**ESS 315 Seattle Landslides Extra Credit Field Trip** **NAME:________________**
**March 4, 2006**

## Introduction

Today we are going to see some of the landslides in the Magnolia neighborhood of Seattle (Figure 1). We will start the day at Discovery Park and review the local glacial stratigraphy and talk about how the geologic setting increases the landslide risk for the area. We will also discuss the differences between the geology here and at Whidbey Island. Then, we will go to the ground-zero of Seattle landslides: Perkins Lane West. This area, known for expensive view homes and expensive landslide damage, experienced a massive slide during the very wet El Niño winter of 1996-1997 (destructive slides have also happened in 1961, 1972, 1980, 1982, 1986, and the spring of 1996). We will walk down a steep staircase and then along a short distance on Perkins Lane and investigate the slide zone first-hand; we will then go to the top of the bluff so we can look at the entire slide area and make some estimates of the retreat rate of the bluff. Finally, we will end the trip at Smith Cove Park/Elliot Bay Marina to look at some of the techniques local homeowners are using to try to stabilize their property. There will be no report to turn in, but we do ask you to participate in this trip and fill out some sections and turn in this handout to get your extra credit.

## Expectations

We will travel together to all the stops. At some of the stops, we will break up into smaller groups to discuss or work out a particular question. At each stop, we will have a whole-group discussion to summarize our observations. For extra credit, you must participate (or at least be present) for all these discussions and turn in this handout.

## Common sense field trip etiquette:

- Be aware of where the group is. Make a buddy in your van to decrease the odds that we will leave you at a park or outcrop somewhere.
- We will be spending a fair bit of time on or near private property. Be respectful and obey No Trespassing signs.
- Be careful when walking/climbing around the landslide zone at the end of Perkins Lane. Be especially careful to not kick or dislodge rocks or dirt when you are on a slope above other people. If you do kick down a rock, yell a warning so the people below you can get out of the way.

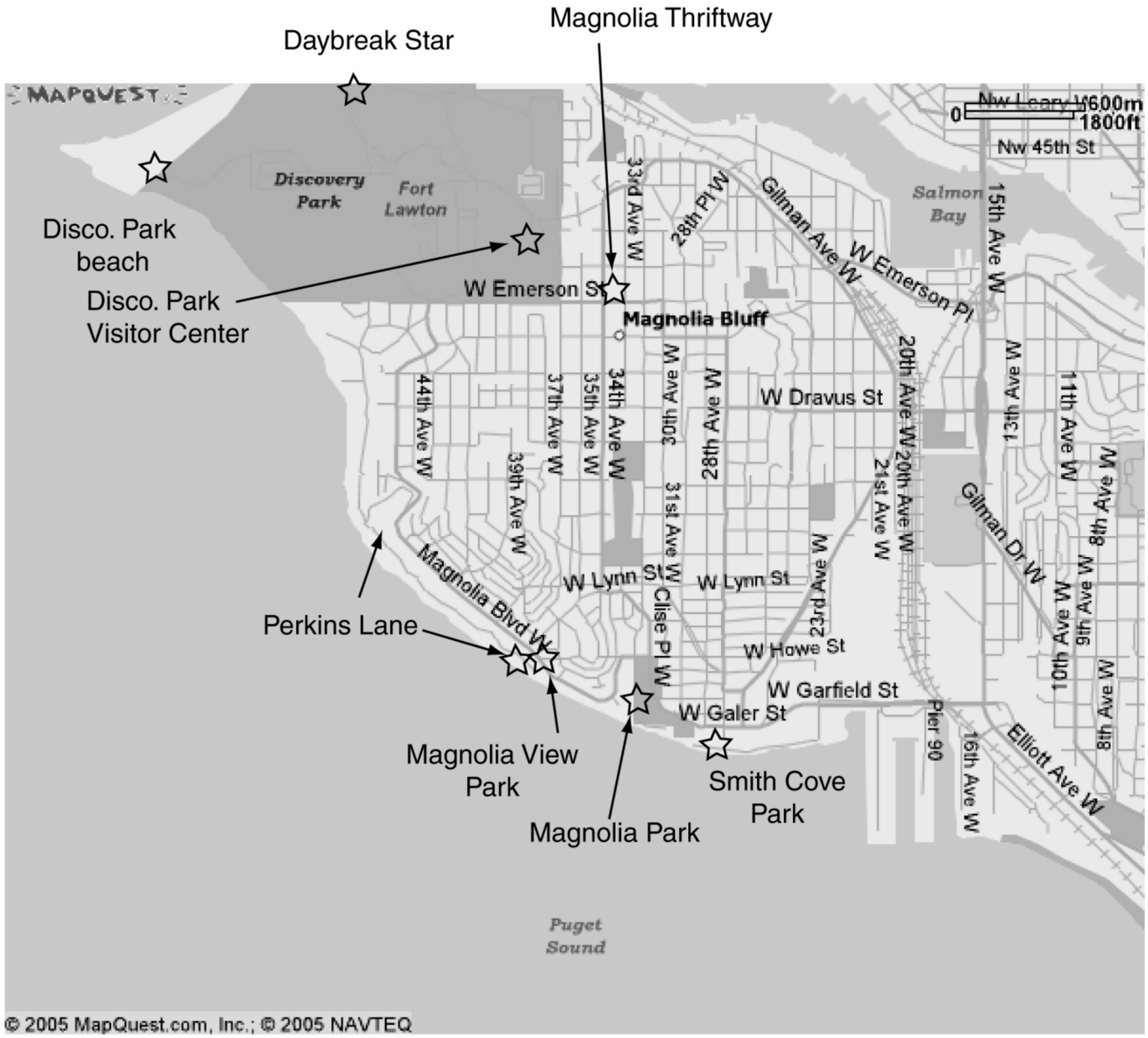



Figure 1. Map of field trip stops

This map shows all the stops from a longer field trip. We will be stopping at 1) Discovery Park Visitor Center, 2) Discovery Park Beach, 3) Magnolia View Park (with a trip down to Perkins Lane), and 4) Smith Cove Park.

## SCHEDULE

**Stop 1: Discovery Park Visitor Center**

We will be stopping here just to pick up parking permits for the beach and to let people use the bathrooms.

**Stop 2: Discovery Park beach**

We will then head down to the lighthouse and look at the geology of the bluff from the beach. This is a great location to see the glacial stratigraphy that forms Magnolia Bluff (and many other parts of Seattle). The "Guide to glacial sediments" below briefly describes the different kinds of sediments created in a glacial or near-glacial environment. Much of this should be a review from Terry's trips the past two weekends. Try to identify the different stratigraphic units seen at the beach, and make a sketch of the stratigraphy. On this sketch, include the topographic profile of the bluff. After we all have a chance to look at this outcrop on our own, we will discuss what this stratigraphy tells us about the history of the advance and retreat of the Puget Lobe over this area. We will use Figure 3 (the map of Puget Sound) to sketch out this advance and retreat.

**Room for sketch:**

**Guide to glacial sediments**

The sedimentary deposits left by glaciers are highly variable in terms of their sorting and grain size. The following is a list of some of common deposits found in glacial and near-glacial environments (see Figures 2 and 3):

- Glaciofluvial deposits ("outwash"). Meltwater streams flow out in front of the ice and can re-work sediment deposited by the glacier. Outwash deposits are typically better sorted than tills, and the finest grains are washed away, leaving cross-bedded sub-rounded to well-rounded sand, gravel, and cobble-sized clasts. Outwash forms in front of advancing and retreating glaciers. The size of the sediment can be a function of the proximity of the glacier (larger clasts closer to the glacier).
- Till. This is sediment deposited directly by the ice. Till can be smeared out under a glacier as it moves (resulting in an over-compacted till), or can melt out of the ice as it ablates. Till is typically very poorly sorted and has angular grains. There is typically no bedding in tills. Often, tills have a bimodal grain size, with a fine-grained matrix and larger clasts. Imagine a sedimentary deposit like a chocolate chip cookie, with the cookie part being the matrix and the chocolate chips being the clasts.
- Glaciolacustrine ("pro-glacial lake") deposits. Glaciers can block streams and create pro-glacial lakes. Sediment carried into these lakes can then settle out on the bottom. Typically, the coarse grained sediment settles near the edges, where streams enter the lake. Fine-grained sediment (silt and clay) can be carried out and settle in the middle of the lake, where it can form very thin layers (called lamination). Sometimes, sediment-rich icebergs can carry larger clasts out to the middle of a lake, melt, and drop them into the finer-grained sediment. These large clasts found within finer-grained lake sediments are called "dropstones."

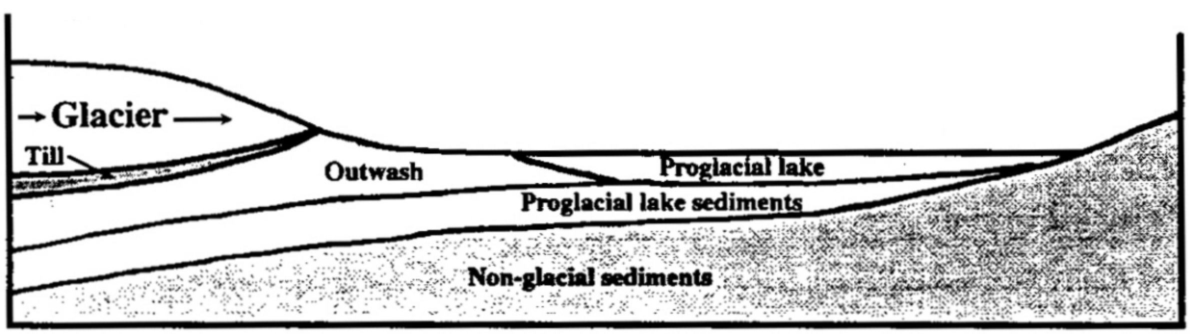



**Figure 2. Cross-section view of sediments deposited in front of and below an ice sheet**

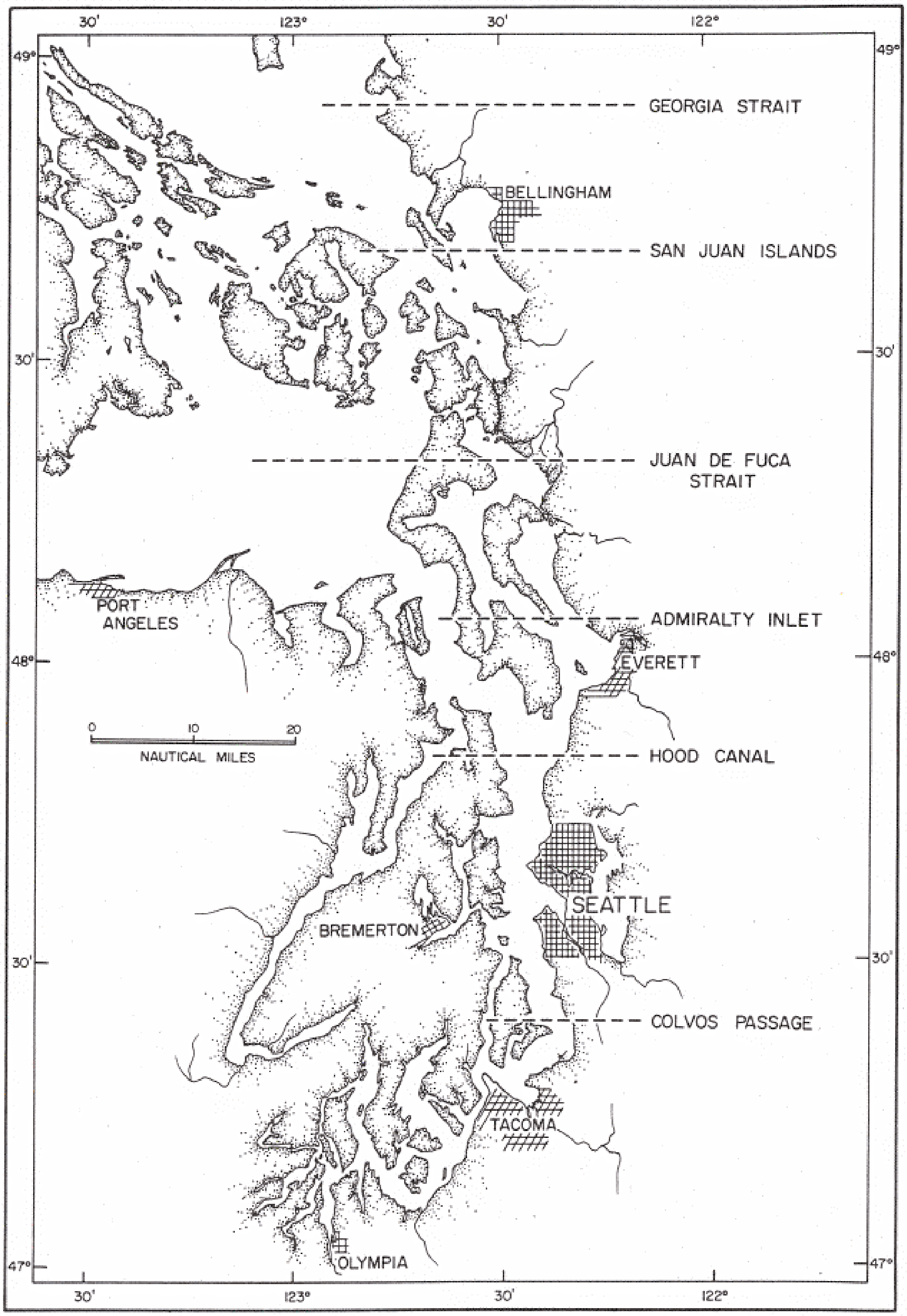



**Figure 3. Map of Puget Sound**

**Stop 3: Perkins Lane**

We are going to park on Magnolia Blvd. above Perkins Lane and take the stairs down to the landslide area. Five homes in this area were destroyed by landslides in 1996. Look at Figure 4, which shows aerial photographs of this area from 1990 (before the most recent slides) and 2002 (after). As you go down the stairs, notice the outcrops on either side. Can you tell what unit this is? At the bottom of the stairs, we will first turn left and investigate the landslide zone. The ground is very uneven and will probably be muddy here, so be careful scrambling around. Divide into groups to answer the following questions:

- Can you identify any of the stratigraphic units? If not, can you guess where the sand/clay contact is, based on the topography?

- From the aerial photos, how has the landscape changed between 1990 and today?

- Can you see any landslide surfaces or blocks? If so, can you estimate the width and thickness?

- The City of Seattle owns the bluff above this property. In 1996, the city hired a geotechnical firm to assess the landslide risk here. The geotechnical firm recommended that the city install dewatering wells to reduce the water pressure at the base of the sand. Before these wells could be installed, the big destructive slides occurred. One of the homeowners in the destroyed area sued the City of Seattle for failing to stabilize the bluff. Eventually, this lawsuit was dismissed. Do you agree with this decision? When slides initiate in one area and destroy property in another, who is responsible? Should homeowners here be responsible for understanding (and accepting) the risk?

Next, we will walk north along the still-habitated part of Perkins Lane. Remember, people live here, so please don't enter private property or be obtrusively loud. Spend some time observing the landscape and the construction. Walk as far north as the house at 2409 Perkins Lane, then turn around and come back.

- What evidence is there for slope instability here?

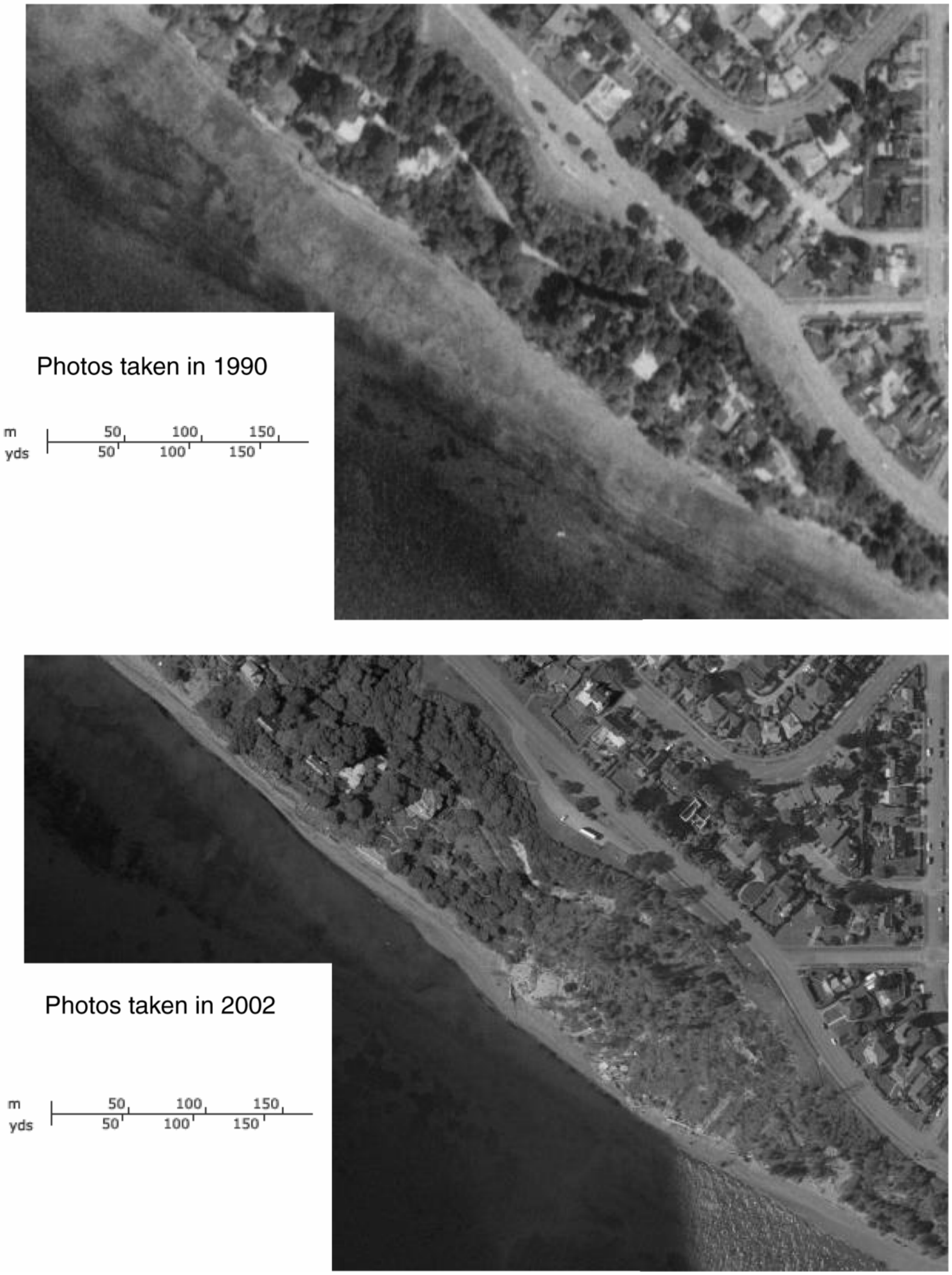
- What techniques are people using to stabilize their property? Though the Factor of Safety equation (remember that from the landslide lab?) is not exactly appropriate, elements of the FS equation such as slope, cohesion, internal friction, and saturation are still relevant. How do the different stabilization methods you observe act to reduce the landslide risk of this area?

- What kinds of things have been done here to actively, but unintentionally, encourage landsliding?

- Note the locations where people have removed houses from the east (hill) side of the road. In some cases, these homes have been relocated to the west (sound) side of Perkins lane. Was this a wise move?

- What are the specific risks to the homes on the east vs. west sides of the road?

**Figure 4**. Aerial photographs of Perkins Lane West area, below Magnolia View Park parking lot



**Stop 4: Magnolia View Park**

Now we will climb the stairs again and reconvene at the far south end of the park, where the fence cuts towards the west. Here we can get a bigger view of the landslide area. Notice how close Magnolia Blvd. is to the edge of the bluff. We are going to estimate the retreat rate of this bluff, and figure out how much longer Magnolia Blvd. has to exist. You will get into small groups and spread out along the road to do these calculations.

First, look at the bathymetric map shown in Figure 5. Notice the underwater wave-cut platform that extends out from the bottom of the bluff. The extent of this platform shows the size of Magnolia Bluff at approximately 6000 years ago, when sea level stabilized (glaciers had finished melting and the ground had finished rebounding from the unloading of the ice). Since 6000 years ago, the waves of Puget Sound have been cutting away at the hill. Using the width and the age of the platform, estimate the retreat rate of the bluff in feet per year. Now, using the tape measures, find the approximate distance from the edge of the bluff to the street (1 meter = 3.28 feet). PLEASE DO NOT FALL OFF THE CLIFF. Assuming the retreat rate hasn't changed through time, how long until the road is threatened? Show your math.

Does the bluff really retreat every year, evenly, at the rate you just calculated? Using the landslide probability map (Figure 6), estimate the recurrence interval of landslides in this area.

Estimated recurrence interval:_________________________

Note that the landslide density contours show the number of landslides that occur in a 4 hectare (400 x 400 m) area, so if you are within the 2-landslide contour, that means 2 historic landslides have occurred somewhere within that 4 hectare region (not necessarily in the same exact spot). See how this corresponds to a recurrence interval of 44.20 years?

**Figure 5. Topography and bathymetry of Magnolia Bluff area**

Bathymetry and altitude of Magnolia area

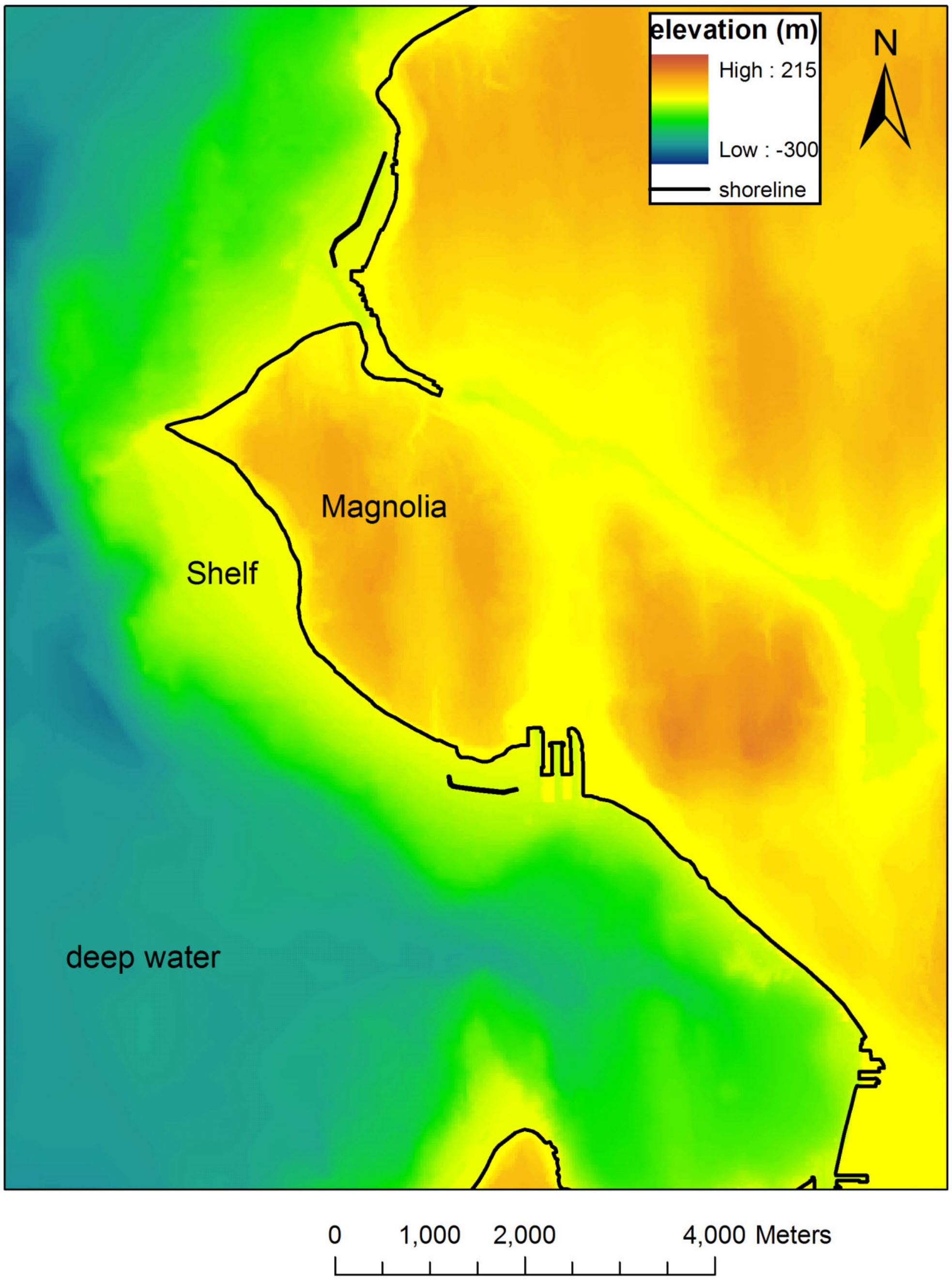
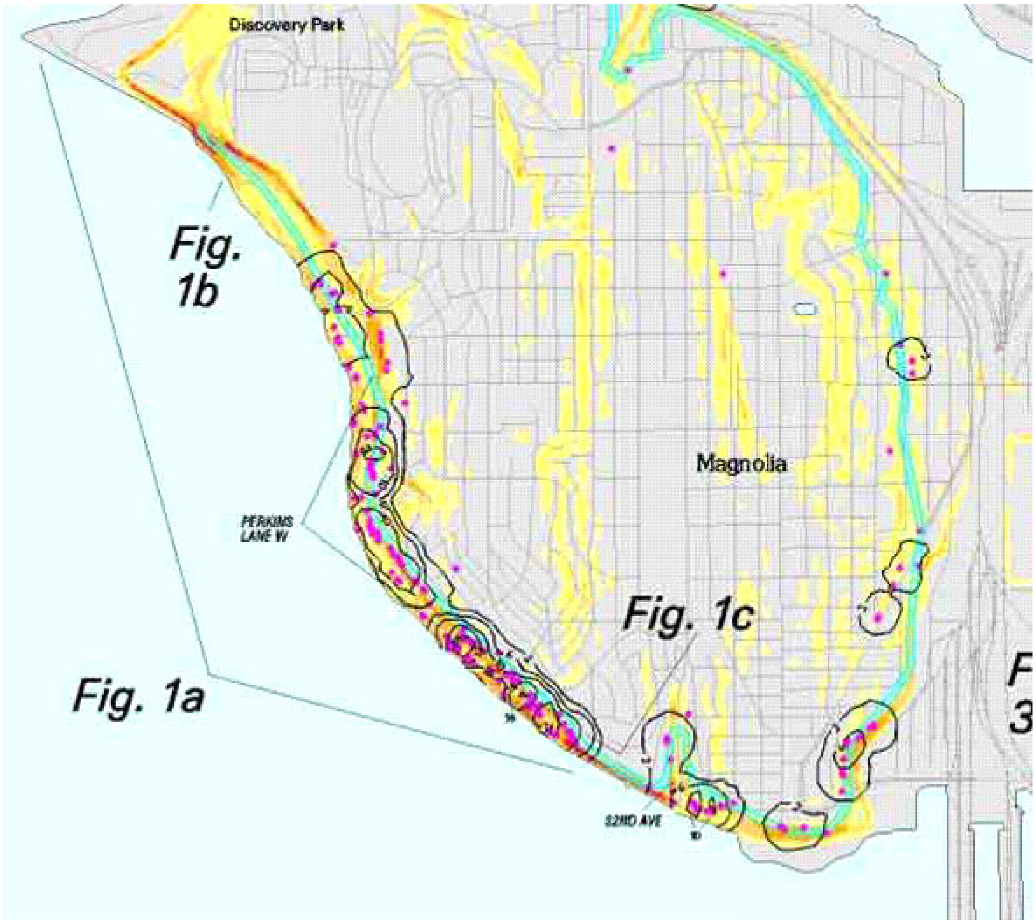


**Figure 6**




Explanation

- Historic landslide locations

Esperance Sand/Lawton Clay contact zone, from Tubbs, 1974

Slope: >40°; 30°-39°; 20°-29°; 10°-19°; 0°-9°

Landslide density contours
Contour interval is 4 landslides/4 hectare count circle
Initial contour is 2 landslides/4 hectare count circle

*Fig. 1 - 4* Location of figures shown in accompaning pamphlet

Table showing mean recurrence interval and annual exceedance probability values for each landslide density contour.

| Landslide Density Contour (number of landslides/ 4 hectare count circle) | Mean Recurrence Interval (years) | Annual Exceedance Probability (percent chance of one or more landslides in any given year) |
|---|---|---|
| 2 | 44.20 | 2.24 |
| 6 | 14.73 | 6.56 |
| 10 | 8.84 | 10.70 |
| 14 | 6.31 | 14.65 |
| 18 | 4.91 | 18.42 |
| 22 | 4.02 | 22.03 |
| 26 | 3.40 | 25.48 |

See table 1 in the accompanying pamphlet for a complete listing of all density, recurrence, and probability values.

**Stop 5: Spring Cove Park/Elliot Bay Marina**

Property with a nice view is expensive and homeowners are willing to pay a substantial amount of money to protect it. Here, we will look at three different landslide mitigation projects (two of them are similar and right next to each other—we'll consider them together). We will pay particular attention to what aspect of slope stability each mitigation method tries to address.

Project #1. Home at top of grassy hill, near parking lot.
How have they modified the landscape here? What elements of slope stability are specifically addressed? What could they do to stabilize this slope even better?

Projects #2 and #3. Homes at west edge of bluff
What has been done to these slopes, and what elements of the FS equation are addressed? List at least 3 modifications they have made here. Do you think these modifications are a permanent fix? Why or why not? What might you do differently?