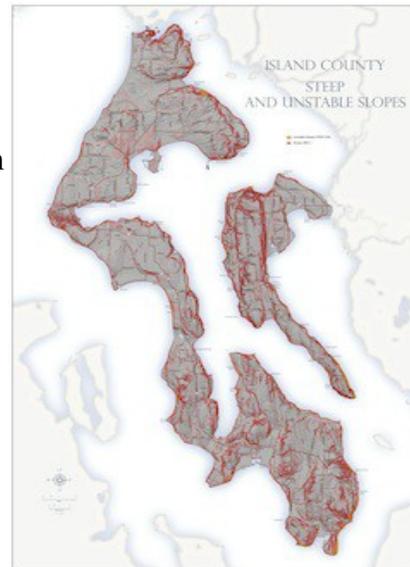


## Island County Landslides

Landslides are always a concern in Island County. Essentially the entire shoreline of Whidbey and Camano Islands south of the Deception Pass area is glacial and interglacial deposits. Erosion has created the current shape of the island. The sea has been gradually whittling away at the costal bluffs ever since the Vashon glacier began to melt and recede about 16,000 years ago after covering the islands with more than 3,000 feet of ice. Retreating glaciers leave drumlin hills in their wake that point in the direction of retreat, which on Whidbey and Camano Islands was northeast trending. Some of these can have significant slopes—the danger of landslides in Island County is not restricted to the margins.

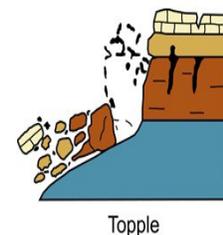


When unstable soil rests on a steep slope the force of gravity acts to cause a landslide. Slopes in Island County have been mapped by geologist and those steeper than 40 degrees are considered steep and in some cases unstable. The accompanying map shows where these are ([click](#) to download a larger pdf image). More detailed maps of specific areas are available through this [link](#) on the Island County Department of Emergency Management website.

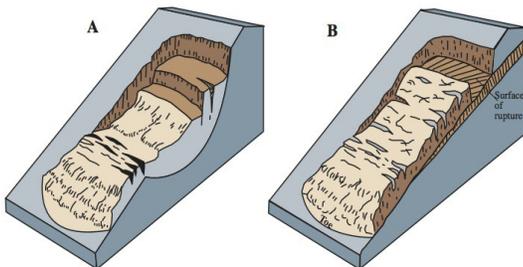
### Type of Landslides

All unstable slopes are subject to mass movements triggered by earthquakes. Lateral spreads are another type of mass-wasting. They occur on flat or very gentle slopes. It is generally a result of liquefaction induced by earthquakes, but any applied force that results in rapid shaking of the terrain can create the same effect (see [Landslides](#) on DEM website for more details).

Wave undercutting has led to instability along the islands' bluffs. The bluffs are subject to a topple mass movement. Toppling failures occur because the top rotates under the actions of gravity about a pivot below or low in the formation. Approach the edge of bluffs with care because the degree of undercutting and imminent failure is not apparent from the top.



Earthquakes are devastating but fortunately few and far between. Rain and, occasionally, snow are not. And, water is the biggest trigger of landslides in Island County. Slope saturation is the culprit. Addition of water from rain or snow melt adds weight to the slope. Water can reduce the friction along sliding surfaces. Water can change the angle of repose—the angle when material on the slope face is on the verge of sliding. The islands are especially vulnerable during the winter and spring months.

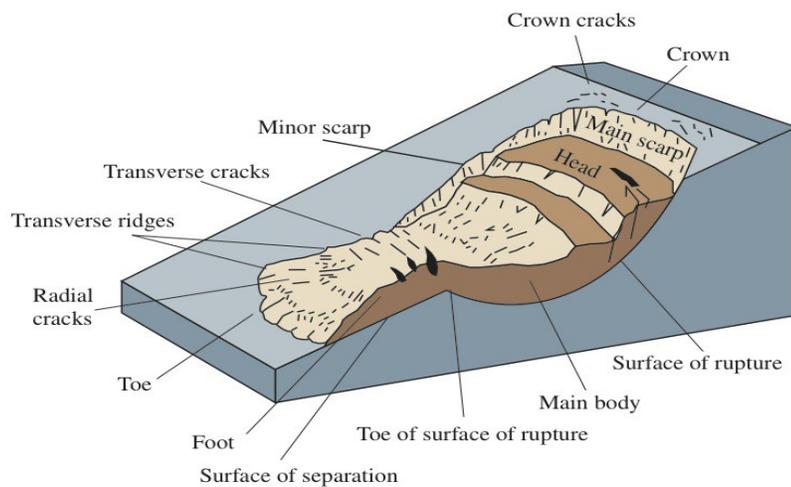


Landslides are a result of failure between layers of soil. If the slope fails because the bottom pushed out and the material above slides down to fill the void, it is generally a rotational landslide—A. If the slope fails all along the

junction between layers then a transitional slide has occurred—B. These two types of slides are shown in the inset diagram. Many slides are a combination of the two.

### **Ledgewood/Bonair Slide**

Geologists use special terms to describe a landslide. The most common terminology is shown in the following diagram (click to enlarge):



Using the Ledgewood/Bonair slide that occurred on March 27, 2013 as an example the crown or top of the slide averages 200 feet above sea level. The toe is slightly over 1,100 feet long and extends approximately 300 feet into Puget Sound. The toe pushed under and uplifted the beach 30 feet. The Ledgewood/Bonair slide was mainly rotational (a more detailed summary is available on the DEM



website) the volume of which was the equivalent of more than 40,000 dump trucks. The slide started

moving as early as 2002, but the entire area has a history of instability stretching back thousands of years.

## ***Recognizing Impending Landslides***

It is important to recognize the signs that a landslide may happen. The Washington Department of Natural Resources (DNR) characterizes landslide as shallow or deep-seated. You can download the DNR [Landslide Factsheet](#). Shallow landslides are common in Washington, often forming as slumps along roadways or fast-moving debris flows down valleys or concave topography. They are commonly called “mudslides” by the news media. Deep-seated landslides are often slow moving, but can cover large areas and devastate infrastructure and housing developments. The Ldgedgewood/Bonair landslide was deep seated and it occurred with virtually no immediate warning. The signs that a landslide may be imminent are:

Shallow Landslide (generally fast-moving)

- Sudden decrease or increase in creek water levels
- Sounds of cracking wood, knocking boulders, or groaning of the surrounding ground, or just unusual sounds
- A hillside that has increasing springs, seeps, or saturated ground
- Formation of cracks
- Deep-Seated Landslide (generally slow-moving)
- Newly developing cracks, mounds, or bulges on streets, sidewalks, or the ground
- Sagging or taut utility lines; leaning telephone poles, fence or trees
- Broken or leaking underground or surface utilities, such as water, septic, or sewer lines
- Separation of foundations from sill plates; movement of soil away from foundation
- Changes in water well levels or cessation of well functioning
- Increase or changes in spring or seep activities; ground becoming soggy or wet

If you notice signs of a landslide, leave the area immediately and report your observations to the Department of Emergency Management or call 911.

There are things that can be done to mitigate against a landslide. It is important to consult a trained professional who may recommend some of the following:

- Steep slopes can be covered or sprayed with concrete or covered with a wire mesh.
- Retaining walls could be built to stabilize a slope.
- Rock bolts may be emplaced to hold the slope together and prevent failure.
- Drainage pipes could be inserted into the slope to more easily allow water to get out and avoid increases in fluid pressure, the possibility of liquefaction, or increased weight due to the addition of water.
- Over-steepened slopes could be graded to reduce the slope to the natural angle of repose.
- Trees or other vegetation could be planted on bare slopes to help hold soil. Some slopes, however, cannot be stabilized, or only stabilized at great expense. In these cases, humans should avoid these areas or use them for purposes that will not increase susceptibility of lives or property to mass movement hazards.