Protecting Natural Gas Pipelines from Geo-Hazards Exacerbated by a Change in Climate*

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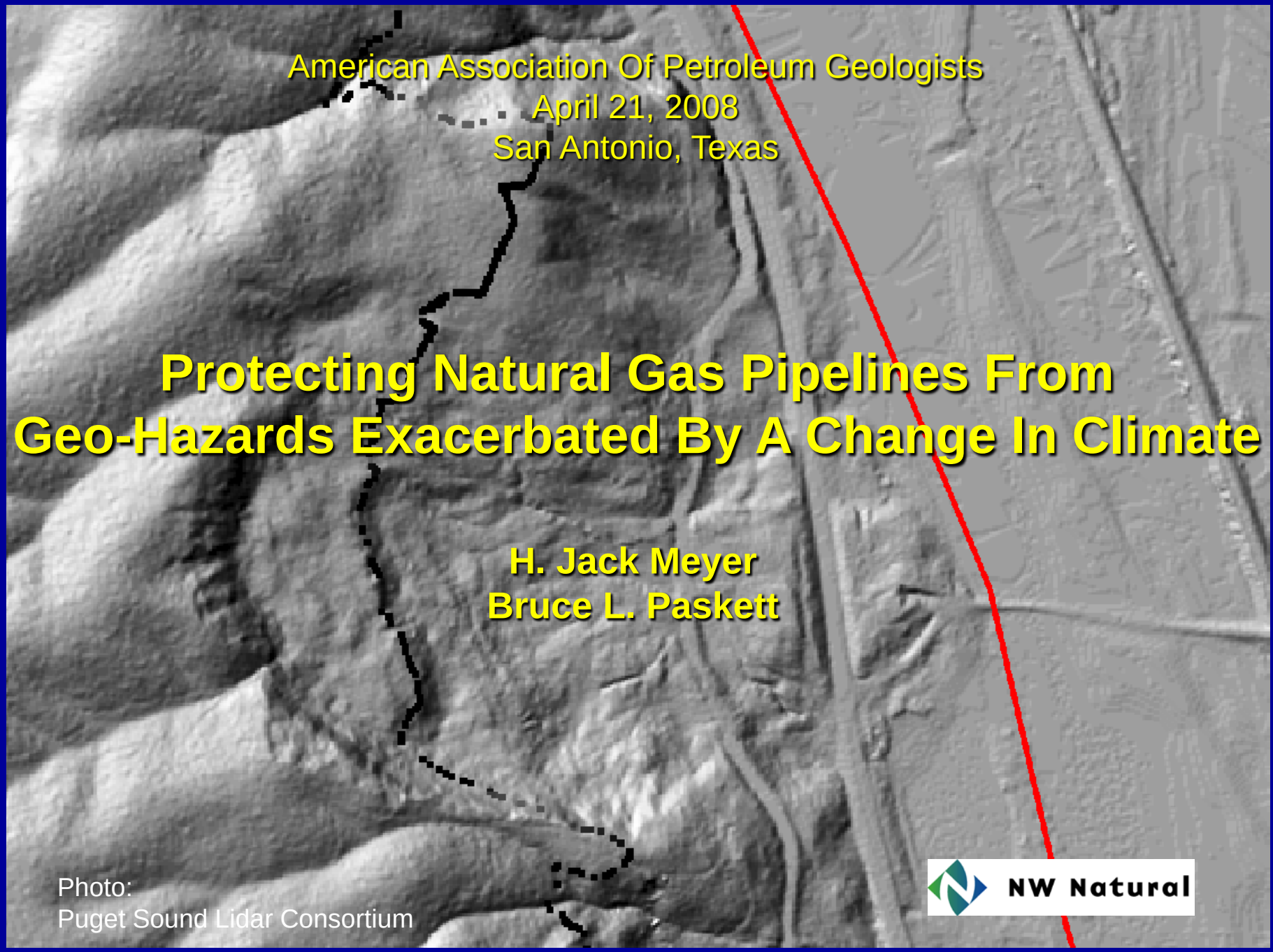
Abstract

NW Natural operates over 600 miles (1000 km) of high pressure natural gas transmission pipelines in western Oregon. 235 miles (392 km) of these pipelines traverse the Oregon Coast Range Mountains. The combination of high winter rainfall, deep weathering, ancient landslides, and disturbed drainage systems can produce geo-hazards, such as erosion and landsliding which may affect the safe operation of a pipeline. In the Pacific Northwest rainfall appears to occur in "wet" or "dry" cycles of 20 to 25 years duration. The majority of NW Natural's Coast Range transmission pipelines were constructed in the late 1960's near the end of a "wet" cycle. During the subsequent "dry" cycle of 20 plus years, pipeline Rights of Way (ROW) were stable. In the mid-1990's, the climate switched to a "wet" cycle. As a consequence, ROW's, particularly when impacted by intense Pacific storms, became much more susceptible to geo-hazards. NW Natural's response to this "climate change" was to create a risk-based "Geo-Hazard Program" for their transmission pipeline system. The program entails identification, assessment, remediation and ongoing monitoring of geo-hazards. Key to this program was the formation of a team, which consisted of pipeline engineers, geotechnical professionals, and pipeline field personnel that had the responsibility of addressing geo-hazard issues. Another important element involved training ROW maintenance personnel to recognize geo-hazards, report/repair them, and collect monitoring data. Rainfall "triggers" were established to initiate immediate inspection of pipeline ROW's. The Geo-Hazard Program exceeds the minimum requirements of Federal pipeline safety regulations, 49 CFR, Part 192. The program was voluntarily initiated by NW Natural in a partnership with the Oregon Public Utility Commission.



American Association Of Petroleum Geologists
April 21, 2008
San Antonio, Texas

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H. Jack Meyer
Bruce L. Paskett

Photo:
Puget Sound Lidar Consortium

NW Natural

Pipelines
Geo-Hazards + Climate Change

A Discussion Of The Evolution Of NW Natural's

Geo-Hazard Program

OR

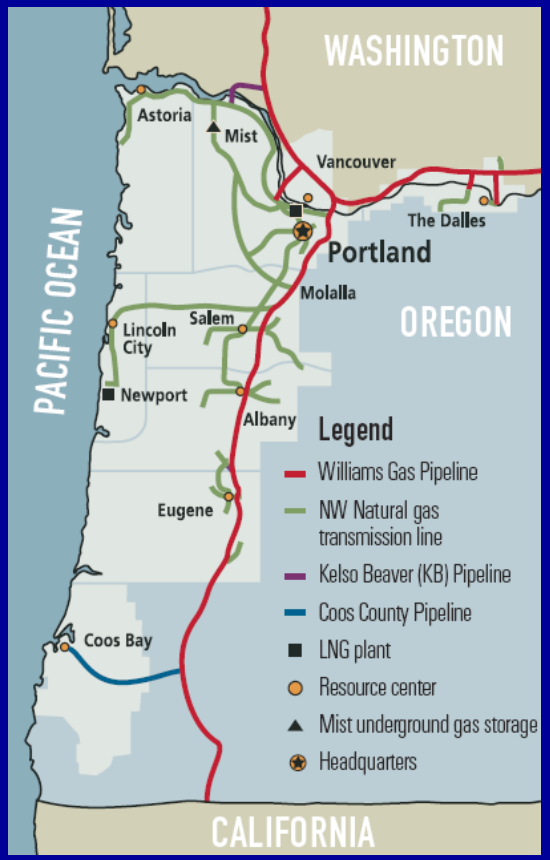
How A Climate Change

Drove A Change In Pipeline Operations

NW Natural

NW Natural

- Investor Owned LDC
- Incorporated 1859
- Serves NW Oregon/SW Washington
- 650,000 Customers
- 13,000 mi. of Distribution Mains
- 609 mi. of Transmission Pipelines
- 235 mi. In Areas Prone to Geo-Hazards



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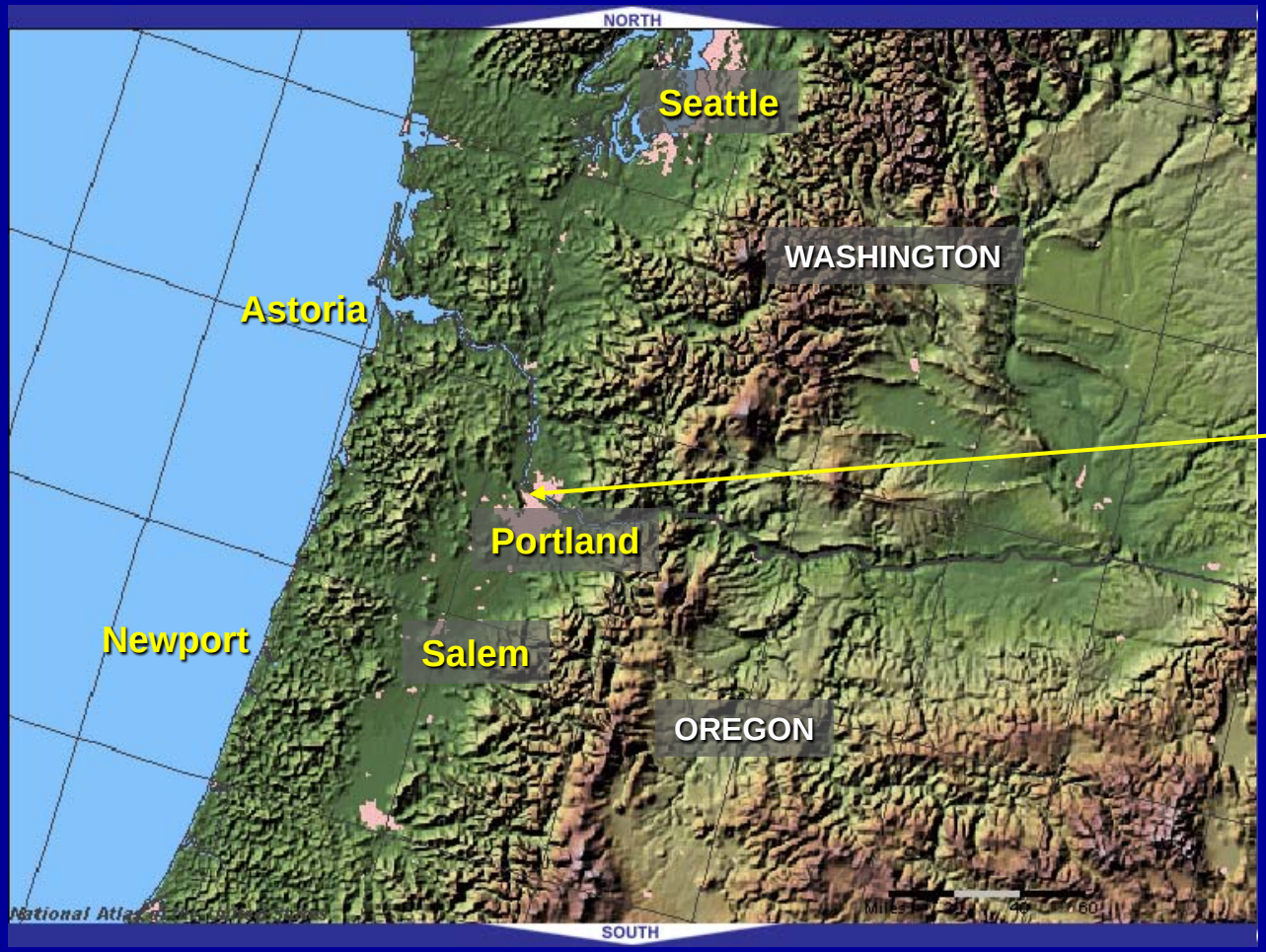
Location, Location, Location



nationalatlas.gov

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Definition Of Geo-Hazard

Any Threat To Pipeline/ROW Integrity

Triggered By:

Rain	Common - Daily, Hourly, Seasonal
Volcanoes	Rare - Centuries to Millennia
Earthquakes	Rare - Unpredictable
Human	Common – Unpredictably Predictable

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Transmission Pipeline Inspection Requirements Required By PHMSA (49 CFR Parts 191,192)

Class 1 & 2: Patrol Once Each Calendar Year NTE 15 Months

Class 1 & 2: Leakage Surveys - Once Each Calendar Year NTE 15 Months

Unusual Conditions: Continuing Surveillance Procedure

Reporting Requirement: If a Threat to the Serviceability of a Pipeline is Detected

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NW Natural's Pre-1999 Transmission Pipeline ROW Inspection Routine

- Patrolled Each Pipeline Four Times A Year
- One Patrol Was A Leakage Survey
- Normal ROW Maintenance
  - Vegetation Control/Brush Clearing
  - Culvert Repair, Marker Poles
  - Police Human ROW Encroachment
  - Geo-Hazards: Local Flooding – Bridge Crossings

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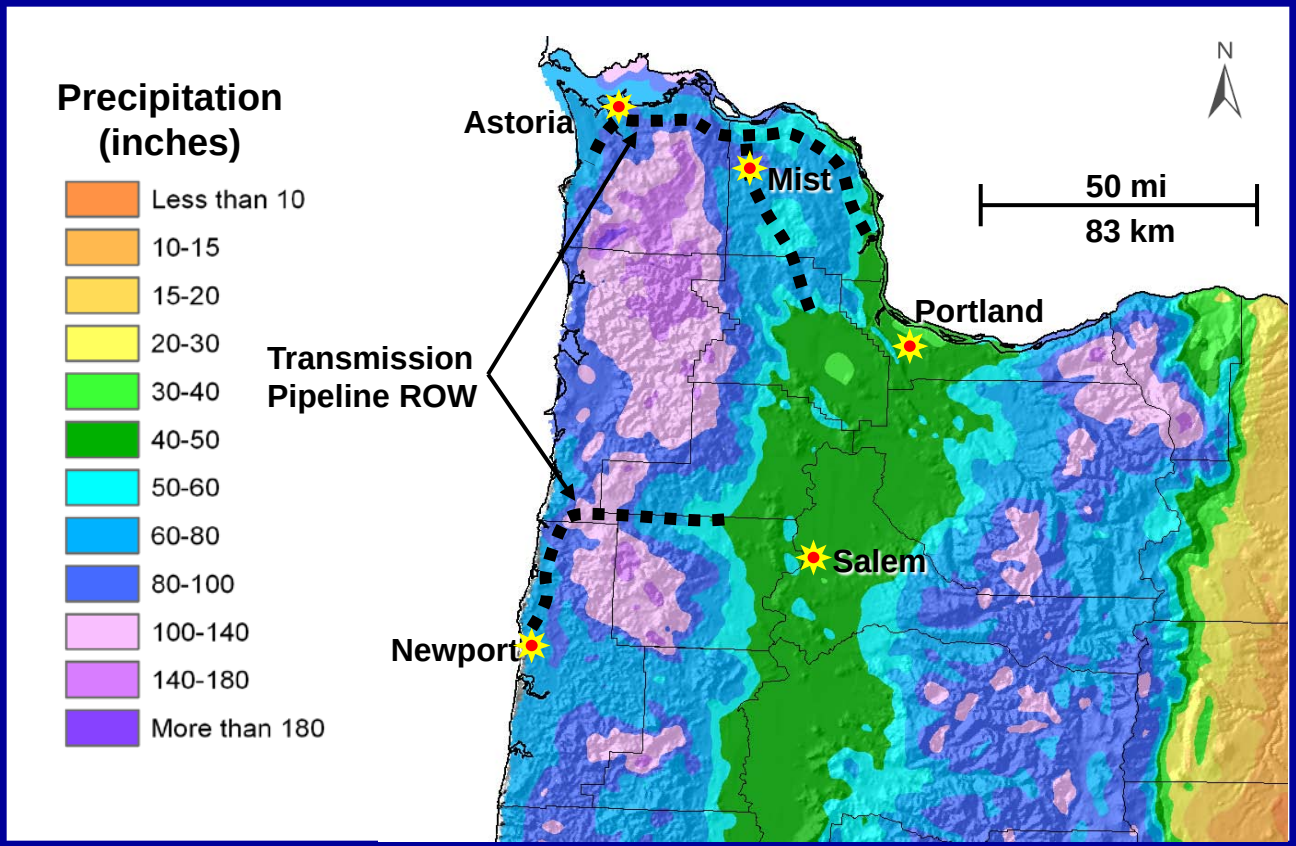
Water Is The Major Geo-Hazard Driver In The Pacific Northwest

NW Oregon Average Annual Precipitation 1971 -2000



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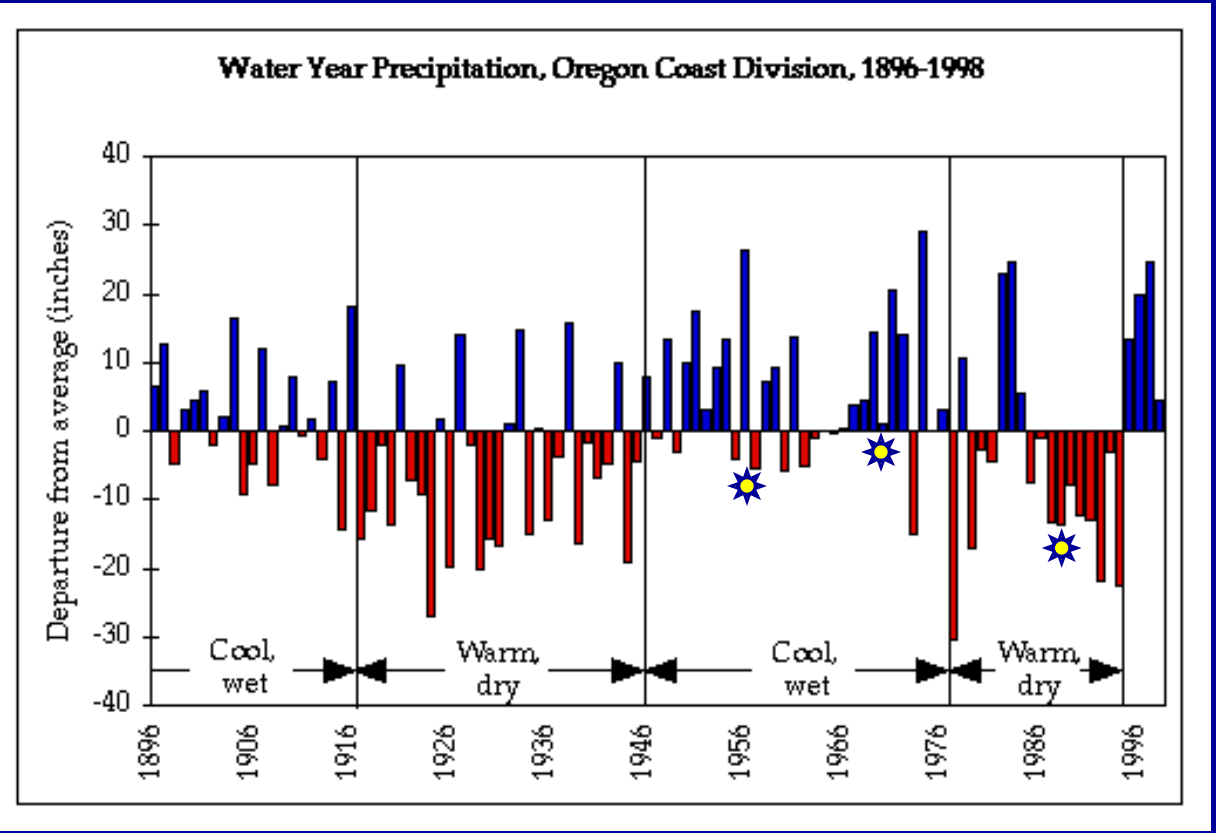
Long Term Wet-Dry Cycles in Oregon

George H. Taylor, Oregon Climate Service



http://www.ocs.oregonstate.edu/index.html

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Threats To The Pipelines Directly As A Result Of Late 90's Increased Rainfall

Slope Movement
Deflection of 20" Pipeline

Exposed Pipe in Stream/River Crossings

Slope Movement

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Rainy Season Of 1998/99

Third Consecutive Very Wet Rainy Season

Portions of Two Large Dormant Landslides Reactivated

Two Transmission Pipelines Threatened

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Rainy Season Of 1998/99 (cont.)

NW Natural's Response:

Formed Ad Hoc Geo-Hazard Team

- Chief Engineer
- Geologist/Geotechnical Engineer
- Field Construction Personnel

Developed and Instituted Investigation, Mitigation and Monitoring Procedures for Affected Areas

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Spring 1999

March 1999 George Taylor, Oregon State Climatologist, Published His Paper on Wet Dry Cycles in Oregon

Realization by NW Natural That Going Forward ROW Maintenance Needed to be Enhanced

It Would be Prudent to be Proactive in Identifying and Mitigating Geo-Hazard Risks to Pipeline Safety

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Spring - 1999

First Steps:

Acquired New Aerial Photography Over ROW's
Interpreted Specifically for Geo-hazards

Contracted With Geo-technical Firm to Conduct Site Specific Studies on 19 Locations Considered "Priority"

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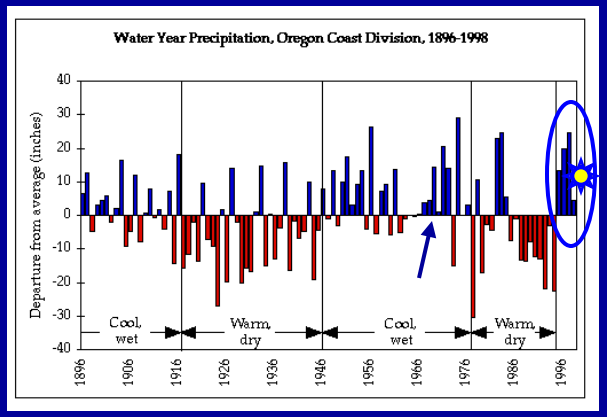
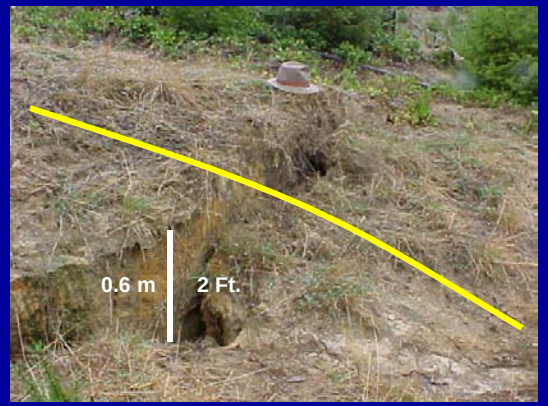
Then The 1999 Thanksgiving Weekend Rain Event Hit



Pipeline Location



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As A Result NW Natural Quickly Formalized It's Geo-Hazard Program

Developed "Priority List" of Areas at Risk of Becoming Chronic Mitigation Sites

Began to Implement Site Specific Mitigation

Trained Field Personnel to Recognize Geo-Hazards

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Formalized Geo-Hazard Program (cont.)

Instituted Risk Based Field Monitoring Schedule

Schedule Defined by Geo-Technical Risk

- Low > 50 ft. Low Potential for Movement
- Moderate < 50 ft. Rapid Movement Unlikely
- High < 50 ft. Active Landslide

Instituted Rainfall Triggered ROW Inspection

Instituted Immediate Geo-technical Investigation of New Events

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Patrol Triggers Unique to NW Natural

Pacific NW Rainstorms "Bulls Eye"

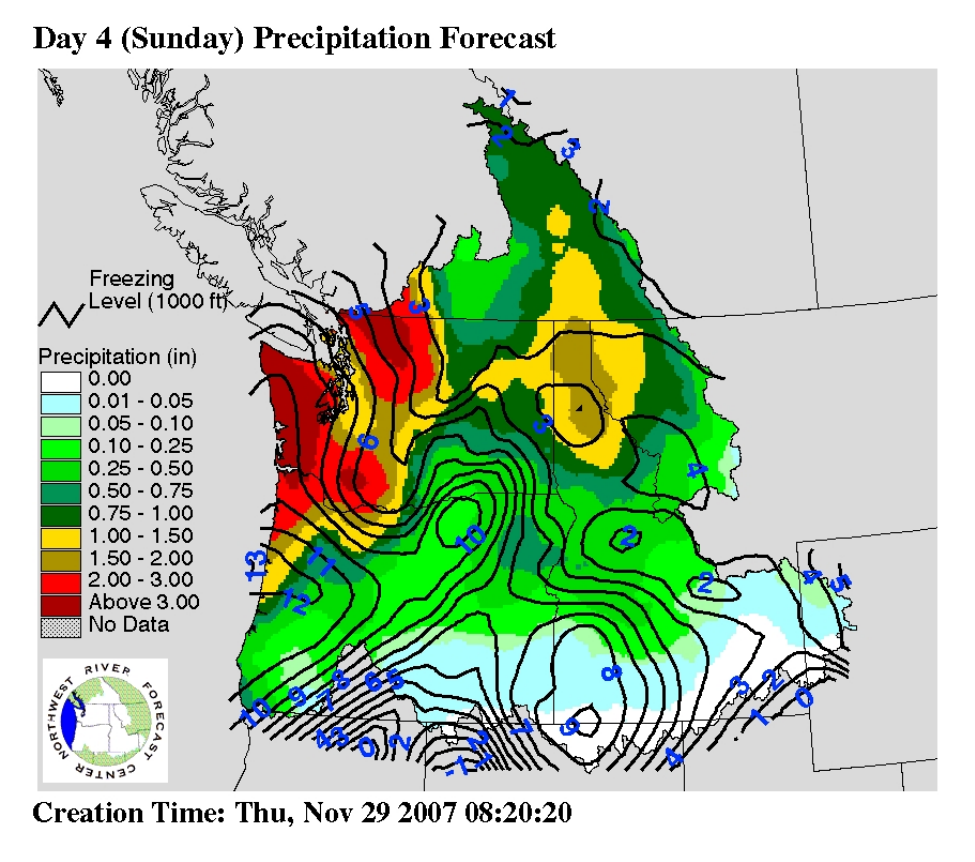
Rainfall Triggered ROW Inspection Criteria

Immediately after 4 or more inches in 48 hrs.

Immediately after 6 or more inches within a 7-day period

Immediately after a rain on snow event

Rainfall is Recorded Daily From Key Locations



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NW Natural's Geo-Hazard Program

Triggered by a Long Term Weather Cycle

Driven by Inherent Corporate Safety Philosophy

Self Designed – "Prudent Operator"

Self Imposed – Exceeds 49 CFR 192

Absolutely Not Possible Without the Support of:
NW Natural Senior Management and the
Oregon Public Utility Commission

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NW Natural's Formal Geo-Hazard Program And The Oregon Public Utility Commission

Enhanced Pipeline Safety Program 2001 - 2006

Annual Rate Treatment for Investigation, Mitigation and Monitoring of Geo-Hazard Threats to Pipeline Safety

Provided the Bridge to Present Day Program Funding

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In Summary - NW Natural's Experience With A "Normal" Climate Change

Taught Us To:

Assess The Geo-Hazard Drive Mechanisms

Form A Responsible Team

Be Proactive – Analyze And Anticipate

Which Led To A:

Fundamental Company Culture Change

NW Natural

Thank You