2007 Landslide Symposium:

New tools and techniques for developing regional hazard maps and future risk management practices

Presented by DOGAMI/USGS/ASCE/AEG

Landslide Symposium Poster Abstracts

Thursday April 26, 2007, Portland State Office Building
800 NE Oregon Street, Portland Oregon, 97232

A NEW WORKING GROUP IN OREGON: THE OREGON LANDSLIDE WORKGROUP (OLW)

William Burns and Yumei Wang, Oregon Department of Geology and Mineral Industries (DOGAMI)

Many areas of Oregon are highly susceptible to landsliding. As population grows, development will expand into steeper terrain, increasing the frequency and extent of damages from landsliding.

In order to reduce future landslide damages in Oregon, a diverse group of people is needed to collaboratively determine possible risk-reduction steps. To address this need, the Oregon Department of Geology and Mineral Industries (DOGAMI) has begun forming a preliminary landslide working group, titled the Oregon Landslide Workgroup (OLW).

OLW will be a partnership of representatives from the public and private sectors including: federal, state, regional, county, and city elected officials; academic researchers; not-for-profit organizations; and consultants, corporations and the insurance industry.

OLW's principal goals will be to:

- Promote efforts to reduce landslide damages and losses;
- Conduct education efforts to motivate key decision makers to reduce risks associated with land slides through land-use planning and design permitting; and
- Foster productive linkages between scientists, engineers, planners, developers, property owners, critical infrastructure providers, businesses and governmental agencies to improve our communities' ability to recover after a major landslide event.

RELATIVE EARTHQUAKE INDUCED HAZARD MAPS AND IDENTIFIED LANDSLIDE HAZARD MAP FOR SIX COUNTIES IN THE MID-WILLAMETTE VALLEY, INCLUDING YAMHILL, MARION, POLK, BENTON, LINN, AND LANE COUNTIES, OREGON

William Burns1, Jon Hofmeister2, and Yumei Wang1, Cartography by Rudie Watzig1

1Oregon Department of Geology and Mineral Industries (DOGAMI)
2 Formerly at Oregon Department of Geology and Mineral Industries

In order to become resilient from geologic hazards, communities in Oregon have begun a large-scale endeavor to perform pre-disaster mitigation. A first step in this process is the development of natural hazards mitigation plans. For this project, six counties and one city merged together resources to begin:

- Identifying potential natural hazards
- Identifying vulnerability to these hazards
- Assessing the level of risk, and thus
- Increasing the level of resilience through pre-disaster mitigation

To assist these six counties in the development of their natural hazards mitigation plans, the Department of Geology and Mineral Industries (DOGAMI) performed the following tasks related to geologic hazards:

- Identified the primary geologic hazards of six counties in the Mid-Willamette Valley including Yamhill, Marion, Polk, Benton, Linn, and Lane Counties and the City of Albany (herein know as the study area or individual communities)
- Developed countywide earthquake and landslide hazard maps for each county
- Developed future earthquake damage estimates for each community

The purpose of this study is to help communities prepare pre-disaster mitigation plans, identify potential geologic hazards, help communities' perform earthquake damage and loss estimation, and to recommend future action items. Several products have been generated as part of this project. They include digital GIS layers for each community, depicting:

- Relative earthquake ground shaking amplification hazards
- Relative earthquake liquefaction hazards
- Relative earthquake-induced landslide hazards
- Identified landslide areas

Damage and loss estimates for each community were analyzed for two earthquake scenarios:

- A magnitude ~6.5 Crustal Fault earthquake
- A magnitude 9.0 Cascadia Subduction Zone earthquake

To improve the existing hazard maps and data, action items are provided. These action items range from site-specific items such as identification of individual school buildings that have a high risk of collapse in an earthquake to identification of landslide hazard areas over large regions of the state.

The identified earthquake-induced hazards include ground shaking amplification, liquefaction, earthquake induced landslides, and tsunamis. In order to evaluate non-earthquake related landslide hazards, we used identified landslide areas, potential "rapid¬ly moving landslide" (debris flow) hazards maps, and an inventory of slope failures in Oregon from three storm events (1996-97). Dam failures are frequently caused by geologic hazard events, and we evaluate these. Finally, we discuss volcanic hazards from Mt. Jefferson and the Three Sisters Region.

The relative earthquake hazard maps developed in this study identify areas of higher or lower potential hazard and can help guide planners who have to determine which areas should require future site-specific seismic evaluations. The identified landslide areas map is a digitized compilation of previously identified landslides. All of these maps should only serve as a guide for future site-specific evaluations.

Ground shaking amplification and liquefaction hazards are usually highest in the young, soft alluvial sediments of the Willamette Valley and along other major stream channels. Landslide hazards are highest in steep, mountainous terrain and at the base of steep canyons. Landslide areas identified in the accompanying GIS files also pose significant hazards for development.

We used regional earthquake hazard information developed in this study to assess potential damage and loss for various earthquake scenarios. We consolidated information into a computer program called HAZUS-MH, which is a federally developed program used to model various earthquake scenarios and estimate associated damage and loss. With the improved HAZUS-MH study region (included with this report), we modeled damage and loss estimates for two earthquake scenarios—resulting in expected total building damage on the order of $11.7 billion for a Cascadia Subduction Zone event.

The products from this study can be used to help the Mid-Willamette Valley communities become more resilient from the impacts of geologic hazards through pre-disaster mitigation.

MODELING THE LANDSLIDE RISK FOR THE BPA TRANSMISSION SYSTEM

John Eidinger1, Donald Wells2, Leon Kempner3, and Jared Perez4

1G&E Engineering Systems Inc., 6315 Swainland Rd, Oakland, CA 94611.
2Geomatrix Consultants Inc., 2101 Webster Street, 12th Floor, Oakland, CA 94612.
3Bonneville Power Admin., 7500 NE 41st St. MS TEL-TPP-3, Vancouver, WA 98662.
4BPA, 7500 NE 41st St. MS TELD-TPP-3, Vancouver, WA 98662.

The Bonneville Power Administration operates the high-voltage transmission network in the Pacific Northwest that includes more than 500 substations and 80,000 transmission towers. BPA is examining the vulnerability of this network to earthquake-induced ground shaking, landsliding and liquefaction hazards.

To assess the major seismic risk, BPA has studied its all of its substations along coastal Washington and Oregon states, and a sample of its transmission lines through the Cascade and the Coastal ranges. The substations are primarily vulnerable to ground shaking hazard, and locally, at a few substations, the liquefaction hazard. The transmission towers are most vulnerable to the landslide hazards in the Coastal and Cascade ranges, and liquefaction near rivers.

To process the large inventory of facilities, a GIS-based risk model called SERA (System Earthquake Risk Assessment) is used. SERA factors in high resolution details of each piece of equipment at substations, and every transmission tower. Overlaid on this inventory are the seismic hazards, computed on a scenario basis. Scenario earthquakes considered include a Cascadia Subduction Zone M 9, Intraplate M 7.5 events centered near Portland or Tacoma, and a variety of crustal events (Seattle fault, Portland fault and several others).

The landslide model factors in the following attributes: season (saturated / dry); morphology (GIS/DEM-based); aerial reconnaissance (visual examination for landslide-prone features); tower style of construction; and the initiating scenario ground motions.

We describe the BPA system's overall performance considering damage (inertial or landslide/liquefaction-induced) to each component, the redundancies in the network, and BPA's ability to restore service post-earthquake. Specifics of the landslide models used, and the difficulties encountered in trying to develop site-specific landslide forecasts by combining regional GIS-based landslide predictors such as slope and geology, site-specific issues, to more than 20,000 transmission locations at widely varying locations are examined. We address the desire to use generic landslide screening tools (High, Medium, Low) that might be suitable for a planning study versus the practicality of needing high confidence that the landslide risk is sufficiently "real" so as to merit spending real mitigation dollars.

US HIGHWAY 26 EMERGENCY LANDSLIDE REPAIR, MILEPOST 24, CLATSOP COUNTY, OREGON

Freitag, George A., CEG1, Kelsay, H. Stanley, PE, GE1, and Braibish, Thomas E., PE2

1GRI Geotechnical & Environmental Consultants, 9725 SW Beaverton-Hillsdale Highway, Suite 140, Beaverton, Oregon, 97005. gfreitag@gri.com; skelsay@gri.com.
2Oregon Department of Transportation, 123 NW Flanders Street, Portland, Oregon, 97209. Thomas.E.BRAIBISH@odot.state.or.us.

Following a period of prolonged, intense precipitation, a landslide occurred on November 7, 2006, that closed the eastbound travel lane of US Highway 26 near milepost 24 in Clatsop County, Oregon. US Highway 26 is a State Highway Freight Route with average daily traffic of about 6,800 vehicles and is the direct connector between metropolitan Portland and communities on the northern Oregon Coast.

The landslide measured about 70 ft wide at the road and extended below the roadway about 1,500 ft (horizontally) and 200 ft (vertically) to Quartz Creek. The landslide locally undermined the outside 1 to 3 ft of pavement, and about 50 ft of guardrail was hanging in mid-air.

The Oregon Department of Transportation (ODOT) contracted GRI to investigate the landslide and develop a plan for repair. Field investigation revealed the landslide area to be generally underlain by soft to medium-hard Tertiary marine sandstone mapped as Cowlitz Formation. Rock Quality Designation (RQD) ranged from 8 to 100%; RQD values were in excess of 90% below a depth of 20 ft. The cored sandstone typically exhibited close to wide joints with local secondary calcite mineralization along discontinuities. Laboratory unconfined compressive strength measurements ranged from 130 to 8,410 psi (n = 16), with values generally increasing with depth.

After consideration of geologic, topographic, right-of-way, and mobility constraints, an anchored soldier pile/micropile wall system was selected for the repair. Berger/ABAM Engineers, Inc. assisted GRI with structural engineering and preparation of construction documents. By December 12, 2006, Moore Excavation, Inc. and their specialty micropile contractor, Scheffler Northwest Inc., were on-site installing the wall system. ODOT reopened the eastbound travel lane to the public on December 31, 2006, meeting the contract requirements of this emergency repair.

SCHOONER LANDING RESORT LANDSLIDE NEWPORT, OREGON FIELD EXAMINATION AND MITIGATION DESIGN

John Jenkins, PG, Senior Engineering Geologist, PBS Engineering and Environmental, Inc.

The Schooner Landing Resort, located on the coast in Newport, Oregon has an active landslide within its boundaries. The landslide failure is in seaward dipping sedimentary rocks. Past problems from various ground movements within this slide required re-leveling building #5 several times a year and relocating all of its underground utilities. Although previous engineering companies had conducted subsurface investigations, no credible mitigation designs were ever developed. The Resort finally engaged PBS to develop corrective actions.

Our work was carried out in a series off sequential phases, starting with detailed landslide/geologic mapping and examining existing engineering reports. The engineering information in these reports and field observations were used to develop a plan to fill in gaps in the data. A subsurface investigation was performed consisting of installing a pumping well to investigate the potential for dewatering, and drilling three borings in critical areas. Multi-level piezometers and slope indicators were installed and monitored and a pump test was completed. The additional borings were used to evaluate the response to pumping and the potential effectiveness of drainage by vertical wells or horizontal drains and provide additional landslide movement data. The dewatering well is currently pumping.

Based on this fieldwork, we developed an understanding of the landslide's geometry and developed a conceptual model of the failure mechanics. From this, we developed a series of remedial treatments consisting of an array of surface drains, vertical wells, and horizontal drains. We are presently in the process of developing construction-related documents, including cost estimates, for stabilizing the slope.

GIANT LANDSLIDES IN THE COBURG HILLS: IMPLICATIONS TO URBAN RURAL DEVELOPMENT

Ian P. Madin, Robert B. Murray, Oregon Department of Geology and Mineral Industries (DOGAMI)

Recent geologic mapping of the Coburg Quadrangle in the southern Willamette Valley has identified a series of major landslides originating from the nearly 800-m high escarpment of the Coburg Hills. Although much of the hills are currently timberland, they are close to the rapidly growing Eugene urban area, and will soon be a site for rural residential development. Understanding the landslide hazards of the area will be crucial to managing this development.

The Coburg Hills consists of a thick sequence of Oligocene basalt flows overlying Eocene and Oligocene volcaniclastic and marine sedimentary rocks. A silicic ash flow interbedded with the basalt flows appears to be the main failure plane for major landslides, probably because it has relatively low permeability. Horizons of severely weathered and altered basalt are also failure planes.

Landslides typically cover 0.5-1.5 km3, and extend over an elevation range of 300-500 m. The slides commonly coalesce into large complexes. From head to toe, the slides consist of steep, , arcuate scarps;, zones of bench-and-scarp topography;, and toes that consist of debris fans resembling large alluvial fans.

We interpret the history of these slides to begin with a catastrophic failure that produced a major debris avalanche which formed the fan-like toes, followed by continued slow failure by block gliding and slumping in the headwall, scarp and bench regions. This sequence has significant implications for future development. It is probably unreasonable to restrict development of the debris avalanche deposits at the base of the slides, because these areas are neither likely to slide further, nor are they likely to experiences future debris avalanches. On the other hand, the steep slopes on the upper reaches of the slides are clearly hazardous for development because of their abundant. small block slides and slumps. However, the greatest risk to life safety is on steep slopes between slides, because future catastrophic failures and debris avalanches are most likely there.

A NEW LANDSLIDE DATABASE FOR OREGON

Ian P. Madin and William J. Burns, Oregon Department of Geology and Mineral Industries (DOGAMI)

In 2007, DOGAMI is preparing a new digital map and database of Oregon landslides as part of a multi-year partnership with the U.S. Geological Survey's landslide program. Over the years, geologists have mapped hundreds of landslides around the state, typically in the course of geologic mapping. Since the landslide information in these maps is not easily available to the general public and local government officials, we are compiling all of the mapped landslides from these sources into a single, uniform, statewide database. This new database will provide a base layer for future efforts to systematically map all landslides in the state using new LiDAR topographic images.

About half of the state is already covered by DOGAMI's OGDC v. 3 digital database which is compiled from the best available mapping. OGDC v. 3 contains 1898 discrete landslide polygons, covering 2000 km2, which is about 1.4% of the entire map area. The landslide database will start with the landslides extracted from OGDC v. 3, and then will cover the rest of the state by digitizing and attributing slides from digital and paper maps.

The database will include information about the age and style of sliding, and will document the map source from which it came. When completed, the new database will be made available as a theme on DOGAMI's interactive geologic map website (http://www.oregongeology.com/sub/ogdc/index.htm) so that the information is readily available to geologists, engineers, planners and the general public.

ASSET MANAGEMENT – BASED UNSTABLE SLOPE RATING SYSTEM FOR OREGON HIGHWAYS

Curran Mohney, C.E.G. and Jamie Schick, C.E.G., Oregon Department of Transportation (ODOT)

The Oregon Unstable Slope Rating System is a new method for rating landslide and rockfall hazards along the Oregon State highway system that follows the Asset Management principles brought forth by the Federal Highway Administration. Previous rating systems used by the agency focused on rockfall problems while ignoring landslides. These systems also focused on the risk of failure but disregarded the consequence of failure at the site as well as the large-scale function of the system. Oregon highways span numerous physiographic and geographic boundaries, each having its own particular stability issue such as high rock cuts in mountainous areas, or large embankments on steep slopes in areas of high annual precipitation. This variability necessitates a rating system that can normalize the differences between physiographic provinces.

In the new Unstable Slope Rating System, risk and consequence are measured equally, but are separable for various analyses conducted under the Asset Management framework. Three main parameters are used to assess unstable slopes: 1) hazard score, 2) route hierarchy, and 3) maintenance and repair cost-to-benefit. These parameters are combined to make effective decisions concerning landslide and rockfall project prioritization, and to evaluate a program's overall financial needs so that long-term funding strategies can be developed.

Information used to develop an individual score is obtained through field and office analyses. Field reconnaissance assessments are conducted for each unstable slope identified to collect information such as site distance, beginning and end points, and cross section. This information is collected and stored in the field along with a GPS point using a Trimble GeoXT. Roadway maintenance managers are interviewed for information such as frequency of events, road closure, accidents, and maintenance costs, the latter being used as part of the cost-benefit analysis. Additional information considered includes detour lengths and average daily traffic (ADT). This information is used to develop a hazard score which is then used to produce an overall score that includes conceptual design costs and maintenance costs. Once the rating is complete, the information is exported to ODOT's GIS platform.

The schedule for State highway surveys generally follows the OTIA prioritization, starting with the interstates and working progressively through secondary highways. The current program effort targets critical slopes for each of ODOT's five Regions. This will allow the more problematic unstable slopes to be incorporated early into the database and potentially targeted for mitigation funding. Currently, approximately 10 percent of the State highways have been surveyed. Up-to-date landslide and rockfall information will soon be available on the agency's website.

SOIL ENGINEERING PROPERTIES OF LANDSLIDE AND DEBRIS FLOW INITIATION SITES, COAST RANGE, OREGON

McKenna, Jonathan P.1, Amblard, Xavier2

1U.S. Geological Survey, Denver Federal Center, Box 25046, MS 966, Denver, Colorado, 80225. jmckenna@usgs.gov. 2Ecole Polytechnique Universitaire Pierre et Marie Curie, de l'Université Paris VI, Scences de la Terre, Tour 56-66 – 2éme étage, case 95, 4 Place Jussieu, 75232 Paris France. xavier_amblard@yahoo.fr

Hundreds of debris flows and landslides occurred in the Oregon Coast Range as a result of heavy rainfall during the months of December 2005, and January 2006. Shallow translational slides and partially liquefied debris flows occurred adjacent to one another. Our field-and lab-based study attempts to explain this relationship by identifying physical differences between soils from the initiation locations of landslides and debris flows in a geologically homogenous terrain. Specific soil properties analyzed in this study are grain-size distribution, porosity, and saturated hydraulic conductivity.

Seven field sites in the Tyee Basin, Oregon, including 14 landslides and 21 debris flows were investigated during the spring and summer of 2006 Soils at all the sites are derived from the underlying Tyee Sandstone. Soils were sampled and measurements made within 2 m upslope of the head scarp of each failure. We collected bulk samples to determine the soils' grain-size distribution, used a modified California sampler on the moist ground to collect undisturbed samples for porosity analyses, and used a field permeameter to measure in-situ saturated hydraulic conductivity.

All soils weathering from the Tyee Sandstone are predominately sand with minor silt and clay, but soils from debris-flow sites contain more fine-grained sand than do those from the landslide sites; however detailed grain-size distribution tests are still ongoing.

Preliminary results indicate that initial porosity affects style of failure. Soils that mobilized as debris flows had an average porosity of 0.55 ± 0.04 while soils that failed as landslides had an average porosity of 0.48 ± 0.02. This is significant because soils initially less porous than "critical" dilate as they begin to shear, while soils initially more porous tend to contract.

Saturated hydraulic conductivity measured at most debris-flow initiation sites clustered between 1.0 x 10-3 to 1.0 x 10-4 cm/s, while at landslide initiation sites, conductivity ranged from 1.5 x 10-2 cm/s to 1.5 x 10-4 cm/s. The optimum saturated hydraulic conductivity for debris-flow initiation is approximately 5.0 x 10-4 cm/s which allows water to enter the soil column rapidly yet be retained in sufficient quantity to partially liquefy the soils upon shearing.

LANDSLIDES MAPPED USING LIDAR IMAGERY, KITSAP COUNTY, WASHINGTON

McKenna, Jonathan P., Lidke, David J, and Coe, Jeffrey A., U.S. Geological Survey, Denver Federal Center, Box 25046, MS 966, Denver, Colorado, 80225. jmckenna@usgs.gov.

Landslides are a recurring problem on hillslopes throughout the Puget Lowland, Washington but can be difficult to identify in this densely forested terrain. However, digital terrain models of the bare-earth surface derived from LiDAR data express topographic details sufficiently well to identify landslides. Landslides and escarpments were mapped using LiDAR imagery and field checked (when permissible and accessible) throughout Kitsap County, WA. We relied almost entirely on derivatives of LiDAR data for our mapping including topographic contour, slope, and hill-shaded relief maps. Each mapped landslide was assigned a level of "high" or "moderate" confidence based on the LiDAR characteristics and on field observations.

A total of 232 landslides were identified representing 0.8% of the land area mapped. Earth topples, shallow falls, and deep-seated landslide complexes are the most common types of landslides. The smallest feature covers an area of 252 m2, while the largest covers nearly 9 km2. Previous mapping efforts relying solely on field and photo-grammetric methods identified only 53 % of the landslides (32% high confidence and 21% moderate confidence). The remaining 47% we identified using LiDAR have 8% high confidence and 39% moderate confidence. Coastal areas are especially susceptible to landsliding; 53% of the landslides mapped lie within 250 m of the present coastline. The remaining 47% occur along drainages farther inland.

The LiDAR data we used for mapping have some limitations including: 1) rounding of corners between low slope surfaces and vertical faces (i.e. along the edges of steep escarpments) which results in scarps being mapped too far headward), 2) incorrect distance measurements, 3) removal of valid ground elevations, 4) false ground roughness, and 5) faceted surface texture. Several of these limitations are introduced by algorithms in the processing software that are designed to remove non-ground elevations from LiDAR data. Despite these limitations, the algorithm-enhanced LiDAR imagery does effectively "remove" vegetation that obscures many landslides, and is therefore a valuable tool for landslide inventories and investigations in heavily vegetated regions such as the Puget Lowland.

CONCEPT PLAN PROCESS FACILITATES THE UPDATE OF MUNICIPAL CODE FOR LANDSLIDE SUSCEPTIBILITY

Tova Peltz, PE, RG1 and Christina Robertson-Gardiner2

1GRI Geotechnical and Environmental
2City of Oregon City

In 2002, nearly 300 acres of rural land located just east of Oregon City were brought into the Portland Metropolitan Urban Growth Boundary (UGB) to accommodate future growth. The Park Place Concept Plan was developed to help the City of Oregon City (City) prepare for this growth by working with local citizens, area stakeholders, and local and regional jurisdictions to develop a common vision for the area. Development of the Concept Plan has been a community-based process, led by the Design Team, which includes land use planners, engineers and City planners, and the Project Advisory Committee (PAC).

Early in the Concept Plan process, the local community identified their its concern regarding landslide hazards and future development. Several local property owners described their own experiences with landslide-related property damage that occurred during the 1996 storms. These experiences reflect an extensive history of landslides in Oregon City and its surroundings, typically associated with landslide-prone, fine-grained soils, steep topography, and groundwater conditions. This history has been well documented in many publications.

These Landslides have caused millions of dollars of property damage for the City and local property owners and continue to occur. The City recognizes the ongoing risk associated with development in landslide-susceptible areas. and, Wwith the Design Team, the City hired GRI to conduct a preliminary geotechnical and geological evaluation of the concept plan area, specifically to 1) identify, on a preliminary basis, the potential geologic hazards associated within the study area, and 2) provide geotechnical considerations for future development.

GRI's evaluation consisted of a limited field reconnaissance and extensive review of geologic reports, maps, available geotechnical reports, subsurface information, and aerial photographs. GRI developed a practical guide provided a document for the Concept Plan to serve as a practical guide to assist the City in their understanding and management of the short- and long-term geologic risks associated with future development in the Park Place Concept Plan area. The City is using this document as a transitional document to update the municipal code toand better identify and mitigate landslide hazards for future development within the City. In the longer term, the City is working with DOGAMI to incorporate a future landslide susceptibility map (expected publication date in late 2008) into its municipal code as a specific reference document to identify the level of geotechnical and geologic investigation required for future development within the City.

PRODUCING THE OREGON CITY LIDAR MAP

Ian P. Madin and William J. Burns, Mark Sanchez, Cartography - Oregon Department of Geology and Mineral Industries (DOGAMI)

During 1996 and 1997, heavier than normal rains in Oregon caused thousands of landslides. Over 700 of these landslides were mapped in the Portland metropolitan area (Burns et al., 1998). Some of these slides were the reactivation of ancient and historically active landslides, and some were new failures. Many of these slides occurred within the Oregon City area; an inventory of these landslides is available through Oregon Department of Geology and Mineral Industries (DOGAMI) Special Paper 34 (Hoffmeister, 2000).
During the 2005-06 winter season, Portland and most of western Oregon again experienced heavier than normal rainfall, which resulted in hundreds of landslides. Again, many of the landslides were also reactivation older landslides, several occurred in the Oregon City area, impacting infrastructure as well as several residential homes and an apartment complex. making the identification of Identifying these existing ancient and historic landslides is thus an obvious priority in the attempt to begin the reduction of reduce the risk from landslide damages. Several of these reactivated landslides occurred in the Oregon City area, impacting infrastructure as well as several residential homes and an apartment complex.

The accompanying map is designed to provide timely access to new information about potential landslide hazards in the Oregon City area. The new information comes from two sources, a recently completed geologic map of the Oregon City 7.5 minute quadrangle (Madin, in preparation) and high-resolution topographic data in the form of a digital elevation model (DEM) derived from light detection and ranging (LIDAR) surveys conducted by the City of Oregon City. This landslide information will eventually be published both as part of the geologic map and as part of a regional landslide geomorphology map. Oregon City is the first Oregon community for which this kind of high resolution landslide geomorphologic mapping is available.

METHODS

The two primary data sources were used to make this map: were serial stereo aerial IR photos of a variety of scales, and a LIDAR-based DEM provided by the City of Oregon City. Landslide geomorphology from both sets of imagery was compiled and then combined using geographic information system (GIS) software (MapInfo™).

The majority Most of the landslide topography occurs in canyons that cut the Oregon City plateau where slopes are typically forested, and topography is obscured when forest cover is intact. In an attempt to get around this problem, a time series of aerial IR photos was examined (1939, 1948, 1956, 1964, 1973, 1980, 1990, and 2000). For all of these photo series, stereographically photo pairs were examined
to look for topography characteristic of landslides such as steep arcuate scarps (cliffs), hummocky topogra-

phy, and cracks and grabens (troughs or depressions) on the surfaces of slopes, and irregular lobate toes. The outlines of areas of landslide topography were transferred from the stereo photos to the GIS by heads-up digitization on a geo-referenced (UTM Zone 10, NAD 27) image of the USGS 1:24,000 scale topographic map (digital raster graphic: DRG). The transfer was accomplished with the DRG zoomed to scales between 1:12,000 and 1: 6,000.

After the completion of the aerial photography analysis was completed, high-resolution, bare- earth LIDAR data became available from the City of Oregon City. LIDAR data are collected by scanning the ground with a laser rangefinder flown in a precision-navigated aircraft. The resultant cloud of elevation data is processed to remove laser returns from vegetation and structures, producing an accurate and detailed model of the shape of the ground surface.

We processed the Oregon City LIDAR data-points to produce a DEM grid (Oregon State Plane N, 1983) with 5 ft by 5 ft cells, then enhanced that DEM with both relief shading and slope maps to highlight subtle topography. We also produced elevation contours at 2- ft intervals to help visualize the data. We then digitized the areas of landslide topography directly from LIDAR imagery at a scale of 1:2400, again using topographic evidence such as scarps, hummocky terrain, and lobate toes. An additional advantage of the LIDAR data was that we could instantly produce topographic cross sections along a suspect slope. With the LIDAR data it was also possible to see subtle fan deposits at the mouths of small canyons that we interpret as debris flow or earth flow deposits.

We compared the areas of landslide topography mapped in this study with those mapped in previous studies (Hammond and others, 1974; Schlicker and Finlayson, 1979; Burns, 1999). We found that previous maps identified most of the larger (greater than 5 acres) slide areas, but LIDAR data provided much more accurate delineation of the boundaries of the areas. Previous studies identified only a few of the smaller slide areas and, in several cases, identified areas which did not show any visible landslide features on the LIDAR DEM. Only the LIDAR DEM showed deposits of debris flows and earth flows. Our confidence in the existence, types, and boundaries of the larger slide areas identified on the LIDAR DEM is very high; we are less confident regarding the more numerous smaller slide areas.

EVALUATION AND MONITORING OF LANDSLIDE HAZARDS ALONG THE OAK LODGE WATER MAIN, CLACKAMAS COUNTY, OREGON: THREADING A NEEDLE WITH A 24-INCH PIPELINE

Erick J. Staley, GeoDesign, Inc., 15575 SW Sequoia Parkway, Suite 100, Portland, Oregon 97224.

The Oak Lodge Water District manages a 24-inch-diameter water main located west of Gladstone, Oregon that serves as a primary link between two 5-million-gallon reservoirs and thousands of residential and commercial properties served by the district. The water main is located between two ancient landslides, parts of which may be active. Although the water main was installed in 1964 and apparently has not experienced damage related to landsliding, repeated cracking in roadways and damage to residences from possible ground movement in the site vicinity caused concern for the water main's stability.

A study of the landslide hazards potentially impacting the water main has been conducted since early 2004 including review of LiDAR ground surface data, reconnaissance landslide mapping, monitoring inclinometers and vibrating-wire piezometers from two borings advanced along the pipeline alignment, and monitoring strain gauges installed on the pipeline.

The limits of the ancient landslide scarps and their respective slide masses are evident on digital elevation models from the LiDAR data. LiDAR data were also used to create an accurate ground surface profile through dense residential development where surveying would have been extremely difficult considering the number of parties involved. Boring logs indicate colluvial soils overlying silts and clays of the Sandy River Mudstone, which in turn overlie weathered basalt of the Columbia River Basalt Group. The interpreted primary slide plane lies along the basalt-mudstone contact; several secondary scarps have developed within each slide mass.

While landslide movements may have damaged residences and roads in the vicinity, the water main appears to be favorably aligned between the two landslides. Recent inclinometer data do not indicate any significant displacement has occurred, while piezometer data show a seasonal variation in water levels of approximately 5 feet. Strain gauges could not be used to evaluate pipe stress because the seasonal change in water temperature within the pipeline causes thermal expansion exceeding the thresholds of the strain gauges.

Future work will include continued monitoring of the pipeline instrumentation to check for subsurface displacement and to establish a range of expected water levels during average to wet winters.

IMPROVING THE 2002 GEOGRAPHIC INFORMATION SYSTEM (GIS) OVERVIEW MAP OF POTENTIAL RAPIDLY MOVING LANDSLIDES IN WESTERN OREGON

Yumei Wang, Oregon Dept of Geology and Mineral Industries (DOGAMI)

Since 2005, DOGAMI has been collaborating with the U.S. Geological Survey and conducting research to improve the accuracy of predictive modeling for debris flows using newly available high-resolution LiDAR. To date, DOGAMI has used LiDAR to identify existing landslides but not for predictive modeling. DOGAMI and the USGS are beginning to conduct pilot studies to develop debris flow hazard maps using LiDAR. Forthcoming LiDAR-based maps will replace the preliminary IMS-22 product, which has been publicly available since 2002. The Geographic Information System (GIS) data from IMS 22 have been plotted at a scale of 1:500,000. A synopsis of the IMS 22 text is provided below.

The preliminary IMS-22 product indicates areas in western Oregon where rapidly moving landslides (debris flows) pose potential hazards. These data provide preliminary but important information to local governments and other property owners about locations that may require site-specific evaluation to determine the actual risks. IMS-22 was co-developed by the Oregon Department of Geology and Mineral Industries (DOGAMI), Earth Systems Institute; Oregon Department of Forestry; and Oregon Department of Land Conservation and Development (Hofmeister and others, 2002).

The extent and severity of the hazard posed by rapidly moving landslides varies considerably across western Oregon. In general, the most hazardous areas are in mountainous terrains—which fortunately are usually sparsely populated—especially drainage channels and depositional fans associated with debris flows.

The IMS 22 data was developed with GIS-based digital modeling, checking and calibrating the models with limited field evaluations, and comparing the models with historic landslide inventories. The GIS data provided in the IMS 22 publication were developed with data at a scale of 1:24,000 (1 in. = 2,000 ft). Therefore, the data are appropriate only at that scale or smaller (e.g., 1:48,000) and cannot show greater detail if enlarged.

Landslides are a serious geologic hazard in Oregon, threatening public safety, natural resources, and infrastructure; and costing millions of dollars for repairs each year. The IMS 22 product is part of the State's attempt to protect the lives and property of its citizens. It does not aim to address all possible landslide hazards, such as rotational landslides and lateral spreading.

Reference: R. Jon Hofmeister, Daniel J. Miller, Keith A. Mills, Jason C. Hinkle, and Ann E. Beier, 2002, "Geographic Information System (GIS) Overview Map of Potential Rapidly Moving Landslides in Western Oregon, Oregon Department of Geology and Mineral Industries Interpretative Map Series IMS 22, 52p.

EVALUATION OF COASTAL EROSION HAZARD ZONES ALONG DUNE AND BLUFF-BACKED SHORELINES IN SOUTHERN LINCOLN COUNTY: SEAL ROCK TO CAPE PERPETUA

Robert C. Whitter, Jonathan C. Allan, and George R. Priest, Oregon Department of Geology and Mineral Industries (DOGAMI), Coastal Field Office, 313 SW 2nd St., Suite D, Newport, Oregon 97365

Four coastal erosion hazard zones for both dune- and bluff-backed shorelines in southern Lincoln County are defined by a digital geographic information system (GIS) database. Our approach follows methods used by Allan and Priest (2001) and Priest and Allan (2004) to evaluate coastal erosion hazards for Tillamook and northern Lincoln Counties, respectively. The database presented here, when combined with erosion hazards data from northern Lincoln County, will provide seamless digital maps that can be used by County and local land use planners to revise ordinances that promote safer and more sustainable development in shoreland, beach and dune environments.

The database includes a map that depicts four erosion hazard zones: the active-hazard zone and the high-, moderate- and low-hazard zones. The active hazard zone is considered the area of beach and bluff subject to historical erosion processes. The high-, moderate-, and low-hazard zones may be viewed as potential areas of future expansion of the active-hazard zone. The erosion hazard zones are derived in part from a 1:4,800-scale shoreland geologic map that extends 1,500- to 3,500-ft (460- to 1070-m) landward of the shoreline. Polygons on the map include geologic units that identify landslides, slide block, and earth flow deposits and classify these features as active, potentially active, or prehistoric. Historical bluff-top erosion rate data, also used to define erosion hazard zones, were estimated from analysis of historical aerial photography, LiDAR and precise surveys using a Trimble 5700/5800 Real-Time Kinematic Differential Global Positioning System (GPS). Estimated bluff-top erosion rates between 1939 and 2007 range from 0 ± 0.21 to -0.49 ± 0.09. Finally, the database also includes a compilation of previously mapped landslides and landslide terrain within 9.5 mi (15.3 km) of the coast.

The active-hazard zone for southern Lincoln County encompasses areas of coastal bluffs and dunes undergoing active erosion, whether by extreme wave erosion, near-shore sediment transport, gradual erosion or mass wasting processes. On dune-backed shorelines, the active-hazard zone reflects the zone of historical beach variability. On bluff-backed shorelines the active hazard zone includes the beach, bluff toe and escarpment, all seaward of the top edge of the bluff.

Three additional scenario-based hazard zones were mapped for dune-backed beaches using a geometric model that predicts the landward extent of erosion when the total water level, produced by storm wave runup superimposed on the tide, exceeds the elevation of the junction between the beach and the dune.

High-, moderate- and low-hazard zones for bluff-backed shorelines predict areas of future erosion derived from calculations that consider coastal geologic mapping, the slope of repose for talus of bluff materials, historical bluff erosion rates, and empirical estimates of maximum landslide block widths. Bluff hazard zones are defined by three scenarios that have decreasing relative likelihood over the next 60 to 100 years.

HAZARD MAPS FOR DEBRIS FLOWS AND ROCK AVALANCHES USING GIS AND LIDAR

Griswold, Julie, and Iverson, Richard, US Geological Survey Cascades Volcano Observatory, 1300 SE Cardinal Ct., Bldg. 10, Vancouver, WA 98683 (360) 993-8949

Hazard maps for lahars, non-volcanic debris flows, or rock avalanches can be prepared using a GIS method employing statistically calibrated predictive equations, LAHARZ software (Schilling, 1998), and digital elevation models (DEMs) to compute and depict patterns of inundation downstream from potential source areas. Although coarse, low-resolution DEMs derived from USGS topographic maps are adequate for assessing hazards from large volcanic lahars, high-accuracy, high-resolution DEMs are necessary to compute and depict hazards from non-volcanic debris flows that are typically smaller than 100,000 cubic meters.

This poster shows examples of computed hazard zones for such prospective rock avalanches along Highway 20 above Newhalem, Washington, and for debris flows along the Umpqua River in southern Oregon. The Newhalem DEM has a minimum resolution of 10 meters. The Umpqua River DEM, generated from LIDAR (light detection and ranging technology) data obtained from the Oregon Department of Forestry, has a resolution of 1 meter.

Uncertainty and error in the hazard maps are addressed in two ways: 1) Standard statistical techniques are used to assess the error in the semi-empirical equations that predict the maximum valley cross-sectional areas and, 2) total downstream planimetric areas likely to be inundated by landslides of various volumes. Nested hazard zones showing inundation limits for prospective landslides with a range of volumes depict the uncertainty in predicting the volumes of future landslides descending any particular drainage.
Hazard zones generated using these methods appear to be comparable to those generated by traditional field mapping techniques but are objective and reproducible.