Landslide Inventory Map of the Bull Run Watershed

2015

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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www.OregonGeology.org

DOGAMI SPECIAL PAPER 46

Surficial and Bedrock Engineering Geology, Landslide Inventory and Susceptibility, and Surface Hydrography of the Bull Run Watershed, Clackamas and Multnomah Counties, Oregon

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Funding for this project was provided by the City Portland Water Bureau (intergovernmental agreement IGA #12122012).

PLATE 1

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 Bull Run Watershed (BRW) is the primary drinking water supply for the City of Portland and several suburbs and is cooperatively managed by the Portland Water Bureau and the U.S. Forest Service. The watershed is located 25 miles (40 km) east of downtown Portland on the western slopes of the Cascade Range. The BRW is a surface water collection system, so the risk of landslide impact directly to the water and the infrastructure is relatively high. Because landslides are one of the most widespread and damaging natural hazards in Oregon, it is important to map and assess the risk in the BRW. The purpose of this study is to assist the Portland Water Bureau in understanding the landslide hazard better and thus increase their ability to reduce future risk. The study publication consists of a text report, five map plates, and three geodatabases.

EXPLANATION

This map is an inventory of existing landslides in the study area. The landslide inventory is one of the essential data layers used to delineate regional landslide susceptibility. This landslide inventory is not regulatory, and we may make revisions to the inventory of this area when new information regarding landslides is available. Landslides not mapped may exist, but it is unlikely that due to we did not identify all landslides within the mapped area; see the limitations section below.

We prepared this inventory map by following the protocol for inventory mapping of landslide deposits developed by Burns and Madin (2009). The three-primary tasks included compilation of previously mapped landslides, 1) review of existing landslide inventories (Schulz, 1958; Wiley, 2000; Burns, 2012; Burns and others, 2012), lidar-based morphologic mapping of landslide features, and review of aerial photographs. We digitally compiled landslides identified by these methods into a GIS database at varying scales. While the protocol recommends data use at a map scale of 1:8,000, and the geodatabase contains data at 1:8,000 or better, for representation purposes we have visualized the data on the map plate at 1:24,000 scale. We also attributed each landslide with classifications for relative age of activity, depth of failure, movement type, and confidence of interpretation. The landslide data are displayed on top of a base map that consists of a lidar-derived hillshade image.

This landslide inventory map is intended to provide users with basic information regarding landslides within the study area. The geologic, terrain, and climatic conditions that led to landslides in the past may provide clues to the locations and conditions of future landslides, and it is intended that this map will provide useful information in areas of proposed land development, regional planning, and scoping investigations for future developments, and to assist in regional planning and mitigation of existing landslides.

LANDSLIDE CLASSIFICATION

We have classified each landslide shown on this map according to a number of specific characteristics identified at the time the data were recorded in the GIS database. The classification scheme was developed by Burns and Mickelson (2016) and is based on Varnes (1978) and Hungr and others (2014). Landslide characteristics recorded in the database are portrayed with symbology on this map. The specific characteristics shown for each landslide are the activity of landsliding, landslide features, deep or shallow failure, confidence of landslide interpretation, and type of landslide movement. These landslide characteristics are determined primarily on the basis of geomorphic features, or landforms, observed for each landslide. The symbology we use to display these characteristics on the map is explained below.

LANDSLIDE ACTIVITY: Each landslide has been classified according to the relative age of last movement. This map display uses color to show the relative age of activity.

HISTORIC and/or ACTIVE (movement less than 150 years ago): The landslide appears to have moved within historic time or is currently moving (active).

PRE-HISTORIC or ANCIENT (movement greater than 150 years ago): Landslide features are slightly eroded and there is no evidence of historic movement. In some cases, the observed landslide features have been greatly eroded and/or covered with deposits that result in smoothed and subdued morphology.

LANDSLIDE FEATURES: Because of the high resolution of the lidar-derived topographic data, some additional landslide features were identified. These include:

HEAD SCARP ZONE and FLANK ZONE: The head scarp or upper most scarp, which in many cases exposes the primary failure plane (surface of rupture), and flanks or shear zones.

HEAD SCARP LINE and INTERNAL SCARP LINES: Upper most extent of the head scarp and internal scarps within the body of the landslide. Hatching is in the down-dropped direction.

DEPTH OF FAILURE: The depth of landslide failure was estimated from scarp height. Failures less than 4.5 m (15 ft) deep are classified as shallow-seated, and failures greater than 4.5 m (15 ft) deep are classified as deep-seated.

SHALLOW LANDSLIDE: Estimated failure plane depth is less than 4.5 m (15 ft).

DEEP LANDSLIDE: Estimated failure plane depth is greater than 4.5 m (15 ft).

CONFIDENCE OF INTERPRETATION: We classified each landslide at the time of mapping according to our "confidence" that the landslide actually exists. We mapped landslides on the basis of characteristic morphology, and the confidence of the interpretation was based on how clearly visible these features were. We did not map landslides where we could not distinguish landslide morphology from erosional degrades the morphology produced by landsliding. With time, landslide morphologies may become so subtle that they resemble morphologies produced by geologic processes and conditions unrelated to landsliding.

Landslides may have several different types of associated morphologies, and we define confidence through a simple point system (see table below). The point system is based on a 0 to 10 point ranking of each of four primary landslide features. For example, if, during mapping, the head scarp and toe of a landslide were identifiable and clearly visible, the mapper would apply 10 points for the head scarp and 10 points for the toe, equaling 20 points, which would be associated with a moderate confidence of identification.

On the map the visual display of this landslide characteristic is through the use of different line styles as shown below.

HIGH CONFIDENCE (≥30 points)

MODERATE CONFIDENCE (20-30 points)

LOW CONFIDENCE (<20 points)

Landslide Feature	Points
Head scarp	0-10
Flanks	0-10
Toe	0-10
Internal scarps, sag ponds, compression ridges, etc.	0-10*

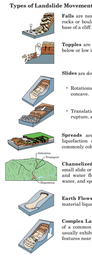
* Applied only once so that total points do not exceed 40.

CLASSIFICATION OF MOVEMENT: We classified each landslide with the type of landslide movement. There are five types of landslide movement: slide, flow, fall, topple, and spread (Varnes, 1978). These movement types are combined with material type to form the landslide classification. Not all combinations are common in nature, and not all are present in this study area.

EFL EFL - Earth Flow - Abbreviation for type of slope movement. The table below displays movement types (Varnes, 1978). Generalized diagrams (some modified from Highland, 2004) showing types of movement are shown in the next column.

Type of Movement	Type of Material		
	Rock	Debris	Soil
Fall	**RF** rock fall	**DF** debris fall	**EF** earth fall
Topple	**RT** rock topple	**DT** debris topple	**ET** earth topple
Slide–rotational	**RS-R** rock slide–rotational	**DS-R** debris slide–rotational	**ES-R** earth slide–rotational
Slide–translational	**RS-T** rock slide–translational	**DS-T** debris slide–translational	**ES-T** earth slide–translational
Lateral spread	**RSP** rock spread	**DSP** debris spread	**ESP** earth spread
Flow	**RFL** rock flow	**DFL** debris flow	**EFL** earth flow
Complex	**C** - complex or combinations of two or more types (for example, ES-R + EFL)		

Types of Landslide Movement:



Falls are near-vertical, rapid movements of masses of materials, such as rocks or boulders. The rock debris sometimes accumulates as talus at the base of a cliff.

Topples are distinguished by forward rotation about some pivotal point, below or low in the mass.

Slides are downslope movements of soil or rock on a surface of rupture

- Rotational slides move along a surface of rupture that is curved and concave.

- Translational slides displace along a planar or undulating surface of rupture, sliding out over the original ground surface.

Spreads are commonly triggered by earthquakes, which can cause liquefaction of an underlying layer and extension and subsidence of commonly cohesive materials overlying liquefied layers.

Channelized Debris Flows commonly start on a steep, concave slope as a small slide or earth flow into a channel. As this mixture of landslide debris and water flows down the channel, the mixture picks up more debris, water, and speed, and deposits in a fan at the outlet of the channel.

Earth Flows commonly have a characteristic "hourglass" shape. The slope material liquefies and runs out, forming a bowl or depression at the head.

Complex Landslides are combinations of two or more types. An example of a common complex landslide is a rotational slide + earth flow, which usually exhibits rotational slide features in the upper region and earth flow features near the toe.

LIMITATIONS

We developed this landslide inventory with the best available data by using the protocol of Burns and Madin (2009). However, there are inherent limitations as discussed below. These limitations underscore that this map is designed for regional applications and should not be used as an alternatives to site-specific studies in critical areas.

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 original input data.
2. Burns and Madin (2009) recommended a protocol to develop landslide inventories that is based on 1) compilation of existing landslide inventories, 2) lidar-based mapping, 3) compilation and review of previously mapped landslides, 3) review of historic air photos, and 4) limited field checking. These tasks can affect the level of detail and accuracy of the landslide inventory. We expect the lidar data quality to improve in the future, and this improvement will likely result in the identification of more landslides with greater confidence. However, we did not map landslides that we did not identify or that were not previously mapped landslides. In some locations, historic air photos may not be available. Because field work is time consuming and therefore expensive, field checking may be extensive in some locations but very limited in other locations.
3. The lidar-based mapping is a "snapshot" view of the current landscape that may change as landslides become reactivated, enlarged, coalesce, or retrogress in the future.
4. Because of the resolution of the lidar data and air photos, landslides that are smaller than 100 square meters (1,075 square feet) may not be identified. Generally, small landslides are included if they are reported by a local governmental agency, a site-specific study, regional study report, or a local area landslide expert, and are found to be accurately located by the mapper.
5. Even with high-quality lidar-derived topographic data, it is possible that some existing landslides were not identified. We relied on the Burns and Madin (2009) protocol for inventory and map in accordance with a published protocol (Burns and Madin, 2009) to minimize these problems.
6. Earthwork related to development on hillsides can remove the geomorphic expressions of past landsliding. This can result in landslides being missed in the inventory. Earthwork on landslides can also create landslide features that are not natural, for example, a landslide with a cut and fill can look like a landslide scarp and toe. This limitation can sometimes be addressed by viewing aerial photographs that predate development in the area being mapped. Therefore, to ensure that past landslides have been adequately identified, if a landslide was identified on the predevelopment air photos, we included the landslide in the landslide inventory, whether or not surface expression was located in the lidar-derived imagery.
7. Some landslides have been mitigated. Because it is not feasible to collect detailed site-specific information on every landslide, for example if it has been mitigated and what level of mitigation was implemented, we have omitted mitigation. Again, 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

Please contact DOGAMI if errors and/or omissions are found so that they can be corrected in future versions of this map.

REFERENCES

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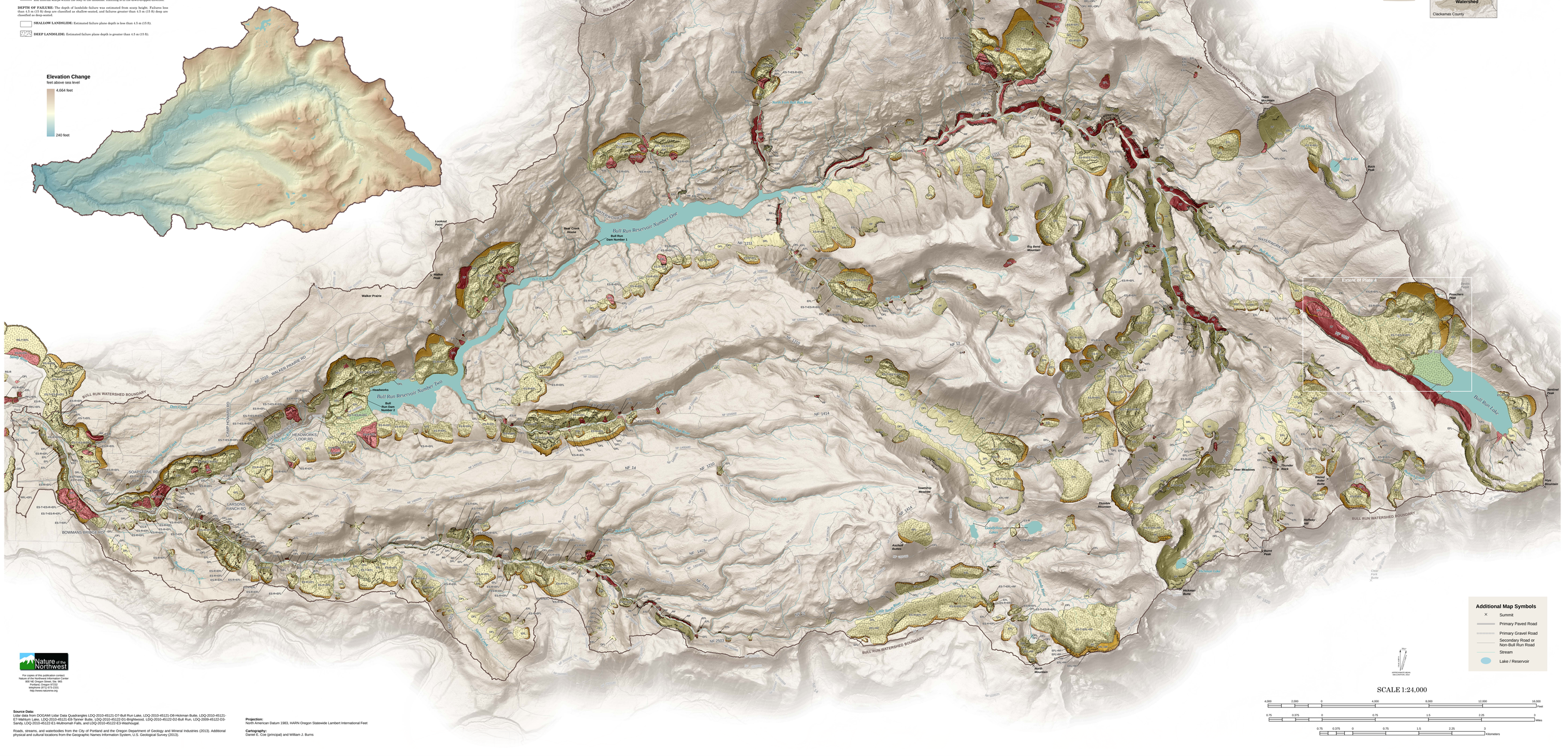
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