Mapping of Potential Landslide Hazards in King County

November 3, 2016
Tolt Middle School

Presented by

Department of Natural Resources and Parks
Water and Land Resources Division
River and Floodplain Management Section

and

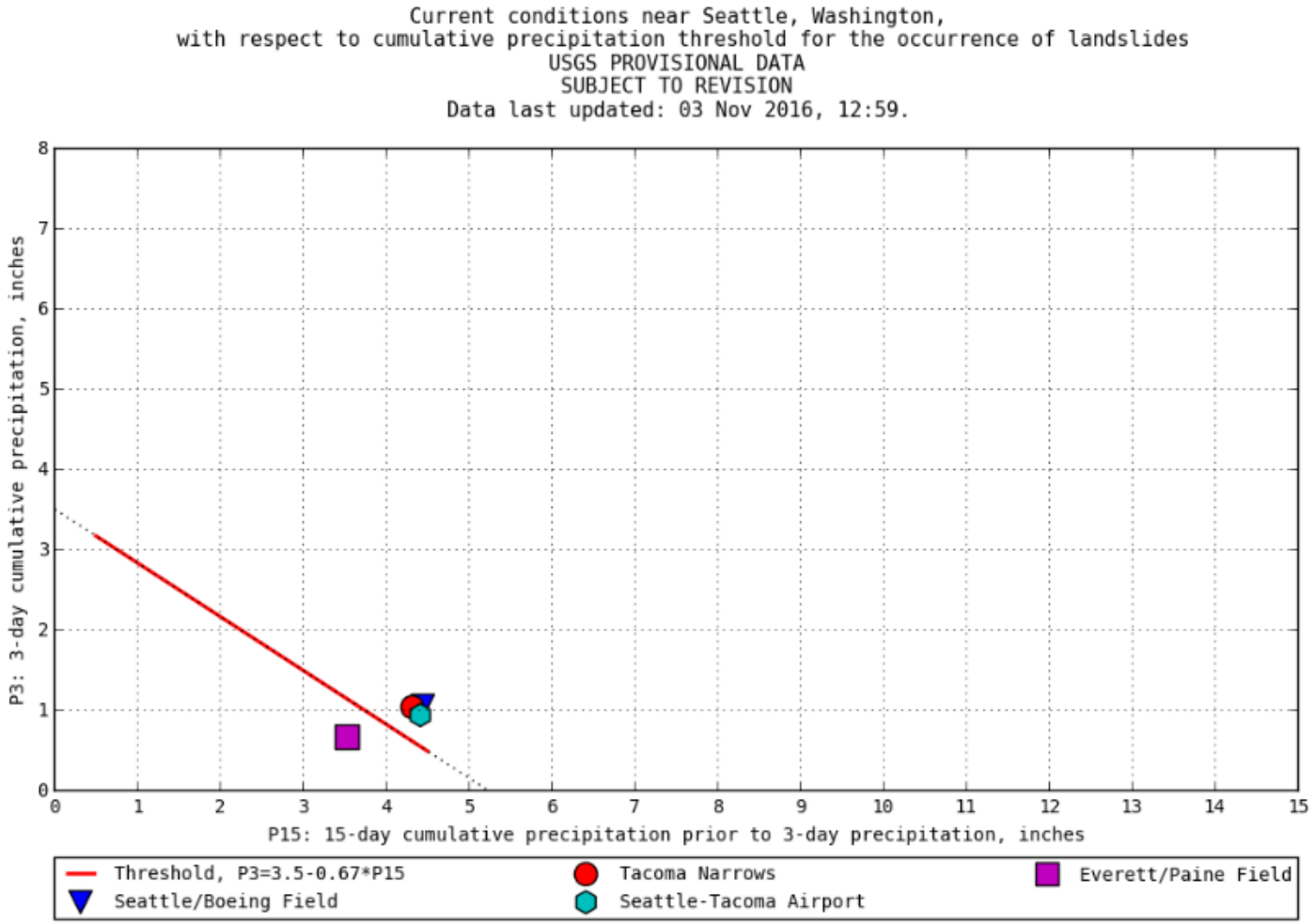
Department of Permitting and Environmental Review

King County

KING COUNTY FLOOD CONTROL DISTRICT

Rainfall Relative to Threshold

Cumulative Precipitation Threshold



Graph shows cumulative precipitation threshold for landslides (red line) and most recent update of 3-day and prior 15-day cumulative precipitation at selected National Weather Service Gages (symbols). Landslides are likely to occur on days when precipitation totals exceed the threshold (plot above or to the right of the red line). Landslides are unlikely to occur when precipitation totals plot below the red line, in the lower left corner of graph. Please direct questions or comments regarding this information to Rex Baum (baum [at] usgs [dot] gov).

Presentation Outline

- **Welcome and Introductions**
- **Landslide Types**
- **New Mapping Products**
  - River Corridor Mapping
  - Department of Permitting and Environmental Review's Map of Potential Landslide Hazards
- **Resources**
- **Question and Answer**

Introductions

Department of Natural Resources and Parks

John Bethel, Geologist, WA LEG

Sevin Bilir, Geologist, WA LHG

Jeanne Stypula, Supervising Engineer, PE

Department of Permitting and Environmental Review

Greg Wessel, Geologist, WA LEG

Resources

- WA State Department of Natural Resources, Geologic Hazards Section, Division of Geology & Earth Resources
- Comments Central – 3 ways to ask questions
- Handouts (Agenda, Landslide FAQs, iMap tutorial, additional info)

Some Introductory Comments

- We live in landslide country
- Why landslide mapping now?
- Why two mapping efforts?
- Hazard vs. Risk

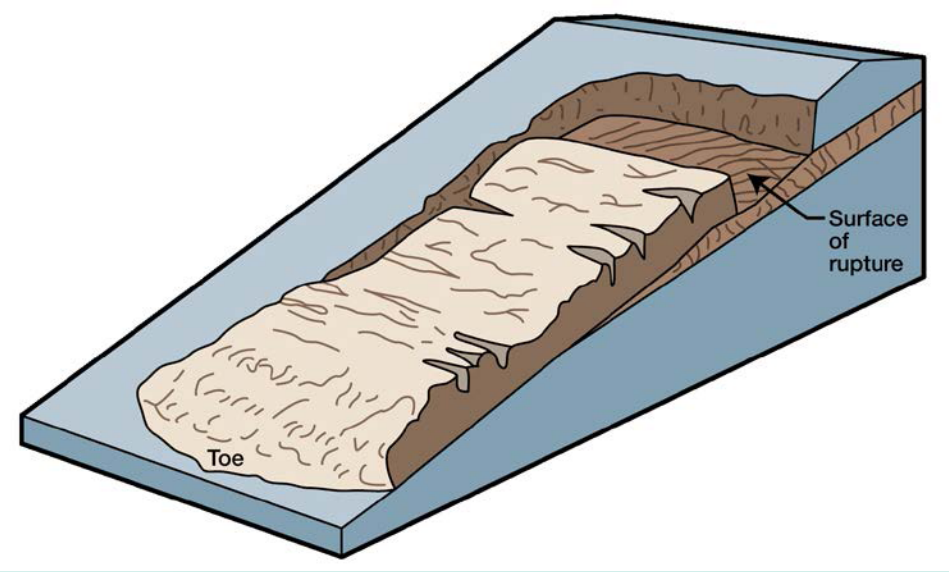
Types of Landslide Hazards in King County

- Shallow debris slides
- Fans and debris flows
- Deep-seated landslides
- Rock fall
- Rock avalanches
- Snow avalanches






Shallow Debris Slides



(Source: USGS Fact Sheet: Landslide Types and Processes, 2004-3072. http://pubs.usgs.gov/fs/2004/3072/pdf/fs2004-3072.pdf)

BNSF Railway
Everett to Seattle

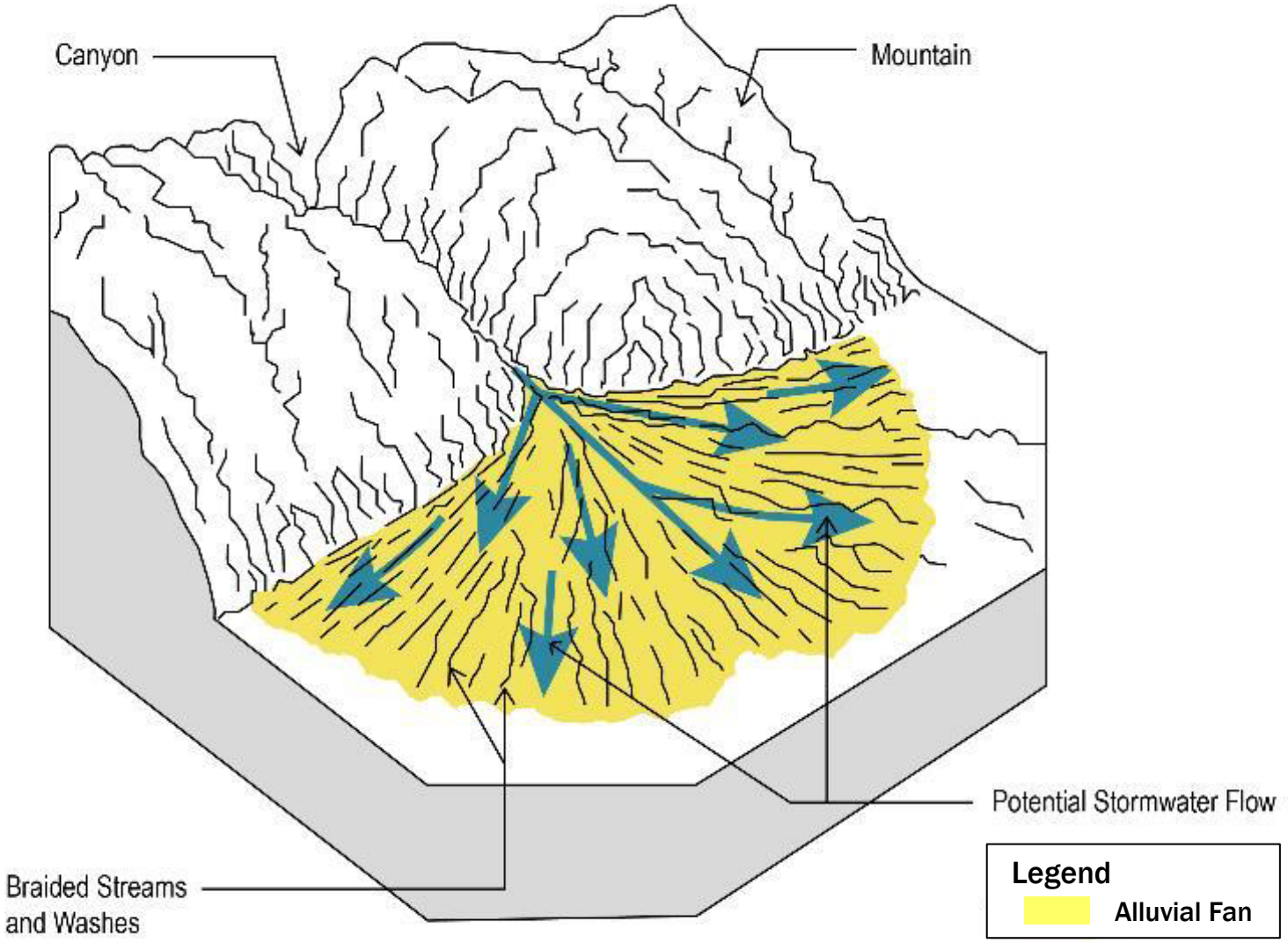
View landslide video (external link)

Concerns with Shallow Debris Slides

- Can move quickly
- Can be highly destructive

(Photo courtesy of WA Department of Ecology)

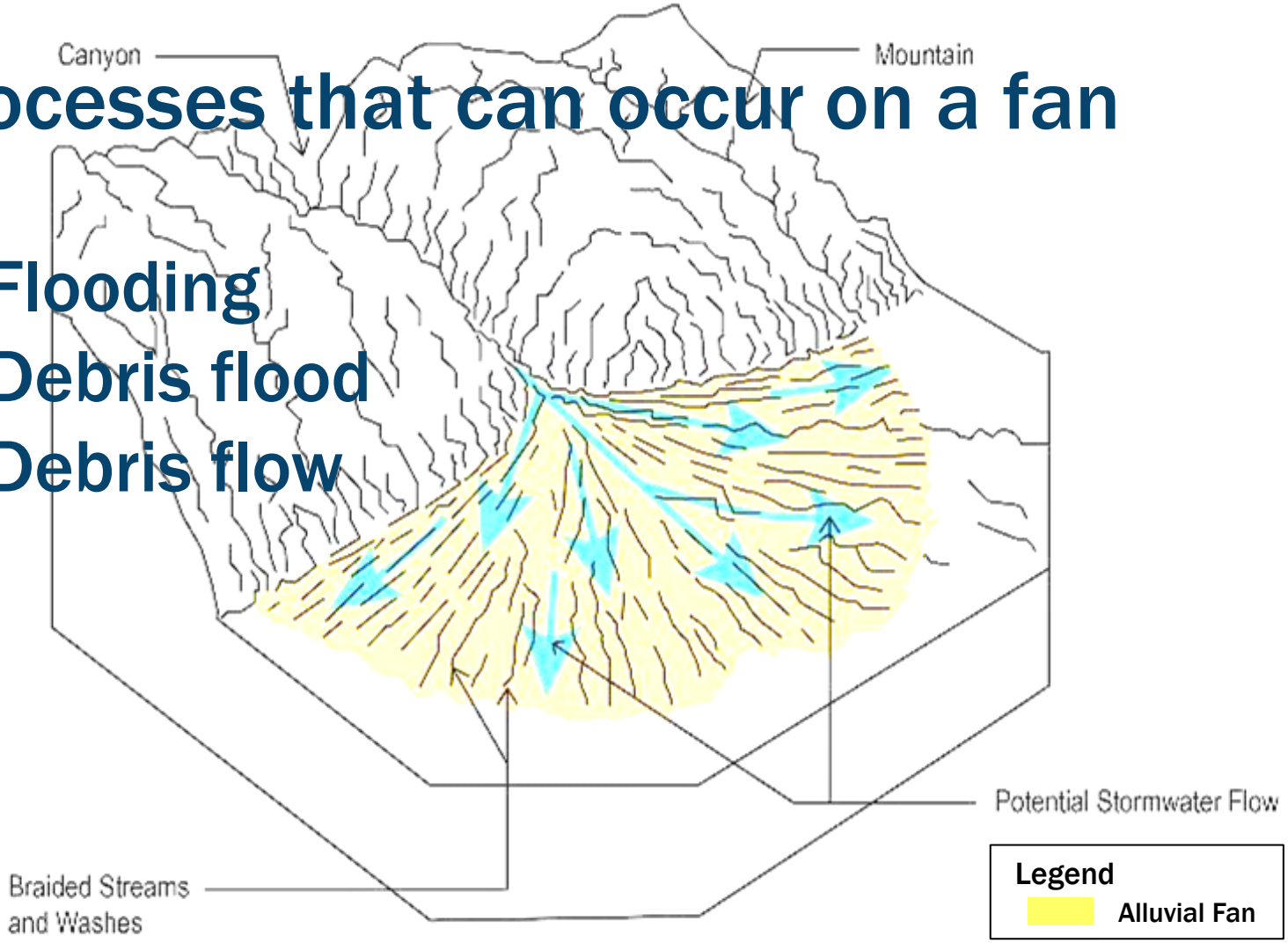
Depositional Fans



Depositional Fans

Processes that can occur on a fan

- Flooding
- Debris flood
- Debris flow



Flooding, Issaquah Creek

Debris Flood, Green Valley Rd. SE

Debris Flow, Washington Pass, SR 20

Concerns on Depositional Fans

- Flooding, Channel Migration, Debris Impact
- Hazard depends on process

Residence near Clough Creek

Debris flood on Deer Creek (2012)

Deep-Seated Landslides

View landslide video (external link)

Concerns with Deep-Seated Landslides

- Can be remobilized
- Hazard depends on location on slide
- Can travel long distances

Aldercrest Banyon Landslide, Kelso, WA
(1998 - 1999)

- 57 homes were destroyed

(Source: J. Rogers)

Landslide offset along a residential access road, Cedar River.


Denny Mt, Alpental area

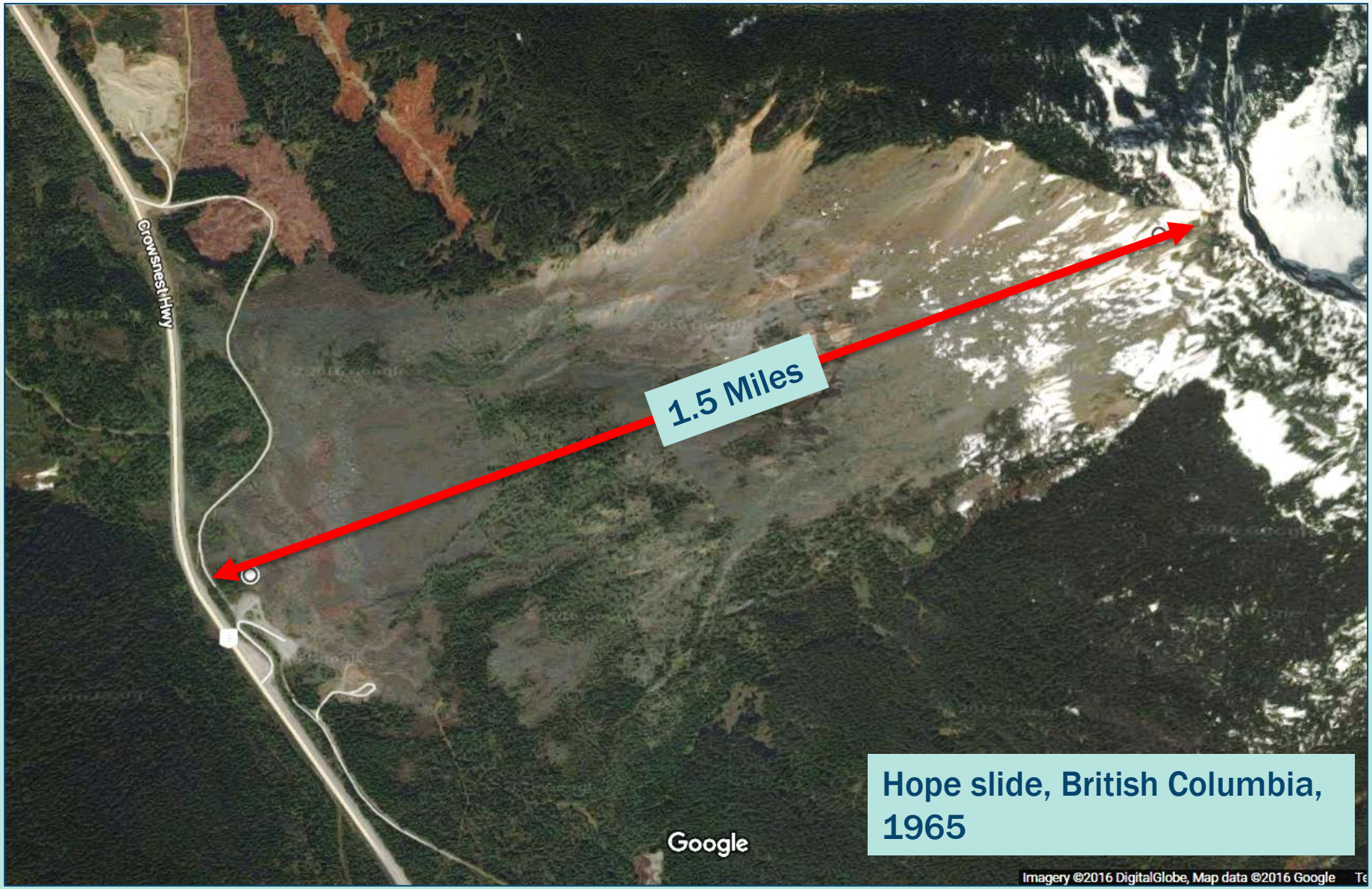
Concerns with Rock Falls

- Fast moving
- Pose a serious threat to anything in their path

Boulder on Highway 2, Tumwater Canyon (2010)

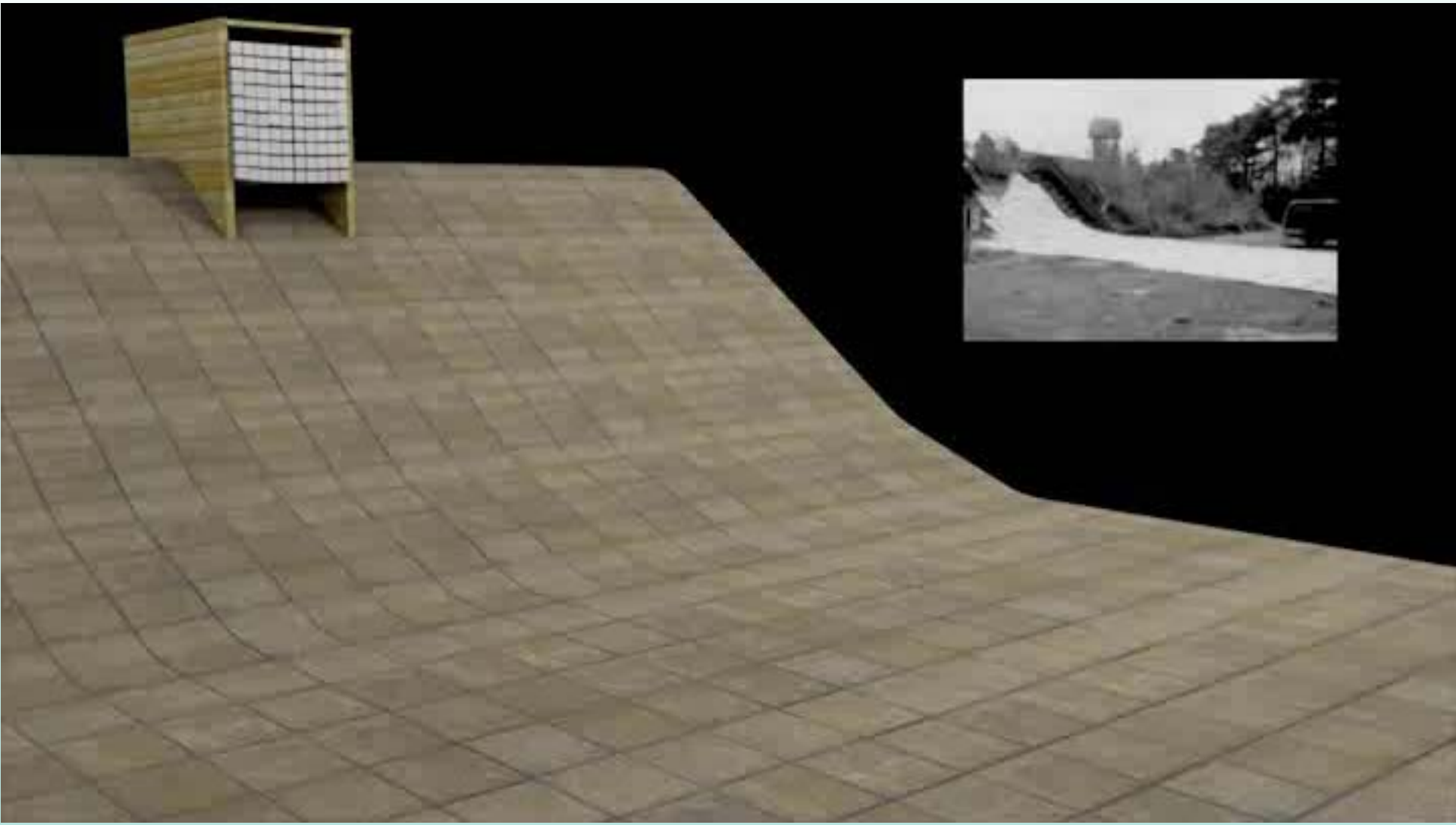
"Huge boulder flattens 300-year-old house," Northern Italy (2014)

Rock Avalanches



Hope slide, British Columbia, 1965

Video of Rock Avalanche Simulation



View landslide video (external link)

(Source: Tipe, Avalanches Rocheuses https://www.youtube.com/watch?v=ZABf78WS1AE)

Concerns with Rock Avalanches

Mt Si area

- Fast moving
- Pose a serious threat to anything in their path

North Fork Snoqualmie River

Snow Avalanches

Large scale avalanche control

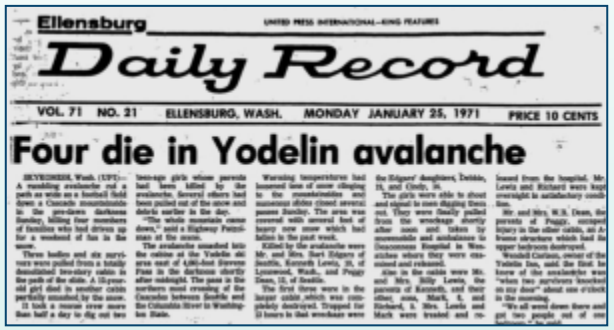
(Source: King County OEM)

Small accidental slab avalanche

(Source: NAC, http://www.nwac.us/observations/pk/262/ December 2015)

Concerns with Snow Avalanches

- Fast moving
- Pose a serious threat to anything in their path

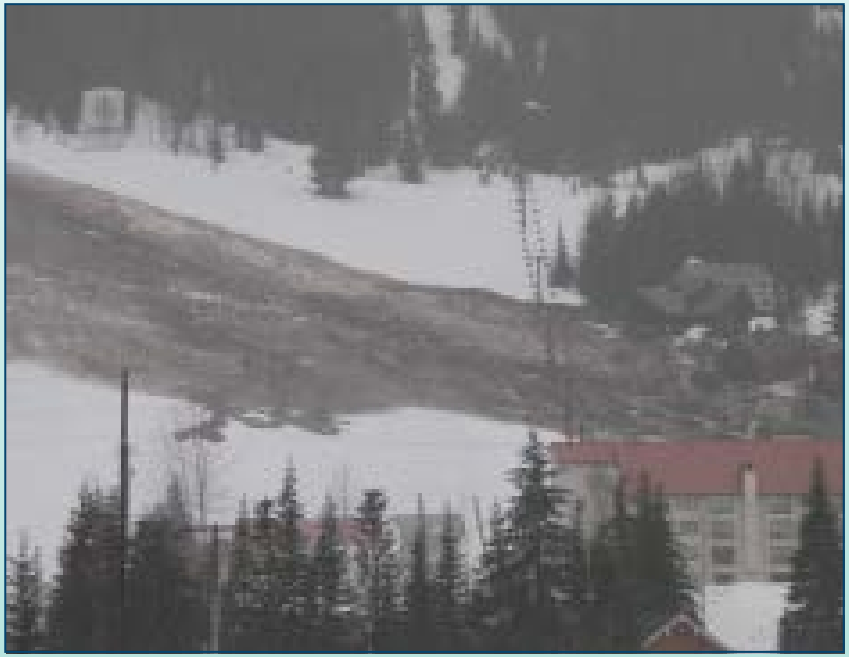


Ellensburg Daily Record

VOL. 71 NO. 21 ELLENSBURG, WASH. MONDAY JANUARY 25, 1971 PRICE 10 CENTS

Four die in Yodelin avalanche

1910 Wellington Avalanche resulted in 96 fatalities.
(Source: Seattle Times (2010); Image from Skykomish Historical Society 2016)



Hyak ski area slide impacting cabins (2009)
(Source: Don Whitehouse, NWAC, https://www.nwac.us/photo-archive/view/13/)

SR 530 (Oso) Landslide

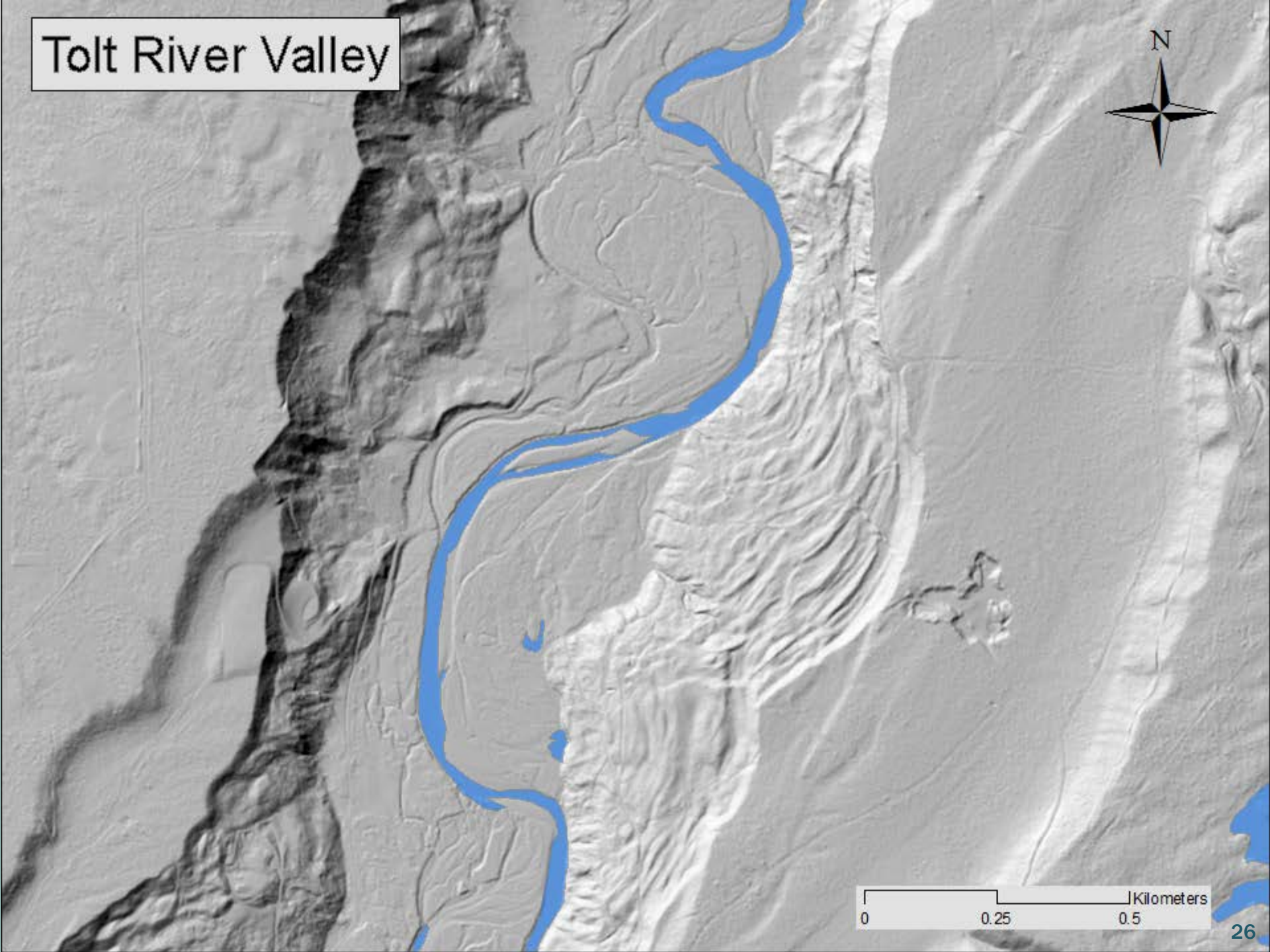
New King County Landslide Products

- River Corridor Mapping
- Potential Landslide Hazards Mapping

Department of Natural Resources and Parks

John Bethel

Environmental Scientist/Engineering Geologist


Tolt River Valley
N
Kilometers
0
0.25
0.5

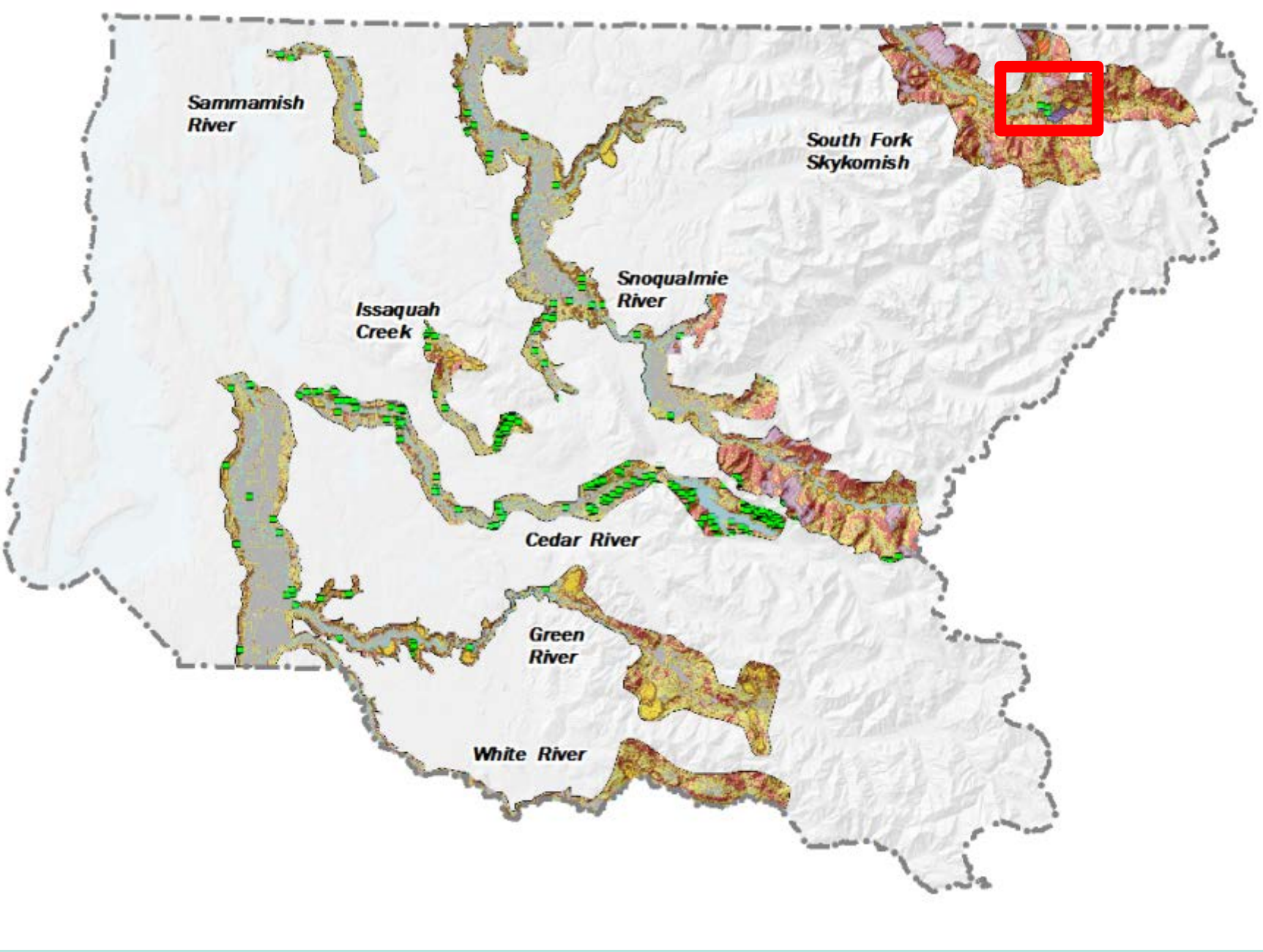
Landslide Types Mapped in River Corridors

- Shallow debris slides
- Fans and debris flows
- Deep-seated landslides
- Rock fall
- Rock avalanches

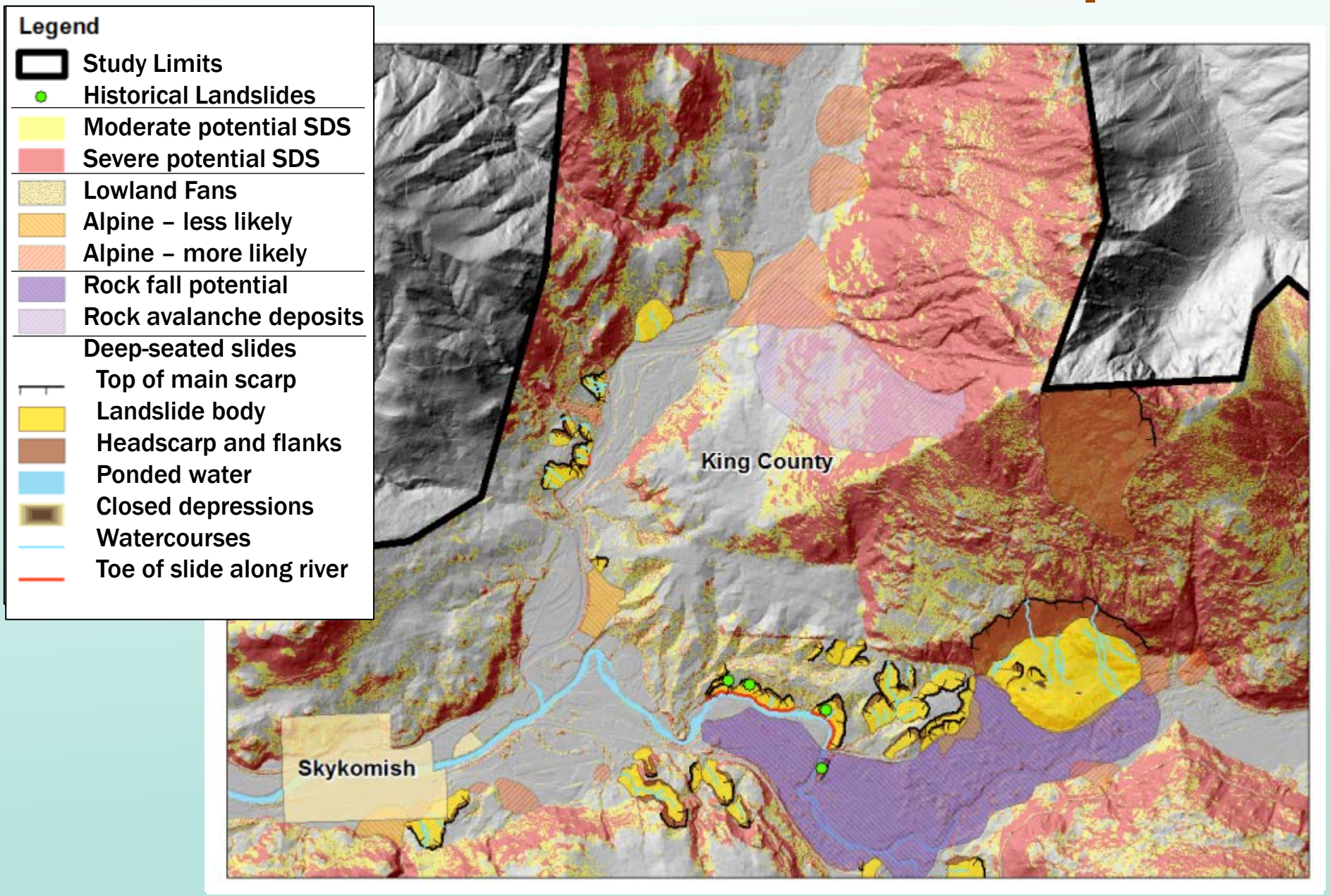




River Corridor Landslide Hazard Map



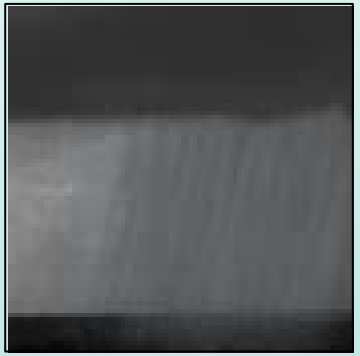
River Corridor Landslide Hazard Map



Considerations in Using Map Information

- Timing and probability of future movement

- Impacts from climate change



- Effects from earthquakes

Uses of River Corridor Mapping

- Intended to support King County river corridor planning and capital projects for flood risk reduction.
- It may also be of use to:
  - —City and County emergency planners
  - —Transportation and utility managers
  - —Geotechnical consultants
  - —Residents

Department of Permitting and Environmental Review

Greg Wessel

Environmental Scientist/Engineering Geologist

Basic principles for mapping and regulating geologic hazards

- Both justification and authority should be clear.
- Specific and understandable criteria: definitions are important.
- Only qualified geologists with applicable experience.
- In line with existing codes.
- Recurrence intervals are important, if known (When is a landslide not a hazard?).

KCC 21A.24.280 Landslide hazard areas — development standards and alterations

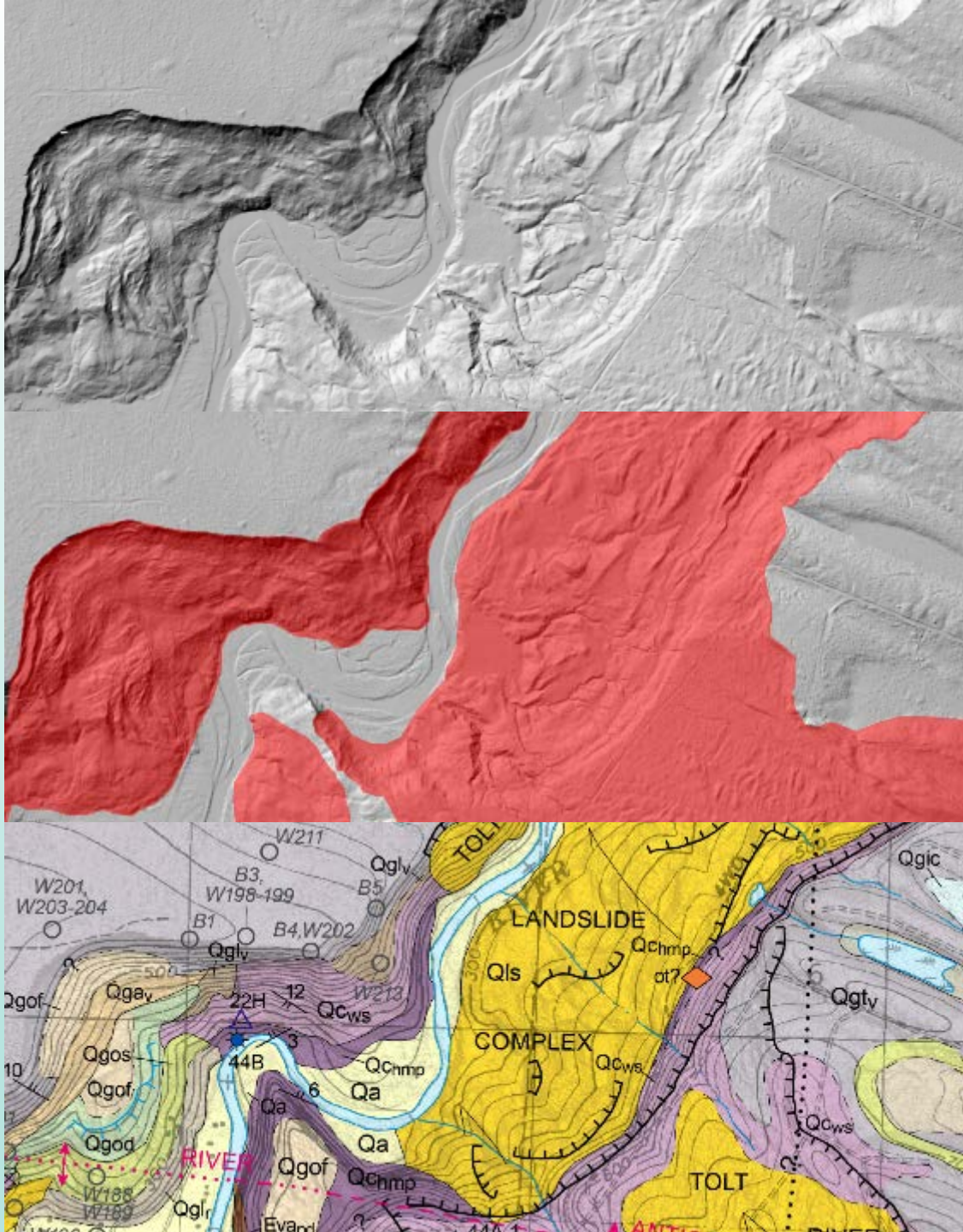
- A buffer is required from all edges of the landslide hazard area. Without a geotechnical study, the buffer is 50 feet wide.
- Alterations in a landslide hazard area located on a slope less than forty percent are allowed if:
  1. The proposed alteration will not decrease slope stability on contiguous properties; and
  2. The risk of property damage or injury resulting from landsliding is eliminated or minimized through mitigation.
- Mitigation may include avoidance or engineering (special structural design additions).

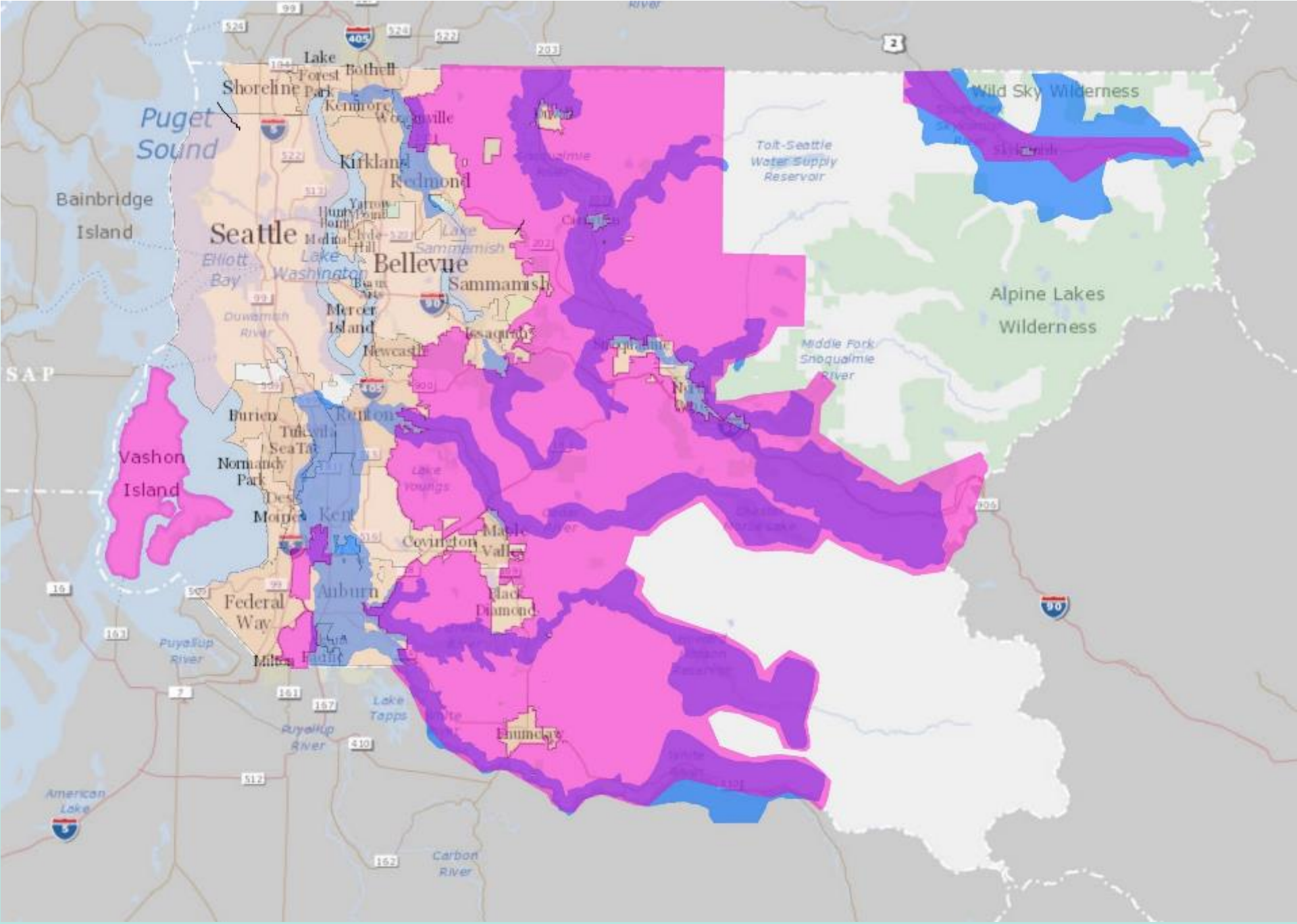
KCC 21A.24.310 Steep slope hazard areas — development standards and alterations

- A buffer is required from all edges of the steep slope hazard area. Without a geotechnical study, the buffer is 50 feet wide.
- New development on or near a steep slope is only allowed if accompanied by a geotechnical study that confirms there will be no adverse impact from the development, either to the development itself or to adjacent properties. (Note: this is essentially the same standard to which landslide hazards are held.)
- As with landslide hazards, mitigation may be required for development on or near steep slopes.

Comparison of LiDAR hillshade, potential landslide hazards, and mapped geology, lower Tolt River valley, King County, WA

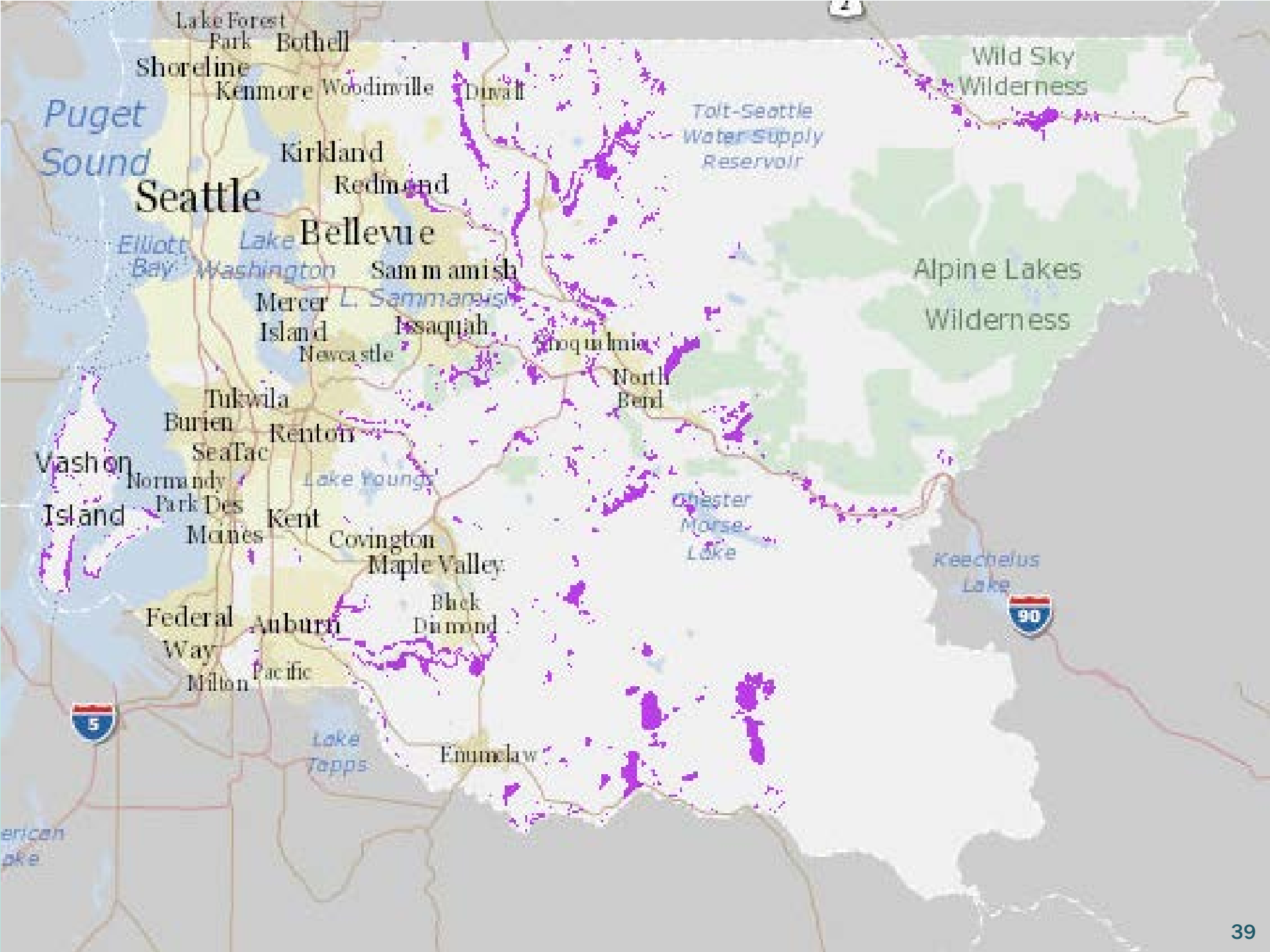
(geology from Dragovich, et al, 2012)




Puget Sound
Bainbridge Island
Seattle
Bellevue
Kirkland
Redmond
Sammamish
Lake Washington
Lake Sammamish
Elliott Bay
Duwamish River
Mercer Island
Issaquah
Newcastle
Renton
Burien
Tukwila
SeaTac
Normandy Park
Vashon Island
Kent
Auburn
Federal Way
Covington
Maple Valley
Black Diamond
Enumclaw
Lake Tapps
Puyallup River
Milton
Lake Youngs
Shoreline
Lake Forest Park
Kenmore
Bothell
Woodinville
Snoqualmie
Tolt-Seattle Water Supply Reservoir
Wild Sky Wilderness
Alpine Lakes Wilderness
Middle Fork Snoqualmie River
American Lake
Carbon River
SAP

Landslide Hazards Mapped

- Slumps and other deep-seated landslides
- Rockfalls
- Rock avalanches
- Debris/alluvial fans
- Snow avalanche zones (to a degree)
- Slopes undercut along a shoreline
- Unclassified larger-scale mass wasting
- Landforms suggestive of dominant mass wasting
- Slopes potentially susceptible to shallow landsliding (steep slopes)


Lake Forest Park
Bothell
Shoreline
Kenmore
Woodinville
Duvall
Puget Sound
Wild Sky Wilderness
Tolt-Seattle Water Supply Reservoir
Kirkland
Redmond
Seattle
Bellevue
Elliott Bay
Lake Washington
Sammamish
L. Sammamish
Alpine Lakes Wilderness
Mercer Island
Issaquah
Newcastle
Snoqualmie
North Bend
Tukwila
Burien
Renton
SeaTac
Vashon Island
Normandy Park
Des Moines
Kent
Lake Youngs
Chester Morse Lake
Covington
Maple Valley
Keechelus Lake
Black Diamond
Federal Way
Auburn
Pacific
Milton
Lake Tapps
Enumclaw
5
90

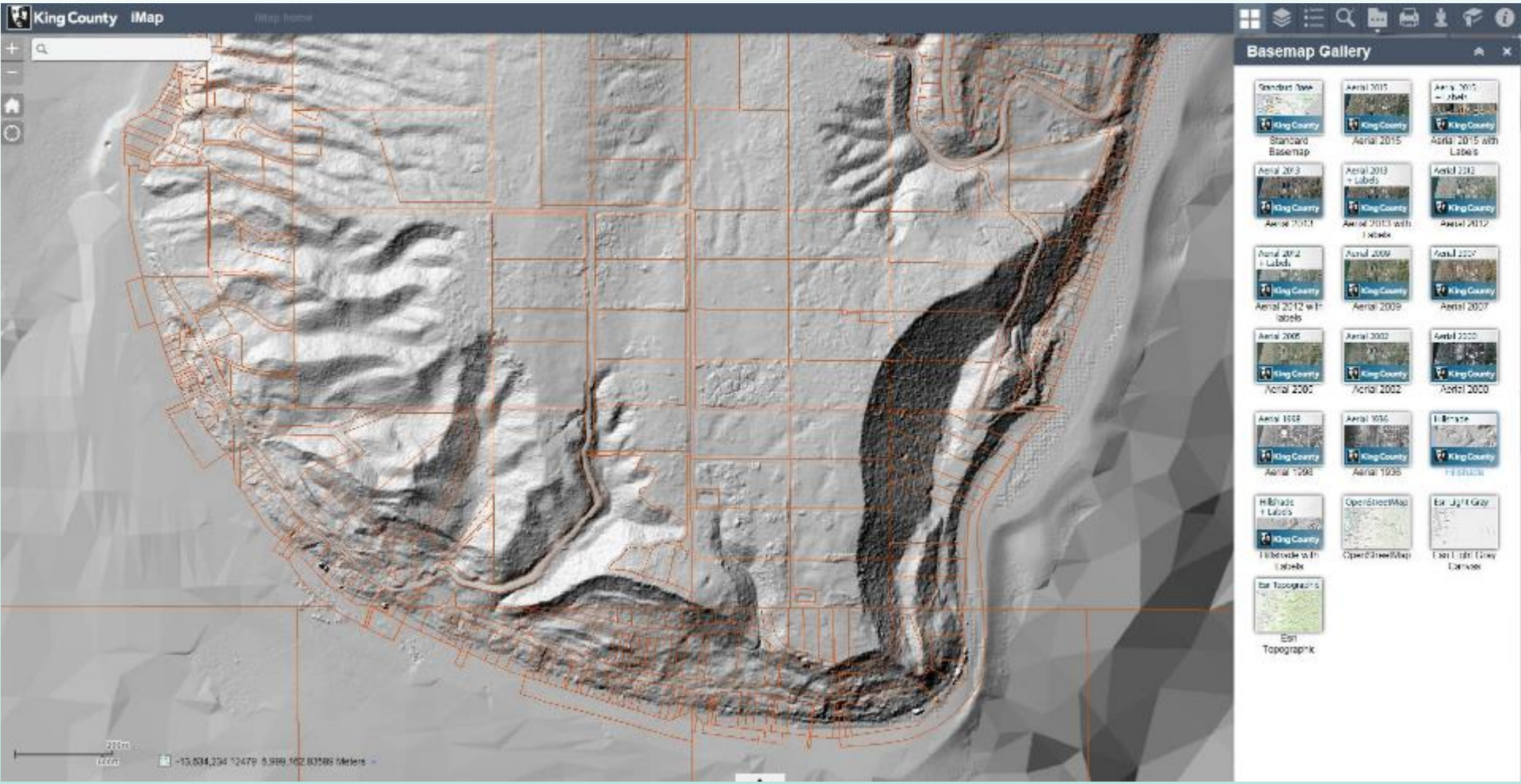
What the mapping is:

- A reasonable approximation of what may be landslide hazards based upon LiDAR photointerpretation by experienced geologists and the best available geologic mapping, which though best available may not be all that good everywhere.
- No field data were collected to use in creating these maps.

What the mapping is not:

- A definitive representation of landslide hazards.
- No field data were collected to use in creating these maps.
- *Further site-specific investigations are necessary to determine the presence and nature of any hazard and the level of risk.*


King County iMap
Basemap Gallery
Standard Basemap
Aerial 2015
Aerial 2015 with Labels
Aerial 2013
Aerial 2013 with Labels
Aerial 2012
Aerial 2012 with Labels
Aerial 2009
Aerial 2007
Aerial 2005
Aerial 2002
Aerial 2000
Hillshade
Hillshade with Labels
OpenStreetMap
Esri Light Gray Canvas
Esri Topographic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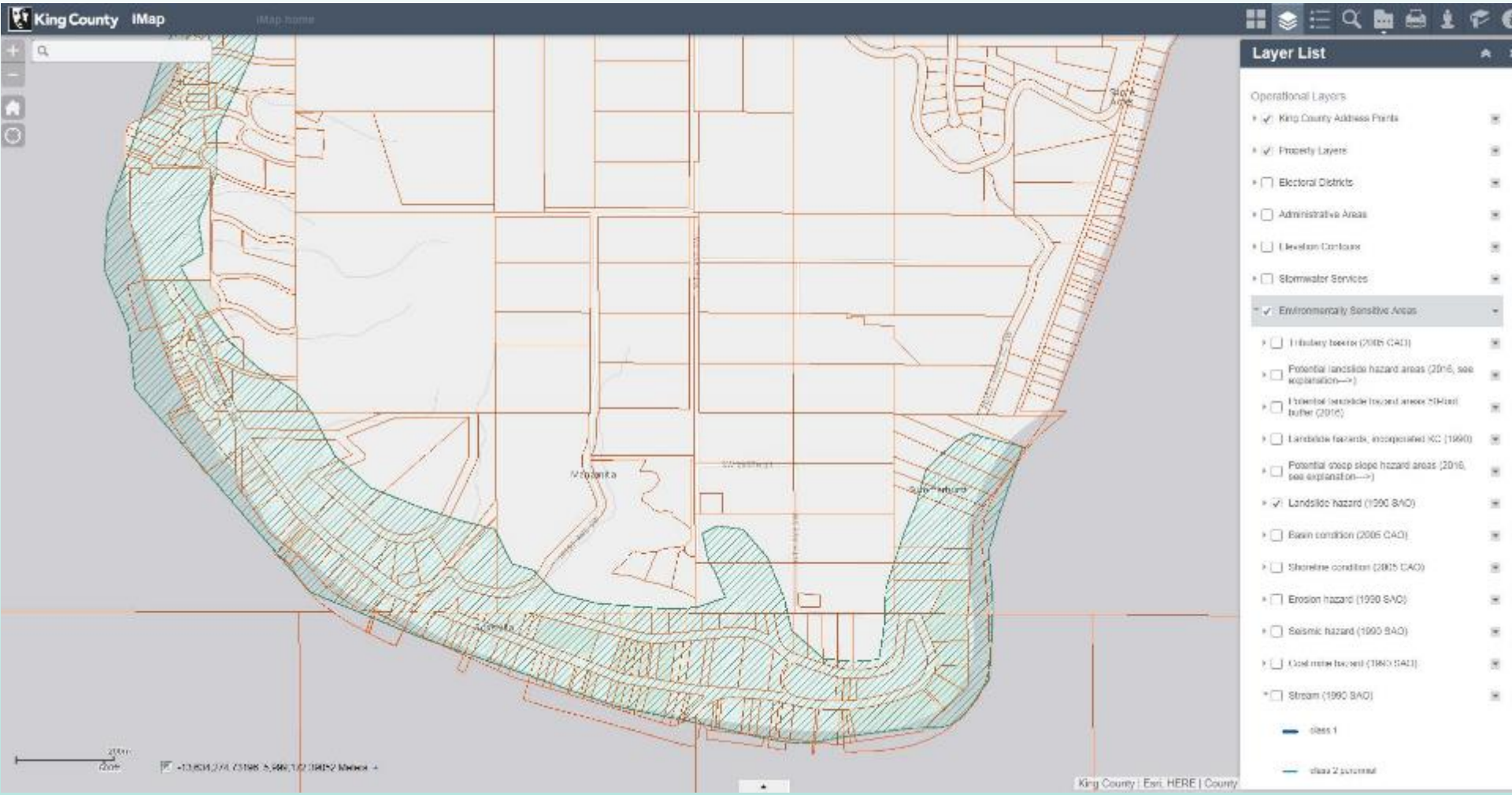
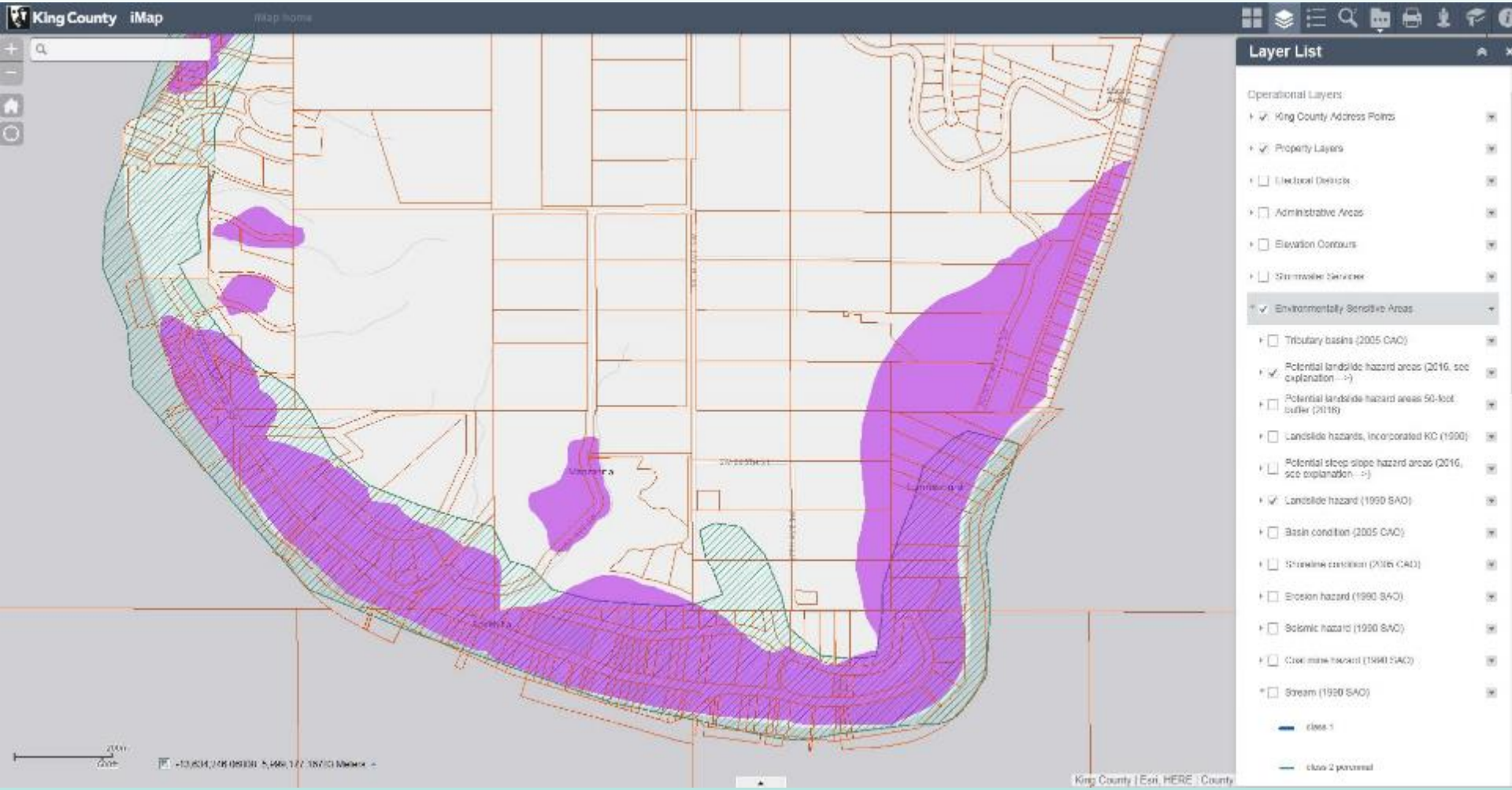
Aerial 1998
Aerial 1936
Hillshade with Labels
OpenStreetMap
Esri Topographic


King County
iMap
Layer List
Operational Layers
King County Address Points
Property Layers
Electoral Districts
Administrative Areas
Stormwater Services
Environmentally Sensitive Areas
Landslide hazard (1990 SAO)
Basin condition (2005 CAO)
Erosion hazard (1990 SAO)
Seismic hazard (1990 SAO)
Stream (1990 SAO)
King County | Esri, HERE | County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Property Layers
Administrative Areas
Elevation Contours
Environmentally Sensitive Areas
Tributary basins (2005 CAO)
Potential landslide hazard areas (2016, see explanation ...)
Landslide hazards, Incorporated KC (1990)
Landslide hazard (1990 SAO)
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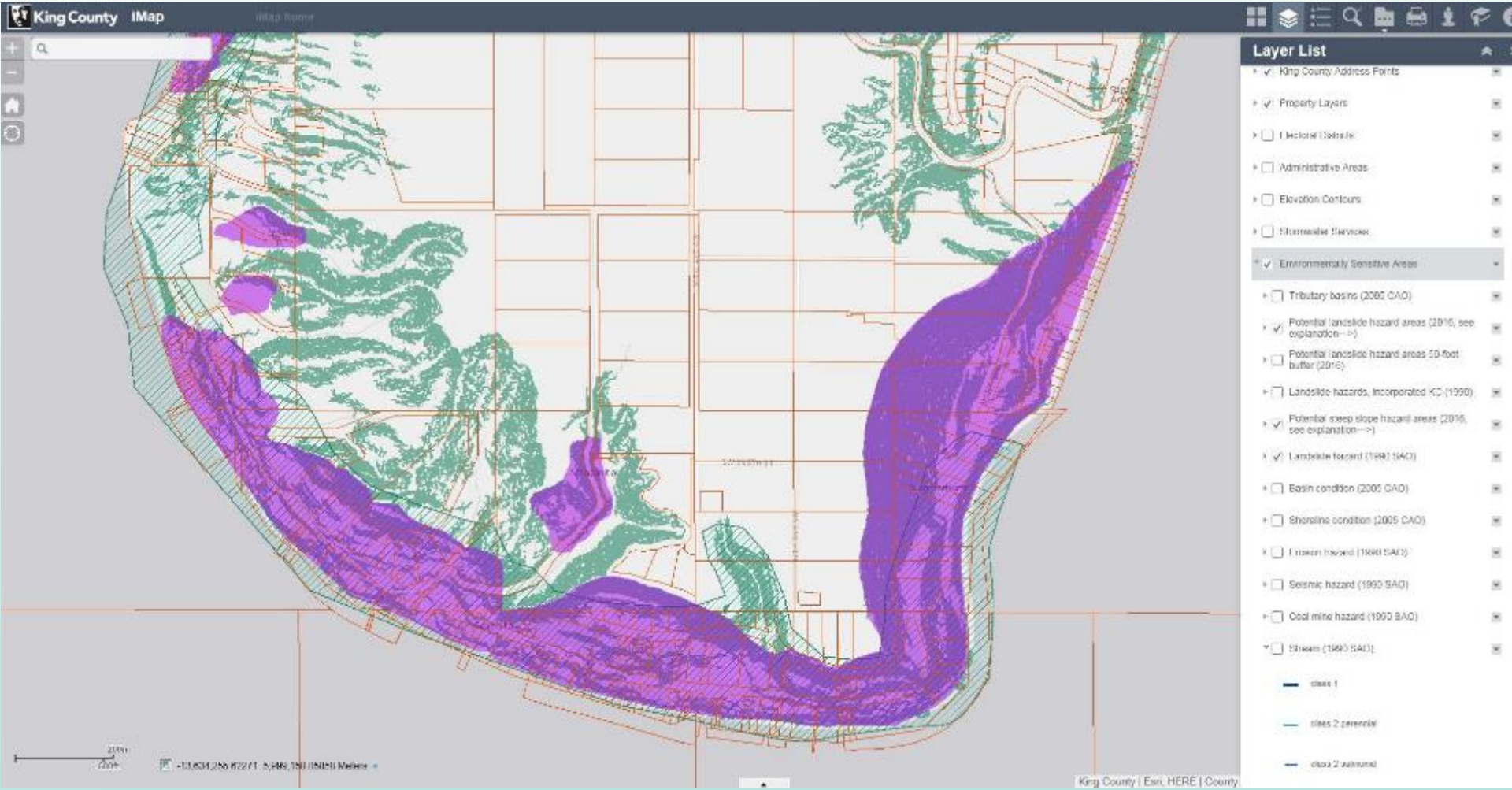
King County | Esri, HERE | County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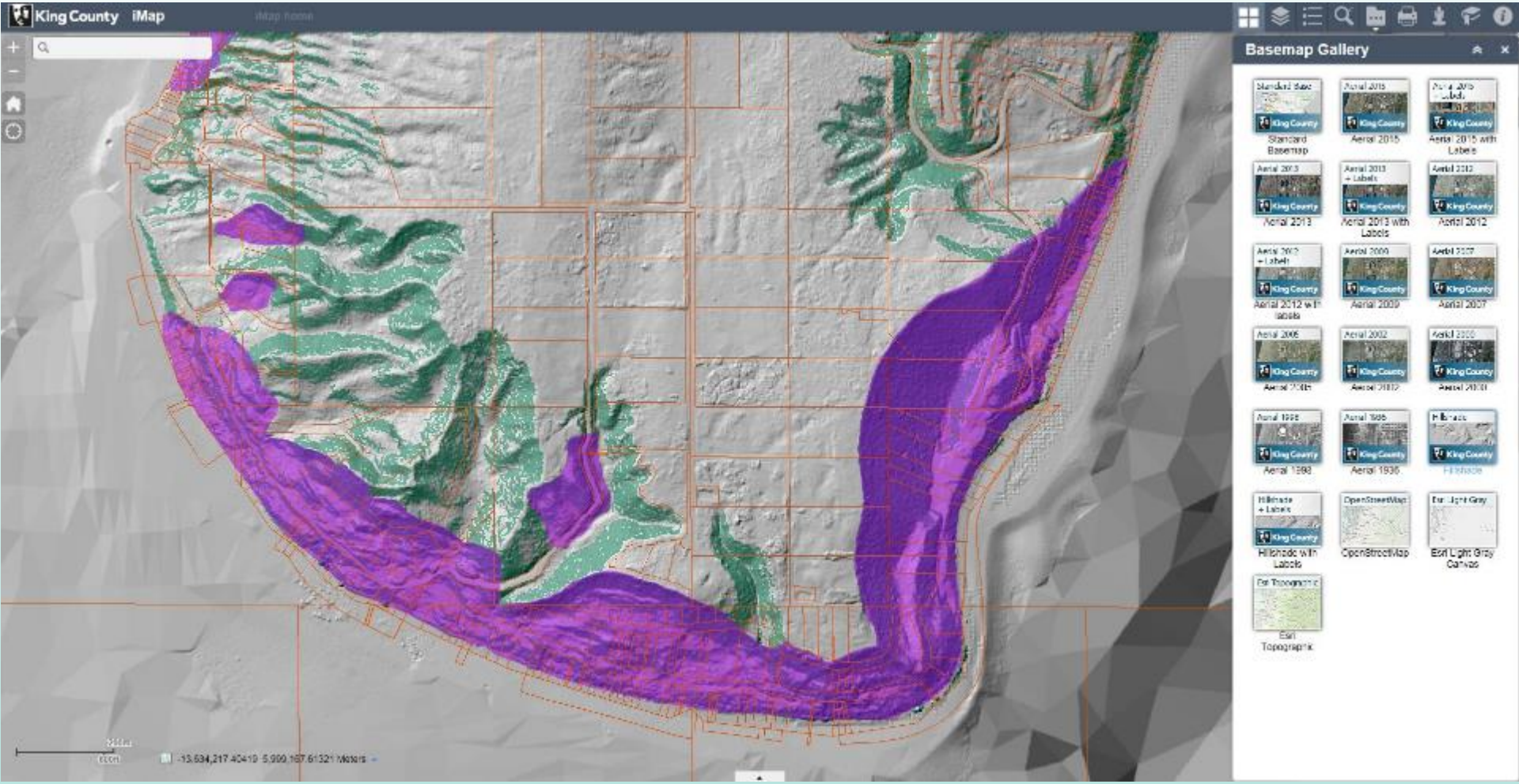
Potential landslide hazard areas 50-foot buffer (2016)
Landslide hazards, Incorporated KC (1990)
Potential steep slope hazard areas (2016, see explanation-->)
Basin condition (2005 CAO)
Shoreline condition (2005 CAO)
Seismic hazard (1990 SAO)
Coal mine hazard (1990 SAO)
class 1
class 2 perennial
class 2 salmonid
King County | Esri, HERE | County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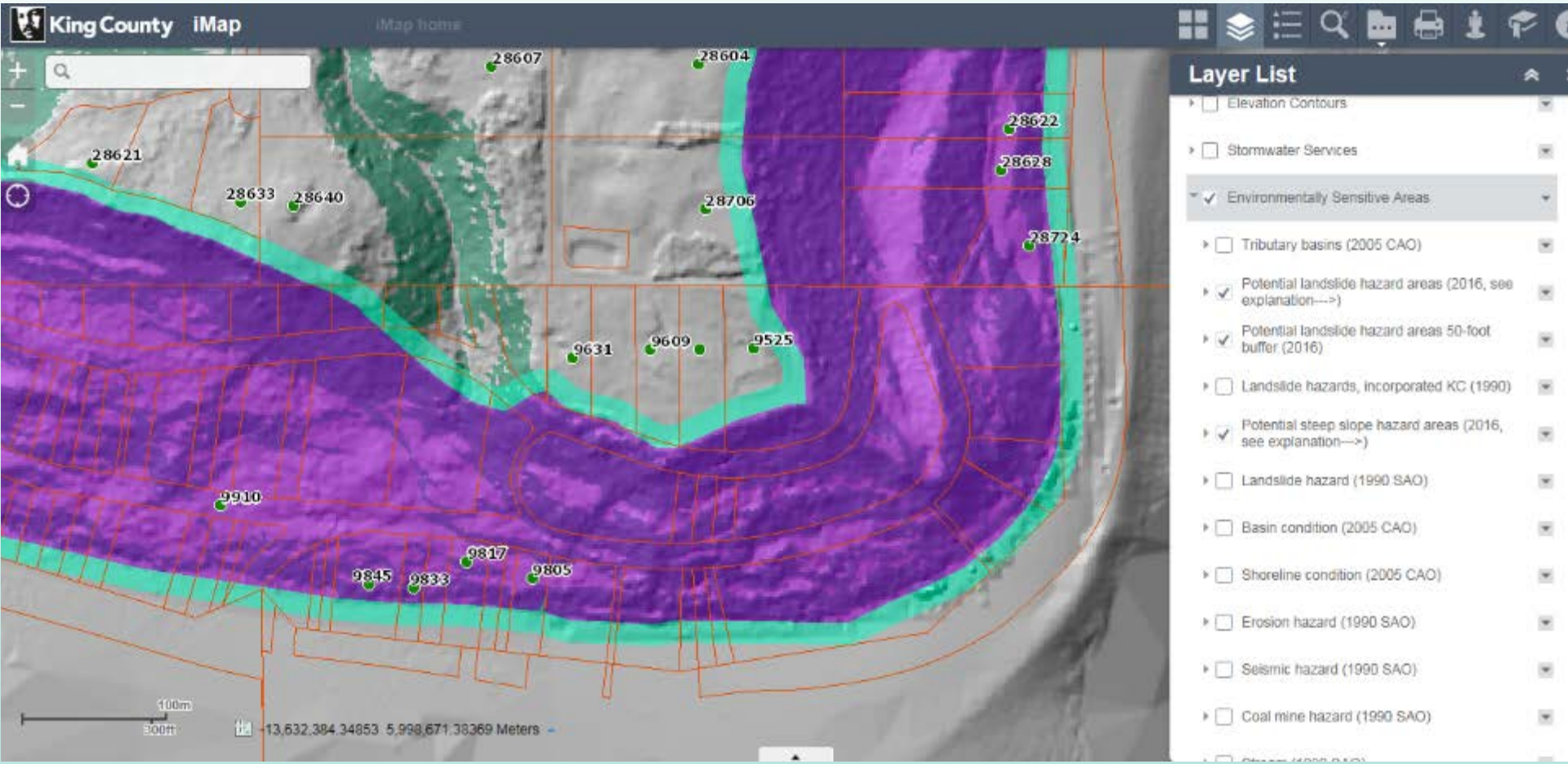
King County iMap
iMap home
28607
28604
28622
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28706
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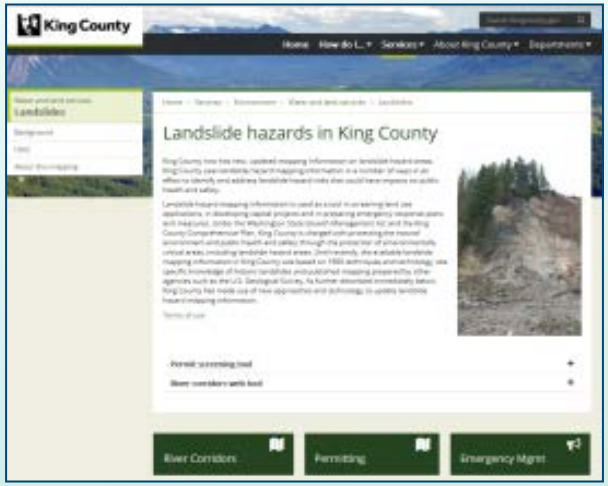
King County Landslide Resources

King County



Permitting

Department of Permitting and Environmental Review

River Corridors Mapping

River and Floodplain Management Section

King County iMAP

King County GIS Center

Emergency Management

Office of Emergency Management

Department of Natural Resources and Parks

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