

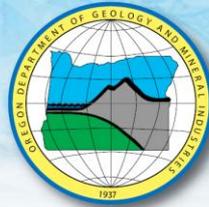
# Multi-Hazard and Risk Study for the Mount Hood Region, Multnomah, Clackamas, and Hood River Counties, Oregon

Oregon Department of Geology and Mineral Industries  
Open-File Report O-11-16



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Engineering Geologist

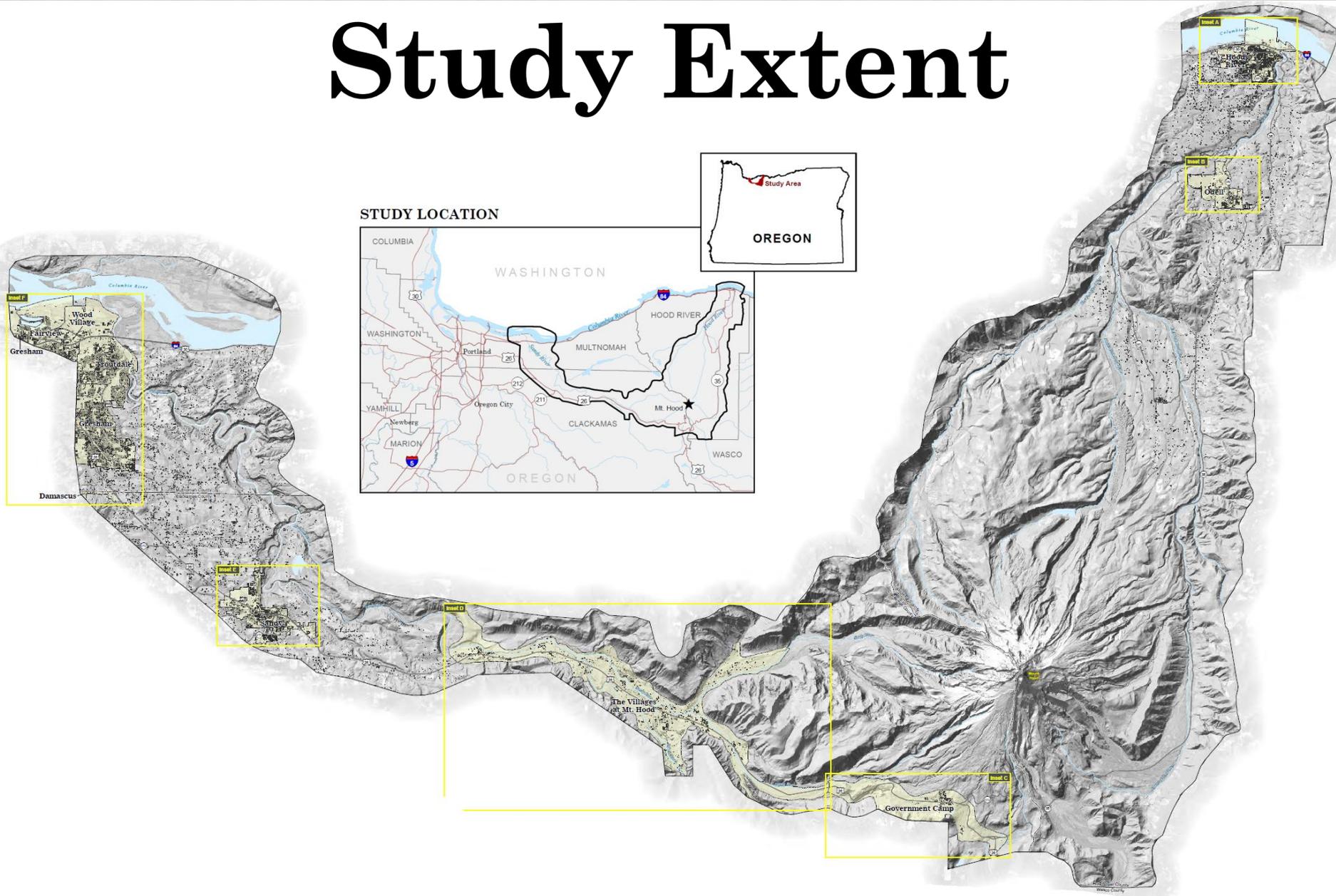


Oregon  
**Department of Geology**  
*and Mineral Industries*

# Talk Overview

1. Mapping the Assets & Hazards
2. Results
3. Conclusions

# Study Extent



# Data Creation Results

## Hazards

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- Volcano
- Landslide
- Flood & Channel Migration
- Earthquake

## Assets (Hood)

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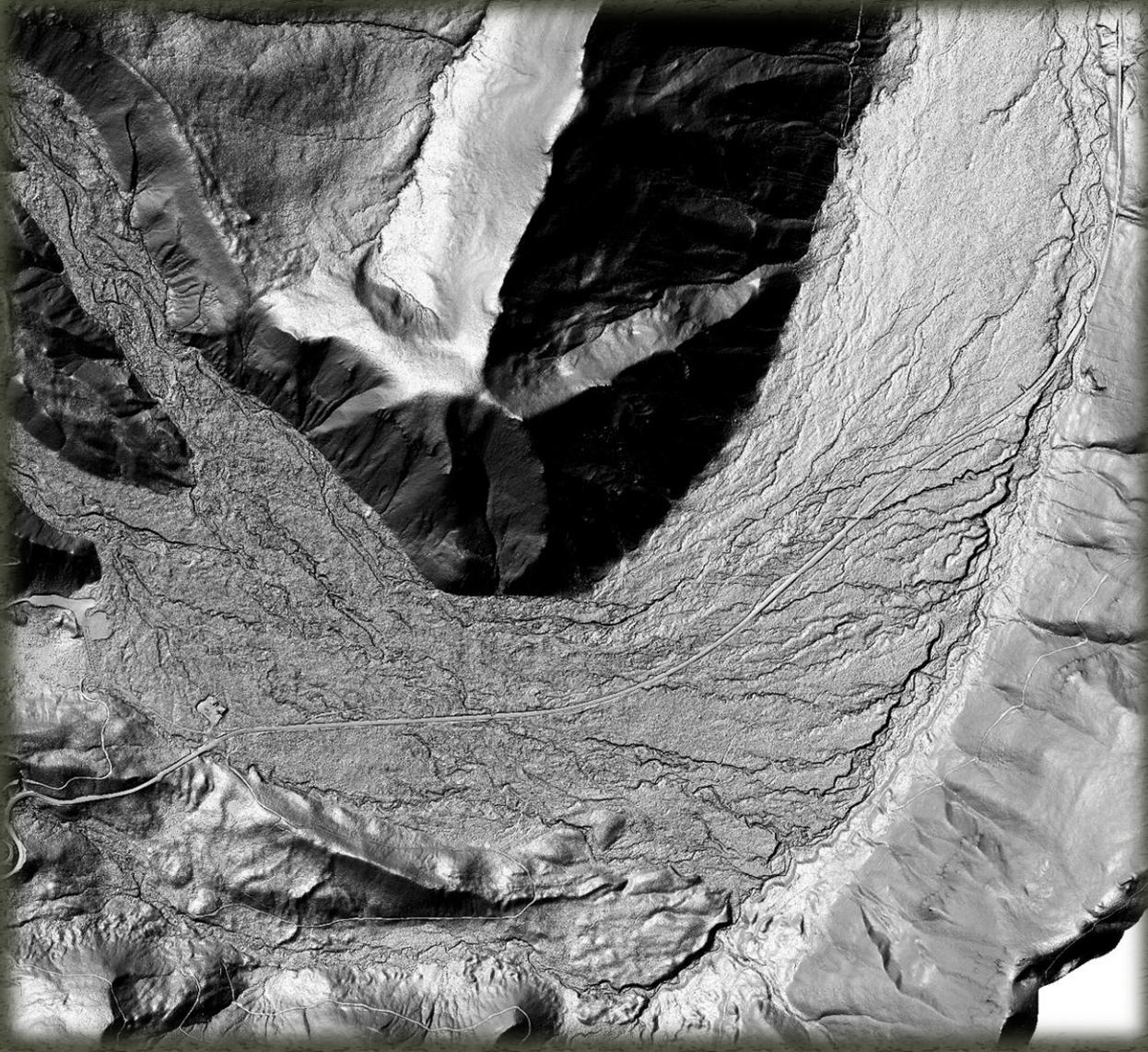
- People 17,051
- Buildings 11,701 / \$1.5B
- Parcels 10,026 / \$1.5B
- 46 Emergency and School Buildings
- 75miles HWY / 117 bridge/crossings
- 200 miles / 332 towers Primary Electric

## Clark & Newton Creeks & HWY 35

LiDAR Hillshade

- 1<sup>st</sup> Return (HH)
- Aerial Photo





## Clark & Newton Creeks & HWY 35

LiDAR Hillshade

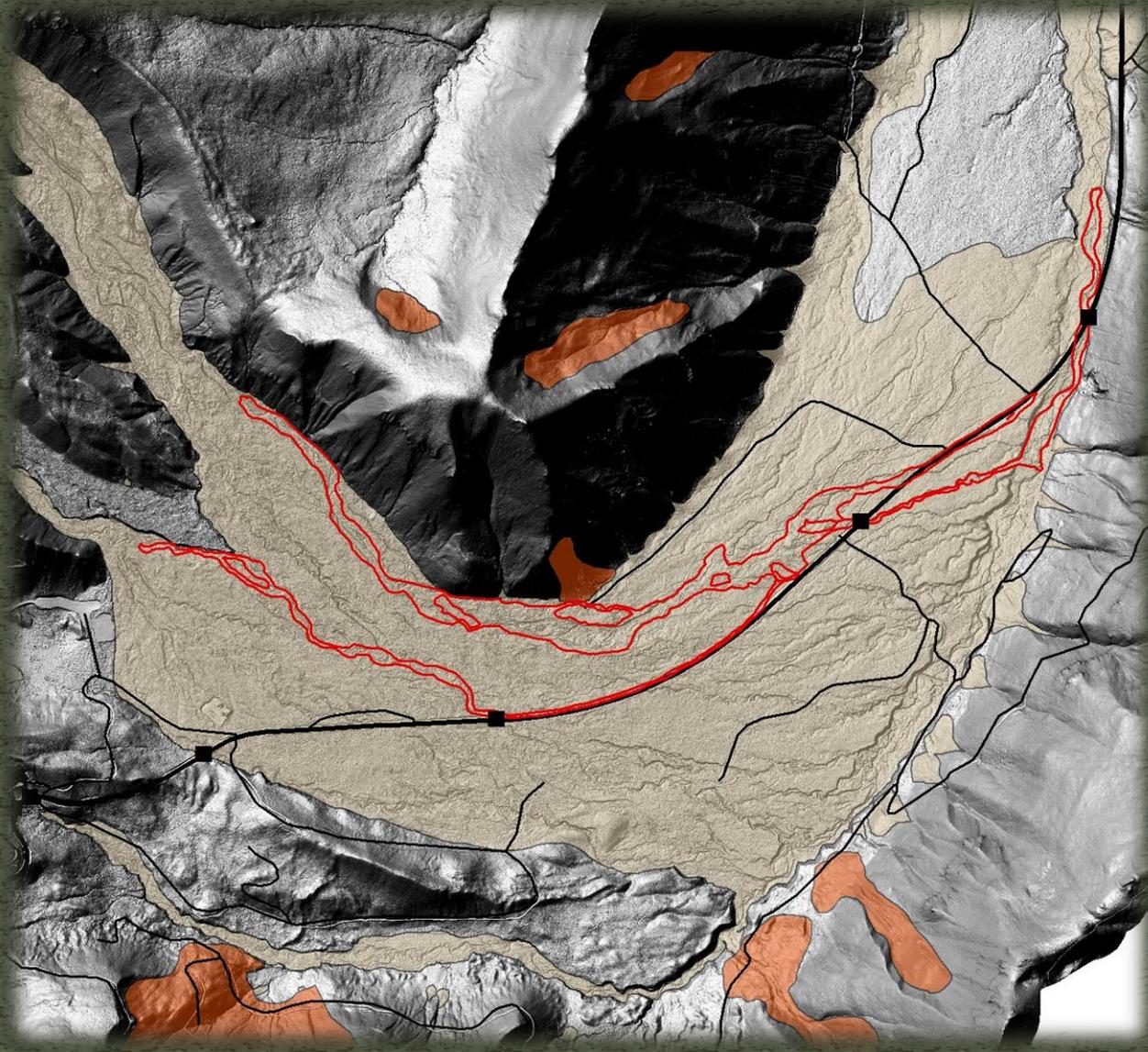
- Bear Earth (BE)



## Clark & Newton Creeks & HWY 35

- Mapped Landslides (orange)
- Mapped Debris Flow Fans (tan)
- Mapped historic Debris Flow Extents (red)





## Clark & Newton Creeks & HWY 35

- Highway and smaller roads
- Bridges and crossings





## East Fork & HWY 35

LiDAR Hillshade

- 1<sup>st</sup> Return (HH)

Aerial Photo

- Current East Fork
- HWY 35





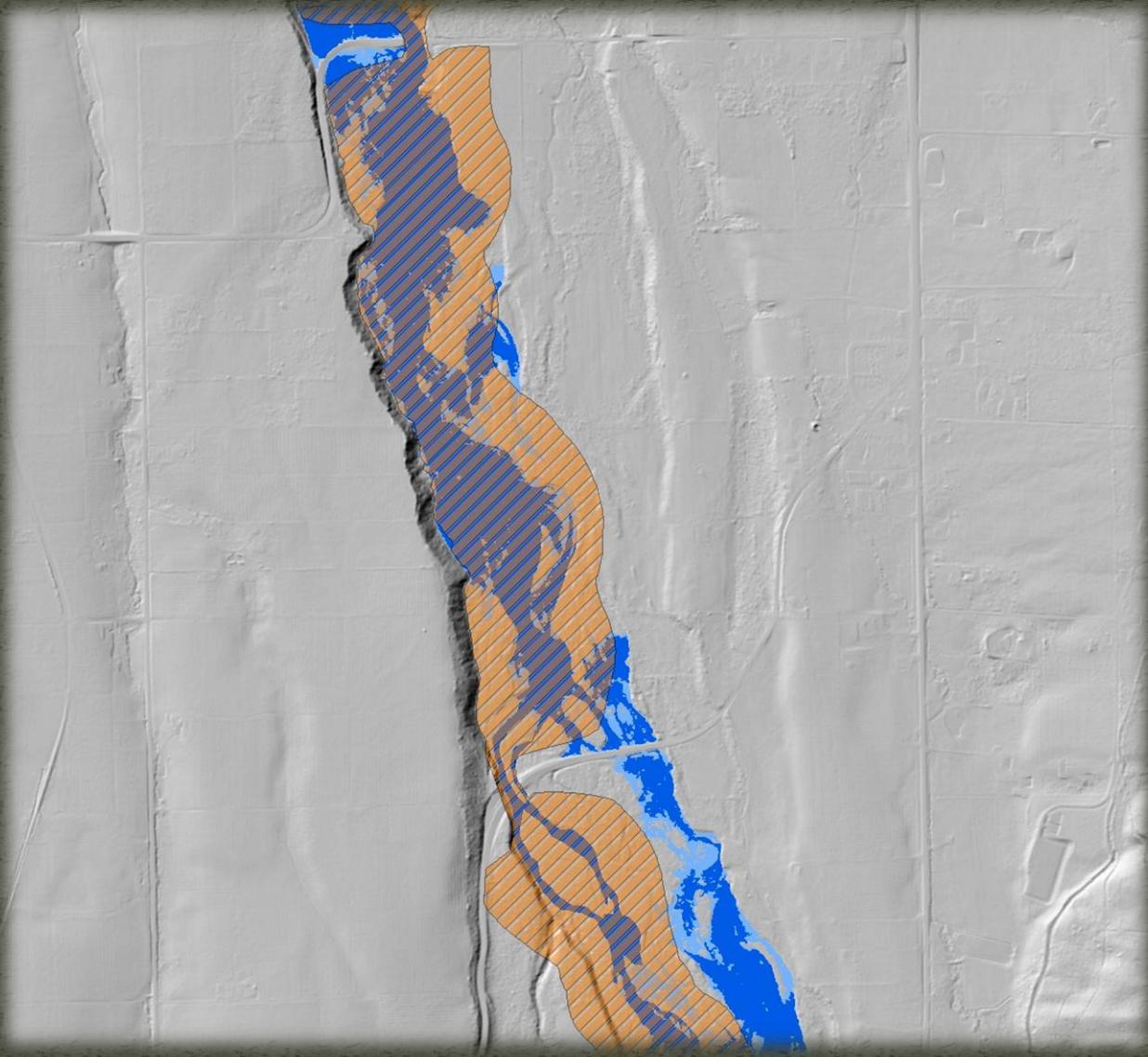
## East Fork

LiDAR Hillshade

- Bare Earth

Past Channels of  
East Fork R.



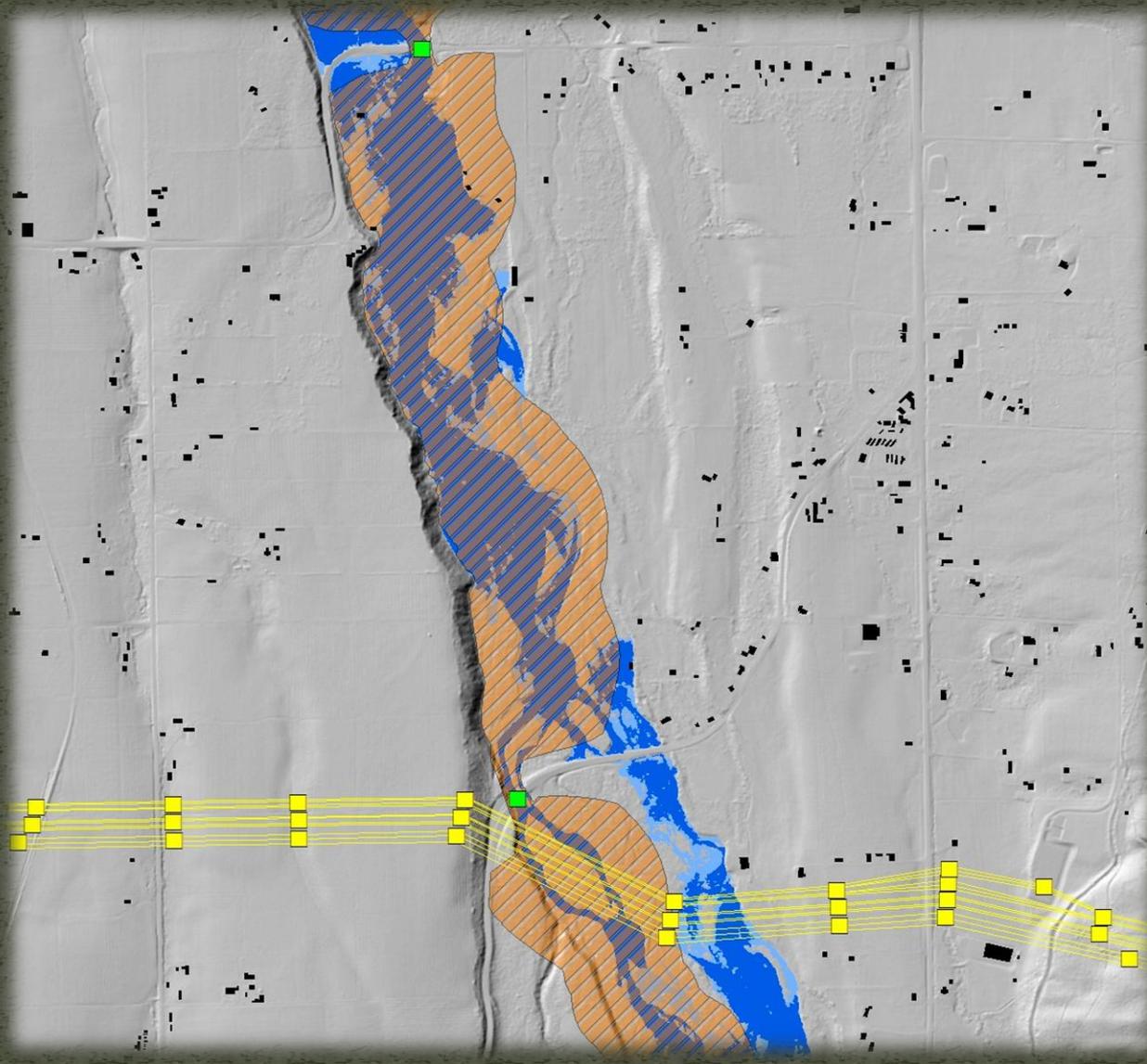


## East Fork

LiDAR Hillshade

- Bear Earth (BE)
- Flood and Channel Migration





## East Fork

LiDAR Hillshade

- Bear Earth (BE)

Assets and Hazards



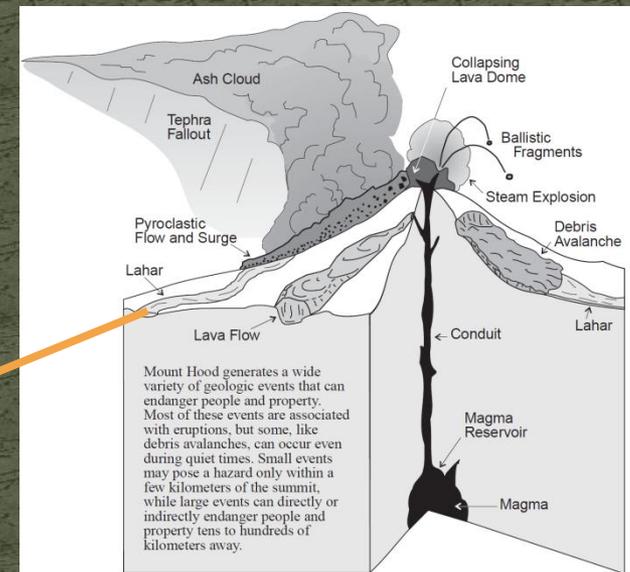


# Volcano

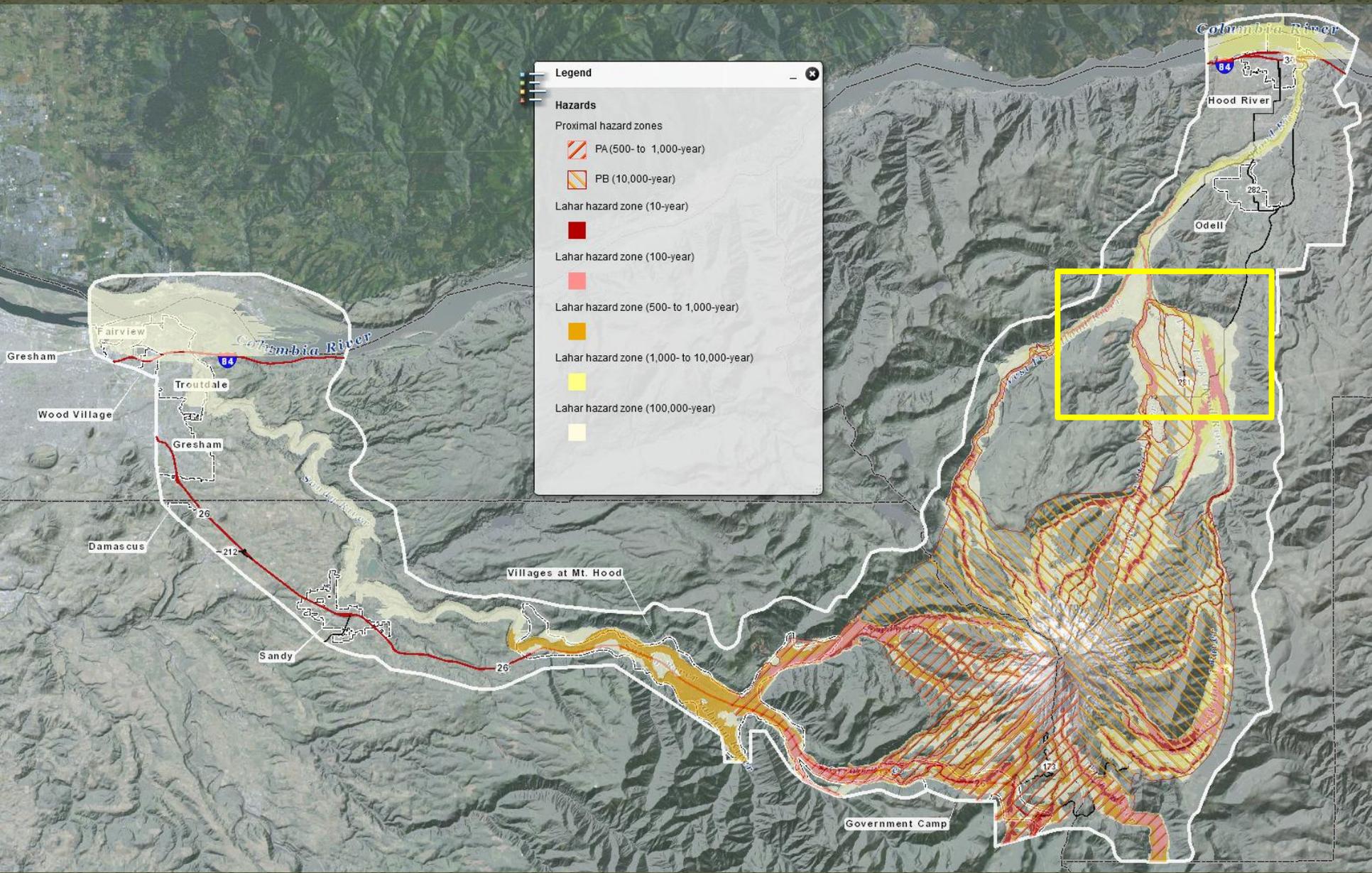
- Focus on Lahar
- Used USGS proximal hazard zones

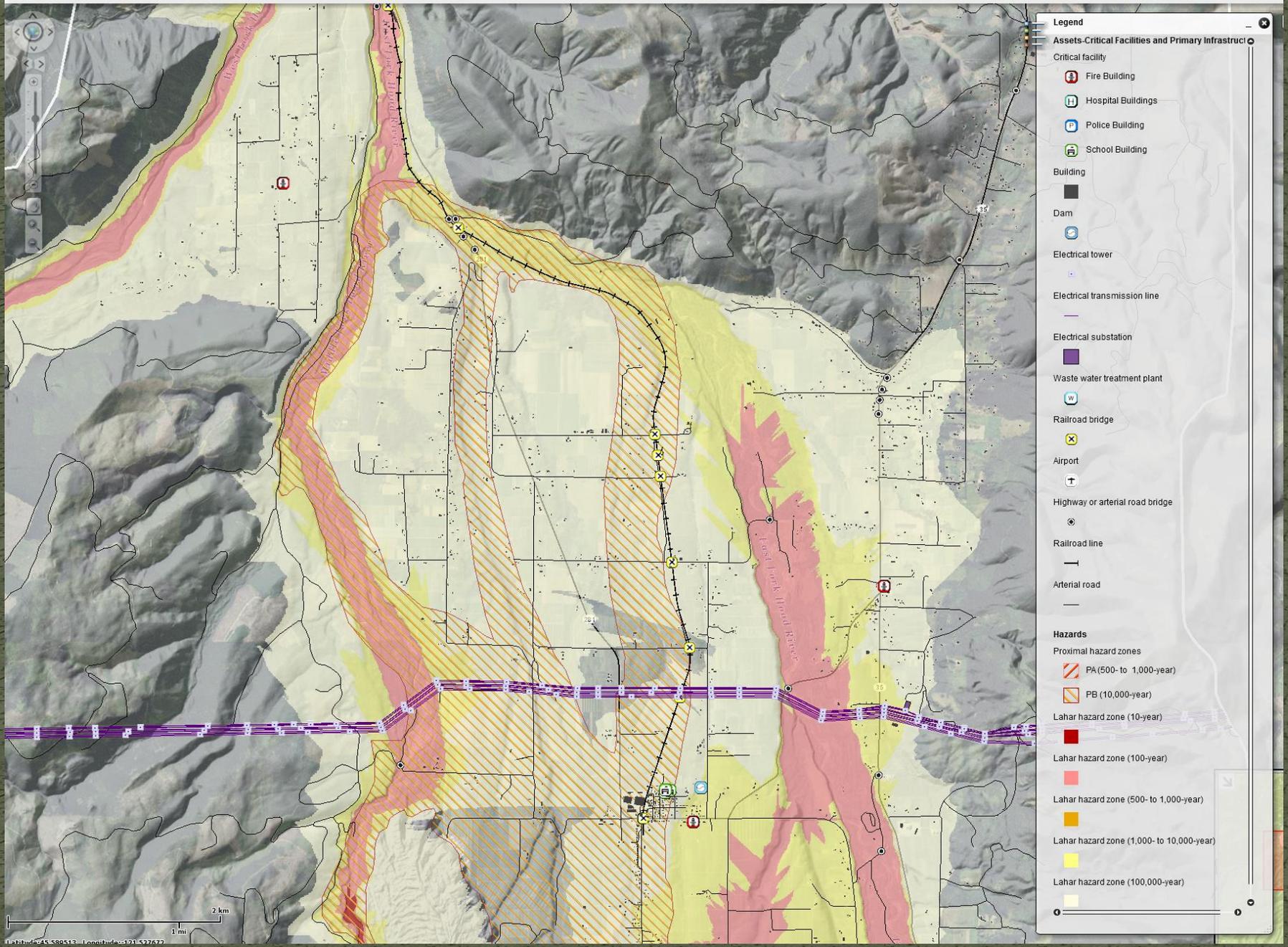


**Figure 9.** Example of a lahar-filled valley following the 1989-1990 eruptions of Redoubt Volcano, Alaska (photograph by C. Gardner, U.S. Geological Survey, June 28, 1990, [http://pubs.usgs.gov/dds/dds-39/images/JPG/large\\_screen/fig49.jpg](http://pubs.usgs.gov/dds/dds-39/images/JPG/large_screen/fig49.jpg)).



# NEW VOLCANO DATA: Lahar Hazard





**Legend**

**Assets-Critical Facilities and Primary Infrastructure**

**Critical facility**

- Fire Building
- Hospital Buildings
- Police Building
- School Building

**Building**

- Building

**Dam**

- Dam

**Electrical tower**

- Electrical tower

**Electrical transmission line**

- Electrical transmission line

**Electrical substation**

- Electrical substation

**Waste water treatment plant**

- Waste water treatment plant

**Railroad bridge**

- Railroad bridge

**Airport**

- Airport

**Highway or arterial road bridge**

- Highway or arterial road bridge

**Railroad line**

- Railroad line

**Arterial road**

- Arterial road

**Hazards**

**Proximal hazard zones**

- PA (500- to 1,000-year)
- PB (10,000-year)

**Lahar hazard zone (10-year)**

- Lahar hazard zone (10-year)

**Lahar hazard zone (100-year)**

- Lahar hazard zone (100-year)

**Lahar hazard zone (500- to 1,000-year)**

- Lahar hazard zone (500- to 1,000-year)

**Lahar hazard zone (1,000- to 10,000-year)**

- Lahar hazard zone (1,000- to 10,000-year)

**Lahar hazard zone (100,000-year)**

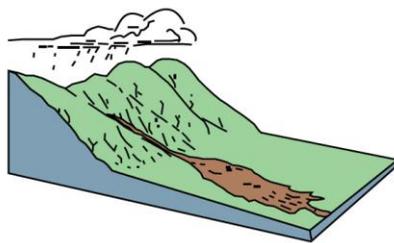
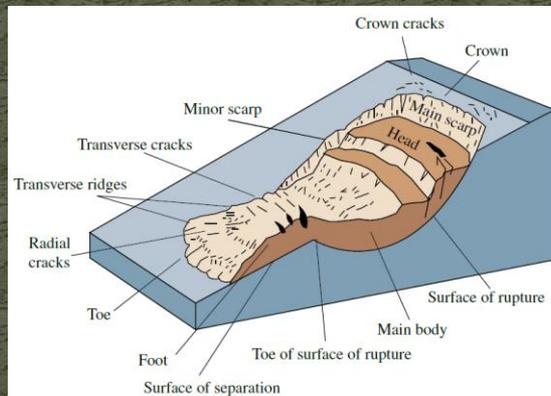
- Lahar hazard zone (100,000-year)

Latitude: 45.589513 Longitude: -121.527672

# Landslide

Focused on 3 hazards:

- 1) Large Deep Landslides
- 2) Debris Flows
- 3) Steep Slopes

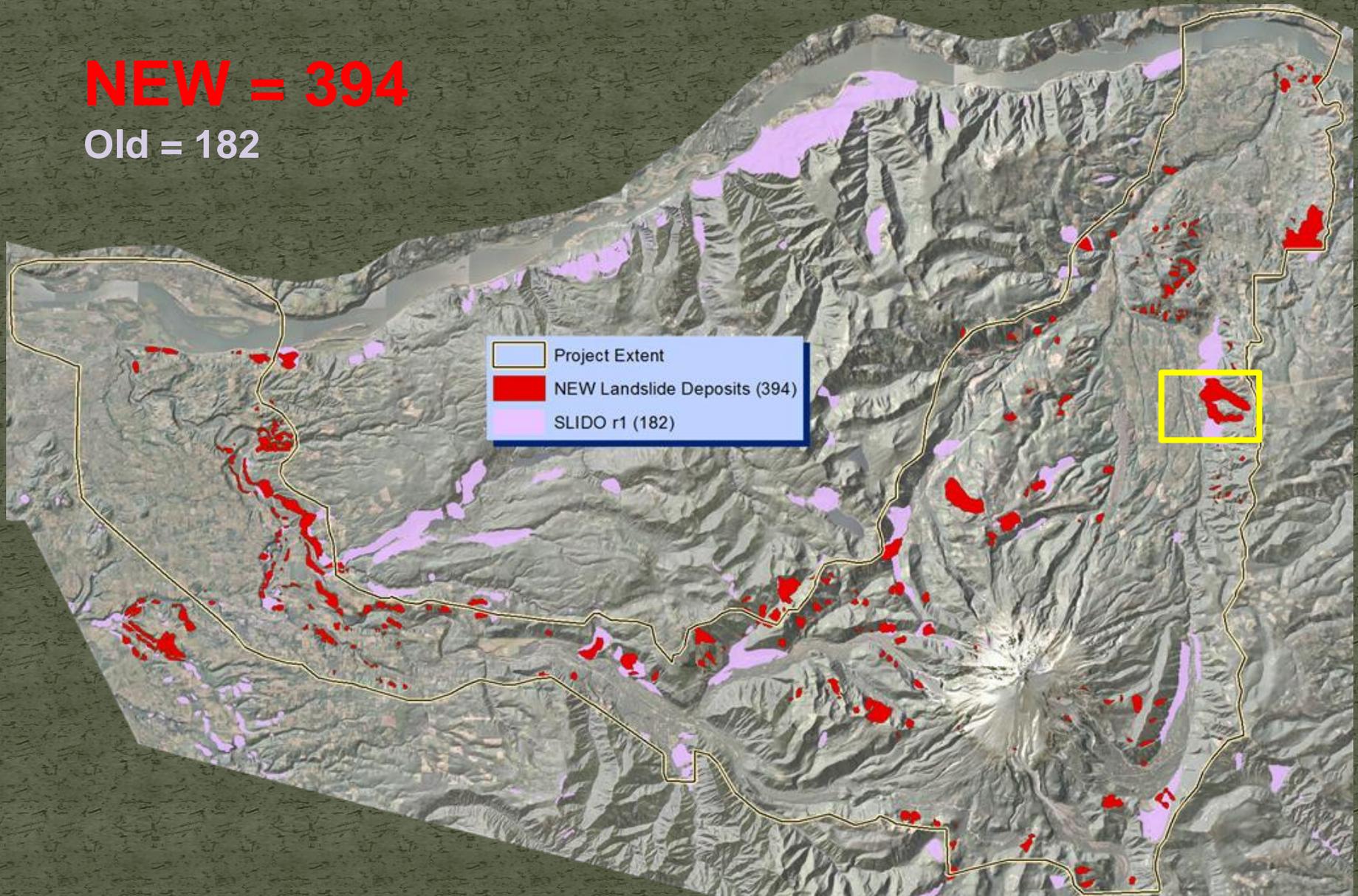


HWY 26, 2009

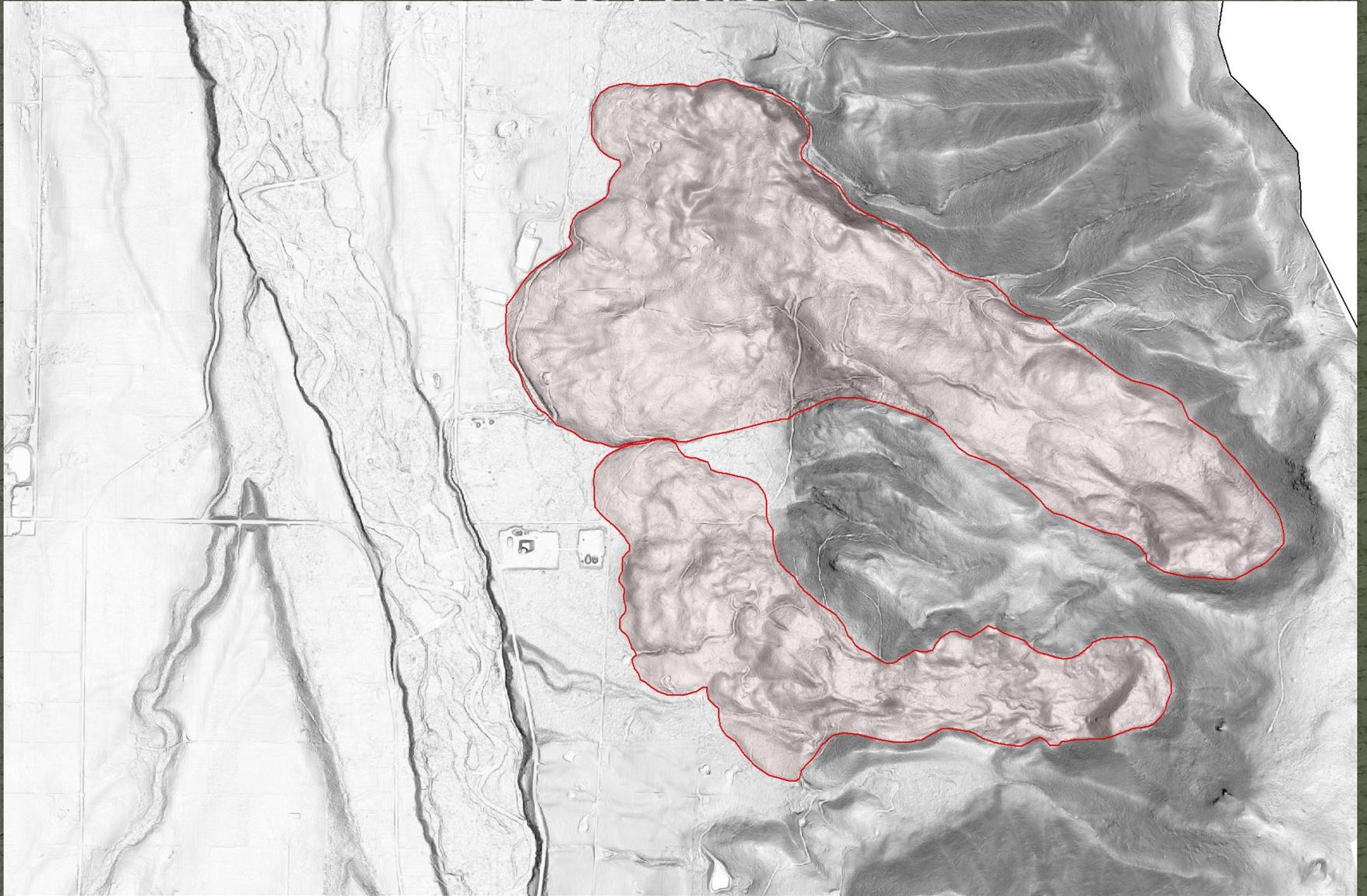
# NEW DATA: Large Deep Landslides

**NEW = 394**

Old = 182



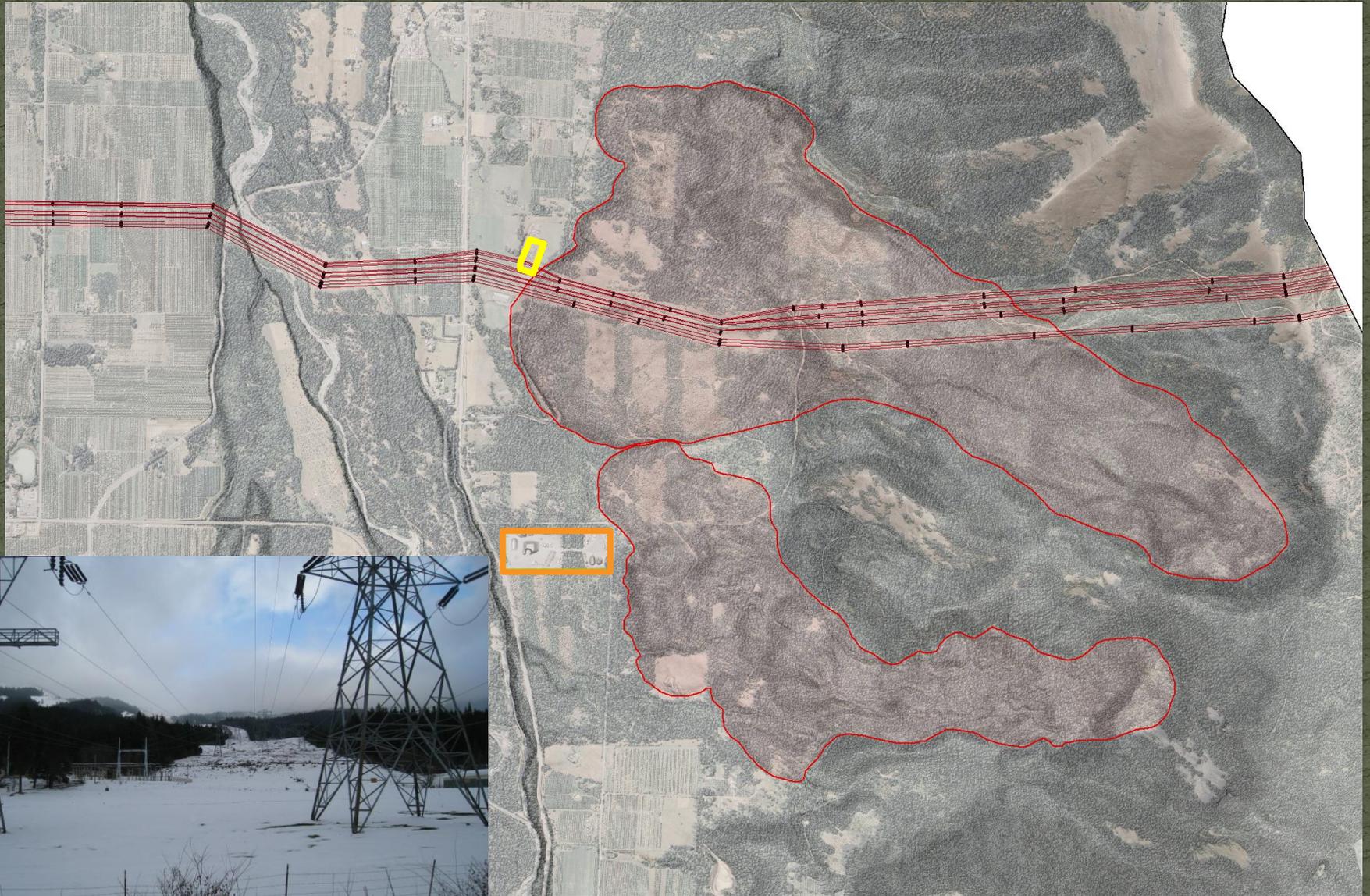
# Bear Earth LiDAR = Landslides Revealed



# 1<sup>st</sup> Return LIDAR + PHOTO – Infrastructure

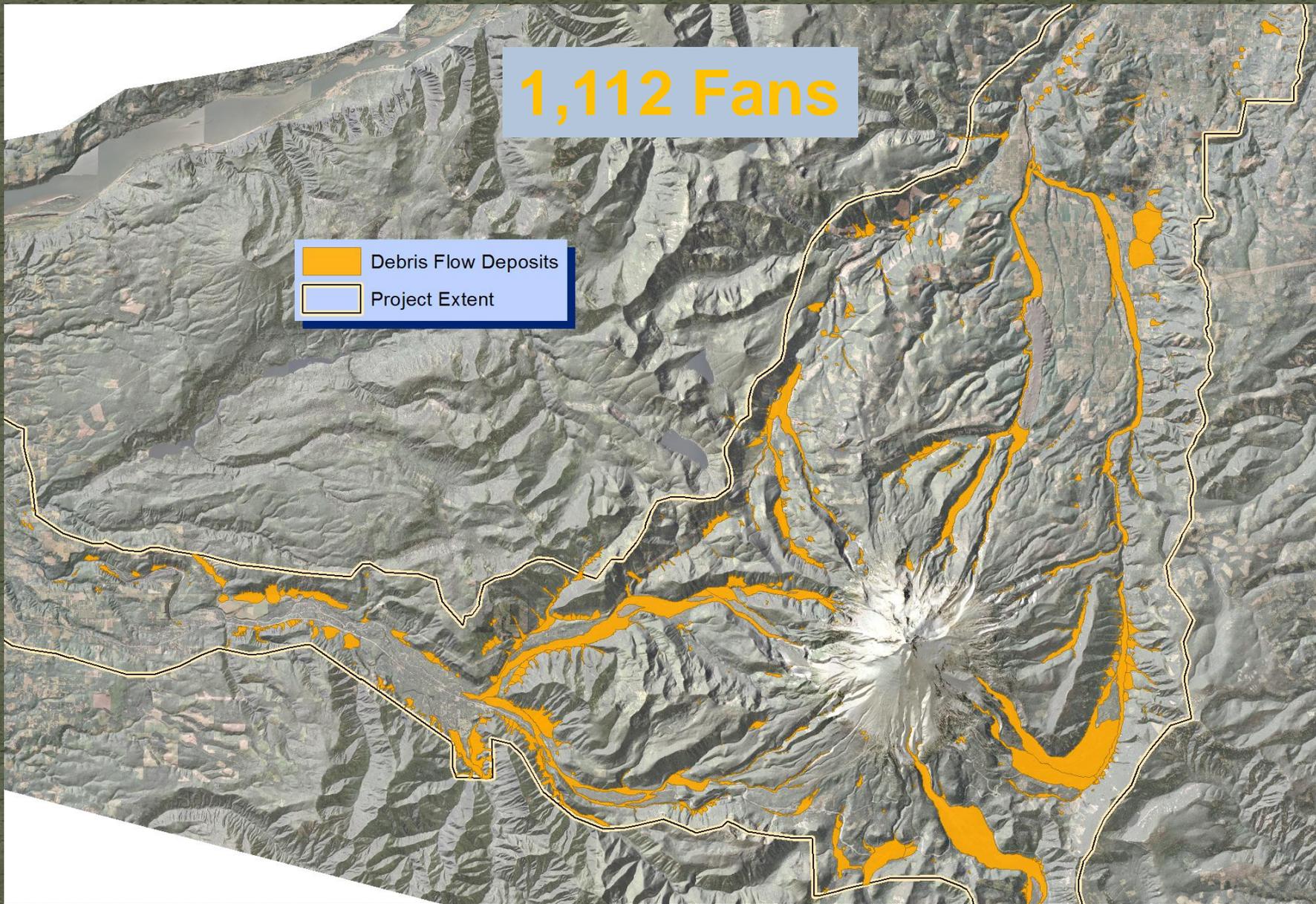
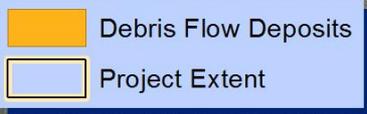


# Asset Database Exposed to Landslide Hazard

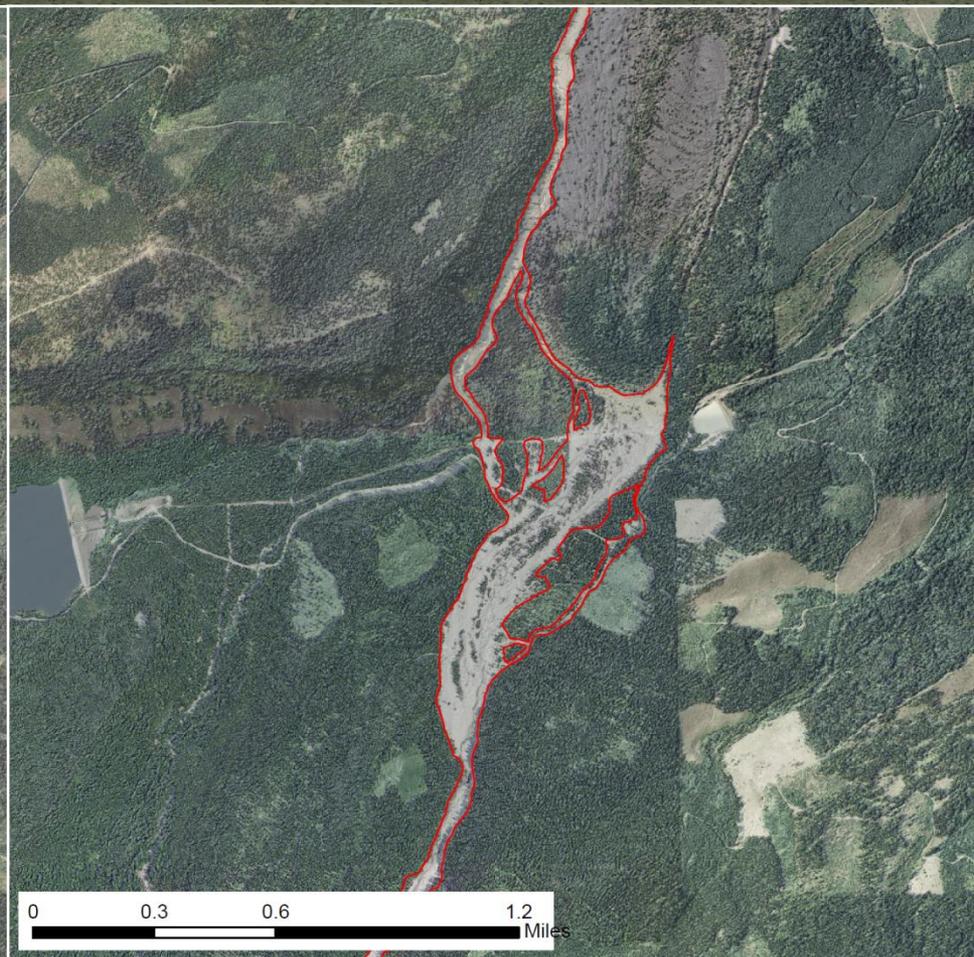
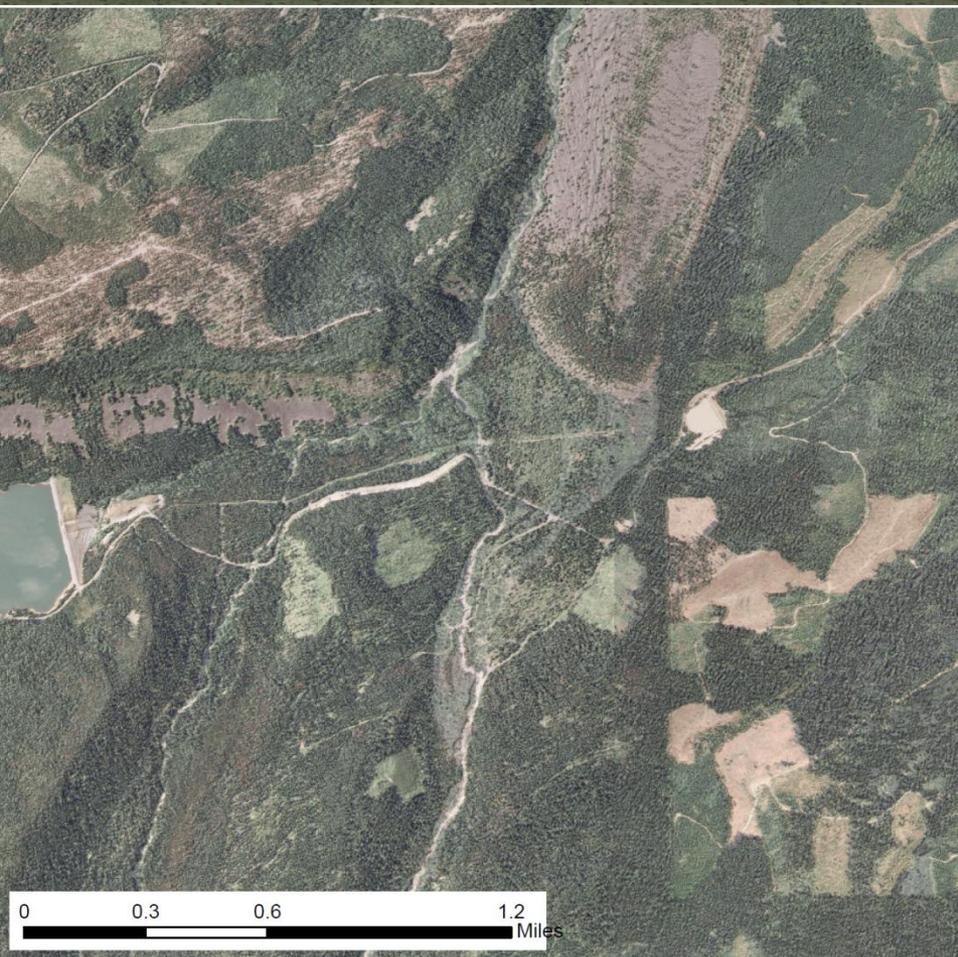


# NEW DATA: Debris Flow Deposits

1,112 Fans

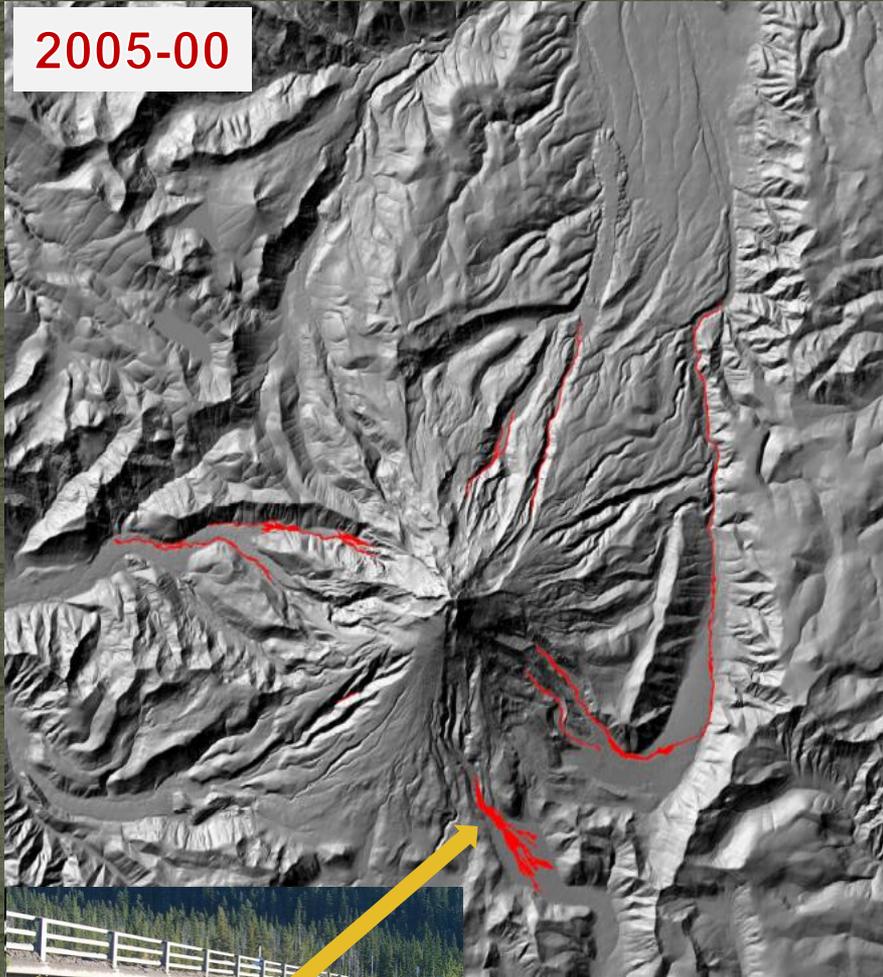


# 2005 & 2009 Photos Capturing 2006 Debris Flows



# Last Decade: 2000-2010

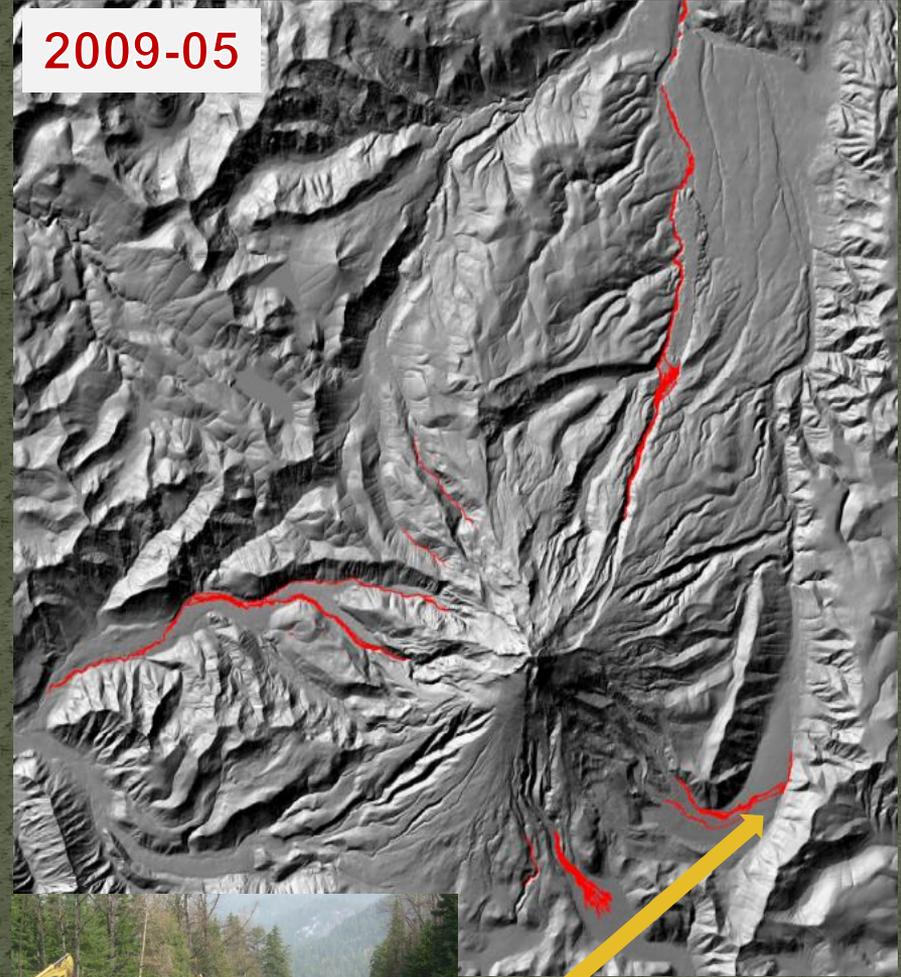
2005-00



White River Bridge - October 2000

White, 2000

2009-05



Oregon

Newton, 2006 (OGAMI)

# Flood & Channel Migration

Focused on 1 short and 1 long return:

- 1) 25-year flood hazard zone
- 2) 500-year flood hazard zone



Hood River, 2006

Focused on 100-year Channel Migration Hazard Zone



Sandy River & Lolo Pass Rd, 2011



## NEW DATA: 25 and 500 year Flood

25-year and 500-  
year flood extents  
are very similar



**NEW DATA:  
25 and 500  
year Flood**

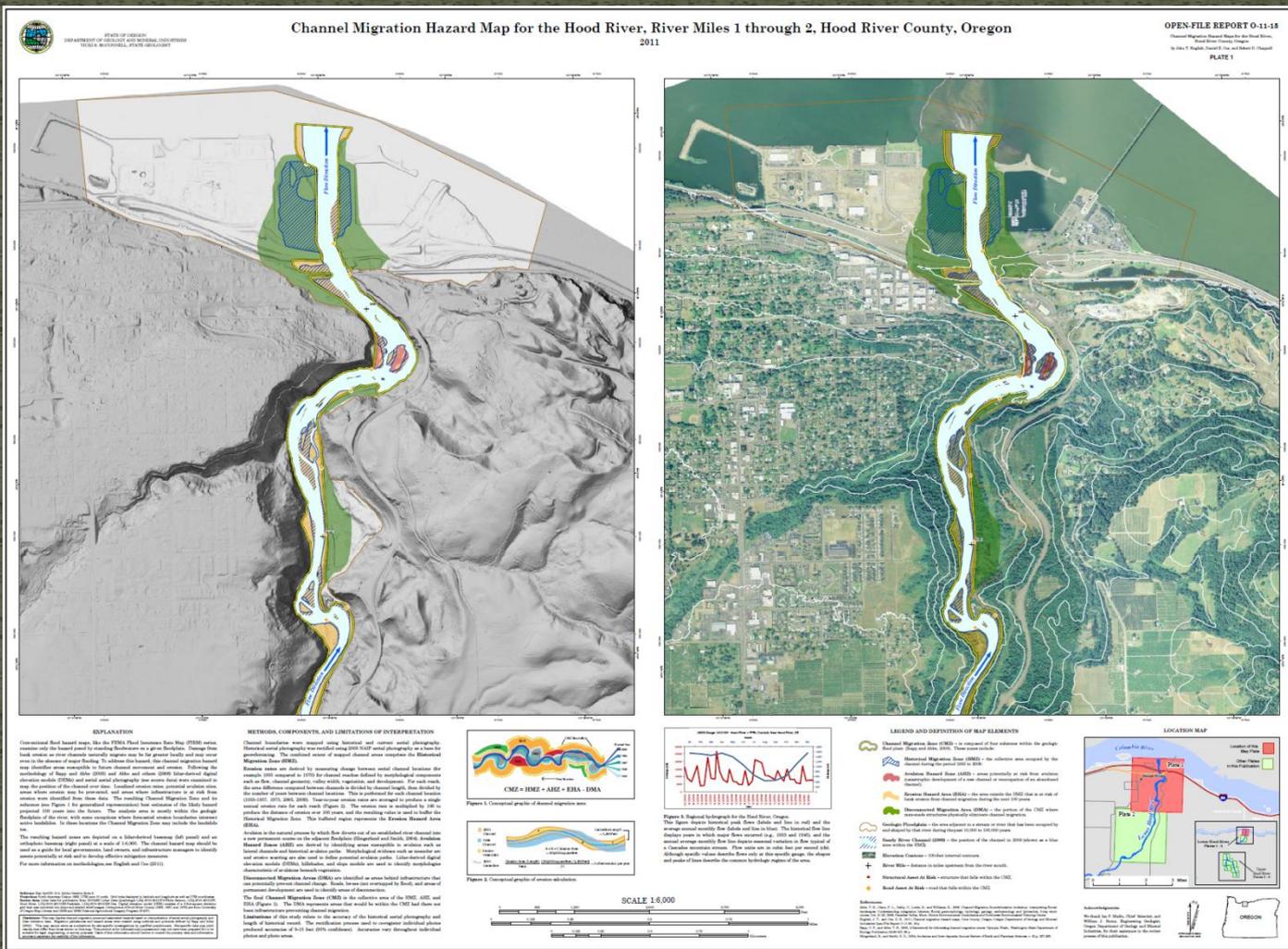


# NEW DATA: Channel Migration

CMZ more  
extensive in  
places than 500-  
year flood

# Channel Migration Hazard Maps

## DOGAMI OFR 11-15 Hood River



# Earthquake

Focused on:

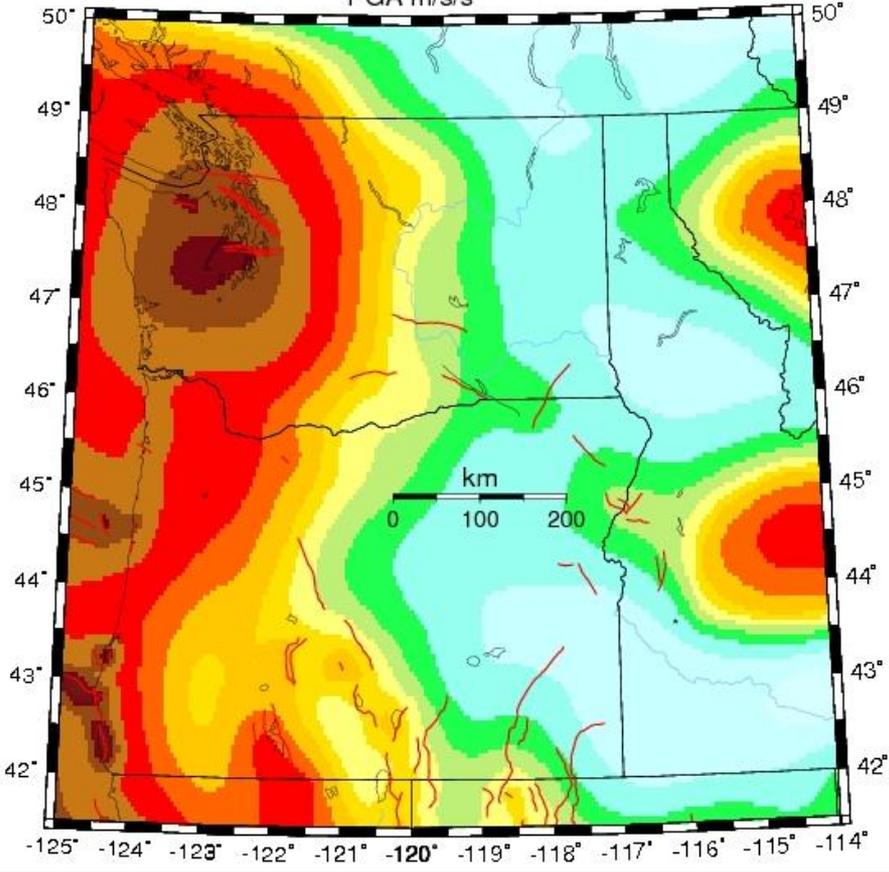
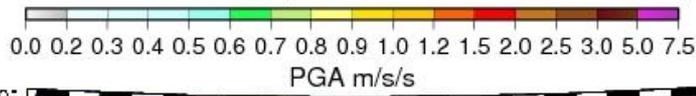
- 1) 500-year Shaking Hazard
- 2) Faults



Damaged  
Molalla High  
School  
(Scotts Mills  
EQ)

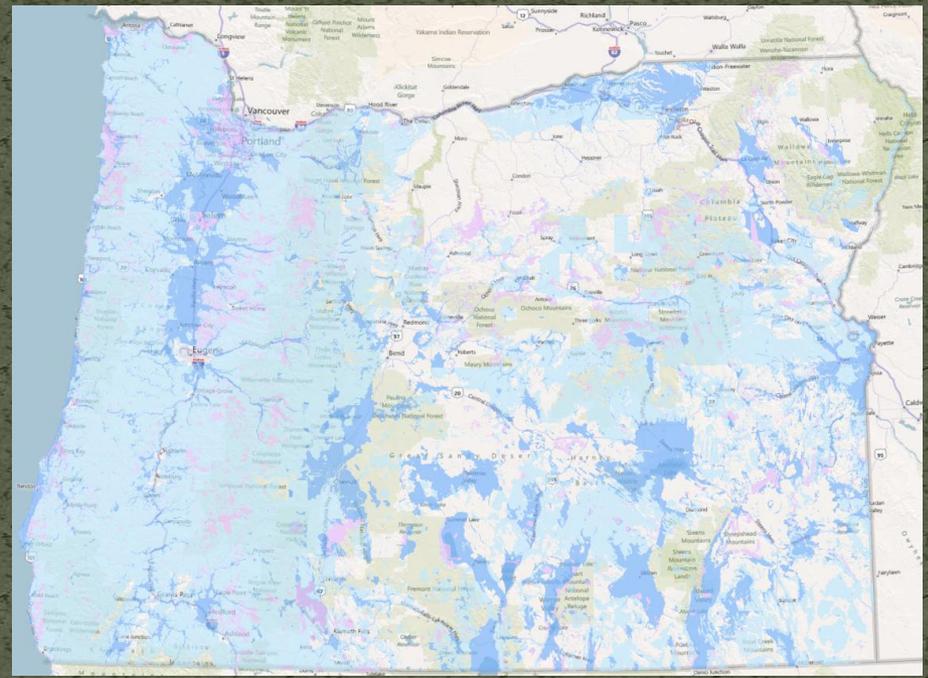
# USGS EQ Hazard and Soil Amplification

Wash-Oreg 2008 PGA w/10%PE50YR



10% in 50 years of 1.0-1.5 PGA (m/s/s)

Soil Types C and D = moderate amplification potential



# NEWDATA: 500-year Earthquake Shaking Hazard

## Magnitude / Intensity Comparison

Magnitude and Intensity measure different characteristics of earthquakes. Magnitude measures the energy released at the source of the earthquake. Magnitude is determined from measurements on seismographs. Intensity measures the strength of shaking produced by the earthquake at a certain location. Intensity is determined from effects on people, human structures, and the natural environment.

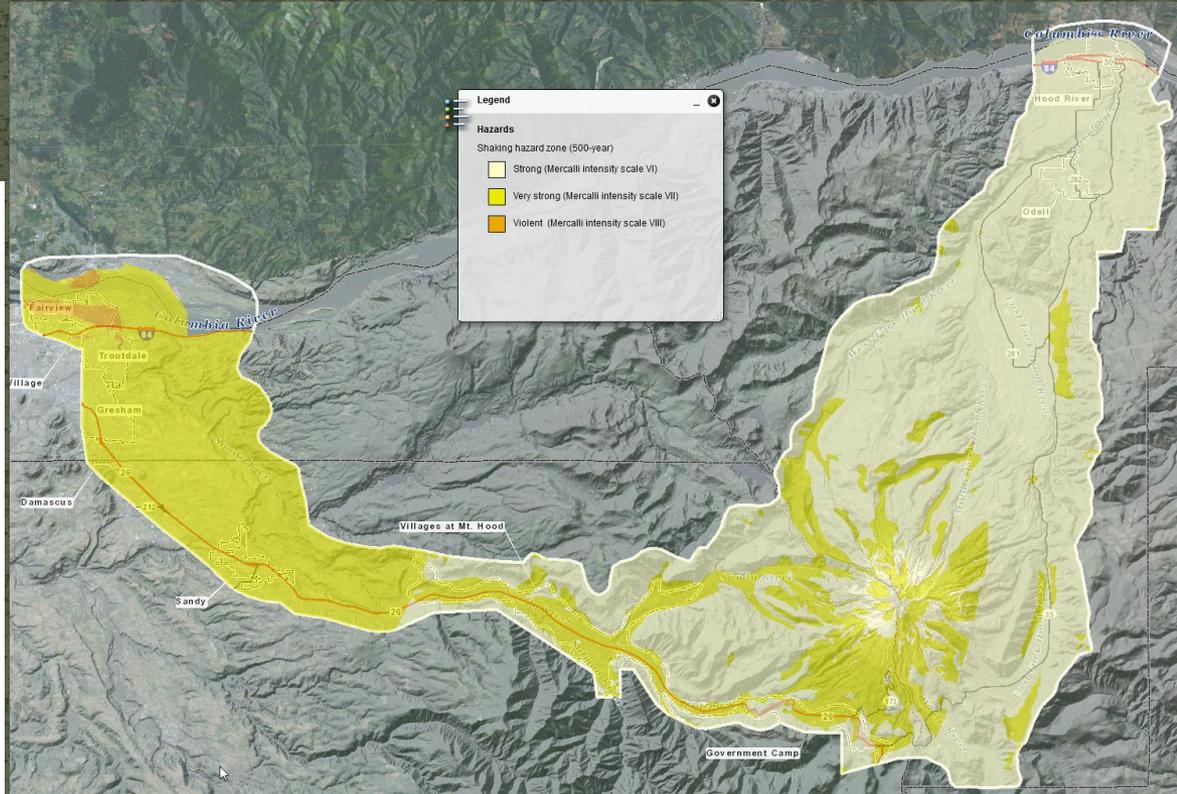
### Magnitude / Intensity Comparison

The following table gives intensities that are typically observed at locations near the epicenter of earthquakes of different magnitudes.

| Magnitude      | Typical Maximum Modified Mercalli Intensity |
|----------------|---|
| 1.0 - 3.0      | I   |
| 3.0 - 3.9      | II - III                                    |
| 4.0 - 4.9      | IV - V                                      |
| 5.0 - 5.9      | VI - VII                                    |
| 6.0 - 6.9      | VII - IX                                    |
| 7.0 and higher | VIII or higher                              |

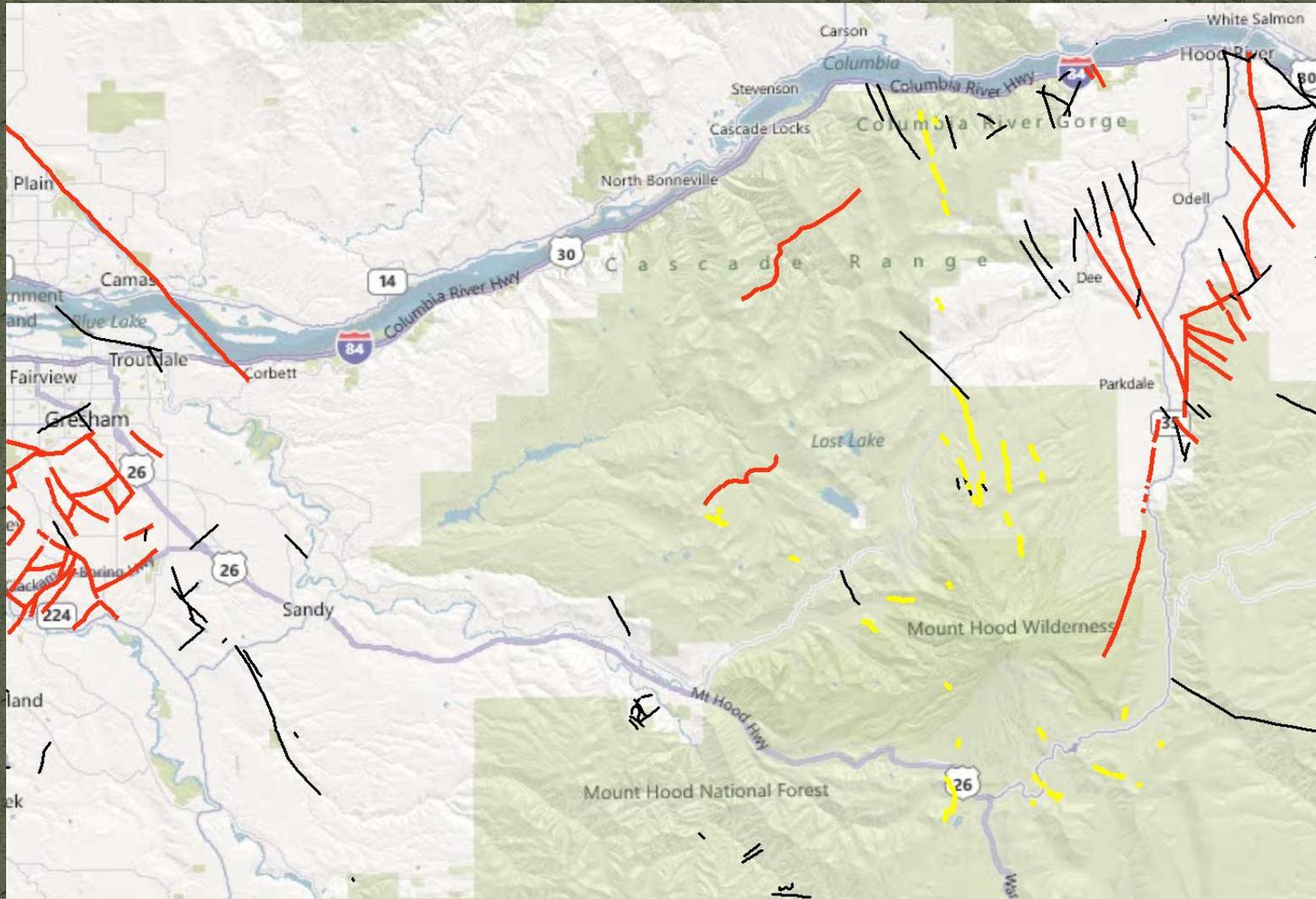
### Abbreviated Modified Mercalli Intensity Scale

- I. Not felt except by a very few under especially favorable conditions.
- II. Felt only by a few persons at rest, especially on upper floors of buildings.
- III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
- IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
- V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
- VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
- VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
- VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
- IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
- X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
- XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
- XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.



| PERCEIVED SHAKING      | Not felt | Weak    | Light   | Moderate   | Strong | Very strong | Severe         | Violent | Extreme    |
|------------------------|----------|---------|---------|------------|--------|-------------|----------------|---------|------------|
| POTENTIAL DAMAGE       | none     | none    | none    | Very light | Light  | Moderate    | Moderate/Heavy | Heavy   | Very Heavy |
| PEAK ACC.(%g)          | <.17     | .17-1.4 | 1.4-3.9 | 3.9-9.2    | 9.2-18 | 18-34       | 34-65          | 65-124  | >124       |
| PEAK VEL.(cm/s)        | <0.1     | 0.1-1.1 | 1.1-3.4 | 3.4-8.1    | 8.1-16 | 16-31       | 31-60          | 60-116  | >116       |
| INSTRUMENTAL INTENSITY | I        | II-III  | IV      | V          | VI     | VII         | VIII           | IX      | X+         |

# NEW DATA: Faults

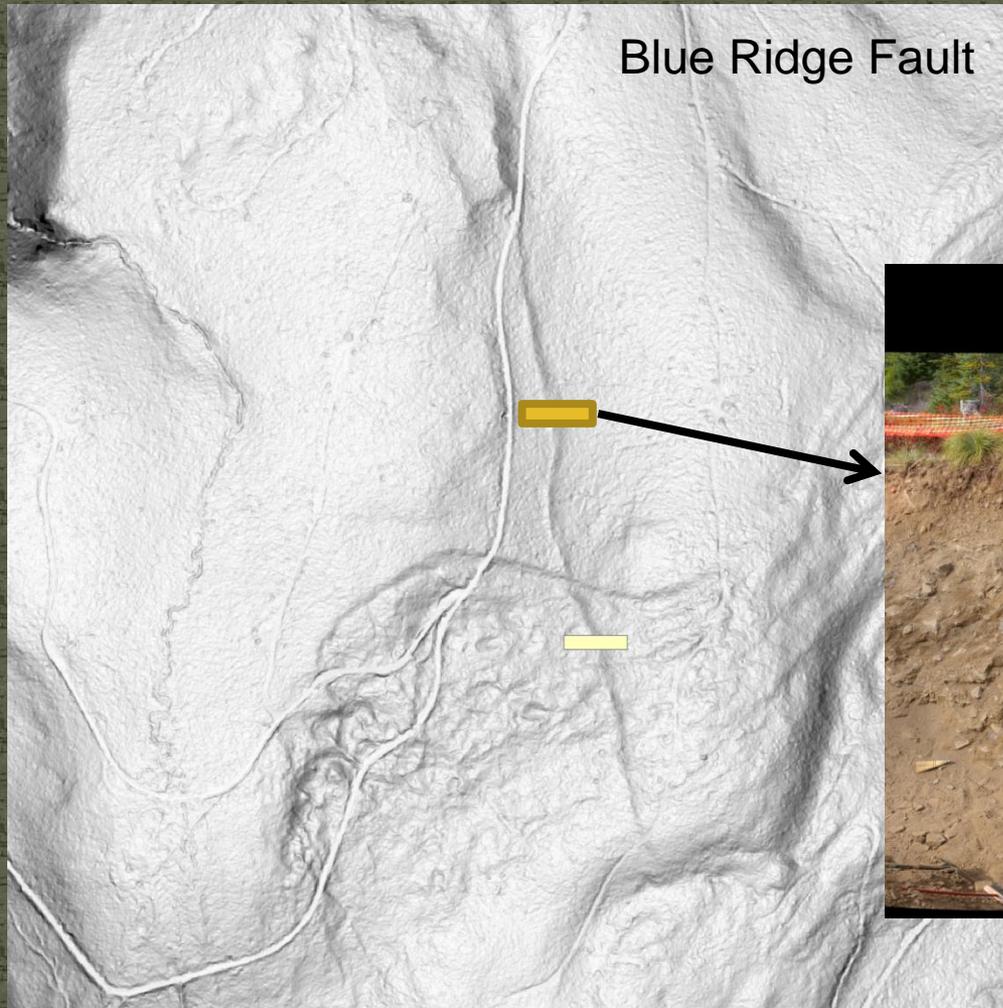


New Faults (active)

USGS Active Faults (active)

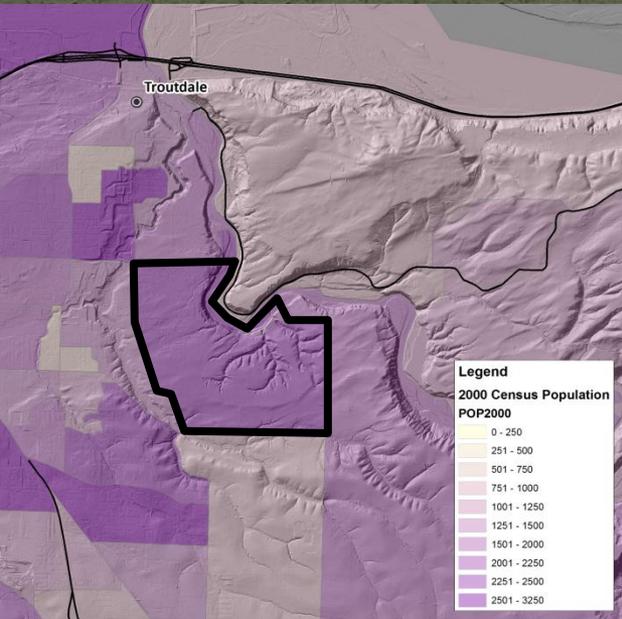
Unknown Activity Faults

# NEW DATA: Unknown Faults

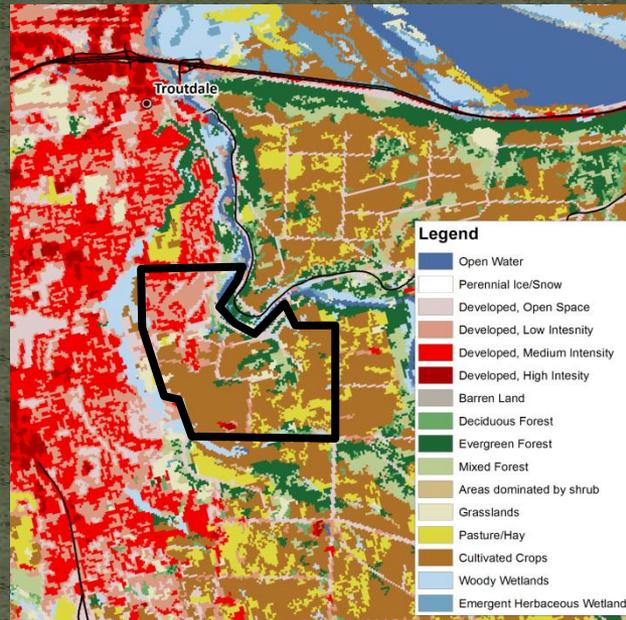


— Trench site (summer 2011)  
Continued research via NEHRP

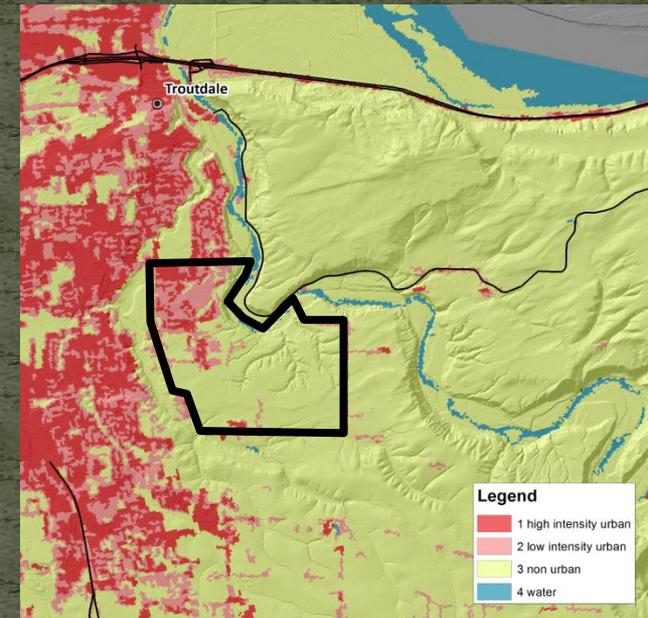
# Population Data (Residents)



Population/Census Block  
(2,253 people)



Land Cover



Population Density Classes

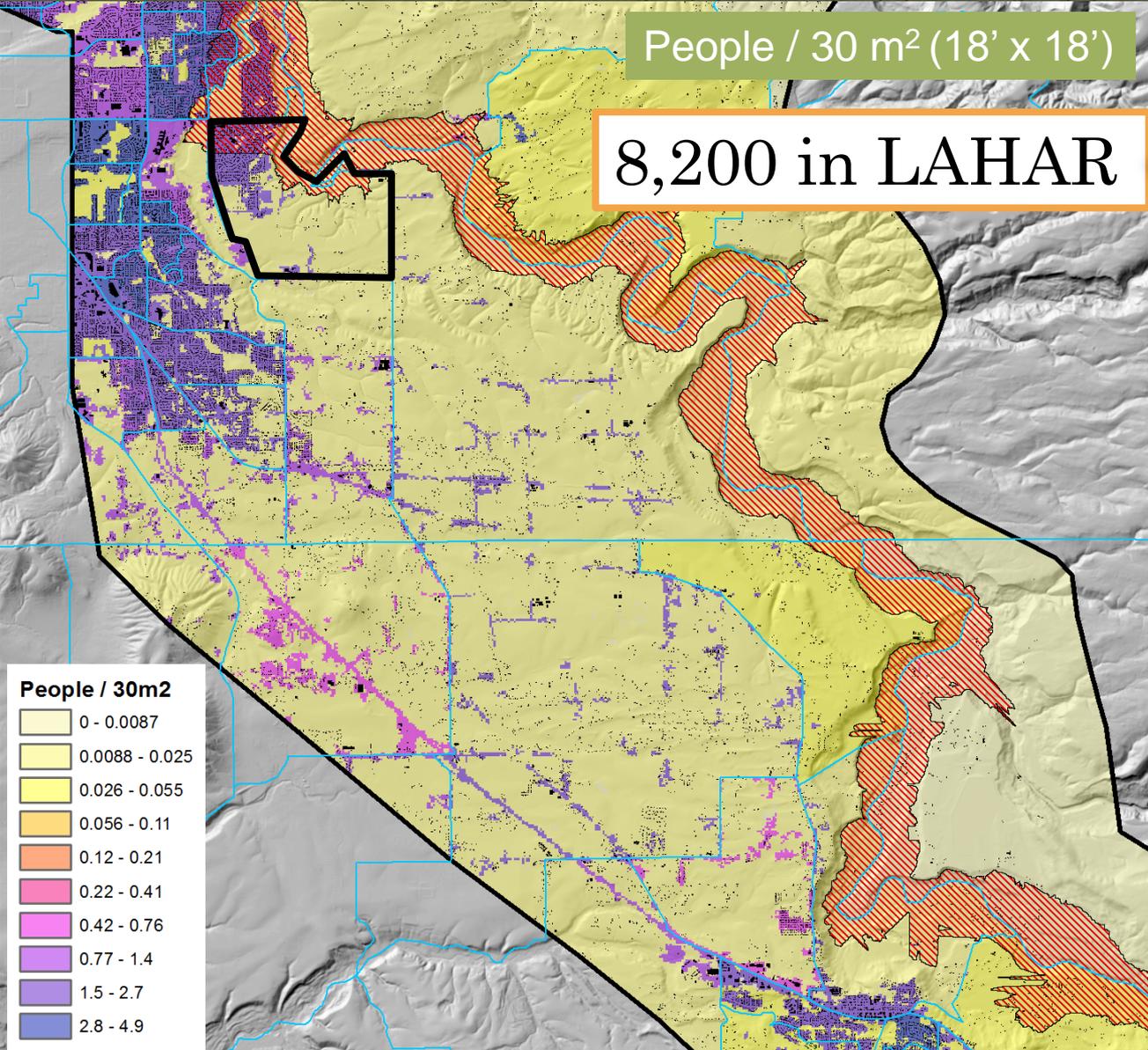
Sleeter, R., and Gould, M., 2007a, Geographic information system software to remodel population data using dasymetric mapping methods: U.S. Geological Survey Techniques and Methods 11-C2, 15 p. Web: <http://pubs.usgs.gov/tm/tm11c2/>

Sleeter, R., and Gould, M., 2007b, Downloadable dasymetric mapping tools, Arc Objects Script for ArcGIS 9.x. Web: <http://geography.wr.usgs.gov/science/dasymetric/data.htm>

# NEW DATA: Gridded Population

People / 30 m<sup>2</sup> (18' x 18')

8,200 in LAHAR

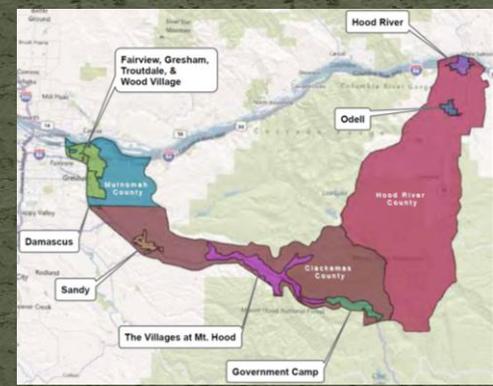


## People / 30m2

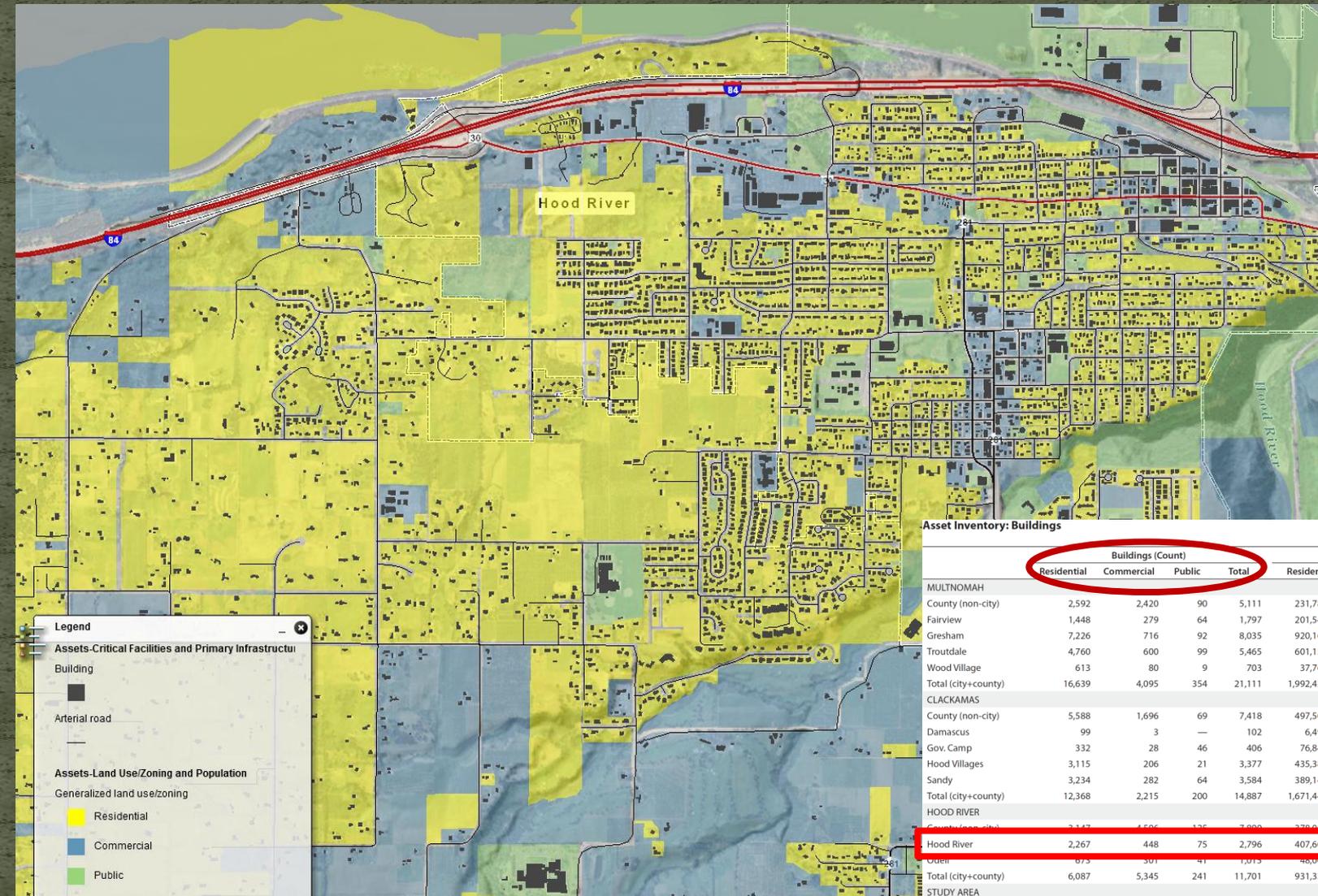


## Asset Inventory: Permanent Population

|                                  | Permanent Population<br>(within study area only) |
|----------------------------------|--|
| <b>MULTNOMAH</b>                 |  |
| County (non-city)                | 6,646  |
| Fairview                         | 2,750  |
| Gresham                          | 21,887   |
| Troutdale                        | 13,708   |
| Wood Village                     | 2,223  |
| <b>Total (city+county)</b>       | <b>47,214</b>                                    |
| <b>CLACKAMAS</b>                 |  |
| County (non-city)                | 8,949  |
| Damascus                         | 122  |
| Gov. Camp                        | 136  |
| Hood Villages                    | 3,376  |
| Sandy                            | 6,089  |
| <b>Total (city+county)</b>       | <b>18,673</b>                                    |
| <b>HOOD RIVER</b>                |  |
| County (non-city)                | 9,429  |
| Hood River                       | 6,281  |
| Odell                            | 1,341  |
| <b>Total (city+county)</b>       | <b>17,051</b>                                    |
| <b>STUDY AREA</b>                |  |
| <b>Total (cities + counties)</b> | <b>82,937</b>                                    |



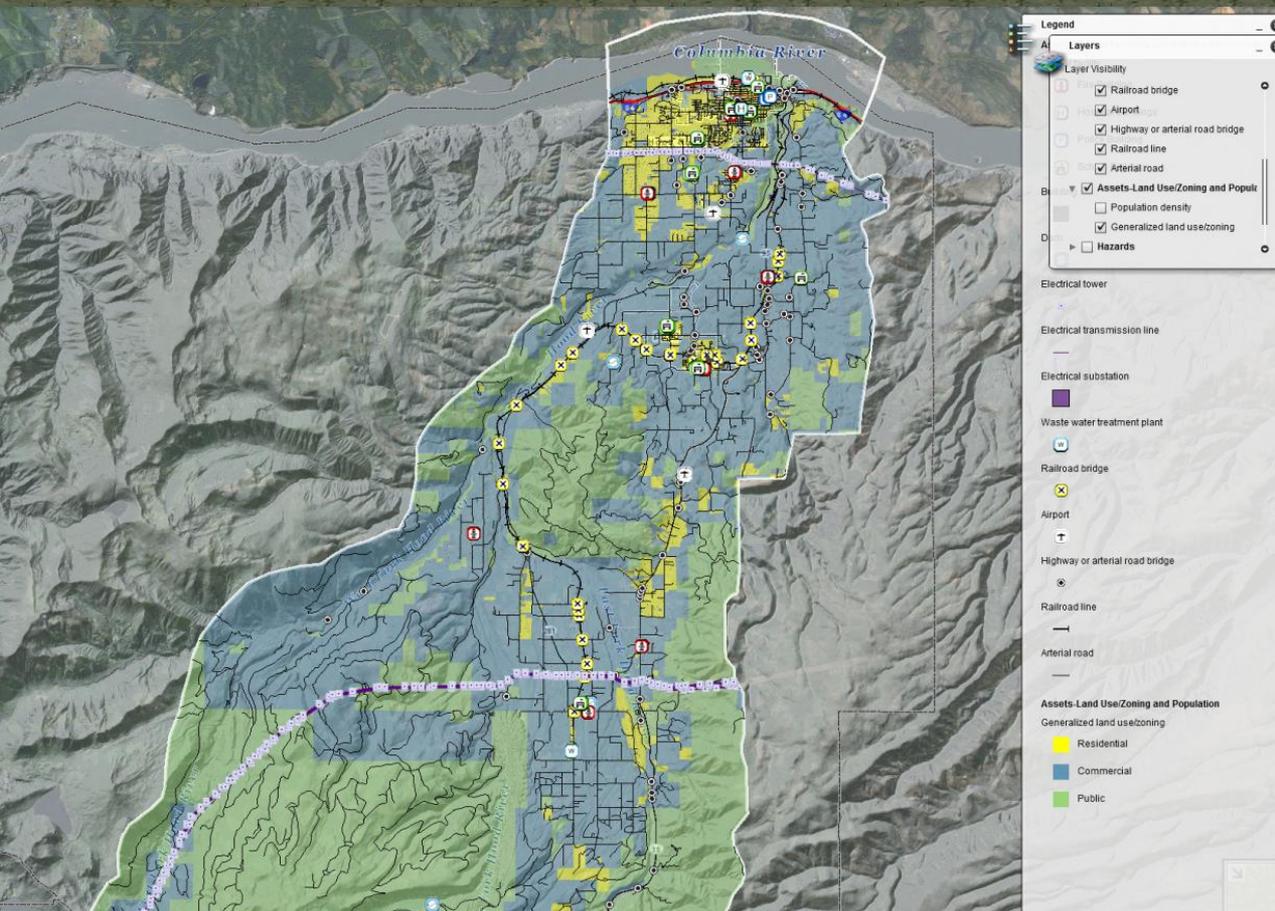
# NEW DATA: Buildings & Generalized Land Use/Zoning



Asset Inventory: Buildings

|                           | Buildings (Count) |            |        |        | Buildings Value (\$) |               |             |               |
|---------------------------|-------------------|------------|--------|--------|----------------------|---------------|-------------|---------------|
|                           | Residential       | Commercial | Public | Total  | Residential          | Commercial    | Public      | Total         |
| MULTNOMAH                 |                   |            |        |        |                      |               |             |               |
| County (non-city)         | 2,592             | 2,420      | 90     | 5,111  | 231,782,510          | 150,590,500   | 65,818,630  | 448,191,640   |
| Fairview                  | 1,448             | 279        | 64     | 1,797  | 201,549,510          | 101,425,260   | 8,160,350   | 311,135,120   |
| Gresham                   | 7,226             | 716        | 92     | 8,035  | 920,164,290          | 282,680,220   | 274,650,270 | 1,477,494,780 |
| Troutdale                 | 4,760             | 600        | 99     | 5,465  | 601,158,640          | 252,493,430   | 71,497,350  | 925,149,420   |
| Wood Village              | 613               | 80         | 9      | 703    | 37,769,570           | 66,975,230    | 2,033,770   | 106,778,570   |
| Total (city+county)       | 16,639            | 4,095      | 354    | 21,111 | 1,992,424,520        | 854,164,640   | 422,160,370 | 3,268,749,530 |
| CLACKAMAS                 |                   |            |        |        |                      |               |             |               |
| County (non-city)         | 5,588             | 1,696      | 69     | 7,418  | 497,500,940          | 160,270,200   | 31,064,730  | 688,835,870   |
| Damascus                  | 99                | 3          | —      | 102    | 6,494,800            | 65,840        | —           | 6,560,640     |
| Gov. Camp                 | 332               | 28         | 46     | 406    | 76,840,890           | 8,698,550     | 5,465,350   | 91,004,790    |
| Hood Villages             | 3,115             | 206        | 21     | 3,377  | 435,381,660          | 20,861,390    | 18,030,210  | 474,273,260   |
| Sandy                     | 3,234             | 282        | 64     | 3,584  | 389,144,660          | 105,620,168   | 30,134,270  | 524,899,038   |
| Total (city+county)       | 12,368            | 2,215      | 200    | 14,887 | 1,671,447,770        | 311,399,078   | 93,831,500  | 1,785,573,598 |
| HOOD RIVER                |                   |            |        |        |                      |               |             |               |
| County (non-city)         | 2,267             | 448        | 75     | 2,796  | 407,606,071          | 149,795,817   | 38,790,990  | 596,192,878   |
| Outfall                   | 873               | 301        | 41     | 1,213  | 46,004,800           | 32,440,740    | 24,927,330  | 125,442,450   |
| Total (city+county)       | 6,087             | 5,345      | 241    | 11,701 | 931,354,473          | 642,561,029   | 149,302,793 | 1,522,678,707 |
| STUDY AREA                |                   |            |        |        |                      |               |             |               |
| Total (cities + counties) | 35,094            | 11,655     | 795    | 47,699 | 4,595,226,763        | 1,808,124,747 | 665,294,663 | 6,577,001,835 |

# Critical Facilities & Primary Infrastructure



**Asset Inventory: Critical Facilities**

|                                  | Buildings (Count) |           |          |           |            |
|----------------------------------|-------------------|-----------|----------|-----------|------------|
|                                  | Hospital          | School    | Police   | Fire      | Total      |
| <b>MULTNOMAH</b>                 |                   |           |          |           |            |
| County (non-city)                | 0                 | 4         | 0        | 5         | 9          |
| Fairview                         | 0                 | 4         | 0        | 0         | 4          |
| Gresham                          | 1                 | 16        | 0        | 1         | 18         |
| Troutdale                        | 0                 | 9         | 1        | 1         | 11         |
| Wood Village                     | 0                 | 0         | 0        | 0         | 0          |
| <b>Total (city+county)</b>       | <b>1</b>          | <b>33</b> | <b>1</b> | <b>7</b>  | <b>42</b>  |
| <b>CLACKAMAS</b>                 |                   |           |          |           |            |
| County (non-city)                | 0                 | 2         | 0        | 1         | 3          |
| Damascus                         | 0                 | 0         | 0        | 0         | 0          |
| Gov. Camp                        | 0                 | 0         | 1        | 1         | 2          |
| Hood Villages                    | 0                 | 2         | 0        | 2         | 4          |
| Sandy                            | 0                 | 5         | 1        | 1         | 7          |
| <b>Total (city+county)</b>       | <b>0</b>          | <b>9</b>  | <b>2</b> | <b>5</b>  | <b>16</b>  |
| <b>HOOD RIVER</b>                |                   |           |          |           |            |
| County (non-city)                | 0                 | 14        | 0        | 9         | 23         |
| Hood River                       | 1                 | 7         | 4        | 1         | 13         |
| Odell                            | 0                 | 8         | 0        | 2         | 10         |
| <b>Total (city+county)</b>       | <b>1</b>          | <b>29</b> | <b>4</b> | <b>12</b> | <b>46</b>  |
| <b>STUDY AREA</b>                |                   |           |          |           |            |
| <b>Total (cities + counties)</b> | <b>2</b>          | <b>71</b> | <b>7</b> | <b>24</b> | <b>104</b> |

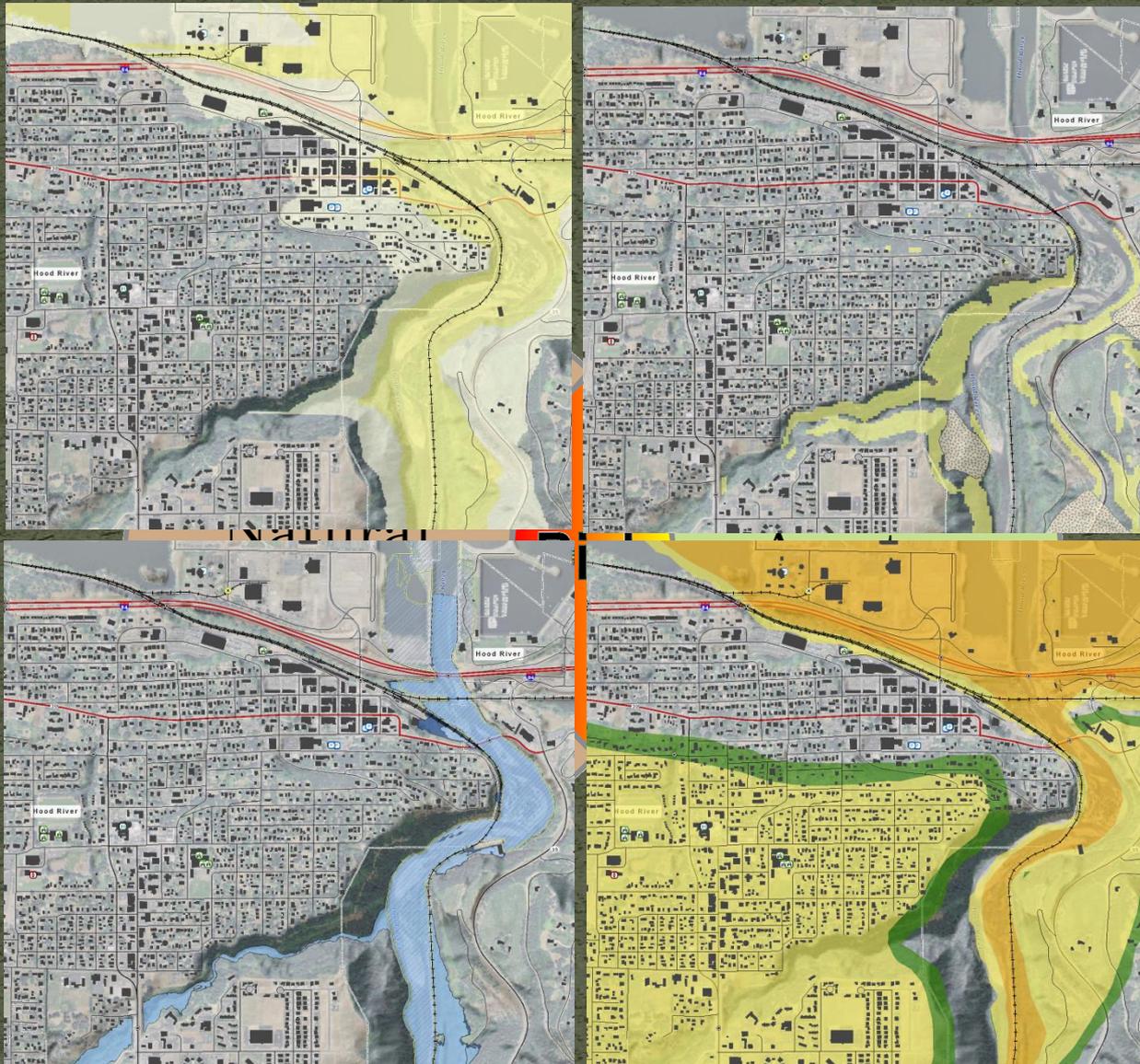
# Risk Analysis

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Task: Explore Risk Methods for  
Multi-Hazards on Volcanoes

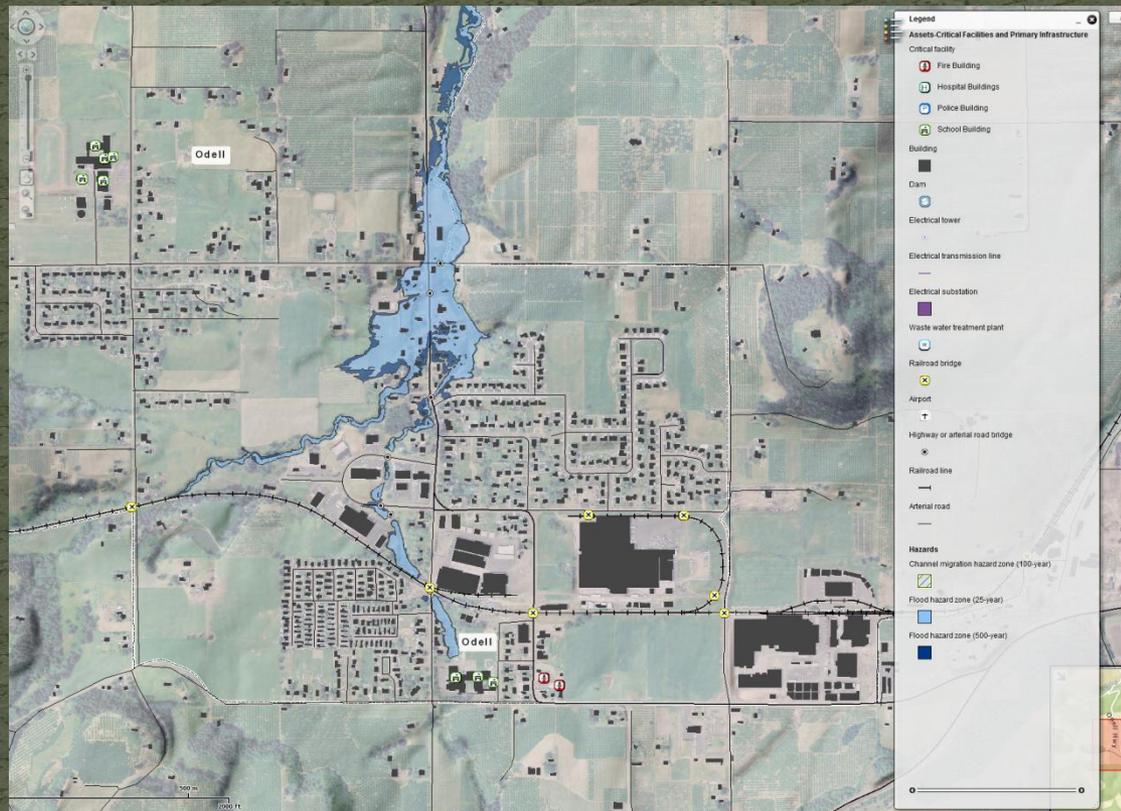
1. Exposure Analysis
2. FEMA's Hazus-MH Analysis

# Exposure Analysis Method



# Exposure Analysis Results

- Primary Results are Maps & Tables



|                           | 25-year Flood Plain 4% Annual Chance |            |            |            |        |            |       |            | 500-year Flood Plain 0.2% Annual Chance |            |            |            |        |            |       |            | Channel Migration Hazard Zone |             |            |            |        |            |       |             |  |
|---------------------------|--------------------------------------|------------|------------|------------|--------|------------|-------|------------|---|------------|------------|------------|--------|------------|-------|------------|-------------------------------|-------------|------------|------------|--------|------------|-------|-------------|--|
|                           | Residential                          |            | Commercial |            | Public |            | Total |            | Residential                             |            | Commercial |            | Public |            | Total |            | Residential                   |             | Commercial |            | Public |            | Total |             |  |
|                           | Count                                | Value (\$) | Count      | Value (\$) | Count  | Value (\$) | Count | Value (\$) | Count                                   | Value (\$) | Count      | Value (\$) | Count  | Value (\$) | Count | Value (\$) | Count                         | Value (\$)  | Count      | Value (\$) | Count  | Value (\$) | Count | Value (\$)  |  |
| <b>MULTNOMAH</b>          |                                      |            |            |            |        |            |       |            |   |            |            |            |        |            |       |            |                               |             |            |            |        |            |       |             |  |
| County (non-city)         | 0                                    | —          | 0          | —          | 0      | —          | 0     | —          | 2                                       | 312,800    | 1          | 1,994,120  | 1      | —          | 4     | 2,306,920  | 91                            | 10,780,890  | 21         | 7,064,050  | 7      | 6,190      | 119   | 17,851,130  |  |
| Fairview                  | 0                                    | —          | 0          | —          | 0      | —          | 0     | —          | 0                                       | —          | 0          | —          | 0      | —          | 0     | —          | 0                             | —           | 0          | —          | 0      | —          | 0     | —           |  |
| Gresham                   | 0                                    | —          | 0          | —          | 0      | —          | 0     | —          | 0                                       | —          | 0          | —          | 0      | —          | 0     | —          | 0                             | —           | 0          | —          | 0      | —          | 0     | —           |  |
| Troutdale                 | 0                                    | —          | 1          | 2,798,320  | 0      | —          | 1     | 2,798,320  | 4                                       | 798,600    | 1          | 2,798,320  | 0      | —          | 5     | 3,596,920  | 53                            | 7,110,690   | 4          | 3,895,980  | 10     | 8,943,160  | 67    | 19,949,830  |  |
| Wood Village              | —                                    | —          | 0          | —          | 0      | —          | 0     | —          | 0                                       | —          | 0          | —          | 0      | —          | 0     | —          | 0                             | —           | 0          | —          | 0      | —          | 0     | —           |  |
| Total (city+county)       | 0                                    | —          | 1          | 2,798,320  | 0      | —          | 1     | 2,798,320  | 6                                       | 1,111,400  | 2          | 4,792,440  | 1      | —          | 9     | 5,903,840  | 144                           | 17,891,580  | 25         | 10,960,030 | 17     | 8,949,350  | 186   | 37,800,960  |  |
| <b>CLACKAMAS</b>          |                                      |            |            |            |        |            |       |            |   |            |            |            |        |            |       |            |                               |             |            |            |        |            |       |             |  |
| County (non-city)         | 20                                   | 2,951,660  | 2          | 284,910    | 4      | 148,930    | 27    | 3,385,500  | 51                                      | 8,250,920  | 2          | 284,910    | 4      | 148,930    | 58    | 8,684,760  | 97                            | 13,053,780  | 6          | 549,770    | 6      | 148,930    | 110   | 13,752,480  |  |
| Damascus                  | 0                                    | —          | 0          | —          | 0      | —          | 0     | —          | 0                                       | —          | 0          | —          | 0      | —          | 0     | —          | 0                             | —           | 0          | —          | 0      | —          | 0     | —           |  |
| Gov. Camp                 | 0                                    | —          | 0          | —          | 0      | —          | 0     | —          | 0                                       | —          | 0          | —          | 0      | —          | 0     | —          | 0                             | —           | 0          | —          | 0      | —          | 0     | —           |  |
| Hood Villages             | 34                                   | 4,733,410  | 3          | —          | 1      | —          | 39    | 4,733,410  | 92                                      | 13,906,430 | 9          | —          | 1      | —          | 105   | 13,906,430 | 630                           | 95,132,320  | 30         | 1,566,570  | 2      | 500,170    | 673   | 97,199,060  |  |
| Sandy                     | 0                                    | —          | 0          | —          | 0      | —          | 0     | —          | 0                                       | —          | 0          | —          | 0      | —          | 0     | —          | 0                             | —           | 0          | —          | 0      | —          | 0     | —           |  |
| Total (city+county)       | 54                                   | 7,685,070  | 5          | 284,910    | 5      | 148,930    | 66    | 8,118,910  | 143                                     | 22,157,350 | 11         | 284,910    | 5      | 148,930    | 163   | 22,591,190 | 727                           | 108,186,100 | 36         | 2,116,340  | 8      | 649,100    | 771   | 110,951,540 |  |
| <b>HOOD RIVER</b>         |                                      |            |            |            |        |            |       |            |   |            |            |            |        |            |       |            |                               |             |            |            |        |            |       |             |  |
| County (non-city)         | 12                                   | 2,511,230  | 15         | 1,447,630  | 4      | —          | 31    | 3,958,860  | 14                                      | 2,762,110  | 20         | 2,408,230  | 6      | —          | 40    | 5,170,340  | 5                             | 1,140,740   | 18         | 2,525,310  | 2      | —          | 25    | 3,666,050   |  |
| Hood River                | 0                                    | —          | 0          | —          | 0      | —          | 0     | —          | 0                                       | —          | 0          | —          | 0      | —          | 0     | —          | 0                             | —           | 0          | —          | 0      | —          | 0     | —           |  |
| Odell                     | 12                                   | 1,132,680  | 2          | 177,000    | 2      | —          | 16    | 1,309,680  | 15                                      | 1,430,690  | 3          | 301,270    | 3      | —          | 21    | 1,731,960  | 0                             | —           | 0          | —          | 0      | —          | 0     | —           |  |
| Total (city+county)       | 24                                   | 3,643,910  | 17         | 1,624,630  | 6      | —          | 47    | 5,268,540  | 31                                      | 4,590,890  | 23         | 2,709,500  | 9      | —          | 63    | 7,300,390  | 5                             | 1,140,740   | 19         | 2,641,280  | 4      | 1,167,650  | 28    | 4,949,670   |  |
| <b>STUDY AREA</b>         |                                      |            |            |            |        |            |       |            |   |            |            |            |        |            |       |            |                               |             |            |            |        |            |       |             |  |
| Total (cities + counties) | 78                                   | 11,328,980 | 23         | 4,707,860  | 11     | 148,930    | 114   | 16,185,770 | 180                                     | 27,859,640 | 36         | 7,786,850  | 15     | 148,930    | 235   | 35,795,420 | 876                           | 127,218,420 | 80         | 15,717,650 | 29     | 10,766,100 | 985   | 153,702,170 |  |

# Hazus-MH Analysis

- Hazus-MH has earthquake, flood, and wind modules only
- So...had to test volcano hazard in existing modules (flood & EQ)
- Primary Results are tables



We performed four different Hazus-MH analyses:

- Flood (flood module):
  - 500-year flood hazard analysis
- Earthquake (earthquake module):
  - 500-year earthquake hazard analysis
- Volcanic (flood module):
  - 500-year volcanic hazard analysis
- Volcanic (earthquake module):
  - 500-year volcanic hazard analysis (with and without landslide/volcanic hazards)

Ex. 500-year Earthquake-Building Damage

**Building Damage**

**Building Damage**

HAZUS estimates that about 9,045 buildings will be at least moderately damaged. This is over 21.00 % of the total number of buildings in the region. There are an estimated 827 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below summarizes the expected damage by general occupancy for the buildings in the region. Table 5 summarizes the expected damage by general building type.

**Table 4: Expected Building Damage by Occupancy**

|                   | None          |       | Slight        |       | Moderate     |       | Extensive    |       | Complete   |       |
|-------------------|---------------|-------|---------------|-------|--------------|-------|--------------|-------|------------|-------|
|                   | Count         | (%)   | Count         | (%)   | Count        | (%)   | Count        | (%)   | Count      | (%)   |
| Agriculture       | 27            | 0.12  | 11            | 0.10  | 10           | 0.16  | 5            | 0.26  | 2          | 0.19  |
| Commercial        | 191           | 0.86  | 118           | 1.08  | 158          | 2.49  | 86           | 4.58  | 36         | 4.39  |
| Education         | 10            | 0.04  | 5             | 0.05  | 6            | 0.09  | 3            | 0.16  | 1          | 0.18  |
| Government        | 16            | 0.07  | 7             | 0.07  | 9            | 0.14  | 4            | 0.22  | 1          | 0.18  |
| Industrial        | 60            | 0.27  | 36            | 0.33  | 55           | 0.87  | 32           | 1.72  | 11         | 1.37  |
| Other Residential | 2,153         | 9.66  | 1,689         | 15.52 | 2,377        | 37.53 | 1,190        | 63.13 | 326        | 39.40 |
| Religion          | 26            | 0.12  | 12            | 0.11  | 13           | 0.21  | 7            | 0.35  | 2          | 0.29  |
| Single Family     | 19,795        | 88.88 | 9,008         | 82.74 | 3,706        | 58.51 | 557          | 29.57 | 447        | 54.04 |
| <b>Total</b>      | <b>22,277</b> |       | <b>10,884</b> |       | <b>6,334</b> |       | <b>1,885</b> |       | <b>828</b> |       |

**Table 5: Expected Building Damage by Building Type (All Design Levels)**

|              | None          |       | Slight        |       | Moderate     |       | Extensive    |       | Complete   |       |
|--------------|---------------|-------|---------------|-------|--------------|-------|--------------|-------|------------|-------|
|              | Count         | (%)   | Count         | (%)   | Count        | (%)   | Count        | (%)   | Count      | (%)   |
| Wood         | 20,417        | 91.65 | 9298          | 85.43 | 3,794        | 59.90 | 540          | 28.64 | 466        | 56.36 |
| Steel        | 105           | 0.47  | 49            | 0.45  | 92           | 1.44  | 53           | 2.82  | 21         | 2.55  |
| Concrete     | 94            | 0.42  | 55            | 0.51  | 76           | 1.20  | 39           | 2.09  | 13         | 1.59  |
| Precast      | 47            | 0.21  | 23            | 0.21  | 47           | 0.74  | 40           | 2.13  | 12         | 1.51  |
| RM           | 10            | 0.05  | 4             | 0.03  | 7            | 0.11  | 5            | 0.29  | 1          | 0.17  |
| URM          | 237           | 1.06  | 157           | 1.45  | 176          | 2.78  | 96           | 5.09  | 58         | 6.75  |
| MH           | 1,367         | 6.14  | 1298          | 11.92 | 2,142        | 33.82 | 1,111        | 58.94 | 257        | 31.08 |
| <b>Total</b> | <b>22,277</b> |       | <b>10,884</b> |       | <b>6,334</b> |       | <b>1,885</b> |       | <b>828</b> |       |

\*Note:  
 RM Reinforced Masonry  
 URM Unreinforced Masonry  
 MH Manufactured Housing

# Conclusions

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# 3 Primary Conclusions

1. Mt. Hood and its drainages are a multi-geologic hazards area.
2. This project demonstrates the necessity of high-resolution lidar data.
3. Two methods of risk analysis were examined: exposure analysis and Hazus-MH and both appear useful.

# Long Term Annualized Losses in Millions of \$

## Short Term (10 years) Annualized Losses in Millions of \$

~\$0M

~\$10sM

~\$10M

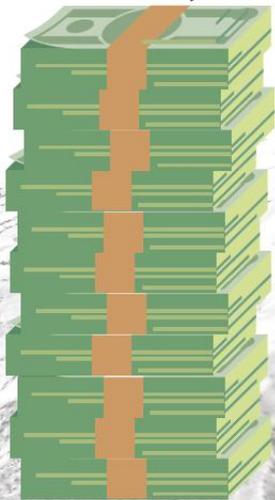
~\$10sM

~\$0M

~\$10sM

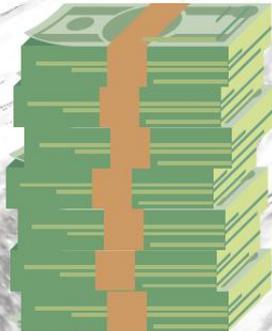
### Loss Estimates Based on Models Used in This Study

~\$5.5M/year



**Volcano**

~\$3.4M/year



**Landslide**

~\$0.8M/year



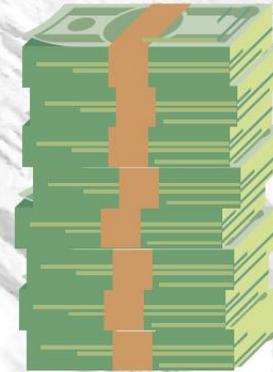
**Flood**

~\$2.8M/year



**Channel Migration**

~\$4.0M/year



**Earthquake**

**Actual Losses**  
based on  
historical data  
2007-2010

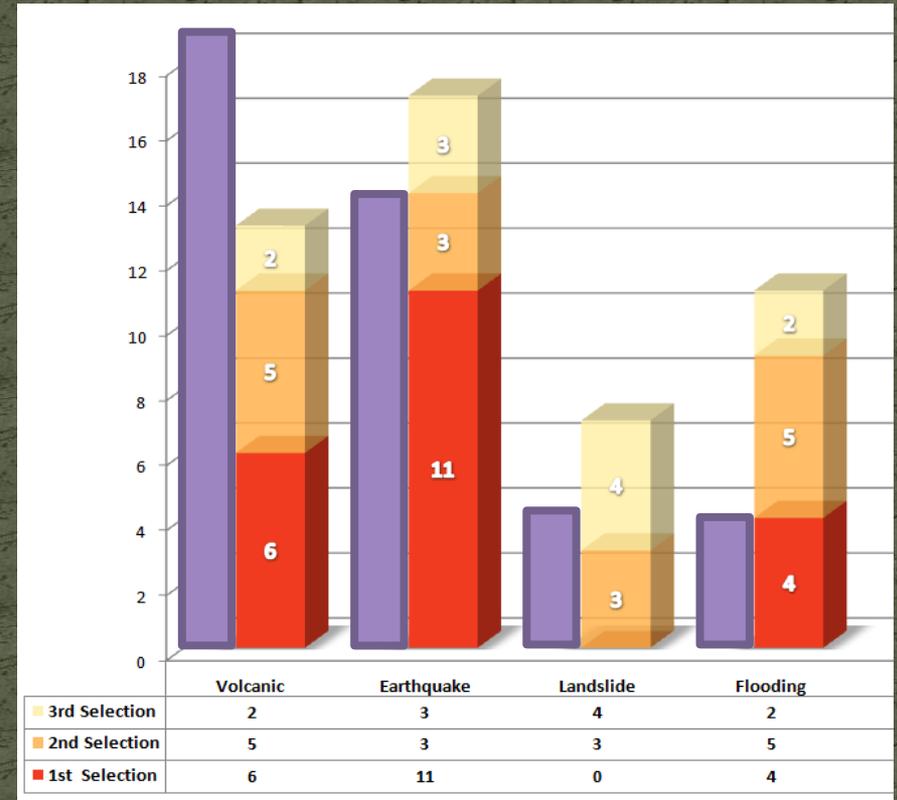
~\$2.5M/year



**House Fire**

# Estimated Long Term Loss Ratios

- Volcano ~ 18%
- Earthquake ~ 13%
- Landslide ~ 3%
- Flood (500-year) ~ 1%
- Channel Migration ~ 2%



# Multi-Hazard and Risk Study for the Mount Hood Region, Multnomah, Clackamas, and Hood River Counties, Oregon

Oregon Department of Geology and Mineral Industries  
Open-File Report O-11-16

