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Washington Geological Survey GIS Statewide Landslide Database—From Design to Implementation

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Introduction

The Department of Natural Resources, Geology and Earth Resources Division (DGER), also known as the Washington Geological Survey, actively identifies, assesses, and maps geologic hazards using modern geotechnical and geophysical methods. Our hazard maps are critical for land-use and emergency-management planning, disaster response, and building-code amendments. As our population grows, there is increasing pressure to develop in hazardous areas; thus, delineating these areas is imperative. In response to the Washington State Growth Management Act's mandate to use the 'best available science,' our geologists meet with local governments and citizens in at-risk communities to educate about geologic hazards and ensure these hazards are taken into account when planning for growth management and for disasters. The DGER is also a first responder to natural disasters, helping to staff the State Emergency Operations Center at Camp Murray and documenting damage in the field. Besides volcanic and earthquake hazards, Washington is also prone to landslides triggered by intense rainfall or earthquakes. Landslides kill more people and cost more overall each year than other natural disasters combined (Bell, 1999). Nationally, landslides account for over 2 billion dollars of loss annually and result in an estimated 25 to 50 deaths a year (Schuster, 1996; Spiker and Gori, 2000; Schuster and Highland, 2001). Additionally, according to Washington State legislative mandate RCW 43.92.

> *" . . . the geological survey must conduct and maintain an assessment of seismic, landslide, and tsunami hazards in Washington. This assessment must include the identification and mapping of volcanic, seismic, landslide, and tsunami hazards, an estimation of potential consequences, and the likelihood of occurrence. The maintenance of this assessment must include technical assistance to state and local government agencies on the proper interpretation and application of the results of this assessment."*

DGER has designed and is implementing a GIS-based, statewide landslide database at both 24K and 100K scales (Figure 1), which is accessible on our ArcIMS site for download as an Arc Coverage file located at *http://wigm.dnr.wa.gov/*.

Data Assembly

Over many years, various landslide databases have been created in different divisions of the Washington Department of Natural Resources (DNR) to meet a variety of purposes. In 1999, the Division of Forest Practices created the first GIS statewide inventory of landslides (Boyd and Vaugeois, 2003). This database incorporated previously mapped landslides of all scales. The DGER has been involved in various projects, from mapping landslide hazards in Cowlitz County in response to the Aldercrest-Banyon landslide, to hazard response such as the Nisqually earthquake in 2001 and the December 3, 2007, storm that caused significant landslide-related damage. However, each of these datasets and databases was intended to meet particular goals. The statewide database includes an assessment of the reliability of database entries and uses the appropriate attributes from these previous databases, with a notation indicating where the data were obtained. An additional database is linked to the statewide database to provide information on the economic impact of landslides when the data are available. This secondary database is intended for mitigation and development planning purposes.

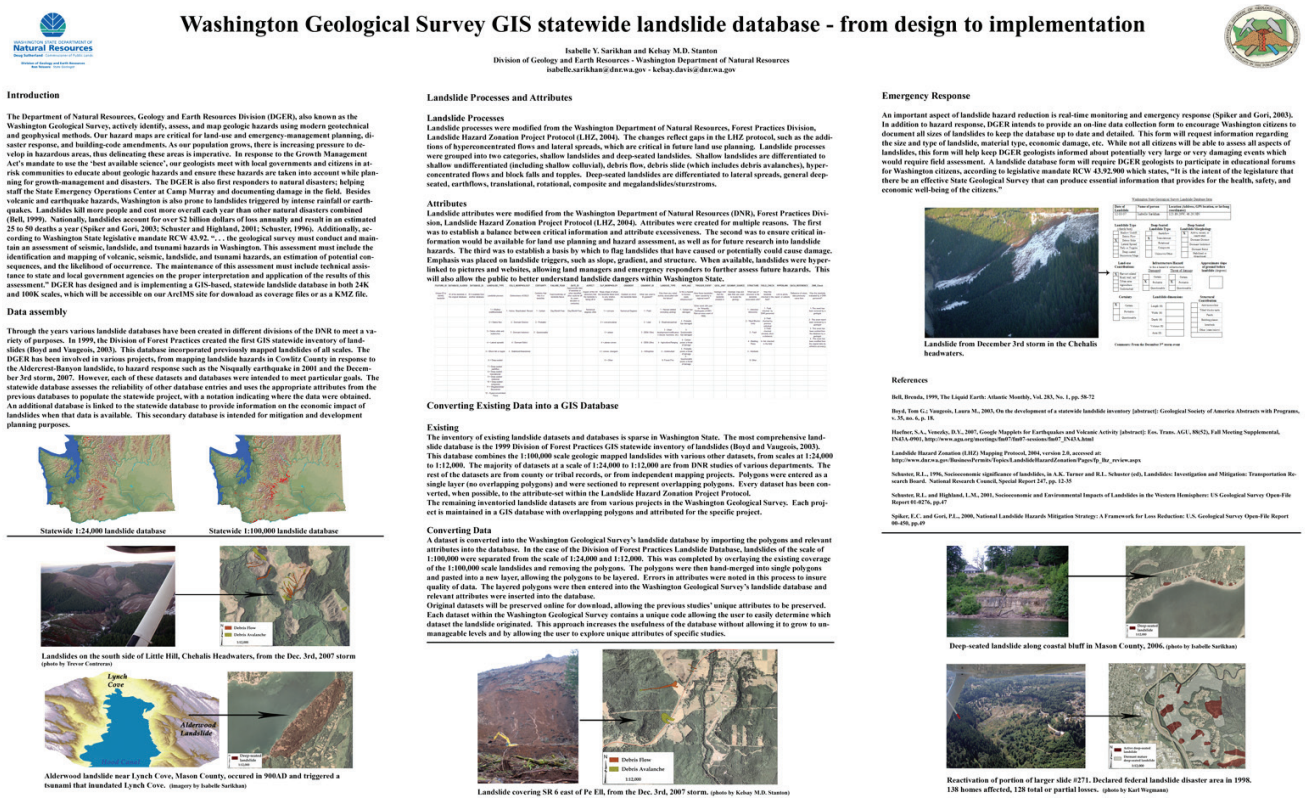

Figure 1. Page-size version of DMT'08 poster showing the DGER statewide landslide database (see full-resolution image at *http://ngmdb.usgs.gov/Info/dmt/docs/DMT08_Sarikhan.pdf*).

Landslide Processes and Attributes

Landslide Processes

The classification of landslide processes was modified from the Washington Department of Natural Resources, Forest Practices Division, Landslide Hazard Zonation (LHZ) Project Protocol (Washington State Department of Natural Resources, 2004). The changes reflect gaps in the LHZ protocol, such as the additions of hyperconcentrated flows and lateral spreads, which are critical in land use planning. Landslide processes were grouped into two categories, shallow landslides and deep-seated landslides. Shallow landslides are classified as shallow undifferentiated (including shallow colluvial), debris flow, debris slide (which includes debris avalanches), hyperconcentrated flows and block falls, and topples. Deep-seated landslides are classified as lateral spreads, general deep-seated, earthflows, translational, rotational, composite, and mega-landslides/sturzstroms.

Attributes

The types of landslide attributes were modified from the Landslide Hazard Zonation (LHZ) Project Protocol (Washington State Department of Natural Resources, 2004). Attributes were created for multiple reasons. The first was to establish a balance between recording the critical information and defining an excessive number of attributes. The second was to ensure critical information would be available for land use planning and hazard assessment, as well as for future research into landslide hazards. The third was to establish a basis by which to identify landslides that have caused or potentially could cause damage. Emphasis was placed on landslide triggers, such as slope, gradient, and structure. When available, landslides were hyperlinked to pictures and websites, allowing land managers and emergency responders to further assess future hazards. This will also allow the public to better understand landslide dangers within Washington State.

Converting Existing Data into a GIS Database

The inventory of existing landslide datasets and databases is sparse in Washington State. The most comprehensive landslide database is the 1999 Division of Forest Practices GIS statewide inventory of landslides (Boyd and Vaugeois, 2003). That database combines the 1:100,000-scale Division of Geology and Earth Resources digital maps of landslides with various other datasets of scales from 1:24,000 to 1:12,000.

The majority of datasets at a scale of 1:24,000 to 1:12,000 are from DNR studies by various departmental divisions. The rest of the datasets are from county or tribal records, or from other types of mapping projects. Polygons were originally entered as a single layer (with no overlapping polygons) and were separated to represent overlapping polygons. Every dataset has been converted, when possible, to the attribute-set within the Washington Geological Survey's Protocol.

For each selected dataset, the polygons and relevant attributes are incorporated into the Washington Geological Survey's landslide database. In the case of the Division of Forest Practices Landslide Database, landslides of the scale of 1:100,000 were separated from the scale of 1:24,000 and 1:12,000. This was done by overlaying the DGER 1:100,000 geologic map's landslide polygons and removing those polygons. The polygons were then hand-merged into single polygons and pasted into a new layer, allowing the polygons to be layered. Errors in attributes were noted in this process, to ensure data quality. The layered polygons were then entered into the Washington Geological Survey's landslide database and relevant attributes were inserted into the database.

The original landslide datasets will be preserved online for download, allowing the previous studies' unique attributes to be preserved and compared to those in the Washington Geological Survey's landslide database. Each dataset within this statewide database contains a unique code that allows the user to easily determine the source dataset for each landslide. This approach increases the usefulness of the database by linking it to the source information, thereby keeping the statewide database to a manageable size.

Emergency Response

An important aspect of landslide hazard reduction is real-time monitoring and emergency response (Spiker and Gori, 2000). In addition to hazard response, DGER intends to provide an online data collection form to encourage Washington citizens to report landslides of any size, in order to help maintain a comprehensive database. This form will request information regarding the size and type of landslide, material type, economic damage, etc. While not all citizens will be able to assess all aspects of landslides, this form will help to keep DGER geologists informed about potentially very large or very damaging events which would require field assessment. A landslide database form will require DGER geologists to participate in educational forums for Washington citizens, according to legislative mandate RCW 43.92.900 which states, "*It is the intent of the legislature that there be an effective State Geological Survey that can produce essential information that provides for the health, safety, and economic well-being of the citizens*."

Public Accessibility

ArcGIS is a specialized tool to which the general public generally does not have access. Therefore, in order to educate the general public, we have developed an ArcServer system that allows easy data acquisition and navigability of landslide features. Additionally, the landslide information will be accessible by KML/Z files, allowing the general public to access this layer of information on simplified spatial visualization programs (such as Google Earth). We also may provide RSS and GeoRSS feeds and corresponding Mapplets (Haefner and Venezky, 2007), for continuous updates during emergency events.

Not only will the public be able to use the information within the database for community planning or hazard mitigation, but an accessible database will bring the public's attention to the high landslide hazard in the Pacific Northwest. Hopefully, a more aware public is a better prepared public!

References

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