

AN ABSTRACT OF THE THESIS OF

Peter (Pece) V. Gorsevski for the degree of Master of Science in Forest Engineering presented on April 29, 1996. Title: An Advanced Inventory Method For Forest Roads.

Abstract approved: _____
Signature redacted for privacy.

Brian W. Kramer

This thesis presents the idea for **FORIN** (*Forest Roads Inventory*), a computerized forest roads inventory system. **FORIN** is a tool to more efficiently inventory and manage information of forest roads. **FORIN** is intended for use by field personnel, who will use pen-based computers to improve productivity, accuracy of inventories, to lower the cost, and provide an efficient management tool for forest roads inventory.

FORIN is a relational database computer system designed for gathering data for forest roads. **FORIN** displays a menu, which controls the display of all other forms. The main purpose of the forms is for data collection, plus data updates for the roads and their elements. The data entry in the forms will be assisted by a pen-based computer, which will allow for fast, efficient, and accurate data gathering.

FORIN replaces the existing paper forms method of inventory with computerized forms, so that collected information can be transcribed into a summary report immediately after the data has been collected and input into the program.

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**An Advanced Inventory
Method
For Forest Roads
by
Peter (Pece) V. Gorsevski**

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AN ADVANCED INVENTORY METHOD FOR FOREST ROADS

1 INTRODUCTION

The inventory of forest roads comprises a significant portion of forest roads management. The current paper-forms method of inventory is overly time consuming. However, by creating a computerized system for forest roads inventory, the whole inventory process could become more efficient and rapid.

There are already similar programs for the inventory of high order roads in existence. These are being used by states and counties and are yielding satisfactory results. The **FORIN** (*Forest Roads Inventory*) database system has been developed for the efficient management and inventory of forest roads. **FORIN** is a database computer system written in **PARADOX** with a visual programming language called **ObjectPAL** (an *object-based language*) specifically for forest roads. **FORIN** is a relational database which links the attributes of each road to a particular road milepost. The attributes of a given road are all of its elements such as its surface, culverts, ditches, turnouts, intersections, railroad crossings, signs, barriers, guardrails, etc. Overall, **FORIN** is a tool to more efficiently inventory and manage information of forest roads.

For easy efficient use, **FORIN** offers unique data collection forms, plus data updates for the roads and their attributes. The forms are an integrated collection of related features that permit the user to easily perform the required task. Each form displays a stationary toolbar and a menu which provides easy access to the desired data.

The program restricts the user from inputting incorrect data by controlling every aspect of the data entry. Initially the forms are opened in View mode, and for each change of data the mode must be changed. When the edit button is clicked or F9 is pressed, a user can insert new records, delete existing records, and end the editing session. Through the use of forms the entered data becomes uniform and standardized. Help menus and help lookup tables are also available within the forms.

Certain fields in the forms have drop-down menus to accelerate data collection. A drop-down menu is one in which the data can be directly typed, or from which the data value can be chosen from a list. After the data is collected, **FORIN** stores the data in tables. Once the data is stored, it can be viewed at any time as a report on the screen or as a printout.

The reports include a menu, table data, the current date, the page number, the name of the table being reported, calculations and summaries. These reports provide the user with many features for creating specialized views of the data, and advantages to achieve the desired goal. For example, reports yield summary information for all forest roads, information about the surface condition, culvert replacement, mountain biking route conditions, and other information for roads which will help road managers make proper maintenance decisions. The data in the reports is sorted by road number, which makes it easy to search for specific information.

For improved precision when linking the attributes of the road, a **DMI** (*Distance Measurement Instrument*) will be installed on a vehicle, which will be used for assisting **FORIN**. The **DMI** measures the distance quickly and accurately between attributes. For

accurate electronic measurement of the distance, sensors attached to a wheel are used. The sensors divide the vehicle tire into pie sections by equally spaced targets attached to the rim. An electronic impulse is generated by each of these sensors, and as the vehicle moves, the signal is mathematically converted to represent the traveled distance, NU-METRIC (18).

FORIN enables the existing paper forms to be replaced by computerized forms, so that collected information can be transcribed into a summary report immediately after the data has been collected. The data entry will be assisted by a pen-based computer, which will allow for fast, efficient, and accurate data gathering. A computer that recognizes pen input is used. The pen method is a little different from using a computer with a keyboard. Using an electronic pen is a fast and easy way to enter data into a computer, according to TelePad (25).

Pen-based computers present an optimal method of data collection in the field. The pen-based computers are light and portable; certain models are wireless, waterproof, and can operate in a wide range of temperatures. Equipping the field force with pen-based computers provides them with access to a much larger amount of information than the existing method. Also, using pen application systems will provide connection and communication between the home office and the field force.

2 LITERATURE REVIEW

The main idea for this thesis project was to create a database application program for forest roads inventory, which could be assisted by a pen-based computer for data entry. Similar programs have already been designed and successfully used for the inventory of high order roads such as highways and county roads.

The most logical start to begin creating a new application for forest roads was to follow one of the previous applications. IRIS, which is a program for taking inventory of county roads was chosen. IRIS is a computer system customized for inventorying roads and was written specifically for Oregon counties. The program is primarily written in Paradox Application Language (PAL), and some parts of the system in C and Pascal.

Having that information, an approach was devised to attack the problem. For this project the research was divided into two parts:

1. The literature research focused on designing the application.
2. The literature research focused on maintenance of forest roads.

2.1 Application Design

The literature research was focused on designing the application. At the beginning stage of application design, research was focused mainly on using Paradox as the software and programming language. Borland Paradox for DOS (4), (5), and (6) was used as a reference for how to start building the application. Paradox Application Language (PAL) was used to create FORIN. PAL was the logical choice because it is a

full-featured, high-level, structured database programming language that writes programs and applications. Literature from Salcedo, B.G. and M.W. Rudy (21) was used to learn how to improve and gain better performance from the application.

The first part of the application was created in PAL for DOS. The next step was to design forms for entering data with a pen-based computer in C and Pascal. The forms for data entry of the pen-based computer component for IRIS were previously designed in C and Pascal. By conducting some more research about creating the pen-based computer part, it was found that the whole application can be designed with ObjectPAL.

ObjectPAL is an integrated programming language for Paradox for Windows. ObjectPAL for Windows and PAL for DOS are different.

At that time, it was best to start from the beginning and use the ObjectPAL option for further design of FORIN. The decision was logical and simple, so instead of using three different programming languages to design the application, it was possible to use just one to accomplish the same objective. Thus it was possible to complete this part of the program while also improving productivity. The other benefit of this is the user is able to use the same application for both PC and pen-based computer. Whereas in IRIS the forms for the PC and the pen-computer are different, and uploading and downloading the data among the forms is time consuming, FORIN's integrated system provides an apparent time advantage.

ObjectPAL was selected to develop the full-featured Windows database application, the focus of research was literature from Borland Paradox for Windows (7), (8), and (9). The software version of Paradox for Windows 5.0 was used to create the

application. The ideas of Salcedo, B.G. and M.W. Rudy (22) were helpful in a creating a high performance application with cutting-edge programming techniques. Although the application has the potential to be a standalone application to provide for users who do not own Paradox, that feature was not included because the program was expensive. Runtime 5.0 for Windows is used for creating standalone applications. Runtime 5.0 also provides an unlimited distribution licence for ObjectPAL. In addition, the EZ-INSTALL Installation Toolkit is available for ObjectPAL applications. The installation toolkit produces installation routines for applications, generates an installation configuration, and creates distribution disks.

2.2 A Focus on Road Maintenance

The literature that was reviewed focused on maintenance of forest roads. In order to provide an efficient computer inventory system for forest roads, it is necessary to have a strong foundation in the maintenance of forest roads. So, this research is focused mostly on the maintenance of forest roads. According to Kantola, M., and P. Harstela (15) there are three types of maintenance:

1. **Emergency maintenance** is needed for sudden intervention that is necessitated by floods, landslides, or other adverse conditions. In case of emergency, the roads must be re-opened quickly to traffic. An inventory for examining why any failures have occurred will be useful for preventing further failures.
2. **Routine maintenance** is needed continuously or at regular intervals. The main task in the routine maintenance is to maintain the road surface. Holes,

deepened tracks and other depressions on the road surface have to be filled.

Maintenance of drains and culverts is necessary. The vegetation growing on the road causes cracks that degrade the road and need to be controlled. In dry periods the road surface may, for example, need some additional binding material. For that reason an inventory should be performed regularly for scheduled routine maintenance.

3. **Road rehabilitation maintenance** is done periodically to restore the original standard of the road. Road rehabilitation maintenance is very costly and, to prevent worsened stages, it is necessary to have this inventory information.

Roads that are not maintained will gradually deteriorate due to unfavorable weather conditions and traffic. When the road standard decreases, the transport costs correspondingly increase. The condition of each road should be inspected regularly to schedule routine maintenance.

During long dry periods, the surface of gravel and earth roads may become pulverized by the passing traffic. As this happens, the dust is blown away by the wind and the surface material is partially lost.

In heavy rains, mud is splashed off the road by passing vehicles, which causes ruts and potholes in the road surface. Water collects in the holes, which causes more damage. The underlying structure of the road is threatened and entire road sections may sink. The traffic itself also permanently wears the surface of the road. Inspection is very important especially after heavy rains.

Holmes D.C.(11) emphasizes the importance of maintaining culverts and ditches.

To minimize disturbance and to protect the roadway from erosion, washouts, and settlement problems, culverts and ditches should be maintained. Drain-ditches culverts are required for all small streambeds to carry the water, to stop the erosion in ditches, and to maintain the ground water supply below the road. Regular inspection during or after storms to detect drainage problems should be done, especially on new roads.

To ensure the proper functioning of the drainage system of roads AISI (3) recommends inspection on a routine basis. The inspection should be on an annual or semi-annual basis, but should always be conducted after major storms. A good example of this would be the inspections of Oregon's forest roads after the floods of 1996. Clear and thorough records should be kept on all maintenance operations to help plan further work and identify facilitates requiring attention.

Ritter, A.M., (20) notes that maintaining or rehabilitating timber bridges is essential to improving public safety, extending the service life of the structure, and reducing frequency and cost of repairs. Bridge maintenance is necessary to preserve the utility of the bridge and ensure the safety of the road users. The maintenance of the bridges is divided into the following categories:

- **Preventive maintenance**, which involves keeping the structure in a good state of repair to reduce future problems.
- **Early remedial maintenance** is performed when decay or other deterioration is present but does not affect the capacity or performance of the bridge in normal service.

- **Major maintenance** involves immediate corrective measures that restore a bridge to its original capacity and condition.

Bridge rehabilitation is another form of restoration and is similar to maintenance of the bridges. The rehabilitation is performed to improve the geometric or load-carrying capacity of an existing bridge.

Identifying roadway hazards and suggested corrective actions were researched by Kehr H. R., J. Kizer and R.D. Layton (16). Their study covers hazards associated with the following highway elements: alignment, ditches, guardrails, intersections, pavement conditions, pavement markings and delineators, railroad crossings, roadside obstructions, shoulders, signs and weather. The study is presented to indicate typical hazards found on a stretch of road, and once identified, how to eliminate these hazards with improved design, and operational control measures or highway appurtenances.

According to Anderson, P., M. Pyles and J. Sessions (2) the maintenance is higher on steep roads and more cost effective. As the road grade increases, both the road surface and the ditch lane require more maintenance. Having a forest roads inventory system will provide immediate information for the most critical roads on steep grades.

Many of the terms and definitions used in FORIN are obtained from AASHTO (1). AASHTO (1) represents a consensus of thinking of State Highway Department Officials throughout the country. AASHTO was developed to serve as a standard or guide for preparation of state specification and as a reference for designers, fabricators and erectors. It is published complete with an informative commentary and is revised periodically to reflect current developments AISI (3). Other sources that yield useful standards for

developing **FORIN**, were: AISI (3), Eaton, R.A., S Gerard and D.W. Cate (10), Hutchinson, M.M. (12), IRIS (13), Scott, S. J. (23), and Stewart, J. (24).

Based on the roads inventory, the user can develop the entire picture of the condition of the roadway and its elements. If needed, some measures for improvement can be undertaken to prevent the damage of the structure and to ensure the safe use of the road. A well documented set of maintenance records and the existing inventory will assist the user in managing the roads in the most safe and cost effective way.

The longevity and the quality of the road construction will be recorded, which will help for making decision in further projects. From the reports of the inventory system we can obtain standardized information for the condition of the roads. Having organized information in the reports will make it easier for the user to come to the most logical solutions. The budgeting for road maintenance can be made in advance. The most deteriorated parts of the road will be considered first. The budget can be planned accurately, since the user knows what has to be fixed or replaced. The annual cost per mile of road maintenance can be obtained from comparable roads. Roads that receive regular and proper maintenance last longer and have lower road-related costs.

3 OBJECTIVES

3.1 Project Objectives

The project objectives were:

- ▶ To find strategies for rapid application development
- ▶ To design the computer program format
- ▶ To create data tables
- ▶ To design the data input forms
- ▶ To design output reports
- ▶ To write the code (putting everything together)
- ▶ To test the system

3.1.1 Strategies for Rapid Application Development

Creating a decision process and devising the best programming strategy is a very important part of application development. The first priority of the newly created application was to give the user a system that solves the user's problems. To accomplish this, the favorite type of report and form of the average user had to be found. The attributes that user prefer, good forms and reports, and what they can do with those forms and reports also had to be ascertained. Once that information was obtained, the development process of the application could start.

To shorten the program development phase, the IRIS program served as a guide. IRIS was a model for developing and designing the layout of the FORIN application.

IRIS became the basis and was expanded to apply it to the field of forestry. **FORIN** was designed to serve as an application for forestry purposes.

3.1.2 Design of the Computer Program Format

The first step in designing an application is creating its foundation: tables, forms and reports. For this project, first it was determined how many tables were needed and how they should be structured. The menus and dialogs were designed to present a logical structure to the user. It is important to know what is on each menu, which menu leads to which, and which tables, forms, and reports are going to be used at each step.

To simplify the application, all the tables, forms, reports, script and library are in a single directory. The layout of how **FORIN** is organized is shown in Figure 1.

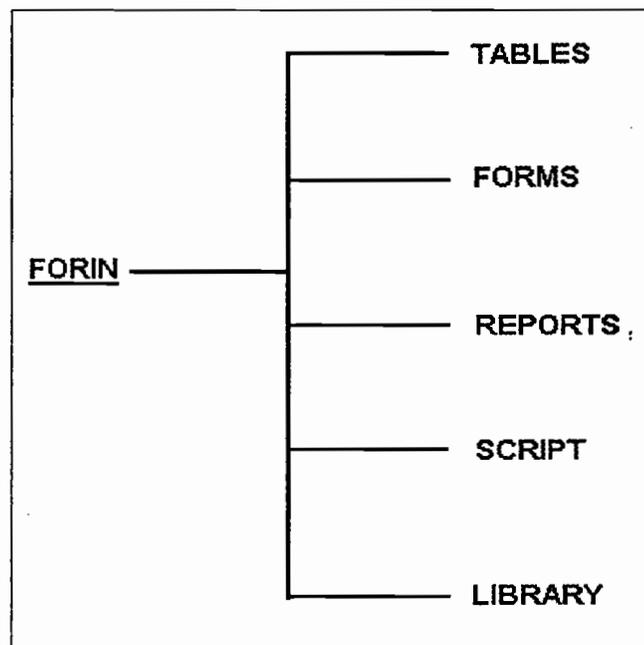


Figure 1. The Layout of FORIN.

3.1.3 Data Tables

Creating data tables is a very important step in designing the application. The tables are a collection of rows and columns, creating a two-dimensional representation of the data in tabular format. The purpose of the tables is to store the user's data, and to track information on forest roads and their attributes. In the relational model, every table has a primary key, and to use multi table forms and reports, keys are required. The primary key is used to uniquely identify a row in relation to one or more attributes.

Figure 2., shown below, shows the relation between the Road Table and the Turnouts Table.

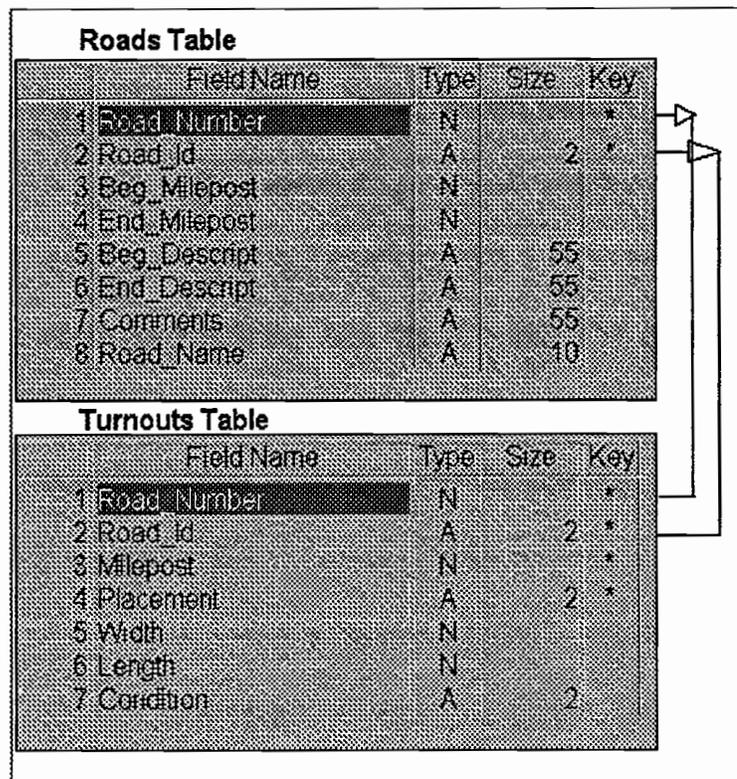


Figure 2. Relational Tables.

The existing data in the tables becomes normalized. According to Salcedo, B.G., and M.W. Rudy. (21) normalization of the Database is a set of rules and techniques based on relational theory. Normalization splits the data into separate tables, thereby simplifying data input, modification, and retrieval. The purpose of normalizing the data is to avoid duplicating rows, to maintain the proper order of the rows and columns, and to eliminate repeating groups.

3.1.4 Design of Data Input Forms

The design of forms is also very important. The forms were designed to enable the user to visually enter and display the data. The forms simplify data entry. Forms also provide alternate presentation of the table's data. . The purpose of designing forms is to show one or many records at a time. While the table image can show a limited number of fields at one time, the form can show many. Furthermore, one form can be embedded on to another table's form, and each form behaves as a distinct image in the form "view" window. Forms that contain embedded forms display data from more than one table. Such forms are called multi-table forms.

Forms are central to the application. All events that occur are processed by forms. Events are the driving force created by ObjectPAL. For example, events are triggered by a computer mouse movement, events result in locks being placed on records, and events cause a button on a form, once it is clicked, to perform a function such as causing a menu to appear.

Objects also appear on the forms. These objects are the ones that the application user will see and interact with. For example, menus, forms, tables, DOS files, and fields are objects. Every object has properties, these properties determine how an object appears, how it behaves when a form is running, and its current state. Examples of an object's properties are the color of the object, button type, field type, and visibility. Furthermore, every object has a name, and this name is assigned through ObjectPAL. Using ObjectPAL, objects in the forms and code modules can be attached, which execute actions when something happens to the object. These ObjectPAL statements are attached to the methods provided by forms under its properties.

3.1.5 Design of Output Reports

Designing the reports entails arranging the data of the tables into a logical report format. Certain reports based on more than one table and with the ability to sort and group records were designed. The design of reports is important because they must be understandable for the person who will interpret and use the data. A priority of the database is printed output of the data stored in tables. Generated reports can be printed as output, or can be sent to the screen. Reports, in addition to including table data, can include specific fields that contain the current time or date, the name of the table being reported, calculations, summaries, images and so on.

3.1.6 Writing Code

After all of the program's vital components had been created and designed, ObjectPAL was used to link the components together. In addition to the code attached to the forms, some of the code is stored in a library. The library consists of objects that provide features for sharing code, variables, and constants. Library code can be accessed through the forms. The code stored in the library is used by several objects, and that code can be used in more than one form. Code stored in the library avoids the need for making more than one copy of code.

A preventive code was also used to preclude problems associated with errors. The problems which can occur were carefully considered. ObjectPAL was used, to eliminate such errors. For example, an error can occur if one of the files is accidentally deleted, or otherwise damaged. The preventive code was imbedded to the forms to provide an error capturing feature.

3.1.7 Testing the System

Testing a system is crucial to the successful implementation of an application. It is necessary to have a test plan. The best test scenario would be to set up a demonstration of the application for users who are familiar with this type of program. Testing the application verifies the design and determines whether all the features that the user needs are included.

The program will be tested by a student from the College of Forestry at Oregon State University. The student is knowledgeable and experienced in making road

inventories. The student previously used IRIS, and she had tracked the time for taking the inventory. The comparison will be between the time used for inventory using IRIS, and the time used for inventory with FORIN. This test will indicate if FORIN is compatible for forest roads inventory.

3.2 Rationale for developing FORIN

The objectives of FORIN are to:

- Develop a computer system for forest roads inventory
- Standardize technical definitions
- Lower data management cost
- Reduce input and output data errors
- Update inventories efficiently
- Provide a management tool that is more cost effective than the existing paper method
- Support expanded office/field information and communication capabilities

3.2.1 Computerized Forest Roads Inventory

Developing a computerized road inventory system allows for rapid access to large amounts of information. A computerized road inventory system is an information system which contains a detailed description of roads and a road network in the forest.

Information in the system can be used for reports which cover all attributes of the road.

The system can yield data on particular roads and specified mileposts. In short, **FORIN** can provide for a complete computerized road inventory system.

3.2.2 Standardize Technical Definitions

The effectiveness of an inventory program depends upon trade standards. When the defined standards are well understood the inventory is more efficient. In this case, every data element can be accurately input into the system, which will reduce improperly recorded or misunderstood inventories. The computer program itself will also limit the user from inputting incorrect data. The place reserved for numbers cannot be the field for letters; the program does not accept clearly inaccurate data. The main benefit of **FORIN** is that it ensures the use of a uniform method for measurements, which improves the accuracy of inventory work. The standards are defined in the “help” menu, which furnishes a quick informational reminder and offers instant instruction to the user.

3.2.3 Lower Data Management Cost

As compared to hand methods, applying a computerized system will lower the cost of data management. Data inputting time will be shortened and reports will be obtained immediately. The cost of inventory will also decrease because the data is input just once, plus the user will have more rapid access to the data. The computerized data certainly has more advantages and flexibility for its management. **FORIN** will help ensure effective data management.

3.2.4 Reduce Input and Output Data Errors

Inputting data with pen-based computers reduces the frequency of errors. Without the use of a pen-based computer system and pen applications, the field force would have to write the information on paper forms, which increases the probabilities for errors to occur. Errors made on paper forms can be repeated during the data-entry process, which increases the overall probability for making errors by using paper forms. In contrast, a single data-entry method, such as the pen-app, greatly reduces the probability for this type of error to occur.

3.2.5 Update inventories efficiently

The inventory can be updated or corrected with new inventory data at any time. Work order forms can be designed to allow the field force to check off each step of a complex work order. For instance, if the growth of vegetation diminishes the visibility of a sign, the distance of visibility can be corrected, but the dimensions of the sign will remain the same. Or if a sign has been replaced with a new sign (for the same purpose), any different element, such as the new sign's increased reflectivity, may be updated in the system.

3.2.6 Provide a Management Tool that is More Cost Effective than the Existing Paper Method

FORIN will also support more accurate inventory information so that forest roads can be more efficiently managed. Information on forest roads which are managed for the

long term can be accessed in detail for every stage when an inventory was made. The information obtained from **FORIN** can encompass vast stores of data which span discrete time periods and specific inventories.

3.2.7 Support Expanded Office/Field Information and Communication Capabilities

Equipping the field force with the latest information and useful communication technology can provide significant organizational benefits. For instance, having a pen-based computer, e-mail and fax communication is possible between the field and the office.

4 HOW TO USE FORIN

4.1 Installation of FORIN

The installation of FORIN can be accomplished in the following manner:

- Before installing FORIN, a copy of Paradox for windows Version 5.0 must be installed on the computer hard drive.

- A diskette with a copy of FORIN is then inserted in the drive and the following line should be typed for the A drive:

```
A:\>INSTALL A: C:\FORIN
```

or for drive B:

```
B:\>INSTALL B: C:\FORIN
```

- The next step will be to enter into Paradox under File/Working Directory... and change the directory to

```
C:\FORIN
```

The new directory should be saved and Exit Paradox.

- After the directory is changed a window icon for the application can be created.

In the windows environment, under File/New.../Program Item, the following box will appear Figure 3.

In the box the following should be typed: Description, Command Line and Working directory in the same manner as in the box above. If Paradox is installed under a different directory in the command line, C:\pdx50\ should be changed with the

appropriate directory. Otherwise the command line should be:

```
C:\pdox50\pdoxwin.exe forin.sdl -q
```

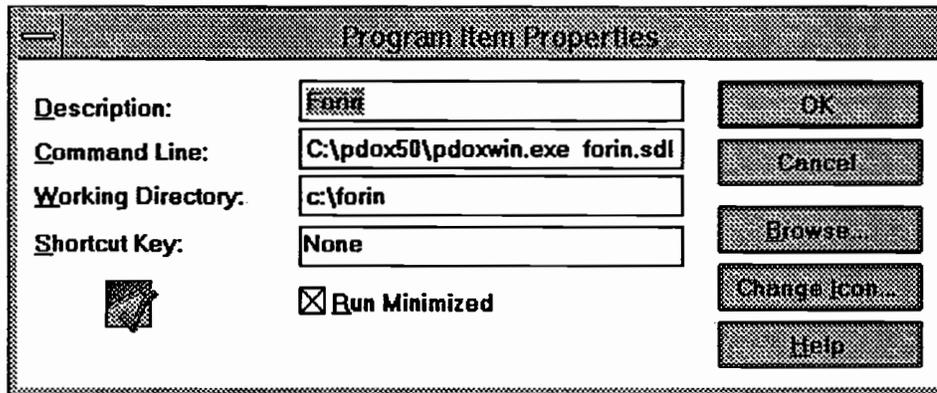


Figure 3. New Windows Icon for FORIN.

The first part of line `C:\pdox50\pdoxwin.exe` initiates Paradox, and the second part, `forin.sdl`, is the name of the startup script which loads **FORIN** to the desktop, and finally `-q` prevents the Paradox for Windows splash screen from coming up on the screen each time when the application is executed. After the properties are saved by clicking on the icon, the application can be started.

4.2 FORIN Main Window

The FORIN Main Menu window is a form which controls the window for the system. The menu of the Main Menu Window (Figure 4.) is a list of items that appears horizontally across the application and a series of push buttons that appear vertically

across the application. The Main Menu has seven options. Each option has a separate pull-down menu, and some options have submenus. By clicking on an item or pressing a key "F10", a pop-up menu associated with each menu option can be obtained. When the user chooses an item from the menu bar or the push buttons, the matching pop-up menu appears.

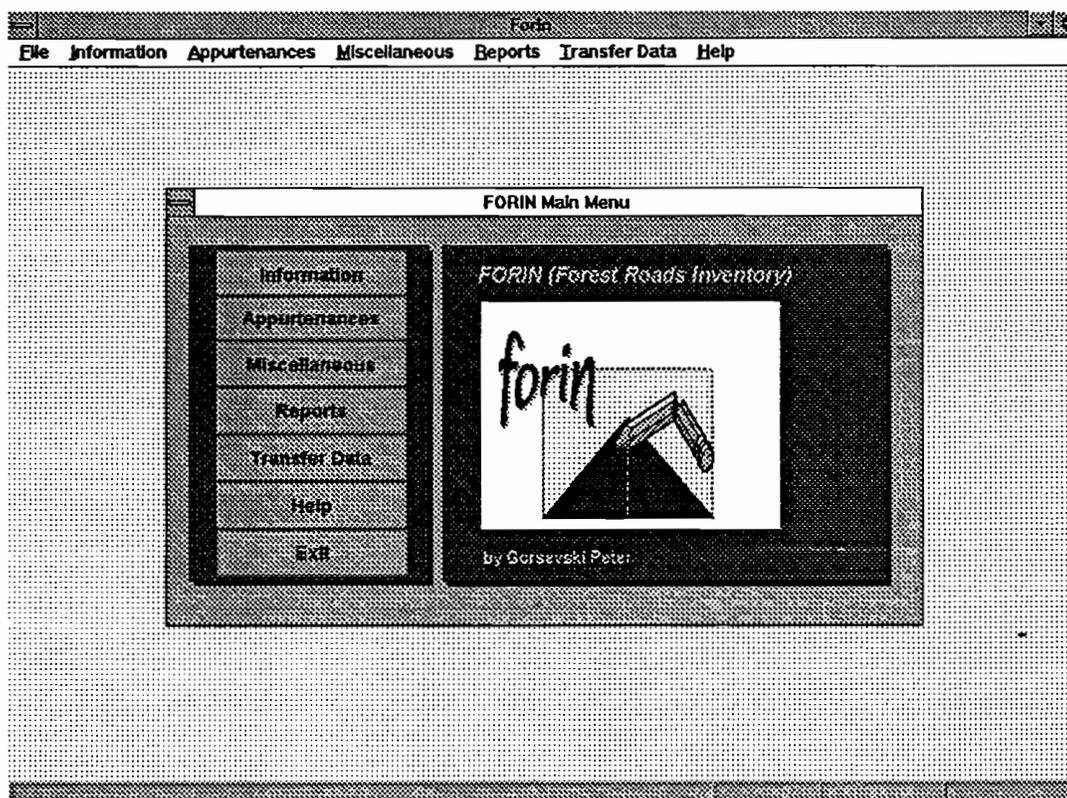


Figure 4. The FORIN Main Window.

Each menu selection displays a separate form. The forms are obtained from the Information, Appurtenances, and Miscellaneous pull-down or pop-up menus. The form

opens and waits until the user closes the form. Each form used for Forest Roads Inventory has some of the same standards. A standard form menu is attached to every form and there are three menu-bar options: File, Edit, and Record. Figure 5. shows a standard form menu for each form.

File	Edit	Record
Print	Undo Alt+Bk Sp	First Ctrl+F11
Printer Setup	Cut Shift+Del	Last Ctrl+F12
Close	Copy Ctrl+Ins	Next F12
	Paste Shift+Ins	Previous F11
		Locate Ctrl+Z
		Locate Next Ctrl+A
		Insert Ins
		Delete Ctrl+Del

Figure 5. Standard Form Menu.

Also standard in each form is a stationary toolbar. Figure 6. shows this toolbar, which is placed in the top-part of each form. The toolbar consists of push buttons; the first eight buttons are navigation buttons. Clicking the buttons enables the user to move quickly to parts of the database, which the user wants to see.

The Edit button is also placed on the toolbar, and toggles between Edit and View mode. The form initially is opened in View mode. The text on the Edit button shows the mode to which the form will switch, if it is clicked. If the text on the button is Edit, by clicking the button the text would change to View. Also by pressing the F9 key, the mode will toggle between the Edit and View modes.



Figure 6. Toolbar Placed on Most of the Forms.

When the form is opened, the user can operate, modify, edit or view the data by using the keyboard , the mouse, or the pen.

4.2.1 Shortcut Keys for FORIN forms

The following keystroke options are available in **FORIN** Forms. The keys listed in Table 1 are used for working in **FORIN** in View mode.

KEY(S)	EFFECT
↓(Down Arrow)	Moves cursor down one line.
↑(Up Arrow)	Moves cursor up one line.
←(Left Arrow)	Moves cursor one character to the left.
→(Right Arrow)	Moves cursor one character to the right.
PgDn	Moves to the next record.
PgUp	Moves to the previous record.

Table 1. View Mode.

KEY(S)	EFFECT
F2	Field View.
F3	Up table (previous table).
F.	Down table (next table).
F5	Locks record for data entry.
F9	Edit mode.
F10	Menu display.
F11	Previous Record.
F12	Next Record.
Ctrl+F11	First Record
Ctrl+F12	Last Record
Ctrl+Z	Locate Record
Ctrl+A	Locate Next
Ctrl+H	Help
Ctrl+C	Criteria

Table 1. View Mode.(Continued)

Shortcut keys are also available in the Edit mode. The keystroke opinions for the Edit mode are:

MENU ITEM	KEY(S)	EFFECT
Undo	Alt+BkSp	Undoes the latest edit.
Cut	Shift+Del	Deletes the selected text and copies to the Clipboard.
Copy	Ctrl+Ins	Copies the selected text to the Clipboard.
Paste	Shift+Ins	Copies the contents of the Clipboard to the cursor insertion point, or, replaces selected text with the contents of the Clipboard.
Delate	Ctrl+Del	Deletes whole record, where the cursor is positioned.
Delate	Del	Deletes the selected text or the character to the right of the cursor.
Insert	Ins	Insert new record.

Table 2. Shortcut Keys in the Edit Mode.

4.2.2 Using a Mouse in the FORIN Forms

The mouse can be used for any mode, and in every form. With the mouse the cursor can be positioned anywhere on the form fields. The Main Menu, the Toolbar, and all push buttons can be activated. The left side is the operating side of the mouse. Single clicking, double clicking, or selecting text can be accomplished by clicking on the left side of the mouse. The right side of the mouse can be used only in the Main Form of the FORIN graph to display information about the program.

4.2.3 Using the Pen

The pen operates in three modes: inking, recognition, and pointing. The mode of the pen is determined by the location of the pen on the screen. Source: TelePad (25).

1. The inking mode is the mode used when the pen is over a writing area and the cursor is displayed as a pen. There are two types of writing areas on the display: text fields and sketch fields.

- Text fields may be displayed with a horizontal line, which is separated with tick marks to separate the printed characters, or without character guide.

- Sketch fields are any areas of the screen where the cursor is displayed as a pen, but are not text fields. Those sketch fields are not interpreted by the computer and are saved in the original form as pictures.

2. A recognition is the collection of pen strokes that the handwriting software uses to interpret characters and gestures. Gestures are unique pen strokes that are used for entering special editing commands. With a single stroke of certain editing

gestures, such as cutting, pasting, and copying the user can specify both a location and the editing operation.

3. The pen is in pointing mode when it is over an operating area of the screen and the cursor appears as an arrow. Operating areas consists of menu bars, buttons, scroll bars, title bars. Touching an object on the screen in the pointing mode is the same as pointing and clicking with the left-hand side of the mouse, and double touching is the same as double clicking with the left-hand side of the mouse.

TelePad SL software was used to accompany **FORIN**. This pen recognition software is “trainable” to recognize the handwriting of the user. The TelePad SL can be taught to recognize characters from variety of pen strokes. For recognition of pen strokes and gestures, the software stores a copy of every pen stroke used to produce character or a gesture. In the recognition set it is recommended for the user to have multiple pen strokes associated with any one character. Too many strokes in a set slows the performance. Strokes can be saved as alternative strokes for matching the entered character. Better interpretation is achieved by creating fine-tuned recognition sets. Each user can create a recognition set with a different name which should be loaded before use.

4.3 Road Information

From The FORIN Main Menu the Information option displays the following drop-down menu on the screen:

Road Identification
Road Characteristics
Unsurfaced Roads
Turnouts
Intersections
Gredability
Reference Points

Figure 7. Road Information Drop-down Menu.

The Road Information modules (Figure 7.) provide the road information via seven different multi-table forms, which define particular types of roads. The Road table is the main table used in all forms, and the rest of the tables are embedded tables in the Road table.

4.3.1 Road Identification

The Road Identification Screen is displayed as a form and consists of the following tables: Road Information, Surface Information, and Lanes Information. A form is a design document that displays the data of one or more tables. The figure below shows the Road Identification screen.

The screenshot shows a software window titled "Road Identification" with a menu bar containing "File", "Edit", and "Record". The window contains three main sections:

Road Information

Road Number: 100.00
 Road Name: A
 Reg. Milepost: 0.00
 End Milepost: 8.50
 Reg. Descriptor: Int. Co. Tampico Rd.
 End Descriptor:
 Comments:

Surface Information

Reg. Milepost	End Milepost	Surface Type	Surface Meth	Surface Depth	Condition	Date Inspected
0.00	8.00	G	16.00	0.20	P	2/12/96

Lanes

Reg. Milepost	End Milepost	Number Lanes	Lane Width	Direction
0.00	8.00	1.00	12.00	1W

Figure 8. Road Identification Form.

4.3.1.1 Road Information

The Roads table is the main table on the Road Identification form which is used for storing the basic road identification information for a particular road. The Road table includes the Road Number, Road Identification, Road Name, Comments, and descriptions for some features at the Beginning and the Ending of the road (Figure 9).

The information in a table image is arranged in rows and columns, whereas the information on the form is arranged in a different way (Figure 8). Displaying or viewing the data in a table image can show only a limited number of fields at one time, while the form can show many. For this reason it is advantageous to use the forms.

Road Number	Road Id	Beg. Milepost	End Milepost	Beg. Description	End Description	Comments	Road Name
-------------	---------	---------------	--------------	------------------	-----------------	----------	-----------

Figure 9. Roads Table.

Road Number: The Road Number is the road identification number assigned to the road. If the road number of an existing road is modified, the previous record will be erased. For inventory of a new road, which is not existing in the data base, the form has to be switched to edit mode. Then, under the Record menu, the new road data can be inserted.

Road Id: The Road Id is the alphabetic portion of the road number, of one exists. The following codes can be used:

A - Arterial

C - Collector

L - Local

Beginning Milepost: The Beginning Milepost is the milepost at the beginning of the road.

Ending Milepost: The Ending Milepost is the milepost at the end of the road. These mileposts define the beginning and ending of each named road segment. The difference between the ending milepost and the beginning milepost is the total length in miles for a particular segment.

Comment: The comment field is provided for additional information-of the road. For example, recreation facilities, special alert, history, and silvacultural treatment.

Start Description: The Start Description is to note a defining feature at the beginning of the road, such as the name of the intersecting road, a road clarification, or a road purpose.

End Description: The End Description is to note a characteristic feature at the ending milepost of the road, such as the name of an intersecting road, a dead end, or a forest line.

4.3.1.2 Surface Information

The Surface Information form is a subject of the Road Identification form, and is stored in a table reserved for Surface Information. The table consists of Beginning Milepost, Ending Milepost, type of surface treatment of the road surfacing, its width, depth, and condition, and the Date of Inspection of the surface condition. The Date of Inspection is very important information for the surface of the road, because for maintenance purposes it gives a whole picture of the current condition of the road. The Surface Information is also very important for forest roads, especially during the wet season when many vehicles are hauling wood.

Beginning Milepost: The Beginning Milepost is the milepost at the beginning of a particular surface type.

Ending Milepost: The Ending Milepost is the milepost at the ending of the surface type. The Beginning and Ending Milepost defines each road segment with the same attributes, i.e., the asphalt segment of the road or a gravel segment.

Surface Type:

By clicking the arrow on the Surface Type field, the program displays a drop-down list, which gives the following choices:

A - Asphalt: A road surface consisting of dark brown to black cementitious materials in which the predominating constituents are bitumens and rock aggregate.

AB - Asphalt, Blade Mix: Hot asphalt applied by a road grader.

AC - Asphalt, Cold Mix: Asphalt temperature at ambient temperature when applied.

D - Dirt/ Graded: A road of natural earth aligned and graded to permit reasonably convenient use by motor vehicles, with or without dust palliative treatment or a continuous course of special borrow material to protect the new roadbed temporarily and to facilitate immediate traffic service. Source IRIS (13).

G - Gravel: A road, surface which consists of crushed or uncrushed aggregate material from water or glacial deposited accumulations of mineral matter, having rounded or subrounded surfaces. Source IRIS (13).

M - Oil Mat: An earth road, a soil-surfaced road, or a gravel or stone road to which has been added by any process a bituminous surface course with or without a seal coat, the total compacted thickness of which is less than 1 inch. Seal coats include those

known as chip seals, drag seals, plant-mix seals, and rock asphalt seals. Source IRIS (13).

O - Other: Any surface type not listed.

PG - Pug(oil/rock mixture): Oil rock mixture.

PR - Primitive Road: Right of way which can not be driven upon by a standard drive motor vehicle(as compared to a four-wheel drive vehicle). The surface is lower type than that of the unimproved road.

R - Rubberized Asphalt: Asphalt rubber mix.

U - Unimproved Road: A road using a natural surface and maintained to provide bare passage for motor vehicles. Source IRIS (13).

Surface Width: Surface width is measured in feet, and is a sum of all lanes widths. When the road is paved, the width is measured from one-to the other edge of pavement. When the road is not paved the width is measured from edge of gravel to edge of gravel.

Surface Depth: Surface depth is measured in inches.

Condition: The Surface Condition is a crucial element which gives a total picture of the surface and can be divided into the following

categories:

VG - Very Good: Surfacing structure is stable, with no cracking, no patching, no deformation evident. Roadways in this category are usually fairly new. Riding qualities are excellent. Nothing would improve the roadway at this time. Source IRIS (13).

G - Good: Surfacing is stable, but may have surface erosion or minor cracking, which is generally hairline and hard to detect, minor patching, and possibly some minor deformation. Riding qualities are very good. The pavement has a dry or light colored appearance. Some type of rejuvenation of the wearing surface is all that is required. Source IRIS (13).

F - Fair: The surfacing structure is generally stable with minor areas of structural weakness evident. Cracking is easier to detect. The pavement may be patched but not excessively. Although riding qualities are good, deformation is more pronounced and easily noticed. Source IRIS (13).

P - Poor: Roadway has areas of instability, marked evidence of structural deficiency, large crack patterns (alligating), heavy and numerous patches, and very noticeable deformation. Riding qualities range from acceptable to poor. Spot repair of the surface base may be required. Source IRIS (13).

VP - Very Poor: Costs of saving the surface structural section would equal or exceed “complete reconstruction”. Source IRIS (13).

Date Inspected: The Date Inspected field shows the date of the last inspection of the Surface Type for a segment of the road. The data values are represented in the form month-day-year (MM/DD/YY). The data has to be specified completely, without omitting the day, month, or year, because the date will be invalid if any date values are missing.

4.3.1.3 Lanes

The AASHTO (1) defines the Lane as a strip of roadway used for a single lane of vehicles. The Lanes table identifies the number of lanes on the road, the direction of traffic flow, and the width of the lanes. Every time any of those elements changes, new Beginning Milepost and Ending Milepost information will be identified. Each segment of the road will be defined as a unique part of the road.

Beginning Milepost: The Beginning Milepost is the milepost at the beginning of the lane location. By changing the number of lanes, width of the lane, or direction of traffic flow, a new Beginning Milepost starts.

Ending Milepost: The Ending Milepost is the milepost at the ending location of the lane. The Beginning Milepost and Ending Milepost define the road segment with the same attributes.

Number of Lanes: This field shows the number of lanes for each road segment.

Lane Width: Lane width is measured in feet.

Direction: The Direction field shows if the traffic flow is one or two ways.

- **1W (one-way):** All traffic on the road flows in the same direction.

- **2W (two-way):** The lane configuration of the road allows for opposing traffic flow.

4.3.2 Road Characteristics

The Road Characteristics Modules describe some of the physical attributes of the road, as well as their appearance and location. The Road Characteristics Screen consists of the following tables: Road Information, Map Locators, Shoulders and Right of Way, and is a multi table form. The Road Characteristics screen is shown in Figure 10.

The screenshot displays a software window titled "Road Characteristics" with a menu bar containing "File", "Edit", and "Record". The main form is divided into several sections:

- Road Information:** Contains fields for "Road Number" (100.00), "Road Name" (A), "Beg. Design" (Int. Co. Tampico Rd.), "Beg. Milepost" (0.00), "End Milepost" (6.50), "End Design", and "Comments".
- Map Locators:** A table with columns for "Map Milepost", "End Milepost", "Township", "Range", and "Section".
- Shoulders:** A table with columns for "Beg. Milepost", "End Milepost", "Placement", "Right Shoulder Type", "Left Shoulder Type", "Right Shoulder Width", and "Left S. W". A dropdown menu is open showing options: ACP, SST, D, GRS, and GRV.
- Right of Way:** A table with columns for "Beg. Milepost", "End Milepost", "Right of Way", "Right Ownership", and "Left Ownership".

At the bottom of the window, a status bar reads: "Start in Edit mode. Press F3 to edit data."

Figure 10. Road Characteristics Modules.

4.3.2.1 Map Locators

The Map Locators table is used to record information on the township, range, and sections in which the road is located.

Beginning Milepost: The Beginning Milepost is the starting point of the section being identified.

Ending Milepost: The Ending Milepost is the ending point of the section being identified.

Township: The Township is the town in which the road is located.

Range: The Range is where the road is located. Township and Range are identified by a number and a compass direction.

Sections: The Sections indicate the areas where the road is located.

4.3.2.2 Shoulders

The road shoulders are the portion of the roadway that are contiguous with the traveled way and which provide space to stop vehicles for emergency use. Shoulders also provide lateral support of base and surface courses. Source AASHTO (1). The purpose of the Shoulder table is to record information on the type of material used for the shoulders, width of the shoulder, and placement of shoulder. Beginning and Ending of milepost is used for every change in width, placement, and material.

Beginning Milepost: The Beginning Milepost is the milepost where the shoulder begins.

Ending Milepost: The Ending Milepost is the milepost where the shoulder ends. The Beginning Milepost and Ending Milepost define a road segment with the same attributes.

Placement: The Shoulder placement choices are:

B - Both Sides of the Road

L - Left Side of the Road

R - Right Side of the Road

If the shoulders start from both sides of the roadway at the same milepost, a "B" (Both Sides of the Road) should be input. If the shoulders are not on both sides, the information for left (L) and right (R) side should be used.

Type: The type is used to show what type of surface material is used for the shoulders. The surface type choices, as listed below, can be obtained from the drop-down menu shown for the Right Shoulder Type:

ACP - Paved (ACP): An asphaltic concrete treatment on a granular or stabilized base. Source IRIS (13).

BST - Paved(BST): An bituminous surface treatment on a granular or stabilized base. Source IRIS (13).

D - Dirt: A natural earth shoulder with no other treatment. Source IRIS (13).

GRS - Grass: A natural earth shoulder with turf.

GRV - Gravel: A gravel or other granular material on a stabilized base. Source IRIS (13).

N - None: No shoulders or road is curbed. Source IRIS (13).

PCC - Paved(PCC): A portland cement concrete treatment on a granular or stabilized base. Source IRIS (13).

Width: The Width of shoulder is measured in feet. By subtracting the sum of the width of all travel lanes, from the width measured from one edge to the other edge of the pavement the total shoulder width will be determined. If the placement of the shoulders is on both sides, the total width is the combined width of both shoulders.

4.3.2.3 Right of Way

Right of Way is a general term denoting land, property, or interest, usually in a strip, acquired for, or a devoted to a highway. Source IRIS (13). The purpose of the Right of Way table is used to record information on the width, ownership, and filing reference. A new Beginning and Ending of Milepost is used for any changes in the right of way.

Beginning Milepost: The Beginning Milepost is the milepost where the right of way begins.

Ending Milepost: The Ending Milepost is the milepost where the right of way ends. The Beginning Milepost and Ending Milepost define a road segment with the same attributes.

Width: The prevailing right of way width is measured in whole feet for the section being identified. Source IRIS (13). The width of right of way to the left or right of the center of the roadway surface can be measured for left or right width.

Filing Reference: The Right of Way Filing Reference is the filing reference of the instrument's recorded number in the County Clerk's office. Source IRIS (13).

Ownership:

The ownership can be Right Ownership, which is ownership of right of way on the right-hand side of the road, or Left Ownership, which is ownership of the right of way on the left-hand side of the road. The type of ownership of the right of way on the right and left side of the road is as follows:

E - Easement: The right of way has been donated or dedicated by one or more person(s) for public road purposes. Source IRIS (13).

F - Fee: The Right of way has been purchased for public road purposes.

P - Prescriptive: The Right of way has been acquired by a use, open and notorious, adverse and continuous for years. Source IRIS (13).

U - Undetermined: If the ownership is unknown.

V - Varies with width values: The ownership of the right of way is a combination of types depending upon the width of the-right of way.

4.3.3 Unsurfaced Roads

An unsurfaced road is any road that does not have Portland cement concrete, asphalt concrete or any other surface treatment. Some agencies consider gravel to be a surfacing material; for the purpose of these forms a gravel road is an unsurfaced road.

Source Eaton, R.A., S. Gerard and D.W. Cate (10). The Unsurfaced Roads Table records information about any unsurfaced road or section of road. The Unsurfaced Roads screen is shown in Figure 11.

The screenshot shows a software window titled "Unsurfaced roads" with a menu bar (File, Edit, Record) and a toolbar. The main content area is divided into two sections:

Road Information

Road Number: 100.00 Road Id: A
 Beg. Description: Int. Co. Tampico Rd.
 End Description:
 Road Name:
 Comments:

Unsurfaced Road Information

Beg. Milepost	End Milepost	Milepost of Sample	Area of Sample	Quantity and Severity	Intercept Cross Section (linear feet)	Inadequate Drainage

The status bar at the bottom indicates "1 of 100 (ROADS.DAT)".

Figure 11. Unsurfaced Roads Modules.

Beginning Milepost: The Beginning Milepost is a beginning of unsurfaced segment which is under inspection.

Ending Milepost: The Ending Milepost of a segment is the milepost where the segment ends.

Milepost of Sample: The Milepost where the sample unit or Area of sample is identified.

Area of sample: A small part of a segment where the actual measurements will be performed for determining the condition of the road. The area is usually rectangular, and can be 100 feet long and as wide, as the width of the road. The area has to be carefully chosen, because the measurements taken of that area will represent the whole section. The number of sample units per mile is recommended not to exceed more than two sample units. So, if the road is less than a half mile long, one sample unit should be enough. Source Eaton, R.A., S. Gerard and D.W. Cate (10).

Quantity and Severity: The Quantity and Severity can be categorized in the following groups:

L - Low amount of distresses

M - Moderate amount of distresses

H - Large amount of distresses

When two or more distresses occur together, each distress has to be measure separately.

Improper Cross

Section:

An unsurfaced road should have a crown with enough slope from the center line to the shoulder to drain all water from the road surface. No crown is used on curves, because they are usually banked. The Severity Levels for Cross Section are:

L - Small amounts of pounding water or evidence of pounding water on the road surface; The road surface is completely flat (no cross-slope).

M - Moderate amounts of pounding water or evidence of pounding water on the road surface; The road surface is bowl shaped.

H - Large amounts of pounding water or evidence of pounding water on the road surface; The road surface contains a severe depression.

An improper cross section is measured in linear feet per sample unit (along the centerline or parallel to the centerline). The cross section runs from outside shoulder break on one side of the road to the outside shoulder break on the outer side. Different severity levels may exist within the sample unit. For example, there could

be 60 feet with medium severity and 40 feet with low severity. The total length would be equal to the length of the sample unit.

Inadequate Roadside Poor drainage causes water to pond. Drainage becomes a problem

Drainage: when ditches and culverts are not in good enough condition to direct and carry runoff water. Severity Levels are:

L - Small amounts of ponding water or evidence of ponding water in the ditches. Overgrowth or debris in the ditches.

M - Moderate amounts of ponding water or evidence of ponding water in the ditches; or overgrowth or debris in the ditches. Erosion of the ditches into the shoulders or roadway.

H - Large amounts of ponding water or evidence of ponding water in the ditches; or overgrowth or debris in the ditches. Water running across or down the road. -Erosion of the ditches into the shoulders or roadway.

Drainage problems are measured in linear feet per section parallel to the centerline. The maximum length is two times the length of the sample unit (two ditches for the total length of the sample unit).

For example, a sample unit may have 120 feet of low severity and 35 feet with high severity.

Corrugations: Corrugations (also known as washboarding) are closely spaced ridges and valleys (ripples) at fairly regular intervals. The ridges are perpendicular to the traffic and loose aggregate. These ridges usually form on hills, on curves, in areas of acceleration or deceleration, or in areas where the road is soft or potholed. The severity levels are:

L - Corrugations are less than 1 inch deep.

M - Corrugations are between 1 and 3 inches deep.

H - Corrugations are deeper than 3 inches.

Corrugations are measured in square feet of surface area per sample unit. The amount cannot exceed the total area of the sample unit. For example, a sample unit may have 230 square feet with moderate severity and 50 square feet with high severity.

Dust: The wear and tear of traffic on unsurfaced roads will eventually loosen the larger particles from the soil binder. As traffic passes, dust clouds create a danger to trailing vehicles and cause significant environmental problems. Severity levels are:

L - Normal traffic produces a thin dust that does not obstruct visibility.

M - Normal traffic produces a moderately thick cloud that partially obstructs visibility and causes traffic to slow down.

H - Normal traffic produces a very thick cloud that severely obstructs visibility and causes traffic to slow down significantly or stop.

The measuring can be accomplished by driving a vehicle at 25 mph and watch the dust cloud. Dust is measured as low, medium or high severity for the sample unit. Those three choices could be obtained from a drop-down menu.

Potholes:

Potholes are bowl-shaped depressions in the road surface. They are usually less than 3 feet in diameter. Potholes are produced when traffic wears away small pieces of the road surface. They grow faster when water collects inside the hole. The road then continues to disintegrate because it loses surface material or weak spots in the underlying soils. The levels of severity based on both the diameter and the depth of the pothole, are shown in the following table:

Maximum Depth	Less than 1 foot	1-2 feet	2-3 feet	More than 3 feet
½ - 2 inches	L	L	M	M
2 - 4 inches	L	M	H	H
4+ inches	M	H	H	H

Table 3. Levels of Severity of the Potholes

Potholes are measured by counting the numbers that are low, medium and high severity in a sample unit and recording them separately by severity level. For example, there may be 14 potholes of medium severity and 8 potholes of low severity.

Ruts:

A rut is a surface depression in the wheel path that is parallel to the road centerline. Ruts are caused by a permanent deformation in any of the road layers or subgrade. They result from repeated vehicle passes, especially when the road is soft. Significant rutting can destroy a road. The Severity levels are:

L - Ruts are less than 1 inch deep.

M - Ruts are between 1 and 3 inches deep.

H - Ruts are deeper than 3 inches.

Ruts are measured in square feet of surface area per sample unit. For example, a sample unit may have 75 square feet with high severity and 240 square feet with medium severity.

Loose Aggregate:

The wear and tear of traffic on unsurfaced roads will eventually loosen the larger aggregate particles from the soil binder. This leads to loose aggregate particles on the road surface or shoulder. Traffic moves loose aggregate particles away from the normal road wheel path and forms berms in the center or along the shoulder (the

less-traveled areas). The Severity levels are:

L - Loose aggregate on the road surface, or a berm of aggregate (less than 2 inches deep) on the shoulder or less-traveled area.

M - Moderate aggregate berm (between 2 and 4 inches deep) on the shoulder or less-traveled area. A large amount of fine soil particles is usually found on the roadway surface.

H - Large aggregate berm (greater than 4 inches deep) on the shoulder or less-traveled area.

Loose aggregate is measured in linear feet parallel to the centerline in a sample unit. Each berm is measured separately. For example, if a sample unit that is 100 feet long has three berms of medium severity loose aggregate - one on each side and one down the middle - then the measurement would be 300 feet at medium severity.

Remarks:

This field is reserved for notes about anything unusual at the site - for example, if two distresses occur together, such as ruts and potholes, erosion around culverts, erosion into road, or standing water on the road.

4.3.4 Turnouts

Turnouts are designed to facilitate vehicle passage for two-directional roads that are only one-lane wide. Turnouts are also designed for two-lane roads, so that the turnout is a widened, unobstructed shoulder which allows slow-moving vehicles to pull out of the through lane to give passing opportunities to following vehicles. Source: AASHTO (1) and Kramer, W.B.(17). The Turnout table records information of any turnout that occurs along the road. The Turnout screen is shown in Figure 12.

The screenshot shows a software window titled 'Turnouts' with a menu bar (File, Edit, Record) and a toolbar. The main area is divided into two sections: 'Road Information' and a table of 'Turnouts'.

Road Information Form:

- Road Number: 200.00
- Road ID: A
- Begin Description: Int. Co. Tampico Rd.
- End Description: (empty)
- Begin Milepost: 0.00
- End Milepost: 10.00
- Road Name: (empty)
- Comments: (empty)

Turnouts Table:

Milepost	Placement	Width	Length	Condition
0.20	B	6.00	110.00	P
0.20	R	6.00	110.00	P
0.33	L	6.00	90.00	P
0.41	R	6.00	90.00	P
0.49	R	4.50	65.00	VG
0.68	R	6.00	65.00	VP
0.72	L	4.50	45.00	F
0.74	R	6.00	75.00	VG

Figure 12. Turnouts Modules.

Milepost: The Milepost of a turnout is the milepost where the turnout begins.

Placement: The placement of a turnout corresponds to the location of the turnout in relation to the road. The placement of turnout can be:

B - Both sides of the road

L - Left-hand side of the road

R - Right-hand side of the road

T - Road Terminus

When the turnout is on both sides of the road for roads which are one-lane and two-directional, usually one half a usable turnout width is placed on both sides of the road. Road Terminus indicates that the turnout is the terminating feature of the current road, and that marks the end of the road.

Width: The width of a turnout refers to usable turnout width measured in feet. If the turnout is placed on both sides of the road, the width of the turnout is equal to a sum of both sides. Usable turnout width is the width from the end of the pavement to the edge of the lane.

Length: The length of turnout is the length measured in feet from the beginning milepost. For the condition of the turnouts the same criterium as the Surface Information table uses can be used.

Condition: The condition of the turnouts is categorized in the following groups:

VG - Very Good

G - Good

F - Fair

P - Poor

VP - Very Poor

For the condition of the turnouts the same criterium as the Surface Information table uses is used.

4.3.5 Gradability

The grade is the rate of ascent or descent of a roadway, expressed as a percent; the change in roadway elevation per unit of horizontal length. Source AASHTO (1), Anderson, P., M. Pyles, and J. Sessions (2). The Grade table is used to record information for steeper grades that occur along the roadway. The Gradability screen is shown in Figure 13.

The screenshot shows a software window titled 'Gradability' with a menu bar containing 'File', 'Edit', and 'Record'. The main content area is divided into two sections:

Road Information

Road Number: 100.00 Road Id: A
 Beg Milepost: 0.00 End Milepost: 8.50
 Beg Descript: Int. Co. Tampico Rd.
 End Descript:
 Road Name:
 Comments:

Road Gradability

Beg Milepost	End Milepost	Adverse Grade	Favorable Grade	Comments
0.00	4.00	10.00		
4.00	8.00		12.00	

Figure 13. Gradability Modules.

Beginning Milepost: The Beginning Milepost of a grade is the milepost where the grade begins.

Ending Milepost: The Milepost where the grade ends or changes to some tolerated grade.

Adverse Grade: The adverse grade is recorded in percents.

Favorable Grade: The favorable grade is recorded in percents.

4.3.6 Intersections

An intersection is the general area where two or more highways join or cross, within which are included the roadway and roadside facilities for traffic movements in that area. Source AASHTO (1). The Intersection table is used to record information for intersections that occur along the roadway. Each intersection of a particular road can be distinguished by a new milepost and unique details. The Intersection module is shown in Figure 14.

Milepost	Placement	Crossroad Number	Crossroad Id	Crossroad Begpost	Crossroad Name
2.32	R	190.00	L	0.00	
2.67	L	190.00	L	0.00	
2.68	R	190.00	L	0.00	
2.82	L	1,010.00		0.00	

Figure 14. Intersection Modules.

Milepost: The Milepost of the road where the road crossing or joining road occurs.

Placement: The placement of the intersection can be identified as follows:

B - Both sides of the road

L - Left-hand side of the road

R - Right-hand side of the road

Crossroad number: The intersecting road number.

Crossroad Id: The intersecting road identification.

Crossroad milepost: The Milepost where the intersection occurs on the intersecting road.

Crossroad Name: The name of the intersective road if one exists.

Crossroad Type: The Road type such as Street, Lane, Blvd, Ave, Ct, etc.

Crossroad Indicates the direction prefix or suffix being described. The

Direction: following codes are used:

N - North

S - South

E - East

W - West

NW - Northwest

SW - Southwest

NE - Northeast

SE - Southeast

Crossroad width: The width of the intersecting road, including shoulders, measured in feet.

Road Use: Road Use is used to indicate ownership of the intersecting road.

The following abbreviations are used:

FS - Forest Service road

BL - Bureau of Land Management road

ST - State highway

PR - Private

LA - Local Access Road

OT - Other

CO - County

4.3.7 Reference Points

The Reference Points table records features along the route which serve as a reference, such as a stream crossing, culvert crossing, bridge crossing, railroad track, houses, or recreation facilities. The Reference Point screen is shown in Figure 15.

The screenshot shows a software interface for managing reference points. The main window is titled 'Form' and has a menu bar with 'File', 'Edit', and 'Record'. Inside, there is a 'Reference Points' window with its own menu bar including 'File', 'Edit', 'Record', and 'Help'. The 'Reference Points' window is divided into two main sections: 'Road Information' and a table for 'Reference Points'. The 'Road Information' section contains several input fields: 'Road Number' (100.00), 'Road ID' (A), 'Beg. Description' (Int. Co. Tampico Rd.), 'Beg. Milepost' (0.00), 'End Milepost' (0.50), and 'Comments'. The 'Reference Points' table has two columns: 'Milepost' and 'Description', with a header row and several empty rows below it.

Figure 15. Reference Points Modules.

Milepost: Milepost of reference point being identified.

Description: Description of the reference point.

4.4 Appurtenances

From The FORIN Main Menu the Appurtenances option displays the following drop-down menu on the screen:

Culverts
Ditch
Storm System
Fences/Gates
Guardrail/Barrier
Pavement Marking
Signs Inventory
Signs History

Figure 16. Appurtenance Menu.

As in the Information drop-down menu (Figure 16), in the Appurtenances option the Road Information module provides the road information via eight different multi-table forms, in which the attributes of the road are described. For example, every road has its own identity, such as road number, road identification, road name, beginning of milepost and end of milepost. Besides the identity the road has other attributes such as culverts, ditches, signs, and bridges. A group of these attributes is distinguished as the appurtenances of the road and is explained in this section. The Road table is the main table used in all forms, and the rest of the tables are embedded into the Road table. Tables about Culverts, Ditches, Storm system, Fences and Gates, Guardrail and Barrier, Pavement Marking, Signs Inventory and Signs History are embedded to the Road Table.

4.4.1 Culverts

Any structure under the roadway with a clear opening of twenty feet or less measured along the center of the roadway is a culvert. Source: AASHTO (1). A culvert is also defined as a pipe, sewer, drain, conduit, box culvert or minor structure which provides an opening primarily for conveyance of liquids, pedestrians, or livestock; exclusive of bridges. Source: IRIS(13). The Culvert table is used for recording data about culverts, which cross under the road, for a particular milepost.

Milepost	Placement	Length	Offset Distance	Cover Depth	Slope	Skew	Carried
2.16	L	31.00	0.00	1.50	0.00	0.00	S
2.16	L	25.00	0.00	2.00	4.00	30.00	S
2.29	L	33.00	0.00	1.50	0.00	16.00	S
2.31	L	33.00	0.00	4.00	0.00	0.00	S

Figure 17. The Culvert Modules.

The fields of the Culvert Module are explained here below.

Milepost:	The beginning of milepost where the culvert is identified.
Placement:	<p>The culvert can be placed on the left or right-hand side of the road.</p> <p>The drop-down menu in the placement field displays the following choices:</p> <p style="padding-left: 40px;">L - Left-hand side of the road</p> <p style="padding-left: 40px;">R - Right hand side of the road</p>
Length:	That is the length of the culvert from one end to the other end. The length is measured in feet.
Offset distance:	The distance from the centerline of the roadway to the end of the culvert is offset distance. The offset distance is measured in feet.
Cover Depth:	The vertical distance between the profile and the crown or the material which is above the culvert. Serves as the basis for calculation of dead load on the structure. The Cover Depth is measured in feet. Source: AISI (3).
Slope:	The difference in the elevation of the culvert ends, divided by the length of the culvert and expressed as a percentage, gives the slope of the culvert.

- Skew:** The angle measured between the center line of the culvert and the perpendicular line of the roadway represents the skew of the culvert. The skew angle is measured in degrees.
- Carried:** This field explains, what is the purpose of the culvert. The drop-down menu offers the following choices:
- B - Named Body:** the name of water carried by the culvert.
 - D - Ditch:** If the purpose for placing the culvert was a ditch.
 - N - Non-water**
 - S - Stream**
- Named Body:** The Named Body is the name of the body of water carried by the culvert.
- System Type:** The drop-down menu offers the following choices: -
- C - Cross culvert:** That is the culvert that goes under the road.
 - A - Approach culvert:** A culvert that goes under approach to the road.
 - I - Intersection Approach:** A culvert which crosses an intersecting road (approach).
- Shape/Cross Section:** The shape of the cross section of the culvert. The drop-down

menu associated with this field has the following options:

C - Circular: A culvert having a circular cross-section.

P - Pipe arch: When the span is greater than the rise, a multi-radius shape with an arch-shaped top and a slightly convex integral bottom, structurally continuous with an invert whose radius of curvature is greater than that of the crown.

E - Ellipse: The cross section is an elliptical, and may be a vertical or horizontal ellipse.

R - Rectangular: Rectangular shape of cross section.

A - Arch: A plate formed to an arch shape and placed on abutments. The invert may be the natural stream bed or any other suitable material.

U - Underpass: An opening under a roadway or a rail-road to allow pedestrians, livestock, or other traffic to pass in safety.

O - Other -

Source: AISI (3), IRIS (13).

Material:

This field refers to the material which is used for the culvert. The drop-down menu displays the following choice:

AB - Acrylonitrile-butadiene-styrene (ABS)

CA - Corrugated aluminum

CL - Clay

CP - Cast-in-place concrete

CS - Corrugated steel

FR - Fiberglass-reinforced (FRP)

MA - Masonry

O - Other

PA - Structural plate aluminum

PC - Precast Concrete

PE - Polyethylene (PE)

PS - Structural plate steel

PV - Polyvinyl Chloride (PVC)

TI - Timber

Source: IRIS (13).

Coating:

The material inside the culvert which coats the culvert has the following choices:

B - Bituminous

C - Concrete

E - Epoxy

F - Fiberglass

G - Galvanizing

N - None

O - Other

P - Polymeric

Source: IRIS (13).

Inlet Treatment: The choices for the Inlet Treatment are the same as the choices for Outlet Treatment. The drop-down menu displays the following choices:

BH - Bevelled with Headwall

BV - Bevelled

FH - Flared with Headwall

FL - Flared

HW - Headwall

O - Other

SB - Step Bevelled

SH - Step Bevelled with Headwall

Headwall is a wall (of any material) at the end of a culvert or drain which serves one or more of the following purposes: to protect fill from scour or undermining, to increase hydraulic efficiency, to divert direction of flow and/or to serve as a retaining wall.

Flared or "U" shaped walls are wrapped walls and the wings of the structure does not exceed 15°.

Bevelled end is a cut-end treatment for structural plate products.

The cut is on a plane inclined to the horizontal. Bevelled inlet is a

large chamfer or flare on the inlet edge of a culvert to improve the inlet coefficient K_e . Source: AISI (3), IRIS (13).

Diameter/Rise/height: The maximum vertical clearance inside a conduit at a given transverse section, usually the centerline. If the culvert has a circular shape of cross section the diameter should be measured. Inside diameter, measured between inside crests of corrugations. The diameter or the rise is measured in inches. Source: AISI (3).

Span/width: That is the horizontal distance between supports, or maximum inside distance between the sidewalls. The distance is measured in inches. Source: AISI (3).

Number of culverts: That is the number of culvert on a particular milepost or the place which is under inventory.

Distance spanned: Spanned distance is the distance between the total number of culverts at the identified location. The distance is measured from the outside wall of the end culvert to the outside wall of the opposite side of the other culvert. If the fill between culverts exists, it should be included. The distance is measured in feet.

Condition:

The definitions for the condition of various types of culverts are adapted from IRIS (13). There is a different rating for different culverts.

1. Rating Guidelines for Round or Vertical Elongated Corrugated Metal Pipe Barrels
2. Rating Guidelines for Corrugated Metal Pipe-Arch Barrels
3. Rating Guidelines for Structural Plate Arch Barrel
4. Rating Guidelines for Low Profile Arch Long - Span Culvert Barrel
5. Rating Guidelines for High Profile Arch Long - Span Culvert Barrel
6. Rating Guidelines for Horizontal Ellipse Long - Span Culvert Barrel
7. Rating Guidelines for Precast Concrete Pipe Culvert Barrel
8. Rating Guidelines for Cast-in-Place Concrete Culvert Barrel
9. Rating Guidelines for Masonry Culvert Barrel

The condition for all of the above ratings is generally divided into the following:

VG - Very Good

G - Good

F - Fair

P - Poor

VP - Very Poor

The ratings for all different types of culverts is listed in the appendix A.

Drainage Adequacy: The drop-down menu offers two choices for drainage adequacy:

A - Adequate: Fully adequate drainage and cross section design.

There is no evidence of flooding, erosion, ponding or other water damage. Drainage structures are structurally sound. Source: IRIS (13).

I - Inadequate: Existence of severe flooding, ponding, erosion or other problems. Drainage structures may be in poor condition.

Considerable excess maintenance effort required due to drainage and sedimentation problems. Source: IRIS (13).

Marker in Place: That is a standard marker on the roadway. The marker helps in locating the culvert. The options of the drop-down menu are:

Y - Yes

N - No

Date Inspected: The Date Inspected field shows the date of last inspection of the culvert. The data values are represented in the form month-day-year (MM/DD/YY). The data has to be specified completely,

without omitting the day, month, or year, because the date will be invalid if any date values are missing.

Maintenance History: That is a field for comments and maintenance actions taken on the culvert.

4.4.2 Ditches

A ditch is either a drainage or an irrigation channel. Source Scott, S. J., (23). The ditches are in cuts at the outer edge of the outer shoulder. The Ditch Table records

The screenshot shows a software window titled "Ditches" with a menu bar (File, Edit, Record) and a toolbar. The main area is divided into two sections: "Road information" and "Ditches".

Road information section:

- Road Number: 100.00
- Road ID: A
- Beg. Description: Int. Co. Tampico Rd.
- End Milepost: 8.50
- Beg. Milepost: 0.00
- End Description: [blank]
- Road Name: [blank]
- Comments: [blank]

Ditches section:

Beg. Milepost	End Milepost	Depth	Width	Offset	Condition
1	2	[blank]	[blank]	[blank]	2

Figure 18. Ditch Modules.

information about the ditches along the road. The Ditch module is shown on Figure 18.

The fields provided in the Ditch Module screen are explained here below.

Beginning Milepost: The Milepost on the roadway where the ditch is being identified.

Ending Milepost: The Milepost where the ditch ends.

Depth: The depth is defined as the vertical difference between the lowest break point of the edge of the road where the ditch is identified and the lowest point of the ditch. The Depth is measured in feet.

Width: The horizontal distance from the lowest break point of the ditch to the opposite side of the ditch is the width of the ditch. The Width is measured in feet.

Offset Distance: The distance of the centerline of the roadway to the inner edge of the ditch is offset distance. The Offset distance is measured in feet.

Condition: **G - Good:** Small (less than 10 percent of the ditch length) amounts of ponding water or evidence of ponding water in the ditch; or debris in the ditch. Source: AISI (3).

F - Fair: Moderate (between 10% and 40% of the ditch length) amount of ponding water or evidence of ponding water in the ditch; or debris in the ditch; or erosion of the ditch into the shoulder or roadway. Source: AISI (3).

P - Poor Large (between 40% and 70% of the ditch length) amounts of ponding water or evidence of ponding water in the ditch; or water running across or down the road; or debris in the ditch; or erosion of the ditch into the shoulder or roadway. Source: AISI (3).

Date Inspected: The Date Inspected field shows the date of the last inspection of the ditch. The data values are represented in the form month-day-year (MM/DD/YY).

Maintenance Date: The field for recording the date and year of maintenance actions taken on the ditch.

Comments: Any additional comments regarding the ditch may be recorded here as the user deems necessary.

4.4.3 Storm System

The Catch Basin is a receptacle for diverting surface water to a sewer or subdrain, having at its base a sediment bowl to prevent the admission of grit and other coarse material into a sewer AISI (3). The Storm Table records information for the catch basins that occur along the road. Figure 19 shows the Storm System module.

The screenshot shows a software window titled "Storm System" with a menu bar containing "File", "Edit", and "Record". The window is divided into two main sections. The upper section, titled "Road Information", contains several input fields: "Road Number" (100.00), "Road ID" (A), "Beg Milepost" (0.00), "End Milepost" (0.50), "Beg Description" (Int. Co. Tampico Rd.), "End Description", "Road Name", and "Comments". The lower section, titled "Storm System", contains a table with the following columns: "Milepost", "Placement", "Offset", "Catch Basin ID", "Material", "Type Grate", "Drains To", and "Count". The table is currently empty.

Milepost	Placement	Offset	Catch Basin ID	Material	Type Grate	Drains To	Count

Figure 19. Storm System Modules.

The fields of the Storm System Module screen are explained below.

Milepost:	The Milepost where the catch basin occurs.
Placement:	That is the location where the catch basin is placed. The placement of the catch basin can be obtained from the drop-down menu, from which the following options are offered: L - Left side of roadway C - Center of the roadway R - Right side of the roadway
Offset:	The distance of the center line of the road to the edge of the catch basin. The distance is measured in feet.
Catch Basin ID:	The identification number of the catch basin if one is assigned.
Material:	The material of which the catch basin is constructed. The drop-down menu gives the following choices: C - Concrete M - Metal O - Other

Type of Grate: The grate over the catch basin can be:

P - Parallel, the bars are lying in one direction

T - Parallel and Transverse, the bars are crossing each other

Drains To: The location where the water drains. The drop-down menu has the following choices:

DW - Dry Well

HP - Holding Pond

OF - Outfall

SU - Sump

O - Other

Comments: Comments about the catch basin, if the user deems necessary.

4.4.4 Fences/Gates

Fencing along right-of-way limits may be desirable to control access. Fencing should be located on the right-of-way line or in the outer separation when frontage roads are present. Fences control indiscriminate entry or crossing of the roadways by either vehicle or pedestrian. Source: AASHTO (1). A gate is a structure forming a barrier across the road which can be swung open and closed. A gate is generally made of posts and wires. Source: IRIS (13). The Fences/Gates table records information about fences or gates that occur along the road. The Fences/Gated module is shown in Figure 20.

Milepost	Type	Width	Material	Date Inspected	Condition	Comments

Figure 20. Fences/Gates Modules.

Milepost : The field for Milepost records information about the beginning of the identified gate or fence.

Type: The choices for Type of Fences/Gates are:

C - Combination

G - Gate

S - Stockguard

Width: That is the total width of the fence or gate and is measured in feet.

Material: The material of which the fence or the gate is built. The drop-down menu gives the following choices:

C - Concrete

M - Metal

O - Other

WI - Wire

WO - Wood

Date Inspected: The Date Inspected field shows the date of the most recent inspection of the fence or gate. The data values are represented in the form month-day-year (MM/DD/YY).

Condition: The Condition of the fences or gates can be categorized:

VG - Very good

G - Good

F - Fair

P - Poor

VP - Very Poor

Comments: Any additional information related to the fences or gates should be recorded in the field for comments.

4.4.5 Guardrail/Barriers

“Guardrails are traffic barriers used to shield hazardous areas from errant vehicles”. Source: AASHTO (1). Guardrails and barriers are located on shoulders and medians as well as those which are placed as transition to bridge. The guardrail Table records information on guardrails along the road. The Guardrail module is shown in Figure 21.

The screenshot shows a software window titled "Guardrail/Barrier". At the top is a menu bar with "File", "Edit", and "Record". Below the menu bar is a toolbar with various icons and a "View" button. The main content area is divided into two main sections. The first section, "Road Information", contains several input fields: "Road Station" with the value "100.00", "Beg Milepost" with "0.00", "End Milepost" with "8.00", "Road Name", and "Comments". The second section, "Guardrail/Barrier", is a table with the following columns: "Beg Milepost", "Placement", "Barrier Type", "End Milepost", "Length", "Other", "Height", and "Post Type". The table contains one row of data with values in each column.

Beg Milepost	Placement	Barrier Type	End Milepost	Length	Other	Height	Post Type

Figure 21. Guardrail/Barrier Module.

Each of the fields which appear on this form is explained below.

Beginning milepost: The milepost where the guardrail begins.

Ending milepost: The ending milepost of the identified guardrail/barrier. The difference between the Ending Milepost and Beginning Milepost defines the length of the guardrail.

Placement: The side or the place of the road where the guardrail is located.

There are the following choices on the drop-down menu:

L - Left

B - Both

R - Right

M - Median

Barrier type: The drop-down menu is also available for this field. The following selection is offered:

C1 - Concrete Barrier Pinned to Ground

C2 - Concrete Barrier Pin and Loop Connection

E - Earth Berm

G1 - Cable Guardrail

G2 - W-Beam Steel Weak Post

G3 - Box Beam

G4 - Blocked Out W-Beam

- G8** - Aluminum Balanced Beam
- G9** - Blocked Out Three Beam
- MB10** - Metal Beam Guard Fence Median Barrier
- MB2** - W-Beam Steel Weak Post Median Barrier
- MB3** - Box Beam Median Barrier
- MB4** - Blocked Out W-Beam Median Barrier
- MB7** - Aluminum Strong Beam Median Barrier
- MB8** - Aluminum Balanced Beam Median Barrier
- MB9** - Blocked Out Three Beam Median Barrier
- O** - Other

Source IRIS(13).

Length: The difference between the Ending Milepost and the Beginning Milepost is the length of the guardrail/barrier. The length is measured in feet. The length of guardrail includes the end treatments.

Offset: The offset distance is the distance measured from the outer edge of the shoulder to the face of the guardrail, or if there is not shoulder, the distance measured from the traveled way to the face of the guardrail. The distance is measured in feet.

Height: The height is measured from the top of the guardrail or barrier to the traveled surface. The height is measured in inches.

Post type: The material of which the post is made. The menu contains the following selections:

WO - Wood

ST - Steel

AL - Aluminum

C - Concrete

O - Other

Source: IRIS(13).

Beginning End Treatment: End treatment at the ending of the guardrail/barrier

AB - Attached to Bridge or Parapet

BC - Breakaway Cable Terminal

CC - Crash Cushion

EB - Earth Berm

FB - Flared and Buried End

TD - Twisted and Turned Down End

TE - Tapered End

Source: IRIS(13).

Ending End Treatment: End treatment at the ending of the guardrail/barrier

AB - Attached to Bridge or Parapet

BC - Breakaway Cable Terminal

CC - Crash Cushion

EB - Earth Berm

FB - Flared and Buried End

TD - Twisted and Turned Down End

TE - Tapered End

Source: IRIS(13).

Number of posts: Number of posts which are placed to hold the guardrail or the barrier.

Number of Rails: Number of rails along the full length of the structure.

Delineators: Guardrails or barriers sometimes have an added benefit of serving as delineation markers for the driver. The menu provides the following choices:

Y - Yes

N - No

Barrier Condition: The condition of the guardrail or the barrier can be divided into:

VG - Very Good: New or nearly new, no sign of damage or deterioration.

G - Good: Minor dents, none of the posts show damage, concrete chipped.

F - Fair: Some damage to posts, visible, moderate damage or deterioration to rails concrete is cracked or misaligned.

P - Poor: Some posts need replacement or portions of the rail or concrete need replacement.

VP - Very Poor: Entire barrier needs replacement (non-functional) concrete is broken or shattered.

Source: IRIS(13).

Date Inspected: The Date Inspected field shows the date of the most recent inspection of the guardrails or barriers. The data values are represented in the form month-day-year (MM/DD/YY).

4.4.6 Pavement Markings

Marking set into the surface of, applied upon, or attached to the pavement for the purpose of regulating, warning, or guiding traffic. Source: IRIS (13), Kehr H.R., J. Kizer and R.D. Layton (16). Pavement Markings include the centerline, edge line, lane lines and raised pavement markers. The Pavement Markings Table is used to record information about all markers which occur on the road. The Pavement Markings module is shown in Figure 22.

The screenshot shows a software window titled "Form" with a menu bar containing "File", "Edit", and "Record". The main content area is divided into two sections:

Road Information

Road Number: 100.00 Road Id: A
 Beg. Milepost: 0.00 End Milepost: 8.00
 Beg. Description: Int. Co. Tampico Rd.
 End Description:
 Road Name:
 Comments:

Pavement Markings

Lane Number	Date of Striping Installation	Date of Installing Symbols/Message	Comments

Figure 22. Pavement Markings Module.

The fields of this Table screen are explained below.

Beginning Milepost: The milepost where the pavement marking initially occurs on the road.

Ending Milepost: That is the place where the pavement markings terminate.

Striping Configuration: The striping configuration for forest roads can be:

N - None

1DY - One Dashed Yellow

2FY - Two Full Yellow

1D1FY - One Dashed and One Full Yellow

1F1DY - One Full and One Dashed Yellow

O - Other

W1DYW - White - One Dashed Yellow - White -

W2FYW - White - Two Full Yellow - White

W1D1FYW - White - One Dashed and One Full Yellow -
White

W1F1DYW - White - One Full and One Dashed Yellow -
White

Source: IRIS (13).

Pavement Markers: Type of pavement markers in place.

PL - Plain: Round dome shaped button with no reflectorization.

RD - Reflectorized Recessed: Paving material is removed prior to installation.

RU - Reflectorized Raised: Install on pavement surface.

Striping/Symbol/Message/Material: Type of material used for pavement marking.

C - Cold Plastic: This material is installed without heat.

E - Epoxy

P - Paint

T - Thermoplastic: Material which requires heat during installation.

Symbol/Message: If the symbol or message is in place.

OL - Only

LA - Left Arrow

RA - Right Arrow

TA - Through Arrow

LS - Left/Straight Arrow

RS -Right/Straight Arrow

LR - Left/Right Arrow

2W - Two Way Left Turn Arrow

RR - Railroad Crossing

ST - Stop line

SC - School Crossing

CW - Crosswalk

Lane Identification: The lane in which the symbol or the message appears. The drop-down menu displays the following abbreviations:

L - Left lane from the centerline of the road.

R - Right lane from the centerline of the road.

Date of Striping Installation: When the striping was installed. The data values are represented in the form month-day-year (MM/DD/YY).

Date/Symbols/Message Installed: When the symbols and the messages were installed. The data values are represented in the form month-day-year (MM/DD/YY).

Comments: Any comments regarding pavement marks should be entered into the field for comments.

4.4.7 Signs Inventory

Road signs are used for uniform traffic control, and are necessary for safe traffic operation. Source: IRIS (13). The Sign Table records information about the signs which are placed along the roadway. The Signs module is shown on the Figure 23.

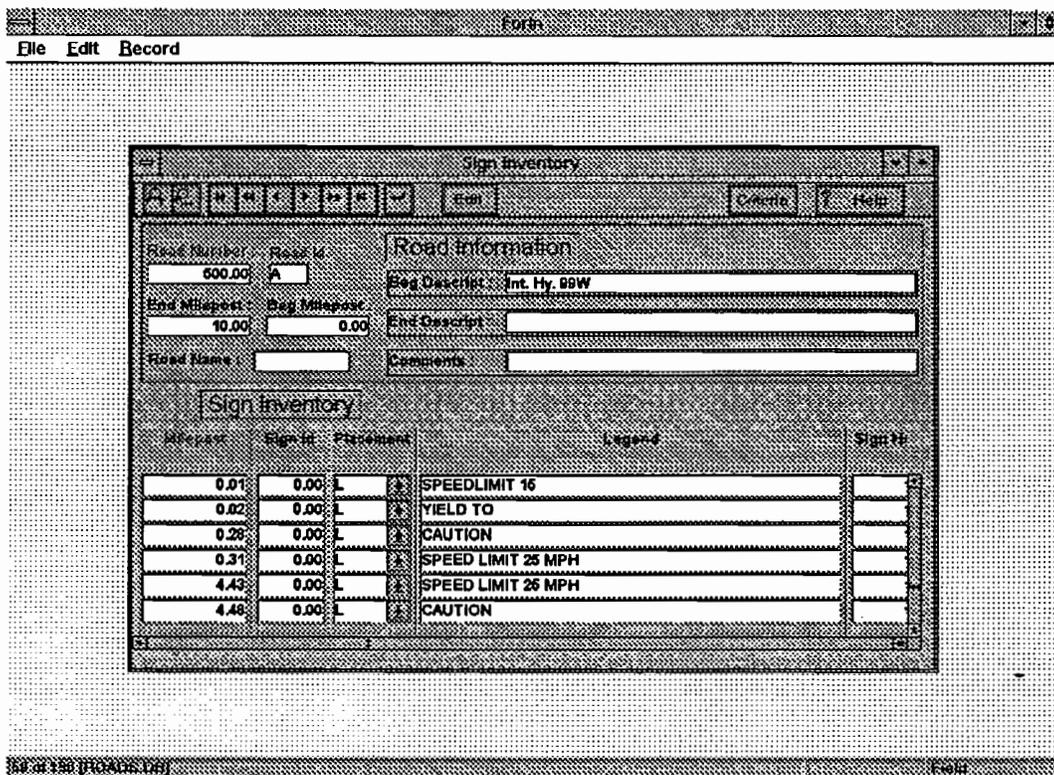


Figure 23. Signs Inventory Module.

The fields of the Signs Inventory screen are explained below.

Milepost: The milepost where the milepost has been identified along the road.

Sign Identification: If some specific ID is assigned to the sign.

Placement: The identified sign can be located in relation to the road as follows:

L - Left side of the roadway.

R - Right side of the roadway.

M - Median.

O - Overhead.

Legend: The message on the sign will be recorded in this field. If the sign has symbols, the meaning of the symbol should be interpreted.

Sign Height: The height is measured vertically in inches for all the signs.

Sign Width: The horizontal width also is measured in inches. Rectangles, pentagons, and octagons are measured by width. Diamond shaped signs are measured by length of side, and circles are measured by diameter.

Foreground Color: Color of sign face, foreground color.

B - Black

Bl - Blue

Br - Brown

G - Green

R - Red

Y - Yellow

W - White

Background Color: Color of sign face, background color.

B - Black

Bl - Blue

Br - Brown

G - Green

R - Red

Y - Yellow

W - White

Post Length: The entire length of the post on which the sign is mounted. The length is measured in feet.

Offset distance: The offset distance is measured from the edge of the sign to the edge of the of the shoulder if a shoulder exists, otherwise it is

measured to the edge of the traveled way. The distance is measured in feet.

Height of Post: The height is measured for the signs from the bottom of the sign to the surface of the traveled way. For an overhead sign the distance is measured from the travel way to the bottom of the sign. The height of post is measured in feet.

Position on Post: If there is more than one sign on the same post, the position on the sign should be indicated. The sign on the top of the post should be marked with number 1, and the signs underneath with subsequent numbers.

Material: Material of the backing the sign face is placed upon.

AL - Aluminum

PL - Plywood

FI - Fiberglass

ST - Steel

O - Other

- Surface:** The surface on the sign face. The drop-down menu offers these choices:
- R - Sign is Reflectorized:** The face of the sign is made of Reflectorized material.
 - N - Sign is not Reflectorized:** The face of the sign is not reflecting and is made of regular material.
 - S - Sign is Illuminated:** A light or other illuminating device is mounted on the face of the sign.
 - F - Flashing:** The sign face is flashing permanently.
- Post ID:** The identifier that the Forest Service has assigned to the sign which is under inventory.
- Number of Posts:** Number of posts which support the sign being identified.
- Post Type:** Material of sign post.
- 44 - Wood post 4" X 4"**
 - 46 - Wood post 4" X 6"**
 - 66 - Wood post 6" X 6"**
 - OT - Other**
 - SP - Steel Pipe**
 - ST - Square Steel Tube**

TR - Tree: Sign is posted on a tree

UC - U Channel

UP - Utility Pole: Sign is posted on pole.

Orientation: Direction sign faces the traffic.

E - East

N - North

NE - Northeast

NW - Northwest

S - South

SE - Southeast

SW - Southwest

W - West

Sign Condition: General condition of the sign is divided as follows: -

VG - Very good: No defects, deformation or weathering.

Generally new condition.

G - Good: Slight weathering, or deterioration but the longevity is still good.

F - Fair: Moderate weathering, or deterioration that does not affect the readability of the message. The sign may need cleaning or repair to restore it to good condition.

P - Poor: Replacement not immediately necessary but should be considered within the year.

VP - Very Poor: Replace the sign as soon as possible.

This condition rating includes condition of backing, face and posts.

The rating is based on the worst condition of any of those items.

Source IRIS (13).

Reflectivity: That is the condition of the reflectivity of the sign.

VG - Very Good

G - Good

F - Fair

P - Poor

VP - Very Poor

Comments: Comments relative to the sign which are not included in the form.

Examples: the sign is double sided, or the sign is invisible due to vegetation.

4.4.8 Sign History

The purpose of the Sign History Table is to collect information on the history of sign for a given road at a particular location. The history of the sign includes information such as the date of installation of the sign, inspection, maintenance, replacement or removal. The Sign History Table will assist the user in ascertaining all actions taken on a sign in a case of legal action. Source: IRIS (13). The Sign History Screen is shown in Figure 24.

The screenshot shows a software window titled "Sign History". At the top, there is a menu bar with "File", "Edit", and "Record". Below the menu bar is a toolbar with several icons and buttons, including "Edit" and "Help". The main content area is divided into two sections. The upper section, titled "Road Information", contains several input fields: "Road Number" (100.00), "Road Id" (C), "Bag Descript" (Int. Co. Temple Rd.), "Bag Milepost" (0.00), "End Milepost" (10.00), "End Descript", "Road Name", and "Comments". The lower section, titled "Sign History", is a table with the following columns: "Milepost", "Mile #", "Sign Date", "Sign Time", "Action", and "Notes". The table is currently empty.

Figure 24. Sign History Module.

The Sign History screen and its fields are described below.

- Milepost:** Milepost is the location of a sign which has been identified and has been under inventory.
- MUTCD:** The number of the sign from the “Manual on Uniform Traffic Control Devices ” prepared by the Federal Highway Administration or the Oregon Sign Number from the Oregon “Sign Policy and Guidelines for the State Highway System” or the NS number assigned by the forest service for a unique sign that is not listed in either of the above documents.
- Sign Date:** The date of the action being recorded.
- Sign Time:** Time of the action being recorded. The Time is 24 hours of the day.
- Action:** Action required on the sign or post.
- Notes:** Notes on action being taken on the date and time being recorded. In this field the user can include notes on: installation, inspection, maintenance, replacement, removal and any other comments related to the sign.

4.5 Miscellaneous

From The FORIN Main Menu the Miscellaneous option displays the following drop-down menu on the screen:

Survey Monumentation
Unique Routes
Biking
Road Use Constraints
Railroad Crossing
Underground Utility Crossing
Bridge Inventory

Figure 25. Miscellaneous Menu.

The drop-down menu, in the Miscellaneous option (Figure 25.) provides the road information for seven different multi-table forms, which contain specific road feature information. These features, together with the attributes of the roads and the information of the roads, provide for the user a whole picture of the condition of the roads. .

4.5.1 Survey Monumentation

The Monument table is used to record surveying monuments located in the roadway. The inventoried information will identify the monument location if the information is used for further purposes. The following screen (Figure 26.) shows the Surveying Monumentation form.

The screenshot shows a software window titled "Survey Monumentation" with a menu bar containing "File", "Edit", and "Record". The main area is divided into two sections. The top section, titled "Road Information", contains several input fields: "Road Number" (100.00), "Road Id" (A), "Beg Milepost" (0.00), "End Milepost" (8.60), "Beg Description" (Int. Co. Tampico Rd.), "End Description", and "Road Name". The bottom section, titled "Survey Monumentation", is a table with the following columns: "Milepost", "Placement", "Type Monument", "Monument Number", "Monument Material", "Cap Material", "Offset", and "Monument Class". The first row of the table contains the following data: "10.00", "R", "GPS", an empty field, "C", "B", an empty field, and "CTL".

Milepost	Placement	Type Monument	Monument Number	Monument Material	Cap Material	Offset	Monument Class
10.00	R	GPS		C	B		CTL

Figure 26. Surveying Monumentation Module.

The fields of the Survey Monumentation Module are explained here below.

Milepost: Milepost is the location where the monument is identified.

Placement: The drop-down menu offers the following choices for the placement of the monument:

C - Center of the road/roadway

L - Lefthand side of the road

R - Right-hand side of the road

Type Monument: The following choices are available:

GPS - Global Positioning System

GV - Government

O - Other

PV - Private

Monument Number: If the monument has an identification number. -

Monument Material: The drop-down menu gives the following selection of the materials:

A - Aluminum Pipe

C - Concrete

P - Iron Pipe

R - Iron Rod

N - Nail/Spike

O - Other

S - Stone

Cap Material: The following choices are available on the menu:

A - Aluminum

B - Brass

O - Other

P - Plastic

Offset: Offset distance is the distance from the center line to the monument. The offset distance is measured in feet.

Monument Class: Monument class choices are the following :

AZ - Azimuth Mark

BM - Bench Mark

CL - Center Line

CTL - Control(Geodetic)

DLC - Donation Land Claim

O - Other

PI - Point of Intersection

PVT - Private

RM - Reference

RW - Right of Way

SEC - Section

4.5.2 Unique Routes

The Unique Routes form records information for uniquely defined roads (Figure 27). The following screen is the screen for recording unique routes.

The screenshot shows a software window titled "Unique Routes" with a menu bar containing "File", "Edit", and "Record". The main area is divided into two sections. The top section, titled "Road Information", contains several input fields: "Road Number" (142.00), "Road Id" (empty), "Beg. Description" (Int. 140 Rd.), "End Milepost" (10.00), "Beg. Milepost" (0.00), "End Description" (empty), "Road Name" (empty), and "Comments" (empty). The bottom section, titled "Unique Routes", contains a table with the following data:

Beginning Milepost	End Milepost	National Forest Highway	Resource Road	Scenic Road	School	Mail	Public Bus	Designated Truck Road
0.00	5.00	Y	N	Y	Y	Y	N	Y

Figure 27. Unique Routes Screen.

The fields of the Unique Routes screen are explained below.

Beginning Mileposts: The milepost at the beginning of the road or a section of the road which is defined as an unique route.

Ending Milepost: The milepost where the road or the road section is finishing.

National Forest Highway: Roads designed by the Forest Service as a forest road under a jurisdiction of, and maintained by, a public authority and open to public travel.

Resource Road: A road used for carrying timber or other resources from the forest to provide service to industrial or commercial facility.

Scenic Road: The road has scenic qualities and has been designated as a scenic road by the State or the County.

School: When the road is used by school buses for carrying children to school it is a School Road.

Mail: When the road is used by mail delivery personnel the road is a mail road.

Public Bus: If the road is used by public buses for transporting the public, the road is a public bus road.

Designated Truck Route: If the road is designated for trucks and used by trucks.

4.5.3 Biking

Mountain biking is a growing sport, especially on the forest roads. The forest roads are preferred places for exercising by mountain bikers and could be used as shared use facilities. Source Hutchinson, M.M. (12). The Shared Use for Biking Table records information for roadway characteristics, such as average daily traffic, lane width, the alignment, as well as the settings of the road. The Shared Use for Biking Screen is shown in Figure 28 below.

Form

File Edit Record

Shared Use for Biking

Road Information

Road Number: 100.00 Road ID: A Reg. Description: Int. Co. Temple Rd.

Reg. Milepost: 0.00 End Milepost: 8.00 End Description:

Road Name: Comments:

Mountain Biking

Beginning Milepost	Ending Milepost	Vertical Alignment	Horizontal Alignment	Road Attribute	Average Daily Traffic	Speed

File Edit Record

Figure 28. Shared Use for Biking screen.

The fields of the Shared Use for Biking screen are described below.

Average Daily Traffic (ADT): The total volume of traffic during a given time period (in whole days), greater than one day and less than one year, divided by the number of days in that period of time. Source Hutchinson, M.M. (12).

Speed Limit: The Speed Limit assigned to the road in miles per hour.

Lane Width (LW): The traffic lane is the portion of the traveled way for the movement of a single line of vehicles. Source AASHTO (1). The width of the lane is measured in feet.

Number of lanes: The number of lanes on each segment of the road.

Scenic Quality(SQ): The Scenic quality of the road is defined as:

H - High: The road has high scenic quality if it has one or more of the following, or similar qualities: several view points exist along the road, the road goes to a scenic destination, the road is in a scenic corridor, it travels along a stream, or it goes through forest or meadow type settings with few or no clearcuts along the road.

M - Medium: The road has medium scenic quality, and includes: road passes in areas recently replanted, it has few moderate view points along the road, or road passes by or through some clearcuts.

L - Low: A low scenic quality road is one with no view points, travels through several recent clearcuts, and is not visually pleasant.

Loop Potential (LP): The loop potential value for a road is:

Y - Yes

N - No

The road has loop potential if that road can be ridden as part of a loop ride. Generally, if the road has at least two junctions with other roads it has loop potential. A road has no loop potential if it is a dead end road.

Surface:

The surface type conditions of the road are also important parts of the inventory. The surface type condition is presented into the following categories:

G - Gravel/Cinders

C - Chip Seal

ND - Natural Dirt

P - Paved

PH - Potholes

WB - Wash boarding

A - Accum Pine Needles

SB - Scattered Boulders

SD - Severe Dips

Source Hutchinson, M.M. (12)

Horizontal Alignment: The Horizontal alignment is classified as follows:

FC - Frequent Curves: if the road has high percentage of curves in

the horizontal alignment, and many may be sharp tight curves of less than a 200 foot radius, or hairpin turns. Braking and slowing would be needed to operate on these curves. The designated speed for these curves would be 25 miles per hour.

MC - Moderate curves: the road has a fair number of curves along its length, but most of the curves are of moderate curvature, from a 200 to 600 foot radius, with a designated speed ranging from 25 to 40 miles per hour.

Vertical alignment: The Vertical alignment is classified as follows:

SG - Severe grades: roads that have several short steep sections or that have long gradual grades. The AASHTO (1) Guide for Development of Bicycle Facilities states “grades over 5 percent are undesirable because the ascents are difficult for many bicyclists to climb and the descents cause some bicyclists to exceed the speeds at which they are competent.” Source Hutchinson, M.M. (12). For these reasons sustained grades over 5 percent and short pitches (less than 500 feet) over 7 percent are considered severe. The road must have five steep sections or more, or have a consistent grade to be classified as a “severe” grade. One steep pitch would not change an otherwise “level road” to a “severe grade”. Source Hutchinson, M.M. (12).

MG - Moderate grades: A road with moderate grades could have a few short steep sections or longer gradual sections, but generally, it will have a “rolling hills” type alignment. Grades should be between 2 percent and 5 percent on moderate grade roads. Source Hutchinson, M.M. (12).

Condition: The condition of the road is divided into:

VG - Very Good

G - Good

F - Fair

P - Poor

VP - Very Poor

For evaluating the condition of the road for biking see the Appendix B.

Comments: The user should record any other relevant remarks about the road such as: ditches along the road, super elevation, or if the surface has more than one attribute.

4.5.4 Road Use Constraints

The Road Use Constraint table records information about the limits and restrictions of the roadway such as weight, height or speed limit. Figure 29, shown below, represents the screen for road use constraints information.

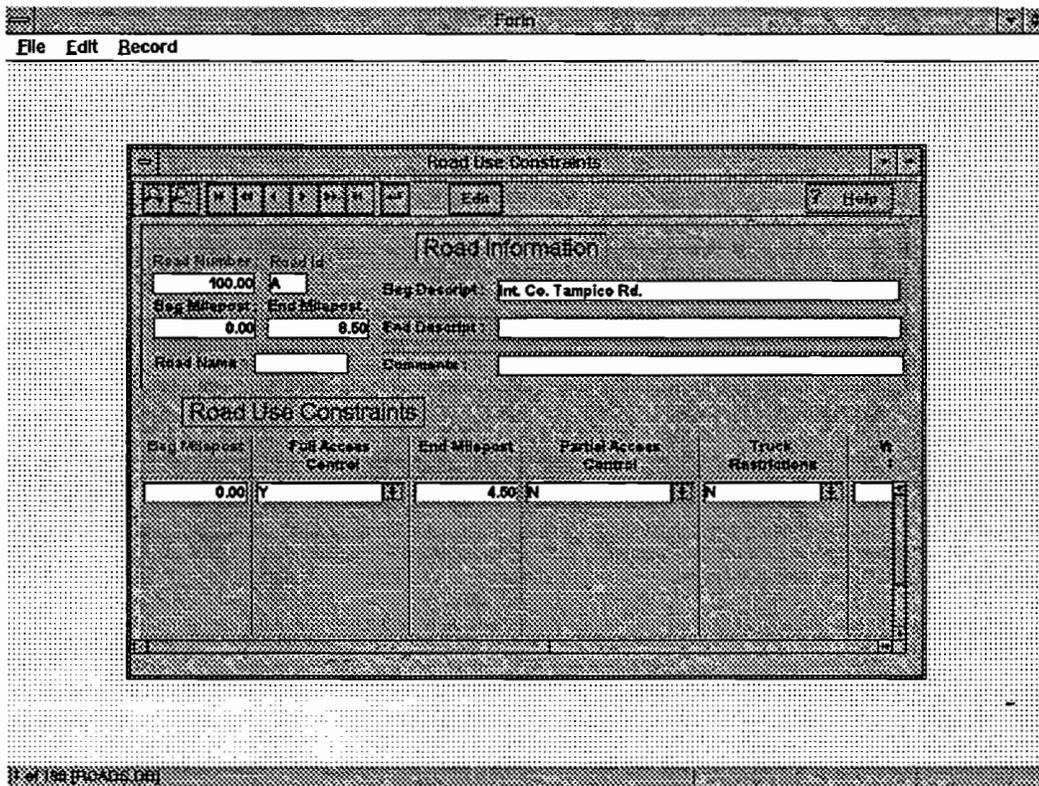


Figure 29. Road Use Constraints Module.

The fields of the Road Use Constraints Module are explained below.

Beginning Milepost: The milepost at the beginning of a segment or a road identified for road use constraints.

Ending Milepost: The milepost identified at the termination of a segment or a road. The Beginning Milepost and Ending Milepost define a road segment or a road with the same constraints.

Full Access Control: If the road has full access to forestry equipment and public traffic.

Partial Access Control: If the road is reserved for a special kind of traffic.

Truck Restriction: If the road is restricted to certain size of trucks.

Weight Limit: Weight limit assigned to the road, if any.

Oversize Permit Route: The Oversize Permit Route indicates the types of oversize permits allowed on the road. The drop-down menu offers the next selection:

H - Over height

L - Over length

W - Overweight

Comments: The user may describe any the road use constraints.

4.5.5 Railroad Crossing

The place where the road and the railroad intersects is the railroad crossing.

Source AASHTO (1). The Railroad Crossing table records information about railroads which cross over the roads. The following screen is displayed for data collection or data browsing (Figure 30).

The screenshot shows a software interface for managing railroad crossing data. It features a menu bar with 'File', 'Edit', and 'Record' options. The main window is titled 'Form' and contains two primary sections: 'Road Information' and 'Railroad Crossing'.

The 'Road Information' section includes the following fields:

- Road Number: 162.00
- Road Id: [empty]
- Beg Descript: Int. 160 Rd.
- End Milepost: 10.00
- Beg Milepost: 0.00
- End Descript: [empty]
- Road Name: [empty]
- Comments: [empty]

The 'Railroad Crossing' section is a table with the following columns and data:

Milepost	Type Traffic Control Device	Track Owner	Crossing Number	Vehicle Crossing Relationship	#Tracks
1.40	N	Pacific Railroad	C-719.2	A	1.00

Figure 30. Railroad Crossing Screen Module.

The field of the Railroad Crossing Screen are explained below.

Milepost: That is the milepost where the railroad crossing is located.

Traffic Control Device: The Traffic Control Device displays a drop-down menu and uses the following codes for each type of traffic control device:

FL - Flashing Lights

GL - Gates with Flashing Lights

HS - Highway Signals (Standard Traffic)

N - None

O - Other

OT - Other Type of Signal

SS - Stop Sign

WW - Wigwags

Track Owner: The Track Owner is the name of a person or company which owns the tracks.

Crossing Number: The number which is used by US DOT/Association of American Railroads Inventory to designate when a railroad crossing exists.

Vehicle Crossing Relationship: The drop-down menu offers the following choices for the crossing relationship between the road and the tracks:

A - At-Grade

O - Railroad Overpass

U - Railroad Underpass

Number of tracks: The number of track sets that the road traffic would have to cross.

4.5.6 Underground Utility Crossing Screen

The Underground Utility Crossing Table is used to record information on the point where the road crosses utilities. The identified locations can be significant when maintaining or installing utility lines and when planning or tracking the interaction of the existing traffic on the road. The screen below (Figure 31.) is displayed to record data on Underground Utility Crossings.

The fields of the Underground Utility Crossing Module are described below.

Milepost: The milepost identified on the roadway where the utilities cross the road.

Type: The drop-down menu displays the following choices of utilities:

G - Gas

E - Electric

C - Communications

W - Water

S - Sewer

O - Other

When two or more of the utilities occur at the same milepost, for each utility a new row with the same milepost should be entered.

Permit Number: The number of permit issued if there is construction, maintenance or repair of the crossing utilities.

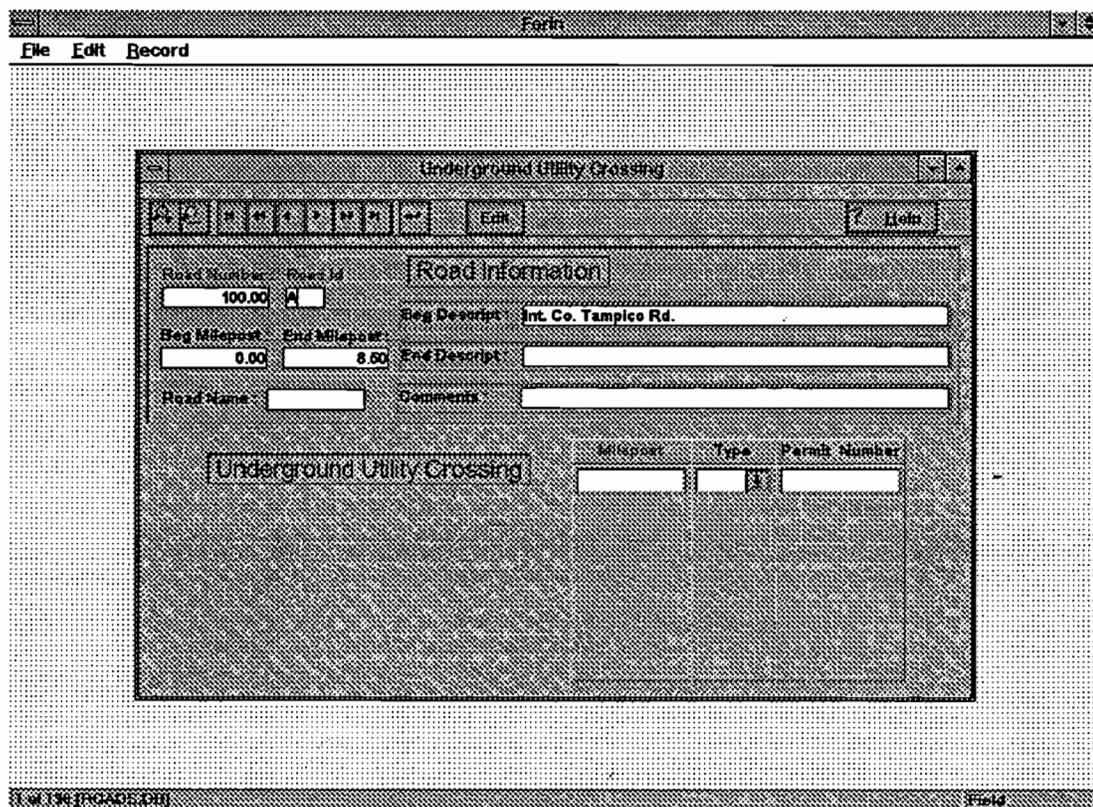


Figure 31. Underground Utility Crossing Module.

4.5.7 Bridge Inventory

A bridge is a structure which has the following features: (1) it is a support erected over a depression or an obstruction such as water, a highway or a railway, (2) it has a track or passageway for carrying traffic or other moving loads, (3) it has an opening measured along the center of the roadway of more than twenty feet between undercopings of abutments or spring lines of arches or extreme ends of openings for multiple boxes and (4) it may include multiple pipes where the clear distance between openings is less than half of the smaller contiguous opening. Source AASHTO (1). The Bridge Table collects information on the bridges along the road. Figure 32. displays the screen for the Bridge Inventory Module. The fields of the Bridge Inventory Module are explained below.

Milepost: The milepost where the identified bridge begins.

Roadway Width: The width of the bridge roadway. The width is measured in feet.

Length: The total length of the roadway which lays on the bridge is measured in feet.

The screenshot shows a software window titled "Bridges" with a menu bar (File, Edit, Record) and a toolbar. The main interface is split into two panes. The top pane, "Road Information", contains several input fields: Road Number (100.00), Road ID (A), Beg Milepost (0.00), End Milepost (8.50), Beg Name, End Name, Beg Description (Int. Co. Tampico Rd.), End Description, and Comments. The bottom pane, "Bridges", contains a table with the following data:

Milepost	Roadway Width	Length	Placement	Sidewalk Width	# NH	County
1.20	16.00	45.00	L	5.00	1234 A607	345B

Figure 32. Bridge Inventory Module.

Placement: The placement of a sidewalk, if one exists. The drop-down menu gives the following choices:

B - Both Sides of the Road

L - Left Side of the Road

R - Right Side of the Road

Sidewalk Width: If a sidewalk exists on the bridge, the sidewalk is measured in feet.

NBI Number:	National Bridge Inventory Number.
Bridge Number:	A bridge number is a number assigned by the Forest Service, County or the State.
Bridge Name:	The name of the bridge if one is assigned.
Weight Limit:	If the bridge is weight restricted, the weight limit should be recorded in tons.
Height Limit:	The height limit of the bridge is recorded in feet.
Speed Limit:	The speed limit which applies to the bridge. The speed limit is in miles per hour.
Feature Crossed:	Identifies the feature which is crossed by the bridge. The following choices appear on the drop-down menu. BW - Body of water: The bridge crosses a body of water. O - Other RA - Ravine: The bridge crosses ravine. RD - Road: The bridge crosses a road. RR - Railroad: The bridge crosses a railroad.

Body Name: If the body has a name like a river, or a highway etc.

Structure Material: That is the material which is used for the bridge structure. The following codes are offered from the drop-down menu:

C - Concrete

CO - Combination

O - Other

ST - Steel

TI - Timber

Comments: Any other additional information about the bridge can be recorded in this fields.

4.6 Reports

The **FORIN** Main Menu provides a choice for Reports which are generated through the forms and the tables. The Report menu option enable viewing reports on the screen or send them to any defined printer. Information Reports, Appurtenances Reports and Miscellaneous Reports on the menu choice are available. For each report selected a dialog box is displayed. The dialog box is shown below in Figure 33.

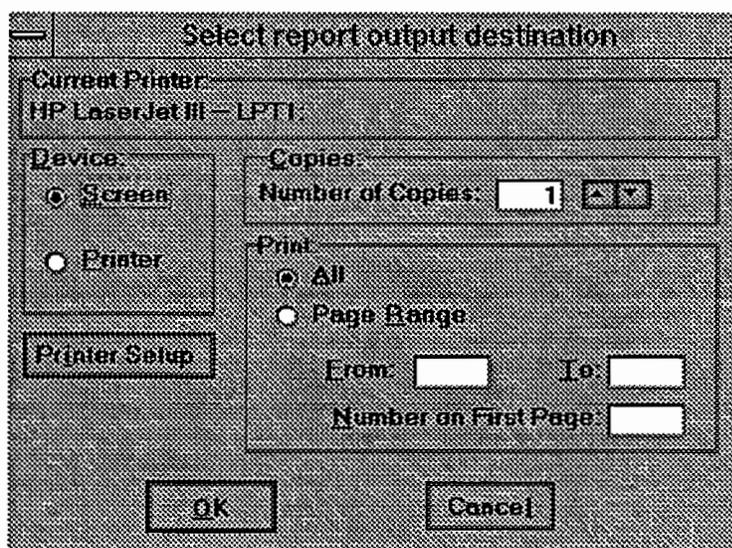


Figure 33. Report destination dialog box.

The dialog box offers two output destination. The Printer output destination and Screen output destination can be selected from the box. When the printer is selected, the current printer is displayed at the top of the dialog box. . A different printer setup can be choose by clicking the Printer Setup button and choosing the wonted printer.

By default all pages are printed, but if a page range is specified, only the selected pages will be printed. The number of copies also can be selected.

All the reports have a custom menu which menu is displayed while the report is being generated. The custom menu is displayed in Figure 34.

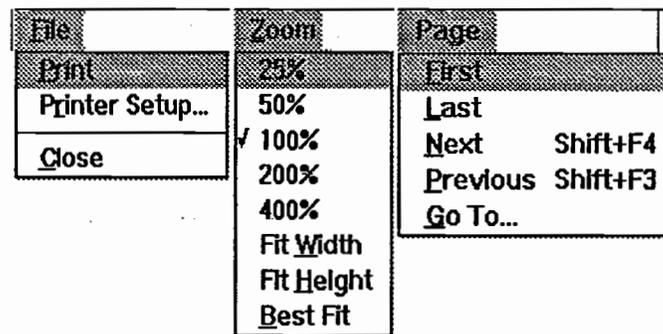


Figure 34. Custom menu for the reports.

The File choice gives an option for printing the report or if the printer setup has to be changed for any reason.

The Zoom choice is used for a closer look at the report and can be zoomed to increase the report to 400% of the original size of the document. Also can be zoomed out to get broader picture of the report to 25% of the original size of the report.

Fit Width is used for proportionally resizing the report, so its full width can be displayed within the window. Fit Height resizes the report so its full height will be displayed within the window. Best Fit resizes the report so its full height and full width can be displayed within the window. When printing the Zoom properties are not retained on the printout.

The Page choice enables to move among the pages of a multipage reports. By clicking the first, last, next or previous page option it is easy to move to the wanted position. The option Go To.. Can be used if the wanted number is known.

By choosing File/Close the report would be closed and the Main Menu form will appear.

The following figures display some of the final reports which show the data results yielded by FORIN. Figure 35 is an example of a Culverts Information report with records grouped by Road Number.

File Zoom Page															
Thursday, April 11, 1996															
Page 1															
Road Number : 100.00															
Road No.	Rd. Id	Mile post (mi)	Piece ment	Length (%)	Cover Depth	Slope (%)	Shew Angle	Carried	Shape Cross Section	Mat. Type	DIA. (ft)	Cond	Marker in Piece	Date Ins.	Maintenance History
100.00	A	2.16	L	31.00	1.50	8.00	8.00	S	C	CS	15.00		Y	11/27/84	OUTLET BURRIED
100.00	A	2.19	L	29.00	2.00	4.00	30.00	S	C	CS	15.00	F	Y	11/27/84	
100.00	A	2.29	L	33.00	1.50	8.00	18.00	S	C	CS	15.00	F	Y	11/27/84	OUTLET PLUGGED
100.00	A	2.31	L	33.00	4.50	8.00	8.00	S	C	CS	18.00	F	Y	11/27/84	OUTLET PLUGGED
100.00	A	2.40	L	0.00	0.00	0.00	0.00	S	C	CS	0.00	F		11/27/84	WATERBLOCKOK
100.00	A	2.50	L	29.00	1.40	8.00	32.00	S	C	CS	15.00		Y	11/27/84	OUTLET PLUGGED
100.00	A	2.98	L	39.00	1.50	11.00	45.00	0	C	CS	15.00	P	Y	11/27/84	INLET DAMAGED 1 OUTLET BURRIED
100.00	A	2.71	L	39.00	1.60	12.00	39.00	S	C	CS	15.00		Y	11/27/84	OUTLET BURRIED
100.00	A	3.15	L	39.00	8.00	15.00	0.00	S	C	CS	24.00	G	N	11/27/84	
100.00	A	3.18	L	29.00	2.30	16.00	10.00	0	C	CS	18.00	F	N	11/27/84	OUTLET PARTIALLY PLUGGED.
Road Number : 130.00															
Road No.	Rd. Id	Mile post (mi)	Piece ment	Length (%)	Cover Depth	Slope (%)	Shew Angle	Carried	Shape Cross Section	Mat. Type	DIA. (ft)	Cond	Marker in Piece	Date Ins.	Maintenance History
130.00	C	0.07	L	30.00	3.40	4.00	0.00	S	C	CS	54.00	G	N	11/27/84	
130.00	C	0.16	L	30.00	1.30	6.00	40.00	0	C	PV	18.00	VO	Y	11/27/84	
130.00	C	0.26	L	29.00	1.50	7.00	35.00	S	C	PV	18.00	VO	Y	11/27/84	
130.00	C	0.32	L	29.00	1.50	17.00	35.00	S	C	PV	18.00	VO	Y	11/27/84	
130.00	C	0.36	L	0.00	1.50	8.00	25.00	S	C	CS	88.00	G	Y	11/27/84	
130.00	C	0.56	L	25.00	1.50	8.00	30.00	0	C	CS	15.00	G	Y	11/27/84	
130.00	C	0.73	L	30.00	1.50	12.00	40.00	S	C	CS	15.00	G	Y	11/27/84	
130.00	C	0.83	L	28.00	1.50	4.00	28.00	S	C	CS	18.00	VP	Y	11/27/84	OUTLET PLUGGED
130.00	C	0.90	L	29.00	1.20	10.00	28.00	S	C	CS	15.00	G	Y	11/27/84	OUTLET PLUGGED
130.00	C	0.99	L	28.00	0.70	8.00	42.00	S	C	CS	15.00	G	Y	11/27/84	INLET OUTLET BURRIED
130.00	C	1.28	L	32.00	0.50	18.00	20.00	S	C	CS	15.00	F	Y	11/27/84	
130.00	C	1.46	L	28.00	0.50	4.00	36.00	0	C	CS	15.00	F	Y	11/27/84	
130.00	C	1.64	L	34.00	2.50	5.00	8.00	S	C	CA	18.00	P	Y	11/27/84	

Figure 35. Culverts Information Report.

Figure 36 shows a tabular presentation of a Intersection report, and Figure 37. shows a tabular presentation of a Mountain Biking report with records grouped by Road Condition.

Intersections Report											
Friday, March 29, 1996											
Page 1											
Road Number	Road Id	Milepost	Placement	XRoad Number	XRoad Id	XMilepost	XRoad Name	XRoad Type	XRoad Direction	Xwidth	Road Use
100.00	A	2.22	R	100.00	L	0.00				50.00	
100.00	A	2.57	L	100.00	L	0.00				40.00	
100.00	A	2.83	R	100.00	L	0.00				100.00	
100.00	A	2.82	L	1,010.00	L	0.00				25.00	
130.00	C	0.38	L	131.00	L	0.00				0.00	
800.00	A	0.16	L	800.00	L	0.00	880			45.00	
800.00	A	0.44	R	870.00	L	0.00	870		SW	33.00	
800.00	A	0.63	L	6,020.00	L	0.00	6020			35.00	
800.00	A	1.09	L	800.00	L	0.00	800			90.00	
800.00	A	3.18	R	800.00	L	0.00	800			75.00	
800.00	A	4.40	R	830.00	L	0.00	830			35.00	
800.00	A	4.49	L	840.00	L	0.00	840			75.00	
800.00	A	4.54	L	820.00	L	0.00	820			45.00	
800.00	A	5.19	R	810.00	L	0.00	810			85.00	
800.00	A	5.22	R	0.00	L	0.00	SULPHUR SPRINGS RD			366.00	
860.00	C	0.41	R	861.00	L	0.00				45.00	
861.00	L	0.21	L	0.00	L	0.00	VIEWPOINT			25.00	
861.00	L	0.22	L	0.00	L	0.00	VIEWPOINT			25.00	
870.00	L	0.20	L	872.00	L	0.00				40.00	
872.00	L	0.35	L	872.00	L	0.00				50.00	
872.00	L	0.40	L	872.00	L	0.00				21.00	
880.00	A	0.25	R	0.00	L	0.00	UNNAMED ROAD			85.00	
880.00	A	0.30	R	891.00	L	0.00				65.00	
880.00	A	0.88	R	882.00	L	0.00				65.00	
890.00	A	0.89	R	882.00	L	0.00				30.00	

Figure 36. Intersections Report.

Mountain Biking																
Thursday, April 11, 1996																
Page 1																
Condition : F																
Road Number	Rd. Id	Seg. Mile	End Mile	Vert. Align.	Horiz. Align.	Road of Arv.	Average Daily Traffic	Speed (mi/h)	Lane Width	Scenic Quality	Surface	Loop Pole rated	Score	Cond.	No. of Lanes	Comments
100.00	A	0.00	1.00	MO	MC	D	500.00	55.00	14.00	H	CS	Y	1.94	F	2.00	
100.00	A	3.00	4.00	MO	FC	D, SE	5.00	25.00	12.00	L	ND, VB	Y	2.05	F	1.00	
100.00	A	4.00	5.00	SO	MC	D	5.00	25.00	12.00	H	ND, VB	N	2.35	F	1.00	
100.00	C	1.00	2.00	SO	FC	D	25.00	15.00	10.00	M	ND	Y	2.48	F	1.00	
100.00	C	2.00	3.00	N	N	D	25.00	25.00	12.00	L	ND	Y	2.17	F	1.00	
110.00	C	0.00	1.00	SO	MC	D	280.00	35.00	12.00	H	P	Y	2.94	F	1.00	

Condition : G																
Road Number	Rd. Id	Seg. Mile	End Mile	Vert. Align.	Horiz. Align.	Road of Arv.	Average Daily Traffic	Speed (mi/h)	Lane Width	Scenic Quality	Surface	Loop Pole rated	Score	Cond.	No. of Lanes	Comments
100.00	A	2.00	3.00	MO	MC	D	5.00	25.00	12.00	M	ND, PH, VB	Y	0.80	G	1.00	
110.00	C	4.00	5.00	SO	FC	D	25.00	15.00	12.00	H	O, VB	Y	1.50	G	2.00	

Condition : P																
Road Number	Rd. Id	Seg. Mile	End Mile	Vert. Align.	Horiz. Align.	Road of Arv.	Average Daily Traffic	Speed (mi/h)	Lane Width	Scenic Quality	Surface	Loop Pole rated	Score	Cond.	No. of Lanes	Comments
100.00	A	1.00	2.00	MO	MC	D	1,000.00	55.00	14.00	H	P	Y	3.76	P	2.00	
100.00	C	3.00	4.00	SO	MC	N	25.00	25.00	12.00	L	ND, PH, SE	N	4.82	P	1.00	

Figure 37. Mountain Biking Report.

Figure 38. is a Culvert Condition Report, which groups the records by the diameter of the culvert and calculates the total linear length of that size of culvert. The report is generated as a result of the user's query regarding the condition of the culvert.

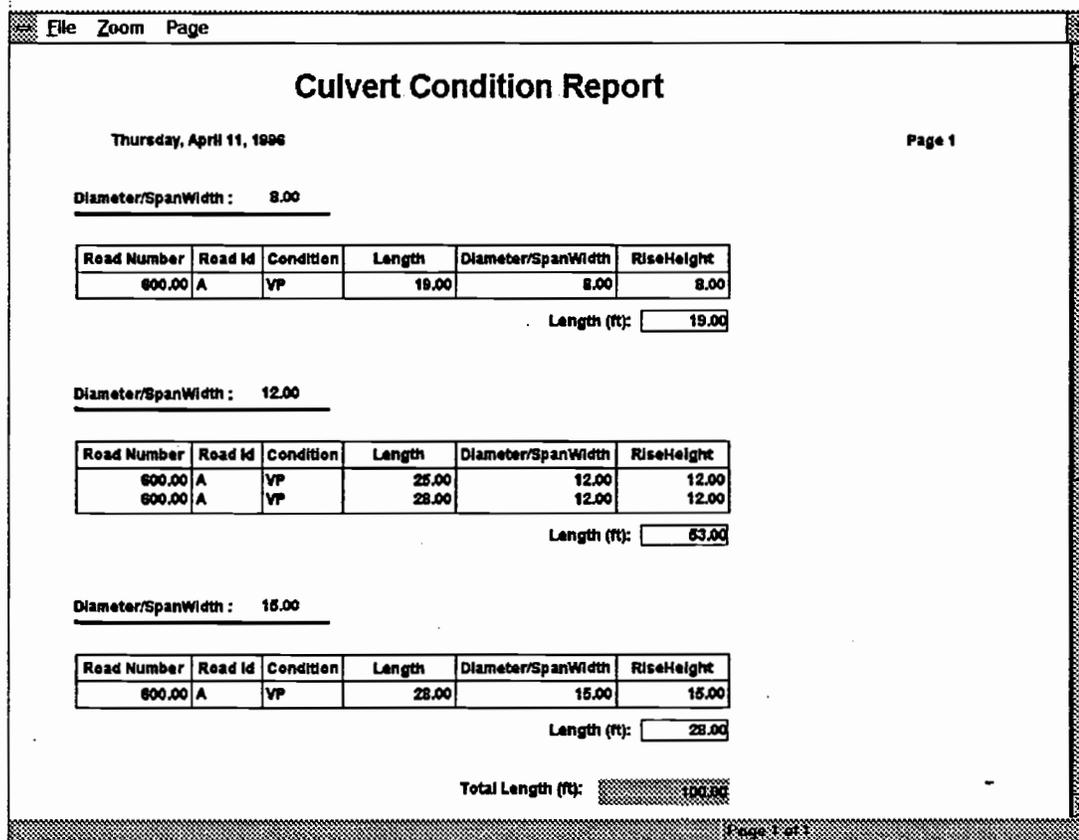


Figure 38. Culvert Condition Report.

The Turnouts Criteria report (Figure 39.), calculates the total area of a specified condition. This report is useful for managers to make decision about repairing turnouts since the total cost of repairs can be estimated from the total area.

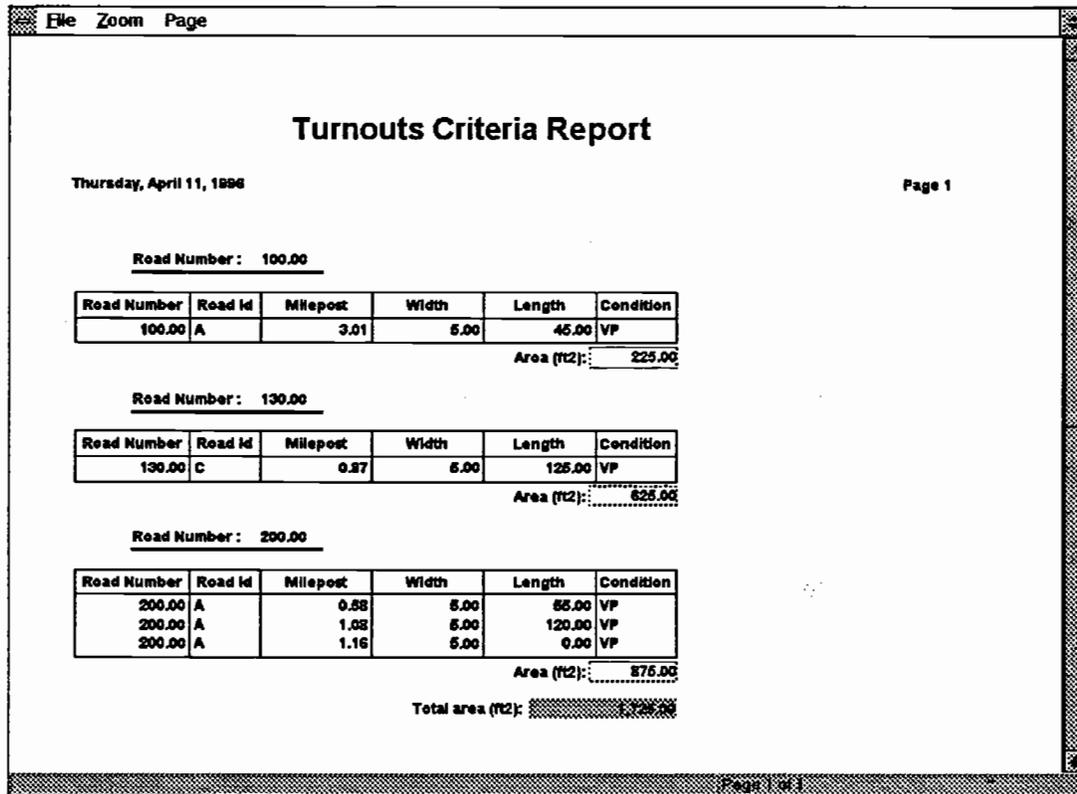


Figure 39. Turnout Criteria Report.

4.7 Files

At the FORIN Main menu, from either the pull-down menu at the top, or the push button menu's Transfer Data option, the following menu which is shown in Figure 40 is displayed.

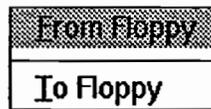


Figure 40. Transfer Data Menu.

Once the user makes the selection "From Floppy", a dialog box which is shown in Figure 41., would appear on the screen.

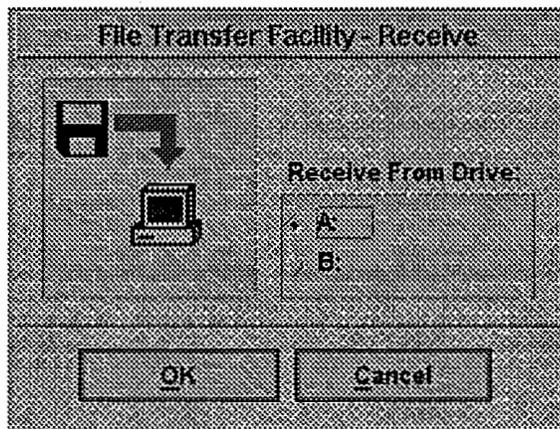


Figure 41. Dialog Box for Transferring Data from Floppy to the Computer.

The target drive and the destination should be specified by a user, and a diskette should be inserted before pressing the "OK" button. The saved file's name is A:\FORIN or

B:\FORIN, which will be received from the target drive as a compressed file. The file is automatically compressed by the PKZIP command in FORIN, and the PKUNZIP command automatically uncompresses the file.

When the user selects the “To Floppy” choice, the dialog box which is shown in Figure 42., is displayed:

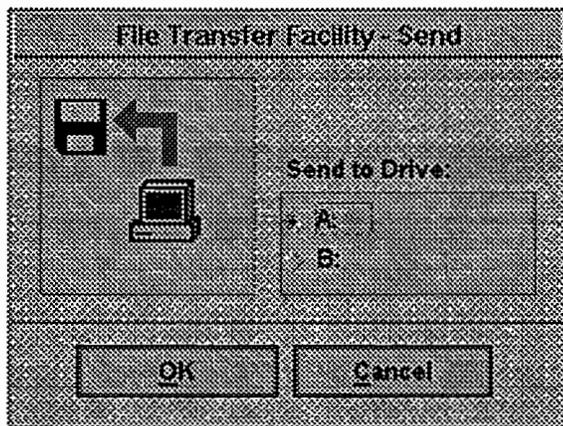


Figure 42. Dialog Box for Transferring Data from the Computer to Floppy

The user should specify the target drive and the destination, and a diskette should be inserted before pressing the “OK” button. A file with name A:\FORIN or B:\FORIN, will be created and sent to the target drive. The sent file will be compressed automatically by DOS’s PKZIP command and saved on a floppy disc.

After the file is sent or received, another dialog box appears, showing a message that the file transfer is complete.

4.8 Help menu

The Help menu provides two options, which are shown below in Figure 43.:



Figure 43. Help Menu Option.

Selecting “Contents” from the Help menu displays the form shown in Figure 44.. This form contains a single field object, a push-button object, and multiple text objects. The single field object consists of radio buttons. By clicking on a given choice of the radio button set, a corresponding text object is selected. For example, there are seven radio buttons, and there are seven associated text objects.

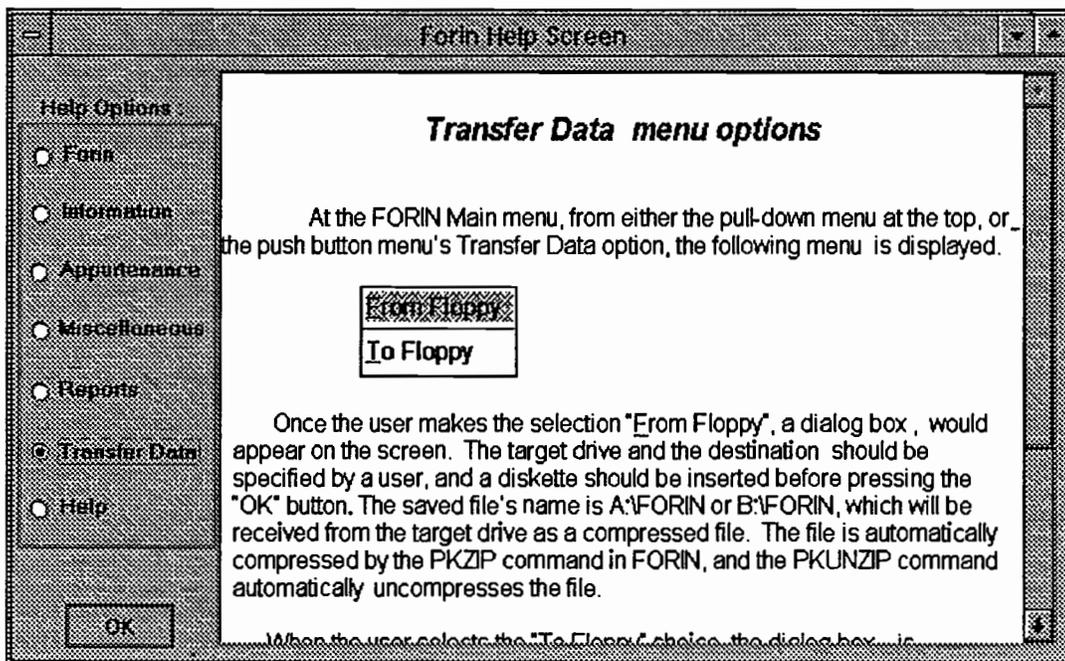


Figure 44. FORIN's Help Screen.

Initially when the form is opened, the “Forin” text object will be displayed. As the current radio button is changed, a corresponding text will follow. The push button with the “OK” label is used to close the Help menu.

The selection “About” in the Help menu displays information about the designer of the application. Figure 45. shown below, displays the box which appears by choosing “About” from the Help menu.

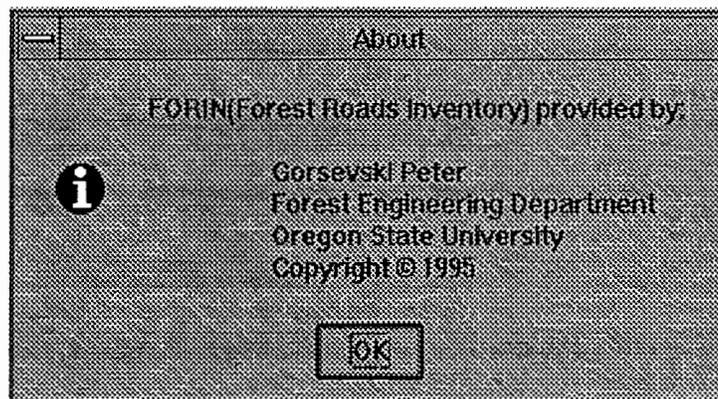


Figure 45. Information Dialog Box.

A Help menu also is available within the forms. By clicking the “Help” push button, or pressing Ctrl-H, a Help menu will be displayed. The Help menu is a form that is similar to the form shown above in Figure 44, and contains information about the form which is displayed on the screen. All forms in **FORIN** have help menus.

Information about individual fields is provided in the Lookup Help Table during an edit session, which is accessible by pressing the Ctrl-Space keys. The Lookup Table is shown below in Figure 46.

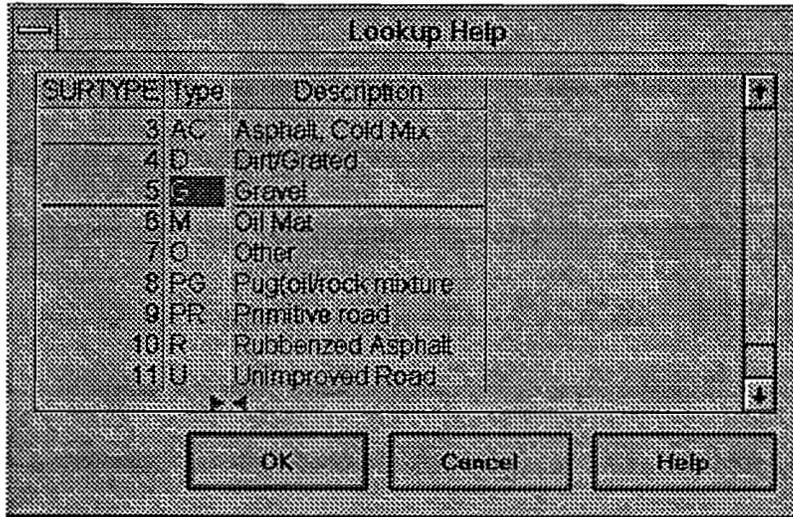


Figure 46. Lookup Table.

4.9 Exit FORIN

To exit the application, the user simply clicks the "Exit" push button, which is also available from the File pull-down menu at the top of the application.

5 FIELD RESULTS

The time for inputting data into the forms was compared between **FORIN** and **IRIS**. The Test Location, Data Collection, Results, Summary of the Results are discussed below.

5.1 Test Location

McDonald Forest, a school forest, was the location where the test was performed. This area was selected since data collected using **IRIS** was available from the last two years. The existing data was gathered previously by group of OSU students who used **IRIS**.

Also, specific roads were chosen for the test based upon various criteria. The roads featured all of the following attributes: culverts, turnouts, and cross sections.

5.2 Data Collection

The existing data was used to compare the two systems. New data was not collected, because the time needed for taking initial measurements was irrelevant. Certain data from last year's collection was selected to represent a variety of different numbers and letters to test and compare between the systems. It was necessary to test the range of numbers and letters to contrast the character interpretation of both pen-based computers.

The total time for filling one form was measured for both programs. The total time is the time used for completely filling in the fields in the form for a particular road and

milepost. Forms for recording data with corresponding attributes with the same fields were compared. Certain forms in IRIS consist of different fields for the same attributes as those in FORIN; for such forms, only the corresponding data fields were chosen to be compared.

An OSU student performed the data entry in the forms of both FORIN and IRIS. The existing data was read to the student tester, and the total time for inputting the data into the forms was measured. The accuracy of the data collection may have been altered because the student had previous experience with IRIS, thus making her data input faster than that of an inexperienced user.

The collected data shown in Table 4. , and plotted in Figure 47 indicate the learning curve of FORIN at the beginning of the test, and the difference in the time for inputting the data into both systems. The forms used for collecting data as shown in Table 4. were forms for Culvert Information. Figure 48 presents the exponential fit of the data which is shown in Figure 47 with a curve to show the difference from the beginning of the test.

By interpreting the graph in Figure 47., it is apparent that FORIN required more time for data entry at the beginning of the test, in comparison with IRIS. As mentioned above, the student tester had worked with IRIS previously, and thus the time she used for inputting data into IRIS was more efficient.

Also, the pen software used for FORIN is “trainable”, and the software had not been trained by the person who performed the test. By training the software, certainly the time required for collecting the data can be reduced.

The second graph, in Figure 48., displays how the difference in time used for inputting data in the forms diminishes over time and usage between the two programs. It is also clear from both systems that more time was used for inputting the data at the beginning of the test than at the end of the test. The performance of data collection improved with time because the tester became familiar with the system. So, the expectation is not that the two curves will still decrease, but that it will flatten and the difference between the two systems will be small and ultimately in favor of FORIN.

The purpose of this type of data collection was to pair the data and to ensure that each subject in one sample matched with one observation in the other sample. Of the available pairs of forms, a form was randomly assigned for different attributes. For example, a culvert form from FORIN was assigned first for inputting data when comparing culverts, and a turnout form was assigned first with IRIS for inputting data, when comparing turnouts.

Milepost (mil.)	FORIN (minutes)	IRIS (minutes)
0.08	8.30	3.42
0.15	4.47	3.32
0.23	3.19	2.23
0.28	3.52	3.10
0.32	4.30	2.27
0.44	4.11	2.37
0.56	3.50	2.20
0.63	2.13	2.38
0.67	3.34	2.07
0.77	3.56	2.01
0.83	2.07	2.59
0.88	2.31	2.38
0.96	3.14	2.42
1.02	2.18	1.59
1.15	1.54	2.10
1.25	3.29	2.59
1.30	2.48	2.11
1.39	1.56	2.40
1.45	3.12	2.43
1.49	2.01	2.10
1.59	3.04	2.30
1.65	2.42	2.15
1.69	2.50	3.10
1.74	2.10	2.28
1.81	1.50	2.10

Table 4. Time Required for Inputting Data in the Forms at the Beginning of the Test

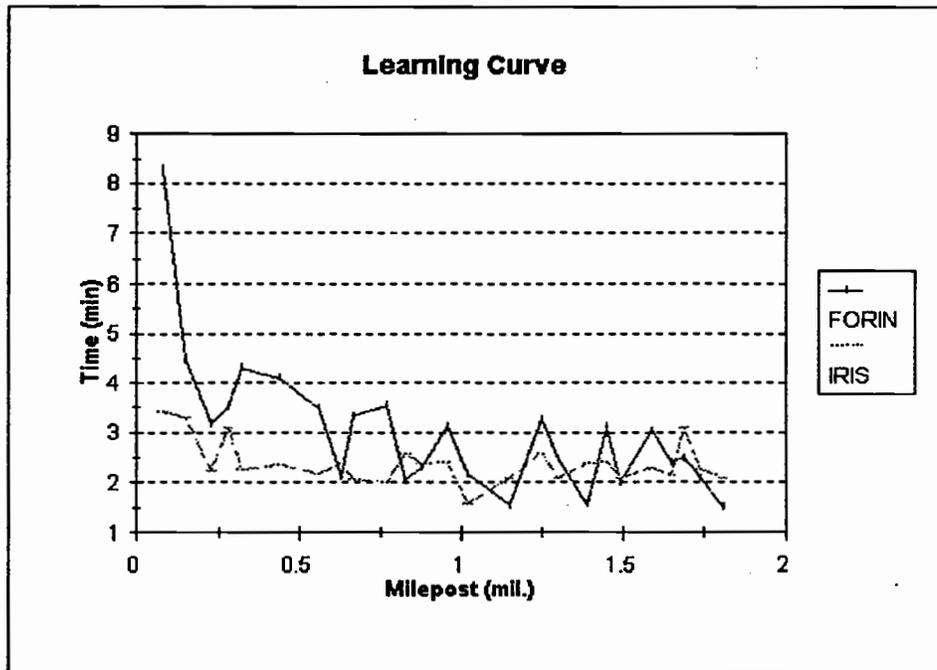


Figure 47. Learning Curve.

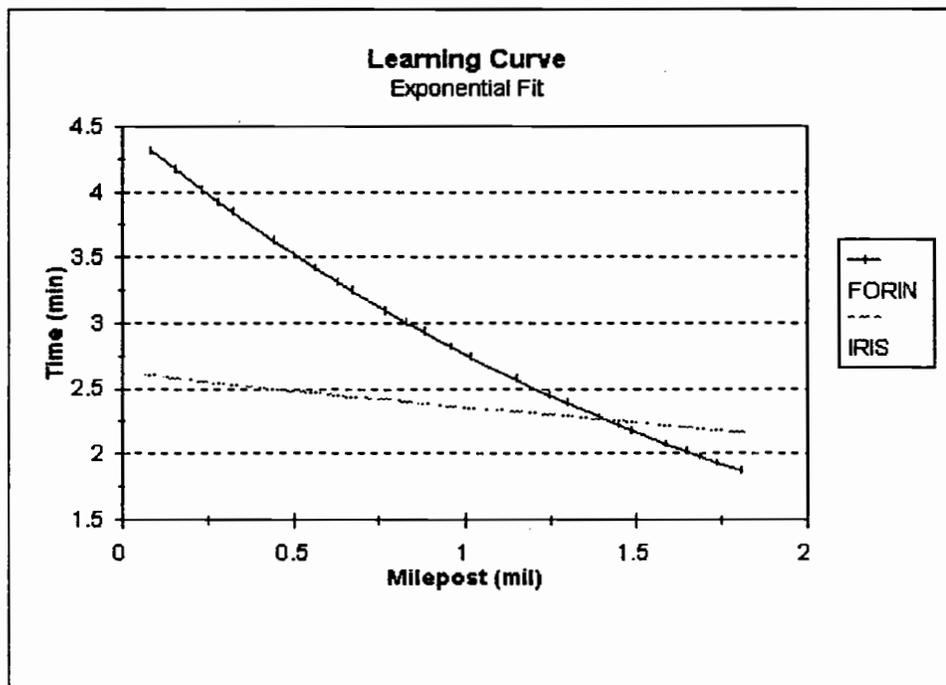


Figure 48. Exponential Fit of the Learning Curve.

5.3 Results

The hypothesis to be tested was that **FORIN** will be a faster program for inputting data for forest roads. For the comparison, a paired t-test and associated confidence interval was used to determine if there was a significant difference between **FORIN** and **IRIS**. The data for the paired-t test for the total time used for inputting the data in the forms is shown in Table 5.

Form	Milepost (mil.)	IRIS (minutes)	FORIN (minutes)	Difference
Culverts <i>Road Number</i> <i>600</i>	1.02	1.59	2.18	-0.59
	1.15	2.1	1.54	0.56
	1.25	2.59	3.29	-0.7
	1.30	2.11	2.48	-0.37
	1.39	2.4	1.56	0.84
	1.45	2.43	3.12	-0.69
	1.49	2.1	2.01	0.09
	1.59	2.3	3.04	-0.74
	1.65	2.15	2.42	-0.27
	1.69	3.1	2.5	-0.6
	1.74	2.28	2.1	0.18
	1.81	2.1	1.5	0.6

Table 5. Paired T-Analyses for the Difference in Data Entry Time Between FORIN and IRIS

Form	Milepost (mil.)	IRIS (minutes)	FORIN (minutes)	Difference
Turnouts <i>Road Number 500</i>	0.17	0.35	0.30	0.05
	0.55	0.33	0.45	-0.12
	0.79	0.28	0.36	-0.08
	0.87	0.27	0.32	-0.05
	1.15	0.34	0.27	0.07
	1.36	0.29	0.33	-0.04
	1.40	0.26	0.27	-0.01
	1.64	0.27	0.25	0.02
	2.78	0.28	0.24	0.04
	3.07	0.35	0.26	0.09
	3.39	0.30	0.34	-0.04
	3.49	0.33	0.26	0.07
	3.59	0.28	0.23	0.05
	3.62	0.27	0.29	-0.02
	3.79	0.30	0.31	-0.01
	4.01	0.28	0.28	0
	4.10	0.24	0.22	0.02
	4.18	0.28	0.19	0.09
	4.33	0.21	0.17	0.04
	4.43	0.27	0.16	0.11
	4.48	0.22	0.19	0.03
	4.55	0.21	0.23	-0.02
	4.56	0.20	0.21	-0.01
4.71	0.24	0.18	0.06	
4.74	0.18	0.19	-0.01	
4.76	0.23	0.24	-0.01	
4.90	0.19	0.20	-0.01	

Table 5. Paired T-Analyses for the Difference in Data Entry Time Between FORIN and IRIS (Continued)

Form	Milepost (mil.)	IRIS (minutes)	FORIN (minutes)	Difference
Cross Sections <i>Road Number</i> 600	0.16	0.31	0.48	-0.17
	0.44	0.57	0.42	0.15
	0.53	0.42	0.38	0.04
	1.66	0.34	0.37	-0.03
	3.16	0.33	0.54	-0.21
	4.40	0.30	0.34	-0.04
	4.49	0.31	0.39	-0.08
	4.54	0.29	0.30	-0.01
	5.19	0.36	0.37	-0.01
5.22	1.12	0.45	0.67	

Table 5. Paired T-Analyses for the Difference in Data Entry Time Between FORIN and IRIS (Continued)

The summary of the statistics for the difference between the two programs is:

Average: 0.002653

Sample Standard Deviation: 0.305694

Standard Error of the Average: 0.043671

Test for Difference:

$$t\text{-statistic} = \frac{\text{Average} - \text{Hypothesized mean difference}}{\text{Standard e of the Average}}$$

or

$$t\text{-statistics} = \frac{0.002653 - 0.0}{0.043671} = 0.060752$$

The data from Table 5 is shown in Figure 49. and Figure 50.

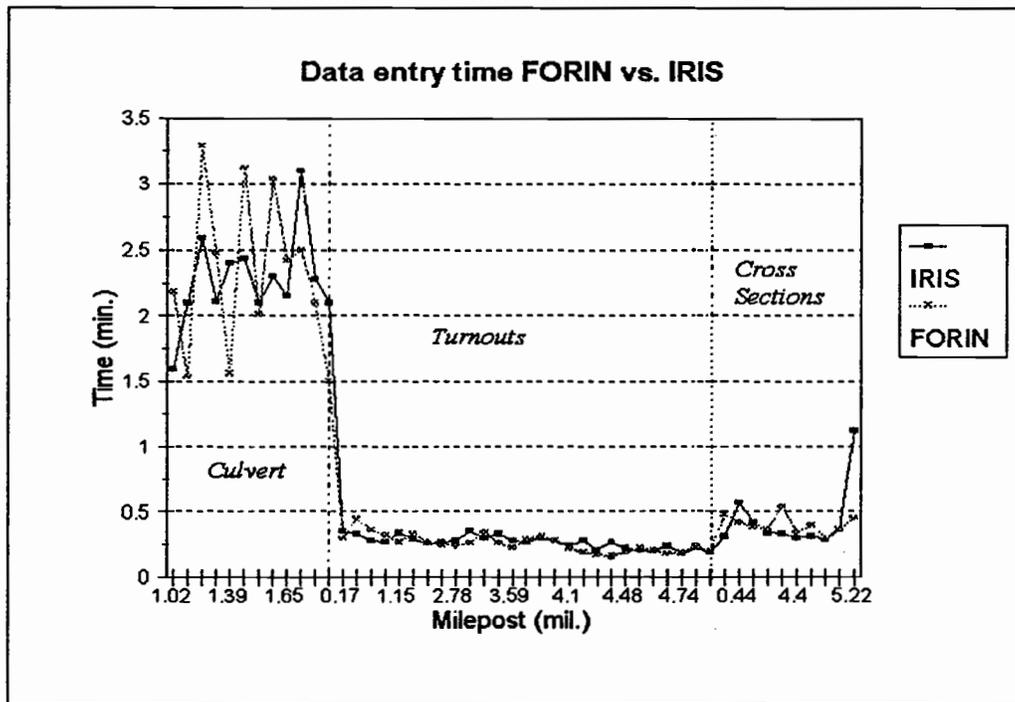


Figure 49. Difference in Data Entry Time.

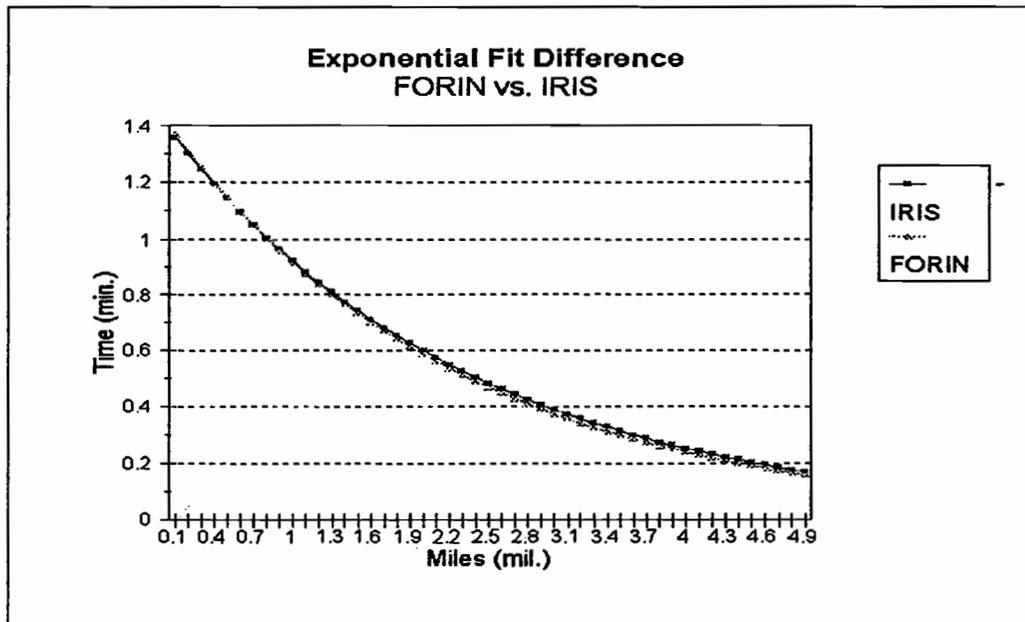


Figure 50. Exponential Fit Difference in Data Entry.

5.4 Summary of the Results

The results from this study indicate that there is not difference in data-entry time between both programs. The t-statistic was equal to 0.060752, which indicates that the difference is negligible. Figure 49. shows the data-entry time for three different forms used for the test. The dashed vertical lines in the graph separate the forms used for data entry. The Culvert form consists of more fields for inputting the data, and as it is apparent from the graph, there is more variation between the programs in the time for inputting the data in those forms. The Turnout form was relatively short and the difference between the programs was insignificant. The Cross Sections form contained more fields than the turnout form, and there is also little variation in time for data entry, thus the difference is still insignificant.

The best comparison picture to prove that these two programs are not different for pen computer data inputting is shown in Figure 50. The graph shows the exponential fit difference between the programs, and it is apparent that the curves for data entry are identical.

However the test that was performed was conducted only in entering data in the forms. Entering data in the forms is just one feature for the effectiveness of the program, and does not indicate the effectiveness of the program as a whole. Also, there are other features for which the program can be measured.

The time used for interpreting the output can also be a measurable feature for comparing the two programs. The interpretation of the output can be measured by

conducting a survey. Output interpretation was not, however, within the scope of the research objectives of this thesis.

The output from IRIS is not possible to be viewed from the field, whereas the output of FORIN can be viewed and printed with a portable printer in the field. Records grouped by certain road attributes, or by conditions of the attributes, makes for an easy search for the desired information.

FORIN also offers queries for searching for particular conditions of attributes, and calculates the area, or length of those attributes. For example, very poor conditions of road segments can be searched, and the results will be reported yielding area calculated to be replaced. This feature makes it a much faster and more efficient system.

Improvements of FORIN can be made in future, based upon different opinions, and improving technology.

6 CONCLUSION

6.1 Summary

Since the use of personal computers has become a necessity of the workplace, being without a computer means being inefficient. By developing the idea for **FORIN** (*Forest Roads Inventory*), a computerized system for the inventory of forest roads, field managers will obtain many benefits. Using information and communication technology with a pen-based computer can improve productivity, accuracy of inventories, lower the cost, and provide an efficient management tool for forest roads inventory.

Using a pen-based computer gives the work force more flexibility than using either paper forms or the bulky and less manageable keyboard type of PC. The pen computer is relatively light and can be held in one hand while the other hand does the writing or data access and entry. The precision of gathering data will be higher than the paper forms method, and the access to information is very quick and easy. Developing a database computer system for forestry purposes is significant, because forest roads need constant maintenance, and routine inventory-taking comprises a significant portion of field work.

The benefits of **FORIN** are threefold. **FORIN** will enable the field user to cut down on the time used for recording inventory data; **FORIN** will provide a clear, standardized set of industry definitions and measurements; **FORIN** will lower the cost of data management. **FORIN**'s pen-based applications will improve the ease and accuracy of recording and updating inventory data. **FORIN** simply applies this useful technology, which is already being used in diverse disciplines, to the field of forest engineering.

6.2 Recommendations for Further Research

There is a great demand and need for using data based programs in the field of forestry. At present, there are many different database programming languages which accommodate the creation of programs for various applications. In the field of forestry, these programs can be created for different purposes. For example, in the field of hydrology such programs can be designed for measuring the water velocity, wind, precipitation; in dendrometry, for finding the volume of wood in the classes, the average height of the trees, and so on.

These programs allow the user to establish a link with other programs. By adding the coordinates x, y, and z in each table, information can be obtained from GPS (Global Positioning System) and used in GIS (Geographic Information System). In brief, these programs will enable foresters to obtain a whole picture of the condition of the forest through this advanced methods of taking inventory.

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APPENDICES

APPENDIX A

Rating Guidelines - Culverts

The acronyms and abbreviated term designations, in this sections provide the explanations for rating guidelines for culverts. The definitions for rating of various types of culverts are adapted from IRIS (13).

Round or Vertical Elongated Corrugated Metal Pipe Barrels

VG Shape: good, smooth curvature in barrel.

Horizontal: within 10 percent of design.

Seams and Joints: tight, no openings.

Metal:

Aluminum: superficial corrosion, slight pitting.

Steel: superficial rust, no pitting.

G Shape: generally good, top half of pipe smooth but minor flattening of bottom.

Horizontal Diameter: within 10 percent of design.

Seams or Joints: minor cracking at a few bolt holes, minor joint or seam openings, potential for backfill infiltration.

Metal:

Aluminum: moderate corrosion, no attack of core alloy.

Steel: moderate rust, slight pitting.

F Shape: fair, top half has smooth curvature but bottom half has flattened significantly.

Horizontal Diameter: within 10 percent of design.

Seams or Joints: minor cracking at bolts is prevalent in one seam in lower half of pipe. Evidence of backfill infiltration through seams or joints.

Metal:

Aluminum: significant corrosion, minor attack of core alloy.

Steel: fairly heavy rust, moderate pitting.

P Shape: marginal significant distortion throughout length of pipe, lower third may be kinked.

Horizontal Diameter: 10 percent to 15 percent greater than design.

Seams or Joints: Moderate cracking at bolt holes on one seam near top of pipe, deflection caused by loss of backfill through open joints.

Metal:

Aluminum: extensive corrosion, significant attack of core alloy.

Steel: extensive heavy rust, deep pitting.

VP Shape: critical, extreme distortion and deflection throughout pipe, flattening of crown, crown radius over 30 feet.

Horizontal Diameter: More than 20 percent greater than design.

Seams: plate cracked from bolt to bolt on one seam.

Metal:**Aluminum:** extensive perforations due to corrosion.**Steel:** extensive perforations due to rust.

Note: As a starting point, select the lowest rating which matches actual conditions.

Corrugated Metal Pipe-Arch Barrels

The rating designations that are listed below apply to corrugated metal pipe-arch barrels.

VG **Shape:** good with smooth curvature.

Horizontal Span: less than 3 percent greater than design.**Joints or Seams:** good condition.**Metal:** minor construction defects, protective coatings intact.**Aluminum:** superficial corrosion, slight pitting.**Steel:** superficial rust, no pitting.

G **Shape:** generally good, smooth curvature in top half, bottom flattened but still curved.

Horizontal Span: within 3 to 5 percent greater than design.**Joints or Seams:** minor cracking at a few bolt holes; minor joint or seam openings, infiltration of backfill possible.**Metal:** protective coating ineffective.**Aluminum:** moderate corrosion, no attack of core alloy.

Steel: moderate rust, slight pitting.

F Shape: fair, smooth curvature in top half, bottom flat.

Horizontal Span: within 5 to 7 percent greater than design.

Joints or Seams: minor cracking all along one seam; minor joint openings with evidence of infiltration.

Metal:

Aluminum: significant corrosion, minor attack of core alloy.

Steel: fairly heavy rust, moderate pitting.

P Shape: marginal, significant distortion all along top of arch, bottom has reverse curve.

Horizontal Span: more than 7 percent greater than design.

Joints and Seams: moderate cracking all along one seam; backfill infiltration causing major deflection.

Metal:

Aluminum: extensive corrosion, significant attack of core alloy.

Steel: extensive heavy rust, deep pitting.

VP Shape: critical, extreme deflection along top of pipe.

Horizontal Span: more than 7 percent greater than design.

Seams: seam cracked from bolt to bolt down one seam.

Metal:

Aluminum: extensive perforations due to corrosion.

Steel: extensive perforations due to rust.

Note: As a starting point, select the lowest rating which matches actual conditions.

Structural Plate Arch Barrel

The rating designations that are listed below apply to structural plate arch barrel

VG **Shape:** good, smooth symmetrical curvature.

Rise: within ± 3 percent of design.

Seams: properly made and tight.

Metal: minor defects and damage due to contraction.

Aluminum: superficial corrosion, slight pitting.

Steel: superficial rust, no pitting.

Footings: good with no erosion.

G **Shape:** generally good with smooth curvature, symmetrical; slight flattening of top or sides in one section.

Rise: within 3 or 4 percent of design.

Seams: minor cracking at a few bolt holes, minor seam opening, possibility of soil infiltration.

Metal:

Aluminum: moderate corrosion, no attack of core alloy.

Steel: moderate rust, slight pitting.

Footings: moderate erosion causing differential settlement and minor cracking in footing.

F Shape: fair, smooth curvature but non-symmetrical; slight flattening of top and sides throughout.

Rise: within 4 to 7 percent of design.

Seams: minor cracking of bolt holes along one or more seams; evidence of backfill infiltration.

Metal:

Aluminum: significant corrosion, minor attack of core alloy.

Steel: fairly heavy rust, moderate pitting.

Footings: moderate cracking and differential settlement of footing due to extensive erosion.

P Shape: marginal, significant distortion and deflection throughout; sides flattened with radius 100 percent greater than design.

Rise: within 7 to 10 percent of design.

Seams: major cracking of seam near crown; infiltration of soil causing major deflection.

Metal:

Aluminum: extensive corrosion, significant attack of core alloy.

Steel: extensive heavy rust, deep pitting.

Footings: rotated due to erosion and undercutting; settlement has caused damage to metal arch.

VP Shape: critical, extreme deflection, throughout; sides flattened; extremely non-symmetrical.

Rise: greater than 10 percent of design seams: cracked from bolt to bolt; significant amounts of backfill infiltration.

Metal:

Aluminum: extensive perforations due to corrosion.

Steel: extensive perforations due to rust.

Footings: severe differential settlement has caused distortion and kinking of metal arch.

Note: As a starting point, select the lowest rating which matches actual conditions.

Low Profile Arch Long-Span Culvert Barrel

The rating designation that are listed below apply to low profile arch long-span culvert barrels.

VG Shape: good appearance, smooth symmetrical curvature.

Top Arc Mid-Ordinate: within 11 percent of design.

Horizontal Span: within 5 percent of design.

Seams: properly made and tight.

Metal: minor defects and damage due to construction.

Aluminum: superficial corrosion, slight pitting.

Steel: superficial rust, no pitting.

Footings: good with no erosion.

G Shape: generally good; curvature is smooth and symmetrical.

Top Arc Mid-Ordinate: within 11 percent to 15 percent of design.

Horizontal Span: within 5 percent of design.

Seams: minor cracking at a few bolt holes, minor seam openings, possibility of backfill infiltration exists.

Metal:

Aluminum: moderate corrosion, no attack of core alloy.

Steel: moderate rust, slight pitting.

Footings: minor differential settlement due to erosion; minor hairline cracking in footing.

F Shape: smooth curvature, shape is non-symmetrical.

Top Arc Mid-Ordinate: within 15 percent of design.

Horizontal Span: more than ± 5 percent of design.

Seams: minor cracking at bolt holes along one seam; evidence of backfill infiltration.

Metal:

Aluminum: significant corrosion, minor attack of core alloy.

Steel: fairly heavy rust, moderate pitting.

Footings: differential settlement due to extensive erosion; moderate cracking of footing.

P Shape: marginal, significant distortion and deflection throughout; mid-ordinate of half top arc less than 50 percent of design.

Top Arc Mid-Ordinate: within 15 to 20 percent of design.

Horizontal Span: more than ± 5 percent of design.

Seams: significant seam cracking all along seam; infiltration of soil causing major deflection.

Metal:

Aluminum: extensive corrosion, significant attack of core alloy.

Steel: extensive heavy rust, deep pitting.

Footings: rotate due to erosion and undercutting; settlement has caused damage to metal arch.

VP Shape: critical, extreme distortion and deflection throughout; mid-ordinate of half top arc more than 70 percent less than design.

Top Arc Mid-Ordinate: more than 30 percent less than design.

Horizontal Span: more than ± 8 percent of design.

Seams: cracked from bolt to bolt; significant amounts of backfill infiltration throughout.

Metal:

Aluminum: extensive perforations due to corrosion.

Steel: extensive perforations due to rust.

Footings: severe differential settlement has caused distortion and kinking of metal arch.

Note: As a starting point, select the lowest rating which matches actual conditions.

High Profile Arch Long-Span Culvert Barrel

The rating designations that are listed below apply to high profile arch long-span culvert barrels.

VG Shape: good appearance, smooth symmetrical curvature.

Top Arc Mid-Ordinate: within 11 percent of design.

Horizontal Span: within 5 percent of design.

Side Plates: smooth curvature.

Seams: properly made and tight.

Metal: minor defects and damage due to construction.

Aluminum: superficial corrosion, slight pitting.

Steel: superficial rust, no pitting.

Footings: good with no erosion.

G Shape: generally good; curvature is smooth and symmetrical.

Top Arc Mid-Ordinate: within 11 percent to 15 percent of design.

Horizontal Span: within 5 percent of design.

Side Plates: side flattened, mid-ordinate less than 50 percent of design.

Seams: minor cracking at a few bolt holes; minor seam openings, possibility of backfill infiltration exists.

Metal:

Aluminum: moderate corrosion, no attack of core alloy.

Steel: moderate rust, slight pitting.

Footings: minor differential settlement due to erosion; minor hairline cracking in footing.

F Shape: smooth curvature, shape is non-symmetrical.

Top Arc Mid-Ordinate: within 15 percent of design.

Horizontal Span: more than ± 5 percent of design.

Side Plates: side flattened, mid-ordinate less than 35 percent of design.

Seams: minor cracking at bolt holes along one seam; evidence of backfill infiltration.

Metal:

Aluminum: significant corrosion, minor attack of core alloy.

Steel: fairly heavy rust, moderate pitting.

Footings: differential settlement due to extensive erosion; moderate cracking of footing.

P Shape: marginal, significant distortion and deflection throughout; mid-ordinate of half top arc less than 50 percent of design.

Top Arc Mid-Ordinate: within 15 to 30 percent of design.

Horizontal Span: more than ± 5 percent of design.

Side Plates: side flattened, mid-ordinate less than 20 percent of design.

Seams: significant seam cracking all along seam; infiltration of soil causing major deflection.

Metal:

Aluminum: extensive corrosion, significant attack of core alloy.

Steel: extensive heavy rust, deep pitting.

Footings: rotated due to erosion and undercutting; settlement has caused damage to metal arch.

VP Shape: critical, extreme distortion and deflection throughout; mid-ordinate of half top arc more than 70 percent less than design.

Top Arc Mid-Ordinate: more than 30 percent less than design.

Horizontal Span: more than ± 8 percent of design.

Side Plates: side flattened, mid-ordinate less than 10 percent of design.

Seams: cracked from bolt to bolt; significant amounts of backfill infiltration throughout.

Metal:

Aluminum: extensive perforations due to corrosion.

Steel: extensive perforations due to rust.

Footings: severe differential settlement has caused distortion and kinking of metal arch.

Note: As a starting point, select the lowest rating which matches actual conditions.

Horizontal Ellipse Long Span Culvert Barrel

The rating designations that are listed below apply to horizontal ellipse long span culvert barrels.

VG Shape: good appearance, smooth symmetrical curvature.

Top Arc Mid-Ordinate: within 11 percent of design.

Horizontal Span: within 5 percent of design.

Bottom Arc: smooth curvature, mid-ordinate within 50 percent of design.

Seams: tight and properly made.

Metal: minor defects and damage due to construction.

Aluminum: superficial corrosion, slight pitting.

Steel: superficial rust, no pitting.

Footings: good with no erosion.

G Shape: generally good; curvature is smooth and symmetrical.

Top Arc Mid-Ordinate: within 11 percent to 15 percent of design.

Horizontal Span: within 5 percent of design.

Bottom Arc: bottom flattened, mid-ordinate less than 50 percent of design.

Seams: minor cracking at a few bolt holes; minor seam openings, possibility of backfill infiltration exists.

Metal:

Aluminum: moderate corrosion, no attack of core alloy.

Steel: moderate rust, slight pitting.

Footings: minor differential settlement due to erosion; minor hairline cracking in footing.

F Shape: smooth curvature, shape is non-symmetrical.

Top Arc Mid-Ordinate: within 15 percent of design.

Horizontal Span: more than ± 5 percent of design.

Bottom Arc: bottom flattened and irregular, mid-ordinate less than 50 percent of design.

Seams: minor cracking at bolt holes along one seam; evidence of backfill infiltration.

Metal:

Aluminum: significant corrosion, minor attack of core alloy.

Steel: fairly heavy rust, moderate pitting.

Footings: differential settlement due to extensive erosion, moderate cracking of footing.

P Shape: marginal, significant distortion and deflection throughout; mid-ordinate of

half top arc less than 50 percent of design.

Top Arc Mid-Ordinate: within 15 to 20 percent of design.

Horizontal Span: more than ± 5 percent of design.

Bottom Arc: bottom virtually flat over center half of arc and deflected down at corners.

Seams: significant seam cracking all along seam; infiltration of soil causing major deflection.

Metal:

Aluminum: extensive corrosion, significant attack of alloy.

Steel: extensive heavy rust, deep pitting.

Footings: rotated due to erosion and undercutting; settlement has caused damage to metal arch.

VP Shape: critical, extreme distortion and deflection throughout; mid-ordinate of half top arc more than 70 percent less than design.

Top Arc Mid-Ordinate: more than 30 percent less than design.

Horizontal Span: more than ± 8 percent of design.

Bottom Arc: bottom reverse curved in center and bulged out at sides.

Seams: cracked from bolt to bolt; significant amounts of backfill infiltration throughout.

Metal:

Aluminum: extensive perforations due to corrosion.

Steel: extensive perforations due to rust.

Footings: severe differential settlement has cause distortion and kinking of metal arch.

Note: As a starting point, select the lowest rating which matches actual conditions.

Precast Concrete Pipe Culvert Barrels

The rating designations listed below apply to precast concrete pipe culvert barrels.

VG Alignment: good, no settlement or misalignment.

Joints: tight with no defects apparent.

Concrete: no cracking, spalling or scaling present; surface in good condition.

G Alignment: generally good, minor misalignment at joints; no settlement.

Joints: minor openings, possible infiltration/exfiltration.

Concrete: minor hairline cracking at isolated locations; slight spalling or scaling present on invert.

F Alignment: fair, minor misalignments and settlement at isolated locations.

Joints: minor backfill infiltration due to slight opening at joints; minor cracking or spalling at joints allowing exfiltration.

Concrete: extensive hairline cracks, some with minor delaminations or spalling; invert scaling less than 0.25 in. deep or small spalls present.

- P** Alignment: marginal; significant settlement and misalignment of pipe; evidence of piping; end sections dislocated about to drop off.
- Joints: differential movement and separation of joints; significant infiltration or exfiltration at joints.
- Concrete: cracks open more than 0.12 in. with efflorescence and spalling at numerous locations; spalls have exposed rebars which are heavily corroded; extensive surface scaling on invert greater than 0.5 in.
-
- VP** Alignment: critical; culvert not functioning due to alignment problems throughout.
- Concrete: severe slabbing has occurred in culvert wall, invert concrete completely deteriorated in isolated locations .

Note: As a starting point, select the lowest rating which matches actual conditions.

Cast-in-Place Concrete Culvert Barrels

The rating designations that are listed below apply to cast-in-place concrete culvert barrels.

- VG** Alignment: good, no settlement or misalignment.
- Joints: tight with no defects apparent.
- Concrete: no cracking, spalling, or scaling present; surface in good condition.
- Footings: good with no invert scour.

0.5 in.

Footings: scour along footing with slight undermining, protection required.

VP **Alignment:** critical; culvert not functioning due to severe misalignment.

Concrete: severe cracks with significant differential movement; concrete completely deteriorated in isolated locations in top slab or invert.

Footings: severe undermining with significant differential settlement causing severe cracks.

Note: As a starting point, select the lowest rating which matches actual conditions.

Masonry Culvert Barrels

The rating designations that are listed below apply to masonry culvert barrels.

VG **Alignment:** good, no settlement or misalignment.

Mortar: tight with no defects apparent.

Masonry: no cracking, no missing dislocated masonry present; surface in good condition.

Footings: good with no invert scour.

G **Alignment:** generally good; minor misalignment at joints; no settlement.

Mortar: shallow mortar deterioration at isolated locations.

Masonry: surface deterioration at isolated locations.

Footings: good with only minor invert scour.

F	<u>Alignment:</u>	fair, minor misalignment or settlement.
	<u>Mortar:</u>	extensive areas of shallow deterioration; missing mortar at isolated locations; possible infiltration or exfiltration; minor cracking.
	<u>Masonry:</u>	minor cracking of masonry units.
	<u>Footings:</u>	minor scour near footings.
P	<u>Alignment:</u>	marginal; significant settlement and misalignment.
	<u>Mortar:</u>	mortar severely deteriorated, significant loss of mortar, significant infiltration or exfiltration between masonry units.
	<u>Masonry:</u>	significant displacement of individual masonry units.
	<u>Footings:</u>	scour along footing with slight undermining, protection required.
VP	<u>Alignment:</u>	critical; culvert not functioning due to severe misalignment.
	<u>Masonry:</u>	individual masonry units in top of culvert missing, or crushed.
	<u>Footings:</u>	severe undermining with significant differential settlement causing severe cracks in footing and distress in walls.

Note: As a starting point, select the lowest rating which matches actual conditions.

APPENDIX B

Rating Method of Forest roads for Mountain Biking

The discussion below provides an explanation of the method of rating forest roads for mountain biking. The definitions for rating of various types of forest roads for mountain biking are adapted from Hutchinson, M.M. (12).

The **horizontal and vertical alignment** for each road needs to be classified in one of the following levels:

Alignment Element	Value
Sever Grades	0.6
Moderate Grades	0.0
Frequent Curves	0.3
Moderate Curves	0.1
Ditches - both sides	0.3
Super elevation	0.1

Table 6. Alignment Factor Values

The Alignment Factor (AF) is equal to the sum of all the conditions that are present. For example the alignment factor for moderately curved roads with ditches would be

$$AF = 0.1 + 0.3 = 0.4.$$

The **surface types** that have a positive effect on suitability are listed as negative values and surface types, and conditions that have a negative effect on the suitability are assigned positive values.

Surface Type / Condition	Value
Gravel / Cinders	0.55
Chip Seal	0.15
Natural Dirt	0.1
Paved	-0.1
Potholes	0.3
Wash boarding	0.6
Accum Pine Needles	0.1
Scattered Boulders	0.4
Severe Dips	0.1

Table 7. Surface Factor Values

The points for the surface condition and the alignment are determined by using the appropriate values from Table 1 and 2 and adjusting them by the following equations:

$$\text{Alignment points} = 2 * AF$$

$$\text{Surface points} = SF / 2$$

For **Average Daily Traffic (ADT)** the total number of points assigned is determine by multiplying the point factor for each variable by the coefficient in the equation. The ADT is shown in the following table:

Actual ADT	Points used
0 - 10	0
11 - 100	0.17
101 - 250	0.33
251 - 400	0.5
401 - 600	0.67
601 - 800	0.83
800 <	1.0

Table 8. ADT Point Factor

For example, a road that has an ADT of 50, has a point factor equal 0.17 and is assigned 1 point, since the coefficient in the formula is 6(ADT pt.factor). For two-lane roads, half the ADT is used to determine the points. For example, a two-lane road with an ADT of 500 would be assigned 2 points instead 4.

For **Speed and Lane Width** the following criterium is used:

Speed(veh)	Points	Lane Width	Points
0 - 15	0	14	0
16-26	0.33	13	0.33
26-35	0.5	12	0.67
36-45	0.67	≤11	1.0
46-55	0.83		
55<	1.0		

Table 9. Speed & Lane Width Point Factor.

Scenic Quality and Loop Potential Point Factors are represented in the following table:

Scen Qual.	Points	Loop Pont.	Points
Low/None	0	No	0
Moderate	0.5	Yes	1.0
High	1.0		

Table 10. Scenic Quality and Loop Potential Point Factors.

The following equation is used for scoring the suitability of forest roads as shared use facilities:

$$\text{Score} = 6(\text{ADT pt. factor}) + 1.5(\text{LW pt. factor}) + 2(\text{Align pt. factor}) + 3(\text{Speed pt. factor}) \\ 1(\text{Surface pt. factor}) - 2(\text{SQ pt. factor}) - 1.5(\text{LP pt. factor}) = 10.0 \text{ points}$$

The scores and rating is shown in the following table:

Score	Rating
≤ 0.5	Very Good
0.5- 1.5	Good
1.5 - 3.5	Fair
3.5 -7	Poor
$7 <$	Very Poor

Table 11. Scores and Rating of Road Suitability.

APPENDIX C

Rating Unsurfaced Roads

The rating for unsurfaced roads as discussed below was adapted from Eaton, R.A., S. Gerard and D.W. Cate. (10).

Step 1. First, calculate the density for each distress type, except dust. The following formula is used for calculating each distress:

$$\text{Density} = \frac{\text{Amount of Distress}}{\text{Area of Sample Unit}} \times 100\%$$

In this example, the density of each distress and severity level is based on a sample unit of 1800 square feet.

- For 100 linear feet of an improper cross section the density is :

$$\frac{100}{1800} * 100 = 5.6$$

- For 900 square feet of corrugations the density is:

$$\frac{900}{1800} * 100 = 50.0$$

- No density calculation is needed for dust.
- For 140 linear feet of lose aggregate, the density is:

$$\frac{140}{1800} * 100 = 7.8$$

Distress Type	Density	Severity	Deduct Value
Improper Cross Section (Linear feet)	5.6	L	13
Corrugations (square feet)	50	M	29
Dust	-	M	5
Loose Aggregate (linear feet)	7.8	M	17
Total Deduct Value = 64			
q = 4			
RATING = GOOD			
URCI = 59			

Table 12. URCI Calculation

Step 2. Second, the deducted value curves have to be used to find the deducted value for each distress type and severity level. The deducted value curves are shown in the following Figures.

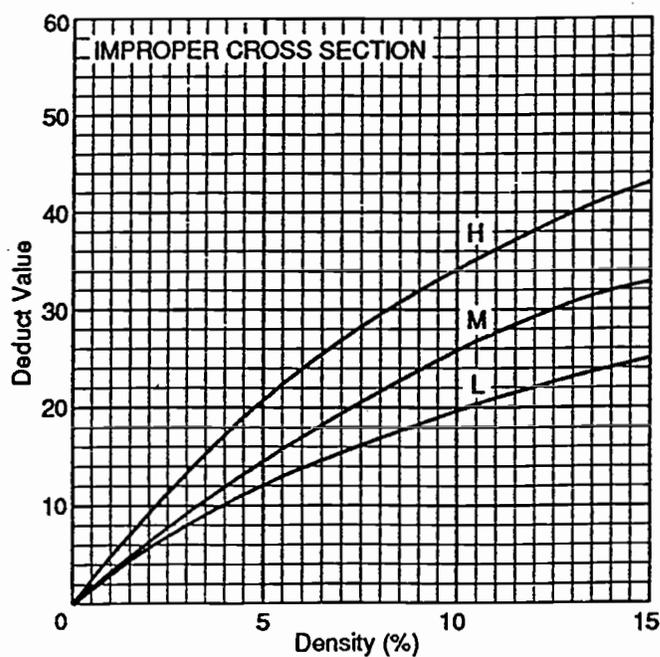


Figure 51. Improper Cross Section.

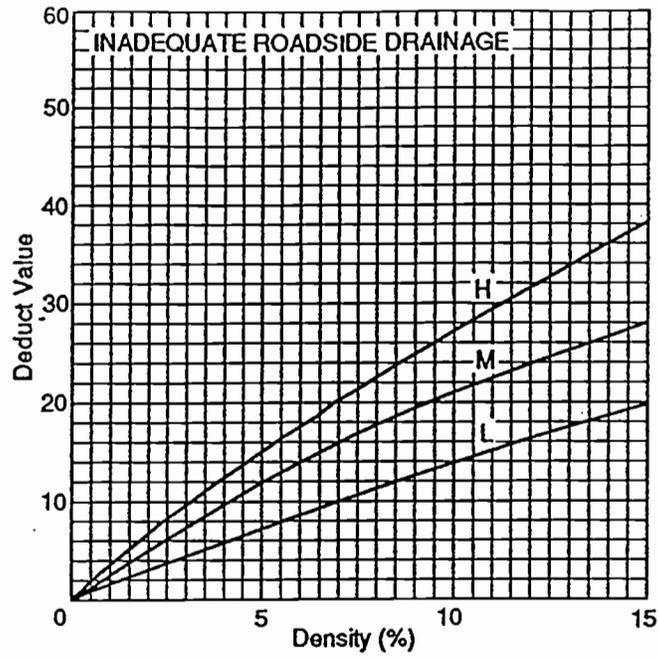


Figure 52. Inadequate Roadside Drainage.

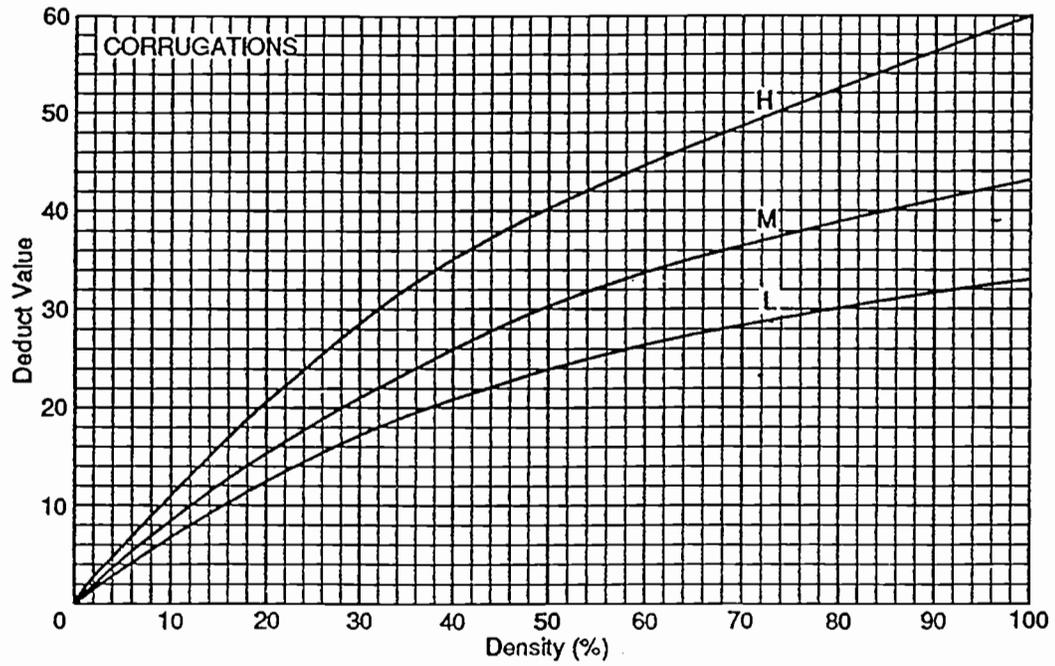


Figure 53. Corrugations.

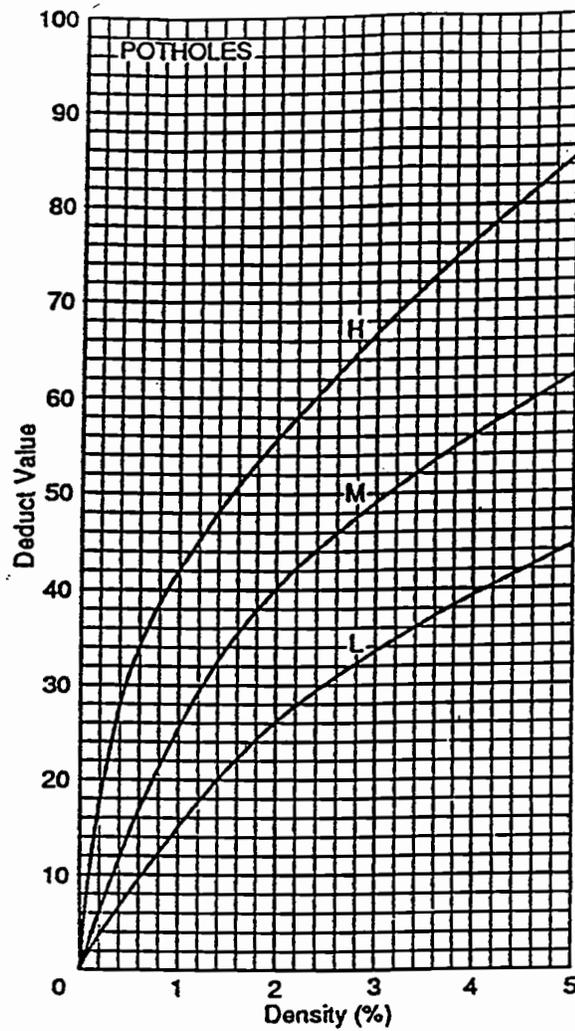


Figure 54. Potholes.

DUST	
Dust is not rated by density. The deduct values for the levels of severity are:	
LOW	2 points
MEDIUM	5 points
HIGH	15 points

Figure 55. Dust.

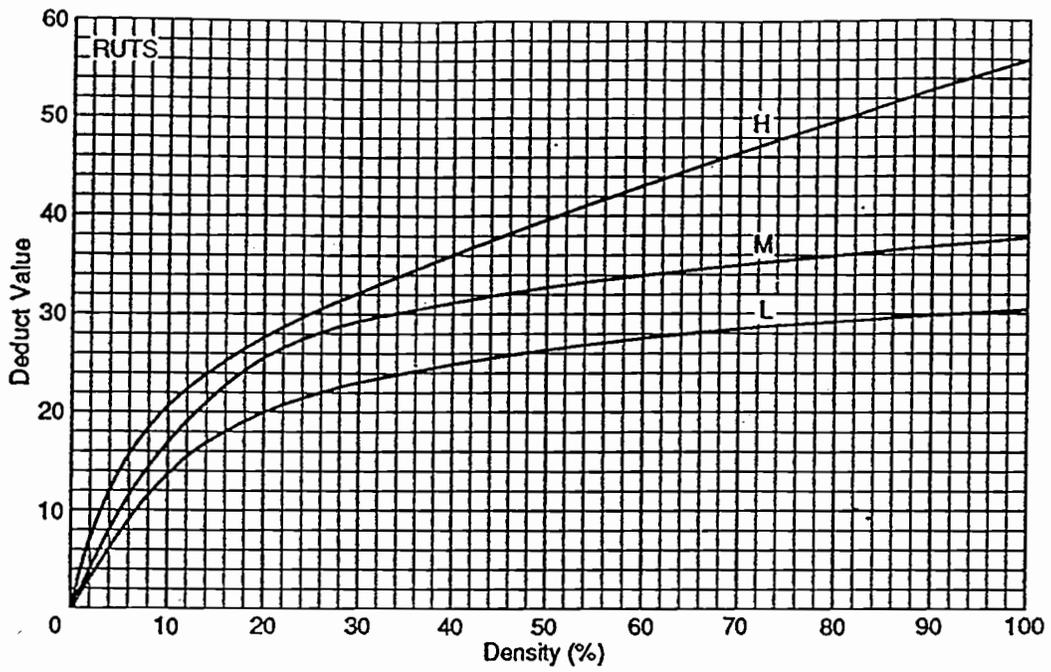


Figure 56. Ruts.

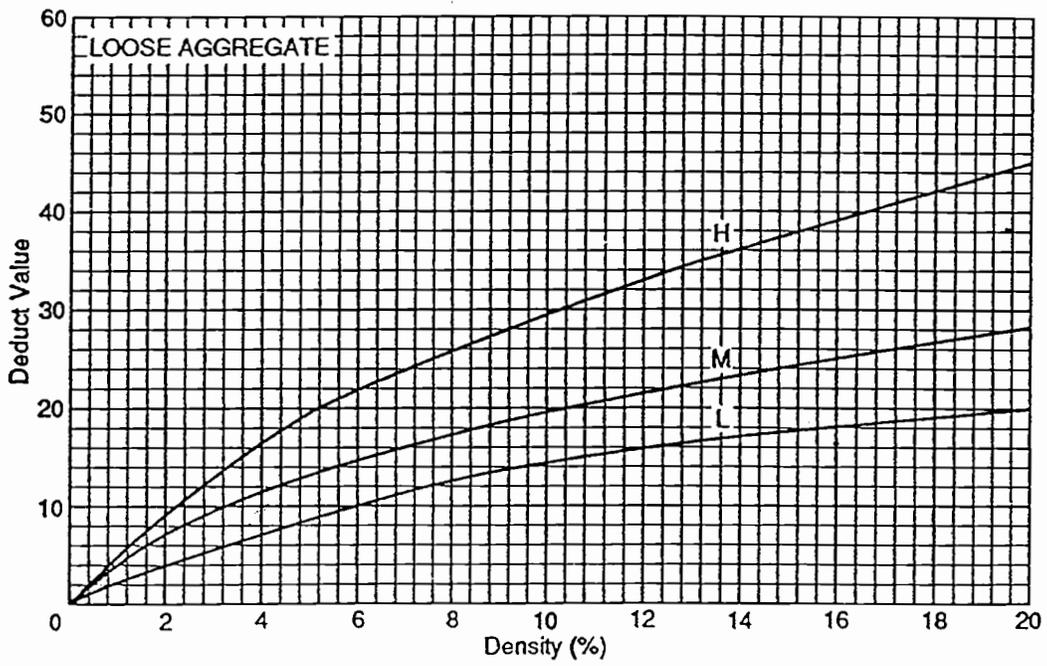


Figure 57. Loose Aggregate.

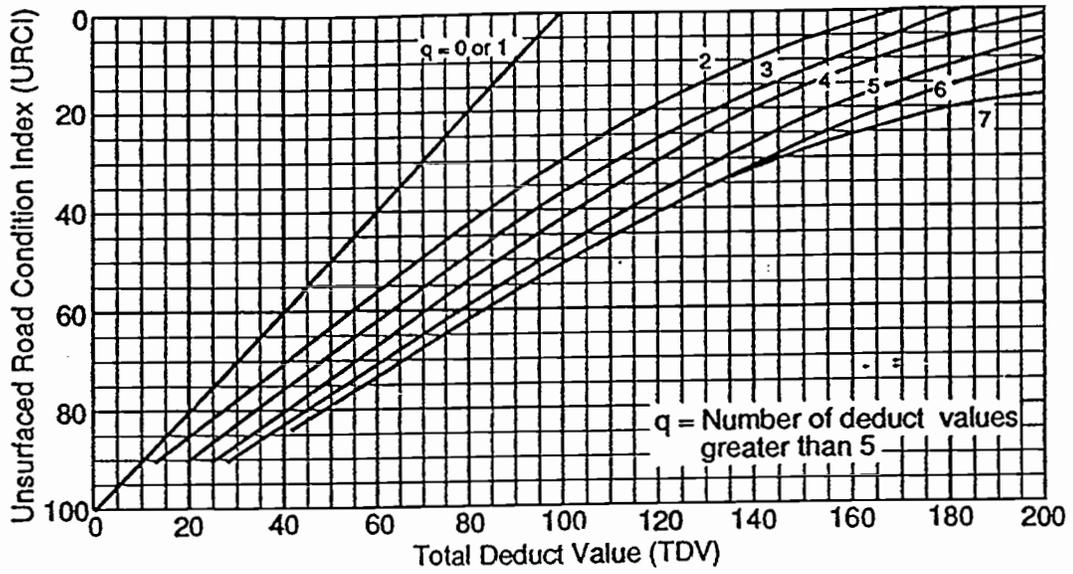


Figure 58. Total Deduct Value.

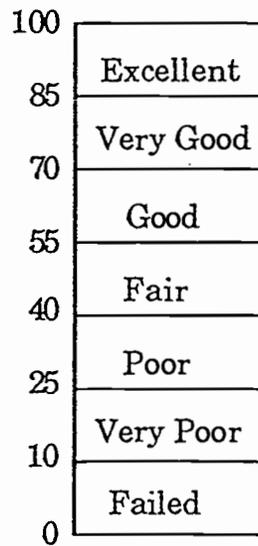


Figure 59. URCI Scale.

Step 3. Find the *Total Deducted Value (TDV)* and the *q* value. TDV can be calculated by adding up all the deducted values. The *q* value is a number of individual deducted values greater than 5.0.

- $TDV = 13 + 29 + 5 + 17 = 64.$
- The *q* value is 3 because 3 deducted values are greater than 5.0.

Step 4. Find the *Unsurfaced Road Condition Index (URCI)* from the *URCI* curve.

- The TDV is 64 and *q* is 3, so the URCI curve shows that the URCI is 59. The rating is “good”.
- This is the rating for this sample unit. The rating for the section is the average of the ratings from all the sample units in the section. For example, URCIs of 63, 59 and 67 in a section would give an average URCI of 63 for the whole section.

AN ABSTRACT OF THE THESIS OF

Peter (Pece) V. Gorsevski for the degree of Master of Science in Forest Engineering
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Abstract approved: _____

Brian W. Kramer

This thesis presents the idea for **FORIN** (*Forest Roads Inventory*), a computerized forest roads inventory system. **FORIN** is a tool to more efficiently inventory and manage information of forest roads. **FORIN** is intended for use by field personnel, who will use pen-based computers to improve productivity, accuracy of inventories, to lower the cost, and provide an efficient management tool for forest roads inventory.

FORIN is a relational database computer system designed for gathering data for forest roads. **FORIN** displays a menu, which controls the display of all other forms. The main purpose of the forms is for data collection, plus data updates for the roads and their elements. The data entry in the forms will be assisted by a pen-based computer, which will allow for fast, efficient, and accurate data gathering.

FORIN replaces the existing paper forms method of inventory with computerized forms, so that collected information can be transcribed into a summary report immediately after the data has been collected and input into the program.