 Name: _____

LAB: MASS WASTING IN WESTERN WASHINGTON

Objectives

(1) to understand the causes of landslides
(2) to examine landslide hazards in the Seattle-Tacoma area
(3) to examine landslide hazards associated with volcanoes

Part A: Landslides in Western Washington

Landslides occur when the force of gravity acting on earth materials is greater than their frictional resistance to downslope movement. Slope stability is affected by:

a) **Type of earth materials present.** Unconsolidated deposits will move downslope more easily than bedrock.

b) **Structural properties of earth materials.** The orientation of layering of some rocks and sediments relative to slope directions, as well as the extent of fracturing of the materials, will affect the landslide potential.

c) **Steepness of slopes.** Landslides are more common on steep slopes.

d) **Water.** Landslides are generally more frequent in areas of seasonally high rainfall because the addition of water to earth materials commonly decreases their resistance to sliding by decreasing internal friction between particles and the cohesive forces that bind clay minerals together; lubricates surfaces along which failure may occur; adds weight to the material; reacts with some clay minerals, causing volume changes in the material; and mixes with fine-grained unconsolidated materials to produce wet, unstable slurries.

e) **Ground shaking.** Strong shaking, for example during earthquakes, can jar and loosen earth materials, making them less stable, and can cause periodic oversteepening during seismic wave propagation.

f) **Type of vegetation present.** Trees with deep, penetrating roots tend to hold bedrock and surficial deposits together, thereby increasing ground stability. On the other hand, trees add weight and roots can break up rock.

g) **Proximity to areas undergoing active erosion.** Rapid undercutting and downcutting along stream courses and shorelines oversteepens slopes, making them particularly susceptible to landsliding.

First, think about some of the factors that may cause landsliding in the area where you currently live.

1. Before looking at any maps, which of the above factors do you think are the most relevant to landsliding in your area? (Be sure to list the place where you live.)

2. What time of the year would you predict most landslides to occur? ***Why?***

3. Name *one specific* location in your area that might be highly prone to landsliding.

Now let's look at some actual data to try to predict what causes landslides to occur in the Seattle area. To complete this section of the lab you will need to use the landslide hazard maps. These images are scanned from a larger series of maps published by the U.S. Geological Survey. Be sure to examine the map legends, as well as the maps themselves, to answer the questions.

First use the ***"Landslides and Associated Damage During Early 1972 in Part of West-Central King Co., WA"*** *map and legend to answer questions 4-9.*

4. What symbol on the map represents landslides that occurred in 1972?

5. What *topographic* characteristics do the locations of most of these landslides have in common?

6. Look at the scanned image of the graphs from the map legend **("Landslides Bar Graphs")**. These bar graphs show the amount of rainfall that occurred on each day in early 1972 and the number of landslides that occurred on each day.

   a. In what units are the precipitation data labeled?

   b. What *specific* period of time does the horizontal axis of the graphs cover?

   c. When do the most landslides occur?

   d. Does this period of time correspond with a period of significant rainfall?

Now let's look at the relationship between annual rainfall and the number of landslides reported for the year. ***Table 1*** *(below) is a list of rainfall and landslide data from 1949 to 1972. Use this information to answer questions 7-9.*

7. a. Construct **two bar graphs** which show (1) rainfall vs. year and (2) number of landslides vs. year. You will need both graphs to answer the following questions. (You may make your graphs in Microsoft Excel, another graphing program, or by hand on graph paper.)

   b. What is the average annual rainfall (from 1949 to 1972)? Include units.

   c. What is the average annual number of Seattle landslides (from 1949 to 1972)? Include units.

8. a. Does there appear to be a significant relationship between annual rainfall and the annual number of landslides? *Explain.*

   b. Are there any years where the data doesn't correlate (e.g., a dry year when there was a large number of landslides)? If so, what year(s)?

   c. 1965 was a relatively dry year that had a large number of landslides. What might have been the cause of this anomaly? (Think about other factors that trigger landslides.)

9. Compare the annual graphs you constructed with the graph from 1972 (question 6). Which seems to be a more important cause of landsliding: high annual rainfall **or** large individual rainstorms? *Give your reasoning.*

Table 1. Seattle Precipitation and Landslides: 1949 to 1972

Year	Annual Precipitation in cm	Number of Landslides
1949	82	8
1950	104	14
1951	103	10
1952	73	0
1953	75	0
1954	100	12
1955	73	4
1956	109	11
1957	81	4
1958	80	2
1959	98	2
1960	91	8
1961	110	12
1962	75	3
1963	90	2
1964	98	3
1965	87	11
1966	90	3
1967	98	6
1968	97	2
1969	110	5
1970	90	1
1971	103	1
1972	102	7

*Now look at the **"Slope Map of Part of West-Central King Co., WA"** map and legend and compare it with the **"Landslides and Associated Damage During Early 1972 in Part of West-Central King Co., WA"** map you just examined to answer questions 10-11.*

10. What was the range of slope gradients (in degrees) of the slopes along which most of the landslides occurred in 1972?

11. a. Where do the steepest slopes occur on the map?

b. What processes form steep slopes in the Seattle-Tacoma area? (They must be continuous processes; otherwise the landscape would be flattened out by landslides in a few hundred years.)

*Now look at the **"Map Showing Relative Slope Stability in Part of West-Central King Co., WA"** map and legend and answer question 12.*

12. a. How many classes of slope stability are defined?

b. Which major factors are used to distinguish between these classes?

Part B: Volcanic Landslides

13. Stratovolcanoes are prone to large mudflows (called lahars). List at least *three* different physical characteristics of stratovolcanoes that can lead to large mudflows.

(i)

(ii)

(iii)

*Use **Figures 1, 2, and 3** (below) to answer the following questions about Mt. St. Helens mudflows.*

14. a. **Figure 1** shows the general area impacted by mudflows (lahars) around Mt. St. Helens in 1980. What controls the direction of the flow of lahars?

b. Approximately how far (in kilometers) did the mudflow travel from the summit of Mt. St. Helens to the Columbia River in 1980? ***(Follow the actual path of the mudflow!)***

Figure 1. The general area impacted by lahars (mudflows) from Mt. St. Helens. (Scott, 1988)

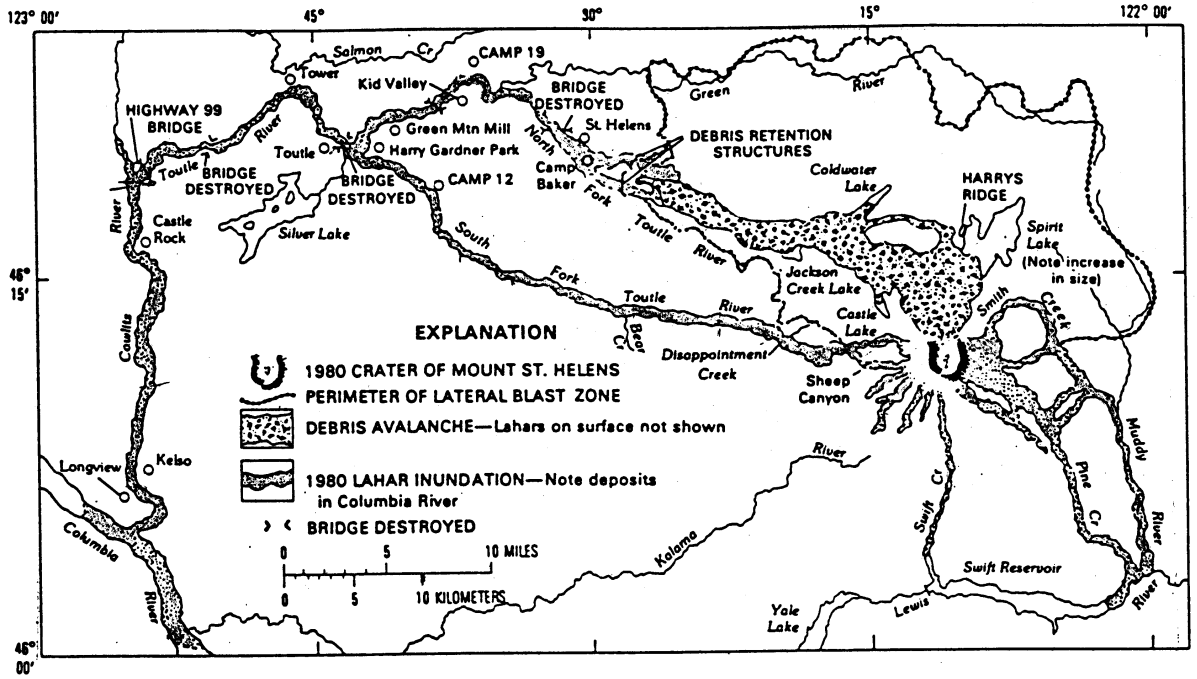
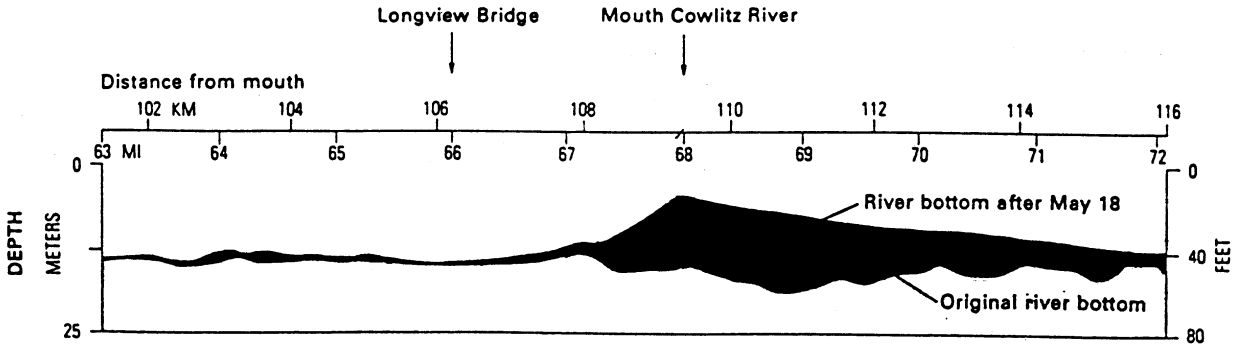


Figure 2. Configuration of the Columbia River bed before and after the 1980 eruption of Mt. St. Helens. (Schuster, 1981)



15. Examine **Figure 2**, which shows the depth of the Columbia River before and after the 1980 eruption.

    a. How thick was the sediment deposited at the mouth of the Cowlitz River? (<u>in meters</u>)

    b. Why can mudflows travel so much farther than avalanches (or debris flows)?

16. Look at **Figure 3** which shows the path taken by the Osceola mudflow on Mt. Rainier.

    a. How far did that mudflow travel? (Measure the actual path the flow took from the summit of Mt. Rainier, in kilometers. Note that the part of the mudflow near the summit is covered with younger deposits and is not shown on the map, and that Sumner is the farthest extent of the flow.)

    b. The average flow rate for mudflows is 40 km/hr. At this rate, how long would it take a mudflow to reach the town of: (*Show your calculations. Remember, Distance = Rate x Time, so Time = Distance / Rate.*)

    Greenwater?

    Auburn?

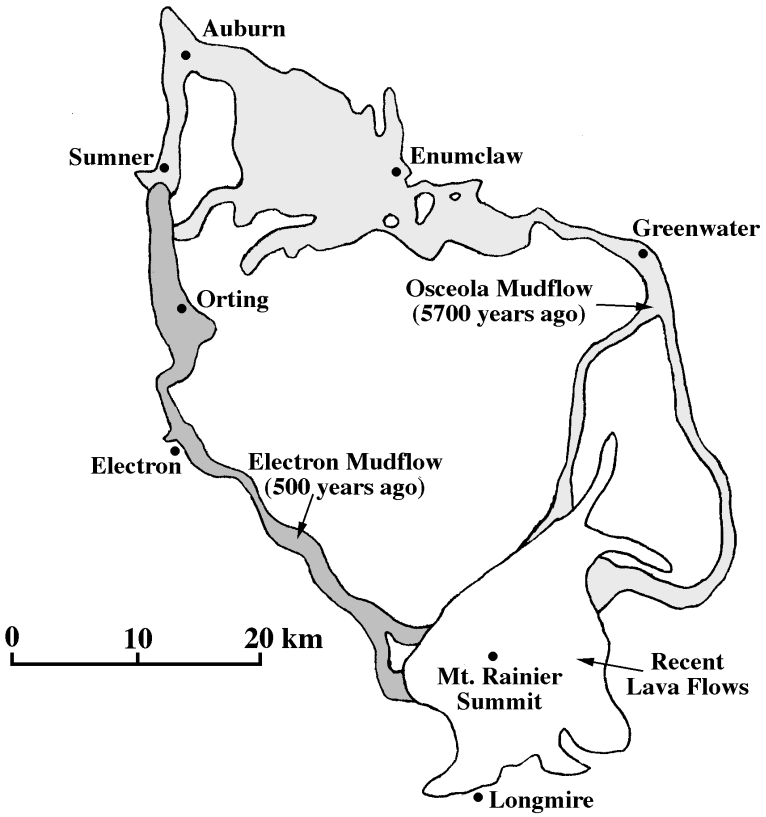


Figure 3. Paths of the Osceola Mudflow and the Electron Mudflow. Both mudflows originated on Mt. Rainier.