NATURAL RESOURCES

WILDFIRE-ASSOCIATED LANDSLIDE EMERGENCY RESPONSE TEAM REPORT

2025 Apple Acres Fire

Chelan and Okanogan Counties, Washington

by Emilie Richard, Kate Mickelson, Bill Medwedeff, and Cora Siebert

WASHINGTON
GEOLOGICAL SURVEY
WALERT Report
September 2025

WASHINGTON STATE DEPARTMENT OF
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(Plates are located at the end of this document)

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by Emilie Richard[1], Kate Mickelson[1], Bill Medwedeff[1], and Cora Siebert[1]

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KEY POINTS

- Soil burn severity mapping for the Apple Acres Fire indicates most of the fire burned at low severity with some patches of moderate severity.
- Debris flow modeling, which considers both probability and estimated debris flow volume, indicates mostly low debris flow hazard with a few areas of moderate hazard.
- Despite the low modeled hazard, there is baseline risk of flooding, debris flows, and rockfall impacting roads and structures, especially where drainages are impeded (for example Antoine Creek Vineyard and State Route 97 crossings).

INTRODUCTION

A Wildfire-Associated Landslide Emergency Response Team (WALERT) assessment was conducted to evaluate the potential risk posed by flash floods and debris flows from the Apple Acres Fire in Chelan County and Okanogan County, Washington. Wildfires can significantly change the hydrologic response of a watershed so that even modest amounts of rainfall can produce dangerous flash floods and debris flows. Increased runoff, flash floods, and debris flow hazards may remain elevated for several years after the fire.

WALERT assessed areas downstream of the burned area to determine whether debris flows or flooding could impact infrastructure, structures, and other areas where public safety is a concern. Further information about these hazards is provided in Appendix A.

WALERT looked for historical evidence of debris flows using field reconnaissance, interpretation of lidar elevation data, and aerial orthoimagery. We also used lidar data to map alluvial fans, which are cone-shaped sediment deposits that form where streams flow onto wide, flat surfaces. Alluvial fans are important post-fire hazards because they are locations where stream runoff, flash flooding, and debris flows are deposited.

This report is primarily a qualitative assessment of post-wildfire landslide hazards based on our professional judgment and experience. The assessment was performed as part of emergency response with the intent to produce a rapid report for decision-makers, land managers, landowners, and other interested parties.

WILDFIRE OVERVIEW

The Apple Acres Fire started on July 2, 2025, at approximately 3:28 p.m. The fire burned 3,410 acres (National Interagency Fire Center, 2025) along the west side of State Route (SR) 97 to the west of the Columbia River, approximately 10 miles northeast of the town of Chelan (Plate 1). This area coincides with much of the area burned in the 2012 Antoine 2 Fire and in the 2015 Reach Fire, as well as overlapping slightly with the southern extent of the 2014 Carlton Complex Fire. The burned area encompasses land owned by the Department of Natural Resources (16.6%), Bureau of Land Management (BLM; 30.6%), Tribal government (6%), and private owners (46.8%). The fire burned primarily in grassland, brush, and ponderosa pine forest.

Soil burn severity

Soil burn severity (SBS) mapping indicates that 17 percent of the area affected by the Apple Acres Fire was either unburned or had very low soil burn severity, 77 percent experienced low soil burn severity, 4.5 percent experienced moderate soil burn severity, and <1 percent experienced high soil burn severity.

The SBS mapping incorporates satellite measurements of infrared reflectance and field observations of soils post-fire to map the spatial variation in soil burn severity within a fire perimeter. For this fire, a comprehensive field evaluation of soil burn severity was limited by road access, but the BLM performed some field validation to help generate the SBS map. If you need assistance accessing or analyzing the SBS data, please contact us and we can provide some support.

U.S. Geological Survey (USGS) post-fire debris flow hazard modeling

The USGS provided a debris flow modeling assessment for the Apple Acres Fire that incorporates the SBS data (King and others, 2025). The modeling data are typically available on their website within a few weeks of being generated (https://landslides.usgs.gov/hazards/postfire_debrisflow/). However, if access is needed prior to these data being made available please contact us and we can provide some support.

There are various outputs and ways to view the model results. Here we will discuss the combined relative debris flow hazard for hydrologic basins, which combines both probability and estimated debris flow volume from the USGS model to provide three different hazard ratings: low, moderate, and high. The USGS also models the combined relative debris flow hazard for stream channel segments within basins using the same hazard ratings. We focus our assessment on locations where public safety and infrastructure could be impacted. If you need assistance accessing or analyzing the debris flow assessment data, please contact us and we can provide support.

The USGS debris flow model results reported here are based on a design storm event with a peak rainfall intensity of approximately 0.25 inches of rain in a 15-minute period or 1 inch of rain in a 60-minute period (6 mm/15 minutes or 24 mm/hour, respectively). Of note, this model does not consider the effect of rain-on-snow or rapid snowmelt events in a recently burned area. Debris flows and flash floods may occur during rain-on-snow events that do not meet the modeled rainfall intensity.

Geography, geology, and climate

The geography of the Apple Acres burn area is dominated by Arbuckle Mountain, which rises approximately 2,100 feet above the Columbia River in the center of the burn perimeter. Several drainage basins cut into Arbuckle Mountain with up to 1,300 feet of vertical relief between the upper reaches of the basins and the downstream areas where stream sediments are deposited on alluvial fans. The Columbia River is on the eastern side of Arbuckle Mountain, where it is impounded by Wells Dam. Along the west bank of the Columbia are a large gravel bar and numerous alluvial fans that have been developed with agricultural fields.

The bedrock geology in the area is characterized by tonalite (an igneous rock similar to granite) and metamorphic gneiss emplaced during the development of the North Cascade mountains (Gulick and Korosec, 1990). However, in the low elevation portions of the burn scar, in particular along the southwestern and southeastern boundaries where Apple Acres Road and SR 97 run, the surface geology is composed of glacial sediments including outwash gravels and sands (Gulick and Korosec, 1990). These sediments may be eroded more easily than bedrock, particularly following vegetation loss after a fire.

The climate in the area is continental, with hot summers, cold winters, and an annual average of only 12 inches of precipitation (National Oceanic and Atmospheric Administration, 2023). Although most of the precipitation falls in the winter, summer thunderstorms with heavy precipitation are not uncommon. Vegetation in the area tends to be steppe/grassland at low elevations, with patchy groves of ponderosa pine at higher elevations and on north facing slopes.

OBSERVATIONS AND INTERPRETATIONS

We assessed post-fire debris flow hazards for the Apple Acres fire by interpreting lidar and aerial imagery, by visiting and inspecting alluvial fans and slopes around the perimeter of the fire, and by analyzing USGS post-fire debris flow models. Below we outline the site-specific implications of this work for post-fire debris flow hazards.

WALERT conducted a remote evaluation prior to a limited field assessment on July 28–29, 2025. Alluvial fans downstream of burned drainage basins were mapped based on interpretation of lidar elevation data and aerial imagery. Aerial imagery was also used during the remote evaluation to identify impacts following historic fires on the same slopes. Aerial photos taken before and after the 2012 Antoine 2 Fire and 2015 Reach fire were inspected to investigate previous flooding, erosion, and debris flow activity following past wildfires in the same area as the Apple Acres Fire. However, no such activity could be definitively identified from imagery anywhere in the burn area following these past events. The only evidence of the fires in 2012 and 2015 observable in imagery were isolated groves of burned timber following these events.

The lack of historic post-fire activity following past wildfires does not preclude these hazards following the 2025 fire. Evaluation of lidar and aerial imagery highlights several regions within and surrounding the burn scar where changes to watershed hydrology by the fire could potentially put life and property at risk due to erosion, flooding, and debris flows. SR 97 runs along the eastern boundary of the fire and crosses over alluvial fans connected to steep drainage basins that extend into the burn area (Plate 1). Several of these alluvial fans crossed by the highway are also developed with structures, private access roads, and agricultural fields, making them the most developed areas with upstream drainage basins within the burn area.

The central region of the fire boundary along the south- and southwest-facing slopes of Arbuckle Mountain contains several large drainage basins with up to 1,300 feet of vertical relief. Alluvial fans at the outlets of these drainage basins, such as those along Antoine Creek Road and Apple Acres Road, are some of the largest fans in the region and several of them have been modified by residential development. Locations of sites discussed in this report are shown on plate 1.

We conducted a field assessment that focused on alluvial fans downstream and at the margin of the fire. Below we integrate these field observations with USGS post-fire debris flow modeling to create holistic assessments of debris flow hazards in specific areas. Alluvial fans within the burned area were not assessed due to limited field access; therefore debris flow and flooding risk are not discussed for those areas within this report.

Antoine Creek vineyard's alluvial fan (Site 1)

This unnamed drainage on the north side of the burn scar is the largest, impacted basin which forms a large alluvial fan on the west bank of the Columbia River. This alluvial fan now supports a productive orchard and vineyard, and at its apex are residential and commercial structures. The apex of an alluvial fan is where the channel loses confinement and is where we would expect the most deposition during flooding and debris flow events. Below the structures, the channel is confined and incised roughly 10 ft into the alluvial fan surface. The channel appears to pass below the private drive and ends at Hwy 97. We did not observe whether either the private driveway or Hwy 97 have culverts to accommodate streamflow, or if they simply obstruct the channel. However, we did observe a standing pool of water on the west (upstream) side of Hwy 97, suggesting that flow may be impeded by the highway. Past debris flow activity is supported by the presence of subrounded cobbles and 4–6 ft diameter boulders observed on the south side of the fan. According to the USGS debris flow modeling, there are several stream segments in the burned drainage basin with a moderate debris flow hazard for the design rainfall event, though the overall basin is estimated to have a low debris flow hazard (Plate 2).

Hwy 97 rockfall and alluvial fans (Sites 2–4)

Along Hwy 97 from milepost 247 to milepost 248, the roadway passes through the toe of several alluvial fans on steep talus slopes beneath cliffs of Tertiary–Cretaceous tonalite (Sites 2 and 3) and below an over-steepened, near-vertical bedrock cliff (site 4). In the lidar, we observe steep, defined drainages, avulsion channels with levees, and lobate surface texture on the fans at Sites 2 and 3 that suggest these features were built by past flooding and/or debris flow processes. In the field, we observed road cuts sloping toward the highway with no ditch along the shoulder where the roadway crosses these fan deposits. According to the USGS debris flow modeling, these basins have a low debris flow hazard (Plate 2), though a baseline risk of debris flow impacts to the highway does exist along this stretch of road. Where the highway curves below a steep bedrock cliff (Site 4), we observed rockfall mitigation. There is no modeling for the likelihood of rockfall after wildfire, but this existing rockfall hazard area may have an elevated risk of loose rocks entering the roadway that are newly exposed to wind and rain after the fire. This rockfall hazard will decrease as vegetation recovers to pre-fire conditions.

Rockfall and alluvial fan near Wells Dam dwellings (Site 5)

Several residential structures and a power line corridor exist at the base of talus slopes beneath cliffs of Tertiary–Cretaceous tonalite (Site 5). The power lines as well as a driveway to the residences intersect the toe of a small alluvial fan. We observed a small amount of water flowing over the bedrock bench above the apex of the fan. We also observed angular cobbles and boulders on the alluvial fan and adjacent to the structures suggesting that rockfall is the primary depositional processes here. According to the USGS debris flow modeling, these basins have a low debris flow hazard (Plate 2), though a baseline risk of flooding, debris flows and rockfall still exist.

Alluvial fans along Hwy 97 (Sites 6–12)

Highway 97 crosses seven mapped alluvial fans at the base of the western slope of the burned area near Azwell, WA (Sites 6–12). The drainages feeding these alluvial fans are eroding through a ~300-ft-tall terrace of Pleistocene glacial outwash. We observed rounded gravel to small boulder sized clasts in this poorly consolidated sandy matrix that is highly erodible. Both glacial deposits and piles of angular tonalite boulders are found at the apex of the alluvial fan at Site 6 (Plate 1), whose drainage erodes into both the glacial terrace and bedrock. These alluvial fans have been excavated through for the construction of Hwy 97 and have no retention structures to prevent the delivery of sediment to the roadway. Most of the contributing basins for these alluvial fans are low debris flow hazard according to the USGS debris flow modeling. The alluvial fan at Site 7 on the map plate is the only basin in the entire burn scar with a moderate debris flow hazard according to the modeling (Plate 2).

Rio Vista Lane alluvial fan (Site 13)

The intersection of Apple Acres Road and SR 97 is located at the apex of an alluvial fan, while Rio Vista Lane traverses its midsection. An upper basin loses confinement onto a larger alluvial fan upstream and then re-channelizes into a short steep channel which conveys material and water to this alluvial fan. At the fan apex, we observed boulders measuring 1–3 feet in diameter along with abundant cobbles within the channel—evidence of past debris flow activity. However, well-established vegetation within the channel, clear culverts, and the absence of active water movement suggest that neither flooding nor debris flows have occurred recently. The channel cuts through poorly consolidated glacial outwash material and active raveling of this material into the channel was observed. According to the USGS debris flow modeling, there are several stream segments in the burned drainage basins with a moderate debris flow hazard, though both basins are modeled to have a low debris flow hazard (Plate 2).

Antoine Creek Road alluvial fans (Sites 14 and 15)

Antoine Creek Road runs along the base of the steep, southwest-facing slopes affected by the fire. Both the road and power lines cross the lower portions of the alluvial fans that extend from the slope base, and several structures are located on the Site 14 alluvial fan. Small boulders (1–1.5 feet in diameter) and cobbles were observed on the fan surfaces. It is uncertain, however, whether these deposits reflect past flooding or debris flow events, or if they resulted from the weathering and erosion of the highly erodible glacial outwash materials on the adjacent slopes. The modeling indicates that these basins have a low debris flow hazard (Plate 2).

SUMMARY AND RECOMMENDATIONS

- Elevated rockfall hazards may be present in locations where the fire perimeter is adjacent to steep slopes along SR 97. This increased threat will decrease as vegetation recovers to pre-fire conditions.
- Managers of transportation networks and private landowners should be aware of the increased likelihood of flooding, sediment transport and deposition, and (or) erosion impacts on alluvial fans following the wildfire. We further recommend inspecting culverts within channels draining areas impacted by the fire both before and after storm events. Blocked culverts can cause additional flooding and damage, which could otherwise be minimized.
- Residents of homes built on alluvial fans and (or) adjacent to streams flowing from burned areas should be aware about potential post-fire flash flooding and debris flow hazards. Residents should seek appropriate professional consulting services for site-specific evaluations of the potential threats to their life, safety, and property. For more information on how to stay safe when at risk from debris flows, please consult our Floods After Fire pamphlet, the After the Fire Washington website, and the USGS’s fact sheet with safety tips relating to post-fire debris flows (links in Appendix A below).
- Landowners and land managers may choose to take action to prevent excessive soil erosion and promote revegetation to help mitigate flooding and meet their management and economic goals. The soil burn severity map created and field-validated by the BLM can be a useful tool to evaluate areas for re-planting. We are willing to help direct users to this map product or provide the data in various formats as needed.

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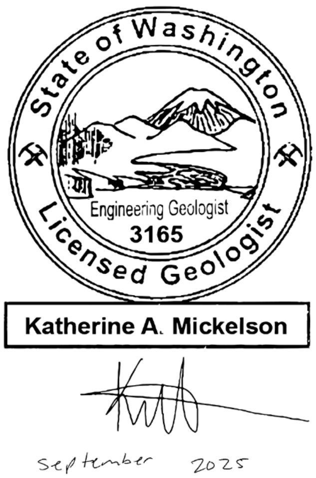
LIMITATIONS

WALERT aims to quickly identify and assess geologic hazards associated with wildfires to inform decision making and help focus the efforts of local officials and residents who may be impacted by post-wildfire hazards. All observations and interpretations are based on empirical evidence and local knowledge. Not all areas or hazards were evaluated. We encourage landowners, land managers, and those potentially at risk from post-wildfire hazards to consult qualified professionals for site-specific analysis of geological hazards and flood risk and prepare accordingly.



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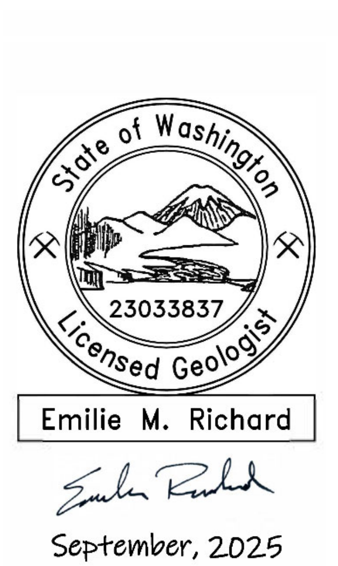

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APPENDIX A: GEOLOGICAL BACKGROUND

Hillslope processes

A variety of factors contribute to the probability of debris flows occurring in burned areas. These include hillslope gradient, channel convergence, availability of fine sediments, severity of hydrophobic (water repellant) soil conditions, burn severity, and the removal of a protective canopy and diminished root strength caused by fire.

Hydrophobic soil conditions in burned areas can increase water runoff potential on hillslopes during a storm by preventing water from infiltrating into the subsurface. Overland flow can result in rills and gullies that further channel water downhill.

When effective ground cover has been denuded after intense fire, soils are also exposed to erosive forces such as raindrop impact and wind. The steepest slopes are most prone to erosion, particularly where soils are shallow or where there is a restrictive subsurface layer such as bedrock. Soils that have developed in volcanic ash and glacial till are easily detachable, having low cohesion and structure, and contain relatively low amounts of organics, resulting in moderately thin topsoil horizons.

Flash floods and debris flows

Debris flows have a specific geologic definition that is often misused by the media, the public, and scientists. Most observed "debris flows" are actually sediment-laden flash floods known as hyperconcentrated flows (HCFs). Below, we explain the differences between these two types of flows.

Flash floods, especially those that originate from recently burned areas, are often described as "debris flows" due to the sediment-laden water transporting woody and vegetative debris, trash, gravel, cobbles, and occasionally boulders. Though "debris flow" may be an observer's description of the event, a true debris flow has specific properties, behaviors, and characteristics that differentiate it from a flash flood. An HCF is the transition between a flash flood and a debris flow. One way geologists differentiate the three is by the percent of sediment (by volume) carried by the flowing water. A flood contains less than 5 percent sediment by volume, an HCF carries around 5 to 60 percent sediment by volume, and a debris flow exceeds 50 percent sediment by volume.

Debris flows are often described as having the appearance of flowing, wet concrete. These flows travel quickly in steep, convergent channels. A moving debris flow can be very loud because it can buoy cobbles, boulders, and debris to the front and sides of the flow. The sound is often compared to that of a freight train and may cause the ground to vibrate. In a post-fire situation, a debris flow may start as a flash flood surge that picks up sufficient sediment to transform into an HCF and, if soil and slope conditions are suitable, can transform into a debris flow.

Debris flow deposits tend to be distinct and include channel-adjacent levees of gravel, cobbles, and boulders. Channel-adjacent trees display upslope damage such as scarring on bark from rock or debris impact. Mud and gravel may be splashed onto trees and other channel-adjacent objects. Because of the ability of a debris flow to buoy these materials to the front of the moving mass, debris flows are extremely dangerous to public safety and infrastructure.

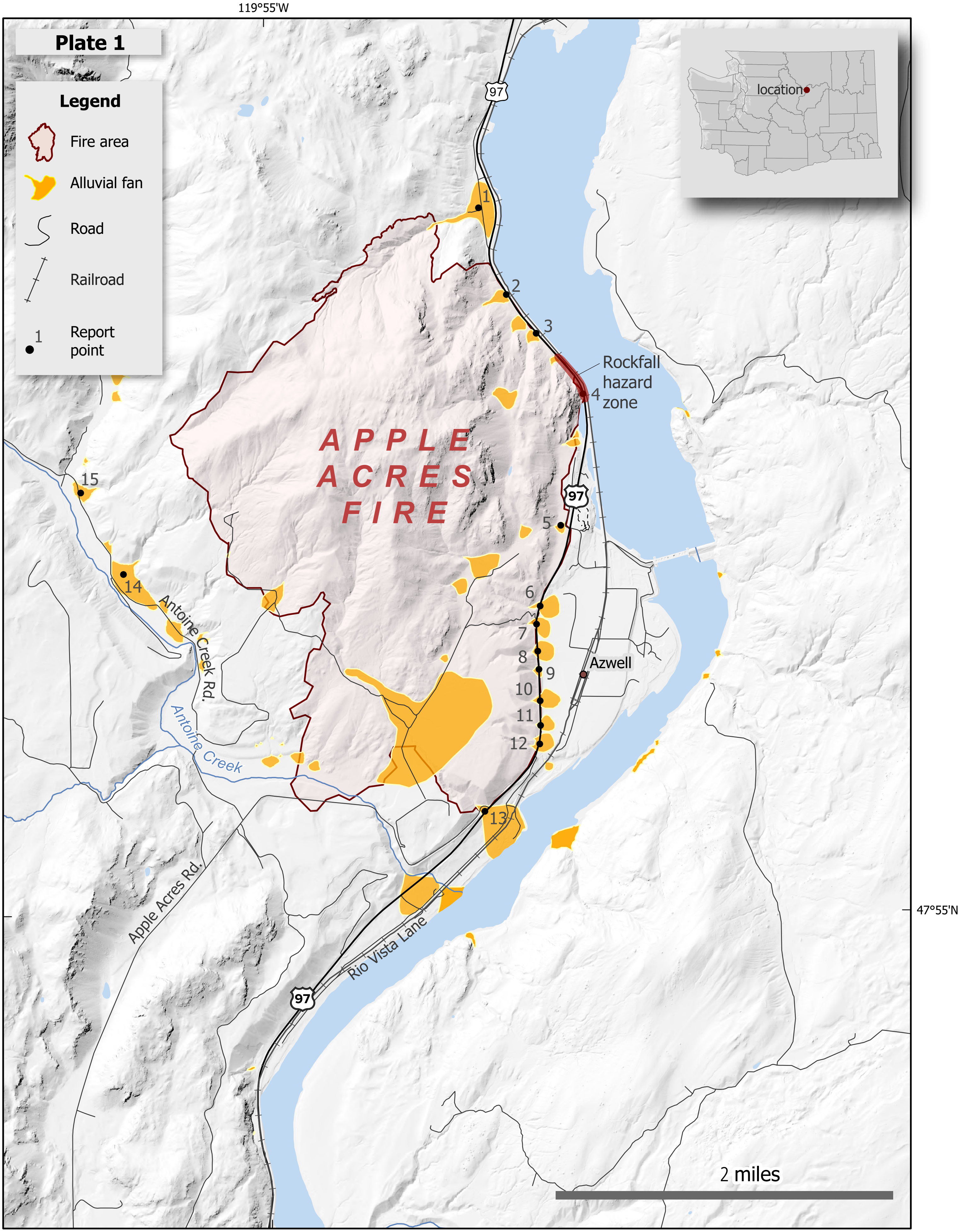
Alluvial fans

Alluvial fans are low-gradient, cone-shaped deposits that consist of sediment and debris. These features often accumulate immediately below a significant change in channel gradient and (or) valley confinement. This might occur at the mouth of a canyon or steep channel that drains from mountainous terrain and emerges onto a low gradient area such as a flood plain. Sediment on the alluvial fan is deposited by streams, floods, HCFs, and (or) debris flows and is typically sourced from a single channel.

Alluvial fans are attractive locations to build cabins and homes due to the slight elevation above the flood plain. However, alluvial fans are active depositional areas that accumulate sediment over time. The sediment can be deposited both slowly, such as during a spring melt when high streamflow transports and deposits fine sediment on the fan, or quickly, when a flash flood, HCF, or debris flow transports sediment and debris to the fan.

Information about alluvial fan hazards are available on our website in both English and Spanish

- https://www.dnr.wa.gov/publications/ger_fs_alluvial_fans.pdf
- https://www.dnr.wa.gov/publications/ger_fs_alluvial_fans_esp.pdf
- The USGS's fact sheet on post-fire debris flows safety: *https://pubs.usgs.gov/fs/2022/3078/fs20223078.pdf*
- https://afterthefirewa.org/



119°55'W
Plate 1
Legend
Fire area
Alluvial fan
Road
Railroad
1
Report point
location
97
APPLE ACRES FIRE
Rockfall hazard zone
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Azwell
Antoine Creek Rd.
Antoine Creek
Apple Acres Rd.
Rio Vista Lane
47°55'N
2 miles

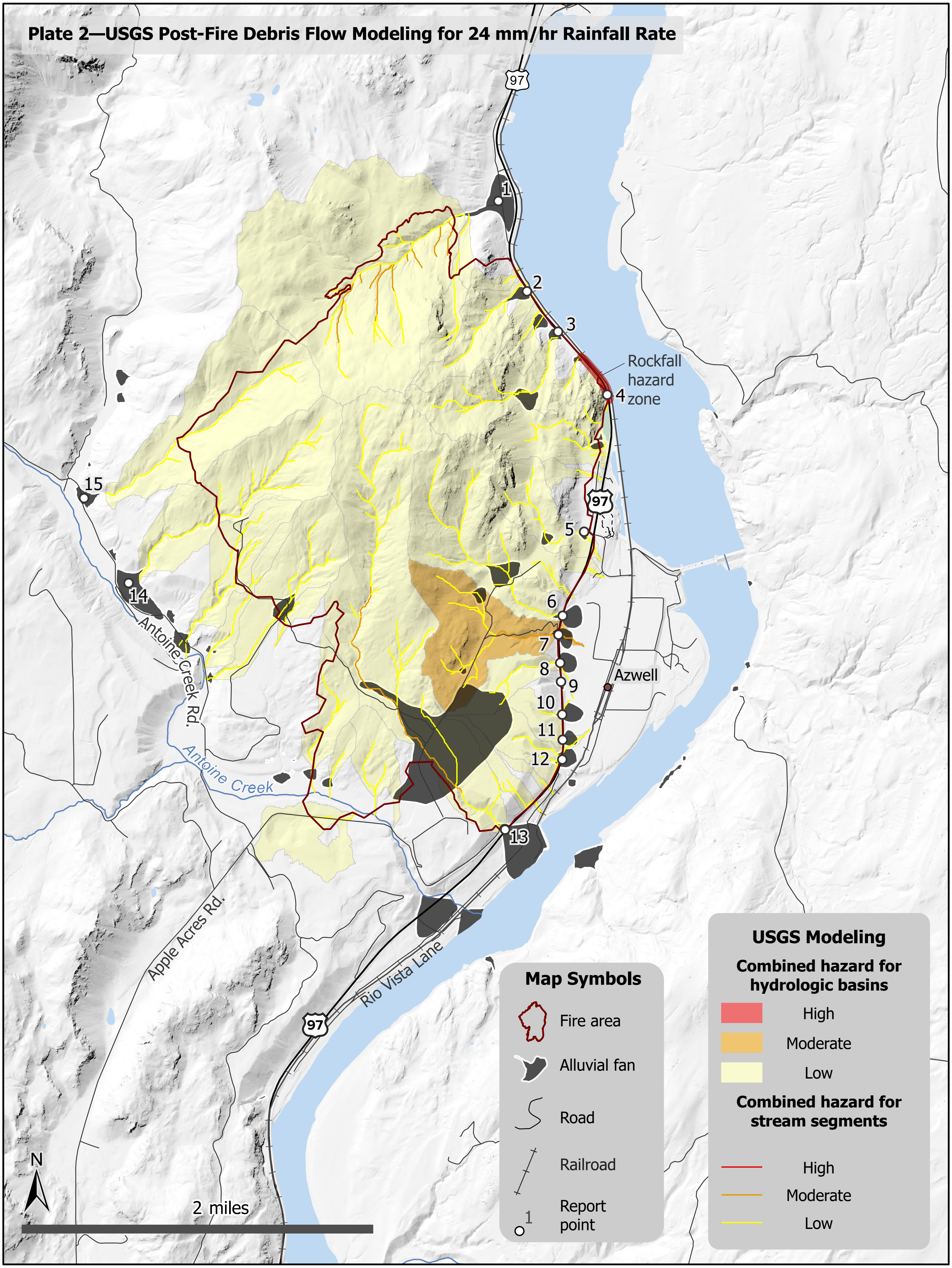


Plate 2—USGS Post-Fire Debris Flow Modeling for 24 mm/hr Rainfall Rate
97
1
2
3
Rockfall
hazard
zone
4
97
5
15
14
Antoine Creek Rd.
6
7
8
9
Azwell
10
11
12
Antoine Creek
13
Apple Acres Rd.
Rio Vista Lane
97
N
2 miles
Map Symbols
Fire area
Alluvial fan
Road
Railroad
1
Report
point
USGS Modeling
Combined hazard for
hydrologic basins
High
Moderate
Low
Combined hazard for
stream segments
High
Moderate
Low