RESOURCES

WILDFIRE-ASSOCIATED LANDSLIDE EMERGENCY RESPONSE TEAM REPORT

NATURAL

Eagle Bluff Fire

Okanogan County, Washington

by Mitchell Allen and Josh Hardesty

WASHINGTON
GEOLOGICAL SURVEY
WALERT Report
September, 2023

WASHINGTON STATE DEPARTMENT OF
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Wildfire-Associated Landslide Emergency Response Team Report for the Eagle Bluff Fire

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[1] Washington Geological Survey
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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 Eagle Bluff Fire in Okanogan County, Washington. Wildfires can significantly change the hydrologic response of a watershed so that even modest rainstorms 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 slopes burned by the wildfire 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, lidar interpretation, and orthoimagery. We also mapped alluvial fans within and downstream of the burn area using lidar data and terrain models generated from digital aerial photogrammetry.

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 stakeholders.

WILDFIRE OVERVIEW

The Eagle Bluff Fire started on July 29, 2023. The fire burned 34,049 acres straddling the United States–Canadian border (INCI Web, 2023). Most of the burn area is owned privately or by the Bureau of Land Management (BLM), with some ownership belonging to the Washington State Department of Natural Resources (DNR) and other landowners within Canada. Within the United States (U.S.), the fire burned 16,843 acres, primarily in short grass, brush, and timber.

OBSERVATIONS AND INTERPRETATIONS

A limited field assessment was performed on September 5 and 6, 2023. This assessment is limited to lands within the U.S. and did not consider potential geologic hazards within Canada. We specifically focused on areas where wildfire effects on watershed hydrology could put life and property at risk along the Similkameen River and the east-facing slopes west of US Route 97 (Plate 1). Terrain models generated from digital aerial photogrammetry were used to map fans where lidar data were absent. Accuracy of remote fan mapping is reduced where lidar data are missing.

Soil burn severity data

OBSERVATIONS

The Burned Area Reflectance Classification (BARC) data, a satellite-derived data layer of post-fire vegetation conditions, were provided and field validated by the BLM to generate a Soil Burn Severity (SBS) map. If you need assistance accessing or analyzing these data, please contact us and we can provide some support.

Within the U.S., SBS mapping shows that 1,451 acres, or 9 percent of the area affected by the Eagle Bluff Fire, were either unburned or had very low soil burn severity. Approximately 12,999 acres (77%) experienced low soil burn severity, 2,301 acres (14%) were moderate in severity, and only 91 acres (1%) were shown to have experienced high burn severity.

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

MODELING RESULTS

The USGS provided a debris flow modeling assessment for the Eagle Bluff fire that incorporates the SBS data provided by the BLM. 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 these data. Here we will discuss the combined relative debris flow hazard for hydrologic basins, which combines both probability and 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 modeling is based on a modeled storm event with a peak rainfall intensity of approximately one-quarter inch of rain in a 15-minute period. Of note, this model also does not consider the effect of rain-on-snow events in a recently burned area. Debris flows and flash floods may occur during rain-on-snow events and do not meet the predicted rainfall threshold.

INTERPRETATIONS

The USGS modeling indicates that there are Low and Moderate debris flow hazards in drainages throughout the burned area. Remote and field observations revealed that some alluvial fans have experienced debris flows and flooding in the past. Accumulated cobbles and boulders, subtle debris levees, and apparent avulsion channels on several fans suggest historic debris flow activity. Debris-clearing maintenance operations along some roadways suggests that flooding and potentially debris flows have been an ongoing hazard in the area prior to the fire.

Several fans are identified along the east-facing slopes along the eastern fire boundary, west of US Route 97 (Plate 1). USGS modeling indicates Low and Moderate debris flow hazards in hydrologic basins upslope of these landforms. For many of these fans, surficial features providing evidence of historic hazards have been obscured by agricultural land use. However, future flooding may impact agricultural lands in these areas.

Even in areas without historical evidence for debris flows, the fire likely impacted the basin’s hydrologic response to future storm events. Increased runoff and the potential for flash floods may remain elevated for several years after the fire. Below we outline areas where flash flooding or debris flows could impact the property and infrastructure that we reviewed during this assessment.

Loomis–Oroville Road (Area 1 on Plate 1)

Loomis–Oroville Road is built across several south-facing fans and talus slopes along the northern side of the Similkameen River. The USGS modeling indicates a Low debris flow hazard for basins upstream of fans and the roadway. Unconsolidated deposits of glacial drift compose much of the basins that contribute to these fans, especially above fans with activity observed in this review. Steep slope gradients and inferred high rates of erosion within these unconsolidated deposits prohibit the establishment of vegetation, and thus these basins did not appear to experience much fire activity. Remote review of historical aerial imagery reveals several flooding and potential debris flow events over the last several decades based on apparent erosion of vegetation or soil in stream channels, or debris deposition on mapped fan surfaces. Recent debris-clearing activities and excavations along many sections of this roadway further support the remote and field observation that flooding and potential debris flows have historically posed a hazard, even prior to the fire. Mobilization of debris during storm events can plug culverts and potentially lead to public safety threats, washouts of the roadway, or increased flooding impacts.

Dispersed camping areas (Area 2 on Plate 1)

The *Similkameen Recreation Site* and *Cutchie #4 Public Access* areas are two dispersed camping sites managed by BLM within mapped fan deposits, downslope of the Loomis–Oroville Road. Based on debris flow modeling, remote observations, and field reconnaissance, flash flooding and debris flows could impact portions of these camping areas.

Enloe Dam (Area 3 on Plate 1)

The Enloe Dam is located on the Similkameen River approximately 5.3 river miles northwest of Oroville. The dam site is on BLM land and is owned and managed by the Okanogan County PUD. Some of the dam infrastructure is positioned at and adjacent to the Ellemeham Draw, an ephemeral stream channel that joins the Similkameen River directly downstream of the dam. Remote and field reviews did not identify historic evidence of debris flow events within or emanating from the Ellemeham Draw or impacting the Enloe Dam site. USGS debris flow modeling indicates that there are low to moderate debris flow hazards within tributary basins to the Ellemeham Draw, which can translate to flooding within the draw. These hazards could impact the steel penstocks and small bridge located at the mouth of the draw. Occurrence of flash flooding within the draw will be at an elevated risk over the next several years such that flood waters and debris associated with debris flows or debris currently sitting in the channel may impact dam infrastructure at the mouth of the draw.

RECOMMENDATIONS

Our assessment suggests that flash flooding and debris flow hazards have occurred in some areas evaluated in this assessment prior to the fire and will likely occur in future storm events within the burn area. Debris flows, flash flooding and increased runoff could impact infrastructure during periods of intense precipitation (approximately one-quarter inch of rain in a 15-minute period), atmospheric river events,[1] or rain-on-snow events.[2]

Residents of homes built on alluvial fans and (or) adjacent to streams flowing from burned areas should be informed of potential post-fire flash flood and debris flow hazards. For more information on how to stay safe when at risk from debris flows, please consult our Floods After Fire pamphlet and the USGS's fact sheet with safety tips relating to post-fire debris flows (links in the footnote at the bottom of this page).[3]

Landowners and land managers may choose to take action to prevent excessive soil erosion, reduce flooding, and promote revegetation to meet their management and economic goals. Utilizing the burn severity map as a tool to find areas of elevated burn severity can assist in this evaluation. We are willing to help direct users to this map product, or to provide the data in various formats as needed. The dispersed camping areas adjacent to Loomis–Oroville Road would benefit from the placement of signs to warn the public of flash flood and debris flow hazards that could occur post-fire.

Managers of transportation networks and private landowners should be reminded of the increased likelihood of sediment transport, sediment deposition, and (or) erosion impacts to roads following wildfires, as well as potential issues with blocked culverts. We further recommend inspecting culverts within channels draining areas impacted by the fires both before and after storm events, specifically along Loomis–Oroville Road and the dam infrastructure at the mouth of the Ellemeham Draw. Blocked culverts can cause additional flooding and damage, which could otherwise be minimized by being proactive about clearing these culverts.

REFERENCES

INCI Web, 2023, Eagle Bluff [webpage]. INCI Web. [accessed August 16, 2023 at https://inciweb.nwcg.gov/incident-information/wanes-eagle-bluff].

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[1] Information about atmospheric rivers can be found at *https://www.noaa.gov/stories/what-are-atmospheric-rivers*

[2] More information and maps for rain-on snow zones in Washington State can be found at *https://data-wadnr.opendata.arcgis.com/datasets/4a8339bfe8ca46b8a0a674195827e6d3_6/about*

[3] The Washington Geological Survey's Floods After Fire pamphlet:
https://www.dnr.wa.gov/publications/ger_fs_alluvial_fans.pdf
The USGS's fact sheet on post-fire debris flows safety:
https://pubs.usgs.gov/fs/2022/3078/fs20223078.pdf

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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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). In the following sections, we explain the differences between these two types of flows.

FLASH FLOODS

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

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.

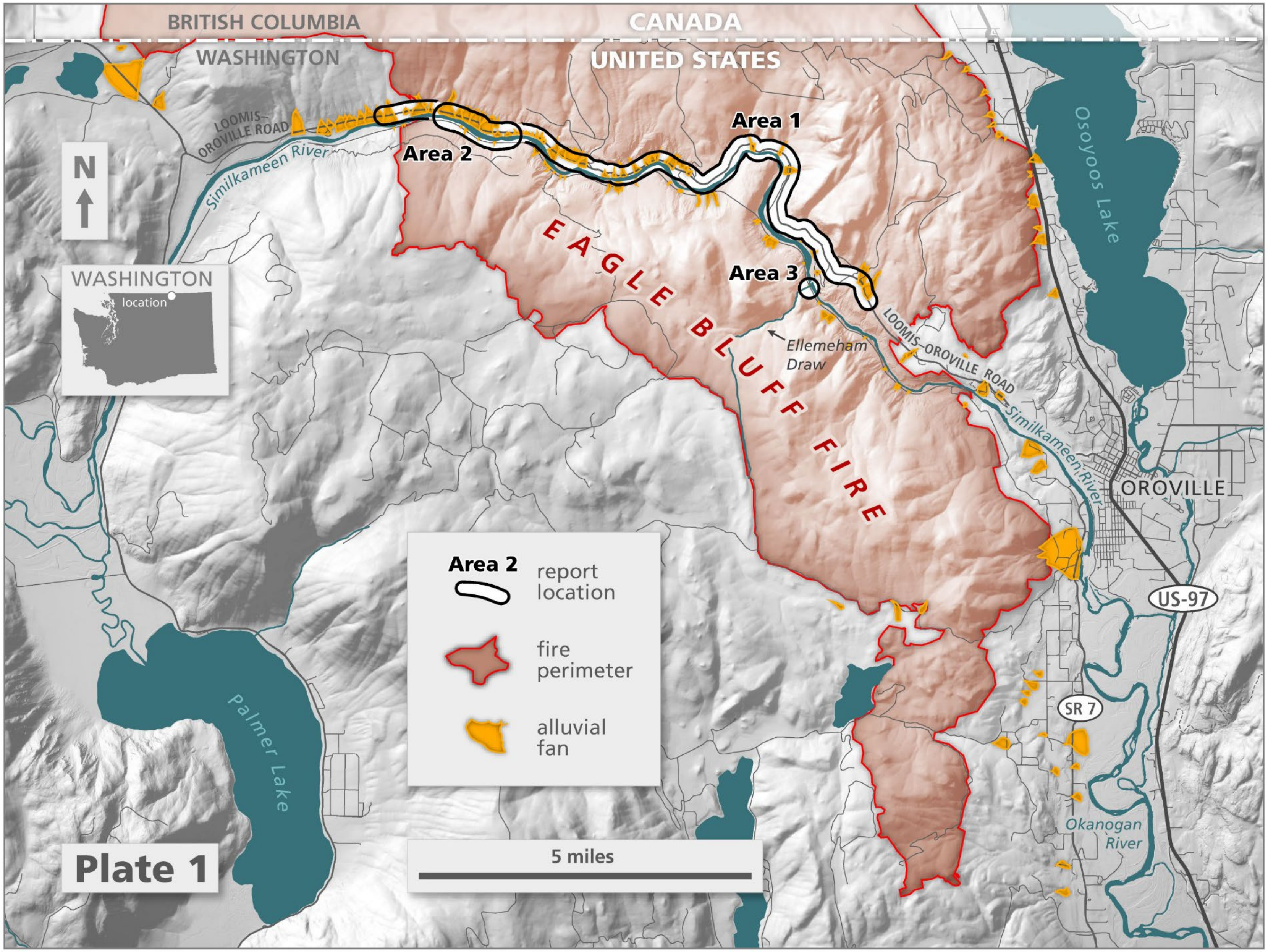
Alluvial fans

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.

An information flyer about alluvial fan hazards is available on our website in both English (https://www.dnr.wa.gov/publications/ger_fs_alluvial_fans.pdf) and Spanish (https://www.dnr.wa.gov/publications/ger_fs_alluvial_fans_esp.pdf).

Plate 1


BRITISH COLUMBIA
WASHINGTON
CANADA
UNITED STATES
N
WASHINGTON
location
LOOMIS–OROVILLE ROAD
Similkameen River
Area 1
Area 2
Area 3
EAGLE BLUFF FIRE
Ellemeham Draw
LOOMIS–OROVILLE ROAD
Similkameen River
Osoyoos Lake
OROVILLE
US-97
SR 7
Okanogan River
Palmer Lake
Area 2 report location
fire perimeter
alluvial fan
5 miles