Mass Movements

Calabria, Italy

http://www.youtube.com/watch?v=f9CeDGY5QuQ

Avalanche and Glacial Outburst Flood, Alps, France

https://www.youtube.com/watch?v=SlGTirtRP4c

Unknown location, possibly Pakistan

https://www.youtube.com/watch?v=XC9AqJlaCj4

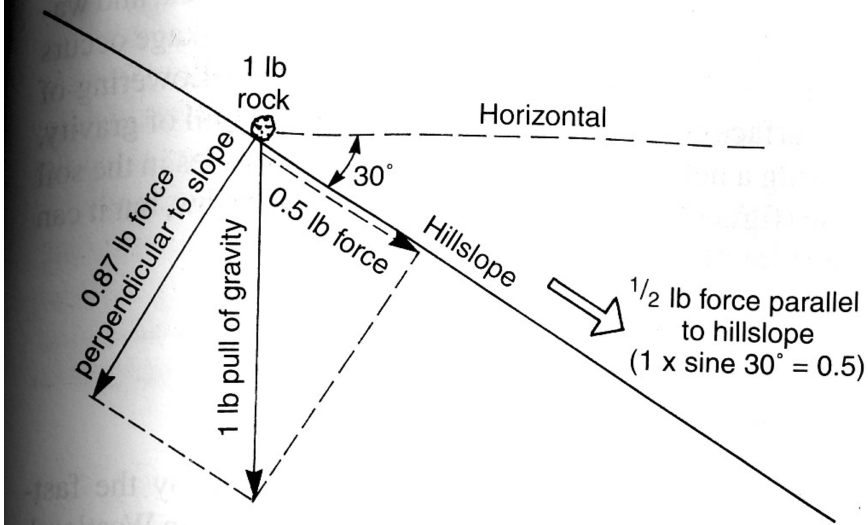
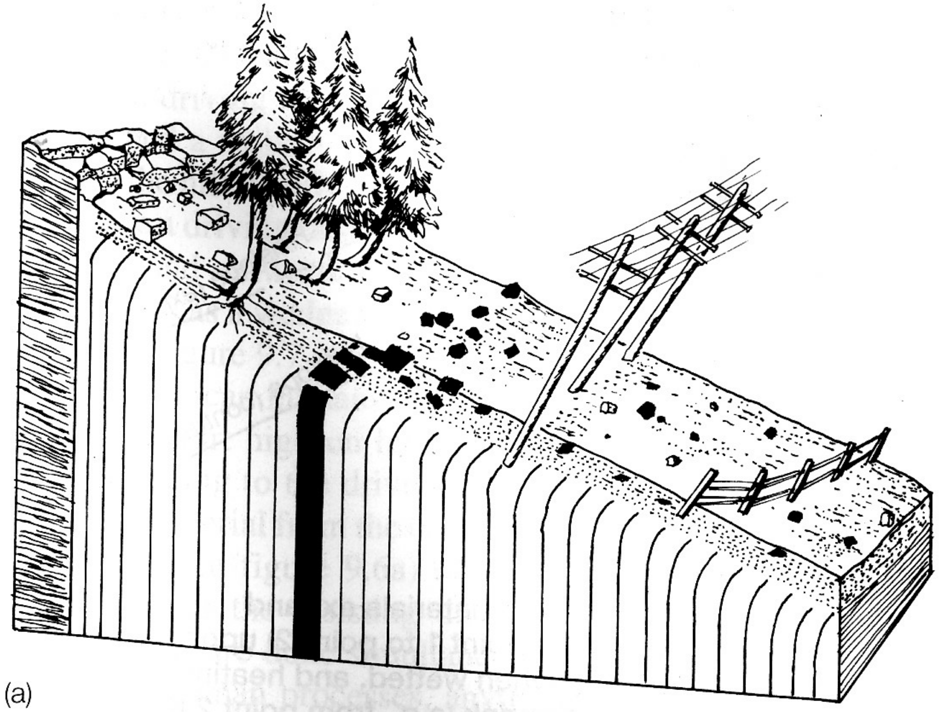
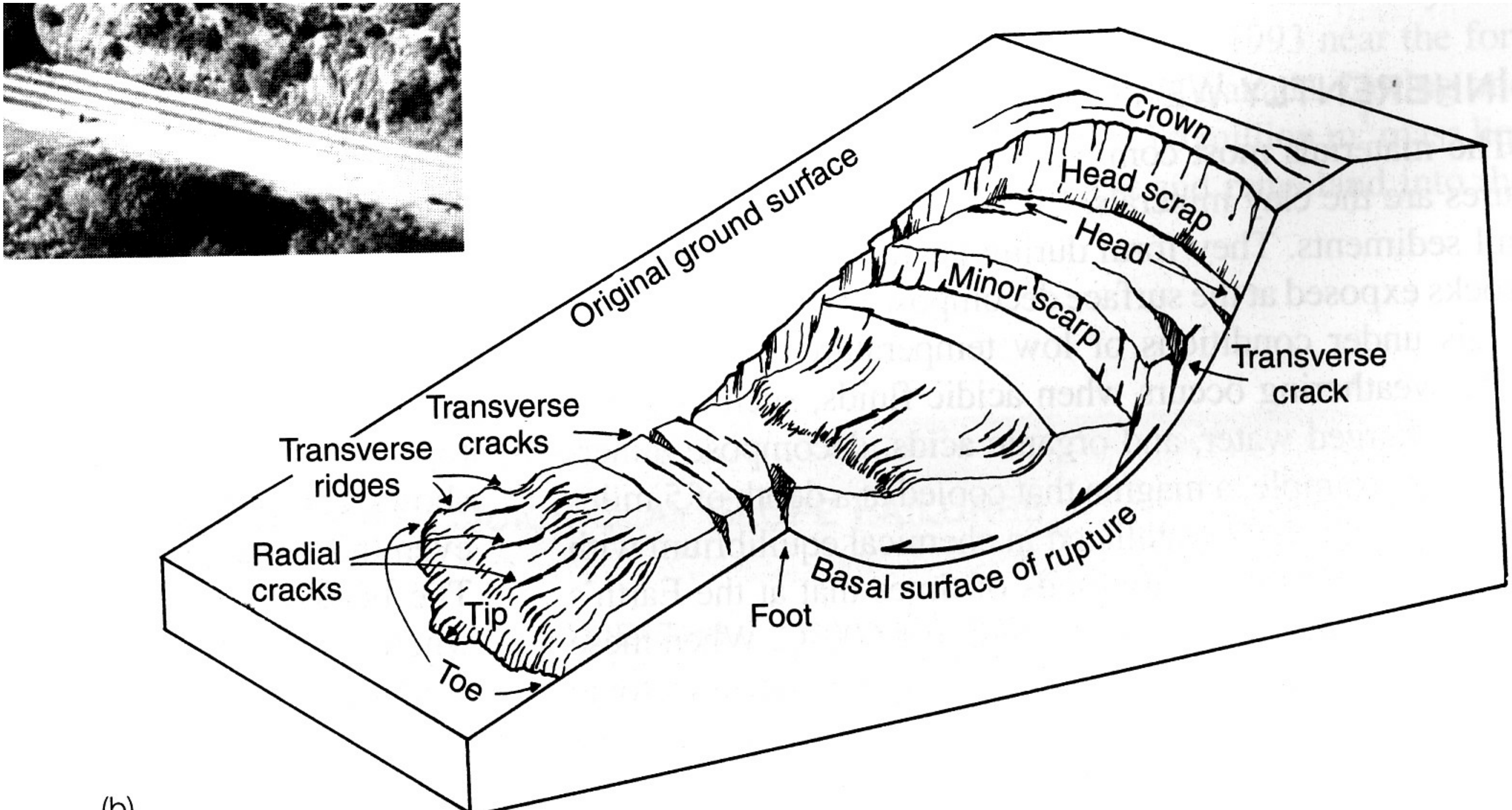


FIGURE 9.2
Gravitational forces acting on a 1 lb boulder sitting on a 30° slope.



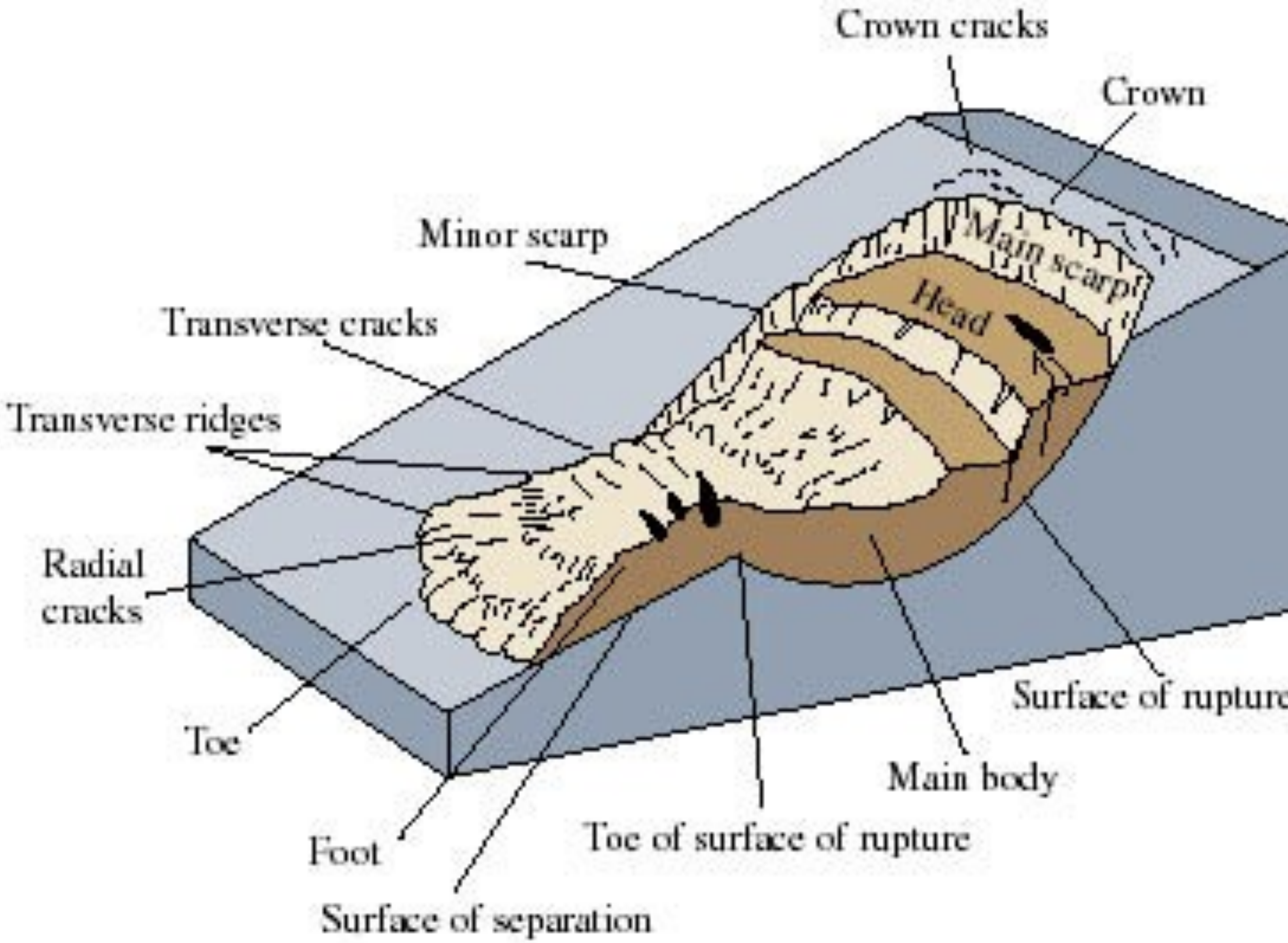
(a)

Abbott 2006



(b)

Abbott 2006


Crown cracks
Crown
Minor scarp
Main scarp
Head
Transverse cracks
Transverse ridges
Radial cracks
Toe
Foot
Surface of separation
Toe of surface of rupture
Main body
Surface of rupture

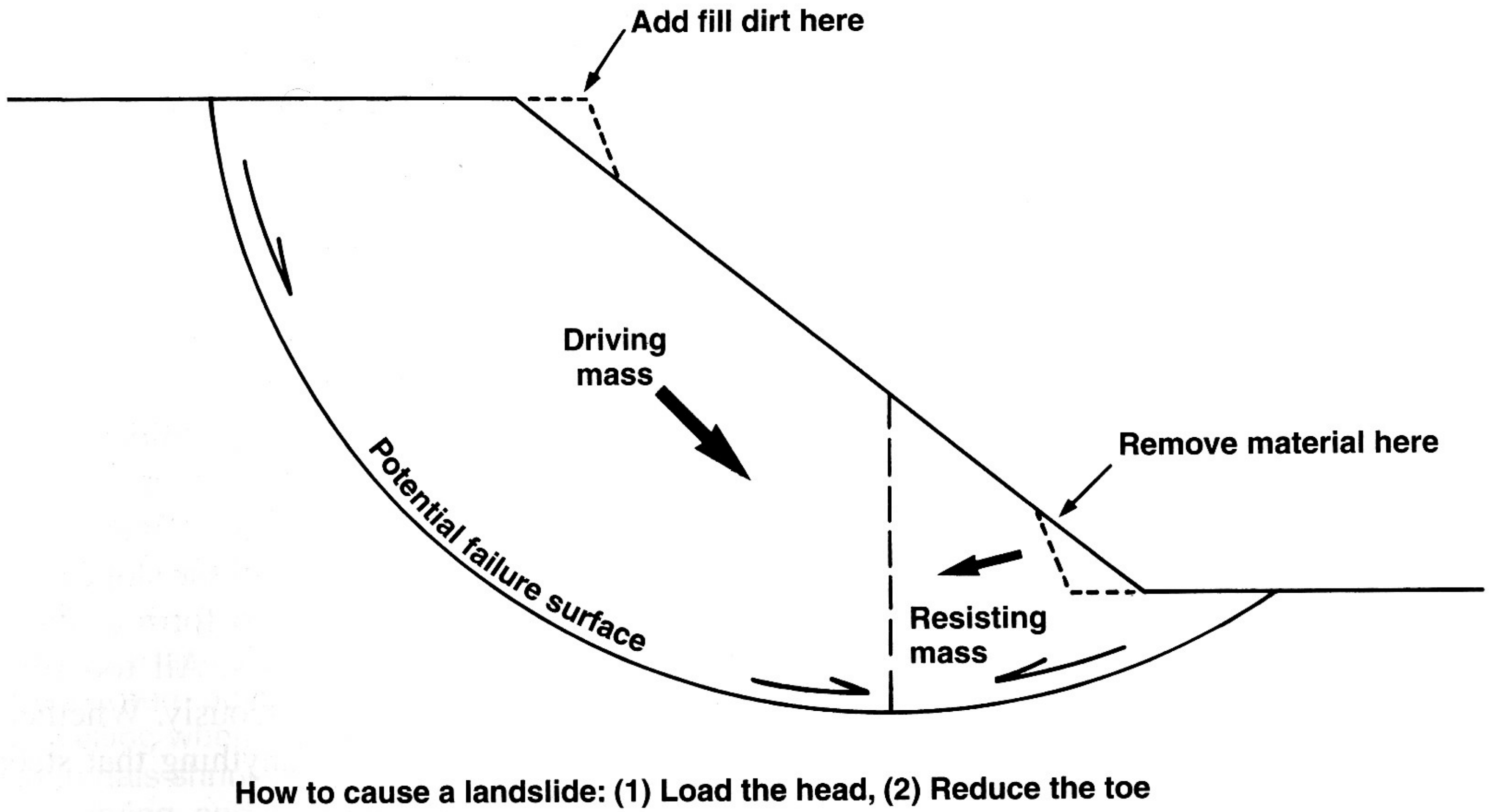
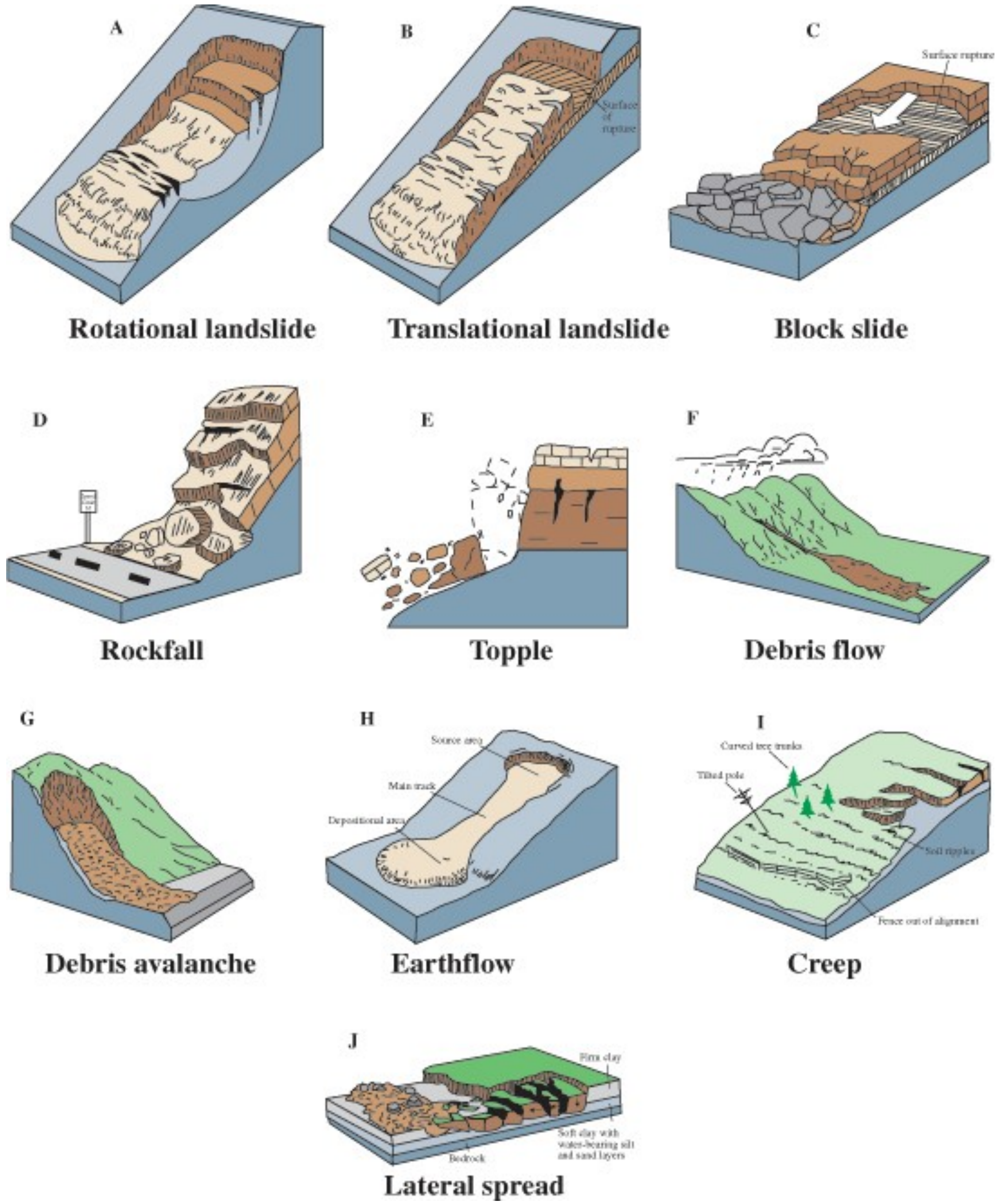


FIGURE 9.7
A hillslope of homogeneous materials may fail along an arcuate basal surface. The slope is in equilibrium when a drivin
mass portion is kept from moving by a resisting-mass portion. Adding to the driving mass or removing from the resistir
mass can cause a landslide. Does this situation bring to mind any construction practices in your area?

Abbott 2006


A
Rotational landslide
B
Surface of rupture
Translational landslide
C
Surface rupture
Block slide
D
Rockfall
E
Topple
F
Debris flow
G
Debris avalanche
H
Source area
Main track
Depositional area
Earthflow
I
Curved tree trunks
Tilted pole
Soil ripples
Fence out of alignment
Creep
J
Firm clay
Soft clay with water-bearing silt and sand layers
Bedrock
Lateral spread

Rainfall February 1996

Impact in Washington State

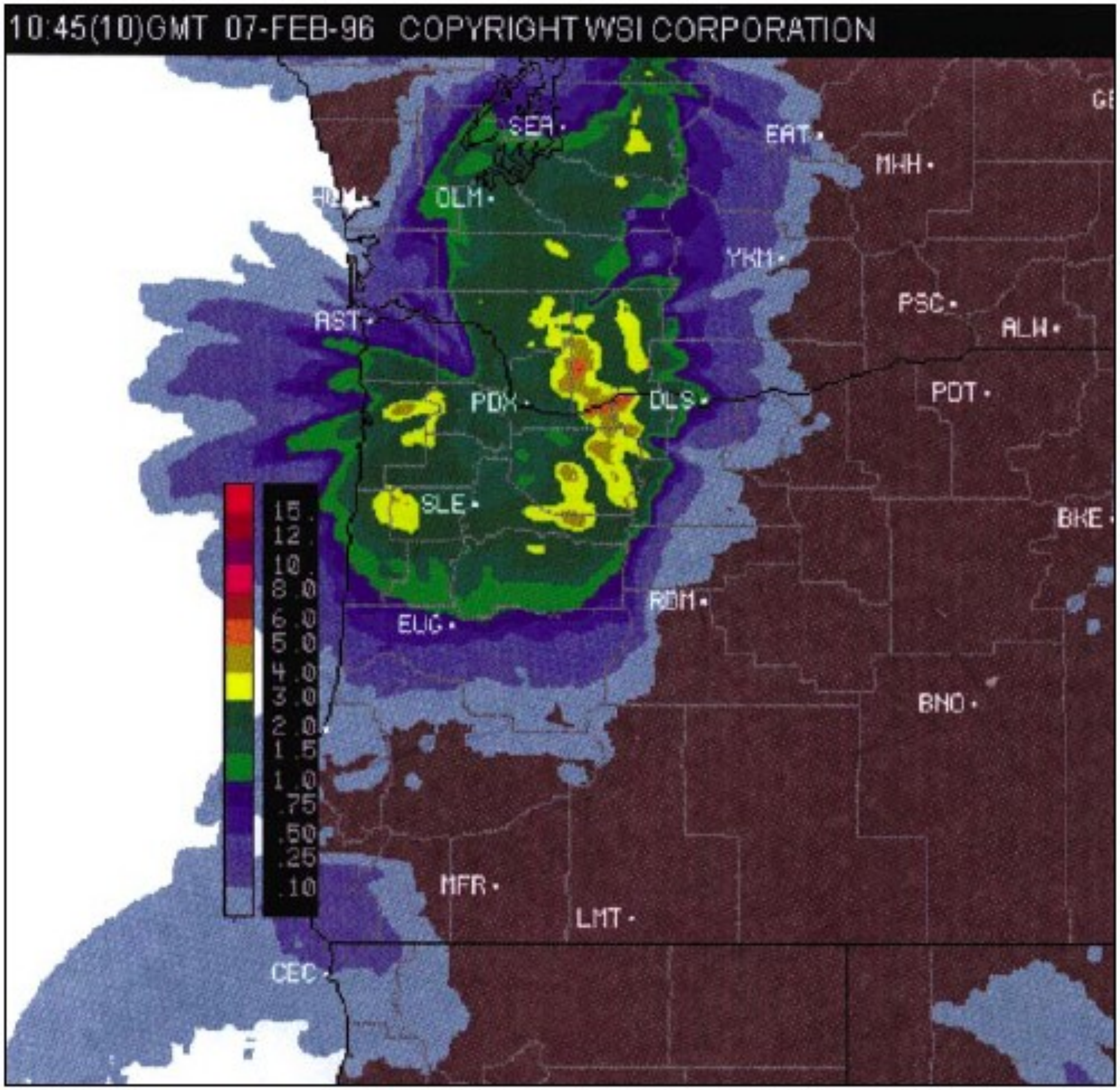


Figure 6. Radar imagery for February 7, 1996 showing high estimated-precipitation cells centered southeast of Mount St. Helens and along the Columbia River gorge near Dodson, Oregon where several large debris flows damaged houses and closed both I-84 and the Burlington Northern rail lines (Reprinted courtesy of WSI Corporation).

Figure 10. Head-scarp area of slump-debris flow shown in figure 9

Figure 9. Large slump-debris flow located about 5 mi west of Stella, Washington on SH–4.

Figure 11. Rock fall next to a house on Perkins Way in northern Seattle. Rock fall is a secondary failure on a larger rotational slump whose failure surface projects beneath the house and Perkins Way.

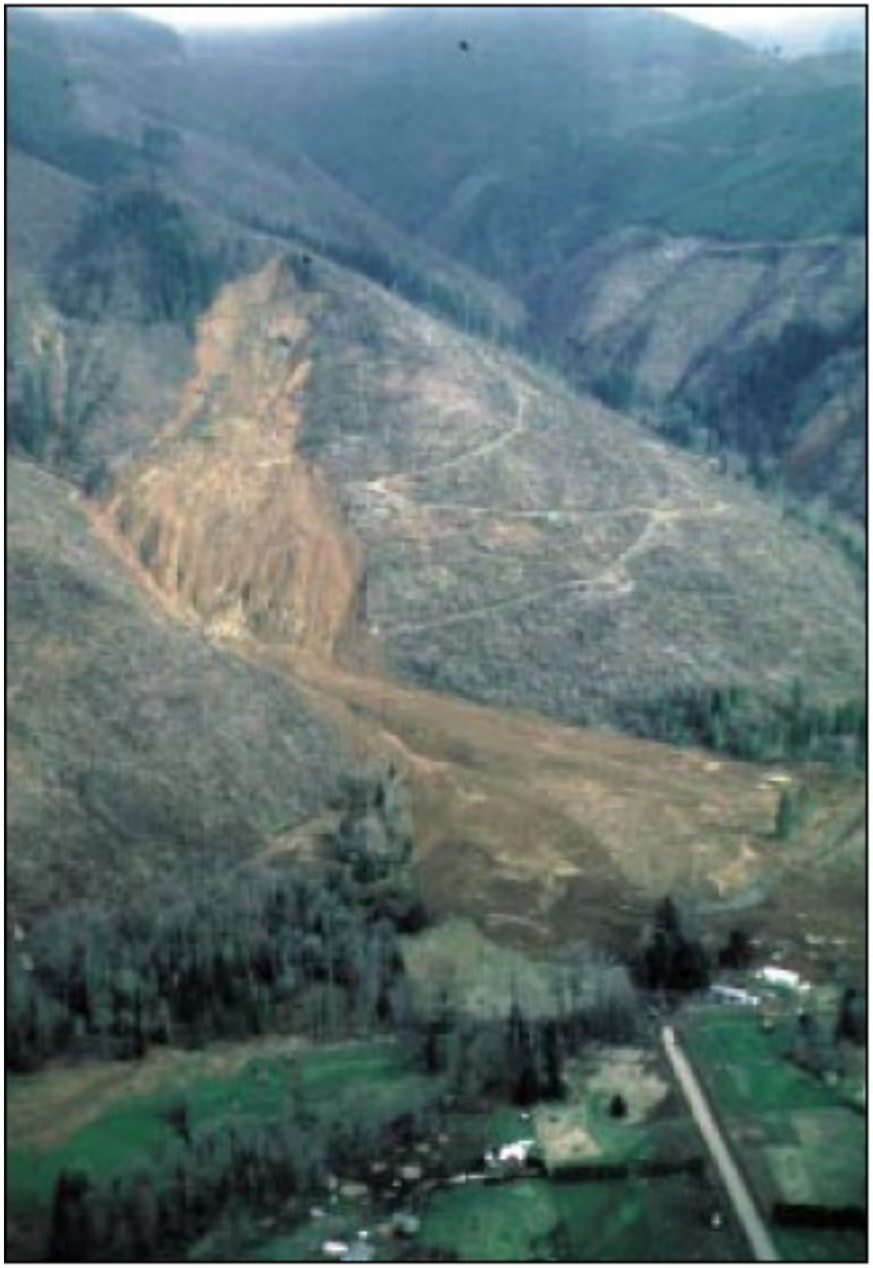


Figure 16. Block slide-debris flow that destroyed house shown in figure 15. House is at bottom right of photo. Near-vertical cliff in headscarp is about 150 ft high.

US 12 east of Wenoma WA

Figure 18. Slump north of Woodland, Washington that covered I-5 and the Burlington Northern-Santa Fe rail line.

Figure 19. Small slump in northwest Vancouver that destroyed a residence located next to a steep slope bordering an old river terrace.

Figure 20. Headscarp area of deep-seated, complex rotational slump-earth-flow in subdivision in Stevenson, Washington. Landslide has resulted in removal of three houses and has threatened six or seven additional residences.

North Stevenson: West of Loop Road and Maple Hill Road junction

Figure 22. Aerial oblique view of Stevenson landslide. At center right is foundation shown in figure 21. Arrows denote additional extension fractures upslope from fractures shown in figures 20 and 21.

Rainfall February 1996

Impact in Oregon

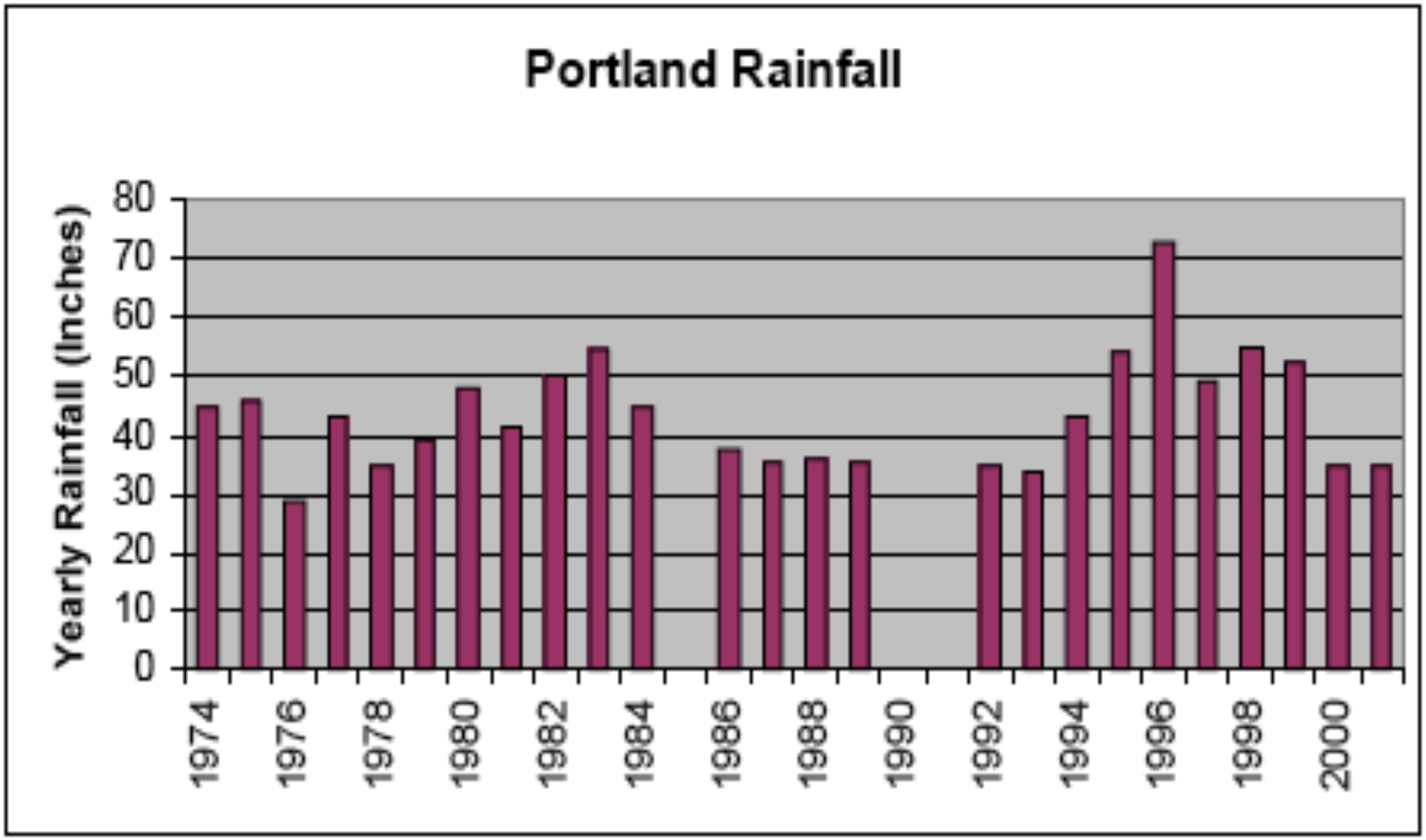


Figure 4. Rainfall data from 1974 to 2001 in Portland, Oregon. This graph shows that rainfall varies from <30 to >70 inches/year.

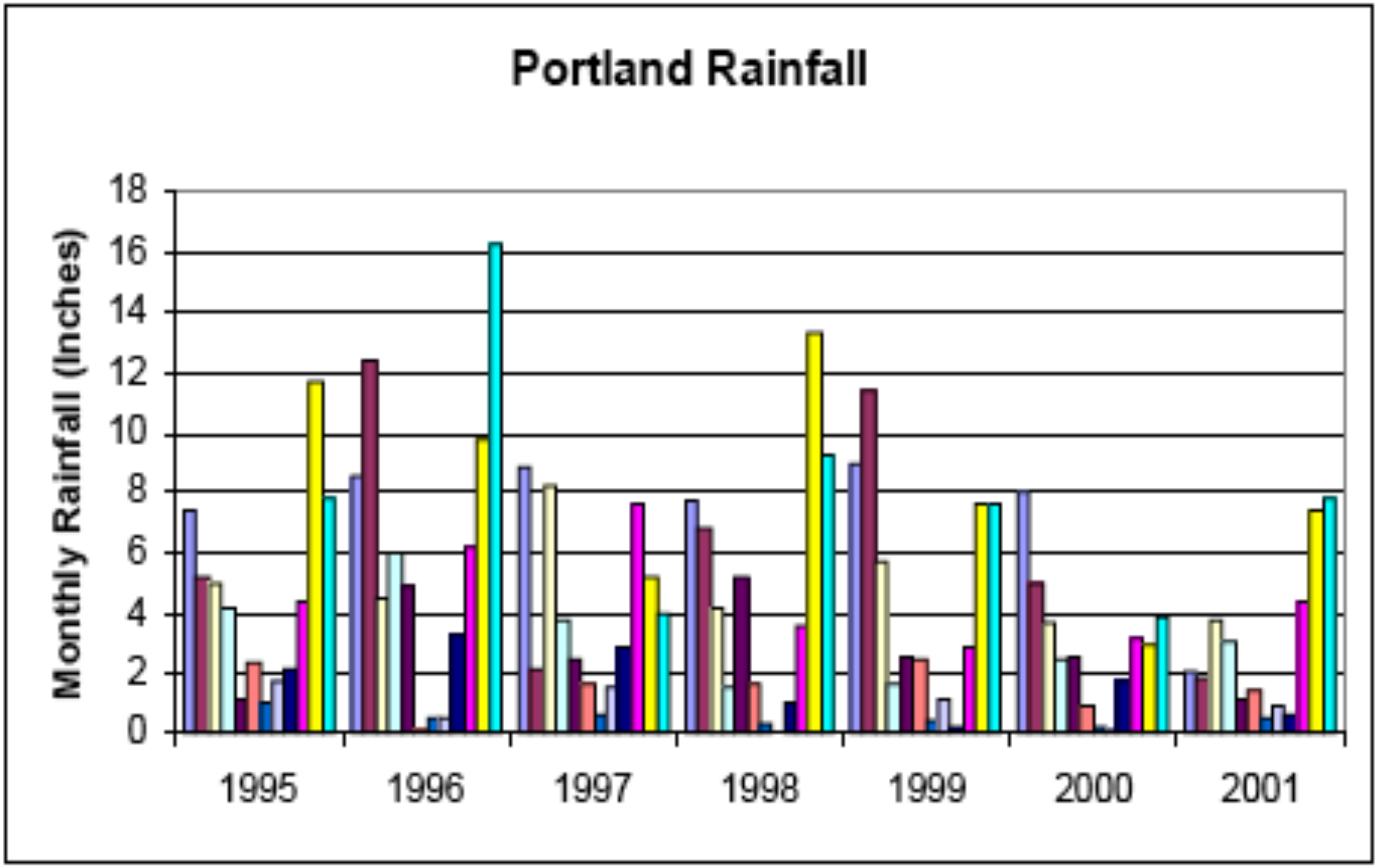
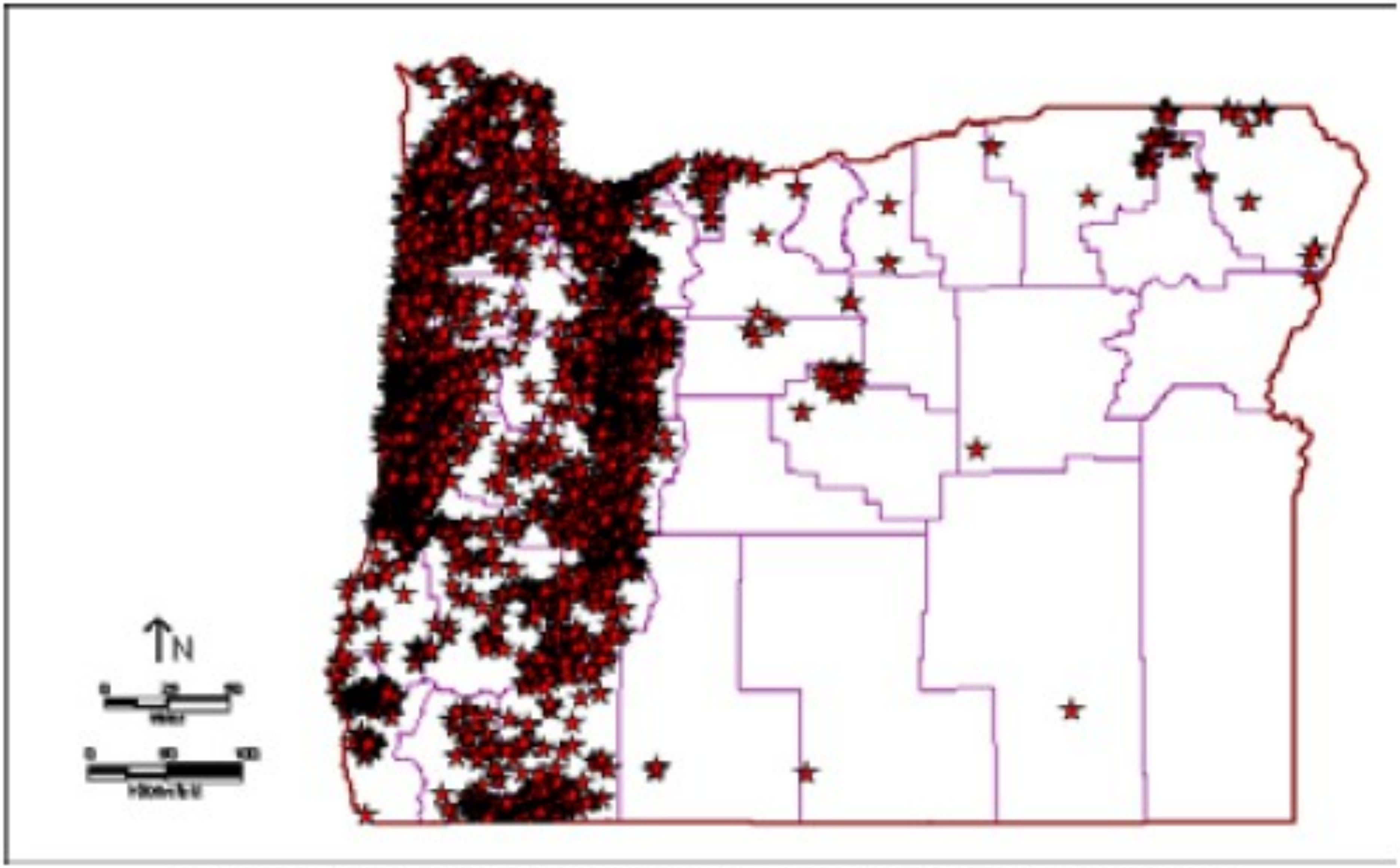


Figure 3. Seven years of monthly rainfall data in Portland, Oregon. This graph shows the variability in rainfall pattern, which directly affects landslide occurrences.



Landslides from the 1996 and 1997 storms (Hofmeister, 2000)

Probable Landslides

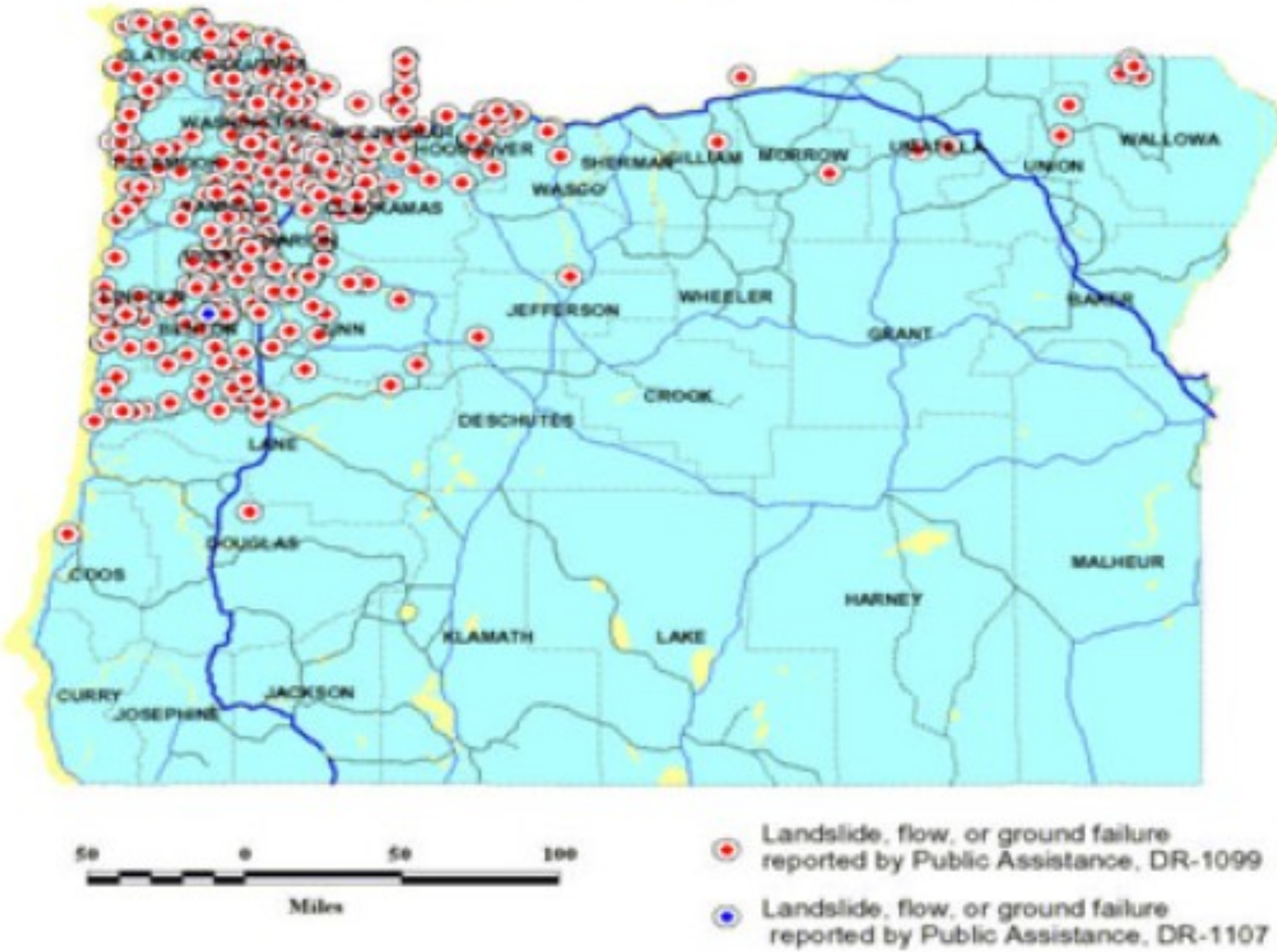


Figure 1. The Capes private housing community experienced landslide and coastal erosion damage associated with the 1997-8 El Nino event. Residents were evacuated and short-term mitigation was implemented. Long-term mitigation options, which need to accommodate coastal building regulations, are still being evaluated. Photo: Paul Komar

Dodson, OR 1996
Debris flow

http://www.flickr.com/photos/44740122@N08/4408334810/in/photostream

Figure 5. A debris flow destroyed this 2-story residence in Dodson, Oregon in the February 1996 FEMA-OR-1099-OR disaster.

Other Places, Other Times

December 2007, US 30 Woodson, Oregon
http://www.oregonlive.com/weather/index.ssf/2012/12/threat_of_heavy_rain_on_satura.html

Figure 4. Rockslide that occurred along the Wilson River Highway (Hwy 6) in 1991. Though not a debris flow, this hazardous area is identified by the Further Review Area model. (Photo courtesy of Susanne L. D'Agnese, Oregon Department of Transportation)

Wilson River Highway 1991

Figure 14. The 1993 Klamath Falls earthquake triggered a fatal rockfall on US I-97.

Site E

Figure 10. Cape Foulweather landslide. The downslope lanes of coastal US Highway 101 was damaged from a fill slope failure in December 1999. Repair work lasted about one month. (ODOT photo)

Figure 11. Cape Cove Landslide. A damaging landslide interrupted traffic in both directions of US Highway 101 in January 2000. Repair work forced an approximate three-month road closure. (ODOT photo)

The Bridge of the Gods: Bonneville Slide

The Bridge of the Gods: Bonneville Slide

Some Landslide Cautions . .

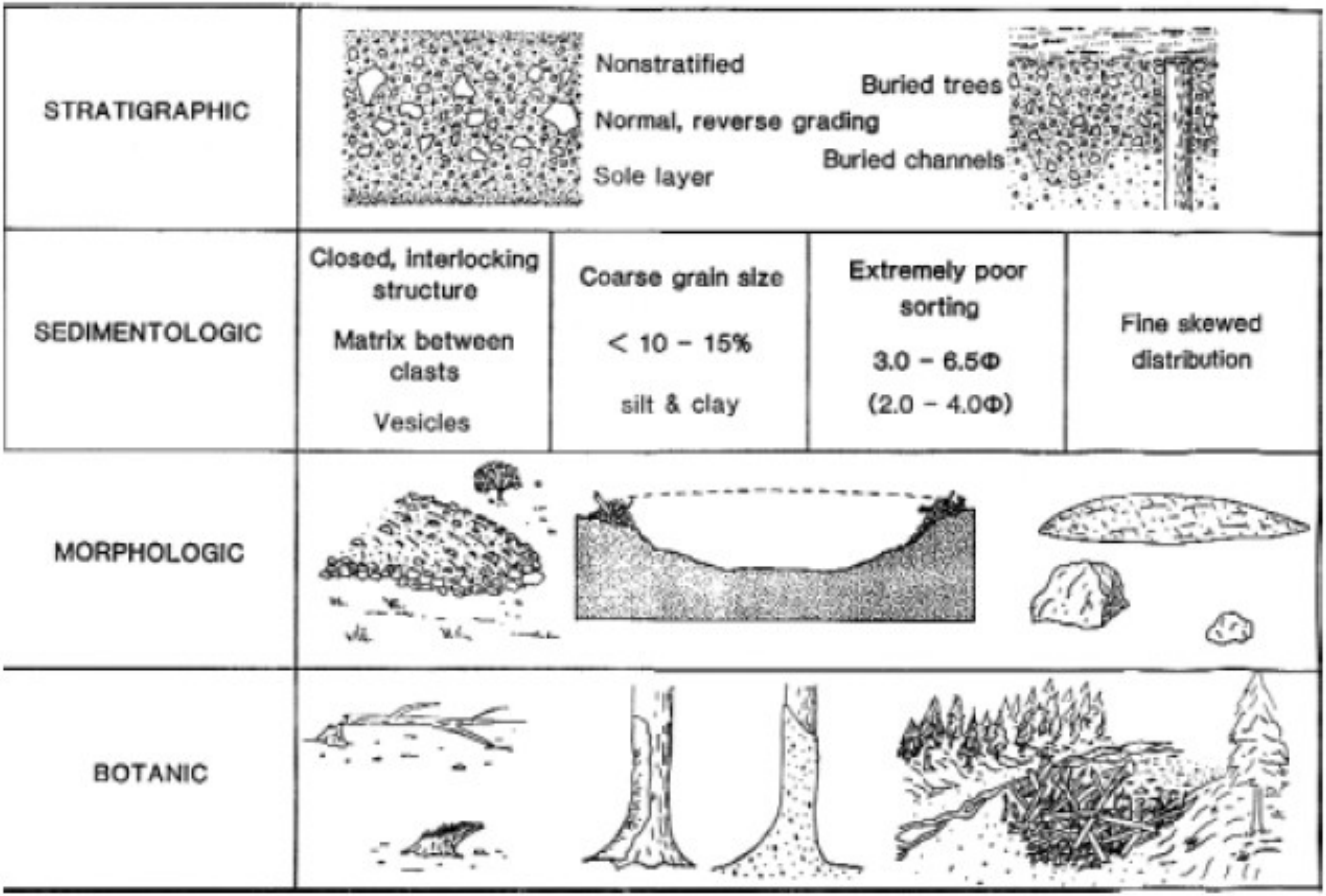


Figure 18. Geomorphic features that can aid in the identification of historic debris flows. (Diagram courtesy of Tom Pierson)

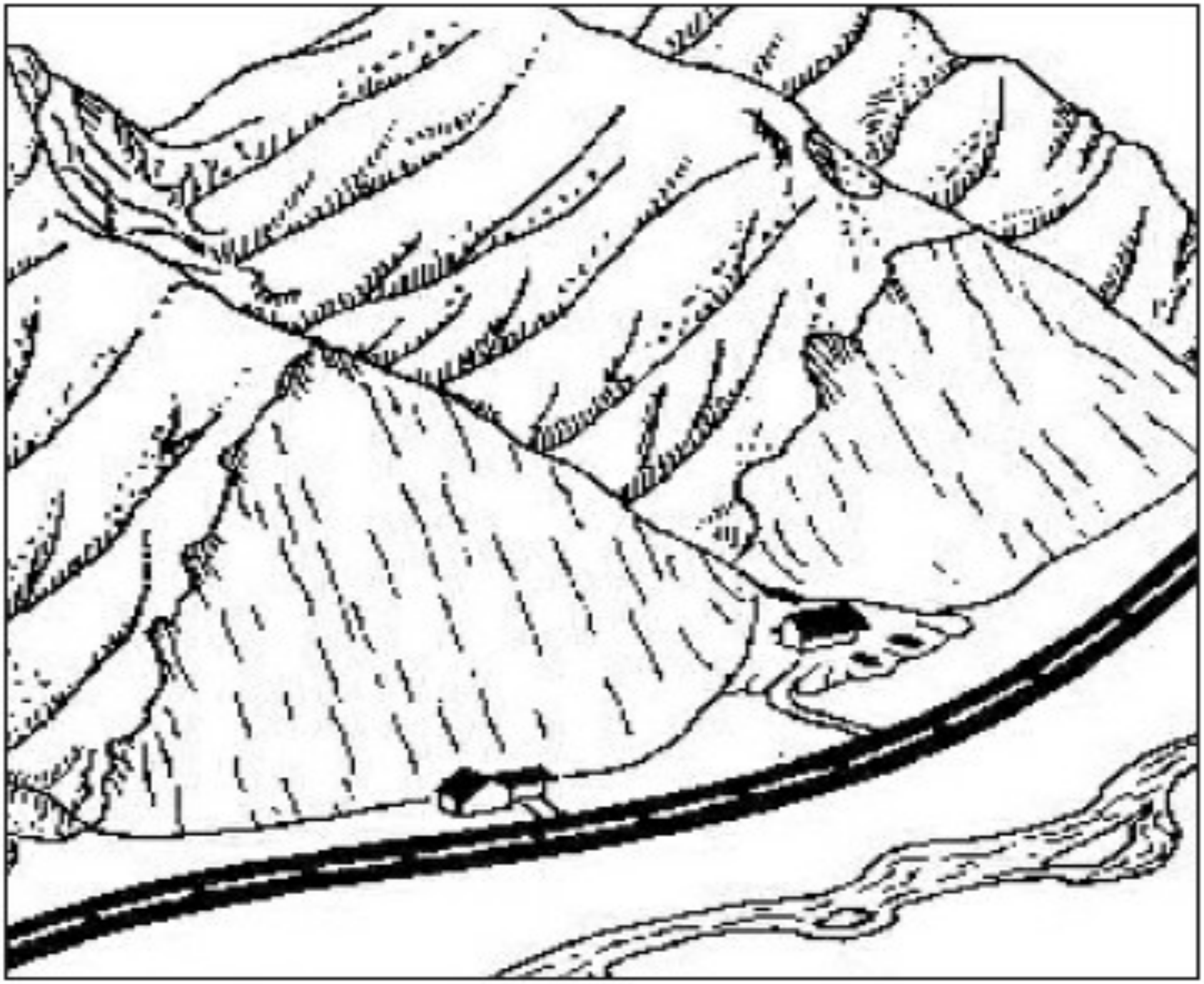


Figure 23. Typical highest hazard home locations: near channel mouths and at the base of very steep slopes. (Illustration courtesy of Oregon Department of Forestry)

Some Floods

Houston, May 2015

https://www.youtube.com/watch?v=wnD3D-4fA9c

Portland, OR February 1996

https://www.youtube.com/watch?v=1AGSFFOSfz0

Some flash floods in the Mojave Desert

https://www.youtube.com/watch?v=kV4aF4AZtY0

Flash flood in the Narrows, Zion National Park

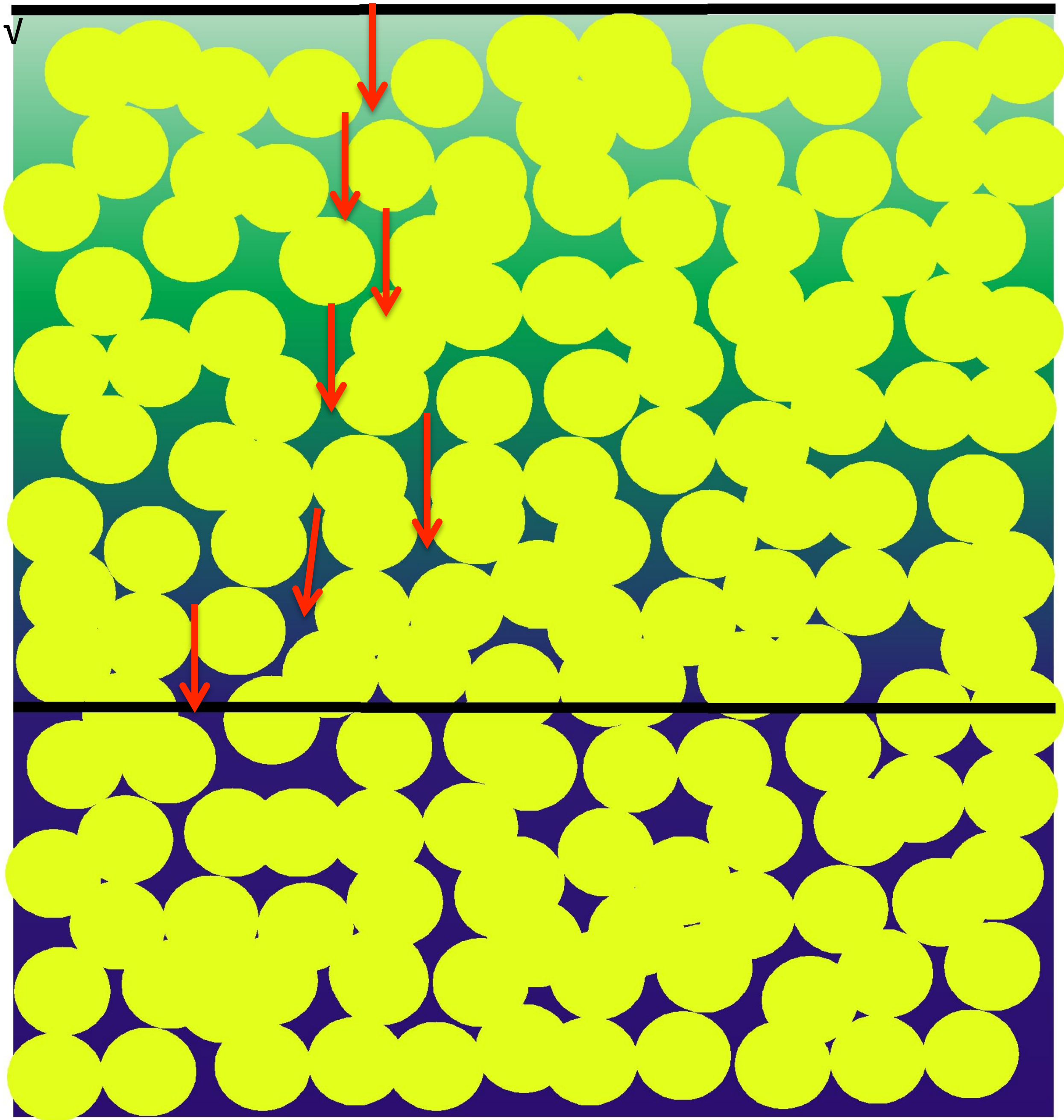
https://www.youtube.com/watch?v=W3akkSEGFhI

Flooding

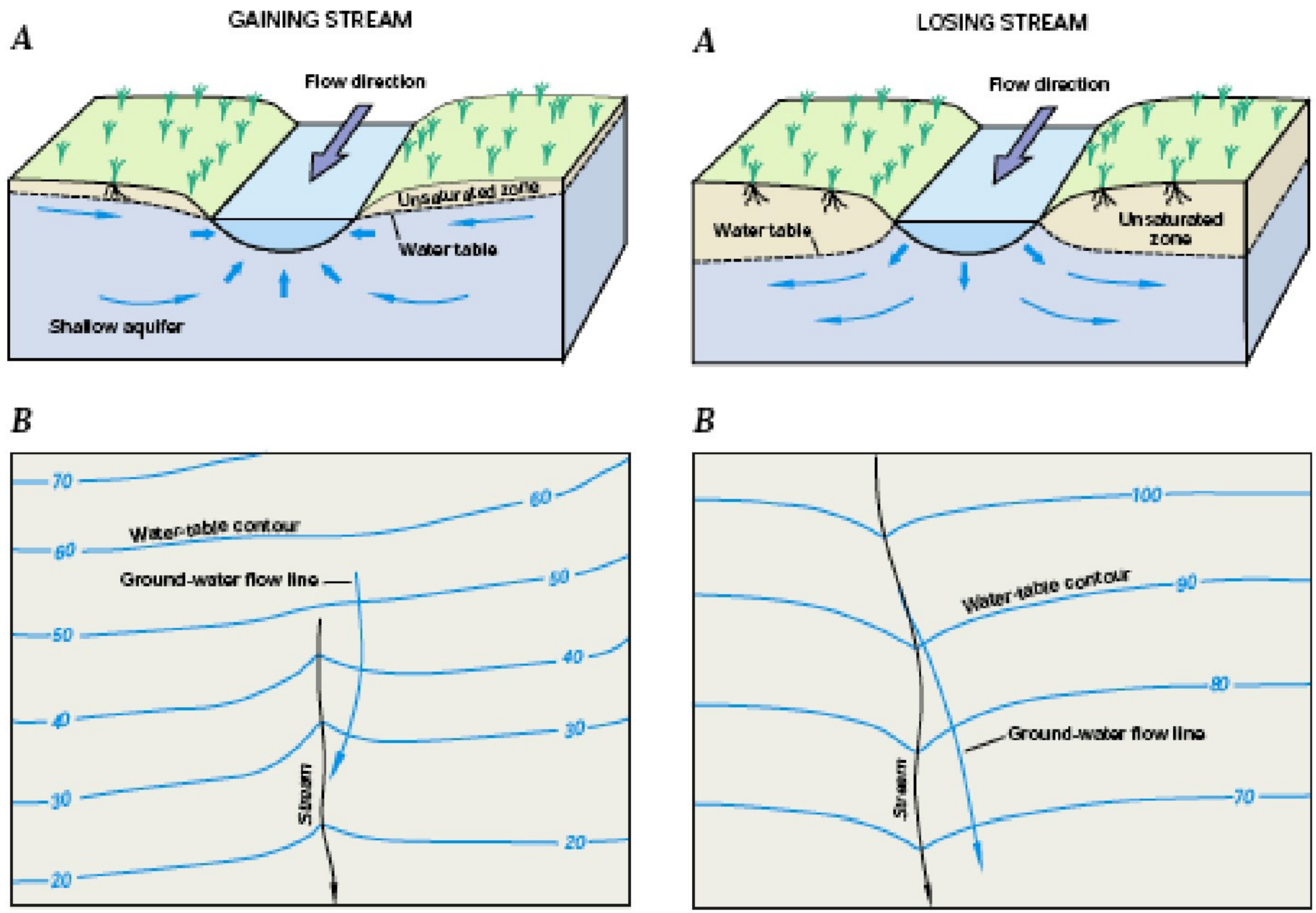
What is a flood?

What causes floods?

1. High tides
2. Storms Surges
3. Extreme Rainfall


Surface
Percolation Path
Aeration Zone
Pw < Pa
Water Table Pw = Pa
Unconfined
Ground Water
Pw > Pa

Ground water flow in the Subsurface



During extreme rainfall, all streams become gaining streams.
During a flood, rainfall exceeds percolation into the subsurface

Historical Floods

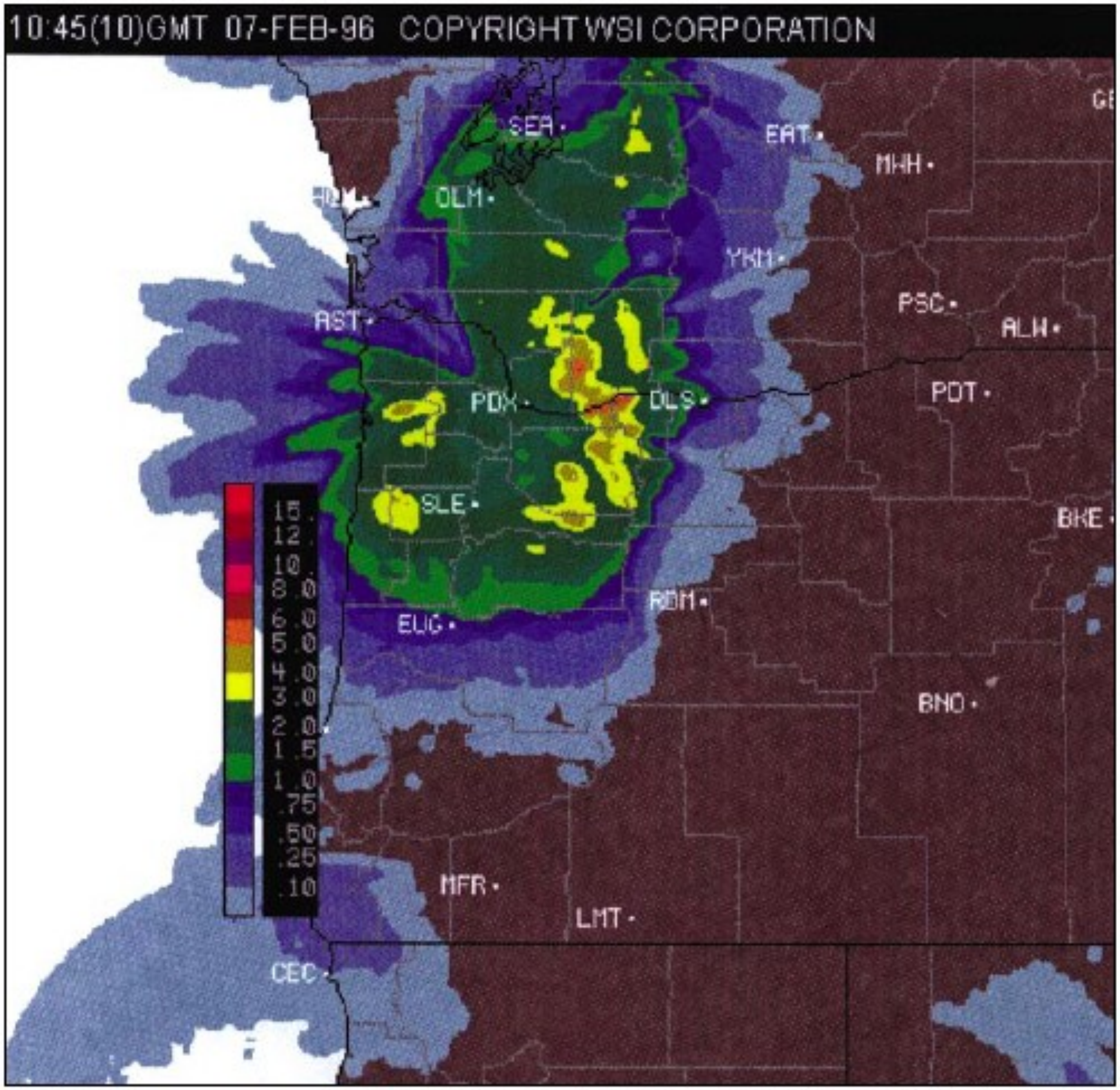
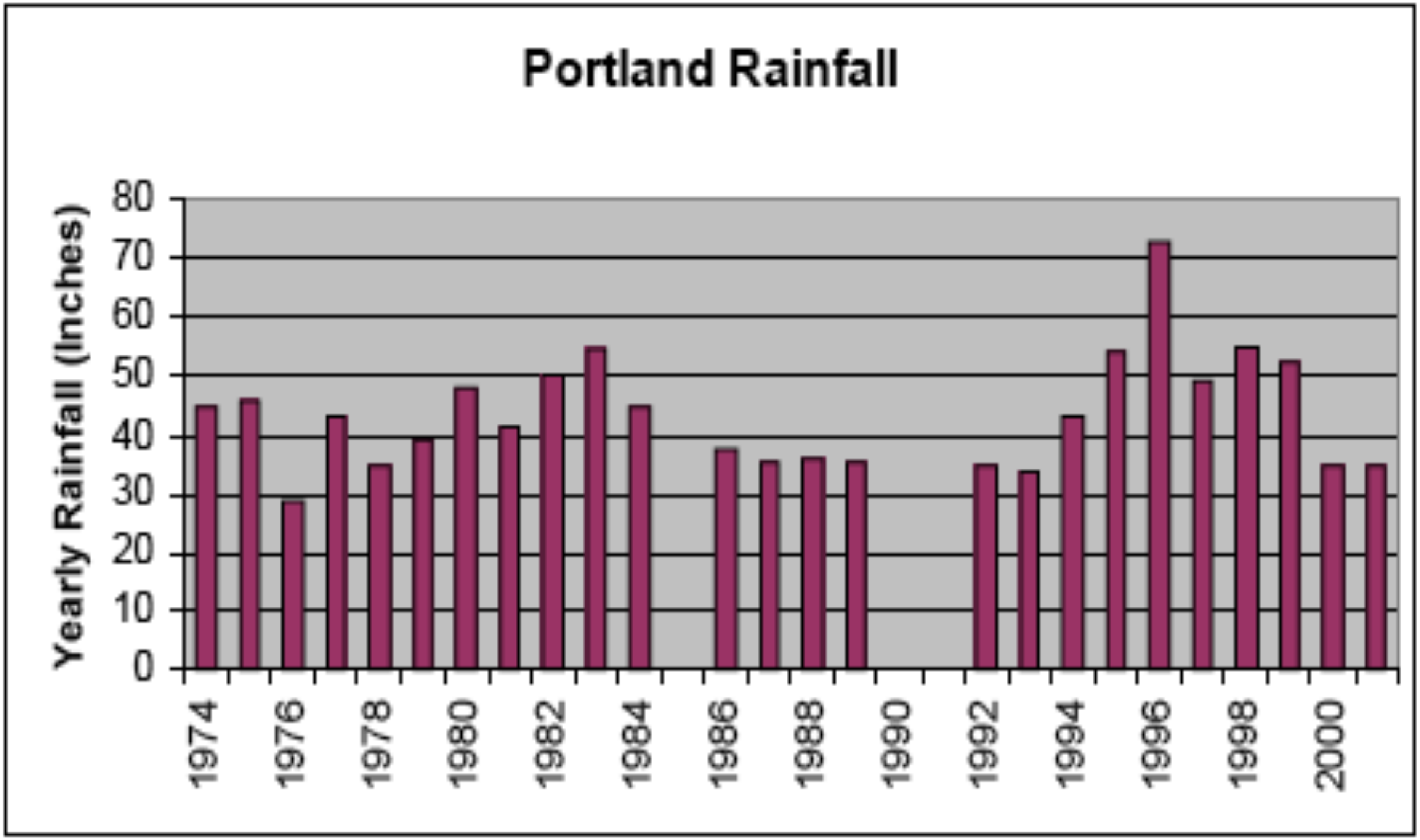


Figure 6. Radar imagery for February 7, 1996 showing high estimated-precipitation cells centered southeast of Mount St. Helens and along the Columbia River gorge near Dodson, Oregon where several large debris flows damaged houses and closed both I-84 and the Burlington Northern rail lines (Reprinted courtesy of WSI Corporation).



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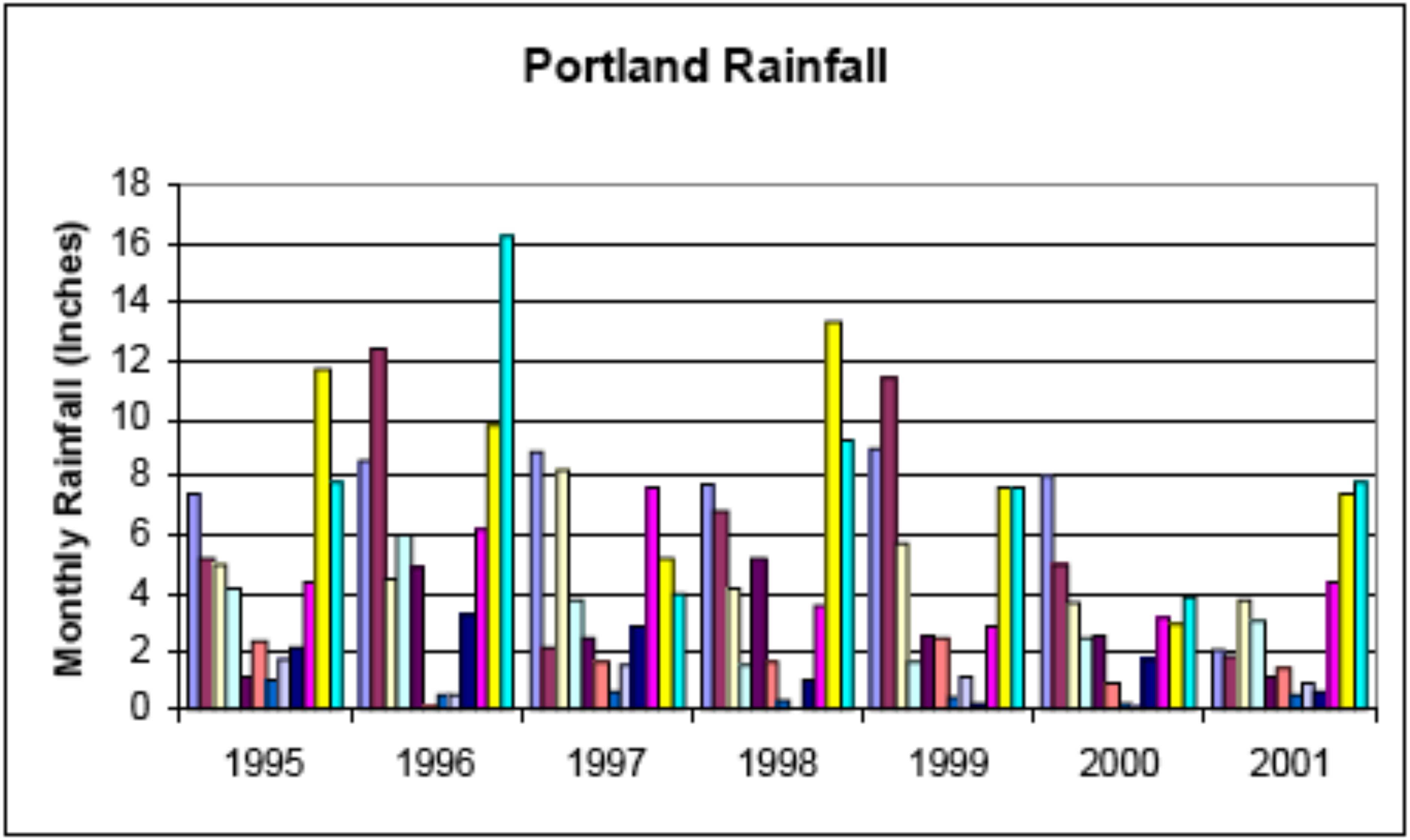


Figure 3. Seven years of monthly rainfall data in Portland, Oregon. This graph shows the variability in rainfall pattern, which directly affects landslide occurrences.

1996 Chehalis, Washington

www.oregonlive.com

1996: I-5 at Centralia, WA

seattletimes.nwsource.com/. ../04/2004052211.jpg

1996 Portland looking south from Broadway Bridge

Other Floods

The Dallas, 1894 (?)

June 14, 1903 Heppner OR

May 1948 Vanport Flood

Johnson Creek 1964

Oaks Bottom and Amusement Park 1964

December, 2007

Tillamook, Oregon January, 2009

newslincolncounty.com/.../ 12/tillamook-flood.jpg

Trask River in flood, January 2011

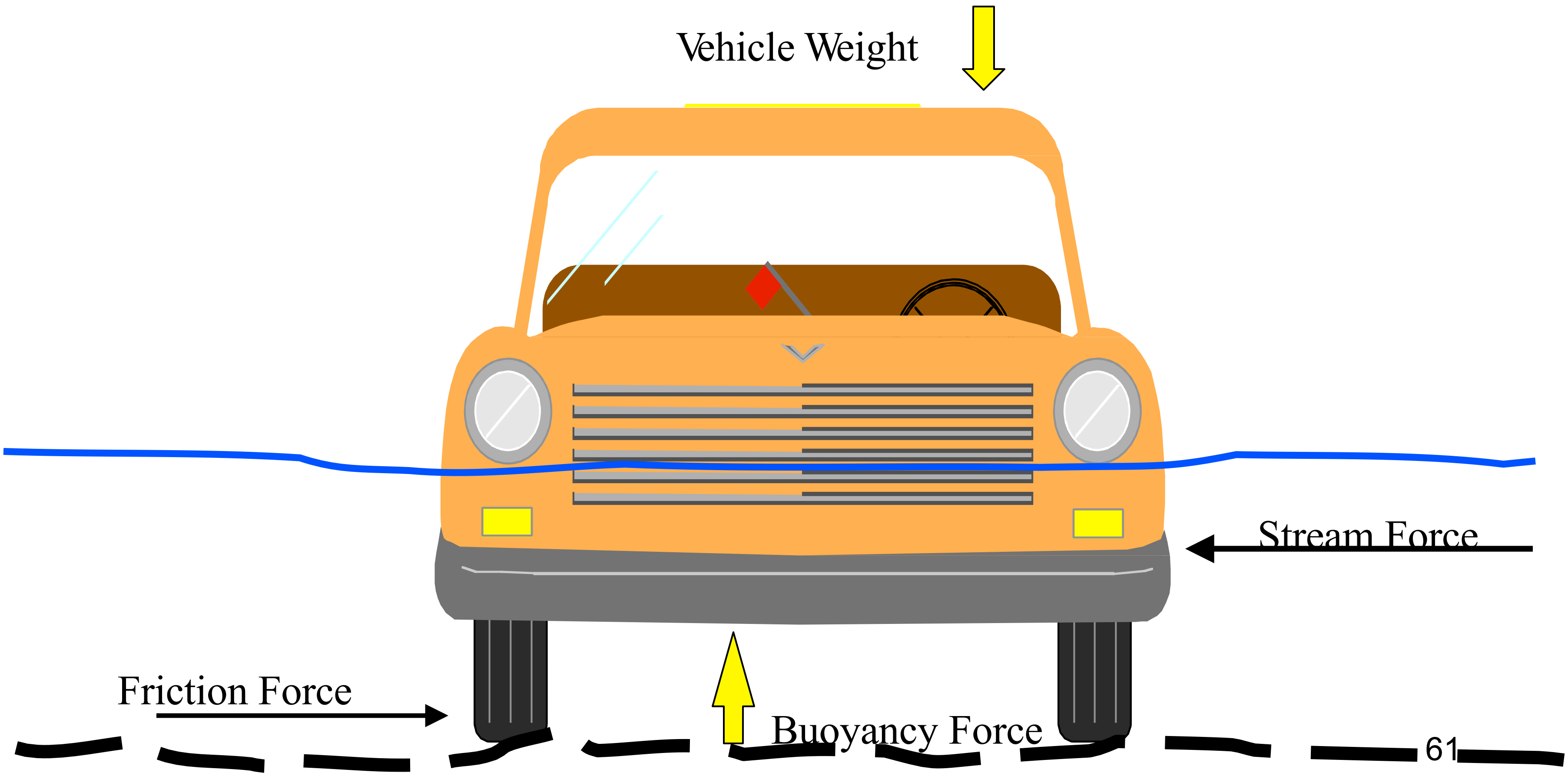
http://www.flickr.com/photos/50732610@N04/5361602158/in/photostream

Archimedes' Principle

The buoyant force on an object is equal to the weight of the fluid displaced by that object

Forces on Vehicles Crossing Streams

The car will float downstream when:
Stream Force > Friction Force



Some Water Physics Facts

- Water weighs 62.4 pounds/cubic foot, and cars displace a lot of it
- The pressure exerted by moving water increases with the square of its velocity
- Water, sand and mud reduce the frictional forces that hold a car in place
- Water clarity and lighting conditions conceal the condition of the roadway beneath you

Fighting a Losing Battle

- Width: 5.5 feet
- Length: 14 feet
- Ground Clearance: 10 inches
- Weight: 3,400 pounds

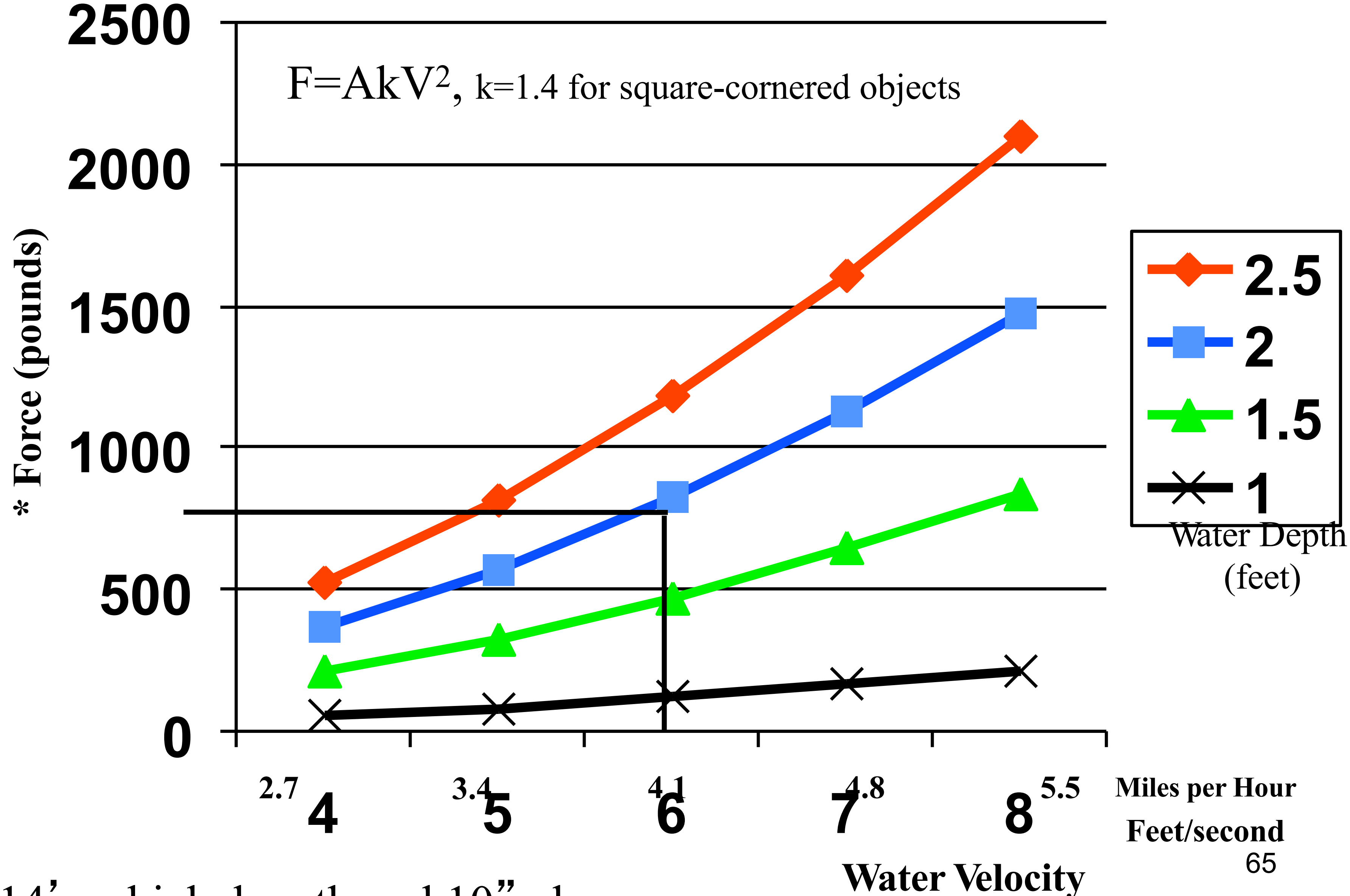
However, 1 foot of water displaced by this vehicle weighs:
(5.5' x 14' x 1' x 62.4 lbs./cu.ft.) = 4,805 pounds

Something a Little Bigger

- Width: 6 feet
- Length: 18 feet
- Ground Clearance: 18 inches
- Weight: 5,040 pounds

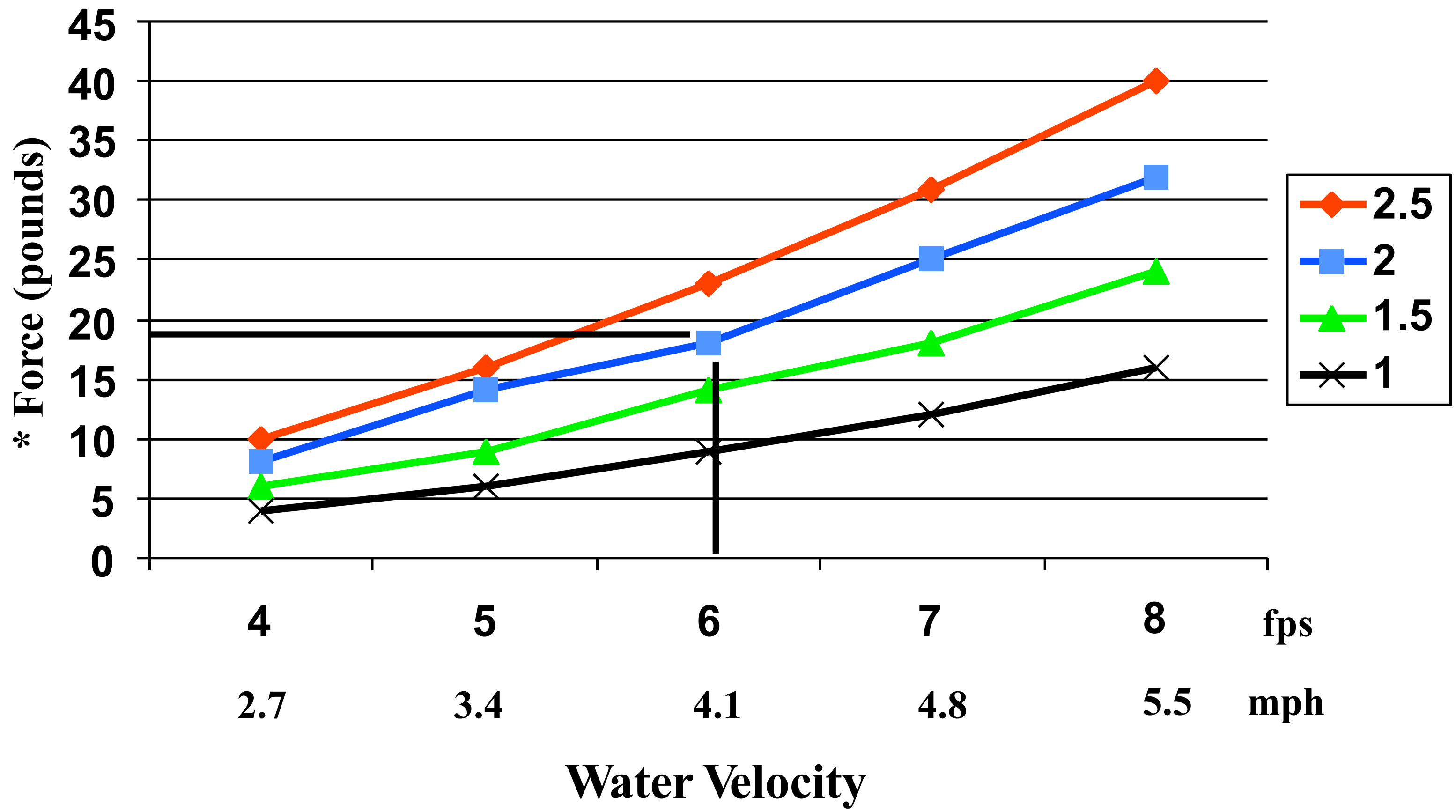
1 foot of water displaced by this vehicle weighs:
(6' x 18' x 1' x 62.4 lbs./cu.ft.) = 6,739 pounds

Stream Forces on Vehicles



* 14' vehicle length and 10" clearance

Stream Forces on Humans



* Force on each leg

https://www.youtube.com/watch?v=7YiB2-yHyuo


INTRODUISEZ les PIECES
APPUYEZ sur la TOUCHE pour CHOISIR votre BOISSON
Coca-Cola
Cet APPAREIL ACCEPTE les PIECES de
ORANGINA