

## Detailed Results of the Deep Landslide Susceptibility Analysis

### Susceptible Geologic Units

In order to determine which geologic units were susceptible to deep landsliding, the engineering geology and deep landslides were spatially joined to determine the number of landslides occurring in each geologic unit. In order for a one-to-one join to be performed, each landslide was converted to a singular point at the landslide's center. This was done since a single landslide polygon may cross several geologic units. The centralized point of each landslide was inspected after the spatial join to confirm the appropriate geologic unit was selected. These points were then joined back to the deep landslide polygons in order to attribute each landslide with the correct geologic unit.

Geology	Landslide Area/Unit	Eng Geol Unit Area	Landslide Area/Unit Area
Fluvial conglomerate and sandstone	0	82274900	0.00
Boring Lava	8648485.245	138297000	6.25
CRBW Sand Hollow	611655.4043	4914510	12.45
Fine-grained Missoula flood deposits	154858.3977	521880000	0.03
Loess	0.608067044	238352000	0.00
Fluvial siltstone	2937573.557	10568100	27.80
CRBG Winter Water	15764228.43	158251000	9.96
CRBG Sentinel Bluffs	23251349.18	292635000	7.95
CRBG Ortley	1223269.854	9907450	12.35

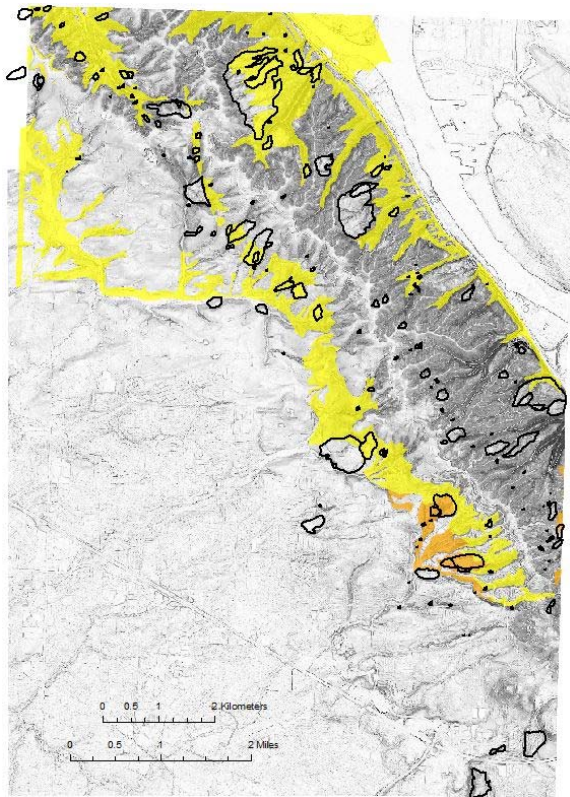
The mean and standard deviation then was determined for Landslide Area/Geologic Unit Area. Scores ranging from 0-2 were then assigned to each geologic unit. A score of zero was assigned to any unit with a Landslide Area/Geologic Unit Area less than the mean. A score of one was assigned to any unit with Landslide Area/Geologic Unit Area greater than or equal to the mean and less than the mean plus one standard deviation. A score of two was assigned to any unit with Landslide Area/Geologic Unit Area greater than or equal to the mean plus one standard deviation. Based on the criteria listed above, three geologic units were assigned a score of two and all others were assigned a score of zero.

Mean and standard deviation of landslide frequency per geologic unit.

Mean	8.53
Standard Deviation	8.80

Relative scores assigned to each geologic unit based upon landslide frequency and criteria listed above.

Geology	Score
Fluvial conglomerate and sandstone	0
Boring Lava	0
CRBW Sand Hollow	1
Fine-grained Missoula flood deposits	0
Loess	0
Fluvial siltstone	2
CRBG Winter Water	1
CRBG Sentinel Bluffs	0
CRBG Ortley	1



Map showing susceptible geologic units with scores of zero (no color, gray) and two (orange). Landslides are outlined in black.

### **Susceptible Geologic Contacts**

In order to determine which contacts were susceptible to deep landsliding, the engineering geology and deep landslide databases were compared. Landslides were overlaid onto the geology dataset to see how many landslides intersect with the boundary between two geologic units. A query was performed for each possible geologic contact to determine the frequency of landsliding. All associated landslides for each susceptible geologic contact were exported into new, separate datasets. Geologic contacts with at least one landslide were selected for further analysis.

Geologic contacts and the number of landslides that intersect each contact.

Contact	Landslides
Boring Lava-Loess	12
Boring Lava-CRBW Sand Hollow	2
Boring Lava-Fine-grained Missoula flood deposits	2
Boring Lava-Fluvial conglomerate and sandstone	5
CRBW Sand Hollow-Loess	2
CRBW Sand Hollow-CRBG Ortley	2
Fluvial conglomerate and sandstone-Loess	4
Fluvial conglomerate and sandstone-CRBG Ortley	4
CRBG Winter Water-CRBG Ortley	17
CRBG Winter Water-CRBG Sentinel Bluffs	45
CRBG Winter Water-Boring Lava	3
CRBG Winter Water-Fine-grained Missoula flood deposits	3
CRBG Winter Water-Loess	12
CRBG Ortley-Loess	4
CRBG Sentinel Bluffs-Loess	18

The mean and standard deviation of the associated landslides for each susceptible geologic contact was determined. Statistical analysis was performed on each landslide dataset to determine the mean landslide width and standard deviation. Two buffers were created around each susceptible geologic contact using the mean landslide width distance and the mean + 1 standard deviation. The mean buffer was assigned a value of two and the mean + 1 standard deviation a one.

Contact	Mean Landslide Width (Ft)	STD	Mean+ 1 STD
Boring Lava-Loess	495	628	1123
Boring Lava-CRBW Sand Hollow	1468	601	2069
Boring Lava-Fine-grained Missoula flood deposits	624	580	1204
Boring Lava-Fluvial conglomerate and sandstone	207	190	397
CRBW Sand Hollow-Loess	1468	601	2069
CRBW Sand Hollow-CRBG Ortley	1468	601	2069
Fluvial conglomerate and sandstone-Loess	511	417	928
Fluvial conglomerate and sandstone-CRBG Ortley	488	445	933
CRBG Winter Water-CRBG Ortley	657	891	869
CRBG Winter Water-CRBG Sentinel Bluffs	482	632	1114
CRBG Winter Water-Boring Lava	305	186	491
CRBG Winter Water-Fine-grained Missoula flood deposits	269	164	433
CRBG Winter Water-Loess	323	271	594
CRBG Ortley-Loess	579	458	1037
CRBG Sentinel Bluffs-Loess	325	230	555

All geologic contact buffers were merged into one file to be used in the final moderate susceptibility mapping.

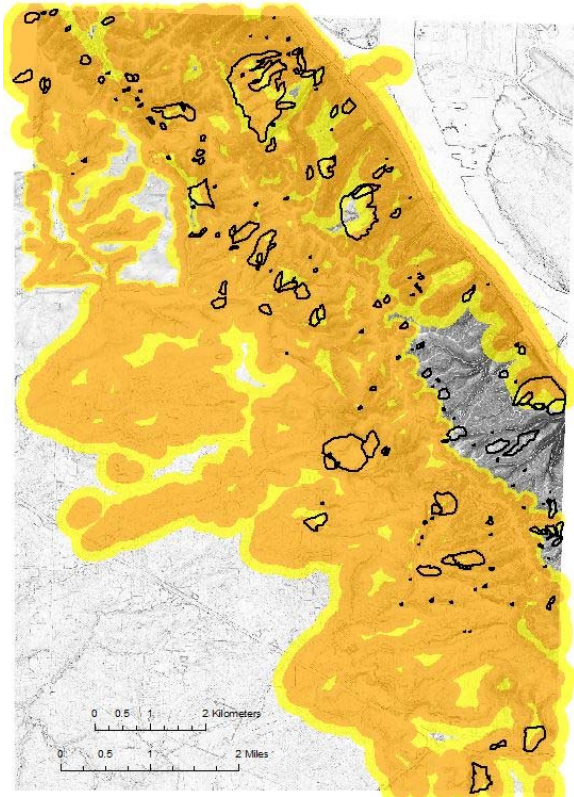


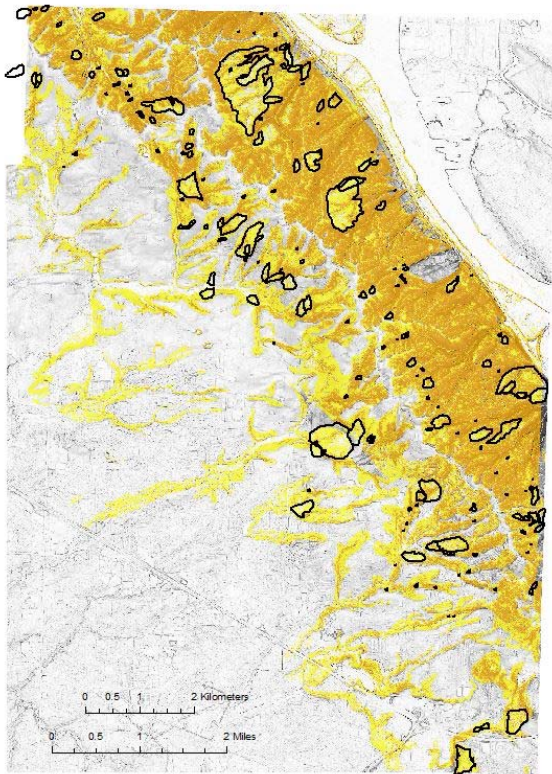
Figure 1. Map showing susceptible geologic contacts with scores of zero (no color, gray), one (yellow), and two (orange). Landslides are outlined in black.

### **Susceptible Slopes**

The deep landslide polygons used in this analysis are the same polygons that were joined with the engineering geology in the Susceptible Geologic Unit section. The Summary statistics were run on the deep landslides polygons to determine the slope mean and standard deviation. The output of summary statistics produces a table. This table was then joined to the engineering geology so that each engineering geology unit now would have an associated mean landslide slope. In addition to the mean landslide slope, a new field also added to each geologic unit. Within this new field, the mean minus two times the standard deviation was calculated.

Geology	Frequency	Mean_Slope	STD_Slope	Mean_2STD
Fluvial conglomerate and sandstone	0	0	0	0
Boring Lava	23	17.9	7.1	3.7
CRBW Sand Hollow	0	0	0	0
Fine-grained Missoula flood deposits	0	0	0	0
Loess	0	0	0	0
Fluvial siltstone	12	18.7	7.1	4.5
CRBG Winter Water	69	20.5	6.3	7.9
CRBG Sentinel Bluffs	80	19	6.8	5.4
CRBG Ortley	5	20.2	6.4	7.4

Queries then were performed with the slope raster based on the mean and the mean minus two times the standard deviation fields. Anywhere where the slope raster equaled the slope mean of a particular geologic unit, that cell was assigned a value of two. Anywhere where the slope raster was less than the slope mean and greater than the mean minus two times the standard deviation of a particular geologic unit, that cell was assigned a value of one.

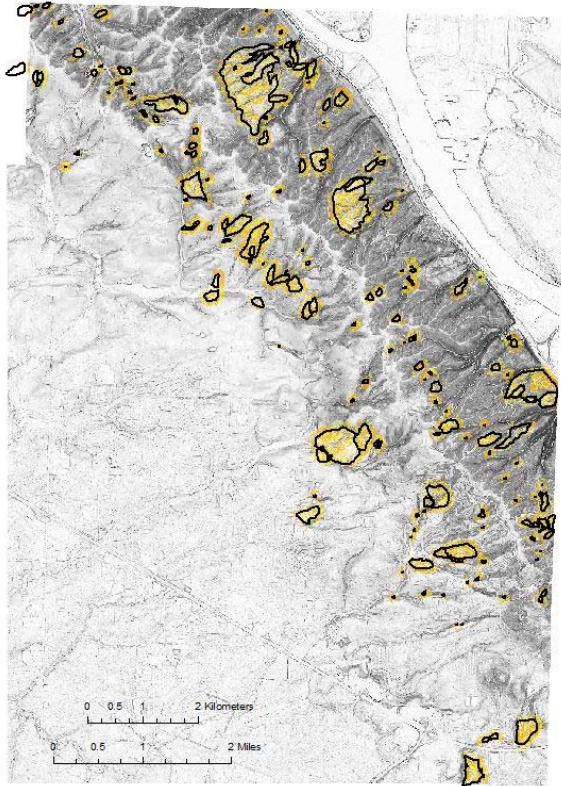


Map showing susceptible slopes with scores of zero (no color, gray), one (yellow), and two (orange). Landslides are outlined in black.

## Preferred Direction of Movement

The landslide polygons were converted to a raster based on the attributed landslide direction. This raster was then converted to points. An interpolated raster surface was created from these points using an inverse distance weighted (IDW) method with a maximum distance set to the mean landslide width (319 ft).

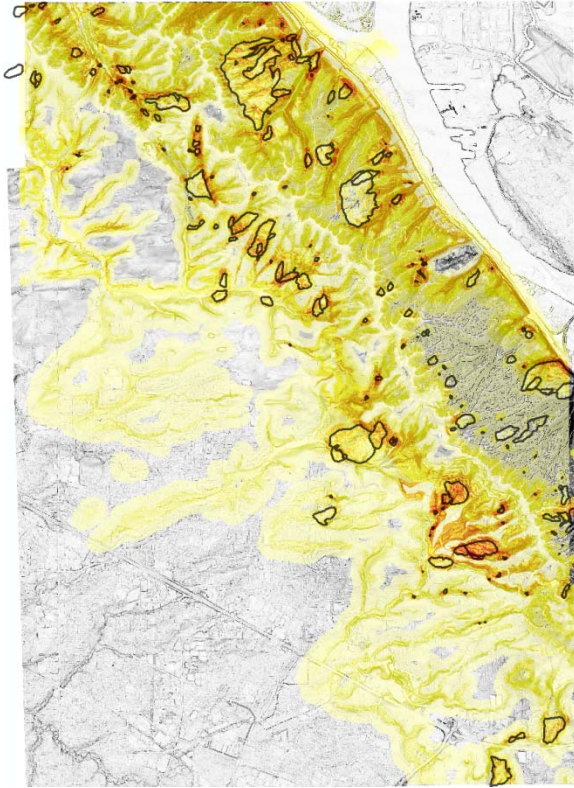
Queries then were performed with the aspect raster and the interpolated IDW raster. Anywhere where the aspect raster was less than or equal to the IDW raster plus 22.5 and where the aspect raster was greater than or equal to the IDW raster minus 22.5, was assigned a value of two. Anywhere where the aspect raster was less than or equal to the IDW raster plus 45 and where the aspect raster was greater than or equal to the IDW raster minus 45, was assigned a value of one.



Map showing preferred direction of movement with scores of zero (no color, gray), one (yellow), and two (orange). Landslides are outlined in black.

## Combined Moderate Factors Score

The final geologic unit, geologic contacts, slopes, and preferred direction rasters then were added together to create a combined moderate factor score. Since these rasters have values of 0, 1, and 2, this final raster has values ranging from 0 to 8. A score of zero mean that none of the factors were present and a score of eight means the all four factor raster were present, each with a score of two.



Map showing combined moderate factor scores ranging from zero to eight. Landslides are outlined in black.