Debris-Flow Model

Los Angeles Department of Public Works
Regional Sediment Management and Water Supply Workshop
July 14, 2010

Presented by Sue Cannon
• USGS approach/model for estimating debris-flow volumes
• How well the model did this winter
• What we might expect for the coming winter
Point 1. Multi-agency and multi-disciplinary effort

Angeles NF, Station fire BAER Team, Riverside Fire Research Station, RSAC

Point 2. A work in progress:

Data deluge, Winter of 2009, Station fire

Post-fire debris-flow researchers
Approach: Station Fire Debris-Flow Hazards Assessment

Fundamental concept: Identify how each drainage basin will respond to storm rainfall.

- 678 basins
- 0.01 km² < area < 30 km²
- defined from 10 m DEM
- (basins > 30 km² subdivided)
Approach for Characterizing Post-Fire Debris-Flow Hazards

- What basins are most prone to debris flow?
- How big will the response be?
- What areas will be impacted?

Empirical/Statistical Models
- Probability of debris flow
- Debris-flow Volume
- Inundation modeling
### Variables used to characterize debris-flow volume for each basin:

<table>
<thead>
<tr>
<th></th>
<th>Volume Model (n=40) (single storm/volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burned extent:</td>
<td>Total area burned</td>
</tr>
<tr>
<td>Soil properties:</td>
<td>None</td>
</tr>
<tr>
<td>Basin gradients:</td>
<td>Length of the longest flow path</td>
</tr>
<tr>
<td></td>
<td>Elevation change</td>
</tr>
<tr>
<td>Storm rainfall:</td>
<td>Total storm rainfall</td>
</tr>
</tbody>
</table>

### Data sources for model development: and implementation

<table>
<thead>
<tr>
<th></th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total area burned</td>
</tr>
<tr>
<td></td>
<td>BAER BARC maps</td>
</tr>
<tr>
<td></td>
<td>Length of the longest flow path, elevation change</td>
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<tr>
<td></td>
<td>10-m DEMs</td>
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<tr>
<td></td>
<td>Rain gages, NOAA Atlas 14, LADPW, Hirshfield, 1961</td>
</tr>
</tbody>
</table>
### Approach: Storm rainfall used in hazard assessment

#### Rainfall and Intensity Summary

<table>
<thead>
<tr>
<th>Zone</th>
<th>3-hour-duration, 1-year-recurrence storm</th>
<th>12-hour-duration, 2-year-recurrence storm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total rainfall, (inches)</td>
<td>Average rainfall intensity, (inches/hour)</td>
</tr>
<tr>
<td>1</td>
<td>1.2</td>
<td>0.40</td>
</tr>
<tr>
<td>2</td>
<td>1.3</td>
<td>0.43</td>
</tr>
<tr>
<td>3</td>
<td>1.4</td>
<td>0.47</td>
</tr>
<tr>
<td>4</td>
<td>1.1</td>
<td>0.37</td>
</tr>
<tr>
<td>5</td>
<td>0.8</td>
<td>0.27</td>
</tr>
</tbody>
</table>
Projected debris flow volumes in response to a 3-hr-duration, 1-yr-recurrence thunderstorm

Volumes between 1,000 and 100,000m³
### Winter of 2009-2010:

<table>
<thead>
<tr>
<th>Date</th>
<th>*Storm Duration (hours)</th>
<th>*Storm Total (inches)</th>
<th>**Storm Recurrence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 13-14, 2009</td>
<td>29</td>
<td>2.3 to 2.5</td>
<td>1 year</td>
</tr>
<tr>
<td>Nov 12, 2009</td>
<td>1.0 to 1.3</td>
<td>0.75 to 1.1</td>
<td>Up to 5 year</td>
</tr>
<tr>
<td>Dec 7, 2009</td>
<td>16</td>
<td>0.8 to 1.4</td>
<td>&lt;1 year</td>
</tr>
<tr>
<td>Dec 11-13, 2009</td>
<td>29 to 38</td>
<td>1.9 to 5.8</td>
<td>Up to 5 year??</td>
</tr>
<tr>
<td>Jan 18, 2010</td>
<td>23</td>
<td>2.1 to 4.3</td>
<td>Up to 2.5 year</td>
</tr>
<tr>
<td>Jan 19, 2010</td>
<td>7</td>
<td>0.4 to 0.7</td>
<td>&lt;1 year</td>
</tr>
<tr>
<td>Jan 20, 2010</td>
<td>15</td>
<td>1.0 to 1.8</td>
<td>&lt;1 year</td>
</tr>
<tr>
<td>Feb 6, 2010</td>
<td>25</td>
<td>3.1 to 4.4</td>
<td>Up to 2.5 year</td>
</tr>
<tr>
<td>Feb 9, 2010</td>
<td>6 to 7</td>
<td>0.4 to 0.9</td>
<td>&lt;1 year</td>
</tr>
<tr>
<td>April 11, 2010</td>
<td>6.5</td>
<td>0.9 to 1.3</td>
<td>&lt;1 year</td>
</tr>
</tbody>
</table>

*Measured from gages along the San Gabriel Mountain Front.

**From Hershfield (1961), Los Angeles County Frequency Analyses Report, and NOAA (Bonnin et al., 2006).

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**Hydrologic Response**
- **negligible**
- **localized debris flows and flooding**
- **widespread debris flows and flooding**

**Modeled storm:** 1.2 to 1.3 inches of rain in 3 hours
November 12, 2009 Storm: Approximate rainfall distribution

0.03 to 0.3 inches in 0.5 to 1.5 hours
<1 year recurrence storm

1.12 inches in ~1 hour
~5-year-recurrence storm

Rain gage
November 12, 2009 Storm: Response in low rainfall area

- Low rainfall area: 0.03 to 0.3 inches in 0.5 to 1.5 hours
- Hillslope erosion
- Angeles Crest Highway closed
- "Muck flow" into Big Briar debris basin
- Drainage tower
- Sediment into Upper Gould debris basin
November 12, 2009 Storm: Response in high rainfall area

- Mullally debris basin full
- Snover & Halls debris basins near capacity
- Angeles Crest Highway closed
- High mud mark
- Homes damaged on Normanton, Earnslow, and Rock Castle Drives (off Ocean View Drive)
- 2000 cfs at Arroyo Seco stream gage
Jan.18 and Feb.6, 2010 Storms: THE BIG ONES

Dunsmore Canyon:

January 19, 2010

February 7, 2010
How well did the debris-flow volume do?

• Run the volume model with measured storm rainfall
• Compare predicted volumes with volumes of material collected in debris basins
First cut: How well did the debris-flow volume do?

Need more data from >10,000 m³ events

Model is an order of magnitude too high for small (<1,000 m³) debris flows

Model is not too bad for debris flows (>1,000 and <10,000 m³)

N = 22
What might we expect for the coming winter?

1. It all depends on the rainfall.
2. If get storms comparable to those in 2009:
   a. It will take just slightly higher rainfall rates to trigger an equivalent response.
What might we expect for the coming winter?

1. It all depends on the rainfall........
2. If get storms comparable to those of 2009:
   a. It will take just slightly higher rainfall rates to trigger an equivalent response
   b. Experience in southern CA indicates that the response of second winter can be comparable to the first
   c. Field observations in the Station fire indicate that although material has been flushed from many of the low-order channels, these bedrock-lined channels could now act as effective water flumes.
What might we expect for the coming winter?

1. It all depends on the rainfall.
2. If comparable storms to 2009:
   a. It will take just slightly higher rainfall rates to trigger an equivalent response
   b. Experience indicates that the response of second winter can be comparable to the first
   c. Field observations in the Station fire indicate that although material has been flushed from many of the low-order channels, these bedrock-lined channels could now act as effective water flumes.

3. If storms are either more intense, longer duration, or closer together than 2009 storms - LARGER, MORE DESTRUCTIVE EVENTS
But what about all that fantastic vegetation growth? Can we quantify its effect on recovery and sediment yields?
Cumulative measure of vegetation change -

Feb to May 2010

Green = more veg during year

Red = less veg during year

Most re-growth to date in low foothills

Effects will be also be lessened with drying and lay down

Jess Clark
USDA Forest Service, Remote Sensing Applications Center,
http://fsweb.rsac.fs.fed.us
Effects of vegetative regrowth on burn severity map and debris flow volume model predictions

Primary change: Areas of moderate burn severity are now classified as low severity

Average change in volume model predictions: -2%
Range 0% to 50%

Burn Severity Map from May, 2010 Imagery
What might we expect for the coming winter?

More of the same, or MORE

Questions??