NATURAL RESOURCES

WILDFIRE-ASSOCIATED LANDSLIDE EMERGENCY RESPONSE TEAM REPORT

Nakia Creek Fire

Clark County, Washington

by Mitchell Allen and Kate Mickelson

WASHINGTON
GEOLOGICAL SURVEY
WALERT Report
January, 2023

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Hilary S. Franz—*Commissioner of Public Lands*

WASHINGTON GEOLOGICAL SURVEY
Casey R. Hanell—*State Geologist*
Jessica L. Czajkowski—*Assistant State Geologist*
Ana Shafer—*Assistant State Geologist*

WASHINGTON GEOLOGICAL SURVEY

Mailing Address:
MS 47007
Olympia, WA 98504-7007

Street Address:
Natural Resources Bldg., Rm 148
1111 Washington St SE
Olympia, WA 98501

Phone: 360-902-1450; Fax: 360-902-1785
E-mail: geology@dnr.wa.gov
Website: http://www.dnr.wa.gov/geology

Publications List:
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Wildfire-Associated Landslide Emergency Response Team Report for the Nakia Creek Fire

by Mitchell Allen and Kate Mickelson

[1] Washington Geological Survey
MS 47007
Olympia, WA 98504-7007

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 Nakia Creek Fire in Clark 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.

Areas downstream of slopes burned by fire were assessed remotely for historic evidence of debris flow impacts using GIS interpretation of lidar and orthoimagery. Field reconnaissance was not performed as part of this assessment due to the late season burn followed closely by inclement weather and snow coverage.

This report is primarily a qualitative remote assessment of post-wildfire landslide hazards based on our professional judgment and experience and is not supported by field observations. 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 Nakia Creek Fire started on October 9, 2022 and was human induced. The fire burned 1,918 acres, primarily in timber and medium logging slash brush (INCI Web, 2023). The lands that burned are owned in part by the City of Camas, the Washington State Department of Natural Resources, and private timber companies. Containment of the fire was achieved by October 31, closely followed by snow accumulation on November 4.

OBSERVATIONS AND INTERPRETATIONS

A remote assessment of the burn area of the Nakia Creek Fire and areas downstream was conducted in late December 2022 through early January 2023. At the time of this assessment, much of the perishable field evidence had been impacted by inclement weather and snowfall. The area burned by the Nakia Creek Fire includes portions of the headwaters of Jones Creek and Boulder Creek, tributaries of the Little Washougal River (Plates 1 and 2). The higher elevation slopes within the burn area are within the rain-on-snow zone. Review of historic orthophotos and aerial imagery demonstrates that much of the headwaters of Jones Creek have been clear-cut harvested since 2006. In 2010, the Hilltop Fire burned 134 acres along the southwestern half of the ridgeline defining the headwaters of Jones Creek.

The relatively steep slopes of the Jones Creek and Boulder Creek headwaters have been incised by second-order tributaries. Gully walls associated with these tributaries largely appear smooth in lidar, with sparse stretches exhibiting relatively sharp topographic breaks characteristic of localized channel scour.

Soil burn severity and Burned Area Reflectance Classification (BARC) data

OBSERVATIONS

Burned Area Reflectance Classification (BARC) data were used as a proxy for soil burn severity for this assessment. This is due to the BARC data not being verified by field observations for soil burn severity (Plate 1). The BARC data were generated by WALERT using the *Normalized Burn Ratio Vegetation Mortality Tool* made available on Google Earth Engine by the U.S. Forest Service.[1] In the absence of field observations of soil burn severity, default thresholds were used to remotely estimate soil burn severity (Table 1).

Table 1. BARC default threshold values used for the soil burn severity mapping.

Soil burn severity	Values (0–256)
High	203–256
Moderate	117–202
Low	77–116
Unburned soil	0–76

According to the BARC map (Plate 1), 914 acres or 48 percent of the area affected by the Nakia Creek Fire was either unburned or had very low soil burn severity. Approximately 626 acres (32%) experienced low soil burn severity, 378 acres (20%) were moderate in severity, and none of the area was shown to have experience high burn severity. Of note, the areas indicating the highest burn severity values within the fire perimeter are coincident with the slopes along the headwaters of Jones Creek that had been clearcut harvested in the last 20 years. If you need assistance accessing or analyzing the BARC data, please contact us and we can provide support.

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

MODELING

The USGS provided a debris flow assessment for the Nakia Creek Fire based on the non-field-validated BARC data provided by WALERT (Plate 2). There are various outputs and ways to view the data. Here we will discuss the combined relative debris flow hazard for basins, which uses 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 channel segments within basins using the same hazard ratings. We focus 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. These models were not developed with data that take into account climate on the western side of the Cascades in the Pacific Northwest. Using non-field-verified BARC data as a proxy for soil burn severity introduces additional uncertainty into these results. Of note, this model does not take into account 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 not meet the predicted rainfall threshold.

INTERPRETATIONS

The USGS modeling suggests that there is Low and Moderate debris flow hazard in drainages throughout the burned area (Plate 2). Remote review of lidar and aerial imagery found little evidence to suggest a history of debris flow events in this area, based on limited channel scour and a lack of alluvial fans or other landforms built by accumulation of sediment deposited by channelized mass wasting events. However, the fire likely impacted the basin's hydrologic response to future storm events. Increased runoff and the potential for flash floods and debris

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[1] The Normalized Burn Ratio Vegetation Mortality Tool is available on Google Earth Engine at *https://code.earthengine.google.com/6746b0199b695be6de5c4515edef045d?accept_repo=users%2Fandrewstratton-usda%2Fr06_Fire*

flows may remain elevated for several years after the fire. Below we outline areas where debris flows and flash flooding could impact the property and infrastructure that we reviewed during this remote assessment.

Boulder Creek and Jones Creek surface water intakes

The Department of Health's (DOH) inventory of surface water intakes identifies two intakes that are owned by the City of Camas within Boulder Creek and Jones Creek downstream of the fire (Plate 2). All but one of the hydrologic basins associated with Boulder Creek and its tributaries were modeled as having a Low debris flow hazard, the one remaining basin has a Moderate hazard. All the hydrologic basins associated with Jones Creek and its tributaries were modeled as having a Moderate debris flow hazard. While debris flow hazards may be modeled as Low and Moderate, flash flooding, debris flows, and increased runoff could impact these surface water intakes during heavy precipitation or rain-on-snow events.

Forest road crossings and recreation trails

Forest road crossings and recreation trails exist within and downstream of the Nakia Creek Fire. Forest roads have been constructed in the headwaters of both Jones Creek and Boulder Creek (Plate 2). Northeast Boulder Creek Road crosses Boulder Creek roughly 1.5 miles downstream of the fire perimeter (south of the map plates), providing access to residential properties and recreation trails. While debris flow hazards may be modeled as Low and Moderate, flash flooding, debris flows, and increased runoff could impact this infrastructure during heavy precipitation or rain-on-snow events.

RECOMMENDATIONS

Our assessment suggests that while debris flow hazards may be modeled as Low and Moderate, flash flooding, debris flows, 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,[2] or rain-on-snow events.[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 BARC map, a proxy for soil burn severity, as a tool to find areas of moderate burn severity should 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.

Managers of transportation networks, surface water intakes, 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. Blocked culverts can cause additional flooding and damage, which could otherwise be minimized. 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).[4]

REFERENCES

INCI Web, 2023, Nakia Creek Fire [webpage]. INCI Web. [accessed January 13, 2023 at https://inciweb.nwcg.gov/incident-information/wapcs-nakia-creek-fire].

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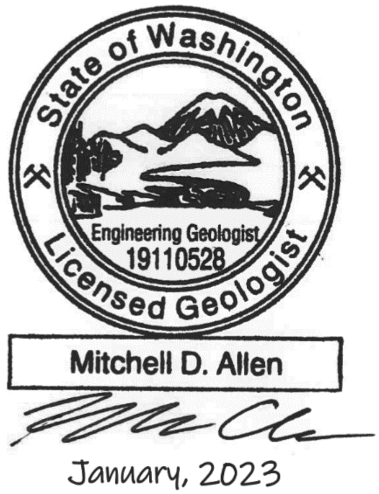
[2] Information about atmospheric rivers can be found at *https://www.noaa.gov/stories/what-are-atmospheric-rivers*

[3] 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*

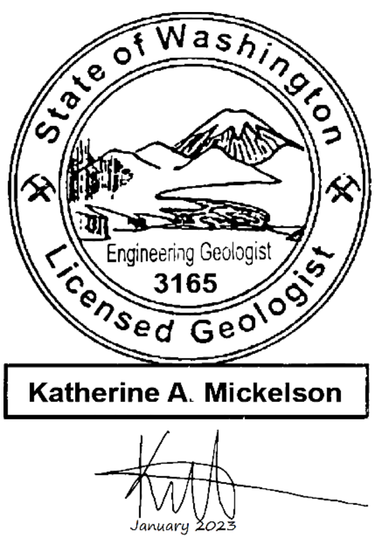
[4] The Washington Geological Survey's Floods After Fire pamphlet: *https://www.dnr.wa.gov/publications/ger_fs_alluvial_fans.pdf*
The USGS's fact sheet on post-fire debris flows safety: *https://pubs.usgs.gov/fs/2022/3078/fs20223078.pdf*

LIMITATIONS

WALERT aims to quickly identify and assess geologic hazards associated with wildfires in order to inform decision making and to 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.



Mitchell Allen
Licensed Engineering Geologist #19110528
Washington Geological Survey
Washington State Dept. of Natural Resources
Olympia, WA
Cell: 360-819-0436
Email: mitchell.allen @dnr.wa.gov



Kate Mickelson
Licensed Engineering Geologist #3165
Washington Geological Survey
Washington State Dept. of Natural Resources
Olympia, WA
Cell: 360-810-0006
Email: kate.mickelson@dnr.wa.gov

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).

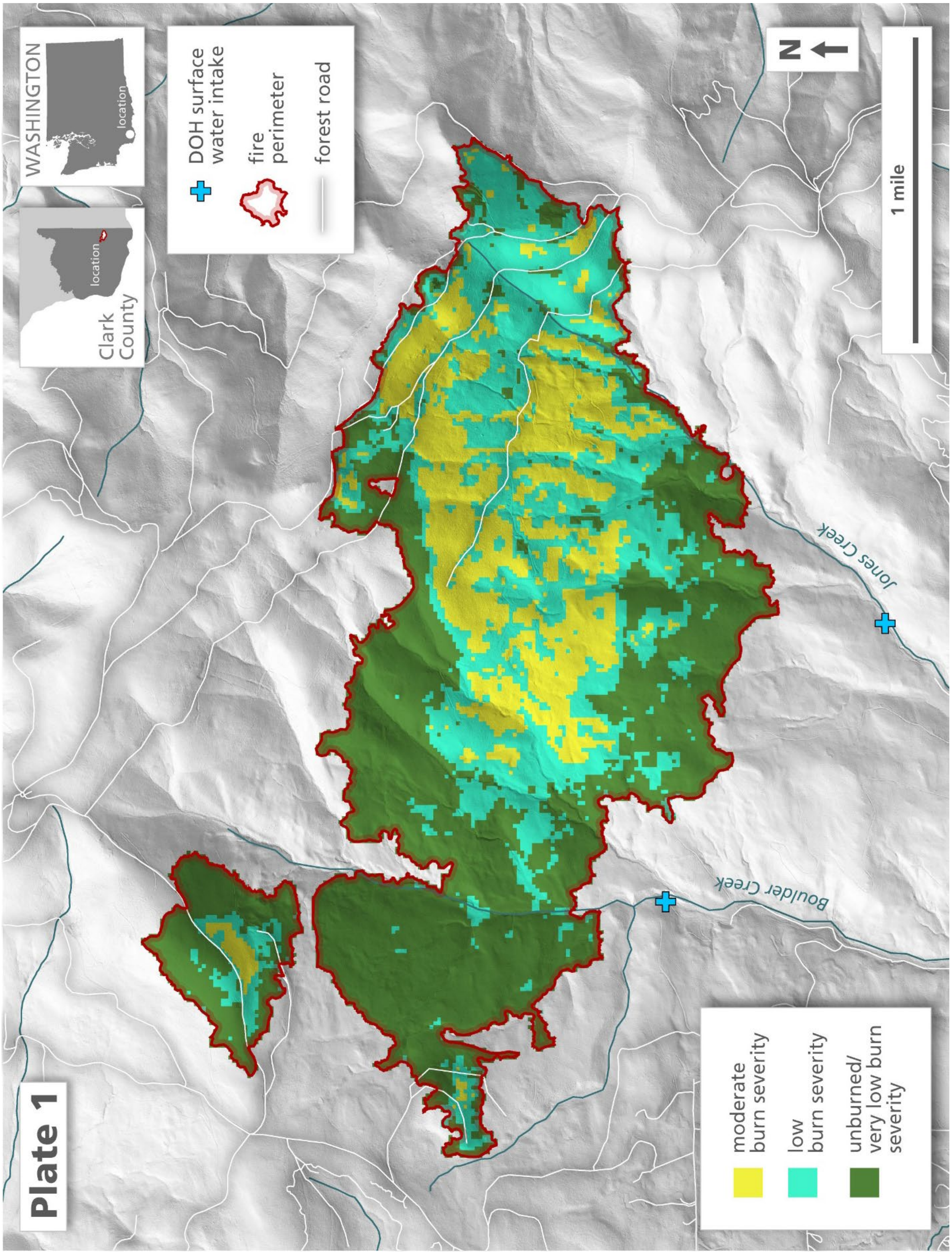


Plate 1
Clark County
location
WASHINGTON
location
DOH surface water intake
fire perimeter
forest road
N
1 mile
Jones Creek
Boulder Creek
moderate burn severity
low burn severity
unburned/ very low burn severity

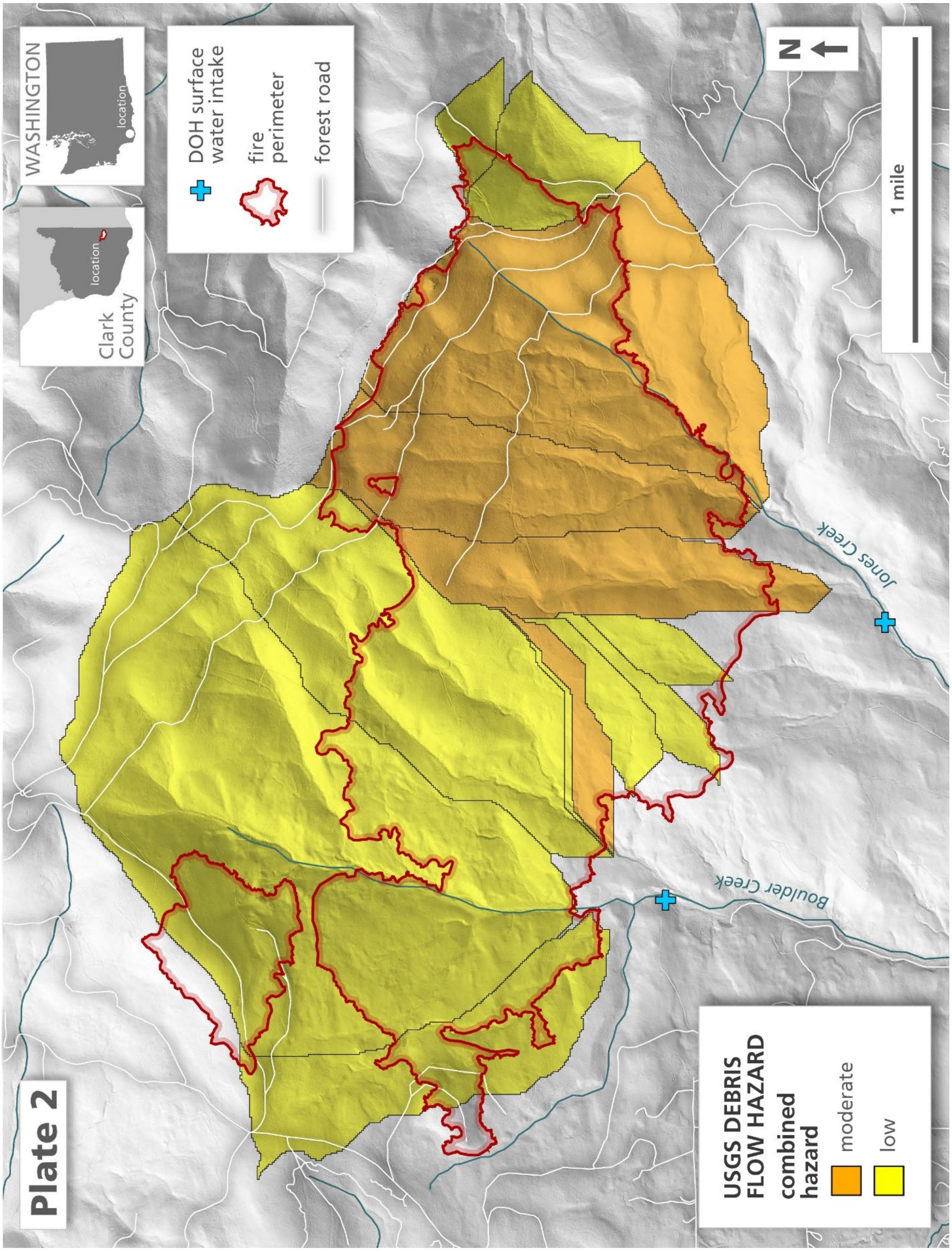


Plate 2
Clark County
location
WASHINGTON
location
DOH surface water intake
fire perimeter
forest road
N
1 mile
Jones Creek
Boulder Creek
USGS DEBRIS FLOW HAZARD
combined hazard
moderate
low