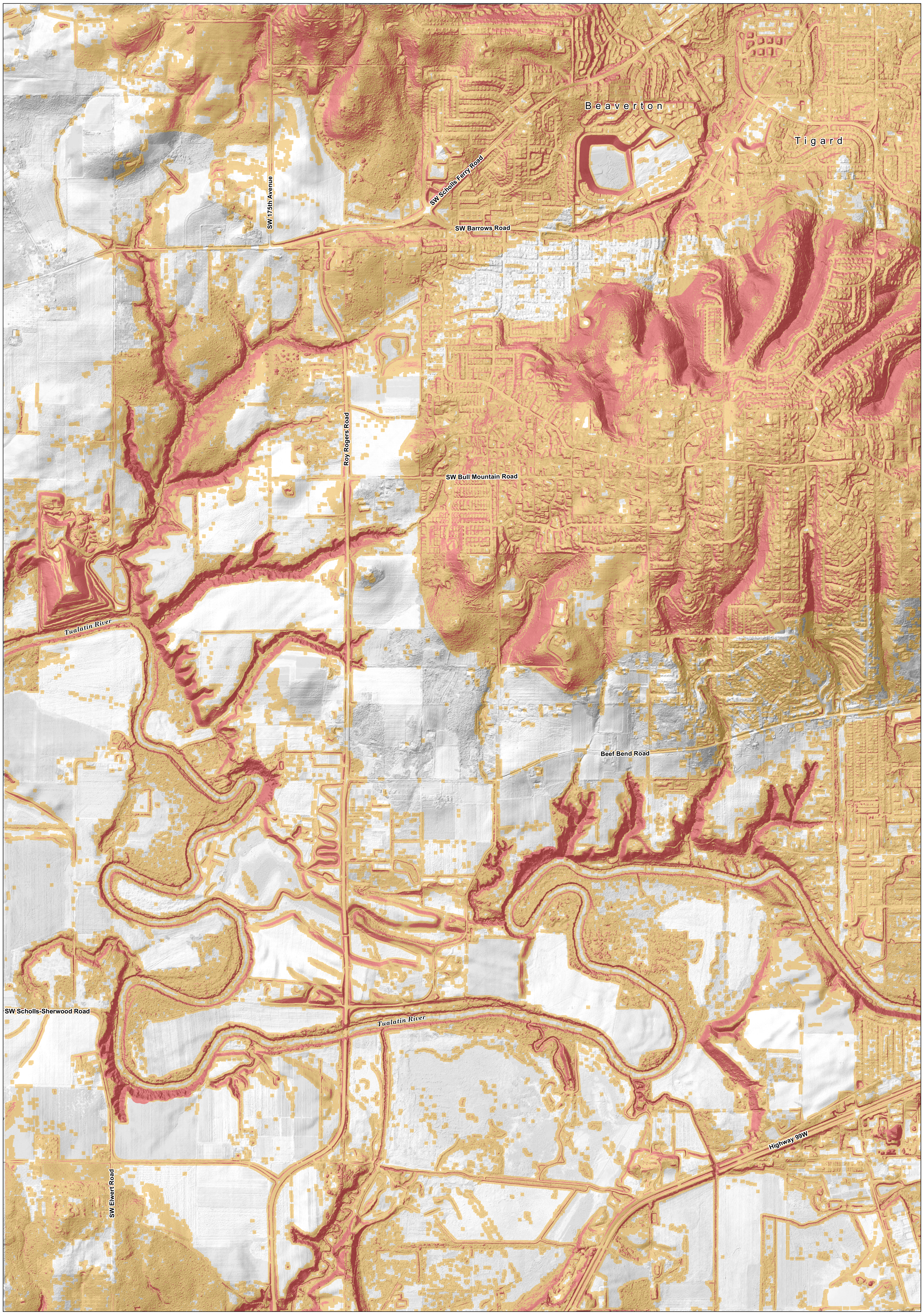
STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
VICKI S. McCONNELL, STATE GEOLOGIST

Shallow-Seated Landslide Susceptibility Map of the Southwest Quarter of the Beaverton Quadrangle, Washington County, Oregon

2008



Base Map:

Elevation data from Oregon Lidar Consortium, 2007. Digital elevation model (DEM) consists of a 3-foot by 3-foot elevation grid with hillshade sunangle at 315 degrees at a 45 degree angle from horizontal. The DEM is multiplied by 5 (vertical exaggeration) to enhance slope areas. Orthophoto is from Oregon Geospatial Enterprise Office, 2005 and consists of 2005 orthophoto draped over DEM with transparency.

Projection: North American Datum 1983, UTM zone 10 north

Software: MapInfo Professional 8.0, ESRI ArcMap 9.2, Adobe Illustrator CS2

Source File: Rocks\Publications\IPlate_2.mxd

SCALE 1:8,000

1,300 650 0 1,300 2,600 3,900 5,200 Feet

0.25 0.125 0 0.25 0.5 0.75 1 Miles

0.25 0.125 0 0.25 0.5 0.75 1 Kilometers

Cartography by William J. Burns, Oregon Department of Geology and Mineral Industries

Outside agency review by Paul Schaefer, Washington County

IMPORTANT NOTICE
This map depicts landslide susceptibility zones on the basis of limited data. The susceptibility zones were created following the protocol defined by Burns (2008). This map cannot serve as a substitute for site-specific investigations by qualified practitioners. Site-specific data may give results that differ from those shown on this map.

OPEN-FILE REPORT O-08-09

Regional Landslide Hazard Maps of the Southwest Quarter of the Beaverton Quadrangle, West Bull Mountain Planning Area, Washington County, Oregon

by William J. Burns

Partial funding provided by Washington County (Project 100075, PO 141319)

PLATE 2

EXPLANATION

The map depicts susceptibility to shallow-seated landslides for this area. For the purpose of this map, shallow-seated landslides are defined as those with a depth to the failure plane of less than 4.5 m (15 ft) (Burns, 2008). This susceptibility map is not regulatory. When new information regarding factors that affect landslide susceptibility becomes available or when new landslides occur, the map may be updated. Therefore, it is possible that susceptible areas within the map area were not identified and that landslides occurred after the map was prepared.

This shallow-seated susceptibility map was prepared by combining three factors: 1) calculated factor of safety (FOS), 2) landslide inventory data, and 3) buffers of the previous two factors. The factor of safety was calculated using a water table at the ground surface. The landslide inventory data were taken from the accompanying inventory map (Plate 1). The combinations of these factors comprise the relative susceptibility hazard zones: high, moderate, and low. The landslide data are displayed on top of a base map that consists of an orthorectified aerial photograph overlain on the lidar data derived digital elevation model. For additional detail on how this map was developed, see Burns (2008) or the accompanying text report.

This susceptibility map is intended to provide users with relative hazard information regarding shallow-seated landslide susceptibility within this area. The map cannot replace site-specific engineering geologic and geotechnical investigations. It is intended that this map will provide useful information to guide regional and site-specific investigations for future developments, to assist in regional planning, and to reduce risk in areas where moderate and high hazards intersect vulnerable population.

SHALLOW-SEATED LANDSLIDE SUSCEPTIBILITY CLASSIFICATION

Each landslide susceptibility hazard zone shown on this map was developed according to a classification scheme that uses a number of specific factors. The classification scheme was developed by the Oregon Department of Geology and Mineral Industries (DOGAMI) (Burns, 2008). The symbology used to display these hazard zones is explained below.

Landslide Susceptibility Zones: This map uses color to show the relative degree of hazard. Each zone is a combination of several factors.

HIGH: High susceptibility to shallow-seated landslides.

MODERATE: Moderate susceptibility to shallow-seated landslides.

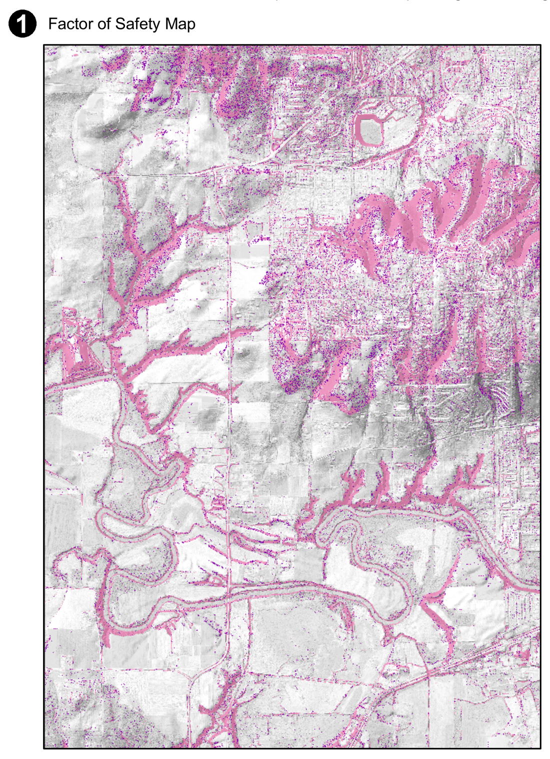
LOW: Low susceptibility to shallow-seated landslides.

Hazard Zone Matrix Table

Contributing Factors*	Final Hazard Zone		
	High	Moderate	Low
1 Factor of Safety (FOS)	less than 1.25	1.25 - 1.5	greater than 1.5
2 Landslide Inventory	included	—	—
3 Buffers	2H:1V (head scarps)	2H:1V (FOS less than1.5)	—

*See explanation of corresponding contributing factors below.

1 Factor of Safety Map



Factor of Safety (FOS) Map: The mechanics of slope stability can be divided into two forces: driving forces and resisting forces. These forces are a function of the material properties and the geometry of the slope. These two forces oppose each other, and slope stability can be thought of as their ratio.

$$\text{Factor of Safety} = \frac{\text{Resisting Forces}}{\text{Driving Forces}}$$

Thus a ratio greater than 1 indicates a stable slope because the resisting forces are greater than the driving forces. A ratio less than 1 indicates an unstable slope because the driving forces are greater than the resisting forces. A critically stable slope has a ratio equal to roughly 1. Because all the conditions present within a slope cannot be accounted for, Senneset (1996) recommends that slopes with a factor of safety of less than 1.5 be considered potentially unstable.

The factor of safety was calculated using the infinite slope equation. Conservative parameters and saturated water conditions were used so that a "worst case" scenario could be evaluated. This map uses color to show the change in the factor of safety across the map as explained below.

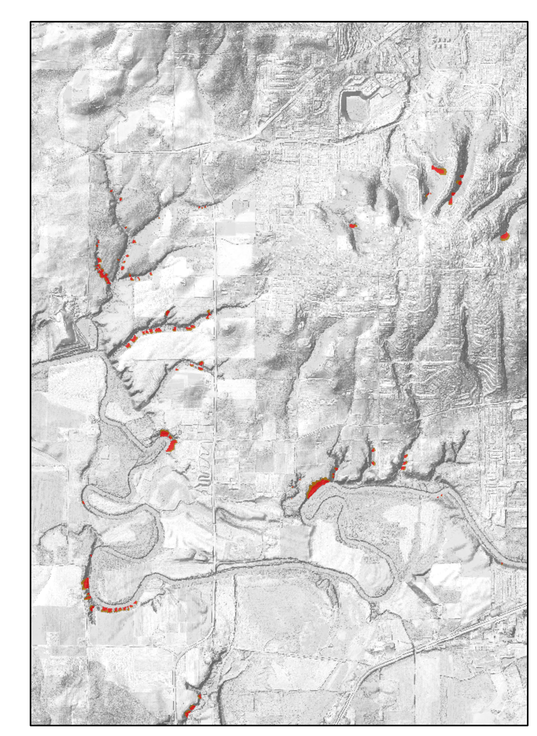
EXPLANATION

Factor of Safety less than 1.25

Factor of Safety between 1.25 and 1.5

Factor of Safety greater than 1.5

2 Landslide Inventory



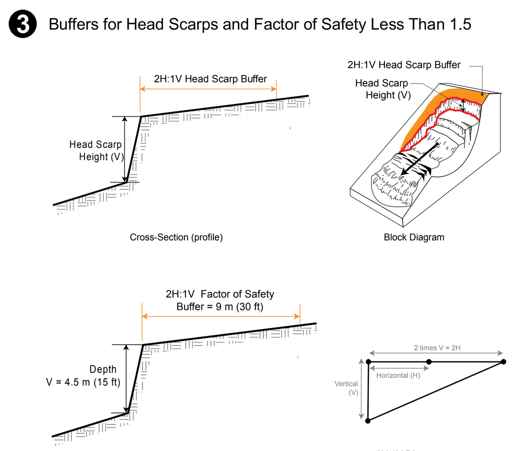
Landslide Inventory: This map is an inventory of existing landslides in this quarter quadrangle (see accompanying landslide inventory map, Plate 1). This inventory map was prepared by compiling previously mapped landslides from published geologic and landslide mapping, analyzing lidar-based geomorphology, and examining aerial photographs. Each landslide was also attributed with classifications for activity, landslide features, depth of failure, confidence of interpretation, and movement type (Burns and Madin, 2008). The map uses color to show different landslide features across the map as explained below.

EXPLANATION

Landslide Deposits

Landslide Head Scarps

3 Buffers for Head Scarps and Factor of Safety Less Than 1.5



Buffer for Head Scarps: This buffer was applied to all head scarps from the landslide inventory (Plate 1). The buffer consists of a 2:1 horizontal to vertical distance (2H:1V). This buffer is different for each head scarp and is dependent on head scarp height. For example, a head scarp height of 2 m (6.5 ft) has a 2H:1V buffer equal to 4 m (13 ft) (Block diagram modified after Highland, 2004).

Buffer for Factor of Safety Less Than 1.5: This buffer was applied to all areas with a calculated FOS less than 1.5. The buffer consists of a 2:1 horizontal to vertical distance (2H:1V). The maximum depth for shallow-seated landslides is 4.5 m (15 ft), the 2H:1V buffer equals 9 m (30 ft).

LIMITATIONS

The shallow-seated landslide susceptibility map was developed following an established protocol (Burns, 2008) with input from many sources, along with expertise gained from years of experience. Several limitations are worth noting and underscore that this hazard map is useful for regional applications but should not be used as an alternative to site-specific studies in critical areas.

1) Although it is possible to check for errors in the GIS and tabular database, it is not feasible verify all original input data.
2) As discussed above, the protocol to develop shallow-seated landslide susceptibility maps is based on three primary factors: a) calculated factor of safety, b) landslide inventory, and c) two buffers. These factors can affect the level of detail and accuracy of the final susceptibility map. For example:
   a. The landslide inventory data have limitations that are discussed in the lidar-based landslide inventory mapping protocol (Burns and Madin, 2008).
   b. Calculation of the factor of safety has two limitations worth noting:
      i. One of the limitations of the use of the infinite slope equation for regional stability analysis is due to the nature of the type of analysis, called grid based analysis. In this type of analysis, the calculations are done on an individual grid cell at a time without regard for the adjacent grids. The results sometimes underestimate or overestimate the level of stability for a certain area. To reduce underestimation of potentially unstable areas), buffers were developed. However, overestimation of potentially unstable areas remains a problem. The primary result that is overestimation is likely due to the high resolution of the lidar-derived DEM. Very small areas (even as small as 3 ft by 3 ft) are identified as potentially unstable. For example, in areas of otherwise low relief, noise in the lidar topographic data due to low vegetation or other factors may introduce very small areas of apparent moderate hazard where there is actually none. These areas should be verified in the field as necessary.
      ii. The second limitation to the factor of safety calculations is the accuracy and resolution of the input data (geology, depth to failure surface, groundwater, and slope angle). All four datasets can have substantial effects on the final calculations.
   c. The two buffers can lead to underestimation or overestimation of the potentially unstable areas.
3) The GIS database is a "snapshot" view of the current data; new information regarding landslides may be found and new landslides may occur.
4) Because the lidar-based digital elevation model (DEM) is only a model of elevation, it does not distinguish elevation changes that may be due to the construction of structures like retaining walls. Because it would require extensive field work to locate all of these existing structures and remove them or adjust the material properties in the model, they have been included as a conservative approach and therefore must be examined on a site-specific basis.
5) Some landslides and slopes have been mitigated. Because it is not feasible to collect detailed site-specific information on every landslide or slope (for example if it has been mitigated and what level of mitigation was implemented) mitigation has been omitted.

Because of these limitations this map is intended for regional purposes only and cannot replace site-specific investigations. However, the map can serve as a useful tool for estimating the regional landslide hazard and as a starting point for future detailed site-specific maps. Please contact DOGAMI if errors and/or omissions are found so that they can be corrected in future versions of this map.

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REFERENCES

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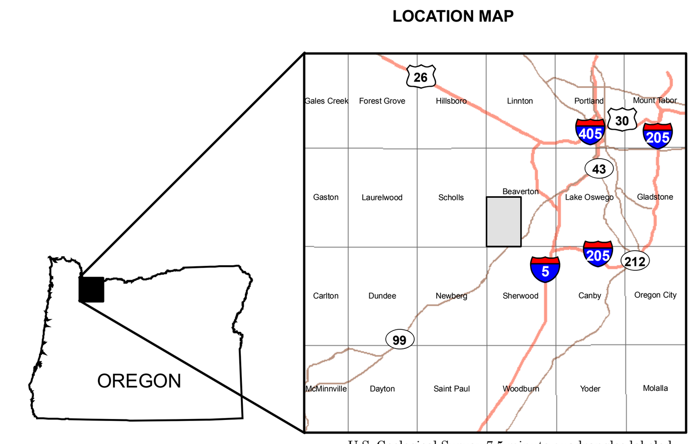
LOCATION MAP



U.S. Geological Survey 7.5 minute quadrangles labeled

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