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# Shallow Landslide Susceptibility Map of Central and Western Multnomah County, Oregon

2018

IMS-57
INTERPRETIVE MAP SERIES

**Landslide Hazard and Risk Study of Central and Western Multnomah County, Oregon**

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Funding for this project was partially provided by the Federal Emergency Management Agency (EMW-2014-CA-00289).

**PLATE 2**

### NOTICE

This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information. This publication cannot substitute for site-specific investigations by qualified practitioners. Site-specific data may give results that differ from the results shown in the publication. See the accompanying text report for more details on the limitations of the methods and data used to prepare this publication.

### ABOUT THIS PUBLICATION

The central and western portion of Multnomah County contains the Cities of Portland, Gresham, Troutdale, Fairview, and Wood Village. The study area is one of the most densely populated areas in Oregon. Because landslides are one of the most widespread and damaging natural hazards in the state, it is important to map and assess the risk in the study area. The purpose of this study is to assist the cities and county in understanding the landslide hazard better and thus increase their ability to reduce future risk. The study publication consists of a text report, three map plates, and GIS data.

## EXPLANATION

This shallow landslide susceptibility map identifies landslide-prone areas that are defined following the protocol of Burns and others (2012).

On the basis of several factors and past studies (described in detail by Burns and Madin [2009]), a depth of 15 ft (4.5 m) is used to divide shallow from deep landslides. We prepared this shallow susceptibility map by combining three factors: 1) calculated factor of safety (FOS), 2) landslide inventory data, and 3) buffers, as described below. We calculated the FOS by using conservative values such as having the water table at the ground surface. We used landslide inventory data from the corresponding inventory map (Plate 1). The combinations of these factors comprise the relative susceptibility hazard zones: high, moderate, and low, as shown by the Susceptibility Hazard Zone Matrix below. The landslide susceptibility data are displayed on top of a base map that consists of the lidar-derived digital elevation model.

### SHALLOW LANDSLIDE SUSCEPTIBILITY CLASSIFICATION

Each landslide susceptibility hazard zone shown on this map has been developed according to a number of specific factors. The classification scheme was developed by the Oregon Department of Geology and Mineral Industries (Burns and others, 2012). The symbology used to display these hazard zones is explained below.

**Shallow Landslide Susceptibility Zones:** This map uses color to show the relative degree of hazard. Each zone is a combination of several factors (see Hazard Zone Matrix, below).

**HIGH:** High susceptibility to shallow landslides.

**MODERATE:** Moderate susceptibility to shallow landslides.

**LOW:** Low susceptibility to shallow landslides.

### Shallow Landslide Susceptibility Hazard Zone Matrix

| Contributing Factors | Final Hazard Zone | | |
|---|---|---|---|
| | High | Moderate | Low |
| Factor of Safety (FOS) | < 1.25 | 1.25 - 1.50 | > 1.50 |
| Landslide Deposits and Head Scarps | included | —— | —— |
| Buffer | 2H:1V (head scarps) | 2H:1V (FOS < 1.5) | —— |

### 1 Factor of Safety (FOS)

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.

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

A slope with a FOS > 1 is theoretically a stable slope because the shear strength is greater than the shear stress. A slope with a FOS < 1 is theoretically an unstable slope because the shear stress is greater than the shear strength. A critically stable slope has a FOS = 1. Because of the inability to know all the conditions present within a slope, most geotechnical engineers and engineering geologists recommend that slopes with a FOS < 1.5 be considered potentially unstable (Turner and Schuster, 1996; Cornforth, 2005).

We calculated the FOS by using the infinite slope equation with conservative parameters. Saturated conditions were used so that a "worst case" scenario could be evaluated. Because of limitations related to a grid type analysis, we removed isolated areas with small (less than 4 ft [1.2 m] high) elevation change by using a standardized process (Burns and others, 2012).

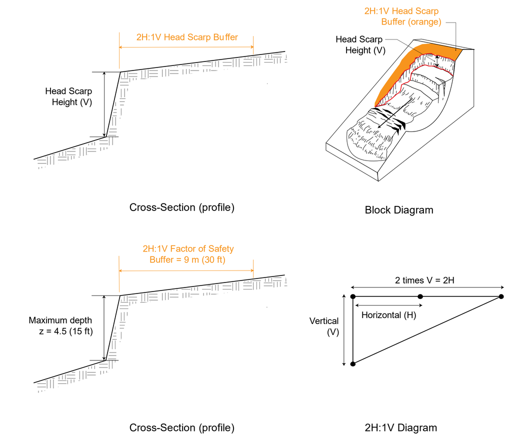
### 2 Landslide Inventory

An inventory of all existing landslides in this area is shown on Plate 1. We prepared this inventory map by compiling all previously mapped landslides from published and unpublished geologic and landslide mapping, analyzing lidar-based geomorphology, and reviewing aerial photographs. We also attributed each landslide with classifications for activity, depth of failure, movement type, and confidence of interpretation. We created the inventory by using the protocol developed by Burns and Madin (2009). We extracted the shallow landslides from the inventory and used these to create this shallow landslide susceptibility map.

### 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. 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 6 ft (2 m) has a 2H:1V buffer equal to 12 ft (4 m).

**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). For example, if the maximum depth for shallow landslides is 15 ft (4.5 m), then the 2H:1V buffer would equal 30 ft (9 m).




(Burns and others, 2012)

## LIMITATIONS

Limitations include the following.

1) Every effort has been made to ensure the accuracy of the GIS and tabular database, but it is not feasible to completely verify all of the original input data.

2) The shallow landslide susceptibility maps are based on three primary components: a) calculated factor of safety, b) landslide inventory, and c) buffers. Factors that can affect the level of detail and accuracy of the final susceptibility map include the following:

a) Factor of safety calculations are strongly influenced by the accuracy and resolution of the input data for material properties, depth to failure surface, depth to groundwater, and slope angle. The first three of these inputs are usually estimates (material properties) or conservative limiting cases (depth to failure surface and groundwater), and local conditions may vary substantially from the estimated values used to make these maps.

b) Limitations of the landslide inventory are discussed by Burns and Madin (2009).

c) Infinite slope factor of safety calculations are done on one grid cell at a time without regard to adjacent grids. The results may underestimate or overestimate the level of stability for a certain area. We developed buffers for areas with low factors of safety to counter the tendency to underestimate susceptibility. We developed the focal relief method to reduce the problem of overestimation of susceptibility due to steep slopes with low relief. However, overestimation and underestimation of susceptible areas are still likely in some isolated areas.

3) This susceptibility map is based on the topographic and landslide inventory data available as of the date of publication. Future new landslides may render this map locally inaccurate.

4) The lidar-based digital elevation model does not distinguish elevation changes that may be due to the construction of structures like retaining walls. Because it would require extensive GIS and field work to locate all existing structures and remove them or adjust the material properties in the model, such features have been included as a conservative approach and must be examined on a site-specific basis.

5) Some landslides in the inventory may have been mitigated, thereby reducing their level of susceptibility. Because it is not feasible to collect detailed site-specific information on every landslide, potential mitigation has been ignored.

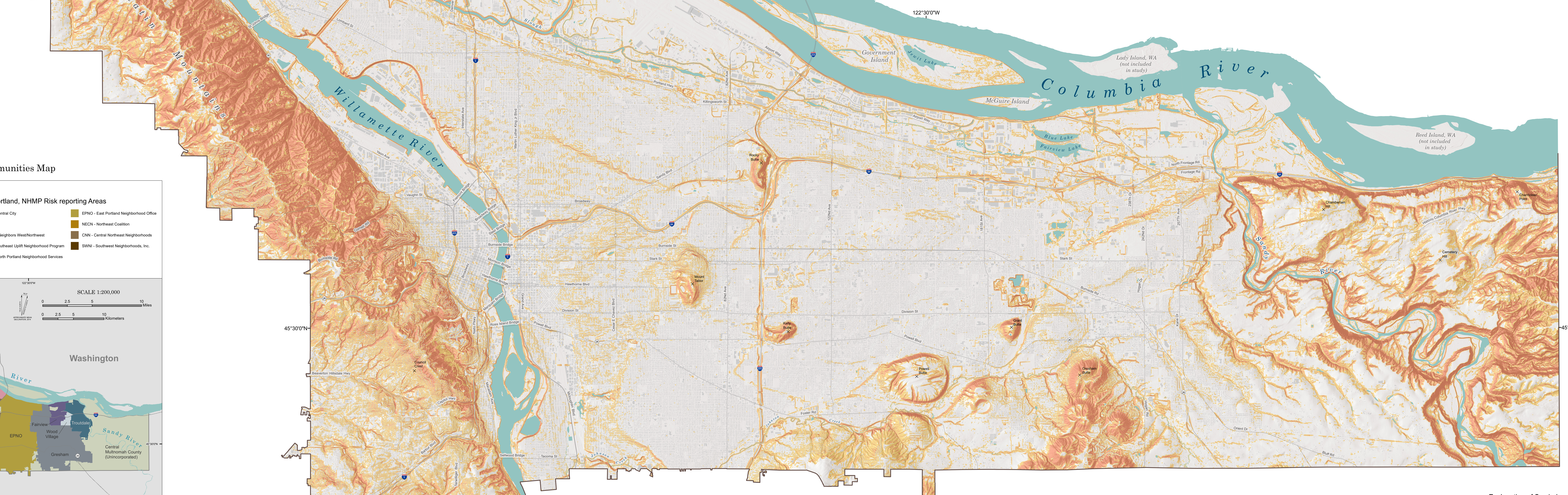
## REFERENCES

Burns, W.J., and Madin, I.P., 2009, Protocol for inventory mapping of landslide deposits from light detection and ranging (lidar) imagery: Oregon Department of Geology and Mineral Industries Special Paper 42, 30 p., geodatabase template.

Burns, W.J., Madin, I.P., and Mickelson, K.A., 2012, Protocol for shallow-landslide susceptibility mapping: Oregon Department of Geology and Mineral Industries Special Paper 45, 32 p.

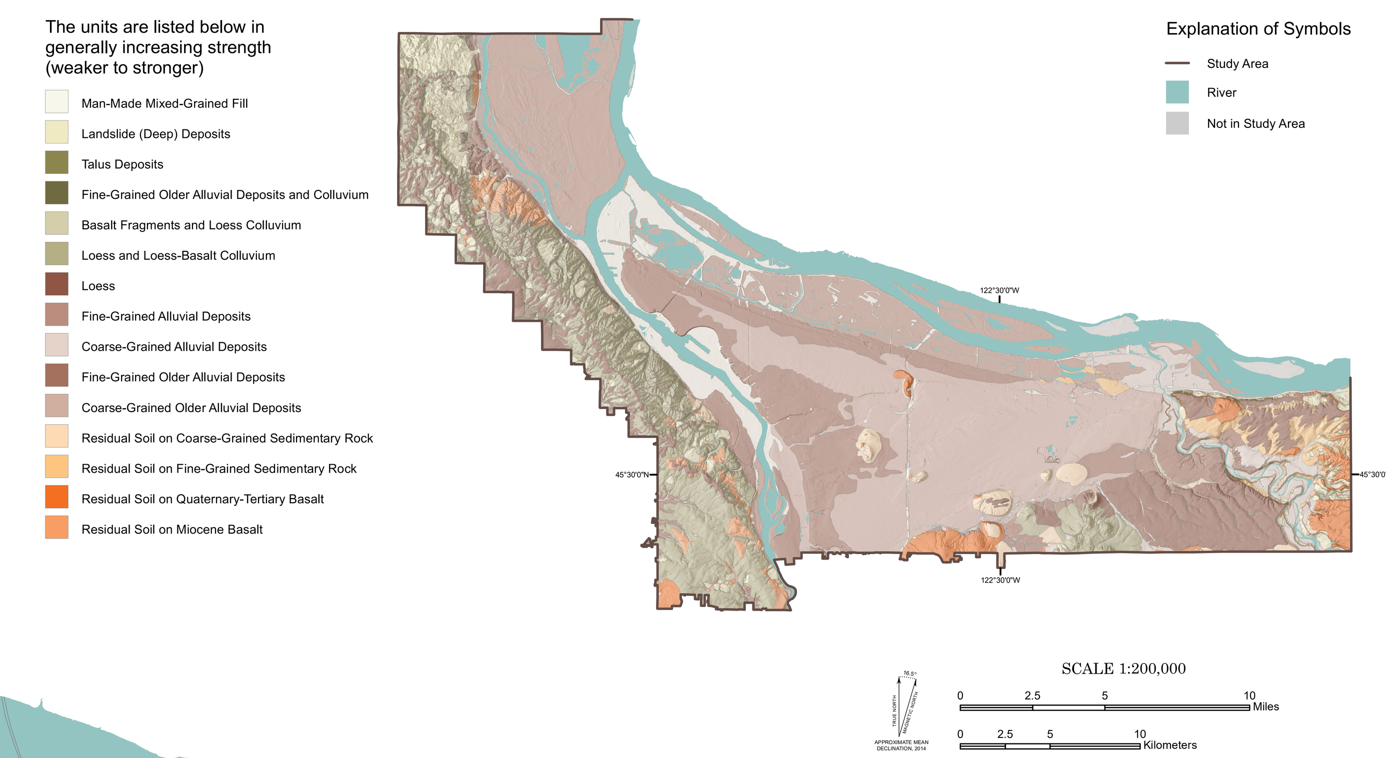
Cornforth, D.H., 2005, Landslides in practice: Investigation, analysis, and remedial/preventative options in soils: Hoboken, N.J., John Wiley and Sons, Inc., 596 p.

Turner, A. K., and Schuster, R. L., eds., 1996, Landslides: investigation and mitigation: Washington, D.C., National Research Council, Transportation Research Board Special Report 247, 673 p.



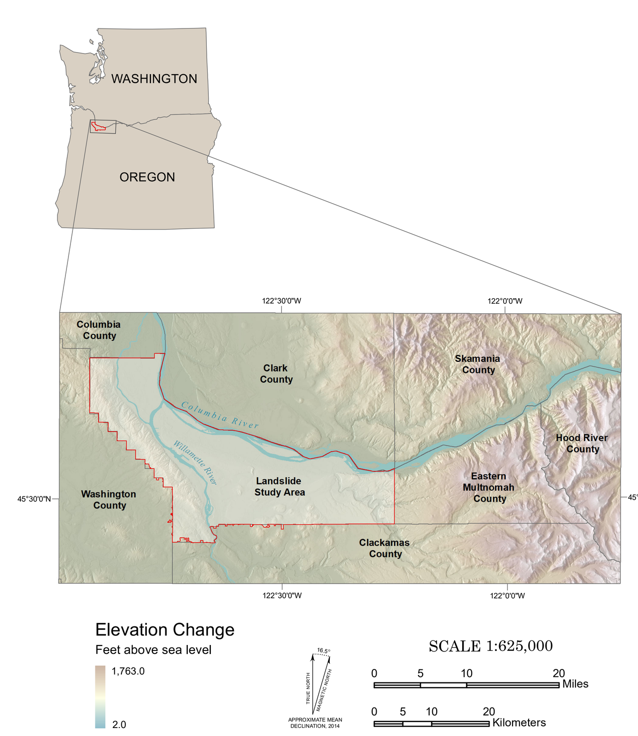

SCALE 1:38,000

## Generalized Surficial Engineering Geology Map

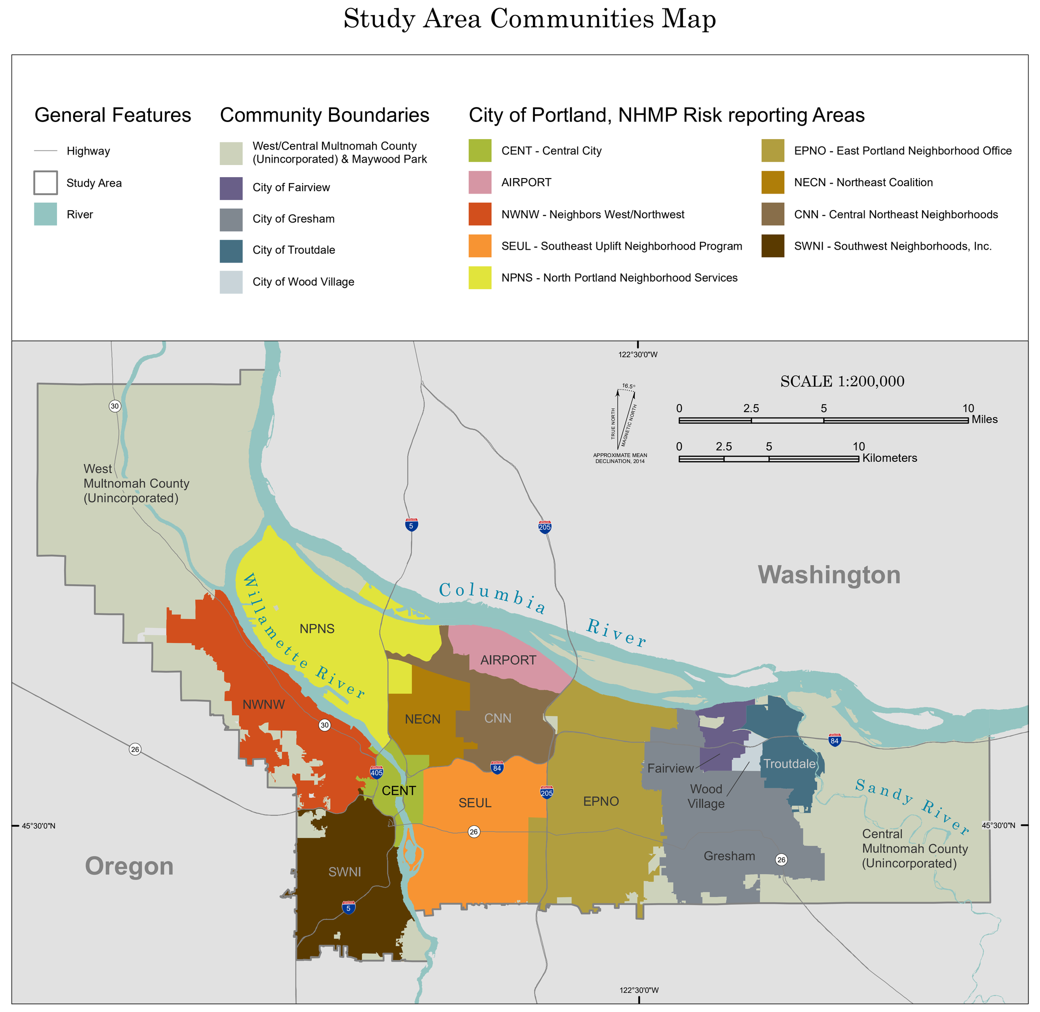



## Study Area Location Map

(See Study Area Communities Map for more detail)




## Study Area Communities Map




## Explanation of Symbols

Summit
Road
Stream
Waterbody
Study Area
Buildings

**Source Data:**
Lidar data from DOGAMI Lidar Data Quadrangles LDQ-2009-45122F8-Dixie Mountain, LDQ-2009-45122F7-Sauvie Island, LDQ-DATE-45122-F6-Vancouver, LDQ-2009-45122E8-Hillsboro, LDQ-2009-45122E7-Linnton, LDQ-2009-45122E6-Portland, LDQ-2009-45122E5-Mount Tabor, LDQ-2009-45122E4-Camas, LDQ-2010-45122E3-Washougal, LDQ-2009-45122D8-Scholls, LDQ-2009-45122D7-Beaverton, LDQ-2009-45122D6-Lake Oswego, LDQ-2009-45122D5-Gladstone, LDQ-2009-45122D4-Damascus, LDQ-2009-45122D3-Sandy.

Roads, streams, waterbodies, county boundary, and community boundary datasets are from the Regional Land Information System (RLIS), Oregon Metro, 2016. Additional physical and cultural locations are from the Geographic Names Information System (GNIS), U.S. Geological Survey, 2013. Natural Hazard Mitigation Plan (NHMP) risk reporting areas are from the City of Portland, Bureau of Emergency Management (2016).

**Projection:**
Oregon Statewide Lambert Conformal Conic, Unit: International Feet, Horizontal Datum: NAD 1983 HARN.

**Software:**
Esri® ArcMap® 10.5.1

**Cartography:**
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