RATING ROCKFALL HAZARD IN TENNESSEE

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ABSTRACT

Rockfall from rock slopes adjacent to roadways is a major hazard and poses a problem for transportation agencies across the country. The state of Tennessee has implemented the Tennessee Rockfall Management System (RMS) as a means of reducing the liabilities associated with rockfall hazard. It utilizes digital data acquisition via PDAs coupled with distribution via an expandable web-based GIS database. The Tennessee Rockfall Hazard Rating System (RHRS) is part of the Tennessee RMS and assigns a numeric hazard rating according relative hazard for all slopes identified as having a high potential for delivering rock blocks onto Tennessee Department of Transportation maintained roadways. The Tennessee RHRS uses standard rock slope failure mechanisms (planar failure, wedge failure, topple failure, differential weathering, and raveling) along with the site and roadway geometry to assess the rockfall hazard of an individual slope. This study suggests methods that will expedite fieldwork, including an informational guide on how to properly identify individual failure mechanisms in the field. Also, the study examines the current method of scoring abundance and suggests an alternative, multiplicative approach. The alternative of using a multiplicative abundance is considered and its results summarized.

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INTRODUCTION

A rockfall hazard exists when a rock slope contains rock that has the potential to roll, slide or fall into the roadway, creating a safety hazard for the motoring public. State transportation agencies have the responsibility to minimize the risk of incidents associated with such hazards. In order to provide for a more proactive management of rockfall hazards, several states have implemented rockfall hazard rating systems in an effort to quantify the relative risk posed by rock slopes on state roadways.

Transportation agencies are not expected to have sufficient, available funds to deal with all safety issues at once. They are however expected to reduce liabilities with respect to rockfall hazard. Agencies have found rockfall hazard rating systems, which identify potentially hazardous rockcuts and prioritize remediation efforts, a proactive means of dealing with these hazards (NHI, 1993). This is accomplished by the implementation of a systems-based approach to rockcut management, which improves public safety by helping engineers and geologists locate potentially hazardous slopes, and aids the implementation of effective and efficient remediation alternatives. This philosophy is consistent with the Federal Highway Administration's (1999) Asset Management Primer.

Beginning in 2001, The Tennessee Department of Transportation (TDOT) began to implement a system to identify and quantify potential rockfall hazards along TDOT maintained roadways. Phase I of the Tennessee Rockfall Management System (RMS) began at this time. The goal of Phase I was to rate all hazardous rock slopes on state-maintained highways and interstate highways in five counties within the state of Tennessee. As of December 2003, Phase II, which started in October of 2002, involved the remaining 72 counties with rock slopes, and was mostly complete with a majority the counties finished and many more in progress.

The Tennessee RHRS was designed to provide information for the Tennessee Rockfall Management System (RMS), a geospatial-database that contains all the information collected for hazardous cut slopes located on TDOT maintained roads (Bateman, 2001). The Tennessee RHRS is a modified form of the National Highway Institute rockfall hazard rating system (NHI, 1993). The Tennessee RHRS uses digital data acquisition via PDA's (Bellamy et al, 2002) coupled with electronic distribution via an expandable web-based GIS database (Rose et al , 2003).

The Tennessee RHRS rates rock slopes along a roadway in a consistent and repeatable manner with respect to rockfall hazard. The Tennessee RHRS has two major components, site and roadway geometry and geologic characterization. The site and roadway geometry is accounted for in much the same way as in the NHI (1993) system with exception of the Ditch Effectiveness category. The majority of the modifications in the Tennessee RHRS were made with respect to the geologic characterization. Unlike the geologic assessment of the NHI (1993) system, the geologic character of the Tennessee RHRS allows multiple modes of failure to be assigned to an individual slope, where in the NHI (1993) only the worst case is rated. Also, the failure modes are based on standard rock slope failure mechanisms.

There are a total of three research teams performing the hazard rating throughout the state of Tennessee. This study focused on counties of northeastern Tennessee, more specifically Campbell, Claiborne, Green, Hancock, Unicoi, and Union counties. The study area offered a diverse geologic setting and encompassed three of Tennessee's six physiographic provinces. The diverse geology provided the opportunity to examine a variety of slopes with different lithologies and structural geology, allowing the researcher to inspect all the failure modes in many different settings.

While implementing Phase II Tennessee RHRS, it was apparent that lessons learned during this stage of development could be incorporated in the future to expedite the rating process. These included observations that make identification of different failure modes more straightforward. The final form of the Tennessee RHRS is intended to be easily learned and correctly employed by individuals with little to no experience in the field of geotechnical and geological engineering. To accomplish these goals, every effort must be made to simplify the process.

The following paper is to be submitted to the American Society of Civil Engineers Journal of Transportation Engineering. It summarizes the Tennessee Rockfall Hazard Rating System. The paper includes each contributor to rockfall hazard and how each is defined and measured. A majority of the discussion focuses on the geological characterization portion of the Tennessee RHRS, because the intended audience is composed mostly of transportation engineers with little background in geotechnical engineering or geology.

Appendix A contains a table of all the rock slopes rated as of December 2003 and presents the hazard rating for both methods of scoring abundance. The table provides the following information for each rated rock slopes, if applicable:

- File Number,
- Date rated,
- County,
- Road,
- Beginning log mile (BLM),
- Latitude-longitude, and
- Geologic character for each failure mode and abundance scoring method

Methods of refining the abundance score were considered during this study as a way of improving the system. Appendix B summarizes a logical and easily-implement means of improving the current, additive abundance scoring method. After evaluating hundreds of slopes the use of an additive abundance seemed to inflate the hazard rating of slopes with a high abundance of failure modes with low consequence of failure and deemphasize slopes with a low abundance of failure mechanisms with high consequence of failure. This phenomenon is also discussed in the paper and a change to the current Tennessee RHRS is proposed

THE TENNESSEE ROCKFALL HAZARD RATING SYSTEM

By

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1. INTRODUCTION

A rockfall hazard exists when a rock slope contains rock blocks that have potential to roll, slide or fall into the roadway. This creates a safety concern for the driving public. In order to provide for a more proactive management of rockfall hazards, several states have implemented rockfall hazard rating systems in an effort to quantify the relative risk posed by rock cuts on state roadways. These states include Oregon, Arizona, California, Idaho, Massachusetts, New Hampshire, New Mexico, Ohio, Washington, and Wyoming, which were part of the 1993 NHI study (1993) and have since revised their rating systems. New Hampshire has increased their rating systems and databases to include structural data of the rock cuts (Fish and Lane, 2002). New York designed their system to include a hazard rating that considers the backslope angle as part of the risk the rock slope presents (GEMS-15, 1996). Additionally, the province of Ontario, Canada (Senior, 1999) has also implemented a rockfall hazard rating system.

Beginning in 2001, The Tennessee Department of Transportation (TDOT) began to implement Phase I of its Rockfall Hazard Rating System (RHRS). The goal of Phase I was to rate the hazard of all hazardous rock slopes on state roads and interstate highways in five counties within the state of Tennessee. In October of 2002, Phase II, involving the remaining 72 counties with rock slopes, was mostly complete with a majority of the counties complete and many more in progress.

The Tennessee Rockfall Hazard Rating System was designed to provide information for the Tennessee Rockfall Management System (RMS), a geospatial-database that contains all the information collected on hazardous slopes located on TDOT-maintained roads

(Bateman, 2001). The Tennessee RHRS is a modified form of the National Highway Institute's RHRS (NHI, 1993). The primary differences between the NHI (1993) system and the Tennessee RHRS are in the area of geologic characterization (Vandewater, 2002). Some changes were also made to the site and roadway geometry section, particularly with respect to ditch effectiveness and how it is defined. This paper provides background information on rockfall hazard rating systems in general, presents the protocol and information structure of the Tennessee RHRS and presents a detailed discussion of the geologic character score. The Tennessee RHRS is part of a larger Rockfall Management System (RMS), which uses digital data acquisition via PDAs (Bellamy et al, 2002) coupled with distribution via an expandable web-based GIS database (Rose et al, 2003).

The state of Tennessee is composed of six physiographic provinces (Fig. 1.1), each with its own geologic characteristics and types of rockfall hazards. The Cumberland Plateau is made up of predominantly flat-lying sequences of interbedded sandstone, limestone, and shale. Because of the lithologic variation, differential weathering is the predominant mode of failure in this region, particularly where shale is overlain by more competent limestone or sandstone (Royster, 1973). The Valley and Ridge province contains faulted and folded bedrock that forms a sequence of elongate, northeast-trending valleys and ridges. Because of the fracturing associated with the faults and folds and the changing orientation of bedding, rock cuts of the Valley and Ridge province are more prone to structural failures. The Blue Ridge province is composed of hard metamorphic and igneous rock. In the Blue Ridge, the structural modes of planar and wedge failure along with raveling, are the main failure mechanisms. The Highland Rim and the Nashville Basin have less local relief than the Cumberland Plateau, Valley and Ridge, and Blue Ridge provinces, which means there are less rock cuts per unit area than in the other three. Western Tennessee is comprised mostly of unconsolidated Quaternary sediments, which does not contain any rock slopes.

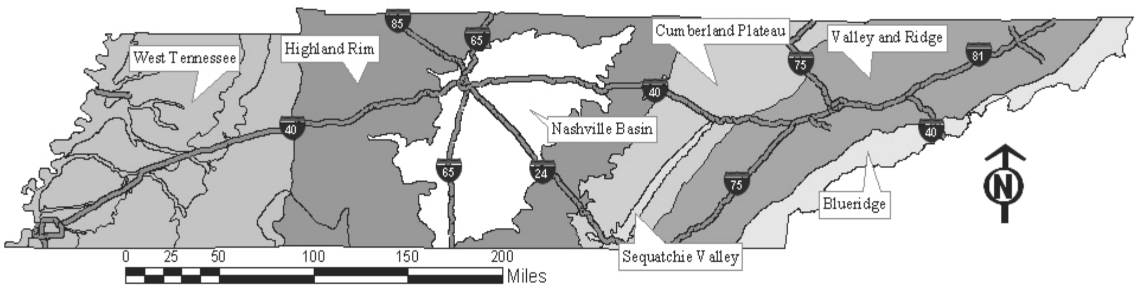


Figure 1.1- Statewide map of Tennessee showing the six physiographic provinces.

1.1 Benefits of a Systems-Based Approach to Rockcut Management

The benefits of a systems-based approach to rock cut management are realized through intelligent, proactive management of resources and risk. A state's roadway network represents a significant resource or asset and is a critical part of civil infrastructure. Unlike asphalt, concrete, and steel, the natural geologic materials underneath and adjacent to the road network are not engineered to have specified mechanical properties. The performance of these materials is therefore not readily predictable without a site-specific investigation and characterization. Even then, the mechanical response of rock slopes is subject to considerable uncertainty. A rock cut management system provides ready access to site-specific, geotechnical data that can be used to prioritize rock slopes in terms of relative hazard, as well as likely maintenance or remediation costs. The existence of a statewide database improves public safety by helping engineers and geologists remain cognizant of slopes that may present a hazard, and facilitate planning for the remediation of such slopes.

The ability to rank slopes according to relative hazard, and make remediation decisions utilizing a statewide database such as the Tennessee RMS, reduces the likelihood that a transportation agency will spend limited financial resources investigating a slope, only to find that the hazard is not sufficient to warrant remediation. One attractive aspect of the Tennessee RHRS is that the fieldwork can be performed by employees with minimal geological or geotechnical experience. While identification of particular failure modes can be challenging, the use of professional engineers or geologists is not essential for routine hazard ratings. This feature cuts down on the labor cost of a statewide survey.

Transportation agencies do not have sufficient available funds to deal with all safety issues at one time. It is becoming increasingly clear, however, that liabilities with respect to rockfall hazard are reduced if agencies have systems in place that identify potentially hazardous rock cuts and prioritize their remediation, as funds become available (NHI, 1993). This can be accomplished by the implementation of a systems-based approach to rock cut management, which improves public safety by helping engineers and geologists locate all potentially hazardous slopes. A systems-based approach to rockfall management can also aid in remediation decisions by providing key geotechnical information about slopes before a full site investigation is carried out. This approach is consistent with the Asset Management philosophy described by the Federal Highway Administration (1999). Asset Management promotes preventative maintenance and long-term planning rather than reactive, short-term patches.

1.2 Advantages of the Tennessee RHRS

The Tennessee RHRS provides the same basic site and roadway geometry information that is incorporated into the NHI (1993) and other rating systems. This includes data on slope length, slope height, roadway width, decision site distance, average vehicle risk, and ditch effectiveness. In addition to these site characteristics, the Tennessee RHRS includes more thorough descriptions of the geologic character of a slope than is provided by other rockfall hazard rating systems (Vandewater, 2002). Digital images are also taken of each rated slope and are entered into the database. The geologic assessment of the Tennessee RHRS considers failure modes based on the standard failure mechanisms of rock slopes. From this information, an engineer can infer the required remediation type from their desk and get a rough estimate of cost without going into the field.

1.3 Tennessee Roadway Information Management System (TRIMS)

The Tennessee Roadway Information Management System (TRIMS) is a system used by TDOT to manage the state maintained roadway network and to aid in maintenance decisions. TRIMS provides a wide range of information to TDOT engineers and geologists, including a digital image log of the entire network of state-maintained roadways.

For each state route and interstate highway, TRIMS contains a sequence of wide-angle digital images taken from the front of a vehicle at 0.016-kilometer (0.01 mile) intervals (Fig. 1.2). On some roads, TRIMS provides an image taken from either side of the vehicle. These images allow a user to identify potentially hazardous rock slopes while sitting at their desktop, prior to going into the field. TRIMS also provides the user with additional information used when rating slope hazard, including the Average Daily Traffic (ADT), beginning log mile of the slope, side of the road on which the cut is located, and road width. Road width is later checked in the field but is gathered here to ensure no major changes have been made to the site since the last update of TRIMS. The TRIMS database must be queried to obtain the road width and ADT for each of the identified rock cuts. The speed limit can be obtained by observation of posted speed limit signs that appear in the image log.

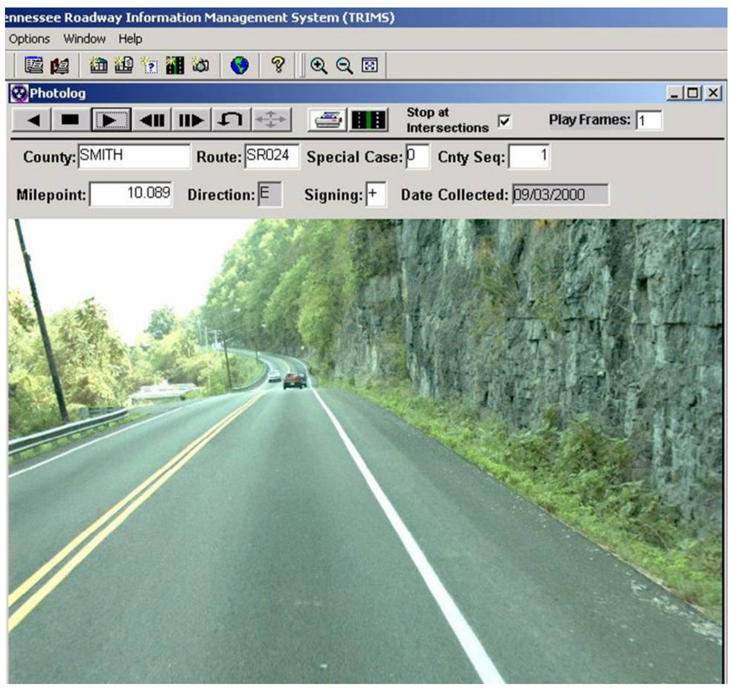


Figure 1.2- Screen-capture of TRIMS digital image log showing rock cut. Note the narrow catchment next to wide paved shoulder

When using TRIMS to locate rock slopes, the recommended procedure is for one person to operate TRIMS and run queries on its database, while a second person records information needed in the field. This method is both convenient and efficient, since for each rock cut there are four to five pieces of information that should be collected from TRIMS.

2. PRELIMINARY RATINGS

Once all rock slopes in the area of interest have been located by utilizing TRIMS and the initial roadway data have been collected, all identified slopes are visited by field personnel and given preliminary ratings. Standard safety protocols are essential for this fieldwork; safety can be a particular concern because the majority of the hazardous slopes tend to be older cuts with narrow ditches and no shoulders.

The preliminary rating is used to assess the general hazard of a rock slope, as high (A), moderate (B), or low (C) following the definitions given in NHI (1993), as follows:

- **A-slopes:** moderate-to-high potential to deliver rock to the roadway and/or high historical rockfall activity.
- **B-slopes:** low-to-moderate potential to deliver rock to the roadway and/or moderate historical rockfall activity.
- **C-slopes:** negligible-to-low potential to deliver rock to the roadway and/or low historical rockfall activity.

C-slopes are the easiest of the three to recognize. Most C-slopes are less than 3 m (10 ft) in height with no significant slope behind, in flat-lying strata, and have catchment or ditch width of at least 1.5 m (5 ft).

Remediated slopes or slopes constructed with features that excludes them from the A and B categories (Wyllie and Norrish, 1996c) designated as R-slopes. Examples include terraced slopes, or slopes isolated from the roadway by means of an engineered rockfall barrier.

If a slope is given a preliminary rating of A or B (Fig. 2.1), the rater records the following in the preliminary data set: TDOT region number, county name and number, state route number, beginning log mile, centerline reference, speed limit, ADT, and GPS coordinates. If a slope is given the preliminary designation of A, the crew can either choose to do a detailed rating immediately or to come back later to do the detailed rating. Slopes classified as B are entered into the RMS database, but no numeric hazard score is given to the slope.

2.1 Distinguishing between A and B Slopes

While the identification of C-slopes is usually straightforward and unambiguous, the distinction between A & B preliminary ratings can be more subjective. The rater must choose whether to call the slope an A and do a detailed rating, or call it a B-slope and move on. The conservative course of action is to designate all borderline cases as A-slopes, but this will distort the database if the slopes are in fact B-slopes. Photographs of typical A & B slopes are shown in Fig. 2.1.

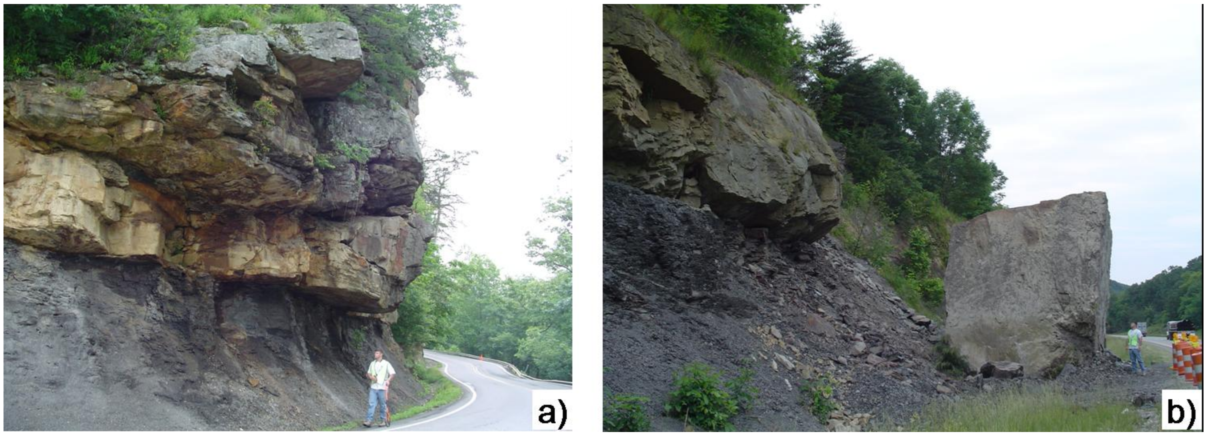


Figure 2.1- Example slopes for typical (a) A-slope and (b) B-slope. Note the low DSD, narrow catchment and large potential block size in (a) and the high DSD and wide enough catchment that was able to contain the rockfall event in (b)

When distinguishing between the A and B preliminary hazard categories, our experience has shown that it is advantageous to consider the following two questions:

1. Is the catchment insufficient to contain the likely range of rockfall events?
2. Is there evidence of past rockfall events reaching the roadway? Such evidence might include impact marks on the road or identification of the slope in maintenance records as a problem area.

Answering YES to either (1) or (2) is indicative of an A-slope. Based on our experience it has been shown useful to also consider the following two questions as aids for answering question (1).

3. Does the slope have characteristics that increase the likelihood of rockfall reaching the roadway? Examples are launching features and a tendency to fill its catchment with talus, creating a ramp that promotes rolling.
4. What is the likely range in size of individual blocks, and volume of potential rockfall events?

If the rater is still unsure as to the preliminary rating, after considering questions (1)-(4), they must consider several site-specific variables in order to make the best decision. The most important of these variables are the ADT and the Decision Site Distance (DSD). For example, if the rock slope is on a major highway or interstate, the rater should be more inclined to call the slope an A-slope because the ADT and hence the public safety risk, is higher. Likewise, if the slope is on a blind curve where a driver is unlikely to see an obstruction in the roadway with adequate time to react, as reflected in a low DSD, then a rater should be more inclined to call the slope an A-slope. In the end, if a rater is still uncertain of the preliminary assessment of the slope, the conservative approach should be adopted. The slope should be given an A designation and a detailed rating performed.

3. DETAILED RATINGS

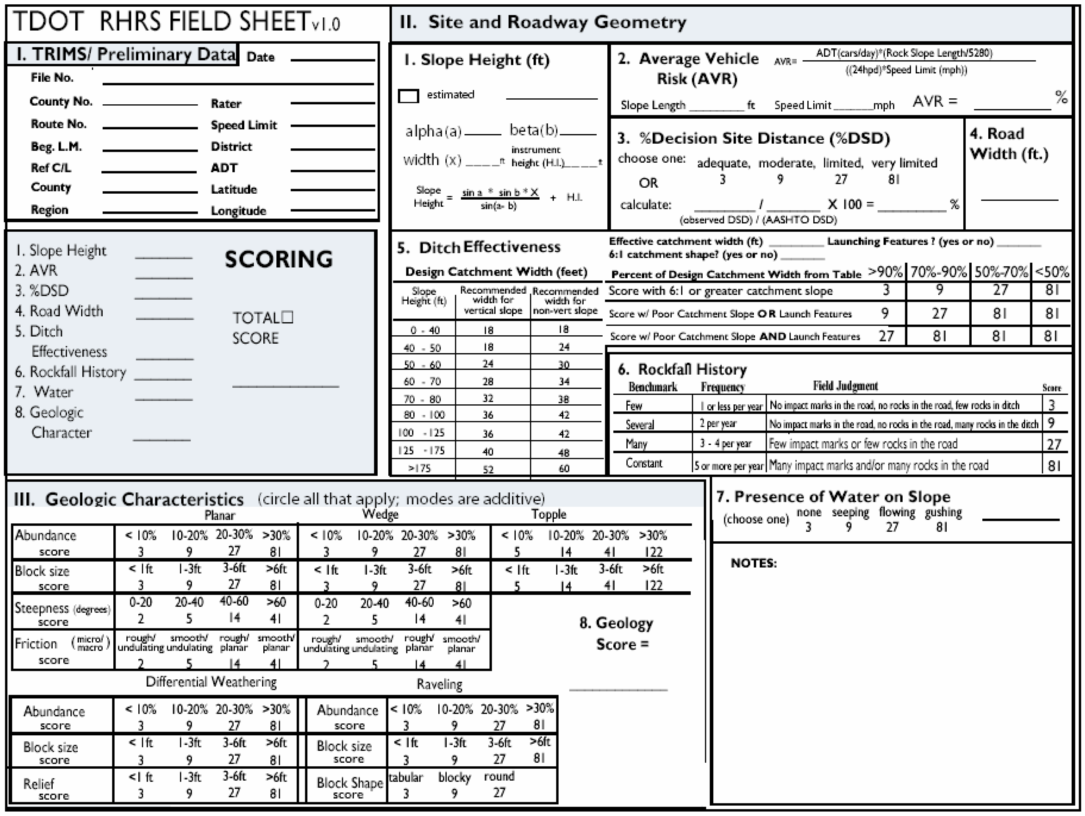
All A-slopes require a detailed rating. The detailed rating portion of the Tennessee RHRS includes two sections: 1) site and roadway geometry and, 2) geologic character. Site and roadway geometry is defined and scored in the Tennessee RHRS much as it is in the NHI (1993) with the exception of the ditch effectiveness. The major difference between the two systems lies in how the geologic hazard of the slope is characterized.

Both the Tennessee RHRS and the NHI system use an exponentially increasing hazard score for each category or parameter, meaning that as a category becomes more hazardous, the score for that category increases exponentially. This is done so that the slopes with a high degree of hazard have a much higher score than the less hazardous slopes (NHI, 1993)

Rating data are entered either manually on a paper form or in digital format on a PDA that exactly mimics the paper form input structure (Fig. 3.1a & b). The data entry forms for the PDA were constructed using Pendragon software (Bellamy et al, 2002). If the paper form is used, numeric hazard scores for individual categories are determined either from lookup tables or using equations as provided in the NHI (1993) system. As a procedural note, while for trained personnel the PDA has tremendous advantages for data entry and calculation of hazard, it is not recommended for training. It is suggested that paper forms be used for training of field personnel so that the hazard determination is transparent and explicit. For clarity, paper forms are referred to in the discussion to follow. The PDA allows for the use of SI or traditional English system of units. However, the paper form was developed for traditional English units.

3.1 Site and Roadway Geometry

The site and roadway geometry section of the detailed ratings takes into account the following factors: Slope Height, Ditch Effectiveness, Average Vehicle Risk, Road Width, and Percent of Decision Site Distance (DSD). Each category and its contribution to the risk assessment of a slope are discussed briefly in the following sections with the exception of ditch effectiveness, each of the categories is scored the same as in the NHI (1993) system.



TDOT RHRS FIELD SHEET v1.0

I. TRIMS/ Preliminary Data

Date ______
File No. ______
County No. ______ Rater ______
Route No. ______ Speed Limit ______
Beg. L.M. ______ District ______
Ref C/L ______ ADT ______
County ______ Latitude ______
Region ______ Longitude ______

SCORING

1. Slope Height ______
2. AVR ______
3. %DSD ______
4. Road Width ______
5. Ditch Effectiveness ______
6. Rockfall History ______
7. Water ______
8. Geologic Character ______

TOTAL SCORE ______

II. Site and Roadway Geometry

1. Slope Height (ft)

estimated ______

alpha(a) ______ beta(b) ______
width (x) ______ ft instrument height (H.I.) ______ ft

Slope Height = (sin a * sin b * X) / sin(a- b) + H.I.

2. Average Vehicle Risk (AVR) AVR= ADT(cars/day)*(Rock Slope Length/5280) / ((24hpd)*Speed Limit (mph))

Slope Length ______ ft Speed Limit ______ mph AVR = ______ %

3. %Decision Site Distance (%DSD)

choose one: adequate, moderate, limited, very limited (3, 9, 27, 81)
OR
calculate: ______ / ______ X 100 = ______ %
(observed DSD) / (AASHTO DSD)

4. Road Width (ft.) ______

5. Ditch Effectiveness

Design Catchment Width (feet)

Slope Height (ft)	Recommended width for vertical slope	Recommended width for non-vert slope
0 - 40	18	18
40 - 50	18	24
50 - 60	24	30
60 - 70	28	34
70 - 80	32	38
80 - 100	36	42
100 - 125	36	42
125 - 175	40	48
>175	52	60

Effective catchment width (ft) ______ Launching Features ? (yes or no) ______
6:1 catchment shape? (yes or no) ______

Percent of Design Catchment Width from Table	>90%	70%-90%	50%-70%	<50%
Score with 6:1 or greater catchment slope	3	9	27	81
Score w/ Poor Catchment Slope OR Launch Features	9	27	81	81
Score w/ Poor Catchment Slope AND Launch Features	27	81	81	81

6. Rockfall History

Benchmark	Frequency	Field Judgment	Score
Few	1 or less per year	No impact marks in the road, no rocks in the road, few rocks in ditch	3
Several	2 per year	No impact marks in the road, no rocks in the road, many rocks in the ditch	9
Many	3 - 4 per year	Few impact marks or few rocks in the road	27
Constant	5 or more per year	Many impact marks and/or many rocks in the road	81

III. Geologic Characteristics (circle all that apply; modes are additive)

	Planar				Wedge				Topple			
Abundance	< 10%	10-20%	20-30%	>30%	< 10%	10-20%	20-30%	>30%	< 10%	10-20%	20-30%	>30%
score	3	9	27	81	3	9	27	81	5	14	41	122
Block size	< 1ft	1-3ft	3-6ft	>6ft	< 1ft	1-3ft	3-6ft	>6ft	< 1ft	1-3ft	3-6ft	>6ft
score	3	9	27	81	3	9	27	81	5	14	41	122
Steepness (degrees)	0-20	20-40	40-60	>60	0-20	20-40	40-60	>60				
score	2	5	14	41	2	5	14	41				
Friction (micro/ macro)	rough/ undulating	smooth/ undulating	rough/ planar	smooth/ planar	rough/ undulating	smooth/ undulating	rough/ planar	smooth/ planar				
score	2	5	14	41	2	5	14	41				

8. Geology Score = ______

Differential Weathering

Abundance	< 10%	10-20%	20-30%	>30%
score	3	9	27	81
Block size	< 1ft	1-3ft	3-6ft	>6ft
score	3	9	27	81
Relief	<1 ft	1-3ft	3-6ft	>6ft
score	3	9	27	81

Raveling

Abundance	< 10%	10-20%	20-30%	>30%
score	3	9	27	81
Block size	< 1ft	1-3ft	3-6ft	>6ft
score	3	9	27	81
Block Shape	tabular	blocky	round	
score	3	9	27	

7. Presence of Water on Slope

(choose one) none 3, seeping 9, flowing 27, gushing 81 ______

NOTES:

Figure 3.1a- Example of the Tennessee RHRS scoring sheet (front side)

Tennessee Rockfall Hazard Rating System Scoring Tables

Slope Height / AVR Scoring Table

Height / %AVR	Score	Height / %AVR	Score
9	1	77	29
10 - 20	2	78	31
21-28	3	79	32
29-34	4	80	34
35-38	5	81	35
39-42	6	82	37
43-45	7	83	38
46-48	8	84	40
49-51	9	85	42
52-53	10	86	44
54-55	11	87	46
56-57	12	88	48
58-59	13	89	50
60	14	90	52
61-62	15	91	55
63	16	92	57
64-65	17	93-94	60
66	18	95	62
67	19	96	65
68	20	97	71
69	21	98	74
70	22	99	78
71	23	100	81
72	24	101	85
73	25	102	88
74	26	103	92
75	27	104	97
76	28	105	100

Road Width Scoring Table

Width	Score	Width	Score
18	100	35	10
19	93	36	9
20	81	37	8
21	71	38	7
22	62	39	6
23	54	40	5
24	47	41	5
25	41	42	4
26	36	43	3
27	31	44	3
28	27	45	3
29	24	46	2
30	21	47	2
31	18	48	2
32	16	49	2
33	14	50	1
34	12		

AASHTO Recommended DSD

Decision Site Distance	MPH
300 ft	20
375	25
450	30
525	35
600	40
675	45
750	50
875	55
1000	60
1015	65

% DSD Scoring Table

% DSD	Score	% DSD	Score
36	100	61	26
37	96	62	24
38	90	63	23
39	86	64	22
40	81	65	21
41	77	66	19
42	73	67	18
43	69	68	17
44	65	69-70	16
45	62	71	15
46	58	72	14
47	55	73-74	13
48	52	75	12
49	49	76-77	11
50	47	80-81	9
51	44	82-83	8
52	42	84-85	7
53	40	86-88	6
54	38	89-92	5
55	36	93-97	4
56	34	98-103	3
57	32	104-112	2
58	30	113	1
59	29		
60	27		

Figure 3.1b- Tennessee RHRS scoring sheet lookup tables (back side)

3.1.1 Slope Height

A rock that falls from high up on a slope will have a greater kinetic energy when it reaches road level than a rock that falls from a lesser height. All other things being equal, greater kinetic energy imparts a higher level of mobility to the rock block, increasing the chance that the block will reach the roadway. Therefore taller slopes present a greater hazard.

The height of a slope is measured at the highest point along the hazardous portion of the slope being rated. It can be measured directly using any of several methods (Vandewater, 2002). The authors found the most convenient tool for height measurement to be a handheld hypsometer, a combined laser range finder and inclinometer. Using the hypsometer is quick and efficient because it requires only one measurement and reduces the uncertainty associated with estimation. Once the height is measured, its hazard value is either obtained from a lookup table provided on the back of the paper form (Fig 3.1b), or calculated from the following equation (NHI, 1993):

$$Height\ Score = 3^x \text{, where } x = Slope\ Height / H_o \text{ ,}$$

where the reference height H_o equals 7.6 m (25 ft). The PDA uses the above equation and calculates the value automatically.

3.1.2 Ditch Effectiveness

Experience shows that all rock slopes shed rock blocks or slabs to some degree, and it would be nearly impossible and extremely costly to design rock slopes so they did not shed any rock (Patton and Deere, 1970). However, a properly sloped, sufficiently wide catchment greatly reduces the probability of rock debris reaching the roadway. It has been the authors' experience that the ability of the catchment to contain the typical range of rockfall events is quite often the deciding factor in identifying a slope as A rather than B.

TDOT requires a minimum catchment width of 5.5 m (18ft) for all slopes up to 12.2 m (40 ft) high. Wider catchments are required for taller slopes and for slopes that are non-vertical. As part of the catchment design, TDOT also requires a minimum 6:1 (H:V) roadway approach slope. However, most of the slopes that are rated as A-slopes were created before such standards were required. Also it is impractical and expensive to remove large portion of a rock slope to make a catchment a few feet wider.

The ditch effectiveness score compares the actual catchment width and slope to TDOT design requirements (Fig. 3.1a). In addition to the design requirements placed on the catchment, the presence or absence of launching features is also considered. Launching features are “topographical protrusions” in the slope profile that can change the trajectory of rockfall debris increasing the likelihood that rocks will reach the roadway. If launching features are present, the catchment width needed to contain a rockfall event is larger than for a slope without launching features. The overall ditch effectiveness score is based on the percentage of design width, the slope of the catchment, and the presence or absence of launching features (Fig. 3.1a).

3.1.3 Average Vehicle Risk (AVR)

The AVR is a measure of public exposure to the slope being rated. The AVR is calculated as a percentage but is not limited to a maximum of 100%. An AVR of 100% means that, on average, there is one car along the portion of road adjacent to the slope at all times. The contribution of AVR to hazard is understandable because the more time vehicles spend adjacent to a hazardous rock slope, the more likely there will be an incident. However, AVR only contributes significantly to the hazard rating when the ADT is very high, as on a major highway or interstate or a very long slope as is shown by the equation used to calculate the AVR (NHI, 1993):

$$AVR = \frac{ADT(cars/day) \bullet Slope\ Length(km)}{24(hours/day) \bullet Speed\ Limit(kph)} \times 100\%$$

For use with standard U.S. units, km and kph are replaced by miles and mph, respectively. The AVR is associated with a hazard score using the lookup tables or automatically using the PDA.

3.1.4 Roadway Width

Road width influences rockfall hazard because a narrow road limits the time and space in which a driver can react, increasing the risk to the motoring public. Roadway width is measured at the narrowest portion of the road adjacent to the slope and perpendicular to the longitudinal axis of the road. Roadway width includes all of the paved right-of-way, including the shoulder, if present. If the slope is on a divided highway then only the side of the highway adjacent to the slope is measured.

3.1.5 Percent Decision Site Distance (%DSD)

Decision Site Distance (DSD) is the maximum distance at which a driver can identify a 15 cm (6 in) diameter obstacle in the road with sufficient time to respond appropriately. The DSD was standardized by AASHTO (1984), and is dependent on the posted speed limit. Rockfall hazard is increased, all else being equal, when a driver’s time to react is reduced.

The Tennessee RHRS gives the rater two options when scoring the DSD: 1) Estimate the DSD as adequate, moderate, limited, or very limited; 2) measure the DSD and calculate the Percent DSD as defined by:

$$\%DSD = DSD_{(measured)} / DSD_{(AASHTO)} \quad ,$$

Once calculated, the Percent DSD hazard score can be obtained from lookup tables, or using equations provided by NHI (1993). The PDA uses the same NHI (1993) equations to automatically calculate the hazard score for Percent DSD.

4. GEOLOGIC CHARACTERIZATION

The Tennessee RHRS includes a number of changes to the geologic character hazard score defined by NHI (1993). These changes were incorporated to improve the repeatability, ease of use, and amount of information provided by the rockfall survey. These changes are as follows:

1. Basing the geological character rating score on conventional rock slope failure modes
2. Allowing for the inclusion of multiple failure modes
3. Reducing ambiguity in verbal descriptions

The NHI system (NHI, 1993) considers just two cases for the geologic character of a slope. Case I is instability involving the structure (bedding and joint sets) of a rock mass, and Case II involves differential erosion as the main source of instability. If a slope contains both Case I and Case II failure conditions, then only the most critical case is scored. If the most critical cannot be easily assessed both conditions are rated and the case with the higher score is kept. This score is added to the site and roadway geometry score to give the overall hazard rating for a slope.

The Tennessee RHRS, in contrast, bases geologic character assessment on standard slope failure mechanisms (Goodman and Kieffer, 2000). The failure modes themselves are descriptive and can be used to begin the process of making remediation decisions.

By allowing the inclusion of all hazardous failure modes of a surveyed slope, a more complete and informative geologic characterization is possible. Repeatability and consistency among raters also increase because failure mechanisms used by the Tennessee RHRS are clearly defined, and the “worse case” judgment is taken out of the system.

The geologic character assessment in the Tennessee system begins by asking the rater to identify pertinent failure modes (Table 4.1). This identification is logical and unambiguous. It is based on slope and geologic characteristics that are readily apparent to a rater with minimal training. The geologic characterization continues with the rater entering binned parameter values describing abundance, block size, steepness, friction, block shape, or relief, depending on the identified failure modes (Table 4.1). The parameters are binned in such a way that the assignment of bin values is also consistent and repeatable. By improving repeatability and decreasing ambiguity of rockfall hazard rating, the Tennessee RHRS increases the reliability and quality of information contained in the Tennessee RMS.

Table 4.1- Failure modes and parameters included in the Tennessee RHRS

Failure Mode	Geological Character Attributes					
	Abundance	Block Size	Steepness	Friction	Relief	Block Shape
Planar	**XXX**	**XXX**	**XXX**	**XXX**	**N/A**	**N/A**
Wedge	**XXX**	**XXX**	**XXX**	**XXX**	**N/A**	**N/A**
Topple	**XXX**	**XXX**	**N/A**	**N/A**	**N/A**	**N/A**
Differential Weathering	**XXX**	**XXX**	**N/A**	**N/A**	**XXX**	**N/A**
Raveling	**XXX**	**XXX**	**N/A**	**N/A**	**N/A**	**XXX**

While the Tennessee RHRS allows multiple failure modes to be assigned to a given slope, the rater must choose only one failure mode to assign an individual rock block or slab. The only exception is when raveling is superimposed onto a structural mode such as planar or wedge failure. A consequence of the inclusion of multiple failure modes is that slopes receive geologic hazards that can be much larger than the maximum NHI (1993) geologic hazard. For the purpose of comparison with the NHI (1993) rating system, which has a maximum geologic character score of 243, the geologic character hazard rating for an individual slope in the Tennessee RHRS is capped at 300.

4.1 Rock Slope Stability

The rock slope stability discussion presented herein is not intended to make the reader an expert on rock slopes. The aim is, rather, to give the reader an understanding of the basic rock slope failure mechanisms that are the basis for the Tennessee RHRS geologic character assessment.

In the context of rock slope engineering, intact rock strength is generally sufficient to support any applied load. However, rock mass strength, rather than intact strength, is the controlling strength in nearly all rock-engineering applications, and the strength of the rock mass is controlled by its discontinuities and other defects, and its weathering characteristics (Hoek and Bray, 1981; Goodman, 1989; Giani, 1991; Bell ed., 1992; Hudson and Harrison 1997).

In rock slope engineering, both kinematic and kinetic conditions must be satisfied to promote instability. The kinematics of a system is satisfied when there is space for rock blocks to move and the plane or set of planes that comprise the slip surface intersect that free space. A kinetic analysis compares the driving forces and resisting forces of a system. Once driving forces exceed resisting forces, movement is initiated. The kinematics of the systems let an investigator know if movement is possible, and the kinetics of a system determine if movement will take place.

4.1.1 Structurally controlled instability

Structural instability results in the initiation of sliding or rotation (toppling) of blocks in a rock mass. In a structurally controlled slope failure, the orientation and shear strength of the discontinuities determine slope stability. Sliding occurs when shear stress exceeds shear strength.

The shear strength of a potential slip surface has two components: 1) frictional resistance between the surfaces in contact and 2) any cohesion that exists between the surfaces. The frictional component is a function of the mineralogy, surface roughness, and the presence or absence of infilling (Barton, 1976; Wyllie and Norrish, 1996a). The angle of friction increases, with increasing surface roughness, due to the additional energy required to either slide over the asperities or shear through them. Cohesion of discontinuities usually takes the form of rock bridges, segments of intact rock that bridge the rock mass across the discontinuity. The cohesion of the discontinuity is proportional to the area the rock bridges occupy.

Rock slope stability may be decreased over time via reduction of shear strength or increases of shear stress. Shear strength can be reduced by decreasing the area rock bridges by stress induced sub-critical crack growth (Kemeny, 2002) or weathering, infilling of discontinuities with low shear strength materials, and other mechanisms including the decrease in effective stress caused by increases in hydrostatic pressure (Wyllie and Norrish, 1996a). Removal of lateral support, increase in lateral pressures, and the addition of surcharge load at the crest of a rock slope will increase the shear stress applied to a slopes thereby decreasing the stability.

4.1.2 Lithologic and weathering related failures

Lithologic changes can juxtapose two units with differing erosion rates. If the underlying unit erodes at a higher rate, support for the upper rock unit is undermined leading over time to slope instability. Rock can also be delivered to the road via overall weathering of the slope. These types of slopes are not structurally instable but can nevertheless shed rock and create a hazard. The properties for weathering related failure can also change over time.

4.2 Identification of Failure Modes

Kinematic conditions determine whether failure is possible; the kinetics of a system determine whether failure will occur. For the Tennessee RHRS, kinematic rules are used to identify the different failure mechanisms, while kinetics is considered when attributes or scores are assigned to each failure mode. The hazard score that result are akin to the probabilities of failure. For example, a lower score is given to a slope with high frictional resistance (rough surface) and low shear stress (shallow dipping slopes). Such a slope would have a low probability of failure. Even though failure is not likely, such slopes are still rated because they meet the kinematic requirements for sliding.

If a slope is given a preliminary designation of A, the rater should already have an idea of the relevant failure mode(s) because failure mechanism(s) have to be recognized for the slope to get an A designation. However, upon further investigation the true failure mechanism(s) of the slope may differ from the original estimation. The following is a discussion about each failure mode in Tennessee RHRS, accompanied by an example. The aim of this discussion is to aid in the identification of failure modes

4.2.1 Planar failure

Plane sliding or planar failure is the simplest structurally controlled failure mechanism to both identify and analyze. Planar failure involves sliding along a single discontinuity or set of discontinuities (Fig. 4.1). In Figure 4.1 note the single plane is part of a set of discontinuities with the same general orientation.

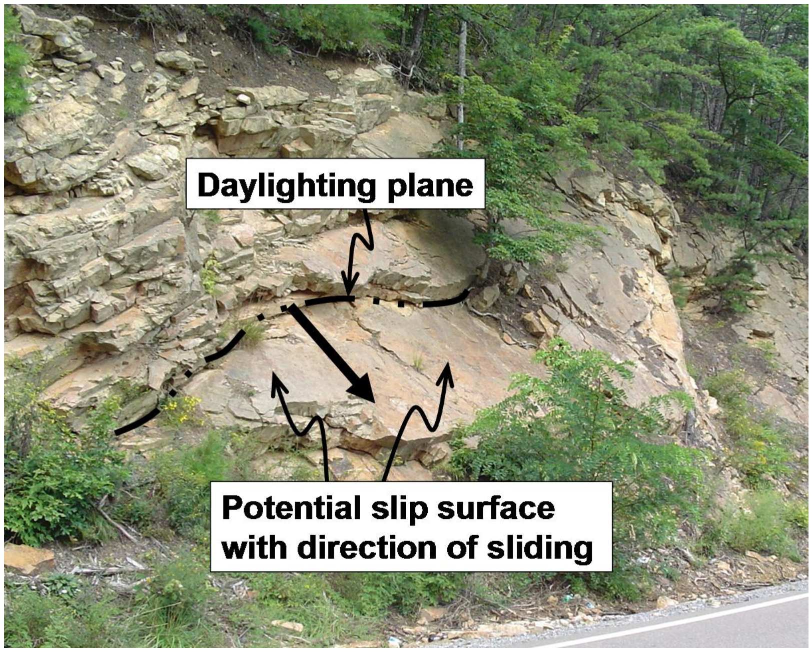


Figure 4.1- Example of planar failure that shows potential slip surface, daylighting planes, and direction of sliding.

The following requirements are given by Hudson and Harrison (1997) for planar instability:

1. The dip of the slope must exceed the dip of the potential slip plane,
2. The potential slip plane must daylight on the slope face,
3. The dip direction of the sliding plane must be within ± 20º of the slope's dip direction, and
4. The dip of the potential slip plane must be such that the strength of the plane is reached.

The first three are the kinematic requirements for movement, and the fourth is the kinetic requirement.

Listed below are some questions about the slope characteristics that aid in field identification of planar failure:

1. Do the planes that make up the potential slip surface daylight as horizontal or sub-horizontal lines on the slope face? A plane that intersects a slope with a dip direction

sub-parallel to the dip direction of the slope, will appear as a nearly horizontal line on the slope face. This condition must be checked along the whole slope. Slopes that change orientation may be stable with respect to planar failure at one location and unstable at another.

2. Is sliding occurring only along a single set of discontinuities? This is the difference between planar failure and wedge failure. A block that fails in plane sliding may be bounded by other discontinuities. The key observation is to check if sliding will involve maintaining contact on two non-parallel planes. If contact is maintained on two planes, the block is failing via wedge failure and should be rated as such. A small change in orientation of a release face may produce wedge failure in one area and planar failure in another, so it is not unusual for a single slope to contain both planar and wedge failure
3. Is the potential slip surface continuous? If all potential sliding blocks have already failed, then further failure on that set of discontinuities is no longer a threat and should not be rated.

4.2.2 Wedge failure

Wedge failure (Fig. 4.2) involves sliding on two intersecting planes rather than on a single discontinuity (Fig. 4.1). There are cases where sliding takes place on multiple intersecting planes (Mauldon and Ureta, 1998); however, these occurrences are rare. If a condition such as this is found in the field, it should be included in the survey and rated as a wedge failure with normal parameters applied. The following are requirements for wedge instability conditions (1) and (2) are kinematic; condition (3) involves kinetics (Hudson and Harrison, 1997):

1. The dip of the slope must exceed the plunge of the line of intersection of the discontinuities associated with the potentially unstable wedge,
2. The line of intersection must daylight the on the slope face, and
3. The plunge of the line of intersection must be such that the strength of the discontinuities is reached.

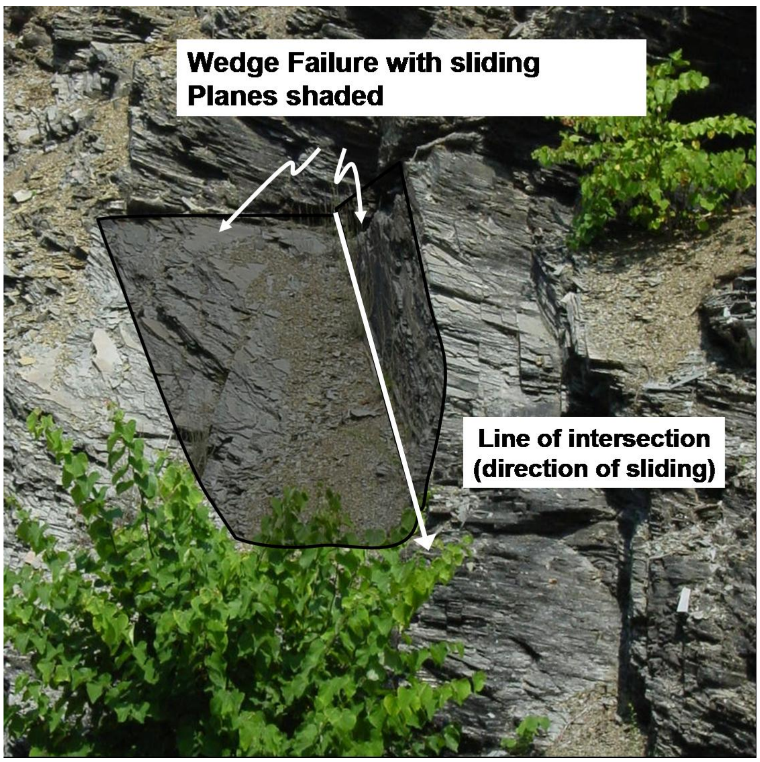


Figure 4.2- Example of wedge failure in Washington County

Wedge failure is a little more difficult to recognize than planar failure. Intersecting planes must be visualized in 3D. The same concepts that apply to planar failure are applicable to wedge failure once a general orientation of the line of intersection is established. The only difference is that the line of intersection takes the place of the dip direction in the analysis.

Many slopes that have the potential to create wedges will display evidence of past failures (Fig. 4.2). If these features are present then the unstable, intersecting planes are known and the uncertainty associated with the estimation of the critical intersecting planes is removed.

4.2.3 Topple failure

The third structurally controlled failure toppling (Goodman and Bray, 1976), which involves the overturning of semi continuous cantilever beams in conjunction with interlayer slip. Topple failure includes the subcategories of flexural toppling, block toppling, and block-flexural toppling. All toppling modes require interlayer slip between adjacent columns. The interlayer slip is the kinetic requirement that must be overcome before there is movement in the slope.

The analysis for toppling failure is complicated, especially when looking at the interactions of multiple blocks rotating simultaneously. However, the identification of potential hazard from toppling is relatively simple. A rater must see planes dipping steeply back into the slope, and if there is enough open space for the blocks to rotate then there is a possibility for instability due to toppling failure (Fig. 4.3).

Although not strictly toppling failure, bedding plane release is scored as topple failure in the Tennessee RHRS. The bedding plane release failure mechanism does not require the interlayer slip as in topple failure, however the identification the failure mode is indicative of instability as in topple failure. Bedding plane release failure may have the appearance of differential weathering, but occurs where there is no change in lithology or weathering characteristics.

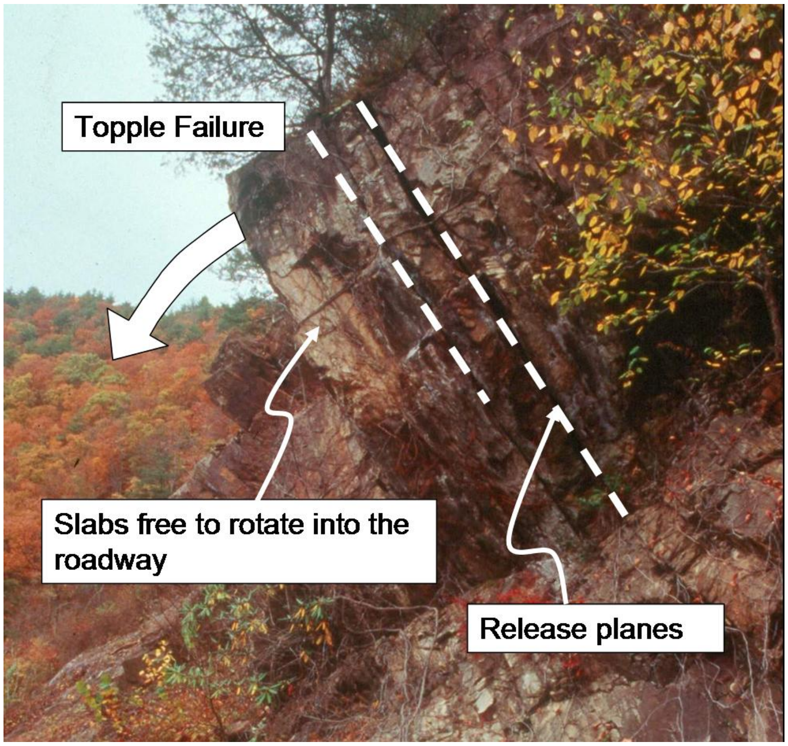


Figure 4.3- Topple failure, Unicoi County
(Photo by Harry Moore)

4.2.4 Differential weathering

Whenever there is a change in lithology within a rock slope, the potential for differential weathering is high. Differential weathering failure has potential to occur when continuous rock layers or blocks weather at differing rates, because of a change in lithology or fracture density. Failure happens when the underlying support is undermined causing the overlying block to rotate out of the slope face. Material that lies on top of the rotating block may stabilize the slope in the short term, but only delays failure. One important factor that contributes to instability is the presence of joints parallel or sub-parallel to the slope face. When these joints are present, the moment produced by the removal of the underlying support needs only be strong enough to cause rotation and not break the rock. A release surface can also be formed by a joint set that intersect behind the slope face.

Differential weathering is a major cause of rockfall hazard in areas with flat lying strata and transgressive-regressive lithologies of interbedded sandstone, limestone, and shale, which are common in the Cumberland Plateau. Figure 4.4 shows a large differential weathering failure that failed after several days of heavy rain in the summer of 2003.

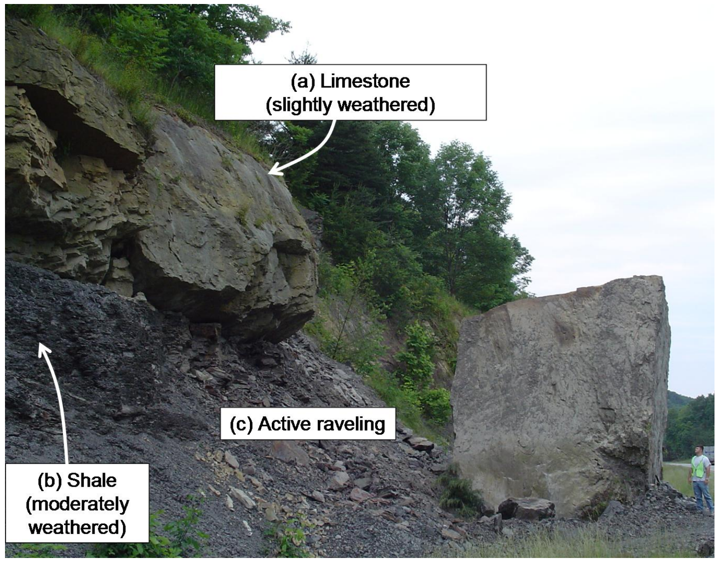


Figure 4.4- Differential weathering and raveling examples.

4.2.5 Raveling

The majority of the slopes surveyed have the potential to ravel. The term raveling, in the context of the Tennessee RHRS, refers to slopes where rocks, usually less than 0.3m (1ft) in diameter, are being shed from the slope face in zones of highly weathering-induced fracture density as well as blasting-induced fracture zones. Raveling is also used as a catchall for situations when the failure mechanism is not readily apparent. With that said, it is still important to find the correct failure mode when conducting the survey so that the engineer knows what to except during a site visit. The identification of the process of release is also valuable because the type of remediation can be dependent in some part on the failure mode.

The process of raveling is a weathering process and not a cause of large-scale slope instability. Raveling presents a hazard when the slope contains launching features or when the slope catchment is insufficient to contain the blocks. Because the mobility of the blocks that ravel from the slope plays a major role in their ability to reach the road, the shape of the block is considered as part of the hazard. A rounded block can move much further from a slope than a tabular mass with all else being equal.

In many of the slopes where differential weathering is a failure mode the faster-weathering rock is raveling from the slope. This is especially true in the Appalachian Plateau, where many slopes are formed from friable highly fractured shale. Figure 4.4 depicts a large differential weathering failure where the shale below was raveling created a talus slope at the toe.

4.3 Scoring Geologic Character Parameters

Once a failure mode has been identified, the hazard score given to the individual failure mode depends on its attributes (Table 4.2). Assigning attributes to a failure mechanism lets the kinetics of a failure mechanism and mobility be considered, and gives an idea of the impact of a failure event. The attributes include abundance, block size, steepness, friction, block shape, and relief. Not all of the attributes apply to each failure mode. For ease of use, the attributes are binned so that quick estimates can be made (Fig. 3.1a).

All the failure modes include an estimate of abundance and block size. For topple failure, these are the only attributes characterized by the RHRS. Because of the complicated nature of toppling mechanics, it is hard generalize the kinetics of an event without complex analysis. This is why only the block size and abundance are estimated.

Table 4.2- Parameters used in the Tennessee RHRS with applicable failure modes

Parameter	Applicable Failure Modes	Description
Abundance	All Modes	The abundance of a failure mode is defined as the ratio of the total surface area slope that is covered by that failure mode. The sum of individual abundances cannot exceed 100%, except in the cases where raveling is superimposed onto the structural modes planar or wedge failure (Fig. 4.2).
Block Size	All Modes	The block size is determined by the longest dimension of the rock blocks associated with the typical range of rockfall events. It is best to characterize the size of rock blocks that have not yet fallen from the slope, but if the blocks are high up on the slope and estimation is not feasible, then similar size blocks in the ditch can be used to estimate the size
Steepness	Planar & Wedge	The steepness component of the two structurally controlled failure mechanisms is the same as the dip of the slip surface for planar failure, and the plunge of the line of intersection for wedge failures. The steepness should be estimated based on the characteristic steepness of the planes or wedges that meet the kinematic requirements for failure.
Friction	Planar & Wedge	The friction score deals with shape of the failure surface on both the micro and macro scales. The macro scale is either planar or undulating. The micro is rough or smooth. Macro friction is more important than the micro friction because the smaller asperities accounting for the roughness are more easily broken through when sheared.
Relief	Differential Weathering	Relief is the measure of the amount of overhanging produced by the differing rates of erosion. As the overhang increases, the destabilizing moment also increases, thereby increasing the hazard of the slope.
Shape	Raveling	Since raveling is just blocks falling from the slope, the mobility a block is a function of the height of release and block shape. Block shape has increasing hazard as a block becomes cubic and rounded.

4.4 Other Scoring Criteria

4.4.1 Water

Water on a slope decreases of the stability of structural failure modes (wedge and planar) by decreasing the effective stress acting on the slip surface and thereby decreasing the frictional resistance. Also, water increases the rate of erosion, and loosens material on the slope, via freeze thaw and other mechanisms, which aid raveling and differential weathering. The bins for water on the slope are: none, seeping, flowing, and gushing.

4.4.2 Rockfall History

The rockfall history of a slope gives the rater an idea of the frequency of a rockfall event. It can be obtained in two ways, through maintenance records if available, or via observation. Maintenance records are typically difficult to obtain, so field observation is the most commonly used technique. The key factors to look for in the field are impact marks in the road and the amount of rock, if any, in the ditch (Fig. 3.1a).

5. CONCLUSIONS

The Tennessee RHRS is an integral part of a statewide geospatial database. The information provided by the Tennessee RHRS is used by TDOT engineers and geologist to prioritize remediation efforts and allocate funds in an efficient and consistent manner. To perform this function the data that the Tennessee RHRS includes should be complete and descriptive as possible. The database can also be expanded in the future to include data collected during more detailed field investigations.

This paper introduces the basic principles and concepts of the Tennessee RHRS and offers guidance for assessing rockfall hazard, particularly those aspects related to the geologic character of rock slope.

A slope's preliminary rating is the most subjective part of the Tennessee RHRS, and can require careful consideration in many borderline cases. This step, if not assessed properly, can skew the statewide database. Once a slope is rated as an A-slope and a detailed rating is performed, the numeric score resulting form the detailed rating allows the slope to be prioritized according to hazard.

By basing the failure modes on standard rock slope failure mechanisms, the Tennessee RHRS provides the engineer or geologist who has not seen the slope valuable information that can be utilized to make probable cost estimates, and prioritize rock slopes, all before additional fieldwork is carried out. The information that the Tennessee system provides TDOT engineers and geologists also aids in the planning of efficient and expeditious site investigations.

As with most engineering problems, the best solution, if not executed appropriately, will only yield a wrong answer. The advantages of the Tennessee RHRS depend largely on proper identification of failure modes and the repeatability of the system. For these reason, state personnel must be adequately trained to recognize failure mechanisms and to correctly score binned geologic parameters.

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Appendix A

Summary of Additive and Multiplicative Abundance Scoring

File Number	Date	County	Road	BLM	Longitude	Latitude	Planar Failure							Wedge Failure						
										Abundance		Total Score					Abundance		Total Score	
							Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative	Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative
04SR030001007.30LRF	7/28/2003	Bledsoe	SR030	7.3	-66.4615	39.47043	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04SR030001007.30RRF	7/28/2003	Bledsoe	SR030	7.3	-66.4615	39.47043	27	5	41	3	1.15	76	84	-	-	-	-	-	-	-
04SR030001007.40RRF	7/28/2003	Bledsoe	SR030	7.4	-66.4519	39.46793	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04SR030001007.70RRF	7/28/2003	Bledsoe	SR030	7.7	-66.4185	39.46229	27	5	41	3	1.15	76	84	-	-	-	-	-	-	-
04SR030001008.50RRF	7/28/2003	Bledsoe	SR030	8.5	-66.3751	39.45126	9	5	41	3	1.15	58	63	-	-	-	-	-	-	-
04SR030001008.60RRF	7/28/2003	Bledsoe	SR030	8.6	-66.3732	39.45094	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07I0075001016.00RRF	6/2/2003	Campbell	I0075	16	-84.28904	36.43738	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07I0075001026.70RRF	6/2/2003	Campbell	I0075	26.7	-84.15697	36.54172	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001005.50RRF	6/3/2003	Campbell	SR009	5.5	-84.04323	36.5721	9	41	14	3	1.15	67	74	-	-	-	-	-	-	-
07SR009001006.30RRF	6/3/2003	Campbell	SR009	6.3	-84.03642	36.56769	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001006.50RRF	6/3/2003	Campbell	SR009	6.5	-84.03731	36.56291	9	2	2	3	1.15	16	15	-	-	-	-	-	-	-
07SR009001007.20RRF	6/3/2003	Campbell	SR009	7.2	-84.04484	36.56064	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001007.30RRF	6/3/2003	Campbell	SR009	7.3	-84.04887	36.55827	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001007.40RRF	6/3/2003	Campbell	SR009	7.4	-84.04896	36.55661	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001008.30RRF	6/3/2003	Campbell	SR009	8.3	-84.05668	36.5519	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001008.65RRF	6/3/2003	Campbell	SR009	8.65	-84.05888	36.5535	27	2	14	3	1.15	46	49	-	-	-	-	-	-	-
07SR009001008.75RRF	6/3/2003	Campbell	SR009	8.75	-84.063	36.55514	27	2	14	3	1.15	46	49	-	-	-	-	-	-	-
07SR009001008.91RRF	6/3/2003	Campbell	SR009	8.91	-84.06337	36.55491	27	2	14	3	1.15	46	49	-	-	-	-	-	-	-
07SR009001010.00RRF	6/4/2003	Campbell	SR009	10	-84.07518	36.54731	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001010.55RRF	6/4/2003	Campbell	SR009	10.55	-84.0792	36.54288	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001011.10RRF	6/4/2003	Campbell	SR009	11.1	-84.08121	36.53792	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001011.60RRF	6/4/2003	Campbell	SR009	11.6	-84.08019	36.53247	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001011.65RRF	6/4/2003	Campbell	SR009	11.65	-84.07895	36.53021	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001011.95RRF	6/4/2003	Campbell	SR009	11.95	-84.07752	36.52624	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001011.99RRF	6/4/2003	Campbell	SR009	11.99	-84.07812	36.52573	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001012.60RRF	6/4/2003	Campbell	SR009	12.6	-84.08188	36.51787	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001018.40LRF	6/4/2003	Campbell	SR009	18.4	-84.08035	36.44286	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001020.35LRF	6/4/2003	Campbell	SR009	20.35	-84.09148	36.41822	-	-	-	-	-	-	-	27	5	14	9	1.3	55	60
07SR009001020.53LRF	6/4/2003	Campbell	SR009	20.53	-84.09221	36.41704	9	2	2	3	1.15	16	15	-	-	-	-	-	-	-
07SR009001020.57LRF	6/4/2003	Campbell	SR009	20.57	-84.09264	36.41665	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR009001020.60LRF	6/4/2003	Campbell	SR009	20.6	-84.09456	36.41592	9	5	14	9	1.3	37	36	-	-	-	-	-	-	-
07SR009001020.80LRF	6/4/2003	Campbell	SR009	20.8	-84.09667	36.41461	9	2	14	3	1.15	28	29	-	-	-	-	-	-	-
07SR009001021.20LRF	6/4/2003	Campbell	SR009	21.2	-84.10067	36.4121	9	2	14	9	1.3	34	33	-	-	-	-	-	-	-
07SR009001023.15LRF	6/4/2003	Campbell	SR009	23.15	-84.1271	36.39252	-	-	-	-	-	-	-	9	2	2	9	1.3	22	17
07SR009001023.25LRF	6/4/2003	Campbell	SR009	23.25	-84.127336	36.39163	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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File Number	Topple Failure					Differential Weathering						Raveling						RHRS Total Score				
	Block Size	Abundance Additive	Abundance Multiplicative	Total Score Additive	Total Score Multiplicative	Block Size	Relief	Abundance Additive	Abundance Multiplicative	Total Score Additive	Total Score Multiplicative	Block Size	Block Shape	Abundance Additive	Abundance Multiplicative	Total Score Additive	Total Score Multiplicative	Site & Roadway	Geologic Hazard Additive	Geologic Hazard Multiplicative	RHRS Hazard Additive	RHRS Hazard Multiplicative
04SR030001007.30LRF	-	-	-	-	-	-	-	-	-	-	-	27	9	81	1.9	117	68	192	117	68	309	260
04SR030001007.30RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	200	103	107	303	307
04SR030001007.40RRF	122	5	1.2	127	146	81	81	81	1.9	243	308	9	9	3	1.15	21	21	260	300	300	560	560
04SR030001007.70RRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	3	1.15	21	21	151	124	128	275	279
04SR030001008.50RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	27	1.6	45	29	226	103	92	329	318
04SR030001008.60RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	27	1.6	45	29	202	45	29	247	231
07I0075001016.00RRF	-	-	-	-	-	9	3	3	1.15	15	14	27	9	9	1.3	45	47	284	60	61	344	345
07I0075001026.70RRF	-	-	-	-	-	27	9	3	1.15	39	41	-	-	-	-	-	-	223	39	41	262	264
07SR009001005.50RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	139	88	95	227	234
07SR009001006.30RRF	-	-	-	-	-	81	9	3	1.15	93	104	81	9	3	1.15	93	104	192	186	208	378	400
07SR009001006.50RRF	-	-	-	-	-	27	9	3	1.15	39	41	-	-	-	-	-	-	190	55	56	245	246
07SR009001007.20RRF	-	-	-	-	-	-	-	-	-	-	-	81	9	9	1.3	99	117	138	99	117	237	255
07SR009001007.30RRF	-	-	-	-	-	-	-	-	-	-	-	9	3	27	1.6	39	19	152	39	19	191	171
07SR009001007.40RRF	-	-	-	-	-	-	-	-	-	-	-	9	3	81	1.9	93	23	138	93	23	231	161
07SR009001008.30RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	139	27	23	166	162
07SR009001008.65RRF	-	-	-	-	-	-	-	-	-	-	-	9	3	27	1.6	39	19	121	85	68	206	189
07SR009001008.75RRF	-	-	-	-	-	-	-	-	-	-	-	27	27	9	1.3	63	70	132	109	119	241	251
07SR009001008.91RRF	-	-	-	-	-	-	-	-	-	-	-	9	3	9	1.3	21	16	121	67	65	188	186
07SR009001010.00RRF	-	-	-	-	-	-	-	-	-	-	-	9	3	9	1.3	21	16	146	21	16	167	162
07SR009001010.55RRF	-	-	-	-	-	-	-	-	-	-	-	27	3	3	1.15	33	35	138	33	35	171	173
07SR009001011.10RRF	-	-	-	-	-	-	-	-	-	-	-	81	3	3	1.15	87	97	114	87	97	201	211
07SR009001011.60RRF	-	-	-	-	-	9	9	3	1.15	21	21	3	3	3	1.15	9	7	119	30	28	149	147
07SR009001011.65RRF	-	-	-	-	-	27	27	3	1.15	57	62	-	-	-	-	-	-	124	57	62	181	186
07SR009001011.95RRF	14	5	1.2	19	17	-	-	-	-	-	-	3	9	3	1.15	15	14	191	34	31	225	222
07SR009001011.99RRF	41	5	1.2	46	49	-	-	-	-	-	-	3	3	9	1.3	15	8	138	61	57	199	195
07SR009001012.60RRF	-	-	-	-	-	-	-	-	-	-	-	81	9	9	1.3	99	117	117	99	117	216	234
07SR009001018.40LRF	-	-	-	-	-	27	9	9	1.3	45	47	3	3	3	1.15	9	7	120	54	54	174	174
07SR009001020.35LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	138	76	81	214	219
07SR009001020.53LRF	-	-	-	-	-	-	-	-	-	-	-	9	3	9	1.3	21	16	135	37	31	172	166
07SR009001020.57LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	116	21	21	137	137
07SR009001020.60LRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	120	37	36	157	156
07SR009001020.80LRF	-	-	-	-	-	-	-	-	-	-	-	3	3	3	1.15	9	7	203	37	36	240	239
07SR009001021.20LRF	-	-	-	-	-	-	-	-	-	-	-	3	3	3	1.15	9	7	143	43	40	186	183
07SR009001023.15LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	3	1.15	15	14	126	37	31	163	157
07SR009001023.25LRF	-	-	-	-	-	-	-	-	-	-	-	27	3	27	1.6	57	48	125	57	48	182	173

File Number	Date	County	Road	BLM	Longitude	Latitude	Planar Failure							Wedge Failure						
										Abundance		Total Score					Abundance		Total Score	
							Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative	Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative
07SR071001000.01LRF	6/3/2003	Campbell	SR071	0.01	-84.09433	36.22419	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR090001000.80LRF	6/3/2003	Campbell	SR090	0.8	-84.04583	36.54653	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR090001001.90LRF	6/3/2003	Campbell	SR090	1.9	-84.04308	36.53583	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR090001001.99LRF	6/3/2003	Campbell	SR090	1.99	-84.04334	36.53508	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR090001002.05LRF	6/3/2003	Campbell	SR090	2.05	-84.04349	36.53438	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR090001002.20LRF	6/3/2003	Campbell	SR090	2.2	-84.04209	36.53249	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR090001002.25LRF	6/3/2003	Campbell	SR090	2.25	-84.04138	36.53229	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR090001004.55LRF	6/3/2003	Campbell	SR090	4.55	-84.01473	36.5393	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR090001004.60LRF	6/3/2003	Campbell	SR090	4.6	-84.01255	36.53877	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR116001004.60RRF	6/3/2003	Campbell	SR116	4.6	-84.21331	36.28861	27	2	2	3	1.15	34	36	27	5	2	3	1.15	37	39
07SR297001000.05RRF	6/2/2003	Campbell	SR297	0.05	-84.30219	36.41492	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR297001001.00RRF	6/2/2003	Campbell	SR297	1	-84.31458	36.4208	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR297001001.35LRF	6/2/2003	Campbell	SR297	1.35	-84.31811	36.42611	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR297001009.04LRF	6/2/2003	Campbell	SR297	9.04	-84.23382	36.50074	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07SR297001010.00LRF	6/2/2003	Campbell	SR297	10	-84.21777	36.51017	-	-	-	-	-	-	-	9	5	14	3	1.15	31	32
07SR297001010.10LRF	6/2/2003	Campbell	SR297	10.1	-84.2201	36.5072	-	-	-	-	-	-	-	9	5	14	3	1.15	31	32
07SR297001010.50RRF	6/2/2003	Campbell	SR297	10.5	-84.21584	36.51306	-	-	-	-	-	-	-	-	-	-	-	-	-	-
08SR053001013.70RRF	7/22/2003	Cannon	SR053	13.7	-58.5967	39.65489	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11SR049001003.60RRF	6/19/2003	Cheatham	SR049	3.6	-49.1028	40.14957	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11SR070001006.30LRF	6/18/2003	Cheatham	SR070	6.3	-49.2503	39.96655	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11SR070001006.40LRF	6/18/2003	Cheatham	SR070	6.4	-49.2634	39.96672	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11SR070001006.80LRF	6/18/2003	Cheatham	SR070	6.8	-49.3038	39.96566	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11SR249001011.00LRF	6/19/2003	Cheatham	SR249	11	-49.5675	40.0807	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11SR249001016.30LRF	6/19/2003	Cheatham	SR249	16.3	-49.2614	40.13723	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13SR033001013.95LRF	6/4/2003	Claiborne	SR033	13.95	-83.48572	36.41889	9	41	2	3	1.15	55	60	-	-	-	-	-	-	-
13SR063001025.30LRF	6/5/2003	Claiborne	SR063	25.3	-83.55888	36.5795	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13SR063001025.35LRF	6/5/2003	Claiborne	SR063	25.35	-83.55775	36.58025	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13SR063001025.50LRF	6/5/2003	Claiborne	SR063	25.5	-83.55599	36.58213	9	5	2	3	1.15	19	18	-	-	-	-	-	-	-
13SR063001025.70LRF	6/5/2003	Claiborne	SR063	25.7	-83.55474	36.58244	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13SR063001025.75LRF	6/5/2003	Claiborne	SR063	25.75	-83.55181	36.58349	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13SR063001026.02LRF	6/5/2003	Claiborne	SR063	26.02	-83.54755	36.58433	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13SR063001028.40RRF	6/5/2003	Claiborne	SR063	28.4	-83.51009	36.58386	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13SR063001036.60RRF	6/5/2003	Claiborne	SR063	36.6	-83.4379	36.53163	81	2	2	3	1.15	88	98	-	-	-	-	-	-	-
13SR063001038.40RRF	6/5/2003	Claiborne	SR063	38.4	-83.4138	36.54679	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13SR090001001.50LRF	6/3/2003	Claiborne	SR090	1.5	-83.96161	36.552	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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File Number	Topple Failure					Differential Weathering						Raveling						RHRS Total Score				
		Abundance		Total Score				Abundance		Total Score				Abundance		Total Score			Geologic Hazard		RHRS Hazard	
	Block Size	Additive	Multiplicative	Additive	Multiplicative	Block Size	Relief	Additive	Multiplicative	Additive	Multiplicative	Block Size	Block Shape	Additive	Multiplicative	Additive	Multiplicative	Site & Roadway	Additive	Multiplicative	Additive	Multiplicative
07SR071001000.01LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	197	21	21	218	218
07SR090001000.80LRF	-	-	-	-	-	81	27	27	1.6	135	173	3	3	3	1.15	9	7	114	144	180	258	294
07SR090001001.90LRF	-	-	-	-	-	81	27	81	1.9	189	205	3	3	9	1.3	15	8	161	204	213	365	374
07SR090001001.99LRF	-	-	-	-	-	81	81	9	1.3	171	211	-	-	-	-	-	-	184	171	211	355	395
07SR090001002.05LRF	-	-	-	-	-	81	81	9	1.3	171	211	-	-	-	-	-	-	169	171	211	340	380
07SR090001002.20LRF	-	-	-	-	-	81	81	9	1.3	171	211	9	9	3	1.15	21	21	216	192	232	408	448
07SR090001002.25LRF	-	-	-	-	-	27	27	9	1.3	63	70	27	9	9	1.3	45	47	225	108	117	333	342
07SR090001004.55LRF	-	-	-	-	-	81	81	27	1.6	189	259	-	-	-	-	-	-	154	189	259	343	413
07SR090001004.60LRF	-	-	-	-	-	-	-	-	-	-	-	9	3	9	1.3	21	16	140	21	16	161	156
07SR116001004.60RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	170	98	98	268	268
07SR297001000.05RRF	-	-	-	-	-	3	9	3	1.15	15	14	-	-	-	-	-	-	119	15	14	134	133
07SR297001001.00RRF	-	-	-	-	-	-	-	-	-	-	-	3	3	81	1.9	87	11	141	87	11	228	152
07SR297001001.35LRF	-	-	-	-	-	81	9	9	1.3	99	117	-	-	-	-	-	-	131	99	117	230	248
07SR297001009.04LRF	-	-	-	-	-	27	9	3	1.15	39	41	-	-	-	-	-	-	134	39	41	173	175
07SR297001010.00LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	140	58	55	198	195
07SR297001010.10LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	139	52	53	191	192
07SR297001010.50RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	157	27	23	184	180
08SR053001013.70RRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	3	1.15	21	21	213	48	44	261	257
11SR049001003.60RRF	-	-	-	-	-	27	27	81	1.9	135	103	9	9	3	1.15	21	21	77	156	124	233	201
11SR070001006.30LRF	14	5	1.2	19	17	9	9	81	1.9	99	34	3	3	3	1.15	9	7	116	127	58	243	174
11SR070001006.40LRF	-	-	-	-	-	9	9	27	1.6	45	29	-	-	-	-	-	-	208	45	29	253	237
11SR070001006.80LRF	-	-	-	-	-	27	27	81	1.9	135	103	3	3	3	1.15	9	7	119	144	110	263	229
11SR249001011.00LRF	-	-	-	-	-	3	9	81	1.9	93	23	-	-	-	-	-	-	150	93	23	243	173
11SR249001016.30LRF	-	-	-	-	-	9	9	3	1.15	21	21	3	3	9	1.3	15	8	212	36	29	248	241
13SR033001013.95LRF	-	-	-	-	-	-	-	-	-	-	-	3	3	3	1.15	9	7	118	64	67	182	185
13SR063001025.30LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	172	21	21	193	193
13SR063001025.35LRF	-	-	-	-	-	3	9	9	1.3	21	16	-	-	-	-	-	-	167	21	16	188	183
13SR063001025.50LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	3	1.15	15	14	157	34	32	191	189
13SR063001025.70LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	9	1.3	21	16	154	21	16	175	170
13SR063001025.75LRF	-	-	-	-	-	3	9	3	1.15	15	14	3	9	3	1.15	15	14	154	30	28	184	182
13SR063001026.02LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	9	1.3	21	16	163	21	16	184	179
13SR063001028.40RRF	-	-	-	-	-	9	9	3	1.15	21	21	3	9	3	1.15	15	14	163	36	35	199	198
13SR063001036.60RRF	-	-	-	-	-	27	27	27	1.6	81	86	-	-	-	-	-	-	163	169	184	332	347
13SR063001038.40RRF	-	-	-	-	-	-	-	-	-	-	-	27	9	9	1.3	45	47	137	45	47	182	184
13SR090001001.50LRF	-	-	-	-	-	3	9	3	1.15	15	14	-	-	-	-	-	-	155	15	14	170	169

File Number	Date	County	Road	BLM	Longitude	Latitude	Planar Failure							Wedge Failure						
										Abundance		Total Score					Abundance		Total Score	
							Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative	Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative
13SR090001003.45LRF	6/3/2003	Claiborne	SR090	3.45	-83.93627	36.562627	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13SR345001000.70RRF	6/5/2003	Claiborne	SR345	0.7	-83.5556	36.46392	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13SR345001004.50LRF	6/5/2003	Claiborne	SR345	4.5	-83.50534	36.49714	27	2	2	3	1.15	34	36	-	-	-	-	-	-	-
13SR345001004.70RRF	6/5/2003	Claiborne	SR345	4.7	-83.50527	36.4992	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14SR052001024.60LRF	7/17/2003	Clay	SR052	24.6	-63.7633	40.41648	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14SR053001000.60LRF	7/17/2003	Clay	SR053	0.6	-62.7985	40.37821	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14SR053001002.50RRF	7/17/2003	Clay	SR053	2.5	-62.926	40.40146	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16SR002001003.40LRF	6/26/2003	Coffee	SR002	3.4			-	-	-	-	-	-	-	-	-	-	-	-	-	-
16SR002001003.80LRF	6/26/2003	Coffee	SR002	3.8	-57.2171	39.38413	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16SR002001003.80RRF	6/26/2003	Coffee	SR002	3.8	-57.2171	39.38413	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18SR001001024.20LRF	8/28/2003	Cumberland	SR001	24.2			-	-	-	-	-	-	-	-	-	-	-	-	-	-
18SR001001024.20RRF	8/28/2003	Cumberland	SR001	24.2	-69.085	39.76115	9	2	14	3	1.15	28	29	-	-	-	-	-	-	-
18SR001001028.50LRF	7/23/2003	Cumberland	SR001	28.5	-69.6388	39.73261	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18SR001001029.00LRF	7/23/2003	Cumberland	SR001	29	-69.6749	39.72899	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18SR001001029.20LRF	7/23/2003	Cumberland	SR001	29.2	-69.7547	39.7294	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18SR001001032.00LRF	7/23/2003	Cumberland	SR001	32	-70.1196	39.71671	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18SR001001032.20LRF	7/23/2003	Cumberland	SR001	32.2	-70.1433	39.71683	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR001001002.40LRF	7/14/2003	Davidson	SR001	2.4	-49.9831	39.94559	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR001001025.30LRF	7/10/2003	Davidson	SR001	25.3	-53.0408	39.95147	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR001001025.30RRF	7/10/2003	Davidson	SR001	25.3	-53.0408	39.95147	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR001001025.40RRF	7/10/2003	Davidson	SR001	25.4			-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR006001000.50LRF	7/14/2003	Davidson	SR006	0.5	-51.9574	39.887	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR006001000.85LRF	7/14/2003	Davidson	SR006	0.85	-51.9922	39.89113	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR006001005.40LRF	7/14/2003	Davidson	SR006	5.4	-52.0396	39.9642	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR006001012.10LRF	7/14/2003	Davidson	SR006	12.1	-52.223	40.05273	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR006001012.70LRF	7/14/2003	Davidson	SR006	12.7	-52.2315	40.061	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR006001012.70RRF	7/14/2003	Davidson	SR006	12.7	-52.231	40.061	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR006001013.00LRF	7/14/2003	Davidson	SR006	13	-52.2455	40.0671	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR011001006.20RRF	7/14/2003	Davidson	SR011	6.2	-52.4739	39.92472	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR011001010.60RRF	7/14/2003	Davidson	SR011	10.6	-52.175	39.98722	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR012001006.20RRF	7/14/2003	Davidson	SR012	6.2	-52.4739	39.92472	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR012001008.40LRF	7/14/2003	Davidson	SR012	8.4	-50.8519	40.07298	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR012001008.40RRF	7/14/2003	Davidson	SR012	8.4	-50.8519	40.07298	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR012001010.70RRF	7/14/2003	Davidson	SR012	10.7	-50.4867	40.0671	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR012001013.00LRF	7/14/2003	Davidson	SR012	13	-50.1996	40.08119	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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File Number	Topple Failure					Differential Weathering						Raveling						RHRS Total Score				
	Block Size	Abundance		Total Score		Block Size	Relief	Abundance		Total Score		Block Size	Block Shape	Abundance		Total Score		Site & Roadway	Geologic Hazard		RHRS Hazard	
		Additive	Multiplicative	Additive	Multiplicative			Additive	Multiplicative	Additive	Multiplicative			Additive	Multiplicative	Additive	Multiplicative		Additive	Multiplicative	Additive	Multiplicative
13SR090001003.45LRF	-	-	-	-	-	81	81	9	1.3	171	211	3	9	3	1.15	15	14	141	186	225	327	366
13SR345001000.70RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	124	27	23	151	147
13SR345001004.50LRF	14	5	1.2	19	17	-	-	-	-	-	-	9	9	9	1.3	27	23	157	80	76	237	233
13SR345001004.70RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	154	27	23	181	177
14SR052001024.60LRF	-	-	-	-	-	27	27	9	1.3	63	70	9	9	9	1.3	27	23	90	90	93	180	183
14SR053001000.60LRF	-	-	-	-	-	81	27	9	1.3	117	140	-	-	-	-	-	-	171	117	140	288	311
14SR053001002.50RRF	-	-	-	-	-	27	9	9	1.3	45	47	9	9	81	1.9	99	34	181	144	81	325	262
16SR002001003.40LRF	-	-	-	-	-	9	9	27	1.6	45	29	-	-	-	-	-	-	133	45	29	178	162
16SR002001003.80LRF	-	-	-	-	-	3	9	81	1.9	93	23	-	-	-	-	-	-	199	93	23	292	222
16SR002001003.80RRF	-	-	-	-	-	3	9	81	1.9	93	23	-	-	-	-	-	-	199	93	23	292	222
18SR001001024.20LRF	14	41	1.75	55	25	-	-	-	-	-	-	9	9	81	1.9	99	34	110	154	59	264	169
18SR001001024.20RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	81	1.9	99	34	114	127	63	241	177
18SR001001028.50LRF	-	-	-	-	-	9	9	27	1.6	45	29	3	9	3	1.15	15	14	127	60	43	187	170
18SR001001029.00LRF	-	-	-	-	-	9	9	81	1.9	99	34	9	9	3	1.15	21	21	186	120	55	306	241
18SR001001029.20LRF	-	-	-	-	-	9	9	27	1.6	45	29	9	9	3	1.15	21	21	209	66	50	275	259
18SR001001032.00LRF	-	-	-	-	-	9	3	9	1.3	21	16	3	3	3	1.15	9	7	187	30	23	217	210
18SR001001032.20LRF	-	-	-	-	-	27	9	9	1.3	45	47	9	9	3	1.15	21	21	183	66	68	249	251
19SR001001002.40LRF	-	-	-	-	-	27	81	81	1.9	189	205	-	-	-	-	-	-	253	189	205	442	458
19SR001001025.30LRF	-	-	-	-	-	9	9	9	1.3	27	23	-	-	-	-	-	-	187	27	23	214	210
19SR001001025.30RRF	-	-	-	-	-	9	9	9	1.3	27	23	-	-	-	-	-	-	187	27	23	214	210
19SR001001025.40RRF	-	-	-	-	-	9	9	9	1.3	27	23	-	-	-	-	-	-	187	27	23	214	210
19SR006001000.50LRF	-	-	-	-	-	9	9	9	1.3	27	23	-	-	-	-	-	-	95	27	23	122	118
19SR006001000.85LRF	-	-	-	-	-	27	9	81	1.9	117	68	3	9	3	1.15	15	14	212	132	82	344	294
19SR006001005.40LRF	-	-	-	-	-	3	3	9	1.3	15	8	3	9	3	1.15	15	14	183	30	22	213	205
19SR006001012.10LRF	-	-	-	-	-	9	9	27	1.6	45	29	-	-	-	-	-	-	212	45	29	257	241
19SR006001012.70LRF	-	-	-	-	-	3	3	9	1.3	15	8	3	9	3	1.15	15	14	192	30	22	222	214
19SR006001012.70RRF	-	-	-	-	-	3	3	9	1.3	15	8	3	9	3	1.15	15	14	192	30	22	222	214
19SR006001013.00LRF	-	-	-	-	-	3	9	9	1.3	21	16	-	-	-	-	-	-	194	21	16	215	210
19SR011001006.20RRF	-	-	-	-	-	3	3	27	1.6	33	10	-	-	-	-	-	-	87	33	10	120	97
19SR011001010.60RRF	-	-	-	-	-	9	9	9	1.3	27	23	3	9	3	1.15	15	14	227	42	37	269	264
19SR012001006.20RRF	-	-	-	-	-	3	3	27	1.6	33	10	-	-	-	-	-	-	186	33	10	219	196
19SR012001008.40LRF	-	-	-	-	-	9	9	9	1.3	27	23	-	-	-	-	-	-	246	27	23	273	269
19SR012001008.40RRF	-	-	-	-	-	9	9	9	1.3	27	23	-	-	-	-	-	-	246	27	23	273	269
19SR012001010.70RRF	-	-	-	-	-	9	9	3	1.15	21	21	27	9	3	1.15	39	41	212	60	62	272	274
19SR012001013.00LRF	-	-	-	-	-	9	9	9	1.3	27	23	3	3	3	1.15	9	7	209	36	30	245	239

File Number	Date	County	Road	BLM	Longitude	Latitude	Planar Failure: Block Size	Planar Failure: Steepness	Planar Failure: Friction	Planar Failure: Abundance Additive	Planar Failure: Abundance Multiplicative	Planar Failure: Total Score Additive	Planar Failure: Total Score Multiplicative	Wedge Failure: Block Size	Wedge Failure: Steepness	Wedge Failure: Friction	Wedge Failure: Abundance Additive	Wedge Failure: Abundance Multiplicative	Wedge Failure: Total Score Additive	Wedge Failure: Total Score Multiplicative
19SR024001001.80RRF	7/14/2003	Davidson	SR024	1.8	-50.7218	39.91715	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR024001002.00LRF	7/14/2003	Davidson	SR024	2	-50.7218	39.91715	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR045001017.50LRF	7/9/2003	Davidson	SR045	17.5	-53.5674	40.03571	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR070001001.60LRF	6/13/2003	Davidson	SR070	1.6	-49.8805	39.94159	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR070001001.80LRF	6/18/2003	Davidson	SR070	1.8	-49.9017	39.94322	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR100001003.50LRF	7/7/2003	Davidson	SR100	3.5	-50.0954	39.8751	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR100001003.50RRF	7/7/2003	Davidson	SR100	3.5	-50.0957	39.87506	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR100001003.60LRF	7/7/2003	Davidson	SR100	3.6	-50.1134	39.87614	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR100001003.80RRF	7/14/2003	Davidson	SR100	3.8	-50.1318	39.87629	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR112001005.90LRF	7/15/2003	Davidson	SR112	5.9	-51.2311	40.14122	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR251001005.90LRF	7/14/2003	Davidson	SR251	5.9	-50.7218	39.91715	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR251001007.90LRF	7/8/2003	Davidson	SR251	7.9	-50.6551	39.97873	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19SR251001007.90RRF	7/8/2003	Davidson	SR251	7.9	-50.6549	39.97874	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20SR100001009.95LRF	6/17/2003	Decatur	SR100	9.95	-40.1497	39.37949	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20SR100001009.95RRF	6/17/2003	Decatur	SR100	9.95	-40.1497	39.37949	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR026001024.10RRF	7/22/2003	DeKalb	SR026	24.1	-61.536	39.80519	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR026001024.90LRF	7/22/2003	DeKalb	SR026	24.9	-61.6213	39.80918	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR026001025.20LRF	7/22/2003	DeKalb	SR026	25.2	-61.6302	39.81096	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR096001010.70LRF	7/22/2003	DeKalb	SR096	10.7	-60.3641	39.93639	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR096001011.90LRF	7/22/2003	DeKalb	SR096	11.9	-60.4653	39.94314	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR096001012.90RRF	7/22/2003	DeKalb	SR096	12.9	-60.5761	39.9555	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR141001000.80RRF	7/22/2003	DeKalb	SR141	0.8	-60.33	39.965	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR141001001.10RRF	7/22/2003	DeKalb	SR141	1.1	-60.339	39.96146	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR141001002.90RRF	7/22/2003	DeKalb	SR141	2.9	-60.5266	39.95276	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR141001003.10RRF	7/21/2003	DeKalb	SR141	3.1	-60.6598	39.96047	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR141001003.40LRF	7/21/2003	DeKalb	SR141	3.4	-60.7201	39.95723	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21SR141001004.00LRF	7/21/2003	DeKalb	SR141	4	-60.7622	39.95363	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22SR046001023.10LRF	6/18/2003	Dickson	SR046	23.1	-45.1294	40.08002	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25SR028001025.90RRF	8/4/2003	Fentress	SR028	25.9	-68.1793	40.41618	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25SR052001005.60RRF	8/6/2003	Fentress	SR052	5.6	-67.6883	40.3207	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25SR052001010.80RRF	8/6/2003	Fentress	SR052	10.8	-68.2758	40.3483	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25SR052001011.00LRF	8/6/2003	Fentress	SR052	11	-68.303	40.34875	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25SR085001003.60LRF	8/6/2003	Fentress	SR085	3.6	-67.2884	40.1452	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25SR085001003.65LRF	8/6/2003	Fentress	SR085	3.65	-67.2899	40.14617	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25SR085001004.30LRF	8/6/2003	Fentress	SR085	4.3	-67.3866	40.15054	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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File Number	Topple Failure					Differential Weathering						Raveling						RHRS Total Score				
		Abundance		Total Score				Abundance		Total Score				Abundance		Total Score			Geologic Hazard		RHRS Hazard	
	Block Size	Additive	Multiplicative	Additive	Multiplicative	Block Size	Relief	Additive	Multiplicative	Additive	Multiplicative	Block Size	Block Shape	Additive	Multiplicative	Additive	Multiplicative	Site & Roadway	Additive	Multiplicative	Additive	Multiplicative
19SR024001001.80RRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	3	1.15	21	21	139	42	42	181	181
19SR024001002.00LRF	-	-	-	-	-	81	27	3	1.15	111	124	9	9	3	1.15	21	21	124	132	145	256	269
19SR045001017.50LRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	3	1.15	21	21	216	42	42	258	258
19SR070001001.60LRF	-	-	-	-	-	9	9	27	1.6	45	29	-	-	-	-	-	-	116	45	29	161	145
19SR070001001.80LRF	-	-	-	-	-	9	9	27	1.6	45	29	-	-	-	-	-	-	55	45	29	100	84
19SR100001003.50LRF	-	-	-	-	-	9	9	9	1.3	27	23	3	3	9	1.3	15	8	190	42	31	232	221
19SR100001003.50RRF	-	-	-	-	-	9	9	9	1.3	27	23	3	3	9	1.3	15	8	215	42	31	257	246
19SR100001003.60RRF	-	-	-	-	-	9	9	9	1.3	27	23	3	3	9	1.3	15	8	211	42	31	253	242
19SR100001003.80RRF	-	-	-	-	-	9	27	27	1.6	63	58	-	-	-	-	-	-	126	63	58	189	184
19SR112001005.90LRF	-	-	-	-	-	81	27	9	1.3	117	140	-	-	-	-	-	-	100	117	140	217	240
19SR251001005.90LRF	-	-	-	-	-	3	9	9	1.3	21	16	3	3	3	1.15	9	7	203	30	23	233	226
19SR251001007.90LRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	27	1.6	45	29	152	72	52	224	204
19SR251001007.90RRF	-	-	-	-	-	9	27	9	1.3	45	47	9	9	9	1.3	27	23	156	72	70	228	226
20SR100001009.95LRF	-	-	-	-	-	3	3	27	1.6	33	10	-	-	-	-	-	-	196	33	10	229	206
20SR100001009.95RRF	-	-	-	-	-	3	3	27	1.6	33	10	-	-	-	-	-	-	195	33	10	228	205
21SR026001024.10RRF	-	-	-	-	-	27	9	9	1.3	45	47	9	9	3	1.15	21	21	188	66	68	254	256
21SR026001024.90LRF	-	-	-	-	-	9	3	9	1.3	21	16	-	-	-	-	-	-	196	21	16	217	212
21SR026001025.20LRF	-	-	-	-	-	9	9	27	1.6	45	29	-	-	-	-	-	-	187	45	29	232	216
21SR096001010.70LRF	-	-	-	-	-	9	9	81	1.9	99	34	-	-	-	-	-	-	222	99	34	321	256
21SR096001011.90LRF	-	-	-	-	-	9	9	27	1.6	45	29	9	9	3	1.15	21	21	131	66	50	197	181
21SR096001012.90RRF	-	-	-	-	-	27	9	9	1.3	45	47	9	9	27	1.6	45	29	158	90	76	248	234
21SR141001000.80RRF	-	-	-	-	-	81	81	27	1.6	189	259	9	9	3	1.15	21	21	276	210	280	486	556
21SR141001001.10RRF	-	-	-	-	-	27	9	9	1.3	45	47	-	-	-	-	-	-	183	45	47	228	230
21SR141001002.90RRF	-	-	-	-	-	81	27	81	1.9	189	205	9	9	3	1.15	21	21	167	210	226	377	393
21SR141001003.10RRF	-	-	-	-	-	27	3	3	1.15	33	35	9	9	27	1.6	45	29	123	78	64	201	187
21SR141001003.40LRF	-	-	-	-	-	27	9	3	1.15	39	41	9	9	3	1.15	21	21	123	60	62	183	185
21SR141001004.00LRF	-	-	-	-	-	27	9	3	1.15	39	41	9	9	9	1.3	27	23	195	66	64	261	259
22SR046001023.10LRF	-	-	-	-	-	27	27	9	1.3	63	70	9	9	27	1.6	45	29	143	108	99	251	242
25SR028001025.90RRF	-	-	-	-	-	9	27	9	1.3	45	47	9	9	9	1.3	27	23	201	72	70	273	271
25SR052001005.60RRF	-	-	-	-	-	27	27	3	1.15	57	62	9	9	3	1.15	21	21	208	78	83	286	291
25SR052001010.80RRF	-	-	-	-	-	27	81	3	1.15	111	124	9	9	3	1.15	21	21	199	132	145	331	344
25SR052001011.00LRF	-	-	-	-	-	27	27	3	1.15	57	62	9	9	3	1.15	21	21	194	78	83	272	277
25SR085001003.60LRF	-	-	-	-	-	3	3	81	1.9	87	11	-	-	-	-	-	-	247	87	11	334	258
25SR085001003.65LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	27	1.6	45	29	172	45	29	217	201
25SR085001004.30LRF	-	-	-	-	-	27	27	27	1.6	81	86	-	-	-	-	-	-	182	81	86	263	268

File Number	Date	County	Road	BLM	Longitude	Latitude	Planar Failure							Wedge Failure						
										Abundance		Total Score					Abundance		Total Score	
							Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative	Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative
25SR085001007.10RRF	8/6/2003	Fentress	SR085	7.1	-67.6104	40.1521	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25SR085001007.20RRF	8/6/2003	Fentress	SR085	7.2	-67.6122	40.15421	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25SR085001007.40RRF	8/6/2003	Fentress	SR085	7.4	-67.6194	40.15738	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25SR085001007.90RRF	8/6/2003	Fentress	SR085	7.9	-67.6285	40.16174	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30SR035001004.20LRF	6/30/2003	Greene	SR035	4.2	-82.95591	36.08384	9	41	5	9	1.3	64	72	-	-	-	-	-	-	-
30SR340001000.70RRF	6/30/2003	Greene	SR340	0.7	-83.0508	36.09891	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30SR340001006.30RRF	6/30/2003	Greene	SR340	6.3	-83.12303	36.12508	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30SR340001006.35RRF	6/30/2003	Greene	SR340	6.35	-83.12468	36.127	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31SR050001009.90RRF	7/31/2003	Grundy	SR050	9.9	-60.7654	39.1368	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33SR002001002.60LRF	7/30/2003	Hamilton	SR002	2.6	-64.8228	38.76337	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33SR002001002.60RRF	7/30/2003	Hamilton	SR002	2.6	-64.8228	38.76337	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33SR002001022.10LRF	7/29/2003	Hamilton	SR002	22.1	-67.83	38.83311	9	5	14	3	1.15	31	32	-	-	-	-	-	-	-
33SR008001016.00RRF	7/30/2003	Hamilton	SR008	16	-64.9909	38.86828	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33SR008001016.20LRF	7/30/2003	Hamilton	SR008	16.2	-65.0007	38.8735	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR031001000.05LRF	6/10/2003	Hancock	SR031	0.05	-83.22191	36.41192	-	-	-	-	-	-	-	27	41	2	9	1.3	79	91
34SR031001000.15LRF	6/10/2003	Hancock	SR031	0.15	-83.22317	36.41123	27	14	2	3	1.15	46	49	-	-	-	-	-	-	-
34SR031001000.30LRF	6/10/2003	Hancock	SR031	0.3	-83.2249	36.41112	9	41	2	3	1.15	55	60	9	14	2	3	1.15	28	29
34SR031001000.50RRF	6/10/2003	Hancock	SR031	0.5	-83.2241	36.41245	-	-	-	-	-	-	-	9	5	2	3	1.15	19	18
34SR033001000.27RRF	6/10/2003	Hancock	SR033	0.27	-83.37515	36.49061	9	14	5	3	1.15	31	32	-	-	-	-	-	-	-
34SR033001001.10RRF	6/10/2003	Hancock	SR033	1.1	-83.36393	36.4684	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR033001001.40LRF	6/10/2003	Hancock	SR033	1.4	-83.35938	36.49662	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR033001008.06LRF	6/10/2003	Hancock	SR033	8.06	-83.2597	36.50213	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR033001008.10LRF	6/10/2003	Hancock	SR033	8.1	-83.25935	36.5018	-	-	-	-	-	-	-	9	5	2	3	1.15	19	18
34SR033001016.10LRF	6/9/2003	Hancock	SR033	16.1	-83.15743	36.55221	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR033001016.40LRF	6/9/2003	Hancock	SR033	16.4	-83.1564	36.5488	27	2	5	3	1.15	37	39	-	-	-	-	-	-	-
34SR033001016.50LRF	6/9/2003	Hancock	SR033	16.5	-83.15465	36.5474	-	-	-	-	-	-	-	9	2	5	9	1.3	25	21
34SR033001016.70LRF	6/9/2003	Hancock	SR033	16.7	-83.15374	36.54632	-	-	-	-	-	-	-	81	2	5	3	1.15	91	101
34SR033001016.75LRF	6/9/2003	Hancock	SR033	16.75	-83.15257	36.5445	-	-	-	-	-	-	-	9	2	2	3	1.15	16	15
34SR033001017.20LRF	6/9/2003	Hancock	SR033	17.2	-83.14436	36.54436	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR033001018.20LRF	6/9/2003	Hancock	SR033	18.2	-83.13117	36.54768	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR033001026.55LRF	6/9/2003	Hancock	SR033	26.55	-83.002	36.59098	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR033001026.60LRF	6/9/2003	Hancock	SR033	26.6	-82.99875	36.59224	-	-	-	-	-	-	-	9	2	2	3	1.15	16	15
34SR066001000.30LRF	6/9/2003	Hancock	SR066	0.3	-83.14564	36.49218	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR066001000.36LRF	6/9/2003	Hancock	SR066	0.36	-83.14444	36.49417	-	-	-	-	-	-	-	3	5	2	3	1.15	13	12
34SR066001000.37LRF	6/9/2003	Hancock	SR066	0.37	-83.14552	36.49296	9	5	5	9	1.3	28	25	-	-	-	-	-	-	-

Continued on next page

File Number	Topple Failure					Differential Weathering						Raveling						RHRS Total Score				
		Abundance		Total Score				Abundance		Total Score				Abundance		Total Score			Geologic Hazard		RHRS Hazard	
	Block Size	Additive	Multiplicative	Additive	Multiplicative	Block Size	Relief	Additive	Multiplicative	Additive	Multiplicative	Block Size	Block Shape	Additive	Multiplicative	Additive	Multiplicative	Site & Roadway	Additive	Multiplicative	Additive	Multiplicative
25SR085001007.10RRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	27	1.6	45	29	248	66	50	314	298
25SR085001007.20RRF	-	-	-	-	-	3	3	81	1.9	87	11	-	-	-	-	-	-	172	87	11	259	183
25SR085001007.40RRF	-	-	-	-	-	9	3	81	1.9	93	23	-	-	-	-	-	-	192	93	23	285	215
25SR085001007.90RRF	-	-	-	-	-	27	27	81	1.9	135	103	-	-	-	-	-	-	237	135	103	372	340
30SR035001004.20LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	3	1.15	15	14	191	79	86	270	277
30SR340001000.70RRF	-	-	-	-	-	-	-	-	-	-	-	3	3	9	1.3	15	8	210	15	8	225	218
30SR340001006.30RRF	-	-	-	-	-	-	-	-	-	-	-	3	9	9	1.3	21	16	226	21	16	247	242
30SR340001006.35RRF	-	-	-	-	-	-	-	-	-	-	-	3	3	3	1.15	9	7	172	9	7	181	179
31SR050001009.90RRF	-	-	-	-	-	9	9	9	1.3	27	23	-	-	-	-	-	-	194	27	23	221	217
33SR002001002.60LRF	-	-	-	-	-	9	9	81	1.9	99	34	-	-	-	-	-	-	94	99	34	193	128
33SR002001002.60RRF	-	-	-	-	-	9	9	81	1.9	99	34	-	-	-	-	-	-	91	99	34	190	125
33SR002001022.10LRF	-	-	-	-	-	9	9	9	1.3	27	23	3	9	3	1.15	15	14	187	73	69	260	256
33SR008001016.00RRF	-	-	-	-	-	81	81	27	1.6	189	259	27	9	3	1.15	39	41	383	228	300	611	683
33SR008001016.20LRF	-	-	-	-	-	27	81	81	1.9	189	205	-	-	-	-	-	-	129	189	205	318	334
34SR031001000.05LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	191	100	112	291	303
34SR031001000.15LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	9	1.3	21	16	140	67	65	207	205
34SR031001000.30LRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	136	83	89	219	225
34SR031001000.50RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	27	1.6	45	29	135	64	47	199	182
34SR033001000.27RRF	-	-	-	-	-	-	-	-	-	-	-	3	9	9	1.3	21	16	177	52	48	229	225
34SR033001001.10RRF	41	5	1.2	46	49	-	-	-	-	-	-	-	-	-	-	-	-	148	46	49	194	197
34SR033001001.40LRF	-	-	-	-	-	9	9	3	1.15	21	21	3	9	3	1.15	15	14	155	36	35	191	190
34SR033001008.06LRF	-	-	-	-	-	3	3	3	1.15	9	7	3	9	3	1.15	15	14	154	24	21	178	175
34SR033001008.10LRF	14	5	1.2	19	17	-	-	-	-	-	-	-	-	-	-	-	-	154	38	35	192	189
34SR033001016.10LRF	-	-	-	-	-	-	-	-	-	-	-	81	9	3	1.15	93	104	158	93	104	251	262
34SR033001016.40LRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	205	37	39	242	244
34SR033001016.50LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	3	1.15	15	14	219	40	35	259	254
34SR033001016.70LRF	-	-	-	-	-	9	27	3	1.15	39	41	-	-	-	-	-	-	161	130	142	291	303
34SR033001016.75LRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	9	1.3	27	23	212	64	59	276	271
34SR033001017.20LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	212	27	23	239	235
34SR033001018.20LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	139	21	21	160	160
34SR033001026.55LRF	41	14	1.4	55	57	-	-	-	-	-	-	9	9	3	1.15	21	21	173	76	78	249	251
34SR033001026.60LRF	-	-	-	-	-	-	-	-	-	-	-	27	9	3	1.15	39	41	165	55	56	220	221
34SR066001000.30LRF	14	5	1.2	19	17	-	-	-	-	-	-	9	3	3	1.15	15	14	181	34	31	215	212
34SR066001000.36LRF	5	14	1.4	19	7	-	-	-	-	-	-	3	9	3	1.15	15	14	172	47	33	219	205
34SR066001000.37LRF	-	-	-	-	-	-	-	-	-	-	-	3	3	3	1.15	9	7	174	37	32	211	206

File Number	Date	County	Road	BLM	Longitude	Latitude	Planar Failure							Wedge Failure						
										Abundance		Total Score					Abundance		Total Score	
							Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative	Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative
34SR066001000.40LRF	6/9/2003	Hancock	SR066	0.4	-83.14449	36.4935	9	41	2	9	1.3	61	68	-	-	-	-	-	-	-
34SR066001000.41LRF	6/9/2003	Hancock	SR066	0.41	-83.14324	36.49429	27	14	5	9	1.3	55	60	-	-	-	-	-	-	-
34SR066001000.50LRF	6/9/2003	Hancock	SR066	0.5	-83.14227	36.49666	9	14	2	3	1.15	28	29	-	-	-	-	-	-	-
34SR066001000.60RRF	6/10/2003	Hancock	SR066	0.6	-83.39787	36.55038	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR066001000.70RRF	6/10/2003	Hancock	SR066	0.7	-83.39674	36.55027	-	-	-	-	-	-	-	9	5	2	3	1.15	19	18
34SR066001000.8RRF	6/10/2003	Hancock	SR066	0.8	-83.39527	36.55012	9	41	2	3	1.15	55	60	-	-	-	-	-	-	-
34SR066001001.70LRF	6/9/2003	Hancock	SR066	1.7	-83.15814	36.4998	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR066001002.10LRF	6/10/2003	Hancock	SR066	2.1	-83.37974	36.55498	-	-	-	-	-	-	-	27	5	2	9	1.3	43	44
34SR066001002.36LRF	6/10/2003	Hancock	SR066	2.36	-83.37808	36.55149	-	-	-	-	-	-	-	9	14	2	3	1.15	28	29
34SR066001003.80LRF	6/10/2003	Hancock	SR066	3.8	-83.36487	36.5402	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34SR066001004.05LRF	6/9/2003	Hancock	SR066	4.05	-83.18084	36.51211	-	-	-	-	-	-	-	27	5	5	9	1.3	46	48
34SR066001004.90LRF	6/9/2003	Hancock	SR066	4.9	-83.18858	36.52038	-	-	-	-	-	-	-	27	5	5	3	1.15	40	43
34SR066001005.00LRF	6/9/2003	Hancock	SR066	5	-83.1852	36.5213	-	-	-	-	-	-	-	3	5	2	3	1.15	13	12
34SR066001007.10LRF	6/10/2003	Hancock	SR066	7.1	-83.32042	36.55486	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41SR048001014.20LRF	6/17/2003	Hickman	SR048	14.2	-45.9271	39.60436	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41SR438001009.40LRF	6/17/2003	Hickman	SR438	9.4	-44.4286	39.59842	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41SR438001010.90LRF	6/17/2003	Hickman	SR438	10.9			-	-	-	-	-	-	-	-	-	-	-	-	-	-
44SR056001018.50RRF	7/16/2003	Jackson	SR056	18.5	-61.7081	40.34661	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44SR096001000.00LRF	7/16/2003	Jackson	SR096	0	-60.9561	40.12281	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44SR096001000.70LRF	7/16/2003	Jackson	SR096	0.7	-60.8923	40.13329	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44SR135001007.10RRF	7/16/2003	Jackson	SR135	7.1	-63.0153	40.23323	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44SR135001008.40LRF	7/16/2003	Jackson	SR135	8.4	-62.978	40.23303	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44SR135001010.40LRF	7/16/2003	Jackson	SR135	10.4	-62.7117	40.24245	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44SR135001012.70LRF	7/16/2003	Jackson	SR135	12.7	-62.5035	40.24479	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50SR242001012.90RRF	6/23/2003	Lawrence	SR242	12.9	-45.6764	38.89998	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52SR010001008.40LRF	6/24/2003	Lincoln	SR010	8.4	-53.9517	38.8555	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54SR039001022.70RRF	8/5/2003	McMinn	SR039	22.7	-73.4701	39.15454	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54SR039001022.80RRF	8/5/2003	McMinn	SR039	22.8	-73.4754	39.15541	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54SR310001003.90LRF	8/5/2003	McMinn	SR310	3.9	-73.102	39.1422	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56SR056001002.10RRF	7/16/2003	Macon	SR056	2.1	-60.4506	40.34029	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56SR056001002.20RRF	7/16/2003	Macon	SR056	2.2	-60.4291	40.33771	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56SR262001008.80LRF	7/16/2003	Macon	SR262	8.8	-60.45	40.32749	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56SR262001009.10LRF	7/16/2003	Macon	SR262	9.1	-60.4422	40.32505	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56SR262001009.70LRF	7/16/2003	Macon	SR262	9.7	-60.4351	40.32425	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58SR002001019.20LRF	7/28/2003	Marion	SR002	19.2	-62.9694	38.77952	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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File Number	Topple Failure					Differential Weathering						Raveling						RHRS Total Score				
		Abundance		Total Score				Abundance		Total Score				Abundance		Total Score			Geologic Hazard		RHRS Hazard	
	Block Size	Additive	Multiplicative	Additive	Multiplicative	Block Size	Relief	Additive	Multiplicative	Additive	Multiplicative	Block Size	Block Shape	Additive	Multiplicative	Additive	Multiplicative	Site & Roadway	Additive	Multiplicative	Additive	Multiplicative
34SR066001000.40LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	3	1.15	15	14	226	76	82	302	308
34SR066001000.41LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	3	1.15	15	14	172	70	74	242	246
34SR066001000.50LRF	41	14	1.4	55	57	-	-	-	-	-	-	-	-	-	-	-	-	174	83	86	257	260
34SR066001000.60RRF	-	-	-	-	-	-	-	-	-	-	-	3	9	81	1.9	93	23	155	93	23	248	178
34SR066001000.70RRF	14	5	1.2	19	17	-	-	-	-	-	-	3	9	3	1.15	15	14	154	53	49	207	203
34SR066001000.8RRF	14	5	1.2	19	17	-	-	-	-	-	-	3	9	9	1.3	21	16	155	95	93	250	248
34SR066001001.70LRF	14	5	1.2	19	17	-	-	-	-	-	-	27	9	9	1.3	45	47	154	64	64	218	218
34SR066001002.10LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	148	64	65	212	213
34SR066001002.36LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	145	55	52	200	197
34SR066001003.80LRF	14	5	1.2	19	17	-	-	-	-	-	-	9	9	9	1.3	27	23	143	46	40	189	183
34SR066001004.05LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	3	1.15	15	14	172	61	62	233	234
34SR066001004.90LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	3	1.15	15	14	181	55	57	236	238
34SR066001005.00LRF	-	-	-	-	-	81	3	9	1.3	93	109	-	-	-	-	-	-	236	106	121	342	357
34SR066001007.10LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	264	27	23	291	287
41SR048001014.20LRF	-	-	-	-	-	9	9	9	1.3	27	23	-	-	-	-	-	-	191	27	23	218	214
41SR438001009.40LRF	-	-	-	-	-	27	27	9	1.3	63	70	-	-	-	-	-	-	249	63	70	312	319
41SR438001010.90LRF	-	-	-	-	-	27	27	9	1.3	63	70	-	-	-	-	-	-	204	63	70	267	274
44SR056001018.50RRF	-	-	-	-	-	9	9	27	1.6	45	29	3	9	3	1.15	15	14	180	60	43	240	223
44SR096001000.00LRF	-	-	-	-	-	9	9	27	1.6	45	29	9	9	3	1.15	21	21	249	66	50	315	299
44SR096001000.70LRF	-	-	-	-	-	27	9	9	1.3	45	47	-	-	-	-	-	-	256	45	47	301	303
44SR135001007.10RRF	-	-	-	-	-	9	9	27	1.6	45	29	9	3	9	1.3	21	16	250	66	45	316	295
44SR135001008.40LRF	-	-	-	-	-	9	9	9	1.3	27	23	3	9	9	1.3	21	16	173	48	39	221	212
44SR135001010.40LRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	9	1.3	27	23	227	48	44	275	271
44SR135001012.70LRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	9	1.3	27	23	249	48	44	297	293
50SR242001012.90RRF	-	-	-	-	-	9	9	9	1.3	27	23	3	3	3	1.15	9	7	142	36	30	178	172
52SR010001008.40LRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	3	1.15	21	21	111	48	44	159	155
54SR039001022.70RRF	-	-	-	-	-	9	9	27	1.6	45	29	-	-	-	-	-	-	208	45	29	253	237
54SR039001022.80RRF	-	-	-	-	-	9	9	9	1.3	27	23	-	-	-	-	-	-	210	27	23	237	233
54SR310001003.90LRF	41	122	2	163	82	9	9	3	1.15	21	21	-	-	-	-	-	-	201	184	103	385	304
56SR056001002.10RRF	-	-	-	-	-	9	9	3	1.15	21	21	9	3	27	1.6	39	19	226	60	40	286	266
56SR056001002.20RRF	-	-	-	-	-	9	3	3	1.15	15	14	9	3	81	1.9	93	23	218	108	37	326	255
56SR262001008.80LRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	81	1.9	99	34	214	120	55	334	269
56SR262001009.10LRF	-	-	-	-	-	27	27	9	1.3	63	70	9	9	3	1.15	21	21	159	84	91	243	250
56SR262001009.70LRF	-	-	-	-	-	9	3	3	1.15	15	14	27	9	27	1.6	63	58	149	78	72	227	221
58SR002001019.20LRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	81	1.9	99	34	176	120	55	296	231

File Number	Date	County	Road	BLM	Longitude	Latitude	Planar Failure							Wedge Failure						
										Abundance		Total Score					Abundance		Total Score	
							Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative	Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative
58SR002001029.90RRF	7/28/2003	Marion	SR002	29.9	-63.9562	38.76697	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58SR027001024.90RRF	7/29/2003	Marion	SR027	24.9	-64.4707	38.92253	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58SR027001026.10RRF	7/29/2003	Marion	SR027	26.1	-64.6318	38.90928	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58SR108001003.50LRF	7/29/2003	Marion	SR108	3.5	-63.5178	39.00339	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58SR108001004.20LRF	7/29/2003	Marion	SR108	4.2	-63.564	39.01362	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58SR108001004.30RRF	7/29/2003	Marion	SR108	4.3	-63.5667	39.01325	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58SR150001004.60RRF	7/29/2003	Marion	SR150	4.6	-62.297	38.87914	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58SR150001004.80RRF	7/29/2003	Marion	SR150	4.8	-62.2695	38.88254	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60SR099001004.50RRF	6/23/2003	Maury	SR099	4.5	-47.5828	39.40222	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62SR068001028.50LRF	8/6/2003	Monroe	SR068	28.5	-74.5899	39.13615	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62SR165001002.10RRF	8/6/2003	Monroe	SR165	2.1	-74.8067	39.16042	-	-	-	-	-	-	-	27	2	2	81	1.9	112	59
62SR165001005.30RRF	8/6/2003	Monroe	SR165	5.3			-	-	-	-	-	-	-	-	-	-	-	-	-	-
62SR165001005.40RRF	8/6/2003	Monroe	SR165	5.4			-	-	-	-	-	-	-	27	14	2	9	1.3	52	56
62SR165001005.70RRF	8/6/2003	Monroe	SR165	5.7	-75.1499	39.15465	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62SR165001019.00LRF	8/6/2003	Monroe	SR165	19	-76.2914	39.17127	9	41	5	81	1.9	136	105	-	-	-	-	-	-	-
62SR165001019.30LRF	8/6/2003	Monroe	SR165	19.3	-76.3032	39.16847	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62SR165001019.40LRF	8/6/2003	Monroe	SR165	19.4	-76.3189	39.16684	-	-	-	-	-	-	-	81	5	2	3	1.15	91	101
62SR165001021.90LRF	8/6/2003	Monroe	SR165	21.9	-76.6473	39.15554	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62SR165001022.10LRF	8/6/2003	Monroe	SR165	22.1	-76.6651	39.15508	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63SR013001017.00LRF	6/18/2003	Montgomer	SR013	17	-46.6212	40.3651	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR062001001.90LRF	5/29/2003	Morgan	SR062	1.9			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR062001003.90LRF	5/29/2003	Morgan	SR062	3.9			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR062001004.90LRF	5/29/2003	Morgan	SR062	4.9			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR062001030.00LRF	6/3/2003	Morgan	SR062	30			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR062001030.10LRF	6/3/2003	Morgan	SR062	30.1			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR062001030.20LRF	6/3/2003	Morgan	SR062	30.2			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR062001030.60LRF	6/3/2003	Morgan	SR062	30.6			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR116001001.90LRF	5/29/2003	Morgan	SR116	1.9			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR116001002.90LRF	5/29/2003	Morgan	SR116	2.9			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR116001003.70LRF	5/29/2003	Morgan	SR116	3.7			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR116001005.60LRF	5/29/2003	Morgan	SR116	5.6			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR298001005.70LRF	5/28/2003	Morgan	SR298	5.7			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR298001005.70RRF	5/28/2003	Morgan	SR298	5.7			-	-	-	-	-	-	-	-	-	-	-	-	-	-
65SR298001006.20LRF	5/28/2003	Morgan	SR298	6.2			9	2	5	3	1.15	19	18	-	-	-	-	-	-	-
65SR298001006.20RRF	5/28/2003	Morgan	SR298	6.2			-	-	-	-	-	-	-	-	-	-	-	-	-	-

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File Number	Topple Failure					Differential Weathering						Raveling						RHRS Total Score				
		Abundance		Total Score				Abundance		Total Score				Abundance		Total Score			Geologic Hazard		RHRS Hazard	
	Block Size	Additive	Multiplicative	Additive	Multiplicative	Block Size	Relief	Additive	Multiplicative	Additive	Multiplicative	Block Size	Block Shape	Additive	Multiplicative	Additive	Multiplicative	Site & Roadway	Additive	Multiplicative	Additive	Multiplicative
58SR002001029.90RRF	-	-	-	-	-	9	9	27	1.6	45	29	-	-	-	-	-	-	118	45	29	163	147
58SR027001024.90RRF	-	-	-	-	-	9	9	9	1.3	27	23	3	9	3	1.15	15	14	126	42	37	168	163
58SR027001026.10RRF	-	-	-	-	-	81	81	9	1.3	171	211	-	-	-	-	-	-	217	171	211	388	428
58SR108001003.50LRF	-	-	-	-	-	9	9	3	1.15	21	21	3	9	3	1.15	15	14	124	36	35	160	159
58SR108001004.20LRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	9	1.3	27	23	214	54	46	268	260
58SR108001004.30RRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	27	1.6	45	29	202	66	50	268	252
58SR150001004.60RRF	-	-	-	-	-	9	9	9	1.3	27	23	3	3	27	1.6	33	10	235	60	33	295	268
58SR150001004.80RRF	-	-	-	-	-	3	3	3	1.15	9	7	3	9	81	1.9	93	23	141	102	30	243	171
60SR099001004.50RRF	-	-	-	-	-	9	9	3	1.15	21	21	-	-	-	-	-	-	134	21	21	155	155
62SR068001028.50LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	173	21	21	194	194
62SR165001002.10RRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	228	112	59	340	287
62SR165001005.30RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	81	1.9	99	34	258	99	34	357	292
62SR165001005.40RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	81	1.9	99	34	243	151	90	394	333
62SR165001005.70RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	81	1.9	99	34	231	99	34	330	265
62SR165001019.00LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	81	1.9	99	34	249	235	139	484	388
62SR165001019.30LRF	122	5	1.2	127	146	-	-	-	-	-	-	27	9	81	1.9	117	68	298	244	214	542	512
62SR165001019.40LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	81	1.9	99	34	284	190	135	474	419
62SR165001021.90LRF	41	5	1.2	46	49	-	-	-	-	-	-	9	9	27	1.6	45	29	210	91	78	301	288
62SR165001022.10LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	81	1.9	99	34	210	99	34	309	244
63SR013001017.00LRF	-	-	-	-	-	27	9	3	1.15	39	41	3	9	27	1.6	39	19	173	78	60	251	233
65SR062001001.90LRF	-	-	-	-	-	3	3	3	1.15	9	7	3	3	9	1.3	15	8	219	24	15	243	234
65SR062001003.90LRF	-	-	-	-	-	9	9	81	1.9	99	34	-	-	-	-	-	-	211	99	34	310	245
65SR062001004.90LRF	-	-	-	-	-	3	9	3	1.15	15	14	9	9	9	1.3	27	23	200	42	37	242	237
65SR062001030.00LRF	-	-	-	-	-	3	9	81	1.9	93	23	-	-	-	-	-	-	114	93	23	207	137
65SR062001030.10LRF	-	-	-	-	-	27	27	27	1.6	81	86	-	-	-	-	-	-	163	81	86	244	249
65SR062001030.20LRF	-	-	-	-	-	9	27	9	1.3	45	47	-	-	-	-	-	-	199	45	47	244	246
65SR062001030.60LRF	-	-	-	-	-	9	27	9	1.3	45	47	-	-	-	-	-	-	206	45	47	251	253
65SR116001001.90LRF	-	-	-	-	-	3	9	9	1.3	21	16	-	-	-	-	-	-	142	21	16	163	158
65SR116001002.90LRF	-	-	-	-	-	27	27	9	1.3	63	70	-	-	-	-	-	-	134	63	70	197	204
65SR116001003.70LRF	-	-	-	-	-	9	27	9	1.3	45	47	9	9	9	1.3	27	23	212	72	70	284	282
65SR116001005.60LRF	-	-	-	-	-	27	27	27	1.6	81	86	-	-	-	-	-	-	203	81	86	284	289
65SR298001005.70LRF	-	-	-	-	-	9	9	3	1.15	21	21	3	9	3	1.15	15	14	218	36	35	254	253
65SR298001005.70RRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	9	1.3	27	23	213	48	44	261	257
65SR298001006.20LRF	-	-	-	-	-	9	9	3	1.15	21	21	3	9	9	1.3	21	16	219	61	55	280	274
65SR298001006.20RRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	9	1.3	27	23	213	48	44	261	257

File Number	Date	County	Road	BLM	Longitude	Latitude	Planar Failure							Wedge Failure						
										Abundance		Total Score					Abundance		Total Score	
							Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative	Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative
65SR298001006.50RRF	5/28/2003	Morgan	SR298	6.5			-	-	-	-	-	-	-	-	-	-	-	-	-	-
67SR052001021.30RRF	8/6/2003	Overton	SR052	21.3	-66.3337	40.29604	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67SR052001021.90LRF	8/6/2003	Overton	SR052	21.9	-66.4073	40.29381	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67SR084001006.50LRF	8/4/2003	Overton	SR084	6.5	-65.2702	40.16017	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67SR111001017.10RRF	8/6/2003	Overton	SR111	17.1	-65.4543	40.33616	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67SR136001014.00LRF	8/4/2003	Overton	SR136	14	-64.1651	40.37042	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67SR136001014.20LRF	8/4/2003	Overton	SR136	14.2	-64.1667	40.37254	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67SR136001014.40RRF	8/4/2003	Overton	SR136	14.4	-64.1814	40.37164	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67SR136001014.50LRF	8/4/2003	Overton	SR136	14.5	-64.1863	40.3699	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67SR294001001.40RRF	8/6/2003	Overton	SR294	1.4	-65.4586	40.35336	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69SR295001000.40RRF	8/4/2003	Pickett	SR295	0.4	-66.8196	40.50473	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70SR030001005.90RRF	8/7/2003	Polk	SR030	5.9	-72.5788	39.00294	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70SR030001006.10RRF	8/7/2003	Polk	SR030	6.1	-72.6022	39.0005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70SR030001006.70RRF	8/7/2003	Polk	SR030	6.7	-72.6317	38.9895	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70SR030001014.50RRF	8/7/2003	Polk	SR030	14.5	-72.3371	38.89863	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70SR030001016.30RRF	8/7/2003	Polk	SR030	16.3	-72.1831	38.89079	-	-	-	-	-	-	-	-	-	-	-	-	-	-
71SR084001012.20RRF	7/21/2003	Putnam	SR084	12.2	-65.3906	40.05059	-	-	-	-	-	-	-	-	-	-	-	-	-	-
71SR084001012.40LRF	7/21/2003	Putnam	SR084	12.4	-65.3906	40.05059	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72SR068001003.90LRF	7/29/2003	Rhea	SR068	3.9	-69.5509	39.57066	27	5	41	27	1.6	100	117	-	-	-	-	-	-	-

Continued on next page

File Number	Topple Failure					Differential Weathering						Raveling						RHRS Total Score				
		Abundance		Total Score				Abundance		Total Score				Abundance		Total Score			Geologic Hazard		RHRS Hazard	
	Block Size	Additive	Multiplicative	Additive	Multiplicative	Block Size	Relief	Additive	Multiplicative	Additive	Multiplicative	Block Size	Block Shape	Additive	Multiplicative	Additive	Multiplicative	Site & Roadway	Additive	Multiplicative	Additive	Multiplicative
65SR298001006.50RRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	9	1.3	27	23	215	54	46	269	261
67SR052001021.30RRF	-	-	-	-	-	27	81	9	1.3	117	140	9	9	9	1.3	27	23	231	144	163	375	394
67SR052001021.90LRF	-	-	-	-	-	27	81	9	1.3	117	140	-	-	-	-	-	-	154	117	140	271	294
67SR084001006.50LRF	-	-	-	-	-	27	27	27	1.6	81	86	-	-	-	-	-	-	227	81	86	308	313
67SR111001017.10RRF	-	-	-	-	-	-	-	-	-	-	-	27	9	81	1.9	117	68	139	117	68	256	207
67SR136001014.00LRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	3	1.15	21	21	219	48	44	267	263
67SR136001014.20LRF	-	-	-	-	-	27	9	27	1.6	63	58	9	9	3	1.15	21	21	194	84	79	278	273
67SR136001014.40RRF	-	-	-	-	-	27	27	27	1.6	81	86	-	-	-	-	-	-	156	81	86	237	242
67SR136001014.50LRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	3	1.15	21	21	236	48	44	284	280
67SR294001001.40RRF	-	-	-	-	-	27	9	3	1.15	39	41	9	9	27	1.6	45	29	219	84	70	303	289
69SR295001000.40RRF	-	-	-	-	-	9	9	81	1.9	99	34	-	-	-	-	-	-	219	99	34	318	253
70SR030001005.90RRF	-	-	-	-	-	27	27	27	1.6	81	86	9	9	3	1.15	21	21	253	102	107	355	360
70SR030001006.10RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	81	1.9	99	34	246	99	34	345	280
70SR030001006.70RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	195	21	21	216	216
70SR030001014.50RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	81	1.9	99	34	246	99	34	345	280
70SR030001016.30RRF	-	-	-	-	-	81	27	3	1.15	111	124	9	3	3	1.15	15	14	197	126	138	323	335
71SR084001012.20RRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	27	1.6	45	29	230	72	52	302	282
71SR084001012.40LRF	-	-	-	-	-	27	27	27	1.6	81	86	9	9	27	1.6	45	29	229	126	115	355	344
72SR068001003.90LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	219	121	138	340	357

File Number	Date	County	Road	BLM	Longitude	Latitude	Planar Failure							Wedge Failure						
										Abundance		Total Score					Abundance		Total Score	
							Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative	Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative
72SR068001003.90RRF	7/29/2003	Rhea	SR068	3.9	-69.5509	39.57066	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72SR068001004.20RRF	7/29/2003	Rhea	SR068	4.2	-69.5234	39.56724	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72SR068001004.40RRF	7/29/2003	Rhea	SR068	4.4	-69.5026	39.56391	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77SR008001007.50RRF	7/31/2003	Sequatchie	SR008	7.5	-64.618	39.03977	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77SR008001010.50RRF	7/31/2003	Sequatchie	SR008	10.5	-64.6996	39.07771	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77SR008001020.50RRF	7/31/2003	Sequatchie	SR008	20.5	-64.3836	39.20471	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77SR008001020.70RRF	7/31/2003	Sequatchie	SR008	20.7	-64.3272	39.20918	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77SR008001020.90RRF	7/31/2003	Sequatchie	SR008	20.9	-64.3046	39.21111	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77SR008001021.20RRF	7/31/2003	Sequatchie	SR008	21.2	-64.2719	39.2131	-	-	-	-	-	-	-	-	-	-	-	-	-	-
78SR073001005.60LRF	6/11/2003	Sevier	SR073	5.6			-	-	-	-	-	-	-	-	-	-	-	-	-	-
78SR073001008.00RRF	6/10/2003	Sevier	SR073	8			9	2	41	9	1.3	61	68	-	-	-	-	-	-	-
81SR049001008.50RRF	6/17/2003	Stewart	SR049	8.5	-43.2558	40.33428	-	-	-	-	-	-	-	-	-	-	-	-	-	-
81SR049001008.70RRF	6/17/2003	Stewart	SR049	8.7			-	-	-	-	-	-	-	-	-	-	-	-	-	-
83SR041001004.10LRF	7/15/2003	Sumner	SR041	4.1	-52.7916	40.27828	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83SR041001004.30LRF	7/15/2003	Sumner	SR041	4.3			-	-	-	-	-	-	-	-	-	-	-	-	-	-
83SR041001004.30RRF	7/15/2003	Sumner	SR041	4.3	-52.7843	40.28339	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83SR041001004.50LRF	7/15/2003	Sumner	SR041	4.5	-52.8017	40.28621	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83SR041001004.50RRF	7/15/2003	Sumner	SR041	4.5	-52.8017	40.28621	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83SR258001006.60LRF	7/15/2003	Sumner	SR258	6.6	-53.3505	40.2752	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83SR376001001.20LRF	7/15/2003	Sumner	SR376	1.2	-56.5427	40.3632	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83SR376001001.20RRF	7/15/2003	Sumner	SR376	1.2	-56.5427	40.3632	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86SR036001000.60RRF	8/19/2003	Unicoi	SR036	0.6	-82.4488	36.0408	27	5	41	27	1.6	100	117	-	-	-	-	-	-	-
86SR036001000.90RRF	8/19/2003	Unicoi	SR036	0.9	-82.45424	36.04015	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86SR036001002.10RRF	8/19/2003	Unicoi	SR036	2.1	-82.47295	36.04146	27	5	5	3	1.15	40	43	-	-	-	-	-	-	-
86SR036001002.20RRF	8/19/2003	Unicoi	SR036	2.2	-82.47448	36.0417	27	14	14	9	1.3	64	72	-	-	-	-	-	-	-
86SR036001002.60RRF	8/19/2003	Unicoi	SR036	2.6	-82.47984	36.0397	27	5	5	81	1.9	118	70	-	-	-	-	-	-	-
86SR036001002.80RRF	8/19/2003	Unicoi	SR036	2.8	-82.48149	36.03928	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86SR036001003.10RRF	8/19/2003	Unicoi	SR036	3.1	-82.48561	36.03953	-	-	-	-	-	-	-	9	5	14	9	1.3	37	36
86SR036001003.20RRF	8/19/2003	Unicoi	SR036	3.2	-82.48652	36.04022	-	-	-	-	-	-	-	9	5	14	9	1.3	37	36
86SR036001003.30RRF	8/19/2003	Unicoi	SR036	3.3	-82.48772	36.04083	-	-	-	-	-	-	-	9	14	14	9	1.3	46	48
86SR036001003.40RRF	8/19/2003	Unicoi	SR036	3.4	-82.48912	36.04078	9	14	14	27	1.6	64	59	-	-	-	-	-	-	-
86SR036001003.80RRF	8/19/2003	Unicoi	SR036	3.8	-82.4932	36.04148	3	14	41	9	1.3	67	75	-	-	-	-	-	-	-
86SR036001005.20LRF	8/19/2003	Unicoi	SR036	5.2	-82.50369	36.05705	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86SR036001005.40LRF	8/19/2003	Unicoi	SR036	5.4	-82.50307	36.0593	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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File Number	Topple Failure: Block Size	Topple Failure: Abundance Additive	Topple Failure: Abundance Multiplicative	Topple Failure: Total Score Additive	Topple Failure: Total Score Multiplicative	Differential Weathering: Block Size	Differential Weathering: Relief	Differential Weathering: Abundance Additive	Differential Weathering: Abundance Multiplicative	Differential Weathering: Total Score Additive	Differential Weathering: Total Score Multiplicative	Raveling: Block Size	Raveling: Block Shape	Raveling: Abundance Additive	Raveling: Abundance Multiplicative	Raveling: Total Score Additive	Raveling: Total Score Multiplicative	RHRS Total Score: Site & Roadway	Geologic Hazard Additive	Geologic Hazard Multiplicative	RHRS Hazard Additive	RHRS Hazard Multiplicative
72SR068001003.90RRF	-	-	-	-	-	27	27	9	1.3	63	70	9	9	3	1.15	21	21	220	84	91	304	311
72SR068001004.20RRF	-	-	-	-	-	27	27	81	1.9	135	103	-	-	-	-	-	-	155	135	103	290	258
72SR068001004.40RRF	41	5	1.2	46	49	81	81	9	1.3	171	211	-	-	-	-	-	-	173	217	260	390	433
77SR008001007.50RRF	-	-	-	-	-	27	81	27	1.6	135	173	9	9	9	1.3	27	23	153	162	196	315	349
77SR008001010.50RRF	-	-	-	-	-	9	9	3	1.15	21	21	3	9	3	1.15	15	14	148	36	35	184	183
77SR008001020.50RRF	-	-	-	-	-	81	81	3	1.15	165	186	9	9	81	1.9	99	34	278	264	220	542	498
77SR008001020.70RRF	-	-	-	-	-	81	81	9	1.3	171	211	9	9	3	1.15	21	21	225	192	232	417	457
77SR008001020.90RRF	-	-	-	-	-	27	9	3	1.15	39	41	9	9	3	1.15	21	21	132	60	62	192	194
77SR008001021.20RRF	-	-	-	-	-	27	27	9	1.3	63	70	9	9	9	1.3	27	23	127	90	93	217	220
78SR073001005.60LRF	14	14	1.4	28	20	9	3	3	1.15	15	14	9	9	3	1.15	21	21	209	64	55	273	264
78SR073001008.00RRF	41	5	1.2	46	49	9	3	3	1.15	15	14	3	9	3	1.15	15	14	214	137	145	351	359
81SR049001008.50RRF	-	-	-	-	-	3	3	3	1.15	9	7	3	9	3	1.15	15	14	209	24	21	233	230
81SR049001008.70RRF	-	-	-	-	-	3	3	3	1.15	9	7	3	9	9	1.3	21	16	152	30	23	182	175
83SR041001004.10LRF	-	-	-	-	-	9	9	27	1.6	45	29	3	3	9	1.3	15	8	278	60	37	338	315
83SR041001004.30LRF	-	-	-	-	-	9	9	9	1.3	27	23	3	3	9	1.3	15	8	220	42	31	262	251
83SR041001004.30RRF	-	-	-	-	-	3	3	3	1.15	9	7	3	3	9	1.3	15	8	271	24	15	295	286
83SR041001004.50LRF	-	-	-	-	-	9	9	9	1.3	27	23	3	3	3	1.15	9	7	225	36	30	261	255
83SR041001004.50RRF	-	-	-	-	-	9	9	9	1.3	27	23	3	3	3	1.15	9	7	275	36	30	311	305
83SR258001006.60LRF	-	-	-	-	-	9	27	9	1.3	45	47	3	3	3	1.15	9	7	140	54	54	194	194
83SR376001001.20LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	27	1.6	45	29	185	45	29	230	214
83SR376001001.20RRF	-	-	-	-	-	-	-	-	-	-	-	27	9	27	1.6	63	58	184	63	58	247	242
86SR036001000.60RRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	257	100	117	357	374
86SR036001000.90RRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	3	1.15	21	21	203	48	44	251	247
86SR036001002.10RRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	192	40	43	232	235
86SR036001002.20RRF	-	-	-	-	-	-	-	-	-	-	-	3	9	3	1.15	15	14	238	79	86	317	324
86SR036001002.60RRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	237	118	70	355	307
86SR036001002.80RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	27	1.6	45	29	235	45	29	280	264
86SR036001003.10RRF	-	-	-	-	-	-	-	-	-	-	-	3	9	81	1.9	93	23	246	130	59	376	305
86SR036001003.20RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	27	1.6	45	29	248	82	65	330	313
86SR036001003.30RRF	-	-	-	-	-	-	-	-	-	-	-	3	9	3	1.15	15	14	246	61	62	307	308
86SR036001003.40RRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200	64	59	264	259
86SR036001003.80RRF	-	-	-	-	-	-	-	-	-	-	-	3	3	81	1.9	87	11	173	154	86	327	259
86SR036001005.20LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	3	1.15	21	21	180	21	21	201	201
86SR036001005.40LRF	14	5	1.2	19	17	-	-	-	-	-	-	9	9	81	1.9	99	34	250	118	51	368	301

File Number	Date	County	Road	BLM	Longitude	Latitude	Planar Failure							Wedge Failure						
										Abundance		Total Score					Abundance		Total Score	
							Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative	Block Size	Steepness	Friction	Additive	Multiplicative	Additive	Multiplicative
86SR036001005.70RRF	8/19/2003	Unicoi	SR036	5.7	-82.50322	36.06317	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86SR036001005.80RRF	8/19/2003	Unicoi	SR036	5.8	-82.50175	36.06495	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86SR036001006.05RRF	8/19/2003	Unicoi	SR036	6.05	-82.50293	36.06853	81	14	14	27	1.6	136	174	-	-	-	-	-	-	-
86SR036001006.40RRF	8/19/2003	Unicoi	SR036	6.4	-82.50048	36.07198	9	14	14	3	1.15	40	43	-	-	-	-	-	-	-
86SR036001006.65RRF	8/19/2003	Unicoi	SR036	6.65	-82.4906	36.04005	-	-	-	-	-	-	-	9	14	14	3	1.15	40	43
86SR036001006.80RRF	8/19/2003	Unicoi	SR036	6.8	-82.49669	36.07709	27	41	14	3	1.15	85	94	-	-	-	-	-	-	-
86SR081001013.10RRF	8/19/2003	Unicoi	SR081	13.1	-82.44049	36.15397	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86SR107001012.25RRF	8/20/2003	Unicoi	SR107	12.25	-82.2519	36.16464	27	5	14	81	1.9	127	87	-	-	-	-	-	-	-
86SR107001012.30RRF	8/20/2003	Unicoi	SR107	12.3	-82.2518	36.16348	27	5	14	81	1.9	127	87	-	-	-	-	-	-	-
86SR107001012.98RRF	8/20/2003	Unicoi	SR107	12.98	-82.24817	36.15641	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86SR107001013.01RRF	8/20/2003	Unicoi	SR107	13.01	-82.24787	36.15582	-	-	-	-	-	-	-	81	2	14	27	1.6	124	155
86SR107001014.80LRF	8/20/2003	Unicoi	SR107	14.8	-82.23193	36.15169	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86SR352001000.80LRF	8/19/2003	Unicoi	SR352	0.8	-82.5965	36.0161	9	41	2	9	1.3	61	68	-	-	-	-	-	-	-
86SR352001002.40LRF	8/19/2003	Unicoi	SR352	2.4	-82.57269	36.02286	-	-	-	-	-	-	-	9	41	2	3	1.15	55	60
86SR352001003.40LRF	8/19/2003	Unicoi	SR352	3.4	-82.55667	36.03171	-	-	-	-	-	-	-	9	41	5	3	1.15	58	63
86SR352001003.58LRF	8/19/2003	Unicoi	SR352	3.58	-82.55482	36.03186	-	-	-	-	-	-	-	9	41	41	9	1.3	100	118
86SR352001003.80LRF	8/19/2003	Unicoi	SR352	3.8	-82.55238	36.03337	27	41	14	9	1.3	91	107	9	41	14	3	1.15	67	74
86SR352001004.80LRF	8/19/2003	Unicoi	SR352	4.8	-82.54184	36.04298	9	14	5	3	1.15	31	32	-	-	-	-	-	-	-
86SR352001005.30LRF	8/19/2003	Unicoi	SR352	5.3	-82.53843	36.04537	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86SR352001006.35LRF	8/19/2003	Unicoi	SR352	6.35	-82.53128	36.05312	-	-	-	-	-	-	-	81	41	14	3	1.15	139	156
86SR352001007.60LRF	8/19/2003	Unicoi	SR352	7.6	-82.51978	36.06715	9	5	14	3	1.15	31	32	-	-	-	-	-	-	-
86SR352001007.90LRF	8/19/2003	Unicoi	SR352	7.9	-82.51563	36.06905	81	14	14	3	1.15	112	125	81	5	14	9	1.3	109	130
86SR395001000.10LRF	8/19/2003	Unicoi	SR395	0.1	-82.36303	36.11134	-	-	-	-	-	-	-	9	41	2	9	1.3	61	68
86SR395001000.50LRF	8/19/2003	Unicoi	SR395	0.5	-82.3673	36.11167	-	-	-	-	-	-	-	-	-	-	-	-	-	-
88SR030001008.00RRF	7/23/2003	Van Buren	SR030	8	-63.7802	39.56389	-	-	-	-	-	-	-	-	-	-	-	-	-	-
88SR030001008.20RRF	7/23/2003	Van Buren	SR030	8.2	-63.7888	39.56513	-	-	-	-	-	-	-	-	-	-	-	-	-	-
88SR030001011.30LRF	7/23/2003	Van Buren	SR030	11.3	-64.1969	39.55355	-	-	-	-	-	-	-	-	-	-	-	-	-	-
88SR030001013.70LRF	7/23/2003	Van Buren	SR030	13.7	-64.4626	39.56596	-	-	-	-	-	-	-	-	-	-	-	-	-	-
88SR285001004.40RRF	7/23/2003	Van Buren	SR285	4.4	-64.3912	39.60528	-	-	-	-	-	-	-	-	-	-	-	-	-	-
93SR001001014.40RRF	7/17/2003	White	SR001	14.4	-64.6076	39.77366	-	-	-	-	-	-	-	-	-	-	-	-	-	-
93SR026001007.00LRF	7/17/2003	White	SR026	7	-63.1735	39.79316	-	-	-	-	-	-	-	-	-	-	-	-	-	-
93SR026001007.00RRF	7/17/2003	White	SR026	7	-63.1735	39.79316	-	-	-	-	-	-	-	-	-	-	-	-	-	-
94SR100001010.80RRF	6/25/2003	Williamson	SR100	10.8	-49.539	39.8487	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Continued on next page

File Number	Topple Failure					Differential Weathering						Raveling						RHRS Total Score				
	Block Size	Abundance		Total Score		Block Size	Relief	Abundance		Total Score		Block Size	Block Shape	Abundance		Total Score		Site & Roadway	Geologic Hazard		RHRS Hazard	
		Additive	Multiplicative	Additive	Multiplicative			Additive	Multiplicative	Additive	Multiplicative			Additive	Multiplicative	Additive	Multiplicative		Additive	Multiplicative	Additive	Multiplicative
86SR036001005.70RRF	-	-	-	-	-	-	-	-	-	-	-	27	9	27	1.6	63	58	246	63	58	309	304
86SR036001005.80RRF	41	5	1.2	46	49	-	-	-	-	-	-	9	9	9	1.3	27	23	183	73	72	256	255
86SR036001006.05RRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	193	136	174	329	367
86SR036001006.40RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	176	67	66	243	242
86SR036001006.65RRF	-	-	-	-	-	3	9	9	1.3	21	16	-	-	-	-	-	-	218	61	59	279	277
86SR036001006.80RRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	146	85	94	231	240
86SR081001013.10RRF	-	-	-	-	-	-	-	-	-	-	-	3	9	81	1.9	93	23	149	93	23	242	172
86SR107001012.25RRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	155	127	87	282	242
86SR107001012.30RRF	14	5	1.2	19	17	-	-	-	-	-	-	-	-	-	-	-	-	155	146	104	301	259
86SR107001012.98RRF	-	-	-	-	-	-	-	-	-	-	-	9	9	27	1.6	45	29	185	45	29	230	214
86SR107001013.01RRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	238	124	155	362	393
86SR107001014.80LRF	-	-	-	-	-	9	9	81	1.9	99	34	-	-	-	-	-	-	224	99	34	323	258
86SR352001000.80LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	3	1.15	15	14	194	76	82	270	276
86SR352001002.40LRF	14	5	1.2	19	17	-	-	-	-	-	-	3	9	3	1.15	15	14	158	89	91	247	249
86SR352001003.40LRF	14	5	1.2	19	17	-	-	-	-	-	-	-	-	-	-	-	-	195	77	80	272	275
86SR352001003.58LRF	-	-	-	-	-	-	-	-	-	-	-	3	3	3	1.15	9	7	213	109	125	322	338
86SR352001003.80LRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	225	158	181	383	406
86SR352001004.80LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	143	58	55	201	198
86SR352001005.30LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	27	1.6	45	29	159	45	29	204	188
86SR352001006.35LRF	122	14	1.4	136	171	-	-	-	-	-	-	-	-	-	-	-	-	88	275	300	363	388
86SR352001007.60LRF	-	-	-	-	-	-	-	-	-	-	-	9	9	9	1.3	27	23	135	58	55	193	190
86SR352001007.90LRF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	167	221	255	388	422
86SR395001000.10LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	9	1.3	21	16	233	82	84	315	317
86SR395001000.50LRF	-	-	-	-	-	-	-	-	-	-	-	3	9	9	1.3	21	16	166	21	16	187	182
88SR030001008.00RRF	-	-	-	-	-	27	9	9	1.3	45	47	9	9	9	1.3	27	23	201	72	70	273	271
88SR030001008.20RRF	-	-	-	-	-	9	27	9	1.3	45	47	9	9	3	1.15	21	21	202	66	68	268	270
88SR030001011.30LRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	9	1.3	27	23	216	54	46	270	262
88SR030001013.70LRF	-	-	-	-	-	9	9	9	1.3	27	23	9	9	27	1.6	45	29	160	72	52	232	212
88SR285001004.40RRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	81	1.9	99	34	251	120	55	371	306
93SR001001014.40RRF	-	-	-	-	-	27	27	27	1.6	81	86	9	9	3	1.15	21	21	297	102	107	399	404
93SR026001007.00LRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	81	1.9	99	34	194	120	55	314	249
93SR026001007.00RRF	-	-	-	-	-	9	9	3	1.15	21	21	9	9	81	1.9	99	34	176	120	55	296	231
94SR100001010.80RRF	-	-	-	-	-	9	9	27	1.6	45	29	3	9	3	1.15	15	14	123	60	43	183	166

Appendix B

Changing the Tennessee Abundance Score to a Multiplicative Abundance

Scoring Abundance

The main functions of the Tennessee Rockcut Management System are to locate rock slopes that present a hazard to the motoring public and to provide a means of classifying slopes according to relative hazard. This will assist with prioritizing remediation efforts, as well as estimating costs. Part of the informational database needed to accomplish these aims is a measure how much of a given slope is subject to a particular failure mode. This is the reason for the inclusion of abundance in the Tennessee RHRS (Vandewater, 2002).

Abundance in the Tennessee RHRS is defined as the aerial extent of a slope face that exhibits a given failure mode (planar, wedge, topple, differential weathering, and raveling) expressed as a percent of the total area. For example, Fig. B.1 shows a schematic drawing based of a rated rock slope in Campbell County Tennessee. The rock slope contains two failure modes, planar failure and raveling, with an individual abundance of less than 10% and 20% respectively.

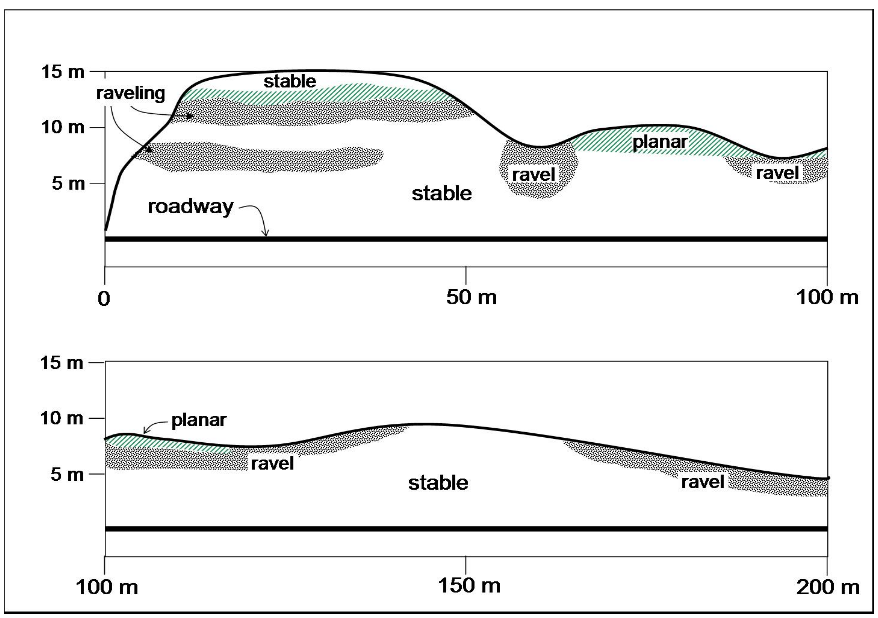

Figure B.1- Schematic of rated slope in Campbell County, Tennessee

During the first phase of carrying out the task of rating rockfall hazard in Tennessee, abundance was scored using an additive exponential score the same as other contributors to hazard such as steepness or slope height. Using an additive abundance has potential to inflate the hazard rating of slopes that have a high abundance of low consequence failure mechanisms. An example of a low consequence failure mechanism is small-scale raveling in a weak, brittle material such as shale. On the other hand, a high consequence failure mechanism such as a large-scale wedge failure may be overlooked because it is has a low abundance and a subsequent lower hazard rating.

In addressing these problems, it was found helpful to think in terms of a unit geological hazard, which represents a combination of stability, block size, and block mobility for a given failure mode. In terms of unit geological hazard, it is possible to consider two ways of scoring abundance:

Additive Score: Total Hazard = Unit hazard + Abundance Score

Multiplicative Score: Total Hazard = Unit Hazard * Abundance Score.

By using a multiplicative abundance, the contribution of a given failure mode to the overall hazard is proportional to the hazard of the individual failure made rather than the score being independent of the rest of the geologic assessment. The multiplicative abundance effectively and retroactively solves the problem associated with inflated scores of low consequence failure mechanisms. The multiplicative abundance also raises the relative hazard of high consequence failure with low abundance.

Comparing Additive and Multiplicative Abundance

The benefit of using a multiplicative abundance is realized by comparing the RHRS hazard rating of slopes that have approximately the same score when an additive abundance is used. Overall effect of the multiplicative abundance does little to the rating of most slopes, but is realized through a slope to slope comparison (Fig. B.2).

The following discusses three pairs of slopes and demonstrates how the use of a multiplicative score emphasizes slopes with greater unit hazard. This is accomplished by comparing the total RHRS hazard rating for both the additive and multiplicative abundance. The multiplicative abundance places emphasis on slope with a greater unit hazard, for the most part, by decreasing the scores of the less hazardous slopes. For the most part the slopes with higher unit hazard stay within the same range as with an additive abundance and the slopes with a lower unit hazard have a resulting decrease in RHRS hazard.

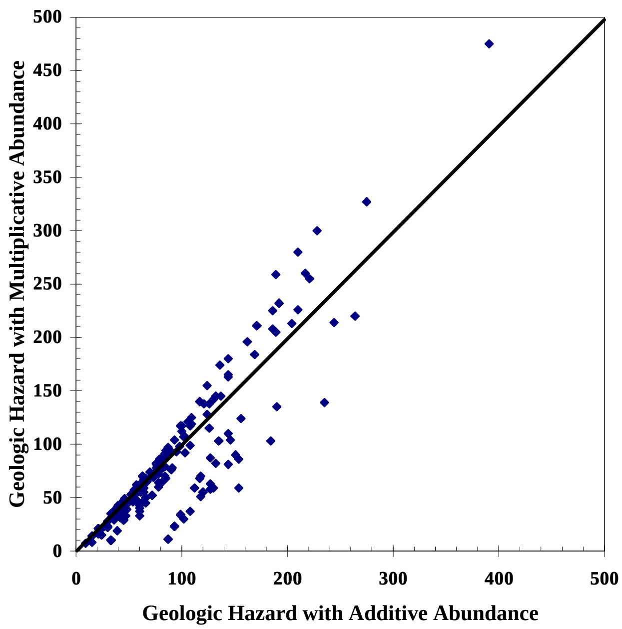

Figure B.2- Comparison of Geologic Hazard with Different Abundance Methods

Comparative Example 1

Figures B.3 and B.4 depict two slopes, each with a single mode of failure. For each slope, differential weathering has been identified as the release mechanism. The slope in Fig. B.3 received a hazard rating of 237 using an additive abundance and a score of 242 using a multiplicative abundance. The slope in Fig. B.4 received a similar score, 228, with an additive abundance, but a much lower score is assigned when a multiplicative abundance is applied, 152. The images show that the consequence of failure in Fig. B.3 is much higher than in Fig. B.4. The slope in Overton County contains large blocks, 1-2 m (3-6 ft), and a large amount of relief, 1-2 m (3-6 ft), while the Campbell County slope contains small blocks, 0.3 m (<1 ft), and a small amount of relief <0.3 m (<1 ft). The use of a multiplicative abundance makes the more hazardous slope have a much higher relative hazard.

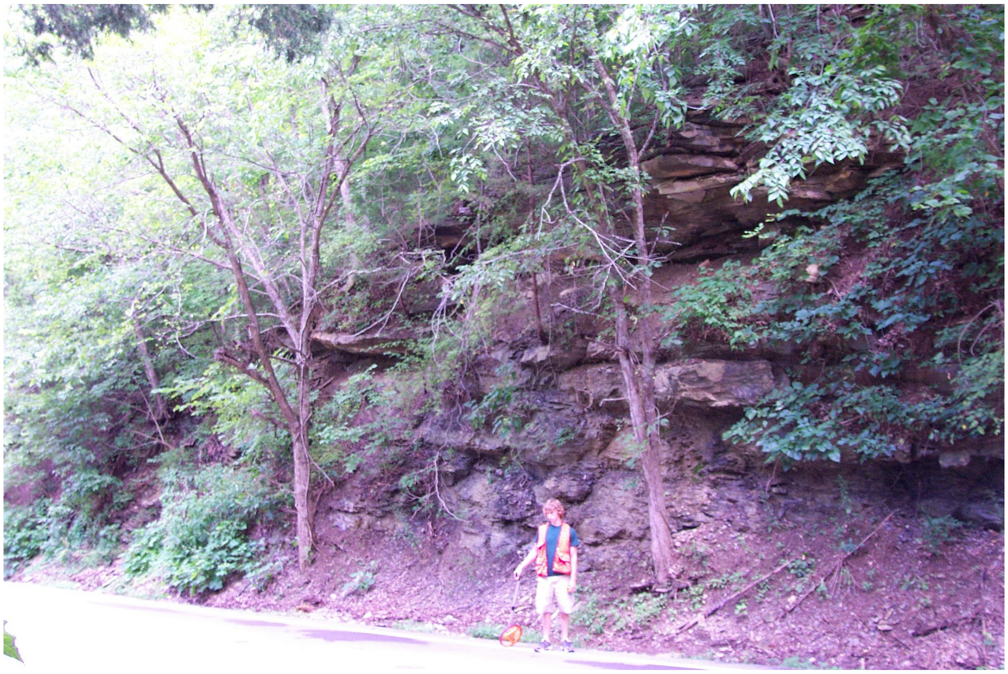

Figure B.3- Example slope in Overton County (RHRS 237 additive; 242 multiplicative)

Figure B.4- Example slope in Campbell County (RHRS 228 additive; 152 multiplicative)

Comparative Example 2

The next two example slopes compare slopes that each has a relatively high hazard. Both slopes score over 300, regardless of the abundance scoring method. The slope in Fig. B.5 has a RHRS rating of 355 with an additive abundance and 395 with the multiplicative, while the slope in Fig. B.6 has an additive and multiplicative rating of 368 and 301, respectively. The Campbell County slope contains differential weathering as a release mechanism, while the Unicoi County slope contains both topple failure and raveling. The slope in Campbell County has the potential to deliver large blocks, larger than 2 m (6 ft), into the road and is highly unstable with a relief of greater than 2m (6 ft), while the Unicoi County slope contains moderately sized blocks, 0.3-1 m (1-3 ft). Both slopes pose a relatively high hazard to the public, but the Campbell County slope clearly is more hazardous than the slope in Unicoi County, and the multiplicative abundance makes this point more apparent.

Figure B.5- Example slope in Campbell County (RHRS 355 additive; 395 multiplicative)

Figure B.6- Example slope in Unicoi County (RHRS 368 additive; 301 multiplicative)

Comparative Example 3

The slopes depicted in figures B.7 and B.8. again show a comparison where the use of a multiplicative abundance results in the slope with a greater relative hazard being easily distinguished from another less hazardous slope that had a similar score when using an additive abundance. The slope in Fig. B.7 keeps approximately the same RHRS rating regardless if the additive or multiplicative abundance scoring method is used, 242 and 246, respectively, while the slope in Fig. B.8 drops from a 243 to a 173 when the multiplicative abundance is applied. In this example the Hancock County slope has two modes of failure, small scale ravel, block size les than 0.3 m (1 ft), and planar failure with large blocks, 1-2 m (3-6 ft), and steeply dipping bedding, 30°-60°. The Cheatham County slope has a single failure mode, differential weather with small blocks, less than 0.3 m (1 ft), and moderated relief, 0.3-1 m (1-3 ft).

Figure B.7- Example slope in Hancock County (RHRS 242 additive; 246 multiplicative)

Figure B.8- Example slope in Cheatham County (RHRS 243 additive; 173 multiplicative)

Summary

Figure B.7 summarizes the current database by giving the percentage of the rated slopes, 324 as of December 2003, that exhibit each failure mode and its contribution to the geologic hazard for the two methods of scoring abundance. The overall difference between the additive and multiplicative abundance scoring methods is minimal except for the raveling failure mode. This is because in most cases raveling is a low consequence failure mechanism. The effect of a multiplicative abundance depends largely on the individual slope and its unit geologic hazard and one would expect the change not to affect the average hazard ratings. It should be noted that the geologic hazard score, regardless of the abundance scoring method used, contributes less than 30% to the total hazard of the slope. The site and roadway geometry is the major contributor to the overall RHRS hazard rating.

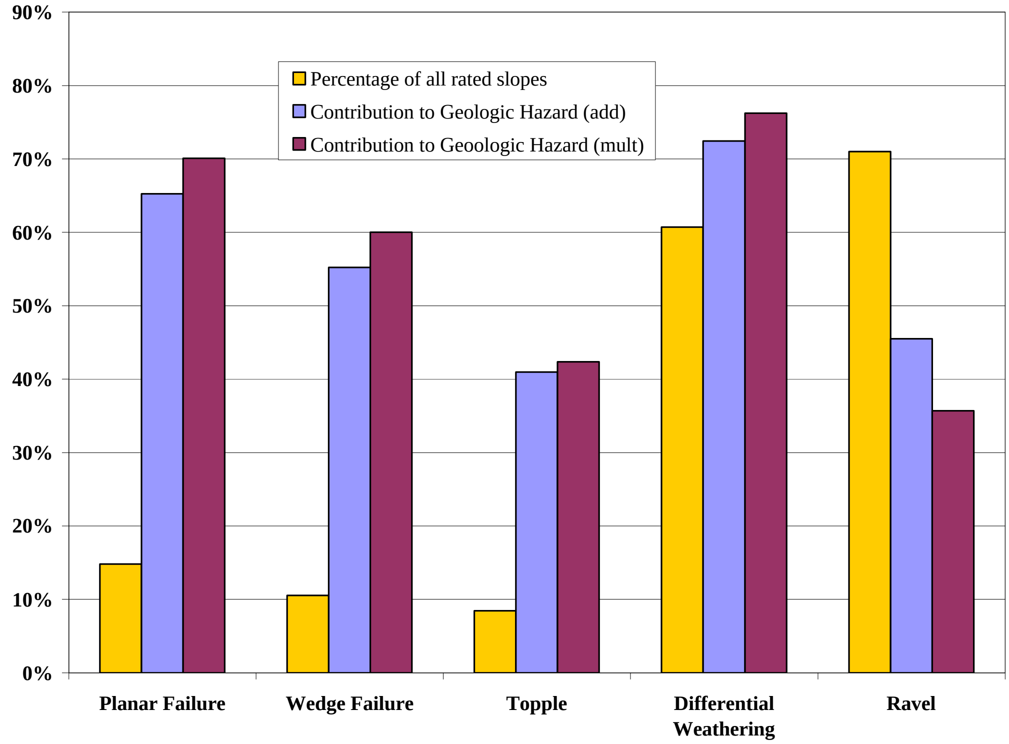

Figure B.9- Percentage of slope that contain a given failure mode and a comparison of multiplicative and additive abundance for individual failure modes.