BAGLEY COMPLEX AREA EMERGENCY RESPONSE

GEOLOGY REPORT

SHASTA TRINITY NATIONAL FOREST

By

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Melanie Stevens
Geologist, Shasta Trinity National Forest

Reviewed By

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Juan delaFuente
Region 5 Northern Province Geologist

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Attachments: BagleyComplex_20120919.pdf

Summary

The Bagley Complex burned approximately 14,009 acres at moderate to high soil burn severity (See Soil Scientist Report for more information). This greatly increased the debris flow potential in Jessie Creek – Horse Creek, Upper Claiborne Creek and West Fork Squaw Creek – Modin Creek HUC 7. With the increased potential the following values have been found to be at risk:

VALUES AT RISKS

- McCloud Penstock Siphon due to increased debris flow potential within the inner gorge, the road failure along road 37N33A and the earthflow at the intersection of road 37N33 and 37N33C. Treatments for the road failure and intersection are described in the Engineering Roads Report.
- Madrone and Chirpchatter Campgrounds due to the increased debris flow and flood potential along Squaw Creek.
- Private residences and outbuildings located along Squaw Creek due to the increased debris flow and flood potential.
- McCloud River Club due to the increase in debris flow and flood potential along Claiborne Creek.
- Nature Conservancy Cabin due to increased debris flow and flood potential along Lady Bug Creek.

RECOMMEDATIONS

- Due to the risk to human life along Squaw Creek, it is recommended that a RAWS station be installed in the headwaters of Squaw Creek so that, if needed, emergency notifications and closures can be made within a timely manner so that the life risk associated with heavy rains, flooding, and debris flows is reduced.
- It is recommended that air photos be acquired to monitor effectiveness of road treatments, and to identify immediate issues within the burn area which may have been overlooked by the BAER process (see monitoring section below).
- For longer term fire recovery monitoring, it is recommended that a high resolution digital elevation model be acquired (LiDAR). This would facilitate refinement of the hazard assessment, and can be used to monitor watershed response.

Purpose

The purpose of this document is to identify existing geological hazards and resources, along with future potential geological hazards caused by the 2012 Bagley Complex (CA-SHF-002744). The Bagley Complex is a 46,010 acre wildland fire located approximately 10 miles south of McCloud and 4 miles west of Big Bend.

Method

Methods to identify geological hazards and resources consisted of field reconnaissance of the burned area (Melanie Stevens - Geologist, Juan dela Fuente – Geologist, Brad Rust – Soil Scientist, Jules Riley - Hydrologist, Bobbie Miller - Fisheries, Todd Moxness - Engineer, Justin Nettleton - Engineer, Keli McElroy - Forestry, Martin Lenz - Botany, Debbie Derby - Wildlife, Paul Hart – OHV/Rec) during the week of 9/11/2012 thru 9/15/2012 , review of 1998 colored and 1980 infrared aerial photos, Google Earth Imagery (1993-1998), GIS geomorphic and bedrock mapping database, previous geologic mapping, Second Draft of the Lower McCloud and Iron Canyon Ecological Unit Inventory, 1997, and the McCloud-Pit Project, FERC No 2106: Assessment of Channel Morphology and Fluvial Geomorphic Processes in the Lower McCloud River (GS-S2), Technical Memorandum 68 (TM-68).

Review of Lithologic and Geomorphic Mapping

The Bagley Complex is almost completely underlain by the Redding terrane which consists of, from east to west, the Potem unit (limestone and argillite), Arvison unit (volcaniclastics), Hosselkus unit (limestone), Modin unit (metasediments and volcaniclastic), Pit unit (metasediments and metavolcanics), and Dekkas Andesite unit (metavolcanics).There are two small units of the Western Cascades terrane on the eastern portion of the fire consisting of basalt and three plutons located in the southern portion of the fire consisting of quartz diorite and granodiorite (Figures 1 and 2).

Geomorphic mapping from the GIS database shows several large dormant landslides located along the fire boundary, with the largest being located at the northern part of the fire across for Ah-Di-Na campground. Inner gorges are mapped within all the drainages within the fire perimeter except for, from north to south, Iron Canyon Reservoir, Pit 5 Power House and East Fork Squaw Creek – Hoffmeister Creek which are all located on the eastern part of the fire boundary (Figure 3).

Field mapping identified three active landslides. One active landslide is located on a private road off road 37N95, within the road cut. The landslide is a shallow debris slide, approximately 50’ x 100’ that is located above road. There is an active spring, <1 gallon per minute, located at the bottom of the failure. Slope material consists of unconsolidated landslide deposits on top of a clay deposit. The slope above the slide is a burned over clearcut that burned at low soil burn severity with some patches of moderate, the slide itself is unburned (see BagleyComplex_20120919.pdf, IMGP1687 and IMGP1690). The second landslide is located along road 37N33 road near the intersection of road 37N33C. This landslide is a large earthflow that terminates at a tributary to the Iron Canyon Creek. The slide is dissected by several flowing streams which pass under the road through culverts. The entire slide burned at a high soil burn severity (see BagleyComplex_20120919.pdf, IMGP1737, IMGP1738 and IMGP1741). The third landslide is a road fill related failure located on road 37N33A near the PG&E pipeline that flows into the same tributary as the previous slide. It is approximately 150’ x 200’ on a 40° slope of unconsolidated fill. A perennial stream is intercepted at the road by a concrete lined ditch that diverts the flow around the slide. Currently the flow is being diverted until midway until the water disappears. It is assumed that the water is seeping into the fill, causing saturation and contributing to the fill failure. The slopes above the slide and perennial drainage burned at high and moderate soil burn severity, respectively, while the slopes adjacent to the slide and below the slide burned at high soil severity. The slide itself did not burn (see BagleyComplex_20120919.pdf, IMG_5035 and IMGP1718). Treatments for both sides along road 37N33A are addressed in the Engineering Roads Report. Multiple rock falls were observed along road 37N86 before the 37N95 intersection, west of Happy Hunting Grounds (BagleyComplex_20120919, IMG_5111, IMG_5113, and IMG_5119. The upper slopes burned at low soil burn severity with patches of moderate. These falls were not mapped.

Google Earth Imagery and Aerial Photos

Google Earth imagery was reviewed from 1993 to 1998, along with 1998 color aerial photos. All though debris flows are known to have occurred during the 1997 flood in Modin Creek and other nearby streams, along with flooding in Squaw Creek. A picnic bench from Chripchatter Campground was observed by District Personnel lodged in a tree, approximately 1 mile downstream (Steve Bachmann, personal communication 2010). Evidence of these events in the fire area is subdued on the 1998 Google Earth imagery and the 1998 aerial photos. However, further downstream, well south of the fire area in Squaw and Winnibulli Creeks, prominent debris slides and debris flows associated with the 1997 flood can be seen on 1998 air photos.

Geological Hazards and Resources

Geological hazards that have been identified as having the potential to occur within one to three years post fire (BAER Assessment Process in Steps, 2011) consist of rock falls, debris slides and debris flows, and deep seated landslides. No known naturally occurring asbestos occurs within the fire area. Geological resources that have the potential to be affected by the fire are caves in the marble outcrops within the fire area.

Rock falls consist of loose rock falling from steep hillslopes. They are *likely*[1] to occur on steep slopes where rock is exposed and fire has burned the organic material which was helping to hold the rock in place. Potential is highest where slopes are greater than 60% and fire severity is moderate to high. However, rock fall potential can be increased in areas of low burn severity where the ground fire consumed all the organic material except for large trees. The area of greatest concern for rock falls is along road 37N86, west of Happy Hunting grounds and the intersection of road 37N95 where there is evidence of current rock fall along the roadway even though the upper slopes burned low with pockets of moderate. Since areas of rock outcrop have not been inventoried, it must be assumed that rock fall

[1] See Tables

Table 2: Qualitative terminology for use in assessing risk to property (modified by Koler from Fell et al., 2005)

potential has been elevated by the fire on all roads traversing steeper slopes, particularly where burn severity above the road is moderate to high. Figure 7 shows all roads which traverse slopes >60% and Figure 8 shows where burn severity above the road is moderate to high. The potential for rock falls will be greatest with the first heavy rains of the fall or with intense summer storms and then decrease over the next few years, as vegetation in the area recovers. Seismic shaking can also trigger deep seated slides.

Debris slides are shallow, rapidly moving landslides and are *possible* where slopes are >36 degrees[2] (Figure 6). The Burn Severity Map (Figure 4) shows areas of moderate and high severity fire, where the Geomorphology Map (Figure 3) shows headwall basins and inner gorges where debris slides may occur. Debris slides also commonly occur on toes of dormant, deep seated landslides thus generating debris flows (Reid, Brien, LaHusen, Roering, de la Fuente, & Ellen, 2003). This elevated potential for debris slides is due to the loss of vegetation and associated evapotranspiration and root support. The large earthflow identified at road 37N33 and road 37N33C intersection is an example of this within the burned area and has the potential to generate a debris slide. Debris slide potential in areas of shallow soils will be greatest later in the winter when soils become saturated by multiple storms, or a single long duration storm. Debris slide potential on the toes of dormant landslides will remain elevated for 10 years or more, and the potential will be greatest when sustained rainfall activates the dormant, deep seated landslides. Seismic shaking also has the potential to trigger debris slides.

Debris flows are thick slurries of water, soil, rock, and organic debris that travel rapidly down channels which strip vegetation from riparian areas and delivers large volumes of sediment to streams. Post fire debris flows can be triggered by rapid inputs of sediment from surface erosion processes into channels, extremely high flow volumes mobilizing channel bed material or by landslides such as debris slides as described above. A debris flow probability model, *Predicting the probability and volume of postwildfire debris flows in the intermountain western United States* (Cannon et al, 2010) was used to determine the probability of post fire debris flows. The model was run on the drainages (HUC7) that are located within the burned area of the Bagley Complex. The following drainages have been identified as having a low, intermediate, high, or very high probability of post fire debris flow: Lower Hawkins Creek, East Fork Squaw Creek – Hoffmeister Creek, Upper Hawkins Creek, Bald Mountain Creek – Hat Mountain Creek, and Iron Canyon Reservoir is modeled to have a low probability post fire debris flows; North Fork Squaw Creek – NE, Ah-Di-Na, Lower Claiborne Creek, and Iron Canyon drainages have an intermediate probability of producing post fire debris flows; Upper Claiborne Creek and West Fork Squaw Creek – Modin Creek have a high probability of producing post fire debris flows; and Jessie Creek – Horse Creek has a very high probability of producing post fire debris flows (Cannon, Gartner, Rupert, Michael, Rea, & Parrett, 2010). See Figure 5 for post fire debris flow potentials.

The potential for debris flows triggered by rapid sediment input from surface erosion or extremely high flows will be greatest with the first heavy rains of the season or with intense summer storms. This potential will decrease over the next few years as vegetation within the area recovers. The potential for

[2] According to *Land Management Handbook # 18*, "Slopes >36 degrees (>73%) tend to be highly unstable" (Chatwin, Howes, Schwab, & Swanston, 1991)

debris flows associated with shallow soil debris slides will be greatest later in the winter when soils become fully saturated by multiple storms. The potential for debris flows associated with the activation of deep seated landslides may take several years after the fire to peak. This activation could occur after several wet years in a row. Seismic shaking can also trigger debris flows.

Deep seated landslides include slumps, earthflows, and block slides where the failure plane is typically >20 feet deep and movement along the landslide is slow. The toe of this type of slide is typically steep and has the potential to generate debris slides as described above. Activation of such slide can occur immediately after the fire, or many years later. Seismic shaking can also trigger movement on deep seated landslides.

Geologic resources in the fire area include marble caves which are known to exist in some of the marble outcrops. Some of these burned at high or moderate severity. In keeping with the Federal Cave resource Protection Act, cave locations are kept confidential, similar to cultural sites. The Lithology Map (Figure 2) shows where marble bodies are located. Lastly, mollusk fossils (pelecypods) are known to exist in some of the metasedimentary rock.

Values at Risk

Potential values at risk from geologic hazards have been identified as the following:

Table 1: Resources at Risk Rating

Values at Risk	Likelihood Descriptor	Consequence Descriptor	Risk Rating
Iron Canyon Reservoir	Unlikely	Minor	Very Low
McCloud Penstock Siphon	Possible	Moderate	Intermediate
Shasta Lake Reservoir	Likely	Minor	Low
Madrone Campground	Possible	Moderate to Major	Intermediate to High
Chirpchatter Campground	Possible	Moderate to Major	Intermediate to High
Ah-Di-Na Campground	Unlikely	Moderate to Major	Low to Intermediate
Ash Camp Campground	Unlikely	Moderate to Major	Low to Intermediate
Hawkins Landing Campground	Unlikely	Moderate to Major	Low to Intermediate
Deadlun Campground	Unlikely	Moderate to Major	Low to Intermediate
Fishermans Loop	Unlikely	Moderate to Major	Low to Intermediate
McCloud River Club	Possible	Moderate to Major	Intermediate to High
Bollibokka Club	Unlikely	Moderate to Major	Low to Intermediate
Private Residences along Squaw Creek	Possible	Moderate to Major	Intermediate to High
Microwave Towers on Tamerack	Unlikely	Minor	Very Low
Nature Conservancy Cabin	Possible	Moderate	Intermediate

Details about each value at risk are found in Appendix A: Field Notes.

Monitoring

Road treatments costing several hundred thousand dollars will be applied in the Bagley Fire area. Effectiveness of these treatments will be evaluated at two levels.

1. Field site visits
2. Air photos

The air photos will be taken as soon as possible this fall (prior to the rains and before the sun angle gets too low), and then re-taken in the spring or summer of 2013. The fall flight will document baseline conditions immediately after the fire, and will allow identification of rills, gullies, and landslides which were present at that time. The summer flight will facilitate an area-wide assessment of the effectiveness of the road treatments, and document the occurrence of debris flows, gullies, and landslides which occurred the first winter. If the winter of 2012-2013 is exceptionally mild, the summer flight can be delayed until 2014.

Other applications of the air photos include:

1. Identification of potentially hazardous sites (overlap of high severity fire with hazardous geologic conditions) which may have been missed during the BAER assessment.
2. Validation of the predictive ability of the debris flow model used in the BAER analysis.
3. Identification of previously unmapped marble bodies which were affected by the wildfire, and could contain caves. Such cave could be at risk of damage by new or increased public use due to increased visibility.

The cost of the air photos would be on the order of $XXXXX ($XXXXX for each flight).

Post BAER Monitoring-

For longer term fire recovery monitoring, it is recommended that LiDAR data be acquired in order to produce a high resolution digital elevation model. This would facilitate refinement of the geologic hazard assessment, and provides an excellent tool to monitor watershed response. The cost for LiDAR is on the order of $XXXXX to $XXXXX per acre.

Limitations

This report is a rapid assessment for the emergency response to the 2012 Bagley Complex. The intent is to identify immediate geologic hazards and resources that have been directly and/or indirectly affected by fire and/or fire suppression efforts located within the fire boundary and within a one to three year period. Due to time constraints and long drive times, some roads were not visited in the field. Other possible sites may be identified during implementation phase of the BAER treatments.

References

Cannon, S., Gartner, J., Rupert, M., Michael, J., Rea, A., & Parrett, C. (2010). Predicting the probability and volume of postwildfire debris flows in the intermountain western United States. *Geological Society of America Bulletin*, 127-143.

Chatwin, S. C., Howes, D. E., Schwab, J. W., & Swanston, D. N. (1991). *A Guide for Management of Landslide-Prone Terrain in the Pacific Northwest.* BC Ministry of Forests.

Fell, R., Ho, K., Lacasse, S., & Leroi, E. (2005). A framework for landslide risk assessment and management. In *Landslide Risk Management* (pp. 3-25). New York: Balkema Publishers.

Reid, M. E., Brien, D. L., LaHusen, R. G., Roering, J. J., de la Fuente, J., & Ellen, S. D. (2003). Debris-flow initiation from large, slow-moving landslides. *Debris-Flow Mitigation: Mechanics, Prediction, and Assessments*, 155-166.

Roath, B. (2011). *BAER Assessment Process in Steps.* Region 5: US Forest Service.

Figures

Figure 1: Geologic terrane of the Bagley Complex

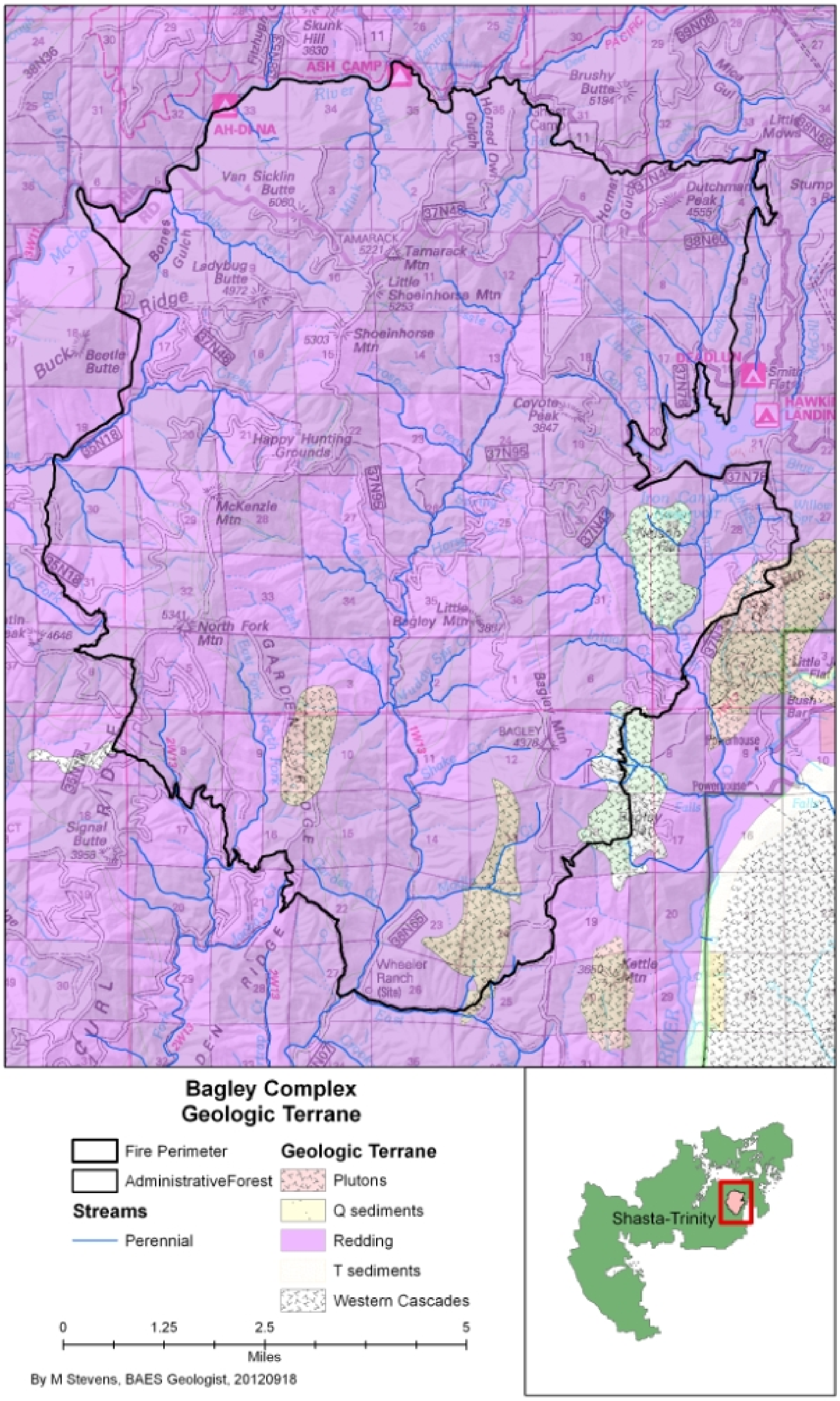


Figure 2: Lithology for the Bagley Complex

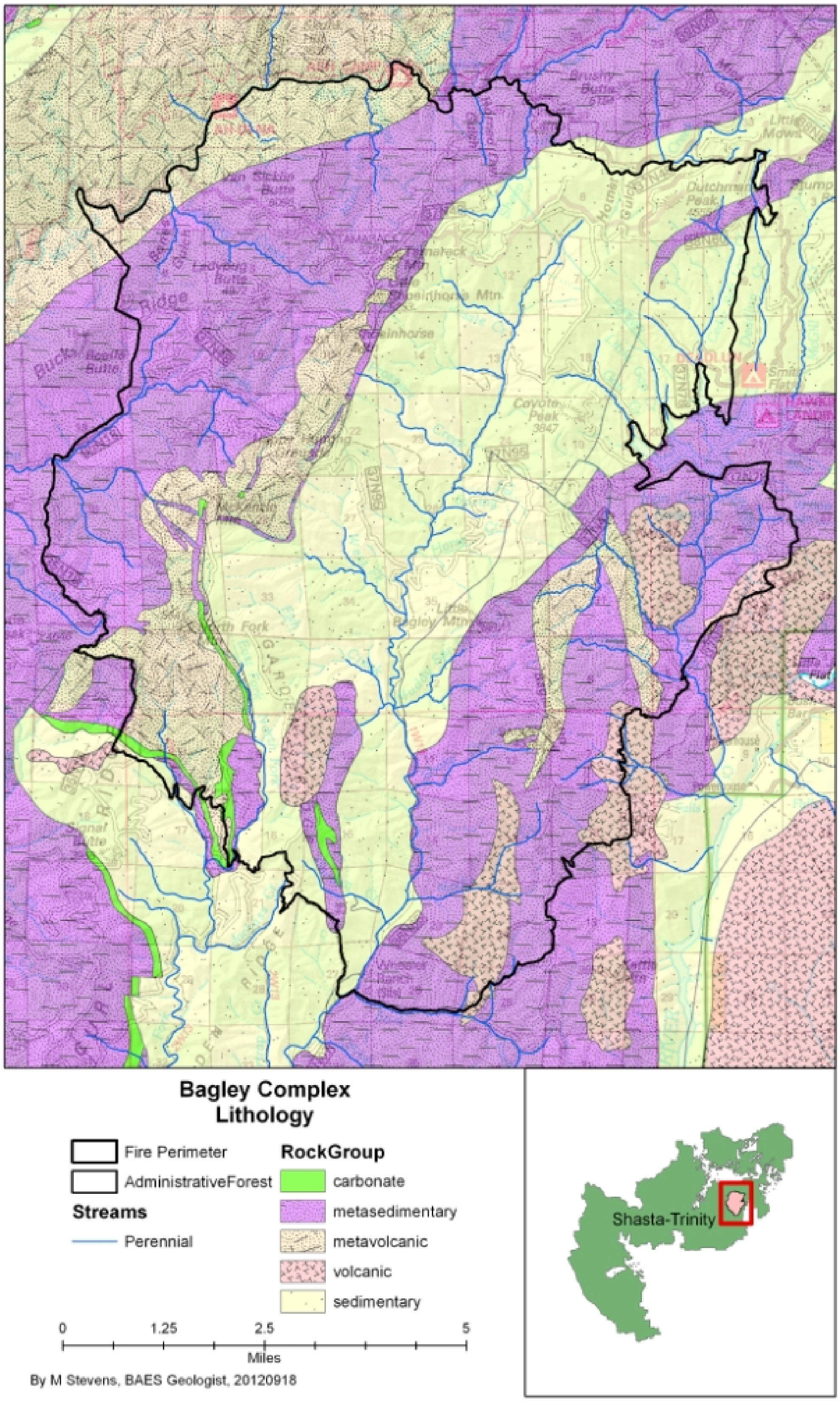


Figure 3: Geomorphology for the Bagley Complex

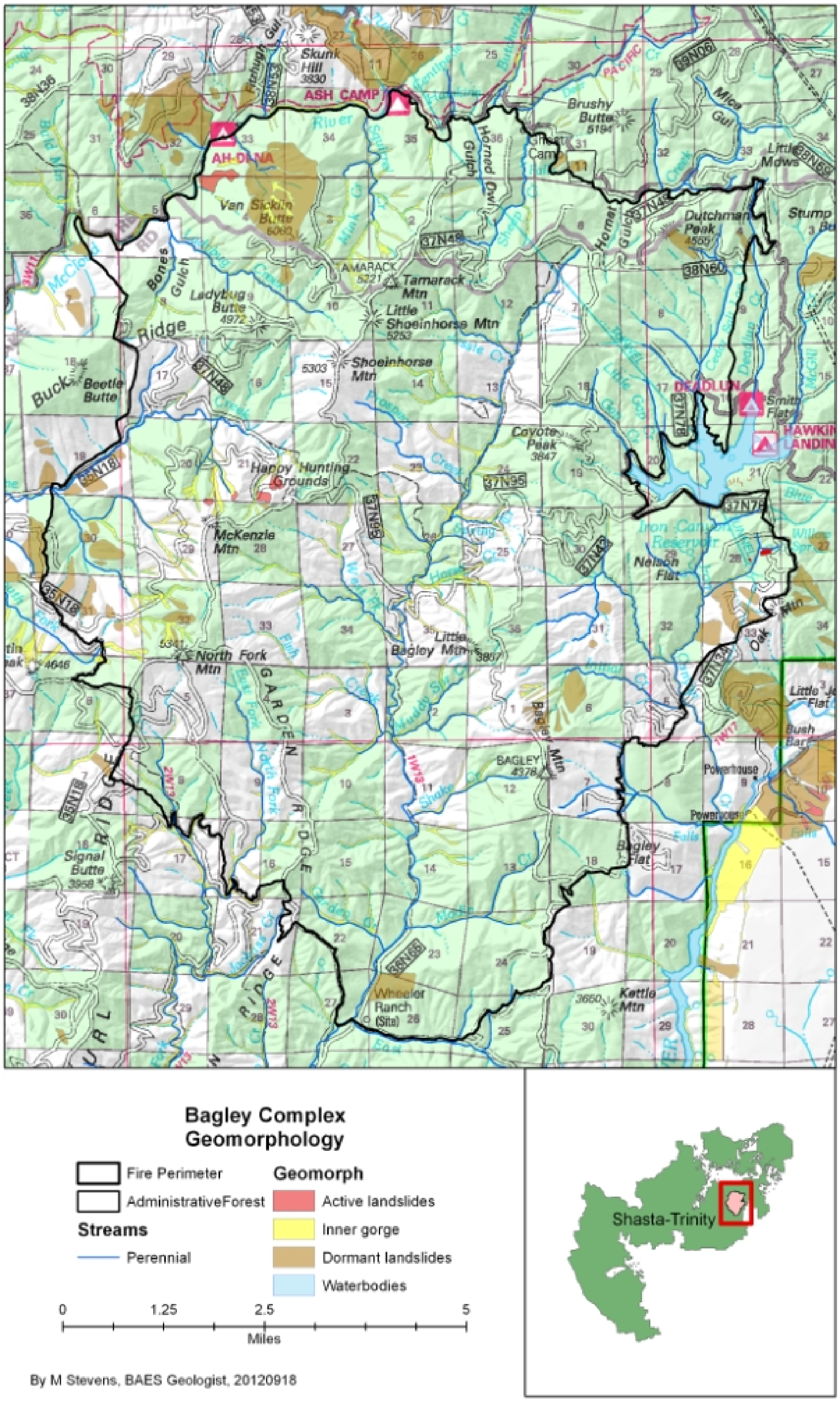


Figure 4: BARC imagery for the Bagley Complex

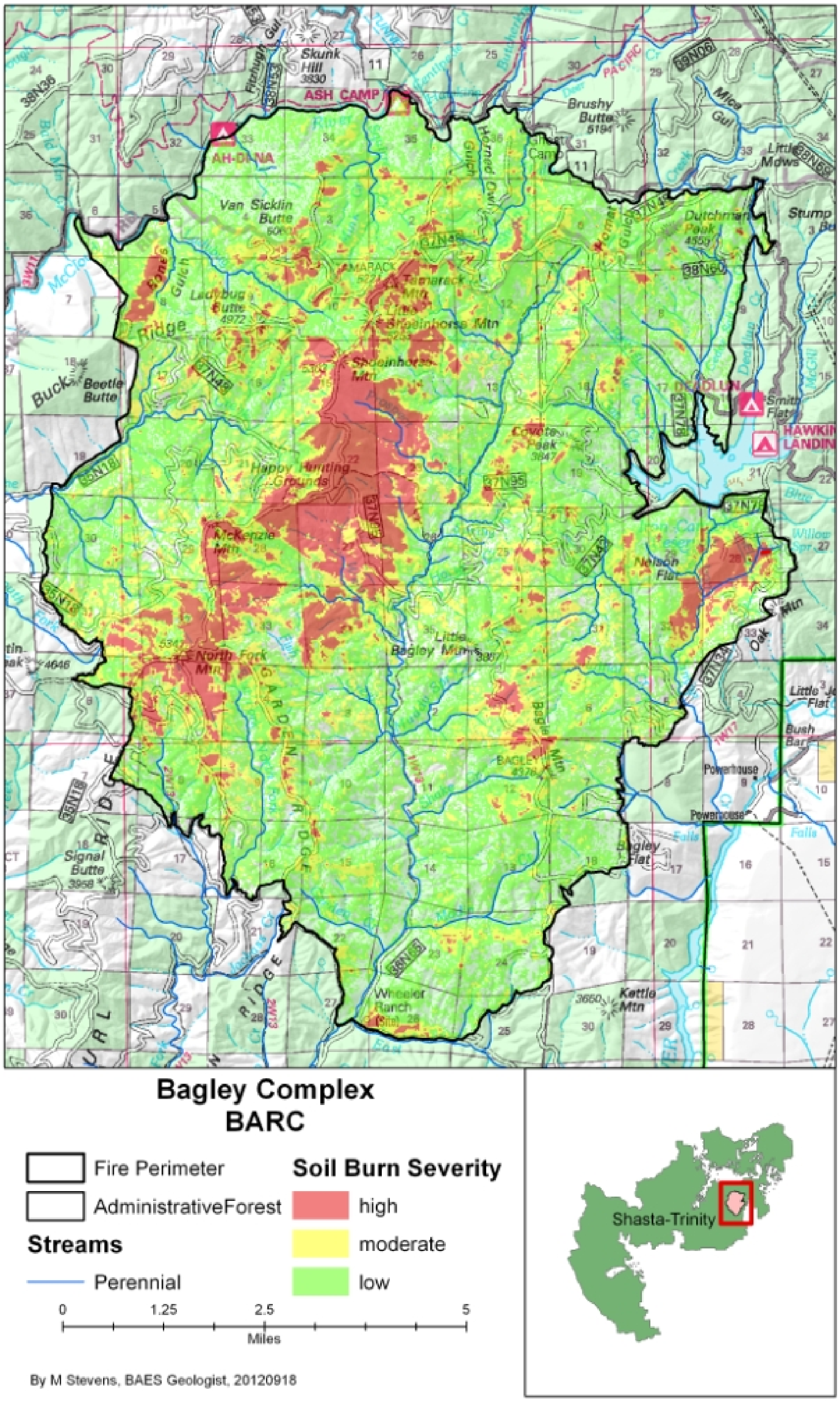


Figure 5: Post fire debris flow probability by hydrological unit code seven (HUC7)

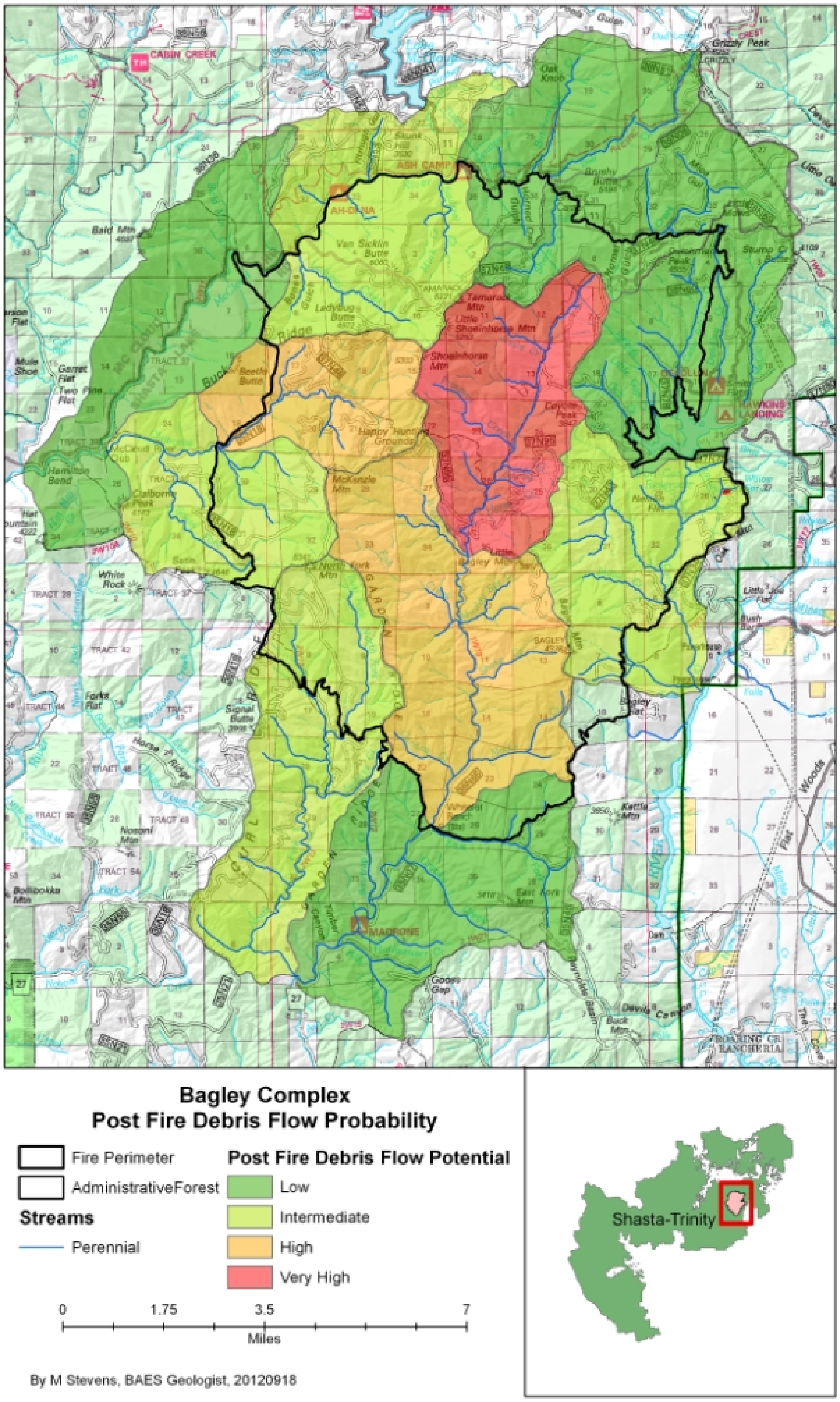


Figure 6: Slope map for the Bagley Complex

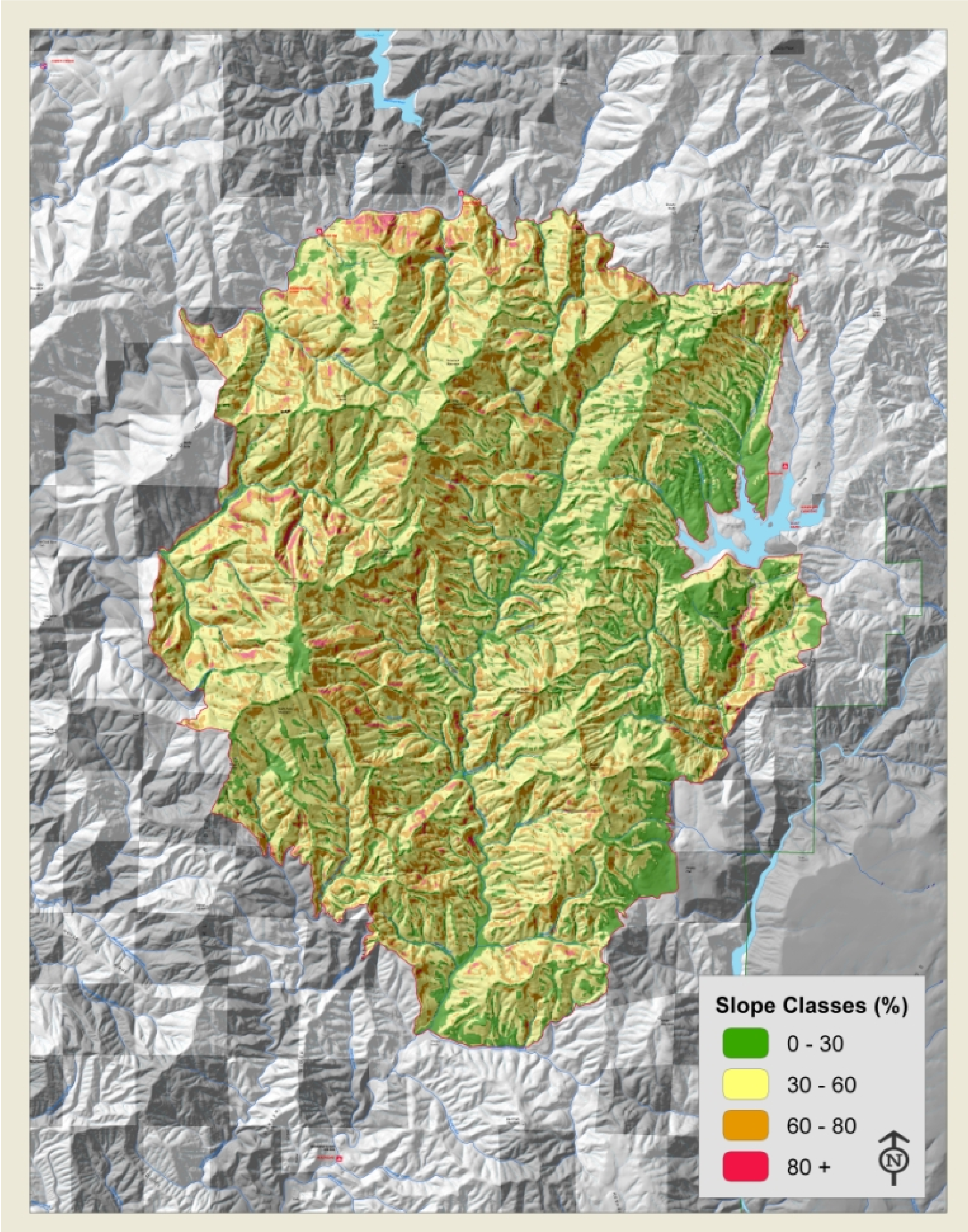


Figure 7: 60% slope and greater overlaid by roads within the burned area

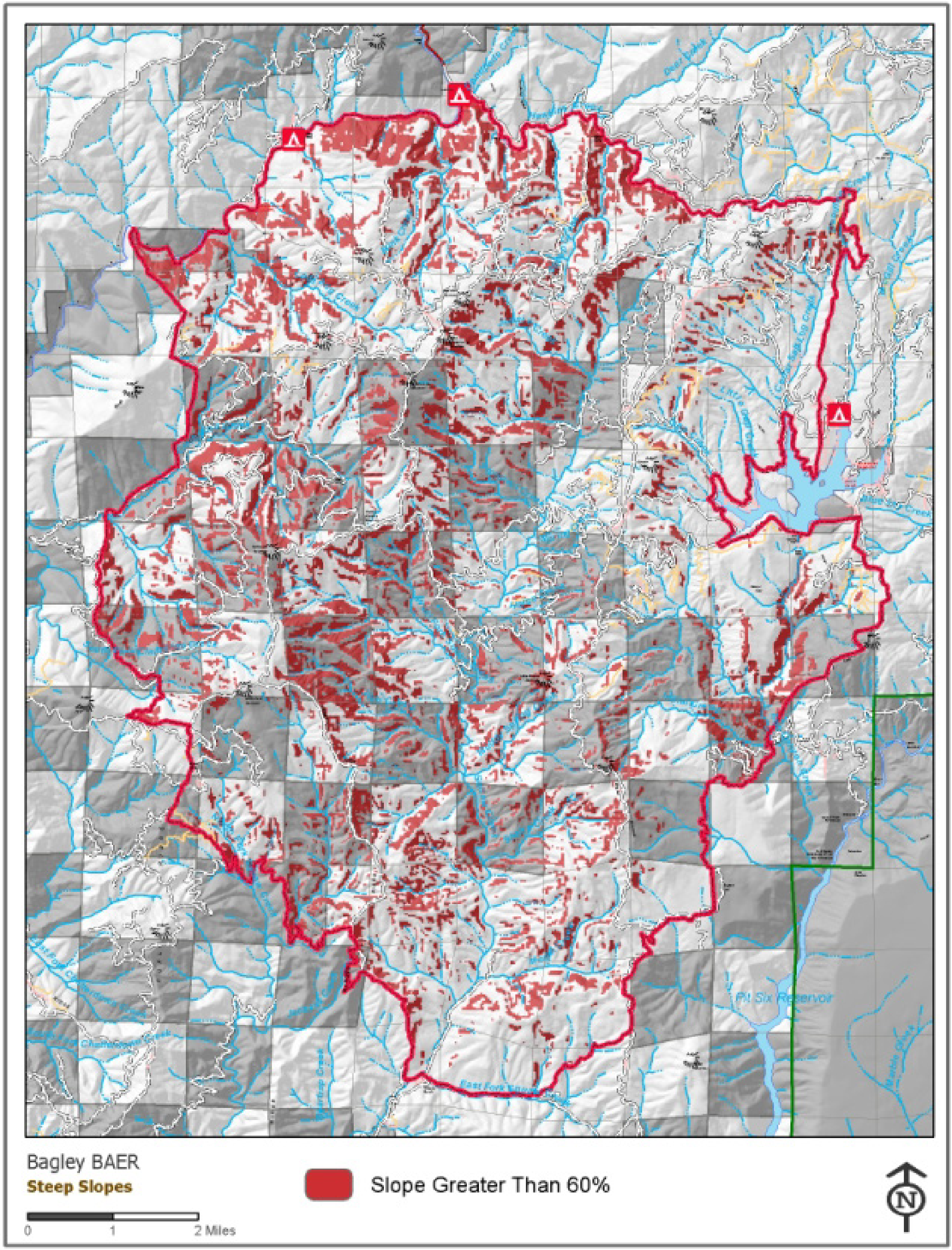
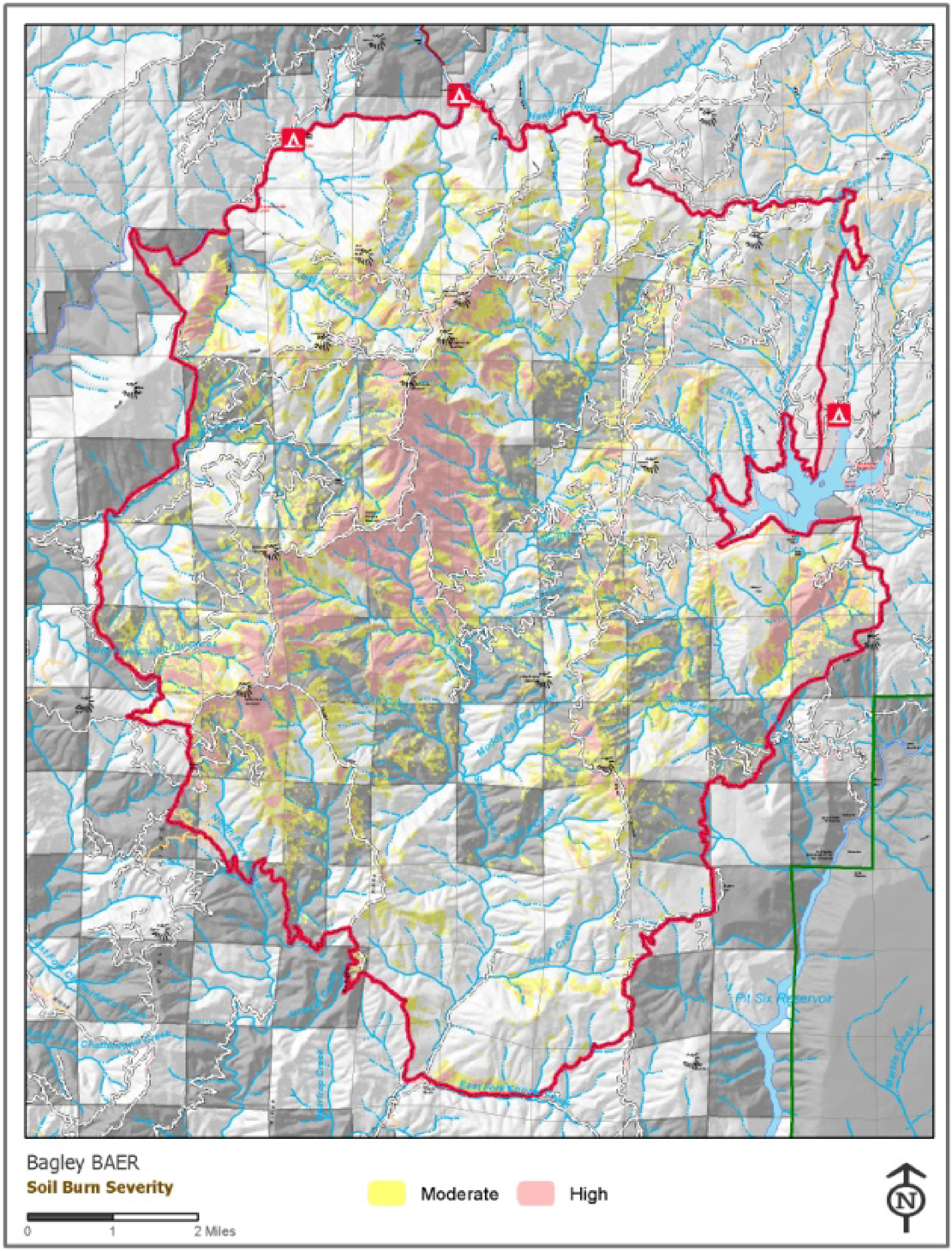


Figure 8: Moderate to high burn severity overlaid by road within the burn area



Tables

Table 2: Qualitative terminology for use in assessing risk to property (modified by Koler from Fell et al., 2005)

Qualitative measures of likelihood of landsliding		
Level	**Descriptor**	**Description**
A	Almost certain	The event is expected to occur
B	Likely	The event will probably occur under adverse conditions
C	Possible	The event could occur under adverse conditions
D	Unlikely	The event could occur under very adverse circumstances
E	Rare	The event is conceivable but only under exceptional circumstances
F	Not credible	The event is inconceivable or fanciful
Qualitative measures of consequences to the resource		
1	Catastrophic	Resource is completely destroyed or large scale damage occurs requiring major engineering works for stabilization
2	Major	Extensive damage to most of the resource, or extending beyond site boundaries requiring significant stabilization
3	Medium	Moderate damage to some of the resource, or significant part of the site requires large stabilization works
4	Minor	Limited damage to part of the resource, or part of the site requires some reinstatement/stabilization works
5	Insignificant	Little damage

Qualitative risk analysis matrix – classes of risk to resource					
	Consequences to the resource				
Likelihood	Catastrophic	Major	Medium	Minor	Insignificant
Almost certain	VH	VH	H	H	H
Likely	VH	H	H	M	L-M
Possible	H	H	M	L-M	VL-L
Unlikely	M-H	M	L-M	VL-L	VL
Rare	M-L	L-M	VL-L	VL	VL
Not credible	VL	VL	VL	VL	VL

Legend – VH: very high risk; H: high risk; M: moderate risk; L: low risk; VL: very low risk

Appendix A: Field Notes

1. Iron Canyon Reservoir – a very small proportion of watershed burned at moderate to high burn severity. As a result, there is a very small increase in sedimentation anticipated.
2. McCloud Penstock Siphon – much of the area around the siphon burned at moderate to high severity. The presence of alders in the channel bottom, up to 24 inches in diameter indicates that large debris flows have not passed through the channel in 30 years or more. Slopes above the east abutment are very wet, apparently from springs, and partially healed debris slide scars are present on the east bank of the stream immediately below the penstock. Due to fire effects, there is a high likelihood for a debris flow to pass through the stream beneath the penstock, along with other tributaries within the stream. The siphon crosses in an area with a pronounced inner gorge with concrete abutments approximately 30 feet apart (BagleyComplex_20120919.pdf, IMG_5378 and IMG_5113). The penstock is approximately 30 feet above stream level. Considering these dimensions, a future debris flow would most likely pass beneath the penstock without damage. However, this assumes that the abutments are founded in bedrock. An outcrop was observed adjacent to one of the abutments, but the presence or absence of bedrock below both abutments could not be verified by field observation. The power company recently repaired issues on the penstock within this vicinity (Kathy Valenzuela, personal communication 2012). The potential consequence of breakage occurring within the penstock is very high, and as a result, the power company should verify that the abutments are founded in bedrock. The earthflow at road 37N33 and 37N33C intersection, GPS points 574 to 578, has the potential to produce a debris slide at the toe of the feature, thus sending a debris flow down the channel. At least two generations of culverts were observed at this site indicating previous drainage issues and slide movement at this site.

   There is a high potential for road failures on road 37N33A leading to the penstock under post fire conditions. The perennial stream at GPS point 547 has the potential to experience a debris flow which could further destabilize the fill failure near the penstock described previously (Picture PowerPoint, Air recon 5378, 5379 20120914). Treatments for the road at this location are available in the Road Engineering report. Key objectives for treatment include: a) directing any future debris flow down the original channel and protecting the unconsolidated material in the fill below the road from erosion from such an event; b) preventing the stream from further saturating the fill, as which it currently does; c) avoiding concentration of water by the road ditch and delivery to unstable areas below the road. Due to the high potential for future failure at the described sites following the fire, final design of road drainage treatments will be field reviewed jointly by engineering, geology and hydrology personnel.
3. James B Black Power House – this area was brought to the attention of the BAER team as a potential issue. A break in the penstock occurred above the power house approximately 30 years ago, which triggered a landslide that delivered a large amount of sediment to Pit River. This required dredging operations for several years following the event (Kathy Valenzuela, personal communication 2012). This area is not directly affected by the fire.

4. Shasta Lake Reservoir – The reservoir is roughly 8 miles south of the fire area but due to the burning of vegetation by the fire, the reservoir will receive fine sediment, woody debris and ash from Squaw Creek. The reservoir will also receive fine sediment and woody debris for the McCloud and Pit River but on a much small degree due to decreased fire effects and intervening dams. Due to insufficient time, the Forest Service Cumulative Watershed Effects GEO model was not used to estimate fire-related sediment delivered to the reservoir.
5. Madrone Campground – has a high potential for flooding and debris flow due to the mod/high severity burn in the Squaw Creek drainage.
6. Chirpchatter Campground – has a high potential for flooding and debris flow due to the mod/high severity burn in the Squaw Creek drainage.
7. Ah-Di-Na Campground – has a low potential for flooding and debris flow due to the low severity burn along McCloud River and the control flows from the McCloud River Dam.
8. Ash Camp Campground – has a low potential for flooding and debris flow due to the low severity burn along McCloud River and the control flows from the McCloud River Dam.
9. Hawkins Landing Campground – has low potential for flooding and debris flow due to the no to low severity burn around the campground area and the regulated lake height due to the Iron Canyon Dam.
10. Deadlun Campground – has low potential for flooding and debris flow due to the no to low severity burn around the campground area and the regulated lake height due to the Iron Canyon Dam.
11. Fishermans Loop – has low potential for flooding and debris flow due to the no to low severity burn around the campground area and the regulated lake height due to the Iron Canyon Dam.
12. McCloud River Club - potential for flooding and debris flow. Examination of air photos revealed that at least one structure is located on the lower floodplain adjacent to Claiborne Creek.
13. Bollibokka Club – has low potential for flooding and debris flow due to the no to low severity burn around the campground area and the regulated lake height due to the Iron Canyon Dam.
14. Private Residences along Squaw Creek – has a high potential for flooding and debris flow due to the mod/high severity burn in the Squaw Creek drainage.
15. Microwave Towers on Tamarack Mtn – situated on a gentle ridge crest, geologic hazards not anticipated.
16. Nature Conservancy Cabin – located along the McCloud River, across from Lady Bug Creek. Has possible potential for flooding and debris flow due to the mod/high severity burn of Lady Bug Creek.