How to see presenter notes . . .

- The following slide set contains the presenter’s notes (when provided) explaining the slide.
- To see the notes, look for an orange-colored text icon in the upper left corner.
- Double click the icon and the notes will appear. Adjust the size of the text box containing the notes by dragging the lower corners.
Potential Landslide Impacts from ARkStorm

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BIOGRAPHICAL SKETCH

Chris Wills is a Supervising Engineering Geologist with the California Geological Survey in Sacramento, CA. He is responsible for projects that involve seismic hazard estimation, landslide mapping, and geologic mapping.

The California Geological Survey is an agency dedicated to finding practical application for the latest geological research. As part of those efforts, Chris Wills has contributed to Alquist-Priolo Earthquake Fault Zones and Seismic Hazard Zones maps, where development is regulated due to the earthquake hazards; preparation of landslide maps, evaluation of hazards following major earthquakes and landslides, review of geologic hazards for construction of new school and hospital facilities; and numerous outreach activities to geologic, engineering, and planning professionals and the general public regarding geologic hazards.

Mr. Wills received an M.S. degree in Geological Sciences from the University of Wisconsin-Madison in 1984, and a B.S. degree in Geological Sciences from USC in 1981. He is a member of the American Geophysical Union, the Geological Society of America, the Seismological Society of America, the Association of Engineering Geologists, and the Earthquake Engineering Research Institute.

ABSTRACT

ARkStorm is a statewide emergency planning scenario hypothesizing severe storms that entrain huge amounts of moisture from the tropical Pacific and dump it on California over a few days. The storm is projected to be similar to, but more intense than recent historic storms that have struck California in recent decades, and approach the massive storms of 1861-1862 in total rainfall. A meteorological model for the ARkStorm has been developed from records of the 1969 and 1986 storms, both of which caused widespread and severe landslides in California.

Estimating the numbers and impact of landslides from the ARkStorm requires models relating rainfall to the numbers and distribution of landslides and detailed records of the impact of landslides in past storms. Neither of these basic data sets exists. Models that estimate the areas with the greatest susceptibility to landsliding do exist, however, and can be combined with the detailed maps of small areas showing the numbers of landslides triggered in individual storms. We have extrapolated the distribution of landslides mapped in past storms to areas where no such maps exist using the landslide susceptibility maps. Similarly, we have extrapolated the incomplete records of damage from landslides in past storms to the ARkStorm using the susceptibility maps. We anticipate that the ARkStorm would trigger thousands of landslides causing hundreds of millions of dollars in direct repair costs.
Landslides and Debris Flows

Chris Wills, CGS; John Stock, USGS,
Ante Perez, CGS, David Branum, CGS, & Sue Perry, USGS
Types of Landslides
- Rock slides
- Earth flows
- Debris slides
- Debris flows

Landslide maps
- Landslide-inventory maps
- Landslide-susceptibility maps

Landslide Losses
- Loss to residential structures
- Loss to commercial structures
- Loss to infrastructure
Large, deep, slow moving landslides that damage structures

Small, shallow, fast-moving landslides that kill people
The 1983 McWay or J.P. Burns slide, an example of a deep rock slide that damaged infrastructure.
An earth-flow in Sycamore Canyon, Santa Barbara County.
A historic (1998?) debris slide near Highway 1
Debris slide (left) and debris flows (right) originating from slightly different materials on a very steep slope.
1982 debris flow on Oddstad Drive in Pacifica triggered by intense rains

Newspaper headline from winter 2010, this is what we expect each rainy season
1999 debris flow in Forest Falls, San Bernardino County
Debris flows in high mountain areas can be damaging, and can occur in summer thunderstorms
We are also preparing separate maps of debris flow potential.
Deep landslides are sensitive to long-term rainfall (weeks to a full season)
Debris flows are triggered by intense rainfall (inches per hour)

For both types of landslide, we can prepare maps showing relative susceptibility, after that we need to know how many landslides are triggered by a storm with a given intensity, and how much damage they cause:

We need to calibrate our landslide susceptibility model with historic records of landslides and landslide data.
January 2005 storm initiates failures in Ventura area (peak hourly rainfall 10-12 mm/hr)
High-resolution historic imagery and LiDAR used to inventory timing and location of failures.
Shallow landslide models (SHALSTAB) can be used to estimate locations of instability.
Problem: landslide susceptibility models overpredict instability for a given storm (212 slides, 0.5% of red cells failed in this basin)
Problem: landslide susceptibility models overpredict instability for a given storm (212 slides, 0.5% of red cells failed in this basin).
Need to calibrate...

<table>
<thead>
<tr>
<th>Percentage of red area failed</th>
<th>Maximum hourly rainfall (mm/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

ARKstorm?  
c. 1969?  
2005, Ventura
<table>
<thead>
<tr>
<th>0013.3083 E 8TH ST.</th>
<th>A5 45 1 1/26/69 9</th>
</tr>
</thead>
</table>

**Storm & Slope Failure Damage Report**

**Job Address**

- House number and street name: 33-37 Thomas Guide

**30-43** Date of Failure

- a. Month: 2
- b. Day: 2
- c. Year: 1

**44-51** Slope Failure (Sketch on back, including structures)

- a. If no failure enter 9
- b. Maximum width (ft): 4
- c. Maximum height (ft): 6
- d. Maximum depth (ft): 6

**52** Slope Characteristics (Only for slope failures)

- a. Circle one only
- b. Critical Cut
- c. Fill
- d. Natural
- e. Cut and fill
- f. Cut and natural
- g. Fill and natural

**60-64** Observed Conditions

- Circle no more than 5
- a. Bore removed, drainage over slope
- b. Drainage terrace blocked
- c. Unsupported cut at toe
- d. Slope saturation
- e. Evidence of water ponded at top
- f. Poor yard drainage
- g. Subsurface water
- h. Other (Specify on reverse side)

**65** Ordinance Involved

- Circle one only
- a. Pre '52
- b. After '52 but before '63
- c. After '63

**73-75** Est. Percentage Damage to Buildings

- a. Minor erosion
- b. Surface slippage
- c. Rotation
- d. Mudflow
- e. Major erosion
- f. Other

**76** Possible Cause of Structural Damage

- Circle one only
- a. Landslide
- b. Mudflow
- c. Subsidence
- d. Stream action
- e. Earth saturation
- f. Other

**77-80** Est. Cost to Repair or Replace all Structures, Include Retaining Wall

- a. No building
- b. No damage to building
- c. Building damaged, non-structural
- d. Building damaged, structural
- e. Retaining wall collapse
- f. Other
681 records of 1969 storm damage from City of Los Angeles
Sorted by “rotation” (deep landslide) vs “mudflow” (debris flow)
Aggregated as total dollar damage in each census tract.
2004 records of 1978 storm damage from City of Los Angeles
Sorted by “rotation” (deep landslide) vs “mudflow” (debris flow)
Aggregated as total dollar damage in each census tract.
**Director's Order Request / Approval**

Use when: Requesting exemption from the State Contract Act for new projects over $120,000; to obtain approval for emergency Equipment Rental contracts, Supplemental Director's Orders or emergency out-of-scope contract change orders, and for Day Labor over $25,000.

### 1. Date and Location of Incident or Problem

<table>
<thead>
<tr>
<th>Location</th>
<th>Bridge No.</th>
<th>Date of Incident</th>
</tr>
</thead>
<tbody>
<tr>
<td>District (2 digits, i.e. 01)</td>
<td>07</td>
<td>45.5</td>
</tr>
<tr>
<td>County (2 or 3 letter abbrev)</td>
<td>P.M. Back/Spot</td>
<td>Year (4 digits)</td>
</tr>
<tr>
<td>Route (3 digits, i.e., 002 or VAR)</td>
<td>P.M. Ahead</td>
<td>Month (2 digits)</td>
</tr>
<tr>
<td>Route, 2nd</td>
<td>P.M. Back 2nd</td>
<td>Day (2 digits)</td>
</tr>
</tbody>
</table>

### 2. Damage or Incident Cause and Extent

**Immediacy**
- Damage or Incident has: ☒ Occurred ☐

**Cause**
- Slide ☒
- Fire ☐
- Slipout ☐
- Culvert Failure ☐
- Washout ☐
- Bridge Scour ☐
Our preliminary data from Caltrans suggest that a high percentage of storm damage to infrastructure comes from a few large landslides and that landslide damage is correlated with rainfall.

<table>
<thead>
<tr>
<th></th>
<th>Flooding and Erosion</th>
<th>Shallow Landslides</th>
<th>Deep Landslides</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>count</strong></td>
<td>28</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td>$48,077,743</td>
<td>$29,602,000</td>
<td>$74,995,850</td>
</tr>
<tr>
<td><strong>average</strong></td>
<td>$1,780,657</td>
<td>$2,114,429</td>
<td>$6,817,805</td>
</tr>
</tbody>
</table>
Conclusion

• Landslide maps show potential for landslides. The hazards are related to steepness of slopes, strength of rocks and the types of landslides that occur.

• Information on the cost of cleanup and repair of historic landslides is needed to relate landslide susceptibility maps to potential losses from the ARkStorm – preliminary data suggest thousands of landslides and hundreds of millions of dollars in repair costs.