Landslide Hazard Management System in West Virginia Phase I

Larry Douglas and Paulus Wahjudi

2013 WVDOT/MPO/FHWA Transportation Planning Conference

September 18, 2013, Weirton, WV
Current WV DOT Landslide Management System

District based:
• 10 districts
• Overseen by District Engineers
• Varying rating criteria
• Varying naming convention
• Paper based or Mixed stored in district office

Problems:
• Civilian Reports
• Landslides are hard to locate: fixed, paved over, new or old
• Funding allocation: proper respond and repair method
• Coordination/prioritization
• Accurate inventory
Phase I Objectives
System Creation and Completing a Pilot Project in District 2

• Conducting an extensive literature review to acquire experience and lessons learnt of other State DOTs.
• Developing an effective electronic field reconnaissance method or form.
• Creating an appropriate database that could meet the current and future landslide management goals.
• Developing, pilot testing and deploying a web-enabled, GIS-based landslide application in District 2.
• Developing a beta version of the WVDOH standardized landslide hazard rating matrix.
Data Dictionary

- A standard data dictionary for landslides in WV
- Standard naming convention:
  - County
  - Road/Highway
  - Slide number
- Digital cameras were used to take photos
- Post Processing done at the office

<table>
<thead>
<tr>
<th>Date</th>
<th>Slide Name</th>
<th>Collected by</th>
<th>Slide Longitude</th>
<th>Slide Latitude</th>
<th>Center Line</th>
<th>ADT</th>
<th>Area</th>
<th>Toe</th>
<th>Scarp</th>
<th>Slope</th>
<th>Break</th>
<th>ASD</th>
<th>Ditch</th>
<th>Guardrail</th>
<th>Utilities</th>
<th>Vegetation</th>
<th>etc...</th>
</tr>
</thead>
</table>

**Date**: 
**Slide Name**: 
**Collected by**: 
**Slide Longitude**: 
**Slide Latitude**: 
**Center Line**: 
**ADT**: 
**Area**: 
**Toe**: 
**Scarp**: 
**Slope**: 
**Break**: 
**ASD**: 
**Ditch**: 
**Guardrail**: 
**Utilities**: 
**Vegetation**: 
**etc...**
Hazard Rating Matrix

• Develop the hazard rating matrix that fits best for West Virginia
• Utilize 12 criteria with varying impact factor (1-5)
  – 5: Very important
  – 1: Least impact
• Four category with odd point scaling (1,3,5,7)
  – 1 point: low risk
  – 7 point: high risk
• Rating Calculation: Total points between 39 to 273
• Overall Risk :
  – Low Risk: $39 \leq \text{Total Score} < 97$
  – Moderate Risk: $97 \leq \text{Total Score} < 156$
  – High Risk: $156 \leq \text{Total Score} < 215$
  – Very High Risk: $215 \leq \text{Total Score} \leq 273$
3. Percent of Decision Sight Distance (% DSD) [5]
4. Is this a certified emergency route (Y/N) ?[3]
5. Impact to Road Structure and Adjacent Features (i.e., such as culverts, tunnels, bridge/flyover and their technical elements) [3]
6. Expected Damage to Structures (i.e. Building, Utilities, Railroad, and other Roads/Structure) [3]
7. Rate of Movement (inches/year) [3]
Hazard Rating Matrix Components

8. Amount of Surface Water (Hydrology) [3]
9. Detour Route Distance [3]
10. Length of Landslide (feet) [3]
11. Vertical & Horizontal Displacement in Road (inches) [2]

Landslide Hazard Rating Criteria and Score
Architecture

ArcCatalog

ArcSDE API

ArcMap

MS SQL Server
- Table
- Raster Dataset
- Feature Class

Web Application

Mobile Devices

PC
Web Application Framework

- Civilian Report
- County Worker Report
- District Engineer Review
- Engineer Decision
- Resolved and Tagged with comment
- Not a slide
- Assigned a unique slide number & collect data
- Calculate Hazard Rating
- Determine Action
Civilian Report

- No login required
- Name, Address and contact information
- County of the landslide
- Free Text:
  - Location of landslide
  - Description of landslide
  - Additional comments
- Image uploading capabilities (3)
- Captcha verification
Civilian Report Feature
County Worker Report

• Provide additional detailed information
• Login required
  – Each county worker is responsible for a county
• All civilian report of landslides in that county will be listed
• County worker will provide and update of the report:
  – Latitude and Longitude
  – Additional images
  – Comments
County Worker Report
Engineer Tools

• Provide additional tools to support district and central office engineers
• Ability to show reports by Civilian and County worker
  – Sorting and filtering capabilities
• Engineers can then update the report
Engineer Reports
Viewing and Updating
Interactive Flex Map

• Interactive Map of landslides in WV
• Utilize various base maps:
  – USA Topo
  – Street Map
  – Imagery
  – WV Geological Map
• Search feature: Landslide ID
• Filters: by county, by district, etc
• Driving Directions
Interactive Flex Map
Flex Map Driving Directions
Hazard Rating Matrix Calculator

Landslide Hazard Management System

Tools Menu

Tools
- View Reports
- View Map
- Hazard Matrix Calculator for Landslide
Landslide Hazard Matrix Calculator

Select a landslide:

Search

Landslide test is at:

MODERATE RISK

Score: 165 out of 315

Fill out the following options to calculate the severity of the selected landslide

Potential Loss of Life:

- Landslides that upon failure would lead to no expected loss of life or significant economic damage
- Landslides that upon failure might cause loss of life or appreciable economic damage
- Landslides that upon failure would cause probable loss of life or serious economic damage
- Landslides that upon failure would cause significant loss of life or severe economic damage

Average Daily Traffic:

- ≤ 2000
- 2001-5000
- 5001-15000
- > 15000

Percent Decision/Actual Sight Distance [%DSD=(A/S)/(D/C)]*100:

- > 90
- 60-89
- 45-69
- < 35

School Bus/Emergency Route Distance (Miles):

- ≤ 5
- 6-15
- 16-25
- > 25

Impact to Road Structure and Adjacent Features:

- Low potential to affect road shoulder and low potential to affect adjacent features
- Low potential to affect roadway and moderate potential to affect adjacent features
- Moderate potential to affect roadway and high potential to affect adjacent features
- High potential to affect roadway and high potential to affect adjacent features
Expected Damage to Structures (i.e. Buildings, Utilities, Railroad, and other Roads/Structure):

- Low potential to affect adjacent structures
- Moderate potential to affect adjacent structures
- High potential to affect adjacent structures
- Very high potential to affect adjacent structures

Rate of Movement (inches/year)

- ≤ 1
- 1-3
- 3-6
- > 6

Amount of Surface Water

- Low
- Medium
- High
- Very high

Posted Traffic Speed (Miles/Hour)

- ≤ 15
- 16-35
- 36-55
- > 55

Detour Route Distance (Miles)

- ≤ 10
- 11-20
- 21-55
- > 55

Length of Landslides (inches)

- ≤ 197
- 198-590
- 591-995
- > 995
Repair Cost (Thousand Dollars per Landslide)
- ≤ 25
- 26-75
- 76-125
- > 125

Vertical and Horizontal Displacement of Scarp (inches)
- ≤ 5
- 6-20
- 21-35
- > 35

Annual Maintenance Cost (Thousand Dollars per Landslide)
- ≤ 10
- 11-20
- 21-30
- > 30

Level of Ground Water (Hydrogeology)
- Low
- Medium
- High
- Very High

Calculate
## Landslide Hazard History for test

<table>
<thead>
<tr>
<th>Date</th>
<th>Score</th>
<th>Risk Level (45-315)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/29/2013 3:03:03 PM</td>
<td>103</td>
<td>LOW</td>
</tr>
<tr>
<td>7/29/2013 3:04:38 PM</td>
<td>165</td>
<td>MODERATE</td>
</tr>
</tbody>
</table>
Phase I Status

- Data Dictionary is complete
- Database is populated with existing landslides in district 2
- Web Application is ready for beta testing
- Currently finalizing Hazard Rating Matrix
  - Perform testing on existing slides
Phase II

- Extend Hazard Rating Matrix evaluation to facilitate landslides in other districts
- Modify and populate database for existing landslide sites for the Districts
- Modify the web-enabled, GIS-based landslide application for the remaining Districts
- Utilize the landslide hazard rating matrix on all the gathered entries of the nine Districts.
Complete Picture

Landslide Project

Geotechnical Data Management Project

Geotechnical Access Database

Bentley Web Publishing

BENTLEY gINT SQL Database

Resilient Modulus Soil Stiffness Access Database
gINT® software

**gINT works seamlessly**
- standard applications
- Microstation
- ArcGIS
- Google Earth™
- More

**Consolidate all of Geotechnical Projects**
- Centralized data storage
- Multi-project reporting
- Extended querying power.

Smart Reports, Graphics, Mapping and Publishing Abilities
Subsurface Information

BENTLEY gINT SQL Database

Landslide SQL Database

Windows 7

MARSHALL

WV DOT DIVISION OF HIGHWAY

31
Thank you