

# **GUIDELINES FOR SLOPE MAINTENANCE AND SLIDE RESTORATION**

P386-245578

Research, Development,  
and Technology

Turner-Fairbank Highway  
Research Center  
6300 Georgetown Pike  
McLean, Virginia 22101

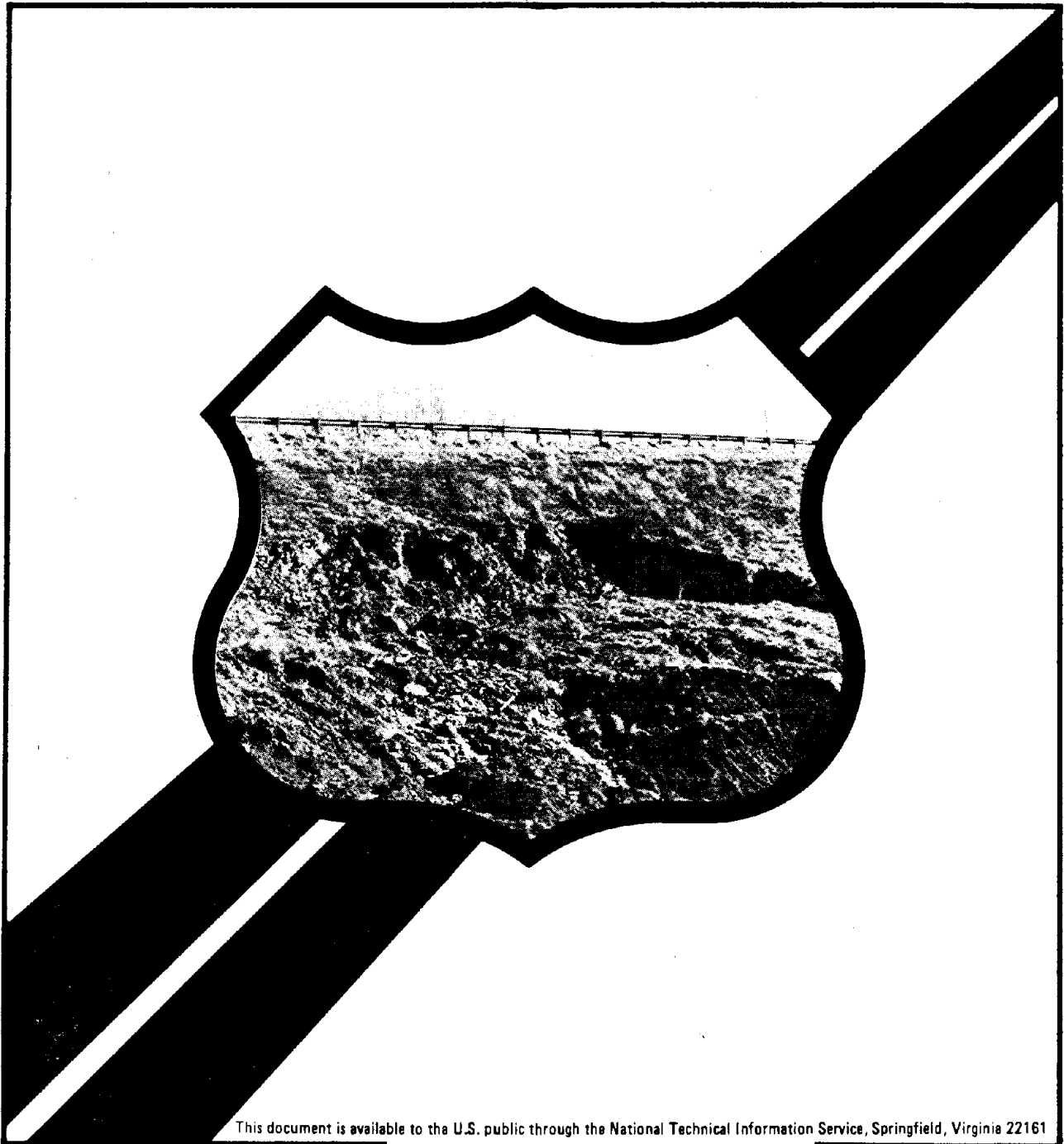


U.S. Department  
of Transportation

**Federal Highway  
Administration**

Report No.  
FHWA-TS-85-231

Final Report  
April 1986



This document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

REPRODUCED BY  
U.S. DEPARTMENT OF COMMERCE  
NATIONAL TECHNICAL  
INFORMATION SERVICE  
SPRINGFIELD, VA. 22161

## FOREWORD

These guidelines were developed to assist the first level maintenance supervisor, the person responsible for scheduling day-to-day maintenance work. The guidelines include recommended practices to prevent and minimize slope problems and quick reference tables of things to look for on the roadway or slopes that would indicate different types of distress.

Research, development, and implementation for improving maintenance operations are included in the Federally Coordinated Program on Highway Research and Development in Project 3A, "Maintenance Management."

Additional copies of the guidelines can be obtained from the National Technical Information Service, Springfield, Virginia 22161.



R. J. Betsold  
Director Office of Implementation  
Federal Highway Administration

## NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the policy of the Department of Transportation.

This report does not constitute a standard, specification, or regulation. The United States Government does not endorse products or manufacturers. Trade or manufacturer's names appear herein only because they are considered essential to the object of this document.

1. Report No. FHWA-TS-85-231		2. Government Accession No.		3. Recipient's Catalog No. <b>PB86 245578/AS</b>	
4. Title and Subtitle Guidelines for Slope Maintenance and Slide Restoration				5. Report Date April 1986	
				6. Performing Organization Code HRT-10	
7. Author(s) Gary Klinedinst Andy Munoz and Charles W. Niessner				8. Performing Organization Report No.	
9. Performing Organization Name and Address Federal Highway Administration 6300 Georgetown Pike McLean, Virginia 22101				10. Work Unit No. (TRAIS) 37A1303	
				11. Contract or Grant No.	
12. Sponsoring Agency Name and Address Federal Highway Administration Office of Implementation 6300 Georgetown Pike McLean, Virginia 22101				13. Type of Report and Period Covered Final Report 3/1984 - 6/1985	
				14. Sponsoring Agency Code HRT-10	
15. Supplementary Notes The information included in this report was developed by personnel from the California, Kentucky, Pennsylvania, Oregon, Texas, and Wyoming highway agencies.					
16. Abstract  As part of a continuing project to evaluate and improve maintenance activities a study on slope maintenance and slide restoration was undertaken. The problem of slope maintenance and slide restoration was identified by a number of States as a major maintenance problem involving a considerable expenditure of maintenance funds.  These guidelines are divided into five chapters: (1) slide identification and definition of terms, (2) investigation and inspection of critical slopes and drainage, (3) maintenance activities that will aid in the prevention and minimization of slides, (4) maintenance activities that are related to particular distress items, and (5) repair and restoration techniques including relative cost information.  The guidelines reflect the collective experience of the six participating States, and are designed for use by the first level maintenance supervisor, the person responsible for scheduling day-to-day maintenance work.					
17. Key Words Slide Restoration, Slope maintenance, maintenance activities slide identification			18. Distribution Statement No Restriction. Available to the public through the National Technical Information Service, Springfield 22161		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 69	22. Price

## Table of Contents

		Page
	INTRODUCTION	1
Chapter 1	SLIDE IDENTIFICATION AND DEFINITION OF TERMS	2
Chapter 2	INVENTORY AND INSPECTION	5
Chapter 3	PREVENTION AND MINIMIZATION OF SLOPE PROBLEMS	7
	I. Slope Maintenance	7
	II. Drainage Maintenance	12
	III. Road Surface Maintenance	20
	IV. Utilities	21
Chapter 4	MAINTENANCE ACTIVITIES RELATED TO PARTICULAR DISTRESS ITEM	23
Chapter 5	REPAIR & RESTORATION TECHNIQUES WITH COST CONSIDERATIONS	52
	I. Cut Slopes	53
	II. Fill Slopes	54
	Appendix	56

## List of Figures

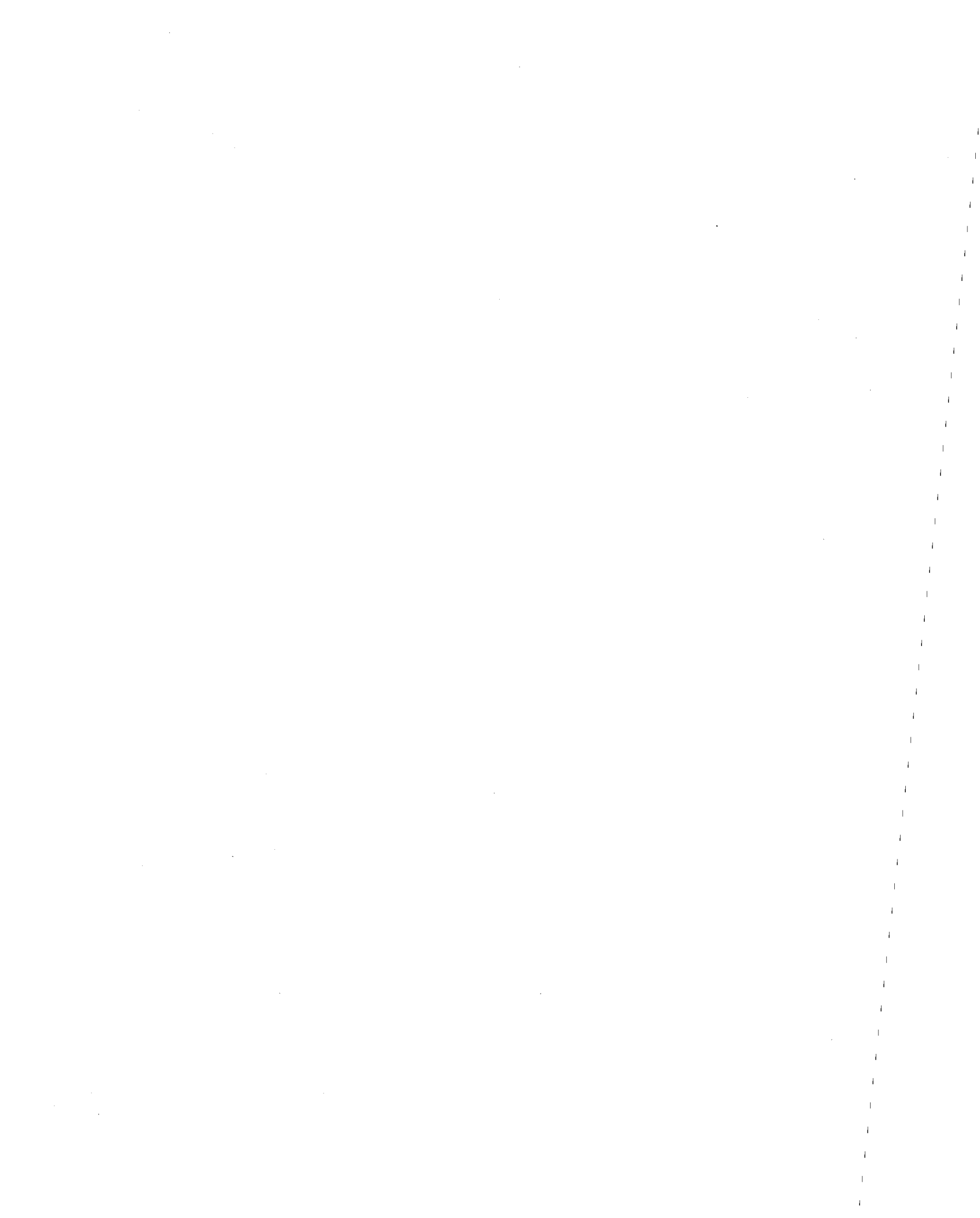
Figure		Page
1a	Slide above highway, side hill cut.	2
1b	Slide below highway.	3
2a	Slide within fill, side hill fill.	3
2b	Slide within original ground.	3
3a	Slide within fill, embankment.	4
3b	Slide within original ground.	4
4	Barrier and wire mesh to prevent falling rocks from reaching pavement.	9
5	Flatten slopes.	10
6	Overloading with asphalt overlays.	12
7	Pipe with separated joints.	13
8	Inlet and outlet protection for pipe.	14
9	Over excavation of ditch.	14
10	Water diverted to slope.	15
11	Short pipe - water empties on slope.	16
12	Rigid pipe in unstable area.	16
13	Geotextile fabric around drain gravel.	17
14	Bridge end drain.	18
15	Filtration material for weepholes.	19
16	Rigid slope paving.	20

## LIST OF TABLES

Table		Page
1a	Preslide symptoms: Settlement of roadway, shoulder, guardrail or adjacent areas, such as walls fences, or rails.	26
1b	Preslide symptoms: Derbis on roadway.	27
1c	Preslide symptoms: Tilting features, such as trees, poles, fences, walls, or rails.	28
1d	Preslide symptoms: Uplifting of roadways.	29
1e	Preslide symptoms: Cracking of pavement, shoulders, ditches, or adjacent areas.	30
1f	Preslide symptoms: Changes in drainage.	31
2a	Slides and rockfall features: Rockfall from massive rock slopes.	32
2b	Slides and rockfall features: Rockfall from differential weathering.	34

LIST OF TABLES (continued)

2c	Slides and rockfall features: Rockfall from a talus slope.	36
2d	Slides and rockfall features: Type A slide above road -- mudflow.	38
2e	Slides and rockfall features: Type B slide above road -- wedge.	40
2f	Slides and rockfall features: Type C slide above road -- rotational.	42
2g	Slides and rockfall features: Type D slide above road -- blockslide.	44
2h	Slides and rockfall features: Type A slide below road -- mudflow.	46
2i	Slides and rockfall features: Type B slide below road -- wedge.	48
2j	Slides and rockfall features: Type C slide below road -- rotational.	50
3	Repair and restoration techniques with relative costs.	53





# Guidelines for Slope Maintenance and Slide Restoration

## INTRODUCTION

As part of a continuing project to evaluate and improve maintenance activities the Office of Implementation, at the request of several States, initiated a study on slope maintenance and slide restoration. The problem of slope maintenance and slide restoration was identified by a number of States as a major maintenance problem involving a considerable expenditure of maintenance funds. In most cases, the true costs of slope maintenance and slide restoration are not accurately reflected in a State's maintenance management system. This is largely due to the methods used for the charging costs to maintenance activities. For example, repair of roadway surface due to settlement may be charged to asphalt patching. Guardrail repair, where the guardrail is sliding down the slope, is charged to the activity code for guardrail repair. No charges are made to slope maintenance. Tracing accurate costs for this problem is highly recommended. A study was conducted by the States of California, Kentucky, Pennsylvania, Oregon, Texas and Wyoming. Each of the States participating in the study provided teams of three or four experts including both maintenance and geotechnical engineers. During the course of the study, five joint meetings were held. An outline for the proposed guidelines was developed at the second meeting. The State teams were divided into three groups and each group was assigned a portion of the outline to expand and develop. The products of these groups were then assembled, reviewed and revised by the entire study team. The guidelines reflect the collective experience of these six States, and are designed for use by the first level maintenance supervisor, the person responsible for scheduling day-to-day maintenance work.

These guidelines are divided into five chapters: (1) slide identification and definition of terms, (2) investigation and inspection of critical slopes and drainage, (3) maintenance activities that will aid in the prevention and minimization of slides, (4) maintenance activities that are related to particular distress items, and (5) repair and restoration techniques including relative cost information.

Chapter 1  
SLIDE IDENTIFICATION AND DEFINITION OF TERMS

This chapter describes and defines the characteristics of slope problems associated with rock and soil cuts and fills. The user of this manual should be thoroughly familiar with the terms used to identify a slope problem before attempting to make use of these guidelines.

Figures 1 to 3 illustrate the three most common type of slope problems associated with highway maintenance operations: side-hill cuts, side-hill fills, and embankments. For each possible slope problem, the sequence of events leading to a failure is illustrated. In each sketch, the problem symptoms (what to look for) are highlighted and the terms that are normally used to describe a slope problem are defined pictorially.

When using these guidelines for either inspecting, maintaining or deciding on corrective courses of action for slope problems, the user should refer to these illustrations to assure proper interpretation of slope distress/failure terms.

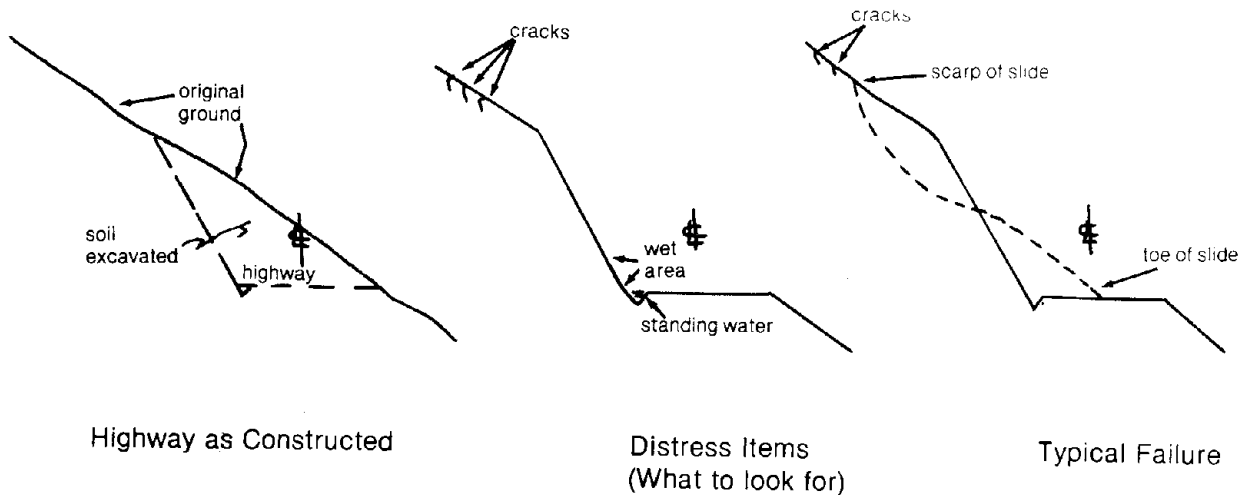


Figure 1a. Slide above highway, side hill cut.

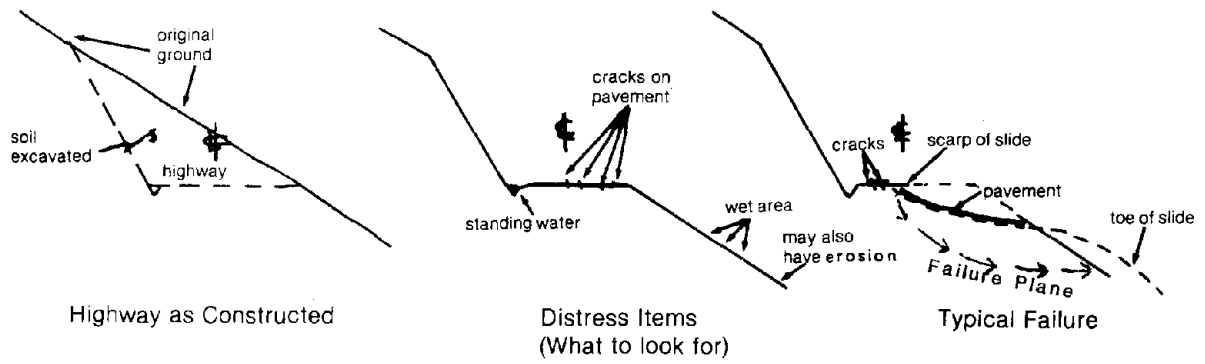


Figure 1b. Slide below highway.

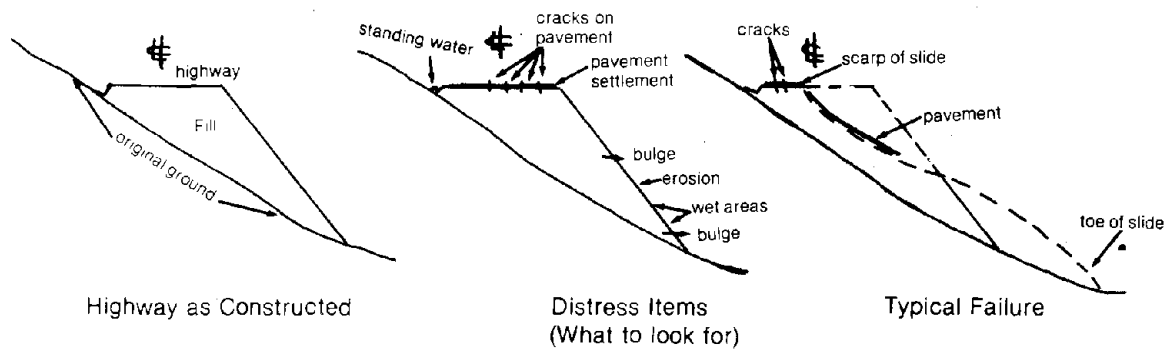


Figure 2a. Slide within fill, side hill fill.

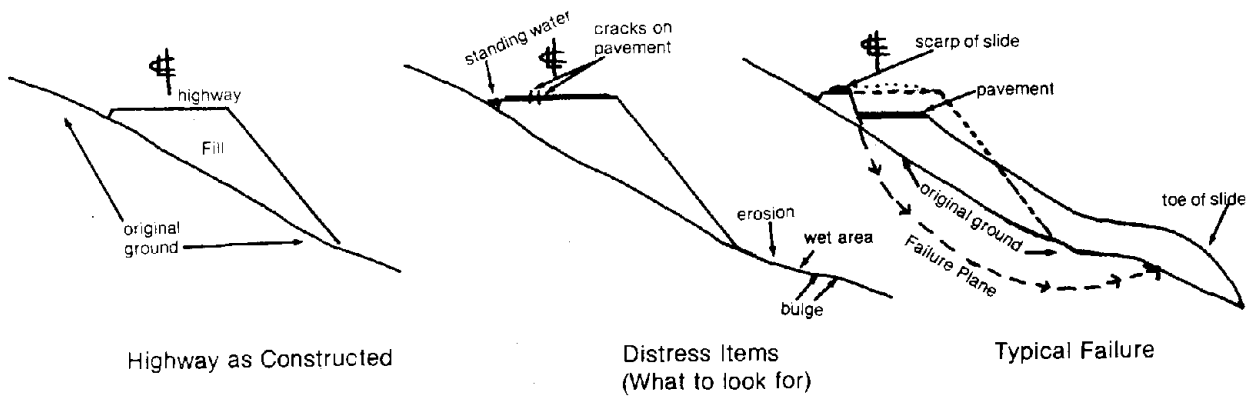


Figure 2b. Slide within original ground.

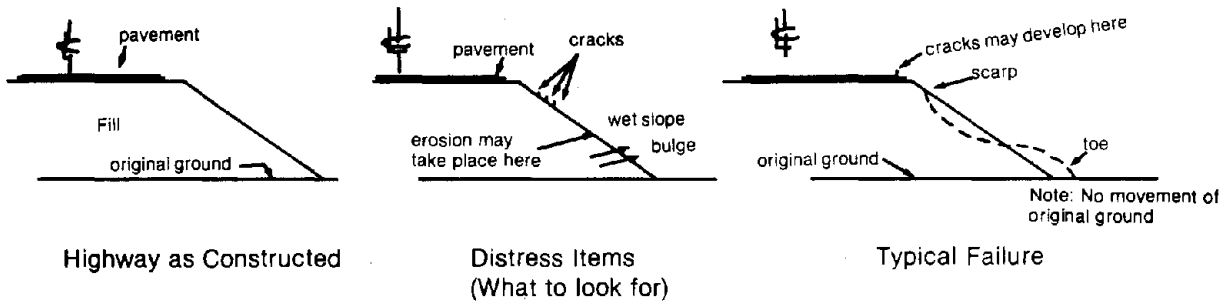


Figure 3a. Slide within fill, embankment.

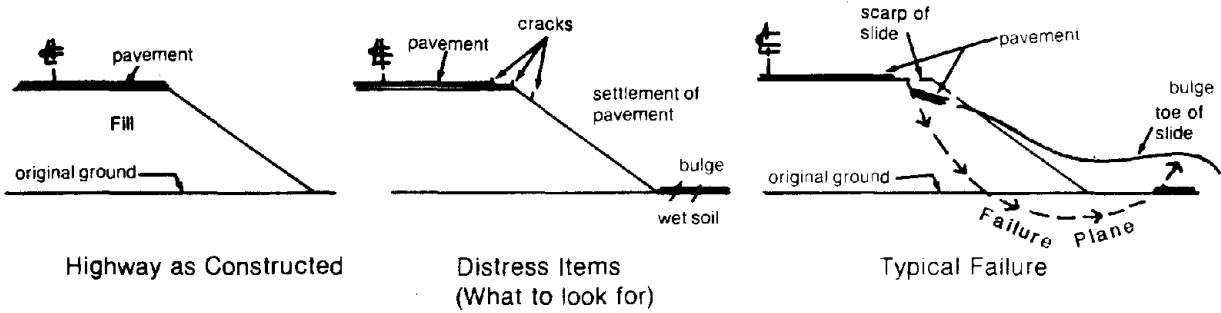


Figure 3b. Slide within original ground.

## Chapter 2 INVENTORY AND INSPECTION

### Inventory

An inventory of all slides, slipouts, and drainage facilities in close proximity to the distress should be established along with a schedule for periodically updating the data and the cost to maintain or repair.

The slide inventory aids in determining the extent of the problem, the progression of an individual slide from year to year and can serve as the basis for developing a priority program for repairs.

Sample inventory forms for the gathering of physical distress data are included in the Appendix.

In developing a program to repair slides and slipouts, the costs of maintenance should be a key factor in determining which areas get corrected first. A method for tracing these costs is very critical to the success of an inventory system.

### Inspection

In order to have knowledge of the existing physical features and to allow the supervisor to have the ability to spot potential problem areas, the following items should be inspected on a periodic basis:

1. All fill and cut slopes greater than critical steepness (parameters to be determined by each state),
2. All drainage features (surface and subsurface), and
3. All known slides and slipouts (as discussed above).

A written record of the inspection and the recording of abnormal appearances should be noted in the slide inventory (inspection report). This will provide

information on the condition of drainage features, slope surfaces, and other data, which is valuable in determining the period of occurrence of a slide and provides clues to its cause.

Drainage outlets and inlets should be clearly marked so that easy identification and inspection can be made in the field. Subsurface drainage features should also be marked and inspected to the extent possible. Periodic inspection of the drainage features and prompt correction of all problems will prevent a considerable number of slope problems in the future.

Chapter 3  
PREVENTION AND MINIMIZATION OF SLOPE PROBLEMS

Prevention and minimization of slope problems is the best way to prevent costly expenditures for slope corrections in the future. This portion of the manual will deal with both items which the maintenance personnel should inspect and with work which should be performed in order to prevent slope failures and in order to minimize the future occurrence of slope problems.

I. Slope Maintenance

This section will deal with maintenance items which should be performed on the slope to prevent or minimize future problems. Slope surface maintenance and slide maintenance techniques will be discussed.

A. Surface Maintenance

This is very important to the prevention of slope problems. Generally the origin of many landslides can be traced to the lack of surface maintenance. This lack of maintenance can result in the direct development of a landslide or can result in the initial surface distress progressing into a landslide. Surface maintenance items which should be performed have been broken down and listed under erosion, vegetation, rockfall, and irrigation of slope vegetation.

1. Erosion.

This is defined as a loss or relocation of surface material through action of wind, water, or gravity. The following maintenance items should be accomplished:

- a. Regularly inspect the erosion control features designed into the roadway to assure their proper functioning;
- b. Maintain interception ditches to prevent water from running over fragile slopes;

- c. Seed slopes immediately after repair and prior to rainy season; and
- d. Repair curbs, dikes, or berms damaged by snow removal or accidents to assure integrity of surface drainage.

2. Vegetation.

The function of vegetation on a slope is to prevent or control slope surface erosion and/or for aesthetic purposes. The following maintenance items should be accomplished:

- a. Maintain slope vegetation by mowing, seeding, fertilizing, and watering where necessary. Caution should be exercised in mowing and herbicide operations in order to prevent turning damage to slopes and overkill by herbicides.
- b. Control vegetation in drainage ditches to prevent restricting or clogging of the ditch.
- c. Notify the maintenance engineer or other responsible authority of trees on slopes that are becoming problems.
- d. Use vegetation where appropriate to dry up wet areas.

3. Rockfall.

This is defined as the random fall of rock to the roadway. The following preventive maintenance should be accomplished:

- a. Inspect areas of rockfall periodically and consider scaling slopes to reduce possibility of random fall.



- b. Place fences, earth berms, or other barriers between the roadway and slope to prevent falling rocks from reaching the pavement. Consider placing netting on slopes where fallout space next to the roadway is limited (figure 4).

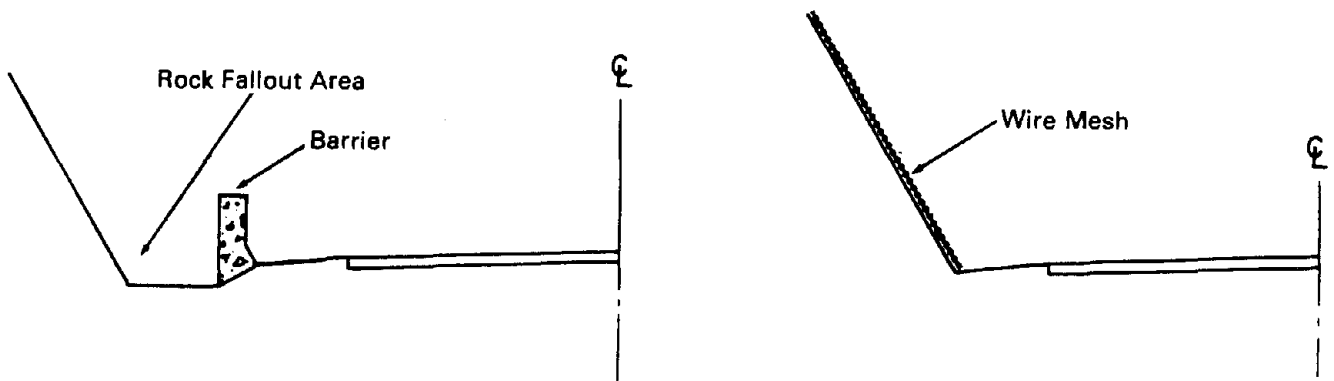


Figure 4. Barrier and wire mesh to prevent falling rocks from reaching pavement.

- c. Maintain drop areas by cleaning and removing fallen rock before the area is full and ineffective. Avoid undercutting slope during the cleaning operation.
4. Irrigation.  
This applies to landscaping and functional plantings. Maintenance should include:

- a. Inspect watering systems periodically to determine damage or leaks in the system; and
- b. Do not over water.

B. Small Slide Maintenance Technique

This section will set forth things to do and not to do for small slides and slumps which develop and which may not need investigation by the maintenance engineer.

1. Recommended Practices

- a. Direct surface water away from slide area.
- b. If wet, drain slide area with subsurface drains, french drains, etc.
- c. Establish vegetation after draining and grading of area.
- d. Seal all cracks on surface of slide.
- e. Flatten slopes, if appropriate using waste material (figure 5).

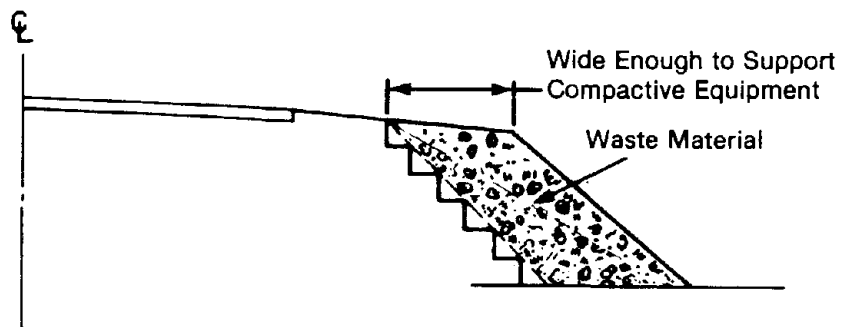


Figure 5. Flatten slopes.

- f. Dispose of unsuitable materials only at approved sites away from slide prone areas.
- g. Monitor, report, and control adjacent development as appropriate to prevent loss of lateral support or change of drainage.
- h. In settlement areas remove 3 to 4 feet of fill material and backfill with light weight fill (sawdust) then overlay with asphalt

2. Practices to Avoid If Possible.

- a. Do not excavate at toe of slope unless effects have been evaluated.
- b. Do not do any over-excavation that removes lateral support or ponds water.
- c. Do not dispose of waste at top of fill, sidecasting.
- d. Do not block drainage by sidecasting, slope flattening, or other operations.

- e. Do not overload top of fill with bituminous patching overlays in slide or settlement areas (figure 6).

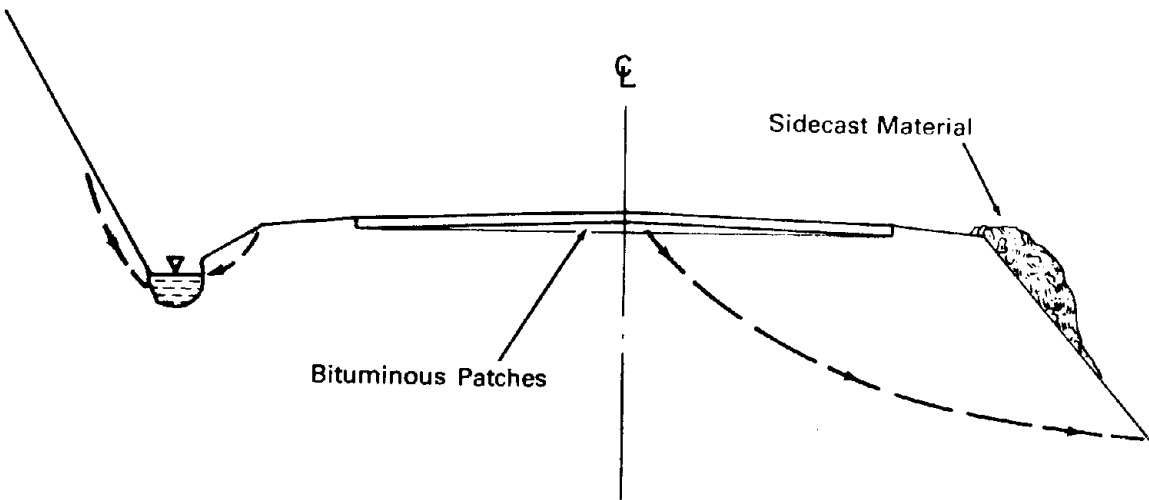


Figure 6. Overloading with asphalt overlays.

## II. Drainage Maintenance

This section will deal with the maintenance of drainage to prevent or minimize future slope problems. Generally the cause of any landslide can be traced to the problem of excess water either from the surface or subsurface. In a good share of the cases of slope instability along an existing roadway, the cause of this instability can be traced to inadequate maintenance of an existing drainage feature. This section will look at drainage features in three categories: surface, subsurface, and structures. Recommended practices (Things to Do) and practices to avoid (Do Not Do) are given for each category.

A. Surface Maintenance

1. Recommended Practices.

- a. Utilize drainage inventory and inspection data for scheduling maintenance operations.
- b. Divert water away from slide/slope area and combine drainage whenever possible.
- c. Clean pipe and channels without fail.
- d. Make immediate repairs of separated joints (figure 7). (Do not allow water to infiltrate from pipe joints).

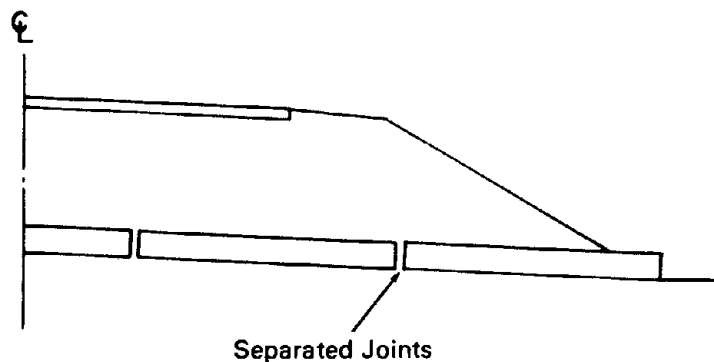


Figure 7. Pipe with separated joints.

- e. Make pipe selection appropriate to conditions. (Consider debris, flow, and movement expected. Specify best type and size.)

- f. Use headwalls and/or slope protection at pipe inlets and outlets (figure 8).

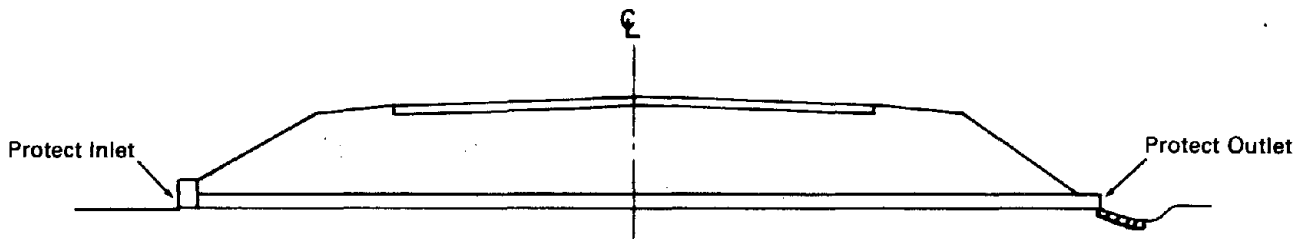


Figure 8. Inlet and outlet protection for pipes.

2. Practices to Avoid.

- a. Do not over-excavate ditches (figure 9).

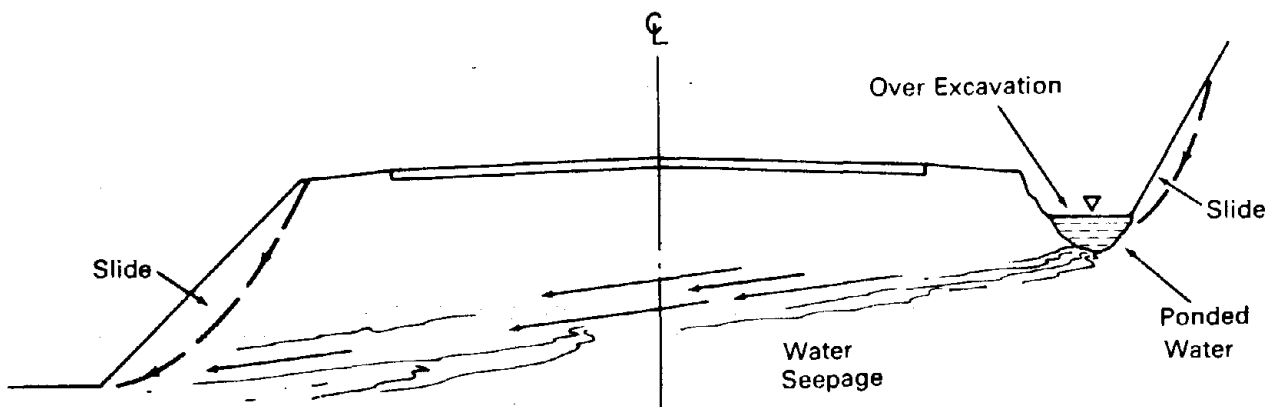


Figure 9. Over-excavation of ditch.

b. Do not divert water towards slide/slope (figure 10).

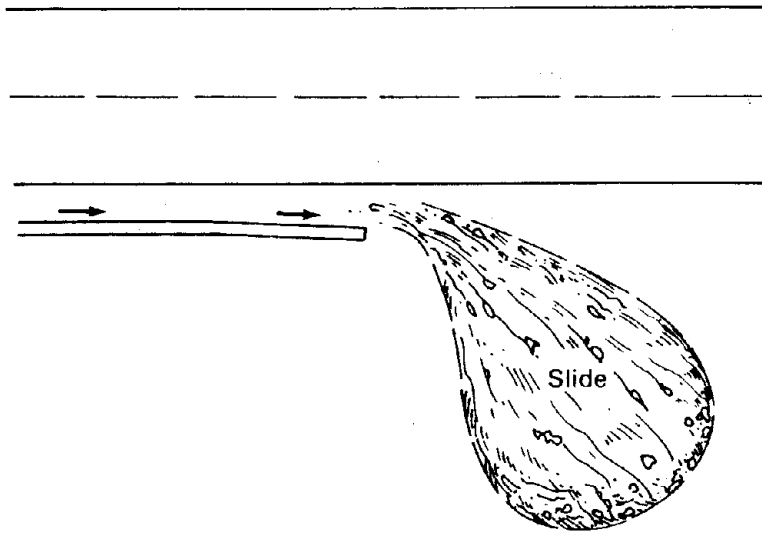


Figure 10. Water diverted to slope.

c. Do not allow water to pond in parallel ditches.

- d. Do not stop pipes too short so that water empties onto slope (figure 11).

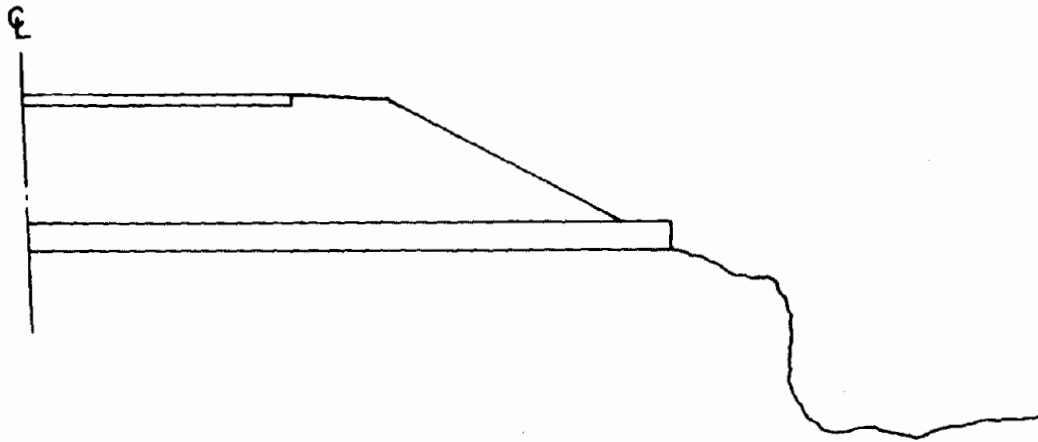


Figure 11. Short pipe-water empties on slope.

- e. Do not use rigid pipe in unstable areas (figure 12).

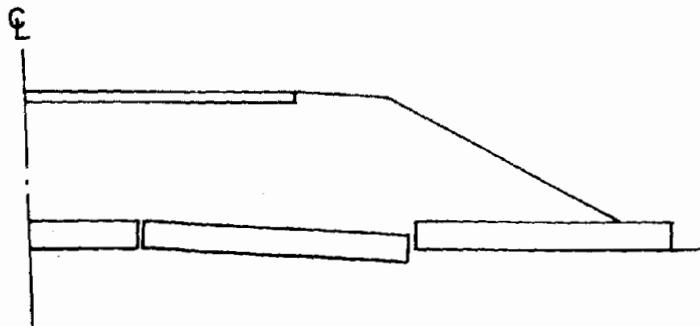


Figure 12. Rigid pipe in unstable area.



B. Subsurface Drainage Systems (Use liberally)

1. Recommended Practices.

- a. Utilize drainage inventory and inspection data for scheduling maintenance operations.
- b. Clean and maintain all subsurface drainage features periodically.
- c. Use a flexible collector system.
- d. Use edge drains under pavement shoulder joints where water is accumulating in roadway section.
- e. Provide access to drains for maintenance purposes.
- f. Install cleanouts for larger pipes.
- g. Use geotextile fabric around drain gravel to prevent plugging of the underdrain system (figure 13).

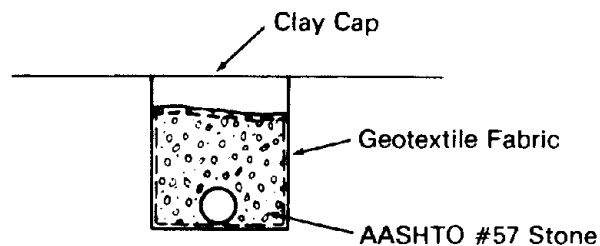


Figure 13. Geotextile fabric around drain gravel.

- h. Evaluate non-functioning systems for repair or replacement.
- i. Monitor utility installations for damage to existing subsurface drainage systems.

2. Practices to Avoid.

- a. Do not design features or construction procedures that hinder the maintenance of the drainage system.
- b. Do not use rigid collectors that will separate under movement and allow water to infiltrate the surrounding slopes.
- c. Do not construct granular backfilled areas which will not drain (bath tub effect).

C. Structures

1. Recommended Practices.

- a. Insure distribution of inventory and inspection data to the proper people for scheduling maintenance operations.
- b. Provide bridge end drainage (figure 14).

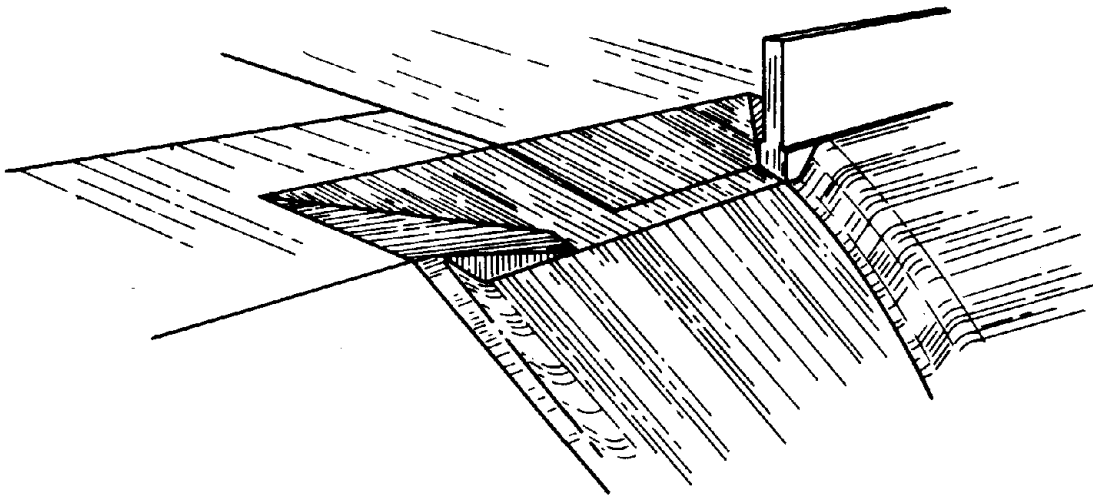


Figure 14. Bridge end drainage.

- c. Provide appropriate filtration materials for weepholes in structures (figure 15).

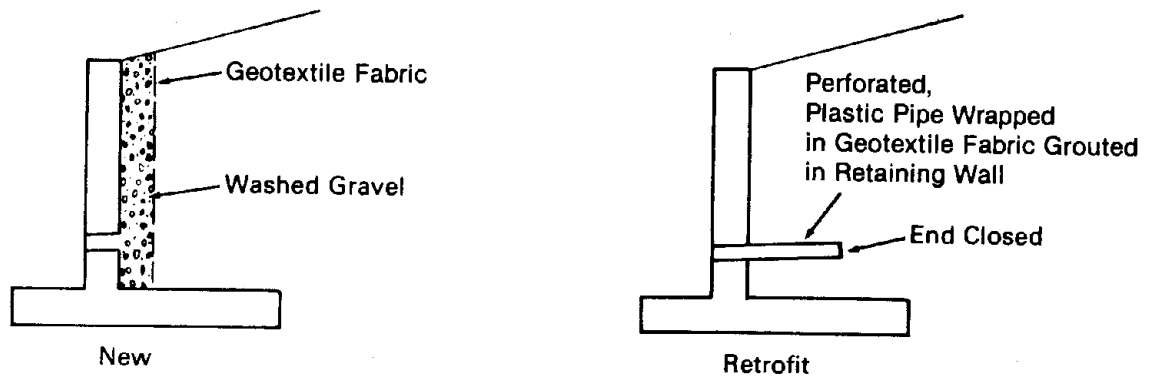


Figure 15. Filtration material for weepholes.

- d. Maintain pump stations, diversion structures, siphons, and irrigation systems.
  - e. Maintain integrity of expansion joints at bridge ends.
2. Practices to Avoid.
- a. Do not channel water behind headwalls or abutments.

- b. Do not use rigid slope paving where water may get behind it (figure 16).

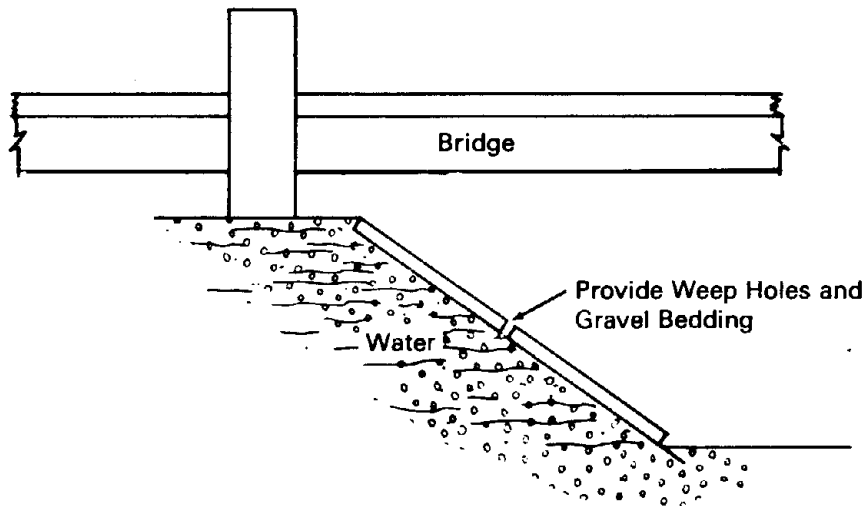


Figure 16. Rigid slope paving.

### III. Road Surface Maintenance

This section of the manual will deal with road surface maintenance as required to prevent slope failures and to minimize movement of existing slope failures. Considerable amounts of surface water can infiltrate the subgrade and infiltrate into the embankment if cracks and joints on the road surface are not kept sealed. Also areas of the roadway which continually require overlays to restore ride quality are, in all probability, experiencing the first phase of failure which will lead to considerable maintenance problems later.

#### A. Crack Sealing

The purpose is to prevent water from entering the subgrade.

1. Seal roadway surface joints and edges on a regular basis but especially in advance of the winter and/or rainy seasons.
2. Seal all cracks and joints that have the potential for permitting water to enter the subgrade. This may include cracks in shoulders or dikes that are a part of the roadway section.
3. Inspect and seal cracks in and around unstable areas as soon as possible.

B. Patching

Patching is spot repair to correct flaws such as potholes, cracks, and uneven settlement in the roadway surface. Repair base and surface failures promptly to provide an adequate ride and to minimize infiltration of water.

C. Overlays

Overlays are complete covering of roadway for extended distances to seal and restore riding surfaces to planned cross slope.

1. Repair base failures prior to an overlay.
2. Taper overlays to maintain capacity of the curbs and/or dikes or raise the dikes.
3. Notify the maintenance engineer of persistent subsidence of the roadway for investigation into alternate repair methods.

IV. Utilities

This section will deal with the effects that utilities and their placement or maintenance can have on prevention and minimization of slope failures. Utility trenches can act as a conduit for water infiltration into slides and quite often are responsible for subsidence associated with the roadway surface or the adjacent shoulder or slope. Installation

of utilities can also disturb or sever existing subsurface drainage, which can have devastating consequences. Installations can also undercut the toe of an existing slope, resulting in slope movement. The following items should be observed and noted during utility work on or adjacent to the roadway:

A. Physical Disturbance

Observe utility excavation to insure the following.

1. Existing subsurface drainage is not severed or disturbed,
2. excavation does not cause adjacent slope instability,
3. compaction of backfill is performed so roadway does not settle,
4. trenches are drained so water cannot collect and infiltrate adjacent slopes, and
5. Vegetation disturbed by utility operations is restored as quickly as possible to minimize erosion and water infiltration.

B. Unusual Conditions

Report unusual conditions to your supervisor for investigation and/or correction.

Chapter 4  
MAINTENANCE ACTIVITIES RELATED TO PARTICULAR DISTRESS ITEMS

This section of the guidelines is composed of tables 1 and 2 which are arranged in a form to serve as a quick reference of things to look for under different types of distress that may appear on the roadway or on the slopes. Table 1, "Preslide Symptoms," includes distresses that would indicate a problem is developing. Table 2, "Slides and Rockfall Features," includes distresses that are evident after a slide develops. Always review the entire table prior to taking action.

Table 1 contains six parts:

- 1a. Settlement of roadway, shoulder, guardrail, or adjacent areas such as walls, fences, or rails
- 1b. Debris on roadway
- 1c. Tilting features such as trees, poles, fences, walls, or rails
- 1d. Uplifting of roadway
- 1e. Cracking of pavement, shoulder, ditches, or adjacent areas
- 1f. Changes in drainage

The major preslide symptom, i.e., "debris on roadway" should be used to locate which table 1 to enter.

Once the proper table is matched with the field detected symptom, the next step is to enter the table under the heading "Things to Look For." Under this heading is a list of surface defects/features usually associated with the type of symptom. Locate the surface defect/feature noted in the field. Proceeding to the right in the table, the next column gives the significance of the observed defect/features. The third column provides the courses of action which should be performed to correct the defect/feature. The fourth column provides helpful hints on actions that should be avoided so as not to make the defect/feature worse. Some symptoms may have more than one defect/feature and each problem area could have more than one symptom. In any case, each symptom and each defect/feature should be investigated and the corrective actions performed as set forth in the tables.

Table 2 is used in the same manner as described above for Table 1. Table 2 contains 10 parts as follows:

- 2a. Rockfall from massive rock slopes
- 2b. Rockfall from differential weathering
- 2c. Rockfall from a talus slope
- 2d. Type A slide above road (mudflow)
- 2e. Type B slide above road (wedge)
- 2f. Type C slide above road (rotational)
- 2g. Type D slide above road (blockslide)
- 2h. Type A slide below road (mudflow)
- 2i. Type B slide below road (wedge)
- 2j. Type C slide below road (rotational)

Massive rock slopes are described as slopes containing very few seams and generally contains rock that is very hard. This is generally characterized by slopes that are very steep.

Differential weathering is characterized by slopes containing both soil or soil-like material, and rock fragments.

Talus slope is a slope made up of boulders or rock fragments.

A sketch accompanying each table 2d to 2j describes what is meant by a Type A, B, C, and D slide both above and below the roadway.



TABLE 1: PRESIDE SYMPTOMS:  
ITEMS TO LOOK FOR THAT INDICATE  
A SLOPE PROBLEM IS DEVELOPING

25

TABLE 2: SLIDES AND ROCKFALL FEATURES:  
TYPES OF SLIDES, ITEMS TO LOOK FOR  
AND STEPS TO TAKE AFTER A SLIDE  
HAS DEVELOPED

Table 1a. Preslide symptoms:

Settlement of roadway, shoulder, guardrail, or adjacent areas such as walls, fences, or rails.

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Surface Cracking in Surrounding Areas	<ul style="list-style-type: none"> <li>o Allows water infiltration.</li> <li>o May outline limits of distress.</li> <li>o May indicate potential major movement.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause of cracking.</li> <li>o Record size, location, &amp; extent; periodically monitor.</li> <li>o Consider sealing cracks.</li> <li>o Monitor for roadway movement with pins and record.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid loading of distressed area.</li> </ul>
B. Blocked, Leaking, or Otherwise Malfunctioning Drainage or Septic Systems Outside R/W	<ul style="list-style-type: none"> <li>o May add water to the problem area.</li> <li>o May be the cause of the problems.</li> <li>o May cause future problem.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause.</li> <li>o Properly drain.</li> <li>o Redirect water if practical.</li> <li>o Seek advice.</li> <li>o Reconstruct or protect eroded area if practical.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not direct water towards problem area.</li> <li>o Do not over excavate when cleaning drainage.</li> </ul>
C. Erosion by Natural Drainage (Including stream flow, springs, lakes, and channel changes)	<ul style="list-style-type: none"> <li>o May be the cause of distress.</li> <li>o May reoccur or progress to travel unless altered.</li> <li>o May be adding water to distressed area.</li> <li>o Constructed side slopes may be too steep.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record changes in distress.</li> <li>o Monitor &amp; record changes in water volume, color, or level.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid sudden change in water levels where controllable.</li> <li>o Avoid blocking natural drainage courses or springs.</li> </ul>
26 D. Slope Bulging or Movement	<ul style="list-style-type: none"> <li>o May indicate location of movement.</li> <li>o May indicate swelling soils.</li> <li>o May indicate frost heave areas.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record locations, changes in size or shape.</li> <li>o Be prepared to close road if changing rapidly.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not disturb until stability evaluated.</li> <li>o Avoid loading distressed area.</li> <li>o Do not remove shrubs, bushes, grasses, etc.</li> </ul>
E. Wasting of Materials on Slope (side casting)	<ul style="list-style-type: none"> <li>o May cause settlement.</li> <li>o May block natural or designed drainage.</li> <li>o May cause moisture to collect, i.e., snow melt or rainfall.</li> </ul>	<ul style="list-style-type: none"> <li>o Remove existing waste material if practical.</li> <li>o Properly drain.</li> <li>o Use designated waste areas.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid wasting or stock piling material at this location.</li> </ul>
F. Adjacent Land Use Changes, Construction, Mining, Logging, etc.	<ul style="list-style-type: none"> <li>o May be cause of distress.</li> <li>o Changes from agricultural to industrial or commercial to urban may cause increased runoff.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate activities and contact supervisor, and/or owner.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not grant access or permits within the distressed area.</li> </ul>
G. Vegetation Changes Such As Tilting, Dying, New Cat Tails, New Green Areas	<ul style="list-style-type: none"> <li>o May indicate movement and outline limits of distress area.</li> <li>o May indicate changed drainage conditions, surface or subsurface.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause; monitor &amp; record changes.</li> <li>o Consider horizontal or underdrains.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid directing water into distressed area.</li> <li>o Do not remove vegetation unless a hazard to travelling public.</li> </ul>

Note: 1) Always evaluate safety first, don't assume it's safe.  
 2) Do not raise roadway until settlement cause has been evaluated.

Table 1b. Preslide symptoms:

Debris on roadway

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Surface Cracking in Surrounding Areas	<ul style="list-style-type: none"> <li>o Allows water infiltration.</li> <li>o May outline limits of distress.</li> <li>o May indicate potential major movement.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause of cracking.</li> <li>o Record size, location, &amp; extent; periodically monitor.</li> <li>o Consider sealing cracks.</li> <li>o Monitor for roadway movement with pins and record.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid loading of distressed area.</li> </ul>
B. Blocked, Leaking or Otherwise Defective Septic Systems Outside R/W	<ul style="list-style-type: none"> <li>o May add water to the problem area.</li> <li>o May be the cause of the problems.</li> <li>o May cause future problem.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause.</li> <li>o Properly drain.</li> <li>o Redirect water if practical.</li> <li>o Seek advice.</li> <li>o Reconstruct or protect eroded area if practical.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not direct water towards problem area.</li> <li>o Do not over excavate when cleaning drainage.</li> </ul>
C. Erosion by Natural Drainage (Including stream flow, springs, lakes, and channel changes)	<ul style="list-style-type: none"> <li>o May be the cause of distress.</li> <li>o Unless altered, may reoccur or progress to travel way.</li> <li>o May be adding water to distressed area.</li> <li>o Constructed side slopes may be too steep.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record changes in distress.</li> <li>o Monitor &amp; record changes in water volume, color, or level.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid sudden change in water levels where controllable.</li> <li>o Avoid blocking natural drainage courses or springs.</li> </ul>
27 D. Bulging or Slope Movement	<ul style="list-style-type: none"> <li>o May indicate location of movement.</li> <li>o May indicate swelling soils.</li> <li>o May indicate frost heave areas.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record locations, changes in size or shape.</li> <li>o Be prepared to close road if changing rapidly.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not disturb until stability evaluated.</li> <li>o Avoid loading distressed area.</li> <li>o Do not remove shrubs, bushes, grasses, etc.</li> </ul>
E. Tilting Features Such as Trees, Poles, Fences Walls, or Rails	<ul style="list-style-type: none"> <li>o May indicate additional distress.</li> <li>o May indicate changed drainage surface or subsurface.</li> <li>o May be source of future debris.</li> <li>o May indicate larger area of distress.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause; monitor &amp; record changes.</li> <li>o Consider horizontal or underdrains.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid directing water into distressed area.</li> <li>o Do not remove vegetation unless a hazard to travelling public.</li> </ul>
F. Adjacent Land Use Changes, Construction, Mining, Logging, etc.	<ul style="list-style-type: none"> <li>o May be cause of distress.</li> <li>o Changes from agricultural to industrial, or commercial to urban may cause increased runoff.</li> <li>o May indicate changed drainage.</li> <li>o Debris may come from equipment disturbance.</li> </ul>	<ul style="list-style-type: none"> <li>o Contact supervisor and/or owner.</li> <li>o Consider restraining structures, berms, fences, K-rail, etc.</li> <li>o Consider rerouting traffic.</li> <li>o Drain properly.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not block drainage with retaining structures.</li> </ul>

Note: 1) Always evaluate safety first, don't assume it's safe.  
 2) Determine type of debris - rock, rock and soil, etc. - to help establish source; look for more loose debris before cleaning up roadway.

Table 1c. Preslide symptoms:  
Tilting features, such as trees, poles  
fences, walls or rails.

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Surface Cracking in Surrounding Areas	<ul style="list-style-type: none"> <li>o Allows water infiltration.</li> <li>o May outline limits of distress.</li> <li>o May indicate potential major movement.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause of cracking.</li> <li>o Record size, location, &amp; extent; periodically monitor.</li> <li>o Consider sealing cracks.</li> <li>o Monitor for roadway movement with pins and record.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid loading of distressed area.</li> </ul>
B. Blocked, Leaking or Otherwise Malfunctioning Drainage; Septic Systems Outside R/W	<ul style="list-style-type: none"> <li>o May add water to the problem area.</li> <li>o May be the cause of the problems.</li> <li>o May cause future problem.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause.</li> <li>o Properly drain.</li> <li>o Redirect water if practical.</li> <li>o Seek advice.</li> <li>o Reconstruct or protect eroded area if practical.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not direct water towards problem area.</li> <li>o Do not over excavate when cleaning drainage.</li> </ul>
C. Erosion by Natural Drainage (Including stream flow, springs, lakes, and channel changes)	<ul style="list-style-type: none"> <li>o May be the cause of distress.</li> <li>o Unless altered may reoccur or progress to travel way.</li> <li>o May be adding water to distressed area.</li> <li>o Constructed side slopes may be too steep.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record changes in distress.</li> <li>o Monitor &amp; record changes in water volume, color, or level.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid sudden change in water levels where controllable.</li> <li>o Avoid blocking natural drainage courses or springs.</li> <li>o Avoid removal of beneficial vegetation.</li> </ul>
D. Bulging or Slope Movement	<ul style="list-style-type: none"> <li>o May indicate location of movement.</li> <li>o May indicate swelling soils.</li> <li>o May indicate frost heave areas.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record locations, changes in size or shape.</li> <li>o Be prepared to close road if changing rapidly.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not disturb until stability evaluated.</li> <li>o Avoid loading distressed area.</li> <li>o Do not remove shrubs, bushes, grasses, etc.</li> </ul>
E. Wasting of Materials on Slope (side casting)	<ul style="list-style-type: none"> <li>o May be causing settlement.</li> <li>o May block natural or designed drainage.</li> <li>o May cause moisture to collect, i.e., snow melt or rainfall collection.</li> </ul>	<ul style="list-style-type: none"> <li>o Remove existing waste material if practical.</li> <li>o Properly drain.</li> <li>o Use designated waste areas.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid wasting or stock piling material at this location.</li> </ul>
F. Adjacent Land Use Changes, Construction, Mining, Logging, etc.	<ul style="list-style-type: none"> <li>o May be cause of distress.</li> <li>o Changes from agricultural to industrial or commercial to urban may cause increased runoff.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate activities and contact supervisor, and/or owner.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not grant access or permits within the distressed area.</li> </ul>

28

Note: 1) Always evaluate safety first, don't assume it's safe.  
2) Consider removing only those features hazardous to travelling public.

Table 1d. Preslide symptoms:

Uplifting of roadways.

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Surface Cracking in Surrounding Areas	<ul style="list-style-type: none"> <li>o Allows water infiltration.</li> <li>o May outline limits of distress.</li> <li>o May indicate potential major movement.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause of cracking.</li> <li>o Record size, location, &amp; extent; periodically monitor.</li> <li>o Consider sealing cracks.</li> <li>o Monitor for roadway movement with pins and record.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid loading of distressed area.</li> </ul>
B. Blocked, Leaking or Otherwise Malfunctioning Drainage or Septic Systems Outside R/W	<ul style="list-style-type: none"> <li>o May add water to the problem area.</li> <li>o May be the cause of the problems.</li> <li>o May cause future problem.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause.</li> <li>o Properly drain.</li> <li>o Redirect water if practical.</li> <li>o Seek advice.</li> <li>o Reconstruct or protect eroded area if practical.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not direct water towards problem area.</li> <li>o Do not over excavate when cleaning drainage.</li> </ul>
C. Tilting Features Such as Trees, Poles, Fences Walls, or Rails	<ul style="list-style-type: none"> <li>o May indicate movements and outline limits of distress area.</li> <li>o May indicate changed drainage conditions, surface or subsurface.</li> <li>o May indicate overloading of adjacent areas.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause; monitor &amp; record changes.</li> <li>o Consider horizontal or underdrains.</li> <li>o Remove material causing adjacent overload if practical.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid directing water into distressed area.</li> <li>o Do not remove vegetation unless a hazard to travelling public.</li> </ul>
D. Bulging or Slope Movement	<ul style="list-style-type: none"> <li>o May indicate location of movement.</li> <li>o May indicate swelling soils.</li> <li>o May indicate frost heave areas.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record locations, changes in size or shape.</li> <li>o Be prepared to close road if changing rapidly.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not disturb until stability evaluated.</li> <li>o Avoid loading distressed area.</li> <li>o Do not remove shrubs, bushes, grasses, etc.</li> </ul>
E. Debris on Roadway	<ul style="list-style-type: none"> <li>o May indicate erosion or freeze-thaw action.</li> <li>o May indicate slope failure above road.</li> <li>o May indicate near future movement and debris.</li> <li>o May indicate ongoing work above roadway.</li> </ul>	<ul style="list-style-type: none"> <li>o Remove debris from roadway.</li> <li>o Investigate cause; monitor &amp; record.</li> <li>o Reestablish vegetation.</li> <li>o Drain properly.</li> <li>o Consider retaining structures, i.e, fences, berms, etc.</li> <li>o If debris continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Remove only as necessary.</li> <li>o Do not undercut slope to increase storage area.</li> <li>o Do not waste material on slopes (side cast).</li> </ul>
F. Adjacent Land Use Changes, Construction, Mining, Logging, etc.	<ul style="list-style-type: none"> <li>o May be cause of distress.</li> <li>o Changes from agricultural to industrial or commercial to urban may cause increased runoff.</li> </ul>	<ul style="list-style-type: none"> <li>o Consider ramping over uplift or rerouting traffic.</li> <li>o Contact supervisor and/or owner.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid overloading when ramping over--additional sliding may result.</li> </ul>

29

Note: 1) Always evaluate safety first, don't assume it's safe.  
 2) May be toe of a slide up slope from roadway.  
 Consider ramping over, do not cut until evaluated.

Table 1e. Preslide symptoms:  
Cracking of pavement, shoulders, ditches,  
or adjacent areas.

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Blocked, Leaking or Otherwise Malfunctioning Drainage; Septic Systems Outside R/W	<ul style="list-style-type: none"> <li>o May add water to the problem area.</li> <li>o May be the cause of the problems.</li> <li>o May cause future problem.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause.</li> <li>o Properly drain.</li> <li>o Redirect water if practical.</li> <li>o Seek advice.</li> <li>o Reconstruct or protect eroded area if practical.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not direct water towards problem area.</li> <li>o Do not overexcavate when cleaning drainage.</li> </ul>
B. Slope Cracking	<ul style="list-style-type: none"> <li>o May outline distress limits.</li> <li>o May be first indication of major movements.</li> <li>o May be removing roadway support causing cracking.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause of cracking.</li> <li>o Record size, location, &amp; extent; periodically monitor.</li> <li>o Consider sealing cracks.</li> <li>o Monitor for roadway movement with pins and record.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid directing water to distressed areas.</li> <li>o Avoid removing vegetation; shrubs, brushes, grasses, etc.</li> <li>o Avoid dumping waste material in distressed area.</li> </ul>
C. Erosion by Natural Drainage (Including stream flow, springs, lakes, and channel changes)	<ul style="list-style-type: none"> <li>o May indicate deteriorated pipes or structures.</li> <li>o May indicate new springs or drainages.</li> </ul>	<ul style="list-style-type: none"> <li>o Repair erosion, if practical.</li> <li>o Properly drain.</li> <li>o Be prepared to close road if changing rapidly.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid sudden change in water levels where controllable.</li> <li>o Avoid blocking natural drainage courses or springs.</li> <li>o Avoid removal of beneficial vegetation.</li> </ul>
D. Bulging or Slope Movement	<ul style="list-style-type: none"> <li>o May indicate location of movement.</li> <li>o May indicate swelling soils.</li> <li>o May indicate frost heave areas.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record locations, and changes in size or shape.</li> <li>o Be prepared to close road if changing rapidly.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not disturb until stability evaluated.</li> <li>o Avoid loading distressed area.</li> <li>o Do not remove shrubs, bushes, grasses, etc.</li> </ul>
E. Wasting of Materials on Slope (side casting)	<ul style="list-style-type: none"> <li>o May be causing settlement.</li> <li>o May block natural or designed drainage.</li> <li>o May cause moisture to collect, i.e., snow melt or rainfall collection.</li> </ul>	<ul style="list-style-type: none"> <li>o Remove existing waste material if practical.</li> <li>o Properly drain.</li> <li>o Use designated waste areas.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid wasting or stock piling material at this location.</li> </ul>
F. Tilting Features Such as Trees, Poles, Fences, Walls, or Rails	<ul style="list-style-type: none"> <li>o May indicate additional distress.</li> <li>o May indicate changed drainage surface or subsurface.</li> </ul>	<ul style="list-style-type: none"> <li>o Evaluate cause of tilting.</li> <li>o Consider horizontal or underdrains.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid directing water into distressed area.</li> <li>o Do not remove vegetation unless a hazard to travelling public.</li> </ul>

03

Note: 1) Always evaluate safety first, don't assume it's safe.  
2) Consider: Monitoring cracks for movement, sealing to keep water out.  
3) Rapidly changing cracks may indicate imminent future movement of a larger extent.

Table 1f. Preslide symptoms:

Changes in drainage

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Blocked Drainage--Culverts, Entrances, Outlets or Inside, Ditches; Underdrains, Horizontal Drains, Natural Drains, Creeks, Gulleys, Springs	<ul style="list-style-type: none"> <li>o May add water to the problem area.</li> <li>o May be the cause of the problems.</li> <li>o May cause future problem.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause, and correct drainage.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not direct water into distress area.</li> <li>o Do not overexcavate when cleaning drainage.</li> </ul>
B. Leaking Drainage - Pipe Separation Lined Ditch Joints, Septic Systems Outside R/W	<ul style="list-style-type: none"> <li>o May be adding water to problem area.</li> <li>o May cause future distress.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause, and correct drainage.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not reroute where additional distress will result.</li> </ul>
C. Rerouted Drainage	<ul style="list-style-type: none"> <li>o May add water to problem.</li> <li>o May cause additional distress.</li> </ul>	<ul style="list-style-type: none"> <li>o Evaluate new route; correct if necessary.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not direct water into distress areas.</li> </ul>
D. Raised or Lowered Roadway Shoulder, Guard Rail, or Adjacent Areas Such as Walls, Fences, Poles, or Rails	<ul style="list-style-type: none"> <li>o May block drainage.</li> <li>o May separate drain pipe.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause; monitor &amp; record.</li> <li>o Drain properly.</li> <li>o Consider traffic realignment.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not cut or fill grade until cause evaluated.</li> </ul>
E. Surface Cracking in Surrounding Areas	<ul style="list-style-type: none"> <li>o Allows water infiltration.</li> <li>o May outline limits of distress.</li> <li>o May indicate potential major movement.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause of cracking.</li> <li>o Record size, location, &amp; extent; periodically monitor.</li> <li>o Consider sealing cracks.</li> <li>o Monitor for roadway movement with pins and record.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid loading of distressed area.</li> </ul>
F. Vegetation Changes Such As: Tilting, Dying, New Green Areas, New Cat Tail Locations	<ul style="list-style-type: none"> <li>o May indicate slope movement.</li> <li>o May indicate changed drainage conditions, surface or subsurface.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate cause; monitor &amp; record changes.</li> <li>o Consider horizontal or underdrains.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid directing water into distressed area.</li> <li>o Do not remove vegetation unless a hazard to travelling public.</li> </ul>
G. Bulging or Slope Movement	<ul style="list-style-type: none"> <li>o May indicate location of distress.</li> <li>o May indicate swelling soils.</li> <li>o May indicate frost heave areas.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record locations, and changes in size or shape.</li> <li>o Be prepared to close road if changing rapidly.</li> <li>o If movement continues, seek help.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not disturb until stability evaluated.</li> <li>o Avoid loading distressed area.</li> <li>o Do not remove shrubs, bushes, grasses, etc.</li> </ul>
H. Adjacent Land Use Changes, Construction, Mining, Logging, etc.	<ul style="list-style-type: none"> <li>o May be cause of distress.</li> <li>o Agricultural to industrial or commercial to urban--increased runoff.</li> </ul>	<ul style="list-style-type: none"> <li>o Investigate activities &amp; notify supervisor, and/or owner.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not grant access or permits within the distressed area.</li> </ul>
I. Springs - New, Discolored or Changed Volume	<ul style="list-style-type: none"> <li>o May develop from changed drainage.</li> </ul>	<ul style="list-style-type: none"> <li>o Drain properly.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid wasting in drainages or spring areas.</li> </ul>

Note: 1) Always evaluate safety first, don't assume it's safe.  
2) Avoid ponding of water.

Table 2a. Slides and rockfall features:  
Rockfall from massive rock slopes.

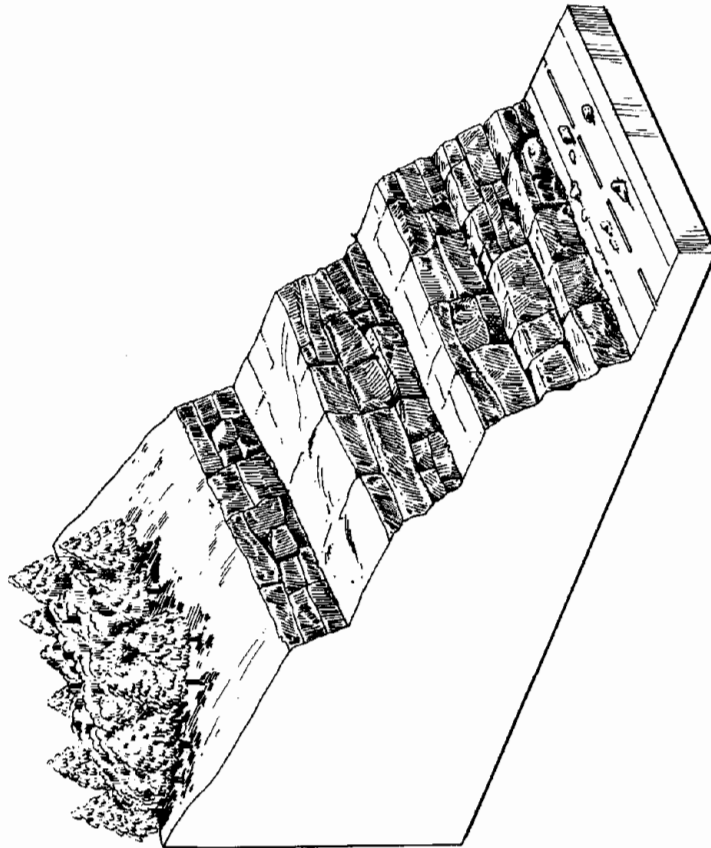




Table 2a. Slides and rockfall features:

Rockfall from massive rock slopes.

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Individual rocks or groups of rock on roadway.	o More debris may fall in future.	o Consider scaling prior to working under slope, or to minimize future uncontrolled rockfall. o Remove rockfall as necessary.	o Avoid wasting rockfall on fill slopes. o Avoid undercutting slope when cleaning ditch or to increase storage area.
B. Debris at toe of slope, or on slope.	o Expect more debris.	o Consider scaling prior to working under slope, or to minimize future uncontrolled rockfall. o Remove rockfall as necessary.	o Avoid wasting rockfall on fill slopes. o Avoid undercutting slope when cleaning ditch or to increase storage area.
C. Irregular slope surfaces with projecting rocks. Rocks being exposed more and more.	o Expect additional rockfall. o Rock exposures may indicate the beginning of a slide.	o Consider scaling prior to working under slope, or to minimize future uncontrolled rockfall. o Remove rockfall as necessary.	o Avoid wasting rockfall on fill slopes. o Avoid undercutting slope when cleaning ditch or to increase storage area.
D. Lighter or darker areas on slope.	o May be source of rockfall.	o Consider scaling prior to working under slope, or to minimize future uncontrolled rockfall. o Remove rockfall as necessary.	o Avoid wasting rockfall on fill slopes. o Avoid undercutting slope when cleaning ditch or to increase storage area.
E. Ground cracking around rock source area.	o May outline disturbed areas which may yield future rockfall.	o Monitor & record size, location.	o Do not obliterate.
F. Adjacent land use changes logging, construction, mining, etc.	o May be source of rockfall. o Expect additional rockfall until use changes.	o Contact your supervisor and/or land owner.	

Note: 1) Always evaluate safety first, don't assume it safe.  
2) Consider rockfall protection system: berms, ditches, fences, slope drapes, bolting, widening at grade, etc.

Table 2b. Slides and rockfall features:  
Rockfall from differential weathering.

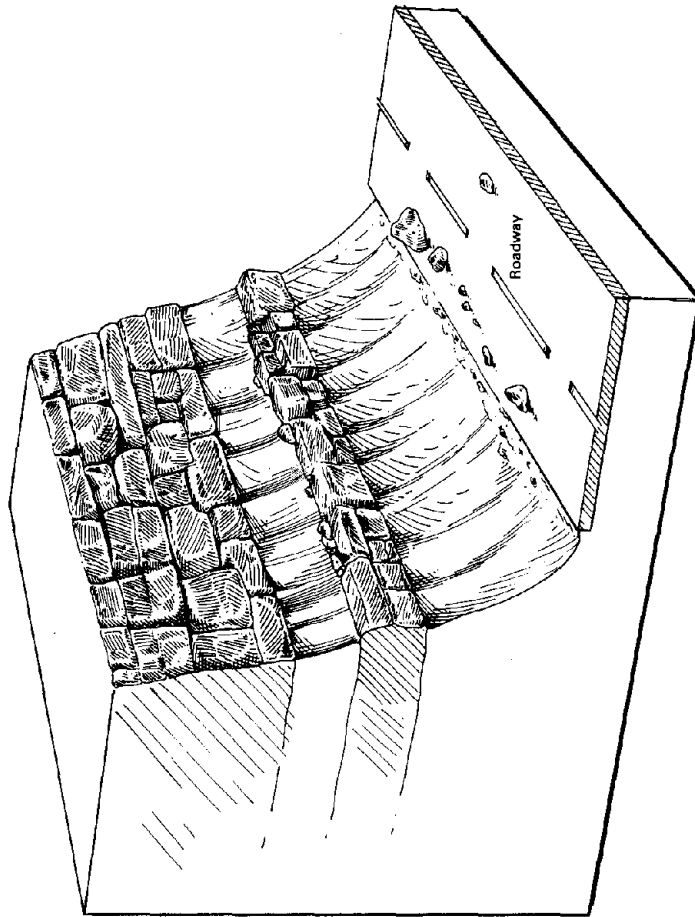
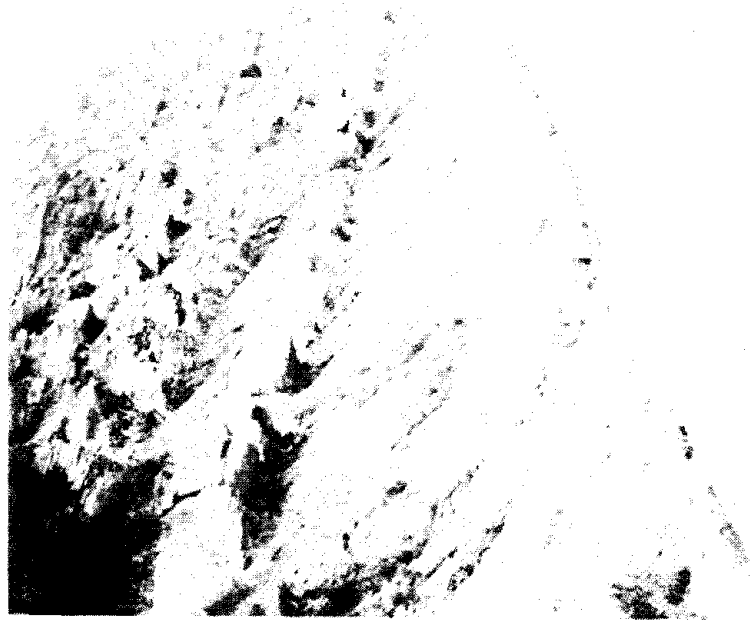


Table 2b. Slides and rockfall features:

Rockfall from differential weathering.

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Individual rocks or groups of rock on roadway.	o More debris may fall in future.	o Consider scaling prior to working under slope, or to minimize future uncontrolled rockfall. o Remove rockfall as necessary.	o Avoid wasting rockfall on fill slopes. o Avoid undercutting slope when cleaning ditch or to increase storage area.
B. Debris at toe of slope, or on slope.	o More debris may fall in future.	o Consider scaling prior to working under slope, or to minimize future uncontrolled rockfall. o Remove rockfall as necessary.	o Avoid wasting rockfall on fill slopes. o Avoid undercutting slope when cleaning ditch or to increase storage area.
35 C. Irregular surfaces projecting or over hanging rocks.	o More debris may fall in future.	o Consider scaling prior to working under slope, or to minimize future uncontrolled rockfall. o Remove rockfall as necessary.	o Avoid wasting rockfall on fill slopes. o Avoid undercutting slope when cleaning ditch or to increase storage area.
D. Lighter or darker areas on slope.	o More debris may fall in future. o May indicate sources of debris and may establish rate of erosion or weathering.	o Consider scaling prior to working under slope, or to minimize future uncontrolled rockfall. o Remove rockfall as necessary.	o Avoid wasting rockfall on fill slopes. o Avoid undercutting slope when cleaning ditch or to increase storage area.
E. Erosion	o More debris may fall in future. o Soft areas of slope may be eroding leaving the rocks to fall down slope. o May result from inadequate or nonfunctioning drainage system.	o Remove rockfall as necessary. o Repair or improve drainage. o Seek advice for slope protection.	o Avoid wasting rockfall on fill slopes. o Avoid undercutting slope when cleaning ditch or to increase storage area. o Do not block drainage.

Note: 1) Always evaluate safety first, don't assume it safe.  
2) Consider rockfall protection system: berms, ditches, fences, slope drapes, bolting, widening at grade, etc.

Table 2c. Slides and rockfall features:  
Rockfall from a talus slope.

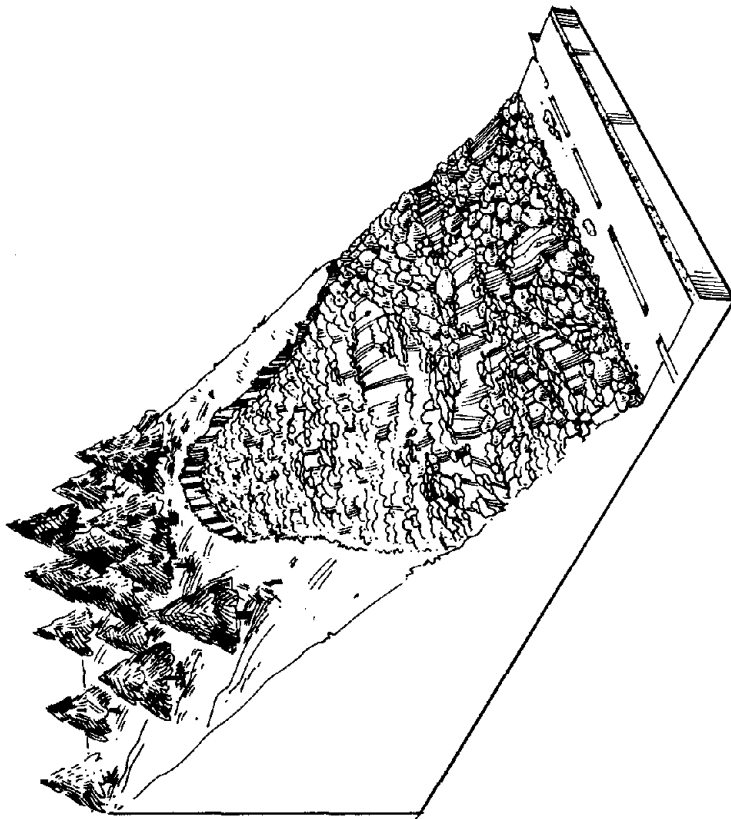


Table 2c. Slides and rockfall features:

Rockfall from a talus slope.

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Rock and dirt piled on roadway.	<ul style="list-style-type: none"> <li>o May indicate instability. Rockfall may be warning of larger slide.</li> <li>o More debris may fall in future.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record location.</li> <li>o Be prepared to close road and remove rockfall as necessary.</li> <li>o Properly drain.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid wasting material on fill slopes.</li> <li>o Avoid undercutting slope when cleaning ditch or to increase storage area.</li> <li>o Don't block drainage.</li> </ul>
B. Loose debris on slope.	<ul style="list-style-type: none"> <li>o May indicate instability. Rockfall may be warning of larger slide.</li> <li>o More debris may fall in future.</li> <li>o Could be sources of rockfall.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record location.</li> <li>o Be prepared to close road and remove rockfall as necessary.</li> <li>o Consider scaling prior to working under slope, or to minimize future uncontrolled rockfall.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid wasting material on fill slopes.</li> <li>o Avoid undercutting slope when cleaning ditch or to increase storage area.</li> <li>o Don't block drainage.</li> </ul>
C. Lighter or darker areas on slope.	<ul style="list-style-type: none"> <li>o May indicate instability. Rockfall may be warning of larger slide.</li> <li>o More debris may fall in future.</li> <li>o Could be sources of rockfall.</li> <li>o May indicate changed water conditions.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record location.</li> <li>o Properly drain.</li> </ul>	
37 D. Tilted features, such as trees, poles, fences, walls	<ul style="list-style-type: none"> <li>o May indicate instability. Rockfall may be warning of larger slide.</li> <li>o More debris may fall in future.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record location.</li> <li>o Consider scaling prior to working under slope, or to minimize future uncontrolled rockfall.</li> </ul>	<ul style="list-style-type: none"> <li>o Don't block drainage.</li> </ul>
E. Springs & vegetation changes.	<ul style="list-style-type: none"> <li>o May indicate instability. Rockfall may be warning of larger slide.</li> <li>o More debris may fall in future.</li> <li>o May indicate changed water conditions.</li> <li>o May cause instability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record location.</li> <li>o Properly drain.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Don't block drainage.</li> </ul>
F. Blocked drainage or changes in drainage.	<ul style="list-style-type: none"> <li>o May indicate instability. Rockfall may be warning of larger slide.</li> <li>o More debris may fall in future.</li> <li>o May cause instability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record location.</li> <li>o Be prepared to close road and remove rockfall as necessary.</li> <li>o Properly drain.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid wasting material on fill slopes.</li> <li>o Avoid undercutting slope when cleaning ditch or to increase storage area.</li> </ul>
G. Adjacent land use changes logging, mining, construction, etc.	<ul style="list-style-type: none"> <li>o May indicate instability. Rockfall may be warning of larger slide.</li> <li>o More debris may fall in future.</li> <li>o Could be sources of rockfall.</li> <li>o May cause instability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor &amp; record location.</li> <li>o Be prepared to close road and remove rockfall as necessary.</li> <li>o Properly drain.</li> <li>o Contact your supervisor and/or land owner.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid wasting material on fill slopes.</li> <li>o Avoid undercutting slope when cleaning ditch or to increase storage area.</li> <li>o Don't block drainage.</li> </ul>

Note: 1) Always evaluate safety first, don't assume it safe.  
 2) Consider rockfall protection system: berms, ditches, fences, slope drapes, bolting, widening at grade, etc.

Table 2d. Slides and rockfall features:  
Type A slide above road -- mudflow.

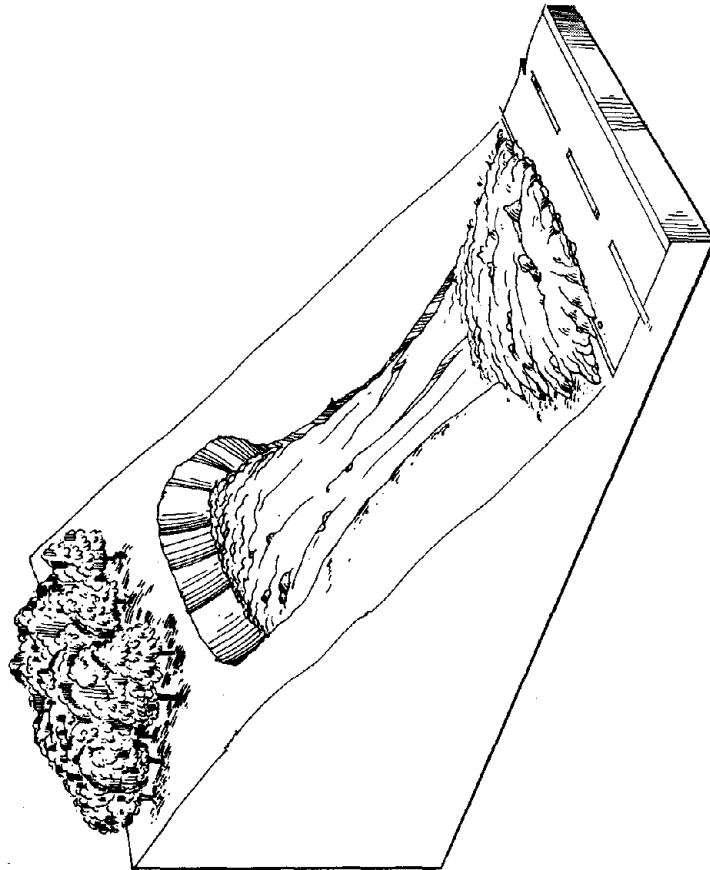


Table 2d. Slides and rockfall features:

Type A slide above road -- mudflow.

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Wet muddy soil mass with or without rock and/or vegetation flowing onto the roadway.	<ul style="list-style-type: none"> <li>o May be a large unstable mass still to come down.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Drain properly.</li> </ul>	<ul style="list-style-type: none"> <li>o Stay out from under until stability evaluated.</li> <li>o Avoid wasting flow material on fill slopes.</li> </ul>
B. Bulging or surface waves.	<ul style="list-style-type: none"> <li>o May be a large unstable mass still to come down.</li> <li>o May indicate saturated mass that will become a liquid flow.</li> <li>o May indicate further water sources or outlets.</li> <li>o May indicate a larger possible failure area.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Monitor for changes. If rapidly changing, evacuate area beneath; be prepared to close road.</li> <li>o Drain properly.</li> </ul>	<ul style="list-style-type: none"> <li>o Stay out from under until stability evaluated.</li> <li>o Do not disturb until stability evaluated.</li> </ul>
C. Blocked drainage.	<ul style="list-style-type: none"> <li>o May be causing bulging.</li> <li>o May make mass soupy, allowing it to flow downhill.</li> <li>o May be contributing water and thus to loss of stability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Drain properly.</li> </ul>	
D. Springs.	<ul style="list-style-type: none"> <li>o May be a large unstable mass still to come down.</li> <li>o May indicate saturated mass that will become a liquid flow.</li> <li>o May be causing bulging.</li> <li>o May make mass soupy, allowing it to flow downhill.</li> <li>o May indicate a larger possible failure area.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Monitor for changes. If rapidly changing, evacuate area beneath, be prepared to close road.</li> <li>o Drain properly.</li> </ul>	
E. Green grass during inappropriate time of year.	<ul style="list-style-type: none"> <li>o May be a large unstable mass still to come down.</li> <li>o May indicate saturated mass that will become a liquid flow.</li> <li>o May indicate further water sources or outlets.</li> <li>o May indicate a larger possible failure area.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> </ul>	
F. Adjacent land use changes Logging, Mining, Construction etc.	<ul style="list-style-type: none"> <li>o May be a large unstable mass still to come down.</li> <li>o May be cause of bulging.</li> <li>o May make mass soupy allowing it to flow downhill.</li> <li>o May be contributing water and to loss of stability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Monitor for changes. If rapidly changing, evacuate area beneath, be prepared to close road.</li> <li>o Drain properly.</li> <li>o Contact your supervisor and/or land owner.</li> </ul>	<ul style="list-style-type: none"> <li>o Stay out from under until stability evaluated.</li> <li>o Avoid wasting flow material on fill slopes.</li> </ul>
G. Tilted features, such as trees, poles, walls, fences	<ul style="list-style-type: none"> <li>o May be a large unstable mass still to come down.</li> <li>o May indicate saturated mass that will become a liquid flow.</li> <li>o May indicate further water sources or outlets.</li> <li>o May be contributing water and to loss of stability.</li> <li>o May indicate a larger possible failure area.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Monitor for changes. If rapidly changing, evacuate area beneath, be prepared to close road.</li> </ul>	<ul style="list-style-type: none"> <li>o Stay out from under until stability evaluated.</li> <li>o Avoid wasting flow material on fill slopes.</li> </ul>

Note: 1) Always evaluate safety first, don't assume it safe.  
2) Be prepared for additional material on roadway.

Table 2e. Slides and rockfall features:  
Type B slide above road --- wedge.

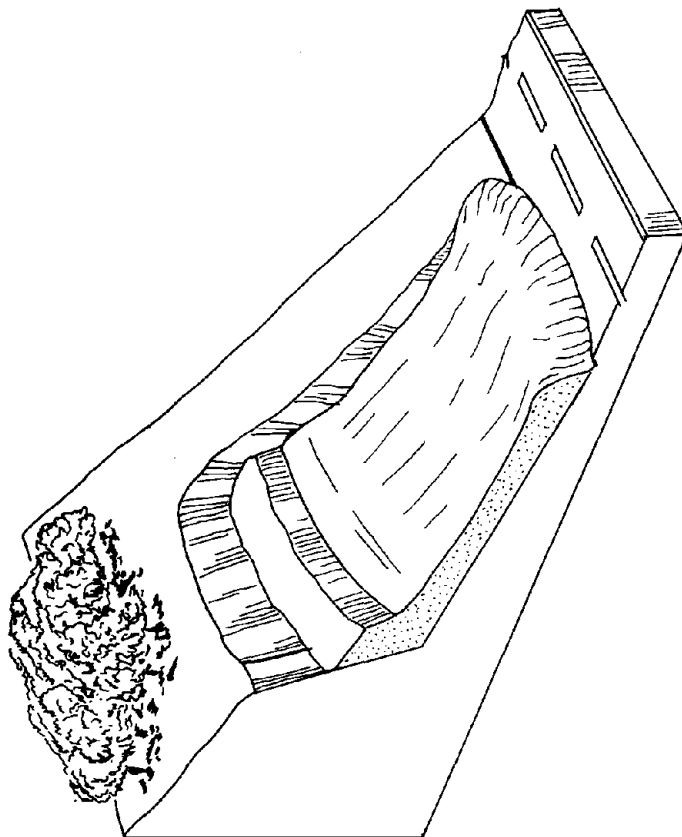




Table 2e. Slides and rockfall features:

Type B slide above road -- wedge

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Soil and/or rock and/or vegetation on roadway.	<ul style="list-style-type: none"> <li>o May result from inadequate or non-functioning drainage systems.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid wasting material on fill slopes.</li> <li>o Do not work under until stability evaluated.</li> </ul>
B. Ground cracking in surrounding area.	<ul style="list-style-type: none"> <li>o May indicate additional unstable area.</li> <li>o May be contributing water and to loss of stability.</li> <li>o May result from inadequate or non-functioning drainage systems.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Properly drain.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not work under until stability evaluated.</li> </ul>
14 C. Tilted features, such as trees, poles, walls, fences	<ul style="list-style-type: none"> <li>o May indicate additional unstable area.</li> <li>o May result from inadequate or non-functioning drainage systems.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Consider removing tilted trees.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not work under until stability evaluated.</li> </ul>
D. Springs	<ul style="list-style-type: none"> <li>o May be cause of slide and/or make problem worse.</li> <li>o May be contributing water and thus to loss of stability.</li> <li>o May result from inadequate or non-functioning drainage systems.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Properly drain.</li> <li>o Seek advice.</li> </ul>	
E. Blocked drainage.	<ul style="list-style-type: none"> <li>o May be cause of slide and/or make problem worse.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Properly drain.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid wasting material on fill slopes.</li> </ul>
F. Adjacent land use changes, i.e., logging, mining, construction, etc.	<ul style="list-style-type: none"> <li>o May be cause of slide and/or make problem worse.</li> <li>o May be contributing water and thus to loss of stability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Properly drain.</li> <li>o Contact supervisor and/or land owner.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid wasting material on fill slopes.</li> <li>o Do not work under until stability evaluated.</li> </ul>

Note: 1) Always evaluate safety first, don't assume it safe.  
 2) Be prepared for additional material on roadway.

Table 2f. Slides and rockfall features:  
Type C slide above road -- rotational.

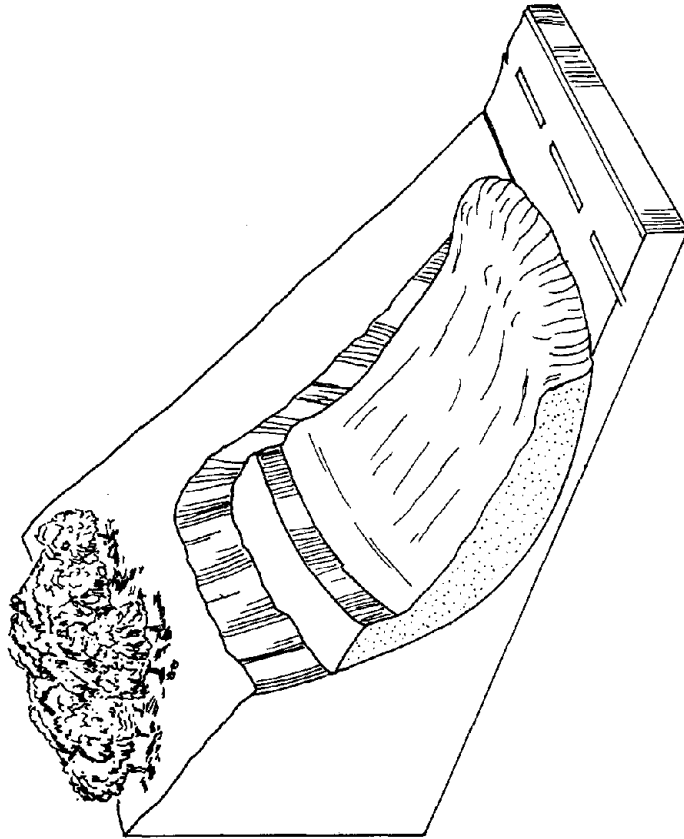


Table 2f. Slides and rockfall features:

Type C slide above road -- rotational.

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Roadway pushing up. Pavement elevation rising.	<ul style="list-style-type: none"> <li>o May indicate unstable slope above roadway.</li> <li>o May indicate additional unstable area.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes. If moving rapidly, be prepared to close road.</li> <li>o Properly drain.</li> <li>o Provide for adequate traffic movement.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid cutting push up, consider ramping over.</li> </ul>
B. Surface cracking - in surrounding area.	<ul style="list-style-type: none"> <li>o May indicate unstable slope above roadway.</li> <li>o May indicate additional unstable area.</li> <li>o May contribute water and to loss of stability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes. If moving rapidly, be prepared to close road.</li> <li>o Properly drain.</li> <li>o Provide for adequate traffic movement.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid disturbing until stability evaluated.</li> </ul>
C. Springs.	<ul style="list-style-type: none"> <li>o May indicate unstable slope above roadway.</li> <li>o May indicate additional unstable area.</li> <li>o May contribute water and to loss of stability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes. If moving rapidly, be prepared to close road.</li> <li>o Properly drain.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid disturbing until stability evaluated.</li> </ul>
43 D. Bulging or surface waves in slope.	<ul style="list-style-type: none"> <li>o May indicate unstable slope above roadway.</li> <li>o May indicate additional unstable area.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes. If moving rapidly, be prepared to close road.</li> <li>o Properly drain.</li> <li>o Provide for adequate traffic movement.</li> </ul>	
E. Tilted features, such as trees, poles, walls, fences	<ul style="list-style-type: none"> <li>o May indicate unstable slope above roadway.</li> <li>o May indicate additional unstable area.</li> <li>o May contribute water and to loss of stability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes. If moving rapidly, be prepared to close road.</li> <li>o Properly drain.</li> <li>o Seek advice.</li> </ul>	
F. Blocked drainage, etc.	<ul style="list-style-type: none"> <li>o May indicate unstable slope above roadway.</li> <li>o May be cause of distress.</li> <li>o May contribute water and to loss of stability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes. If moving rapidly, be prepared to close road.</li> <li>o Properly drain.</li> <li>o Provide for adequate traffic movement.</li> <li>o Seek advice.</li> </ul>	
G. Adjacent land use changes, i.e., logging, mining, construction, etc.	<ul style="list-style-type: none"> <li>o May be cause of distress.</li> </ul>	<ul style="list-style-type: none"> <li>o Contact supervisor and/or land owner.</li> </ul>	
H. Loose debris on slope.	<ul style="list-style-type: none"> <li>o May indicate unstable slope above roadway.</li> <li>o May indicate additional unstable area.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes. If moving rapidly, be prepared to close road.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid disturbing until stability evaluated.</li> </ul>

Note: 1) Always evaluate safety first, don't assume it safe.  
 2) Be prepared for additional material on roadway.

Table 2g. Slides and rockfall features:  
Type D slide above road -- blockslide.

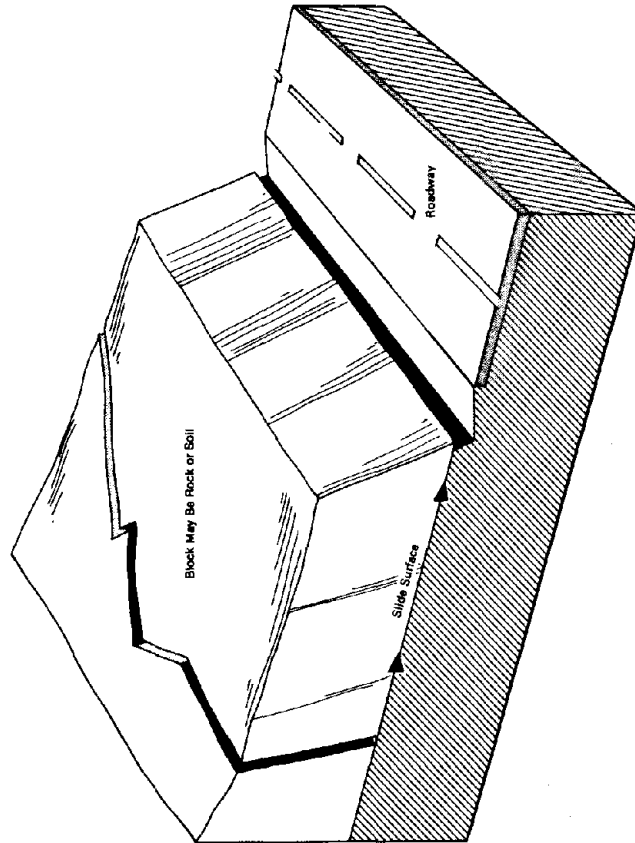


Table 2g. Slides and rockfall features:

Type D slide above road -- blockslide.

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Soil and/or rock on roadway.	o May indicate extensive distress.	o Monitor and record location. o Provide for adequate traffic movement. o Seek advice.	o Avoid working under until stability evaluated. o Avoid wasting material on fill slopes. o Avoid undercutting the slope during removal or ditch cleaning.
B. Springs	o May be cause of sliding.	o Monitor and record location. o Properly drain.	
C. Blocked drainage.	o May be cause of sliding.	o Monitor and record location. o Properly drain. o Provide for adequate traffic movement.	o Avoid wasting material on fill slopes. o Avoid undercutting the slope during removal or ditch cleaning.
D. Adjacent land use changes, i.e., logging, mining, construction, etc.	o May be cause of sliding.	o Monitor and record location. o Properly drain. o Provide for adequate traffic movement.	
E. Loose debris on remaining slope.	o May indicate extensive distress. o May indicate limits of distress.	o Monitor and record location. o Consider scaling. o Provide for adequate traffic movement.	o Avoid working under until stability evaluated. o Avoid wasting material on fill slopes.
F. Surface cracking in surrounding area.	o May indicate extensive distress. o May indicate limits of distress.	o Monitor and record location. o Properly drain. o Seek advice.	
G. Tilted features, such as trees, poles, walls, fences, etc.	o May indicate extensive distress. o May indicate limits of distress.	o Monitor and record location. o Provide for adequate traffic movement.	o Avoiding working under until stability evaluated. o Avoid undercutting the slope during removal or ditch cleaning.

Note: 1) Always evaluate safety first, don't assume it safe.  
2) Be prepared for additional material on roadway.

Table 2h. Slides and rockfall features:  
Type A slide below road -- mudflow.

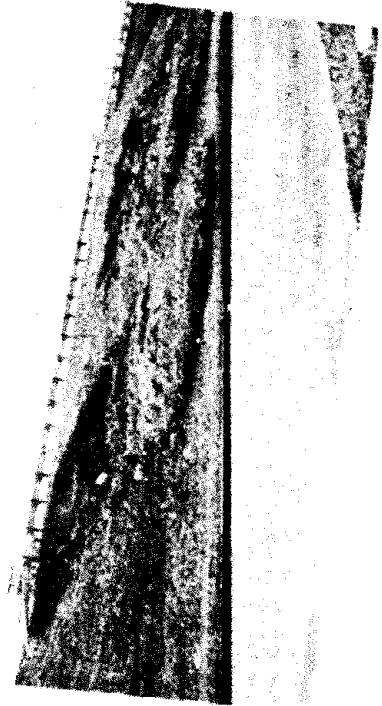
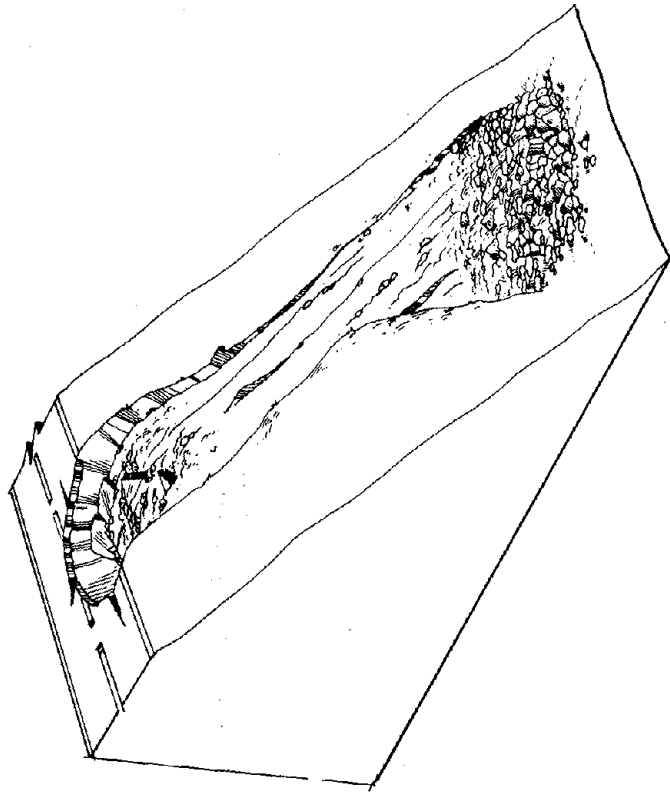


Table 2h. Slides and rockfall features:

Type A slide below road -- mudflow

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Wet muddy soil mass with or without rock and/or vegetation - moving downslope.	<ul style="list-style-type: none"> <li>o May progress up slope to roadway.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Monitor for changes. If rapidly changing, evacuate area beneath; be prepared to close road.</li> </ul>	<ul style="list-style-type: none"> <li>o Stay out from under until stability evaluated.</li> <li>o Do not disturb until stability evaluated.</li> </ul>
B. Bulging or surface waves.	<ul style="list-style-type: none"> <li>o May progress up slope to roadway.</li> <li>o May indicate saturated mass that will become a liquid flow.</li> <li>o May indicate further water sources or outlets.</li> <li>o May indicate a larger possible failure area.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Monitor for changes. If rapidly changing, evacuate area beneath; be prepared to close road.</li> <li>o Drain properly.</li> </ul>	<ul style="list-style-type: none"> <li>o Stay out from under until stability evaluated.</li> <li>o Do not disturb until stability evaluated.</li> </ul>
C. Blocked drainage.	<ul style="list-style-type: none"> <li>o May make mass soupy, allowing it to flow downhill.</li> <li>o May be contributing water and thus to loss of stability.</li> <li>o May be causing bulging.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Drain properly.</li> </ul>	
D. Springs.	<ul style="list-style-type: none"> <li>o May indicate saturated mass that will become a liquid flow.</li> <li>o May make mass soupy, allowing it to flow downhill.</li> <li>o May indicate a larger possible failure area.</li> <li>o May be contributing water and thus to loss of stability.</li> <li>o May be causing bulging.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Monitor for changes. If rapidly changing, evacuate area beneath; be prepared to close road.</li> <li>o Drain properly.</li> </ul>	
E. Green grass during inappropriate time of year.	<ul style="list-style-type: none"> <li>o May indicate saturated mass that will become a liquid flow.</li> <li>o May indicate further water sources or outlets.</li> <li>o May indicate a larger possible failure area.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Drain properly.</li> </ul>	
F. Adjacent land use changes, i.e., Logging, Mining, Construction etc.	<ul style="list-style-type: none"> <li>o May make mass soupy, allowing it to flow downhill.</li> <li>o May be cause of bulging or flow.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Drain properly.</li> <li>o Contact your supervisor and/or land owner.</li> </ul>	
G. Tilted features, such as trees, poles, walls, fences etc.	<ul style="list-style-type: none"> <li>o May progress up slope to roadway.</li> <li>o May indicate saturated mass that will become a liquid flow.</li> <li>o May indicate further water sources or outlets.</li> <li>o May indicate a larger possible failure area.</li> <li>o My be contributing water and thus to loss of stability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record location.</li> <li>o Monitor for changes. If rapidly changing, evacuate area beneath; be prepared to close road.</li> </ul>	<ul style="list-style-type: none"> <li>o Stay out from under until stability evaluated.</li> </ul>

Note: 1) Always evaluate safety first, don't assume it safe.  
 2) Be prepared to re-route or otherwise provide for traffic when roadway drops.

Table 2i. Slides and rockfall features:  
Type B slide below road -- wedge.

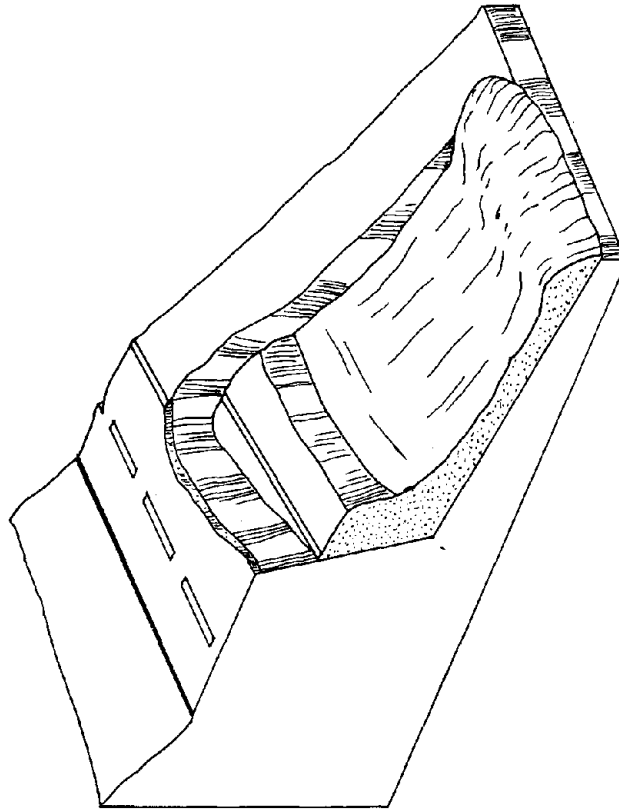




Table 2i. Slides and rockfall features:

Type B slide below road -- wedge.

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Roadway and/or guardrail dropped.	<ul style="list-style-type: none"> <li>o May result from inadequate or non-functioning drainage systems.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes.</li> <li>o Provide for adequate traffic movement.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not work under until stability evaluated.</li> <li>o Avoid loading the distressed area until evaluated.</li> </ul>
B. Surface cracking - in surrounding area.	<ul style="list-style-type: none"> <li>o May indicate additional unstable area.</li> <li>o May be contributing water and thus to loss of stability.</li> <li>o May result from inadequate or non-functioning drainage systems.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes.</li> <li>o Properly drain.</li> <li>o Provide for adequate traffic movement.</li> <li>o Consider sealing cracks.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not work under until stability evaluated.</li> <li>o Avoid loading the distressed area until evaluated.</li> </ul>
C. Tilted features, i.e., trees, poles, walls, fences, etc.	<ul style="list-style-type: none"> <li>o May indicate additional unstable area.</li> <li>o May result from inadequate or non-functioning drainage systems.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes.</li> </ul>	
D. Springs	<ul style="list-style-type: none"> <li>o May be cause of slide and/or make problem worse.</li> <li>o May be contributing water and thus to loss of stability.</li> <li>o May result from inadequate or non-functioning drainage systems.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes.</li> <li>o Properly drain.</li> <li>o Seek advice.</li> </ul>	
E. Blocked drained.	<ul style="list-style-type: none"> <li>o May be cause of slide and/or make problem worse.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes.</li> <li>o Properly drain.</li> <li>o Provide for adequate traffic movement.</li> </ul>	
F. Adjacent land use changes, i.e., logging, mining, construction, etc.	<ul style="list-style-type: none"> <li>o May be cause of slide and/or make problem worse.</li> <li>o May be contributing water and thus to loss of stability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes.</li> <li>o Contact supervisor and/or land owner.</li> </ul>	
G. Improper material wasting. (side casting)	<ul style="list-style-type: none"> <li>o May be cause of slide and/or make problem worse.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations and changes.</li> <li>o Seek advice.</li> <li>o Consider removing waste material where practical.</li> </ul>	<ul style="list-style-type: none"> <li>o Do not waste additional material in vicinity.</li> </ul>

Note: 1) Always evaluate safety first, don't assume it safe.  
 2) Be prepared to re-route or otherwise provide for traffic when roadway drops.

Table 2j. Slides and rockfall features:  
Type C slide below road -- rotational.

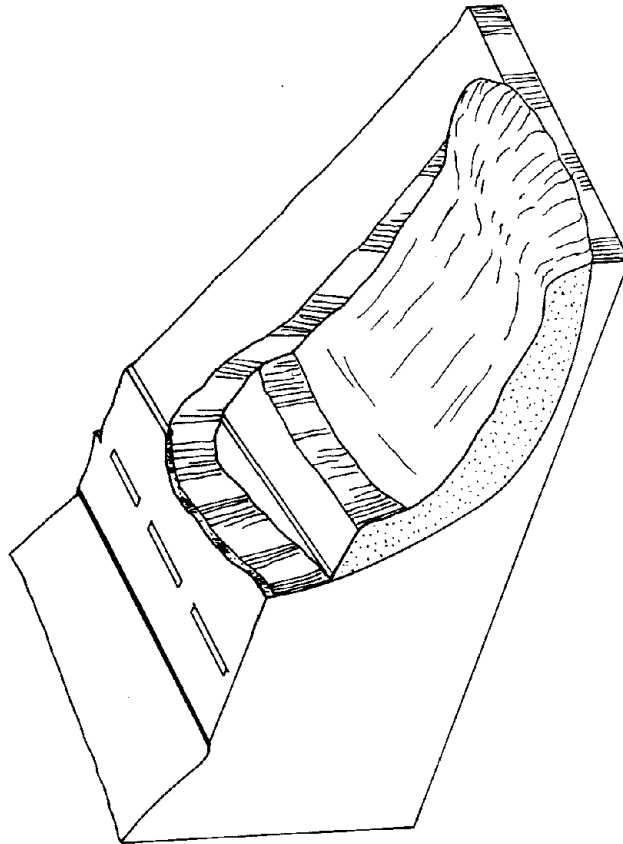


Table 2j. Slides and rockfall features:

Type C slide below road -- rotational

51

<u>THINGS TO LOOK FOR</u>	<u>SIGNIFICANCE OF OBSERVED FEATURE</u>	<u>COURSE OF ACTION</u>	<u>THINGS TO AVOID</u>
A. Roadway dropping and/or guardrail dropped.	<ul style="list-style-type: none"> <li>o May indicate extensive instability.</li> <li>o Allows water infiltration.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations.</li> <li>o Be prepared to close road.</li> <li>o Properly drain.</li> <li>o Provide for adequate traffic movement.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid loading distressed area until evaluated.</li> </ul>
B. Surface cracking in surrounding area.	<ul style="list-style-type: none"> <li>o May indicate extensive instability.</li> <li>o Allows water infiltration.</li> <li>o May indicate additional movement.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations.</li> <li>o Properly drain.</li> <li>o Consider sealing cracks.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid loading distressed until evaluated.</li> </ul>
C. Spring or wet spots.	<ul style="list-style-type: none"> <li>o May be cause of dropping.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations.</li> </ul>	<ul style="list-style-type: none"> <li>o Do <u>not</u> block outlet.</li> </ul>
D. Bulging or surface waves in slope below roadway.	<ul style="list-style-type: none"> <li>o May indicate extensive instability.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations.</li> <li>o Seek advice.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid loading distressed area until evaluated.</li> </ul>
E. Tilted features, such as trees, poles, walls, fences	<ul style="list-style-type: none"> <li>o May be cause of dropping.</li> <li>o May add water to problem area.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations.</li> <li>o Seek advice.</li> </ul>	
F. Blocked drainage.	<ul style="list-style-type: none"> <li>o May indicate extensive instability.</li> <li>o May indicate additional movement.</li> <li>o May be cause of problem.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations.</li> <li>o Seek advice.</li> <li>o Properly drain.</li> </ul>	<ul style="list-style-type: none"> <li>o Avoid loading distressed area until evaluated.</li> </ul>
G. Improper material wasting (cast casting).	<ul style="list-style-type: none"> <li>o Allows water infiltration.</li> <li>o May be cause of dropping.</li> <li>o May add water to problem area, snow melt, or rainfall collection.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations.</li> <li>o Properly drain.</li> <li>o Consider removing waste material</li> </ul>	<ul style="list-style-type: none"> <li>o Do <u>not</u> waste additional material in vicinity.</li> </ul>
H. Pushup at toe or below fill; bulge in toe of fill.	<ul style="list-style-type: none"> <li>o May indicate extensive ability.</li> <li>o May indicate additional movement.</li> </ul>	<ul style="list-style-type: none"> <li>o Monitor and record locations.</li> <li>o Provide for adequate traffic movement.</li> <li>o Seek advice.</li> </ul>	

Note: 1) Always evaluate safety first, don't assume it safe.  
 2) Be prepared to re-route or otherwise provide for traffic when roadway drops.

Chapter 5  
REPAIR AND RESTORATION TECHNIQUES WITH COST CONSIDERATIONS

Table #3 contains a list of slide repair and restoration techniques commonly used. The costs for the different slope repair and slide restoration techniques varies depending on the size of the failure, location, availability of materials, etc. Table 3 includes relative indications of costs for labor, equipment, and material (L--lowest, M--medium, H--highest) for each of the repair techniques. A relative cost is also indicated if the work is performed by contract rather than State forces.

It is recognized that each highway agency has its own approach to developing budgets, monitoring expenditures, delegation of the management level at which expenditures are authorized, etc. In slope repair and slide restoration, the cost generally falls into three broad categories:

1. Routine maintenance
2. Extraordinary maintenance after the problem occurs, and
3. Slide repair to restore to original condition.

Generally, routine maintenance is designed to control the natural deterioration of the facility. These costs are available to each highway agency through historical records.

When the deterioration at a specific site becomes accelerated, i.e., slide problem appears and extraordinary costs are incurred. Each highway agency should develop a mechanism to monitor the costs incurred at these sites. An inventory using the form in the Appendix can be modified and used for this purpose.

As the extraordinary maintenance costs approach the restoration costs or other conditions dictate, consideration of full restoration is advised.

Table 3. Repair and restoration techniques with relative costs.

I. Cut Slopes		Labor	Equip	Mat'l	Contract
A. Rock Slopes					
1. Barriers/Retaining Walls					
a)	Dirt Berm	L	M	L	M
b)	Chain Link Fence	L	L	L	L
c)	Double <u>+</u> Guardrail	L	L	L	M
d)	PCC Median Barrier	L	L	M	M
e)	Piles and Lagging	L	H	H	H
f)	Gabions	M	L	L	M
2. Slope Treatments					
a)	Wire Mesh	H	L	M	H
b)	Scaling-Water jet	H	M	L	H
c)	Pre Split (nonexplosive)	H	H	H	H
d)	Gunite	H	H	H	H
e)	Rock Bolts	H	H	H	H
II. Soil Slopes					
A. Barriers/Retaining Walls					
1.	PCC Median Barrier	L	L	M	M
2.	Piles and Lagging	L	H	H	H
3.	Gabions	M	L	L	M
4.	Cribbing	M	L	M	M
5.	Poured Concrete	H	H	H	H

Table 3. Repair and restoration techniques with relative costs (continued).

	Labor	Equip	Mat'l	Contract
<b>B. Slope Treatment</b>				
1. Flatten	M	H	-	M
2. Vegetation, Straw	H	M	M	M
3. Mix with Fly-Ash Lime or Cement	H	H	H	H
4. Bench	H	H	H	H
5. Do not Disturb	-	-	-	-
6. Horizontal Drain	M	H	L	M
7. Slope Reinforce	H	H	H	H
8. Pressure Injection	NA	NA	NA	H
9. Remove Sloughage	L	L	L	L
10. Rock Inlay	H	H	H	H
<b>C. Drainage</b>				
1. Interceptor Ditches	L	M	-	M
2. Dike at top of slope	L	M	-	M
3. Underdrain	M	M	H	H
4. Flumes and Channels (Lined)	H	H	H	H
5. Flexible Pipes	M	M	H	M
6. Well Points	M	H	H	H
7. Seal Cracks	L	H	L	M
<b>III. Fill Slopes</b>				
A. Divert surface water (Curbs, dikes etc.)	M	L	L	M
B. Remove subsurface water	M	H	L	H
C. Remove saturated material and stabilize or replace with suitable material	M	H	L	M

Table 3. Repair and restoration techniques with relative costs (continued).

III. Fill Slopes	Labor	Equip	Mat'l	Contract
D. Vegetate slope	M	M	M	M
E. Flatten slope or blanket with permeable material	M	H	L	M
F. Buttress	M	M	M	M
G. Utilize light weight fill in settlement areas	M	M	L	M

Note: Notify maintenance engineer and seek the advice of a geotechnical engineer for complex problems and when further soils information is required for study and analysis.

L = Low Cost  
M = Moderate Cost  
H = High Cost

Appendix

SLIDE INVENTORY/INSPECTION REPORT

- I. District \_\_\_\_\_
  - County \_\_\_\_\_
  - Route \_\_\_\_\_
  - Milepost/Station \_\_\_\_\_
  - Location \_\_\_\_\_
  - Date Discovered \_\_\_\_\_
  - AADT \_\_\_\_\_
  
- II. Type of Slide
  - A. Rockfall
    - 1) Massive Rock Slope
    - 2) Differential Weathering
    - 3) Talus
  
  - B. Slide Above Roadway
    - 1) Mud Flow
    - 2) Wedge
    - 3) Rotational
    - 4) Blockslide
  
  - C. Slide Below Roadway
    - 1) Mud Flow
    - 2) Wedge
    - 3) Rotational
  
- III. Contributing Factors
  - A. Subsurface Drainage
  - B. Surface Drainage
  - C. Broken Drainage Structures
  - D. Blocked Drainage Structures
  - E. Flooding/Washouts





C. Utilities Affected

1. None Observed or known
2. Gas Line \_\_\_\_\_ Size (If Known)
3. Water Line \_\_\_\_\_ Size (If Known)
4. Sewer Line \_\_\_\_\_ Size (If Known)
5. Telephone
  - a) Overhead
  - b) Underground
6. Electric
  - a) Overhead
  - b) Underground
7. Cable TV
8. Oil Pipeline
9. Other       (List)
10. \_\_\_\_\_
11. \_\_\_\_\_

D. Adjacent Properties Involved

1. Vacant Land
2. Residences
3. Businesses
4. Other Improvements       (List)
5. \_\_\_\_\_
6. \_\_\_\_\_

E. Maintenance Activity

1. None Required
2. Yearly
3. Monthly
4. Weekly
5. Daily
6. Road Closed
  - a) Permanent
  - b) Temporary (No. Times/Year)

- V. Additional Notes/Sketches  
(one or more pages in inventory)
  
- VI. Pictures  
(one or more pages in inventory)
  
- VII. Cross Section Sheet  
(one or more pages in inventory)

Example

CULVERT INVENTORY/INSPECTION REPORT

District        1  
County         Lincoln  
Route          20

Mile Point	Culvert Size	Culvert Type	Culvert Length	Date Inspected/B	Comments
2.7	18"	B.C.C.M.P	36'	1/15/85 CHB	Outlet Channel Blocked
3.9	10 x 10	R.C.B.C	60'	1/15/85 CHB	Good Cond.
5.7	36"	R.C.P	40'	1/15/85 CHB	Joints Separated
10.3	17 x 13	C.A.P	36'	1/15/85 CHP	1/2 Silted

## FEDERALLY COORDINATED PROGRAM (FCP) OF HIGHWAY RESEARCH, DEVELOPMENT, AND TECHNOLOGY

The Offices of Research, Development, and Technology (RD&T) of the Federal Highway Administration (FHWA) are responsible for a broad research, development, and technology transfer program. This program is accomplished using numerous methods of funding and management. The efforts include work done in-house by RD&T staff, contracts using administrative funds, and a Federal-aid program conducted by or through State highway or transportation agencies, which include the Highway Planning and Research (HP&R) program, the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board, and the one-half of one percent training program conducted by the National Highway Institute.

The FCP is a carefully selected group of projects, separated into broad categories, formulated to use research, development, and technology transfer resources to obtain solutions to urgent national highway problems.

The diagonal double stripe on the cover of this report represents a highway. It is color-coded to identify the FCP category to which the report's subject pertains. A red stripe indicates category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, and green for category 9.

### *FCP Category Descriptions*

- 1. Highway Design and Operation for Safety**  
Safety RD&T addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act. It includes investigation of appropriate design standards, roadside hardware, traffic control devices, and collection or analysis of physical and scientific data for the formulation of improved safety regulations to better protect all motorists, bicycles, and pedestrians.
- 2. Traffic Control and Management**  
Traffic RD&T is concerned with increasing the operational efficiency of existing highways by advancing technology and balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, coordinated signal timing, motorist information, and rerouting of traffic.
- 3. Highway Operations**  
This category addresses preserving the Nation's highways, natural resources, and community attributes. It includes activities in physical

maintenance, traffic services for maintenance zoning, management of human resources and equipment, and identification of highway elements that affect the quality of the human environment. The goals of projects within this category are to maximize operational efficiency and safety to the traveling public while conserving resources and reducing adverse highway and traffic impacts through protections and enhancement of environmental features.

### **4. Pavement Design, Construction, and Management**

Pavement RD&T is concerned with pavement design and rehabilitation methods and procedures, construction technology, recycled highway materials, improved pavement binders, and improved pavement management. The goals will emphasize improvements to highway performance over the network's life cycle, thus extending maintenance-free operation and maximizing benefits. Specific areas of effort will include material characterizations, pavement damage predictions, methods to minimize local pavement defects, quality control specifications, long-term pavement monitoring, and life cycle cost analyses.

### **5. Structural Design and Hydraulics**

Structural RD&T is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highway structures at reasonable costs. This category deals with bridge superstructures, earth structures, foundations, culverts, river mechanics, and hydraulics. In addition, it includes material aspects of structures (metal and concrete) along with their protection from corrosive or degrading environments.

### **9. RD&T Management and Coordination**

Activities in this category include fundamental work for new concepts and system characterization before the investigation reaches a point where it is incorporated within other categories of the FCP. Concepts on the feasibility of new technology for highway safety are included in this category. RD&T reports not within other FCP projects will be published as Category 9 projects.

