

# Landslide and Debris-Flow Early Warning in the United States

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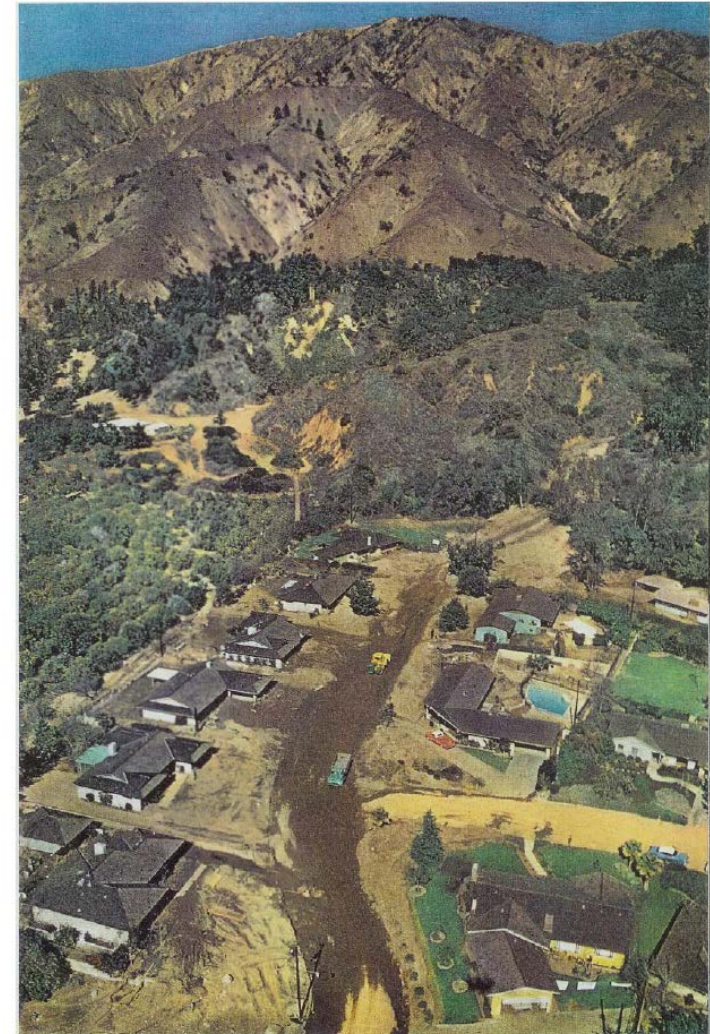
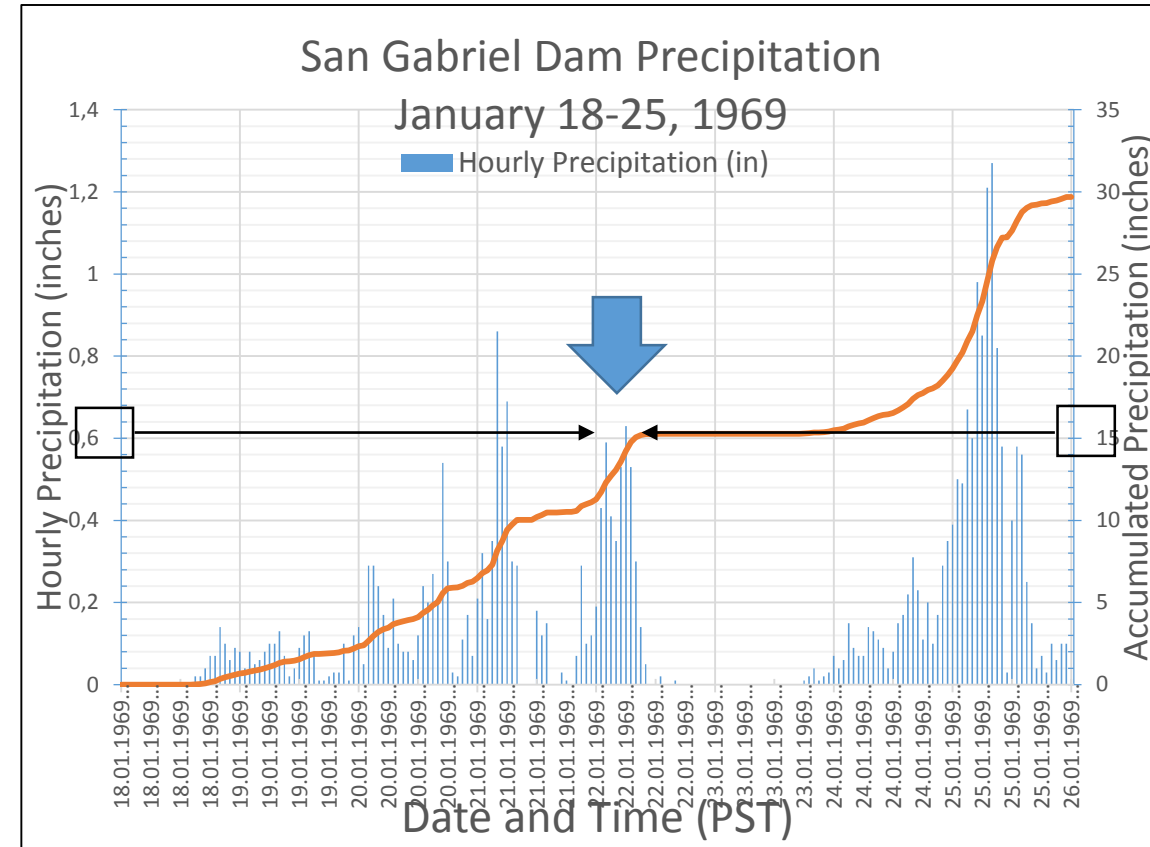
<sup>2</sup>U.S. Geological Survey, Landslide Hazards Program, Menlo Park CA USA





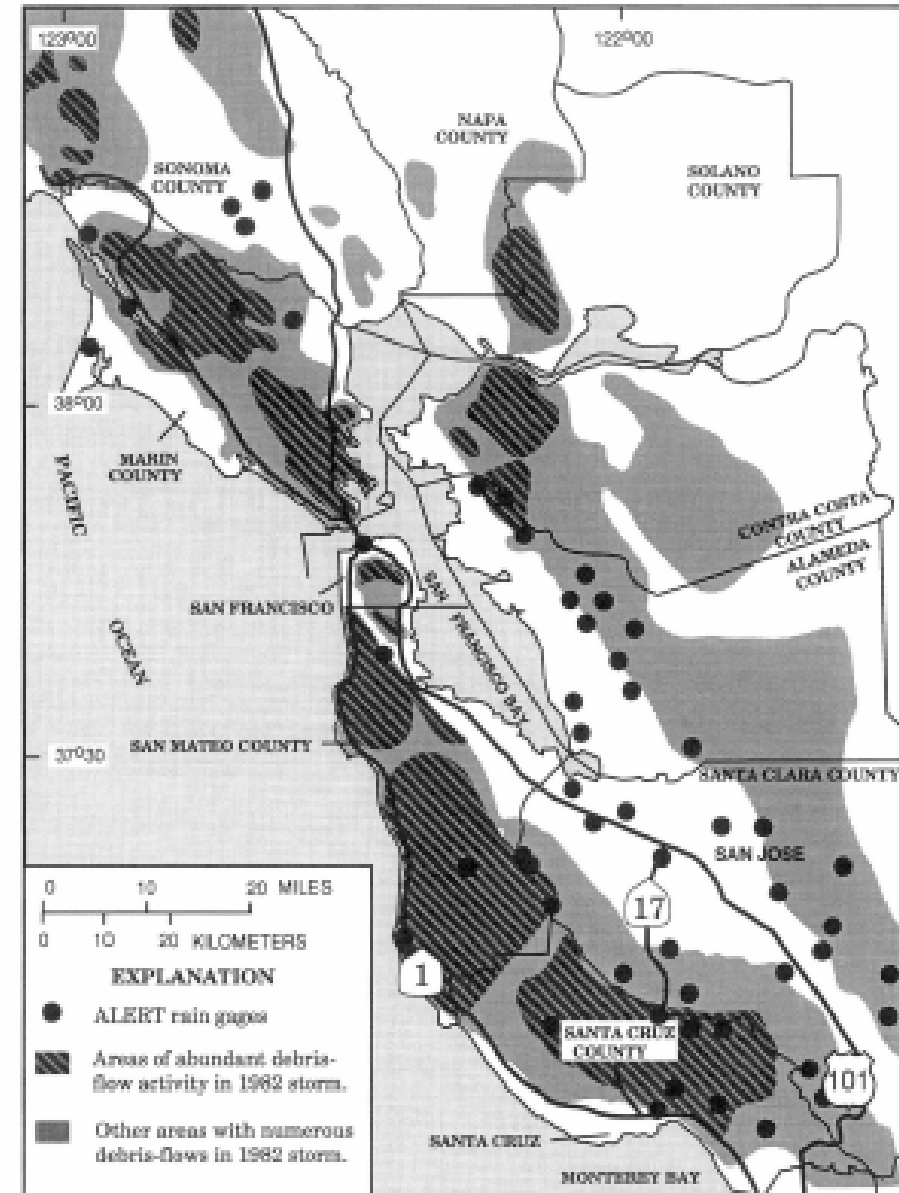
# Motivation: Significant Events

Southern California, January 1969



# Motivation: Significant Events

San Francisco Bay Area, January 1982





# Motivation: Significant Events

Southern California, December 2003

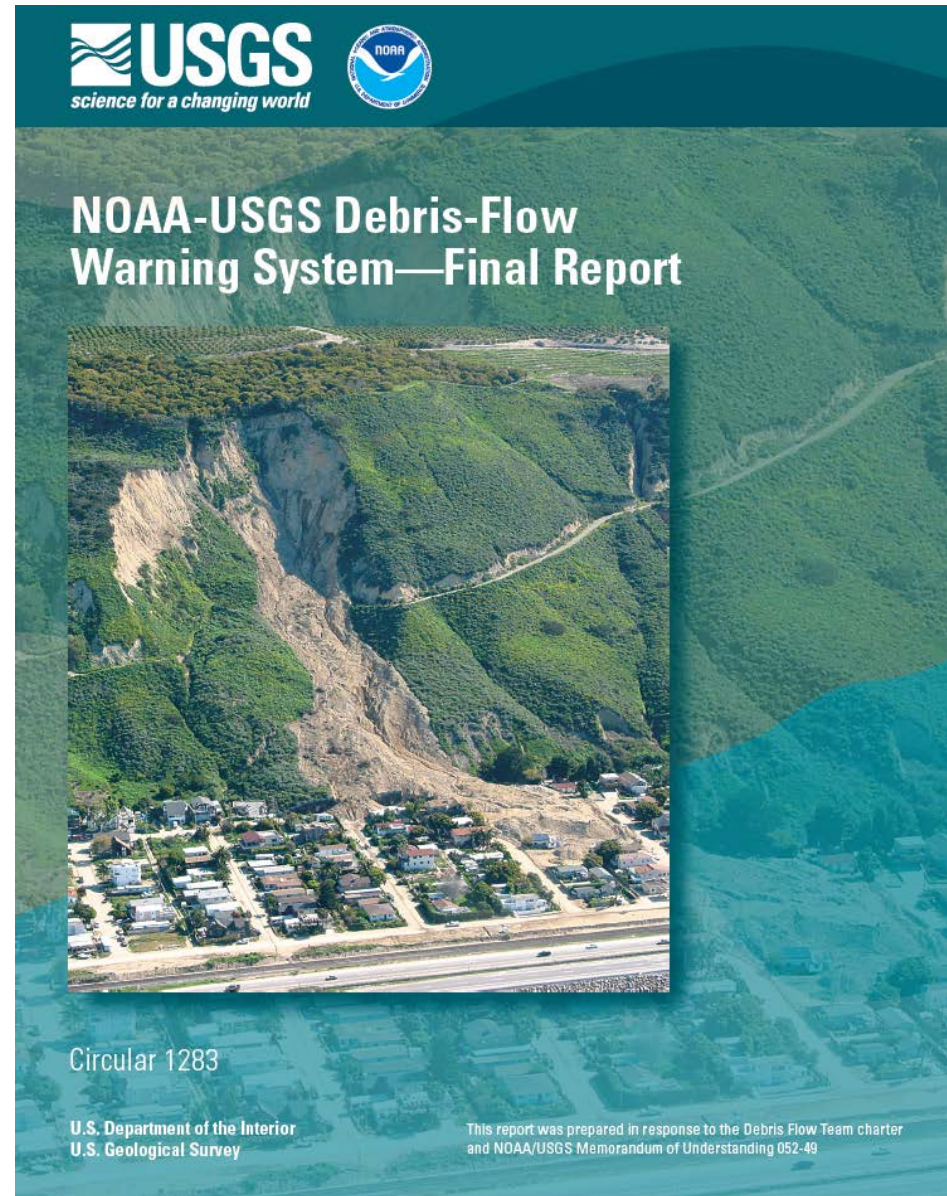
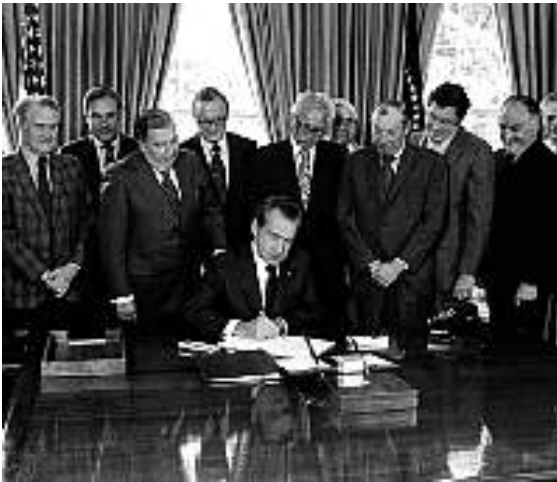




# Official Actions

Disaster Relief Act of 1974.

Formation of NOAA-USGS Debris-flow task force in 2004.



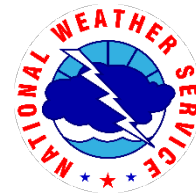
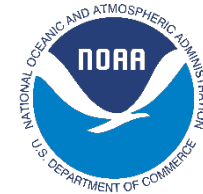
# Warning Infrastructure

## U.S. Geological Survey (USGS) Partnership with National Oceanic and Atmospheric Administration (NOAA) – National Weather Service (NWS)



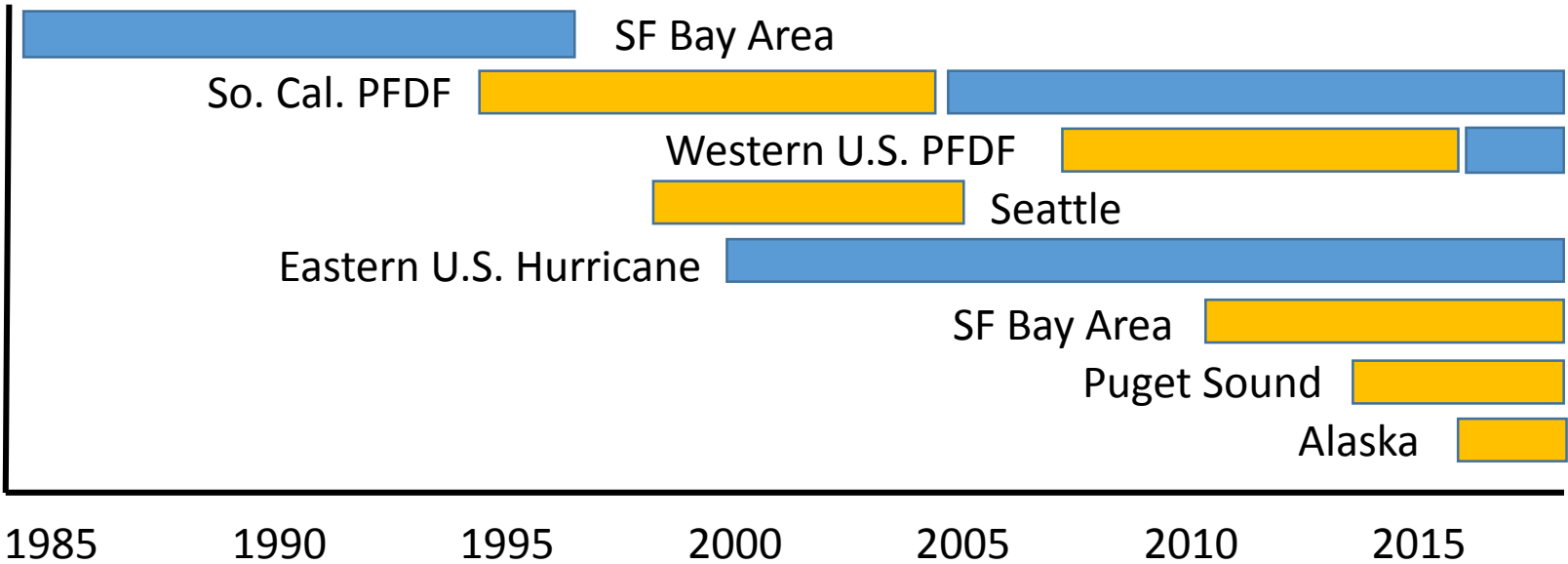
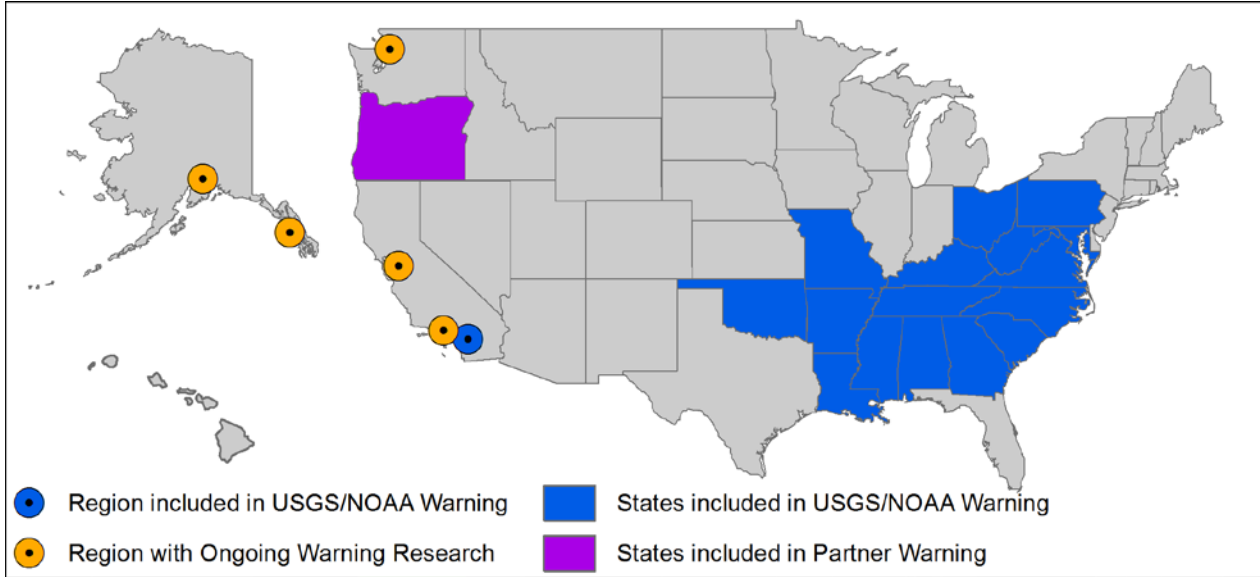
Provide sound scientific guidance on the physiographic, hydrologic, and meteorological conditions that contribute to landslide and debris-flow initiation and growth.

Annual Program Budget \$3.5 million USD, ~\$1 million USD specific to early warning.



Provide forecasted and real-time monitoring of meteorological conditions, and technical infrastructure for issuance of outlooks, watches, and warnings.

# Existing / Proposed Warning Systems





# Challenges and Opportunities



- Diversity of initiation processes and slide/flow types in the U.S.
- Small size of the USGS Landslide Hazards Program.
- Impacts on National Weather Service (NWS) performance metrics.
- Lack of long-term memory of public and elected officials.



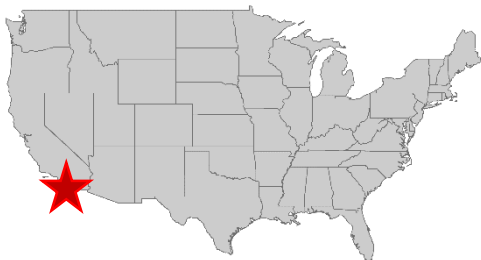
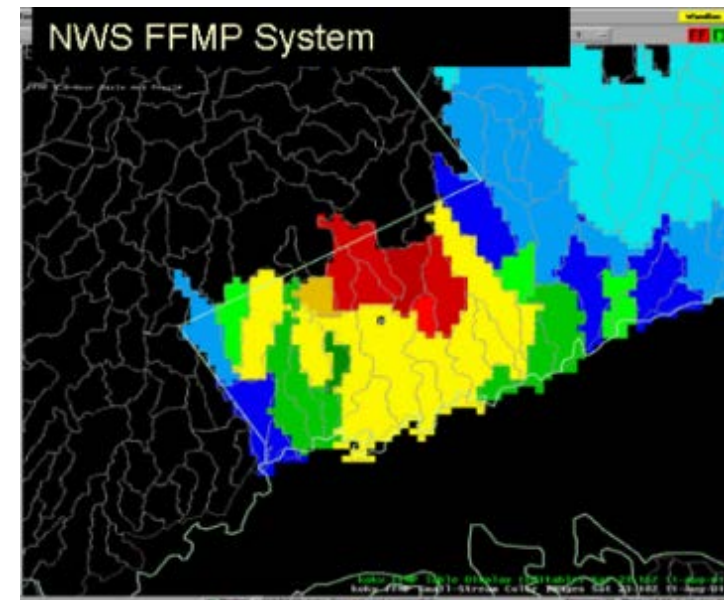
# Southern California: 2005 - Present

Warning system based on USGS post-fire debris-flow thresholds and NWS flash-flood products

NWS incorporates USGS thresholds into existing Flash Flood Monitoring and Prediction System (FFMP).

NWS forecasts and monitors rainfall intensities and compare to existing USGS thresholds. NWS issues Outlook, Watch or Warning.

Interest at NWS in expanding the warning system beyond southern California



# San Francisco Bay Area: 1986 – 1995, 2010 – Present

San Francisco Bay area, California

7.2 million people and 18,000  
km<sup>2</sup> (~400 persons/km<sup>2</sup>)

Development in steep areas

Long history of landslides from winter  
storms

e.g., 1943, 1955, 1968-69, 1972-  
73, 1982, 1997-98, 2006, 2010-11

Large financial impact

~65 damaging landslides/yr\*

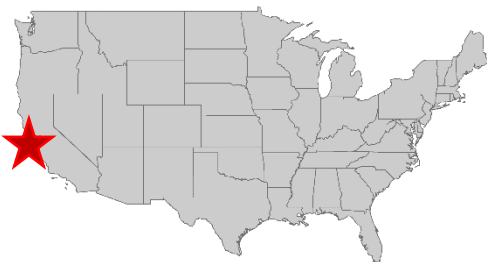
~US\$15 million/yr\*



Photo: M. Reid, USGS



Photo: M. Reid, USGS



\*Crovelli and Coe, *Georisk*, 2009

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# San Francisco Bay Area: 2010 - Present

Method: monitor landslide-prone areas and obtain a long-term record of subsurface hydrologic conditions

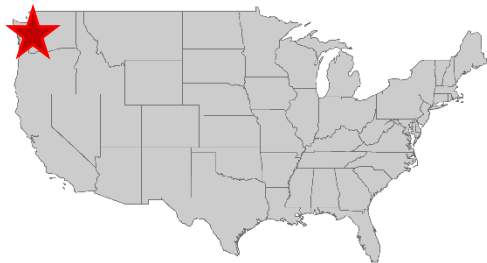
Analysis: identify conditions which promote shallow landslides and debris flows

Goal: provide guidance on potentially hazardous conditions

- Antecedent moisture thresholds
- Rainfall intensity thresholds



# Puget Sound: 2014 – Present

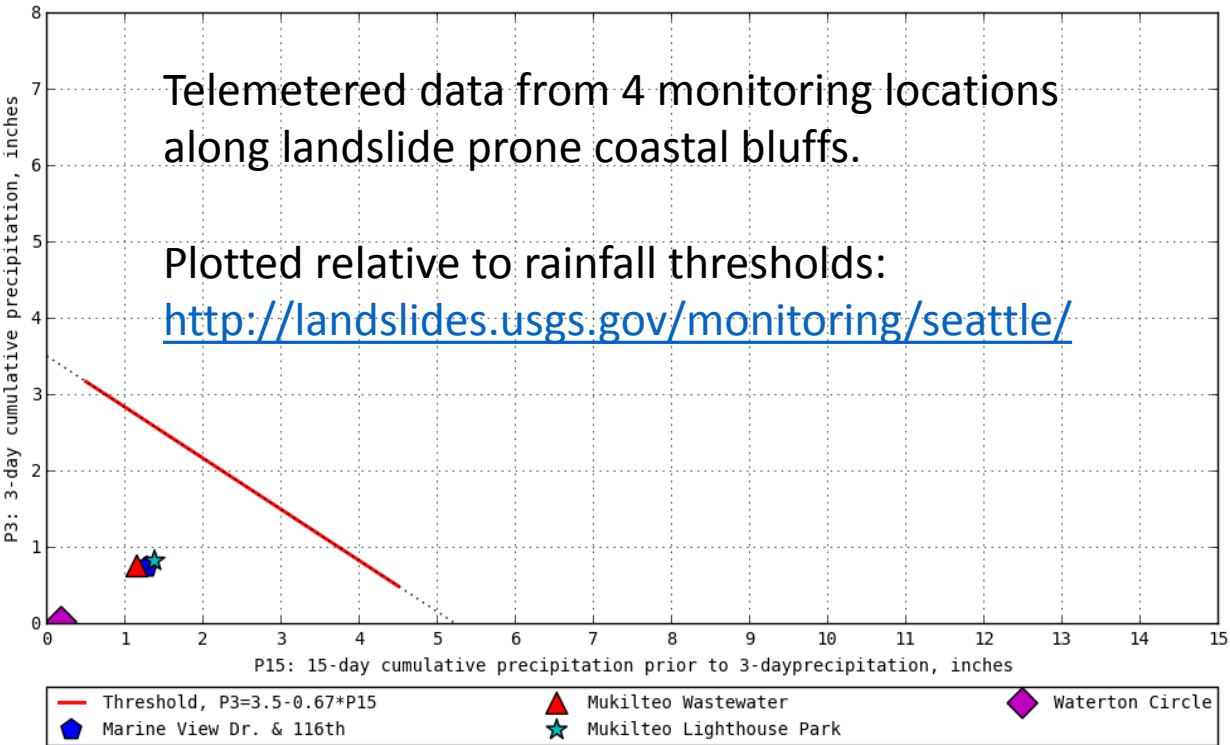




# Puget Sound: 2014 - Present



Current conditions in Mukilteo, Washington,  
with respect to cumulative precipitation threshold for the occurrence of landslide  
USGS PROVISIONAL DATA  
SUBJECT TO REVISION  
Data last updated: 05 Oct 2016, 12:00.



# More Information: Questions and Discussion

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