Debris Flow Summary, Haypress Fire, 2017

Natalie Cabrera, Acting Forest Geologist

February 7, 2018

On the south facing slopes below Irving Mountain, in September 2017, the Haypress fire produced soil burn intensities within the basins above road 15N17 from low near the road, to moderate and high near the peak and saddle (see Maps 1 and 2). Late November rainfall caused surface sheet erosion, and hillslope rilling in the upper basin which developed into bank and channel erosion in the lower basin before meeting the road stream crossing on 15N17. The erosion extended the entire distance of about 2,600 feet from ridge to road. The eroded volume produced easily overwhelmed the inlet basin. It deposited debris 4 feet high at the upstream end of the basin against an 8 foot tall boulder drop, and about 2-3 feet deep around the sides of the basin above the inlet. The inlet, while plugged, ponded water above the sediment which overflowed across the former road surface before the fill gave way in mass. The fill failure left sediment stains up to 15 feet high on large trees in the stream valley below. Blocks of road fill and perched sediment remain poised to contribute further. The debris flow scoured massive amounts of more sediment along the channel for about 950 feet between 15N17 and road 13N11 below. 13N11 intercepted the flow and allowed deposition for much of the material, but its liquefied nature also allowed much of it to flow across the road and to divert left about 75 feet to leave the road and deliver to tributaries only about 100-200 feet downslope of 13N11. The 13N11 also suffered two large gullies through its fill. The flow on 13N11 was quickly restored to the centerline with heavy equipment to prevent further erosion by the diversion, but not enough to reopen the road. There is not a plan currently in place to restore and repair the damage roads, but forest service engineers estimate costs of about $300,000 to repair 13N11, and about $600,000 to repair 15N17. These are very rough estimates and when and where funding will be obtained is uncertain. It is likely that these roads will not reopen until 2019 at the earliest.

Timing of occurrence is not exactly known. A forest service employee was informed by a local resident on December 4. The resident discovered the situation on December 2. Examination of archived Doppler radar (National Oceanic and Atmospheric Association (NOAA) 2018a) revealed rainfall between November 26 and 28. November 26 experienced a long duration, 8 hour duration of rainfall from about 6 am to 2 pm with several incidents of higher 5 minute intensities of about 0.22 in/hr. The short duration higher intensities represent 2-5 year recurrence intervals (NOAA 2018b). The longer duration, but lower intensities represent less than a 1-year recurrence interval storm. The total estimated rainfall for the storm was about 0.4-0.6 inches. The rainfall on November 28 lasted only about 4 hours with 5 minute intensities all in the 0.05 to 0.10 in/hr range. The debris flows must have been triggered during this November 26-28 time period.

The initial surface erosion, inlet basin, and fill failure volumes were measured in the field. The channel scour volume between roads was estimated by visual examination of dimensions visible from each road, and length measured from a map. The road failure on 15N17 was about 55 feet wide and about 30 feet deep on average.

Delivery of all sediment produced was estimated visually to be about 60 to 75%. A large volume of sediment is now propagating through the stream network. The small channels that received the sediment are tributaries to Irving Creek, a major tributary to the Klamath River.

VOLUMES

Initial Surface Erosion: 150 yd^3

15N17 Fill Failure Initial: 1,170 yd^3

15N17 Fill Potential for Future Failure: 640 yd^3

Channel Erosion Between Roads: 4,775 yd^3

13N11 Gully Volumes: 220 yd^3

Total Volume Produced (not including future potential): 6,315 yd^3

Estimated Volume Delivered to Channel Network (75%): 4,740 yd^3

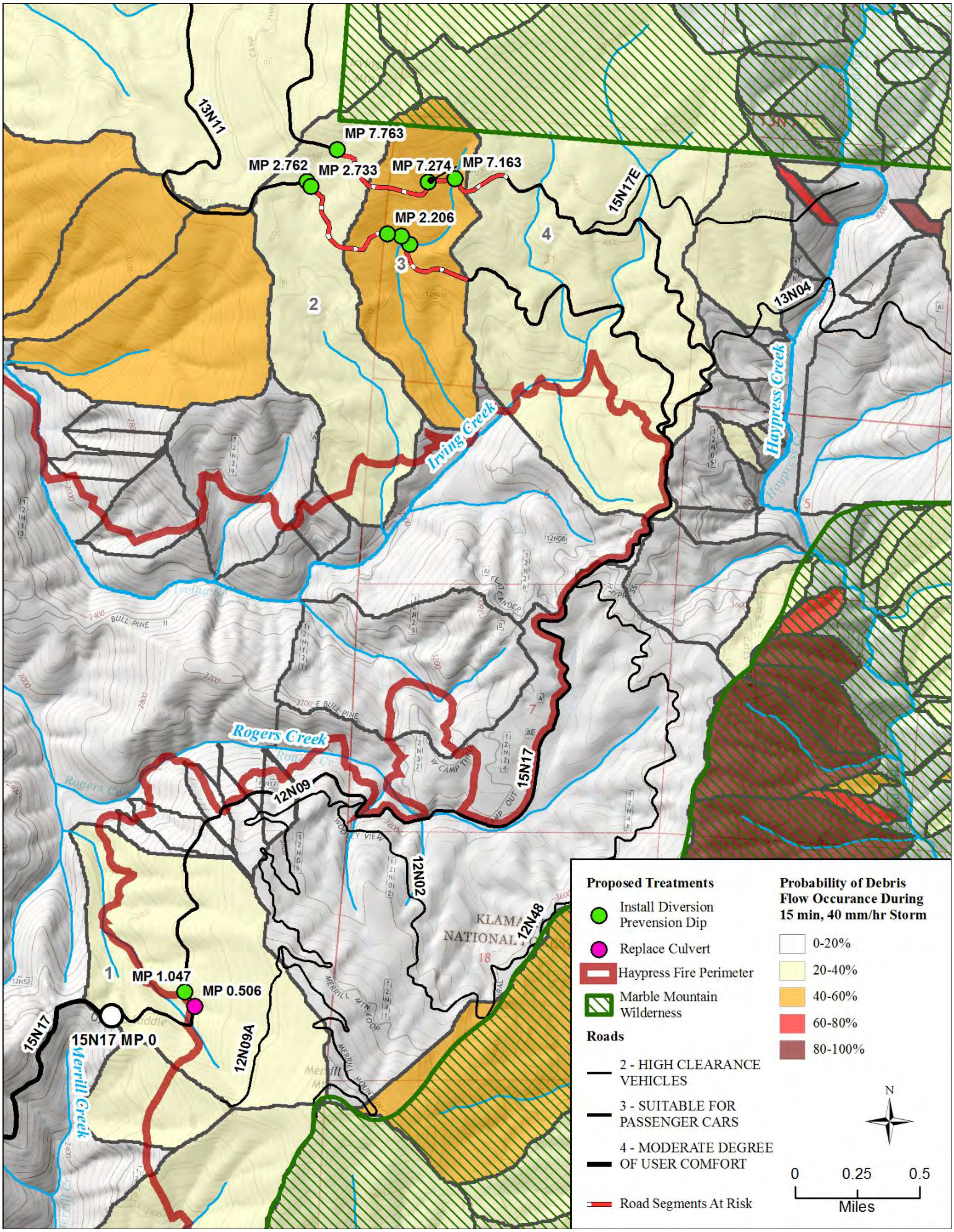
The eroded volume that reached the inlet basin easily overwhelmed the basin capacity. Photos below show the buried culvert is about 1.5-2 feet lower than the deposited sediment. Using the known location of the inlet and photos of the inlet basin prior to the debris flow, it was estimated that the former basin volume capacity was about 33 yd^3. The 150 yd^3 of sediment, in addition to the volume of water that carried the sediment, far outpaced the capacity of the inlet basin and 18 inch diameter culvert inlet. The pipe was installed with a drastic skew to the right, and with an inadequate low gradient slope, but regardless of these poor installation conditions, the inlet would have plugged. In two other debris flows that occurred in September (see below), the inlets were rapidly overwhelmed at such a rate that no material was observed within the pipe itself. The material rapidly fills the basin overtopping the inlet without much flow or sediment actually passing into the pipe itself. I believe the same mechanism was at work on this debris flow. Only an excavation of the buried inlet will definitively reveal the fact of this case. The professional assessment of this geologist/hydrologist is that the conditions created by the fire allowed for accelerated surface erosion that rapidly buried the pipe inlet with sediment.

The debris flow occurred in a basin that, during the BAER effort, was predicted to be at risk for debris flow by the USGS Debris Flow Hazard Model (United States Geological Survey 2018). The neighboring basin was predicted to have a higher risk, and while it showed minor signs of surface erosion and rilling, it produced no debris flow. This highlights the unpredictable nature of debris flow occurrence. They depend on highly variable storm intensity, duration and location, as well as highly variable soil characteristics such as degree of hydrophobicity, root structure, duff cover, and antecedent moisture (Wondzell and King 2003). In this case it may have been a highly localized storm cell couple with rain-on-snow that limited the extent to this basin only.

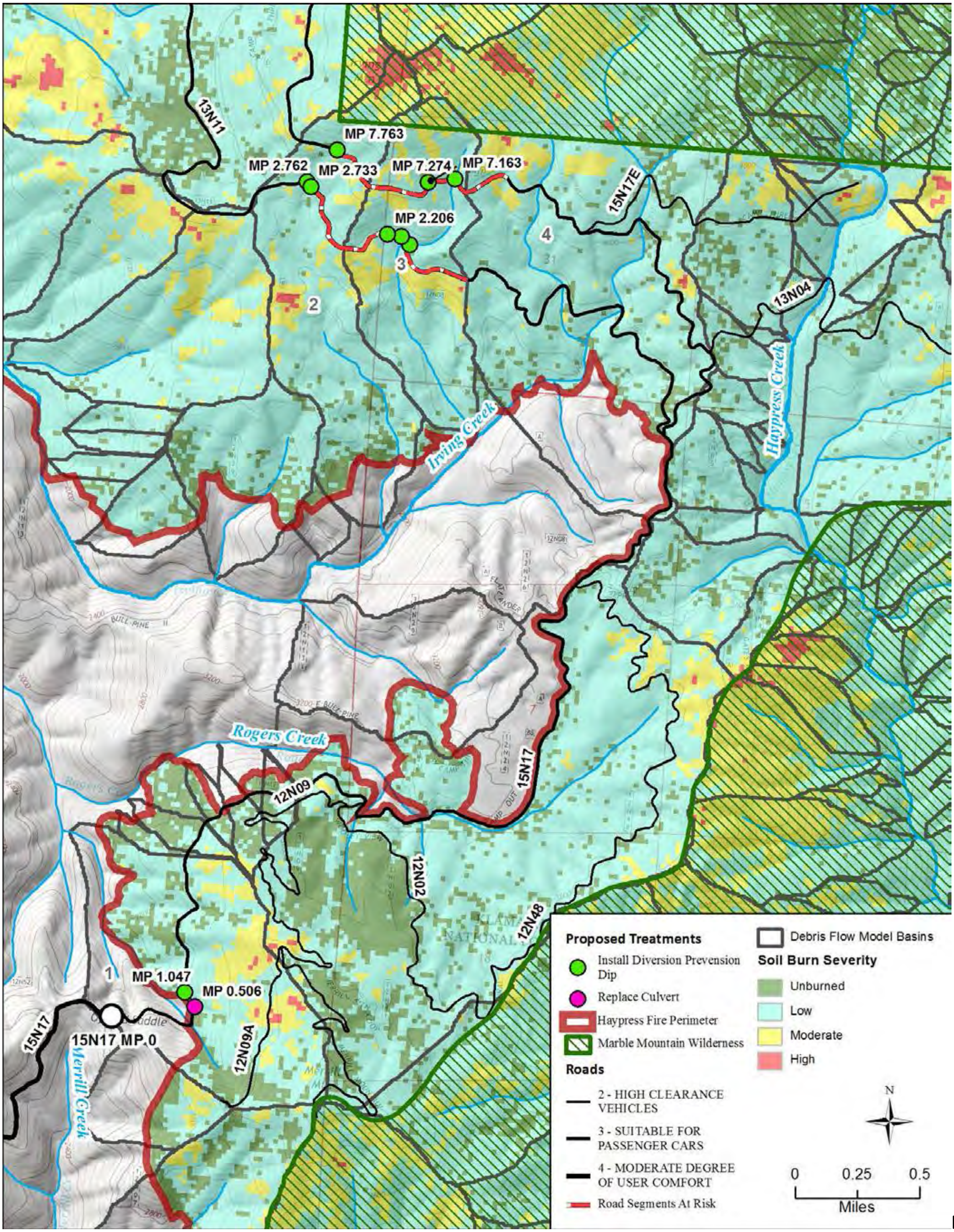
Two other debris flows occurred on 15N17 about 6.7 miles south on September 7. They were similar in that the storm cell that caused them was likely highly localized, and neighboring areas with equal soil burn intensities did not produce debris flows. The area of origination was plantation that burned at high intensity across the upper half of the basin. Because they occurred while suppression repair activities were underway, the buried inlets could be excavated immediately preventing large fill failures, and minimized sediment delivery. Rainfall intensities were a little more intense on September 6 and 7 than in November. Rainfall occurred on September 6 and 7 (NOAA 2018a) between about 1 am on September 6, and 11 am on September 7. Intensities were mostly less than 0.22 in/hr, but were notable at 1.9 in/hr (47 mm/hr) and 4 in/hr (100 mm/hr) at 6 – 6:10 am on September 7. These represent 2-25 year recurrence intervals (NOAA 2018b). Total rainfall amount for the storm is unknown, but a nearby rain gage at Wooley Creek reported about 0.20 in for the storm.

Risk of future debris flows is dependent on rainfall. A mild winter may spare the hillslopes significant erosion and adequate water to produce debris flows. However, intense storms may trigger further slides. It is typical that within 3-5 years post-fire, duff and surface vegetation recovery is typically significant (Shakesby and Doerr 2006) to prevent debris flows. The Haypress fire was not so severe as to slow vegetation recovery. Needle cast, fungal growth, and sprouts were already observed during the BAER effort in late September.

Map 1. Debris flow occurred at MP 7.763 on 15N17, and at MP 2.762 on 13N11. The two earlier debris flows occurred at MPs 0.506 and 1.047. The map displays the results of the USGS Debris Flow Hazard model by basin for a 15 min, 40 mm/hr (1.57 in/hr) design storm. The design storm, in this area represents a 5-year storm recurrence interval. It is the largest design storm that was provided with the model results.



Map 2. Map showing same basins as in map 1 and soil burn severity.



Photos

Photos

Figure 1. 15N17 failure viewed from right side (if facing downhill).

Figure 2. 15N17 failure viewed from left side (if facing downhill).

Figure 3. View of right scarp near top of 15N17 failure showing in place culvert with buried inlet. Inlet is roughly to the right (as viewing photo) of the base of downed trees about 1.5-2 feet below surface of deposited sediment.

Figure 4. Overview of sediment filled inlet basin.

Figure 5. View looking downslope just below 15N17 failure showing scoured channel and mud stained trees.

Figure 6. Close up of same trees as in Figure 5. Mud stains are about 5-15 feet high.

Figure 7. Close up of downstream end of 15N17 inlet basin showing stratigraphy with needles at base, then sand, then mud toward right that deposited while basin was full of water. Inlet is about 1.5-2 feet below arrow head.

Figure 8. Close up of upstream end of 15N17 inlet basin showing 4 ft. height of sand deposition against boulder bank.

Figure 9. Overview of 15N17 inlet basin showing 4 ft. height of sand deposition against boulder bank, and 2 ft. height of sand deposition towards downstream edge. Buried inlet lies 1.5-2 feet below surface at notch through center just downstream of two small trees on right bank (arrow points to present surface).

Figure 10. Right side (if looking downslope) of 15N17 road surface showing rafted debris from overtopped, water filled Inlet basin.

Figure 11. Left is looking upstream at boulder head of inlet basin before debris flow (Sept. 2017 during fire activity). Photos on the right were taken after the debris flow. Colors match analogous landmarks, and the dark red line shows level of sediment deposition. The inlet is about 1-2 feet downstream, and about 1.5-2 feet below the green circled boulder.

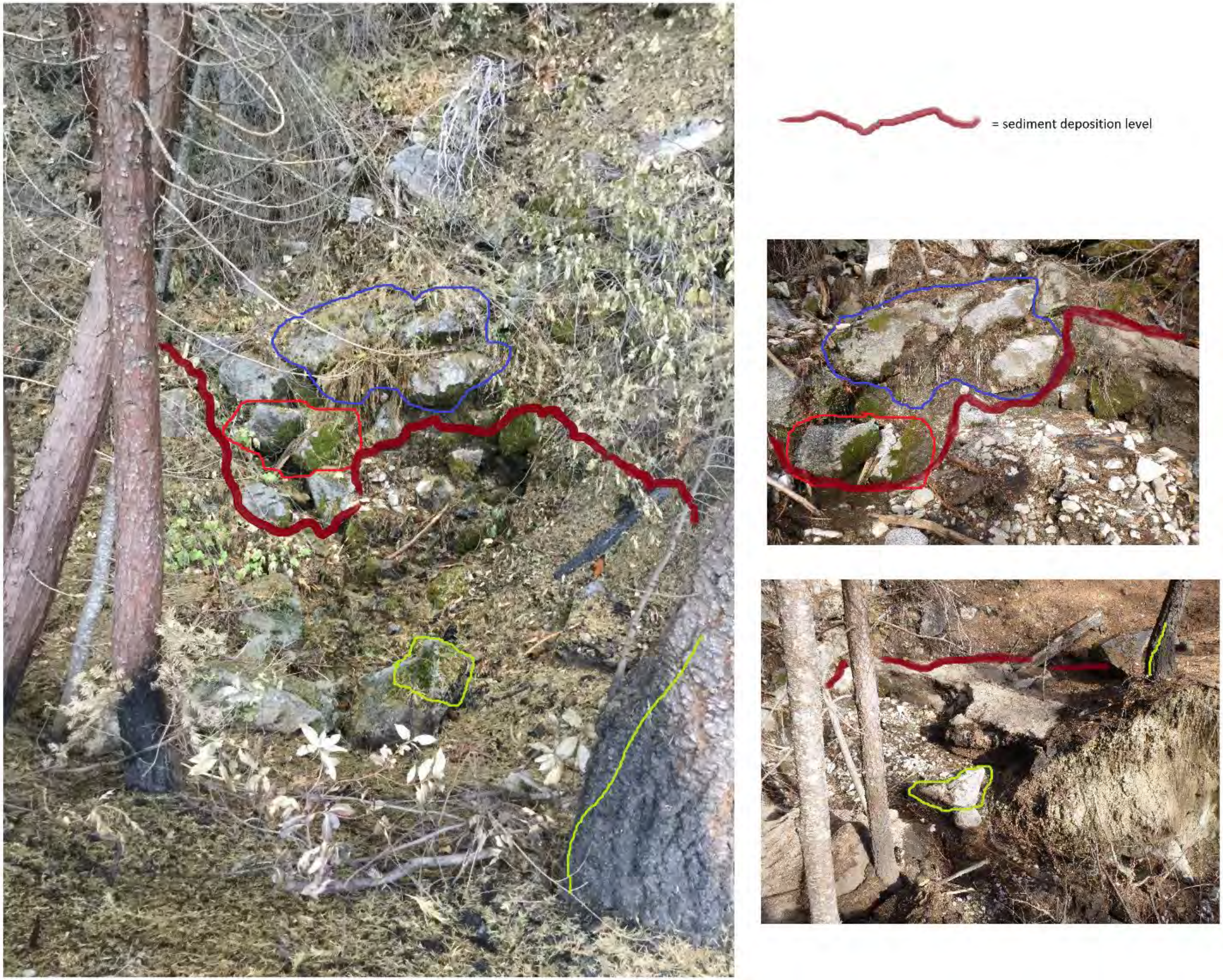


Figure 12. Channel and bank erosion about 100 feet above 15N17.

Figure 13. Channel and bank erosion above 15N17.

Figure 14. Channel and bank erosion within 100 feet above 15N17.

Figure 15. Sheetwash erosion and 1 ft. high needle cast levees about midslope between 15N17 and saddle below Irving Mountain, above defined channel.

Figure 16. Sheetwash erosion at midslope between 15N17 and the saddle below Irving Mountain.

Figure 16. Hillslope rill erosion at midslope between 15N17 and the saddle below Irving Mountain.

Figure 17. Saddle below Irving Mountain. Irving Mountain is in background.

Figure 18. 13N11 buried by failed debris post repair to restore flow.

Figure 19. 13N11 buried by failed debris post repair to restore flow.

Figure 20. Looking upstream at eroded channel from 13N11. Taken by Adam Dresser prior to repair.

Figure 21. Looking upstream from 13N11 prior to debris flow occurrence. Taken September 2017 during fire suppression.

Figure 22. Looking downstream at gully through centerline of fill on 13N11. Taken by Adam Dresser prior to repair.

Figure 23. Looking downstream at lower end of gully and base of 13N11 fill.

Figure 24. Looking right (if facing downhill) at diverted flow and sediment from debris flow on 13N11.

Figure 25. Closer view looking right (if facing downhill) at diverted flow and sediment from debris flow on 13N11.

Figure 26. Looking downslope from 13N11 to confluence of channels about 100 feet below road that received debris flow material. Hillslope is also rilled and eroded.

References

National Oceanic and Atmospheric Association. 2018a. National Radar Map webpage. Accessed February 7, 2018 at https://gis.ncdc.noaa.gov/maps/ncei/radar

National Oceanic and Atmospheric Association. 2018b. Hydrometeorological Design Studies Center, Precipitation Frequency Data Server webpage. Acessed February 7, 2018 at https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ca

Shakesby, R.A., Doerr, S.H. 2006. Wildfire as a hydrological and geomorphological agent. Earth-Science Reviews 74, 269-307.

Wondzell, S.M., King, J.G., 2003. Postfire erosional processes in the Pacific Northwest and Rocky Mountain regions. Forest Ecology and Management 178, 75–87.

United States Geological Survey. 2018. Emergency assessment of post-fire debris flow hazards. Accessed February 7, 2018 at https://landslides.usgs.gov/hazards/postfire_debrisflow/