OVERVIEW OF THE WGS LANDSLIDE MAPPING PROGRAM

Kate Mickelson LG
Landslide Hazards Program
Washington Geological Survey
Washington Department of Natural Resources
OBJECTIVES

• Discuss landslide types
• Briefly describe the WGS Landslide Hazards Program
• “Why do we need landslide mapping?”
• Describe how we map landslides and landslide susceptibility
WHY DO WE NEED LANDSLIDE MAPPING?

- **Who:** Planners, emergency managers, public works, community leaders, GIS user, and the public
- **What:** landslide hazard mapping based on best available science
- **Why:** Evaluate the potential hazard to people and property when considering development
  - Building codes and CAO
  - Types of the land uses and construction methods
- **Results:** Create a disaster-resistant population (resiliency!)
WHAT IS A LANDSLIDE?

• Downslope movement of soil, rocks, vegetation, water, etc. driven by gravity

• Two types of landslides
  • Shallow
  • Deep
SHALLOW VS. DEEP

• Difference? Location of the failure surface
  • Deep landslide failure surface in bedrock
  • Shallow landslide failure surface in “soil”
  • Rate of movement
SHALLOW LANDSLIDES

- Debris slides, debris avalanche, debris flows
  - Media calls them: mudslide, mudflow, slide
- Most common landslide category and often associated with land use
DEEP LANDSLIDES

- Often associated with long periods of precipitation
- When reported, nearly always a pre-existing landslides that reactivated
SIGNIFICANT DEEP LANDSLIDES

• Perkins Lane, 1997
• Aldercrest-Banyan in Kelso, 1998
• Carlyon Beach in Thurston County, 1999
• Ledgewood on Whidbey Island, 2013
• SR 530 “Oso” slide, 2014; killed 43 people
• Nile, Index, Hazel
• All reactivated landslides
PERKINS LANE LANDSLIDE, 1997

Reactivated landslide in the Magnolia District of Seattle claimed five houses
ALDERCREST-BANYAN LANDSLIDE, 1998

Two years of above-average rainfall reactivated a deep landslide and destroyed 135 homes. FEMA buyouts up to $0.30 to the dollar. >$110 million in damage
February 1999. After 3 years of above-average rainfall, movement began on a dormant landslide, forcing 36 families from their homes.
DNR LANDSLIDE HAZARDS PROGRAM

- Five landslide hazards geologists
- Emphasis is landslide mapping around population, infrastructure, highways
- Map inventory (where landslides have occurred) and susceptibility (where landslides may occur)
WHAT’S SO IMPORTANT ABOUT LANDSLIDES?

• Landslides are the most poorly understood geologic hazard
  • People are surprised by landslides

• Internationally, between 2004-2010, 2620 fatal landslides killed a total of 32,322 people (Petley, 2012)
  • Excludes seismically-induced landslides

• US doesn’t keep statistics on landslides
  • In Washington, the average annual loss from landslides is >>$20 million

• >58,000 landslides mapped in Washington
  • ~10% of the state has detailed, systematic mapping
  • Majority of mapping in managed forestlands
WHY IS LANDSLIDE MAPPING IMPORTANT TO CITIES AND COUNTIES?

Growth Management Act (GMA)

There are five critical areas identified in the GMA:

- Wetlands
- Areas with a critical recharging effect on aquifers used for potable water
- Frequently flooded areas
- Geologically hazardous areas
- Fish and wildlife habitat conservation areas
GEOLOGICALLY HAZARDOUS AREAS

Areas susceptible to one or more of the following types of hazards:

- Erosion hazard (including river and coastal streambank erosion areas and channel migration areas)
- Landslide hazard
- Seismic hazard
- Areas subject to other geological events such as coal mine hazards and volcanic hazards including: mass wasting, debris flows, rock falls, and differential settlement

“Counties and cities should consider classifying geologically hazardous areas as either known or suspected risk, no risk, or risk unknown where data are not available to determine the presence or absence of a geological hazard.” - Critical Areas Assistance Handbook
LANDSLIDE DAMAGE IS PARTICULARLY COSTLY TO LOCAL GOVERNMENT

- All geologic hazards can be insured except landslides and earth movement
- For those with landslide-damaged property litigation is often the only recourse
WHAT IS LIDAR?

- light pulses
- light pulse return
- point cloud colored by elevation
- first return (top surface)
- last return (bare earth)
TOP SURFACE
“first returns” including trees and structures interpolated into a continuous surface
vertical view ➔ oblique view ➔
colored elevation surface with shaded relief

BARE EARTH
“last returns” of the bare ground interpolated into a continuous surface
vertical view ➔ oblique view ➔
colored elevation surface with shaded relief
LIDAR AT DGER

- RCW 43.92.025 - DGER granted funding to collect, maintain, and distribute lidar data in support of geologic hazards
  - Collect high quality data that will support multiple applications
  - Maintain and offer lidar collection contract services
  - Partner with state, local, tribal and Federal agencies as well as private groups to maximize resources
  - Develop a public portal for lidar data and derivative products distribution
  - Move forward with state-wide collection
- Abby Gleason - Lidar Manager - Abigail.Gleason@dnr.wa.gov

- www.dnr.wa.gov/lidar
The Process

INVENTORY AND SUSCEPTIBILITY
PHASED LANDSLIDE MAPPING

- Phase 1 - detailed landslide inventory
  - Detailed landslide inventory with attributes
  - 1:4000-scale mapping
  - Mapping extent limited
- Phase 1a - Streamlined landslide inventory protocol (SLIP)
  - Simple landslide mapping in remote areas
- Phase 2 - deep and shallow landslide susceptibility
  - Where landslide might occur
DETAILED INVENTORY
PROTOCOL FOR LANDSLIDE INVENTORY MAPPING FROM LIDAR DATA IN WASHINGTON STATE


WASHINGTON GEOLOGICAL SURVEY
Bulletin 81
April 2017

PEER REVIEWED
### Landslide Mapping Protocol Database Schema

- **landslide_deposit** (polygon)
  - LANDSLIDE_ID
  - MATERIAL
  - MOVEMENT
  - MOVE_CODE
  - CONFIDENCE
  - RELATIVE_AGE
  - YEAR_MOVE
  - FIELD_VERIFIED
  - SLOPE_DEG
  - HS_HEIGHT_FT
  - FAIL_DEPTH_FT
  - MVMT_AZIMUTH_DEG
  - VOLUME_FT3
  - AVG_SCARP_DIST_FT
  - COMMENTS

- **fan** (polygon)
  - FAN_ID
  - FAN_TYPE
  - CONFIDENCE
  - RELATIVE_AGE
  - YEAR_MOVE
  - FIELD_VERIFIED
  - SLOPE_DEG
  - FAN_HEIGHT_FT
  - FAN_VOLUME_FT3
  - COMMENTS

- **field_check_simple** (point)
  - LANDSLIDE_ID
  - FAN_ID
  - ROCKFALL_ID
  - FIELD_DATE
  - LS_NAME
  - LAND_USE
  - HEADSCARP
  - FLANKS
  - INT_SCARP
  - HUMBROCKS
  - INT_CRACKS
  - CROWN_CRACKS
  - SAG_POND
  - SPRING_SEEP
  - WETLAND
  - PISTOL_BUTT
  - SWALE_TREE
  - LEANING_TREE
  - DISRUPTED_STREAM
  - FRESH_SOIL_ROCK
  - INTERNAL_SLIDE
  - ROAD
  - RAIL
  - HOUSE
  - STRUCTURE
  - PIPELINE
  - BRIDGE
  - UTILITIES
  - COMMENTS

- **scarp_and_flank** (polygon)
  - LANDSLIDE_ID
  - SCARP_FLANK_ID
  - COMMENTS

- **scarp** (line)
  - LANDSLIDE_ID
  - SCARP_ID
  - COMMENTS

- **rock_fall_deposit** (polygon)
  - ROCKFALL_ID
  - CONFIDENCE
  - RELATIVE_AGE
  - YEAR_MOVE
  - FIELD_VERIFIED
  - SLOPE_DEG
  - MVMT_AZIMUTH_DEG
  - COMMENTS

- **rock_fall_scarp** (line)
  - ROCKFALL_ID
  - RF_SCARP_ID
  - COMMENTS

- **recent_landslide_point** (point)
  - RECENT_LS_ID
  - MATERIAL
  - MOVEMENT
  - CONFIDENCE
  - LOCATION_Accuracy
  - YEAR_OBSV
  - DATE_MOVE
  - FIELD_VERIFIED
  - MAPPING_SOURCE
  - VISIBLE_RUNOUT_FT
  - COMMENTS

- **SLIP_landslide** (polygon)
  - SLIP_ID
  - CONFIDENCE
  - COMMENTS

*denotes domain field*
SUSCEPTIBILITY MAPPING
SHALLOW LANDSLIDE SUSCEPTIBILITY

- DOGAMI SP-45
- Soil properties
- Slope gradient
- Factor of safety formula
Pierce Counties unstable slopes layer
LHP shallow landslide susceptibility

- Reduced area by 59%
- 99.6% capture rate of shallow landslide points
DEEP LANDSLIDE SUSCEPTIBILITY

- DOGAMI SP-48
- Susceptible geologic units
- Susceptible geologic contacts
- Slope
- Preferred direction of movement
Compared to the existing Pierce County unstable slopes layer, the LHP landslide and susceptibility areas results in a 51% reduction in area.
DISSEMINATION OF INFORMATION
WEBSITE AND FACT SHEETS
A Homeowner’s Guide to Landslides
for Washington and Oregon

HOMEOWNER’S GUIDE TO LANDSLIDES

- Landslide triggers
- Areas prone to landslides
- Signs of landslide activity
- How to reduce your risk
Proposed Project Area
for Landslide Inventory and Susceptibility Mapping in King County
FINAL THOUGHTS

• Final product is an updated unstable slopes layer that uses the best available lidar and follows scientifically sound methods...

• ...following protocols developed by Oregon geologic survey and used for nearly a decade
  • USGS funded the study and validated the methods
  • Our data is reproducible and methods transparent

• WGS Landslide Hazards Program has nearly 50 years combined landslide mapping experience

• Data is published and distributed freely

• WGS landslide staff are working with Commerce to develop planners guide...
HOW TO INTEGRATE WGS DATA

<table>
<thead>
<tr>
<th>Mapped landform</th>
<th>Points</th>
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<tbody>
<tr>
<td>Deep Moderate</td>
<td>1</td>
</tr>
<tr>
<td>High</td>
<td>2</td>
</tr>
<tr>
<td>Shallow Moderate</td>
<td>1</td>
</tr>
<tr>
<td>High</td>
<td>2</td>
</tr>
<tr>
<td>Landslide</td>
<td>3</td>
</tr>
<tr>
<td>Tacoma Municipal Code</td>
<td>?</td>
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<table>
<thead>
<tr>
<th>Total points</th>
<th>Land use trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No review necessary</td>
</tr>
<tr>
<td>2</td>
<td>Further review? Field?</td>
</tr>
<tr>
<td>3+</td>
<td>Geotech report required</td>
</tr>
</tbody>
</table>
THANK YOU!