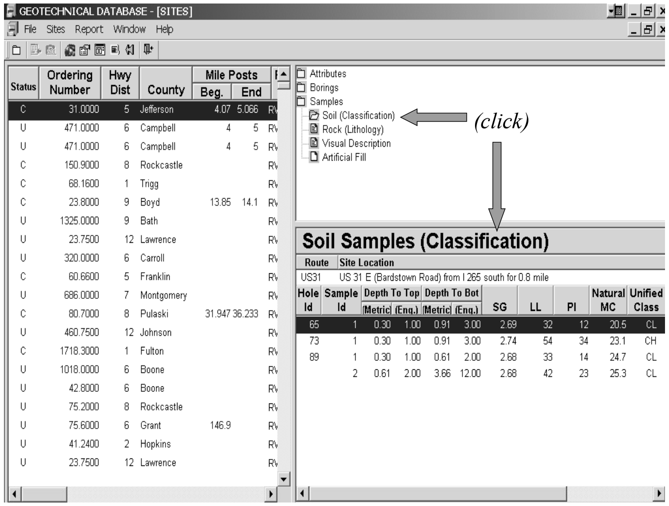

Figure 154. Accessing soil classification data for samples. (Note the details shown --lower right portion of GUI—such as specific gravity or liquid limit are different than the detained information for other types of samples

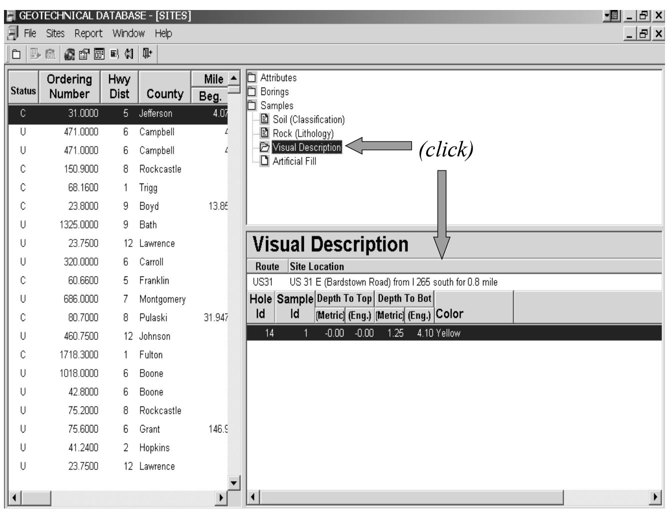

Figure 156. Retrieving Visual description samples.

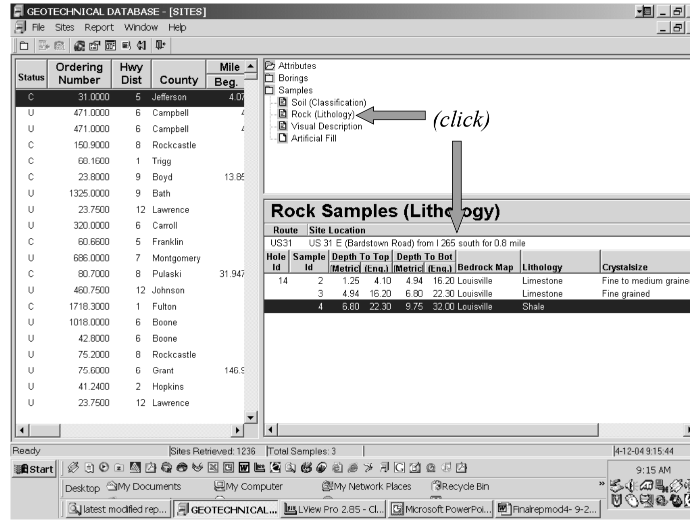

Figure 155. Rock lithology information.

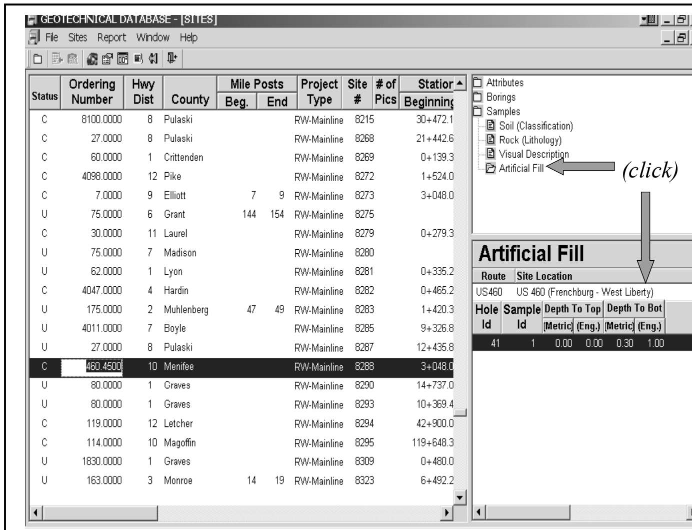

Figure 157. Artificial fill information.

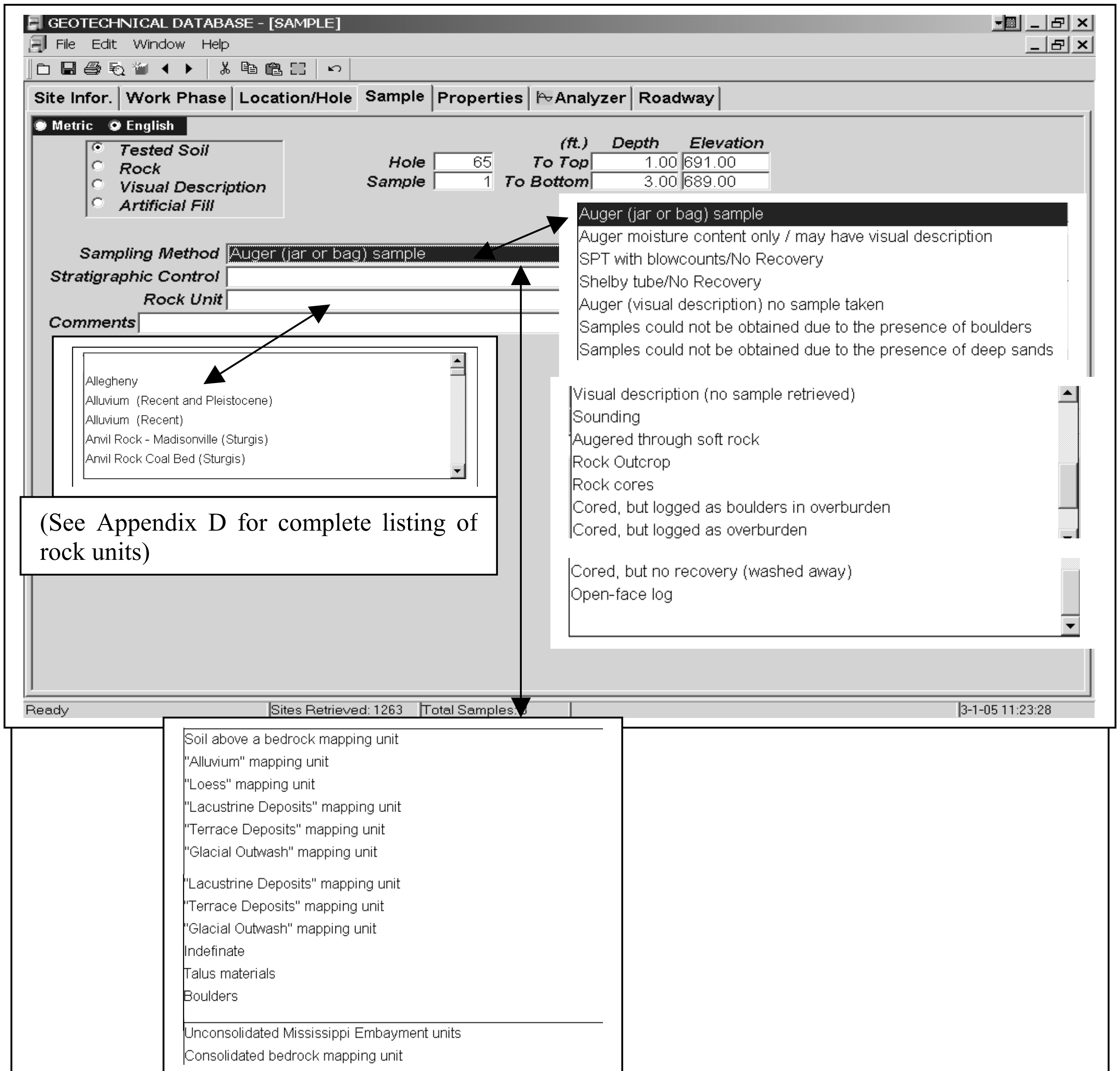

Figure 158. GUI for Tested Soil Samples.

Sampling methods, whereby rock samples may be obtained (or viewed, described, and entered as samples), are **Rock Cores**, **Cored but logged as boulders in overburden**, **Augered through soft rock, Rock Outcrop**, and **Open-Face Log** (not all open face log samples are rock; some could also be soil samples with visual descriptions). The main "Sample-level" data entry GUI for rock samples, shown in Figure 160, is similar to that for soil samples except that it has additional fields to allow the input of voids, joints and other features characteristic of rock, but not of soils. A complete listing of rock units, appearing in a drop down menu in Figure 160, is given in Appendix A. Properties' folders, attached to these rock samples, allow for the input of characteristics and test results that are applicable to rock samples, but differ entirely from the Properties' GUIs for soil samples.

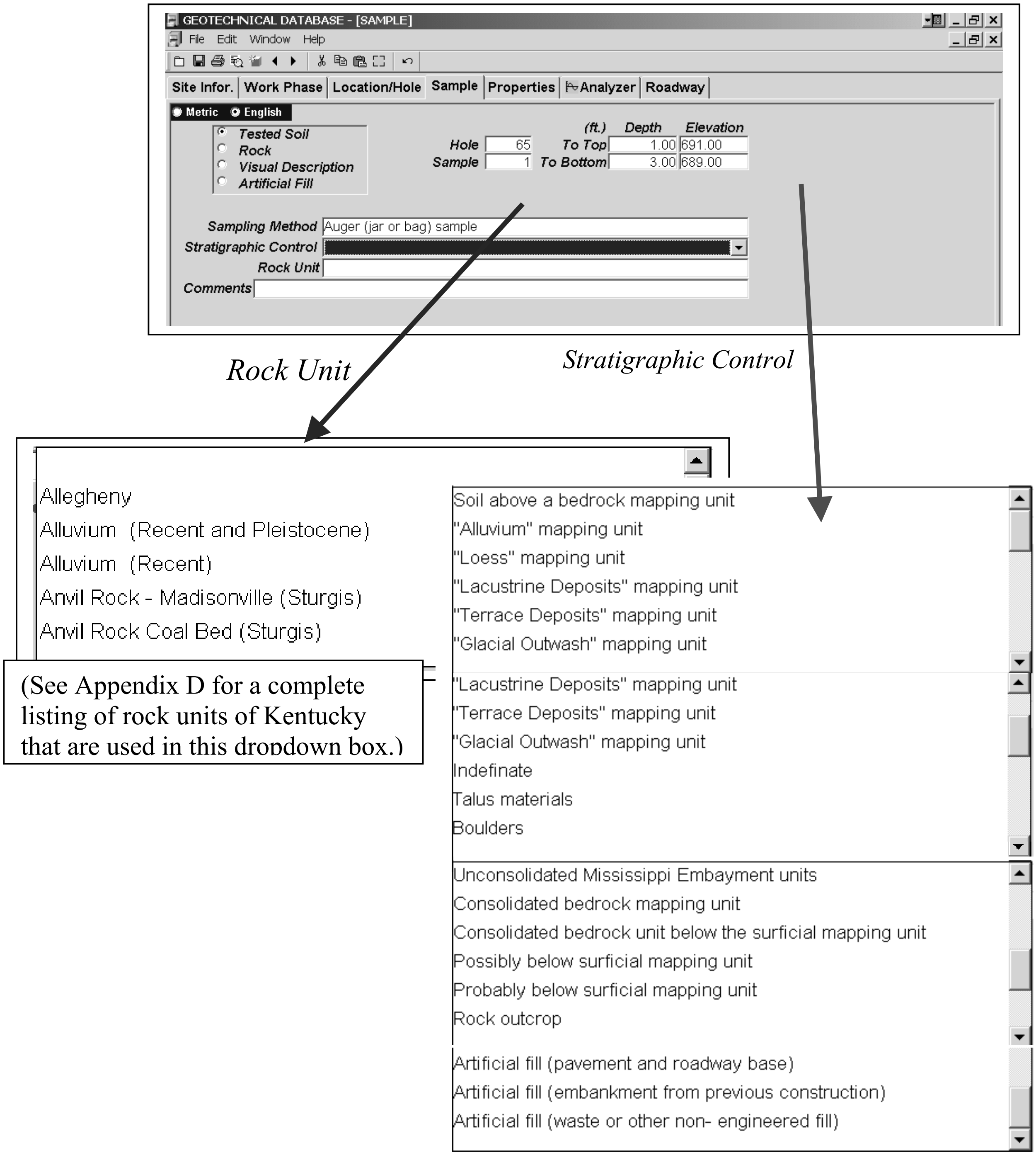

Figure 159. Complete menu for "Rock Unit" is shown in Appendix D. A complete menu for "Stratigraphic Control" is shown here.

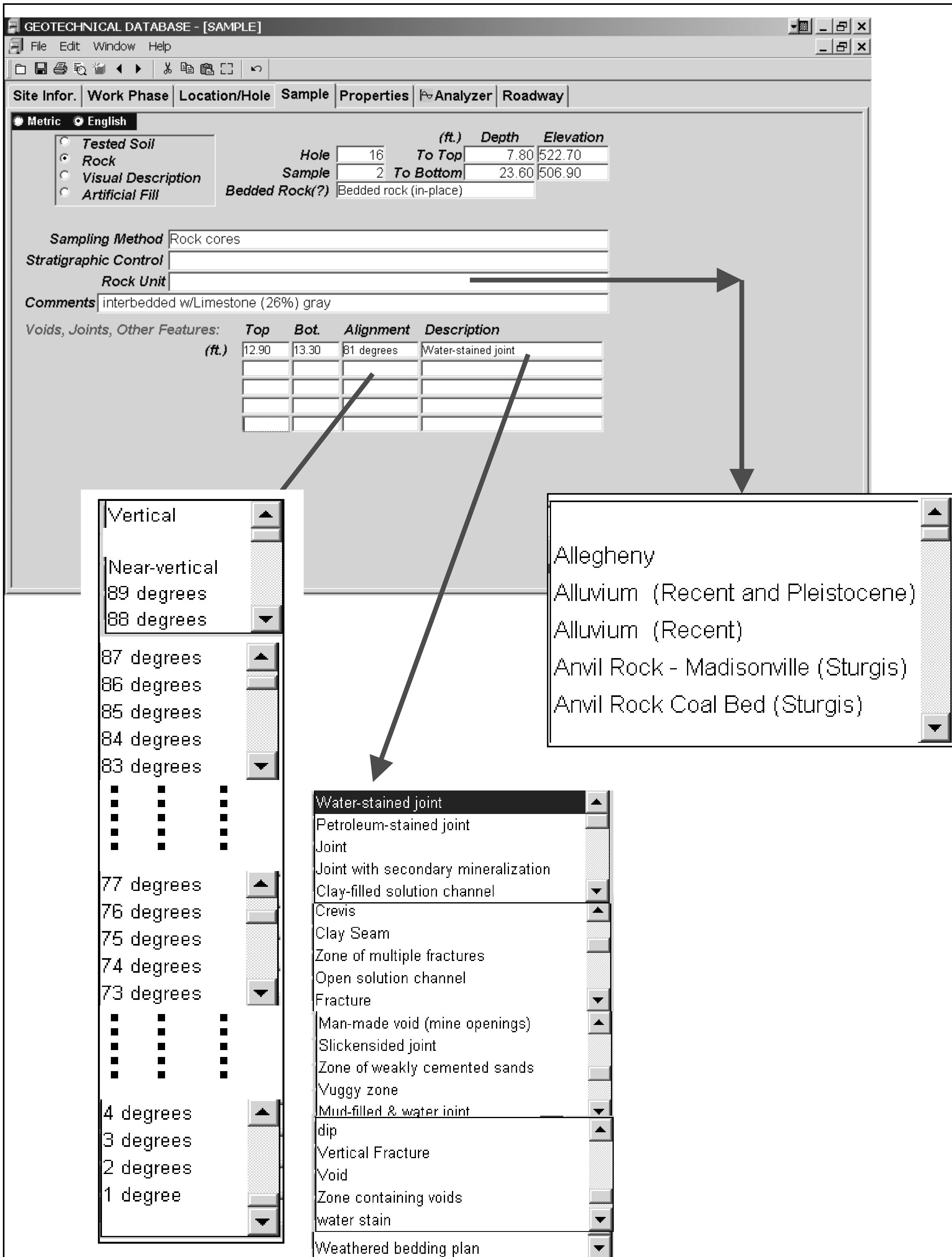

Figure 160. GUI for rock samples and drop down menus for describing voids, joints, and other features.

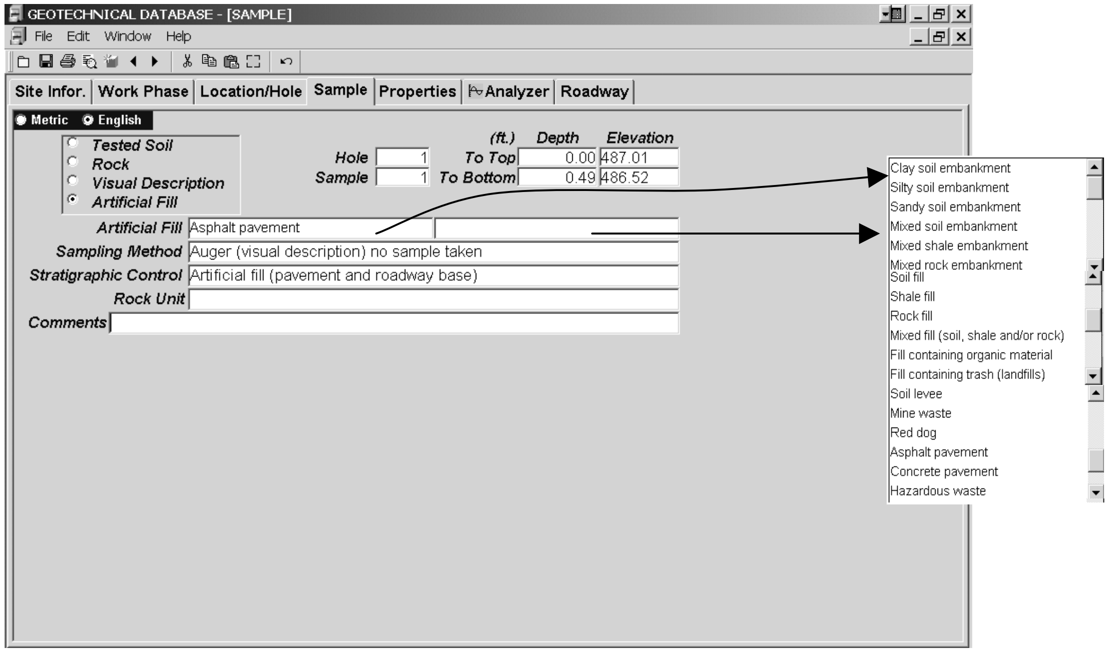

Figure 161. GUI for artificial fill.

Visual description is typically a major portion of the characterization of rock samples, but it is used less for soils where laboratory testing commonly plays a larger role. Thus, visual description of rock samples, providing composition, color, texture and grain size, are always included with rock samples (However, these rock samples are never referred to as "Visual Description" samples). For tested soil samples, the real emphasis, even though visual description may be included, is focused more on test results. Thus, when a soil sample is referred to as a visual description sample, it is always referring to soil samples, for which no testing has been performed (the only measurement which might be included for these samples is natural moisture content). As noted above, the data entry GUI for **Visual Description Samples** is the same as for T**ested Soil Samples as** in Figure 158. The absence of test results for these samples means that none of the attached soil "Properties" folders that accompany "tested soil samples" is required for "visual description samples."

Artificial fill samples may be either soil or rock. The main data entry GUI is like that for soil (Figure 158), except that it includes a pair of fields to indicate the nature of the fill – soil or rock, or mixtures of both (Figure 161), and of what types. It is important to recognize that such materials have been placed by human activities, and not by nature. Naturally occurring materials may be quite uniform over broad areas, and change gradually, and perhaps predictably, horizontally. By contrast, artificial fill is likely to change most abruptly, and unpredictably. Properties folders attached to artificial fill samples are the same as those for tested soils, since soil artificial fill can be tested using the same procedures applied to naturally occurring soils. If these samples are rock, the visual description folder, which includes choices for rock can be used alone, and all of the other attached folders ignored.

When any type of sample data entry GUI is retrieved, several related "display screens" will also be accessible by tabs. The site screen, for example, will allow the user to see what site this particular sample is in, just as the location/boring tap would allow viewing of data for the boring which includes this particular sample. While the sample screen is active, and information relating to that particular sample can be added or changed (provided the user has **"data entry status"**) the other screens are view only. Were it necessary to modify such data, the user would need to exit samples, and re-enter at the boring or site level.

From the **Hole/Sample query box** on the **Simple Search Screen** (Figure 132), users may select sites with particular types of samples. These may be used alone, or in combination with other selection criteria. As examples, if the user selected "Artificial Fill," and nothing else, a search would yield all sites that include one or more artificial fill samples, throughout Kentucky, and even in other states, if such data exist. If the user selected rock, and Adair County, a search would yield all sites in Adair County that have one or more rock samples. These could be used in the same manner with numerous other selection criteria, including route, geologic quadrangle, or a specific geotechnical report. If **Holes** is selected in the **Hole/Samples** query box, all sites for which borings and samples have been entered would be retrieved, but sites that do not have borings would not be retrieved.

Once a search has been made, and a particular site from the sites list has been highlighted, if the user clicks on "**Samples,"** all samples, regardless of type, will be listed in the lower portion of the sidebar. As shown previously in Figure 153, displayed data include a heading line showing route and site location, and a samples details list which includes sample type, hole and sample identifications, and depth intervals. In the example shown, the samples include "Visual Description" (from auger cuttings), "Rock" and "Tested Soil."

Alternatively, assuming all sites had samples of each type, the user could select "**Tested Soil** (or **Soil Classification**)" from the four selections below **Samples**, and only tested soils would appear, as shown in figure 154. The same thing could also be done by selecting "Rock (Lithology)" to show only rock samples, or "Visual Description" to show only visual description samples, or "Artificial Fill" to show only artificial fill samples, as illustrated in Figures 155 through 157, respectively. With each of these selections, headings in the summary box will change to show more specific data relating to that particular type of sample.

Soil Properties

Grain Size for Soil Samples

The physical and engineering properties of sands differ dramatically from those of clays, and the significance of the distribution of grain size within various soils has been recognized for centuries. In current practice, even though a number of other types of testing and soil characterization have been developed, the determination of grain size distribution continues to be of great importance.

Three different tests are employed in measuring grain size distribution. **Wash gradation** (AASHTO T 11) is a quick and simple test that allows determination of a single important value, the percentage of fines (silt plus clay) that are present in the sample. Water is used to flush the fines through a number 200 sieve. It is assumed that all particles with nominal diameters less than 75-μm (that is all of the silt and clay) will pass through the sieve. Sands and gravel will be retained on the sieve. The difference between the initial dry weight of the total sample being sieved, and the dry weight of material retained on the sieve after washing represents the fines which are then expressed as a percentage (by weight) of the total sample.

If a more detailed breakdown of grain size distribution within the coarse grained (sand plus gravel) fraction is required, **sieve analysis** (AASHTO T 27) is performed. The wire cloth sieves used in this analysis are pans that can be nested in vertical stacks. It is not uncommon that 100 percent of the soil will pass through the uppermost sieve that could have openings as large as 3” square. The size of the openings decreases progressively downward, however, and the weight of soil retained on each sieve is weighed and expressed as a percentage of total weight. It should be noted that the values recorded in the database are percent passing values. In some cases, these values are presented directly on the subsurface data sheets. In other cases, however, different, though related information (such as percent sand, percent silt and percent clay) is given and the percent passing various sieve sizes must be calculated.

There is, of course, a lower limit to how small the openings in wire cloth can be without becoming unserviceable. In general practice, this is the number 200 sieve, with 200 wires per inch. Particles passing the number 200 sieve (silt and clay particles) are too small to determine by sieving, and the **hydrometer method** (AASHTO T 88 and KM 64-519) is used to indirectly measure those small particle sizes. The basic principals of hydrometer testing are as follows. Soils consist of solids (particles) and voids between particles that may be filled with either air or water. The particles have specific gravities that are much higher than the specific gravity of water. Thus water carrying suspended solids is heavier than clear water. Larger particles, such as a sand grain would settle to the bottom very rapidly, but the smaller the particles are the longer they will remain in suspension. This is the basis of *Stoke’s Law* that relates particle size and weight to the time required for such particles to settle out of suspension. As more and more particles are removed from the fluid (by settling to the bottom) the specific gravity of the water decreases. The hydrometer measures this specific gravity, and by application of *Stoke’s Law* one can determine, from how dense the sediment-laden water is at specific times, what percentage of the soil has nominal diameters greater than some specific size. These calculations are precise enough that even the variation in the viscosity of water as temperature changes will affect the calculations, so a thermometer must be used to adjust each reading for the temperature at that time. Some simplifying assumptions must be made to allow these grain size calculations to be made at all. The most critical one is that all of the silt and sand grains have the same specific gravity, equal to the average value as determined for the sample as a whole. Of course this is not true and it introduces some inaccuracy. Still the results of hydrometer testing produce results that can be quite useful in characterizing a soil.

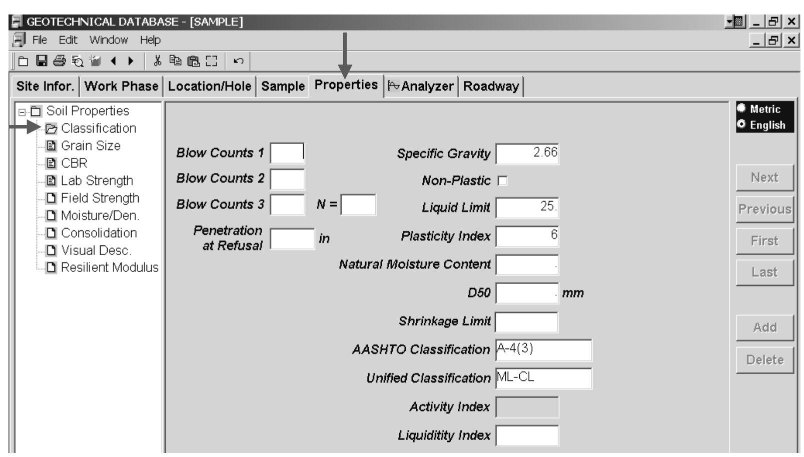

Figure 162. Soil properties’ menu and classification GUI.

Graphical User Interfaces for Soil Properties

When a soil sample has been opened, an attached **“Properties”** tab will allow access to a series of folders to enter and store soil properties. The first of these folders is “**Classification**” and the

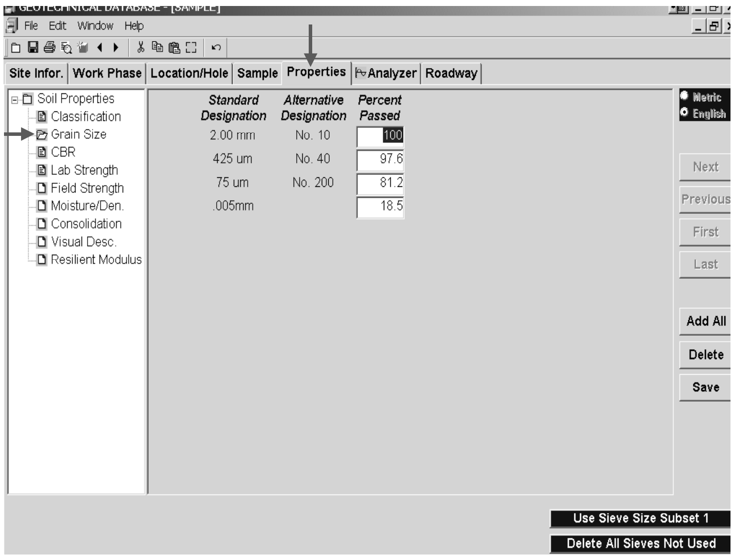

Figure 163. Grain size GUI.

GUI for this comes up first by default. An example classification GUI screen is shown in Figure 162. It presents fields for the AASHTO and Unified Soil Classification Systems, and other fields, including "Blow Counts, Specific Gravity, Liquid Limit, Plasticity Index, Natural Moisture Content, and D_{50} values."

Within soil "**Properties**," a menu of each available folder is displayed on the left portion of the screen. Sheets in this menu indicate that data has been entered if the sheet is lined, or that no data has been entered (and consequently there would be no need to open the folder) if the sheet is blank. While the "Classification" GUI always comes up first, by default, double-clicking on any folder in the menu will cause a GUI that pertains to the clicked item to appear.

The GUI in Figure 163 appears when grain size is clicked. In entering grain size data, the user has two options. The user may choose "**Use Sieve Size Subset 1**," as shown in Figure 164. This set of sieves is frequently used. Alternatively, the user may display all U. S. standard sieve sizes, Figure 165 by clicking the button "**Add All**" (all sieves can be viewed when the scroll feature is used). By clicking the button, "Delete All Sieves Not Used," unused sieves are deleted and only those containing percent data entry values appear, as shown in Figure 163. The user may also delete manually any unused sieve.

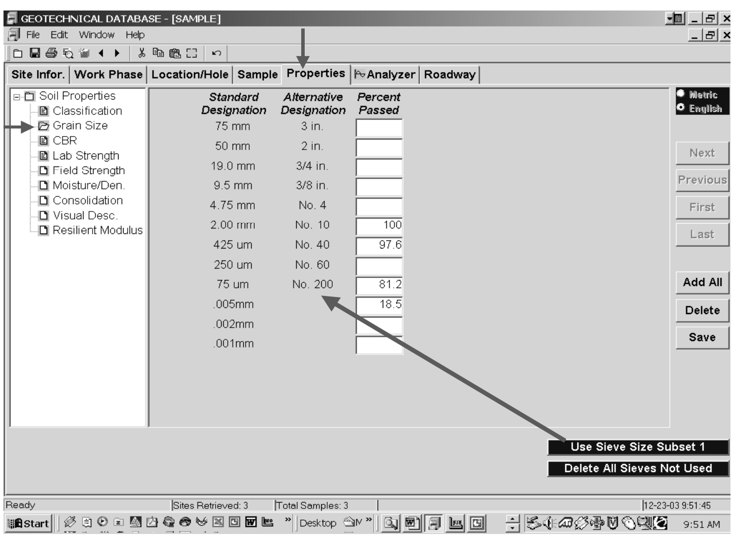

Figure 164. Sieve sizes that appear when the "Use Sieve Size Subset 1" button is clicked.

By clicking on "**CBR,**" the GUI shown in Figure 166 appears. CBR data obtained from the Kentucky Method (Kentucky Methods 1999) or/and AASHTO method can be entered using the drop down menu feature in the GUI. CBR values of specimens that have been soaked or/and unsoaked may be entered. The value of CBR, dry density, and moisture content of the soil specimen may be entered.

When "Lab Strength" is clicked the GUI shown in Figure 167 appears. Different types of triaxial data may be entered. These include unconsolidated-undrained (and unconfined compression), consolidated-drained, and consolidated–undrained with pore pressure measurements. Also, the wet and dry densities of the soil specimen, confining pressure, and the angle of internal friction, and cohesion may be recorded.

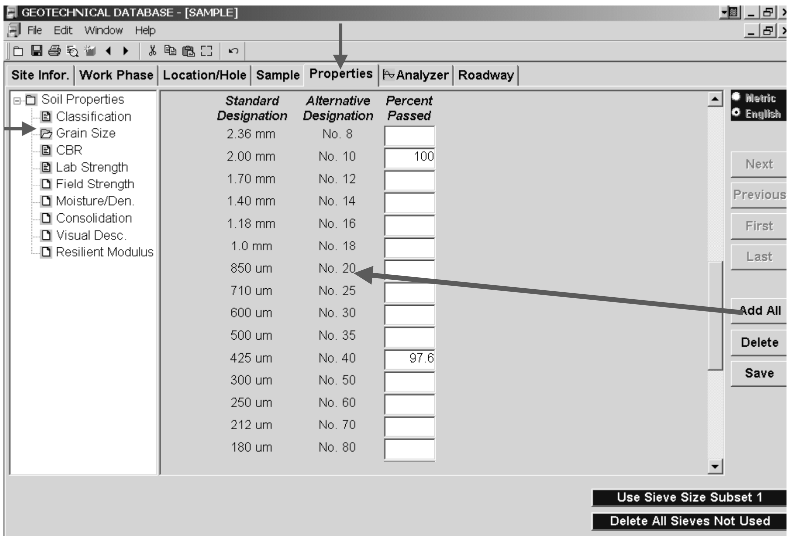

Figure 165. Option for displaying all U. S. standard sieve sizes. Note only a portion of these are shown here. The remainder could be viewed by sliding the sidebar up or down.

The "Field Strength" GUI, Figure 168, is under construction. After completion of the field strength GUI, the user will be able to enter data obtained from different types of field tests. Field tests will include in-situ CBR, standard penetration, Dutch cone, vane shear, and other tests that may be added in the future (GUI's for the field tests are under construction). Other GUI screens for entering moisture density, consolidation, and visual description, are shown in Figures 169 through 172, respectively. When "Visual Description" is clicked a graphical user interface appears as illustrated in figure 171. This GUI allows the user to describe the primary composition, consistency, and color of the soil sample. Complete dropdown menus for these three items are illustrated in this figure. By clicking the "Next" button in Figure 171, secondary and tertiary descriptions may be added as illustrated in the graphical user interfaces shown in Figure 172. A graphical user interface is also provided for entering resilient modulus data, as shown in Figure 173.

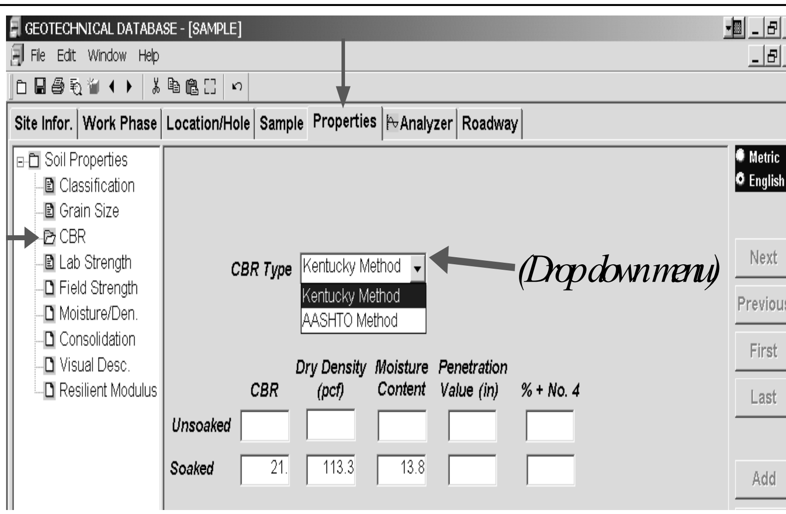

Figure 166. CBR GUI.

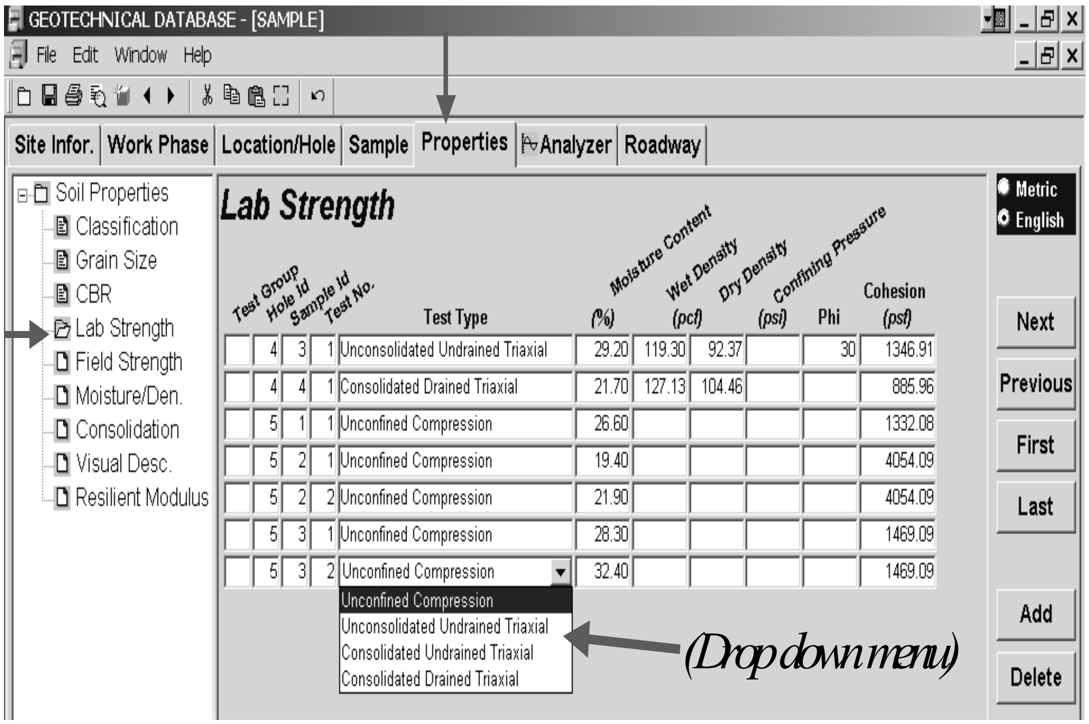

Figure 167. Laboratory strength GUI.

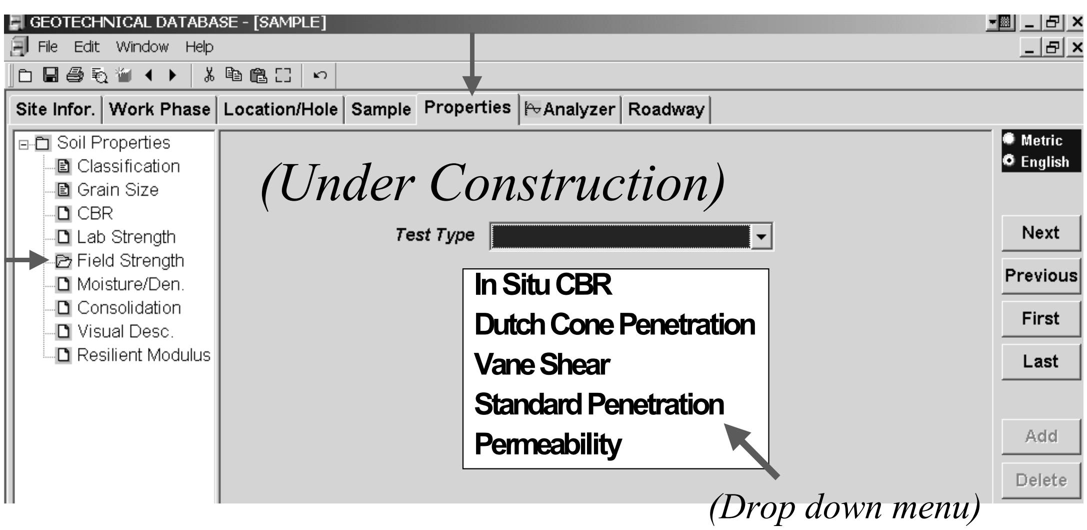

Figure 168. Field strength main GUI Menu *(This GUI and other field strength GUIs are under construction).*

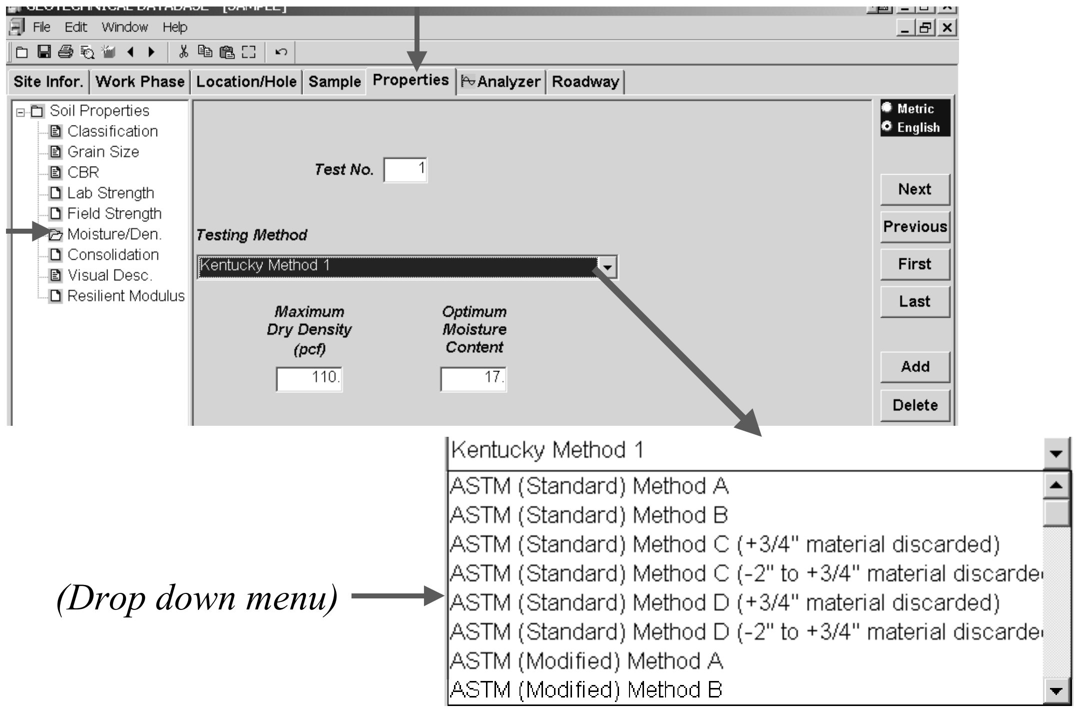

Figure 169. Moisture-Density GUI.

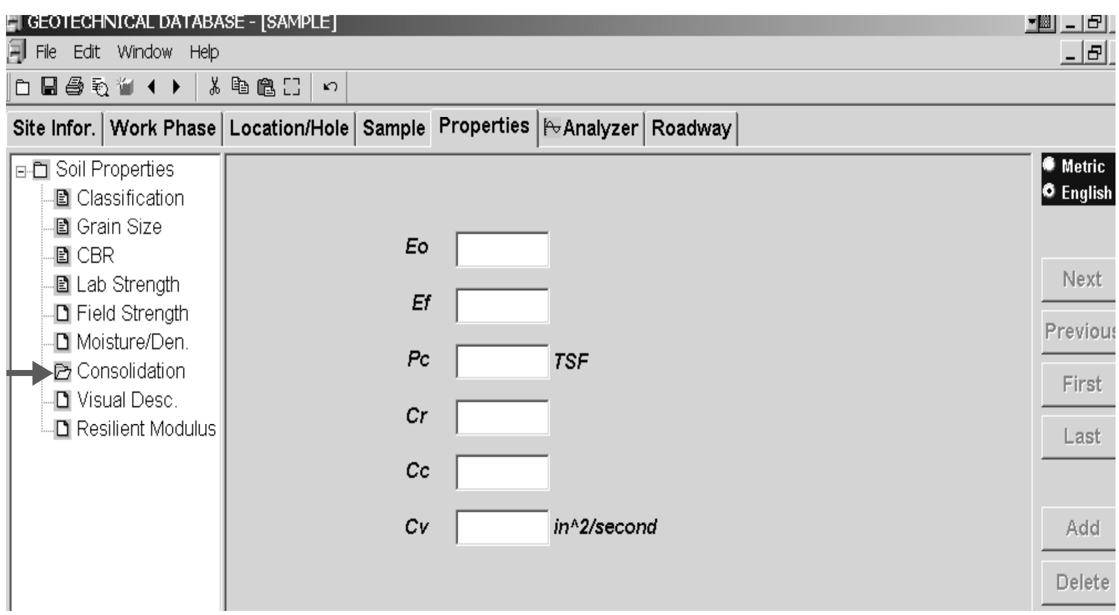

Figure 170. Consolidation GUI.

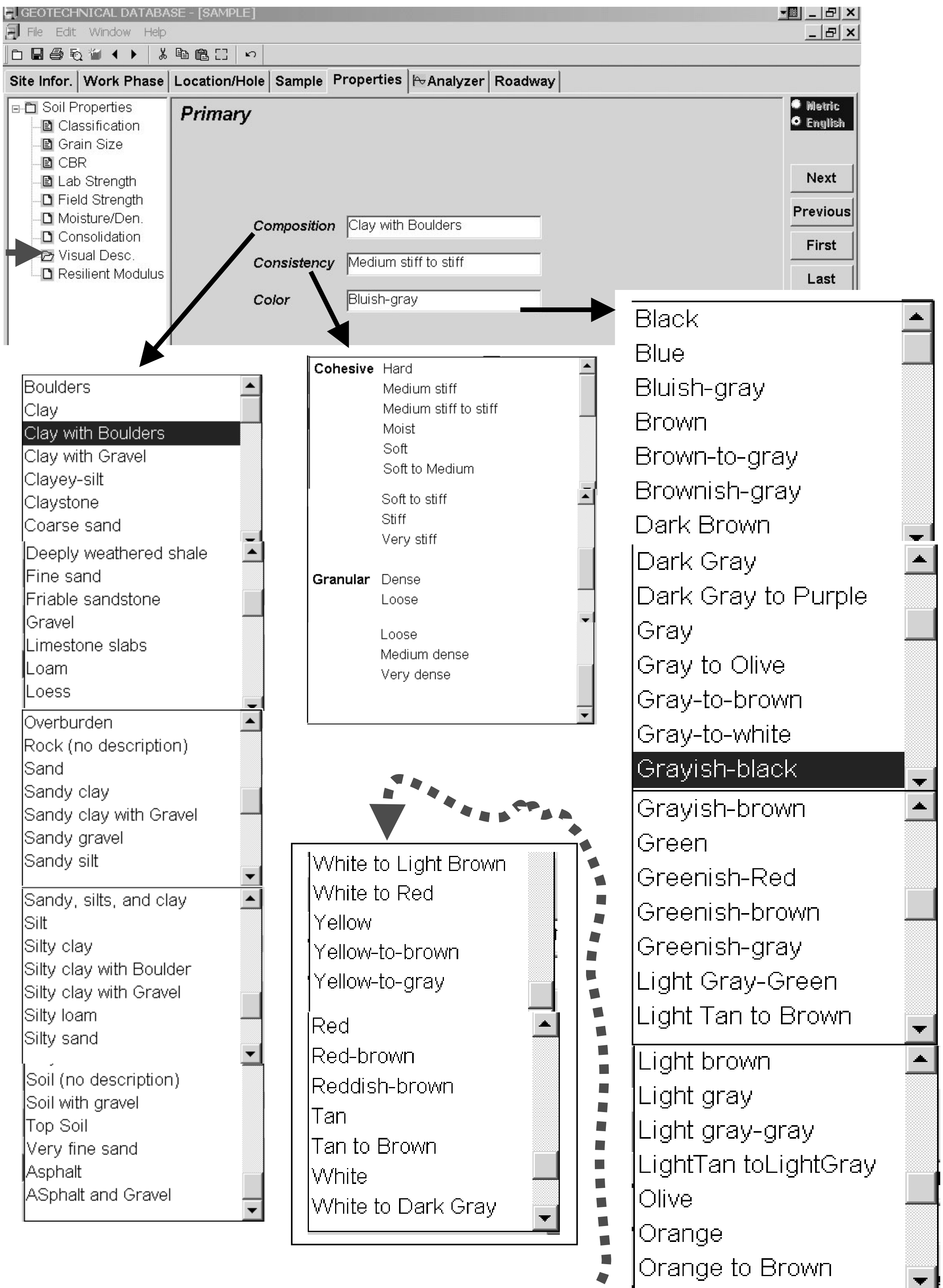

Figure 171. Visual Description GUI.

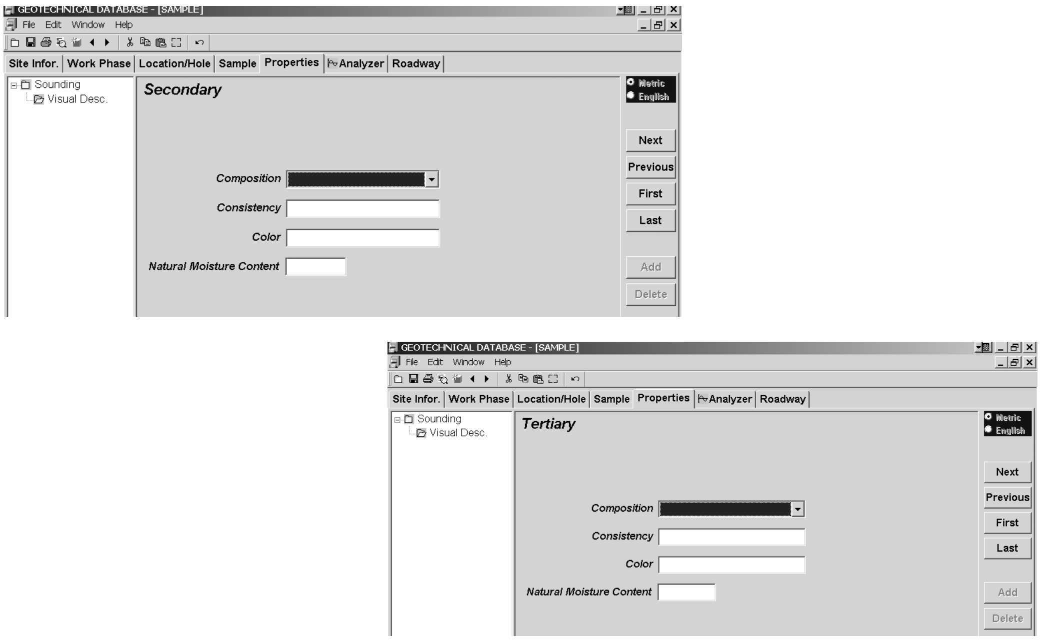

Figure 172. Graphical user interfaces for adding secondary and tertiary descriptions of soil samples.

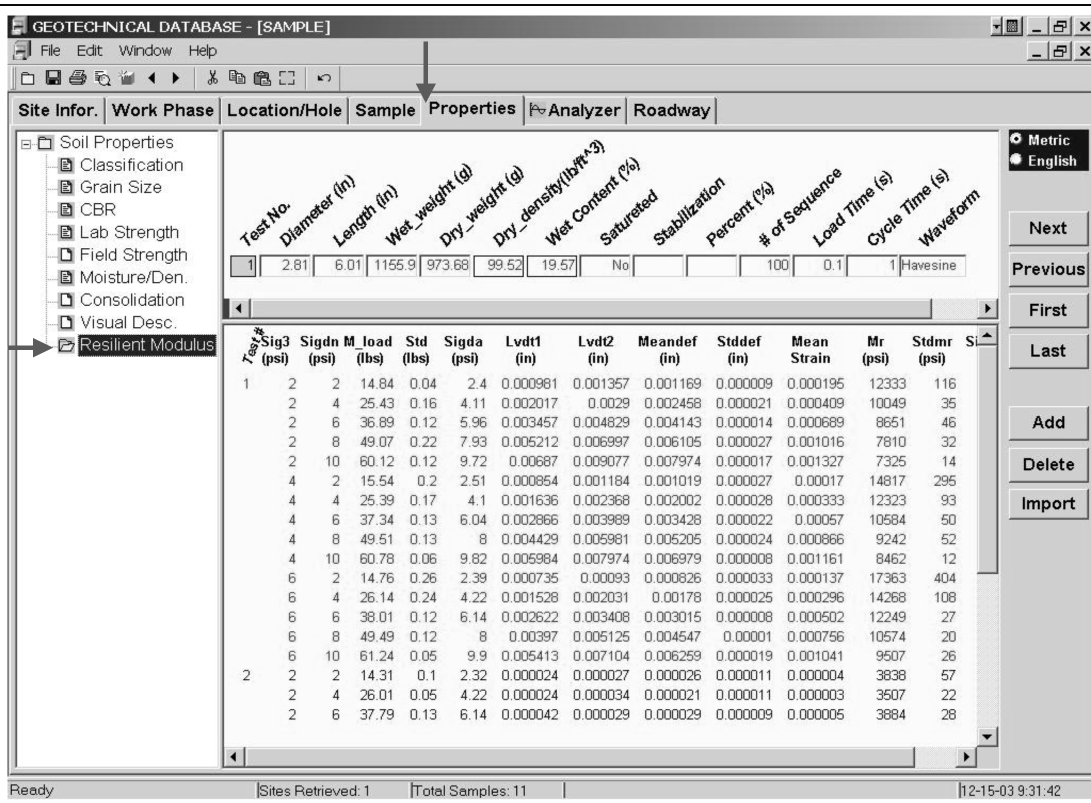

Figure 173. GUI for entering and storing resilient modulus data in the Kentucky Geotechnical Database.

Rock Properties

Defining Bedrock Samples

In borings where thin-walled tube samples or Standard Penetration Test samples are obtained through the overburden, the drilling process itself determines soil-sample intervals and frequency, and samples may be separated by intervals that have not been sampled (see Figure 152). Definition of bedrock samples, by contrast, are defined on the basis of changes in lithology, and may be of any length. An entire core could be a single sample, if it has a constant lithology throughout, or it could be divided into several samples of contrasting lithologies. As examples, a long core consisting entirely of shale, or entirely of limestone with minor shale partings, would be a single sample, even if it were 10 meters (30 feet) or more in length. Alternatively, if a sandstone several feet thick, were underlain by several feet of shale, which was in turn underlain by another sandstone, then they would be defined as three sequential samples of different thicknesses.

A rock sample can contain more than a single lithology. If, for example, the core is interbedded shale and limestone, and over the entire interval they occur in approximately the same proportions, then the core could be defined as a single sample consisting of interbedded shale and limestone. Whichever of these two lithologies is predominant, by volume, would be entered as the primary lithology, and the other as the secondary lithology. Obviously, the alternative, treating each thin shale bed and each thin limestone as separate samples, could give a hundred or more samples over a ten-foot core run, and would be highly impractical. It is possible, in a few cases, that a sample might also contain a third (or tertiary) type of lithology. One of the more common cases where this might occur is shale containing numerous thin beds of coarser-grained materials, some of which are sandstones, and others which are siltstone.

For each rock sample, there will always be a primary lithology. In nearly all cases, it will constitute more than 50 percent of the rock, by volume, though, at least theoretically, it could be lower when both secondary and tertiary lithologies are present. Often the primary lithology will make up 100 percent of the rock and there will be no secondary lithology. However, whenever the primary lithology is less than 100 percent, a secondary lithology, and perhaps a tertiary lithology as well, can be described. The relationship between primary and secondary lithologies is described in terms of the secondary (and tertiary) lithology occurring as interbeds, partings or laminae. Also the percentage of secondary lithology, within the sample as a whole, can be recorded. Interbeds have a thickness greater than 3 cm. Partings are thinner, varying from 0.3 cm to 3 cm while laminae are often paper thin, though they may be as thick as 0.3 cm.

Numerous, but very thin beds of contrasting lithology would necessarily need to be considered component parts of some thicker sample, as described for the interbedded shale and limestone unit discussed above. Conversely, thick beds of contrasting lithology are best considered to constitute separate samples. There are, however, no hard and fast rules for where to draw the line between them. How thick, or how numerous do these beds need to be in order to be considered separate samples? In practice, if a limestone, for example, contained two or three shales several inches thick, they would be entered as interbeds (a secondary lithology) occurring within the limestone sample. The depths at which they occur can even be recorded. If the thin beds of contrasting lithology exceed the maximum thickness for interbeds, considering them to be separate samples (primary lithologies for relatively thin samples rather than secondary lithologies—interbeds—within a larger sample) would probably be preferable.

Even for thinly interbedded lithologies, in which it would be inconceivable to enter each thin bed as a sample, it may be advantageous to create more than a single sample. As an example, consider again a sequence of interbedded shale and limestone. If the upper portion of this interval of interbedded lithologies is predominantly limestone, but shale gradually increases in abundance downward until lower portions of the interval are predominantly shale, two or more samples could be defined to reflect those changes.

In contrast with soil samples, rock samples must abut one another, covering the entire interval from top of rock to bottom of core. There are cases, either in limestones (which are water soluble, and may develop caves and other karstic features) or where coal may have been removed by underground mining, where voids may occur. Thin voids may be defined to occur within a sample, while thick voids may be considered to constitute a sample interval within itself (particularly if the material above the void is different than the material below the void).

For each lithology (primary, secondary, or tertiary), and for every sample (sequences of primary lithologies) lithologic modifiers may be used. Thus, the lithology selection may indicate that a rock sample is limestone. Lithologic modifiers, selected from a wide list of choices, might indicate that it is an argillaceous, cherty, oil-stained limestone. Further the color and grain/crystal size of each lithology can be shown.

Grain/Crystal Size in Rock

In analyzing soil, a determination of grain size distribution is very important, and the use of sieves to separate and directly measure grain size is applied for coarser grains, while settling rates allow measurement of the very fine grained portion. Because the grains composing sedimentary rock are commonly firmly cemented, methods applied to soil typically cannot be applied to rock. Still, a determination of grain size distribution of the sediments that accumulated as individual grains, and were later (under high heat and pressure) consolidated into rock, can provide valuable information relating to physical characteristics and how the rocks formed. Since grain size in rock cannot be measured directly, it is necessary to estimate grain size based visual appearance. This requires a great deal of expertise, and should be performed by geologists who have the necessary training. Of course, even under the best of circumstances, visual estimates of grain size are far less precise than direct measurement techniques used for soil. It is not possible, therefore, to present the results as a series of percentage values smaller than specified diameters, as is common for soils. Rather, a series of descriptive terms relating to grain size are applied. These are conglomeritic, coarse grained, medium grained, fine-grained, and very fine-grained.

Many rocks (referred to as detritus) formed from the weathering and redeposition of pre-existing rock masses, and they consist, consequently, of discrete particles and rock fragments. These are the one to which the grain size (particle size) terminology is applicable. There are other rocks, however, particularly many of the carbonates, which consist of crystals. The mode of formation in these rocks was totally different. Crystals of various minerals, such as calcium carbonate (limestone), magnesium carbonate (dolomite) and sulfates, such as halite and gypsum, precipitate out of supersaturated seawater. This requires a corresponding crystal size terminology. Rocks can consist entirely of grains, or entirely of crystals, but there are also rocks consisting of mixtures of crystals and grains. This is why there are two-grain size/crystal size fields on the rock samples properties screen.

As similar to the soil properties' tab, the rock "Properties" tab displays a screen with a menu along the left sidebar. It is a smaller list than the soils properties' listing and only contains three items: **Lithology, SDI/Jar Slake**, and **Other tests, as illustrated in** Figure 174 (additional rock tests can be added in the future when needed). **SDI/Jar Slake** tests are performed routinely on shale (and siltstone sometimes). Data entry (Figure 175) indicates depth of the sample, and the Jar Slake and SDI test results. As shown in Figure 176, data from the results of **LA Abrasion Test** and/or **Unconfined Compression** testing may be entered. However, these tests are rarely performed.

The principal characterization of rock samples, however, is not by lab testing, but rather by visual description. These observations, by experienced geologists, are entered on the **Lithology Data Entry GUI,** Figure 174**.** Clicking on the data entry box entitled **Lithology** produces a drop-down list of common (limestone, siltstone, sandstone, shale, dolomite, coal) and less common rock types. Lithology modifiers have also been include in a drop box in other boxes, up to two colors can be entered. A complete listing of color choices in the drop down box is shown in Figure 171.

Grain size, as applied to rock, is quite different than applied to soils. In analyzing soil, the use of sieves to separate and directly measure grain size is applied for coarser grains, while settling rates allow measurement of the very fine grained portion. Because the grains composing sedimentary rock are commonly firmly cemented, methods applied to soil typically cannot be applied to rock. Still, a determination of grain size distribution of the sediments that accumulated as individual grains, and were later (under high heat and pressure) consolidated into rock, can provide valuable information relating to how the rocks formed and what their physical characteristics are. Since grain size in rock cannot be measured directly, it is necessary to estimate grain size based upon visual appearance. This requires a great deal of expertise, and should be performed by geologists who have the necessary training. Of course, even under the best of circumstances, visual estimates of grain size are far less precise than direct measurement techniques used for soil. It is not possible, therefore, to present the results as a series of percentage values smaller than specified diameters, as is common for soils. Rather, a series of descriptive terms relating to grain size are applied. These are conglomeritic, coarse grained, medium grained, fine -rained, and very fine-grained. A complete listing is shown in figure 174.

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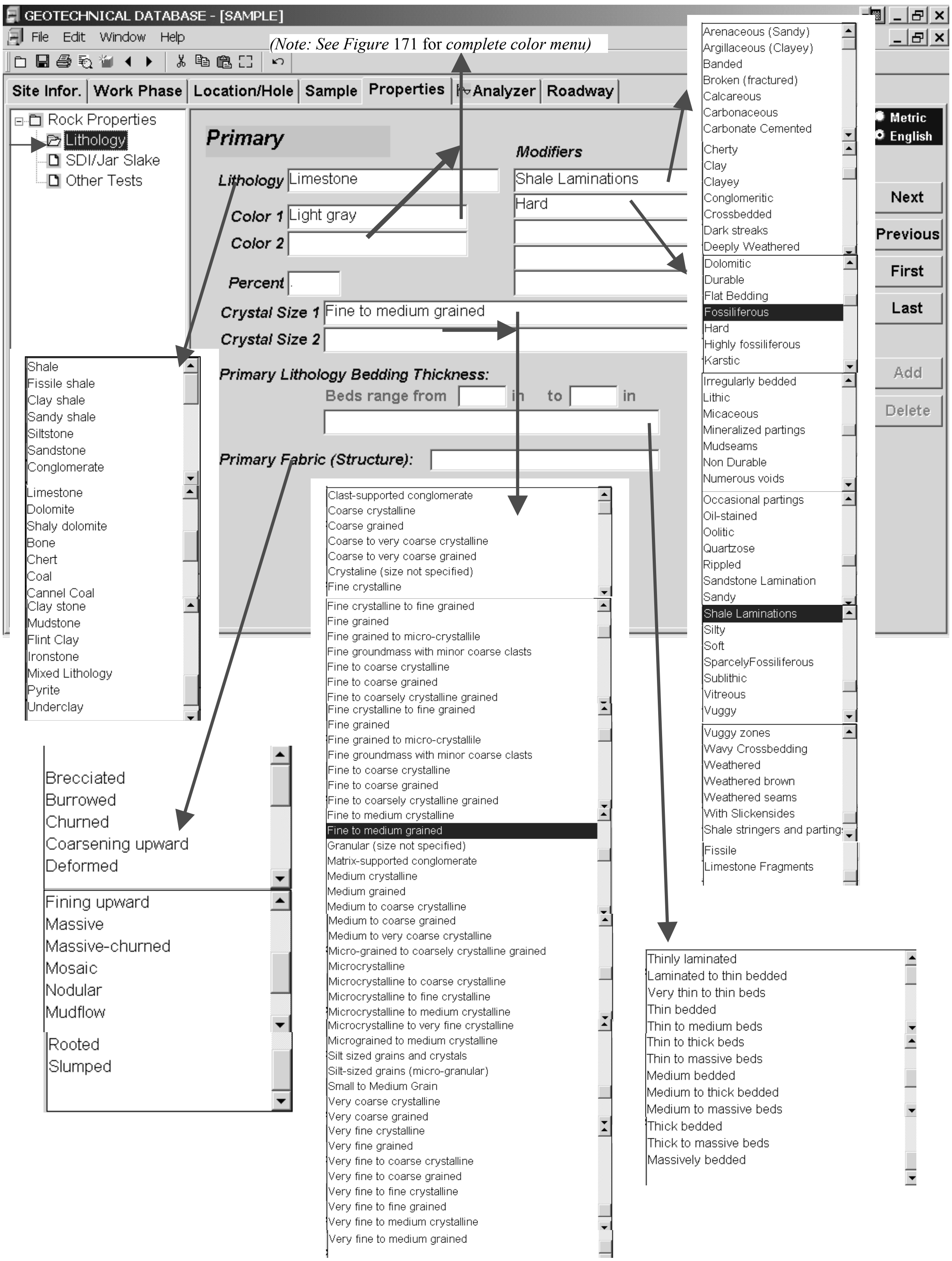


Figure 174. Graphical user interface for describing primary rock properties of rock samples.

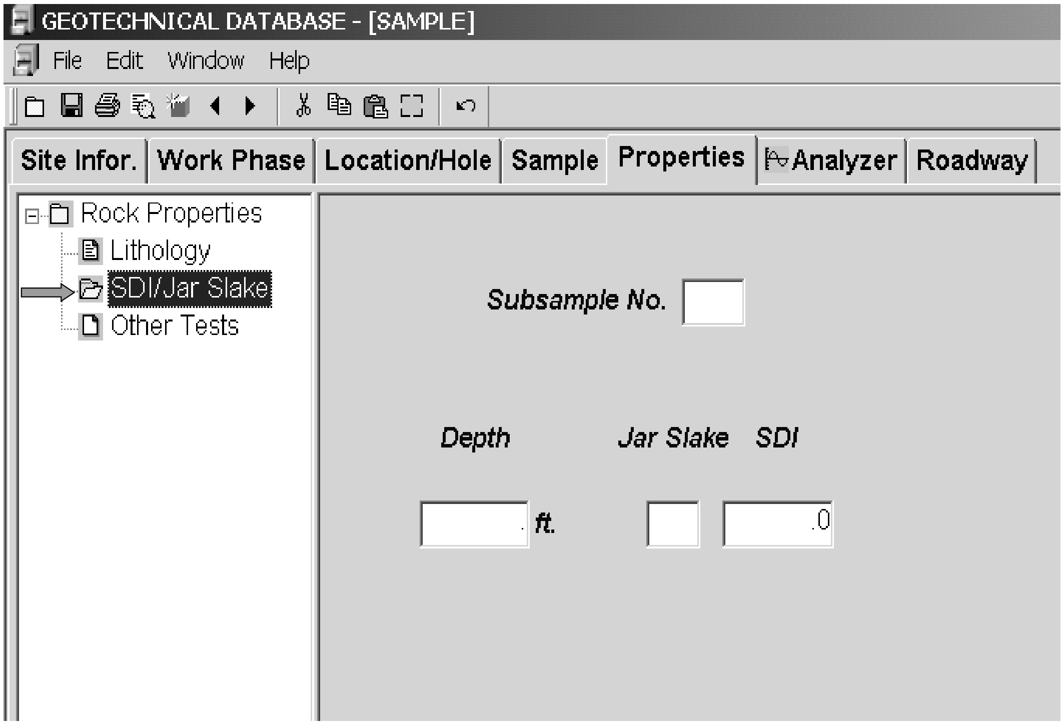


Figure 175. Graphical user interface for entering Slake Durability Index (SDI) and Jar Slake data.

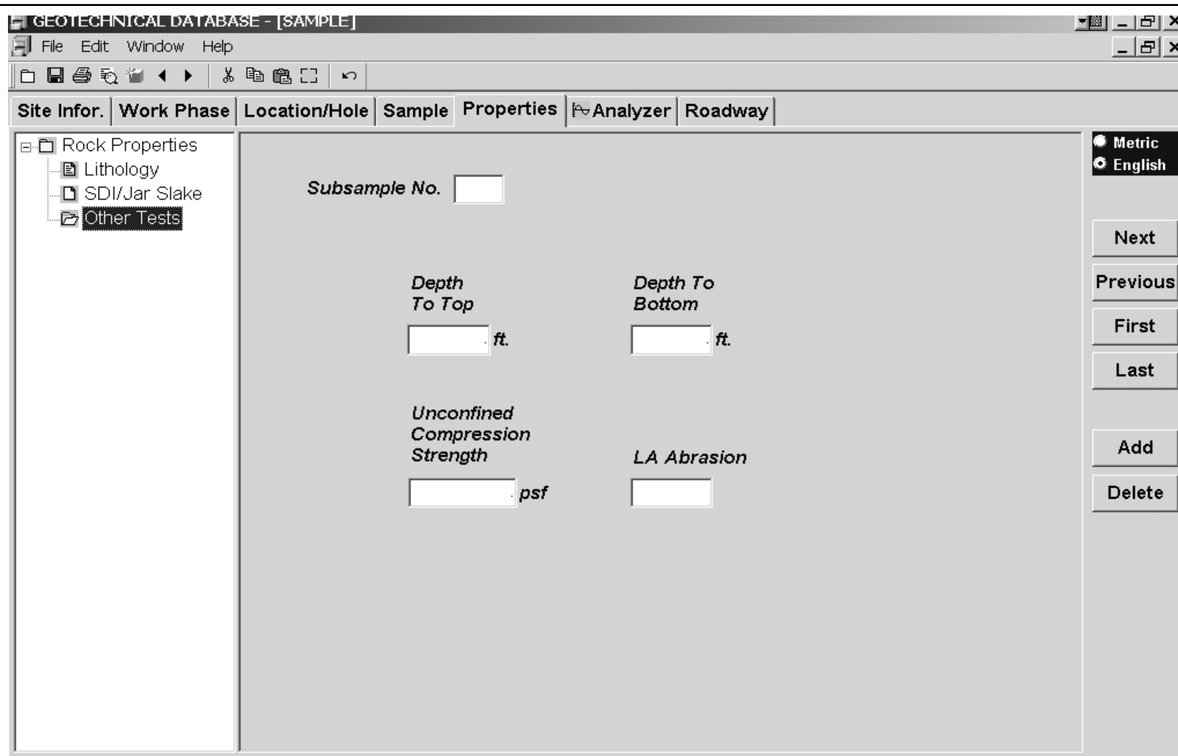
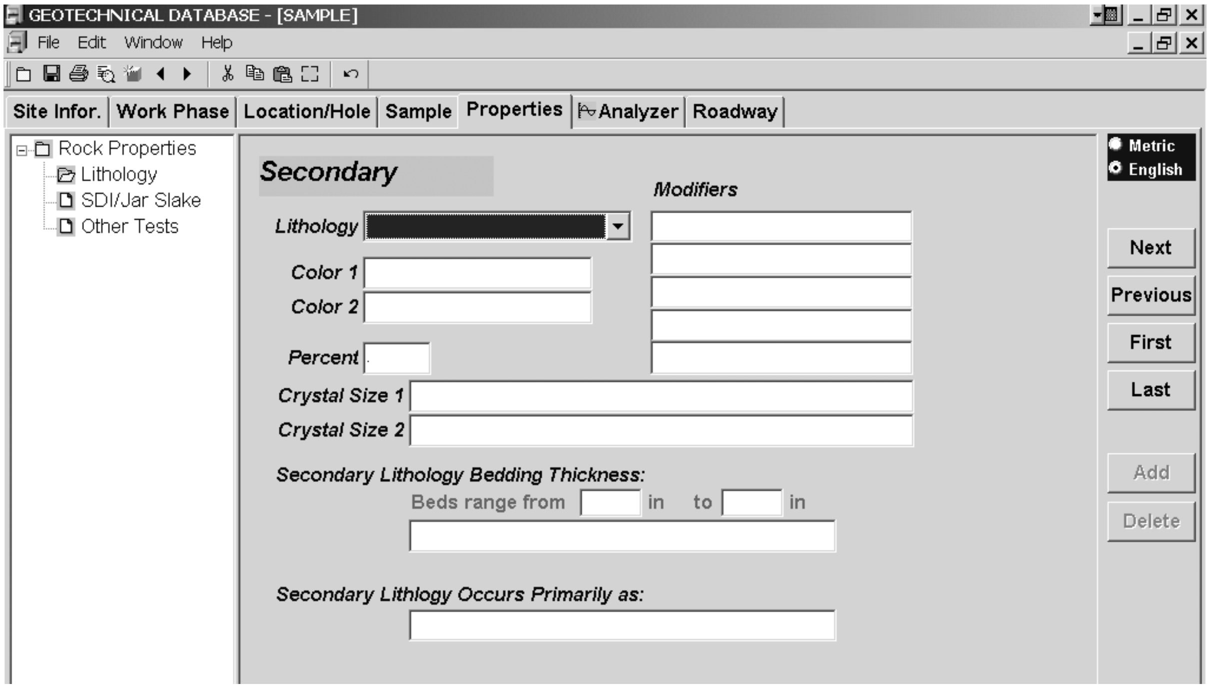


Figure 176. Graphical user interface for entering unconfined compressive strength and LA abrasion data.



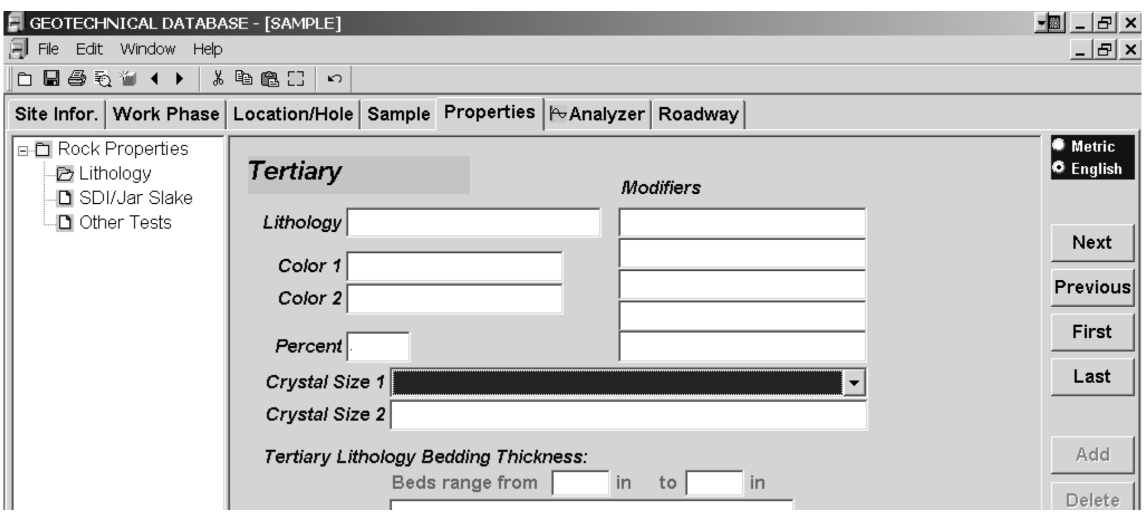


Figure 177. Graphical user interfaces for describing secondary and tertiary rock properties of rock samples.

SECONDARY COMPONENTS

Secondary components of the geotechnical database include a series of statistical and data regression analyzers, engineering software applications, and visual features, which include electronic photographs and map displays. These components have been either been programmed by the authors or other software has been embedded into the database. Another planned secondary feature will allow the storage and reduction of field geotechnical instrumentation data. The secondary components are described in more detail below.

Statistical and Regression Analyzers

To avoid the inconvenience of having to download data to other programs and perform some type of analysis, the database contains a collection of statistical and regression analyzers developed by the authors. These software programs can be used while "on line " with the database. This feature allows the refining of selected raw data in the database for the purposes of supplying reliable data for preliminary, or in some cases, final engineering designs and for obtaining correlations among different types of data. Functions of this portion of the database analysis are to map out the distributions of all type of data and construct their internal correlation. The results can be presented in both tabular and graphical format.

Currently, data in the Geotechnical Database includes landslide, rock fall, and soil and rock engineering and geologic information. First, programs in the analysis section will present the distribution of those data across the state or any selected and particular location. For instance, data for a highway district, selected county, quadrangle, or other unit area, can be retrieved and analyzed, as shown in Figure 178. In this example, the user is interested in CBR values of soils in a selected highway district in Kentucky. All CBR values that exist in the database for the selected county are retrieved and displayed as a function of percentile test value. For a preliminary pavement design analysis, the user might select the CBR at the 85th percentile test value (Yoder 1969, 1975). Other situations exist where this approach could be useful. For instance, the approach could be used when very small design jobs arise, such as a new ramp off a roadway and it is not very economical to obtain samples for CBR testing. The CBR value at a selected percentile value could be used for designing pavement thickness of the ramp. Analyzers have also been included in the program for examining the distribution of different soil and rock types, or classes, of a selected area, as well as other engineering properties. Distributions (and statistics) by soil class—AASHTO Soil classifications and Unified Soil Classifications—can be displayed for any selected area, or highway corridor. Knowledge of predominant soil classifications of an area is invaluable for assessing general construction problems that may arise. For example, if the predominant soil classification is known, then the designer, and contractor, can select the most suitable compaction equipment for that area. For preliminary construction cost estimation, this is invaluable.

Secondly, methods for analyzing and disclosing how different types of data are related are included. For example, analysis can present how rock falls and landslides relate to the type of soil and rock, as well as their properties. Stored regression analyzers yield correlation, or "best data fit," between different soil parameters. Finally, the large amount of stored data in the Kentucky Geotechnical Database is very useful for research purposes.

Conventional models of stress-strain, consolidation, and modulus-stress will be available for performing data analysis. When choosing any model for soils in a particular location,

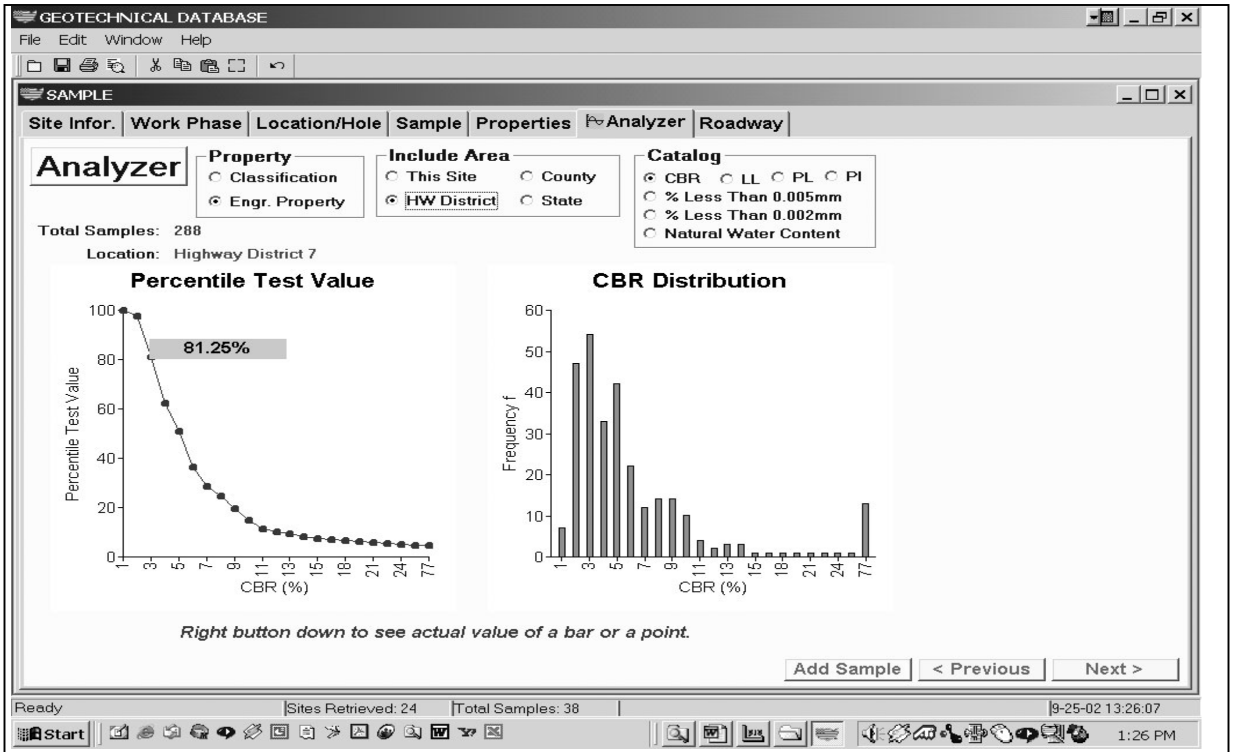
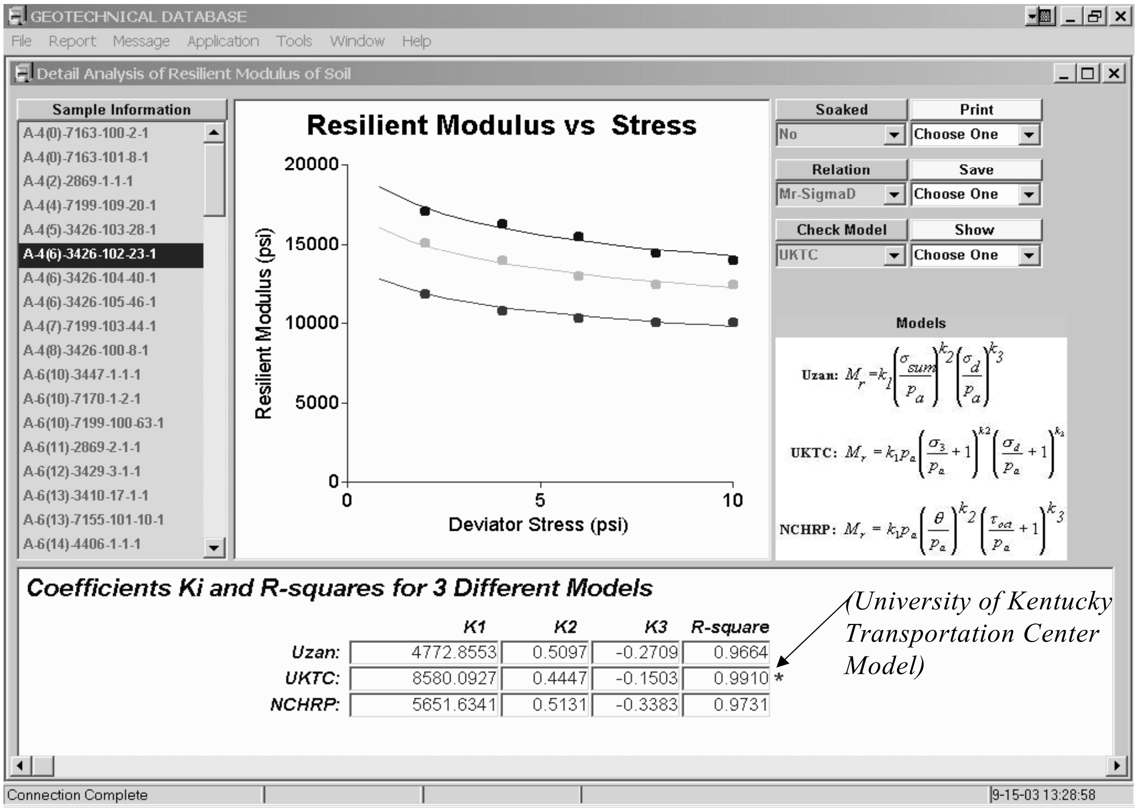


Figure 178. Use of statistical analyzers to determine the relationship between percentile test values and laboratory CBR values of Highway Route 7 in Kentucky.

programmed procedures of the analysis section will show the coefficients for the model selected. For instance, models for predicting the resilient modulus (AASHTO 1992, 1993; SHRP 1989) of various types of soils and aggregates have been programmed into the database. When the AASHTO soil classification of a soil is known, the resilient modulus can be determined by using the GUI screen illustrated in Figure 179. Various resilient modulus models have been programmed into the database. Included in the models is a model suggested by Ni et al (2002) and Hopkins et al (2002). However, models suggested by Uzan (1985) and NHCRP (2002) have been included. The model proposed by the authors includes two independent variables, the confining stress, F_3, and the deviator stress, F_d, and a dependent variable, the resilient modulus, M_r. A view of the regression plane, based on the authors' model, for a typical Kentucky soil is illustrated in Figure 180. All model analyses are based on multiple regression analysis. The analyses are performed automatically when the user clicks on a soil type in the left-hand portion of Figure 179.

Engineering Applications

Applications in the Geotechnical Database are a collection of computer programs for performing engineering designs of geotechnical structures and for obtaining selected designs in geotechnical engineering. Routine designs such as pavement, foundation, retaining wall, and slope stability are programmed into the Geotechnical Database. In some instances, the programmed computer procedures strictly follow published procedures, standards, regulations, or mathematical algorithms. In other cases, the authors have developed customized computer programs. Examples of programmed procedures and graphical user interfaces include the 1993



	K1	K2	K3	R-square
Uzan:	4772.8553	0.5097	-0.2709	0.9664
UKTC:	8580.0927	0.4447	-0.1503	0.9910 *
NCHRP:	5651.6341	0.5131	-0.3383	0.9731

Figure 179. Method of selecting coefficients of various resilient modulus models.

AASHTO[1] and 1981 Kentucky[1] flexible pavement design procedures, as shown in Figures 181 and 182, respectively. By storing these programs in the database, on-line analysis and designs can be generated. This is very useful in performing preliminary, as well as final designs. The graphical user interface of the computer program illustrated in Figure 183 includes a cost analyzer (Figure 182), which can be used to examine and compare the costs of different pavement design sections composed of pavement layers of different thickness.

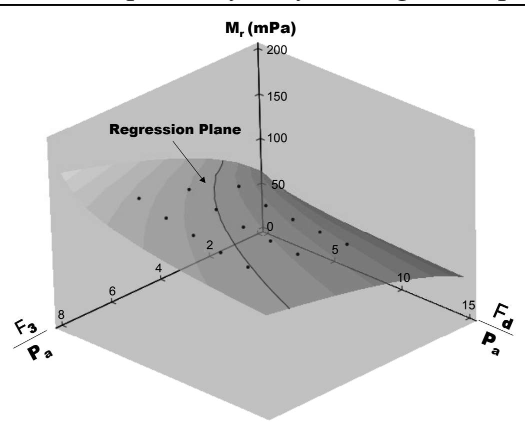


Figure 180. Least square multiple regression plane --after Ni et al (2002) and Hopkins et al (2002).

Another program in the applications' section of the database can be used to analyze and design retaining walls constructed of driven, or drilled-in railroad steel rails, as illustrated in Figures 184 and 185, and back filled with soil, or lightweight materials. The notion of developing this program for the database occurred after analyzing some 1400 landslides on Kentucky's highways and

[1] Computer programs developed by Charlie Sun, Bixian Ni, and Tommy C. Hopkins of the University of Kentucky Transportation Center, Geotechnology Section in 2000.

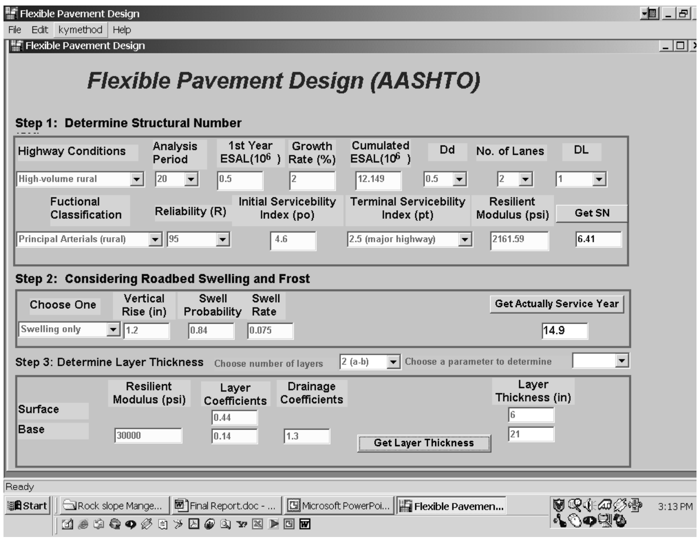


Figure 181. GUI data entry screen for designing the thickness of an asphalt pavement using the AASHTO Design Procedure (1993 Guide).

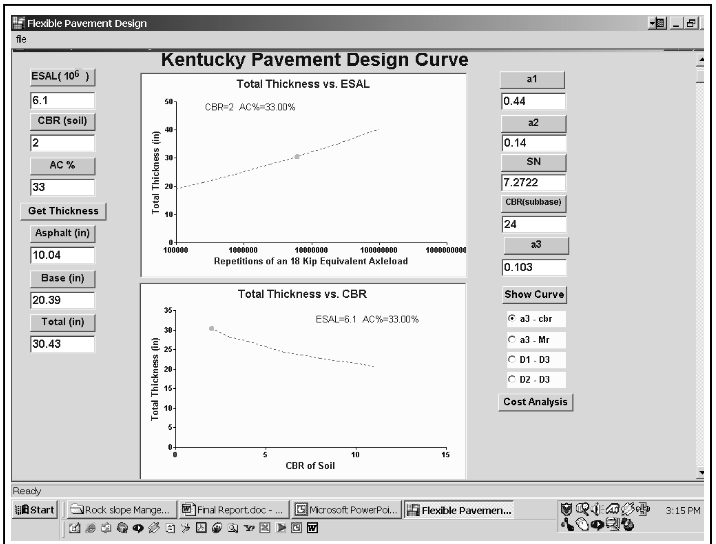


Figure 182. GUI data entry screen for designing the thickness of an asphalt pavement using the 1981 Kentucky Design Procedure.

finding that in at least twenty percent of those cases retaining walls constructed of railroad steel rails had been driven, or fixed into bedrock, in an attempt to halt highway landslide movement. The interactive, data entry GUI screen for determining the factor of safety of a rail piling retaining structure is illustrated in Figure 186. Unit weight of any material may be inserted by merely entering its numerical value. Lightweight materials, such as geofoam, "red dog", lightweight aggregates, cinders from coal-fired, power plants may be used in the program. Algorithms used in the program were derived and developed to account for the use of lightweight backfill materials.

In many cases, railroad rails used as pile retaining structures have not worked. By making a design program available, highway district personnel can quickly develop a proper design for use of this landslide repair technique. In many observed failures, the technique did not work when the backfill was greater than about twenty feet, when the steel rails were not anchored into bedrock, or the soil backfill flowed through the rails. When any of those conditions prevail, state geotechnical engineers do not recommend using steel rail retaining walls. However, the database design program now identifies additional cases where this correction method, which is favored by many district operations (maintenance) offices, might be successful. By using lightweight backfill, and particularly where the rail piling can be anchored into bedrock, slides approaching heights of 18-20 feet, or slightly greater, could be repaired. The amount of lightweight backfill required to achieve a safe design (or a selected factor of safety) is determined from the computer program. District personnel and geotechnical staff of the central office can review the solution simultaneously.

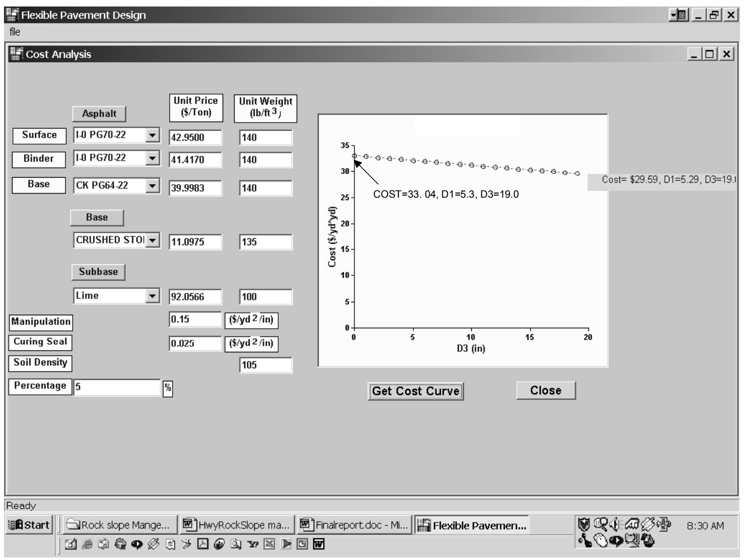


Figure 183. GUI screen for performing cost analyses of flexible pavements with and without chemical stabilization.

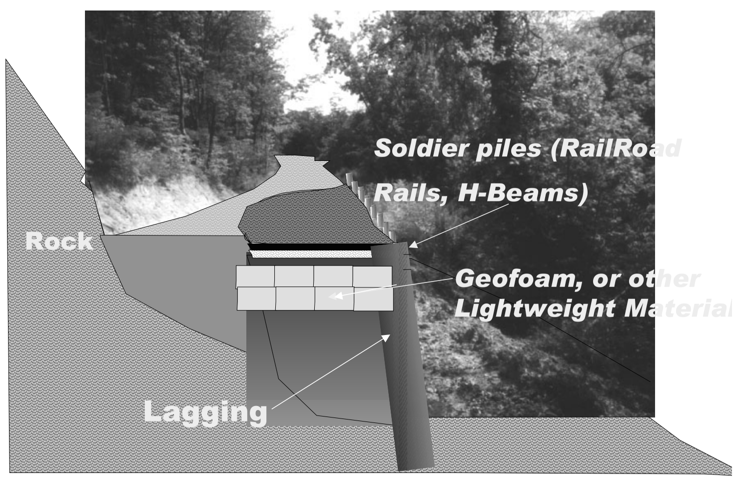


Figure 184. Repairing small highway landslides (20 ft or less) using railroad steel rails (anchored into bedrock) to form a retaining structure and lightweight backfill.

Figure 185. Installation in 1998 of railroad rails to form a wall to restrain a hillside landslide. Concrete panels were installed behind the anchored rails. The wall was backfilled with lightweight backfill, which consisted of cinders and shredded rubber tires (After Hopkins, Beckham, Sun, and Butcher 2002).

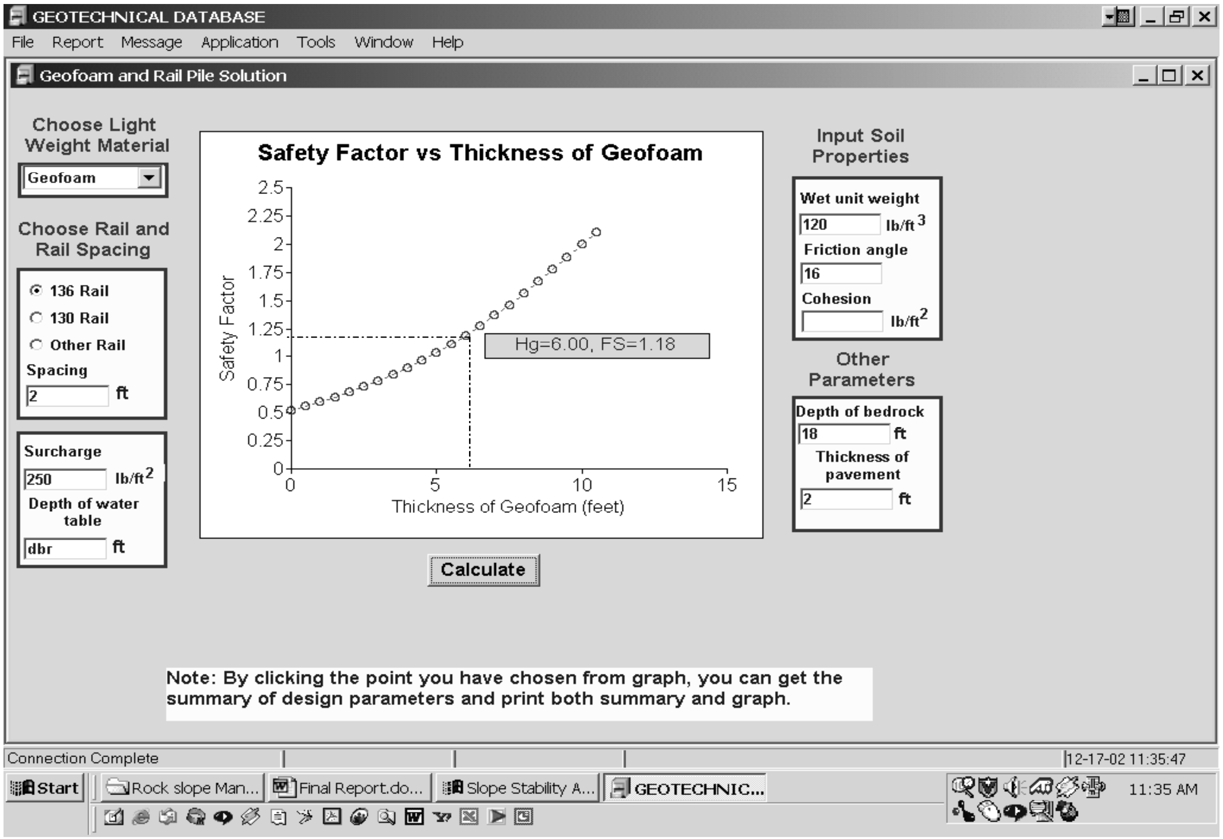


Figure 186. GUI data entry screen for designing a railroad rail retaining structure backfilled with lightweight material and regular fill material.

The database programs also provide reports and drawings for all needs of routine sign in the geotechnical field. This will greatly increase the design efficiency, reduce errors, and supply uniformity. Furthermore, geotechnical staff of the central office can immediately review designs by district personnel and review comments can be transmitted through an internal message exchange channel setup inside the geotechnical database. This is particularly useful when remedial measures may be needed to handle some emergency case, such as a highway landslide. The situation in the field can be sent to the database by digital photographs and cross sections. The state geotechnical and geologist staff can examine and evaluate the situation immediately. Properties of soil and rock in the field can be obtained from the database and used, when available, in the built-in applications to forge a “ real-time” decision on the best approach to solving the emergency situation.

Other computer programs for performing routine analysis and design are continually being added to the applications’ section of the database. For example, a windows-based computer program for analyzing reinforced and unreinforced earth structures (Slepak and Hopkins 1993, 1995a, and 1995b), such as highway slopes and walls has been included. Graphical user interface screens for performing these types of analyses are shown in Figure 187 and 188. Data in Figure 188 shows the stability analyses of a slope using a noncircular shear surface.

This advanced software can also be used to perform bearing capacity analysis, or stability analysis, of unreinforced flexible asphalt pavements, or flexible pavements reinforced with geotextiles (Hopkins 1986; Hopkins 1991; Hopkins et al 2002; Hopkins 1994a, b; Slepak et al

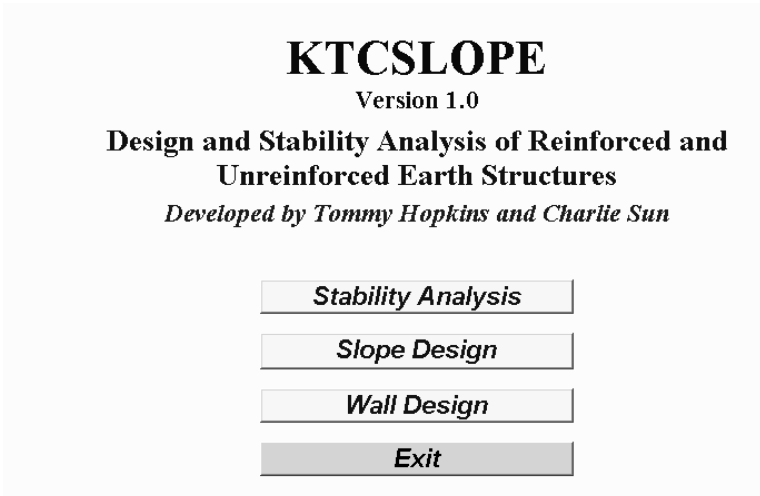


Figure 187. GUI screen (Min Menu) for analyzing the stability of unreinforced and reinforced slopes, walls, and flexible asphalt pavements.

1995b; Hopkins et al 2002). Bearing capacity analysis of footings resting on multilayered soils may be performed using the advanced equilibrium models. Examples of graphical user interfaces for entering data and performing this type of analysis is illustrated in Figures 189 and 190. In Figure 189, the bearing capacity of an unreinforced flexible pavement resting on a soft soil subgrade is shown. The factor of safety against failure was about 1.00. Using geotextile reinforcement, the factor of safety can be increased to about 1.30 (Figure 190).

Software to be included in the database (under development) includes a windows-based computer program for analyzing and simulating rock fall at a selected rock slope site. Other engineering and management software will be added in the future.

Visual Features –Electronic Photographs and Map displays

This visual function is an extremely important feature for users. Colored photographs of highway sites, such as, landslide and rock slopes, can provide valuable visual information. Features can be viewed in photographs that are not necessarily evident in narrative descriptions, or if they could be described, the descriptions would have to be lengthy. Technically, handling visual data in a database is much more difficult than handling text data because visual data is much greater in size than text data. Because of the size issue, data transmitting speed, processing time, and storage space requirements are primary factors that must be considered. In the early development of the

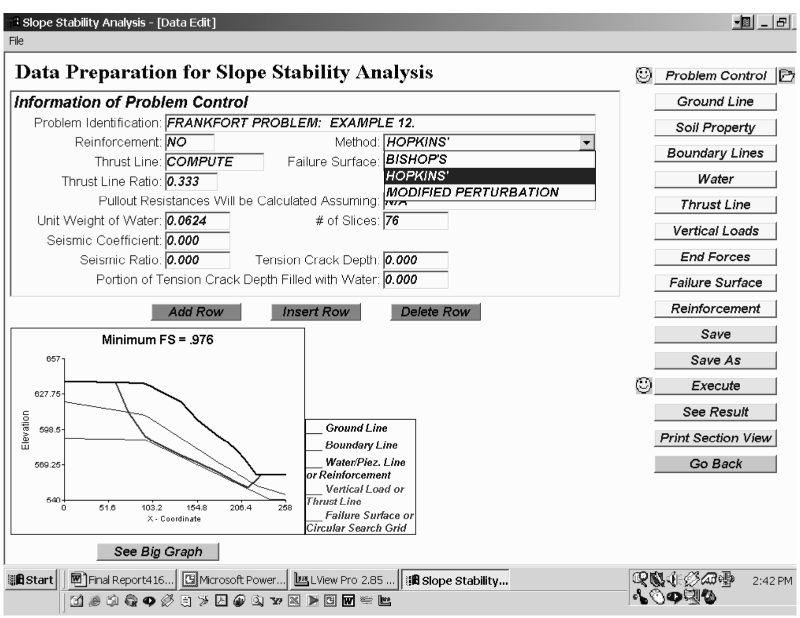


Figure 188. Graphical user interface for analyzing unreinforced and reinforced earth slopes and walls

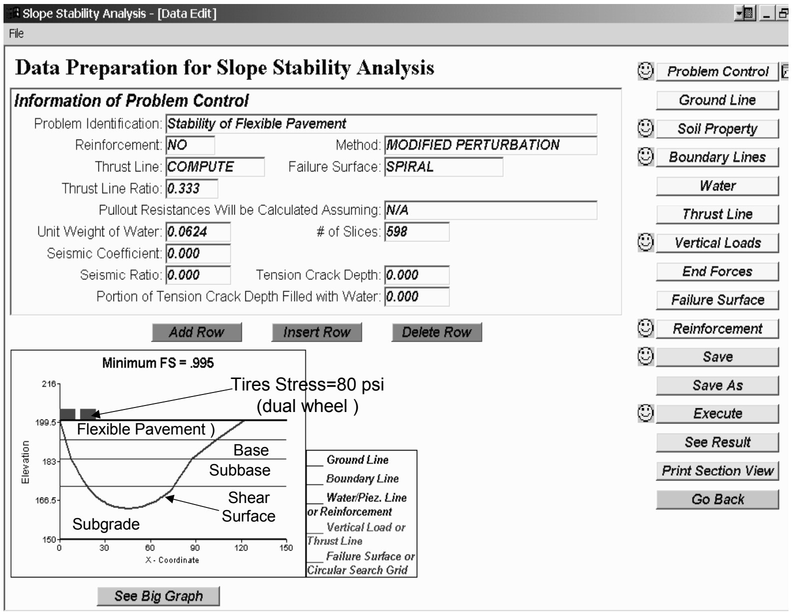


Figure 189. Data entry GUI screen for performing bearing capacity analysis involving flexible pavement multiple layers (unreinforced).

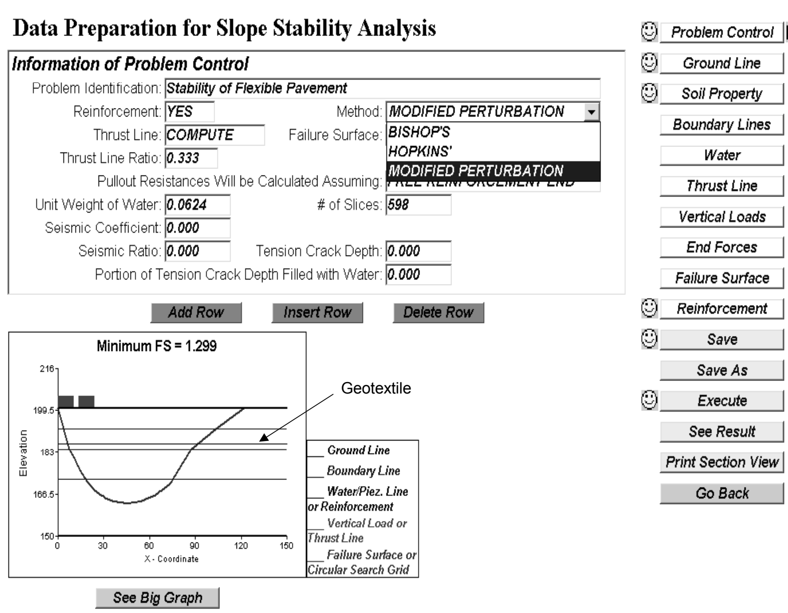


Figure 190. Data entry GUI screen for performing bearing capacity analysis of flexible pavement reinforced with geotextiles.

database, photographs were stored as a Bitmap file (a product of Microsoft). The file size was 2.5 Megabytes (Mb). By saving the electronic file photographs in a JPEG format, the file size was reduced to 44 Kilobytes (Kb) and reduced space requirements. Currently, there are about 5,200 photographs (of landslide and rock slope sites) in the Kentucky Geotechnical database. An example of a series of photographs of an example rock slope was shown previously in Figure 77. By double clicking the computer mouse, an enlarged view of one of the small photographs stored in the database is obtained, as shown previously in Figure 78.

Other visual images embedded in the database include 120 county maps showing major highway routes of Kentucky. By using MapObject® software, processing speed for displaying maps is extremely fast, and maps can be displayed almost instantly. Moreover, locations and distributions of hazardous rock slope and landslides can be displayed on roadways of the embedded maps, since latitude and longitude of each site was obtained using GPS equipment. A zoom feature is included for enlarging viewing areas for details. An example of those features was shown previously in Figure 80. When a rock slope or landslide location on the map is clicked, the user is switched to detailed information, and visa versa. A limited number of digitized geological quadrangles have been embedded in the database (the Kentucky Geological Survey has a program to digitize all geological quadrangles of Kentucky and only a few of those maps are currently available).

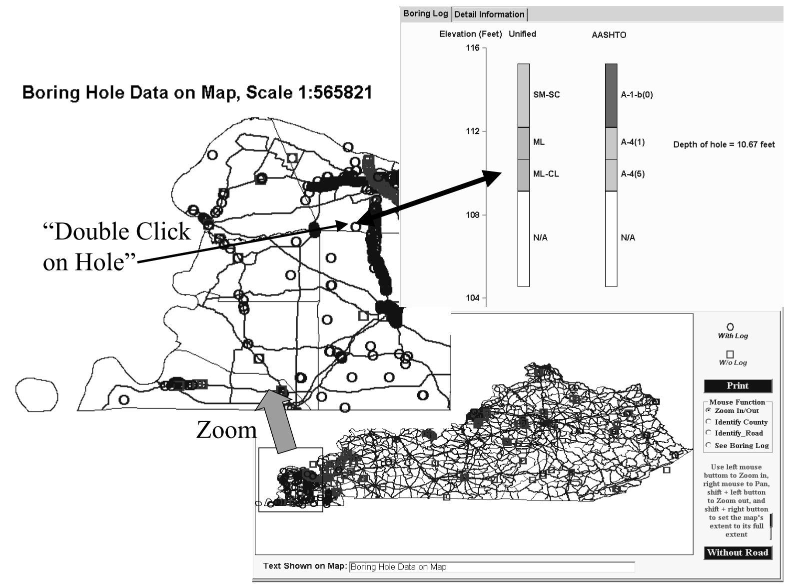


Figure 191. Illustrations of plotted hole locations on a map of Kentucky, the zoom feature, and an example soil profile.

Locations of holes can be displayed on the embedded roadway maps almost instantly. The user can click on a hole location displayed on the map and a plot of the boring showing soil classification (as function of depth or elevation) is graphical displayed, as illustrated in Figure 191. Merely pointing and clicking the mouse can identify any roadway on the roadway map.

Security

In developing a database involving many users, and users playing different roles in supplying different portions of the data, database security is a major issue that must be addressed because stored data can be erased, or corrupted, unknowingly by users who are not familiar with the database protocol. To maximize the security of the Kentucky Geotechnical Database, three types of systems are used. The first is called the *registered user system*. The user must be approved by the Database Administrator and registered in the database. When the user logs on, Figure 192, the system automatically checks the user's identification and password. Only after the user identification and password matches the stored values is the user allowed the privilege of logging on and connecting to the database.

The second security system is called a *role-based system*. Users are divided and assigned to different groups based upon their roles in the Geotechncial Database group. Hence, a hierarchy of users is established. A table of users is maintained, as shown in figure 192. Support tables may be accesses from the "Attributes, Borings, and Samples" graphical user interface. The Titles of users in the group include Database Administrator (DBA), Officer, Data Entry, Regional Data Entry, Special, and Viewer. The DBA has full operational functions including read, insert, update, and delete. The Officer has a full operational function but cannot delete. Data Entry Users have full (add and delete) operational functions statewide. Regional Data Entry Users have full operational functions only for sites within their own district. The Special administrator has full powers to change anything the database. The Viewer is only allowed to read and print stored data.

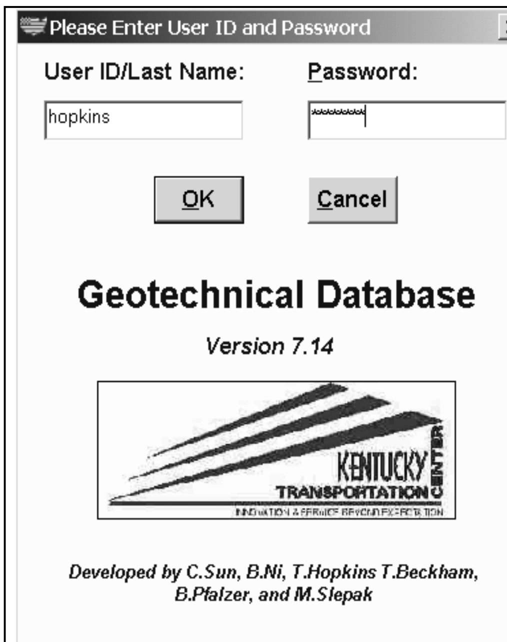


Figure 192. GUI security screen for entering user's ID and password.

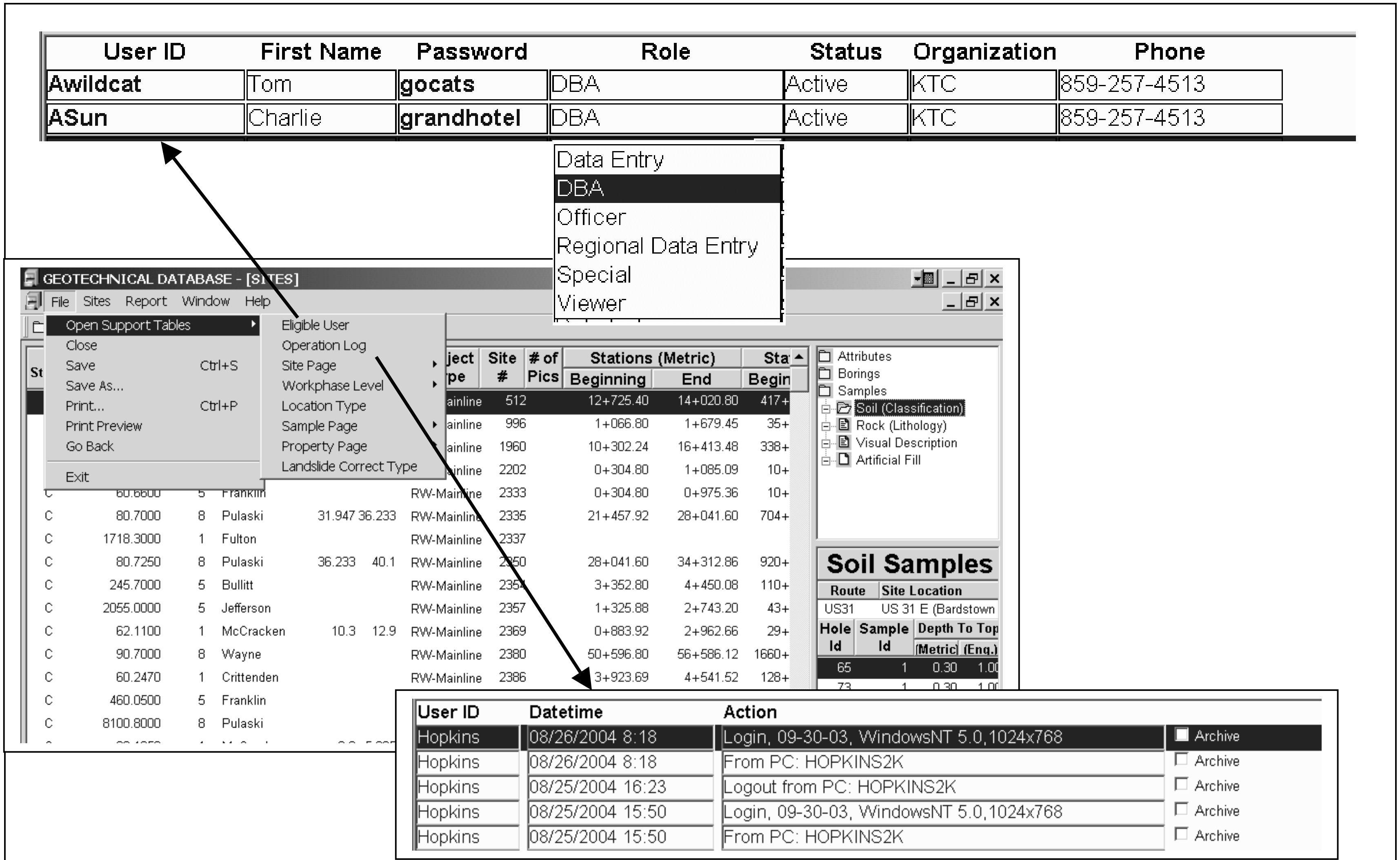


Figure 193. Enhancing database security by maintaining an eligible user's table and operational log of users.

Finally, the third security system is a recording system, as illustrated in Figure 193. Internally, the database application records and writes each operation performed by the user, such as logon and logoff times, insert, update, and delete operations. Reviewing this record, the DBA can not only trace the user's operations on the data, but also determine who is interested in the database. This feature is very valuable in tracking and locating errors in data entry, and for implementation of the database.

Engineering Units

Selection of the units for displaying engineering data is a major issue in developing an engineering database. Different users have different backgrounds and schooling, and they may find it difficult to use an unfamiliar unit system. The unit issue is also most important when different types of analyses are performed. If data were stored in the database in a mixture of both metric and English units, the user would have trouble in analyzing the data. For these reasons, all engineering data are stored in one system of units. In this case, the data is stored in Metric units. However, in the local interface, the user can switch from Metric units to English and vice versa, as desired. This feature applies to both data entry and data retrieval.

Strategies for Data Entry, Retrieval, and Map/Graphical Displays

Data Entry

To facilitate data entry, a series of graphical user interfaces (project type) were developed, as shown previously in examples in Figures 34, 107, and 137 through 143. As noted previously, the main GUI screens contain a series of tabs near the top of the screen. Regarding rock slopes (Figure 34), the tabs are labeled site information, total score, traffic, geometry, geologic character, climate/rock fall history, report, and picture. A graphical user interface screen for a rock slope site (see Figure 27) contains boxes for entering such information as route number, project type, milepost markers, latitude and longitude and other site information. Values--state plane coordinates--in NAD 27 and NAD 84--are automatically calculated from stored algorithms as well as latitude and longitude. By clicking a selected tab, a data-entry GUI screen, or report, or picture(s) appears. Tabs for landslides (Figure 107) include site information, attributes and impact, history (and severity rating), maintenance costs (and activities), design and costs. When any one of these tabs is clicked, a GUI screen appears. For example, the GUI screen for attributes includes boxes for entering such information as contributing factors, utilities damaged and not damaged, average annual daily traffic and adjacent properties. Whenever possible, the "drop-down" list feature is used so the amount of typing is minimized.

Other project type graphical user interfaces (Figures 137 through 143) contain series of tabs. Some tabs are labeled site information, work phase, location/hole, sample, (engineering) properties, and (statistical) analyzer. When any one of those tabs is clicked, a data entry GUI screen appears. Work performed at different times at the same site is identified by work phases. Some types of information include hole number, sample type and number, elevations, work phase number, hole depth, depth to bedrock, water depth in hole, surface elevations, location accuracy of latitude and longitude, station number and offset, and USGS quadrangle number where the hole is located. Graphical user interfaces pertaining to boring/locations level were illustrated in Figures 146 through 151. Graphical user interfaces dealing with sample types and sampling methods were illustrated in Figures 153 through 177.

When soil samples is clicked (Figure 154), a GUI screen is obtained, which displays a menu of soil properties, such as classification, grain size, CBR, laboratory strengths (different types of tests), field strengths (different types of tests), moisture-density tests, consolidation, visual manual descriptions, and resilient modulus test values. Clicking any item on the menu brings up a GUI screen for entering soils data for that test selected.

When an item on rock lithology in Figure 155 is clicked, a rock menu of tests is displayed. Clicking any item on the rock menu brings up a GUI screen for entering data pertaining to that test. These screens contain such data entry boxes for hole number, type of boring, depth of bedrock, depth to the RDZ, station number and offset, sample type and number, elevations, and sampling method.

Data Retrieval Search Schemes

Different types of data retrieval schemes have been incorporated into the database, as shown in the main menu, Figure 194. Data may be retrieved using either a "**Simple Search**" or a "**Comprehensive Search.**"

When the simple search is executed, the GUI screen in Figure 195 appears. Full views of drop down menus are shown in this Figure. The different types of sites, or project types, such as landslides, or rock slopes, and their attributes, located in a selected county or geologic quadrangle maybe retrieved. Other project types include RW (roadway)-Mainline, Side roads, Interchanges, Bridge Approaches, Bridges, Building, Culvert, Dam, drainage, Pavement, SCS (Soil Conservation Service, USDA), Utilities, Planning Studies, and Wall. Walls are divided as to type and include MSE (mechanically stabilized earth wall), Gravity, Semigravity, Cantilever,

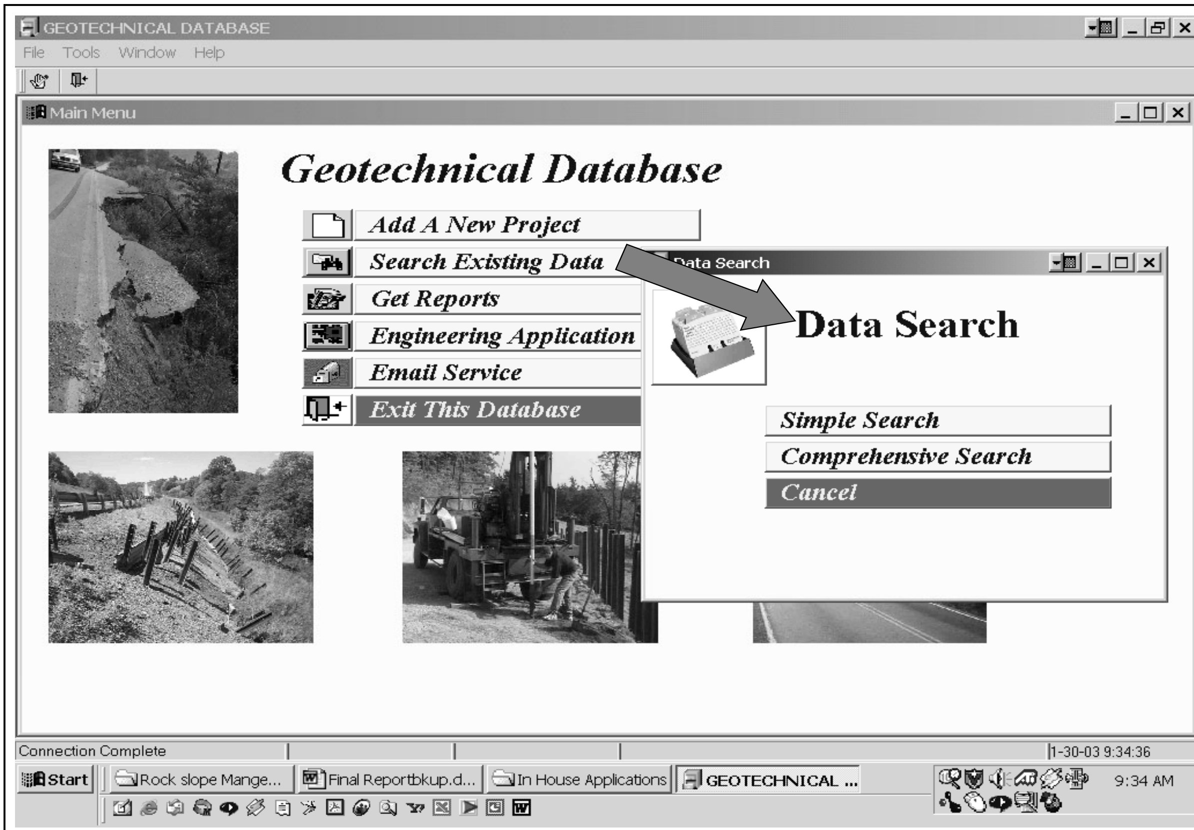


Figure 194. Types of data searches.

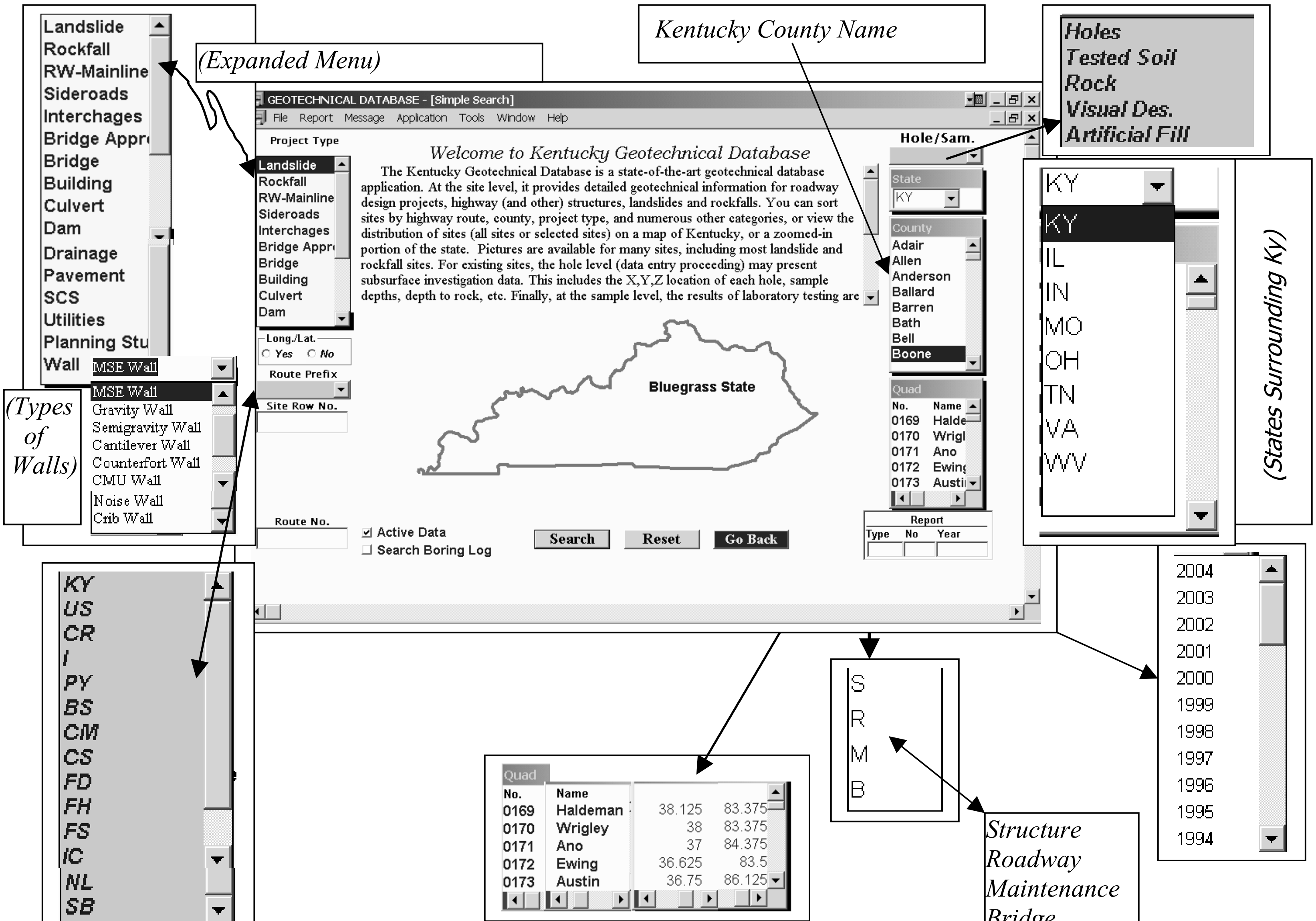


Figure 195. Graphical user interface for performing a “simple” search of data.

counterfort, CMU, Noise, Cribwall, and Tiedback. The search can be narrowed to a particular route by using route prefixes (figure 195) and route number as shown in the left-hand portion of Figure 195. Choosing any project type and using the dropdown menu labeled "Hole/Sam.," the upper right-hand corner of Figure 195, the user may select one of the items listed in the menu and only those sites having that label would be retrieved. For example, if the user selected "Tested Samples," then only those sites where soil or rock tests had been performed would be retrieved. If the search needs to be narrowed, the user could click only a county, or a selected route, and only a listing of those sites for the county or route having tested samples would appear. The database is set-up to include counties of states surrounding Kentucky. A complete listing of the counties in Kentucky and in counties in other states contiguous to Kentucky is

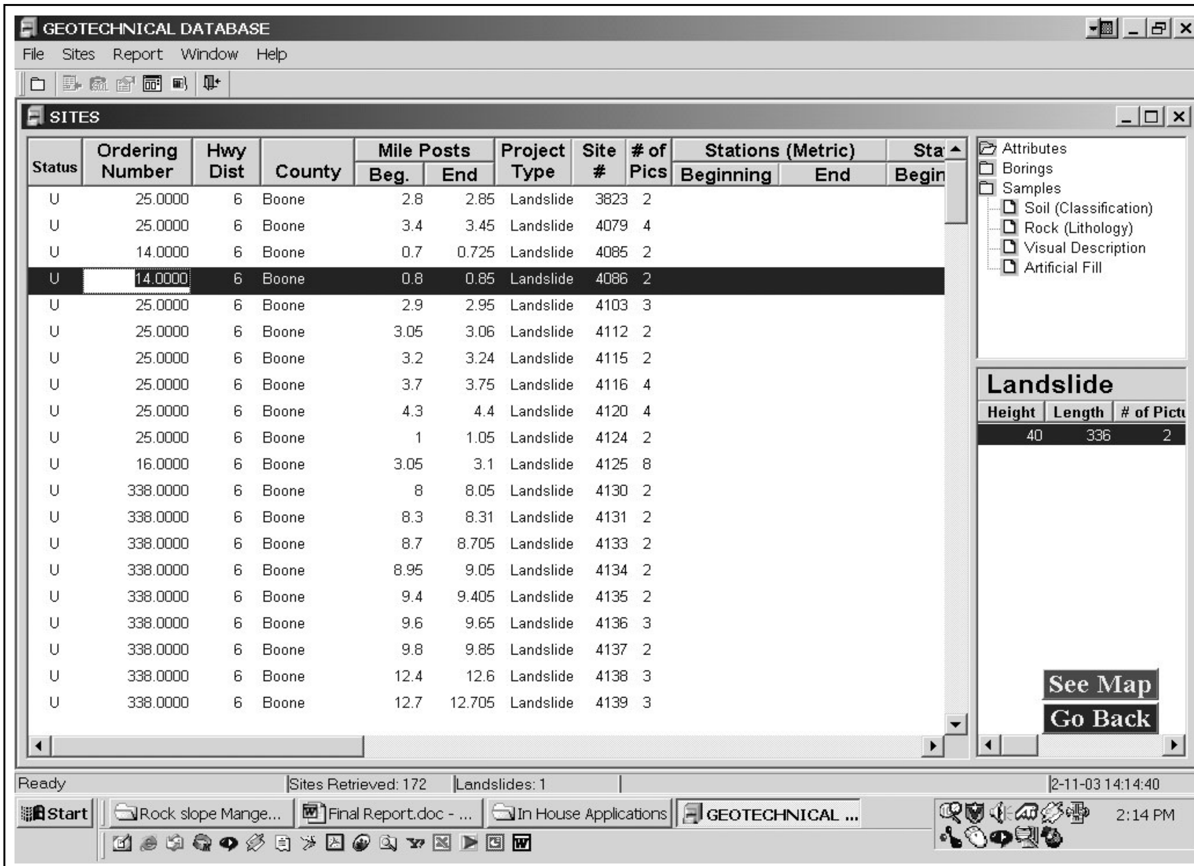


Figure 196. Data retrieved from the "Simple Search" routine.

given in Appendix D. Hence, data from other surrounding states and counties can eventually be included in the database. This arrangement will be valuable when common projects, such as bridges, are constructed as joint projects.

A mechanism has been included for retrieving reports issued by the Geotechnical Branch of the Kentucky Transportation Cabinet. By clicking on Report "Type" a drop list (S, R, M, or B) is obtained. If the user clicks on one of the letters, provides a report number, and year, the user will be able in the future to retrieve the report. A project type, such as landslides, or rock slopes, and located in a selected county or geologic quadrangle, may be retrieved. For example, assume the user wishes to retrieve a listing of landslides in Boone County, Kentucky using the commands in Figure 195. The user clicks “Landslide” and “Boone” and the listing is obtained, as shown in Figure 196.

Previously, support tables for “Eligible user” and “Operation Log” were shown in Figure 193. Other support tables have been provided in the database on the “Attributes, Borings, and Samples” graphical user interface, as shown in Figure 197. The tab labeled “Site Page” allows the user (or DBA) to open support tables labeled “Counties, Project Types, Route Prefixes, Route Suffixes, and Sources (of geotechnical data).” A complete listing of counties is given in Appendix D. Tables listing “ Workphase and Location Type” are displayed in Figure 198. Under the tab, “Sample Page”, tables of descriptive items used in the database pertaining to “Artificial Fill,” “Joint Alignment,” “Joint, Voids, and Other Structures,” “Rock Names,” and “ Sampling Method” are displayed in Figure 199. A complete listing of rock names in Kentucky is given in Appendix A. Other descriptive items associated with “Sample Page” are shown in Figure 200. Those tables include “Sampling Method,” “Stratigraphic Controls,” “Testing Method,” and Void Type.” Support tables of descriptive terms pertaining to the “Property Page” are shown in Figures 201 and 202. Those tables display a listing of terms used to describe bedding thickness, colors, composition, crystal sizes, lithology modifiers, lithology names, lithology23, and lithology structure. Sieve sizes are shown in Figure 203. Also, a listing of the different types of landslide corrections is shown in Figure 203.

The second retrieval scheme is a comprehensive search routine for amassing data. After clicking “Search Existing Data” on the main menu (Figure 194) and “Comprehensive Search”, the GUI screen shown in Figure 204 appears. This system uses a series of operators such as equal to, or greater than, less than, etc. Using this retrieval method, the user may construct any type of report. In this scheme the user may use a Comprehensive “simple” search routine (lower part of Figure 204) involving a limited number of prefixed parameters and operators or the user may use a comprehensive scheme using any number of selected parameters.

For instance, in the example shown in Figure 204, the user wanted a listing of all landslides on the Mountain Parkway in Kentucky that were located at or greater than mile point 33.6 and that have occurred before April 10, 2003. After clicking on the “Search Existing Data” and “Comprehensive Search,” in Figure 194, and clicking the button, “Simple Search” (on the Comprehensive Screen, lower part of Figure 204), the screen in the lower portion of the Figure appears. Using a dropdown list of routes, the user clicks “MT”, uses the operator, > =, inserts 33.6 into the “Beg.MP” box, and uses the operator, <or =, and inserts the date, 04/10, 2003. Clicking okay, the data illustrated in Figure 205 appears. By double clicking on a selected landslide site, (highlighted at the right-hand portion of the screen), the GUI screen at the lower portion of the figure appears. This screen displays a number of tabs, labeled “Site, Attributes and Input, History, Maintenance Cost, Design and Cost, and Pictures”. Clicking any one of those tabs will display detailed information.

The comprehensive data search is illustrated in Figure 206. In the latter approach, the user may add as many database parameters and operators as desired to build the data search. In the example, the user is retrieving rock slopes that were rated (RHRS score) 650 but less than 670. In this case, two operators, > or = and <, were used to retrieve the data report schemes. Results of this search are shown in Figure 207.

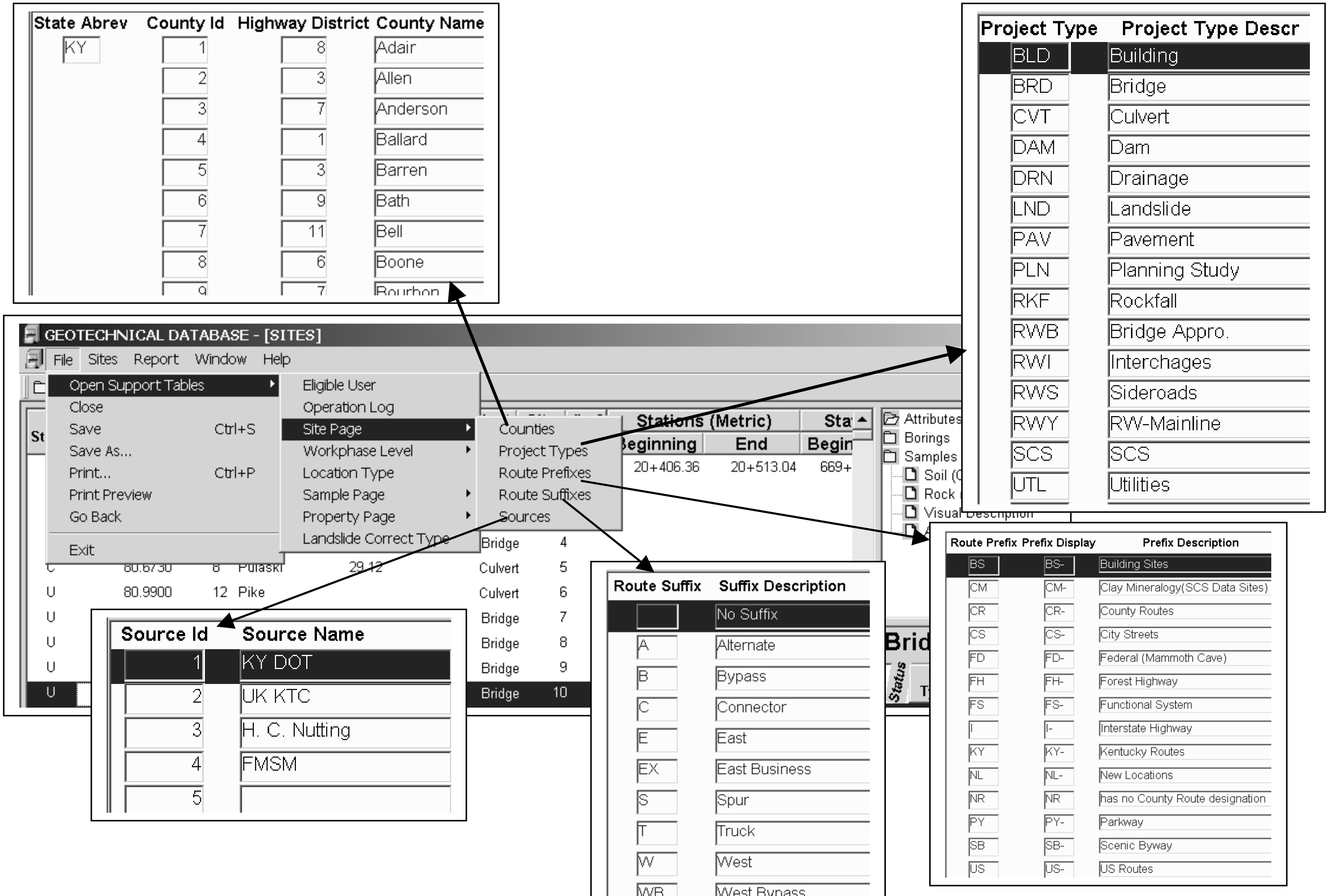


Figure 197. Support tables listing various types of information in the database pertaining to the "Site Page."

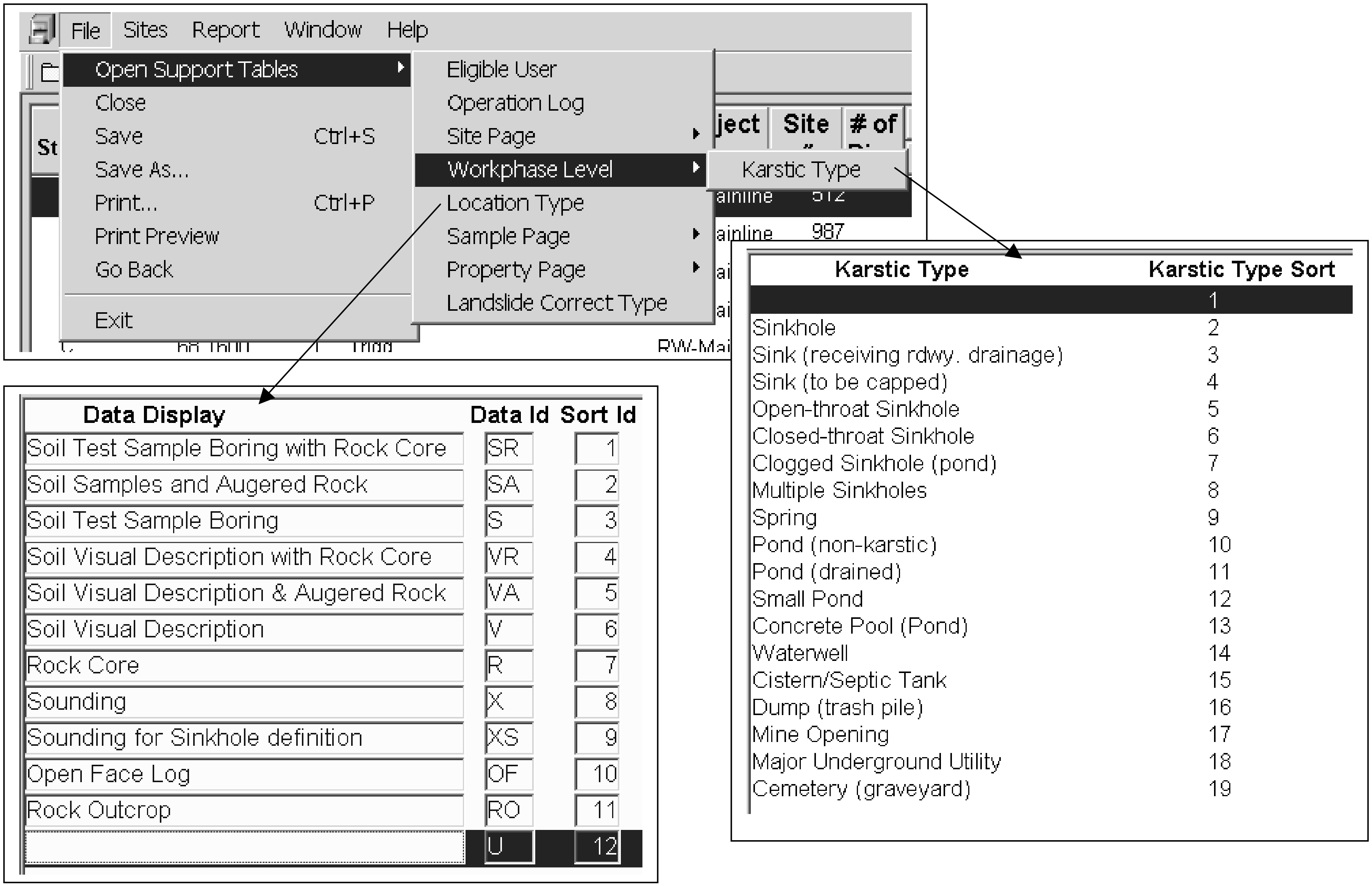


Figure 198. Support tables for “Workphase Level” and “Location Type.”

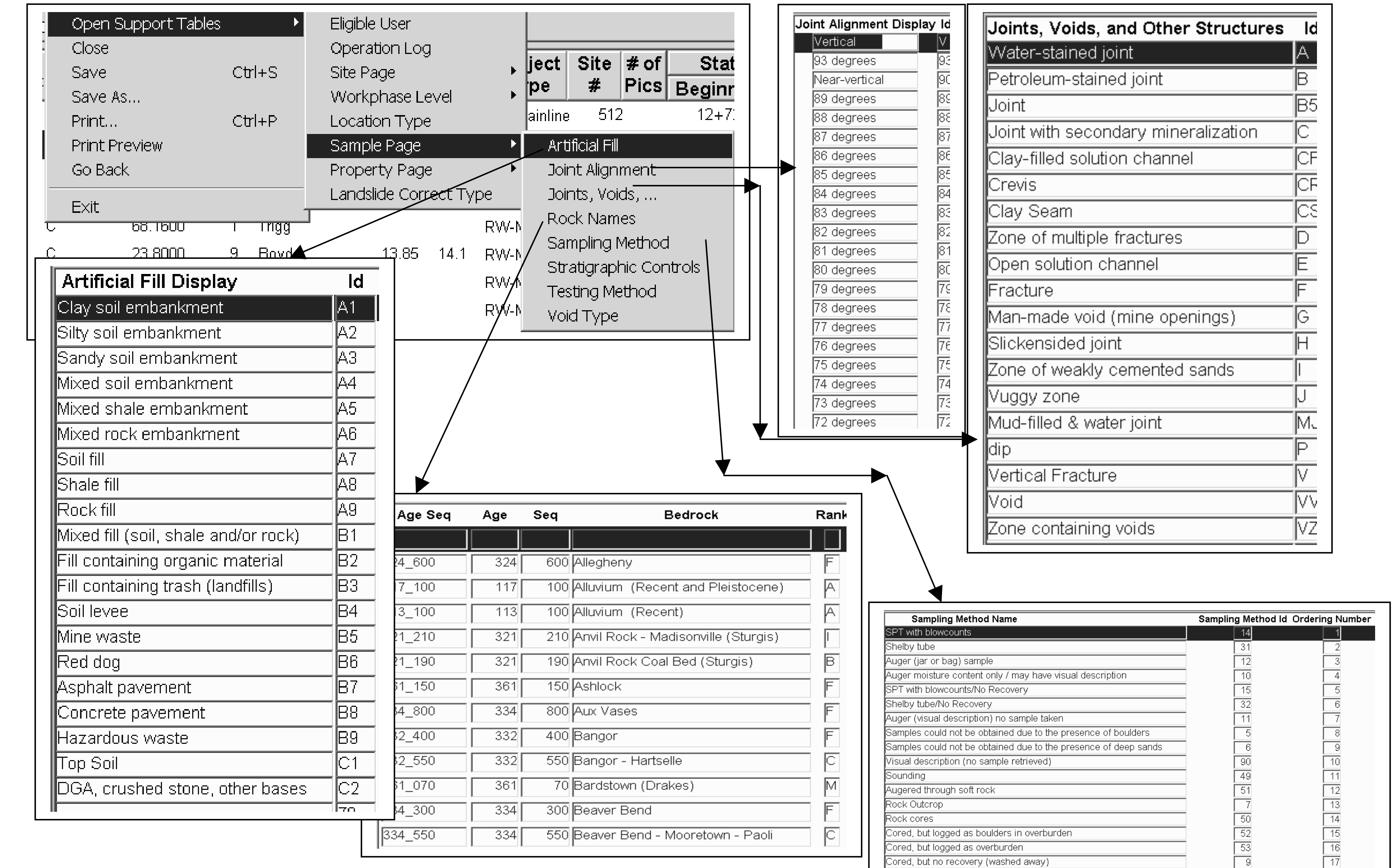
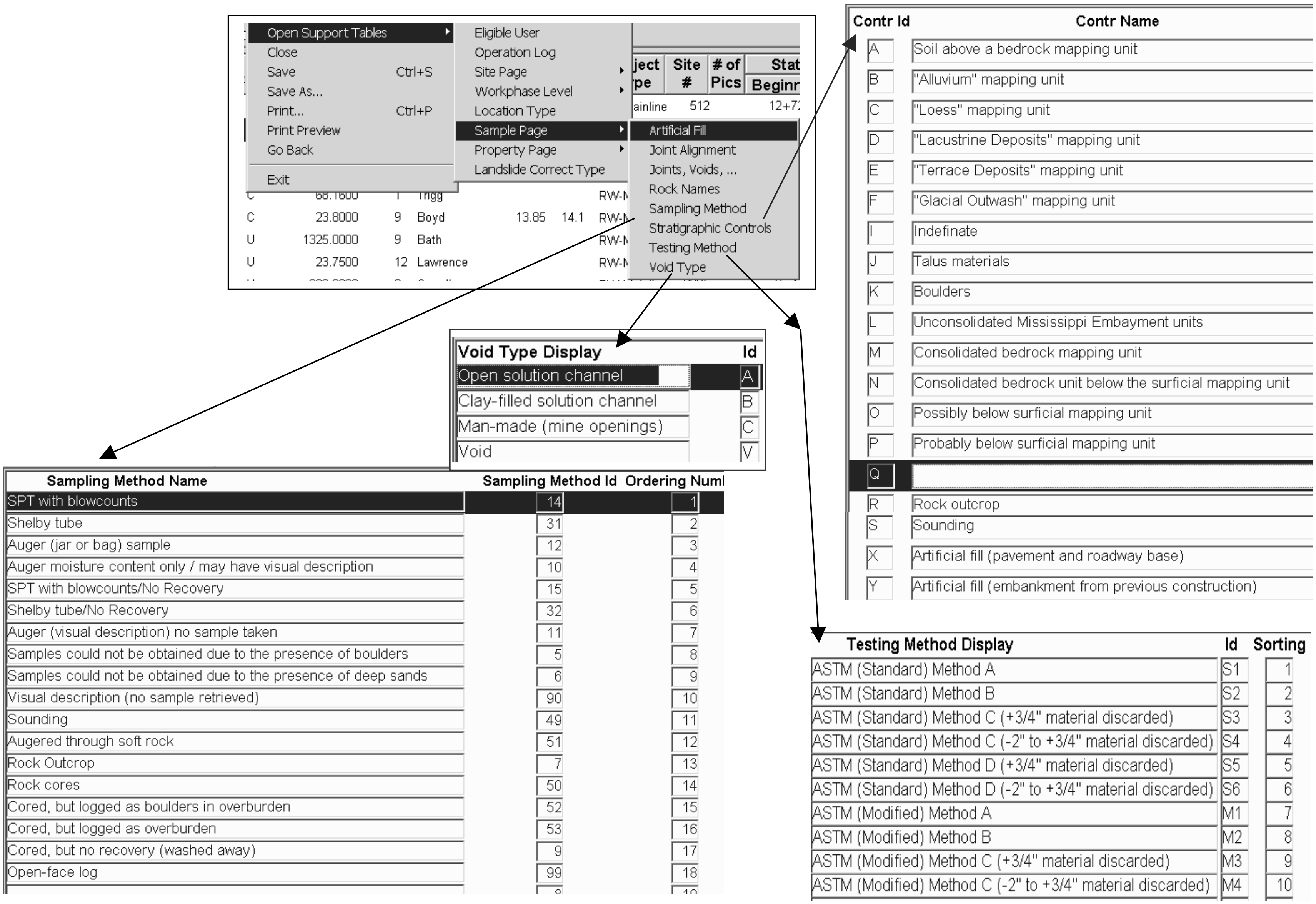


Figure 199. Information in support tables associated with the “Sample Page.”



Contr Id	Contr Name
A	Soil above a bedrock mapping unit
B	"Alluvium" mapping unit
C	"Loess" mapping unit
D	"Lacustrine Deposits" mapping unit
E	"Terrace Deposits" mapping unit
F	"Glacial Outwash" mapping unit
I	Indefinate
J	Talus materials
K	Boulders
L	Unconsolidated Mississippi Embayment units
M	Consolidated bedrock mapping unit
N	Consolidated bedrock unit below the surficial mapping unit
O	Possibly below surficial mapping unit
P	Probably below surficial mapping unit
Q	
R	Rock outcrop
S	Sounding
X	Artificial fill (pavement and roadway base)
Y	Artificial fill (embankment from previous construction)

Void Type Display	Id
Open solution channel	A
Clay-filled solution channel	B
Man-made (mine openings)	C
Void	V

Sampling Method Name	Sampling Method Id	Ordering Numl
SPT with blowcounts	14	1
Shelby tube	31	2
Auger (jar or bag) sample	12	3
Auger moisture content only / may have visual description	10	4
SPT with blowcounts/No Recovery	15	5
Shelby tube/No Recovery	32	6
Auger (visual description) no sample taken	11	7
Samples could not be obtained due to the presence of boulders	5	8
Samples could not be obtained due to the presence of deep sands	6	9
Visual description (no sample retrieved)	90	10
Sounding	49	11
Augered through soft rock	51	12
Rock Outcrop	7	13
Rock cores	50	14
Cored, but logged as boulders in overburden	52	15
Cored, but logged as overburden	53	16
Cored, but no recovery (washed away)	9	17
Open-face log	99	18

Testing Method Display	Id	Sorting
ASTM (Standard) Method A	S1	1
ASTM (Standard) Method B	S2	2
ASTM (Standard) Method C (+3/4" material discarded)	S3	3
ASTM (Standard) Method C (-2" to +3/4" material discarded)	S4	4
ASTM (Standard) Method D (+3/4" material discarded)	S5	5
ASTM (Standard) Method D (-2" to +3/4" material discarded)	S6	6
ASTM (Modified) Method A	M1	7
ASTM (Modified) Method B	M2	8
ASTM (Modified) Method C (+3/4" material discarded)	M3	9
ASTM (Modified) Method C (-2" to +3/4" material discarded)	M4	10

Figure 200. Other support tables for “Sample Page.”

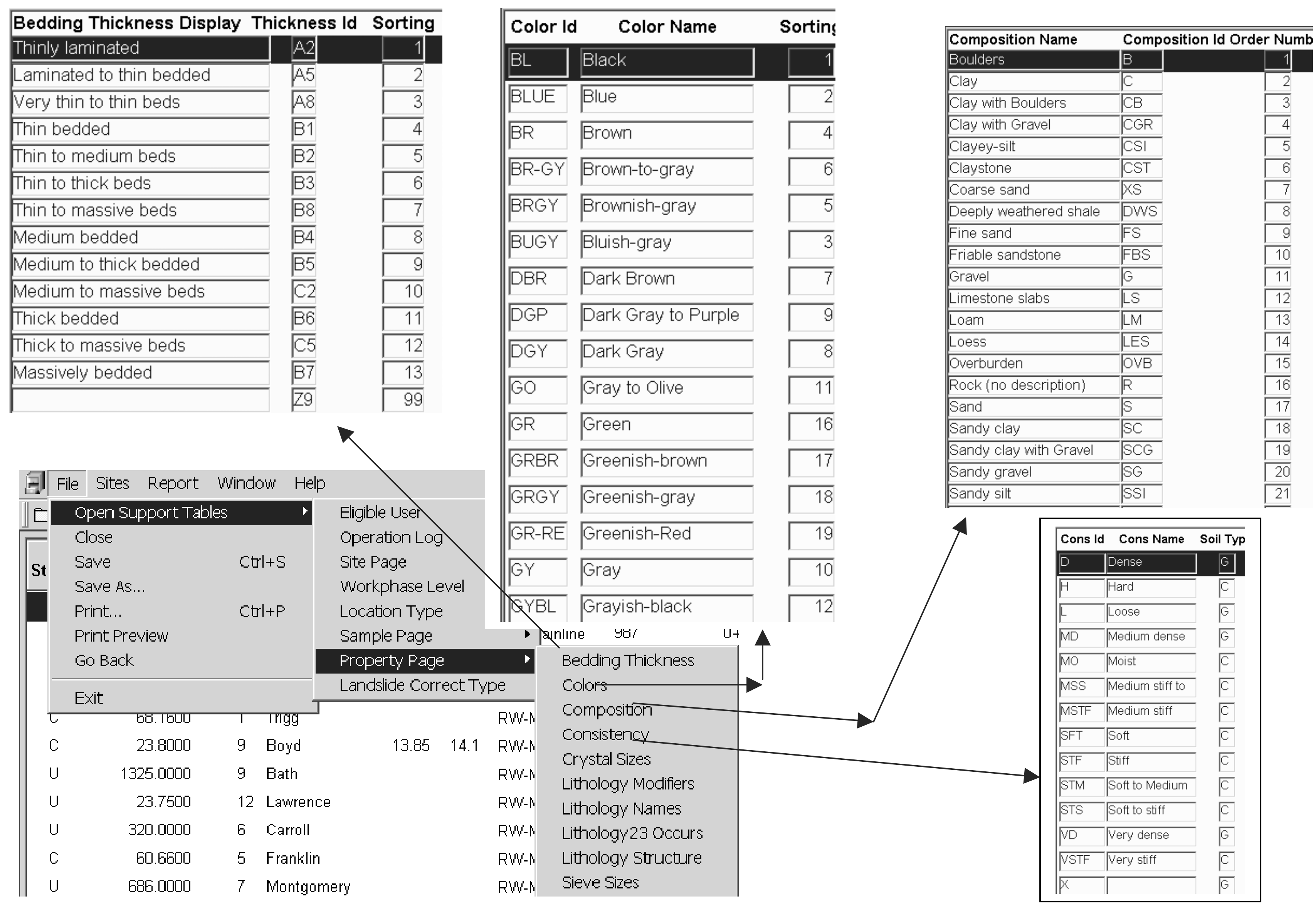


Figure 201. Drop down menus pertaining to the “Property Page.”

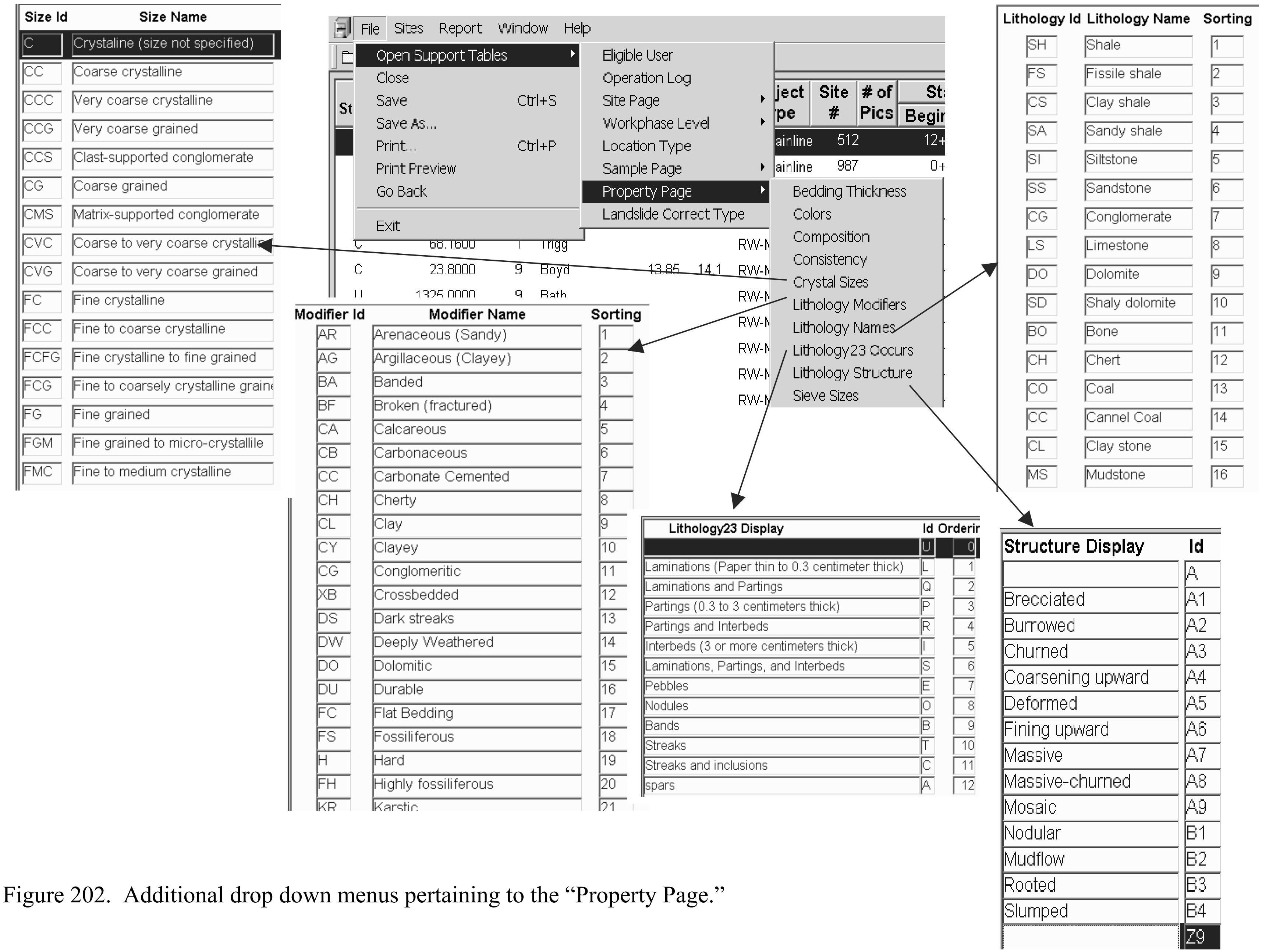
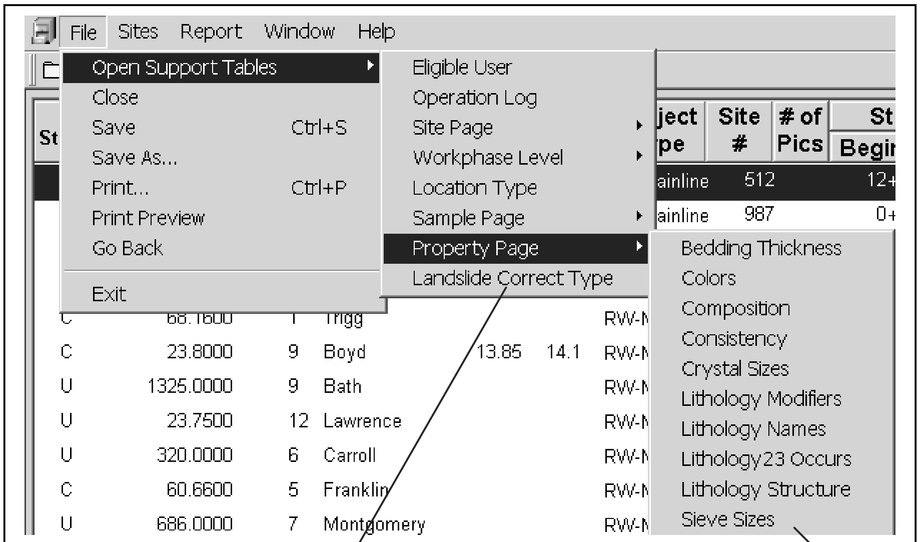


Figure 202. Additional drop down menus pertaining to the “Property Page.”



Correct Type	Correct Describtion
A	Change Roadway Alignment
B	Use Berm, Rock Butress, etc.
C	Reconstruct Slopes or Fills
D	Improve Surface or Subsurface Drainage
E	Excavate and Replace Sliding Mass
F	Flatten Existing Slopes
G	Use Gabion Type Retaining Wall
H	Use Bridge to Get out of Sliding Area
I	Use Insert Wall
K	No Correction Selected to Date
L	Use Lightweight Material (Elastizell, Tires, etc.)
M	Maintain Roadway (Do-Nothing Approach)
P	Use Piles or Pile Wall
R	Use Railroad Rails or Rail Wall
S	Construct Shear Key into Embedded Material
T	Construct Tie-Back Wall
U	Unload the Sliding Mass (Benching, etc)
V	Many Possibilities or A Combination Correction
W	Other Retaining Structures (Gravity Wall, Crib Wall)
Z	

Sieve Id	Stand Design	Alt Design
10	100 mm	4 in.
20	90 mm	3-1/2 in.
30	75 mm	3 in.
40	63 mm	2-1/2 in.
50	50 mm	2 in.
60	45 mm	1-3/4 in.
70	38.1 mm	1-1/2 in.
80	31.5 mm	1-1/4 in.
90	25.0 mm	1 in.
100	22.4 mm	7/8 in.
110	19.0 mm	3/4 in.
120	16.0 mm	5/8 in.
130	12.5 mm	1/2 in.
140	11.2 mm	7/16 in.
150	9.5 mm	3/8 in.
160	8.0 mm	5/16 in.
190	4.75 mm	No. 4
200	4.00 mm	No. 5
210	3.35 mm	No. 6
220	2.36 mm	No. 8
230	2.00 mm	No. 10
240	1.70 mm	No. 12
250	1.40 mm	No. 14
260	1.18 mm	No. 16
270	1.0 mm	No. 18
280	850 um	No. 20
290	710 um	No. 25
300	600 um	No. 30
310	500 um	No. 35
320	425 um	No. 40
330	300 um	No. 50
340	250 um	No. 60
330	300 um	No. 50
340	250 um	No. 60
350	212 um	No. 70
360	180 um	No. 80
370	150 um	No. 100
380	125 um	No. 120
390	106 um	No. 140
400	90 um	No. 170
410	75 um	No. 200
420	63 um	No. 230
430	53 um	No. 270
435	.005mm	
440	45 um	No. 325
450	38 um	No. 400
460	.002mm	
470	.001mm	

Figure 203. Listing of landslide repair techniques and sieve sizes of the “Property Page.

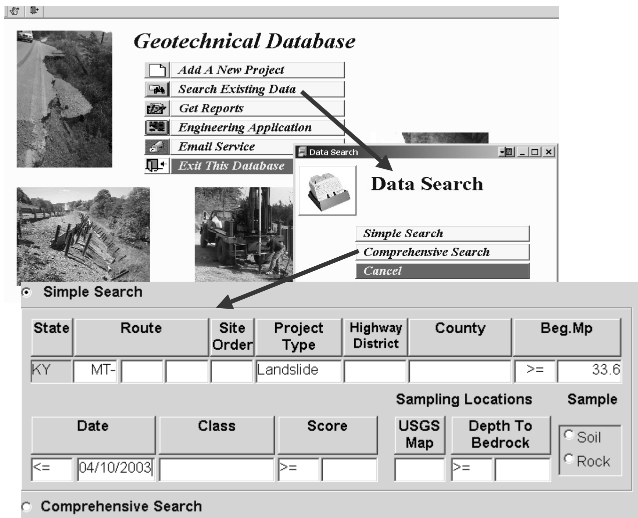


Figure 204. Method for performing a comprehensive ("simple") data search.

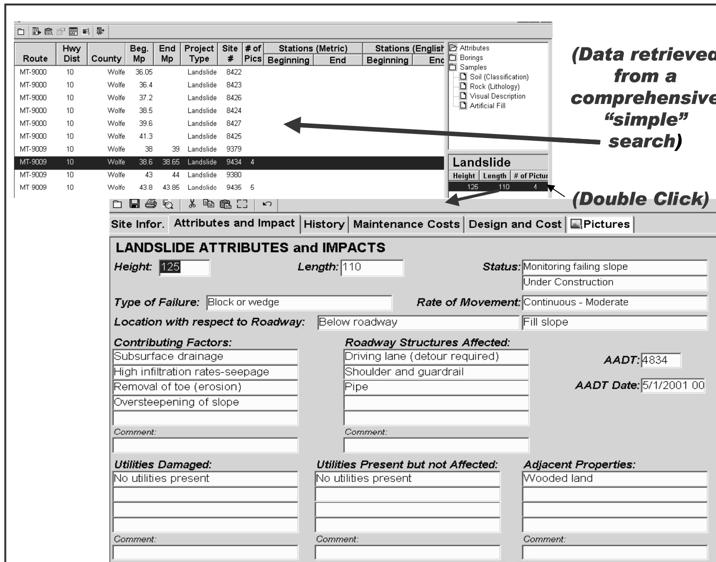


Figure 205. Retrieved data using the comprehensive ("simple") search routine.

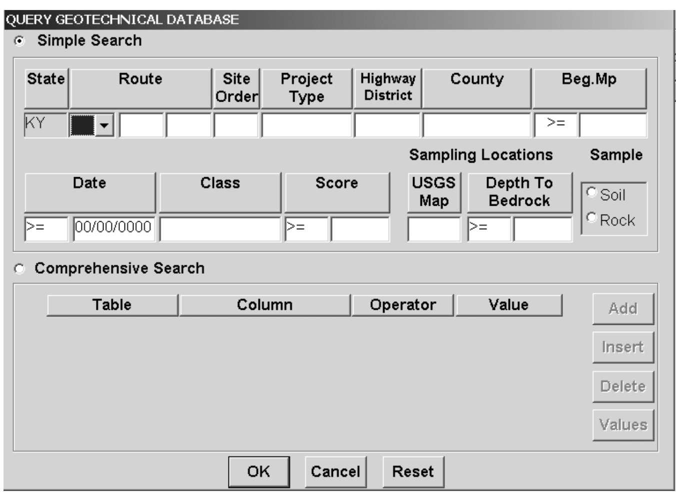


Figure 206. Comprehensive search GUI screen.

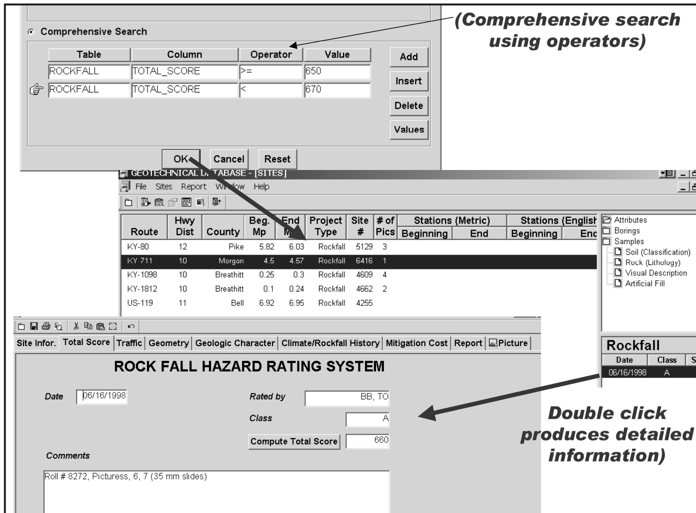


Figure 207. Comprehensive search using operators.

Data report Schemes

In addition to the simple and comprehensive search features, another scheme has been included in the database for retrieving and generating data reports. When the “Get Reports” button on the main menu is clicked, the GUI screen shown in figure 208 appears. The user has five choices for generating reports. These are titled “Special,” “ Flexible,” and “Sample Properties,” “Free Pickup Report,” and “Create report”

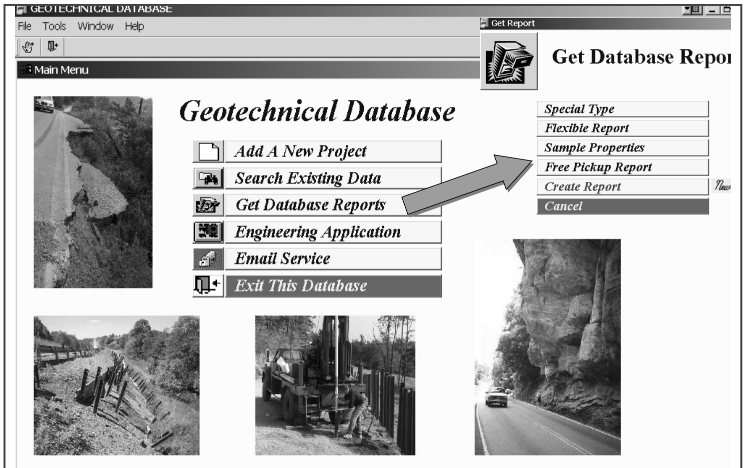


Figure 208. GUI screen for retrieving and generating reports.

When the “Special” report button is clicked, the GUI screen in Figure 209 appears. Clicking on the “selection” button displays several choices: Counties, Route number, Highway District, Report Type (refers to reports issued by the Geotechnical Branch, Division of Materials, of the Kentucky Transportation Cabinet). This scheme allows the user to construct many different types of listing and combinations of various parameters. For instance, if the “Report Type” is clicked, then the listing, “ B, L, M, R, and S,” appears in the right-hand side of the GUI screen (Figure 209). Clicking, for example on “R” (rock fall reports), produces the listing of reports in the central portion of the GUI screen.

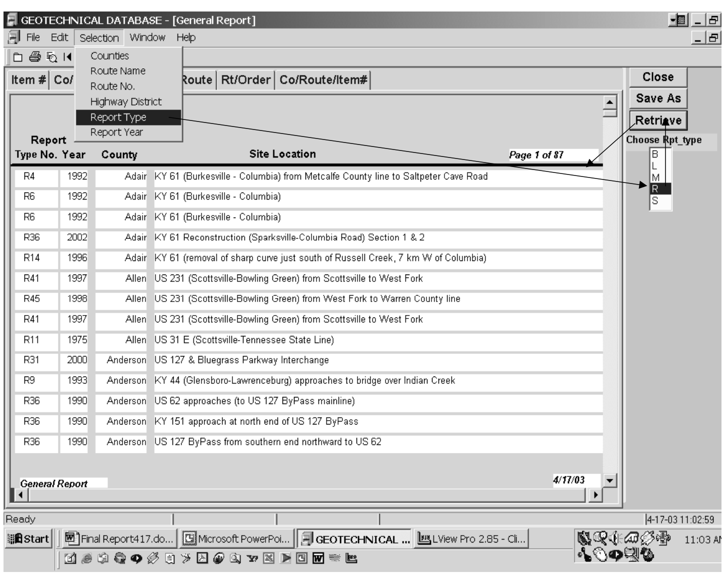


Figure 209. GUI screen for generating report listing.

In the second type of report generator, data can be filtered to obtain the desired data. Although the parameters used for filtering are preset, a great deal of flexibility has been programmed into the filtering process. The database contains three preset filtering retrieval schemes. Soil and rock data and other attributes pertaining to landslides, roadways, rock slopes, SCS (Soil Conservation Service), and structures may be retrieved to generate reports. When the landslide button is clicked, the GUI format shown in Figure 210 appears. In this format the user may select a particular highway district[2], or a combination of highway districts, or “All” highway districts, route, the

[2] There are twelve highway districts in Kentucky under the jurisdiction of the Kentucky Transportation Cabinet.

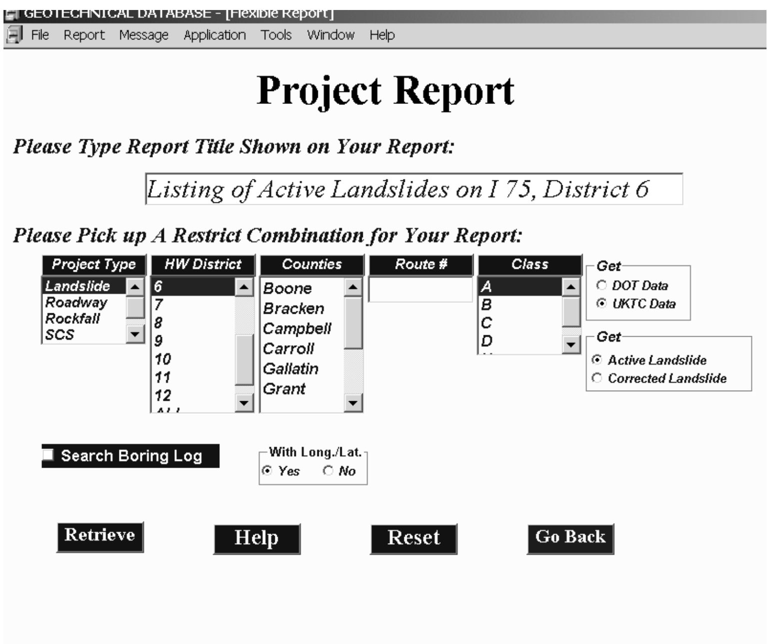


Figure 210. GUI format for filtering and generating a landslide report for a specific area (highway district or county), route(s), and class of landslide.

class of landslide (A, B, C, D)[3], landslide data collected by the Kentucky Transportation Cabinet (KYTC), or the University of Kentucky Transportation Center (UKTC), active or corrected landslides, boring log, latitude and longitude.

An example of using the flexible report procedure for compiling a landslide report is shown in Figure 210. In this example, the user is interested in obtaining a listing of active landslides rated "A" (very serious) in Highway District 6 in the northern portion of Kentucky. The user clicks "Landslide", "HW District" 6, Class "A" and punches the buttons "UKTC Data", "Active", and "With Long/Lat". When highway district 6 is clicked, the counties in that district are automatically listed. The report is given a title, as shown in Figures 210 and 211. After punching the "Retrieve" button, the GUI listing appears as shown in Figure 211. The data shows that there are a total of 16 landslides in Highway District 6 rated "A". As of the date of this report, about 370 landslides have been identified in Highway District 6 that are rated "A" and "B"(very serious and serious, respectively). A total of about 545 landslides were identified in the district. A map of the "A" landslides may be obtained by clicking on "Distribution on Map". By highlighting and clicking on a site, the GUI shown in Figure 212 appears giving detailed information. Photographs of the site may be viewed by clicking "Pictures".

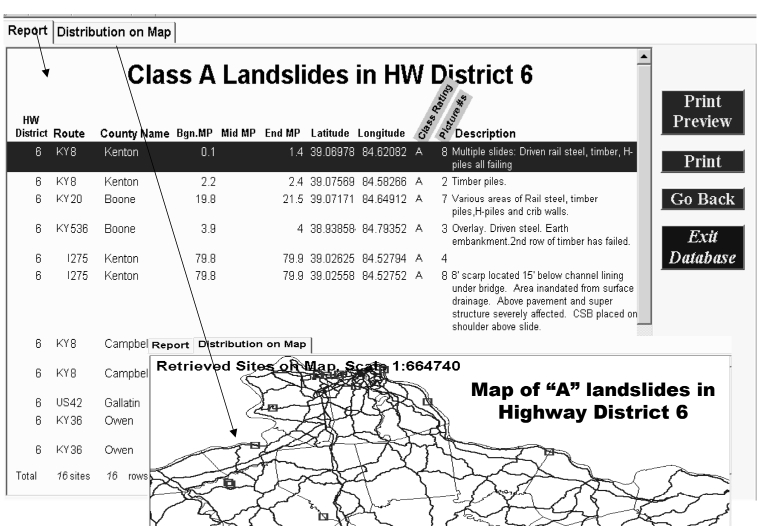


Figure 211. Report listing class "A" landslides in highway district 6 in northern Kentucky.

By clicking "Roadway" in Figure 213, the user may retrieve hole data. In this example, the user wishes to retrieve hole data with latitudes and longitudes in Highway district 1. The user

[3] Classes of landslides described in previous section entitled "Landslide Data and Management System," pages 61 and 62.

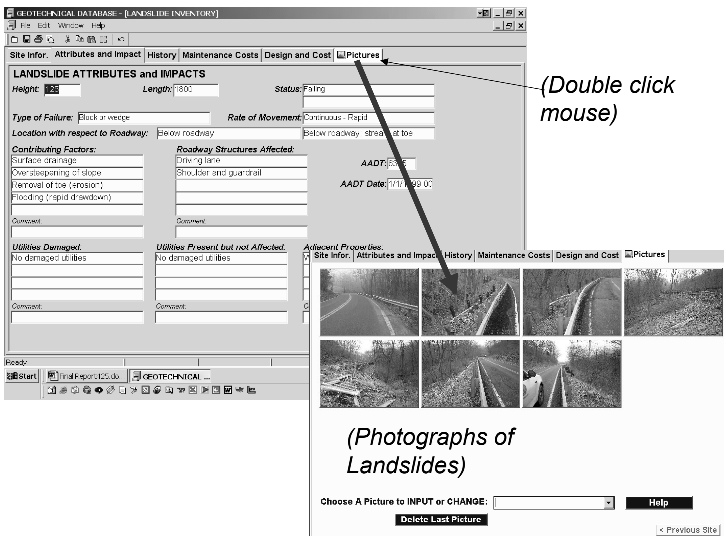


Figure 212. Details, including photographs, of a selected landslide.

clicks "Roadway", "HW District" 1, "Holes", and "With "Long./Lat." The listing appears as shown in Figure 214. By clicking on "Distribution on Map", view of the holes on a map of the western portion of Kentucky appears. The user may use a zoom feature to get closer views of the plotted holes. When data is available, the user may view a boring log by clicking on a hole on the map, as illustrated previously in Figure 191.

Another example of using the filtering process is illustrated in Figure 215. In this example, potentially hazardous rock fall sites on Interstate 75 in Kentucky having a numerical rating equal to or greater than 350 is sought. Numerical score is based on the Oregon Department of Transportation rockfall hazardous rating system, Pierson and Vickle, 1993. The generated report is illustrated in Figure 216. By clicking on any heading, the data are sorted (ascending or descending) according to the selected heading. For instance, by clicking on the heading, " total score" the user can arrange the data in ascending numerical scores. Moving the cursor to any selected site (highlighted) and double clicking takes the user to detailed information of the rock fall site. By clicking on "see Map" the rock fall sites on Interstate 75, having numerical ratings of 350 or greater, are displayed on a roadway map of Kentucky (lower right-hand portion of the figure).

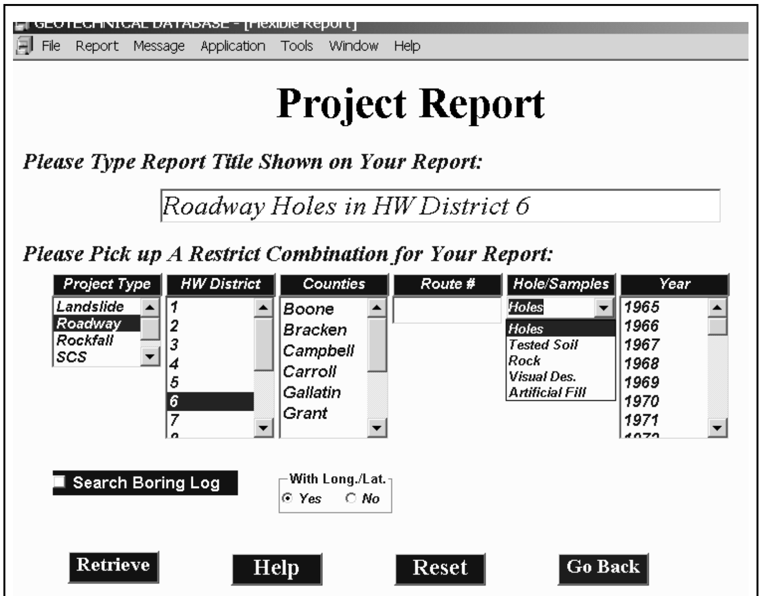


Figure 213. Compiling a listing of roadway holes in district 6.

As shown in Figure 217, soil and rock data properties in the database may be retrieved using the "Sample Properties" button of the main menu. For example, if "Classification" on the menu is clicked, then classification data of all stored data is retrieved as shown in Figure 218. Tables of other sample properties, such as gradation, CBR, lab and field strengths, consolidation, visual descriptions, slake durability, and rock quality designation (RQD), may be obtained.

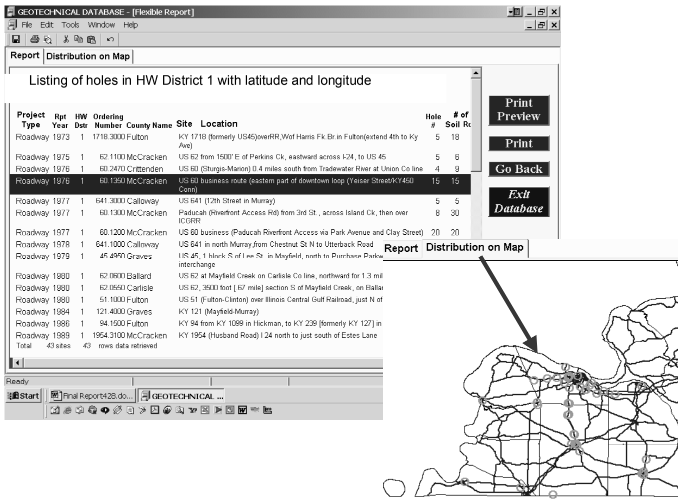


Figure 214. Listing of holes in Highway District 1 with latitudes and longitudes.

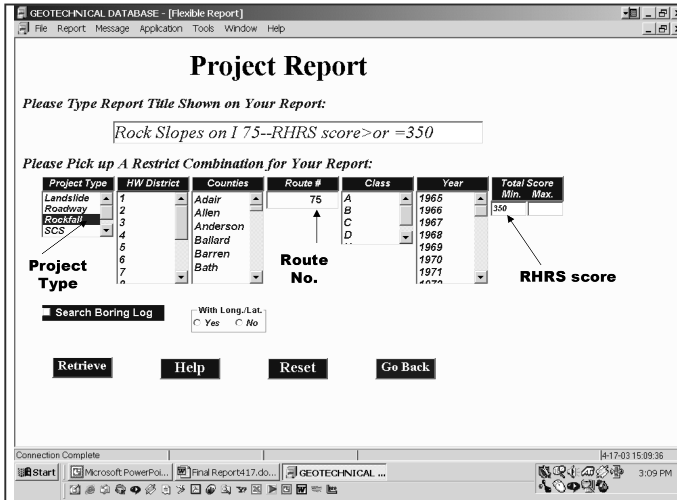


Figure 215. Compiling a listing of rock slopes on I 75 with RHRS scores greater than or equal 350.

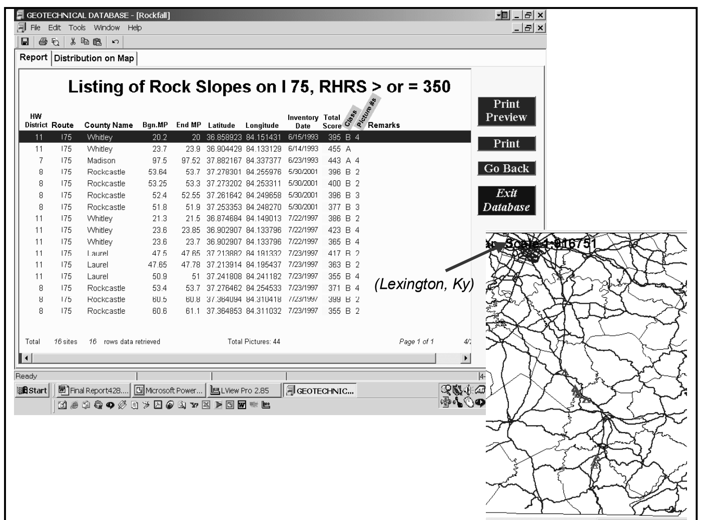


Figure 216. Listing of rock slopes on I 75 with RHRS scores greater than or equal to 350.

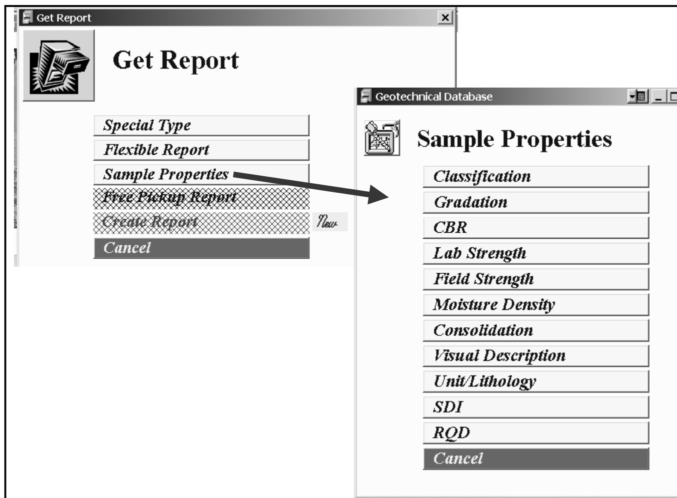
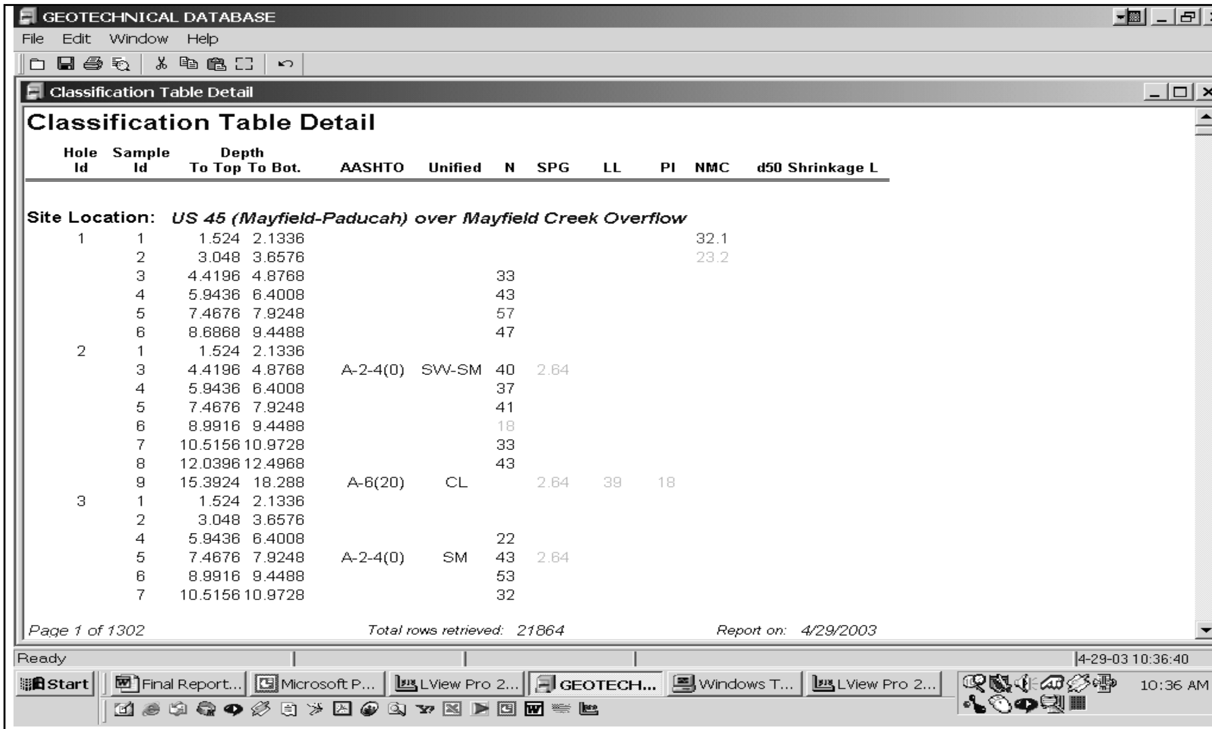


Figure 217. Method of retrieving soil properties of all stored data in the database



Classification Table Detail

Hole Id	Sample Id	Depth To Top	Depth To Bot.	AASHTO	Unified	N	SPG	LL	PI	NMC	d50	Shrinkage L
Site Location: *US 45 (Mayfield-Paducah) over Mayfield Creek Overflow*												
1	1	1.524	2.1336							32.1		
	2	3.048	3.6576							23.2		
	3	4.4196	4.8768			33						
	4	5.9436	6.4008			43						
	5	7.4676	7.9248			57						
	6	8.6868	9.4488			47						
2	1	1.524	2.1336									
	3	4.4196	4.8768	A-2-4(0)	SW-SM	40	2.64					
	4	5.9436	6.4008			37						
	5	7.4676	7.9248			41						
	6	8.9916	9.4488			18						
	7	10.5156	10.9728			33						
	8	12.0396	12.4968			43						
	9	15.3924	18.288	A-6(20)	CL		2.64	39	18			
3	1	1.524	2.1336									
	2	3.048	3.6576									
	4	5.9436	6.4008			22						
	5	7.4676	7.9248	A-2-4(0)	SM	43	2.64					
	6	8.9916	9.4488			53						
	7	10.5156	10.9728			32						

Page 1 of 1302 *Total rows retrieved: 21864* *Report on: 4/29/2003*

Figure 218. Listing of classification data.

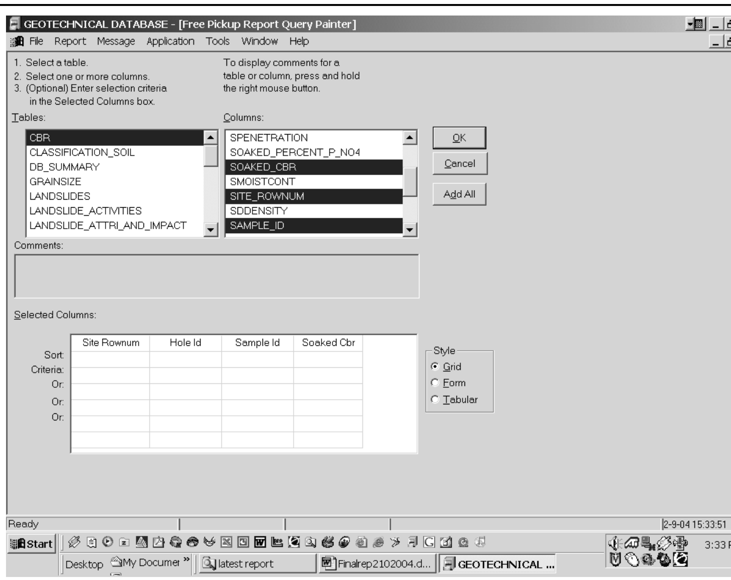
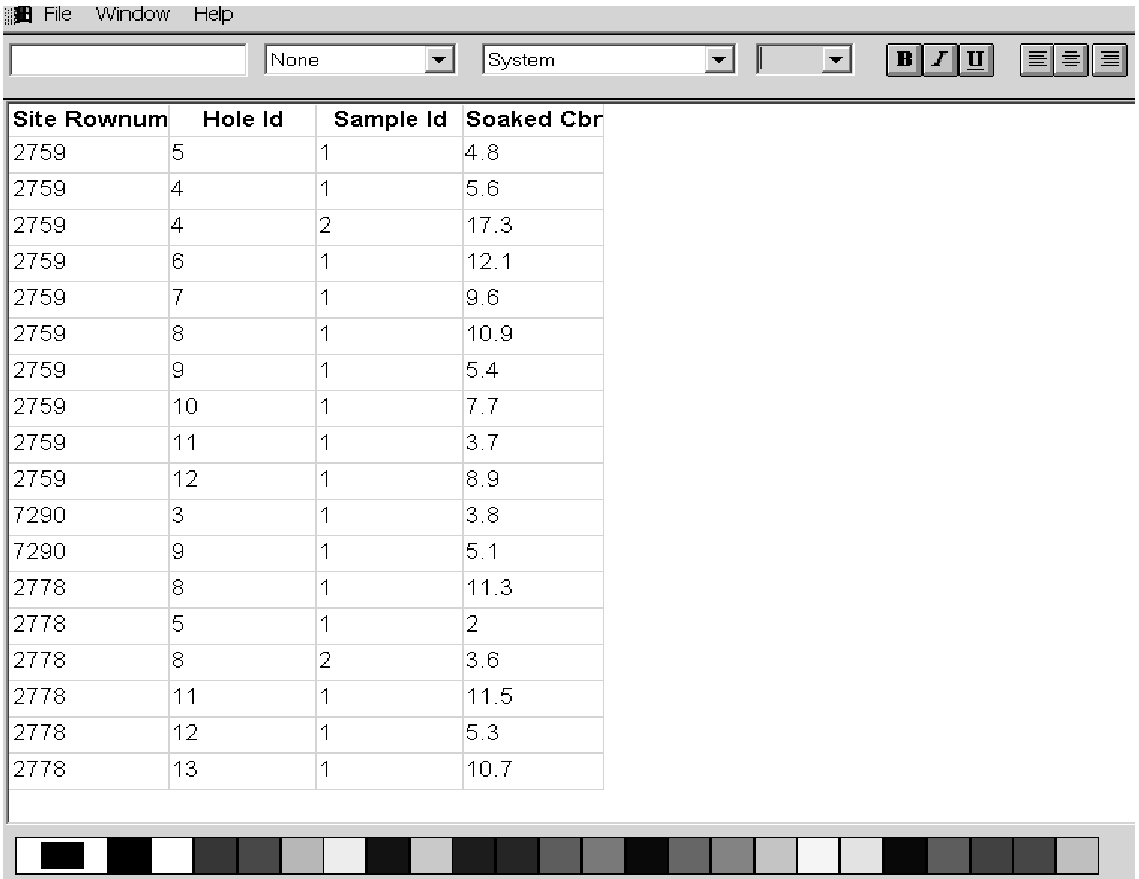


Figure 219. Method for getting data directly from the data base table.

The user also has a method of selecting data from the database table directly. When the user clicks on "Free Pickup Report," Figure 217, the screen shown in Figure 219 appears. The user has an array of options for generating report data. For instance, suppose the user wishes to examine all of the "soaked" CBR data in the database table. The table illustrated in Figure 220 may be constructed by first clicking on CBR in the "Table" box of Figure 219 and then clicking on "Site Row," "Hole ID," "Sample ID," and "Soaked CBR" in the "Column Box." Selected text within the generated table may be highlighted in color. Selected columns in the "column Box" may be clicked to arrange the data in different fashions.

By clicking "Create Reports" in Figure 217, a GUI screen, Figure 221, appears for creating a listing of geotechnical projects published by the Geotechnical Branch of the Kentucky



Site Rownum	Hole Id	Sample Id	Soaked Cbr
2759	5	1	4.8
2759	4	1	5.6
2759	4	2	17.3
2759	6	1	12.1
2759	7	1	9.6
2759	8	1	10.9
2759	9	1	5.4
2759	10	1	7.7
2759	11	1	3.7
2759	12	1	8.9
7290	3	1	3.8
7290	9	1	5.1
2778	8	1	11.3
2778	5	1	2
2778	8	2	3.6
2778	11	1	11.5
2778	12	1	5.3
2778	13	1	10.7

Figure 220. Listing of all “Soaked” CBR data in the database table.

Transportation Cabinet or other types of reports. Three different levels of reports may be generated. These are, as follows:

1. Site level
2. Boring level
3. Sample level.

By clicking on any report icon, a retrieval screen appears and the user has certain filter options. For example, if the “County” icon (under Site Level Report) is clicked, then a GUI screen, illustrated in Figure 222, appears. In the example, the user wants to retrieve a listing of geotechnical roadway reports issued by the Geotechnical Branch (Division of Materials) for Interstate 64 in Fayette County, Kentucky. The dropdown list (Report type), “R” and “Fayette, “ are clicked and after the interstate number, 64” is inserted and “retrieved” is clicked, the listing appears as illustrated in Figure 223. The “Year” is not clicked so that a listing of all reports may be retrieved.

Figure 224 illustrates a method of generating a bedrock depth boring report. In this case, a listing of bedrock depths, locations, and site numbers are tabulated, as shown in Figure 225. Sample level reports may be generated as shown in Figure 226 and 227. In this case, a listing of grain sizes and classifications were retrieved for Daivess County, Kentucky.

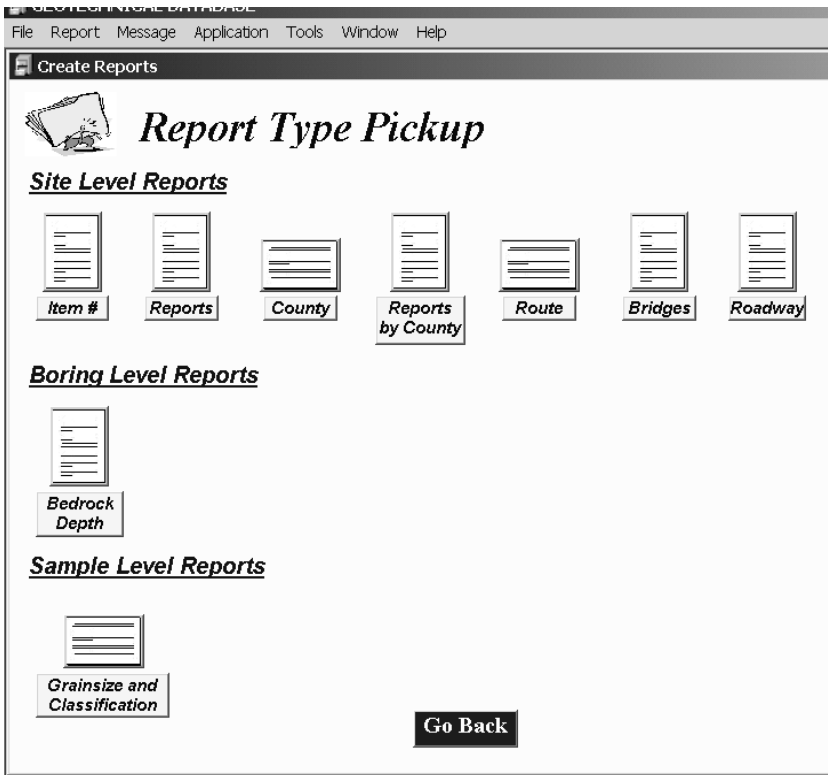


Figure 221. Method for creating site, boring, and sample level reports.

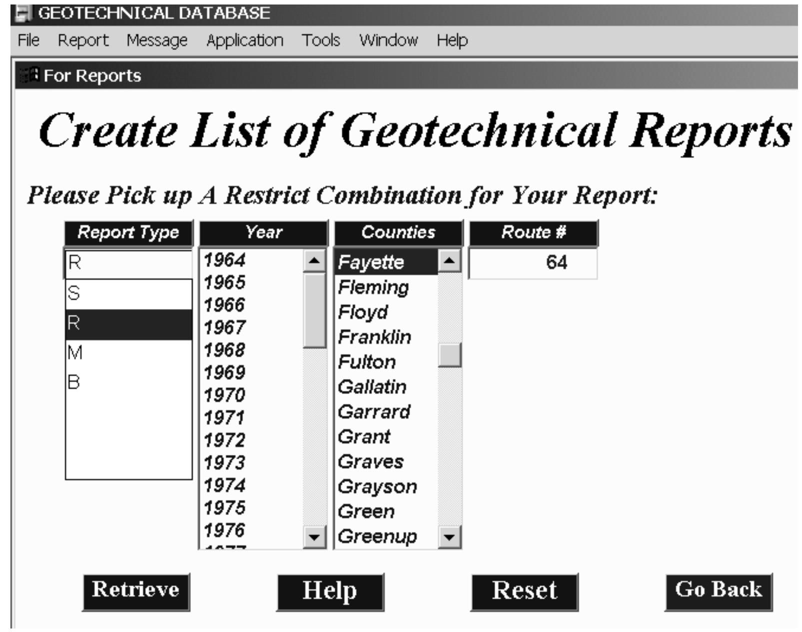


Figure 222. Method for retrieving and creating a site level geotechnical report type and by county.

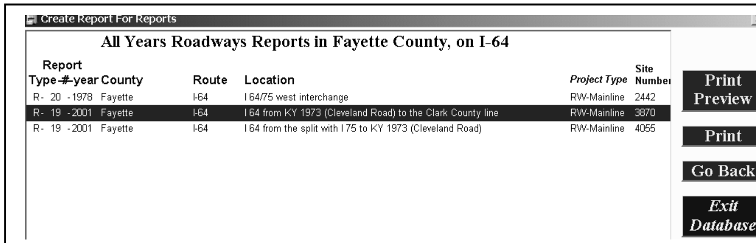


Figure 223. A listing of roadway reports for I 64 in Fayette County, Kentucky.

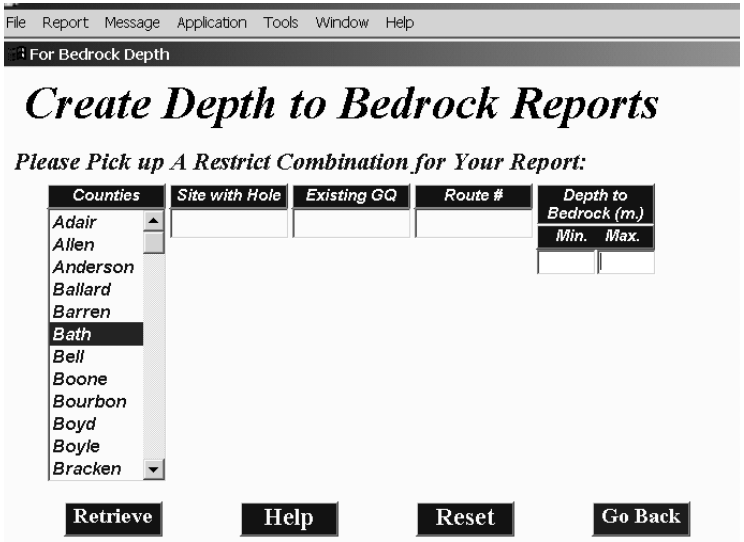


Figure 224. Creating a boring level report.

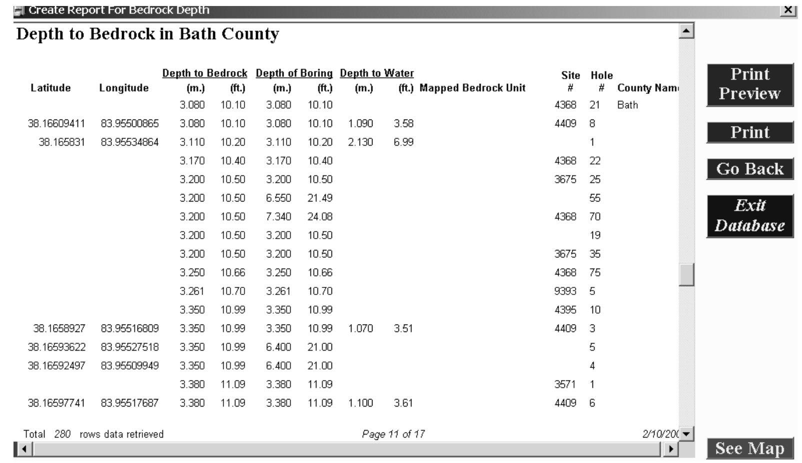


Figure 225. Listing of bedrock depths in Bath County Kentucky.

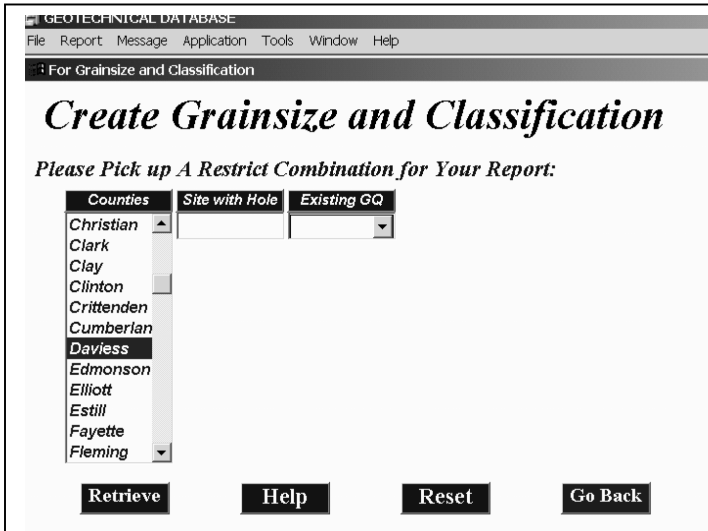


Figure 226. Creating a sample level report.

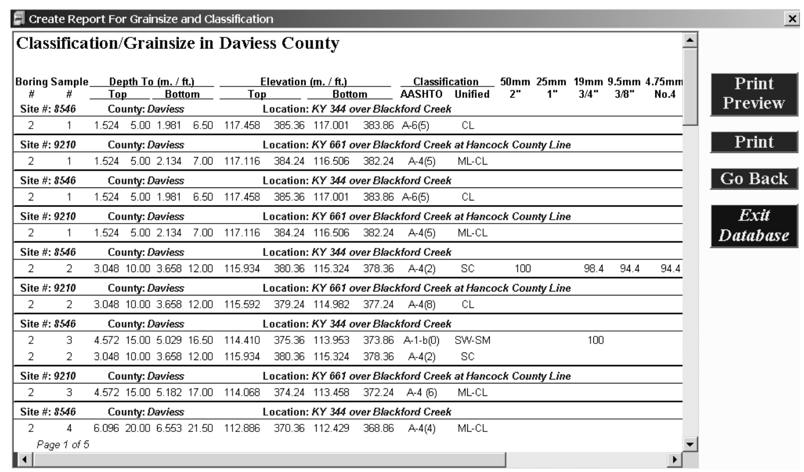


Figure 227. Grain size and classification report for Daivess County, Kentucky.

E-mail Service

Provision has been made in the database for e-mail. However, the e-mail component has been built into the database so that users may avoid undesirable e-mail usually encountered on the Internet. This eliminates “Spam” e-mail and the user can receive and send messages that deal with only work-related items. The e-mail GUI is illustrated in Figure 228. Names of users may be built into the service, as illustrated in the right-hand portion of Figure 228.

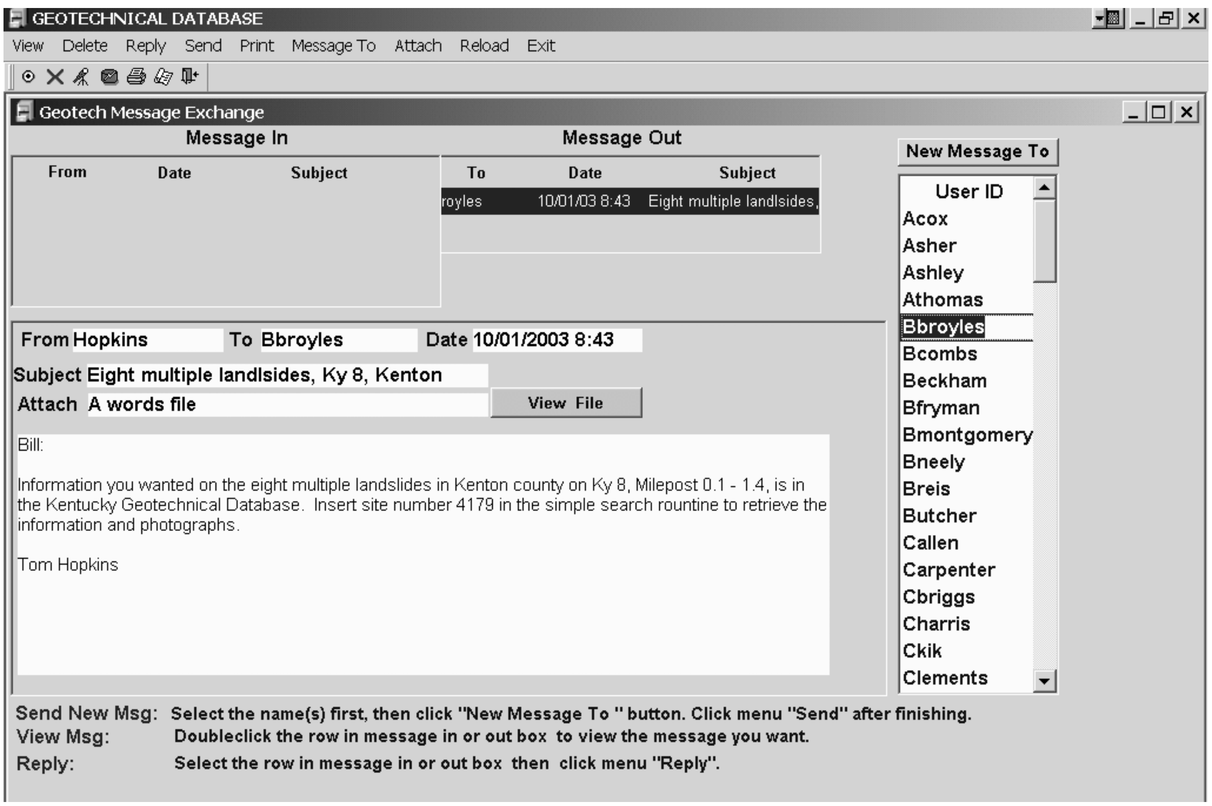


Figure 228. E-mail GUI.

SUMMARY AND CONCLUSIONS

As a means of establishing a comprehensive system for managing rock slope and landslide problems in Kentucky, as well as storing soil and rock geotechnical data, a geotechnical database was developed and is described herein. Developing a geotechnical database in a client /server and windows environment facilitates and provides efficient means of entering and retrieving geotechnical data. Development tools included Oracle® 7.3 and PowerBuilder® 6.0 and 7.0 software. The database was partitioned into major and secondary components. Major parts of the database consist of rock slope, landslide, structures, and soil and rock engineering data. Programmed procedures of the database are used by the Kentucky Transportation Cabinet to identify hazardous conditions and for risk management of landslides and rock slopes. Procedures for entering and retrieving historical soil and rock engineering data have been developed.

Procedures for retrieving soil and rock data, as it is generated, are under development. Methods of analyzing data statistically while connected to the database were developed for user convenience. Also, design applications, such as pavement design, or retaining wall design, have been developed and are included in the database as a convenience to users and to improve efficiency. Other applications are under development. Three procedures for safeguarding use of the database are described. Engineering units are stored using one system of units, but conversions from one system to another can be made on screen at any time. Saving and storing electronic photographs using JPEG software minimized storage requirements and, yet, did not sacrifice picture quality. File size of each photograph was only about 44 Kilobytes. MapObjects® software provided a good means for displaying quickly roadway maps and overlays of locations of landslide, rock slope, and boring locations.

RECOMMENDATIONS

It is strongly recommended that the rock slope and landslides management systems proposed herein (and elsewhere) be immediately adopted by the Kentucky Transportation Cabinet and every effort should be made to implement the use of the management systems. To effectively use the management systems, it is essential that highway personnel begin to populate the database with rock slope and landslide field information. Specifically, when rock fall occurs at any site, highway personnel should immediately enter this information into the database. An estimate of the size and volume of rock fall (or debris flow) and date of occurrence should be entered into the system. When any type of maintenance is performed at a rock slope site or landslide the type of maintenance and estimated (or actual cost) cost of the work should be entered into the database. If a rock slope or landslide site is not in the database, then personnel should create a new site in the database. By populating the database with up-to-date information, adjustments and refinements in the ratings of the rock slopes and landslides can be made. Attributes of the site should be noted and the hazardous nature of the site should be rated using the Oregon/FHWA Hazardous Rockfall Rating System. Similarly, the landslide could be given a rating alas suggested herein.

After a trial period of using the systems, it may be necessary to make adjustments and modifications in the database structure. It should be recognized that it was not feasible to catalog all hazardous rock slopes and landslides on Kentucky's highways because UKTC researchers could not be aware of all hazardous sites. Consequently, it is essential that field personnel, who may have the best knowledge of a potentially hazardous site, identify sites not listed in the database. Whenever a site is repaired this information should be entered into the database.

Identifying the numerous and potentially hazardous rock slopes and landslides on Kentucky's highway and constructing database management systems represents the first stage in addressing those problems. The management and rating systems provide means of developing a priority list of sites that may need repairs or the application of remedial measures. The second stage will involve developing engineering remedial, or mitigation, plans and cost estimates. This information can be stored in the database. It is recommended that a research study be initiated to explore ways of obtaining, rapidly, rock slope cross sections for engineering analysis. Specifically, the use of two-and three dimensional laser technology should be examined as a fast means of obtaining cross sections and open-face geological logs of rock slope problem sites. These data could be stored in the database for future analysis. By storing the Colorado Rock Fall Computer Simulation software in the database, rock slope analysis and design could be performed via of the database. The use of GPS should be examined as a very quick means of obtaining topographical surveys of landslide sites and cross sections for stability analysis. Consequently, results of the analysis would be available for review and discussion by engineering personnel that has an interest in the rock slope and landslide problem sites.

Considering the sheer number of potentially, hazardous rock slopes identified in this study (about 2,400) and landslides (1.400) and that many of those rock slopes were partially financed by federal funds originally, federal participation in future funding of repairs, or mitigation measures, should be requested by the Kentucky Transportation Cabinet. It is estimated that rock slope repairs or mitigation measures will cost hundreds of million of dollars and may be beyond the scope of expenditures that the state could earmark for this problem. Hence, it is recommended that a special federal highway fund be established to address the rock slope problems not only in Kentucky but also for all states that have severe rock slope problems.

Finally, it was recommended during Research Study Advisory Committee meetings near the end of this study that the Kentucky Geotechnical Database, which exists in a client/server structure, be programmed for the Internet. By reprogramming for a Web Browser, the geotechnical database of Kentucky would be made available to a much larger group of users. Hence, not only would engineers and planners in Kentucky would have access to the database but national, as well as international users, would eventually have access to the database. Moreover, the data could be displayed easier on map-based platforms. At the end of this study, work was initiated on building a dynamical geotechnical database for the Internet.

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Appendix A

Names of Rock Units in Kentucky

Age_seq	Age	Seq	Bedrock	Rank
324_600	324	600	Allegheny	F
117_100	117	100	Alluvium (Recent and Pleistocene)	A
113_100	113	100	Alluvium (Recent)	A
321_210	321	210	Anvil Rock - Madisonville (Sturgis)	I
321_190	321	190	Anvil Rock Coal Bed (Sturgis)	B
361_150	361	150	Ashlock	F
334_800	334	800	Aux Vases	F
332_400	332	400	Bangor	F
332_550	332	550	Bangor - Hartselle	C
361_070	361	70	Bardstown (Drakes)	M
334_300	334	300	Beaver Bend	F
334_550	334	550	Beaver Bend - Mooretown - Paoli	C
334_560	334	560	Beaver Bend - Paoli	C
337_700	337	700	Beaver Creek	M
339_800	339	800	Bedford	F
339_650	339	650	Bedford - Berea	C
339_350	339	350	Bedford - Sunbury	C
333_600	333	600	Beech Creek	F
333_650	333	650	Beech Creek (Golconda)	M
344_110	344	110	Beechwood (Sellersburg)	M

Age_seq	Age	Seq	Bedrock	Rank
361_310	361	310	Bellevue Tongue (Grant Lake)	T
339_500	339	500	Berea	F
334_400	334	400	Bethel	F
333_500	333	500	Big Clifty	F
333_550	333	550	Big Clifty Member, Golconda	M
354_500	354	500	Bisher	F
338_000	338	0	Borden	F
344_300	344	300	Boyle	Y
364_300	364	300	Brannon (Lexington)	M
357_100	357	100	Brassfield	F
327_400	327	400	Breathitt	F
327_680	327	680	Breathitt-Lee	C
332_200	332	200	Buffalo Wallow	F
361_130	361	130	Bull Fork	F
361_400	361	400	Calloway Creek	F
370_000	370	0	CAMBRIAN	P
364_850	364	850	Camp Nelson	F
337_500	337	500	Cane Valley (Fort Payne)	M
324_300	324	300	Carbondale	F
321_310	321	310	Carthage - Lisman (Sturgis)	I

Age_seq	Age	Seq	Bedrock	Rank
321_350	321	350	Carthage to top of Sturgis	I
327_300	327	300	Caseyville	F
327_750	327	750	Catron	F
100_000	100	0	CENOZOIC	E
341_500	341	500	Chattanooga	F
331_000	331	0	CHESTERIAN	S
124_200	124	200	Clairborne	F
361_550	361	550	Clays Ferry	F
210_100	210	100	Clayton	F
210_150	210	150	Clayton-McNairy	C
331_400	331	400	Clore	F
331_450	331	450	Clore - Palestine	C
321_700	321	700	Conemaugh	F
121_010	121	10	Continental Deposits	F
338_420	338	420	Conway Cut (Cowbell (Borden))	B
327_600	327	600	Corbin (Breathitt/Lee)	M
364_230	364	230	Cornishville (Perryville (Lexington))	B
124_450	124	450	Costal Plane Deposits	F
338_400	338	400	Cowbell (Borden)	M
354_600	354	600	Crab Orchard	F

Age_seq	Age	Seq	Bedrock	Rank
355_500	355	500	Crab Orchard - Brassfield	C
210_000	210	0	CRETACEOUS	P
361_750	361	750	Cumberland	F
364_050	364	50	Curdsville (Lexington)	M
333_700	333	700	Cypress	F
333_850	333	850	Cypress - Paint Creek	C
333_950	333	950	Cypress - Paint Creek - Bethel	C
331_300	331	300	Degonia	F
331_350	331	350	Degonia-Clore	C
364_500	364	500	Devils Hallow (Lexington)	M
340_000	340	0	DEVONIAN	P
361_030	361	30	Drakes	F
361_010	361	10	Drakes - Ashlock	C
361_570	361	570	Elk Riffle	B
333_800	333	800	Elwren	F
124_000	124	0	EOCENE	S
210_300	210	300	Eutaw	F
361_350	361	350	Fairview	F
338_900	338	900	Farmers (Borden)	M
364_210	364	210	Faulconer(Perryville (Lexington))	B

Age_seq	Age	Seq	Bedrock	Rank
337_200	337	200	Fort Payne	F
333_530	333	530	Fraileys Member, Big Clifty	M
335_400	335	400	Fredonia (Ste Genevieve)	M
361_500	361	500	Garrard	F
361_230	361	230	Gilbert (Ashlock)	M
334_900	334	900	Girkin	F
332_500	332	500	Glen Dean	F
333_300	333	300	Golconda	F
361_300	361	300	Grant Lake	F
364_450	364	450	Greendale Lentil (Lexington)	F
364_120	364	120	Grier - Curdsville	C
364_150	364	150	Grier (Lexington)	M
338_620	338	620	Gum Sulphur (Nancy (Borden))	B
338_200	338	200	Halls Gap (Borden)	M
327_850	327	850	Hance	F
333_400	333	400	Haney Limestone	F
333_450	333	450	Haney Member, Golconda	M
332_700	332	700	Hardinsburg	F
336_800	336	800	Harrodsburg	F
332_600	332	600	Hartselle	F

Age_seq	Age	Seq	Bedrock	Rank
338_920	338	920	Henley (Farmers (Borden))	B
327_700	327	700	Hignite	F
113_000	113	0	HOLOCENE	S
338_500	338	500	Holtsclaw (Borden)	M
337_600	337	600	Jabez (Fort Payne)	M
124_100	124	100	Jackson	F
344_200	344	200	Jeffersonville	F
344_150	344	150	Jeffersonville / Sellersburg	C
220_000	220	0	JURASSIC	P
338_700	338	700	Kenwood (Borden)	M
333_100	333	100	Kidder Member, Monteagle	M
339_000	339	0	KINDERHOOKIAN	S
331_200	331	200	Kinkaid	F
331_250	331	250	Kinkaid - Degonia	C
331_280	331	280	Kinkaid - Degonia - Clore	C
331_380	331	380	Kinkaid - Degonia - Clore - Palestine	C
337_300	337	300	Knifley (Fort Payne)	M
361_450	361	450	Kope	F
354_300	354	300	Laurel	F
327_900	327	900	Lee	F

Age_seq	Age	Seq	Bedrock	Rank
361_800	361	800	Leipers	F
332_100	332	100	Leitchfield	F
335_600	335	600	Levias (Ste Genevieve)	M
364_010	364	10	Lexington	F
337_580	337	580	Limestone (of Fort Payne)	M
321_330	321	330	Lisman Coal Bed	B
321_370	321	370	Lisman to top of Sturgis	I
117_500	117	500	Loess	F
364_100	364	100	Logana (Lexington)	M
354_100	354	100	Louisville	F
347_000	347	0	LOWER DEVONIAN	S
336_450	336	450	Lower St Louis - Salem	C
321_270	321	270	Madisonville - Carthage (Sturgis)	I
321_230	321	230	Madisonville Coal Bed (Sturgis)	B
210_200	210	200	McNarry	F
331_600	331	600	Menard	F
331_650	331	650	Menard - Waltersburg	C
331_750	331	750	Menard-Waltersburg-Vienna-Tar Springs	C
335_000	335	0	MERAMECIAN	S
200_000	200	0	MESOZOIC	E

Age_seq	Age	Seq	Bedrock	Rank
344_000	344	0	MIDDLE DEVONIAN	S
364_550	364	550	Millersburg (Lexington)	M
327_800	327	800	Mingo	F
122_000	122	0	MIOCENE	S
330_000	330	0	MISSISSIPPIAN	P
321_400	321	400	Monongahela	F
321_650	321	650	Monongahela-Conemaugh	C
335_100	335	100	Monteagle	F
334_500	334	500	Mooretown	F
337_800	337	800	Muldraugh	M
338_300	338	300	Nada (Borden)	M
338_550	338	550	Nancy - Holtsclaw (Borden)	C
338_600	338	600	Nancy (Borden)	M
341_200	341	200	New Albany	F
338_750	338	750	New Providence - Kenwood (Borden)	C
338_800	338	800	New Providence (Borden)	M
335_200	335	200	Newman	F
341_700	341	700	Ohio	F
123_000	123	0	OLIGOCENE	S
360_000	360	0	ORDOVICIAN	P

Age_seq	Age	Seq	Bedrock	Rank
364_750	364	750	Oregon	F
337_000	337	0	OSAGIAN	S
354_400	354	400	Osgood	F
117_150	117	150	Outwash (Wisconsin)	A
333_900	333	900	Paint Creek	F
125_000	125	0	PALEOCENE	S
300_000	300	0	PALEOZOIC	E
331_500	331	500	Palestine	F
334_700	334	700	Paoli	F
332_300	332	300	Pennington	F
320_000	320	0	PENNSYLVANIAN	P
117_300	117	300	Peoria Loess	F
117_350	117	350	Peoria Loess & Roxana Silt	C
310_000	310	0	PERMIAN	P
364_200	364	200	Perryville (Lexington)	M
117_000	117	0	PLEISTOCENE	S
117_200	117	200	Pleistocene silt and sand (unnamed)	U
121_000	121	0	PLIOCENE	S
361_600	361	600	Point Pleasant Tongue (Clays Ferry)	B
125_300	125	300	Porters Creek	F

Age_seq	Age	Seq	Bedrock	Rank
361_110	361	110	Preachersville (Drakes)	M
400_000	400	0	Pre-CAMBRIAN	E
321_160	321	160	Providence - Anvil Rock (Sturgis)	I
321_180	321	180	Providence - Madisonville (Sturgis)	I
321_130	321	130	Providence Coal Bed (Sturgis)	B
110_000	110	0	QUARTERNARY	Q
361_170	361	170	Reba (Ashlock)	M
337_550	337	550	Reef Limestone (Fort Payne)	M
334_100	334	100	Reelsville	F
334_150	334	150	Reelsville - Sample	C
334_600	334	600	Renault	F
337_900	337	900	Renfro	M
335_500	335	500	Rosiclare Member, Ste Genevieve	M
338_430	338	430	Roundstone (Cowbell (Borden))	B
361_090	361	90	Rowland (Drakes)	M
117_400	117	400	Roxana Silt	F
336_500	336	500	Salem	F
336_550	336	550	Salem - Warsaw	C
361_050	361	50	Saluda (Drakes)	M

Age_seq	Age	Seq	Bedrock	Rank
364_220	364	220	Salvisa (Perryville(Lexington))	B
334_200	334	200	Sample	F
336_750	336	750	Science Hill (Warsaw)	M
344_100	344	100	Sellersburg	F
350_000	350	0	SILURIAN	P
344_120	344	120	Silver Creek (Sellersburg)	M
336_650	336	650	Somerset Member, Warsaw	M
344_130	344	130	Speeds (Sellersburg)	M
336_200	336	200	St Louis	F
336_350	336	350	St Louis - Salem	C
336_300	336	300	St Louis Member, Newman	M
364_400	364	400	Stamping Ground (Lexington)	M
335_300	335	300	Ste Genevieve	F
336_050	336	50	Ste Genevieve - St Louis	C
336_020	336	20	Ste Genevieve - Upper St Louis	C
335_700	335	700	Ste Genevieve Member, Monteagle	M
335_800	335	800	Ste Genevieve Member, Newman	M
361_220	361	220	Stingy Creek - Gilbert(Ashlock)	C

Age_seq	Age	Seq	Bedrock	Rank
361_210	361	210	Stingy Creek (Ashlock)	M
364_600	364	600	Strodes Creek (Lexington)	M
321_100	321	100	Sturgis (Lisman-Henshall-Dixon)	F
364_350	364	350	Sulphur Well (Lexington)	M
339_200	339	200	Sunbury	F
364_250	364	250	Tanglewood (Lexington)	M
331_900	331	900	Tar Springs	F
361_250	361	250	Tate (Ashlock)	M
361_190	361	190	Terrill (Ashlock)	M
120_000	120	0	TERTIARY	T
327_100	327	100	Tradewater	F
327_290	327	290	Tradewater / Caseyville	C
230_000	230	0	TRIASSIC	P
210_750	210	750	Tuscaloosa	F
364_650	364	650	Tyrone	F
341_000	341	0	UPPER DEVONIAN	S
341_100	341	100	Upper Devonian Black Shale (undivided)	C
333_200	333	200	Upper Member (Newman)	M

Age_seq	Age	Seq	Bedrock	Rank
331_800	331	800	Vienna	F
331_850	331	850	Vienna - Tar Springs	C
354_200	354	200	Waldron	F
331_700	331	700	Waltersburg	F
336_600	336	600	Warsaw	F
337_100	337	100	Warsaw - Fort Payne	C
336_700	336	700	Warsaw argillaceous dolomite	M
338_980	338	980	Waverly	F
124_300	124	300	Wilcox	F
338_100	338	100	Wildie (Borden)	M

Appendix B

Entity Relationship For Database geo

Entity Relationship for Database geo

Table Name: sites

Primary Key: PK_SITES: site_rownum
Index: pk_sites: site_rownum
Foreign Key: none

Table Name: locations

Primary Key: PK_LOCATIONS: site_rownum, hole_id
Index: PK_LOCATIONS: site_rownum, hole_id
Foreign Key: 1. LOCATIONS_TO_SITES: site_rownum;
2. LOCATIONS_TO_PHASES: site_rownum, phase

Table Name: workphase

Primary Key: PK_WORKPHASE: site_rownum, phase
Index: PK_WORKPHASE: site_rownum, phase
Foreign Key: WORKPHASE_TO_SITES: site_rownum

Table Name: samples

Primary Key: PK_SAMPLES: site_rownum, hole_id, sample_id
Index: PK_SAMPLES: site_rownum, hole_id, sample_id
Foreign Key: SAMPLES_TO_LOCATIONS: site_rownum, hole_id

Table Name:* *bridge_general

Primary Key: PK_BRIDGE_GENERAL: site_rownum, bridge_id
Index: BRIDGE_GENERAL_X: site_rownum, bridge_id
Foreign Key: BRIDGE2SITES: site_rownum

Table Name:* *culvert

Primary Key: PK_CULVERT: site_rownum
Index: CULVERT_X: site_rownum
Foreign Key: FK_CULVERT2SITES: site_rownum

Table Name:* *landslide_attri_n_impact

Primary Key: PK_LND_ATTRI_N_IMPACT: site_rownum
Index: LND_ATTRI_N_IMPACT_X: site_rownum
Foreign Key: FK_LND_ATTRI_N_IMPACT: site_rownum (IN SITES TABLE)

Table Name:* *rockfall

Primary Key: PK_ROCKFALL: site_rownum, inventory_date
Index: PK_ROCKFALL: site_rownum, inventory_date
Foreign Key: ROCKFALL_TO_SITES: site_rownum

Table Name:* *roadway_general

Primary Key: PK_ROADWAY_GENERAL: site_rownum
Index: PK_ROADWAY_GENERAL: site_rownum
Foreign Key: FK_ROADWAY_GENERAL: site_rownum (IN SITES TABLE)

Table Name: walls_mse

Primary Key: PK_WALLS_MSE: site_rownum
Index: PK_WALLS_MSE: site_rownum
Foreign Key: FK_WALLS_MSE: site_rownum (IN SITES TABLE)

Table Name: brd_appr_stations

Primary Key: PK_BRD_APPR_STNS: site_rownum
Index: PK_BRD_APPR_STNS: site_rownum
Foreign Key: FK_BRD_APPR_STNS2SITES: site_rownum (IN SITES TABLE)

Table Name: interchange_ramps

Primary Key: PK_INTERCHANGE_RAMP: site_rownum, ramp_id
Index: PK_INTERCHANGE_RAMP: site_rownum, ramp_id
Foreign Key: FK_INTERCHANGE_RAMP2SITES: site_rownum

Table Name: roadway_comments

Primary Key: PK_ROADWAY_COMMENTS: site_rownum, comment_id
Index: PK_ROADWAY_COMMENTS: site_rownum, comment_id
Foreign Key: PK_RDW_CMTS2GENERAL: site_rownum (IN SITES TABLE)

Table Name: roadway_karstic

Primary Key: PK_RDW_KARSTIC: site_rownum, karstic_id
Index: PK_RDW_KARSTIC: site_rownum, karstic_id
Foreign Key: FK_RDW_KARSTIC: site_rownum (IN SITES TABLE)

Table Name: roadway_equations
Primary Key: PK_RDW_EQUATIONS: site_rownum, equation_id
Index: PK_RDW_EQUATIONS: site_rownum, equation_id
Foreign Key: FK_RDW_EQUATION2GENERAL: site_rownum (IN SITES TABLE)

Table Name: roadway_sideroads
Primary Key: PK_RDW_SIDEROAD: site_rownum, sideroad_id
Index: PK_RDW_SIDEROAD: site_rownum, sideroad_id
Foreign Key: FK_RDW_SIDEROAD2GENERAL: site_rownum (IN SITES TABLE)

Table Name: landslide_history
Primary Key: PK_LND_HISTORY: site_rownum, history_id
Index: PK_LND_HISTORY: site_rownum, history_id
Foreign Key: FK_LND_HISTORY: site_rownum (IN SITES TABLE)

Table Name: landslide_maintenance
Primary Key: PK_LND_MAINTENANCE: site_rownum, maintenance_id
Index: PK_LND_MAINTENANCE: site_rownum, maintenance_id
Foreign Key: FK_LND_MAINTENANCE: site_rownum (IN SITES TABLE)

Table Name: landslide_remedial_n_cost
Primary Key: PK_LND_RMD_N_COST: site_rownum
Index: PK_LND_RMD_N_COST: site_rownum
Foreign Key: FK_LND_RMD_N_COST: site_rownum (IN SITES TABLE)

Table Name: cbr

Primary Key: PK_CBR: site_rownum, hole_id, sample_id
Index: PK_CBR: site_rownum, hole_id, sample_id
Foreign Key: CBR_TO_SAMPLES: site_rownum, hole_id, sample_id

Table Name: classification_soil

Primary Key: PK_CLASSIFICATION_SOIL: site_rownum, hole_id, sample_id
Index: PK_CLASSIFICATION_SOIL: site_rownum, hole_id, sample_id
Foreign Key: CLASS_TO_SAMPLES: site_rownum, hole_id, sample_id

Table Name: consolidation

Primary Key: PK_CONSOLIDATION: site_rownum, hole_id, sample_id
Index: PK_CONSOLIDATION: site_rownum, hole_id, sample_id
Foreign Key: CONS_TO_SAMPLES: site_rownum, hole_id, sample_id

Table Name: grainsize

Primary Key: PK_GRAINSIZE: site_rownum, hole_id, sample_id, sieve_id
Index: PK_GRAINSIZE: site_rownum, hole_id, sample_id, sieve_id
Foreign Key: FK_GRAINSZ2SAMPLE: site_rownum, hole_id, sample_id

Table Name: lithology

Primary Key: PK_LITHOLOGY: site_rownum, hole_id, sample_id, primsec
Index: PK_LITHOLOGY: site_rownum, hole_id, sample_id, primsec
Foreign Key: LITH_TO_SAMPLES: site_rownum, hole_id, sample_id

Table Name: moistdensity

Primary Key: PK_MOISTDENSITY: site_rownum, hole_id, sample_id,testnum
Index: PK_MOISTDENSITY: site_rownum, hole_id, sample_id,testnum
Foreign Key: MOIST_TO_SAMPLES: site_rownum, hole_id, sample_id

Table Name: mr

Primary Key: MR: site_rownum, hole_id, sample_id, sample_no
Index: MR: site_rownum, hole_id, sample_id, sample_no
Foreign Key: MR_F: site_rownum, hole_id, sample_id

Table Name: otherrocktests

Primary Key: PK_OTHERROCKTESTS: site_rownum, hole_id, sample_id,otsubsample_id
Index: PK_OTHERROCKTESTS: site_rownum, hole_id, sample_id,otsubsample_id
Foreign Key: OTHER_TO_SAMPLES: site_rownum, hole_id, sample_id

Table Name: sdi_jarslake

Primary Key: PK_SDI_JARSLAKE: site_rownum, hole_id, sample_id sdisubsample_id
Index: PK_SDI_JARSLAKE: site_rownum, hole_id, sample_id sdisubsample_id
Foreign Key: SDI_TO_SAMPLES: site_rownum, hole_id, sample_id

Table Name: soilfieldstrengthtest

Primary Key: ***PK_SOILFIELDSTRENGTHTESTS: site_rownum, hole_id, sample_id***

Index: ***PK_SOILFIELDSTRENGTHTESTS: site_rownum, hole_id, sample_id***

Foreign Key: FIELD_TO_SAMPLES: site_rownum, hole_id, sample_id

Table Name: soillabstrengthtest

Primary Key: PK_SOILLABSTRENGTHTESTS: site_rownum, hole_id, sample_id, strentestnum

Index: PK_SOILLABSTRENGTHTESTS: site_rownum, hole_id, sample_id, strentestnum

Foreign Key: LAB_TO_SAMPLES: site_rownum, hole_id, sample_id

Table Name: soilvisdesc

Primary Key: PK_SOILVISDESC: site_rownum, hole_id, sample_id, primsec

Index: PK_SOILVISDESC: site_rownum, hole_id, sample_id, primsec

Foreign Key: VISUAL_TO_SAMPLES: site_rownum, hole_id, sample_id

Table Name: rockfall_pictures

Primary Key: PK_ROCKFALL_PICTURES: site_rownum, picture_id

Index: PK_ROCKFALL_PICTURES: site_rownum, picture_id

Foreign Key: RKF_PIC2SITES: site_rownum

Table Name: pictures

Primary Key: PK_PICTURES: site_rownum, picture_id
Index: PK_PICTURES: site_rownum, picture_id
Foreign Key: FK_PICTURES: site_rownum (IN SITES TABLE)

Table Name: landslide_pictures

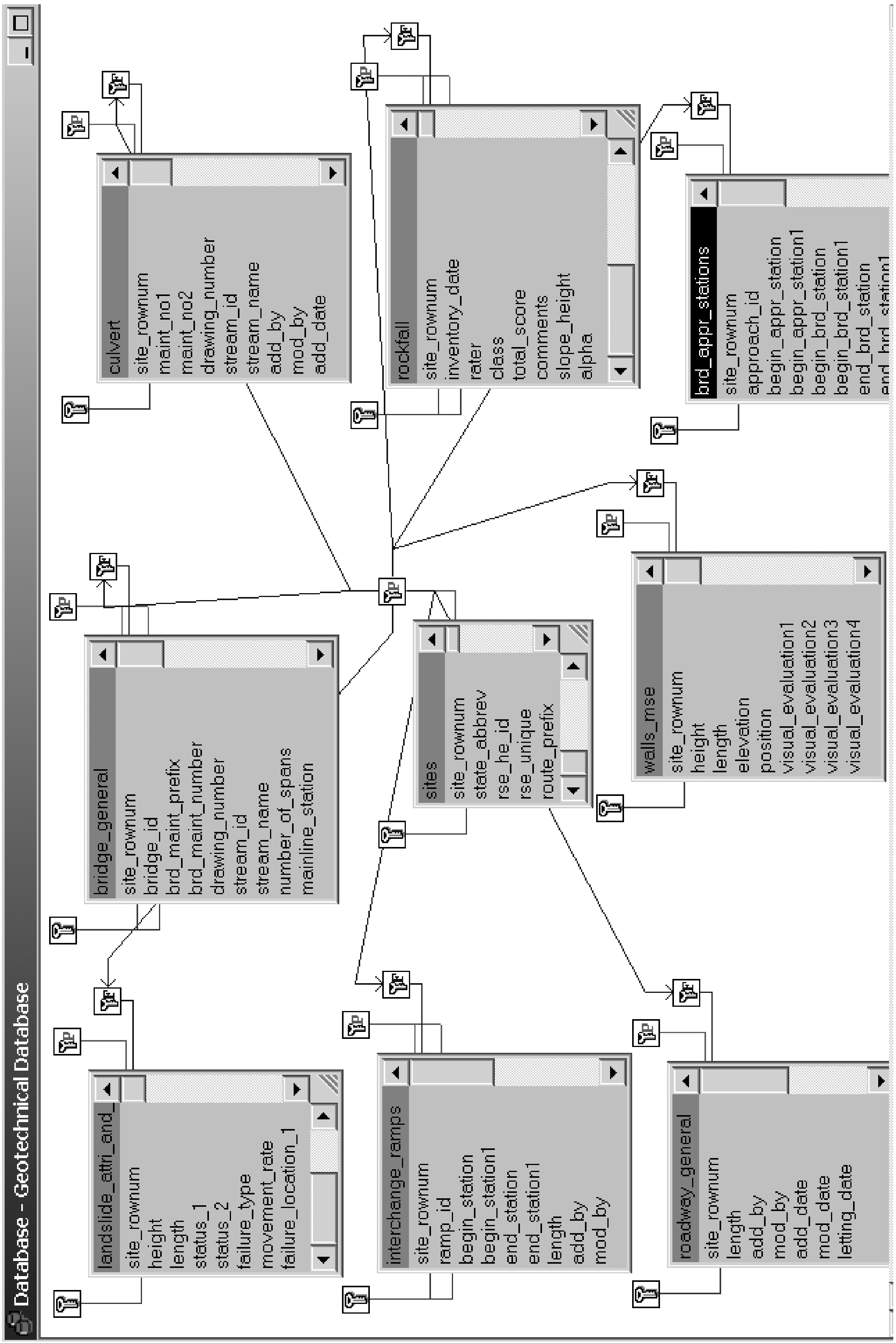
Primary Key: PK_LANDSLIDE_PICTURES: site_rownum, picture_id
Index: PK_LANDSLIDE_PICTURES: site_rownum, picture_id
Foreign Key: FK_LANDSLIDE_PICTURES: site_rownum (IN SITES TABLE)

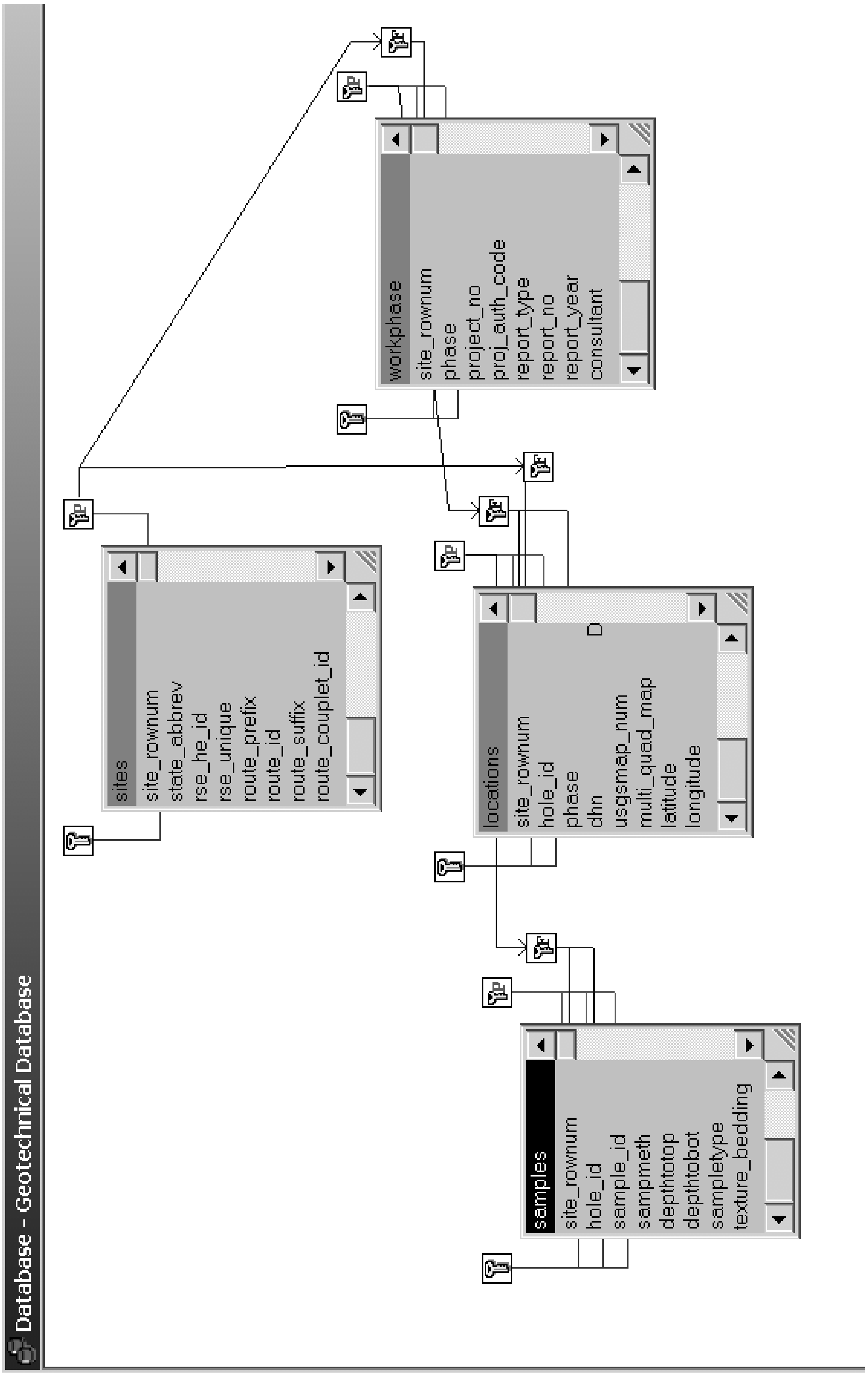
Table Name: users

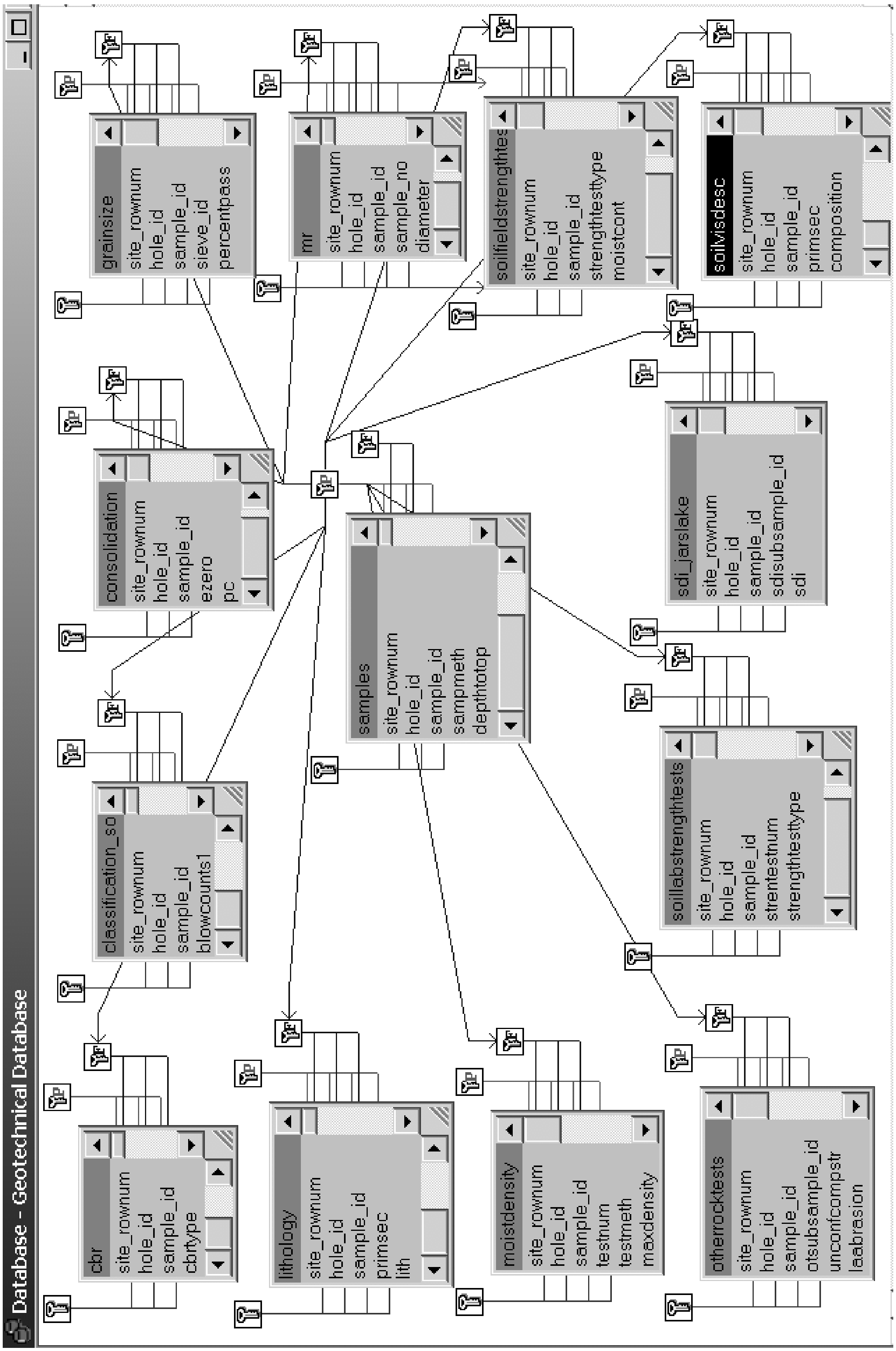
Primary Key: None
Index: USERS_X: last_name
Foreign Key: None

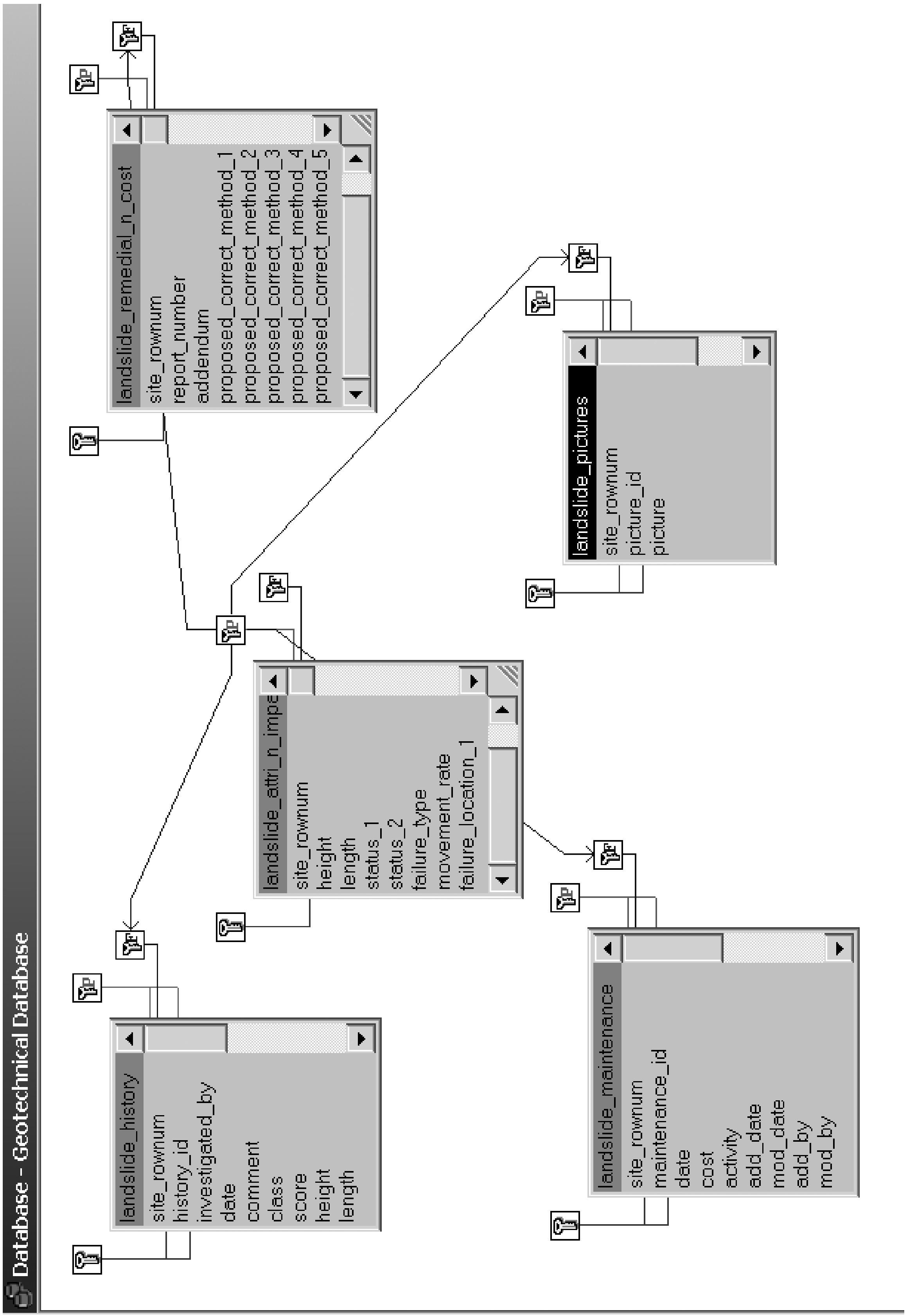
Table Name: db_summary

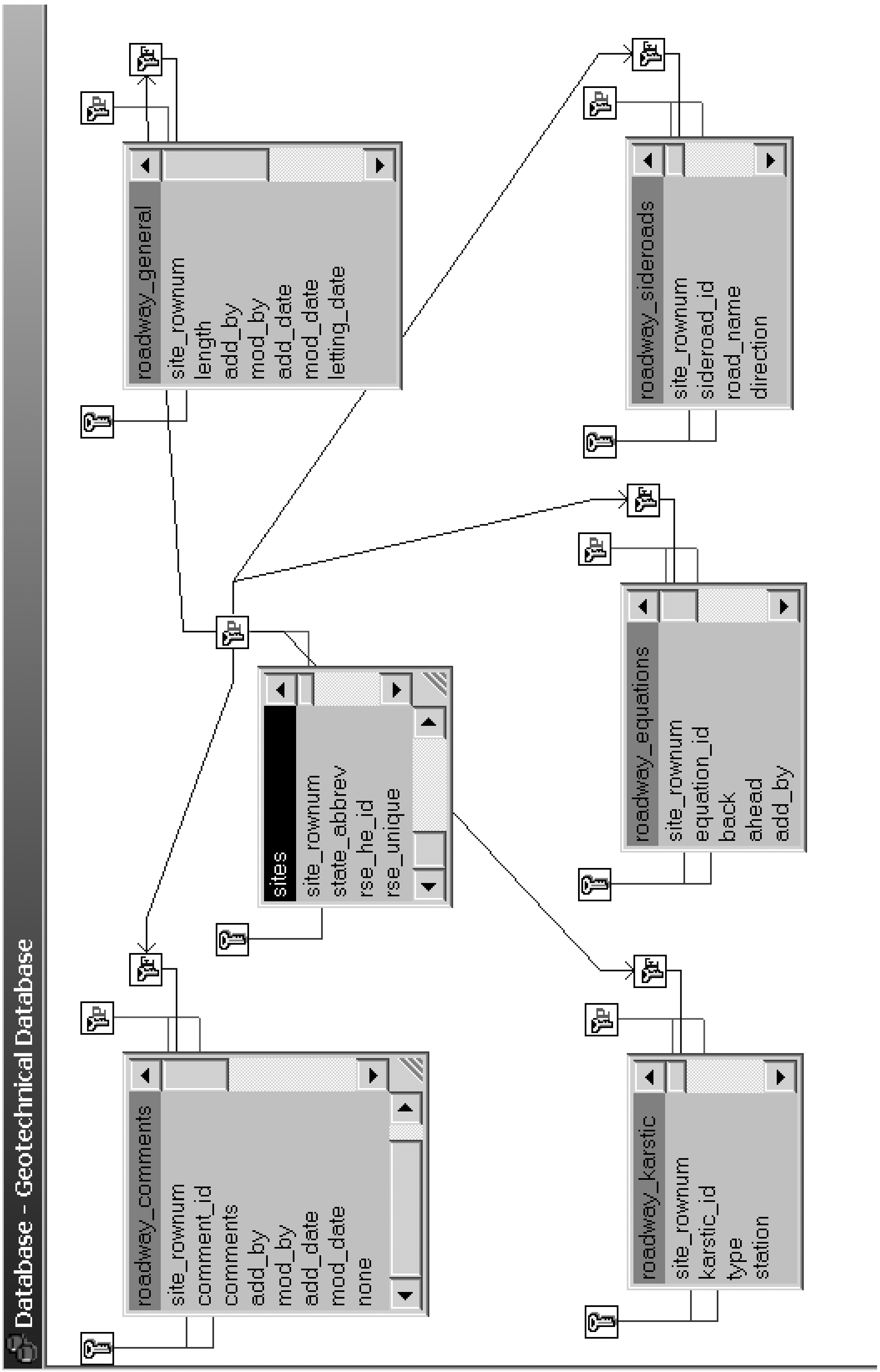
Primary Key: DB_SUMMARY_ID: county_id
Index: DB_SUMMARY_ID: county_id
Foreign Key: None


Database - Geotechnical Database
culvert
site_rownum
maint_no1
maint_no2
drawing_number
stream_id
stream_name
add_by
mod_by
add_date
rockfall
site_rownum
inventory_date
rater
class
total_score
comments
slope_height
alpha
brd_appr_stations
site_rownum
approach_id
begin_appr_station
begin_appr_station1
begin_brd_station
begin_brd_station1
end_brd_station
bridge_general
site_rownum
bridge_id
brd_maint_prefix
brd_maint_number
drawing_number
stream_id
stream_name
number_of_spans
mainline_station
sites
site_rownum
state_abbrev
rse_he_id
rse_unique
route_prefix
walls_mse
site_rownum
height
length
elevation
position
visual_evaluation1
visual_evaluation2
visual_evaluation3
visual_evaluation4
landslide_attri_and_
site_rownum
height
length
status_1
status_2
failure_type
movement_rate
failure_location_1
interchange_ramps
site_rownum
ramp_id
begin_station
begin_station1
end_station
end_station1
length
add_by
mod_by
roadway_general
site_rownum
length
add_by
mod_by
add_date
mod_date
letting_date


Database - Geotechnical Database
sites
site_rownum
state_abbrev
rse_he_id
rse_unique
route_prefix
route_id
route_suffix
route_couplet_id
workphase
site_rownum
phase
project_no
proj_auth_code
report_type
report_no
report_year
consultant
locations
site_rownum
hole_id
phase
dhn
usgsmap_num
multi_quad_map
latitude
longitude
samples
site_rownum
hole_id
sample_id
sampmeth
depthtotop
depthtobot
sampletype
texture_bedding


Database - Geotechnical Database
grainsize
site_rownum
hole_id
sample_id
sieve_id
percentpass
mr
site_rownum
hole_id
sample_id
sample_no
diameter
soilfieldstrengthtes
site_rownum
hole_id
sample_id
strengthtesttype
moistcont
soilvisdesc
site_rownum
hole_id
sample_id
primsec
composition
consolidation
site_rownum
hole_id
sample_id
ezero
pc
samples
site_rownum
hole_id
sample_id
sampmeth
depthtotop
sdi_jarslake
site_rownum
hole_id
sample_id
sdisubsample_id
sdi
classification_so
site_rownum
hole_id
sample_id
blowcounts1
soillabstrengthtests
site_rownum
hole_id
sample_id
strentestnum
strengthtesttype
cbr
site_rownum
hole_id
sample_id
cbrtype
lithology
site_rownum
hole_id
sample_id
primsec
lith
moistdensity
site_rownum
hole_id
sample_id
testnum
testmeth
maxdensity
otherrocktests
site_rownum
hole_id
sample_id
otsubsample_id
unconfcompstr
laabrasion


Database - Geotechnical Database
landslide_remedial_n_cost
site_rownum
report_number
addendum
proposed_correct_method_1
proposed_correct_method_2
proposed_correct_method_3
proposed_correct_method_4
proposed_correct_method_5
landslide_pictures
site_rownum
picture_id
picture
landslide_attri_n_impe
site_rownum
height
length
status_1
status_2
failure_type
movement_rate
failure_location_1
landslide_history
site_rownum
history_id
investigated_by
date
comment
class
score
height
length
landslide_maintenance
site_rownum
maintenance_id
date
cost
activity
add_date
mod_date
add_by
mod_by


Database - Geotechnical Database
roadway_general
site_rownum
length
add_by
mod_by
add_date
mod_date
letting_date
roadway_sideroads
site_rownum
sideroad_id
road_name
direction
sites
site_rownum
state_abbrev
rse_he_id
rse_unique
roadway_equations
site_rownum
equation_id
back
ahead
add_by
roadway_comments
site_rownum
comment_id
comments
add_by
mod_by
add_date
mod_date
none
roadway_karstic
site_rownum
karstic_id
type
station

Appendix C

Data Dictionary of the Kentucky Geotechnical Database

Table Name: sites

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of an RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

state_abbrev: A standard two-character abbreviation for the state the site is located in. For example, if a site is in Kentucky, KY is the input value. KY is the default site. States bordering Kentucky can be selected.

rse_he_id; Not used[3]

rse_unique: Not used

route_prefix; A designation used to describe the route prefix type used by the Kentucky Transportation Cabinet. KY designates a Kentucky route, I designates an Interstate route, US designates an US route, CR designates a County route maintained by a local county road department, CS is a local city street, FD is a Federal Park Service route, FH is a National Forest Service route, PY is a Parkway, NL is a new road being planned that has not had a route prefix or number assigned by the Kentucky Transportation Cabinet.

route_id; The Route Number assigned by the Kentucky Transportation Cabinet.
Route numbers used in Kentucky for **interstates, parkways, US highways and state routes**, are unique (with a single exception discussed below). For example, since Interstate 64 runs through Kentucky, there is no US 64 or KY 64. Similarly, US 60 runs through Kentucky, so 60 is not applied to any state route (there is no KY 60). This allows that, when querying data, only the route number is required. If, in the route number retrieval box, we enter 60, 61 and 64, we will automatically get US 60, KY 61 and Interstate

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[3] *Italics, or red color, denote columns that are no longer used because of requested changes by the Owner and will be removed in the future.*

64. The lone exception to this uniqueness is US 79/KY 79. US 79 enters Kentucky near Guthrie, on the Tennessee state line in Todd County, and runs northeasterly to Russelville. From there, KY 79 continues north to Brandenburg on the Ohio River. When 79 is entered as the route number, data for both US 79 and KY 79 are retrieved. This is not a problem, however, since they are contiguous roadway segments. Kentucky's nine parkways are numbered from 9000 to 9009. The same numbers are used in the database. They are unique as no state or county routes have numbers this high.

This uniqueness of route numbers does not extend to **county routes**. In each county these routes begin with CR 1001 and the highest CR numbers are in the 1600's. Jefferson County does not have numbered county routes (other than US and state routes, roads and streets in Jefferson County go by name only). At the time of this writing, if the database was queried asking for route 1001, without specifying County, three sites would be accessed. They are CR 1001 (Jackstown Road) in Bourbon County, CR 1001 (Middle Knottsville Road) in Hancock County, and CR 1001 (Poindexter Road) in Harrison County. There are no interstates or US highway routes with numbers this high (they never have four digits), but some **state routes** share the same numbers as **county routes**. Had the database included data on KY 1001, it would also have been retrieved.

Route numbers used in the database are identical to actual route numbers of roads and highways. However, because it is very convenient to access data by route number, the database also employs temporary and fictitious "route numbers". These numbers apply only to the database and are not used by other departments or agencies. To date, state routes (other than frontage roads which use numbers in the 6000's) are never higher than 3599. Numbers in the 4000's, 5000's (see ordering numbers), 7000's and 8000's are not used for actual highway routes, but these numbers are employed within the database. The following schemes have been used.

Four-thousand series "route numbers" are used for **new location routes**, which have no route number during design, but will be assigned a route number prior to being opened to traffic. In current practice By Passes, being constructed around towns where no By Pass existed before, commonly fall into this category. The Route Prefix "NL" (new location) is used for these roadway and structure sites. For the most part, data entered with new location route numbers is temporary storage. Ideally, as actual route numbers are assigned to these roadways, site level entries should be updated to reflect the change. The way NL-series (4000-series) route numbers are assigned is the last three digits are for the county in which the road (or structure) is located. Thus NL 4001 is a new (officially unnumbered) route in Adair County (county 001) while NL 4097 would be a new route in Perry County (since Perry County is county 097). Since Kentucky has 120 counties, 4000-series numbers higher than 4120 are never used.

Eight-thousand series "route numbers" are used for **city streets** and/or **unnumbered rural roads** (having no county route designation). The prefixes CS (city street) and UR (unnumbered rural road) are used. As with 4000- and 7000-series "route numbers" the last three digits designate which county these streets and roads are in. Thus "route" 8056 is city streets in Jefferson County while 8024 is city streets in Christian County, et cetera. ***Ordering Number*** is then used to alphabetize entries within these "routes."

route_suffix; An abbreviated suffix, such as BY for Bypass, and is followed by Route Number, which is assigned by the Kentucky Transportation Cabinet.

route_couplet id; not used

site location; Used for any additional information regarding the location of a site.

site descr; Used for any additional information that is used to describe a site.

order number; An arbitrary system used to align sites on a route within a county. Ordering numbers are used to arrange sites in convenient ways. They were initially applied to sites along numbered highway routes, but were soon expanded to apply to other types of sites as well. The first portion of this discussion applies to numbered highway routes, and a discussion of other types of sites follows.

For numbered highway routes, all ordering numbers are eight digits in length; four before the decimal point, and four after. For US and state routes, as well as interstates, the four digits before the decimal correspond directly to the route numbers. Thus, that portion of the ordering number before the decimal point simply arranges sites by route number. Of course it is possible to arrange a list of sites in various ways – by project type, or by county, for example. However, in an all inclusive listing, arranged by ordering number, all sites along KY 1 would be printed first, followed by all sites along KY 2, et cetera. The various interstates would not be printed until further down the list, once their respective numbers were reached. The same would be true of the various US routes. Following the system used by other divisions within the Transportation Cabinet, we add 4000 to all county routes, which duplicate some numbers used for state routes. This means that in a listing arranged by ordering number, county routes would be grouped together in a section following the listing of all state, federal and interstate routes.

Of course, it is not necessary to retrieve an all-inclusive list of sites. Using the *Route Prefix* button on the "Simple Search Screen" we could select only interstates, only US routes, or numerous other groupings. In the case of Interstates, all I 24 sites would be printed first, followed by I 64 sites, then 65, 71, et cetera, and the sites for I 471, the highest numbered interstate would be printed last. If we selected all sites in Adair County, and then ordered by ordering number, sites from route ---- would be shown first, because this is the lowest numbered route in Adair County (or the lowest to currently have entered sites). The four digits following the decimal point are used for secondary ordering within routes. Sites along any given route are numbered as one would come to them driving down the road.

route_prefix secondary; A designation used to describe the prefix type of a route that intersects, or is part of an interchange, with the initial route the site is identified in. The prefixes are used by the Kentucky Transportation Cabinet. KY designates a Kentucky route, I designates an Interstate route, US designates an US route, CR designates a County route maintained by a local county road department, CS is a local city street, FD is a Federal Park Service route, FH is a National Forest Service route, PY is a Parkway.

route_secondary; A designation indicating the number assigned by the Kentucky Transportation Cabinet of a route that intersects, or is part of an interchange, with the route the site is identified in.

route_suffix secondary; A designation used to describe the suffix of a route that intersects, or is part of an interchange, with the initial route the site is identified in.

couplet secondary;

order_number_secondary; An arbitrary system used to align sites on a route that intersects or interchanges with the initial route within a site within a county.

project_type; A project can be a landslide, rock fall, RW-Mainline (roadway mainline), sideroad, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. Wall is subdivided into different types of retaining walls; MSE (mechanically stabilized earth) gravity, semigravity, cantilever, counterfort, CMU, noise, and crib

source_id; The name of the organization that created the site, Example UK KTC is the University of Kentucky Transportation Center, KYDOT is the Kentucky Department of Transportation. Some Engineering consulting firms that perform geotechnical services for the KYDOT are also included.

county_id; The county where the site is located in.

highway_district; The Highway District (Kentucky only) the site is located in. If another state (and county) is selected, Highway District defaults to 0.

center_line; Used to describe the side of a site - left or right- (when feasible such as a landslide, rock slope, wall) with respect to the highway centerline. By convention, highway centerlines are considered to run north for odd numbered and east for even numbered roads.

Direction; The direction of the traveling lane a site is located on. This is helpfully when sites are located on divided highways with medians.

begin_mp; The beginning milepoint, if known of a site location.

end_mp; The ending milepoint, if known of a site location.

latitude; If latitude is entered in degrees, minutes and seconds, decimal degrees (and state plane coordinates) will be calculated and the corresponding fields will be filled.

longitude; If longitude is entered in degrees, minutes and seconds, decimal degrees (and state plane coordinates) will be calculated and the corresponding fields will be filled.

railroad_crossing; This field is used to indicate if the site includes a railroad crossing.

wet_crossing; This field is used to indicate if the site includes a stream crossing.

stream_id; The stream number assigned by the DBA (Database administrator), or other designated personnel, if the site includes a stream crossing.

stream_name; The stream name, if the site includes a stream crossing.

add_date; A calendar date automatically recorded by the database system when data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing data.

begin_station; The beginning station integer number assigned by the Kentucky Transportation Cabinet. Each integer equals one-foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

end_station; The ending station integer number assigned by the Kentucky Transportation Cabinet.

begin_sta1; The beginning station decimal number assigned by the Kentucky Transportation Cabinet when it is not an even foot distance (English units). The project begin station may be listed as 100 + 00.000. This divides the unit used (feet) into thousandths).

ed_sta1; The ending station decimal number assigned by the Kentucky Transportation Cabinet.

no_holes; The number of holes or borings that are associated with the site. A site within the database may or may not have holes or borings associate with it. If holes are not associated with the site does not imply that no borings were performed. Hole or boring data has been entered for many sites, but it is not complete.

no_s_sam; The number of soil samples associate with a site. A hole or boring may contain zero to an infinite number of soil samples. The number of samples is compiled as the data is entered.

no_r_sam; The number of rock samples associate with a site. A hole or boring may contain zero to an infinite number of rock samples. The number of rock samples is compiled as the data is entered.

no_phases; The number of phase associate with a site. The value of the geotechnical database derives in part from the fact that sites where geotechnical investigations are performed may eventually become the focus of additional study. Consider, for example, a bridge constructed in the mid 1970's. A geotechnical investigation was performed, and the results of drilling and lab testing were entered into the database. The date of the drilling, who performed the drilling, who the bridge designer was, and who performed the laboratory testing are among the data entered. The item number, that English (as opposed to Metric) units were used, and the vertical control datum (sea level or assumed, for example) were also entered.

Now, some thirty years later, a new bridge, wider than the original to accommodate increased traffic volume, is required. The new bridge is to be constructed at essentially the same location as the existing bridge. In some situations of this type, information obtained from the original geotechnical investigation could be adequate for developing plans for the new structure, saving both time and money. In other cases, however, additional drilling will be required. Since the location of the bridge has not changed, it is logical to consider it to be the same site. However, much of the information previously recorded will have changed. It is unlikely that the organization and individuals performing the new drilling will be the same as those who performed these jobs years earlier. The same is true of the bridge designer, and the new job may even be designed in Metric units as opposed to the English units of the older design. To accommodate these changes, the database format allows that when a new phase of work is identified, any or all of these fields can change. The bridge designer for the structure built in the 1970's (that is the Phase 1 bridge designer) is retained in the records, but the bridge designer for the new (Phase 2) bridge is also shown.

It may also be advantageous to assign different phases of work on the same general project. During design it may be discovered that additional information beyond that provided by the original geotechnical investigation is required. Thus, many months, or even a couple of years after the original investigation a drill crew is sent out for additional borings and samples. It is convenient, then, to identify the original work as phase 1, and the additional work as phase 2. A different crew than the crew that performed the phase 1 drilling could easily perform phase 2 drilling. However, by identifying the work as different phases, this and other changes are easily accommodated.

has_drill_data; Used to indicate if a site has drill (boring) data.

hole_data_complete; Indicates if all hole data for the site is complete.

has_soil_samples; Indicates if soil samples were obtained from holes at the site.

soil_sample_data_complete; Indicates if all soil sample data for the site is complete.

has_bedrock_samples; Indicates if bedrock samples were obtained from holes at the site.

rock_sample_data_complete; Indicates if all rock sample data for the site is complete.

kgs_stratigraphy_complete; Indicates if the Kentucky Geological Survey has identified mapped rock intervals with depth. This is not currently used.

structure_station; Culverts bisect the roadway which crosses them. The point where the center of the culvert intersects the centerline of the roadway is defined as the culvert location with respect to the roadway stations.

stru_sta1; The decimal portion of the roadway station number (structure_station column) where the roadway intersects with the culvert.

no_b_sam; The number of samples obtained from holes or borings described as boulders within the site. Boulders are large rocks present as fill material or in soil deposits, not in place bedrock.

no_o_sam; The number of soundings in a site. A Sounding is a type of boring which is used to determine the depth to bedrock. Soil and rock samples are not obtained when soundings are performed. Soundings are advanced, without sampling, to bedrock, or alternatively to some considerable depth, to confirm that the bedrock surface is at greater depth. Even though no soil samples are obtained, determining depth to bedrock is often important since the rock surface is frequently employed as the load-bearing strata for various types of structure foundations (end bearing piles or spread footings on bedrock, for example).

no_p_sam; The number of rock outcrops associated with a site. A rock outcrop is where bedrock is exposed at the surface.

new_order_number; A new ordering number assigned to an existing site.

mid_mp; The approximate middle mile point of a landslide. This information was included in an older database maintained by the Geotechnical Branch that was imported into the current structure.

no_l_sam; The number of open face logs for an individual location. An open face log is sometimes uses to describe rock units in a highway cut, especially where reconstruction of an existing route is being designed**.** The system allows an open face log to be recorded before construction and a subsequent open face log can be recorded after construction.

old_data; Landslide data that was imported older database maintained by the Geotechnical Branch that was imported into the current structure.

number_of_pictures; The number of photographs embedded in the database associated with the site.

corrected; An indicator used to archive an active landslide. This is used when a landslide has been repaired. The landslide site remains in the database.

road_system; Highways maintained by the Kentucky Transportation Cabinet are divided into systems. Funding for construction and maintenance is sometimes dependent on the type of Road System. The systems are Interstate (I), State Primary (SP), State Secondary (SP), Rural Secondary (RS), Supplemental (SUP), and Parkway (MP).

wall_type; Many types of walls are constructed along highway routes. Wall type is subdivided into different types of retaining walls; MSE (mechanically stabilized earth) gravity, semigravity, cantilever, counterfort, CMU (concrete masonry unit), noise, and crib. Geotechnical information has been or can be generated for all sites.

no_holes_w_lat_long; Indicates the number of bore holes within the site that have latitude and longitude coordinates**.**

Table Name: locations

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

hole_id; An integer number used to identify holes or borings within a site. Hole numbers are assigned as the hole data is entered into the database. An effort has been made to number holes in ascending order with project station numbers. This is not always the case as some holes are added at later dates. Borings (holes), Rock Outcrops and Open-face Logs are referred to in this database as locations. Although there are several different types of borings, a single layout for the *borings GUI* is used throughout. Rock outcrop locations also use the borings GUI. However Open Face Logs have their own input screen.

phase; A numerical number used to indicate a work phase of a project**.** The value of the geotechnical database derives in part from the fact that sites where geotechnical investigations are performed may eventually become the focus of additional study. Consider, for example, a bridge constructed in the mid 1970's. A geotechnical investigation was performed, and the results of drilling and lab testing were entered into the database. The date of the drilling, who performed the drilling, who the bridge designer was, and who performed the laboratory testing are among the data entered. The item number, that English (as opposed to Metric) units were used, and the vertical control datum (sea level or assumed, for example) were also entered.

Now, some thirty years later, a new bridge, wider than the original to accommodate increased traffic volume, is required. The new bridge is to be constructed at essentially the same location as the existing bridge. In some situations of this type, information obtained from the original geotechnical investigation could be adequate for developing plans for the new structure, saving both time and money. In other cases, however, additional drilling will be required. Since the location of the bridge has not changed, it is logical to consider it to be the same site. However, much of the information previously recorded will have changed. It is unlikely that the organization and individuals performing the new drilling will be the same as those who performed these jobs years earlier. The same is true of the bridge designer, and the new job may even be designed in Metric units as opposed to the English units of the older design. To accommodate these changes, the database format allows that when a new phase of work is identified, any or all of these fields can change. The bridge designer for the structure built in the 1970's (that is the Phase 1 bridge designer) is retained in the records, but the bridge designer for the new (Phase 2) bridge is also shown.

It may also be advantageous to assign different phases of work on the same general project. During design it may be discovered that additional information beyond that provided by the original geotechnical investigation is required. Thus, many months, or even a couple of years after the original investigation a drill crew is sent out for additional borings and samples. It is convenient, then, to identify the original work as phase 1, and the additional work as phase 2. A different crew could easily perform phase 2 drilling than performed the phase 1 drilling. However, by identifying the work as different phases, this and other changes are easily accommodated.

dhn; The drillers hole number is an integer number assigned when the hole is drilled.

usgsmap_num; 7.5 minute quadrangle maps of bedrock in Kentucky, and many other states, nave been published by the United States Geological Survey. Each map has a unique integer number used to identify it. The Tollesboro Quadrangle, located in parts of Lewis and Fleming Counties KY, is GQ map # 661, for example.

multi_quad_map; A one character suffix, A , B or C, for some partial 7.5 minute geologic quadrangles that are positioned along the border line of Kentucky and other states. The maps do not cover an entire 7.5 minute quadrangle. The maps have the same number as an adjacent 7.5 minute map.

latitude; The latitude of a hole input as degrees, minutes, and seconds or decimal degrees.

longitude; The longitude of a hole input as degrees, minutes, and seconds or decimal degrees..

locacc; An estimate of the accuracy of the latitude and longitude of the hole in feet or meters, whichever unit is selected. Some holes have survey grade accuracy while others are determined from maps or plans.

stationa; The integer part of the station number of a hole.

stationb; The integer part less than 100 feet (English units) and decimal portion of the station number of a hole.

stoffset; The distance from the centerline station of the roadway or structure that a hole is drilled at.

offsetdir; The direction, Right or Left, of the centerline of the roadway or structure a hole is drilled at.

surfelev_drillingtime The surface elevation of the hole at the time it was drilled. The elevation may be a surveyed *mean sea level, approximate mean sea level, unknown, assumed,* or obtained from a *crossroads elevation* used for project control.

surfelev_postconstr; The surface elevation of the hole location after the highway or structure has been constructed. The horizontal location will not change. The elevation may be a *surveyed mean sea level, approximate mean sea level, unknown, assumed*, or obtained from a crossroads elevation used for project control.

surfelevcorr; Oftentimes an assumed elevation control elevation is used during construction. All elevations for the project are based on the assumed control elevation. A surface elevation correction is sometimes applied at a later date to correct the assumed elevations to mean sea level.

refusal; A term used to define when a boring advanced with augers or probe rods cannot be advanced due to bedrock.

depthtobedrock; The distance from the top of the hole or boring to where bedrock is encountered.

depthtordz; The distance from the top of the hole to the base of the rock desintergration zone (RDZ) is encountered. The RDZ is the subsurface materials that are composed of weathered and decomposed bedrock. The depth to the base of the RDZ is generally indicated on core logs for roadway projects.

matchmapunit; An indicator used to determine if the rock samples obtained from a hole match those on the bedrock maps. Bedrock maps are usually 7.5-minute geologic quadrangles published by the United States Geological Survey.

depthtowat; The depth to water measured in an observation well installed in a drill hole.

waterdate; The date the depth to water measurement was performed.

bedrock_map_unit; The mapped unit, usually obtained from 7.5 minute geological quadrangles, is the uppermost bedrock unit at the hole location. The unit selected is made from a choice of all mapped bedrock units in Kentucky.

add_date; A calendar date automatically recorded by the database system when data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing data.

rdz_sign; A mathematical operator used to describe if the depth of the RDZ is equal to or greater than an entered depth.

lab_sample_number; An identification assigned to a particular soil or rock sample, obtained from a hole, by the Geotechnical Branch or consultant. The identification may be a number, letters, or combination of both.

no_l_sam; The number of open face logs for an individual location. An open face log is sometimes uses to describe rock units in a highway cut, especially where reconstruction of an existing route is being designed**.** The system allows an open face log to be recorded before construction and a subsequent open face log can be recorded after construction.

location_type; This field describes the various types of borings that may be performed in a geotechnical investigation. The types of borings included are: *Soil Test Sample with Rock Core, Soil Samples and Augured Rock, Soil Test Sample Boring, Soil Visual Description with Rock Core, Soil Visual Description &Augured Rock, Soil Visual Description, Rock Core, Sounding, Sounding for Sinkhole Definition, Open Face Log, and Rock Outcrop*. Soil sample borings provide soil materials for laboratory testing to determine physical properties including strength, grain size, plasticity, et cetera. The principal types of soil samples are Shelby Tubes, and SPT samples. These boring are terminated at or above the rock surface. No soil samples are obtained in rock core borings, but the rock cores are described and characterized to allow estimates of their load-carrying capacity or stability in highway cuts. Soil sample borings with rock cores, as the name implies, yield both soil and rock.

boulder; An operator used to indicate if a boulder or boulders were encountered when drilling a hole.

comments; A field used to indicate any comments associated with the hole.

bedrock_map_unit2; Used when the hole location is near the boundary between two bedrock mapping units. This is used when there is a second possible choice for the mapped bedrock unit.

possibly_1; A descriptor used to describe if the uppermost mapped bedrock unit *is, probably is* or *possibly is* the unit selected from the Bedrock Mapped Unit field that includes all mapped bedrock units in Kentucky. Select, is, when the mapped unit is known.

possibly_2; A descriptor used to describe if uppermost mapped bedrock unit *probably is* or *possibly is* the unit selected from the Bedrock Mapped Unit field that includes all mapped bedrock units in Kentucky. This is used when the rock samples obtained from the hole cannot be correlated with certainty with the mapped bedrock unit.

beneath_1; Used to describe if the uppermost mapped bedrock unit is beneath alluvium, or river deposits.

beneath_2; Used to describe if the secondary uppermost mapped bedrock unit selected is beneath alluvium, or river deposits.

Table Name: workphase

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet. A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

phase; A numerical number used to indicate a work phase of a project**.** The value of the geotechnical database derives in part from the fact that sites where geotechnical investigations are performed may eventually become the focus of additional study. Consider, for example, a bridge constructed in the mid 1970's. A geotechnical investigation was performed, and the results of drilling and lab testing were entered into the database. The date of the drilling, who performed the drilling, who the bridge designer was, and who performed the laboratory testing are among the data entered. The item number, that English (as opposed to Metric) units were used, and the vertical control datum (sea level or assumed, for example) were also entered.

Now, some thirty years later, a new bridge, wider than the original to accommodate increased traffic volume, is required. The new bridge is to be constructed at essentially the same location as the existing bridge. In some situations of this type, information obtained from the original geotechnical investigation could be adequate for developing plans for the new structure, saving both time and money. In other cases, however, additional drilling will be required. Since the location of the bridge has not changed, it is logical to consider it to be the same site. However, much of the information previously recorded will have changed. It is unlikely that the organization and individuals performing the new drilling will be the same as those who performed these jobs years earlier. The same is true of the bridge designer, and the new job may even be designed in Metric units as opposed to the English units of the older design. To accommodate these changes, the database format allows that when a new phase of work is identified, any or all of these fields can change. The bridge designer for the structure built in the 1970's (that is the Phase 1 bridge designer) is retained in the records, but the bridge designer for the new (Phase 2) bridge is also shown.

It may also be advantageous to assign different phases of work on the same general project. During design it may be discovered that additional information beyond that provided by the original geotechnical investigation is required. Thus, many months, or even a couple of years after the original investigation a drill crew is sent out for additional borings and samples. It is convenient, then, to identify the original work as phase 1, and the additional work as phase 2. A different crew could easily perform phase 2 drilling than performed the phase 1 drilling. However, by identifying the work as different phases, this and other changes are easily accommodated.

project_no; A variable character used to enter the project number assigned by Kentucky Transportation Cabinet for a particular project. No longer used.

proj_auth_code; A number identifying the project authorization code assigned by Kentucky Transportation Cabinet for a particular project. No longer used.

report_type; A single character used to select the report type from the following: *Roadway (R), Structures (S) Landslide, L), Building (B) ,Construction (C), Estimates (E), General Counsel (G), Maintenance (M), Planning (P), Rock Sloe Design (K),* and *Traffic Permits (T).* The Geotechnical Branch and consultants issue hundreds of reports annually for these type of projects.

report_no; A number assigned to each report type. The numbers are assigned chronologically beginning in January and continuing through out the calendar year. The first Roadway Report issued in January would R-01-XX, with XX being the last two digits of the year the report was issued.

Since 1973, most reports issued by the Geotechnical Branch have been assigned numbers, to facilitate tracking them. The format is X-#-Y, where X indicates the type of report, Y is the year in which it was published, and # is a sequential numbering of reports of the specified type issued during any given year. In paper files, year was historically, and commonly even now, reported with two digits (79 means 1979 while 02 means 2002). Of course it is always recorded with four digits in the database. Report types include R (roadway), S (structure), L (landslide) C (construction) and M (maintenance). Structure (S) reports include bridges, culverts and walls. On occasion they could also include buildings (salt domes, rest area facilities, or other buildings).

The Geotechnical Branch has also issued RSD (rock slope design) reports to facilitate construction of highway cuts in rock. Generally, drilling results and rock core logs presented in RSD reports are also presented, along with a good deal of additional information, in a roadway report for the same project. In these cases, which apply to over 90% of the RSD reports, it is unnecessary to enter RSD report data in the database. If all data from the roadway report is entered, then data in the RSD report would be redundant (but since the roadway report includes data not presented in the RSD report, the reverse would not be true). There are cases where an RSD report is issued for a project, but no roadway report is ever issued. When we find an RSD report that has no accompanying roadway report, meaning data presented in the RSD report are not duplicated elsewhere, this information should be input into the database. Since there are only a few of these (the exact or even approximate number is unknown) and also because the 3-character RSD designation is a problem in a database structure that allows only one character to specify report type, we have developed an alternate recording scheme. We record them as R (roadway) reports with #'s beginning with 900. The highest number used for regular roadway reports, to date, is 63, so a number 900 or above indicates that the data was actually issued as an RSD report rather than as a regular roadway report.

Prior to 1973, no numbers were assigned to reports. Some of these reports are still available in hard-copy project files, however, and as time permits this data may be input. To facilitate cataloguing, these reports are assigned a report number (the lowest unused number, for the particular type of report, for the appropriate year). Often, geotechnical reports prepared by geotechnical consultants, are issued by the Geotechnical Branch, and assigned a number at the time they are issued. In numerous other cases, however, they were not assigned numbers. When such data are entered into the database, these consultant reports are also given newly assigned report numbers.

report_year; The two digit integer indicating which year a report was issued.

consultant; No longer used

addendum; A 1 digit integer used to indicate any addendums to the original report. The original report uses a default value of zero (0). Up to six additional addendums can be added.

driller; The name or an abbreviation of the organization or consulting firm performing the drilling and the name of the driller.

drilling_year; A four digit integer indicating the year which the drilling was conducted.

geolab; The name of the laboratory that performed the geotechnical testing of the samples obtained from drilling operations.

geotech; The name of the organization or consulting firm that performed the geotechnical engineering analysis for the project.

report_who; The person who wrote the geotechnical report.

report_who2; A second person who wrote the geotechnical report.

item; Used to denote the Item number assigned to the project by the Kentucky Transportation Cabinet

cbrp; A field used to designate if a bridge design is included in the *County Bridge Replacement Program.* The Kentucky Transportation Cabinet administers the program which funds bridge replacements for roads maintained by county road departments.

drawg; A variable character number assigned to bridges and other structures by the Kentucky Transportation Cabinet.

datum; The method used to determine elevations for the project. The elevations may be a surveyed mean sea level, approximate mean sea level, unknown, assumed, or obtained from a crossroads elevation used for project control.

designer; The name of the firm designing the structure, roadway segment , or corrective measures.

bridge_maint_no1; A number issued by the Kentucky Transportation Cabinet for individual bridges within a county. Bridges on roads maintained by local county road departments are included in the bridge numbering system. The bridge number begins with B or C followed by a five-digit integer. Numbers are unique for the county only. The same bridge number may be repeated within different counties. **Note: This column renamed brd_maint_number and moved to another table, Bridge-general, after revision.**

bridge_maint_no2; not used

let_date; The calendar date that a contract was let for a construction project.

units; A field used to designate the type of measuring system – English or Metric—when a project was first initiated. During the mid to late 1990's the Kentucky Transportation Cabinet used the Metric system for highway projects.

add_date; A calendar date automatically recorded by the database system when data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing data.

no_holes; The number of holes (borings) drilled at a site which are entered into the database.

no_s_samples; The number of soil samples, obtained from holes, at a site which are entered into the database.

no_r_samples; The number of rock samples, obtained from holes, at a site which are entered into the database.

comments; a field used to indicate any comments associated with the hole.

no_b_sam; The number of samples obtained from holes or borings described as boulders within the site. Boulders are large rocks present as fill material or in soil deposits, not in place bedrock.

no_o_sam; The number of soundings in a site. A sounding is a type of boring which is used to determine the depth to bedrock. Soil and rock samples are not obtained when soundings are performed. Sounding**s** are advanced, without sampling, to bedrock, or alternatively to some considerable depth, to confirm that the bedrock surface is at greater depth. Even though no soil samples are obtained, determining depth to bedrock is often important since the rock surface is frequently employed as the load-bearing strata for various types of structure foundations (end bearing piles or spread footings on bedrock, for example).

no_p_sam; The number of rock outcrops associated with a site. A rock outcrop is where bedrock is exposed at the surface.

surfelevcorr; Oftentimes an assumed elevation control elevation is used during construction. All elevations for the project are based on the assumed control elevation. A surface elevation correction is sometimes applied at a later date to correct the assumed elevations to mean sea level.

no_l_sam; The number of open face logs for an individual location. An open face log is sometimes uses to describe rock units in a highway cut, especially where reconstruction of an existing route is being designed**.** The system allows an open face log to be recorded before construction and a subsequent open face log can be recorded after construction.

xy_accuracy; Used to designate the horizontal accuracy of the hole location.

z_accuracy; Used to designate the vertical accuracy (elevation) of the hole location.

report_date; The calendar date any type of geotechnical report was issued by the Geotechnical Branch.

issued_by; The organization that issued the geotechnical report.

additional_drilling; Used to designate if any additional drilling was performed after the initial drilling was completed.

additional_lab_test; Used to designate if any additional laboratory testing was performed on samples obtained from drilling after the initial drilling was completed.

month; Used to indicate the month the initial drilling was performed in.

Table Name: samples

site_rownum: Each site within the database is associated with a unique site number, and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are write on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. However, when a new site is created by copying an existing site, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), sideroad, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfalls. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW_Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

hole_id; The number of the hole, within the site, that a sample was obtained from.

sample_id; The number of the sample obtained from a hole. Samples obtained from a hole are numbered in the order they are obtained from top to bottom.

sampmeth; The method used to obtain the sample. There are several methods used to obtain soil and rock samples. Common methods of obtaining soil samples are Shelby (thin-walled) tubes, auger, and Standard Penetration Tests. Rock samples are typically obtained using coring techniques.

depthtotop; The depth from the top of the hole to the top of the sample obtained.

depthtobot; The depth from the top of the hole to the bottom of the sample obtained.

sampletype; The types of samples are Tested Soil, Rock, Visual Description, and Artificial Fill.

texture_bedding; Choices available if the sample type is rock are: Bedded Rock (in place), possibly a boulder, probably a boulder, or boulder (transported rock**).**

comments; Any comments pertaining to sample types, depths, or methods.

rock_unit; The mapped rock unit**.** The unit selected is made from a choice of all mapped bedrock units in Kentucky.

Stratcontr; Various terms used to describe the sample.

add_date; A calendar date automatically recorded by the database system when sample data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when sample data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added sample data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing sample data.

Voids; Used to describe any voids observed in a rock core sample. A maximum of five voids can be described within one rock sample. Voids are openings within the bedrock mass. Natural voids, solution channels, fractures, man made openings (mine shafts) are considered voids in this database.

Joints; Used to describe any joints observed in a rock core sample. A maximum of five joints can be described within one rock sample. Joints are cracks or fissures with the bedrock mass.

void_number_1 The first void documented in a rock sample.

void_number_2 The second void documented in a rock sample.

void_number_3 The third void documented in a rock sample.

void_number_4 The fourth void documented in a rock sample.

void_number_5 The fifth void documented in a rock sample.

void_top_1 The depth to the top of the first void documented in a rock sample.

void_top_2 The depth to the top of the second void documented in a rock sample.

void_top_3 The depth to the top of the third void documented in a rock sample.

void_top_4 The depth to the top of the fourth void documented in a rock sample.

void_top_5 The depth to the top of the fifth void documented in a rock sample.

void_bottom_1 The depth to the bottom of the first void or joint documented in a rock sample.

void_bottom_2 The depth to the bottom of the second void or joint documented in a rock sample.

void_bottom_3 The depth to the bottom of the third void or joint documented in a rock sample.

void_bottom_4 The depth to the bottom of the fourth void or joint documented in a rock sample.

void_bottom_5 The depth to the bottom of the fifth or joint void documented in a rock sample.

void_type_1 The type of the first void documented in a rock sample.

void_type_2 The type of the second void documented in a rock sample.

void_type_3 The type of the third void documented in a rock sample.

void_type_4 The type of the fourth void documented in a rock sample.

void_type_5 The type of the fifth void documented in a rock sample.

joit_number_1 The first joint documented in a rock sample.

joit_number_2 The second joint documented in a rock sample.
joit_number_3 The third joint documented in a rock sample.

joit_number_4 The fourth joint documented in a rock sample.

joit_number_5 The fifth joint documented in a rock sample.

joit_from_1; Not used after a revision was made.

joit_from_2; Not used after a revision was made.

joit_from_3; Not used after a revision was made.

joit_from_4; Not used after a revision was made.

joit_from_5; Not used after a revision was made.

joit_to_1; Not used after a revision was made.

joit_to_2; Not used after a revision was made.

joit_to_3; Not used after a revision was made.

joit_to_4; Not used after a revision was made.

joit_to_5; Not used after a revision was made.

joit_alingment_1 The alignment in degrees of the first joint in a rock sample.

joit_alingment_2 The alignment in degrees of the second joint in a rock sample.

joit_alingment_3 The alignment in degrees of the third joint in a rock sample.

joit_alingment_4 The alignment in degrees of the fourth joint in a rock sample.

joit_alingment_5 The alignment in degrees of the fifth joint in a rock sample.

joit_description_1 The description of the first joint or void in a rock sample.

joit_description_2 The description of the second joint or void in a rock sample.

joit_description_3 The description of the third joint or void in a rock sample.

joit_description_4 The description of the fourth joint or void in a rock sample.

joit_description_5 The description of the fifth joint or void in a rock sample.

rock_type; The type of rock the sample is -- limestone, shale, sandstone, siltstone, mudstone, coal, for example.

artificial_fill; A description of an artificial fill sample – boulder, sand, gravel, etc.

artificial_fill2; A secondary description for an artificial sample.

Table Name: bridge_general

Column name; site_rownum: Each site within the database is associated with a unique site number, and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. However, when a new site is created by copying an existing site, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), sideroad, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfalls. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW_Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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bridge_id; A number assigned to each bridge within a site. In most cases a bridge will be a site. If two or more bridges exist or are being designed, with each bridge having separate travel lane directions a bridge number greater than one would be assigned.

brd_maint_prefix; A prefix C or B that is part of the bridge maintenance number assigned by the Kentucky Transportation Cabinet.

brd_maint_number; A number issued by the Kentucky Transportation Cabinet for individual bridges within a county. Bridges on roads maintained by local county road departments are included in the bridge numbering system. The bridge number begins with B or C followed by a five digit integer. Numbers are unique for the county only. The same bridge number may be repeated within different counties.

drawing_number; A variable character number assigned to bridges and other structures by the Kentucky Transportation Cabinet. The drawing number is included in the structure plans.

stream_id; The stream number assigned by ??? , if the site includes a stream crossing.

stream_name; The stream name, if the site includes a stream crossing.

number_of_spans; The number of spans on a bridge. A span is the segment that extends from the abutment or end of the bridge to a pier and any segments that extend from one pier to another.

mainline_station; The station number of the center of the bridge along the mainline of the highway the bridge is a part of before the + sign. Station numbers are assigned by the Kentucky Transportation Cabinet. If the station is 100 + 00.00, this field is reserved for 100, or the station number before the + sign. Not used here in this table. Data moved to table, bridge_detail.

mainline_station1; Not used.

other_station_type; Identifies whether the other station type of secondary road is a sideroad, or if the secondary road is northbound, southbound, eastbound, westbound, or a situation survey.

other_station; The station number of the other station type.

railroad_crossing; This field is used to indicate if the site includes a railroad crossing.

wet_crossing; This field is used to indicate if the site includes a stream crossing.

county_bridge_repl_prog; A field used to designate if a bridge design is included in the *County Bridge Replacement Program.* The Kentucky Transportation Cabinet administers the program, which funds bridge replacements for roads maintained by county road departments.

stream_id; The stream number assigned by Data Base Administrator, if the site includes a stream crossing.

stream_name; The stream name, if the site includes a stream crossing.

add_date; A calendar date automatically recorded by the database system when data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing data.

length; The length of the bridge.

skew_degree; The degree part of the skew angle of the bridge.

skew_direction; The skew direction, Right or Left, of the bridge.

letting_date; The date a contract was let to construct the bridge.

report_id; The geotechnical report number of the bridge.

skew_ minutes; The minutes part of skew angle of the bridge.

skew_seconds; The seconds part of the skew angle of the bridge.

Table Name: culvert

site_rownum; Each site within the database is associated with a unique site number, and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. However, when a new site is created by copying an existing site, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), sideroad, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfalls. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW_Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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maint_no1; A prefix that is part of the culvert number assigned by the Kentucky Transportation Cabinet.

maint_number_2 ; A number issued by the Kentucky Transportation Cabinet for individual culverts within a county.

drawing_number; A variable character number assigned to bridges and other structures by the Kentucky Transportation Cabinet. The drawing number is included in the structure plans.

stream_id; The stream number assigned by ??? , if the site includes a stream crossing.

stream_name; The stream name, if the site includes a stream crossing.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing data.

add_date; A calendar date automatically recorded by the database system when data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when data at an existing site is changed or modified.

Height; The height of the culvert.

Width; The width of the culvert.

Length; The length of the culvert.

Type; The type of culvert. Choices are: RCBC (Reinforced Concrete Box Culvert), Arch, or Pipe

Foundation; The type of foundation the culvert is construction: Yielding (the foundation settles when the culvert and fill are constructed), Non-yielding (the foundation is rigid and will not yield) , or Unknown.

allowable_bearing; The recommended allowable bearing capacity of the foundation.

inlet_elevation; The elevation (assumed or sea level) of the inlet or the end water flows into of the culvert.

outlet_elevation; The elevation (assumed or sea level) of the outlet or the end water flows out of the culvert.

inlet_ext_date; The date an extension to the inlet of the culvert was completed.

inlet_ext_length; The length of an extension at the inlet end of the culvert.

inlet_ext_orig_elev; The elevation (assumed or sea level) of the inlet end of the extension before construction.

inlet_ext_post_elev; The elevation (assumed or sea level) of the inlet end of the extension after construction.

outlet_ext_date; The date an extension to the outlet of the culvert was completed.

outlet_ext_length; The length of an extension at the outlet end of the culvert.

outlet_ext_date; The date an extension to the inlet of the culvert was completed.

outlet_ext_length; The length of an extension and the outlet end of the culvert.

outlet_ext_orig_elev; The elevation (assumed or sea level) of the outlet end of the extension before construction.

outlet_ext_post_elev; The elevation (assumed or sea level) of the outlet end of the extension after construction.

comment; A field for any comments about the design , construction, performance problems, etc, of the culvert.

num_of_barrels; The number of barrels or openings in the culvert that are present. Some box culverts are divded into sections creating more than one opening. One or more arch or pipe culvert may be constructed parallel to each other to allow more water to flow. These culverts would be considered one culvert.

skew_degree; The degree part of the skew angle of the culvert.

skew_direction; The skew direction, Right or Left, of the culvert.

letting_date; The date a contract was let to construct the culvert.

Table Name: landslide_attri_n_impact

Column name; site_rownum: Each site within the database is associated with a unique site number, and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. However, when a new site is created by copying an existing site, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

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A side road is an approach road to a RW_Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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height; The vertical height of the landslide. Height is usually estimated, although measured heights may be available from plans if the are being designed for repairs.

length; The approximate length of the landslide. Length is usually estimated, although measured lengths may be available from plans if the are being designed for repairs.

status_1; Used to describe the status of the landslide; failing, monitoring, being designed, under construction, corrected, monitoring corrections, failing after construction or correcting.

status_1; A landside may be in any of several stages. Used to describe the status of the landslide failing, monitoring, being designed, under construction, corrected, monitoring corrections, failing after construction or correcting.

status_2; A second fields to describe the status of a landside. A landslide may be in any of several stages. Used to describe the status of the landslide failing, monitoring, being designed, under construction, corrected, monitoring corrections, failing after construction or correcting.

movement_rate; A field used to designate how fast a landslide is moving. Landslides do not move at the same rates. Individual landslides move at different rates at different times based on physical and environmental factors.

failure_location_1; Used to designate if the failure (landslide) is above the roadway (cut slope) or below the roadway (fill or embankment).

failure_location_2; A second failure location field used to designate if the failure (landslide) is above the roadway (cut slope) and is also below the roadway (fill or embankment).

contributing_factor_1; Many factors such as water, failed corrective measures, erosion, steep slopes, etc can contribute to a landslide This filed allows one of the factors to be selected.

contributing_factor_2; Many factors such as water, failed corrective measures, erosion, steep slopes, etc can contribute to a landslide This filed allows one of the factors to be selected.

contributing_factor_3; Many factors such as water, failed corrective measures, erosion, steep slopes, etc can contribute to a landslide This filed allows one of the factors to be selected.

contributing_factor_4; Many factors such as water, failed corrective measures, erosion, steep slopes, etc can contribute to a landslide This filed allows one of the factors to be selected.

contributing_factor_5; Many factors such as water, failed corrective measures, erosion, steep slopes, etc can contribute to a landslide This filed allows one of the factors to be selected.

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rdw_stru_affected_1; Different parts of a roadway can be affected by a landslide; driving lane, shoulder culvert, guardrail, drainage ditches, etc. This filed allows one of the factors to be selected.

rdw_stru_affected_2; Different parts of a roadway can be affected by a landslide; driving lane, shoulder culvert, guardrail, drainage ditches, etc. This filed allows one of the factors to be selected.

rdw_stru_affected_3; Different parts of a roadway can be affected by a landslide; driving lane, shoulder culvert, guardrail, drainage ditches, etc. This filed allows one of the factors to be selected.

rdw_stru_affected_4; Different parts of a roadway can be affected by a landslide; driving lane, shoulder culvert, guardrail, drainage ditches, etc. This filed allows one of the factors to be selected.

rdw_stru_affected_5; Different parts of a roadway can be affected by a landslide; driving lane, shoulder culvert, guardrail, drainage ditches, etc. This filed allows one of the factors to be selected.

utility_damaged_1; Different utilities such as overhead and underground electric, telephone, cable TV, fiber optics, and underground utilities such as gas, water, or sewer may be damaged due to movement of the landslide. This field allows one of the damaged utilities to be selected.

utility_damaged_2; Different utilities such as overhead and underground electric, telephone, cable TV, fiber optics, and underground utilities such as gas, water, or sewer may be damaged due to movement of the landslide. This field allows one of the damaged utilities to be selected.

utility_damaged_3; Different utilities such as overhead and underground electric, telephone, cable TV, fiber optics, and underground utilities such as gas, water, or sewer may be damaged due to movement of the landslide. This field allows one of the damaged utilities to be selected.

utility_damaged_4; Different utilities such as overhead and underground electric, telephone, cable TV, fiber optics, and underground utilities such as gas, water, or sewer may be damaged due to movement of the landslide. This field allows one of the damaged utilities to be selected.

utility_not_damaged_1; Different utilities such as overhead and underground electric, telephone, cable TV, fiber optics, and underground utilities such as gas, water, sewer may be present, but not damaged, due to movement of the landslide. The utilities could be damaged if the landslide continues moving and they will have to be considered for any corrective actins taken This field allows one of the damaged utilities to be selected.

utility_not_damaged_2; Different utilities such as overhead and underground electric, telephone, cable TV, fiber optics, and underground utilities such as gas, water, sewer may be present, but not damaged, due to movement of the landslide. The utilities could be damaged if the landslide continues moving and they will have to be considered for any corrective actins taken This field allows one of the damaged utilities to be selected

utility_not_damaged_3; Different utilities such as overhead and underground electric, telephone, cable TV, fiber optics, and underground utilities such as gas, water, sewer may be present, but not damaged, due to movement of the landslide. The utilities could be damaged if the landslide continues moving and they will have to be considered for any corrective actins taken This field allows one of the damaged utilities to be selected

utility_not_damaged_4; Different utilities such as overhead and underground electric, telephone, cable TV, fiber optics, and underground utilities such as gas, water, sewer may be present, but not damaged, due to movement of the landslide. The utilities could be damaged if the landslide continues moving and they will have to be considered for any corrective actins taken This field allows one of the damaged utilities to be selected

adjacent_property_1; Properties adjacent to a landslide can be affected by the movement of the landslide and the use of the property has to be considered when corrective measure are designed and constructed. Types of properties include agricultural land, residential, industrial, park, wooded land, and railroad.

adjacent_property_2; Properties adjacent to a landslide can be affected by the movement of the landslide and the use of the property has to be considered when corrective measure are designed and constructed. Types of properties include agricultural land, residential, industrial, park, wooded land, and railroad.

adjacent_property_3; Properties adjacent to a landslide can be affected by the movement of the landslide and the use of the property has to be considered when corrective measure are designed and constructed. Types of properties include agricultural land, residential, industrial, park, wooded land, and railroad.

adjacent_property_4; Properties adjacent to a landslide can be affected by the movement of the landslide and the use of the property has to be considered when corrective measure are designed and constructed. Types of properties include agricultural land, residential, industrial, park, wooded land, and railroad.

contributing_factor_cmt; A comments field for Contributing Factors of a landslide. This field may be used if a contributing factor is not available from the drop down menu.

rdw_str_affected_cmt; A comments field for Roadway Structures Affected. This field may be used if a roadway structure affected is not available from the drop down menu.

utility_damaged_cmt; A comments field for Utilities Damaged. This field may be used if a type of (or types) utilities is not available from the drop down menu.

utility_not_damaged_cmt; A comments field for Utilities Not Damaged. This field may be used if a type or types of utilities is not available from the drop down menu.

adjacent_property_cmt; A comments field for Adjacent Properties. This field may be used if a type or types of adjacent properties is not available from the drop down menu.

aadt; The average annual daily traffic for the landslide site. It is obtained from the Kentucky Transportation Cabinet. The volume of traffic on a highway has to be considered when funding and repair options are considered.

Aadt_date; The date the average annual daily traffic for the landslide site was obtained from the Kentucky Transportation Cabinet. Daily traffic can vary with time.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added landslide data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing landslide data.

add_date; A calendar date, automatically recorded by the database system, when landslide data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when landslide data at an existing site is changed or modified

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number_of_pictures; The number of photographs embedded in the database that is associated with the landslide site. Currently, a maximum of 12 photographs can be store with each landslide.

Table Name: rockfall

Column name; site_rownum: Each site within the database is associated with a unique site number, and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. However, when a new site is created by copying an existing site, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

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inventory_date; The date a rock slope was rated using the Rockfall Hazard Rating System developed by the Oregon DOT.

rater; The name or initials of the person rating the slope.

class; The preliminary classification of a rock slope. The classification is based on potential of rocks falling from a slope into the driving part of a highway. An “A” slope has a large potential for rocks falling into the roadway. A “B” slope has some potential for rocks falling into the roadway. There is little no potential for rocks falling in to the roadway from a “C” rated slope.

total_score; The total score of a rock slope when all categories of the Rockfall Hazard Rating System are totaled. Higher scores indicate a larger chance of falling rocks hitting the roadway.

slope_height; The height of the rock slope (feet) being evaluated. Height of the slope can be directly entered or the Slope Height can be determined by using angles and distances. Two angles can be entered as degrees: Alpha and Beta, the horizontal distance, X, representing the distance in feet between the two location angles were obtained (i.e. edge of pavement or lane stripes) and an Instrument Height, in feet.

alpha; The larger angle obtained closer to the slope used in calculating the height.

beta;. The smaller angle obtained closer to the slope used in calculating the height

x_distance; The horizontal distance between the locations, in feet, where Alpha and Beta angles are used.

instrument_height; The Instrument Height (eye level if using a hand held inclinometer) above the datum plane (typically the pavement).

ditch_effectiveness; The ability of the ditch or the area between the paved roadway and the rock slope to retain any

roadway_width; The width of the paved section of roadway in feet at the point the rock slope is being evaluated. A Roadway Width score is calculated and stored based on the width entered.

speed_limit; The posted speed limit in Miles per Hour at the rock slope being evaluated. It is used in calculating Average Vehicle Rick.

Avr; . A calculation to determine the percent of time a vehicle may be in the roadway adjacent to the rock slope. Average Vehicle Risk (AVR) is a calculated value based upon Speed Limit, Slope Length, and Average Daily Traffic. AVR can be input directly or it can be calculated from the values entered in the Speed Limit, Slope Length and Average Daily Traffic.

slope_length; The length of the slope in feet. It is used in calculating Average Vehicle Rick.

adt; The average annual daily traffic at the rock slope, obtained from the Kentucky Transportation Cabinet. It is used in calculating Average Vehicle Rick.

sight_distance_actual; The Actual Sight Distance, in feet, from the point the rock slope is being evaluated to the point which a driver would see a rock in the roadway. Vertical (hills) or horizontal curves can control sight distance.

sight_distance; The Decision Sight Distance, calculated by dividing the Actual Sight Distance by a Decision Sight Distance obtained from The American Association of Highway and Transportation Officials (AASHTO) “Policy for Geometric Design of Highway’s and Street’s.” The sight distance is expressed as a percentage.

struct_cond; The geologic structural condition of the rock slope Rock slopes with joints, or fissures, and different types of bedding planes between rock layers are much more likely to have rockfall events than intact rock. Joints are considered to be Continuous if they are greater than ten feet in length, or Discontinuous if they are less than ten feet long.

joint_orientation; The joints in the rock slope can be oriented in different directions. It is possible for the orientation of the joints to be favorable, which may aid any falling rock to go away from the highway, When this situation occurs, the joints are considered to have a favorable orientation. By default, The RHRS considers any joint greater than 10 feet length to have an unfavorable orientation. Some joint patterns within a slope may be randomly distributed.

rock_friction; The Rock Friction along jointed contributes to the potential for rockfalls. Blocks of rocks with Rough Irregular surfaces can interlock when they across a joint, decreasing their ability to fall**.** Some rocks may have rough surfaces with undulating bedding planes where friction is obtained from the rock surface only. Planar or smooth surfaces may exist with rocks with smoother surfaces. The worst conditions exist when Clay Infilling, or Slickenslides occur. This happens when the joints are filled with clay or has slickenslides, smooth failure planes that are created due to the rubbing action of the rocks masses sliding against each other.

dif_er_features; Differential Erosion between rock units is a major contributor to rockfalls in Kentucky. Oftentimes durable rock layers exist over softer layers in highway rock cuts. Over time the softer rock layers erode causing a lack of support for the overlying durable layers. The rocks will fall due to joints or tension cracks that develop in the overlaying layers, due to the lack of support.

dif_er_rates; The rate of erosion between layers of rock contributes the Differential Erosion Features and to the overall stability of the slope. Faster rates create more stability problems.

block_size; **B**locks, that have fell , or may fall into a roadway create serious safety problems. Block size is selected when individual blocks are more likely to fall.

block_volume; Large volumes of various sized rocks, that can fall into a roadway create serious safety problems just as individual blocks can. Volume is selected when the material that has fell or may fall is composed of various size rocks.

precipitation; Precipitation in any form contributes to rock slpe instability. Water on the slope and freeze-thaw cycles contributes to rockfalls. Surface water contributes to erosion and water within a slope exerts pressure on rock when it accumulates in joints or fissures.

freezing; Freezing and thawing of contributes creates a jacking mechanism which loosens rock blocks leading to failure.

water_on_slope; Water on the slope also contributes to rockfalls. Surface water contributes to erosion increasing the rate of erosion between layers.

history; The rockfall history is used to determine activity at site and access any potential for future rockfalls.

slope_rem; A field reserved for any remarks concerning the height of the slope. Any remarks are also recorded on the Report screen.

ditch_rem; A field reserved for any remarks concerning the ditch or rock catchment area between the roadway and slope. Any remarks are also recorded on the Report screen.

avrh_rem; A field reserved for any remarks concerning the Average Vehicle Rick category. Any remarks are also recorded on the Report screen.

sight_dist_rem; A field reserved for any remarks concerning the sight distance, horizontal or vertical, of the slope being rated. Any remarks are also recorded on the Report screen.

roadway_width_rem; A field reserved for any remarks concerning the Roadway Width. Any remarks are also recorded on the Report screen.

struct_cond_rem; A field reserved for any remarks concerning the Structural Condition of the rock mass. Any remarks are also recorded on the Report screen.

rock_frict_rem; A field reserved for any remarks concerning the Rock Friction between rock masses. Any remarks are also recorded on the Report screen.
dif_er_features_rem; A field reserved for any remarks concerning the Differential Erosion Features of the rock units. Any remarks are also recorded on the Report screen.

dif_er_rates_rem; A field reserved for any remarks concerning the Differential Erosion Rates between rock units. Any remarks are also recorded on the Report screen.

block_size_rem; A field reserved for any remarks concerning Block Size or Volume. Any remarks are also recorded on the Report screen.

climate_rem; A field reserved for any remarks concerning the Climate (Precipitation, Freeze-Thaw, Water on Slope) at the site being evaluated. Any remarks are also recorded on the Report screen.

history_rem; A field reserved for any remarks concerning the Rockfall History of the site. Any remarks are also recorded on the Report screen.

slope_score; The numerical score from 0 to 100 of the Slope Height Category, based on the height of the slope. The score is automatically calculated and stored.

ditch_score; The choices used in selecting the range of scores possible for the Ditch Effectiveness Category, The choices and score are based on four parameters used to quantify the Ditch Effectiveness: 1.) Good 0-9; 2.) Moderate 10-27; 3.) Limited 28-81; and 4.) None 82-100.

sight_dist_score; The numerical score from 0 to 100 of the Sight Distance Category, based on ratio between the Actual Sight Distance and a recommended Decision Sight Distance. The score is automatically calculated and stored.

avr_score; The numerical score from 0 to 100 of the Average Vehicle Rick Category, based on the Posted Speed Limit. Slope Length and Average Daily Traffic. The score is automatically calculated and stored.

roadway_width_score; The numerical score from 0 to 100 of the Roadway width Category, based on the width of the paved portion of the highway. The score is automatically calculated and stored.

struct_cond_score; The length and orientation of joints used to select the numerical score of the Structural Condition and Joints Orientation Category, The selection and subsequent scoring is based on four parameters: 1.) Discontinuous Joints, Favorable Orientation 0-9; 2.) Discontinuous Joints, Random Orientation 10-27; 3.) Discontinuous Joints, Adverse Orientation 28-81; and 4.) Continuous Joints, Adverse Orientation 82-100.

rock_frict_score; The factors used in describing possible conditions in the Rock Friction Category, The factors and score are based on four parameters used to quantify the Rock Friction: 1.) Rough, Irregular 0-9; 2.) Undulating 10-27; 3.) Planar 28-81; and 4.) Clay Infilling/Slickenslides 82-100.

dif_er_features_score; The choices used to describe the Differential Erosion Features Category, The choices and score are based on four parameters used to quantify the Differential Erosion Features: 1.) Few, 0-9; 2.) Occasional 10-27; 3.) Numerous 28-81; and 4.) Many 82-100.

dif_er_rates_score; The choices used to establish the rate or differential erosion. The choices and score are based on four parameters used to quantify the Differential Erosion Rates: 1.) Small, 0-9; 2.) Moderate 10-27; 3.) Large, Favorable Structure 28-81; and 4.) Large, Unfavorable Structure 82-100.

climate_score; The description of weather and groundwater used in the Climate Category, The score is based on three parameters 1.) Precipitation – Low [less than 20 inches per year]; Moderate [21 to 50 inches per year]; High [greater than 50 inches per year]; and 2.) Freezing Periods - None, Short, and Long; 3.) Water on Slope - None, Intermittent, and Continual.

history_score; The selections available to describe Rockfall History at a site. The score is based on four parameters used to quantify the Rockfall History: 1.) Few 0-9; 2.) Occasional 10-27; 3.) Many 28-81; and 4.) Constant 82-100.

ditch_range_code; The numerical score of the Ditch Effectiveness Category, The score is based on four parameters used to quantify the Ditch Effectiveness: 1.) Good 0-9; 2.) Moderate 10-27; 3.) Limited 28-81; and 4.) None 82-100..

struct_cond_range_code; The numerical score of the Structural Condition and Joints Orientation Category, The scoring is based on four parameters: 1.) Discontinuous Joints, Favorable Orientation 0-9; 2.) Discontinuous Joints, Random Orientation 10-27; 3.) Discontinuous Joints, Adverse Orientation 28-81; and 4.) Continuous Joints, Adverse Orientation 82-100.

rock_frict_range_code; The numerical score of the Rock Friction Category, The score is based on four parameters used to quantify the Rock Friction: 1.) Rough, Irregular 0-9; 2.) Undulating 10-27; 3.) Planar 28-81; and 4.) Clay Infilling/Slickenslides 82-100.

dif_er_features_range_code; The numerical score of the Differential Erosion Features Category, The score is based on four parameters used to quantify the Differential Erosion Features: 1.) Few, 0-9; 2.) Occasional 10-27; 3.) Numerous 28-81; and 4.) Many 82-100.

dif_er_rates_range_code; The numerical score of the Differential Erosion Rates Category, The score is based on four parameters used to quantify the Differential Erosion Rates: 1.) Small, 0-9; 2.) Moderate 10-27; 3.) Large, Favorable Structure 28-81; and 4.) Large, Unfavorable Structure 82-100.

climate_range_ code; The numerical score from 0 to 100 of the Climate Category, The score is based on three parameters 1.) Precipitation – Low [less than 20 inches per year]; Moderate [21 to 50 inches per year]; High [greater than 50 inches per year]; and 2.) Freezing Periods - None, Short, and Long; 3.) Water on Slope - None, Intermittent, and Continual.

history_range_code; The numerical score of the Rockfall History Category, The score is based on four parameters used to quantify the Rockfall History: 1.) Few 0-9; 2.) Occasional 10-27; 3.) Many 28-81; and 4.) Constant 82-100.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added rockfall data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing rockfall data.

add_date; A calendar date, automatically recorded by the database system, when rockfall data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when rockfall data at an existing site is changed or modified.

rockfall_picture_1; The original column for rockfall pictures. No longer used.

number_of_pictures; The number of photographs embedded in the database that is associated with the rockfall site. Currently, a maximum of 12 photographs can be store with each landslide.

Table Name: roadway_general

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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Length; The length of the roadway segment in meters, kilometers, feet, or miles, within the associated site. When length is entered as any one of these units, the others are units are calculated.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added roadway data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing roadway data.

add_date; A calendar date, automatically recorded by the database system, when roadway data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when roadway data at an existing site is changed or modified.

letting_date; The date a contract was let to construct the roadway segment associated with the site.

Table Name: walls_mse

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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height; The height of the Mechanically stabilized Earth (MSE) Wall being evaluated.

length; The length of the Mechanically stabilized Earth (MSE) Wall being evaluated.

elevation; The means sea level of the highest part of the Mechanically stabilized Earth (MSE) Wall being evaluated.

position; The position (above or below the roadway) of the Mechanically stabilized Earth (MSE) Wall being evaluated.

visual_evaluation1; A parameter selected from a drop down list used to evaluate conditions which may affect the performance of an MSE wall.

visual_evaluation2; A second parameter selected from a drop down list used to describe conditions which may affect the performance of an MSE wall.

visual_evaluation3; A third parameter selected from a drop down list used to describe conditions which may affect the performance of an MSE wall.

visual_evaluation4; A fourth parameter selected from a drop down list used to describe conditions which may affect the performance of an MSE wall.

ve_comments1; Any comment pertaining to the first visual evaluation selection.

ve_comments2; Any comment pertaining to the second visual evaluation selection.

ve_comments3; Any comment pertaining to the third visual evaluation selection.

ve_comments4; Any comment pertaining to the fourth visual evaluation selection.

topography1; A field selected from a drop list o describe the landform where the MSE wall is located.

topography2; An additional field selected from a drop list o describe the landform where the MSE wall is located.

backfill_material1; A field used to classify a sample of material taken behind the MSE wall being evaluated.

backfill_material2; A field used to classify a second sample of material taken behind the MSE wall being evaluated.

backfill_material3; A field used to classify a third of material taken behind the MSE wall being evaluated.

soil_condition1; A field use to describe the type of soil (sand, silt, clay, loam, organic) above and MSE wall**.**

soil_condition2; A additional field use to describe the type of soil (sand, silt, clay, loam, organic) above and MSE wall**.**

soil_ph; The numerical value of the pH of the soil obtained from the MSE wall.

soil_aci_alk; Used to indicate if the soil at the MSE wall is acidic or alkaline.

photo_number; The number of photos associated with the site.

photo_type; The type of photos taken (digital, print, slide).

evaluator; The person evaluating the MSE wall.

evaluate_date; The date the MSE wall was evaluated.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added MSE wall data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing MSE wall data.

add_date; A calendar date, automatically recorded by the database system, when MSE wall data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when MSE wall data at an existing site is changed or modified.

kytc_drawing_num; A variable character number assigned to bridges and other structures including MSE walls by the Kentucky Transportation Cabinet. The drawing number is included in the structure plans.

manuf_drawing_num; A variable character number indicating the MSE wall manufacturer's drawing number. The drawing number is included in the structure plans.

manufacturer: The company that supplied the components for the MSE wall.

year_constructed; The year construction of the MSE wall was completed.

general_comments; Reserved for any comments about the MSE wall being evaluated.

constructed; Used to indicate if construction of the MSE wall is complete.

Table Name: brd_appr_stations

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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approach_id; The identification number of the bridge approach. (usually 1 or 2).

begin_appr_station; The beginning station integer number assigned by the Kentucky Transportation Cabinet of the bridge approach. Each integer equals one foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

begin_appr_station1; The decimal portion of the beginning station number of the bridge approach.

begin_brd_station; The beginning station integer number assigned by the Kentucky Transportation Cabinet of the bridge approach. Each integer equals one foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

begin_brd_station1; The decimal portion of the beginning station number of the bridge approach.

end_appr_station; The ending station integer number assigned by the Kentucky Transportation Cabinet of the bridge approach. Each integer equals one foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

end_appr_station1; The decimal portion of the ending station number of the bridge approach.

end_brd_station; The ending station integer number assigned by the Kentucky Transportation Cabinet of the bridge approach. Each integer equals one foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

end_brd_station1; The decimal portion of the ending station number of the bridge approach

total_length; The total length of the bridge approach and the bridge.

appr_length; The total length of the bridge approach only. **add_by;** The person, recorded by the database system automatically, based on the user's log on id, who added bridge approach data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing bridge approach data.

add_date; A calendar date, automatically recorded by the database system, when bridge approach data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when bridge approach data at an existing site is changed or modified.

Table Name: interchange_ramps

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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ramp_id; The identification number of the ramp. (usually a letter A, B, etc).

begin_station; The beginning station integer number assigned by the Kentucky Transportation Cabinet of an interchange ramp. Each integer equals one foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

begin_station1; The decimal portion of the beginning station number of an interchange ramp.

end_station; The ending station integer number assigned by the Kentucky Transportation Cabinet of an interchange ramp. Each integer equals one-foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

end_station1; The decimal portion of the ending station number of an interchange ramp.

appr_length; The total length of the bridge approach only.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added bridge approach data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing bridge approach data.
add_date; A calendar date, automatically recorded by the database system, when bridge approach data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when bridge approach data at an existing site is changed or modified.

length; The length of the interchange ramp.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added interchange data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing interchange data.

add_date; A calendar date, automatically recorded by the database system, when interchange data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when interchange data at an existing site is changed or modified.

Table Name: interchange_ramps

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

ramp_id; The identification number of the ramp. (usually a letter A, B, etc).

begin_station; The beginning station integer number assigned by the Kentucky Transportation Cabinet of an interchange ramp. Each integer equals one foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

begin_station1; The decimal portion of the beginning station number of an interchange ramp.

end_station; The ending station integer number assigned by the Kentucky Transportation Cabinet of an interchange ramp. Each integer equals one-foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

end_station1; The decimal portion of the ending station number of an interchange ramp.

appr_length; The total length of the bridge approach only.

add_by; The person, recorded by the database system automatically, based on the user’s log on id, who added bridge approach data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user’s log on id, who modified existing bridge approach data.

add_date; A calendar date, automatically recorded by the database system, when bridge approach data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when bridge approach data at an existing site is changed or modified.

length; The length of the interchange ramp.

add_by; The person, recorded by the database system automatically, based on the user’s log on id, who added interchange data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user’s log on id, who modified existing interchange data.

add_date; A calendar date, automatically recorded by the database system, when interchange data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when interchange data at an existing site is changed or modified.

Table Name: roadway_comments

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

comment_id; The identification number of any associated structure or related sites of the roadway segment. The structures and related sites are numbered beginning with one and continuing until all are numbered sequentially.

comments: Reserved for any comments concerning associated structures and related sites.

add_by; The person, recorded by the database system automatically, based on the user’s log on id, who added roadway data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user’s log on id, who modified existing roadway data.

add_date; A calendar date, automatically recorded by the database system, when roadway data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when roadway data at an existing site is changed or modified.

none; Used to indicate if any structures, and associated sites are within the roadway segment.
structure; What type of structure (bridge, culvert, wall, etc.) is within the roadway segment

structure_site_num; The database site number of the structure within the roadway segment.

report_num; The Geotechnical Report Number of the structure within the roadway segment.

begin_station; The beginning station integer number assigned by the Kentucky Transportation Cabinet of the roadway segment. Each integer equals one-foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

begin_station1; The decimal portion of the beginning station number of the roadway segment.

end_station; The ending station integer number assigned by the Kentucky Transportation Cabinet of the roadway segment. Each integer equals one-foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

end_station1; The decimal portion of the ending station number of the roadway segment.

Table Name: roadway_karstic

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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karstic_id; The identification number of the karstic type or feature on or near the roadway. Features are described beginning with one and continuing until all features are numbered sequentially.

station; The beginning station integer number assigned by the Kentucky Transportation Cabinet of the feature. Each integer equals one-foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

station1; The decimal portion of the beginning station number of the feature within the roadway segment.

station type; The type of station used to locate the feature (Alpha, Southbound, Eastbound, Mainline).

offset; The distance from the centerline of the roadway the feature is located at.

none_check: An indicator used to show if no karstic features are on or near the roadway segment.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added features data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing features data.

add_date; A calendar date, automatically recorded by the database system, when features data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when features data at an existing site is changed or modified.

direction; The direction, right or left of centerline, or on the centerline the feature is located at.

length; The length or diameter of the feature described.

width; The width of the feature described.

comments: Reserved for any comments associate with the feature.

Table Name: roadway_equations

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-

Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.
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equation_id; The identification number of the equation used to modify station numbers. Equations begin with one and continuing until all features are numbered sequentially.

back; The equation used to modify station numbers less than those from the point the equation is effective at .

ahead; The equation used to modify station numbers greater than those from the point the equation is effective at.

offset; The distance from the centerline of the roadway the feature is located at.

none_check; An indicator used to show if no karstic features are on or near the roadway segment.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added equations data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing equations data.

add_date; A calendar date, automatically recorded by the database system, when equations data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when equations data at an existing site is changed or modified.

none: An indicator used to show if no equations are used to modify station numbers within the roadway segment associated with the site.

Table Name: roadway_sideroads

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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sideroad_id; The identification number of the sideroad used to modify station numbers. The numbers begin with one and continuing until all sideroads within the roadway segment are numbered sequentially.

road_name; The name of the sideroad intersecting the mainline. Each sideroad will also have an identification number.

direction; The direction, Right or Left, from the centerline or Crossroad, if the sideroad crosses the mainline.

mainline_station; The beginning station integer number assigned by the Kentucky Transportation Cabinet of the mainline where the sideroad intersects the mainline. Each integer equals one foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

mainline_station1; The decimal portion of the beginning station number of the mainline where the sideroad intersects the mainline.

sideroad_station; The beginning station integer number assigned by the Kentucky Transportation Cabinet of the sideroad where the sideroad intersects the mainline. Each integer equals one foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

sideroad_station1; The decimal portion of the beginning station number of the sideroad where the sideroad intersects the mainline.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added sideroads data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing sideroads data.

add_date; A calendar date, automatically recorded by the database system, when sideroads data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when sideroads data at an existing site is changed or modified.

none; An indicator used to show if no sideroads intersect roadway segment.

Table Name: landslide_history

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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history_id; The identification number used to record the number of times a landslide history is updated. This field is automatically stored. It is not an input by the user.

investigated_by; The name of the person or persons, or highway district evaluating the landslides on a given date.

date; The date the landslide was evaluated.

comment; Any comments concerning the landslide on the date it was evaluated. The comments are including when reports are generated using A Flexible Report menu that is available in the database.

class; A characterization of the severity of the landslide with respect to its impact on the roadway. An “A” landslide is very serious, needs repaired immediately, and poses a safety concern. A “B” slide is serious and in needs repair. The roadway is damaged but useable. A “C” slide has moderate damage to the roadway, and with a ”D” there is no roadway damage, but some slope movement or erosion.

score; This is reserved for future use if a numerical scoring system is used to characterize landslides.

height; The vertical height of the landslide. Height is usually estimated, although measured heights may be available from plans if they are being designed for repairs.

length; The approximate length of the landslide. Length is usually estimated, although measured lengths may be available from plans if they are being designed for repairs.

add_date; A calendar date, automatically recorded by the database system, when landslide data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when landslide data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added landslide data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing landslide data.

Table Name: landslide_maintenance

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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maintenance_id; The identification number used to record the number of times maintenance costs and activities are documented within the database. This field is automatically stored. It is not an input by the user.

date; The date the maintenance costs and activity were documented.

cost: The cost of the maintenance activity that was performed at a landslide.

activity: The type of maintenance activity that was performed at a landslide.

add_date; A calendar date, automatically recorded by the database system, when landslide maintenance data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when landslide maintenance data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added landslide maintenance data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing landslide maintenance data.

Table Name: landslide_remedial_n_costs

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

report_number; The number of the Geotechnical Report issued for repair recommendations.

addendum; The number, sequentially, of any addendums to the Geotechnical Report.

proposed correction_method_1; Many choices are available to correct a landslide such as flatten slope, soil or rock berms, excavate and replace rock or soil, shear key, rails, walls, drainage correction, alternate fill type, etc. This filed allows one of the factors to be selected.

proposed correction_method_2; Many choices are available to correct a landslide such as flatten slope, soil or rock berms, excavate and replace rock or soil, shear key, rails, walls, drainage correction, alternate fill type, etc. This filed allows one of the factors to be selected.

proposed correction_method_3; Many choices are available to correct a landslide such as flatten slope, soil or rock berms, excavate and replace rock or soil, shear key, rails, walls, drainage correction, alternate fill type, etc. This filed allows one of the factors to be selected.

proposed correction_method_4; Many choices are available to correct a landslide such as flatten slope, soil or rock berms, excavate and replace rock or soil, shear key, rails, walls, drainage correction, alternate fill type, etc. This filed allows one of the factors to be selected.

proposed correction_method_5; Many choices are available to correct a landslide such as flatten slope, soil or rock berms, excavate and replace rock or soil, shear key, rails, walls, drainage correction, alternate fill type, etc. This filed allows one of the factors to be selected.
group1; Used to show if two or more proposed methods of correction may be grouped together.

group2; Used to show if two or more proposed methods of correction may be grouped together.

group3; Used to show if two or more proposed methods of correction may be grouped together.

group4; Used to show if two or more proposed methods of correction may be grouped together.

group5; Used to show if two or more proposed methods of correction may be grouped together.

estimated_cost1; The estimated cost of the first proposed correction method.

estimated_cost2; The estimated cost of the second proposed correction method.

estimated_cost3; The estimated cost of the third proposed correction method.

estimated_cost4; The estimated cost of the fourth proposed correction method.

estimated_cost5; The estimated cost of the fifth proposed correction method.

selection_factor1: The selection factor or reason the first proposed correction method was selected.

selection_factor2: The selection factor or reason the second proposed correction method was selected.

selection_factor3: The selection factor or reason the third proposed correction method was selected.

selection_factor4: The selection factor or reason the fourth proposed correction method was selected.

selection_factor5: The selection factor or reason the fifth proposed correction method was selected.

actual_cost_1; The actual cost of the construction used to repair the landslide.

actual_cost_2; The actual cost of the construction used to repair the landslide when the first method failed.

correction_method_1; The method used to correct the landslide**.** Many choices are available to correct a landslide such as flatten slope, soil or rock berms, excavate and replace rock or soil, shear key, rails, walls, drainage correction, alternate fill type, etc.

correction_method_2; The method used to correct the landslide when the first method failed**.** Many choices are available to correct a landslide such as flatten slope, soil or rock berms, excavate and replace rock or soil, shear key, rails, walls, drainage correction, alternate fill type, etc.

performance; Used to document the performance of the corrective measures.

construction_date; The date construction of the landslide repairs was complete.

add_date; A calendar date, automatically recorded by the database system, when landslide remedial design and construction costs data was added to an existing site.
mod_date; A calendar date, automatically recorded by the database system, when landslide remedial design and construction costs data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added landslide remedial design and construction costs data to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing landslide remedial design and construction costs data.

Table Name: cbr

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

hole_id; The identification of the hole (usually a number), within a site, that the soil sample used to perform the CBR (California Bearing Ratio) test the was obtained from.

sample_id; The identification of the soil sample (usually a number), obtained from a hole, that the CBR (California Bearing Ratio) test was performed on.

Cbrtype; The type of CBR test performed. The Kentucky Transportation Cabinet has their own method to perform some geotechnical tests that differs from AASHTO specifications. The test may be performed following specifications outlined by Kentucky or AASHTO methods.

unsoaked_cbr; The value obtained from CBR tests is typically a value that results from soaking the test specimen in water for a prescribed time. This field is reserved for values obtained from the CBR test on a unsoaked sample.
uddensity; The dry density of the CBR specimen before soaking in water.

umoistcont; The moisture content of the CBR specimen before soaking in water.

Upenetration; The depth of penetration that the unsoaked CBR test value was obtained (0.1, 0.2, 0.3, 0.4, or 0.5 in).

soaked_cbr; The value obtained from CBR tests is typically a value that results from soaking the test specimen in water for a prescribed time.
sddensity; The dry density of the CBR specimen after soaking in water.

smoistcont; The moisture content of the CBR specimen after soaking in water.

spenetration; The depth of penetration that the soaked CBR test value was obtained (0.1, 0.2, 0.3, 0.4, or 0.5 in).

add_date; A calendar date, automatically recorded by the database system, when CBR data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when CBR data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added CBR to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing CBR data.

soaked_percent_p_no4; The percentage of material larger than No. 4 sieve (4.75-mm) can influence the results obtained from CBR tests. This field indicates the percentage of material that was retained on the No. 4 sieve when a CBR test was performed with the specified soaking period.

unsoaked_percent_p_no4; The percentage of material larger than No. 4 sieve (4.75-mm) can influence the results obtained from CBR tests. This field indicates the percentage of material that was retained on the No. 4 sieve when a CBR test was performed when the specimen was not soaked.

Table Name: classification_soil

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

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A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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hole_id; The identification of the hole (usually a number), within a site, that the soil sample was obtained from.

sample_id; The identification of the soil sample (usually a number), obtained from a hole. Samples are usually numbered in chronological order from the top of the hole to the bottom.

blowcounts1; The number of blows required to advance the sampler six inches. The Standard Penetration Test (SPT) is performed by driving a split-barrel sampler with a 2.0 inch outside diameter and a 1 3/8 inch inside diameter into a soil mass with 140-pound rammer. The sampler is advanced by the rammer falling 30 inches to impact rods connected to the sampler. The purpose of the test is to obtain a soil sample for testing and to measure the resistance of soil to penetration of the sampler. The resistance is measured by counting the blows from the falling rammer required to advance the sampler in three separate six inch intervals of penetration The first six-inch interval is considered a seating interval. The next two six inch intervals are summed with total being the N value, or the resistance to penetration. Driving the sampler can stop when a total of 50 blows have been applied over one six inch increment or if there is no observed advance during the application of 10 successive blows, or a total of 100 blows have been applied.

[4]The Standard Penetration Test (SPT) involves driving a split-spoon sample barrel into the ground from the bottom of a borehole by dropping a 140 lb (63.5 kg) hammer a height of 30 inches (0.76 m). From the test a penetration resistance or blowcount (N) is obtained which equals the number of blows required to drive the sampler over the depth interval between 6 and 18 inches (150 to 450 mm) The N value is reported in blows per foot (blows per 300 mm). Standard testing procedures are described in ASTM D 1586.

blowcounts2; The number of blows required to advance the sampler from six to 12 inches depth.

blowcounts3; The number of blows required to advance the sampler from 12x to 18 inches depth.

aashtoclass; AASHTO Soil Classification – This soil classification system (AASHTO M 145) was initially developed in 1928 by the US Bureau of Public Roads, and revised several times since then. It divides soils into eight groups (and further subdivides some of these for thirteen groups total), based upon load carrying (pavement support) characteristics. The basic groups are referred to as A-1 through A-8, with A-1 soils having the best subgrade characteristics, and the other groups exhibiting a progressive decrease in performance to the poorest (A-7 and A-8) groups. The division into groups is actually based upon

[4] Definitions written in the font, "tahoma," or green, were mainly from the Reference entitled, Association of Geotechnical Data Specialists (AGS), "Electronic Transfer of geotechnical Data from Ground Investigations," 1992, United Kingdom.

grainsize and plasticity except for group A-8), which can be easily determined in the laboratory, and are in turn related to field performance (load carrying capacity). A-1 through A-3 soils are granular, while the A-4 through A-7 soil are composed predominantly of silt and clay mixtures. A-8 materials are peat and muck. Soils within the A-1 through A-7 groups meet the following criterion:

GrainsizePlasticityGroup Index
passingpassingliquid limitplasticity index
40 sieve# 200 sieve

A-150% (max) 25% (max)6 (max)0
A-235% (max)non-plastic0 or 0-4 (see below)
A-3over 50%10% (max)may or may not exhibit plasticity0
A-4over 35%40% (max)10% (max)0-8
A-5over 35%over 40%10% (max)1-12
A-6over 35%40% (max)over 10%1-16
A-7over 35%over 40%over 10%1-20

To determine how a soil should be classified, check the qualifications in A-1 through A-7 order, with the single exception that A-3 qualifications should be checked before considering A-2. However, A-2 soils are still considered preferable to A-3 in terms of field performance. Three of these groups (A-1, A-2, and A-7) are further subdivided as discussed below.

For A-1 soils, if 50% (max) passes the # 10 sieve, 30% (max) passes the # 40 sieve, and 15% (max) passes the # 200 sieve, it is A-1-a. Otherwise it is A-1-b.

A-1-a soils are predominantly gravel, with or without a soil binder.

A-1-b soils are predominantly coarse sand, with or without a soil binder.

A-2 soils are granular (at least 65% sand and gravel), and generally perform well as foundation soils. Still, the fine-grained portion is significant (between 10 and 35%). A-2 soils are divided into four groups, A-2-4 through A-2-7 depending upon whether the fine-grained portion would classify as A-4 through A-7. Depending upon the amount and character of the fine-grained portion, A-2 soils can become soft in wet weather and loose and dusty in dry weather. A-2-4 and A-2-5 soils are non-plastic while A-2-6 and A-2-7 soils may exhibit some plasticity, with group indexes as high as 4.

A-3 soils are sands deficient in both coarse material and fine-grained binder. These relatively pure sands perform well in foundations if confined, but are subject to erosion where exposed. They are also subject to pumping.

A-4 soils contain a relatively high percentage of silt, although they can contain up to 64 % sand and gravel. Texturally they classify as sandy loams, silt loams and clay loams. They have an affinity for water and are difficult to compact. Also, because some A-4 soils can draw water up through capillary action, they can readily soften and lose strength even when they have been compacted properly. In design, it is recommended, therefore, that only the strength of these soils when saturated be assumed. The affinity for water also makes these soils susceptible to swell and frost heave. Group Index values typically vary from 0 to 8 with higher values indicative of a greater percentages of fines.

A-5 soils occur less commonly than A-4 soils, which they are similar to, particularly in regards to their affinity for water. Like the A-4 soils, therefore, they are susceptible to swell, frost heave, and loss of strength when not well drained. The principal difference between A-5 and A-4 soils is that A-5's are diatomaceous or micaceous, which makes them highly elastic as reflected by high liquid limits. Group Index values typically vary from 1 to 12, the higher values reflecting a combination of an increasing percentage of fines and higher liquid limits.

A-6 soils are quite common. Although they may be as much as 65% sand and gravel, it is more common that they are 75 % or greater silt plus clay. Group Index values, which typically vary from 1 to 16 are indicative of this variation, with higher values corresponding to a greater percentage of fines, higher liquid limits. A-6 soils have high dry strength, but lose much strength upon absorbing water. They shrink and swell with changes in moisture content. When used in fills (and specifically in the shoulder adjacent to pavements) shrinkage upon drying causes the soil to move away from the edge of pavement, thereby allowing water to penetrate beneath the pavement during subsequent rains.

A-7-5 soils have liquid limits greater than 40, and a plasticity index equal to or less than the liquid limit minus 30. In addition to undergoing considerable volume change with variation in moisture content, these soils may also be highly elastic.

A-7-6 soils have liquid limits greater than 40, and a plasticity index greater than the liquid limit minus 30. While less likely to be elastic, these soils are subject to extreme volume change.

A-8 Peat and muck are highly organic soils that were not classified within the AASHTO classification system until recently. From a construction standpoint they have many undesirable properties and should be avoided whenever possible

Unifclass; The Unified Soil Classification system (ASTM D 2487) was proposed by Casagrande in 1942. In 1985 ASTM approved a method for using this system. It divides soils into three divisions: coarse-grained soils, fine-grained soils, and highly organic soils. These divisions are further divided into 15 basic soils groups based on liquid limit and plasticity index. Coarse-grained soils are those with more than 50% retained on a No. 200 (0.075 mm) sieve. Fine-grained soils have 50% or more passing a No. 200sieve (0.075 mm). Organic soils are fine-grained soils whose ratio of Liquid Limit (oven dried) to Liquid Limit (air dried) is less than 0.75.

Criteria for Assigning Unified Group Symbols using Laboratory Tests from “Engineering Properties of Soils and Their Measurement” Bowles, J. E., 1992

Coarse grained ifNo. 200 Fine-grained
More than 50% is retained onif more than 50% passes

4.75-mm0.075-mm
GravelSandSilt or Clay

If more than 50% ofIf more than 50% of Fine-grained soils is
coarse fraction is re-coarse fraction passesSilt (M)
tained on the No. 4the No. 4 sieve (4.75-mm)Clay (C)
sieve. (4.75-mm)Organic (O)

Gravels and sands are: GW, GP, SW, or SP

If less than 5% of the material passes the No 200 sieve G= gravel; S = Sand; W = well-graded; P = poorly graded. Well and poorly graded are determined from particle size testing.

Gravels and sands are: GM, GC, SM or SC

If more than 12% of the material passes the No 200 sieve M= Silt; C = Clay. The silt or clay designation is determined by performing liquid and plastic limit tests.

Gravels and sands are: GW-GC, SW-SC, GP_GC, SP-SC
Or
GW-GM, SW-SM, GP-GM, SP-SM

If between 5 and 12% of the material passes the No 200 sieve If 5 to 6% is passing the No. 200 sieve and it is not possible to perform the plastic limit tests, do not use dual classification – instead classify as GW, GP, SW, or SP. The silt or clay designation is determined by performing liquid and plastic limit tests.

Fine-grained soils (> 50% passing the No. 200 sieve are: ML, OL, or CL

If the liquid limit is < 50%;vM = Silt, O = organic; C = Clay, and L = less than 50 % liquid limit;

Fine-grained soils are MH, OH, or CH

If the liquid limit id ≥ 50%; H = higher than 50%.

Whether a soil is a Clay (C), Silt (M), or Organic (O) depends on whether it plots above or below a line on an XY chart of Plastic Index (y-axis) versus Liquid Limit (x-axis) whose equation = [0.73(liquid limit-20)]. This line is commonly referred to a s the “A-Line.”

The organic designation also depends on: the ratio of air-dried liquid limit to oven dried liquid limit < 0.75, if the appearance and odor indicate the soil is organic.

specgrav; The ratio of the mass of a unit volume of soil solids to the mass of the same volume of gas-free distilled water at 20° C.

liqlim; The water content of a soil at the arbitrary boundary between the semi-liquid and plastic states, generally expressed in percent.

Plastind; Plastic Index is the difference between the Liquid Limit and the Plastic Limit - The water content of a soil at the arbitrary boundary between the plastic and semi-solid states, generally expressed in percent.

Natmoistcont; Natural Moisture Content is the water content of a soil in it's natural in situ moisture condition, generally expressed in percent.

d50; Grain diameter corresponding to 50 percent passing.

shrinkage_limit; Shrinkage Limit –The maximum water content at which a reduction in water content will not cause a decrease in volume of the soil mass, generally expressed in percent.

add_date; A calendar date, automatically recorded by the database system, when soil classification data was added to an existing site.

mod_date; A calendar date, automatically recorded by the database system, when soil classification data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added soil classification to a site.

mod_ by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing soil classification data.

no_plastic; Non- plastic an indicator used to classify as soil as non plastic.

penetration_at_refusal; The depth at which refusal is encountered. Refusal can be considered when the following occurs: Driving the sampler can stop when a total of 50 blows have been applied over one six inch (150 mm) increment, or if there is no observed advance during the application of 10 successive blows, or a total of 100 blows have been applied.

blowcounts_n; **N value** – The uncorrected SPT N-Value is defined as the sum of second and third increments (from 6 to 18 inches – 150 to 450 mm). Deviation from this definition occurs if penetration is stopped due to any of the 6 inch (150 mm) increments reaching 50 blows or if there is no observed advance during the application of 10 successive blows or the total number of blows have reached 100. Such deviations should be reported as number of blows for each 6-inch increment or number of blows for each partial increment. Partial increments should be reported to the nearest inch (25 mm).

Table Name: consolidation

Consolidation is the gradual reduction in volume of a soil mass caused by an increase in compressive stress on the soil mass. (ASTM D 653). Results from one-dimensional consolidation tests are used to predict the rate and time of settlement in a soil mass when a load (such as an embankment) is constructed on it. Soft soil layers should consolidate slowly, to avoid excess pore pressure build up, which can lead to stability problems, and they should compress almost completely so future settlement will be minimal**.**

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hole_id; The identification of the hole (usually a number), within a site, that the soil sample was obtained from.

sample_id; The identification of the soil or rock sample (usually a number), obtained from a hole. Samples are usually numbered in chronological order from the top of the hole to the bottom.

ezero; The initial ratio of voids to solids, e_0, of a soil sample or mass prior to loading or consolidating.

Pc; The preconsolidation pressure**,** P_c**,** of a soil mass. Soil masses in nature may have overburden pressures acting upon them currently or they could have been exposed to overburden pressures in the past that has been removed by erosion or other methods. This value can be determined from consolidation tests performed on soil specimens.

Cr; The recompression, C_r, index of an undisturbed soil mass obtained by removing or unloading stresses on the soil sample.

Cc; The compression index, C_c, of a soil mass. C_c, is determined from the linear portion of the consolidation versus pressure curve that occurs after the preconsolidation pressure.

add_date; A calendar date, automatically recorded by the database system, when consolidation test data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when consolidation test data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added consolidation test data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing consolidation test data.

Ef; The final ratio of voids, e_f, to solids of a soil sample or mass after consolidating and unloading.

Table Name: grainsize

The physical and engineering properties of sands differ dramatically from those of clays, and the significance of the distribution of grain size within various soils has been recognized for centuries. In current practice, even though a number of other types of testing and soil characterization have been developed, the determination of grainsize distribution continues to be of great importance.

Three different tests are employed in measuring grain size distribution. The gradation test is a quick and simple test that allows determination of a single important value, the percentage of fines (silt plus clay), which are present in the sample. Water is used to flush the fines through a # 200 sieve. It is assumed that all particles with nominal diameters less than 75-μm (that is all of the silt and clay) will pass through the sieve. Sands and gravel will be retained on the sieve. The difference between the initial dry weight of the total sample being sieved, and the dry weight of material retained on the sieve after washing represents the fines which are then expressed as a percentage of the total sample.

If a more detailed breakdown of grain-size distribution within the coarse grained (sand plus gravel) fraction is required, sieve analysis is performed. The wire cloth sieves used in this analysis are pans that can be nested in vertical stacks. It is not uncommon that 100% of the soil will pass through the uppermost sieve, which could have openings as large as 3" square. The size of the openings decreases progressively downward, however, and the weight of soil retained on each sieve is weighed and expressed as a percentage of total weight. It should be noted that the values recorded in the database are % passing values. In some cases, these values are presented directly on the subsurface data sheets. In other cases, however, different, though related information (such as % sand, % silt and % clay) are given and the % passing various sieve sizes must be calculated.

There is, of course, a lower limit to how small the openings in wire cloth can be without becoming unserviceable. In general practice, this is the # 200 sieve, with 200 wires per inch. All material that passes through the U. S. number 200 sieve (the silt and clay) is too small to characterize by sieving, and the hydrometer method is used to indirectly measure these small particle sizes. The basic principals of hydrometer testing are as follows. Soils consist of solids (particles) and voids between particles, which may be filled with either air or water. The particles have specific gravities that are much higher than the specific gravity of water. Thus water carrying suspended solids is heavier than clear water. Larger particles, such as a sand grain would settle to the bottom very rapidly, but the smaller the particles are the longer they will remain in suspension. This is the basis of *Stoke's Law,* which relates particle size and weight to the time required for such particles to settle out of suspension. As more and more particles are removed from the fluid (by settling to the bottom) the specific gravity of the water decreases. The hydrometer measures this specific gravity, and by application of *Stoke's Law* one can determine from how dense the sediment-laden water is at specific times, what percentage of the soil has nominal diameters greater than some specific size. These calculations are precise enough that even the variation in the viscosity of water as temperature changes will affect the calculations, so a thermometer must be used to adjust each reading for the temperature at that time. Some simplifying assumptions must be made to allow these grain-size calculations to be made at all. The most critical one is that all of the silt and sand grains have the same specific gravity, equal to the average value as determined for the sample as a whole.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

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hole_id; The identification of the hole (usually a number), within a site, that the soil sample was obtained from.

sample_id; The identification of the soil or rock sample (usually a number), obtained from a hole. Samples are usually numbered in chronological order from the top of the hole to the bottom.

sieve_id; The sieve opening or the size of the soil particles.

percentpass; The percentage of soil passing or finer by weight or mass for each sieve or size of soil particle.

add_date; A calendar date, automatically recorded by the database system, when grain size data was added to an existing site.

mod_date; A calendar date, automatically recorded by the database system, when grain size data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added grain size data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing grain size data.

Table Name: lithology

Lithology is the structure and composition of rock units including the thickness and types of rock (shale, sandstone, limestone, coal, etc.).

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

hole_id; The identification of the hole (usually a number), within a site, that the rock sample was obtained from.

sample_id; The identification of the soil or rock sample (usually a number), obtained from a hole. Samples are usually numbered in chronological order from the top of the hole to the bottom.

primsec; The value (type of rock) that describes the primary, secondary, and tertiary lithology of a rock sample. Primary would be the most prevalent type of rock. Secondary would be used to document the second most prevalent type of rock in the sample and tertiary would be the third type of rock described.

lith; Oftentimes Rock units contain different types of rocks, ie., limestone and shale, or sandstone, shale, and siltstone. This field allows up to three types of rocks to describe the rock sample.

mod1; A word or term used to describe the rock sample. It is selected from a drop down list of accepted geologic modifiers.

mod2; A second word or term used to describe the rock sample. It is selected from a drop down list of accepted geologic modifiers.

mod3; A third word or term used to describe the rock sample. It is selected from a drop down list of accepted geologic modifiers.

mod4; A fourth word or term used to describe the rock sample. It is selected from a drop down list of accepted geologic modifiers.

mod5; A fifth word or term used to describe the rock sample. It is selected from a drop down list of accepted geologic modifiers.

crystalsize; A word or term selected from a drop down list used to describe the crystal size of the rock sample.

color; A word or term selected from a drop down list used to describe the color of the rock sample.

percent; The percent of the sample that is primary (largest), secondary (second largest), or tertiary (third largest). Oftentimes Rock units contain different types of rocks, ie., limestone and shale, or sandstone, shale, and siltstone.

add_date; A calendar date, automatically recorded by the database system, when rock sample data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when rock sample data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added rock sample data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing rock sample data.

color2 ; A second word or term selected from a drop down list used to describe the color of the rock sample.

crystalsize2; A second word or term selected from a drop down list used to describe the crystal size of the rock sample.

lithology_occurs; Not Used

bedding_thickness; A word or term selected from a drop down list used to describe the thickness of bedding planes in a rock sample.

beds_range_from; A dimension (inches or centimeters) used to designate the smallest thickness of bedding planes in a rock sample.

beds_range_to; A dimension (inches or centimeters) used to designate the largest thickness of bedding planes in a rock sample.

Structure; A word or term selected from a drop down list used to describe the fabric or structure of the lithology.

Table Name: moistdensity

Moisture-density relations' tests are performed to obtain the maximum dry density and optimum water content of a particular soil. Many tests are performed on a single highway project. The density of soil can be increased with the same amount of compactive energy to a point the optimum water content is reached. After that point, an increase in the water content will cause water, which has a lower density than soil, to fill voids between soil particles and the density decreases. Results from these tests are used in construction control and in CBR testing. When properly compacted soil structures such as embankments and subgrades will carry loads more effectively and will be less prone to instability and settlement problems.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

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hole_id; The identification of the hole (usually a number), within a site, that the rock sample was obtained from.

sample_id; The identification of the soil or rock sample (usually a number), obtained from a hole. Samples are usually numbered in chronological order from the top of the hole to the bottom.

testnum; The laboratory test number of the sample. Sometimes more than one moisture-density relations test is performed on the same soil sample.

testmeth; The test specification followed when performing the moisture-density relation test. The method used may be a Kentucky Transportation Cabinet or ASTM method with each having different procedures depending on the particle size distribution of the sample.

maxdensity; The maximum dry density, expressed in mass per unit volume, obtained from the moisture-density relations test.

optmoist; The optimum moisture content, expressed as a percent, obtained from the moisture-density relations test.

add_date; A calendar date, automatically recorded by the database system, when moisture-density test data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when moisture-density test data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added moisture-density test data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing moisture-density test data**.**

Table Name: mr

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

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A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

hole_id; The identification of the hole (usually a number), within a site, that the rock sample was obtained from.

sample_id; The identification of the soil or rock sample (usually a number), obtained from a hole. Samples are usually numbered in chronological order from the top of the hole to the bottom.

samplenum; The laboratory test number of the sample. Sometimes more than one resilient modulus sample is prepared from the same soil sample.

diameter; The average diameter of the resilient modulus sample obtained from a minimum of three measurements.

length; The average length of the resilient modulus sample obtained from a minimum of three measurements.

weight; The weight (mass)of the resilient modulus sample at the time of testing.

w_content; The water content of the resilient modulus sample expressed as a percent of the dry mass.

no_sequence; The number of loads applied to the sample for each load sequence of the resilient modulus test, usually 100.
loadtime; The time the load is actually applied to the sample during the resilient modulus test, usually 0.1 sec.

cycletime; The time of one load cycle applied to the sample during the resilient modulus test, usually 1.0 second with 0.1 being load time and 0.9 sec. off.

waveform; The type of wave used to generate the load cycles during the resilient modulus test, usually haversine.

saturated; Used to indicate if the resilient modulus test sample has been saturated prior to testing.

stabilization; The type of chemical stabilization (lime, cement, etc.) used, if any, of the resilient modulus test sample.

percent; The percent, of dry mass, of chemical stabilizer used when preparing the resilient modulus test sample.

sigma3; The cell, or pressure applied around the sample during testing. Sometimes referred to as confining pressure - symbolized as: δ_3.

sigmadn; The target deviator stress or pressure to the sample during testing.

meanload; The average load applied to the sample during the last five cycles of a 100 cycle test increment.

std; The standard deviation of the load applied to the resilient modulus sample during the last five cycles of a 100 cycle test increment.

sigmada; The applied deviator stress or pressure applied to the resilient modulus sample during testing- symbolized as: δ_d.

sigmasum; The sum of all stresses or pressures applied to the resilient modulus sample during testing, symbolized as: δ_{sum}.

lvdt1; The measured elastic deformation obtained from a deflection transducer, of the sample, during the last five cycles of a 100 cycle test increment.

lvdt1; The measured elastic deformation obtained from a second deflection transducer, of the sample, during the last five cycles of a 100 cycle test increment.

meandef; The average elastic deformation obtained from two deflection transducers, of the sample, during the last five cycles of a 100 cycle test increment.

stddef; The standard deviation of the elastic deformation obtained from two deflection transducers, of the sample, during the last five cycles of a 100 cycle test increment.

meanstrain; The average strain of the resilient modulus sample obtained from two deflection transducers, of the sample, during the last five cycles of a 100 cycle test increment.

mr; The average resilient modulus, of the sample, during the last five cycles of a 100 cycle test increment.
stdmr; The standard deviation of the resilient modulus, of the sample, during the last five cycles of a 100 cycle test increment.

sigmasum; The sum of the stresses, deviator and confining, applied to the sample during the test.

dry_weight; The oven dry weight (mass)of the resilient modulus sample obtained after testing.

dry_density; The dry density of the resilient modulus sample, expressed in mass per unit volume, calculated from the wet weight and moisture content.

test_no; The test number assigned to the sample. Sometimes more than one test (saturated and unsaturated) are performed on specimens re-compacted from a bulk soil sample**.**

Table Name: otherrocktests

Unconfined compressive strength tests are performed on rock core samples to evaluate the load carrying capacity of the rock mass. Los Angeles Abrasion tests are performed on crushed rock core samples to determine the rocks resistance to abrasion.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

hole_id; The identification of the hole (usually a number), within a site, that the rock sample was obtained from.

sample_id; The identification of the soil or rock sample (usually a number), obtained from a hole. Samples are usually numbered in chronological order from the top of the hole to the bottom.

otsubsample_id; Oftentimes more than one test is performed on a sample. This field permits multiple subsamples , obtained from the sample interval, to be numbered.

Unconfcompstr; The unconfined compressive strength of the rock subsample.

laabrasion; The Los Angeles Abrasion test is a standard test used to determine the “wearability” of rock.

otdepth_top; The depth from the top of the boring to the top of the rock subsample.

otdepth_bot The depth from the top of the boring to the bottom of the rock subsample.

add_date; A calendar date, automatically recorded by the database system, when rock test data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when rock test data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added rock test data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing rock test data**.**

Table Name: sdi_jarslake

Bedrock exposed in highway cut slopes and streambeds are susceptible to erosion. Slake Durability Index and Jar Slake tests are performed on rock core samples (usually shale or other non-durable rocks) to obtain design parameters for rock slopes and bridge foundations. Slake durability index and jar slake tests also indicate which rock units nondurable or soil like and should be compacted as a soil material, not rock.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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hole_id; The identification of the hole (usually a number), within a site, that the rock sample was obtained from.

sample_id; The identification of the soil or rock sample (usually a number), obtained from a hole. Samples are usually numbered in chronological order from the top of the hole to the bottom.

sdisubsample_id; Oftentimes more than one Slake Durability or Jar Slake test is performed on a sample. This field permits multiple subsamples , obtained from the sample interval, to be numbered.

sdi; The value, expressed as percent wear obtained from a Slake Durability test.

sdidepth; The depth from the top of the boring to the top of the detph of the SDi or Jar Slake Sample. Unlike unconfined compressive strength, a depth to bottom is not reported for these two tests.

jarslake; The value obtained from a the Jar Slake test.

add_date; A calendar date, automatically recorded by the database system, when Slake Durability or Jar Slake test data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when Slake Durability or Jar Slake test data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added Slake Durability or Jar Slake test data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing Slake Durability or Jar Slake test data**.**

sdidepth_top; Depth to top was originally used to designate the depth of the SDI sample. A format to use depth was adopted later.

Table Name: soillabstrengthtest

Several types of strength tests are performed by geotechnical engineers and consultants on soil samples obtained from borings. These include unconsolidated-undrained (and the special case, unconfined compressive) triaxial tests, unconsolidated-undrained triaxial tests with pore pressure measurements, and, occasionally, consolidated-drained triaxial tests. The angle of internal friction, N, and cohesion, c, are obtained from those tests. Results from the soil strength tests are used for design and construction recommendations. Sample moisture and density data are provided with strength test results because soil strengths are dependent on those factors.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

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hole_id; The identification of the hole (usually a number), within a site, that the rock sample was obtained from.

sample_id; The identification of the soil or rock sample (usually a number), obtained from a hole. Samples are usually numbered in chronological order from the top of the hole to the bottom.

srentestnum; Oftentimes more than one Strength test is performed on a sample. This field permits multiple strength test numbers for one sample.

strengthtesttype; The type (Unconfined Compressive, Unconsolidated-Undrained, Consolidated-Undrained, or Consolidated-Drained Triaxial)of strength test med on the soil sample.

moistcont; The moisture content, expressed as a percentage of waste to dry mass, of the strength test specimen.

wetdensy; The wet density, expressed in mass per unit volume, of the strength test specimen.

drydens; The dry density, expressed in mass per unit volume, of the strength test specimen.

confpres; The pressure applied around the strength test specimen while testing. Sometimes referred to cell pressure and designated as δ_3.

phi; The internal angle of friction between particles in a soil specimen, expressed in degrees, obtained from soil strength tests.

cohesion; The strength between particles in a soil specimen, expressed in units of stress, obtained from soil strength tests.

add_date; A calendar date, automatically recorded by the database system, when Soil Strength test data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when Soil Strength test data at an existing site is changed or modified.
add_by; The person, recorded by the database system automatically, based on the user's log on id, who added soil strength test data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing soil strength test data**.**

test_group; Multiple triaxial strength tests of the same soil type are required to obtain accurate phi and Cohesion values. Oftentimes different samples from the same boring, or multiple borings, are grouped together to perform soil strength tests. This field shows which samples were grouped together to obtain single phi and cohesion test results.

natmoistcont; The natural. Or in situ, moisture content, expressed as a percentage of waste to dry mass, of the Soil Visual Description sample.

Table Name: soilvisdesc

Visual descriptions (color, texture, odor, etc.) of soil samples are recorded for all samples obtained from borings. The descriptions are based on accepted standardized terminology. If samples obtained from the same project have similar descriptions they may be combined with other samples for testing, or it is inferred the samples have the similar properties.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

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hole_id; The identification of the hole (usually a number), within a site, that the rock sample was obtained from.

sample_id; The identification of the soil or rock sample (usually a number), obtained from a hole. Samples are usually numbered in chronological order from the top of the hole to the bottom.

primsec; One soil sample may have different characteristics such as composition, consistency, and color. This field provides three values that describe the primary, secondary, and tertiary lithology of a soil sample. Primary would be the most prevalent type of soil. Secondary would be used to document the second most prevalent type of soil in the sample and tertiary would be the third type of soil within the sample described.

composition; The type of soil, clay, sand, silt, top soil, clay with gravel etc.

consistency; The consistency of soil sample – hard, soft, stiff, etc.

color; The color of the soil sample.

add_date; A calendar date, automatically recorded by the database system, when Soil Visual Description data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when Soil Visual Description data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added Soil Visual Description data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing Soil Visual Description data**.**

Table Name: rockfall_pictures

Electronic images (jpeg) of rock slopes rated using the Rockfall Hazard Rating System are stored within the data base. Up to 12 images can be stored with each rockfall site. The images are useful when questions about the rock slope arise. Different people can access the rock slope data and images at the same time and discuss any concerns about the slope. The images can also be used to document physical changes in the slope.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

picture_id; A number, automatically assigned to each picture associated with a site. A maximum of 12 pictures can be associated with each rockfall site.

picture; Raw data stored in binary format.

Table Name: pictures

A separate database of mechanically stabilized earth walls is a segment of the Kentucky Geotechnical Database. Electronic images (jpeg) of each mechanically stabilized earth wall site store can be stored within the database. Up to 12 images can be stored for each wall site. The images are useful when questions about the wall slope arise. Different people can access the rock slope data and images at the same time and discuss any concerns about the slope. The images can also be used to document physical changes in the wall.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

picture_id; A number, automatically assigned to each picture associated with a site. A maximum of 12 pictures can be associated with each site.

blob; Raw data stored in binary large object format.

Table Name: landslide_pictures

Electronic images (jpeg) of landslides, whose attributes are documented, are stored in the database. Up to 12 images can be stored with each landslide site. The images are useful when questions about the landslide arise. Different people can access the landslide data and images at the same time and discuss any concerns about the slide. The images can also be used to document physical changes in the slope.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

picture_id; A number, automatically assigned to each picture associated with a landslide site. A maximum of 12 pictures can be associated with each site.

picture; Raw data stored in binary format.

Table Name: users

Each user of the database is assigned a logon id and password by an authorized data base administrator. Each user is assigned a role by a data base administrator. Roles are: Data base administrator (can make any changes and delete any data), Data Entry, (can enter data and delete data the user entered), Regional Data Entry (can enter or change data within the user's district or organization), Viewer (can view data only).

last_name; The last name of an authorized user.

first_name; The first name of an authorized user.

role; Different users are assigned roles by a data base administrator. Roles are: Data base administrator (can make any changes and delete any data), Data Entry, (can enter data and delete data the user entered), Regional Data Entry (can enter or change data within the user's district or organization), Viewer (can view data only).

status; The status of a user active or terminated**.** User's may be terminated for various reasons, usually they retire, transfer, or change employers.

organization; The organization, highway district or department the user is employed at.

phone; The phone number of the user.

Table Name: db_summary

The summary table is used to store and query the total number of sites, including rockfall, landslide, walls, bridges, roadways, culverts, and buildings. The number of borings, borings with test samples, the types of samples, type of tests, or classification can also be queried. Queries can be made by state, site, district, route, county, or any combination of these.

county_id; The numerical identification number of the county. Counties in Kentucky are assigned numbers 1 through 120, alphabetically.

sites; The total number of sites in the data base.

sites_with-borings; The total number of sites in the data base with borings associated with them.

landslide_sites; The total number of landslide sites in the data base.

rockfall_sites; The total number of rockfall sites in the data base.

total_borings; The total number of borings in the data base.

total_locations; The total number of boring, open face log, and rock outcrop locations in the data base.

total_test_sample borings; The total number of borings with test samples in the data base.

soil_visual_descriptions; The total number of borings with soil visual description samples in the data base.

rock_cores; The total number of borings with rock core samples in the data base. Not used due to a change in format.

sounding_holes; The total number of soundings in the data base. A sounding is a type of boring used to determine the depth to rock.

open_face_logs; The total number of open face log samples in the data base. Open face logs are used in place of rock core borings to describe rock layers in highway cuts when the rock layers are visible and can be mapped and described.

rock_oucrop_locations; The total number of rock outcrop locations in the data base. A rock outcrop is where bedrock is exposed at the earth's surface.

tested_soil_samples; The total number of tested soil samples in the data base. Tested soil samples can be obtained in various ways--Shelby Tube, Standard Penetration Test (Split Spoon), Visual Description, Auger

shelby_tube_samples; The total number of Shelby of thin-walled tube soil samples in the data base.

spt_samples; The total number of Standard Penetration Test (SPT), sometimes referred to as split spoon samples, tested soil samples in the data base.

svd_samples; The total number of Soil Visual Description samples in the data base.

rock_core_samples; The total number of rock core samples in the data base.

artificial_fill_samples; The total number of artificial fill samples in the data base.

state_abbrev; The standard two letter abbreviation for the state, ie Kentucky (KY). Data for states bordering KY can be in the database.

building_sites; The total number of sites classified as a building in the data base.

bridges; The total number of bridges in the data base.

culverts; The total number of culverts in the data base.

walls; The total number of walls in the data base.

soil_tb_w_rock; ***Not used due to a change in format.***

soil_vd_w_rock; ***Number of soil visual description samples with rock. Not used due to a change in format.***

soil_vd_no_rock; ***Number of soil visual description samples with no rock. Not used due to a change in format.***

total_rock_borings; The total number of borings with rock core samples in the data base.

cbr_tests; The total number of California Bearing Ratio (CBR) tests in the data base.

multi_point_gradations; The total number of gradation, or sieve analysis, tests where more than one sieve size is used.

single_point_gradations; The total number of gradation, or sieve analysis, tests where one sieve (No. 200) is used. Classification of soils can be accomplished when the amount of material passing the No. 200 sieve (0.75-mm) sieve is known.

specific_gravities; The total number of specific gravity tests in the data base.

natural_moisture_content; The total number of natural moisture content tests in the data base.

d50; The total number of tests where the sieve size, or particle diameter, of 50% of the sample passes or is finer than has been determined from multi point gradation tests.

aashto _classifications; The total number of total number of soil samples classified by the AASHTO (American Association of Highway and Transportation Officials) method in the data base.

unified _classifications; The total number of total number of soil samples classified by the UCS (Unified Classification System) method in the data base.

unconfined_compression; The total number of soil unconfined compressive strength tests in the data base.

uu_triaxial_tests; The total number of unconsolidated-undrained triaxial compressive strength tests in the data base.

cu_triaxial_tests; The total number of consolidated-undrained triaxial compressive strength tests in the data base.

cd_triaxial_tests; The total number of consolidated-drained triaxial compressive strength tests in the data base.

moisture_density_tests; The total number of moisture-density relations tests in the data base.

consolidation_tests; The total number of one dimensional consolidation tests in the data base.

sdi; The total number of slake durability index (SDI) tests in the data base.

roadway_sections; The total number of roadway sections in the data base.

loc_w_lat_long; The total number of borings, rock outcrops, or open face logs with latitude and longitude cordinates associated with them in the data base.

loc_w_map_unit; The total number of borings, rock outcrops, or open face logs with the mapped bedrock unit associated with them in the data base.

Table Name: bridge_detail

Bridges are structures designed, constructed, and maintained to carry traffic safely over obstacles such as streams, rivers, or other large bodies of water, ravines, railroads, or other highways**.** A large amount of geotechnical data is generated for the design and construction of bridges.
This table is designed to document detailed design and construction of spans, type of supporting elements, footing elevations, and bearing capacity features associated with a bridge.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-

Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.
SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

bridge_id; A number assigned to each bridge within a site. In most cases a bridge will be a site. If two or more bridges exist or are being designed, with each bridge having separate travel lane directions a bridge number greater than one would be assigned.

span_id; A Span is the portion of the bridge between the supporting elements (abutments, end bents or piers. Abutments and end bents are at the ends of a bridge. Piers are supporting elements between the ends. Bridges may have one (no pier; two abutments or end bents) to several spans (piers between the end supporting elements). Spans are numbered beginning with one.

span_length; The length of the associated span.

subs_element; The type of substructure supporting element: pier, abutment or end bent. Abutments and end bents are at the ends of a bridge. Piers are supporting elements between the ends. Bridges may have no piers, just two abutments or end bents, called a single span bridge. Bridges with a pier or piers between supporting elements are multi span bridges.

foundation_type; The type of foundation (spread footings, piles, shafts, etc.) the supporting elements are constructed on.

bof_pte_design; The design elevation for the foundation base or pile tip.

bof_pte_as_built; The actual or "as built" elevation for the foundation base or pile tip.

allowable_bearing_; The designed bearing capacity the foundation element can support.

comment; A field for recording comments concerning the supporting elements of a bridge.

add_date; A calendar date automatically recorded by the database system when substructure element data was added to an existing site.

mod_date; A calendar date, automatically recorded by the database system, when substructure element data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added substructure element data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing substructure element data.

station; The station number of the center of the substructure supporting element along the mainline of the highway the bridge is a part of before the + sign. Station numbers are assigned by the Kentucky Transportation Cabinet. If the station is 100 + 00.00, this field is reserved for 100, or the station number before the + sign.

station1; The station number of the substructure supporting element of the bridge along the mainline of the highway the bridge is a part of after the + sign. Station numbers are assigned by the Kentucky

Transportation Cabinet. If the station is 100 + 00.00, this field is reserved for 00.00, or the station number after the + sign.

substructure_id; not used.

Table Name: bridge_history

This table is designed to document any changes made during the design, construction, and maintenance of bridge.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

bridge_id; A number assigned to each bridge within a site. In most cases a bridge will be a site. If two or more bridges exist or are being designed, with each bridge having separate travel lane directions a bridge number greater than one would be assigned.

history_id; A field for recording, in chronological order, dates and comments associated with the history of a bridge.

comment; A field for recording comments concerning the history of a bridge.

add_date; A calendar date automatically recorded by the database system when bridge history comments was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when bridge history comments at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added bridge history comments to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing bridge history comments.

Table Name: interchange_equations

Ramps are parts of an interchange used to move traffic onto and off of heavily traveled roadways. Ramps are assigned station numbers that do not coincide with the mainline route (or routes) station numbers. Each ramp in an interchange has a unique identifier, such as a letter, and its own set of station numbers**.** Equations are sometimes used to equate the ramp stations with the mainline route station numbers.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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equation_id; A field used to determine the length of the ramp when the beginning and ending stations ramp number s are entered.

ramp_station; The station number of the ramp before the + sign. Station numbers are assigned by the Kentucky Transportation Cabinet. If the station is 100 + 00.00, this field is reserved for 100, or the station number before the + sign.

ramp_station1; The station number of the ramp after the + sign. Station numbers are assigned by the Kentucky Transportation Cabinet. If the station is 100 + 00.00, this field is reserved for 00.00, or the station number after the + sign.

ramp_name; The name of the ramp.

route station; The station number of the mainline route before the + sign. Station numbers are assigned by the Kentucky Transportation Cabinet. If the station is 100 + 00.00, this field is reserved for 100, or the station number before the + sign.

route_station1; The station number of the mainline route the + sign. Station numbers are assigned by the Kentucky Transportation Cabinet. If the station is 100 + 00.00, this field is reserved for 00.00, or the station number after the + sign.

route_name; The name of the mainline route associated with the interchange.

add_date; A calendar date automatically recorded by the database system when interchange data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when interchange data was is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added interchange data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing interchange data.

Table Name: logon_record

This table documents the name, date, and time of all users log into the database.

last_name; The last name of the person who logged into the data base.

date_time; The date and time a user logged into the data base.

status; A field (Active or Terminated) used to define if a user has access to the data base.

logon_time_span; The time, in minutes, a user was logged into the data base.

archive; A check (yes or no) system used to archive log on records.

Table Name: mr_coefficient_456

(This table replaces Table Name: mr_coefficient_all described below)

Resilient modulus is a measure of elastic movement of the pavement layers when repetitive loads are applied. This field is used for calculating and storing coefficients needed to model the resilient modulus of subgrade or soil laver below the asphalt and gravel base pavement components. Several models have been developed to calculate resilient modulus from laboratory tests. This table was initially constructed for the database and included six different mathematical resilient modulus expressions relating resilient modulus to testing stresses. A full discussion of the different models is described in studies by:

> Hopkins, T.C., Beckham, T.L., Sun, L. and Ni, B.; (2002). "***Resilient Modulus of Kentucky Soils,***" Research Report KTC-01-07/SPR-163-95-1F, University of Kentucky Transportation Center, Lexington Kentucky, USA.
>
> Ni, B., Hopkins, T. C., and Sun, L. (2002). ***"Modeling the Resilient Modulus of Soils,"***

Proceedings, Sixth International Conference on the Bearing Capacity of Roads, Railways (BCRA'02) and Airfields, Lisbon, Portugal.

Resilient modulus models initially considered are as follows:

[5]**Model 1**: Moossazadeh and Witczak (1981):

$$M_r = k_1 \left(\frac{\sigma_d}{p_a} \right)^{k_2},$$

where M_r is the resilient modulus, k_1 (y-intercept) and k_2 (slope of the line) are coefficients obtained from a linear regression analysis, and p_a is a reference pressure. In this model, the effect of the confining stress, F_3, is not considered.

Model 2: Dunlap (1963):

$$M_r = k_1 \left(\frac{\sigma_3}{p_a} \right)^{k_2},$$

where k_1 and k_2 are regression coefficients and F_3 is the confining stress. The influence of the deviator stress is ignored in this relationship.

Model 3: Seed et al. (1967):

$$M_r = k_1 \left[\frac{\sigma_{sum}}{p_a} \right]^{k_2}.$$

where k_1 and k_2 are regression coefficients and the term,$F_{sum,}$ is the sum of principal stresses ($F_1 + F_2 + F_3$), or for the triaxial compression case, the term is equal to ($F_1 + 2F_3$).

Model 4: May and Witczah (1981) and Uzan (1985):

$$M_r = k_1 \left(\frac{\sigma_{sum}}{p_a} \right)^{k_2} \left(\frac{\sigma_d}{p_a} \right)^{k_3}.$$

The terms, k_1, k_2, and $k_{3,}$ are multiple correlation regression coefficients. Under identical loading ($\sigma_1 = \sigma_2 = \sigma_3$).

Model 5: Ni-Hopkins-Sun (2001):

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[5] *Although initially Models 1, 2, and 3 described here were included in the "Applications" section of the database, they were later excluded because research (Hopkins, et al., 2002) showed that they generally were not suitable for fitting resilient modulus data. Only Models 4, 5, and 6 have been included in the database.*

$$M_r = k_1\left(\frac{\sigma_3}{p_a}+1\right)^{k_2}\left(\frac{\sigma_d}{p_a}+1\right)^{k_3},$$

where the terms, k_1, k_2, and k_3, are multiple correlation regression coefficients.

Model 6: NCHRP (National Highway Cooperative Research Program (Fall 2001):

$$M_r = k_1\left(\frac{\sigma_{sum}}{p_a}\right)^{k_2}\left(\frac{\tau_{oct}}{p_a}+1\right)^{k_3},$$

where: F_{sum} = sum of all orthogonal normal stresses acting at a given point (or as listed in the summary, F_{sum} is defined using the symbol, 2, which is defined as the bulk stress).

J_{oct} =Octahedral shear stress acting on the material, or

$$\tau_{oct} = \frac{\sqrt{2}}{2}(\sqrt{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}\ .$$

$$\tau_{oct} = (\sigma_1-\sigma_2) = (\sigma_1-\sigma_3) = \sigma_d = deviator\ \ stress$$

$$M_r = k_1\left(\frac{\sigma_{sum}}{p_a}\right)^{k_2}\left(\frac{\sigma_d}{p_a}+1\right)^{k_3},$$

Column name; classification; The classification of the soil determined by the AASHTO system.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

hole_id; The identification of the hole (usually a number), within a site, that the soil sample used to perform the resilient modulus test the was obtained from.

sample_id; The number of the sample obtained from a hole. Samples obtained from a hole are numbered in the order they are obtained from top to bottom.

test_no: The test number, in sequential order beginning with one. Frequently, more than one test is performed on the same sample.

soaked; An indicator (Yes or No) to mark if the resilient modulus sample was saturated, or soaked, prior to testing.

uzan_k1; The k_1 multiple regression coefficient derived for Uzan's resilient modulus model.

uzan_k2; The k_2 multiple regression coefficient derived for Uzan's resilient modulus model.

uzan_k3; The k_3 multiple regression coefficient derived for Uzan's resilient modulus model.

uzan_rs; The R–squared value, used to measure the accuracy of the data fit, obtained from Uzan's resilient modulus model.

uktc_k1; The k_1 multiple regression coefficient derived for UKTC's (University of Kentucky Transportation Center) resilient modulus model.

uktc_k2; The k_2 multiple regression coefficient derived for UKTC's resilient modulus model.

uktc_k3; The k_3 multiple regression coefficient derived for UKTC's resilient modulus model.

uktc_rs; The R–squared value, used to measure the accuracy of the data, obtained from UKTC's resilient modulus model.

nchrp_k1; The k_1 multiple regression coefficient derived for NCHRP's (National Cooperative Highway Research Program) resilient modulus model.

nchrp_k2; The k_2 multiple regression coefficient derived for NCHRP's resilient modulus model.

nchrp_k3; The k_3 multiple regression coefficient derived for NCHRP's resilient modulus model.

nchrp_rs; The R–squared value, used to measure the accuracy of the data, obtained from NCHRP's resilient modulus model.

Table Name: mr_coefficient_all

(This table replaced by Table Name: mr_coefficient_456 *—Models 1, 2, and 3--Moossazadeh and Witczak; Dunlap; and Seed, respectively-- were deemed not very applicable to relating resilient modulus and testing stresses and were dropped when the replacement table,* ***mr_coefficient_456 was created).***

Column name; classification; The classification of the soil determined by the AASHTO system.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

hole_id; The identification of the hole (usually a number), within a site, that the soil sample used to perform the resilient modulus test the was obtained from.

sample_id; The number of the sample obtained from a hole. Samples obtained from a hole are numbered in the order they are obtained from top to bottom.

test_no: The test number, in sequential order beginning with one. Frequently, more than one test is performed on the same sample.

soaked; An indicator (Yes or No) to mark if the resilient modulus sample was saturated, or soaked, prior to testing.

sigma3; The cell pressure applied around the resilient modulus sample during testing. Sometimes referred to as confining pressure - symbolized as: F_3.

sigmad; The applied deviator stress or pressure applied to the resilient modulus sample during testing - symbolized as: F_d . The applied deviator stress is the difference between the major principle stress, F_1, and the confining stress, or minor principle stress, F_3 .

m1k1; *The k_1 regression coefficient derived for Moossazadeh and Witczak 's resilient modulus model.*

m1k2; *The k_2 regression coefficient derived for Moossazadeh and Witczak 's resilient modulus model.*

m2k1; *The k_1 regression coefficient derived for Dunlap's resilient modulus model.*

m2k2; *The k_2 regression coefficient derived for Dunlap's resilient modulus model.*

m3k1; *The k_1 regression coefficient derived for Seed"s resilient modulus model* **.**

m3k2; *The k_2 regression coefficient derived for Seed's resilient modulus model.*

m4k1; *The k_1 regression coefficient derived for Uzan's resilient modulus model.*

m4k2; *The k_2 regression coefficient derived for Uzan's resilient modulus model*

m4k3; *The k_3 regression coefficient derived for Uzan's resilient modulus model.*

m5k1; *The k_1 regression coefficient derived for UKTC's resilient modulus model.*

m5k2; *The k_2 regression coefficient derived for UKTC's resilient modulus model.*

m5k3; *The k_3 regression coefficient derived for UKTC's resilient modulus model*

rs: *The R–squared value, used to measure the accuracy fit of the data, obtained from the Moossazadeh and Witczak 's resilient modulus model.*

rs1: *The R–squared value, used to measure the accuracy fit of the data, obtained from the Dunlap's resilient modulus model.*

rs2: *The R–squared value, used to measure the accuracy fit of the data, obtained from the Moossazadeh and Witczak 's resilient modulus model.*

rs3; *The R–squared value, used to measure the accuracy fit of the data, obtained from the Moossazadeh and Witczak 's resilient modulus model.*

rs4; *The R–squared value, used to measure the accuracy fit of the data, obtained from the Moossazadeh and Witczak 's resilient modulus model.*

m6k1; *The k_1 multiple regression coefficient derived for NCHRP's resilient modulus model.*

m6k2; *The k_2 multiple regression coefficient derived for NCHRP's resilient modulus model.*

m6k3; *The k_3 multiple regression coefficient derived for NCHRP's resilient modulus model.*

rs6: *The R–squared value, used to measure the accuracy fit of the data, obtained from the NHCRP resilient modulus model.*

Table Name: open_face_log

An open face log is sometimes uses to describe rock units and the geometry of an existing rock cut or slope. The open face log can substiuted for a rock core boring to document the rock units. It will provide the information necessary to design a new slope, especially where reconstruction of an existing route is being designed**.**

The system allows an open face log to be recorded before construction and a subsequent open face log can be recorded after construction.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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hole_id; The identification of the hole (usually a number), within a site. An open face log is considered a hole.

phase; A numerical number used to indicate a work phase of a project**.** The value of the geotechnical database derives in part from the fact that sites where geotechnical investigations are performed may eventually become the focus of additional study. Consider, for example, a bridge constructed in the mid 1970's. A geotechnical investigation was performed, and the results of drilling and lab testing were entered into the database. The date of the drilling, who performed the drilling, who the bridge designer was, and who performed the laboratory testing are among the data entered. The item number, that English (as opposed to Metric) units were used, and the vertical control datum (sealevel or assumed, for example) were also entered.

Now, some thirty years later, a new bridge, wider than the original to accommodate increased traffic volume, is required. The new bridge is to be constructed at essentially the same location as the existing bridge. In some situations of this type, information obtained from the original geotechnical investigation could be adequate for developing plans for the new structure, saving both time and money. In other cases, however, additional drilling will be required. Since the location of the bridge has not changed, it is logical to consider it to be the same site. However, much of the information previously recorded will have changed. It is unlikely that the organization and individuals performing the new drilling will be the same as those who performed these jobs years earlier. The same is true of the bridge designer, and the new job may even be designed in Metric units as opposed to the English units of the older design. To accommodate these changes, the database format allows that when a new phase of work is identified, any or all of these fields can change. The bridge designer for the structure built in the 1970's (that is the Phase 1 bridge designer) is retained in the records, but the bridge designer for the new (Phase 2) bridge is also shown.

It may also be advantageous to assign different phases of work on the same general project. During design it may be discovered that additional information beyond that provided by the original geotechnical investigation is required. Thus, many months, or even a couple of years after the original investigation a drill crew is sent out for additional borings and samples. It is convenient, then, to identify the original work as phase 1, and the additional work as phase 2. A different crew could easily perform phase 2 drilling than performed the phase 1 drilling. However, by identifying the work as different phases, this and other changes are easily accommodated.

station_a; The station integer number assigned by the Kentucky Transportation Cabinet, along the centerline of the highway, at the point the open face log was obtained. Each integer equals one-foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

station_b; The decimal portion of the centerline station number of the open face log.

offset direction; The distance from the centerline station of the roadway the open face log is located at.

usgsmap_num; The number of the 7.5 minute geologic quadrangle map the open face log is located on. 7.5 minute quadrangle maps of bedrock in Kentucky, and many other states, nave been published by the United States Geological Survey. Each map has a unique integer number used to identify it. The Tollesboro Quadrangle, located in parts of Lewis and Fleming Counties KY, is GQ map # 661, for example.

location_accuracy; Used to designate the horizontal accuracy (±) of the open face log location. An estimate of the location accuracy of the latitude and longitude of the hole is stated in terms of feet or meters, whichever unit is selected. Some holes have survey grade accuracy while others are determined from maps or plans.

rdz_elevation; The distance from the top of the open face log to the top of the rock disintegration zone (RDZ). Materials in the RDZ are composed of weathered and decomposed bedrock. The depth to the base of the RDZ is generally indicated on core logs for roadway projects.

latitude; The latitude of a hole input as degrees, minutes, and seconds or decimal degrees.

longitude; The longitude of a hole input as degrees, minutes, and seconds or decimal degrees.

begin_station1; The integer portion of the station number where the cut or rock face begins.

end_station1; The decimal portion of the station number where the cut or rock face begins.

begin_station2; The integer portion of the station number where the cut or rock face ends.

end_station1; The decimal portion of the station number where the cut or rock face ends.

matchmapunit; An indicator used to determine if the rock description of the open face log matches the rock unit described on the bedrock maps. Bedrock maps are usually 7.5-minute geologic quadrangles published by the United States Geological Survey.

pre_elevation_1; The top elevation of the first feature (slope or bench) described in the open face log.

pre_elevation_2; The top elevation of the second feature (slope or bench) described in the open face log.

pre_elevation_3; The top elevation of the third feature (slope or bench) described in the open face log.

pre_elevation_4; The top elevation of the fourth feature (slope or bench) described in the open face log.

post _elevation_1; The top elevation of the first feature (slope or bench) described in the open face log after construction.

post_elevation_2; The top elevation of the second feature (slope or bench) described in the open face log after construction.

post_elevation_3; The top elevation of the third feature (slope or bench) described in the open face log after construction.

post_elevation_4; The top elevation of the fourth feature (slope or bench) described in the open face log after construction.

pre_angle_or_length_1; The angle of the first slope to the first bench slope or the length of the first bench (highest) described in the open face log.

pre_angle_or_length_2; The angle of the second slope to the first bench slope or the length of the first bench (highest) described in the open face log

pre_angle_or_length_3; The angle of the third slope to the first bench slope or the length of the first bench (highest) described in the open face log

post_angle_or_length_1; The angle of the first slope to the first bench slope or the length of the first bench (highest) described in the open face log after construction.

post_angle_or_length_2; The angle of the second slope to the first bench slope or the length of the first bench (highest) described in the open face log after construction.

post_angle_or_length_3; The angle of the third slope to the first bench slope or the length of the first bench (highest) described in the open face log after construction.

pre_slope_or_bench_1; A radio button used to indicate if the first feature described in the open face log is a slope or a bench.
pre_slope_or_bench_2; A radio button used to indicate if the second feature described in the open face log is a slope or a bench.

pre_slope_or_bench_3; A radio button used to indicate if the first feature described in the open face log is a slope or a bench.

post_slope_or_bench_1; A radio button used to indicate if the first feature described in the open face log after construction is a slope or a bench.

post_slope_or_bench_2; A radio button used to indicate if the second feature described in the open face log after construction is a slope or a bench.

post_slope_or_bench_3; A radio button used to indicate if the third feature described in the open face log after construction is a slope or a bench.

pre_offset_of_base; The offset distance from the centerline of the highway station to the base of the slope the open face log is documenting.

post_offset_of_base; The offset distance from the centerline of the highway station to the base of the slope the open face log is documenting after the slope is reconstructed.

percent_covered*; Not used.*

fault_station_1_1; The integer portion of the station number where a fault is documented on an open face log.

fault_station_2_1; The integer portion of the station number where a second fault is documented on an open face log.

fault_station_3_1; The integer portion of the station number where a third fault is documented on an open face log.

fault_station_4_1; The integer portion of the station number where a fourth fault is documented on an open face log.

fault_station_5_1; The integer portion of the station number where a fifth fault is documented on an open face log.

fault_station_1_2; The decimal portion of the station number where a fault is documented on an open face log.

fault_station_2_2; The decimal portion of the station number where a second fault is documented on an open face log.

fault_station_3_2; The decimal portion of the station number where a third fault is documented on an open face log.

fault_station_4_2; The decimal portion of the station number where a fourth fault is documented on an open face log.

fault_station_5_2; The decimal portion of the station number where a fifth fault is documented on an open face log.

location_type; The type of boring (rock core, soil sample, sounding, etc.) or open face log.

comments; A field used to indicate any comments associated with the open face log.
add_by; The person, recorded by the database system automatically, based on the user's log on id, who added data to an existing open face log. site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified an existing open face log.

add_date; A calendar date, automatically recorded by the database system, when new data was added to an existing open face log.

mod_date; A calendar date, automatically recorded by the database system, when data was added to an existing open face log.

multi_quad_map; A one character suffix (A, B or C) for some partial 7.5 minute geologic quadrangles that are positioned along the border line of Kentucky and other states. The maps do not cover an entire 7.5 minute quadrangle. The maps have the same number as an adjacent 7.5 minute map.

Table Name: project_history

This table is designed to document any changes made during the design, construction, and maintenance of components (bridges, culverts, walls, roadway, etc.) in a highway.
Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not

always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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history_id; A field for recording, in chronological order, dates and comments associated with the history of a bridge.

history_date; A calendar date use d to document when project history data is added.

comment; A field used to indicate any comments associated with the project history.

add_by; The person, recorded by the database system automatically, based on the user’s log on id, who added data to an existing project history.

mod_by; The person, recorded by the database system automatically, based on the user’s log on id, who modified an existing project history.

add_date; A calendar date, automatically recorded by the database system, when new data was added to an existing project history.

mod_date; A calendar date, automatically recorded by the database system, when data was added to an existing project history.

Table Name: quadrangle

7.5 minute (latitude and longitude) quadrangle maps of bedrock in Kentucky, and many other states, have been published by the United States Geological Survey. Each map has a unique integer number used to identify it. The Tollesboro Quadrangle, located in parts of Lewis and Fleming Counties KY, is GQ map # 661, for example.

Column name; quadrangle_name; The name of the 7.5 minute geologic quadrangle.

usgs_map_no; The integer number of the 7.5 minute geologic quadrangle.

min_lat; The minimum latitude of the 7.5 minute quadrangle. A reference point used in data searches to search the quadrangle.

max_lon; The maximum longitude of the 7.5 minute quadrangle. A reference point used in data searches.

usgs_code; A one character suffix; A, B or C, following the quadrangle number, for some partial 7.5 minute geologic quadrangles that are positioned along the border line of Kentucky and other states. The maps do not cover an entire 7.5 minute quadrangle. The maps have the same number as an adjacent full 7.5 minute map.

Table Name: report

This table is used to compare and search reports by state, district, county, or route. The report table is used to store and query all geotechnical reports issued.

Since 1973, most reports issued by the Geotechnical Branch have been assigned numbers, to facilitate tracking them. The format is X-#-Y, where X indicates the type of report, Y is the year in which it was published, and # is a sequential numbering of reports of the specified type issued during any given year. In paper files, year was, historically, and commonly even now, reported with two digits (79 means 1979 while 02 means 2002). Of course it is always recorded with four digits in the database. Report types include R (roadway), S (structure), L (landslide) C (construction) and M (maintenance). Structure (S) reports include bridges, culverts and walls. On occasion they could also include buildings (salt domes, rest area facilities, or other buildings).

The Geotechnical Branch has also issued RSD (rock slope design) reports to facilitate construction of highway cuts in rock. Generally, drilling results and rock core logs presented in RSD reports are also presented, along with a good deal of additional information, in a roadway report for the same project. In these cases, which applies to over 90% of the RSD reports, it is unnecessary to enter RSD report data in the database. If all data from the roadway report is entered, then data in the RSD report would be redundant (but since the roadway report includes data not presented in the RSD report, the reverse would not be true). There are cases where an RSD report is issued for a project, but no roadway report is ever issued. When we find an RSD report that has no accompanying roadway report, meaning data presented in the RSD report are not duplicated elsewhere, this information should be input into the database. Since there are only a few of these (the exact or even approximate number is unknown) and also because the 3-character RSD designation is a problem in a database structure that allows only one character to specify report type, we have developed an alternate recording scheme. We record them as R (roadway) reports with #'s beginning with 900. The highest number used for regular roadway reports, to date, is 63, so a number 900 or above indicates that the data was actually issued as an RSD report rather than as a regular roadway report.

Prior to 1973, no numbers were assigned to reports. Some of these reports are still available in hard-copy project files, however, and as time permits this data may be input. To facilitate cataloguing, these reports are assigned a report number (the lowest unused number, for the particular type of report, for the appropriate year). Often, geotechnical reports prepared by geotechnical consultants, are issued by the Geotechnical Branch, and assigned a number at the time they are issued. In numerous other cases, however, they were not assigned numbers. When such data are entered into the database, these consultant reports are also given newly assigned report numbers.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

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report_id; The type, number, and year of the geotechnical report. All three parts are combined automatically.

report_type; Each report issued by the Geotechnical Branch is a unique type. The type is indicated by a single character field: L =Landslide, S = Structure (includes bridges, walls, culverts) B= buildings, C = construction, L = Landslide. G = General Counsel, M = Maintenance, P = Planning, k = Rock Slope Design, T = Traffic Permits.

report_no; A number assigned to each report type. The numbers are assigned chronologically beginning in January and continuing through out the calendar year. The first Roadway Report issued in January would R-01-XX, with XX being the last two digits of the year the report was issued.

report_year; The year the report was issued. The numbers are assigned chronologically beginning in January and continuing through out the calendar year. The first Roadway Report issued in January would R-01-XX, with XX being the last two digits of the year the report was issued.

addendum; A 1 digit integer used to indicate any addendums to the original report. The original report uses a default value of zero (0). Up to six additional addendums can be added.

report_date; The calendar date the report was issued.

report_who; The person who wrote the geotechnical report.

issued_by; The firm or department who issued the report, Usually the Geotechnical Branch.
comments; A field reserved for any comments concerning the geotechnical report.

add_date; A calendar date automatically recorded by the database system when report data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when report data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added report data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing report data.

phase; The number of a phase associated with a site.

report_id4list; An internal working table used to combine report type, year, and number into one field to match the report number in projects table.

completed_status; A yes or no indicator used to show if design is completed for the project associated with this site.

completed_construction; A yes or no indicator used to show if construction is completed for the project associated with this site.

Table Name: rockfall_cost

The Rockfall Mitigation Cost screen can be used to evaluate the cost of techniques that can be used to repair a hazardous slope. The graphical user input screens allows the user to input the type, quantity, and unit cost of the elements needed to repair the slope. Oftentimes, more than one element is required. Total cost, as well as a Cost to Rockfall Hazard Rating Score is also calculated. This provides a method to evaluate the cost of the repairs versus the risk of a rockfall occurring.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

inventory_date; The calendar the rock slope was evaluated using the Rockfall Hazard Rating System.

designer; The name of the person designing the mitigation of the rock slope.

option description; A field reserved for any comments concerning the design options considered.

design_type; The type of design (correction or hazard reduction).

element_1; The first type of mitigation measures used in the design.

element_2; The second type of mitigation measures used in the design.

element_3; The third type of mitigation measures used in the design.
element_4; The fourth type of mitigation measures used in the design.

element_5; The fifth type of mitigation measures used in the design.

element_6; The sixth type of mitigation measures used in the design.

element_7; The seventh type of mitigation measures used in the design.

element_8; The eighth type of mitigation measures used in the design.

quantity_1; The number of elements for the first type of mitigation measures used in the design.

quantity_2; The number of elements for the second type of mitigation measures used in the design.

quantity_3; The number of elements for the third type of mitigation measures used in the design.

quantity_4; The number of elements for the fourth type of mitigation measures used in the design.

quantity_5; The number of elements for the fifth type of mitigation measures used in the design.

quantity_6; The number of elements for the sixth type of mitigation measures used in the design.

quantity_7; The number of elements for the seventh type of mitigation measures used in the design.

quantity_8; The number of elements for the eighth type of mitigation measures used in the design.

unit_cost_1; The unit cost of the element for the first type of mitigation measures used in the design.

unit_cost_2; The unit cost of the element for the second type of mitigation measures used in the design.

unit_cost_3; The unit cost of the element for the third type of mitigation measures used in the design.

unit_cost_4; The unit cost of the element for the fourth type of mitigation measures used in the design.

unit_cost_5; The unit cost of the element for the fifth type of mitigation measures used in the design.

unit_cost_6; The unit cost of the element for the sixth type of mitigation measures used in the design.

unit_cost_7; The unit cost of the element for the seventh type of mitigation measures used in the design.

unit_cost_8; The unit cost of the element for the eighth type of mitigation measures used in the design.

unit _1; The unit for the first type of mitigation measures used in the design.

unit _2; The unit for the second type of mitigation measures used in the design.

unit_3; The unit for the third type of mitigation measures used in the design.

unit_4; The unit for the fourth type of mitigation measures used in the design.

unit_5; The unit for the fifth type of mitigation measures used in the design.

unit_6; The unit for the sixth type of mitigation measures used in the design.

unit_7; The unit for the seventh type of mitigation measures used in the design.

unit_8; The unit for the eighth type of mitigation measures used in the design.

total_cost The estimated cost of the design repairs, calculated automatically, based on the elements, quantity, units, and unit cost input by the designer.

cost_score_ratio The ratio, calculated automatically, of the estimated cost divided by the Rockfall Hazard Rating Score.

add_date; A calendar date automatically recorded by the database system when mitigation cost data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when mitigation cost data at an existing site is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added mitigation cost data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing mitigation cost data.

Table Name: rqd_percrec

Rock Quality Designation (RQD) is an estimate of the insitu rock quality. The international method of determining RQD is a percentage ratio of intact rock lengths to total length of the core run (usually five or ten feet). The total length of rock core pieces which are hard, sound, and 4 inches or greater in length are summed, and divided by the total inches of the rock core run. The Kentucky Transportation Cabinet uses the same method except hard id defined as difficult to break by hand. Some judgment is required to determine hard rock. Any breaks caused by drilling are ignored. Percent recovery ratio is the length of rock recovered divided by the length of the core run. Rock quality is not a factor in percent recovery. The percent recovery may be less than 100 if soft rock is washed away by the drilling fluid or if voids and fractures are encountered.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.
A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

hole_id; The identification of the hole (usually a number), within a site.

rqdsubsample; RQD is determined from a length of rock core sample (usually five or ten feet). More than one RQD sample may be within the limits of a rock core sample obtained from a hole or boring. The rock core sample is based on the lithology or rock type.

Rqd; The RQD value determined from the ASTM D 58778 method.

kyrqd; The RQD value determined from the Kentucky Transportation Cabinet Method.

rqddepth; The depth to the bottom of the RQD sample from the top of the hole.

rqd;The RQD value determined from the ASTM D 58778 method

percentrec: The percent recovery of the core run.

add_date; A calendar date automatically recorded by the database system when rqd data was added to an existing hole**.**

mod_date; A calendar date, automatically recorded by the database system, when rqd data at an existing hole is changed or modified.

add_by; The person, recorded by the database system automatically, based on the user’s log on id, who added rqd data a hole.

mod_by; The person, recorded by the database system automatically, based on the user’s log on id, who modified existing rqd data.

rqddepth_top; The depth to the top of the RQD sample from the top of the hole.

Table Name: sideroads

Sideroads within this database are routes that intersect with the mainline route. Oftentimes, during construction of a mainline route, roads that intersect the route are relocated. Relocating the roads requires the same level of geotechnical exploration, testing, and designs as required for the mainline route. Because a considerable amount of geotechnical information is generated for the approaches or intersections they are included as a site type.

Column name; site_rownum: Each site within the database is associated with a unique site number; and each site number is associated with a particular site in a one-to-one correspondence. These numbers are assigned (automatically by database programming) selecting the lowest available site number. Ordinarily, all available numbers will have been used up to a certain value equal to the total number of sites in the database, and the next site created will use the next available number. This is not always the case, however. If some old sites were deleted for some reason such deletions would create gaps within the site number sequence. These inordinately low values would be reused first to fill any gaps within the numbering sequence. Although site number has no meaning in terms of site characteristics, it plays a vital role in facilitating bookkeeping within the database. Also, if site number is known (site numbers are noted on Geotechnical Report hardcopies), or can be determined from various database lists, it is a convenient way to retrieve only the site or sites the user is interested in. When a new site is created from scratch, the site number shown on the entry screen is valid for this new site. Copying an existing site creates a new site, however, the site number displayed is that of the existing site. To determine the site number of the new site one must close and save the entered data and then retrieve the site by some other criterion (county, route and project type, for example) to be able to determine the site number for the newly created site.

A site can be a landslide, rockfall, RW-Mainline (roadway mainline), side road, interchange, bridge approach, bridge, building, culvert, dam, drainage, pavement, SCS (soil conservation service) utilities, planning study, and wall. With the current structure there can be sites within sites. For example RW-Mainline is a roadway segment that currently exists, has been designed, is in the design process, or is being constructed. Within that segment other sites could physically be located such as sideroads, bridge approaches, bridges, interchanges, culverts, walls, landslides, and rockfall. The beginning and end of a RW-Mainline site is defined by station numbers assigned by the Kentucky Transportation Cabinet.

A side road is an approach road to a RW Mainline. Geotechnical information exists for a side road because it typically is realigned to intersect with the mainline roadway.

SCS is used to store geotechnical data that the Kentucky Transportation Cabinet generated for the Soil Conservation Service.

direction; A direction, Right or Left, or crosses the centerline mainline route.

m_report_type; Each report issued by the Geotechnical Branch is a unique type. The type is indicated by a single character field: L =Landslide, S = Structure (includes bridges, walls, culverts) B= buildings, C = construction, L = Landslide. G = General Counsel, M = Maintenance, P = Planning, k = Rock Slope Design, T = Traffic Permits.

m_report_no; A number assigned to each report type. The numbers are assigned chronologically beginning in January and continuing through out the calendar year. The first Roadway Report issued in January would R-01-XX, with XX being the last two digits of the year the report was issued.

m_report_year; The year the report was issued. The numbers are assigned chronologically beginning in January and continuing through out the calendar year. The first Roadway Report issued in January would R-01-XX, with XX being the last two digits of the year the report was issued.

m_site_rownum: The unique site number, automatically assigned, to the site the sideroad intersects.

station; The beginning station integer number assigned by the Kentucky Transportation Cabinet of the sideroad where the route intersects the mainline. Each integer equals one foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

station1; The decimal portion of the beginning station number of the sideroad where the route intersects the mainline

mainline_station; The beginning station integer number assigned by the Kentucky Transportation Cabinet of the mainline where the sideroad intersects the mainline. Each integer equals one foot distance (English units). A project or site with a beginning station number 0+00 and an ending station number 100 + 00 would be 1,000 feet in length.

mainline_station1; The decimal portion of the beginning station number of the mainline where the sideroad intersects the mainline.

add_by; The person, recorded by the database system automatically, based on the user's log on id, who added sideroads data to a site.

mod_by; The person, recorded by the database system automatically, based on the user's log on id, who modified existing sideroads data.

add_date; A calendar date, automatically recorded by the database system, when sideroads data was added to an existing site**.**

mod_date; A calendar date, automatically recorded by the database system, when sideroads data at an existing site is changed or modified.

none; An indicator (yes or no) used to show if sideroads intersect roadway segment.

Appendix D

Listing of Counties in Kentucky and Contiguous Counties in States Surrounding Kentucky

State	County ID	Highway District	County Name
KY	1	8	Adair
KY	2	3	Allen
KY	3	7	Anderson
KY	4	1	Ballard
KY	5	3	Barren
KY	6	9	Bath
KY	7	11	Bell
KY	8	6	Boone
KY	9	7	Bourbon
KY	10	9	Boyd
KY	11	7	Boyle
KY	12	6	Bracken
KY	13	10	Breathitt
KY	14	4	Breckinridge
KY	15	5	Bullitt
KY	16	3	Butler
KY	17	2	Caldwell
KY	18	1	Calloway
KY	19	6	Campbell
KY	20	1	Carlisle
KY	21	6	Carroll
KY	22	9	Carter
KY	23	8	Casey
KY	24	2	Christian
KY	25	7	Clark
KY	26	11	Clay
KY	27	8	Clinton
KY	28	1	Crittenden
KY	29	8	Cumberland
KY	30	2	Daviess
KY	31	3	Edmonson
KY	32	9	Elliott
KY	33	10	Estill
KY	34	7	Fayette
KY	35	9	Fleming
KY	36	12	Floyd

State	County ID	Highway District	County Name
KY	37	5	Franklin
KY	38	1	Fulton
KY	39	6	Gallatin
KY	40	7	Garrard
KY	41	6	Grant
KY	42	1	Graves
KY	43	4	Grayson
KY	44	4	Green
KY	45	9	Greenup
KY	46	2	Hancock
KY	47	4	Hardin
KY	48	11	Harlan
KY	49	6	Harrison
KY	50	4	Hart
KY	51	2	Henderson
KY	52	5	Henry
KY	53	1	Hickman
KY	54	2	Hopkins
KY	55	11	Jackson
KY	56	5	Jefferson
KY	57	7	Jessamine
KY	58	12	Johnson
KY	59	6	Kenton
KY	60	12	Knott
KY	61	11	Knox
KY	62	4	Larue
KY	63	11	Laurel
KY	64	12	Lawrence
KY	65	10	Lee
KY	66	11	Leslie
KY	67	12	Letcher
KY	68	9	Lewis
KY	69	8	Lincoln
KY	70	1	Livingston
KY	71	3	Logan
KY	72	1	Lyon

State	County ID	Highway District	County Name
KY	76	7	Madison
KY	77	10	Magoffin
KY	78	4	Marion
KY	79	1	Marshall
KY	80	12	Martin
KY	81	9	Mason
KY	73	1	McCracken
KY	74	8	McCreary
KY	75	2	McLean
KY	82	4	Meade
KY	83	10	Menifee
KY	84	7	Mercer
KY	85	3	Metcalfe
KY	86	3	Monroe
KY	87	7	Montgomery
KY	88	10	Morgan
KY	89	2	Muhlenberg
KY	90	4	Nelson
KY	91	9	Nicholas
KY	92	2	Ohio
KY	93	5	Oldham
KY	94	6	Owen
KY	95	10	Owsley
KY	96	6	Pendleton
KY	97	10	Perry
KY	98	12	Pike
KY	99	10	Powell
KY	100	8	Pulaski
KY	101	6	Robertson
KY	102	8	Rockcastle
KY	103	9	Rowan
KY	104	8	Russell

State	County ID	Highway District	County Name
KY	105	7	Scott
KY	106	5	Shelby
KY	107	3	Simpson
KY	108	5	Spencer
KY	109	4	Taylor
KY	110	3	Todd
KY	111	1	Trigg
KY	112	5	Trimble
KY	113	2	Union
KY	114	3	Warren
KY	115	4	Washington
KY	116	8	Wayne
KY	117	2	Webster
KY	118	11	Whitley
KY	119	10	Wolfe
KY	120	7	Woodford
MO	416	0	Cape Girardeau
MO	467	0	Mississippi
MO	472	0	New Madrid
MO	478	0	Pemiscot
MO	500	0	Scott
MO	403	0	Stoddard
IL	202	0	Alexander
IL	230	0	Gallatin
IL	235	0	Hardin
IL	244	0	Johnson
IL	264	0	Massac
IL	276	0	Pope
IL	277	0	Pulaski
IL	283	0	Saline
IL	291	0	Union
IL	297	0	White

State	County ID	Highway District	County Name
IN	310	0	Clark
IN	313	0	Crawford
IN	315	0	Dearborn
IN	319	0	Dubois
IN	322	0	Floyd
IN	326	0	Gibson
IN	331	0	Harrison
IN	339	0	Jefferson
IN	350	0	Ohio
IN	362	0	Perry
IN	365	0	Posey
IN	372	0	Scott
IN	374	0	Spencer
IN	378	0	Switzerland
IN	382	0	Vanderburgh
IN	387	0	Warrick
IN	388	0	Washington
OH	501	0	Adams
OH	508	0	Brown
OH	509	0	Butler
OH	513	0	Clermont
OH	514	0	Clinton
OH	527	0	Gallia
OH	531	0	Hamilton
OH	536	0	Highland
OH	544	0	Lawrence
OH	566	0	Pike
OH	573	0	Scioto
WV	803	0	Boone
WV	806	0	Cabell
WV	822	0	Lincoln
WV	823	0	Logan
WV	827	0	Mason
WV	824	0	McDowell

State	County ID	Highway District	County Name
WV	830	0	Mingo
WV	840	0	Putnam
WV	850	0	Wayne
WV	855	0	Wyoming
VA	714	0	Buchanan
VA	726	0	Dickenson
VA	752	0	Lee
VA	781	0	Russell
VA	782	0	Scott
VA	794	0	Wise
TN	603	0	Benton
TN	607	0	Campbell
TN	611	0	Cheatham
TN	613	0	Claiborne
TN	614	0	Clay
TN	619	0	Davidson
TN	622	0	Dickson
TN	629	0	Grainger
TN	640	0	Henry
TN	642	0	Houston
TN	644	0	Jackson
TN	648	0	Lake
TN	656	0	Macon
TN	663	0	Montgomery
TN	665	0	Morgan
TN	666	0	Obion
TN	667	0	Overton
TN	625	0	Pentress
TN	669	0	Pickett
TN	674	0	Robertson
TN	676	0	Scott
TN	681	0	Stewart
TN	692	0	Weakley
TN	695	0	Wilson