

SECTION 2: TOE SLOPE ANGLE OF NATURAL TERRAIN LANDSLIDES

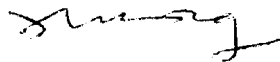
A.S.W. Choi, E.K.S. Fung, A.M.H. Law & J.P. King

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FOREWORD

This study examines the slope angle at the toe of recent large natural terrain landslides. It provides data on debris run-out that can be used to help identify areas that could be affected by natural terrain landslide debris. The results have been used in developing the "Alert Criteria" currently adopted by the GEO for screening new development sites that may be affected by natural terrain landslides. The documentation given in this report serves to present the technical data for the development of the criteria and to facilitate possible future review of the criteria when additional data become available.

The study was carried out in April 1999 by the Engineering Geology Graduates A.S.W. Choi, E.K.S. Fung and A.M.H. Law (in alphabetical order) under the supervision of J.P. King. K. C. Ng reviewed the Technical Note.



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ABSTRACT

Natural terrain landslides typically originate on steep slopes and the debris moves down hill before coming to rest on flatter slopes. The ground slope angle at the distal end of a landslide debris trail (toe slope angle) is one of the parameters that may give an indication about the mobility of landslide debris. Data on the toe slope angle was collected for 569 of the large recent landslides (>15 m wide) in the Natural Terrain Landslide Inventory, using 1:5000 and 1:1000-scale maps and a digital terrain model based on 1:20,000-scale input data. The 1:5000-scale data show that debris from 67 of the landslides reached ground with a slope angle less than 15°. None of these landslides resulted in debris reaching more than 50 m beyond the 15° break-in-slope.

The slope angles recorded from the different scale maps were compared. The correlation is poor between the 1:20,000 data and those from the 1:5000 and 1:1000-scale maps. The 1:5000 and 1:1000 data generally show a reasonable match although local steep slopes and flat areas shown by the 1:1000-scale contours are not given in the 1:5000-scale maps.

The findings from this study have been used in developing the “Alert Criteria” currently adopted by the GEO for screening new development sites that may be affected by natural terrain landslides.

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1. INTRODUCTION

Simple criteria are needed to help judge if a site could possibly be affected by natural terrain landslide debris and hence requires a study to establish the potential hazards. Natural terrain landslides typically originate on steep slopes and the debris moves down hill before coming to rest on flatter slopes. The ground slope angle at the distal end of a landslide debris trail (i.e. toe slope angle) is one of the parameters that may give an indication about the mobility of landslide debris.

This study examines the toe slope angle and the distance that the debris trails extended beyond 15° ground slope for some larger natural terrain landslides in Hong Kong. These data were used to develop the criteria for screening sites that may be affected by natural terrain landslide hazards. The effect of map scale on deriving slope angle data has also been examined.

2. LARGE RECENT LANDSLIDES

2.1 Selection of Landslides

The Natural Terrain Landslide Inventory (NTLI), which was compiled from interpretation of high-level aerial photographs, comprises some 26,000 natural terrain landslides. The landslide locations were plotted on 1:5000-scale topographical maps and data was tabulated for each landslide (King, 1997). The Large Landslide Study (LLS) used low-level aerial photographs to identify natural terrain landslides with source areas more than 20 m wide (Scott Wilson, 1999). The LLS included a review of all NTLI landslides that had been interpreted to be more than 20 m wide. Recent landslides from this subset of the NTLI have been used to collect data on the toe slope angle. Most of this subset can be classified as open slope debris avalanches and channelized debris flows although it may include debris slides. However, channelized debris flows with multiple small sources would not be included.

2.2 Recent Landslides

NTLI landslides are divided into Relict and Recent. Recent landslides have a fresh scar with minimal vegetation cover whereas Relict landslides are vegetated (King, 1997). The distinctive light toned scars of Recent landslides can be easily identified from aerial photographs. Their debris deposits and trails can commonly be distinguished and the trail length can be a good representation of the extent of debris run-out. Therefore, only Recent NTLI landslides were used in this study.

2.3 Confirmation of Large Landslides

Some of the greater-than-20-m-wide NTLI landslides examined on low-level aerial photographs during the LLS were re-interpreted as erosion, graves or other non-landslide features (Scott Wilson, 1998). The LLS study confirmed 569 Recent landslides with a nominal, NTLI width of greater than 20 m. Of the 569 confirmed large NTLI Recent landslides, the LLS re-interpreted 460 to have a source width of 15 m to 20 m and 109 to be

wider than 20 m. Landslide debris mobility has been shown to increase with total landslide volume (e.g. Wong et al, 1998; Evans et al, 1999). Therefore, these 569 large, confirmed Recent landslides would give a generally conservative estimate of debris run-out, since all other landslides in the NTLI are smaller-scale.

3. DATA COLLECTION

3.1 Toe Slope Angle Data

Toe slope angle is defined as the slope angle at the distal end of a debris trail shown on the NTLI maps. This was measured for all 569 large confirmed Recent landslides. To investigate the scale effect, data on the toe slope angle was obtained from three different scales, namely, 1:1000, 1:5000 and 1:20,000.

3.2 Measurement from 1:5000-scale Maps

The toe slope angle was measured by hand from the original hand drawn 1:5000-scale NTLI maps by taking the distance between the contours on either side of the toe. On 1:5000-scale maps, 1 mm represents 5 m. Measurement on the map was to the nearest 0.5 mm and each measurement thus represents a possible range of 0.25 mm on either side of the measured distance, e.g. a measurement of 3.0 mm represents a distance class of 2.75-3.25 mm. On the 1:5000-scale map this gives a ground distance of 13.75-16.25 m, which results in a slope angle class of 32°-36°. The range of the slope angle classes becomes larger when closer contour spacing is measured at higher slope angles. Table 1 shows the entire range of slope angle classes based on 0.5 mm accuracy of measurement using 1:5000-scale maps with a 10 m contour spacing.

In most cases the lower part of the landslide trails extend down a concave slope that gradually becomes flatter until the trail ends. However, other situations were encountered where the slope angle measurement was influenced by factors such as a break-in-slope, a stream course, or lack of contours due to intersecting a cliff or developed area. A letter was used to identify these situations (Appendix A).

3.3 Measurement from 1:1000-scale Maps

The digitised location of the landslides was transferred to 1:1000-scale topographic maps so that the toe slope angles could be measured in the same way as for the 1:5000-scale maps. Measurement was accurate to 0.5 mm. As the 1:1000-scale maps have a 2 m contour spacing, the ratio of scale to contour spacing is the same as the 1:5000-scale maps. Therefore, the same slope angle classes listed on Table 1 were obtained. If the landslide toe was not on a gradually flattening concave slope, a letter was used to identify this as with the 1:5000-scale maps (Appendix A).

Due to scale effects, some landslide toes appeared to be located on different slope facets to those recorded from the 1:5000-scale map. In these cases the slope on the 1:1000-scale map was recorded as the toe slope angle. However, an average slope angle to represent the slope facet recorded from the 1:5000 scale map was also measured on the

1:1000-scale maps as the comparison class. This generally occurred where a trail ended on a flat area that was too small to be shown on the 1:5000-scale map. In other cases, the trails did not fit reasonably with the 1:1000-scale topography such as crossing contour lines at an oblique angle or crossing streams. This accounted for 56 landslides and these were re-plotted on the 1:1000-scale map through interpretation of low-level aerial photographs. The slope angle at the new toe location was recorded as the API class. If appropriate, a comparison class for the situation measured on the 1:5000-scale map was also recorded.

3.4 Measurement from 1:20,000-scale Maps

The toe slope angle from the 1:20,000-scale map was obtained by Geographic Information System (GIS) query of a slope angle map with regular 5° classes. This map was generated from a Triangulated Irregular Network (TIN) model created from the Lands Department 1:20,000-scale topographical maps that have 20 m contour intervals (20K DTM). The digitised landslide locations were superimposed on this slope angle map and the slope angle class at the toe of each landslide trail was recorded.

4. DISTRIBUTION OF TOE SLOPE ANGLES

The toe slope angles for each landslide measured from the three map scales are tabulated in Appendix B. The frequency distribution of toe slope angle classes for all three map scales is shown on Table 2 and Figure 1. For the 1:1000-scale data the API class is used where available (see section 3.3 above).

To give regular slope angle classes and allow comparison of the data, the toe slope angles from the 1:5000 and 1:1000-scale maps were grouped into the same 5° slope angle classes that were used for the 1:20,000-scale map. Where the toe slope angle class covers more than one 5° class the number of landslides was distributed in proportion to the extent of the overlap. (Table 1). Appendix C gives a comparison of the slope angles obtained from the different map scales.

The data show that only 12% to 18% (depending upon which scale is used) of the landslides reached slopes of less than 15° (Table 2). The 1:5000-scale data shows that only 67 landslide trails (about 12%) extend beyond 15° slopes. For the 67 trails the point where the slope reduced to 15° was estimated as described in Appendix A. The distance the trail extended beyond this point was measured on the maps (Appendix B). A summary of the results is given on Table 3. Only 19 landslide trails extend more than 20 m beyond the 15° break-in-slope and only 2 more than 50 m, representing 3.39% and 0.36% respectively, of the 569 large confirmed Recent landslides in the NTLI. For 55 of the 67 cases, the debris trails had passed over a break-in-slope onto the flatter bottom of a stream valley before stopping. This suggests that the debris from natural terrain landslides rarely reaches slopes of less than 15° unless it encounter a rapid flattening of the ground.

5. FINDINGS

5.1 Toe Slope Angle

Data collected from 1:5000-scale maps show that debris from less than 12% of the confirmed large Recent landslides in the NTLI ran out beyond slopes of less than 15°. Most of the debris stopped within 20 m of a 15° slope, often upon reaching the bottom of a stream valley where the slope angle decreased rapidly. Only two landslides ran out more than 50 m on slopes less than 15°, representing 0.36% of the 569 large confirmed Recent landslides in the NTLI.

The study provides an indication of the typical extent of debris run-out of the large (> 15 m wide) Recent NTLI landslides, including both open slope debris avalanches and channelized debris flows. However, large-scale channelized debris flows involving multiple small sources or significant entrainment along the debris trail might not have been included in the data set. Such landslides may have resulted in more mobile debris.

5.2 Effect of Map Scale

The digital slope angle maps derived from the 1:20,000-scale digital terrain model should not be used with the 1:5000-scale toe slope angle data.

If the 1:1000-scale maps are used with the 1:5000-scale toe slope angle data to predict the area that could be affected by landslide debris, the result is generally conservative.

6 DISCUSSION

The findings from this study have been incorporated with data on the travel angle of Recent NTLI landslides (King, in prep) in developing the “Alert Criteria” currently adopted by GEO for screening new development sites that may be affected by natural terrain landslides.

With improved understanding of the characteristics and mechanisms of natural terrain landslides, and availability of more data, there is room for refining the alert criteria in the future. Consideration should be given to the following:

- (a) Inclusion of data collated from studies of natural terrain landslides, with particular attention given to cases involving run-out of debris beyond the zone defined by the “Alert Criteria”.
- (b) Improvement of the accuracy of data collection and analysis, including the use of geographic information system and digital photogrammetric techniques.
- (c) Classification of mechanisms of landslides and debris movement, to help establish the potential influence zones for different types of natural terrain landslides.

- (d) Possible use of other parameters, e.g. combination of travel angle and debris run-out distance, and consideration of run-out distance beyond other breaks-in-slope

7. REFERENCES

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Table 1 - Slope Angle Class for 0.5 mm Measurements from 1:5000-scale Maps with 10 m Contour Interval or 1:1000-Scale Maps with 2 m Contour Interval

Distance Between Contours on Map Measured in 0.5 mm Increments		True Distance (m)	Slope Angle Class (degrees)	5° Slope Angle Class	
Recorded Distance	Distance Class			Angle	Class
0.00	0.00-0.25	0.00-1.25	83-90	85-90, 80-85	18 17
0.50	0.25-0.75	1.25-3.75	69-83	80-85, 75-80, 70-75, 65-70	17 16 15 14
1.00	0.75-1.25	3.75-6.25	58-69	56-70, 60-65, 55-60	14 13 12
1.50	1.25-1.75	6.25-8.75	49-58	55-60, 50-55, 45-50	12 11 10
2.00	1.75-2.25	8.75-11.25	42-49	45-50, 40-45	10 9
2.50	2.25-2.75	11.25-13.75	36-42	40-45, 35-40	9 8
3.00	2.75-3.25	13.75-16.25	32-36	35-40, 30-35	8 7
3.50	3.25-3.75	16.25-18.75	28-32	30-35, 25-30	7 6
4.00	3.75-4.25	18.75-21.25	25-28	25-30	6
4.50	4.25-4.75	21.25-23.75	23-25	20-25	5
5.00	4.75-5.25	23.75-26.25	21-23	20-25	5
5.50	5.25-5.75	26.25-28.75	19-21	20-25, 15-20	5 4
6.00	5.75-6.25	28.75-31.25	18-19	15-20	4
6.50	6.25-6.75	31.25-33.75	17-18	15-20	4
7.00	6.75-7.25	33.75-36.25	15-17	15-20	4
7.50	7.25-7.75	36.25-38.75	14-15	10-15	3
8.00	7.75-8.25	38.75-41.25	14	10-15	3
8.50	8.25-8.75	41.25-43.75	13-14	10-15	3
9.00	8.75-9.25	43.75-46.25	12-13	10-15	3
9.50	9.25-9.75	46.25-48.75	12	10-15	3
10.00	9.75-10.25	48.75-51.25	11-12	10-15	3
10.50	10.25-10.75	51.25-53.75	11	10-15	3
11.00	10.75-11.25	53.75-56.25	10-11	10-15	3
11.50	11.25-11.75	56.25-58.75	10	5-10	2
12.00	11.75-12.25	58.75-61.25	9-10	5-10	2
12.50	12.25-12.75	61.25-63.75	9	5-10	2
13.00	12.75-13.25	63.75-66.25	9	5-10	2
13.50	13.25-13.75	66.25-68.75	8-9	5-10	2
14.00	13.75-14.25	68.75-71.25	8	5-10	2
14.50	14.25-14.75	71.25-73.75	8	5-10	2
15.00	14.75-15.25	73.75-76.25	7-8	5-10	2
15.50	15.25-15.75	76.25-78.75	7	5-10	2
16.00	15.75-16.25	78.75-81.25	7	5-10	2
16.50	16.25-16.75	81.25-83.75	7	5-10	2
17.00	16.75-17.25	83.75-86.25	7	5-10	2

Table 1 - Slope Angle Class for 0.5 mm Measurements from 1:5000-scale Maps with 10 m Contour Interval or 1:1000-Scale Maps with 2 m Contour Interval (Cont.)

Distance Between Contours on Map Measured in 0.5 mm Increments		True Distance (m)	Slope Angle Class (degrees)	5° Slope Angle Class	
Recorded Distance	Distance Class			Angle	Class
17.50	17.25-17.75	86.25-88.75	6-7	5-10	2
18.00	17.75-18.25	88.75-91.25	6	5-10	2
18.50	18.25-18.75	91.25-93.75	6	5-10	2
19.00	18.75-19.25	93.75-96.25	6	5-10	2
19.50	19.25-19.75	96.25-98.75	6	5-10	2
20.00	19.75-20.25	98.75-101.25	6	5-10	2
20.50	20.25-20.75	101.25-103.75	6	5-10	2
21.00	20.75-21.25	103.75-106.25	5-6	5-10	2
21.50	21.25-21.75	106.25-108.75	5	0-5	1
22.00	21.75-22.25	108.75-111.25	5	0-5	1
22.50	22.25-22.75	111.25-113.75	5	0-5	1
23.00	22.75-23.25	113.75-116.25	5	0-5	1
23.50	23.25-23.75	116.25-118.75	5	0-5	1
24.00	23.75-24.25	118.75-121.25	5	0-5	1
24.50	24.25-24.75	121.25-123.75	5	0-5	1
25.00	24.75-25.25	123.75-126.25	5	0-5	1
25.50	25.25-25.75	126.25-128.75	4-5	0-5	1
26.00	25.75-26.25	128.75-131.25	4	0-5	1
26.50	26.25-26.75	131.25-133.75	4	0-5	1
27.00	26.75-27.25	133.75-136.25	4	0-5	1
27.50	27.25-27.75	136.25-138.75	4	0-5	1
28.00	27.75-28.25	138.75-141.25	4	0-5	1
28.50	28.25-28.75	141.25-143.75	4	0-5	1
29.00	28.75-29.25	143.75-146.25	4	0-5	1
29.50	29.25-29.75	146.25-148.75	4	0-5	1
30.00	29.75-30.25	148.75-151.25	4	0-5	1
30.50	30.25-30.75	151.25-153.75	4	0-5	1
31.00	30.75-31.25	153.75-156.25	4	0-5	1
31.50	31.25-31.75	156.25-158.75	4	0-5	1
32.00	31.75-32.25	158.75-161.25	4	0-5	1
32.50	32.25-32.75	161.25-163.75	3-4	0-5	1
33.00	32.75-33.25	163.75-166.25	3	0-5	1
33.50	33.25-33.75	166.25-168.75	3	0-5	1
34.00	33.75-34.25	168.75-171.25	3	0-5	1
34.50	34.25-34.75	171.25-173.75	3	0-5	1
35.00	34.75-35.25	173.75-176.25	3	0-5	1
35.50	35.25-35.75	176.25-178.75	3	0-5	1
36.00	35.75-36.25	178.75-181.25	3	0-5	1
36.50	36.25-36.75	181.25-183.75	3	0-5	1
37.00	36.75-37.25	183.75-186.25	3	0-5	1
37.50	37.25-37.75	186.25-188.75	3	0-5	1
38.00	37.75-38.25	188.75-191.25	3	0-5	1
38.50	38.25-38.75	191.25-193.75	3	0-5	1
39.00	38.75-39.25	193.75-196.25	3	0-5	1
39.50	39.25-39.75	196.25-198.75	3	0-5	1
40.00	39.75-40.25	198.75-201.25	3	0-5	1
40.50	40.25-40.75	201.25-203.75	3	0-5	1

Table 2 - Frequency Distribution of Toe Slope Angles from Different Map Scales

Toe Slope Angle Class (Degrees)	1:20,000 (Frequency)			1:5000 (Frequency)			1:1000 (Frequency)		
	Number	%	Cum %	Number	%	Cum %	Number	%	Cum %
0 - 5	32	5.85	5.85	6	1.07	1.07	19	3.39	3.39
5 - 10	24	4.39	10.24	19	3.39	4.46	20	3.57	6.96
10 - 15	43	7.86	18.10	42	7.50	11.96	56	10.00	16.96
15 - 20	44	8.04	26.14	73	13.04	25.00	56	10.00	26.96
20 - 25	92	16.82	42.96	77	13.75	38.75	91	16.25	43.21
25 - 30	148	27.06	70.02	128	22.86	61.61	95	16.96	60.18
30 - 35	115	21.02	91.04	108	19.29	80.89	101	18.04	78.21
35 - 40	36	6.58	97.62	57	10.18	91.07	51	9.11	87.32
40 - 45	7	1.28	98.90	28	5.00	96.07	31	5.54	92.85
45 - 50	3	0.55	99.45	16	2.86	98.93	26	4.64	97.50
50 - 55	3	0.55	100.00	2	0.36	99.28	4	0.71	98.21
55 - 60	0	0.00	100.00	2	0.36	99.64	4	0.71	98.93
60 - 65	0	0.00	100.00	1	0.18	99.82	3	0.54	99.46
65 - 70	0	0.00	100.00	1	0.18	100.00	3	0.54	100.00
70 - 75	0	0.00	100.00	0	0.00	100.00	0	0.00	100.00
75 - 80	0	0.00	100.00	0	0.00	100.00	0	0.00	100.00
80 - 85	0	0.00	100.00	0	0.00	100.00	0	0.00	100.00
85 - 90	0	0.00	100.00	0	0.00	100.00	0	0.00	100.00
Total	547	100.00	100.00	560	100.00	100.00	560	100.00	100.00

Table 3 - Distribution of Run-out Distance Beyond 15° Slopes Using the 1:5,000 Scale Map Data

Run-out Distance (m)	S	B	NB	D	NT	Total Class	% of Total Database (569)	Cumulative %
0 - 10	22	2	0	0	3	27	4.82	11.95
10 - 20	20	0	0	1	0	21	3.74	7.13
20 - 30	8	2	0	0	0	10	1.78	3.39
30 - 40	3	2	1	0	0	6	1.07	1.61
40 - 50	0	1	0	0	0	1	0.18	0.54
50 - 60	1	0	0	0	0	1	0.18	0.36
60 - 70	1	0	0	0	0	1	0.18	0.18
70 - 80	0	0	0	0	0	0	0.00	0
Total	55	7	1	1	3	67	11.95	
Legend : S Landslide trail encountered a break-in-slope at a stream at the toe of a valley side slope. B Landslide trail encountered a break-in-slope other than S. NB Landslide trail did not encounter a break-in-slope. D Landslide trail encountered sloping developed area such as a cut slope. NT Landslide source was located on a slope of less than 15° and had no trail.								

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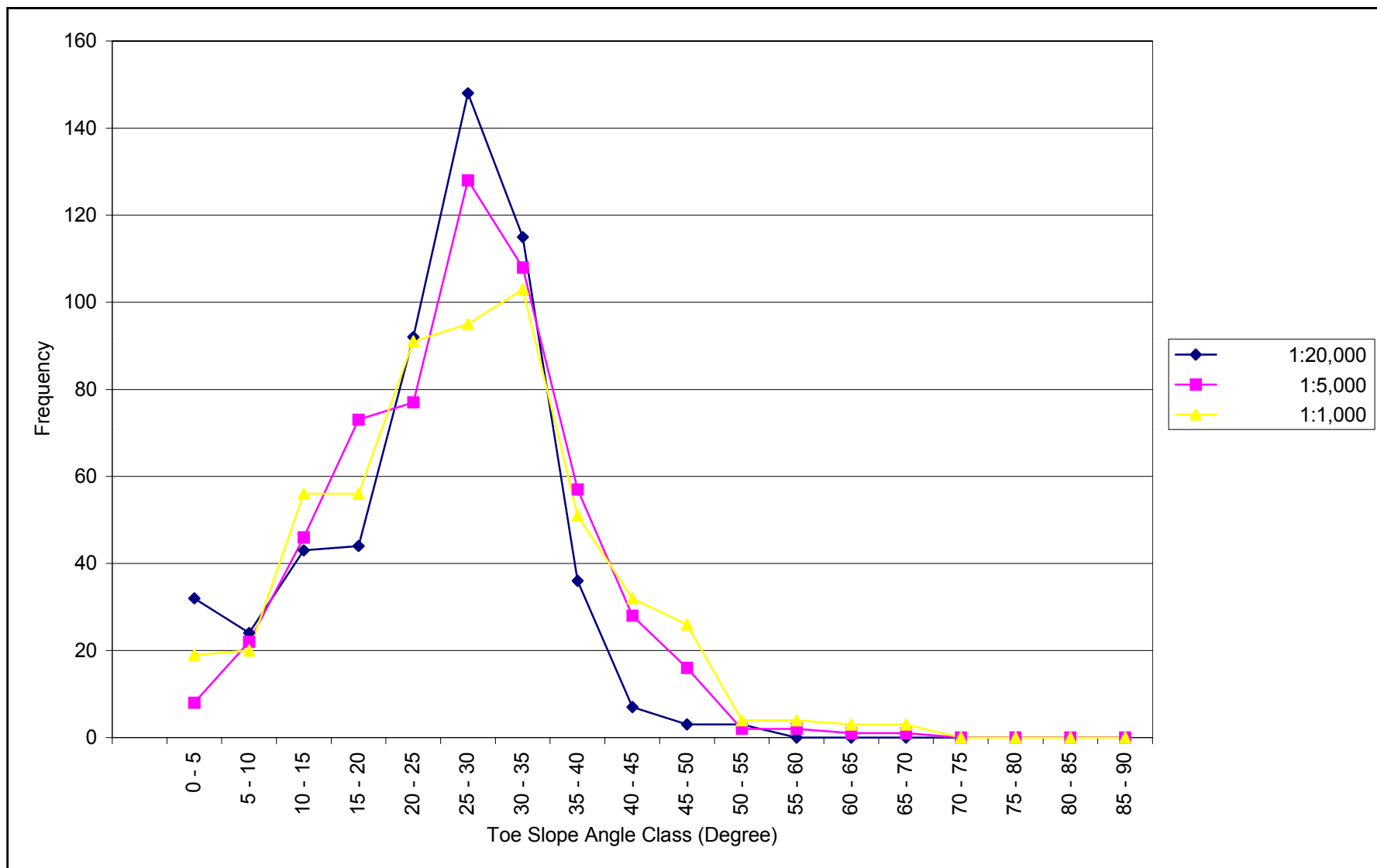


Figure 1 - Frequency Distribution of Toe Slope Angle Classes at Different Scales

APPENDIX A

CRITERIA FOR DETERMINATION OF TOE SLOPE ANGLES OF THE LANDSLIDES FROM 1:5000 & 1:1000-SCALE MAPS

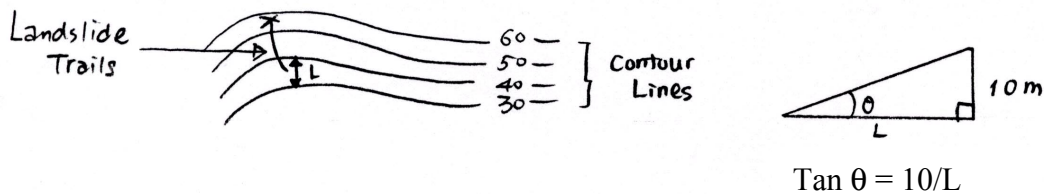
APPENDIX A

CRITERIA FOR DETERMINATION OF TOE SLOPE ANGLES OF LANDSLIDES FROM 1:5000 & 1:1000 SCALE MAPS

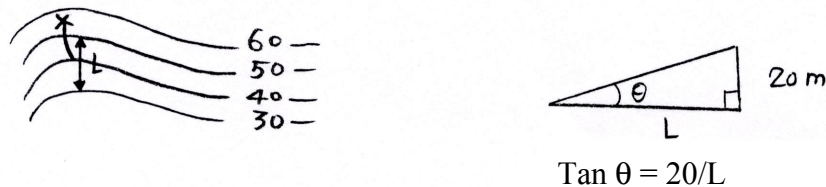
The slope angle at the toe of each landslide was assessed by measuring the distance between contours on the 1:5000 and 1:1000 scale maps using 10 m and 2 m contour intervals respectively.

Measurement on 1:5000 scale maps

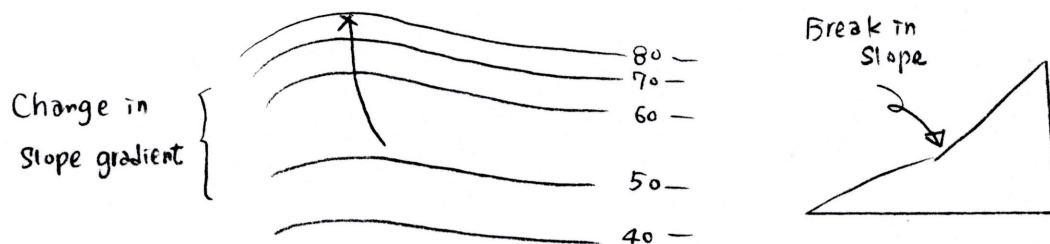
1. The distance L that is perpendicular to the last two contour lines at the end of a landslide trail was measured and the toe slope angle was obtained by trigonometry.



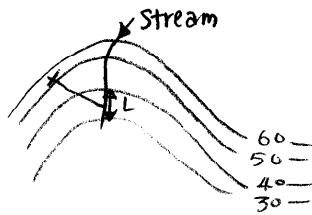
2. If the toe of a landslide is touching a contour, an average was taken for the distance between the two adjacent contours.



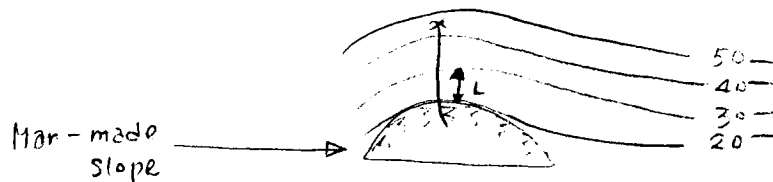
3. The symbol “B” was recorded if the landslide trail crosses a break in slope, i.e. a significant change in slope gradient (approximately larger than 20°) indicated by an obvious change in contour spacing.



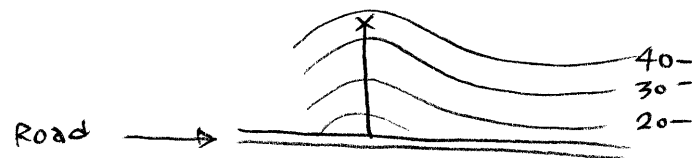
4. The symbol “S” was recorded when the toe of a landslide was at the bottom of a stream valley and the slope along the stream valley between adjacent contours was measured.



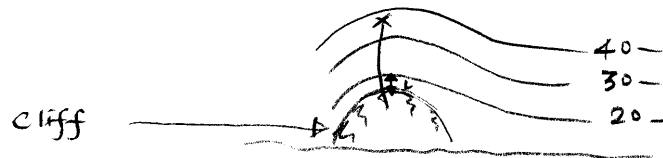
5. A symbol “D” was recorded when the toe of a landslide was at a sloping developed area such as cut slopes, buildings or fields where no contour lines were present. In this case the distance between the last contour lines and the developed area would be measured to assess the toe slope angle. The measured toe slope angle might deviate from the actual toe slope angle.



6. A symbol “0” was marked for the case that the landslide toe was on a flat developed area such as land-fill or a major road. In these cases the toe slope angles were assumed to be zero.



7. A symbol “C” was recorded where a landslide trail extended across a sea cliff and the contour lines are not shown. The upslope angle just above the cliff was measured.

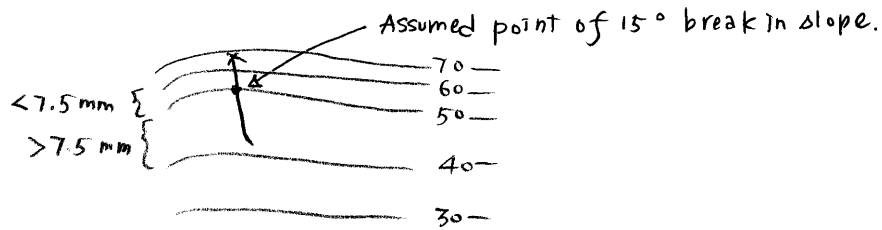


8. The symbol “?” was given to those landslides that do not have any trail.

Slopes less than 15°

All measured distances between two contours larger than 7.5 mm represent slopes of less than 15°. Therefore the 15° break in slope was defined as the upper contour of the first pair of contours with spacing larger than 7.5 mm. The length of the landslide trail that extended beyond

the 15° break in slope was measured and recorded.



Measurements on 1:1000 scale maps

1. If landslide trails transferred from 1:5000 scale maps were reasonably located on the 1:1000 scale map, i.e. did not obliquely cross a slope, go uphill or cross a stream, the same procedures used for the 1:5000 scale maps were applied.
2. If a landslide trail was reasonably located on the 1:1000 scale map, but the toe was located on a stream or other flat area not shown on the 1:5000 scale map, this slope angle was recorded and used for the plots. However, in addition a "Comparison" angle of the same overall slope as was measured on the 1:5000 scale map, was also recorded.
3. If a landslide trail was not reasonably located on the 1:1000 scale map, it was examined using low level API and relocated as necessary. The toe slope angle was then assessed and recorded as the "Real" toe slope angle.

APPENDIX B

LIST OF TOE SLOPE ANGLE DATA FOR ALL CONFIRMED LARGE RECENT
LANDSLIDES

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
02NED0027L	39	25-30	6	18-19		4		18-19				4
02NED0040*	39	5-10	2	32-36		7		32-36				7
02SEB0059*	39	0-5	1	5	S	1		5	S		5	1
02SED0180*	34	0-5	1	17-18	S	4		25-28	S			6
02SED0188*	39	20-25	5	15-17	S	4		18-19	S			4
02SED0189*	30	20-25	5	15-17	S	4		18-19	S			4
02SED0200L	39	30-35	7	28-32		6		32-36				7
02SED0214*	45	30-35	7	32-36		7		25-28			32-36	6
02SWD0001*	27	5-10	2	42-49		10		14-15			14-15	3
02SWD0002*	33	5-10	2	36-42		8		36-42			42-49	8
02SWD0008*	33	30-35	7	32-36		7		28-32			28-32	6
02SWD0009*	33	10-15	3	18-19		4		21-23			21-23	5
02SWD0010*	24	0-5	1	36-42		8		19-21				4
02SWD0011L	45	0-5	1	42-49	D	10		42-49	D			10
02SWD0012*	38	0-5	1	28-32		6		25-28			0	6
02SWD0013*	45	0-5	1	32-36	D	7		21-23	D	0		5
02SWD0014*	30	0-5	1	36-42		8		32-26				7
02SWD0018*	27	10-15	3	36-42		8		32-36				7
02SWD0019*	30	10-15	3	32-36		7		42-49				10
02SWD0020*	45	25-30	6	28-32		6		32-36				7
02SWD0021*	30	0-5	1	28-32		6		32-36				7
02SWD0022*	30	10-15	3	42-49		10		42-49				10
03NEA0004*	30	20-25	5	19-21		4		13-14				3
03NEA0010*	45	15-20	4	21-23		5		28-32				6
03NEA0127*	39	35-40	8	25-28		6		42-49				10
03NEB0005*	34	0	1	32-36		7		42-49				10
03NEB0041*	34	0	1	28-32		6		25-28			?	6
03NEB0110*	39	20-25	5	25-28		6		13-14			13-14,	3
03NEC0025*	34	15-20	4	21-23	S	5		9	S			2
03NEC0049*	34	5-10	2	32-36	S	7		7-8	S			2
03NEC0203L	45	30-35	7	25-28		6		19-21	S			4
03NEC0210L	30	0-5	1	19-21		4		19-21				4
03NED0058*	34	20-25	5	21-23		5		21-23			21-23	5
03NED0084*	26	30-35	7	25-28		6		25-28				6
03NED0099*	39	35-40	8	32-36		7		28-32				6
03NED0100*	39	10-15	3	25-28		6		23-25				5
03NED0106*	45	35-40	8	23-25		5		36-42, 36-42				8
03NED0114*	30	10-15	3	36-42	D	8		14-15	D		10-11	3

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
03NED0115*	30	20-25	5	25-28	S	6		14-15	S			3
03NED0116*	30	15-20	4	19-21	S	4		21-23	S			5
03NED0145*	34	30-35	7	32-36		7		36-42				8
03NED0156*	30	30-35	7	36-42		8		36-42				8
03NED0159*	34	30-35	7	42-49		10		36-42				8
03NED0161*	34	15-20	4	18-19	S	4		15-17	S		15-17	4
03NED0178L	30	10-15	3	15-17		4		19-21		19-21		4
03NED0307*	34	25-30	6	32-36		7		25-28				6
03NED0309L	34	20-25	5	28-32		6		42-49				10
03NED0317*	30	20-25	5	28-32		6		25-28				6
03NED0344L	34	25-30	6	23-25		5		32-36				7
03NED0375*	39	30-35	7	28-32		6		32-36		23-25	23-25	7
03NED0390*	34	30-35	7	9	S	2	0	8-9	S		9	2
03NWD0002*	27	20-25	5	36-42		8		32-36				7
03NWD0051L	39	25-30	6	49-58		12		58-69				14
03NWD0061*	39	25-30	6	28-32		6		28-32				6
03NWD0063*	34	25-30	6	28-32		6		28-32				6
03NWD0132*	34	25-30	6	14	B	3	25	13-14	B	13-14	13-14	3
03NWD0150*	34	25-30	6	32-36	D	7		25-28	D	25-28		6
03NWD0157L	34	25-30	6	32-36		7		28-32				6
03NWD0169*	27	5-10	2	58-69	D	14		19-21	D			4
03SEA0006L	34	25-30	6	28-32		6		28-32				6
03SEA0014L	39	30-35	7	36-42		8		23-25				5
03SEA0048L	30	25-30	6	25-28		6		23-25				5
03SEA0106L	30	35-40	8	36-42		8		32-36				7
03SEA0107L	30	25-30	6	10	S	2	2	10-11	S		28-32	3
03SEA0108L	30	25-30	6	32-36, 25-28		7		28-32, 32-36				6
03SEA0110L	45	35-40	8	36-42		8		19-21				4
03SEA0112L	39	25-30	6	42-49		10		28-32				6
03SEA0500*	30	15-20	4	21-23		5	35	18-19		4	4	4
03SEA0501L	34	20-25	5	19-21, 18-19		4		23-25, 23-25				5
03SEB0001L	30	25-30	6	19-21		4		15-17				4
03SEB0136*	34	25-30	6	36-42	D	8		21-23	D	21-23		5
03SEB0284*	45	35-40	8	28-32, 28-32		6		32-36				7
03SEB0298*	34	25-30	6	19-21		4		25-28				6
03SEB0371*	34	25-30	6	36-42, 28-32, 28-32		8		32-36, 32-36, 18-19				7

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
03SEB0409L	34	20-25	5	25-28		6		21-23				5
03SEB0417*	30	25-30	6	25-28	S	6		25-28	S		25-28	6
03SEB0446*	34	30-35	7	36-42		8		36-42				8
03SEB0464L	39			28-32		6						
03SEB0474*	30	20-25	5	32-36	D	7		14-15	S			4
03SEB0493L	34	30-35	7	28-32		6		32-36				7
03SEC0047L	34	10-15	3	32-36		7		49-58				12
03SED0016L	34	25-30	6	17-18		4		8-9				2
03SED0043*	39	25-30	6	14	S	3	7.5	17-18	S			4
03SED0050L	34	30-35	7	25-28		6		32-36		28-32		7
03SED0152*	39	25-30	6	28-32	D	6		28-32	D		32-36	6
03SED0172*	39	30-35	7	21-23		5		36-42				8
03SWB0121L	27	25-30	6	25-28		6		21-23				5
03SWB0279L	34	30-35	7	28-32		6		25-28				6
03SWC0049L	30	25-30	6	19-21		4		23-25				5
03SWC0078L	30	25-30	6	25-28		6		23-25				5
03SWD0004*	34	20-25	5	19-21	S	4		23-25	S	23-25	21-23	5
03SWD0027L	34	10-15	3	28-32		6		18-19			0 (O)	4
03SWD0030*	34	40-45	9	25-28		6		49-58				12
03SWD0037*	27	25-30	6	28-32		6		32-36				7
03SWD0279L	34	30-35	7	28-32		6		32-36				7
03SWD0515*	34	25-30	6	14	S	3	25	10-11	S		10-11	3
03SWD0516L	34	25-30	6	28-32		6		32-36				7
04NWC0001*	30	10-15	3	42-49	D	10		32-36	D			7
04NWC0055L	34	10-15	3	25-28		6		19-21				4
04NWC0236*	30	25-30	6	18-19	D	4		25-28	D			6
04NWC0239*	34	30-35	7	32-36		7		36-42				8
04NWC0240*	34	0-5	1	32-36		7		36-42				8
04SWA0002*	30	30-35	7	28-32		6		21-23				5
04SWA0013*	39	25-30	6	17-18		4		25-28		17-18		6
04SWA0021*	39	35-40	8	36-42	S	8		32-36	S			7
04SWA0032*	34	25-30	6	23-25		5		25-28				6
04SWA0033*	30	10-15	3	36-42	D	8		42-49	D	42-49		10
04SWA0093*	34	0	1	25-28		6		21-23				5
04SWA0441L	45	35-40	8	36-42		8		42-49				10
04SWA0448*	34	30-35	7	23-25	S	5		25-28	S		25-28	6
04SWA0450L	27	15-20	4	42-49		10		23-25				5
04SWA0470*	34	10-15	3	7	S	2	5	5	S	25-28		1
04SWA0492*	39	35-40	8	42-49		10		58-69				14

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
04SWA0494*	34	35-40	8	25-28, 28-32		6		25-28, 28-32				6
04SWA0506*	39	30-35	7	25-28, 25-28		6		42-49, 25-28				10
04SWA0520*	39	25-30	6	18-19		4		17-18			17-18	4
04SWA0523*	30	30-35	7	19-21		4		32-36			32-36	7
04SWB0113L	39	30-35	7	32-36		7		36-42				8
04SWB0177*	34	25-30	6	28-32		6		42-49		28-32		10
04SWB0316*	30	40-45	9	28-32		6		19-21				4
04SWC0001*	39	25-30	6	14	S	3	0	5	S			1
04SWC0002*	34	20-25	5	15-17	S	4		10-11	S	42-49	12-13	3
04SWC0003*	34	20-25	5	21-23	S	5		18-19	S		18-19	4
04SWC0042*	34	15-20	4	17-18	S	4		36-42	S			8
04SWC0059*	34	25-30	6	36-42		8		36-42			32-36	8
04SWC0115*	34	25-30	6	18-19		4		18-19				4
04SWC0129*	34	0	1	32-36		7		21-23				5
05SEB0021L	33	25-30	6	28-32		6		21-23				5
05SEB0024L	50	5-10	2	12	D	3	64					0
06NEB0274L	34	0-5	1	25-28	D	6		14	D			3
06NEB0484*	34	0-5	1	42-49	D	10		28-32	D			6
06NEB0490*	27	10-15	3	42-49	D	10		21-23	D	23-25		5
06NEB0492*	30	15-20	4	18-19	D	4		23-25	D			5
06NEB0496*	27	15-20	4	25-28	D	6		21-23	D			5
06NEB0497*	34	15-20	4	21-23		5		23-25				5
06NEB0498*	34	5-10	2	23-25		5		19-21		19-21		4
06NEB0500*	34	25-30	6	28-32		6		28-32				6
06NEB0501*	45			25-28		6		32-36				7
06NEB0507*	34	25-30	6	14	S	3	25	14	S			3
06NEB0520*	45	20-25	5	17-18	S	4		14-15	D			3
06NEB0521*	39	20-25	5	11-12	S	3		5	S			1
06NEB0525*	39	25-30	6	23-25	S	5		19-21	S			4
06NEB0559*	39	30-35	7	28-32		6		19-21				4
06NEB0573*	45	25-30	6	10	S	2		7	S			2
06NEB0575*	30	20-25	5	18-19		4		18-19		18-19		4
06NWA0150*	27	25-30	6	23-25		5		25-28				6
06NWC0058*	27	30-35	7	28-32		6		36-42		32-36		8
06NWC0059*	30	20-25	5	36-42		8		28-32				6
06NWC0084*	34	15-20	4	14	S	3	17.5	11-12	S		11-12	3
06NWC0087*	45	15-20	4	11-12	S	3	10	14	S	19-21		3
06NWC0090*	34	10-15	3	11-12	S	3	10	28-32	S	28-32	18-19	6

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
06NWD0016L	34	20-25	5	15-17	S	4		14	S			3
06NWD0020L	18	10-15	3	21-23		5		28-32				6
06NWD0023L	39	30-35	7	25-28		6		28-32				6
06SEA0072L	39	20-25	5	25-28		6		28-32		28-32		6
06SEC0138*	45	20-25	5	18-19	D+O	4		21-23	D+O			5
06SEC0181*	39	10-15	3	32-36		7		42-49				10
06SEC0183*	34	20-25	5	36-42		8		28-32				6
06SEC0233*	39	25-30	6	25-28		6		25-28			4	6
06SEC0234*	34	25-30	6	25-28		6		36-42				8
06SEC0260*	22	10-15	3	36-42		8		42-49		18-19		10
06SEC0262*	30	30-35	7	19-21		4		25-28				6
06SEC0298*	30	25-30	6	14	S	3	27.5	7-8	S		7-8	2
06SED0100*	18	15-20	4	15-17		4		12-13				3
06SED0103L	22	20-25	5	18-19		4		12-13				3
06SED0118*	39	5-10	2	14	B	3	32.5	?				0
06SWA0057*	34	0-5	1	32-36		7		32-36				7
06SWA0083*	34	30-35	7	14-15	S	3	15	11-12	S	23-25		3
06SWA0094*	45			15-17	S	4		15-17	S			4
06SWA0095*	34	15-20	4	14-15	B	3	40	17-18	B	19-21		4
06SWA0230*	27	20-25	5	14-15	S	3	15	13-14	S	36-42		3
06SWB0037L	34	30-35	7	19-21		4		23-25				5
06SWB0053L	45	20-25	5	23-25		5		21-23				5
06SWB0063*	39	15-20	4	15-17	S	4		15-17	S			4
06SWB0067*	45	30-35	7	28-32		6		28-32				6
06SWB0077*	45	30-35	7	13-14	S	3	13	12-13	S			3
06SWB0097*	30	0-5	1	23-25		5		23-25				5
06SWB0138*	30	25-30	6	15-17	S	4		18-19	S	18-19		4
06SWB0146*	34	25-30	6	13-14	S	3	25	12-13	S	42-49	14	3
06SWB0150*	45	20-25	5	19-21	S	4		18-19	S		32-36	4
06SWB0151*	45	30-35	7	19-21	S	4		18-19	S		32-36	4
06SWB0152*	34	10-15	3	8	S	2	30	4	S		4	1
06SWB0160*	45	10-15	3	28-32		6		42-49				10
06SWB0167*	34	10-15	3	9-10	S	2		7	S			2
06SWB0175*	39	15-20	4	36-42	D+O	8		19-21	D+O		19-21	4
06SWB0179L	39	5-10	2	36-42		8		32-36			25-28	7
06SWD0031*	18	30-35	7	36-42		8		42-49				10
06SWD0041*	36	0-5	1	15-17	S	4		6	S			2
06SWD0042*	45	5-10	2	25-28		6		21-23				5
06SWD0054*	33	25-30	6	14	B	3	7.5	11-12	B			3

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
06SWD0149*	33	25-30	6	19-21	S	4		14	S	25-28		3
07NEB0037*	34	30-35	7	25-28		6		25-28				6
07NEC0069L	34	20-25	5	23-25		5		36-42				8
07NEC0077L	34			36-42		8						
07NED0100*	45	30-35	7	28-32		6		23-25				5
07NWA0030*	39	40-45	9	36-42		8		32-36				7
07NWA0056*	18	25-30	6	23-25		5		21-23				5
07NWA0062*	45	30-35	7	32-36		7		32-36				7
07NWA0076*	45	30-35	7	25-28		6		36-42				8
07NWA0083*	45	35-40	8	25-28		6		32-36				7
07NWA0084*	45	45-50	10	36-42		8		36-42				8
07NWA0088L	30	30-35	7	28-32		6		42-49				10
07NWA0096*	39	30-35		36-42								
07NWA0097*	45	30-35		32-36								
07NWA0121*	34	30-35		28-32								
07NWA0122*	34	30-35		25-28								
07NWA0125*	30	30-35	7	28-32		6		32-36				7
07NWA0140*	45	35-40	8	36-42		8		42-49				10
07NWA0152*	45	25-30	6	23-25		5		28-32				6
07NWA0193*	39	30-35	7	36-42		8		32-36				7
07NWA0216*	45	35-40	8	28-32		6		36-42				8
07NWA0238*	34	25-30	6	25-28		6		36-42		32-36		8
07NWA0258*	34	25-30	6	11-12	S	3	25	11-12	S		9	3
07NWA0267*	39	45-50	10	23-25	S	5		19-21	S			4
07NWA0268*	39	30-35	7	21-23	S	5		23-25	S			5
07NWA0304*	30	35-40	8	32-36		7		28-32				6
07NWA0315*	34	20-25	5	18-19		4		36-42				8
07NWA0338L	27	35-40	8	19-21		4		42-49				10
07NWA0343*	24	15-20	4	12-13	B	3	7.5	12-13	B			3
07NWB0023*	34	25-30	6	23-25		5		21-23				5
07NWB0024*	34	20-25	5	28-32		6		25-28				6
07NWC0088*	30	30-35	7	28-32	S	6		32-36	S			7
07NWD0027L	27	10-15	3	28-32		6		28-32				6
07SEA0080*	39	10-15	3	? It occurs on a man-made slope		0		?	D			0
07SEA0174*	22	25-30	6	6-7	S	2	5	14	S			3
07SED0003*	45	30-35	7	36-42		8		42-49				10
07SWA0133L	45	30-35	7	36-42		8		36-42				8
07SWC0086*	39	35-40	8	49-58	S	12		28-32	S	42-49		6

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
07SWD0084*	34	15-20	4	14-15	S	3	60	9-10	S		9-10	2
08NEA0008*	30	0	1	42-49		10		49-58				12
08NEA0174L	33	20-25	5	15-17		4		12				3
08NEB0023*	33	30-35	7	32-36		7		42-49				10
08NEB0027*	33	30-35	7	42-49	S	10		32-36	S	42-49		7
08NEC0072L	33	20-25	5	25-28		6		28-32				6
08NEC0086*	33	25-30	6	32-36		7		28-32				6
08NEC0087*	33	25-30	6	32-36		7		42-49				10
08NEC0088*	33	15-20	4	15-17	S	4		18-19	S	18-19		4
08NEC0178*	30	25-30	6	21-23		5		23-25				5
08NEC0296*	33	30-35	7	13-14	S	3	10	12-13	S			3
08NEC0423*	30	30-35	7	32-36		7		32-36				7
08NED0002*	33	25-30	6	25-28		6		32-36				7
08NED0004*	26	10-15	3	9		2	17.5	10-11				3
08NED0051*	24	0	1	23-25		5		25-28		28-32		6
08NED0277*	38	10-15	3	32-36		7		32-36				7
08NED0278*	38	10-15	3	25-28		6		28-32				6
08NWA0076*	38	20-25	5	32-36		7		23-25				5
08NWA0183*	35	25-30	6	28-32		6		28-32				6
08NWA0243*	33	30-35	7	36-42, 25-28	S	8		32-36, 36-42	(S)	32-36, 36-42		7
08NWA0269*	33	30-35	7	36-42		8		32-36				7
08NWA0410*	30	15-20	4	0, v. low angle	S	1	12.5	0	S	18-19		1
08NWA0411*	33	15-20	4	6	S	2		3	S			1
08NWA0422*	30	20-25	5	28-32		6		32-36				7
08NWA0450*	33	25-30	6	25-28	S	6		28-32	S	23-25		6
08NWA0486*	30	30-35	7	32-36		7		19-21				4
08NWB0357*	38	25-30		25-28								
08NWB0397*	30	20-25	5	12-13	S	3	25	5	S			1
08NWB0406*	38	10-15	3	42-49	D	10		49-58	D			12
08NWC0013*	39	30-35	7	32-36		7		21-23				5
08NWC0197L	39	0	1	32-36		7		32-36				7
08NWC0366*	26	25-30	6	17-18	S	4		13-14	S			3
08NWC0387*	34	30-35	7	12-13	S	3	2.5	11	S		14	3
08NWC0398*	39	35-40	8	32-36		7		32-36				7
08NWC0401*	34	5-10	2	5-6	S	2	7.5	0	S			1
08NWC0409*	34	20-25	5	18-19	S	4		17-18	S		17-18	4
08NWD0337L	30	20-25	5	21-23		5		18-19				4
08NWD0467*	33	15-20	4	32-36		7		28-32				6

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
08NWD0645L	45	30-35	7	32-36		7		28-32				6
08NWD0792*	33	25-30	6	14(S)	S	3	17	15-17	S			4
08SEA0137*	22	20-25	5	15-17	D+O	4		9	D+O			2
08SEA0286*	26	5-10	2	42-49		10		49-58				12
08SEA0665*	33	5-10	2	25-28		6		32-36				7
08SEA0666*	33	25-30	6	21-23	S	5		19-21	S			4
08SEA0667*	33	30-35	7	21-23		5		25-28				6
08SEA0668*	33	30-35	7	25-28		6		25-28				6
08SEA0673*	33	30-35	7	9-10	S	2	20	0	S			1
08SEA0693*	33	25-30	6	19-21	S	4		18-19	S			4
08SEB0195*	33	10-15	3	19-21		4		23-25				5
08SEC0018*	11	0-5	1	25-28		6		18-19				4
08SEC0044*	24	25-30	6	21-23		5		21-23				5
08SEC0047*	29	30-35	7	28-32		6		42-49				10
08SEC0160*	18	10-15	3	13-14	S	3		11-12	S			3
08SEC0173*	38	25-30	6	25-28	S	6		28-32	S	32-36		6
08SEC0196*	26	20-25	5	23-25		5		21-23				5
08SEC0197*	26	20-25	5	19-21	S	4		23-25	S	28-32		5
08SEC0228*	33	25-30	6	32-36		7		36-42				8
08SEC0229*	33	5-10	2	25-28		6		25-28				6
08SEC0245L	30	20-25	5	23-25		5		25-28				6
08SEC0265*	33	25-30	6	32-36		7		36-42				8
08SEC0271*	26	10-15	3	7	S	2	10	5	S			1
08SED0022*	33	30-35	7	32-36		7		32-36				7
08SWB0176*	33	35-40	8	42-49		10		58-69				14
08SWD0203*	30	20-25	5	28-32		6		?	D			0
08SWD0208*	18	5-10	2	0, v. low angle	S	1	20	0	S	6		1
09SEA0108L	30	25-30	6	21-23	S	5		14	S			3
09SEA0109L	30	30-35	7	21-23	S	5		14	S			3
09SEA0110*	30	25-30	6	21-23		5		21-23				5
09SEA0111*	34	25-30	6	25-28		6		32-36				7
09SEA0113L	34	30-35	7	32-36		7		25-28				6
09SEA0114L	34	25-30	6	28-32		6		28-32				6
09SEA0117L	34	25-30	6	32-36		7						5
09SEB0018*	30	10-15	3	25-28		6		28-32				6
09SEB0108*	39	15-20	4	32-36		7		28-32				6
09SEB0109*	39	15-20	4	32-36		7		32-36				7
09SEB0121*	34	30-35	7	32-36		7		42-49				10

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
09SEB0154*	34	25-30	6	25-28		6		32-36				7
09SEB0165L	34	20-25	5	11-12		3	2.5	13-14			7-8 (S)	3
09SEB0218*	39	35-40	8	28-32		6		28-32				6
09SEB0235*	30	35-40	8	28-32		6		32-36				7
09SEB0245L	30	25-30	6	25-28		6		25-28				6
09SEB0248*	39	25-30	6	14	S	3	3.5	18-19	S			4
09SEB0260*	45	30-35	7	36-42		8		42-49				10
09SEB0278*	45	25-30	6	28-32		6		32-36				7
09SEB0280*	39	35-40	8	42-49		10		58-69				14
09SEB0312*	34	25-30	6	32-36		7		32-36				7
09SEB0319*	45	40-45	9	32-36		7		36-42				8
09SEB0330*	39	5-10	2	25-28		6		58-69				14
09SEB0348*	39	30-35	7	28-32		6		28-32				6
09SEB0352*	45	50-55	11	15-17		4		42-49				10
09SEB0353*	45	15-20	4	15-17		4		19-21				4
09SEB0377*	34	25-30	6	23-25		5		25-28				6
09SEB0378*	30	25-30	6	23-25		5		32-36				7
09SEB0387L	39	35-40	8	32-36		7		32-36				7
09SEB0394*	39	25-30	6	19-21	S	4		19-21	S	25-28		4
09SEB0398*	45	20-25	5	18-19	S	4		15-17	S	36-42		4
09SEB0407*	34	30-35	7	25-28		6		32-36				7
09SEB0451*	27	20-25	5	23-25		5		36-42				8
09SEB0454*	27	20-25	5	25-28		6		32-36				7
09SEB0456L	27	25-30	6	23-25		5		23-25				5
09SEB0463*	30	25-30	6	32-36		7		32-36				7
09SEB0473*	34	25-30	6	25-28		6		21-23				5
09SEB0477*	34	25-30	6	28-32		6		28-32				6
09SEB0479*	30	30-35	7	28-32		6		32-36				7
09SEB0482*	39	20-25	5	25-28		6		21-23				5
09SEB0501*	39	25-30	6	32-36		7		32-36				7
09SEB0582L	39	25-30	6	15-17	S	4		14-15	S			3
09SEB0590*	34	25-30	6	18-19	S	4		15-17	S			4
09SEB0601*	34	25-30	6	32-36		7		32-36				7
09SEB0619*	30	20-25	5	21-23		5		23-25				5
09SEB0623L	39	25-30	6	32-36		7		25-28				6
09SEB0663*	34	25-30	6	28-32	S	6		21-23	S	19-21		5
09SEB0682L	24	25-30	6	36-42		8		23-25				5
09SEC0448*	34	30-35	7	28-32		6		32-36				7
09SEC0507*	34	25-30	6	25-28		6		19-21				4

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
09SEC0530*	30	20-25	5	10-11	S	3	0	14-15	S			3
09SEC0531*	27	15-20	4	21-23		5		23-25				5
09SEC0547*	27	25-30	6	28-32		6		32-36				7
09SEC0557*	34	20-25	5	25-28		6		18-19				4
09SEC0574*	30			9-10	S	2	17.5	17-18	S			4
09SEC0584L	34	20-25	5	28-32		6						6
09SEC0587*	27	20-25	5	19-21		4		28-32				6
09SEC0591*	30	20-25	5	19-21		4		19-21				4
09SEC0592*	34	25-30	6	19-21	S	4		12	S			3
09SEC0595*	34	25-30	6	19-21		4		18-19				4
09SEC0597*	30	20-25	5	25-28		6		32-36				7
09SEC0598*	30	25-30	6	23-25		5		21-23				5
09SEC0612*	39	30-35	7	28-32		6		32-36				7
09SEC0623L	39	15-20	4	25-28		6						4
09SEC0624L	30	15-20	4	12-13		3	10	13-14				3
09SEC0629*	30	25-30	6	23-25		5		32-36				7
09SEC0633*	34	25-30	6	42-48		10		42-49				10
09SEC0635*	39	20-25	5	18-19		4		25-28				6
09SEC0636*	24	20-25	5	21-23		5		25-28				6
09SEC0637L	34	30-35	7	28-32		6		25-28				6
09SEC0639*	34	20-25	5	23-25		5		25-28				6
09SEC0648*	24	15-20	4	21-23		5		25-28				6
09SEC0655*	30	10-15	3	25-28		6		28-32				6
09SEC0657*	39	30-35	7	36-42		8		25-28				6
09SED0350*	39	5-10	2	25-28	S	6		14-15	S			3
09SED0408*	27	15-20	4	0	No Trail	1	0	32-36				7
09SED0412*	27	25-30	6	25-28		6		32-36				7
09SED0413*	30	25-30	6	42-49		10		32-36				7
09SED0419*	34	30-35	7	32-36		7		36-42				8
09SED0426*	34	25-30	6	21-23		5		28-32				6
09SED0428*	45	20-25	5	28-32		6		36-42				8
09SED0429*	45	35-40	8	32-36		7		36-42				8
09SED0430*	34	30-35	7	32-36		7		25-28				6
09SED0437*	34	25-30	6	28-32		6		28-32				6
09SED0471*	34	30-35	7	32-36		7		49-58				12
09SED0480*	45	30-35	7	25-28		6		32-36				7
09SED0482*	30	30-35	7	28-32		6		32-36				7
09SED0483*	27	10-15	3	25-28		6		58-69				14
09SED0489*	34	25-30	6	25-28		6		36-42				8

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
09SED0499*	39	25-30	6	19-21		4		23-25				5
09SED0510*	34	15-20	4	32-36		7		42-49		3		10
09SED0534*	24	5-10	2	42-49		10		42-49				10
09SED0535*	24	25-30	6	42-49		10		42-49				10
09SED0541*	34	30-35	7	28-32		6		42-49				10
09SED0545*	30	5-10	2	6	S	2	9	5	S			1
09SED0553*	27	40-45	9	32-36		7		23-25				5
09SED0556*	39	30-35	7	32-36		7		32-36				7
09SED0558*	34	20-25	5	25-28		6		25-28				6
09SED0576L	39	30-35	7	28-32		6		28-32				6
09SED0577L	34	30-35	7	32-36		7		25-28				6
09SED0582*	30	25-30	6	28-32		6		25-28				6
09SED0584*	39	25-30	6	18-19	S	4		23-25	S			5
09SED0599*	39	25-30	6	25-28		6		36-42				8
09SED0600L	39	25-30	6	28-32		6						8
09SED0603*	27	20-25	5	25-28		6		23-25, 28-32				5
09SED0604*	30	25-30	6	25-28		6		28-32				6
09SED0605*	30	20-25	5	25-28		6		21-23				5
09SED0608*	34	35-40	8	28-32		6		28-32		42-49		6
09SED0618*	34	25-30	6	49-58		12		42-49				10
09SED0619*	34	30-35	7	28-32		6		36-42				8
09SED0621*	34	25-30	6	19-21	B	4		12-13	B			3
09SED0635*	45	30-35	7	25-28		6		25-28		32-36		6
09SED0638*	39	25-30	6	23-25		5		25-28				6
09SED0639*	34	20-25	5	23-25		5		25-28				6
09SED0640*	39	20-25	5	19-21		4		19-21				4
09SED0645*	27	15-20	4	36-42		8		21-23				5
09SED0649*	30	20-25	5	25-28		6		23-25		23-25		5
09SED0657*	34			32-36		7		25-28				6
09SED0662*	39	35-40	8	32-36		7		28-32				6
09SED0663*	30	15-20	4	14-15	S	3	37.5	18-19	S			4
09SWD0446*	39	25-30	6	28-32		6		28-32				6
09SWD0474*	30	20-25	5	9	S	2	7.5	6	S	23-25		2
09SWD0506*	24	30-35	7	32-36		7		32-36				7
09SWD0520*	30			13-14	S	3	7.5	12-13	S			3
09SWD0521*	30			13-14	S	3	7.5	12-13	S			3
09SWD0535*	30	30-35	7	32-36		7		32-36				7
09SWD0546*	30	15-20	4	13	S	3	17.5	6-7	S			2

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
09SWD0549*	39	0-5	1	12-13	S	3	25	10-11	S			3
09SWD0554*	34	20-25	5	18-19		4		17-18		17-18		4
09SWD0568*	39	35-40	8	19-21	S	4		25-28	S	32-36		6
09SWD0597*	34	15-20	4	18-19	S	4		17-18	S			4
09SWD0600*	34			13-14	S	3	2.5	17-18	S			4
09SWD0615*	39	25-30	6	25-28		6		25-28				6
09SWD0620*	45			32-36		7		36-42				8
09SWD0622*	45			32-36		7		28-32				6
09SWD0623*	39	20-25	5	32-36		7		28-32				6
09SWD0625*	34	30-35	7	28-32		6		28-32				6
09SWD0626*	34	30-35	7	28-32		6		32-36				7
09SWD0628*	30	5-10	2	11-12	S	3	12.5	12-13	S			3
09SWD0630*	27	35-40	8	32-36		7		23-25				5
09SWD0632*	30	35-40	8	32-36		7		28-32	S			6
09SWD0633*	30	45-50	10	18-19	S	4		36-42	S	36-42		8
09SWD0637*	39	10-15	3	12-13	S	3	10	12-13	S			3
09SWD0639*	30	15-20	4	10	S	2	17.5	7	S			2
09SWD0640*	34	25-30	6	0	No Trail	1	0	0		32-36		1
09SWD0642*	27	25-30	6	25-28		6		25-28				6
09SWD0645*	30	10-15	3	12-13	B	3	40	15-17	B	15-17		4
09SWD0647*	24	15-20	4	10-11	S	3	0	13-14	S			3
09SWD0648*	34	10-15	3	5-6	S	2	22.5	6	S	13-14		2
09SWD0649*	30			5-6	S	2	4.5	6	S			2
09SWD0651*	34	20-25	5	28-32		6		25-28				6
09SWD0652*	30	20-25	5	23-25		5		21-23				5
09SWD0653*	34	20-25	5	28-32		6		23-25				5
09SWD0654*	34	5-10	2	7-8	S	2	17.5	7	S			2
09SWD0655*	27	10-15	3	18-19		4		12				3
09SWD0658*	39	20-25	5	32-36		7		28-32				6
09SWD0667*	34			4	S	1		17-18	S			4
09SWD0679*	30	20-25	5	28-32		6		25-28				6
09SWD0681*	27	20-25	5	25-28		6		36-42				8
09SWD0684*	34	20-25	5	28-32		6		25-28				6
09SWD0685*	39	25-30	6	36-42		8		32-36				7
09SWD0686*	39	35-40	8	0	No Trail	1		0				1
09SWD0708*	34			36-42		8		32-36				7
09SWD0710*	39	30-35	7	32-36		7		32-36				7
09SWD0711*	45			28-32		6		28-32				6
09SWD0712*	39	30-35	7	28-32		6		32-36				7

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
09SWD0717*	39	10-15	3	18-19		4		21-23				5
09SWD0718*	30	10-15	3	25-28		6		21-23				5
10NEA0077L	24	35-40	8	15-17		4		23-25				5
10NEB0098*	34			19-21		5		42-49				10
10NEB0100*	45			17-18	D	4		28-32	D			6
10NEB0100L	45			15-17		4						
10NEB0101*	45			23-25		5		25-28				6
10NEB0105*	34			28-32	D	6		28-32		28-32	28-32	6
10NWB0028L	39	0	1	42-49		10		? No Contours, cannot measured				0
10NWC0066*	27	15-20	4	18-19		4		32-36				7
10NWC0067*	17	10-15	3	14		3	7.5	?			0	0
10NWC0075L	27	15-20	4	15-17		4		11-12			7	3
10SWA0106*	30	25-30	6	28-32		6		25-28			28-32	6
10SWA0118*	34	0-5	1	10	S	2	32.5	8	S			2
10SWA0132*	34	10-15	3	14	S	3	65	21-23	S	18-19		5
10SWA0138*	30	30-35	7	28-32		6		25-28			32-36	6
10SWA0168*	27	15-20	4	28-32		6		21-23			21-23	5
10SWB0065*	34	30-35	7	32-36		7		32-36				7
10SWB0067L	34	10-15	3	32-36	D	7		?		36-42		0
10SWC0103*	45	30-35	7	25-28		6		19-21				4
10SWC0111*	34	15-20	4	28-32		6		28-32				6
10SWC0139*	39	20-25	5	17-18		4		19-21				4
10SWC0146*	34	25-30	6	32-36		7		23-25		14-15		5
10SWC0151*	45	30-35	7	32-36	S	7		12-13	S	25-28		3
10SWC0159*	34	30-35	7	18-19	S	4		21-23	S	49-58		5
10SWC0195*	45			21-23		5		42-49				10
10SWC0207*	30	30-35	7	25-28		6		28-32		18-19		6
10SWC0210*	45	25-30	6	17-18	S	4		13-14	S			3
11NEA0062*	39	35-40	8	32-36		7		36-42				8
11NEA0063L	45	30-35	7	25-28		6		25-28				6
11NEB0070*	45	25-30	6	18-19		4		23-25				5
11NED0092L	45	5-10	2	36-42		8		0-5, Flat Rocks				1
11NED0093L	39	5-10	2	23-25		5		36-42				8
11NED0123L	39	30-35	7	14-15		3	5	42-49				10
11NWB0049*	45	50-55	11	42-49		10		15-17				4
11NWB0060*	45	30-35	7	15-17		4		42-49		7	23-25	10
11NWB0063*	39	20-25	5	36-42	D	8		32-36	D	32-36	0	7

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
11SEA0016*	45	30-35	7	32-36		7		32-36				7
11SEA0016L	45	30-35	7	32-36		7		32-36				7
11SEC0025L	45	30-35	7	36-42		8		36-42				8
11SEC0045L	30			36-42		8						
11SEC0048L	34	35-40	8	32-36		7		32-36				7
11SED0017L	30	40-45	9	42-49		10		42-49				10
11SED0018L	27	20-25	5	17-18		4		17-18				4
11SWA0061*	34	20-25	5	21-23		5		21-23			15-17	5
11SWA0069*	34	20-25	5	19-21	D	4		?	D			0
11SWA0073*	39	25-30	6	23-25		5		21-23				5
11SWA0074*	45	25-30	6	23-25		5		21-23			21-23	5
11SWA0090*	39	20-25	5	14		3		9		7-8	7-8	2
11SWA0098*	39	30-35	7	36-42	D+O	8		42-49	D		36-42	10
11SWC0049*	30	25-30	6	28-32	D+O	6		0	D+O			1
11SWD0015L	39	15-20	4	36-42	D	8						10
12NWA0019L	45	20-25	5	32-36	C	7		23-25	C			5
12NWA0038*	39	25-30	6	32-36		7		32-36			12	7
12NWC0088L	34	25-30	6	28-32		6		32-36				7
12NWC0090*	27	5-10	2	42-49	D	10		42-49	D			10
12SWA0031L	39	0	1	36-42	C	8		36-42	C			8
12SWA0035L	45	35-40	8	42-49	C	10		42-49	C			10
12SWB0039*	45	50-55	11	32-36		7		21-23		21-23		5
12SWC0040*	45	25-30	6	36-42	C	8		32-36	C			7
12SWC0041*	45	25-30	6	32-36	C	7		42-49	C			10
12SWC0066L	34	20-25	5	23-25		5		11-12				3
12SWC0096*	30	15-20	4	58-69		14		18-19				4
13NEA0430*	39	25-30	6	25-28		6		32-36				7
13NEA0679*	30	30-35	7	42-49		10		32-36				7
13NEA0723*	39	20-25	5	23-25		5		28-32				6
13NEB0079*	39	30-35	7	36-42		8		36-42				8
13NEB0118*	34	25-30	6	28-32	S	6		25-28	S	25-28		6
13NEB0154*	39	20-25	5	28-32		6		19-21				4
13NEB0169*	34	20-25	5	25-28		6		25-28				6
13NEB0204*	34	30-35	7	32-36	S	7		32-36	S			7
13NEC0121L	45	20-25	5	25-28		6		25-28				6
13NWA0157*	30	35-40	8	28-32		6		28-32				6
13NWA0162*	24	25-30	6	23-25		5		23-25				5
13NWB0312*	34	25-30	6	11-12	S	3	10	10	S	32-36	10	2
13NWB0359*	39	20-25	5	23-25		5		18-19				4

NTLI No.	NTLI Crown Slope Angle	1:20,000 Scale		1:5000 Scale				1:1000 Scale				
		Recorded Class	5° Class	Recorded Class	Situation	5° Class	Extend < 15° in Meters	Recorded Class	Situation	Comparison Class	API Class	5° Class
13NWB0389L	39	30-35	7	28-32		6		32-36				7
13NWB0406*	39	0-5	1	23-25	D	5		0	D	0		1
13NWB0425L	30	25-30	6	?	No Trail	0		?		32-36		0
13NWB0433*	30	20-25	5	36-42		8		36-42		42-49		8
13NWB0459*	30	20-25	5	25-28		6		28-32				6
13NWB0467*	39	15-20	4	15-17	S	4		10-11	S			3
13NWB0472L	30	20-25	5	25-28		6		25-28				6
13NWB0473*	39	25-30	6	28-32		6		32-36				7
13NWB0479*	39	20-25	5	18-19	D	4		23-25	D	23-25		5
13NWB0488*	30	30-35	7	25-28		6		23-25				5
13NWB0492*	39	30-35	7	32-36		7		25-28				6
13NWB0499*	39	25-30	6	0	S	1	7.5	0	S			1
13NWB0506*	30	25-30	6	25-28		6		21-23				5
13NWC0194*	39	30-35	7	12-13	S	3	10	12-13	S	28-32		3
13NWC0206*	45	35-40	8	36-42		8		42-49			32-36	10
13NWC0209*	45	30-35	7	25-28		6		32-36				7
13NWC0210*	45	25-30	6	32-36		7		32-36				7
13NWC0212L	30	25-30	6	19-21		3.92						6
13NWD0135*	45	0-5	1	10	S	2	0	7	S			2
13NWD0142*	34	25-30	6	25-28		6		25-28				6
13SEC0022*	45	30-35	7	32-36		7		49-58				12
14NEB0075L	45	0	1	?	C	0		?		7		0
14NEB0080L	39	0	1	18-19		4		14				3
14NEB0082*	39	0	1	25-28		6		36-42				8
14NEB0084*	34	40-45	9	36-42		8		49-58				12
14NWA0106*	34	20-25	5	32-36		7		32-36, 28-32				7
14NWA0108*	30	25-30	6	25-28		6		23-25				5
14NWA0116L	39	25-30	6	15-17		4						5
14NWD0020*	39	35-40	8	32-36		7		42-49				10
15NWA0009*	45	30-35	7	23-25		5		14				3
15NWA0078*	27	30-35	7	36-42		8		32-36				7
15NWA0080*	45	10-15	3	36-42	D+O	8		28-32	D+O			6
15NWA0094L	39	25-30	6	58-69		14		32-36				7
15NWB0022*	45	25-30	6	49-58		12		58-69				14

APPENDIX C

COMPARISON OF SLOPE ANGLES FROM DIFFERENT SCALE MAPS

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COMPARISON OF SLOPE ANGLES FROM DIFFERENT SCALE MAPS

1. GENERAL

It is assumed that slope angles recorded from the 1:1000-scale maps represent field conditions and can serve as a standard to compare angles recorded from other map scales.

2. COMPARISON OF 1:5000 SCALE WITH 1:1000 SCALE

Figure C-1 compares the 1:5000-scale data with the 1:1000-scale data. There is generally a good correlation between the two data sets. For the toe slope angles below 25°, the correlation is good with the 1:5000-scale values generally within 5° of the 1:1000-scale values. For slopes above 30°, variation is generally less than 10°. A small group of 1:1000-scale 15° to 20° slopes are recorded as 10° or less on the 1:5000-scale maps and a group of 30° to 40° slopes on the 1:1000-scale maps were recorded as 50° on the 1:5000-scale maps.

The comparison suggests that for measuring slope angles below 25°, the 1:5000-scale maps give a similar result to the 1:1000-scale maps. It also implies that slope angles taken from 1:1000-scale maps on gently sloping ground may be steeper than those obtained from 1:5000-scale maps.

3. COMPARISON OF 1:5000 SCALE WITH 1:20,000 SCALE

Figure C-2 compares the 1:5000-scale data with the 1:20,000-scale data. Although there is a general correlation for the main body of data, a significant group of slopes recognised as 30° on the 1:5000-scale maps were recorded as 15° to 20° on the 1:20,000-scale maps. More than half of the 15° to 20° slopes on the 1:20,000-scale maps are 5°-15° steeper than on the 1:5000-scale maps.

There is also a significant group of landslides where toe slope angles of 25° to 40° were derived from the 1:20,000-scale maps while much lower 5° to 20° angles were obtained from the 1:5000-scale maps. This may be local flat areas on the 1:5000-scale maps that are not represented on the digital slope angle map derived from 1:20,000-scale topographical data. This suggests that the 20K DTM should not be used to derive toe slope angle data.

4. COMPARISON OF 1:20,000 SCALE WITH 1:1000 SCALE

Figure C-3 compares the 1:20,000-scale data with the 1:1000-scale data. The correlation is very weak. This again suggests that the 20K DTM should not be used to obtain toe slope angle data.

5. SUMMARY

If toe slope angle data from the 1:5000-scale maps are used to predict the travel

distance of landslide debris this should not be used with the slope angle maps derived from the 20K DTM. However, if the data is used with 1:1000-scale maps, the prediction of travel distance is likely to be conservative, as slope angles from the 1:1000-scale maps tend to be steeper than those recorded from 1:5000-scale maps.

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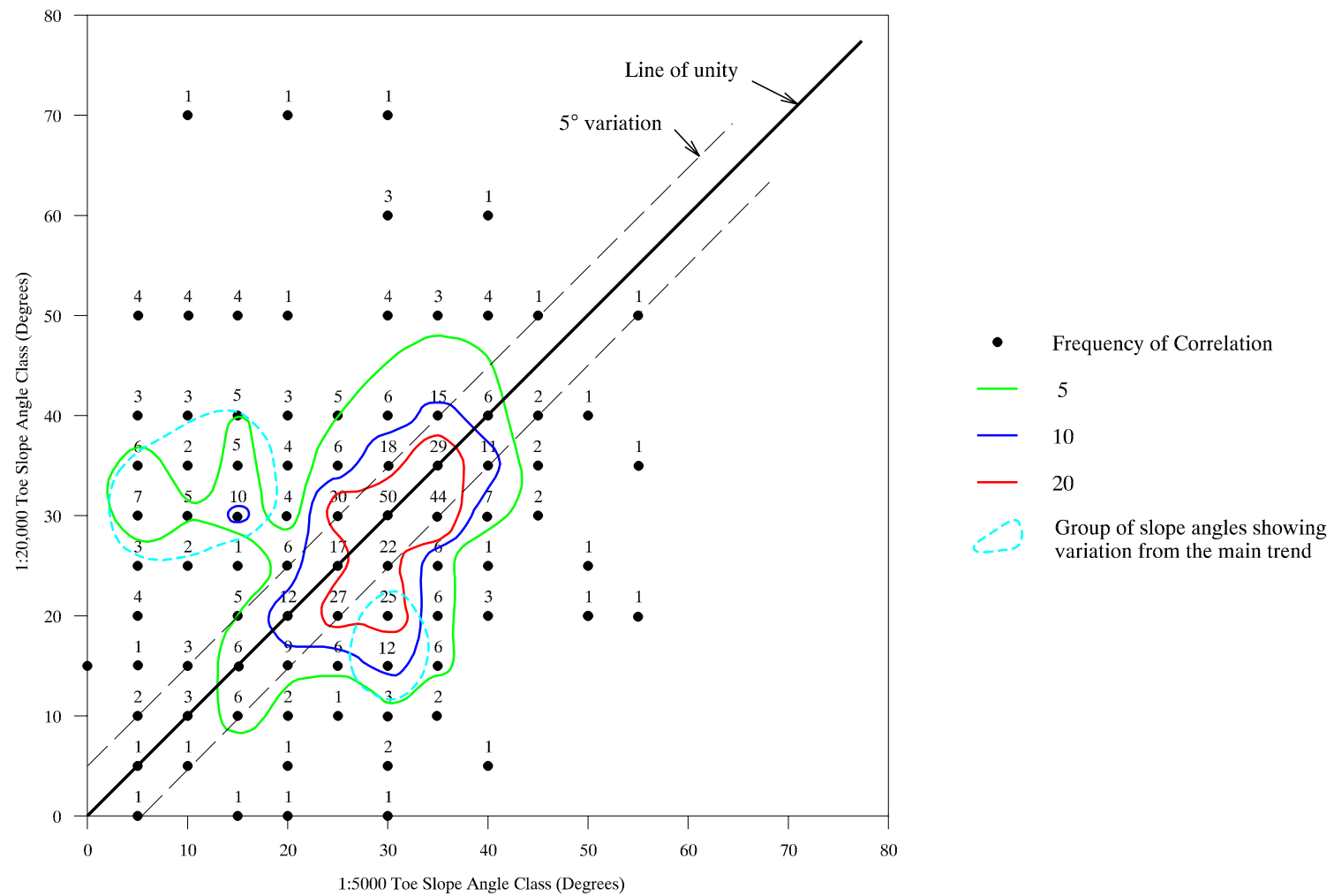


Figure C-2 Comparison of Toe Slope Angle, 1:5000 and 1:20,000 Scales

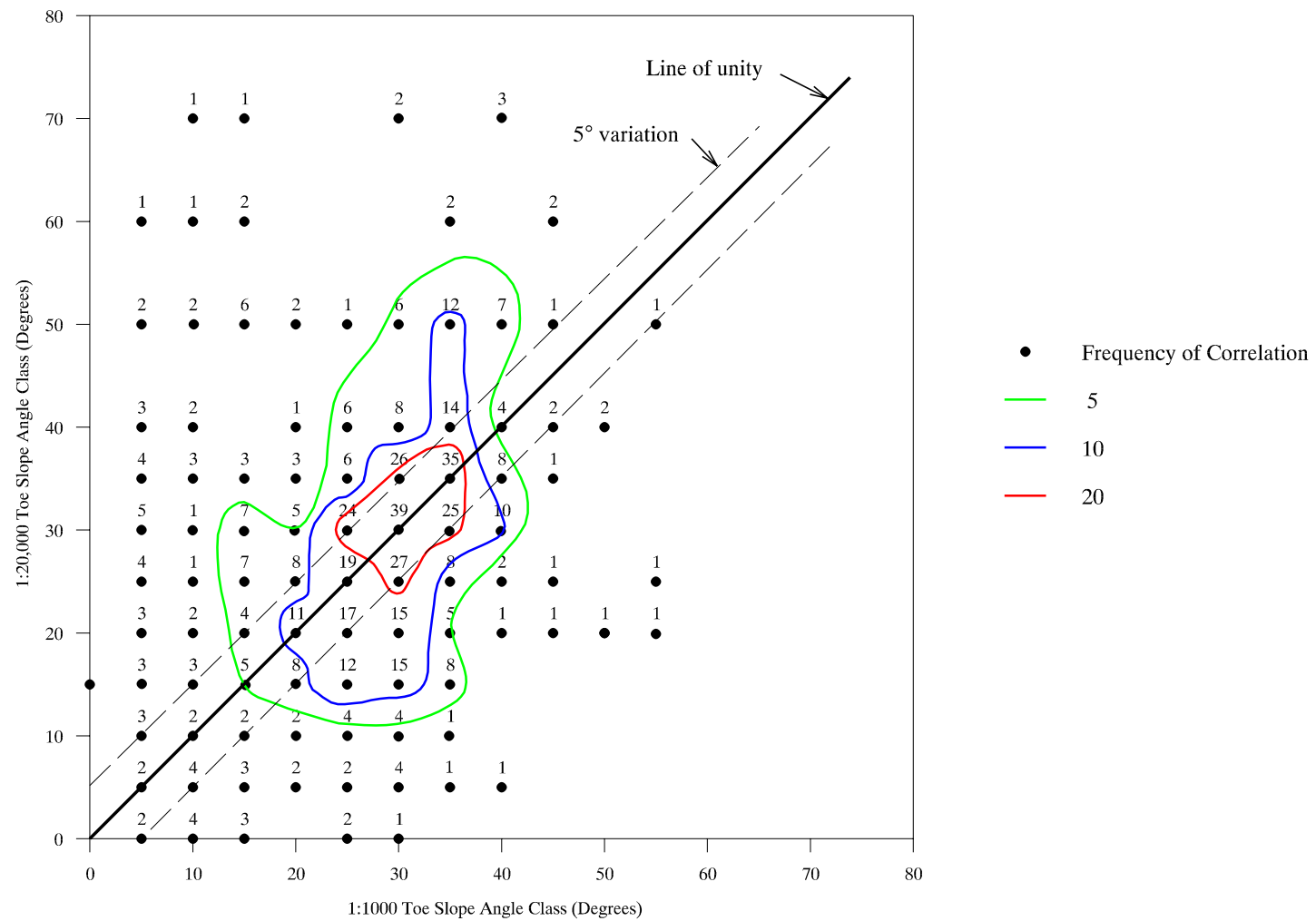


Figure C-3 Comparison of Toe Slope Angle, 1:1000 and 1:20,000 Scales