Middle Truckee River Tributaries Sediment Source Assessment

Prescription Plan

Truckee River Watershed Council

USDA Forest Service, Tahoe National Forest, Truckee Ranger District

August 2016

Introduction

The purpose of this project is to conduct a sediment source assessment in key uncontrolled tributaries of the Middle Truckee River, develop a plan prescribing sediment control treatments, and complete related environmental impact analyses. This work is in support of the Truckee River TMDL.

The project area includes Cabin Creek, Deep Creek, Pole Creek, Silver Creek, Deer Creek, Bear Creek, undefined areas along the main stem of the Truckee River (cumulatively called the Highway 89 South Corridor), and Prosser Creek below Prosser Reservoir Dam. These lands contain dirt roads, recreational trails and sites, unauthorized user impacts, legacy timber harvest and ski area development sites that contribute sediment to the tributaries of the Truckee River. See Figure 1 for a map of the Hwy 89 South Corridor assessment area and Figure 2 for the Prosser Creek assessment area.

Project partners, the Truckee River Watershed Council and the US Forest Service, previously inventoried sediment sources on Forest Service lands in the project area. These sources were prioritized based on potential for treatment to reduce sediment production. This current document describes those sediment reduction treatments.

It should be noted that the prescription plan is not ready for implementation at this stage. Portions of the prescription plan will need to comply with the National Environmental Policy Act and the California Environmental Quality Act. Final proposed actions will be decided upon after environmental analysis. Some of the proposed prescriptions are significant in potential impact, and may require critical thinking and additional information to become viable solutions that can be implemented. This document identifies where this is the case. Other elements of this prescription plan are more straight-forward and can be implemented as time and funding become available.

[NOTE: Private lands and other non-forest service lands within the Hwy 89 South Corridor are not included in the assessment. This includes Highway 89 South itself managed by Caltrans, the Truckee River Trail managed by the Tahoe City Public Utility District, the Eastern Regional Landfill Material Recovery Facility and Transfer Station in Cabin Creek managed by Tahoe Truckee Sierra Disposal, most of Squaw Valley, and private property within portions of Bear Creek and Pole Creek. Features in these areas do contribute substantial sediment to the Truckee River and its tributaries, and exacerbate problems on forest lands. These observed sites can lead to a better understanding of existing sediment source areas, and are noted in the assessment where possible. No treatment recommendations were made.]

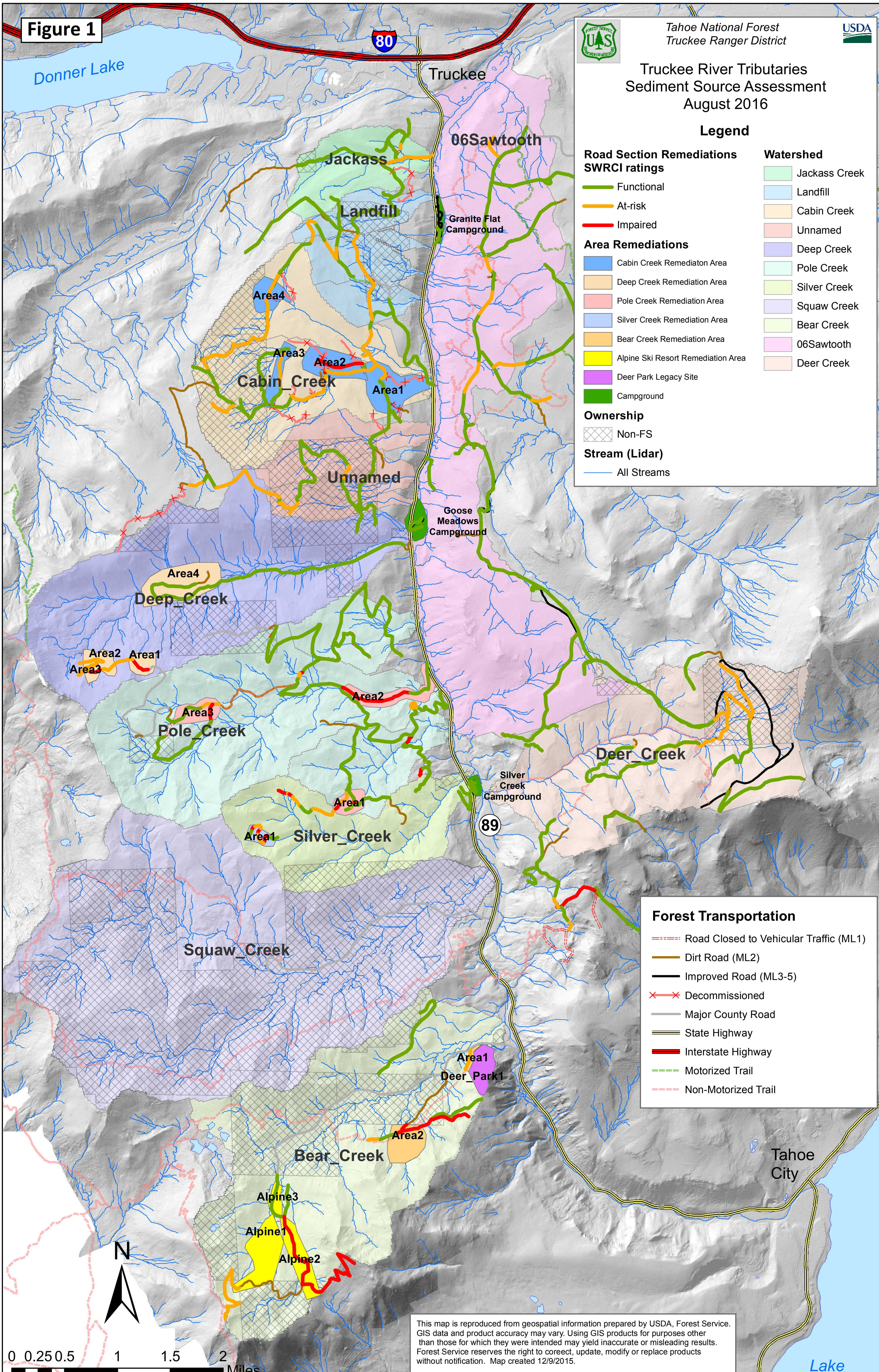
Figure 1
Tahoe National Forest
Truckee Ranger District
USDA
Truckee River Tributaries
Sediment Source Assessment
August 2016
Legend
Road Section Remediations SWRCI ratings
Functional
At-risk
Impaired
Area Remediations
Cabin Creek Remediaton Area
Deep Creek Remediation Area
Pole Creek Remediation Area
Silver Creek Remediation Area
Bear Creek Remediation Area
Alpine Ski Resort Remediation Area
Deer Park Legacy Site
Campground
Ownership
Non-FS
Stream (Lidar)
All Streams
Watershed
Jackass Creek
Landfill
Cabin Creek
Unnamed
Deep Creek
Pole Creek
Silver Creek
Squaw Creek
Bear Creek
06Sawtooth
Deer Creek
Forest Transportation
Road Closed to Vehicular Traffic (ML1)
Dirt Road (ML2)
Improved Road (ML3-5)
Decommissioned
Major County Road
State Highway
Interstate Highway
Motorized Trail
Non-Motorized Trail
Donner Lake
80
Truckee
06Sawtooth
Jackass
Landfill
Granite Flat Campground
Area4
Area3
Area2
Cabin_Creek
Area1
Unnamed
Goose Meadows Campground
Area4
Deep_Creek
Area2
Area1
Area3
Area2
Area3
Pole_Creek
Deer_Creek
Silver Creek Campground
Area1
89
Area1
Silver_Creek
Squaw_Creek
Area1
Deer_Park1
Area2
Bear_Creek
Alpine3
Alpine1
Alpine2
Tahoe City
Lake Tahoe
N
0 0.25 0.5 1 1.5 2
Miles
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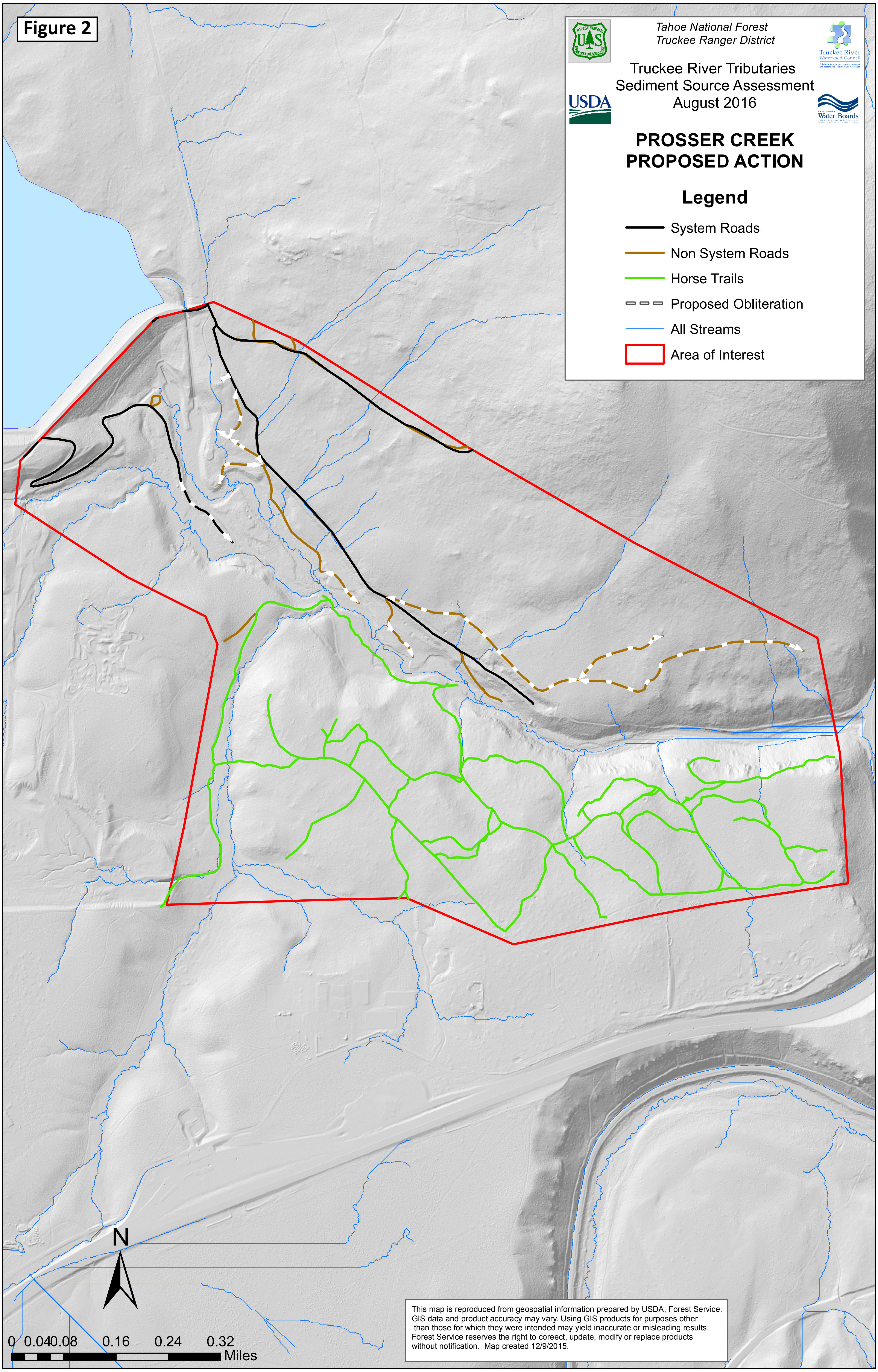

Figure 2
Tahoe National Forest
Truckee Ranger District
Truckee River Tributaries
Sediment Source Assessment
August 2016
PROSSER CREEK
PROPOSED ACTION
Legend
System Roads
Non System Roads
Horse Trails
Proposed Obliteration
All Streams
Area of Interest
N
0 0.04 0.08 0.16 0.24 0.32
Miles
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Summary of Sediment Sources

Following is a summary of the key functional areas contributing sediment within the assessment area. Each of these sediment sources impact the hydrologic function of the specific area, as well as have a cumulative effect on a watershed-scale.

Roads:

> **Forest Service Roads:** Many of the mostly unpaved roads within Forest Service lands require improvement to reduce sediment production and transport. Primary sources include road cuts and fills and poorly designed road drainage networks. Prescribed actions include full obliteration, relocation and restoration of the abandoned segment, redesign, drainage improvement, and basic maintenance of heavily used areas.
>
> **Non-Forest Service Roads:** Many state, county and private roads immediately outside of the project area contribute substantial sediment to the watershed. Assessing these sources and prescribing treatment are outside the scope of this project. While we noted both paved and unpaved roads not on Forest Service lands, potential treatments are not proposed. Additional collaboration with other property owners and stakeholders is needed to fully assess these areas.

Winter use/snow management: Maintenance and operations of roads to access winter sports areas generate additional sediment and pollutants. Plowing scrapes off asphalt with each pass and sanding/salting the roads as needed for public safety adds pollutants.

Legacy Sites: Legacy sites are often poorly located, poorly designed, or non-maintained features that have modified the original topography. This results in areas of concentrated flow patterns, stream capture and gully formation. Linear features contribute to modified drainage networks and increased erosion. While legacy sites are mostly inactive, many have been incorporated into current uses.

Ski Area Development and Management: There are two active ski resorts and one closed ski resort within the project area. Portions of the resorts are on Forest Service lands under permit, and other portions are on privately owned lands. Road access to the resort and upper mountain infrastructure, slope grading, installed utilities and other land disturbances disrupt the natural hydrology. This increases erosion and sedimentation from the hillslopes to the streams. The closed ski area is identified for restoration. The Forest Service will work with active ski resorts to address sediment sources within these permitted areas.

Recreation Site Development and Management: There are several campgrounds, motorized and non-motorized trails, and horse stables in the project area. The campgrounds are not significant contributors of sediment, and there is no prescribed action. Several trails need improved drainage to reduce sediment from these sources.

Prescription Priorities

Priority 1 – Improve/Maintain Existing Forest Service Roads:

The top priority in all the sub-watershed in the assessment area is to maintain or improve identified road drainage over forest service designated Management Level I, II, III and better roads. This can be completed as adequate funding sources become available and do not require in-depth environmental assessment.

Priority 2 - Recreation Site Development and Management:

- o Bear Creek- Alpine Meadow Road Section: Alpine Meadow SUP; East Slope, West Slope and Parking lots reduce sediment delivery to drainages.

Priority 3 – Redesign/Obliterate Forest Service Roads, Rehabilitate Adjacent Areas

These areas require more attention than standard maintenance and improvement. Prescriptions include decommission, obliterate and re-contour impaired access routes, roads, skid trails and landings; redesign road surface segments; add, remove, or improve water diversions and culverts.

Priority 4 – Non-Forest Service Lands

Collaborate with non-Forest Service property managers and stakeholders, particularly in Cabin Creek, Bear Creek, and Deep Creek. Work to gain acceptance, approval and access to fully assess sediment sources, prescribe action, and begin treatment.

Priority 5: Restore Legacy Sites

Remove legacy road beds and restore natural slope contours within a high alpine sloping stringer meadow in Silver Creek. Restore the legacy Deer Park Ski Area in Bear Creek. Requires additional investigations.

Summary of Prescription Recommendations by Sub Watershed

The following recommendations are for watershed improvement projects to reduce sediment production from sites identified in the sediment source inventory. Recommendations are made for each sub-basin area inventoried.

Bear Creek Sub Watershed – 3,326 acres total, 1,976 acres on Forest Service land (59% of sub watershed)

- Deer Park Ski Area Legacy Site: Obliteration of access roads, re-contour and revegetate graded ski slopes.
- Area 1: Alpine Stables closed road re-contouring.
- Area 2: Recontouring of hillslope up and down stream of road. Installation of culverts on non-motorized road and dips/waterbars on dirt road.

- Alpine Meadows Ski Resort: Upper mountain access road drainage improvements, improvements to parking lot drainage and sediment capture.
- Install dips/waterbars in road not included in area assessments.

Cabin Creek Sub Watershed – 1,668 acres total, 1,027 acres on Forest Service land (62% of sub watershed)

- Area 1: Obliterate access roads and recontour slope to normal gradient. Installation of road drainage structures.
- Area 2: Obliterate access roads. Install road drainage structures on dirt road.
- Area 3: Obliterate access roads. Recontour to put channel into natural drainage.
- Area 4: Install multiple road drainage structures. Obliterate access roads.
- Decommission multiple unauthorized roads and skid trail access routes. Outslope remaining roads and install drainage structures.

Pole Creek Sub Watershed – 3,018 acres total, 2,885 acres on Forest Service land (96% of sub watershed)

- Area 1: Obliterate spur roads and install inside ditches and culverts to return drainage to original channel. Recontour and revegetate slope.
- Area 2: Obliterate access road and recontour slope.
- Area 3: Complete culvert removal and obliterate access road. Reorient current road drainages. Recontour slope above road.
- Install waterbars/culverts on impaired roads not mentioned in Area assessments.

Silver Creek Sub Watershed – 1,054 acres total, 888 F acres on Forest Service land S (84% of sub watershed)

- Area 1: Remove older road fill and outslope areas that are at risk of intercepting flow and contributing sediment.
- Install culverts on impaired roads to allow natural drainage and alleviate road degradation.

Deep Creek Sub Watershed – 2,618 acres total, 1,963 acres on Forest Service land (75% of sub watershed)

- Area 1: Obliterate landing and access roads. Install proper drainage structures on road.
- Area 2: Remove and replace current drainage structures. Outslope and drain road.
- Area 3: Remove stream diversion and recontour. Install drainage structures on road.
- Area 4: Remove culvert; recontour and revegetate. Obliterate landings and access roads.
- Improve road drainage along segment not mentioned in Area recommendations.

Jackass Creek Sub Watershed – 456 acres total, 435 acres on Forest Service land (95% of sub watershed)

- Improve roads and decommission trails.

Landfill Area – 525 acres total, 283 acres on Forest Service land (54% of sub watershed)

- Improve roads and decommission trails.

Prosser Creek Area – below Prosser Reservoir Dam.

- Decommission unauthorized roads/trails and increase water diversions on existing roads and trails.
- The area below Prosser Dam is a small percentage of the Prosser Creek watershed area (less than 5%) but has a very high density of eroding dirt roads, recreational impacts, and legacy sites that contribute sediment directly to the Truckee River

The following areas were not included in the inventory and prescription plan. As noted previously, these areas do impact sedimentation…

Highway 89 Corridor

- Alpine Meadow Horse Trail: Legacy Road Segment
- East Slope/Sawtooth: Big Chief Area, Deer Creek and Minor Tributaries. Initial SWRCI surveys and sediment source area information applies. Proposed road drainage improvements applies from earlier survey work shown on Figure 1.
- Highway 89 South – Eroding cut slopes, extra wide shoulders, inside ditch to culvert. See attachment: Highway 89 South for overview of potential sediment sources. No prescription recommendations are proposed due to multiple ownerships, various utility linear features and road right of ways or easements'.
- River Access Trail – Lake Tahoe to River Ranch (mostly on Tahoe Basin Management Unit). Inventory completed and attached – no prescription recommendations.

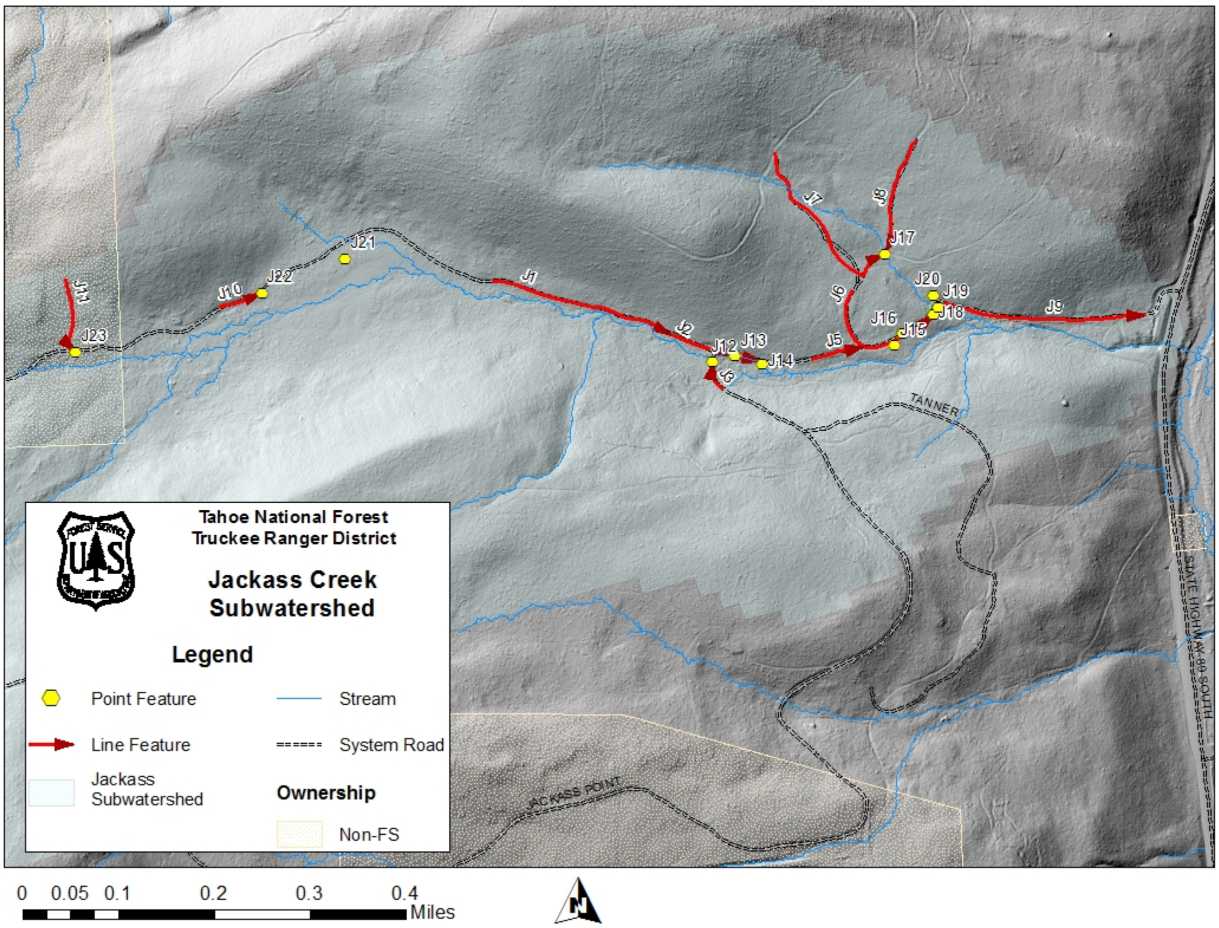
Squaw Creek Sub Watershed – 5,136 acres, 1,209 acres on Forest Service land (24% of sub watershed)

- Two trails in upper watershed. One is main FS trail, the other is undefined user created trail on south side of creek. Main FS trail moderate to good shape but could use drainage maintenance. Trail on south side of creek has a lot of erosion problems and is multiple trails in some locations. The south side trail should be developed into official trail – not all on FS lands.
- Squaw Valley Ski Area and other commercial developments and residential sub division has not been inventoried for sediment sources

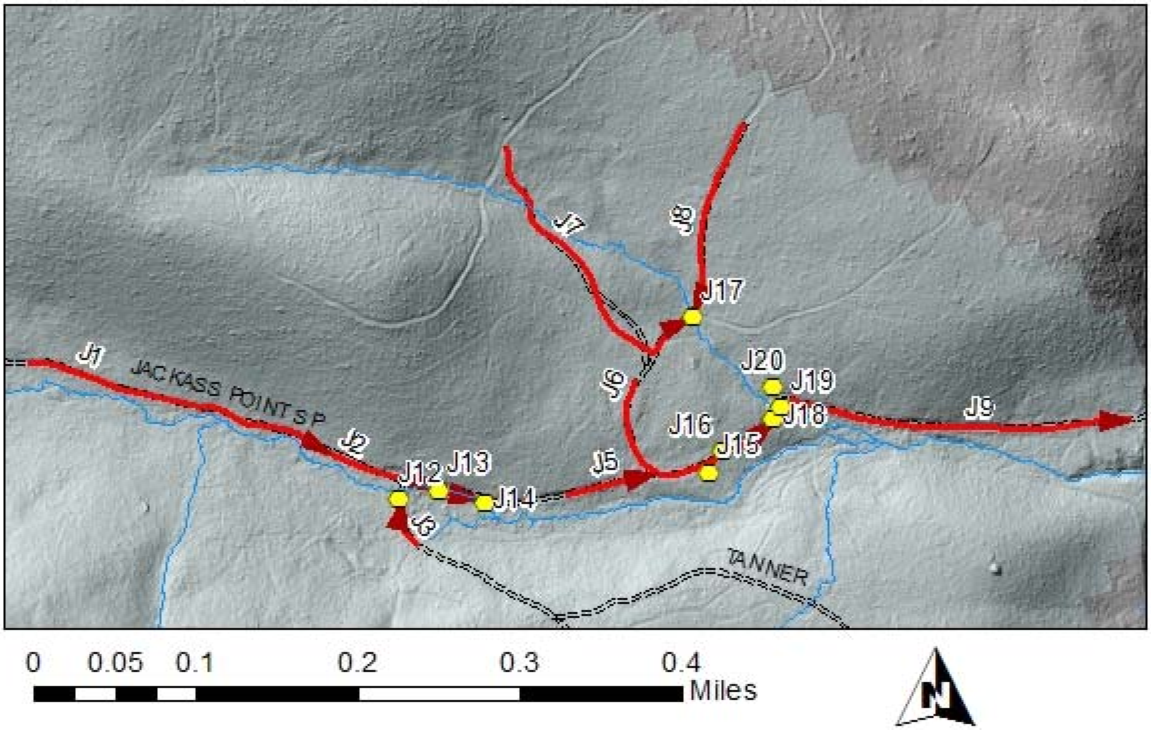
Jackass Creek Watershed Assessment

Description

The development of roads running directly adjacent and parallel to channels are the main source of sediment deposition to Jackass Creek. Many dips have leadouts filled with sediment, and show flow paths filled with sediment entering the channel. One area of this subwatershed has a network of roads with high gradients on failing waterbars that allow road surface runoff to accumulate, allowing the formation of rilling and transport of sediment downslope into nearby water systems.



Road Features



J1: Road segment of Jackass Point Spur road. Waterbars/dips are installed on the length of road on average 200 ft apart on a 5% gradient. Road surface runoff on this length is large enough for leadouts for these road surface drainages to transport sediment through a small buffer and directly into the channel.

J1. Leadout filled with sediment heading towards channel.

J2: Road surface runoff accumulates on this length of Jackass Point spur road and Jackass Point road due to a lack of surface drainage structures. It eventually exits at J13, transporting sediment into channel.

J2. Leadout filled with sediment from runoff from J2 heading towards channel.

J3: Road surface runoff accumulates on this length of Jackass Point road. Nearby landing also contributes the accumulated surface runoff. Runoff and sediment flows over the outlet of this crossing.

J3. Accumulated sediment on runoff flowing over and around outlet of crossing.

J3. Accumulated sediment on runoff flowing from road and nearby landing.

J4: Excess runoff from J2 continues and flows out to next leadout. Transports sediment to channel.

J5: Road surface runoff from this length of Jackass Point road combines with surface runoff from J6.

J6: Road surface runoff on this length of Jackass Point spur road has accumulated to large amounts due to a lack of functional waterbars/dips and has created multiple rills and ruts. This length also captures runoff from J5. Multiple leadouts do capture some runoff and direct it downslope towards Jackass Creek. The remaining runoff exits the road via leadout J18 before reaching the next crossing.

J6. Accumulated surface runoff forming rills and ruts.

J6. Accumulated surface runoff forming rills and ruts.

J7: Road surface runoff from this length of Jackass Point spur road is allowed to accumulate due to no waterbars/dips installed. Runoff flows down this spur road and flows north towards the crossing J17 and J8.

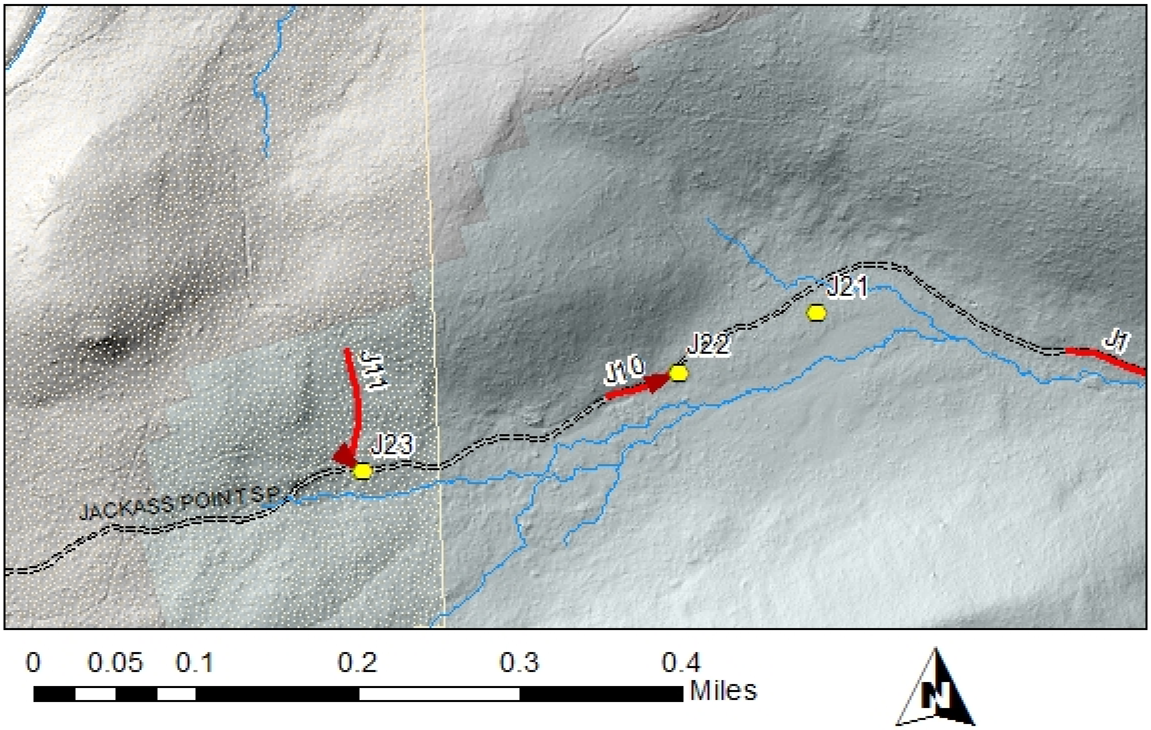
J8: Road surface runoff from this length of Jackass Spur North road is allowed to accumulate due to failing waterbars/dips. Runoff flows down this road and into crossing J17.

J9: Road segment of Jackass Point road. Road surface runoff carries large amounts of sediment. Waterbars are installed approximately 200 ft apart on a 10% gradient. Leadouts are filled with sediment. Sediment is transported directly to Jackass Creek.

J9. Road surface runoff transports large amounts of sediment into leadouts. Runoff is large enough to transport sediment to Jackass Creek.

J10: Road surface runoff of this segment Jackass Point spur road accumulates and transports sediment into leadout J22 that outlets into a meadow.

J11: Skid trail that travels to the north from Jackass Point spur road. This trail is on private property. This trail accumulates large amounts of surface runoff and transports sediment out of leadout J23 and into Jackass Creek.



Point Features

J12: Concrete crossing structure for Jackass Creek. Surface runoff and sediment from J3 flows over the outlet of this crossing and into the channel.

J13: Leadout where runoff and sediment from J2 flows into. This leadout is filled with sediment and continues towards Jackass Creek.

J14: Leadout where runoff and sediment from J4 flows into. This leadout is filled with sediment and continues towards Jackass Creek.

J14. Leadout for runoff from J4. Leadout is filled with sediment and continues into Jackass Creek.

J15: Pullout/landing that captures some runoff and sediment from J6. This area outslopes runoff and sediment into Jackass Creek.

J15. Pullout/landing pooling sediment captured from J6.

J16: Failed waterbars here allow for runoff from J6 to continue down to road and accumulate more surface runoff. The leadout here still captures some runoff of J6 and is filled with sediment. Sediment continues into Jackass Creek.

J16. Failed water bar while leadout still captures runoff from J6. Leadout is filled with sediment.

J17: Stream crossing where surface runoff from J7 and J8 enter the tributary channel. No crossing structure exists for this ephemeral channel.

J17. At crossing looking south where runoff of J7 flows from.

J18: Road begins to outslope before reaching crossing J19: Runoff from J6 leaves road before passing over culvert and enters Jackass Creek.

J18. Runoff from J6 leaving road before flowing over crossing J19. The road outslopes sediment off road and into the creek.

J19: Culvert crossing. Sediment can be seen at the outlet.

J19: Looking at outlet of culvert crossing. Sediment is starting to fill outlet.

J20: A depression that can turn into a sediment pond has developed on a bike trail. This may have been a waterbar to divert runoff from the bike trail, but now appears to pool runoff and sediment.

J20. Looking at a depression on a bike trail heading towards Jackass Point road.

J21: Motor vehicles have access to the meadow south of this point. A sign is posted prohibiting vehicle access. Ruts for tires have developed here and into the meadow.

J21. Looking south at user created trail to access meadow. Tires have created ruts towards the meadow.

J22: Leadout for runoff from J10. Runoff is accumulating enough to fill this leadout and transport sediment further into the meadow.

J22. Leadout filled with sediment from runoff of J10. Sediment continues into a meadow.

J23: Leadout the captures surface runoff from skid trail J11. On private property. Sediment is seen in the leadout and beyond towards Jackass Creek.

J23. Leadout catching runoff from J11.

Proposed Action: Fixing the roads and installing more road surface drainage structures is the best remedy for this subwatershed. The road shape for J1, J4, J9, and J10 should be reshaped to be outsloped. These segments of road do have the proper number of waterbars at the proper distance apart installed for this road design, but the road consist of native surface that is highly susceptible to erosion. Removing surface runoff immediately would be the best way to prevent any amount of runoff accumulation that would start surface erosion. J2, J3, J5, J6, J7, and J8 should have more waterbars/dips installed and current ones maintained. These road segments lack the proper number of waterbars/dips or have poorly maintain waterbars/dips for their road design. Installing new and maintaining current waterbars/dips will prevent flow to accumulate to a capacity that will transport large amounts of sediment. A proper crossing structure such as a culvert should be installed at J17. This will prevent any runoff from road segments J7 and J8 to enter the channel. Skid trail J11 should be obliterated. This trail does not have a functional use and is provided a vector for road surface runoff to accumulate and transport sediment.

Sediment Models

Table 1. Input parameters for road segments in WEPP: Roads Batch. Values are before remediation.

Road Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
J1.1	Insloped, bare ditch	native high	4.59	270	13.12	26.83	8.2	3	38	10	675
J1.2	Insloped, bare ditch	native high	4.59	196	13.12	26.83	8.2	3	38	10	349
J1.3	Insloped, bare ditch	native high	4.59	299	13.12	26.83	8.2	3	38	10	821
J1.4	Insloped, bare ditch	native high	4.59	121	13.12	26.83	8.2	3	38	10	126
J1.5	Insloped, bare ditch	native high	4.59	154	13.12	26.83	8.2	3	38	10	210
J2	Insloped, bare ditch	native high	4.49	379	13.12	11.43	13.12	4.48	1	10	1,108
J3	Insloped, bare ditch	native high	3.93	178	27.88	26.68	13.12	4	1	10	492
J4	Insloped, bare ditch	native high	4.83	145	20.2	16.26	19.68	5.71	70	10	291
J5	Insloped, bare ditch	native high	16	306	14.76	36.59	16.4	6.92	477	10	4,922
J6	Insloped, bare ditch	native high	7.27	784	20	30.49	16.4	20	50	10	11,498

Table 1 (cont.).

Road Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
J7.1	Insloped, bare ditch	native low	11.97	877	11.48	24.39	16.4	8.47	177	10	5,790
J7.2	Insloped, bare ditch	native low	8.47	177	12	11.43	6.56	8.5	1	10	170
J8	Insloped, vegetated or rocked ditch	graveled high	15.52	670	12	4.22	42.64	15	1	10	4,210
J9.1	Insloped, bare ditch	native high	9.5	65	20	17.42	22.96	1.43	71	15	164
J9.2	Insloped, bare ditch	native high	9.5	273	20	17.42	22.96	1.43	72	15	2,644
J9.3	Insloped, bare ditch	native high	9.5	180	20	17.42	22.96	1.43	73	15	1,212
J9.4	Insloped, bare ditch	native high	9.5	191	20	17.42	22.96	1.43	74	15	1,352
J9.5	Insloped, bare ditch	native high	9.5	181	20	17.42	22.96	1.43	75	15	1,216
J9.6	Insloped, bare ditch	native high	9.5	231	20	17.42	22.96	1.43	76	15	1,985
J10	Insloped, bare ditch	native high	5.28	246	15	13.86	18.04	3.38	148	20	680

J1 and J9 were separated into multiple parts to show segments that are divided by waterbars/dips. J7 was separated into two parts as each part had different road characteristics.

Table 2. Input parameters for road segments in WEPP: Roads Batch. Values are post remediation.

Road Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
J1.1	Outsloped, unrutted	native high	4.59	270	13.12	26.83	8.2	3	38	10	41
J1.2	Outsloped, unrutted	native high	4.59	196	13.12	26.83	8.2	3	38	10	30
J1.3	Outsloped, unrutted	native high	4.59	299	13.12	26.83	8.2	3	38	10	46
J1.4	Outsloped, unrutted	native high	4.59	121	13.12	26.83	8.2	3	38	10	19
J1.5	Outsloped, unrutted	native high	4.59	154	13.12	26.83	8.2	3	38	10	24
J2 (2)	Insloped, bare ditch	native high	4.49	189.5 (2)	13.12	11.43	13.12	4.48	1	10	520
J3	Insloped, bare ditch	native high	3.93	178	27.88	26.68	13.12	4	1	10	492
J4	Outsloped, unrutted	native high	4.83	145	20.2	16.26	19.68	5.71	70	10	40
J5 (2)	Insloped, bare ditch	native high	16	153 (2)	14.76	36.59	16.4	6.92	477	10	2,586
J6 (4)	Insloped, bare ditch	native high	7.27	196 (4)	20	30.49	16.4	20	50	10	3488

Table 2 (cont).

Road Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
J7.1 (6)	Insloped, bare ditch	native low	11.97	146.17 (6)	11.48	24.39	16.4	8.47	177	10	1110
J7.2	Insloped, bare ditch	native low	8.47	177	12	11.43	6.56	8.5	1	10	170
J8 (7)	Insloped, vegetated or rocked ditch	graveled high	15.52	95.71 (7)	12	4.22	42.64	15	1	10	595
J9.1	Outsloped, unrutted	native high	9.5	65	20	17.42	22.96	1.43	71	15	64
J9.2	Outsloped, unrutted	native high	9.5	273	20	17.42	22.96	1.43	72	15	270
J9.3	Outsloped, unrutted	native high	9.5	180	20	17.42	22.96	1.43	73	15	178
J9.4	Outsloped, unrutted	native high	9.5	191	20	17.42	22.96	1.43	74	15	189
J9.5	Outsloped, unrutted	native high	9.5	181	20	17.42	22.96	1.43	75	15	179
J9.6	Outsloped, unrutted	native high	9.5	231	20	17.42	22.96	1.43	76	15	229
J10	Outsloped, unrutted	native high	5.28	246	15	13.86	18.04	3.38	148	20	54

J2, J5, J6, J7.1, and J8 were separated into smaller lengths post remediation. This is to represent the divisions of road segments due to the installation of waterbars/dips. J1, J4, J9, and J10 were modified to on outsloped road design.

Table 3. Sediment loss values before and after remediation.

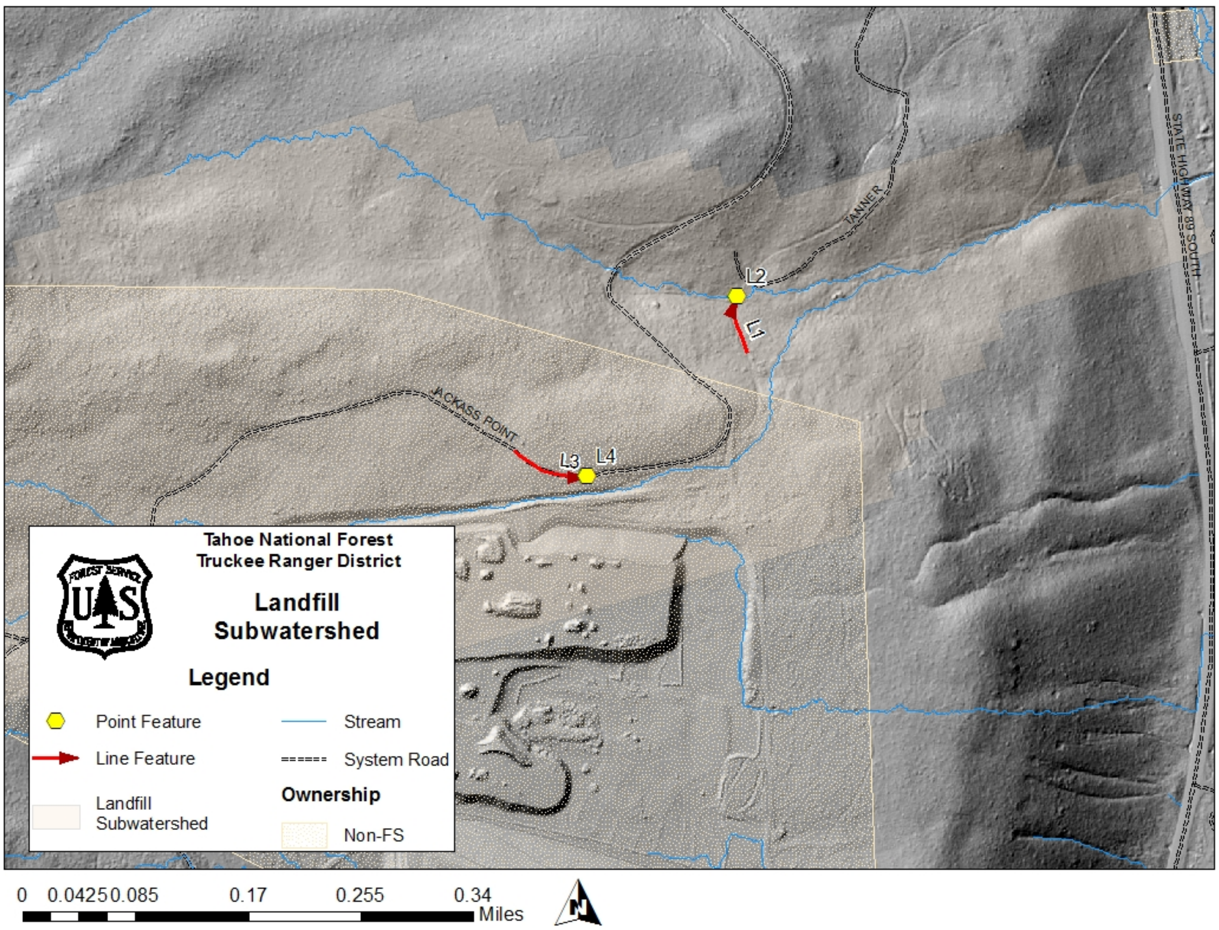
	Current Conditions	Post Remediation	
Road Segment	Annual Sediment Leaving Road (lbs)	Annual Sediment Leaving Road (lbs)	Percent Reduction
J1.1	675	41	93.93
J1.2	349	30	91.40
J1.3	821	46	94.40
J1.4	126	19	84.92
J1.5	210	24	88.57
J2	1,108	520	53.07
J3	492	492	0.00
J4	291	40	86.25
J5	4,922	2,586	47.46
J6	11,498	3488	69.66
J7.1	5,790	1110	80.83
J7.2	170	170	0.00
J8	4,210	595	85.87
J9.1	164	64	60.98
J9.2	2,644	270	89.79
J9.3	1,212	178	85.31
J9.4	1,352	189	86.02
J9.5	1,216	179	85.28
J9.6	1,985	229	88.46
J10	680	54	92.06
Total	**39915**	**10324**	**74.14**

J3 and J7.2 see no change as their lengths are too short to implement more waterbars. Overall there is a 74.14% reduction after the changes are implemented.

<u>**Landfill Area Watershed Assessment**</u>

Description

The Landfill subwatershed consist of an area north of the Placer County Eastern Regional Landfill and south of the Jackass Creek subwatershed. Access to this subwatershed are found on the Jackass Point road either from the south through Cabin Creek or the north from Jackass Creek. Most channels in this subwatershed are ephemeral. There are no strong erosion events found in this area, and the small few appear unrelated to the usage of the landfill. There are multiple skid trails and drainages that appear on Lidar, but many of them appear stable and show no signs of erosion.



List of Features

L1: Road surface runoff on this length of skid trail enters the ephemeral channel at crossing L2.

L2: Incision at crossing outlet. There is no crossing structure installed here. Surface runoff from skid trail L2 flows directly into this channel at this crossing.

L3: Road surface runoff from this length of Jackass Point road is accumulating enough runoff to transport sediment to turnout L4.

L4: Turnout off Jackass Point road is diverting road runoff from length of road L3.

Proposed Action:

The skid trail L1 can be obliterated as the trail is not a Forest Service system trail or road. Removal of the trail will prevent any surface runoff from the trail to flow into the channel. Removal of this vector of surface runoff will allow the channel to stabilize and no longer incise. Additional waterbars/dips to the length of road L3 will reduce the amount of accumulated flow leaving the turnout L4. A lower amount of flow will lower the capacity for the sediment to be transported to the channel.

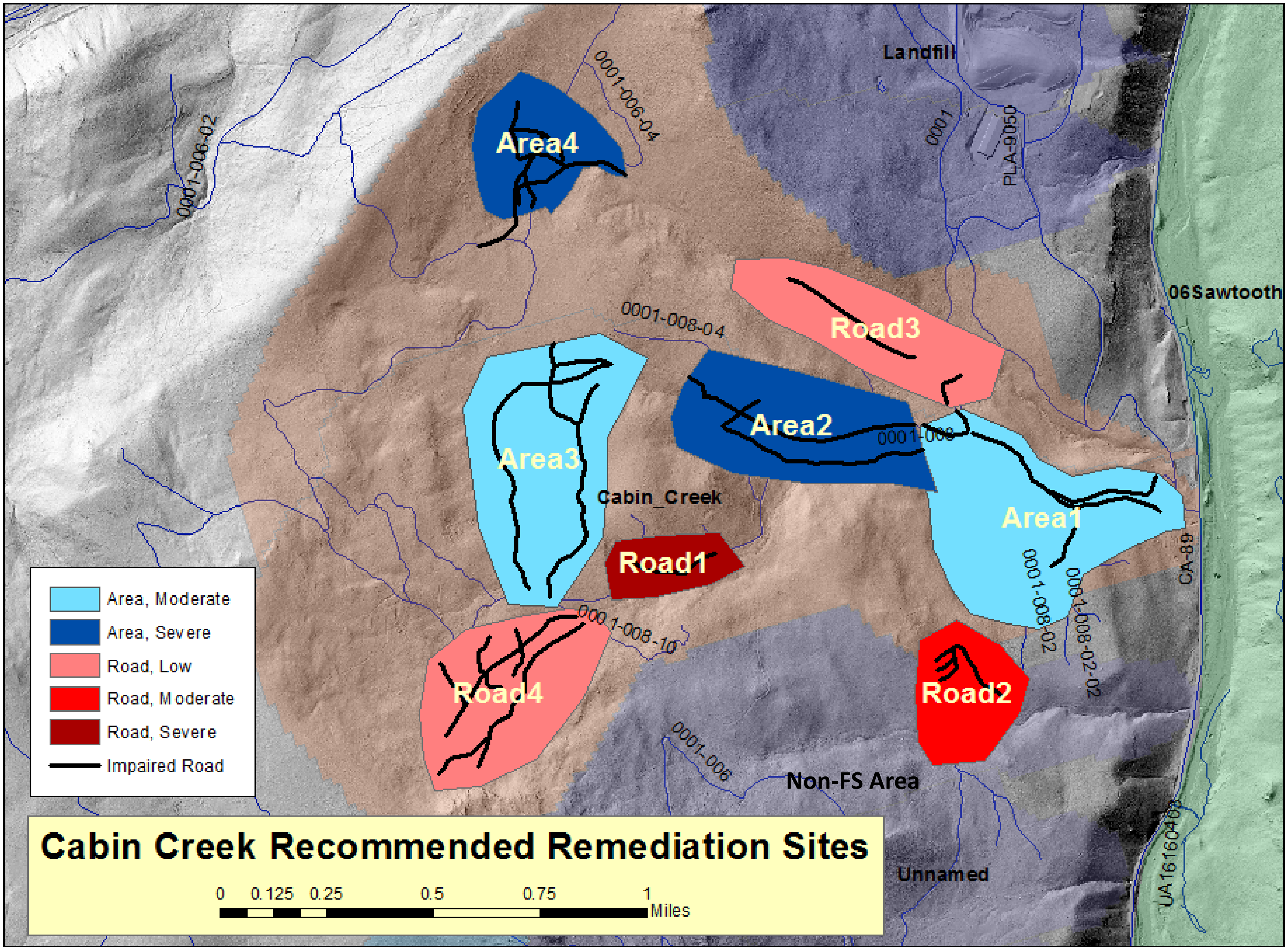
Sediment Model

Table 1. Input parameters for road segments for modeling. WEPP: Roads Batch was used to model and determine output.

Road Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
L1	Insloped, vegetated or rocked ditch	native none	16.31	233	13.12	16.01	26.24	16.3	1	25	122

The proposed action consists of obliterating L1. The removal of this skid trail should effectively remove any sediment transport into the nearby channel, lowering sediment loss by 95-100% of its current value.

Cabin Creek Watershed Assessment



	Site	Priority	Major Concerns	Recommendations
Area	**1**	2	Skid trails/roads channel flow that is actively eroding the roads	Obliterate road and skid trails
	2	3	Heavily rutted active and abandoned roads	Obliterate abandoned road and add proper drainage structures to current road
	3	2	Abandoned roads channeled surface flow from Areas 3 and 2	Obliterate Skid Trail 3; properly drain Skid Trail 2
	4	3	Skid trails and roads are headwaters for drainage	Obliterate skid trails; install adequate drainage structures along road
Road	**1**	3	Asphalt road is heavily rutted	Road maintenance including asphalt removal
	2	2	Skid trail remediation failing drastically	Obliterate skid trail
	3	1	Skid trail cutslope is eroding	Mesh and revegetate bare slopes
	4	1	Skid trails create headwaters for drainage	Rockfill drainages at skid trail crossings
Non FS		2	Abandoned and modern trails are channeling flow allowing for incision at headwaters of drainages.	Make contact with private landowners to discuss possible in-depth assessment and remediation

Summary:

Primary remediation recommendations for the Cabin Creek sub watershed are to obliterate 3.2 miles of abandoned logging trails, and install proper drainage structures on 0.8 miles of poorly drained modern trails and unpaved roads. This will result in an annual reduction of 12.052 tons of sediment that enters the Truckee River from the Cabin Creek sub watershed.

We also recommend plugging and/or rock-filling unnatural headwater channels resulting from legacy logging activities including clear-cutting, surface grading landings, and skid trail placement. This will result in the restoration of the natural hydrology to 184 acres in the upper catchments of the watershed.

The Cabin Creek sub watershed is segmented into 4 separate drainages, each draining directly into the Truckee River. Two of these drainages are almost entirely on USFS land, except for their upper reaches. The northern drainage (Drainage D), as delineated for the purpose of this report, overlaps with the Landfill sub watershed (please refer to the Landfill section of the report for more details on the assessment). Cabin Creek's southern drainage (Drainage C) is almost entirely on privately owned land, but does put substantial pressure on proposed solutions within forest service land. Therefore we include a general assessment of the conditions that negatively impact the watershed and a recommendation for timely communication and collaboration with the private landowners.

*NOTE: In figures of this report the term skid trail was used prior to proper understanding of the use of that term. Therefore, in text and tables we use the term abandoned roads to refer to those roads that are titled skid trails in figures.

Area 1

Current Situation – Channeled flow brought in along skid road of Area 2 combines with channeled flow of Road 1 in the northwest part of this area. This combined flow then spills over the road and erodes Slope 2 or is captured by Skid Trail 3 and the ML-2 road that parallels it. At Photo A the skid trail and ML-2 road meet, as does their drainage. Some of this is diverted down to Slope 3, which has eroded due to this flow. Any additional drainage is channeled by Skid Trails 4 and 5. Skid Trail 4 has several drainages; however, these run directly into Skid Trail 5, which has no drainage structures, allowing the flow to regain velocity and turbidity and erode road segment 5.

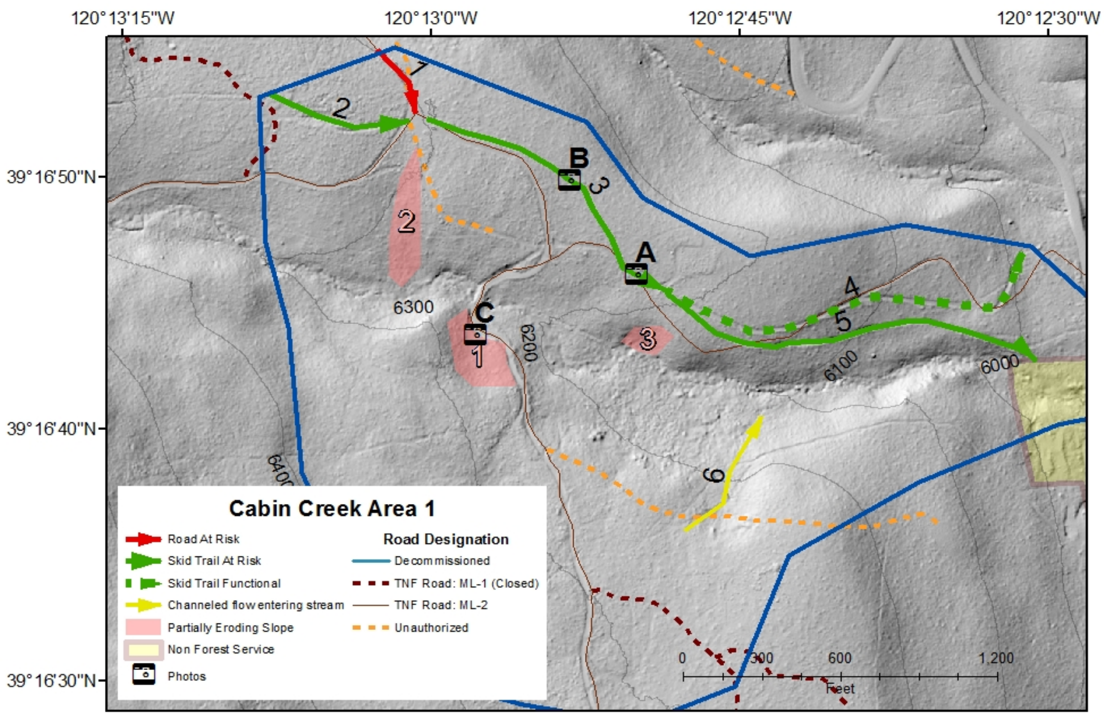
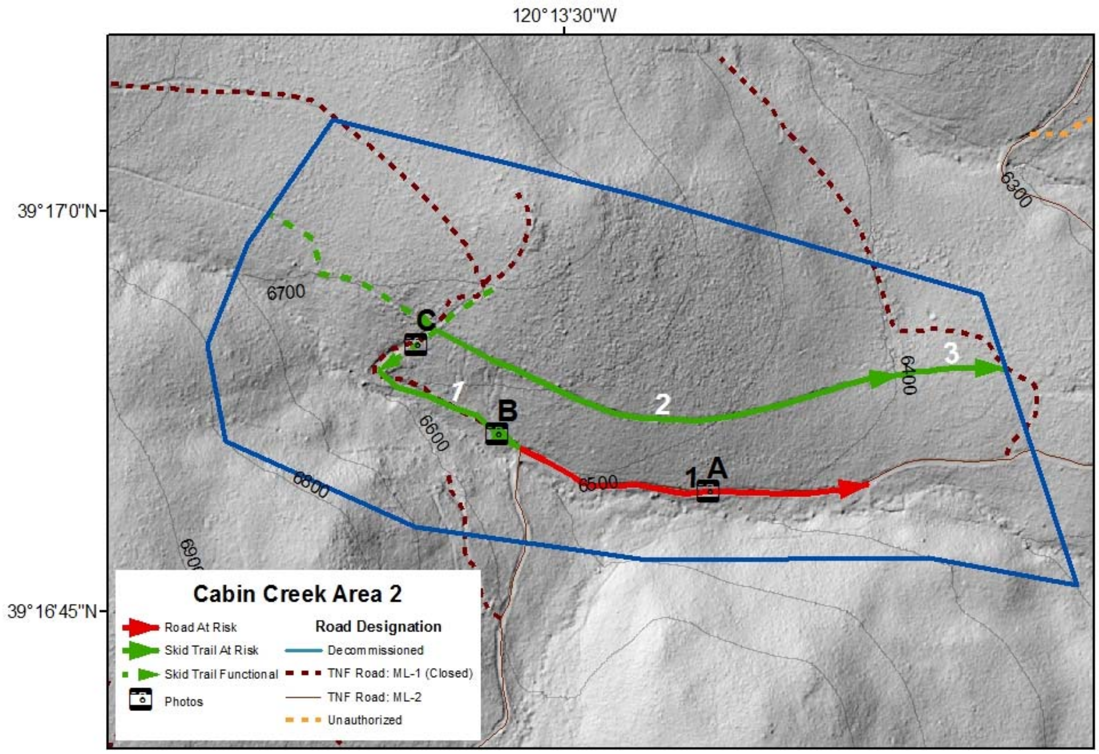


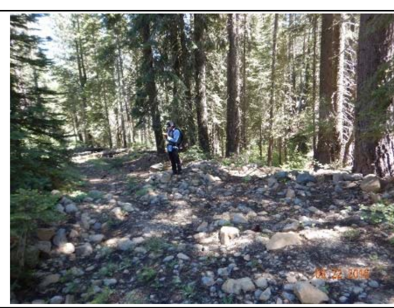
		
Photo A **Heading: 300** 300 ft. of road drainage and 500 ft. of skid trail drainage meet here and is diverted south. Flow remains channeled to downslope stream.	**Photo B** **Heading: 135** Skid Trail 3 catches overflow from roads 1 and 2 (above) and this captured flow has incised approximately 4 ft.	**Photo C** **Heading: 245** Cutslope of road exposes loose sediment that is captured along inslope and dumped directly into stream channel.

Proposed Action - Skid Trail 3 needs obliterated and recontoured to eliminate its capability to keep channeling overflow from Road 1 and the skid road in Area 2. The road directly south of Skid Road 3 functions properly until it reaches the intersection between photo A and C. At this point the eastern junction of the road catches drainage and is moderately rilled until it reaches the leadout at photo A. High flow situations have led to scouring and rilling of this leadout; flow remains channeled and sediment in the channel can be transported directly into Cabin Creek. Skid Trail 4 has numerous waterbars and leadouts making it functional, however these dump directly into Skid Trail 5, which has no drainage structures. The fillslope of Skid Trail 5 consists of a 4 foot high berm that needs removed to allow proper drainage. Lastly, Eroding Slope 1 needs meshed and revegetated to reduce sediment influx into Cabin Creek.

Area 2

Current Situation: The main channel that began in Area 3 continues through this area. The skid trail that began in the northern part of Area 3 continues through here, although west of the intersection with the ML-1 Road (Photo C in the figure), the road is well vegetated and probably only carries water during large storm events. After the intersection at Photo C Skid Trail 2 is less vegetated and rilling and gullying suggest it carries a significant amount of water and picks up sediment. Some of the drainage is diverted along the ML-1 Road at Photo C and is then captured by Skid Road 1. The presence of boulders at the leadout at Photo B attest to the amount of sediment brought into the main channel from Skid Trails 1 and 2.



		
Photo A **Heading: 180** Leadout from road contains abundance of silt which can be traced to stream <40ft downslope.	**Photo B** **Heading: 135** Leadout from road has significant boulder sized clasts that are not present further down road. This outlet is <30ft above channel.	**Photo C** **Heading: 225** Leadout from road diverts flow from road, but flow remains channeled and is captured by skid road 1 further downslope.

Proposed Action - Ultimately the preferred remediation would be to obliterate both E-W trending roads in this section. Sheetflow is being channeled along both, increasing velocity and turbidity of the stream once both drain into the channel, and rilling and scouring of the road and trail adds to sediment influx into Cabin Creek. Because Skid Trail 2 is no longer in use, we recommend full obliteration; however proper drainage structures will probably alleviate most of the problem provided action is taken on the downslope ML-2 road, Road 1. While full obliteration of the ML-2 road would be ideal, the road can be left in its present location provided it is ripped and proper drainage structures such as waterbars are emplaced along this section. The N-S skid trail at the southwest of this area catches drainage and should also be removed.

Area 3

Current situation – North to South trending skid trails are capturing sheetflow on the western and eastern sides of this area. The western skid trail has numerous waterbars and leadouts and is considered functional; no channels were observed coming from these. The eastern skid trail has significantly fewer drainage structures and therefore captures enough flow that when it does exit the trail, it does not disperse but remains channeled. There are obvious vegetated areas that were previously watered by dispersed flows are now captured by the skid trail. Skid Trail 2 crosscuts the natural drainage of a meadow capturing the normally dispersed flow. The captured runoff in the skid trail spills over and creates a channel at Photo A that is immediately captured by an old road and diverted along the northern slope.

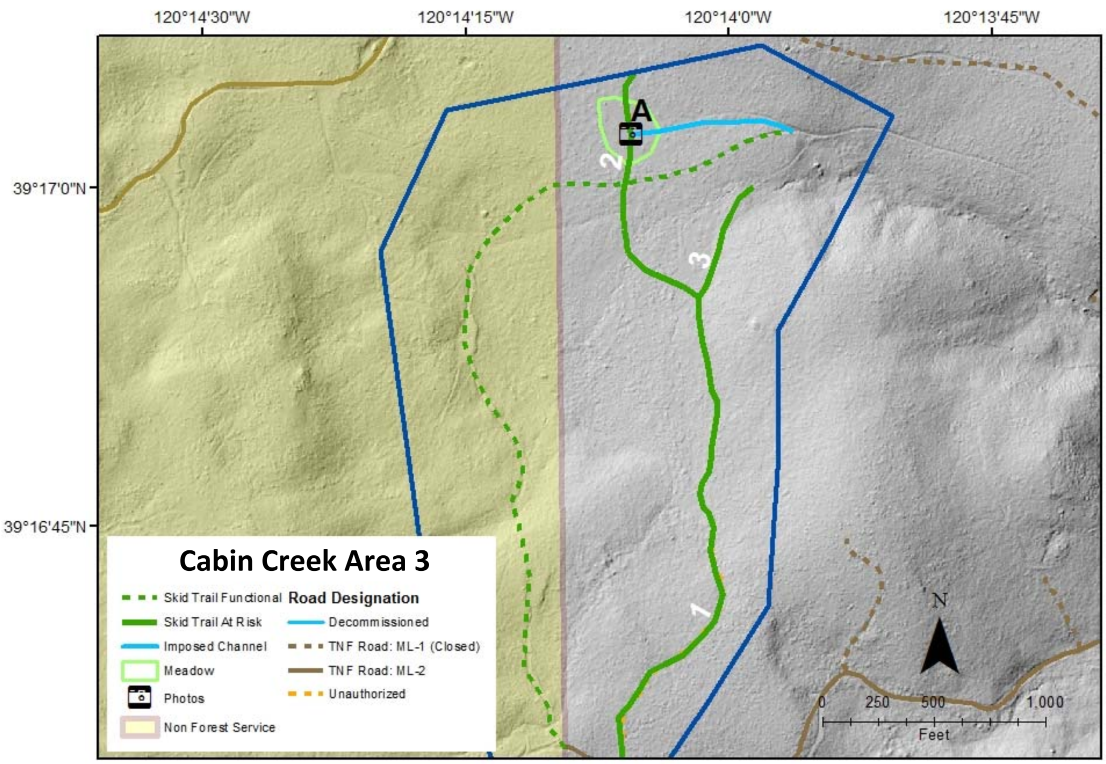
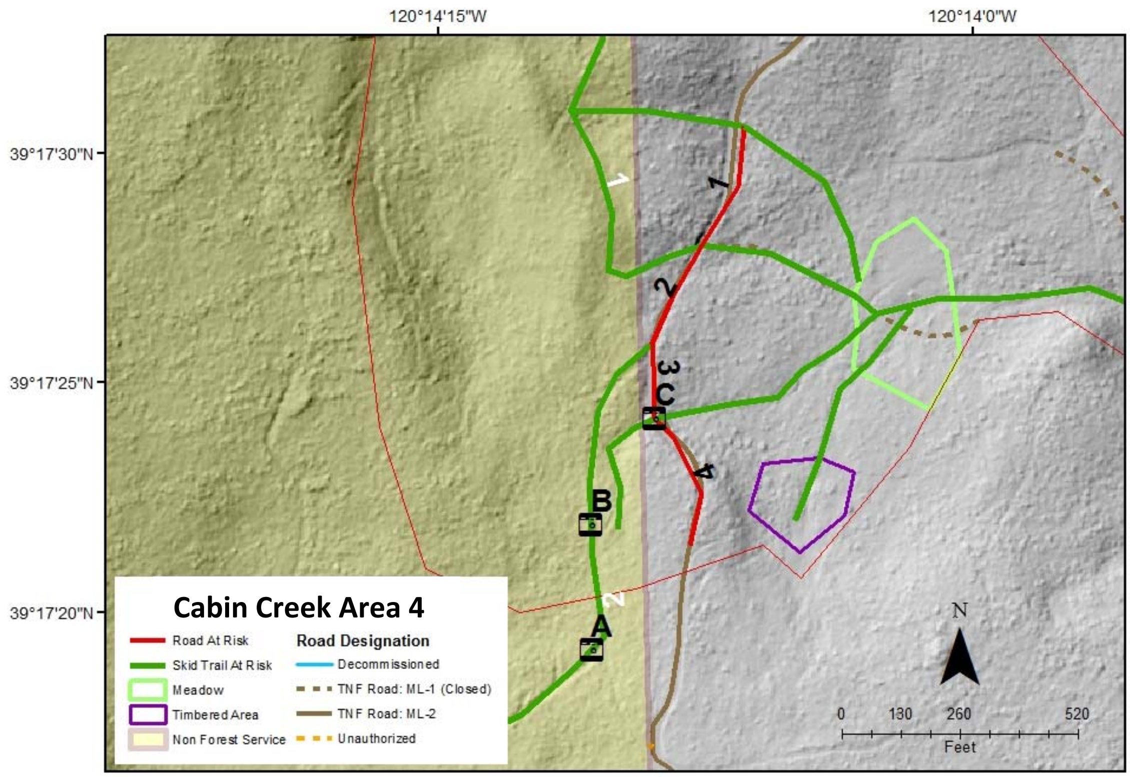


	**Photo A** **Heading: 180** Road through meadow causes normally dispersed shallow lateral flow to surface and concentrate, beginning channel that is captured by skid road to east

Proposed Action - We suggest obliterating the eastern, N-S trending skid trail segments 1-3 shown in in Area A- 3. Although sediment contributions through this section are probably only moderate, the road has captured flow from the through cut into the slope and intercepts hillslope water disrupting flow to the main channel (Photo A) and increasing sediment transport and having an increased long-term risk of erosion and capture of hillslope water. We also suggest plugging the main channel that flows out from the north east of this section as this will help to 1) reduce the influx of sediment added to the road channel in Area 2; and 2) reduce channel velocity and turbidity and therefore reduce sediment created by scouring of the main channel.

Area 4

Current Situation - Skid trails 1 and 2 still have exposed soils and are moderately rilled along several sections (Photos A and B). Low spots and exits in these roads have created channels that have eroded the hillslope; this erosion can be observed in LiDAR images of the area. The channels are captured and diverted by the FS 01-6 road, (Photo C), but then come together at a meadow on the eastern side of the drainage. This channel is the headwaters for Drainage 2.



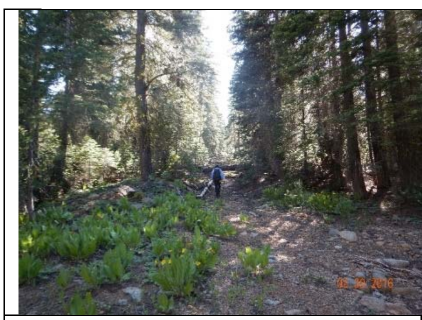


Photo A **Heading: 225** Skid trail is capturing drainage. Trail is moderately eroded. Drainage continues into trail of Photo B	**Photo B** **Heading: 000** Skid trail is capturing drainage and creating channel. Trail is moderately eroded. Sparse vegetation.	**Photo C** **Heading: 90** Incised channel created by skid trail and road channeling. This begins headwaters for this drainage.

Proposed Action – Work with the land owner to see if the skid trails in the privately owned areas can be improved to reduce runoff and concentration of water. If possible, see if the area can be remediated to alleviate effects to the headwater area and reduce channelization of Drainage #2 as the active erosion is contributing sediment to Cabin Creek. The N-S trending FS 01-6 road through the center of Area B-2 would best be taken care of by obliterating the road. As this road is moderately used, covers both Forest Service and non-Forest Service area, and allows for backroad access to multiple watersheds, obliteration is not a viable alternative. Instead, FS 01-6 road needs to be ripped and restructured with numerous drainage structures spaced at most 75 ft. apart throughout this section. Channel incision through the meadow is not deep enough to justify action in the meadow, provided the road is functioning properly.

Road 1

The road in this area is heavily rilled and scoured. It was previously paved, but almost 50% of the pavement has been eroded away.

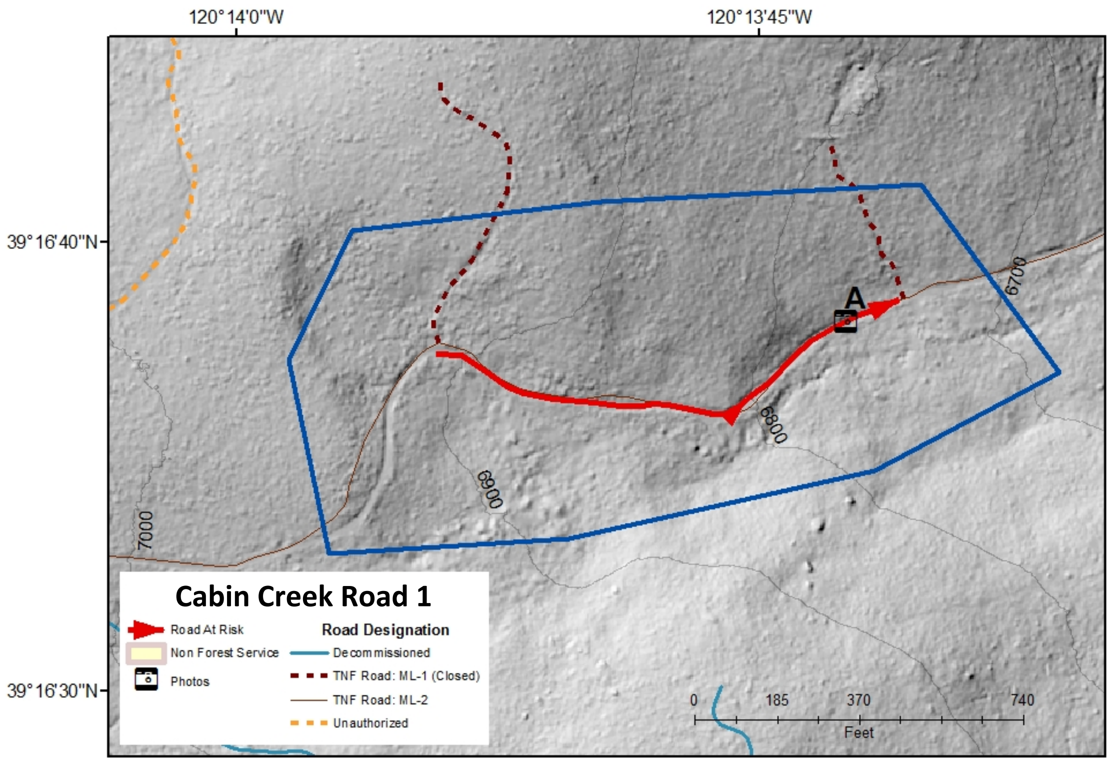


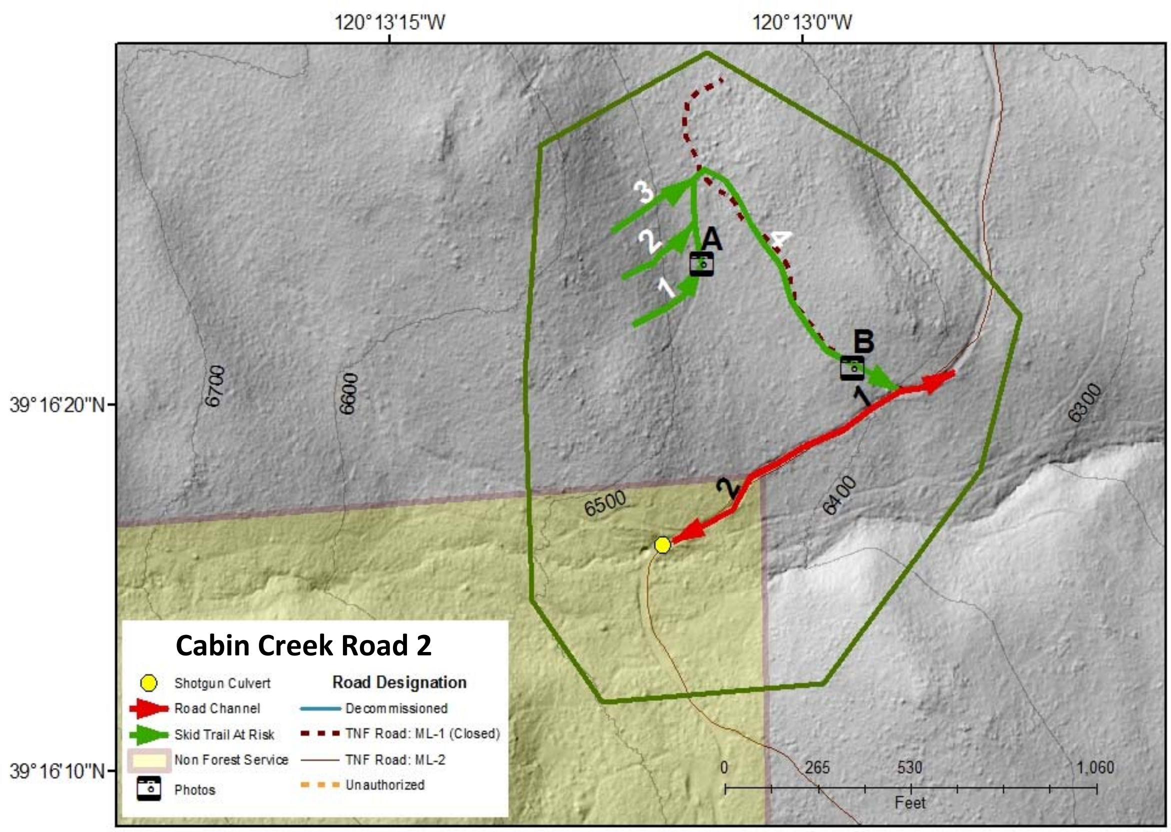
Photo A
Heading: 250

500 ft. of east travelling road captures and channels southerly directed sheetflow. Road is significantly rilled and rutted. The only drainage structure present is one waterbar that empties <10ft above the channel.

Proposed Action - This road segment does is over steepened and poorly located it would be best to decommission this segment to eliminate sediment production and restore the adjacent riparian area. However, this road does connect into private land, initial measures to control erosion were to seal the surface with chip seal. To minimize erosion this would be the best solution if this road segment is retained. The chip seal should occur over the drivable dips as the road is too steep to retain a gravel surface over the road segment. Chip seal with dips will significantly reduce sediment influx due to road erosion. At a minimum, the road needs proper drainage structures emplaced at 75 foot intervals throughout the section.

Road 2

Only a brief overview of Drainage C was conducted due to it being dominantly in Privately Owned area. However, we did look at one section immediately within the Forest Service boundary. An old skid trail exists that has several spurs continuing upslope. These spurs are sparsely vegetated and allow for capture of slope runoff. This captured flow is then channeled onto the 'main' skid trail, 4. This trail has several water bars and berms, but most of these show evidence of failure, with large mounds of deposition at their outlets and incision through the berms that keeps flow channeled on the road. Flow that is channeled on the skid trail enters Road 1, where it scours the road before it drains onto the hillslope and is then channeled into the main drainage.



Proposed Action – Because practices employed are unsuccessful, we recommend obliterating this road and recontouring the slope to reduce erosion off this trail and the road downslope. Adding proper waterbars along the road every ~100 ft. should significantly reduce any other sediment influx from this site into the creek.

	
Photo A **Heading: 250** Erosion of skid spur at Skid Trail 1	**Photo B** **Heading: 135** Skid Trail 4 erosion controls have failed, channels maintain on road

Road 3

Current Situation – An old skid trail follows the drainage about 100 ft. above the channel on the northern slope. The skid trail is moderately vegetated and has functional drainage structures throughout its length. However, the cutslope has a lot of exposed loose soil along its length, (Photos A and B). This exposed soil is actively eroding and, because of proximity to the channel, is entering the channel along this length. Sediment from the road cut at Cutslope Erosion 3 is also deposited directly into the channel. Road 1 captures runoff and is moderately rilled; this flow is diverted off the road by an old skid trail that has been converted to a camping site. The diverted flow remains channeled, showing some rilling that can be traced to the main channel.

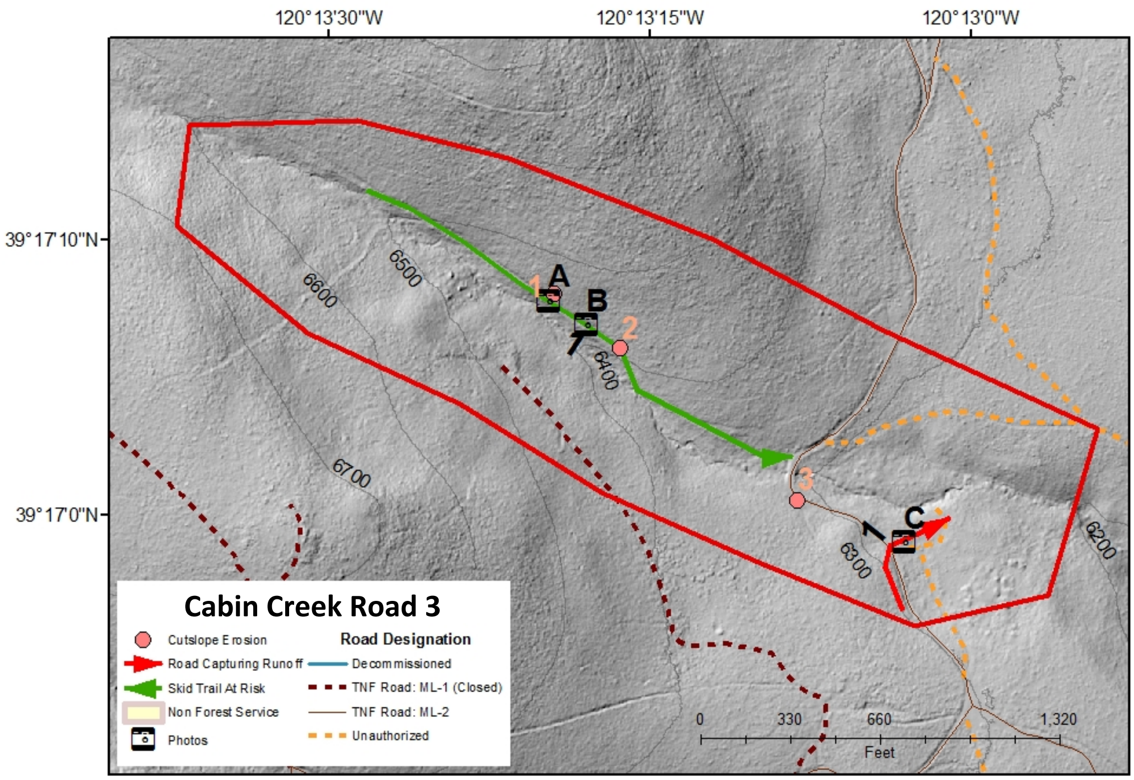


		
Photo A **Heading: 330** Cutslope erosion along Skid Trail 1.	**Photo B** **Heading: 120** Sheet erosion over bare soil above Skid Trail 1 that is caught and channeled for ~150 ft. before depositing into creek.	**Photo C** **Heading: 250** Drainage captured by road is diverted onto landing and remains channeled until it reaches creek.

Proposed Action – The cutslope of the skid trail needs recontoured and revegetated in several locations. Leadouts and waterbars along skid trail need reworked to function properly. Waterbars need to be emplaced along Road 1 every ~75 ft. to eliminated channel through landing.

Road 4

Current Situation - Skid trails perpendicular to slope have channeled sheetflow and concentrated it into two imposed drainages that mark the headwaters for the main channel of Drainage 1. These skid trails are on Non-Forest Service land, but they incise moderately once they reach FS land, (Photo C).

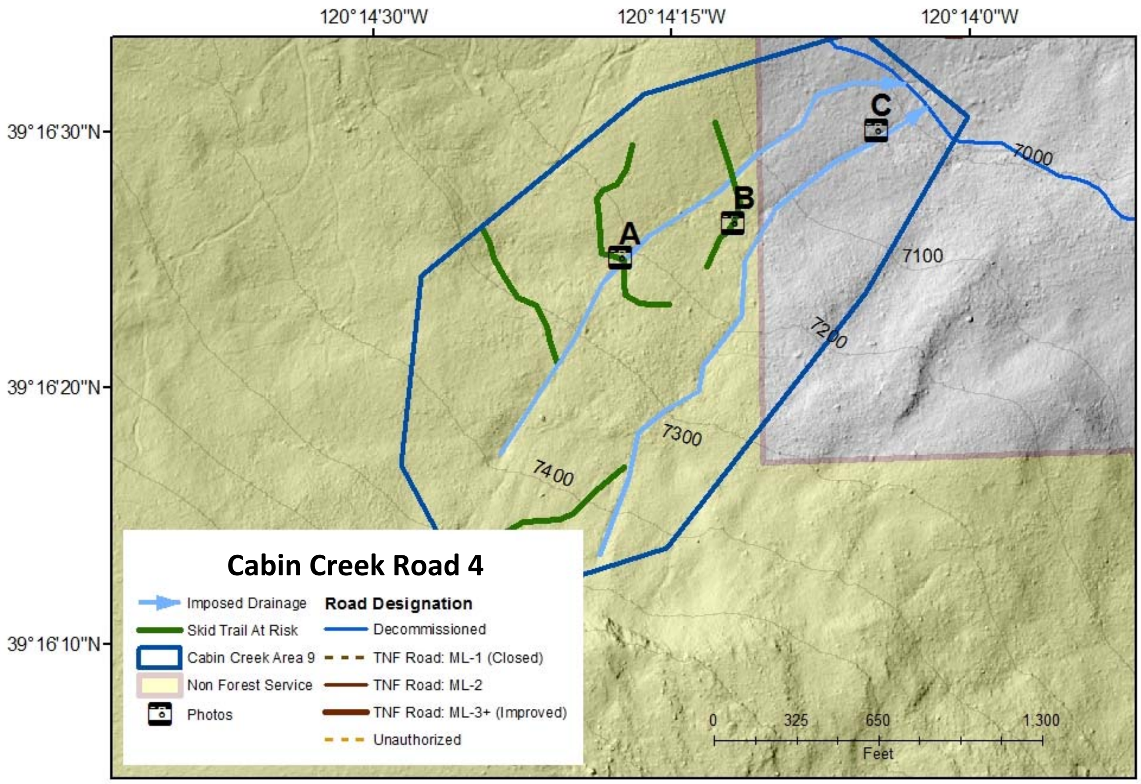




Photo A	Photo B	Photo C
Heading: 300	**Heading: 045**	**Heading: 315**
Skid trail is capturing drainage and creating channel at low spot in road.	Skid trail is capturing sheetflow which is now channeling and somewhat incising.	Channel possibly induced by skid trails is now more moderately incised to a depth of about 4 ft.

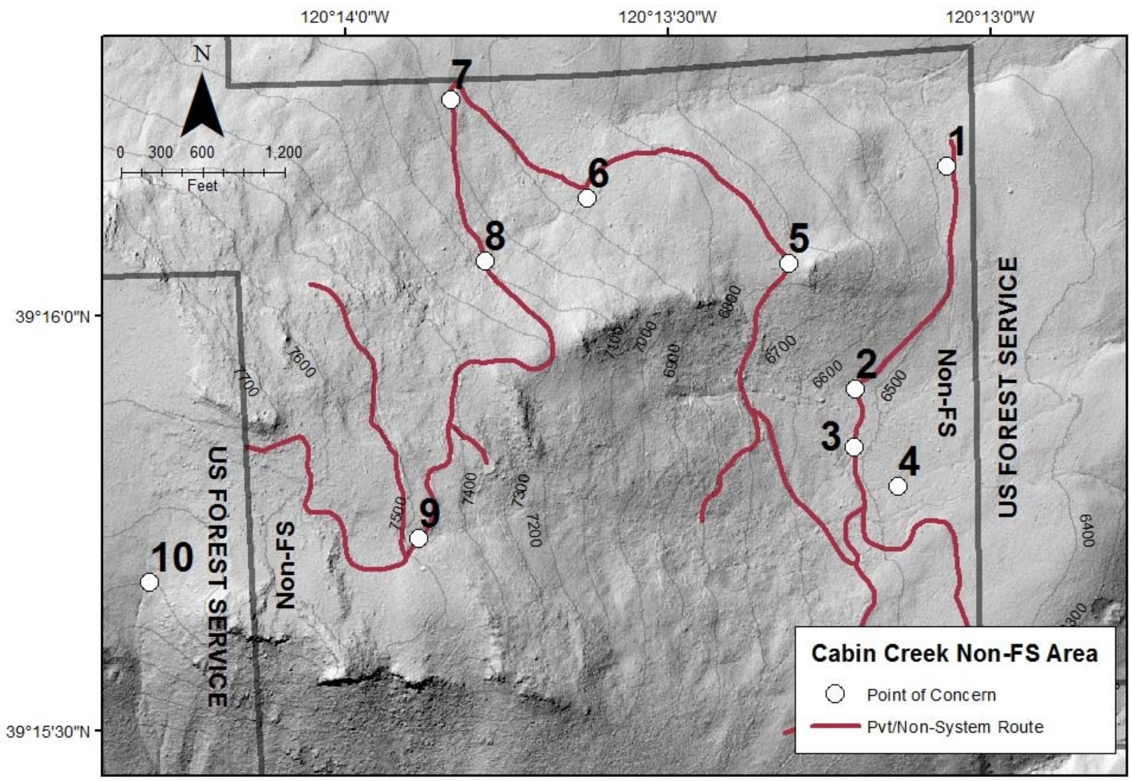
Proposed Action – The preferred remediation would include obliteration of these trails. With remediation of the skid trails additional measures to restore stream channel/dry meadow hydrology within the forest boundary. Approximately 0.87 miles of stream channel would be infilled with rock or sod riffles and where capable infilled to restore stringer meadow capability. This would allow for revegetation, reduce erosion and increase the capacity of sediment distribution in the stringer meadow.

Non-Forest Service Area

Overview of Problems:

Because the issues presented here are on Non-Forest Service lands, a comprehensive analysis of each point was not conducted. Rather they are presented here simply to identify sites where substantial volumes of sediment is being picked up and transported within these drainages and ultimately into the Truckee River. Efforts need to be made to contact landowners in the area to establish plans of remediation.

Much like the rest of Cabin Creek, drainage patterns in this area can be characterized as having been heavily impacted by logging activity and associated roads and skid trails. In some cases the trails capture and channel sheet flow, becoming headwaters for streams; in others the roads/trails divert an existing channel or stream; others are just poorly constructed and are therefore actively rutting and eroding. 9 such locations have been identified and are described individually.



Area of Concern 1

Road construction activities at Area of Concern 1 have led to large piles of loose sediment that can be transported during high precipitation events along road into the drainage to the north.

	
Photo 1A **Heading: 315** Excess dirt from road construction activities is piled and left along roadside. This dirt is easily washed away during rain events	**Photo 1B** **Heading: 270** Excess dirt from road construction activities is piled and left along roadside. This dirt is easily washed away during rain events

Area of Concern 2

An old E-W access road crosscuts the N-S road at this point, leading to an old landing in the west and a drainage to the east. This access road parallels a channel's northern bank, catching runoff from the northern slope. Drainage structures are present but no longer function properly to divert water from the access road and down into the channel. Instead, water that is kept on the access road is picking up energy, increasing scour and rilling of the road. This concentrated flow eventually rejoins the channel just before the channel spills the hill to the east; scouring and incision of the hillslope is increased because of the energy of the water that was previously channeled by the access road.

Area of Concern 3

Several skid trails in this area divert upslope from the main road. These skid trails are not hydrologically remediated; they are poorly vegetated, have a lot of loose sediment, and drain directly into the road below as can be evidenced by rilling. The road itself shows signs of water transport and erosion and requires proper drainage structures to alleviate channeling along the road.

Photo 3
Heading: 315
Excess dirt from road construction activities is piled and left along roadside. This dirt is easily washed away during rain events

Area of Concern 4

An access road runs east from the 'main' road and crosscuts the natural drainage of a small meadow. This allows the access road to divert water from the meadow along the road. This drainage leads to a small cut in the hillslope to the east that can be clearly identified on LiDAR (see map above). This access road needs obliterated to restore the natural dispersed flow.

Photo 4
Heading: 090
This small meadow is no longer adequately hydrated due to diversion of water east along the access road.

Area of Concern 5

Road is heavily rilled and rutted. It carries a significant amount of water south for several hundred feet before diverting into the spot where the E-W access road and N-S main road intersect. The spot of intersection is very well vegetated and seems to be functioning properly. Coarse sediment from road erosion is no doubt deposited in the vegetation; fines may still remain in channel during high precipitation events.

	**Photo 5** **Heading: 180** Substantial road erosion at this location; however this drains into a very well-vegetated channel that probably works to significantly reduce the amount of sediment in the water.

Area of Concern 6

Two abandoned access roads come from upslope to the south and southwest of this point. These roads carry water in presumed high velocity channels as evidenced by size of boulders left in drainage. The present day road is itself carrying water from the northwest. All three combine and drain in a channel towards the north-northwest. The abandoned access roads need demolished and the present road corrected with proper drainage structures to reduce channel velocity in the NNW drainage.

	
Photo 6a **Heading: 285** Access road channels and main road channels converge at this point. Velocity of flow is evidenced by size of boulders in drainage (right side of photo).	**Photo 6b** **Heading: 180** Access road channels and main road channels converge at this point. Main channel is moderately rilled and eroded at this point.

Area of Concern 7

Massive cutslope at this hairpin turn is actively eroding. Road is entrenched on upslope side and is eroding both sides. Road itself is rilled and rutted adding more sediment to runoff.

	
Photo 7a **Heading: 270** Massive cutslope is actively eroding. Vegetation is sparsely holding on at top	**Photo 7b** **Heading: 135** Road is eroding as well. It is rilled and rutted. Size of transported clasts can be seen in photo.

Area of Concern 8

Small channel is diverted by road and begins stream that is caught again further downslope to NE by abandoned roads. Suggest properly draining this this road and the downslope abandoned roads.

Area of Concern 9

Road in this area carries a lot of water and is significantly rilled. Some water comes from the abandoned road upslope that parallels this road. The one outlet from road diverts flow downslope but because it is already channeled it begins to incise. Downslope, an old road from a landing also carries water and contributes to the headwaters of this channel. Suggest obliterating old abandoned roads and properly draining this road.

	**Photo 8** **Heading: 160** Road capturing channel from west (right in photo). This channel is diverted and captured downslope by abandoned roads.

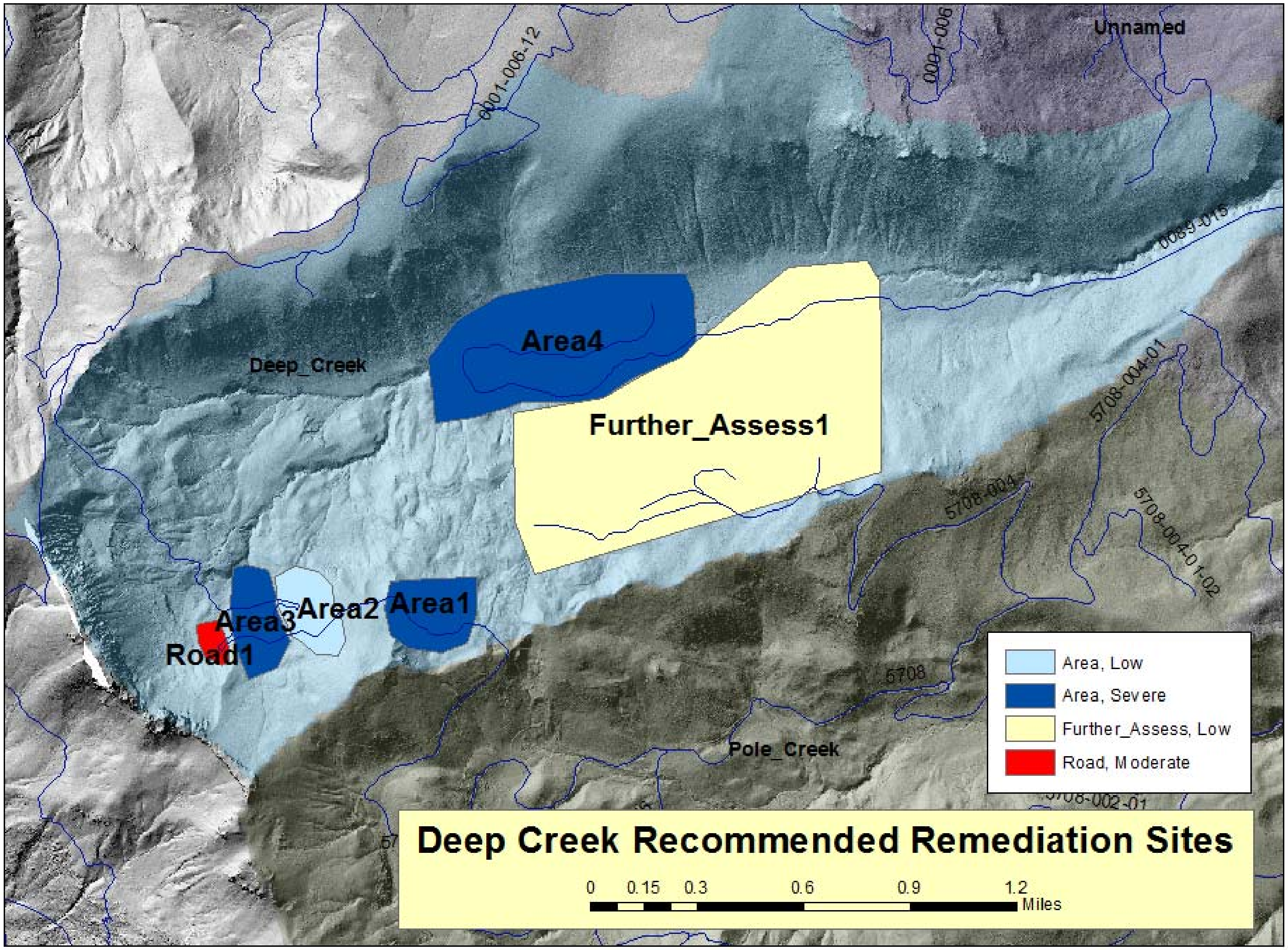
Area of Concern 10

This area is natural and functioning properly. No remediation in this section.

Deep Creek Watershed Assessment

Summary:

The Deep Creek watershed has numerous issues that stem from the construction of two major roads: 1) 089-015 is a 3.84 mile road which runs E-W parallel to the axis of the drainage until it crosses the main channel and loops back towards the 89; and 2) 16E84, of which 2.84 miles runs roughly SE-NW along the far western edge of the drainage and crosses over to the Pole Creek watershed to the south and the Cabin Creek watershed to the north. 1) Abandoned access roads and skid trails have induced 4 major and 3 minor channels that road 089-015 crosses before it reaches Deep Creek proper; 2 of the major 089-015 channel crossings and all of the minor ones are not adequately sized to allow for proper drainage during high precipitation/runoff events. Additionally, the major culvert where 089-015 crosses Deep Creek proper is not adequately sized and has increased incision of Deep Creek through the immediately adjacent downstream meadow, causing draining of this meadow. Road erosion over the channel crossings and concentrated vs. dispersed flow at the culvert outlets leads to incision and bank erosion that could potentially add significant, (350+ tons), of sediment into Deep Creek and eventually the Truckee River. We recommend decommissioning approximately 1 mile of this road and removal of all the culverts to allow system to return to its natural drainage pattern. 2) The present day trail 16E84 exploits old access roads that, at the southern side of Deep Creek, were built over large landslides. The shallow water table in these landslides allows for seepage at any point the road is cut into the slope. This seepage is immediate channeled by the road and begins to incise and erode banks when it eventually is diverted from the road. Public usage of Trail 16E84 means full decommissioning is unlikely; therefore we have suggested several remediation projects that seek to 1) restore natural drainage patterns to the area, and 2) reduce the estimated, (using WEPP:Roads and the Tahoe Basin Sediment Model), 10.5 tons/acre of sediment eroded from cutslopes and trails along this road by 75-85%.

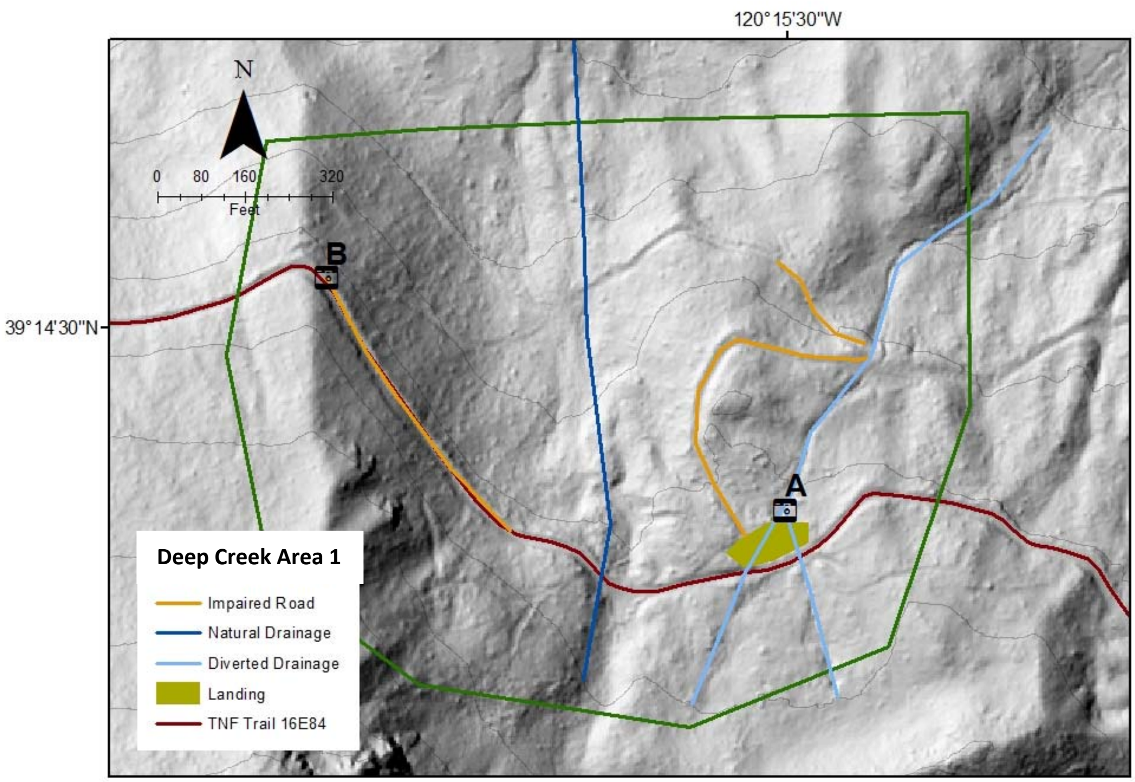

Deep Creek Recommended Remediation Sites
Unnamed
0001-006-12
0001-006
0089-015
Deep_Creek
Area4
Further_Assess1
5708-004-01
5708-004
5708-004-01-02
Area3
Area2
Area1
Road1
5708
Pole_Creek
Area, Low
Area, Severe
Further_Assess, Low
Road, Moderate
0
0.15
0.3
0.6
0.9
1.2
Miles

	Site	Priority	Major Concerns	Recommendations
Area	**1**	3	Old landing is pooling surface flow creating headwaters for diverted drainage.	Obliterate landing and recontour landscape.
	2	1	Road crosses old landslide.	No recommendation at this time.
	3	3	Roads cut through meadow and drainage exposing and channeling surface flow	Reroute stream from east side to west side of meadow. Rockfill and plug channel.
	4	3	Abandoned road and old logging practices lead to significant sediment influx.	Remove culverts to allow proper dispersed flow. Obliterate skid trails; install adequate drainage structures along road.
Road	**1**	1	Road cuts through drainage exposing surface flow.	No recommendation at this time.
Non FS		1	Abandoned and modern trails are channeling flow allowing for incision at headwaters of drainages.	Make contact with private landowners to discuss possible in depth assessment and remediation

Area 1

Access road and skid trails have led to channeled flow from the upper hillslope into a landing just south of photo point A. Water and sediment pools on this landing until it spills over into either the NNE directed now ‘natural’ drainage at photo A or the NW impaired access road shown by the orange line. At the northern point of connection of the two another road that diverts to the northwest captures overflow from this channel and diverts it to the northwest.

On the western side of Sub-Area C_1 the cutslope of 16E84 is very unstable and is eroding onto the road, where high precipitation/runoff flow channels this sediment north until it drains, still channeled, near where the road passes the ridge of the hill.



Proposed Action: Obliterate landing and all impaired roads. Stabilize the slope along impaired road at B to reduce sediment influx into headwaters of channel.

Area 1 Photos

Photo A
Heading: 015

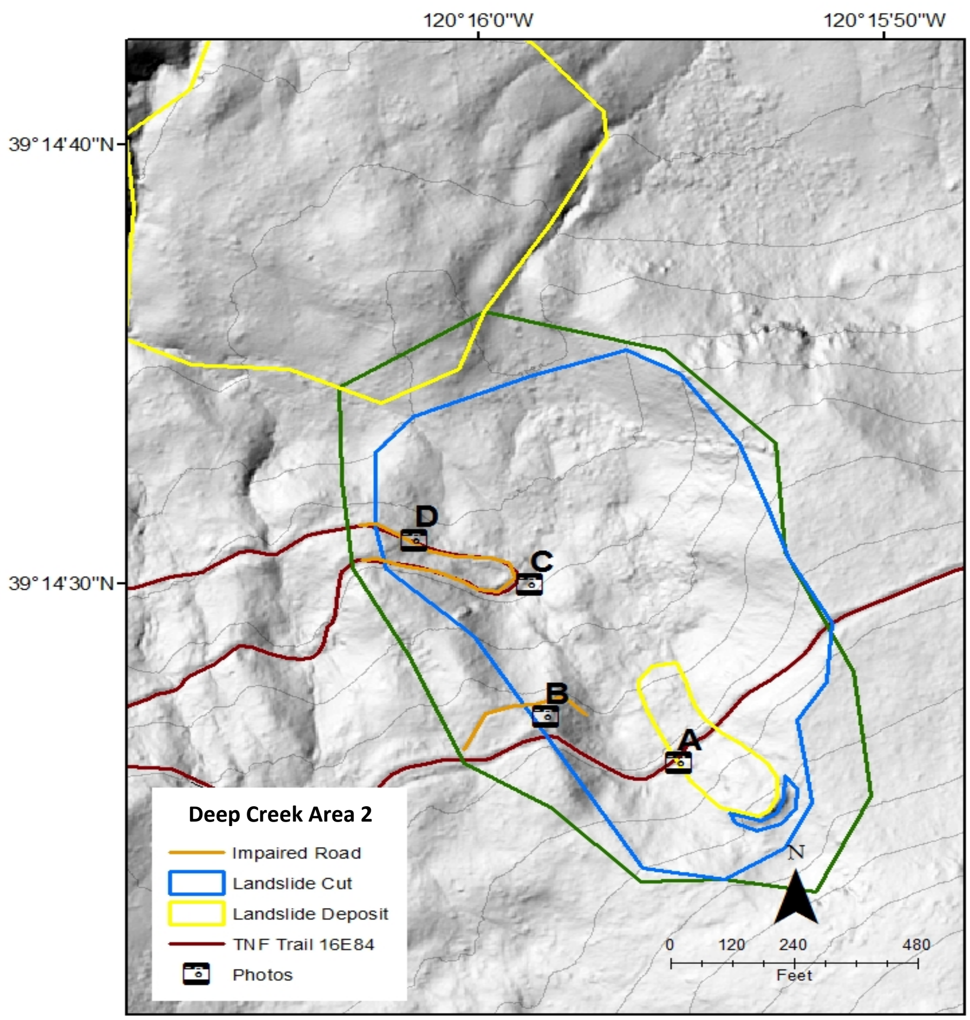
Channel leading from landing is actively incising.

Photo B
Heading: 165

Cutslope is unstable and actively eroding onto road to be carried directly into drainage to NE.

Area 2

The entire Sub-Area C_2 was the cutslope of a landslide. An access road was cut into the slope; a significantly smaller landslide was triggered and covered about 50 feet of road at A. The road was then rebuilt over the landslide deposit without properly addressing the instability of the upslope sediment. The slope is cut back east of point B and is actively eroding and depositing sediment on the fillslope (see photo B). During high runoff events this sediment can be transported directly into the downslope channel. The concentrated runoff has also led to significant channel incision of this drainage (see photo C). The road, RTE 16E84, cuts through the hillslope at points C and D, allowing shallow subsurface laminar flow to reach surface and become channeled along the road (see photo D) eventually diverting to the north at D and incising notably on the LiDAR image.



Proposed Action: Stabilize cutslope and fillslope of road at point A and east of point B. Stabilize and revegetate banks of channel at Point C. Add waterbars along road between points C and D to allow exposed subsurface flow to infiltrate back into subsurface; rockfill the channel cut north of D to reduce incision of this channel.

Area 2 Photos

Photo A
Heading: 110

Loose sediment from landslide erodes directly into channel. Sediment covers old road, current road can be seen on left side of photo.

Photo B
Heading: 200

Cutslope is unstable and erodes directly into headwaters of channel.

Photo C
Heading: 090

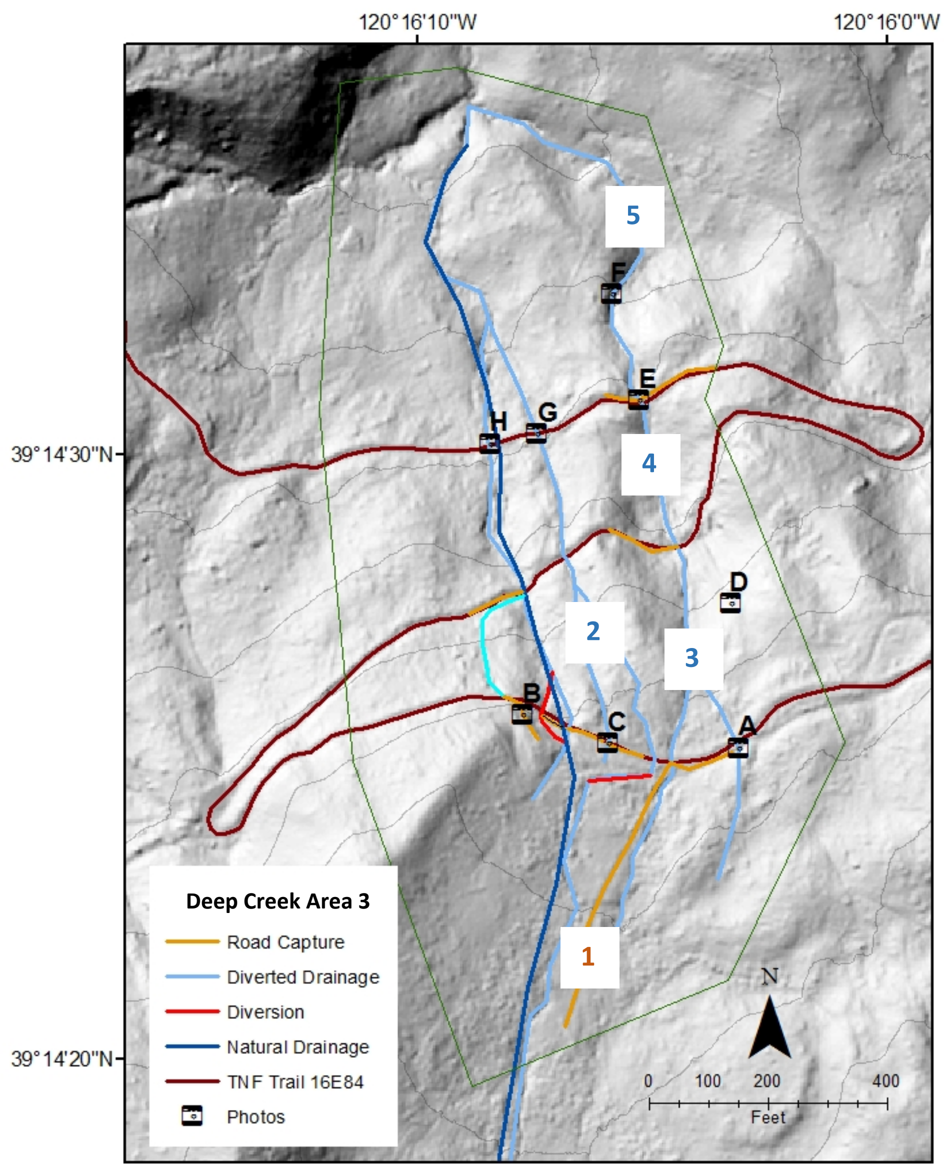
Channel deeply incises in close proximity to headwaters. Banks are unstable and require revegetation.

Photo D
Heading: 080

Road cuts expose shallow subsurface lateral flow. Flow is channeled alongside of road ~100ft before crossing.

Area 3:

Drainage patterns of this sub-watershed have again been heavily impacted by logging and associated road emplacement. Drainage used to flow to the northwest out of this subwatershed; an old access route to the south and RTE 16E84 have diverted the drainage to the north. One of the channels on the west side of the drainage that used to empty along the proper path was actively diverted to drain to the east (diversion below point C on map). The roads zig-zags in a Z shape down the slope, bringing shallow subsurface lateral flow to the surface and immediately capturing and channeling it. Everywhere the road diverts flow is heavily rutted and rilled. All these problems have combined to make numerous channels that carry high sediment loads, (suspended sediment was observed in one of these channels), and eventually enter into Deep Creek's main drainage.



Proposed Actions: This site is incredibly complex. The presumed natural drainage pattern is shown in the figure. We make this presumption based on the fact that all the overflow channels, (BH and CG), tend to drain to the northwest, as opposed to the NNE drainage AE. Also, the access road the leads SW from halfway between A and C appears to direct the drainage to the NE. We suggest: 1) full obliteration of the SW access road (1); 2) obliterate the diversion of channel (2) (just south of photo C in the figure) and return its drainage to the northwest; 3) at (3) (4) and (5) rockfill and plug this channel to reduce flow velocity; and install culverts at sites C, B, G and H to reduce road capture and erosion.

Area 3 Photos

Photo A
Heading: 000

Log acts as culvert under road, risking sediment dump into channel when log eventually decomposes. Road crosses left to right while log 'outlet' is in center.

Photo B
Heading: 090

Roadcut allows subsurface flow to reach surface, channel and become headwaters for subsidiary stream

Photo C
Heading: 290

Stream diverted east (parallel to road) empties onto road and immediately follows road for ~50 ft before diverting off into NW channel

Photo D
Heading: 180

Two paths of runoff from top of road can be seen. The left path has left mud deposits on the slope, suggesting it carries significant fine sediment loads..

Photo E
Heading: 335

No obvious drainage structure, but channel does flow under road. Road is actively eroding and near failure; when it fails that portion of road will immediately enter the channel

Photo F
Heading: 345

Channel incision downslope. Bank is thinly vegetated and actively erodes into channel.

Photo G
Heading: 90

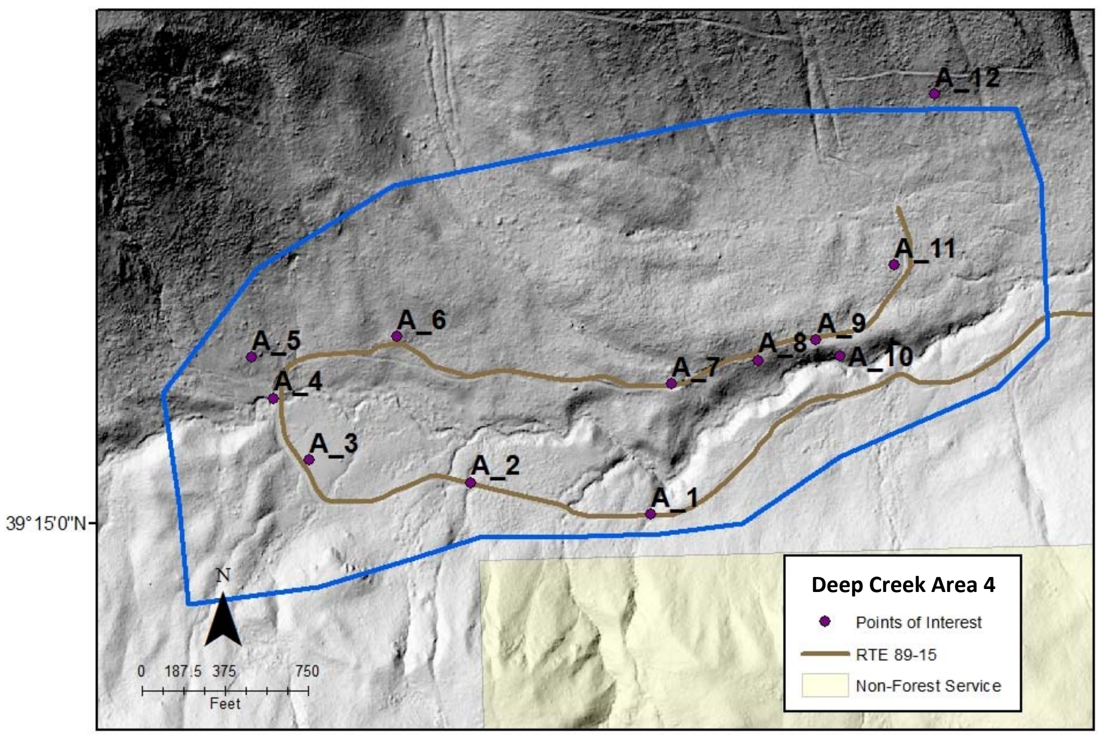
Channel from upslope runs on road ~50 ft, moderately incising and picking up more sediment.

Photo H
Heading: 270

Channel from upslope runs on road ~50 ft, moderately incising and picking up more sediment.

Area 4

Sediment issues in Deep Creek Area A are predominantly associated with contouring of the landscape associated with the construction of RTE 89-15. These actions have resulted in large piles of sediment in close proximity to Deep Creek (A_7 and A_8) and the exposure of bare soils on and adjacent to the road (A_5 and A_11). The road also disrupts the natural hydrology of a meadow system (A_3), bringing to surface and channeling shallow subsurface lateral flow. Several culverts acting as stream crossings are not adequately sized to accommodate channel flow during high precipitation events (A_2 and A_1). Another culvert that allows the main creek to pass under RTE 89-15 has concentrated flow at the inlet into the meadow, keeping the channel focused and not allowing proper dispersal and infiltration. We recommend full obliteration of this road from the first major stream crossing (A_1), up the drainage past where the trail crosses Deep Creek proper, and through its entire length on the north side of Deep Creek. This will serve to reduce flow velocity and associated incision and scouring of Deep Creek and its tributaries and will restore the natural hydrology of its banks, particularly on the southern side where concentrated drainage has led to channel incision through and subsequent draining of a 3.2 acre meadow. Culvert removal and returning channels to their natural contour will result in ~400 tons of dirt that can be used as fill in other projects associated with the 89 Corridor.



Proposed Actions: We recommend full obliteration of the road, (including removal of all culverts), recontouring of the landscape and revegetation past point A_1. (Site specific recommendations can be found in the overview descriptions above.) The road is not used past this point and its disruption of the natural landscape makes it a major contributor of sediment into Deep Creek.

Area 4 Photos

Location: A_1
Latitude: 120 16'06.102 W
Longitude: 39 15'49.794 N
Heading: 090
Map Datum: WGS 84

Culvert to allow northeast drainage under road has loose sediment pooled atop the culvert, indicating the road is carrying runoff and sediment and depositing directly into the channel. Recommend removing the culvert, obliterating the road within 100 feet of the crossing and recontouring the landscape to reduce influx of sediment from road. 76.5 tons of dirt removed from this site can be used as fill for other sites within this watershed and the rest of the 89 Corridor.

Location: A_2
Latitude: 120 16'15.742 W
Longitude: 39 15'01.161 N
Heading: 010
Map Datum: WGS 84

Another channel that crosses RTE 89-15 through a culvert carries a lot of sediment, as evidenced by deposit piles within the stream channel within 100 yards of the culvert. Recommend removing culvert, obliterating road within 100 feet of the crossing and recontouring landscape to reduce influx of sediment from road channel. 56 tons of dirt will be removed from this site.

Location: A_3
Latitude: 120 15’25.462 W
Longitude: 39 15’02.525 N
Heading: 060
Map Datum: WGS 84

Three stream crossings initiated by skid trails to SW are further concentrated through 3 separate culverts as the channels enter the meadow. These culverts are not allowing the water to disperse through the meadow and instead remain channeled, allowing for incision and subsequent draining of the meadow. We suggest removing the 3 culverts and recontour RTE 89-15. The lack of significant incision through the meadow suggests obliteration of skid trails is unnecessary; once the culverts are removed flow should disperse properly throughout the meadow. A cumulative 79.3 tons of dirt will be available for use at other remediation sites.

Location: A_4
Latitude: 120 15’27.342 W
Longitude: 39 15’05.273 N
Heading: 090
Map Datum: WGS 84

Massive culvert at main channel crossing adding to channel concentration immediately as it enters the meadowed area. We recommend removing the culvert and recontouring the landscape within the drainage to allow for more dispersed flow during high precipitation events. Revegetate to reduce short term high sediment influx from landscape activities. Culvert removal and road obliteration of this site will result in 175 tons of dirt that can be used at other sites.

Location: A_5
Latitude: 120 15’28.755 W
Longitude: 39 15’07.237 N
Heading: 335
Map Datum: WGS 84

Exposed soils near RTE 89-15 that can be picked up by surface flow and carried to road and dumped directly into main channel of Deep Creek. Recommend revegetating this area to reduce sediment pickup during storm events.

Location: A_6
Latitude: 120 15’20.440 W
Longitude: 39 15’08.199 N
Heading: 270
Map Datum: WGS 84

Felled trees disallow vehicle passage beyond this point. Suggests road is entirely unused in this area, supporting request to decommission road.

Location: A_7
Latitude: 120 15'04.813 W
Longitude: 39 15'05.642 N
Heading: 220
Map Datum: WGS 84

Large mounds of loose sediment left during creation of road are in close proximity to main channel of Deep Creek. During high precipitation events mound can erode directly into channel. Suggest leveling and revegetating this mounds. Pile consists of ~10 tons of dirt.

Location: A_8
Latitude: 120 14'59.581 W
Longitude: 39 15'06.429 N
Heading: 135
Map Datum: WGS 84

More loose sediment along road needs leveled and revegetated during obliteration of RTE 89-15. Removed sediment mounds combine to ~5 tons of dirt that can be used at other sites requiring fill.

Location: A_9
Latitude: 120 14'56.463 W
Longitude: 39 15'07.504 N
Heading: 000
Map Datum: WGS 84

Bare soil disturbance between road and stream. Further support for obliterating road, as this will reduce surface flow and help to allow proper infiltration.

Location: A_10
Latitude: 120 14'55.236 W
Longitude: 39 15'06.466 N
Heading: 225
Map Datum: WGS 84

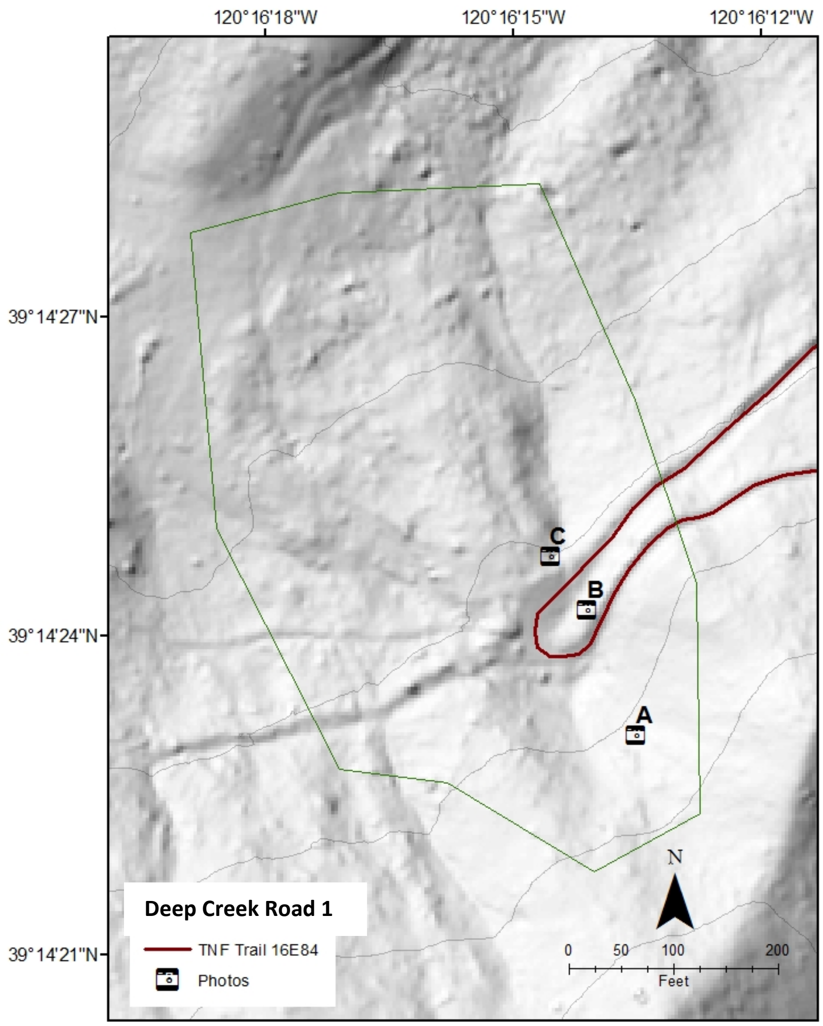
Bare bank exposes soil that dumps directly into creek. Creek is cut to bedrock so erosion is along banks. Suggest bank stabilization measures to reduce sediment dumping into creak. 8000 m^2 of banks are identified for remediation at this site.

Location: A_11
Latitude: 120 14'51.657 W
Longitude: 39 15'10.501 N
Heading: 060
Map Datum: WGS 84

Old landing site exposes soil upslope from road. Runoff brings sediment directly into stream channel. Obliterate old landing site.

Road 1:

This hairpin turn is the site of an old landing that has numerous access roads leading to and away from it; some of them are near parallel the slope of the hillside. The site is particularly problematic because it is a sharp redirection of the road after it has channeled overland flow for over 300 feet. The road is cut deep into the slope, such that it is actively eroding. The skid trails have waterbars and leadouts and are functional at present. All erosion from the road and cutslope immediately enters the channel leading north.



Proposed Actions: We recommend installing gravel on the road through this section, and rockfilling the leadout at point C. We also suggest a thorough geo-technical assessment to identify practical and efficient methods of stabilization and revegetation of the exposed hillslopes both upslope and downslope of the road through this section.

Photo A
Heading: 130

Cutslope shows evidence of erosion at its base. Eroded sediment is delivered directly to channel to the south. Slope needs revegetated.

Photo B
Heading: 130

Cutslope shows major evidence of erosion at its base. Eroded sediment is delivered directly to channel to the south.

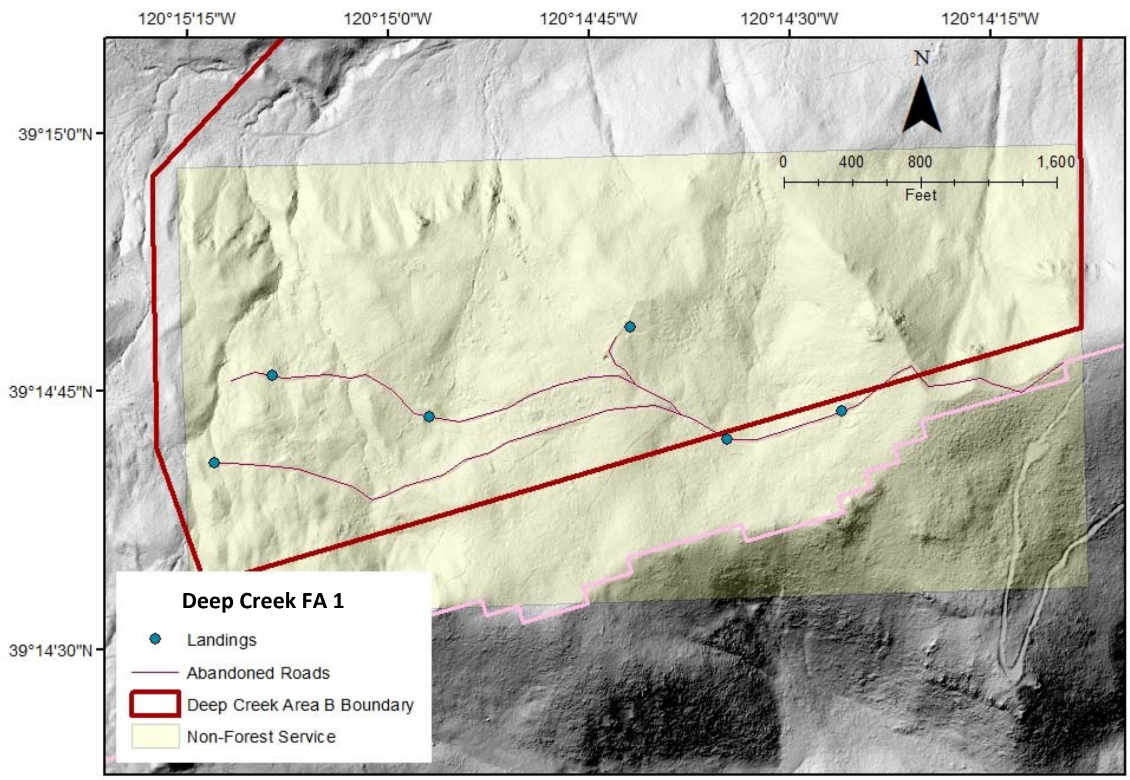
Photo C
Heading: 130

Leadout in road helps to channel flow. Recommend deepening the leadout and rockfilling to reduce current turbidity during high stormflow events.

FURTHER ACCESS – Non-FS

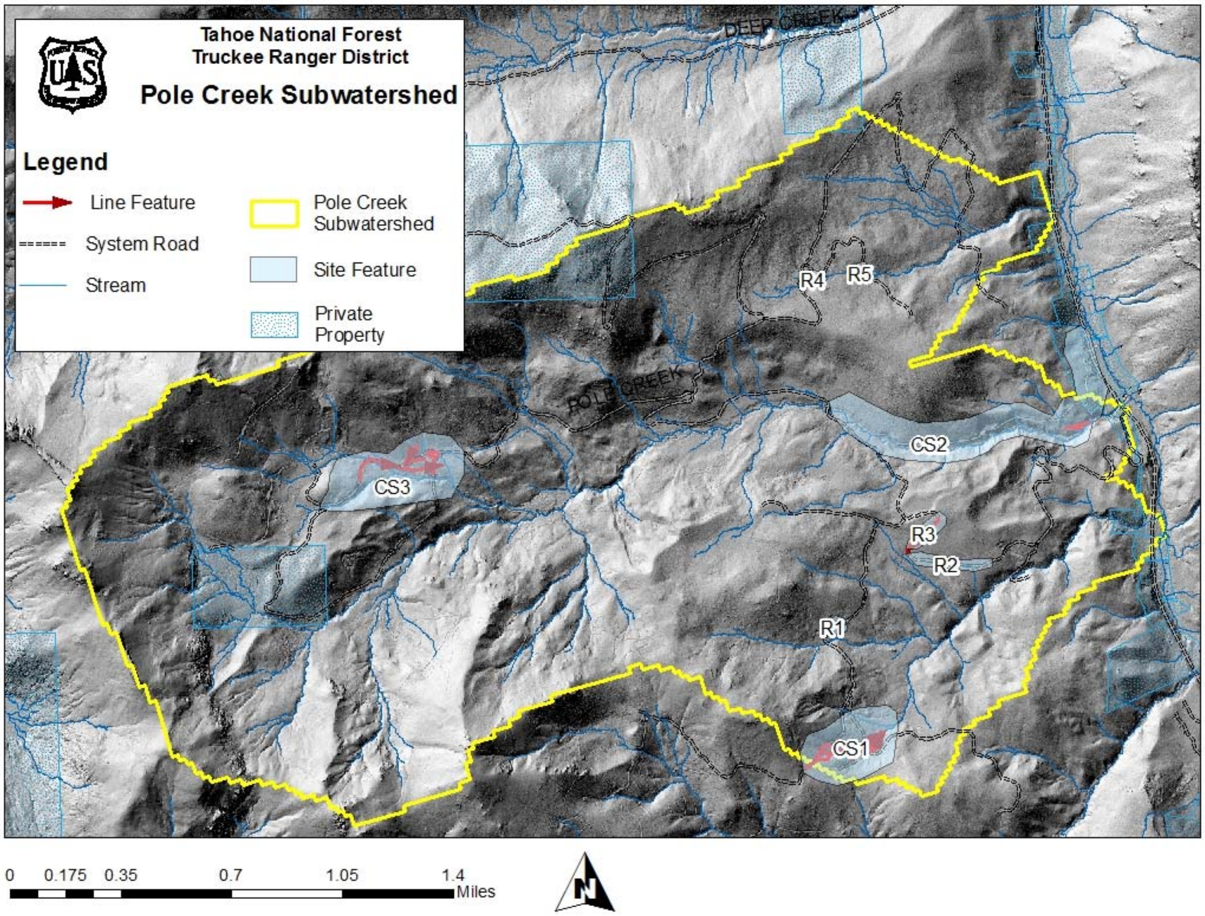
Overview of Problems

Abandoned logging roads and landings have had significant impact on drainage of the hillslope in this area. LiDAR images suggest drainage cuts begin at the sites of old landings. These drainages then incise down the hillslope and deposit directly into Deep Creek. Because these landings and roads are located on private, Non-Forest Service land, we suggest contact be made with landowners to discuss potential for remedial actions prior to a full ground assessment of Area B.



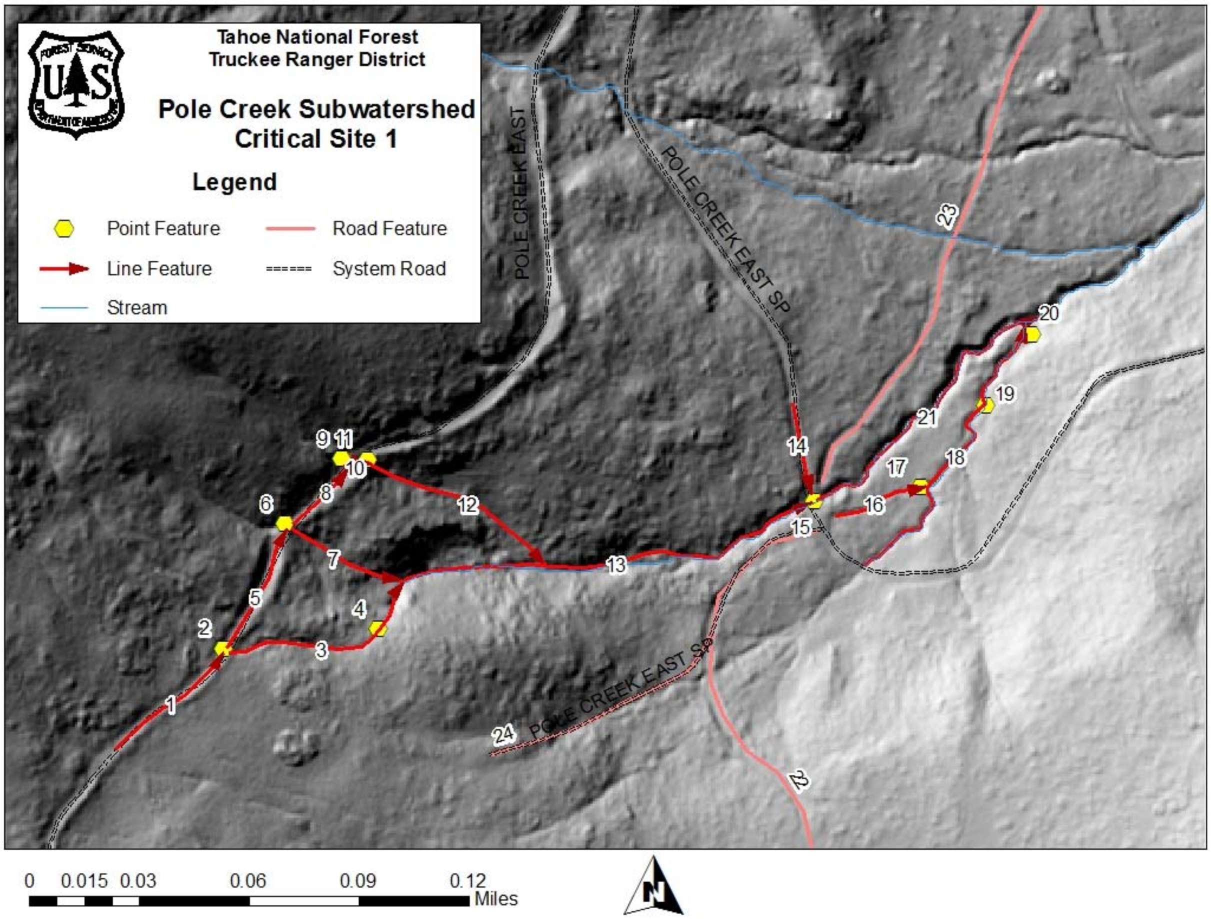
Recommendations: Make initial field assessment to identify problems and potential remedies. Begin discussion with landowners to determine feasibility of remedies.

Pole Creek Watershed Assessment



Area/Critical Site 1

The main feature of this site is a deeply incised channel downstream of a crossing with Pole Creek East Spur Road. Average incision depth is 6ft. Geomorphology suggest this channel is unnatural as it is not the low point in the valley. Another, more stable, channel is found southeast at a lower elevation. There are signs of what may be the original flow path of the incised channel, but the development of the spur roads to the southwest and northeast of the crossing may have caused the relocation of the channel. Discharge in this incised channel has also increased due to the large amounts of road surface runoff entering the channel from the Pole Creek East road found uphill from the crossing. Poor maintenance and placement of road surface drainages have allowed road runoff to accumulate to amounts high enough to incise leadout outlets and adjacent fillslopes. This has allowed unnatural flow paths to lead into the headwaters of the incised channel downstream. Sediment from the erosion of the road and fillslopes enter the channel.



List of Features

1.1: Road surface runoff from this length of Pole Creek East road accumulates and exits at leadout 1.2.

1.2: Leadout for road surface runoff from 1.1. Runoff is high enough that it has incised the outlet and fillslope, forming a flow path (1.3).

1.3: A flow path in a meadow from accumulated runoff from the Pole Creek East road. This flow path has incised enough to expose bedrock at 1.4. This flow path ultimately feeds the headwaters of the incised channel downstream.

1.4: Bedrock is exposed at this point due to scouring from flow path 1.3.

1.5: Length of Pole Creek East road where runoff accumulates. The runoff drains above the outlet of a stream crossing culvert (1.6), incising around the culvert and fillslope.

1.6: Stream crossing culvert. Surface runoff from the Pole Creek East road flows over the outlet of this culvert, and has been eroding the surrounding fillslope. The outlet now shotguns, giving discharge from the stream more potential energy to scour the channel downstream.

1.7: Flow path of an ephemeral channel with surface runoff from Pole Creek East road. This channel flows into the main incised channel downstream.

1.8: Segment of Pole Creek road that accumulates surface runoff. This runoff flows into a stream that has flowed onto the road.

1.9: Ephemeral channel flows along Pole Creek East road for ~20ft (1.10). The channel and road surface runoff exits at leadout 1.11 and flows into the headwaters of the incised channel downstream.

1.10: Segment of Pole Creek East road where an ephemeral channel flows onto. The channel leaves the road at leadout 1.11.

1.11: Leadout where surface runoff from Pole Creek East road and an ephemeral channel leave the road.

1.12: This channel formed from combined runoff from an ephemeral channel and the Pole Creek East road.

1.13: This channel accumulates flow from multiple flow paths coming off of the Pole Creek East road. Due to the unnatural nature of these flow paths, that amount of water in this channel is above natural. This channel is crossed by the Pole Creek East Spur road downstream at feature 1.15, and becomes heavily incised after crossing the road.

1.14: Surface runoff from this length of Pole Creek East Spur road flows into the channel crossing 1.15, contributing to the discharge of the incised channel.

1.15: Channel crossing for Pole Creek East Spur road. The crossing is a ford that is lined with rocks as armor. Downstream of this crossing, the channel becomes deeply incised. The installation of this crossing may have diverted this channel to create an unnatural flow path, indicated by the high amounts of incision and lack to bank stability.

1.16: Possible channel in which water from the incised channel use to flow naturally in. This channel is topographically lower than the current incised channel. Water would have preferred this flow path, but the installation of the Pole Creek East Spur roads may have forced the diversion of this channel.

1.17: Headcut on the old channel 1.16.

1.18: This natural channel is topographically the lowest point in this valley, indicating it may be the overall preferred flow path.

1.19 and 1.20: Headcuts in the natural channel 1.18 south of the main incised channel.

1.21: The current channel downstream of crossing 1.15. This channel is highly incised with average depths of 6 ft. The slope banks are bare and allow for mass movement into the channel. This channel is unnatural and may have formed due to the installation of the Pole Creek East Spur road crossing and the spur roads to the north and south.

1.22: Spur road that connects to the south end of the Silver Creek subwatershed. This spur road is not listed as a Forest Service system road. Vehicle access for the road ends at the next drainage crossing. The south end of this spur road is inaccessible because it abruptly ends when it meets Silver Creek.

1.23: Another spur road that is not list as a Forest Service system road. The south end at this spur road ends at crossing 1.15 with Pole Creek East Spur Road. The south end entrance may have been removed during the installation of the crossing. Motor Vehicle entrance at the south end is nonexistent. Access on the north end of this spur road is developed enough for OHVs.

1.24: Segment of the Pole Creek East spur road that is listed as a Forest Service system road, however does not exist here.

Proposed Actions

Reshaping the problematic segments of the Pole Creek East road into an outsloped road shape will allow overland sheet flow to return to the meadow and remove unnatural flow paths. When not possible, additional waterbars/dips should be installed and current ones maintained. Road surface runoff should be widely dispersed into overland flow, directing water into other nearby natural channels and decreasing the amount of discharge flowing into the incised channel. A culvert crossing structure should be installed at crossing 1.9 to prevent direct road surface runoff to flow into the stream.

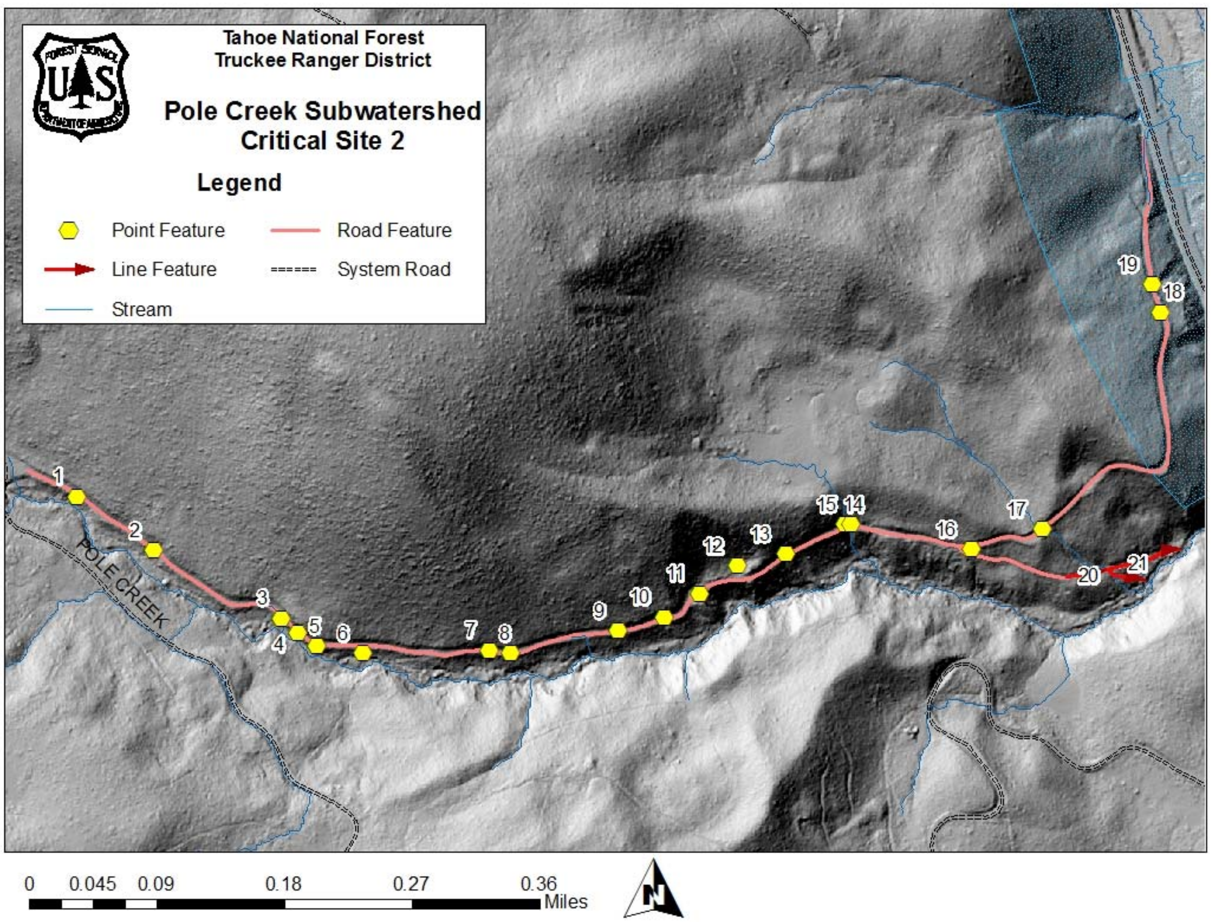
Similarly at the downstream end of the site, waterbars/dips should be installed on the road north of the crossing with the main incised channel to mitigate road surface discharge into the channel. This crossing should be reinstalled to allow the flow path to follow its original natural channel, 1.16. Afterwards, the incised channel should be buried. Multiple headcuts were identified on the original channel and an adjacent tributary to the south. They should be repaired to prevent further erosion.

Spur roads 1.22 and 1.23 should be obliterated. Both spur roads are not listed as Forest Service system roads and have poor access and development for motor vehicle use. The roads have poorly maintained road surface drainages, which is allowing runoff to accumulate on roads, creating erosional features such as rills and incisions at the outlets. The removal of both roads would remediate these issues and return proper overland sheet flow, providing more infiltration time of sediments before entering the nearest channel.

Spur road 1.24 is shown as a Forest Service system road, but does not actual exist. This spur road should be removed from the system.

Area/Critical Site 2

This site consists of a decommissioned road found directly north of Pole Creek. This road likely served as another way to access the Pole Creek watershed from Highway 89. The entire length of the road parallels Pole Creek before turning north and running semi parallel to the highway. This road sees no usage from any motor vehicles as access on the west and east end of the road is barricaded by multiple boulders. Due to its status as a decommissioned and unauthorized road, maintenance for its drainage features is nonexistent. Many waterbars and dips are no longer functional, and allow for runoff to accumulate to high amounts. This has allowed the formation of rillings on the road, and incision at leadouts and fillslopes. The eroded sediment from the roads and fillslope are allowed to flow directly into Pole Creek due the short length of buffer. A portion of the road appears have been built on the toe of a landslide, with the fillslope consisting of the moved mass. The road may have allowed for a washout event, causing a large amount of the fillslope to fail and deposit into the channel.



List of Features

2.1 and 2.2: Leadout catching excessive amounts of runoff from road. Incision at the outlet and fillslope occurs.

2.3: Fillslope is failing and has exposed and bare soils.

2.4: Leadout is eroding back and incising fillslope.

2.5: Fillslope is failing and has exposed and bare soils.

2.6: Fillslope material appears to have failed and collected at the slope base and in the channel.

2.7-2.10: Leadout catching excessive amounts of runoff from road. Incision at the outlet and fillslope occurs. Fillslope is failing.

Example of leadout and fillslope incision.

2.11: Segment of road built on toe of a landslide. A washout event may have allowed mass failure of the fillslope. Mass amounts of fillslope is no longer present and has left the remaining fillslope with low vegetation and bare soils.

2.11 (cont.)

2.12: Exposed cutslope allowing for mass movement of sediment.

2.13: Failing cutslope. Mass movement is collecting on road.

2.14: Stream crossing. Stream is incising fillslope.

2.15: Gully is forming in inside ditch.

2.16: Trough of the inside ditch. Runoff and sediment pools here. Skid trail starts here and moves southeast.

2.17: Inside ditch continues here and enters an ephemeral channel. Ephemeral channel flows down into Pole Creek, however, surface runoff from a skid trail connects to this channel.

2.18: On private property. Leadout is catching excessive amounts of runoff from the upslope portion of road. Incision at the outlet of the leadout and fillslope occurs.

2.19: On private property. Fillslope is failing and exposing bare soils.

2.20: Surface runoff along this length of skid trail collects and flows into the ephemeral channel.

2.21: Skid trail east of the ephemeral channel is catching some flow and connects with Pole Creek.

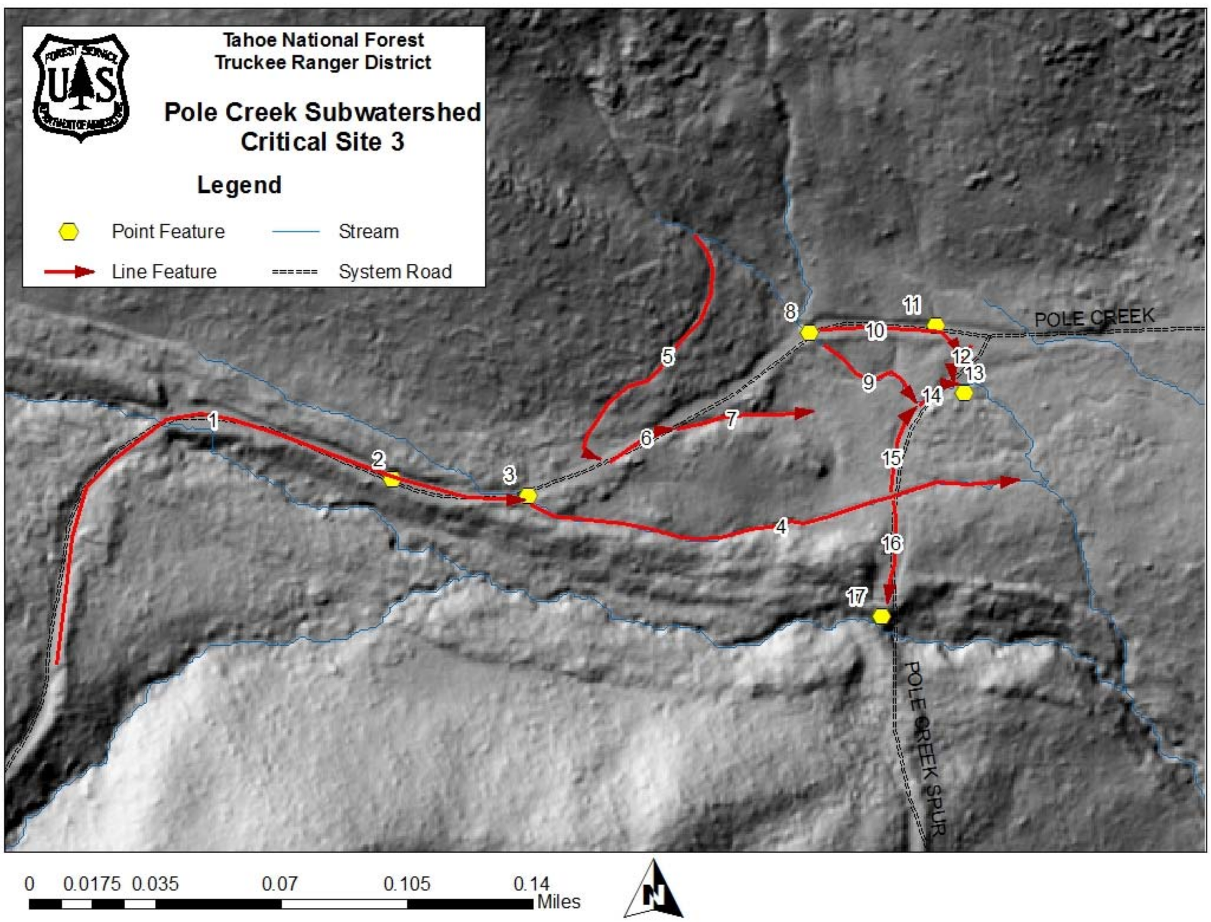
2.22: Unnatural flow path downslope of the skid trail that connects with Pole Creek.

Proposed Action

The entire length of road should be obliterated and recontoured to a natural slope gradient. The road is no longer used or maintained. Returning the entire length of road will effectively remove all erosional features from this area and return natural sheet flow over the hillslope.

Area/Critical Site 3

This site is found off Pole Creek road, in the northwest section of the watershed. It exists due to an old spur road built across the western end of the meadow in this area. The road is no longer used, but has caused the diversion of natural flow paths in this meadow. Pole Creek road connects to this spur road and contains poorly placed or failing drainage structures. These poor drainage structures have allowed excessive runoff to enter the vicinity of the spur road, furthering the development of unnatural flow paths here. The spur road continues south to a crossing. At another point in time, this crossing was functional and allowed the spur road to continue south. That crossing has been removed since, and now is being incised by the natural channel flowing here. The banks at this crossing are bare and exposed. A section of the spur road slopes toward the channel, allowing road runoff to enter the channel at this crossing. Continued existence of these problems will allow further incision of the channel at the crossing, erosion and formation of nick points in the meadow, and sediment to deposit in the meadow and in the channel.



List of Features:

3.1: Length of Pole Creek road where runoff is not drained off properly. Road runoff accumulates due to the lack of functioning waterbars or dips. The accumulated runoff exits out through dip 3.3, where it has created an unnatural drainage (3.4).

3.2: Location of a failed dip along the length of 3.1.

3.3: Leadout that collects road surface runoff from Pole Creek road. The runoff collected here has created a small channel that flows into the meadow.

3.4: Unnatural drainage created by the excess runoff from Pole Creek road. This drainage bisects the spur road in the meadow.

3.5: An old skid trail that collects surface runoff and drains down towards Pole Creek road.

3.6: Surface runoff from this length of Pole Creek road flows into an unnatural flow path in the meadow.

3.7: An unnatural flow path for the accumulated runoff from Pole Creek road.

3.8: A culvert crossing that has been aligned wrong, allowing the channel to create an unnatural flow path (3.9).

3.9: The unnatural channel that was created from the incorrect installation of the culvert crossing.

3.10: Length of Pole Creek road that collects surface runoff that flows into unnatural flow path 3.12.

3.11: Channel crossing. Channel flows onto Pole Creek road, combines with surface runoff from Pole Creek road, and continues into flow path 3.12.

3.12: Small incised flow path from the accumulated runoff of Pole Creek road and the channel that flows onto it.

3.13: Unnatural runoff diversion for surface runoff from the Pole Creek Spur road. Runoff from Pole Creek road that reaches the spur road flows out into the meadow here as well.

3.14: Segment of spur road in meadow that accumulates some runoff from Pole Creek road.

3.15: Segment of Pole Creek spur road that contributes to the accumulated flow exiting at the unnatural runoff diversion 3.13.

3.16: Length of Pole Creek spur road that flows into the channel at its crossing.

3.17: Fill placed in channel to provide a crossing when the spur road was functional. It is now being incised by the natural channel, eroding the fill and allowing sediment to enter the channel.

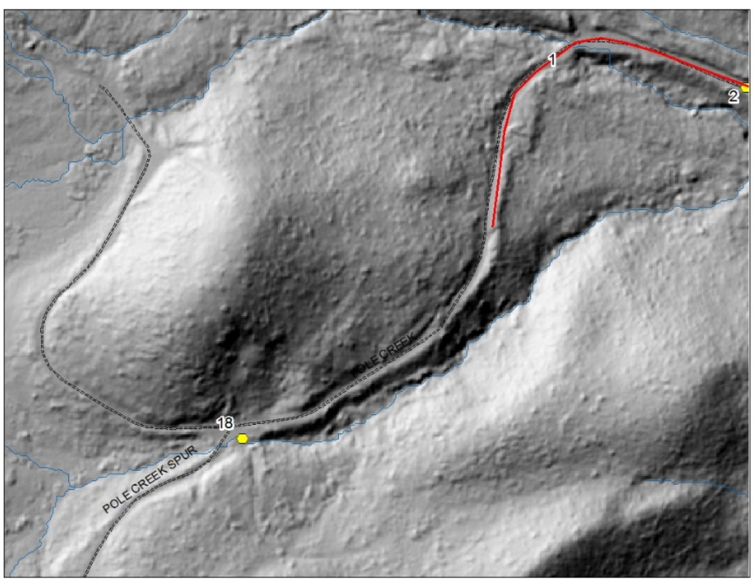
3.18: Fill placed in channel to provide for road crossing at west end of the Pole Creek Spur road. 3.18 is found further west on Pole Creek road from the rest of the features.

Proposed Action

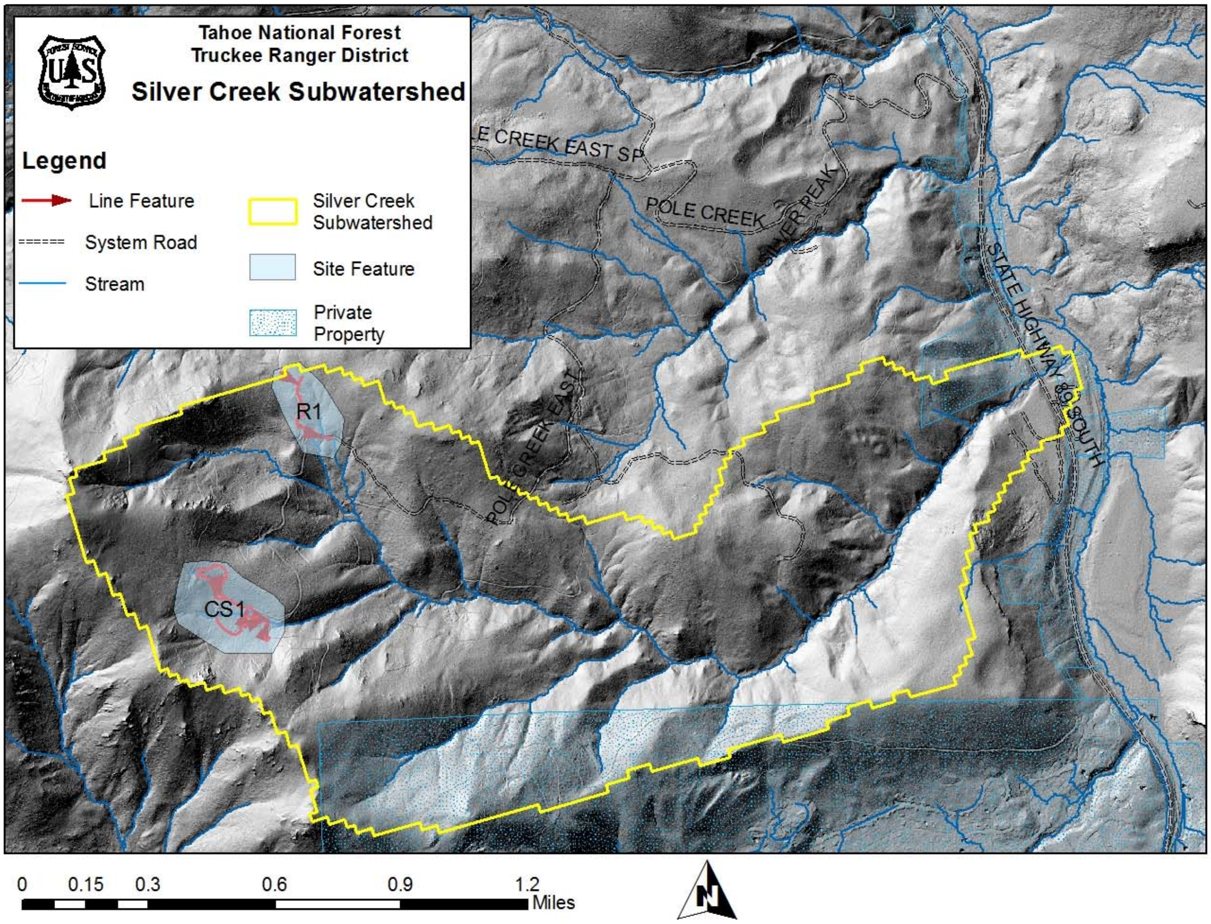
Managing surface runoff properly on segments of Pole Creek road upland of the site would help mitigate runoff issues into the meadow. Problematic road segments should have additional waterbars/dips installed and existing ones maintained to prevent the further inset of unnatural flow paths. Any segments directly upland of the meadow should be reshaped to an outsloped design, returning overland sheet flow to the meadow. The skid trail that comes off Pole Creek road to the north should be obliterated to prevent surface runoff to accumulate on the road. The culvert crossing 3.8 will need to be reinstalled and reoriented to direct the channel south instead of southeast from the outlet, following its more natural flow path. The Pole Creek spur road running north and south in the meadow should be obliterated to prevent road surface runoff to accumulate and discharge into unnatural flow paths. The unnatural flow paths in the meadow currently should be recontoured to allow dispersed sheet flow in the meadow. The fill material used for the spur road crossing will need to be removed so the natural V-shape seen upstream can return and prevent further fill material to be eroded into the stream.

Other Notes

Further west on Pole Creek road, the road again crosses the same channel incising the fill of feature 3.17. A similar problem exists where fill was placed into the channel to allow for a road crossing. Currently, the fill appears to be stable due to the large amount of established vegetation here. There are currently no proposed action for this feature as remediation might be more detrimental than leaving it in its current condition. Further monitoring will continue to ensure its stability and/or determine a proposed action when it is deemed beneficial.



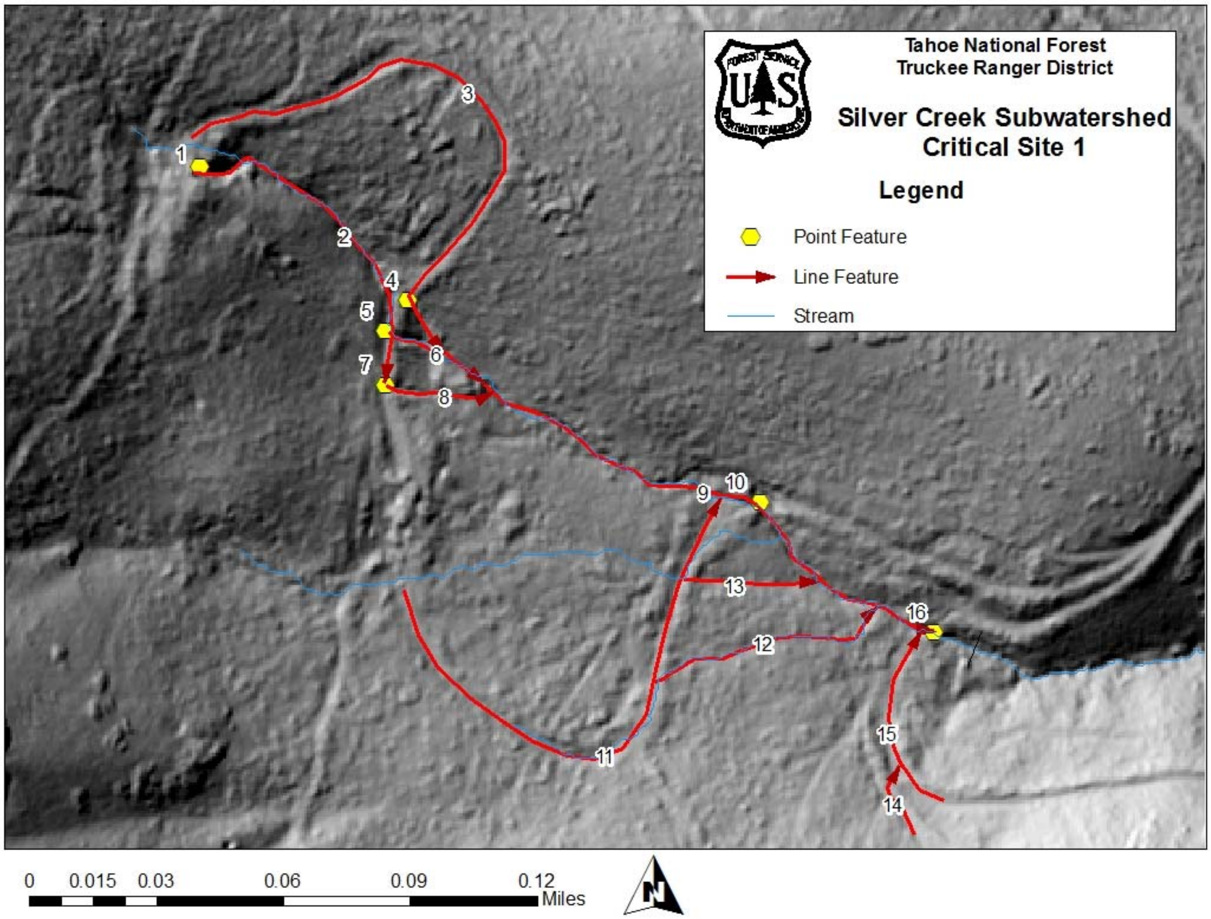
Silver Creek Watershed Assessment



Area/Critical Site 1

Description

This area of Silver Creek has had a series of very old road development/bench cut following logging in the late 50's or 60's. Road fill crosses the drainage in multiple locations and there is no evidence that at any point in time these fills have either had culverts or any other structured drainage. These fills have since failed and resulted in transport of sediments transported through the fluvial system. There continue to be raw areas of fill remaining along the crossings and on roads that have potential for future sediment transport. Much of the road fill was developed over glacial till formed under the foot of the glacier.



List of Features

1.1 Accumulative runoff from the upland slope incises this leadout and fillslope.

Looking downstream at channel 1.2 from left bank at leadout 1.1.

1.2 Channel formed by the incision of the runoff flowing into leadout 1.1. Channel is incised approximately 3 ft. Runoff from this channel flows onto the road downstream and captured by leadouts 1.5 and 1.7.

1.3 Road surface runoff accumulates to large amounts on this length of road due to the lack of waterbars/dips. This length captures some runoff that flows in the leadout of 1.1. The accumulative runoff leaves the road at leadout 1.4, incising the fillslope and forming a small channel before feeding into channel 1.9.

1.4 Leadout for accumulative runoff from 1.3. Leadout is incised and fillslope is eroding due to the large amount of runoff.

1.5 Leadout is capturing some runoff from channel 1.2. Runoff is still large enough to deeply incise the leadout and fillslope.

Looking downstream at channel 1.6 from leadout 1.5.

1.6 Channel formed from the large amount of runoff flowing into 1.5 and incising fillslope. Channel is incised approximately 4 ft. This channel feeds into channel 1.9.

Looking upstream in channel 1.8 at leadout 1.7.

1.7 Leadout that is capturing some runoff from channel 1.2 and upslope runoff. Runoff is large enough to deeply incise the leadout and fillslope. Leadout discharges into channel 1.8.

1.8 Channel formed due to the large amount of runoff captured by leadout 1.7 from upland runoff and from 1.2. Channel is incised approximately 4ft. This channel feeds into channel 1.9.

1.9 Channel formed from accumulated runoff of 1.3, 1.6, and 1.8. Channel is more stable at higher elevations due to vegetation but becomes more incised closer to crossing 1.10. Headcut erosion has likely propagating upstream. This channel may have formed here due to a plane of weakness, likely at the contact of landslide fill with native slope substrate.

1.10 Road crossing that has been deeply incised and eroded away. The V-shape of this channel at this crossing is high angled. Incision at this channel is approximately 6ft deep. Fill material used for this crossing was highly erodible as seen by the deep incision.

Looking upstream in channel 1.9 at crossing 1.10.

Looking downstream at channel 1.9 and crossing 1.10 on the right bank upstream from crossing 1.10.

1.11 This length of road captures some upland surface runoff and accumulates with road surface runoff. The accumulated runoff is captured by channels 1.12 and 1.13 before flowing into channel 1.9 directly upstream of 1.10.

1.12 Channel formed by some runoff of 1.11. Flows into channel 1.9.

1.13 Channel formed by some runoff of 1.11 and upland surface runoff. Flows into channel 1.9.

1.14 Skid trail's surface runoff flows onto main road and accumulates with road surface runoff 1.15 before flowing into channel 1.9 at crossing 1.16.

1.15 Road surface runoff accumulates along this length of road and skid trail runoff from 1.14 before flowing into channel 1.9 at the road crossing at 1.16.

Looking downslope at road surface runoff 1.15 sloped towards channel 1.9 and crossing 1.16.

1.16 Crossing with the Pole Creek East Spur road. Channel 1.9 has incised and eroded the fill material used to make this crossing. Incision at this crossing is approximately 4 ft deep. Incision continues before channel turn slightly north. Its turn to the north is likely due to channel flowing over a different substrate, and may represent the original flow path prior to the landslide.

Looking upstream along channel 1.9 downstream of crossing 1.16.

Looking downstream along channel 1.9 on the left bank at crossing 1.16.

Proposed Action

It is recommended that the road fill and cut slopes that have potential to carry more sediment through the system be removed and natural slope contours be restored, while using out-sloping topography where the potential to collect and transport water over in-sloped road cuts exists. Use of road cuts previously developed but, found in more stable locations (not a product of glacial till) could be used to restore the glacial alpine soils in two locations. This glacial till has the capacity to respond as a high alpine sloping meadow as is evidenced by remnant vegetation. This site will require additional investigations to attain the final remedy.

Sediment Models

Table 1. Input parameters for the road segments of Critical Site 1. Output was modeled using WEPP: Roads Batch. Values are pre-remediation.

Road Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average sediment leaving road (lb/yr)
R3	Insloped, vegetated or rocked ditch	graveled none	16.04	692	9.84	30.49	19.68	16.04	1	50	484
R2	Insloped, vegetated or rocked ditch	native none	13.33	105	9.84	38.11	13.12	13.33	1	30	11
R11	Insloped, vegetated or rocked ditch	native none	12.1	719	13.12	25.41	24.6	12.1	1	40	968
R14	Outsloped, rutted	native none	16.5	103	6.56	48.78	16.4	16.5	1	50	53
R15	Outsloped, unrutted	native none	9.13	252	4.92	30.49	16.4	9.12	1	50	12

Table 2. Sediment loss values pre and post remediation.

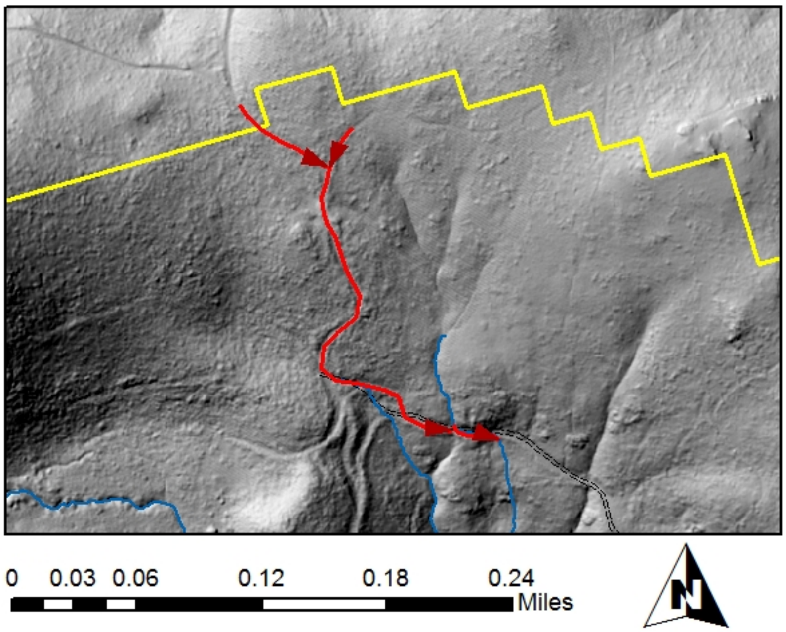
	Current Conditions	Post Remediation	
Road Segment	Annual Sediment Leaving Road (lbs)	Annual Sediment Leaving Road (lbs)	Percent Reduction
R3	484	<24.2	95-100
R2	11	<0.55	95-100
R11	968	<48.4	95-100
R14	53	<2.65	95-100
R15	12	<0.6	95-100
Total	**1,528**	**<76.75**	**94.98**

Proposed action indicates the natural contours for the roads be restored to natural conditions. This should effectively lower sediment lost to 95-100% of their current value.

The volume of the current drainages that have formed through incision is estimated at approximately 24700 ft^3. Assuming that prior to the development of logging here, the landscape followed natural topography. This suggests that 24700 ft^3 of soil and sediment was lost in the last 50-60 years since the roads development. These drainages have the potential to lose more than that amount in the next 50-60 years as more surface area is exposed in comparison.

Problem Road Segments

R1: A spur road for the Pole Creek East road is accumulating road surface runoff due to the lack of road surface drainage structures. Runoff begins collecting at this road's extent at the top of the subwatershed. A small segment of a skid trail intersects with this spur road, and contributes its own surface runoff. South of the skid trail intersection, the road has a higher grade and bisects a small meadow. Runoff from the west meadow flows onto the road. Runoff continues to accumulate along down the road and turns to the east and onto Pole Creek East road. Some road runoff exits the road via leadout, however some continues to stay on the road. An ephemeral channel flows onto the road and collects the accumulated runoff from the spur road and continues for approximately 35 feet before exiting Pole Creek East road through a leadout.



Road grade is elevated (at base of tree) compared to the meadow (grass at bottom of picture)

Proposed Action

If the spur road is not needed to travel from the Silver Creek subwatershed to the Pole Creek subwatershed here, the road should be obliterated. It is not a Forest Service system road. The skid trail should be obliterated as well. If the road needs to remain open, additional waterbars/dips should be added to divert surface runoff off the road. The grade should be lowered at its crossing with a meadow 30 ft. down the road from the intersection with the skid trail. The road has a higher grade than a small meadow to the west here, and collects the runoff from the meadow. If lowering the grade is not an option, a crossing culvert should be installed to allow runoff from the meadow to flow east past the road, where the meadow continues and forms headwaters for an ephemeral channel. A stream crossing structure such as a culvert should be installed to allow for the ephemeral channel to cross the Pole Creed East road properly and prevent road surface runoff to enter the channel.

Sediment Models

Table 3. Input parameters for the road segments of R1. Output was modeled using WEPP: Roads Batch. Values are pre-remediation.

Road Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
R1.1	Insloped, vegetated or rocked ditch	graveled none	5.78	277	18.86	17.07	16.4	17.55	564	50	25
R1.2	Outsloped, unrutted	native none	4.64	125	9.84	26.68	6.56	17.92	547	25	8
R1.3	Insloped, vegetated or rocked ditch	graveled none	14.8	966	16.4	37.26	29.52	14.8	1	50	1,496
R1.4	Insloped, vegetated or rocked ditch	graveled none	14.55	110	19	30.49	26.24	14.55	1	50	20

Table 4. Input parameters for the road segments of Critical Site 1. Output was modeled using WEPP: Roads Batch. Values are post remediation. Values for R1.1, R1.2, and R1.4 were not calculated as those segments will no longer be connected to a drainage post remediation.

Road Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
R1.3(4)	Insloped, vegetated or rocked ditch	graveled none	14.8	241 (4)	16.4	37.26	29.52	14.8	1	50	280

Table 5. Sediment loss values pre and post remediation.

	Current Conditions	Post Remediation	
Road Segment	Annual Sediment Leaving Road (lbs)	Annual Sediment Leaving Road (lbs)	Percent Reduction
R1.1	25	1.25	95-100
R1.2	8	0.4	95-100
R1.3	1,496	280	81.28
R1.4	20	1	95-100
Total	**1,549**	**283**	**81.75**

R1.1, R1.2, and R1.4 see a reduction of 95-100% as they are no longer connected to a drainage system post remediation.

Bear Creek Watershed Assessment

Middle Bear Creek Section

Summary

Several locations in the Bear Creek Sub-watershed Middle Bear Creek assessment area are identified as needing moderate to major remediation efforts to decrease sediment influx into Bear Creek. The primary sediment contributions from forest lands is from area 5E. Sheet flow capture and flood plain function are interrupted by old skid trails access routes and poor road location placed within the drainage and flood plain which create road/stream capture and gully issues and major sediment influx into feeder streams of Bear Creek. Reduction of stream capture resulting in gully erosion is one focus of remediation recommendations included in this report. We have identified 0.62 miles of USFS roads where the WEPP:Roads model suggests we can reduce 75% of road erosion. Remediation of 0.45 miles of unauthorized roads, (presently foot trails), can reduce as much as 95% of road erosion according to the WEPP:Roads model, even when assuming a 50% error margin.

Overview of Recommendations

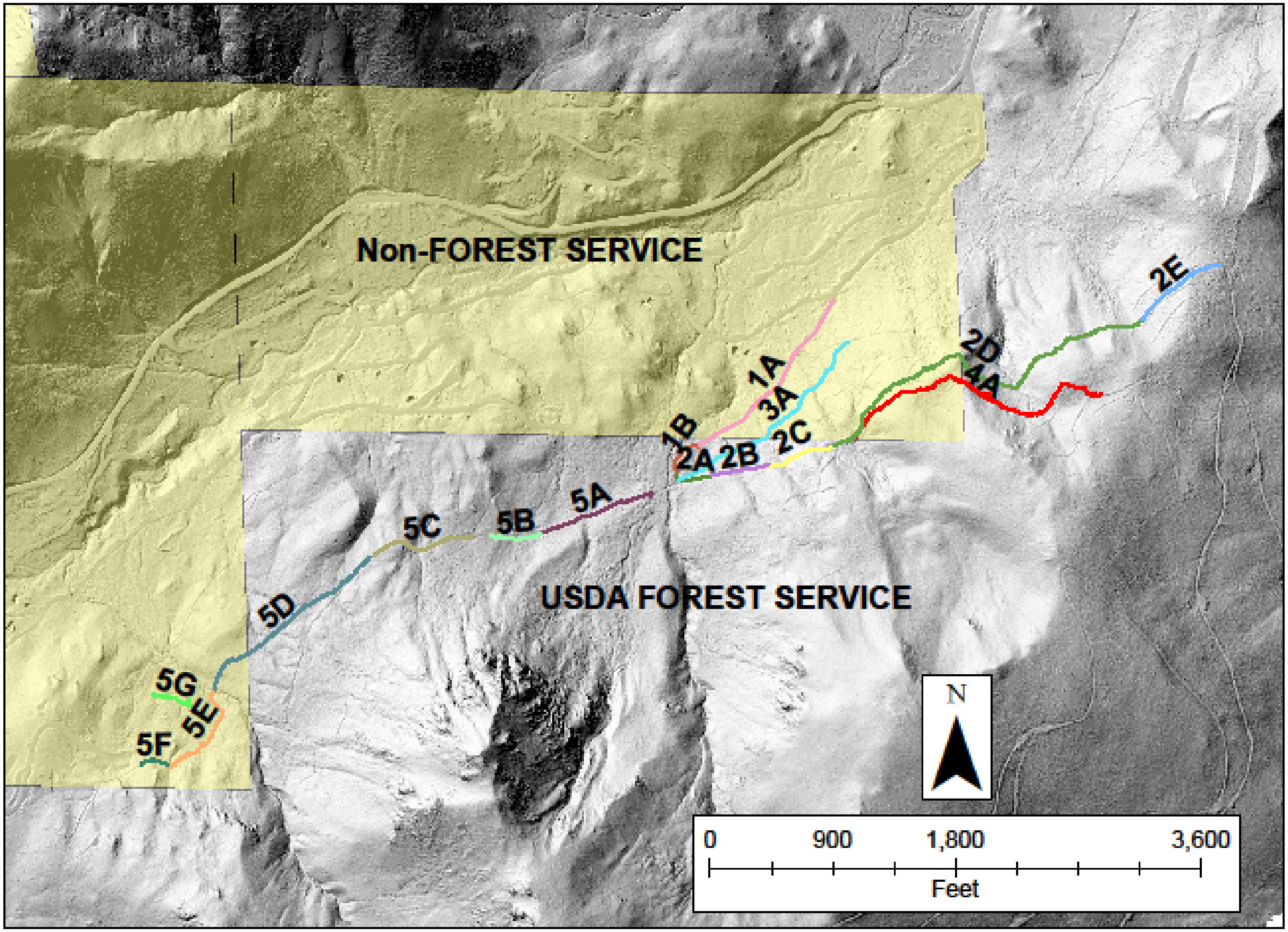
The highest priority item within this section is to return drainage at the junction of 5A, 1B and 2A to its presumed original flow along its eastern fork. This can be accomplished by modifying the stream crossings in Segment 5A and by creating raised topography on the eastern bank to direct stream flows at both stream crossings. This would relieve water delivery to the road system and follow existing hydrology patterns while significantly lowering the amount of sediment influx from the road, (as much as 200 lbs./yr.) during high flow events.

The second priority in this section would be to emplace proper drainage structures absent along several road segments. Segment 5E is a dirt road that runs roughly perpendicular to the hillslope and channels nearly all drainage from the north side of the mountain. Lack of proper drainage structures leads to as much as 1223 lbs. of sediment entering the main channel. Emplacement of proper drainage structures such as rolling dips and waterbars would help to lower the amount of sediment influx, (down to 22.5 lbs. according to the WEPP model), into the channel.

The third priority is to remediate several meadows whose hydrology has been disrupted by dirt roads and foot trails. Meadows typically allow dispersed, low rate flow that is not capable of picking up and transporting sediment. Channeling created by roads and foot trails has interrupted the typical flow pattern and allowed for sediment to stay within the runoff and eventually enter into Bear Creek.

USDA Forest Service Road Remediation Effects							
Road	**Segment**	**Road Ownership**	**Road Type**	**Length (ft.)**	**Priority Level**	**Major Recommendation**	**Annual Sediment Reduction %**
5	A	USFS	ML2 - Closed	1160	High	Improve road/trail channel crossings, install appropriate drainage diversions, reconfigure road, decommission where feasible	92 (combined reduction of 1B and 1A)
5	C	USFS	ML2 - Closed	823	High	Install water diversions along road and restore natural meadow hydrology of road/trail system	97
1	B	USFS	ML2 - Closed	351	High	Add waterbars on uphill half; add culverts on bottom half	96
2	A	USFS	ML2 - Closed	311	Mid	Clear culverts and add waterbars between culverts	58
5	D	USFS	Non-Motorized Trail	1652	Mid	Reconnect meadow hydrology	unk
2	B	USFS	ML2 - Closed	452	Low	Clear present culverts	unk
2	C	USFS	ML2 - Closed	522	Low	Clear present culverts; remediate high angle cutslope	unk
2	D	USFS	ML2 - Closed	3040	Nil	No recommendation	N/A
2	E	USFS	ML2 - Closed	736	Nil	No recommendation	N/A
5	B	USFS	ML2 - Closed	410	Minimal	No Immediate Recommendations	unk
4	A	USFS	ML2 - Closed	2823	Nil	Section has been successfully remediated	N/A

Private Road Remediation Effects							
Road	**Segment**	**Road Ownership**	**Road Type**	**Length (ft)**	**Priority Level**	**Major Recommendation**	**Annual Sediment Reduction (%)**
1	A	Private	ML2 - Closed	1489	Mid	Clear culverts and add waterbars between culverts to relieve flow on inslope	78
5	E	Private	ML2 - Closed	893	Mid	Clear fillslope and install waterbars	95
3	A	Private	Non-Motorized Trail	2417	Mid	Obliterate trail to reduce seepage	unk
5	G	Private	Non-Motorized Trail	356	Mid	Install waterbars	64
5	F	Private	ML2 - Closed	235	Low	Clear fillslope and install waterbars	94



Middle Section of Bear Creek Watershed and Road Sections

Road remediation:

7 road segments have been identified as needing remediation. Numerical values for sediment influx directly from the road before and after proposed remediation efforts were calculated using WEPP:Road batch results version 2015.03.02. Total sediment influx into Bear Creek is greater than presented values; the WEPP program only calculates sediment picked up along the road. See area E for more discussion related to road gully effects; additional contributions from sand application for winter road operations on paved roads additionally are not valid under this methodology.

Road Segment	Average annual sediment leaving buffer (lb)						
	Using WEPP					Allowing for Inaccuracy of Model (50%)	
	Before Remediation		After Remediation	Calculated Reduction	**Percent Reduction**	Presumed Reduction	**Percent Reduction**
	No diversion	With Current Diversion					
1A TOTAL	102	35	5	30	**86**	27	**78**
1B TOTAL	78	39	1	38	**97**	38	**96**
2A TOTAL	87	22	6	16	**72**	13	**58**
5C TOTAL	111	39	0	39	**100**	38	**97**
5E TOTAL	1223	430	15	415	**97**	408	**95**
5F TOTAL	11	3	0	3	**100**	2	**64**
5G TOTAL	116	48	2	46	**96**	45	**94**
Cummulative Effect of Remediation	1728	614	29	585	**95%**	569	**93%**

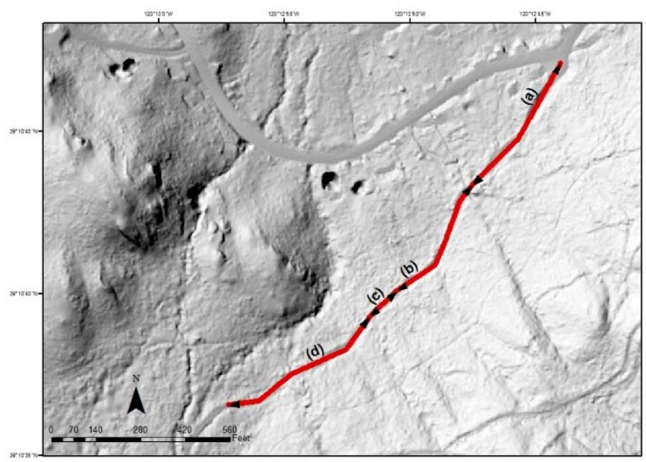
Private Land Segment 1- A: This private land road is assessed in this document because it provides access to the forest service section and a joint action could be possible if the landowner is interested.

SEGMENT 1A: This private land road is insloped and moderately rutted in places. The road catches stream subsurface and surface runoff from the cutslope and diverts flow as much as 125 ft. in places before allowing runoff. Prior attempts to mitigate runoff have been made to alleviate this flow with culverts spaced approximately 75 ft. apart through some of the segment.

Latitude: **120 12’49.300 W**
Longitude: **39 10’40.832 N**
Heading: **92**
Map Datum: WGS 84

Potential Remediation:

Remediation of This segment is divided into 5 sections: Section (a) improve the number of water diversions to approximately every 75 ft.; (b) needs no restoration; (c) improved with additional culverts through the segment; (d) improved with additional water diversions to approximately every 60 ft.



SEGMENT 1B:

This section of Forest Service Road has not been maintained for some time and significant remediation is required in this section. Overflow from upslope streams is channeled along the road in this section. This overflow has led to heavy rutting of the road and formation of gullies on the inside edge of the road at the bottom of this section. Tightly spaced waterbars are needed along the upper section and culverts on the lower section to alleviate concentrated flows.

Suggested Remediation: We recommend emplacing waterbars through this entire segment every 50 feet.

Latitude: 120 12'59.531 W
Longitude: 39 10'35.115 N
Heading: 51
Map Datum: WGS 84

SEGMENT 2A: This road segment needs increased water diversions spaced at approximately 50 ft. apart between the existing culverts. Culverts need to be cleaned out (at right). Some culverts overhang and water drops 2-3 ft. causing significant erosion beneath the culvert. Improve outlet designs to alleviate some of this erosive effect.

Suggested Remediation: We recommend cleaning out existing culverts, cutting back overhanging culverts, and adding water diversions through entire segment evenly spaced at 50 ft.

Latitude: 120 12'52.441 W
Longitude: 39 10'34.520 N
Heading: 00
Map Datum: WGS 84

SEGMENT 2B: Road exhibits little to no signs of rilling suggesting road has little effect on water flow. Several culverts exist to allow normal drainage of streams under the road. Some of these culverts need maintenance of vegetation and clearing debris.

Suggested remediation: Clear existing culverts

Latitude: 120 12'49.300 W
Longitude: 39 10'40.832 N
Heading: 351
Map Datum: WGS 84

SEGMENT 2C: Road is generally in good condition. One overhanging culvert outlet needs improvement to reduce impact from falling water. The existing cutslope is actively eroding in some locations and could use vegetative stabilization to reduce erosive effects. An area with standing water on the road may require a designed sub-drain.

Suggested remediation: Vegetate high angle cutslopes.

Latitude: 120 12'35.851 W
Longitude: 39 10'41.362 N
Heading: 260
Map Datum: WGS 84

SEGMENT 2D, 2E Roads are in good condition and do not require any remediation in this section.

Suggested Remediation: None

SEGMENT 3A: The foot trail between main throughways diverts channel flow, exposes subsurface flow, and concentrates flow. An old skid trail crosses the foot trail just due south of the locked gate but, does not interrupt natural hydrology.

Suggested Remediation: Obliterate foot trail

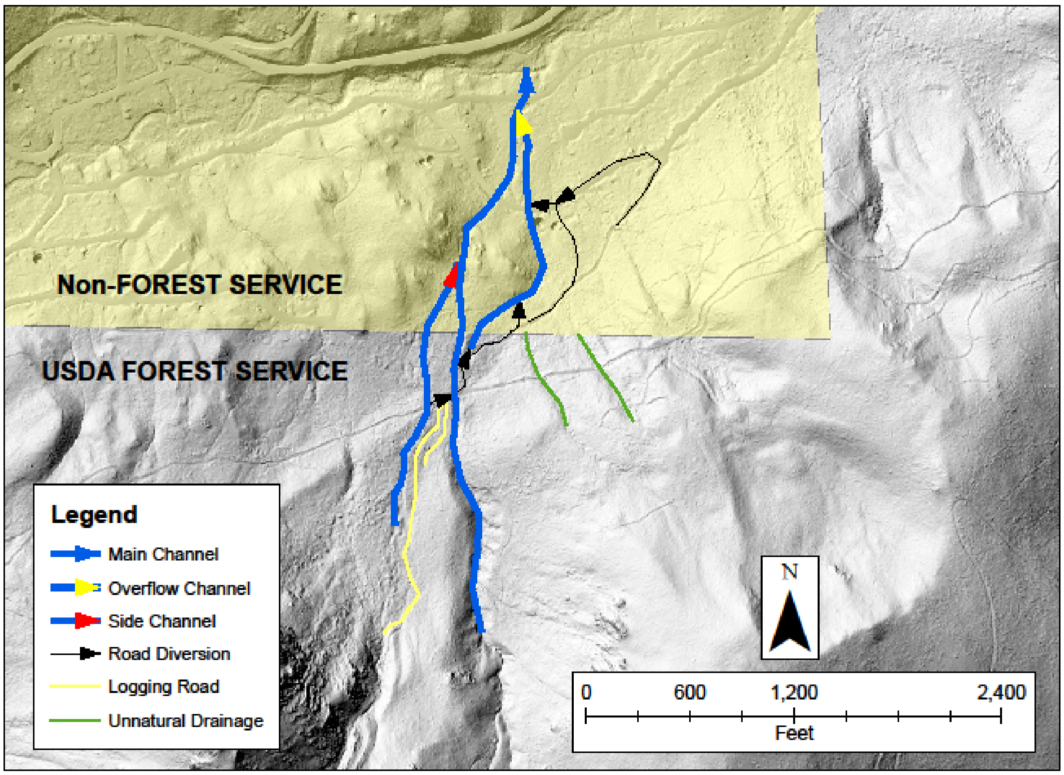
Latitude: 120 12'46.289 W
Longitude: 39 10'40.274 N
Heading: 95
Map Datum: WGS 84

SEGMENT 4A: Numerous waterbars exist and are functioning; vegetative growth has made the road nearly impassable in multiple places. At one point the cutslope has failed and filled the road. The disturbance required to get machinery to this location make mechanical remediation unreasonable.

Suggested Remediation: None

Latitude: 120 12'30.062 W
Longitude: 39 10'38.759 N
Heading: 161
Map Datum: WGS 84

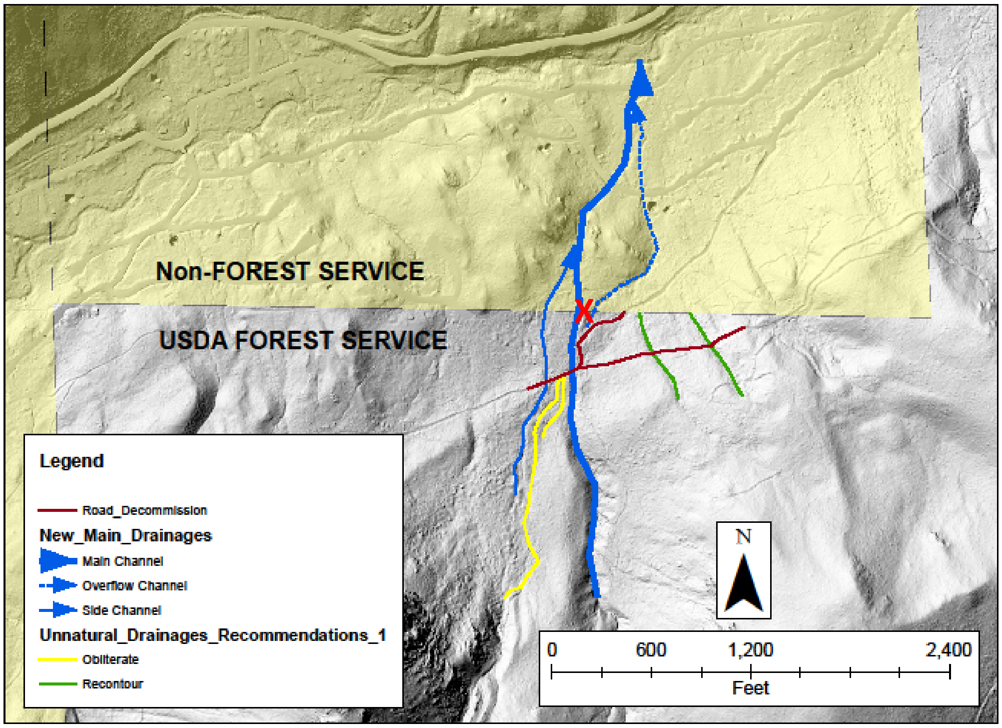
SEGMENT 5A: Significant remediation measures are needed in this area. Two streams cross the trail but overflow is not captured. Diversions were placed to maintain flow along the stream's present day pathway, but traffic has caused the raised topography to be worn down. During times of high runoff overflow the road now captures this runoff and allows significant erosion off the road. The high mound where the drainages split show signs of deposition and over time water has coursed on one side or the other; flow has since been controlled to allow for timber harvesting and housing development downstream.



Latitude: 120 13'01.519 W
Longitude: 39 10'32.969 N
Heading: 270
Map Datum: WGS 84

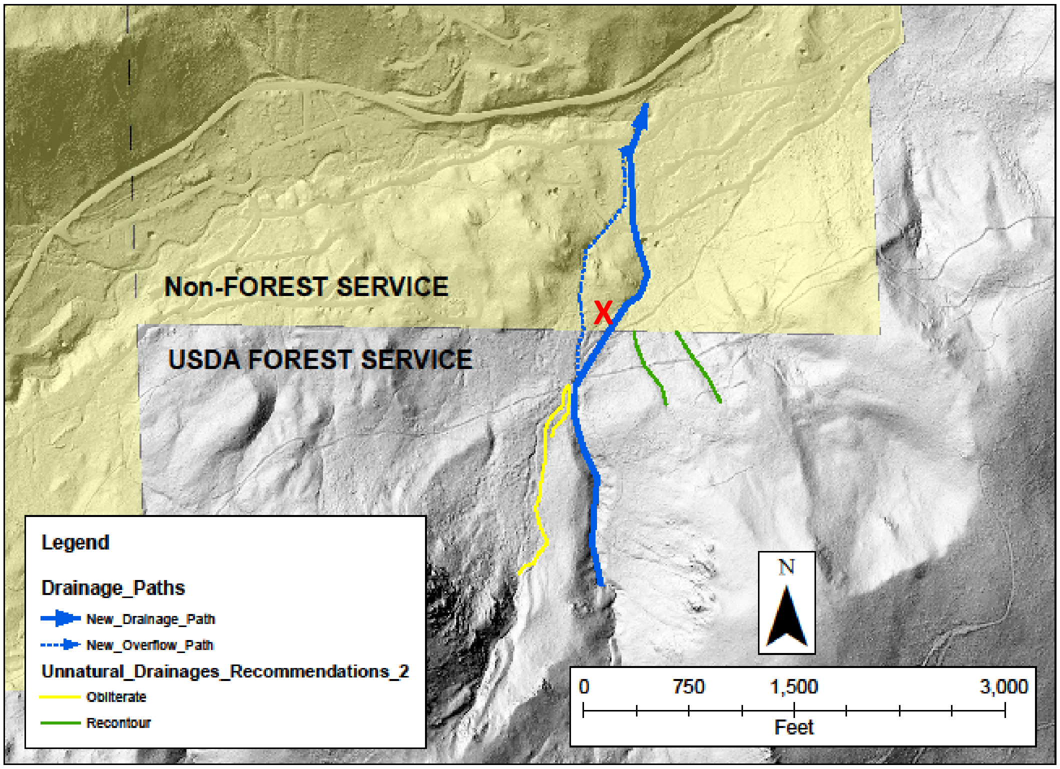
Latitude: 120 12'59.928 W
Longitude: 39 10'33.467 N
Heading: 180
Map Datum: WGS 84

Suggested 5A Remediation 1:



If the road is decommissioned and obliterated the site would be restored to allow the stream to disperse around both lobes as channel morphological changes occur near the X in the figure. The area where the stream crosses the road would need to be re-contoured to its approximate original shape, by decommissioning the road in this area and restoring the stream channel reconnecting pre-existing flow routes. This would incorporate some redistribution of disturbed timber access routes within the wet slope above the X on the map.

Suggested 5A Remediation 2:

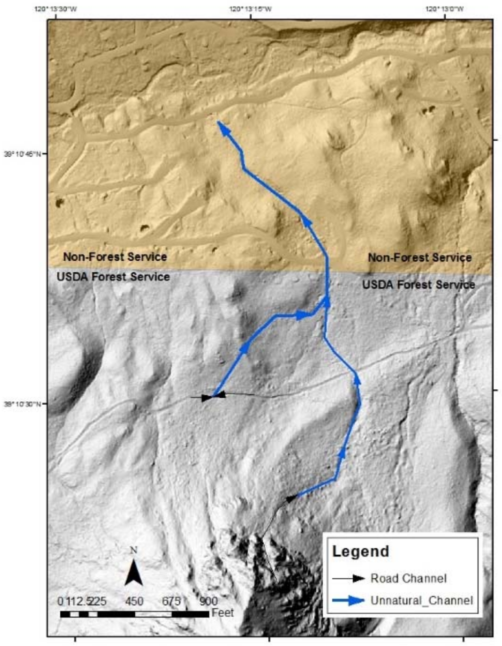


This alternative is the most probable for site remediation. The proposal would be to maintain the existing road and to ensure all drainage is maintained to the west of the X around the natural mound in the middle of the figure. This can be done in a fashion similar to plan 1: repairing the drainage across the road and designing bridge or other appropriate drainage crossing; with an option to decommission and/or rerouting the road that runs NE to alleviate drainage capture. Improvements may include; restoring an old skid trail that channels water east of the X that contributes to road erosion, and may include recontour of skid trails and berms upslope along the western most drainage. This will prevent much of the road erosion that is occurring in this section.

SEGMENT 5B: Some rilling of road. One natural stream crossing.

Suggested Remediation: None

SEGMENT 5C (east): Road has captured and channelized drainage (photo B). Channel empties into meadow on fillslope and has channeled flow through the meadow (photo A).



Suggested Remediation: Add water diversions along the road approximately every 55 ft. Restore meadow hydrology by reconnecting hydrologic flows across meadow surface.

Latitude: 120 13'19.406 W
Longitude: 39 10'30.178 N
Heading: 40
Map Datum: WGS 84

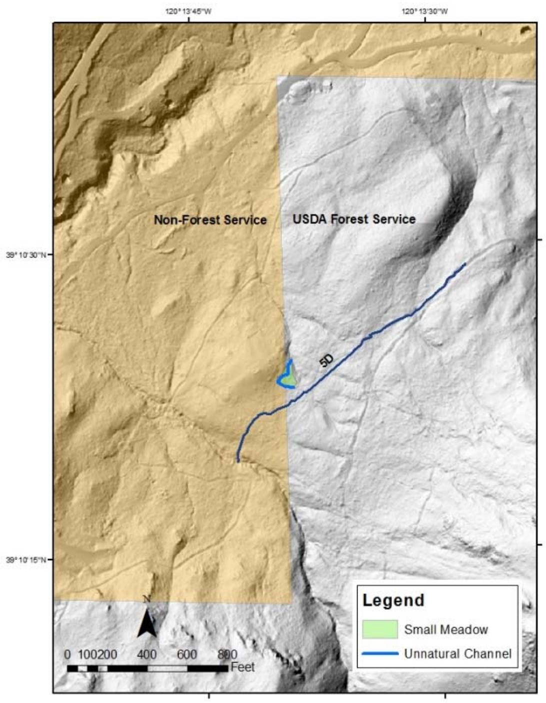
Latitude: 120 13'19.912 W
Longitude: 39 10'30.186 N
Heading: 90
Map Datum: WGS 84

SEGMENT 5C (west): Road captures runoff and channels into preexisting channel paths. Along hilltop runoff has mounded sediment on the fillslope that allows runoff to channel around the mound.

Suggested Remediation: Remove mounded sediment below road.

Latitude: 120 13'25.248 W
Longitude: 39 10'30.210 N
Heading: 35
Map Datum: WGS 84

SEGMENT 5D: Overall road 5D is in good shape. However, at point 38 a meadow is incised from trail use. This cut catches all water flow through the meadow and channelizes it. To the SE, topographically above road 5D in this section, the road appears to be channeling runoff in several areas. We suggest further review of this southern road.

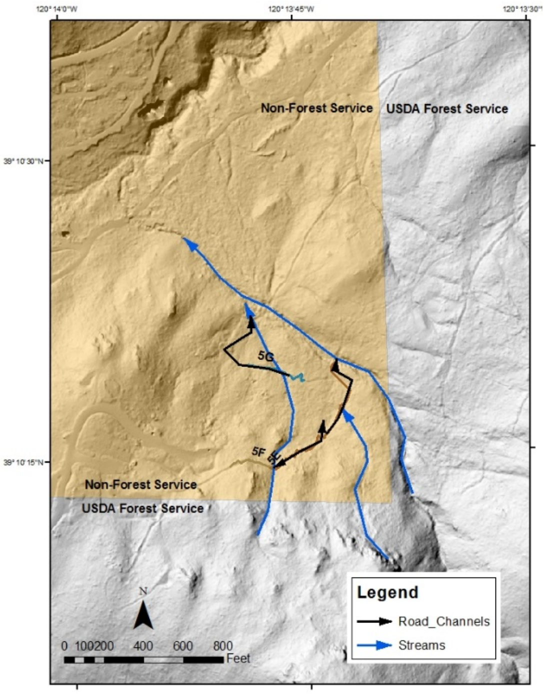


Suggested Remediation: Repair trail and road to promote dispersed flow through meadows and assess need for access through segment over forest service lands.

Latitude:	**120 13'40.129 W**
Longitude:	**39 10'23.251 N**
Heading:	**100**
Map Datum:	**WGS 84**

Private Land Segment 5E, 5F and 5G: This private land road is assessed in this document only because it contributes to the main Bear Canyon drainage and may contribute to the impacts seen on Forest Service Lands Downstream.

SEGMENT 5E: Road channels significant flow in both sections. Numerous felled trees parallel the road on the fillslope of 5E and help to contain water flow onto road. Felled trees need removed and waterbars need emplaced to reduce flow rate. Cutslope adds to sediment erosion at places.



Latitude:	**120 13'44.427 W**
Longitude:	**39 10'15.565 N**
Heading:	**78**
Map Datum:	**WGS 84**

SEGMENT 5F: Road is in good shape in this section. No remediation needed.

SEGMENT 5G: Road catches a lot of flow and diverts into meadow to the NW. Due to downstream infrastructure a detailed study may be needed to determine. Recommend waterbars to slow down channeling of water into meadow. The meadow the road crosses to the NW (in photo) shows signs of previous studies as it is flagged and at least one well is present. No sign of previous study or remediation in Segment 5G however.

Suggested Remediation: Install culvert at stream crossing. Add water diversions every 50 ft. on west sloping road west of stream crossing.

Latitude:	**120 13'49.509 W**
Longitude:	**39 10'20.416 N**
Heading:	**178**
Map Datum:	**WGS 84**

Bear Creek Watershed Assessment

Deer Park Ski Area: Legacy Site

1. Existing Conditions:

The Deer Park Ski area (previously named Powder Bowl) was initially developed in the late 50's with the first signs of grading showing up on forest service aerial photos in 1966. The ski area changed hands and was operated as Deer Park in 1983 and 1984. The responsible party for Deer Park ski operations filed bankruptcy. Ski area lift facilities were removed from the ski area under the special use permit in 1984. Since that time, a special use permit was acquired by Alpine Meadows Inc. (in 1993) but, there were never any ski operations in the area. The ski area portion was released from the Alpine Meadows Inc. in 1998 but, the parking lot and small facilities were retained by Alpine Meadows for overflow parking and some facilities operations. At the time when the ski area was constructed it was a common practice to regrade slopes and the Deer Park Ski area development utilized major slope re-grading for the ski runs. Current signs of heavy use by the public in this area is not obvious.

The slope regrading removed natural roughness features, removed the rock fragments from the top soil surface, and removed tree and shrub vegetation replacing the site with a smooth monoculture of grass. While erosion control structures as low profile slope diversions were constructed on the graded slopes, these erosion control features have failed. These modifications from the natural slope conditions now create a long flow path down the fall line of the ski slope. As the years progressed since abandonment of the faciliities, the unnatural drainages have worsen, creating rilling and incisional features. Because of a lack of roughness and vegetative changes, the site has directed an unnatural amount of discharge to the northern slope base of this area (See the general flow patterns on Map 1: Deer Park Legacy: Existing Conditions and the positively affected areas on Map 2: Deer Park Legacy: Remediation). The existing conditions include rill and gully formation as shown on the map and in the site photos (Figure 1). There is evidence of transport of water and sediment to drainage structures that are found in the adjacent parking lot and road to the north. The creation of ski slopes by grading reduces ecosystem function and decreases the predictability of soil and vegetation recovery. The documentation suggest the existing graded ski slopes may benefit from restoration of soils and vegetation (Burt and Clary, 2016). Approximately 4.85 acres are disturbed from development of this ski area.

Figure 1. Looking upslope at the hillside from the parking lot directly north of Deer Park.

2. Remediation Summary:

The plan for remediation of this site was developed and will be used during the NEPA planning phase to determine the final proposed action. The preferred alternative is to re-contour the ski slope features and return the area to near natural slope patterns.

This preferred alternative would include:

- Restore infiltration through reincorporating rock and roughness to the ski slope surface areas
- Restore natural flow patterns through re-grading to approximate original slope where feasible and effective
- Restore natural vegetation types to increase rainfall interception, reduce raindrop splash and increase infiltration rates.
- Provide water control measures (waterbars-to support re-graded site conditions).
- Bust up burry/and or remove cement lift infrastructure and other infrastructure as identified.

These actions would increase infiltration and allow slope hydrologic properties to be re-established while decreasing the length of concentrated flow patterns. Flow paths for water should return to patterns similar to those present prior natural gradient flows. The disturbed

4.85 acres from the development of this ski area will be returned to near natural conditions, and approximately 3.14 acres downslope of disturbed features would be positively affected. This action would result in a long-term reduction from the likely continued increase in erosion and sediment production. However there would be some potential for erosion over the first years following restoration until the site would attains vegetative stabilization.

A second option could include the reinforcement of existing erosion control structures and installation of more structures in areas that are lacking. This would have short term reduced impacts but would have long-term erosion consequences and require long-term monitoring and long-term maintenance.

3. Map Features

The Deer Park Legacy site consists of multiple disturbed features. These include: fills/berms, depressions that require fill and recontour, graded slopes and respective cut and fillslopes, entrenched roads/trails. The following is an itemized list with their corresponding feature label for the pre and post remediation maps. Each item describes the problem and remediation associated with the feature.

3.1 Fill/Berm Material:

Fill/Berm material consist of local materials cut and transported then placed above the natural slope. These features prevent proper sheet flow over the slope, as well as create unnatural flow paths for runoff. They provide possible fill material for re-contouring and re-grading.

Fill/Berm Material Feature:

F1: This berm can be moved to the west to close off the road and fill in erosional features and drainages associated with the adjacent abandoned road feature. There is a landing to the east that contains bare earth, and would require mulch and seed to cover exposed soils.

F2: Small berm, should be moved and/or recontoured to natural gradient to prevent unnatural rill formation.

F3: Small bench cut. Should be recontoured.

F4: Fill/berm found on the hillcrest directly south of feature C3. Material should be moved so surrounding area can return to natural gradient. Material can be used as fill material for the recontour of feature C3.

3.2 Landings

There are two landings found in Deer Park that have exposed soils due to poor cover. Exposed soils allow for erosion due to rainfall and runoff. Adding mulch and seed to cover exposed soils will prevent surface erosion.

Landing Features:

L1: Landing to the east of fill/berm feature F1. There's a small trail that leads to this landing to the northeast. There are exposed soils here that a vulnerable to erosion from surficial flow and rainfall. Adding mulch and seed to cover exposed soils will mitigate erosion.

L2: Landing found to the southwest C3 and attached to the west end of road feature R7. This landing appears to have been made by cutting in to the slope. There is a small berm here. Landing has exposed soils that are vulnerable to erosion from overland flow and rainfall. The small berm could be brought back to the cut slope for recontouring. Revegetation would provide ground cover to the bare soils and prevent erosion.

3.2 Road Treatments:

Multiple linear features that resemble old roads/trails were found in the area. Nearly all are connected, with rilling seen throughout. These old roads/trails are transporting runoff from the graded slopes down to the northern base slope of the site. Road treatments are for linear road features that does not consist of a major cut into hill slope. Treatments mainly consist of either: waterbars, fill, and/or recontour.

Road Treatment Features:

R1: Recontour/Waterbar. Fill feature F1 could be used for recontouring.

R2: Recontour/Waterbar. Material nearby fill feature F3 can be used. This segment's material consist of a large amount of rock, importing rock maybe required (Figure 2).

Figure 2. Looking upslope of feature R2. This feature cuts into substrate that consist of bedrock.

R3: Recontour/Waterbar. Material that can be used to recontour may come from nearby fill feature F3.

R4: Recontour/Waterbar. Segment of road is entrenched and channeling upland flow downhill into the lower features. Recontour and adding waterbars will disconnect upstream flows and reduce the amount of channelized flow.

R5: Recontour/Waterbar. Segment of road is nearly outslope shaped. Waterbars would allow for effective diversion of water down the west slope (Figure 3). Once upstream flows are disconnected this slope would have a large reduction in channelized flows.

Figure 3. Looking downslope along feature R5. Slope drops down to the left (west) past vegetation.

R6. Recontour/Waterbar. While short, this segment contributes to the runoff found on R4 which accumulates and continues into the rest of the road features. Fill material for the recontour of this segment can be found in the berm directly north from cut feature.

R7: Small path attached to landing L2. East end of path ends in C3 fillslope. Should be recontoured and have waterbars constructed to return natural overland sheet flow.

3.3 Requires Fill/Recontour Areas:

Several areas require to be filled to help recontour to natural gradient. This will prevent unnatural preferred flow paths and return sheet flow over the slope.

Requires Fill/Recontour Area Features:

N1: Depression at the base of this area (Figure 1). The depression has allowed for a steeper slope gradient, providing more energy for water to incise the slope. Returning this area to a natural gradient will return natural sheet flow the slope. Fill material from this area can be taken from fill feature F1.

N2: Fill near the top of area. Feature is near the top of crest. This can be removed and used to fill against cutslope/depression near feature C3. Filling of the depression downslope will allow flow to sheet flow across slope.

3.4 Unnatural Drainages

There are two unnatural drainages that flow north towards the base of Deer Park. These features may have been created as part of the construction of a lift. Slope runoff now flows into these drainages, further incising into the slope and carrying large amounts of runoff into other flow paths such as R1. Filling and recontouring these features will allow the slope to return to proper sheet flow.

D1: Closest drainage flowing into R1. Cuts through a significant amount of slope. Filling in these feature will prevent slope runoff to concentrate in this channel and further incise.

D2: Drainage above D1. There appears to be a small break consisting of a small plateau before D2 flows into D1. Still, it increases the accumulated flow that flows into D1 and further down into R1. Similarly, cuts through a significant amount of slope. Filling in this feature will prevent slope runoff to concentrate here and further incise this feature.

D3: Unnatural drainage that is incising the slope at the base of Deer Park (Figure 1). Large amounts of water flow through this drainage due its connectivity to nearly all the features in this area. This large amount of flow is initiating rill and gully formation. Filling in this feature will prevent runoff from focusing in this channel, and return proper overland flow to this slope.

3.5 Graded Slopes:

These areas are major cut/fill created ski runs. These features are significant alterations to the landscape that are directly related to the unnatural drainage patterns in the area. The cutslopes are poorly vegetated and exposing over steepened eroding bare soils. This allows for mass sediment movement from these slopes and onto the bench cut. The sediment then becomes available for transport downslope and into other drainages, causing further damage. Waterbars were built on these graded slopes to mitigate erosion. However, since the time of their construction, they have not been properly maintained and have failed. Some are failing due to brush and other vegetation blocking the diversion, others appear due to rodent burrows. The preferred solution is to recontour, roughen, and vegetate the surface of these features to their natural slope and gradient. This will effectively increase infiltration for runoff in this area and restore proper sheet flow. Drainages downslope will receive less accumulated flow from properly dispersed flow uphill, and effectively stop further incision.

At a minimum reinforcement and exaggeration of the waterbars across the features would mitigate impacts and prevent accumulated water to rundown existing rills.

Graded Slope Features:

C1: Graded slope is lightly vegetated, mainly consisting of grass (Figure 4). However, the waterbars have failed due to lack of maintenance. This has produced rillings that can be seen from the top of this area to the base and continues onto road R4. Fill material can be used from the west bench feature F5. Material removed from the cutslope appears to have been used as the fill slope to widen the area. This fill slope material can be pulled back and used for recontouring. Revegetation and surface roughening will allow the flow of water to slow down, and prevent future rilling. Reinforcement of waterbars or recontouring will temporarily reduce concentrated flows, preventing rills from increasing in incision.

Figure 4. Looking upslope (south) at feature C1.

C2: This area is the narrowest of the other graded slopes, but has the most exposed cutslope (Figure 5). Cutslope material has slid down and deposited at the base of the cutslope, where rills occur. Water from uphill sheet flow is being concentrated and flowing down into the cross drains. Areas of failure contribute to the rilling and concentrated flow. Recontouring is the recommended remediation for this feature. Material from fill/berm, F6, can be pulled back and used to recontour the graded slope and connect back to the cutslope. Revegetation and surface roughening will allow the flow of water to slow down, and prevent future rilling. This should increase proper hill sheet flow, infiltration, and remove unnatural preferred flow paths.

Figure 5. Looking upslope (northeast) at the base of feature C2. Rilling can be seen at center of the photo and moving to the bottom right. Cutslope has exposed surface.

C3: The largest and the highest elevated graded slope in the area (Figure 6). Vegetation is found on the graded slope, and consists of mainly grass with some shrubs. The cutslope is poorly vegetated and exposed. Waterbars were constructed on this slope, but most have failed due to lack of maintenance. Rilling occurs and gully erosion is present due to the lack of functioning erosional control. The flow continues down to the northwest end of this feature and connects with rilling found in C2. A portion of the flow is directed to an adjacent channel. Flow then continues through the majority of features found at this site and ends at the base, next to the parking lot and connecting with the drainage system there. As this area of disturbance is the highest in the site, its contribution to unnatural discharge and flow paths is the highest priority. Its remediation would positively affect the rest of the features. Enlarging, reinforcing and increasing the number of existing waterbars will help in dispersing water flow properly, however lack of continued maintenance would eventually result in enlarged gully erosion and increased delivery to the stream channel and drainage ways. Recontouring provides a long-term solution. Revegetation and surface roughening will allow the water to infiltrate, increase vegetative interception and transpiration and slow down flow velocities to reduce future erosion processes. The fillslope and its adjacent parts of the graded slope can be pulled back and reconnected to cutslope. More material can be acquired from fill feature F7.

Figure 6. Looking upslope (south) at the base of feature C3.

4. Positively Affected Areas

Two areas at the base of this site will see reduction in erosion and sediment transport once features higher up in slope become remediated. The excess transport of water to these base areas due to unnatural drainage channels and accumulated flow has initiated rill and gully formation on these slopes (Figure 1). Once the uphill restoration has stabilized, the amount of water directed to these locations should be effectively lowered, and erosion reduced. Approximately 3.14 acres will see these benefits.

5. Sediment Loss and Reduction

Modeling for road segment sediment lost was done using WEPP: Road Batch. Modeling for graded slopes was done using WEPP for Windows.

5.1 Road Segments

Table 1. Parameter inputs for WEPP: Road Batch for road segments before remediation.

Road Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
R1	Outsloped, rutted	native none	17.99	224	5	25	9.9	10	46	50	209
R2	Outsloped, rutted	native none	16.35	218	5	10	29.7	36	288.7	50	171
R3	Outsloped, rutted	native none	14.14	236	5	31.25	13.2	5.4	275	50	169
R4	Outsloped, rutted	native none	18.9	323	5	28.57	5.78	29.8	443	50	478
R5	Outsloped, rutted	native none	14.74	88	5	6	13.2	35	163	50	23
R6	Insloped, bare ditch	native none	14.1106	85	7	17.4279	11.48	28.67	579	50	27
R7	Outsloped, unrutted	native none	18.1	221	13.12	44.3459	18.04	37	1000	50	144

Table 2. Parameter inputs for WEPP: Road Batch for road segments after remediation.

Road Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
R1	Outsloped, unrutted	native none	17.99	224	5	25	9.9	10	46	50	21
R2	Outsloped, unrutted	native none	16.35	218	5	10	29.7	36	288.7	50	16
R3	Outsloped, unrutted	native none	14.14	236	5	31.25	13.2	5.4	275	50	16
R4	Outsloped, unrutted	native none	18.9	323	5	28.57	5.78	29.8	443	50	30
R5	Outsloped, unrutted	native none	14.74	88	5	6	13.2	35	163	50	6
R6	Outsloped, unrutted	native none	14.12	85	7	17.42	11.48	28.67	579	50	10
R7	Outsloped, unrutted	native none	18.1	221	13.12	44.35	18.04	37	1000	50	144

Table 3. Sediment lost values for road segments before and after remediation.

	Current Conditions	Post Remediation	
Road Segment	Annual Sediment Leaving Road (lbs)	Annual Sediment Leaving Road (lbs)	Percent Reduction
R1	209.00	21.00	89.95
R2	171.00	16.00	90.64
R3	169.00	16.00	90.53
R4	478.00	30.00	93.72
R5	23.00	6.00	73.91
R6	27.00	10.00	62.96
R7	144.00	<13.24	90.81
Total	**1221.00**	**112.24**	**90.81**

R1 through R6 see a major reduction due to the change in road type used for WEPP. Before remediation parameters for these segments indicating rutting. Parameters for post remediation indicate no rutting due to proposed recontouring. R7 sees no reduction because the current condition of the road is outsloped with no ruts. However, recontouring this section of road and altering its road fill properties to a natural slope gradient has the potential lower its current sediment lost. There's an overall 90.81% percent reduction for the other existing roads, and we use this value to project the potential loss for segment R7.

5.2 Graded Slopes

Table 4. Parameters for graded slopes used as inputs for WEPP for Windows.

	Acres	Length (ft)	Width (ft)	Steepness (%)	Shape	Management Grass	Soil Name	Average Annual Soil Loss ton/A	Average Annual Soil Loss lbs/yr
C1	0.849	514	78	18	Concave	Grass	Sod Grass Sandy Loam	0.116	196.968
C2	0.135	246	23	23	Uniform	Grass	Sod Grass Sandy Loam	0.003	0.81
C3	2.09	631	148	23.5	S-Shape	Grass	Sod Grass Sandy Loam	0.492	2056.56

Table 5. Parameter inputs for WEPP: Road Batch for ruts found on C1 and C2 in current condition.

Rut Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
C1	Insloped, bare ditch	native none	15.9	519	1	40	33	37	462	50	194
C2	Insloped, bare ditch	native none	21.12	250	1	50	23.1	47	356.4	50	64

Table 6. Parameter inputs for WEPP: Road Batch for ruts found on C1 and C2 after remediation.

Road Segment	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
C1	Outsloped, unrutted	native none	15.9	519	1	40	33	37	462	50	5
C2	Outsloped, unrutted	native none	21.12	250	1	50	23.1	47	356.4	50	3

Table 7. Sediment loss values before and after remediation.

	Current Conditions	Post Remediation	
Graded Slope	Average Annual Soil Loss (lbs/yr)	Average Annual Soil Loss (lbs/yr)	Percent Reduction
C1	209	10.45	95-100
C2	171	8.55	95-100
C3	169	8.45	95-100
Total	**549**	**27.45**	**95-100**

WEPP for windows was used to model soil loss for the graded slopes in their current condition. Post remediation would have all graded slopes to near natural conditions and natural background soil loss. It is predicted to see a 95-100% reduction in the amount of soil loss. C1 and C2 both have rut components in their graded slopes, and those were modeled using WEPP: Roads Batch. Both were classified as insloped bare ditch in their current condition, and post remediation would have them classified as outsloped unrutted. We see a ~95-97% reduction in sediment leaving the ruts.

<u>Bear Creek Watershed Assessment</u>

Alpine Meadows Main Road

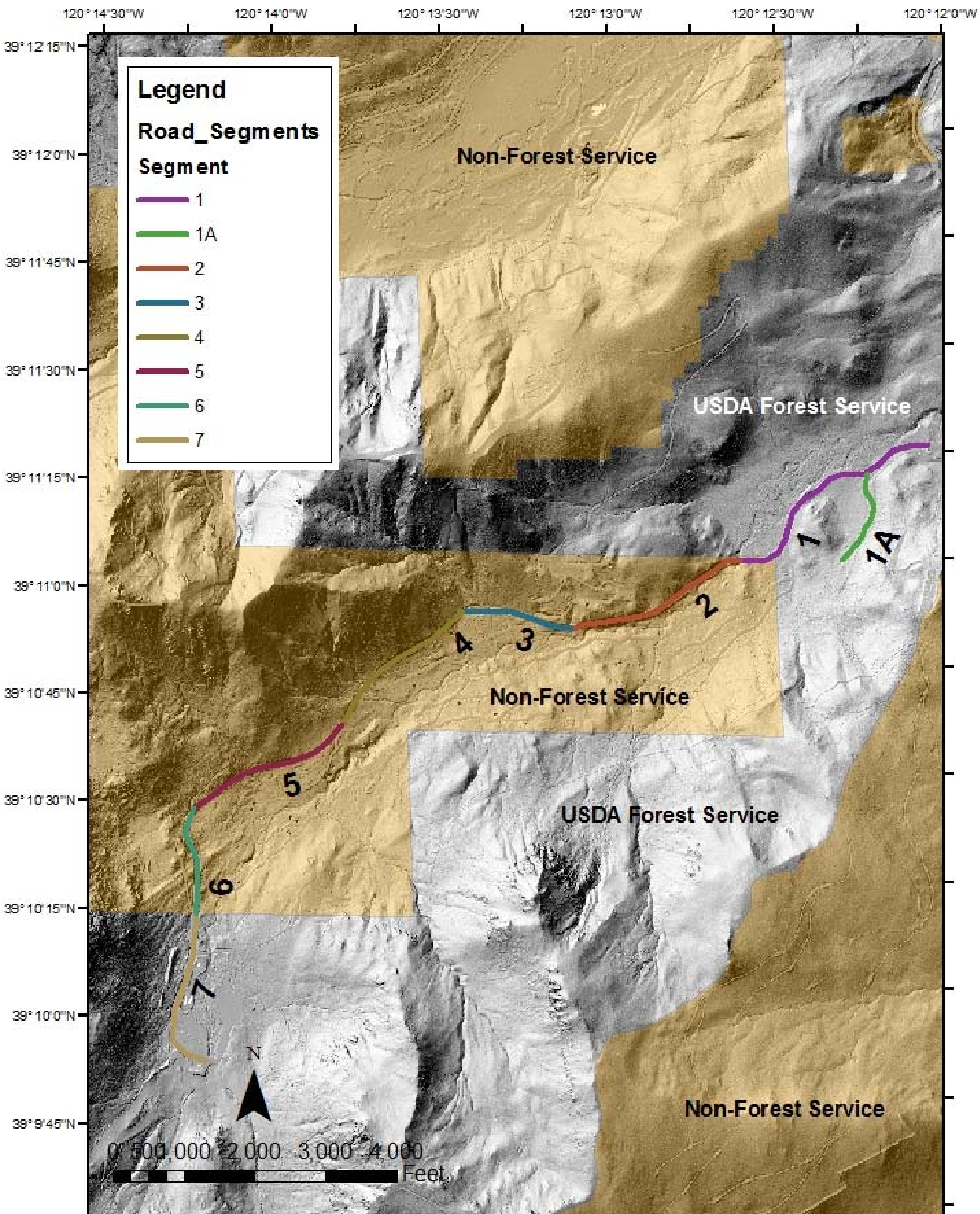
Summary

The majority of sediment influx in the Bear Creek Sub-Watershed within the Alpine Meadows Road assessment area is due to winter ski operations (plowing and sanding) on county roads (Segment 7). One focus area within Forest lands Special Use area is within the Alpine Meadows parking lot (Segment 7). It is estimated that over a 3-5 year period the grading of the parking lot decomposes the surface aggregate up to 2 ½ inches deep, resulting in as much as 9000 tons of sediment that is freed up and deposited in the floodplain of Bear Creek. Other contributors of sediment into Bear Creek include materials from road sanding and associated winter plowing effects. In the area immediately adjacent to Alpine Meadows Road contributions can be attributed to occur from hillslope erosion and ravel off high angle road cuts. Insloped roads with gullies that have culverts spaced an average of over 500 feet apart transport sediment from these high angle slopes directly into Bear Creek. Sediment influx due to low infiltration across road surfaces and associated ditch and gully erosion is calculated for the segment of road within USDA Forest Service jurisdiction assuming both current and suggested outlet spacing; using the WEPP:Roads model we can expect an 89% reduction in sediment into Bear Creek by emplacing culverts spaced 100 ft. apart. There is also a side road that that catches and channels significant sheet flow from uphill along the length of the slope cut. It is insloped and bermed along the fillslope through the majority of its length, and the channeled flow it creates remains channeled until it reaches Bear Creek, making it a moderate contributor of sediment. The meadow system on forest service lands is affected by these sediment inputs and has been negatively influenced from these numerous upstream conditions has also been negatively affected by the road culvert at the end of segment 2. Further future assessment and reconnaissance is required to determine remediation plans that could restore function of this meadow system.

Overview of Recommendations

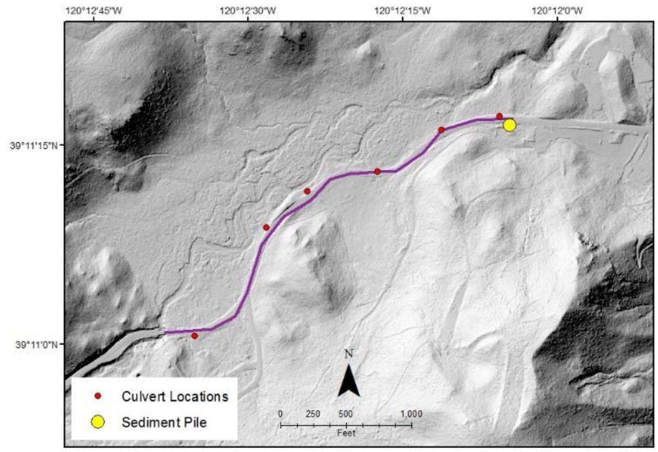
Proper disposal of decomposed parking lot materials created through plowing paved surfaces at the Alpine Creek Ski Resort is emphasized as an area for remediation efforts over forest service lands. Along with the Segment 1A is recommended for a complete recontour of the road bed to recover the natural hillslope drainage pattern. The inside ditches along Segment 1, while lengthy, are heavily vegetated and close enough to the river to reduce levels to background sediment, provided remediation's along Road 1A are implemented. Other sites could potentially be improved however county road right of ways and easements along with other infrastructure could make improvements problematic. Much more integration with our external parties would need to be explored. It would be good to review plowing patterns over the county road because much of the sediment collected at outlets of culverts along the Bear Creek on Forest Service lands appears to be primarily from winter road operations. Other drainage infrastructure would be good to be explored at a time when other road construction needs arise.

Road	USFS	Road Type	Length (ft)	Priority Level	Major Recommendation
7	USFS	County	1569	High	Bi-annual repavement of parking lot means old lot is dumped into Bear Creek
1A	USFS	Non-Motorized	1404	Low	Recountour slope along old road to return natural flow pattern
1	USFS	County	3416	Low	Additional culverts
2	Private	County	2644	Mid	Cover exposed hillslope and install proper drainage structure
3	Private	County	1565	Mid	No remediation along road; northern drainage needs investigated
4	Private	County	2372	Mid	Cutslope needs covered and revegetated
5	Private	County	2464	Nil	Functional
6	Private	County	2404	Nil	Functional



Road segment designation for the Bear Creek Main Road segment

SEGMENT 1



Segment 1 is characterized as having inside ditches and gullies along the entirety of its length. Currently culverts are spaced very widely apart (red dots identify culvert locations), and can be increased in frequency to improve hydrologic connectivity across the road to the meadow system. This action can improve function of the meadow system across the road increasing vegetative stability, reducing runoff delivery velocity through the culverts and resulting in a decrease in in-channel erosion and sediment transport. The current condition along this length is affected by hillslope conditions and infrastructure improvements that allows flow to build up significant volume and energy and enables it to carry heavy sediment loads from winter snow operations and from upslope sediment through the culverts and is evidenced as active sediment concentrations seen at the outlets of every culvert (below). An additional contributor comes from the Deer Park/Alpine Meadows Special Use Permit Area at the south west corner of their parking lot and facilities. Here a large storage area of winter operations waste is piled at the north west of their operating area (3rd photo) and this material is directly adjacent to the drainages and culverts without a mitigation for sediment control, which then transports these materials directly through the system to the Bear Creek Drainage floodplain.

Latitude: 120 12’29.015 W
Longitude: 39 11’08.390 N
Heading: 315
Map Datum: WGS 84

Sediment buildup at culvert outlet indicates amount of energy channeled flow has during high precipitation/runoff events

Latitude: 120 12’06.294W
Longitude: 39 11’17.472 N
Heading: 165
Map Datum: WGS 84

This channeled flow can have high enough energy to cut paths from culvert to Bear Creek

Latitude: 120 12’05.087W
Longitude: 39 11’15.497 N
Heading: 255
Map Datum: WGS 84

Suggested Remediation:

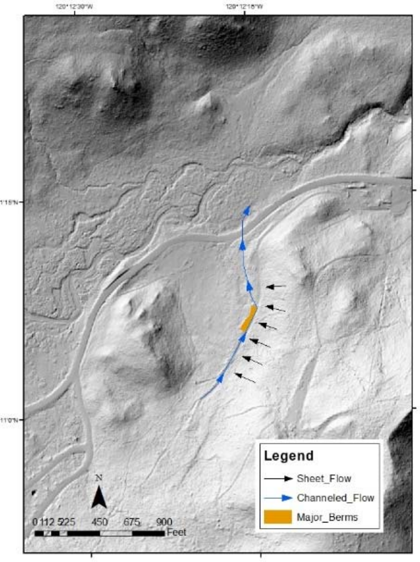
To reduce velocity and depositional rates at the existing culverts, additional culverts and cross drains could be emplaced between the currently existing ones. By increasing the spacing to approximately 100 ft. between culverts (see map above) sediment transport could be reduced and water would be more efficiently distributed in the stream system. When this culvert spacing was ran through the WEPP:Roads model, we saw an 89-94% decrease in sediment influx into Bear Creek. In addition, a thorough geo-technical assessment to identify practical and efficient methods of stabilization and revegetation of the exposed hillslopes both upslope and downslope of the road through this section could improve delivery of sediment to road ditches.

	CURRENT CONDITION	IF CULVERTS EMPLACED	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving buffer (lb)	
Partial Segment 1			Insloped, bare ditch	native low	3	460	3	30	5	10	60	10	0.1	1.2	46	
																0
Partial Segment 2			Insloped, bare ditch	native low	3	594	3	60	10	8	20	10	0.1	2.6	132	
																3
Partial Segment 3			Insloped, bare ditch	native low	3	594	3	30	5	10	45	10	0.1	1.9	92	
																5
Partial Segment 4			Insloped, bare ditch	native low	3	419	3	15	2	20	30	10	0.1	2	54	
																3
Partial Segment 5			Insloped, bare	native low	3	403	3	40	3	15	90	10	0	0.7	29	
																2
TOTAL															**353**	**26**

Reduction in sediment influx into Bear Creek along Segment 1 using improved culvert spacing

SEGMENT 1A

An old road exists south of the present day road and parallels Alpine Meadows road until it bifurcates at Alpine Meadows Stables. South of this point of bifurcation the break in slope of this old road combined with raised berms on its fillslope allows it to catch sheet runoff from the slope to the southeast, divert it and channel it along the old road. The energy of this channeled flow allows it to carry a high sediment load that is routed immediately east of the stables and emptied directly into Bear Creek. Downstream of where the flow is diverted off the skid trail the two roads parallel and begin to run adjacent to each other, the old road does not hold much runoff.



Latitude: 120 12'17.800 W
Longitude: 39 11'02.946 N
Heading: 349
Map Datum: WGS 84

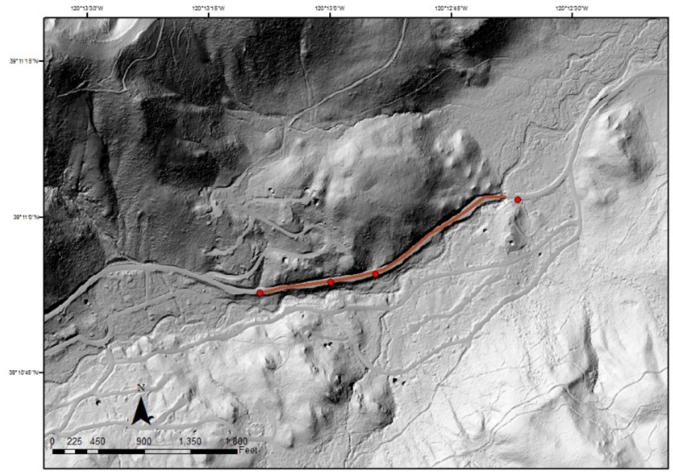
Scouring of old road picks up sediment later drained into Bear Creek.

Latitude: 120 12'16.454 W
Longitude: 39 11'04.909 N
Heading: 260
Map Datum: WGS 84

Old road cuts through hillside with fillslope higher than old road, allowing for heavy capture and channeling of runoff.

SEGMENT 2

Segment 2 is similar to Segment 1 in having inside ditches along the entirety of its length but only very widely spaced culverts to return flow to its original pathways (red dots identify current culverts). The road cut on the NW side is heavily eroding and is deposited almost directly into the river. A thorough geo-technical assessment may identify practical and efficient methods of stabilization and revegetation of the exposed hillslopes both on the upslope's eastern side and the entire downslope area of road through this section. Additional culverts could improve efficiency of road water interactions and sediment transport.



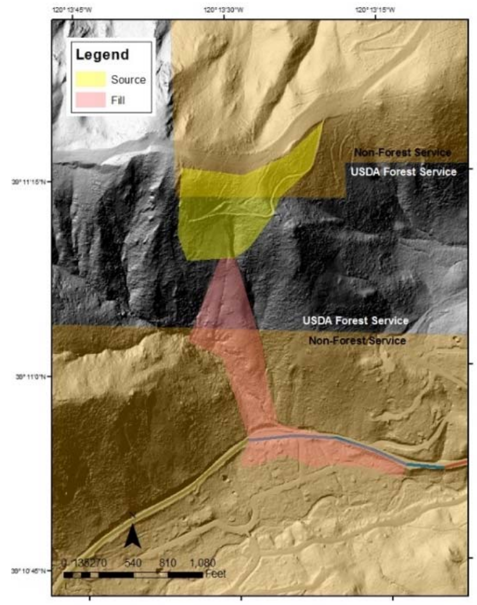
Latitude: 120 12'42.766 W
Longitude: 39 11'00.727 N
Heading: 270
Map Datum: WGS 84

High angle cutslope with inside ditch is catching and channeling erosion and runoff

Latitude: 120 12'42.766 W
Longitude: 39 11'00.727 N
Heading: 90
Map Datum: WGS 84

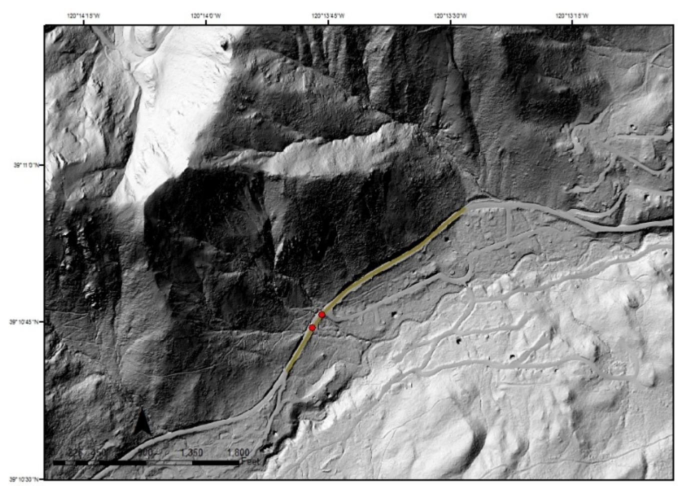
View downstream of ditch showing it feed directly into river.

SEGMENT 3



Sediment accumulation within this rut does not appear natural; however, there are some geologically instable lands upstream and it is in an avalanche runout zone. While this sediment accumulation could be primarily from those sources there may be a connection to the source from the road that runs parallel to slope above the accumulation. At the time of this survey, the crew was not able to gain access and the road manager typically checks this road. Additional review of the need for this road due to the associated risk from the location should be assessed.

SEGMENT 4



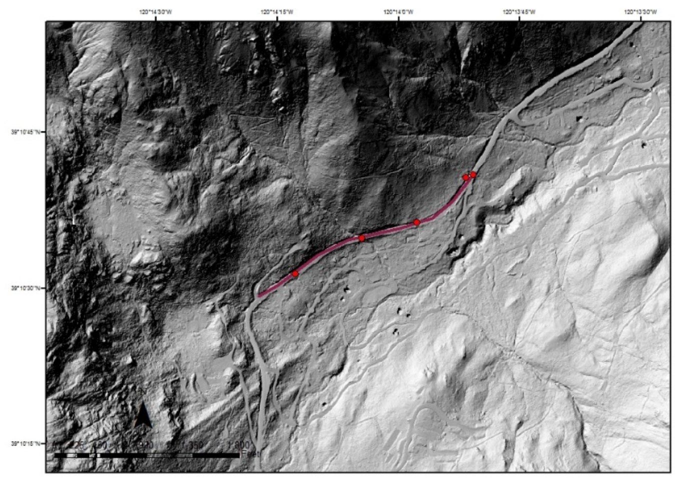
Along the eastern half of this segment the cutslope is heavily eroding, being captured in the inside ditch and eventually channeled through a culvert into Bear Creek. A thorough geo-technical assessment to identify practical and efficient methods of stabilization and revegetation of the exposed hillslopes both upslope and downslope of the northern side of the road may provide beneficial reductions in sediment through this section. Drainage along the western half is functional, however; there could be some flood flow constriction influencing downstream capacity due to encroachment within the near stream zone.

Latitude: 120 13’33.093 W
Longitude: 39 10’51.838 N
Heading: 320
Map Datum: WGS 84

Cutslope along eastern half of road segment needs covered and revegetated.

SEGMENT 5

Drainage through this segment looks functional. Culverts exist but are placed immediately along preexisting drainage channel. Older access routes are heavily vegetated and no longer divert and/or channel flow off hillslope.



Latitude: 120 13’52.569 W
Longitude: 39 10’39.542 N
Heading: 283
Map Datum: WGS 84

Older access route is well vegetated and shows no sign of interrupting or channeling flow.

SEGMENT 6

This road segment is functioning normal and needs no remediation.

SEGMENT 7

The parking lot at Alpine Meadows Ski Resort is repaved approximately every 3-5 years. During snow removal activities decomposed pavement and sand are transported immediately adjacent to the parking lot. During spring runoff and snow melt periods some of the loose pavement and dirt accumulated in the snowbanks are transported directly into the Bear Creek floodplain. Some of the parking lot area may drain to the adjacent water retention ponds developed for snow making, but the area presented in the map below is likely delivered to the flood plain and drainage as evidenced at the site this year. Additionally, influence from materials plowed into this zone adds to the accumulation of materials that reach the Bear Creek flood plain. To quantify the amount of pavement potentially plowed from this area that may be delivered to Bear Creek, the contributing area was determined, and a density of 145 lbs./ft^3 was assumed for the pavement. Observations by the Forest Road Manager on forest cleared parking lots noted that the rate of pavement decomposition is high were show removal requirements are frequent. Based on his observations values were determined for an assumed 1" thickness and 2.5" thickness being decomposed over every 3-5 years. This means between 3500 and 9000 tons of pavement could potentially be delivered to the floodplain in-between the time the parking area is repaved. If the lot is repaved every 3-5 years, a min-max of 700-3000 tons of materials from the parking has the potential to be deposited in the flood zone on a yearly basis.

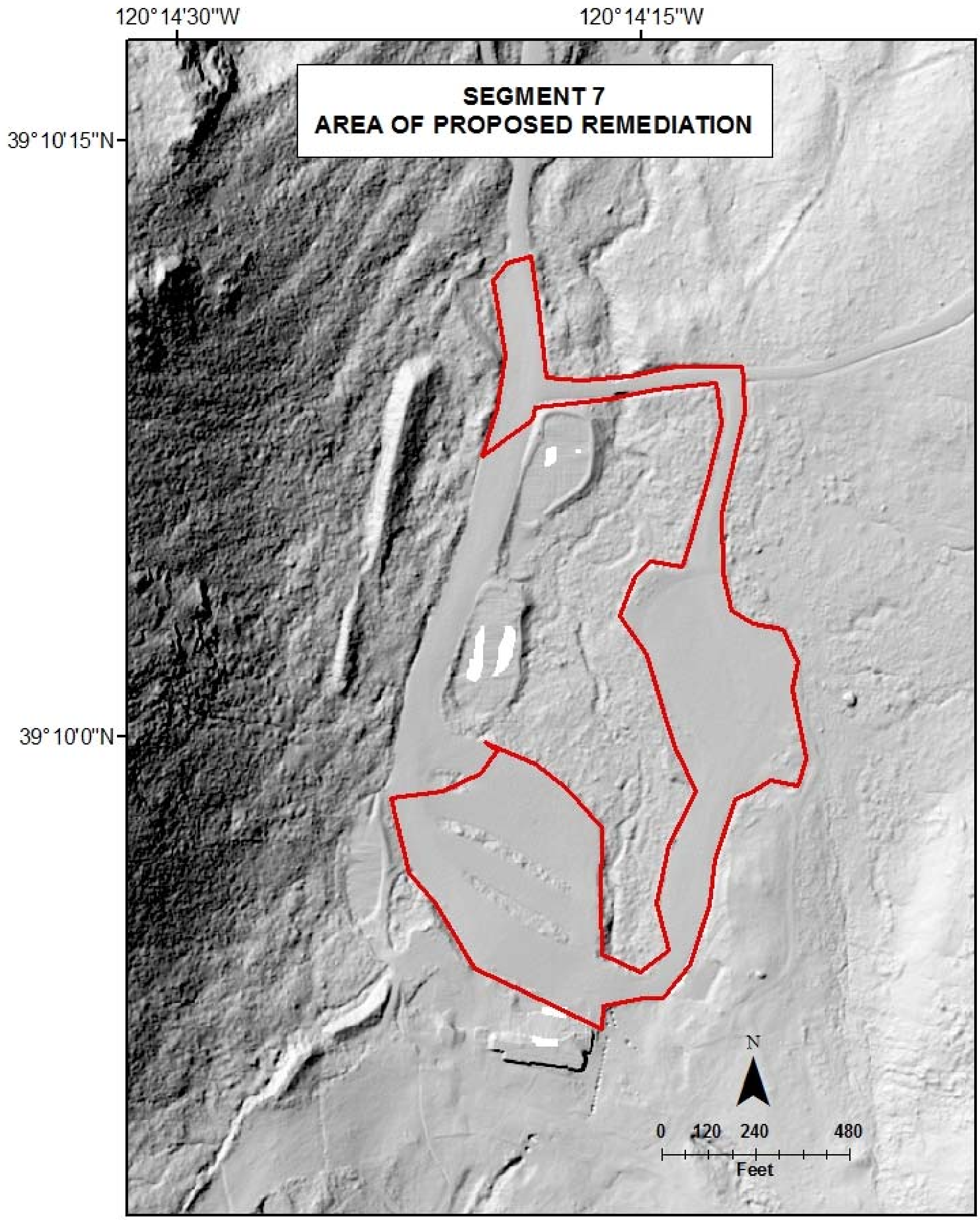
Recommendations associated with Alpine Meadows Special Use Permit are highlighted here, after review and discussion with the permittee these or similar actions deemed to reach the goal of reduced sediment delivery to the flood plain would be incorporated in the annual operating plan:

Recommended Winter Snow Operations Remedial Action

1. In conjunction with the Alpine Ski Operations provide new provisions for snow removal that address delivery of sediment to Bear Creek floodplain.

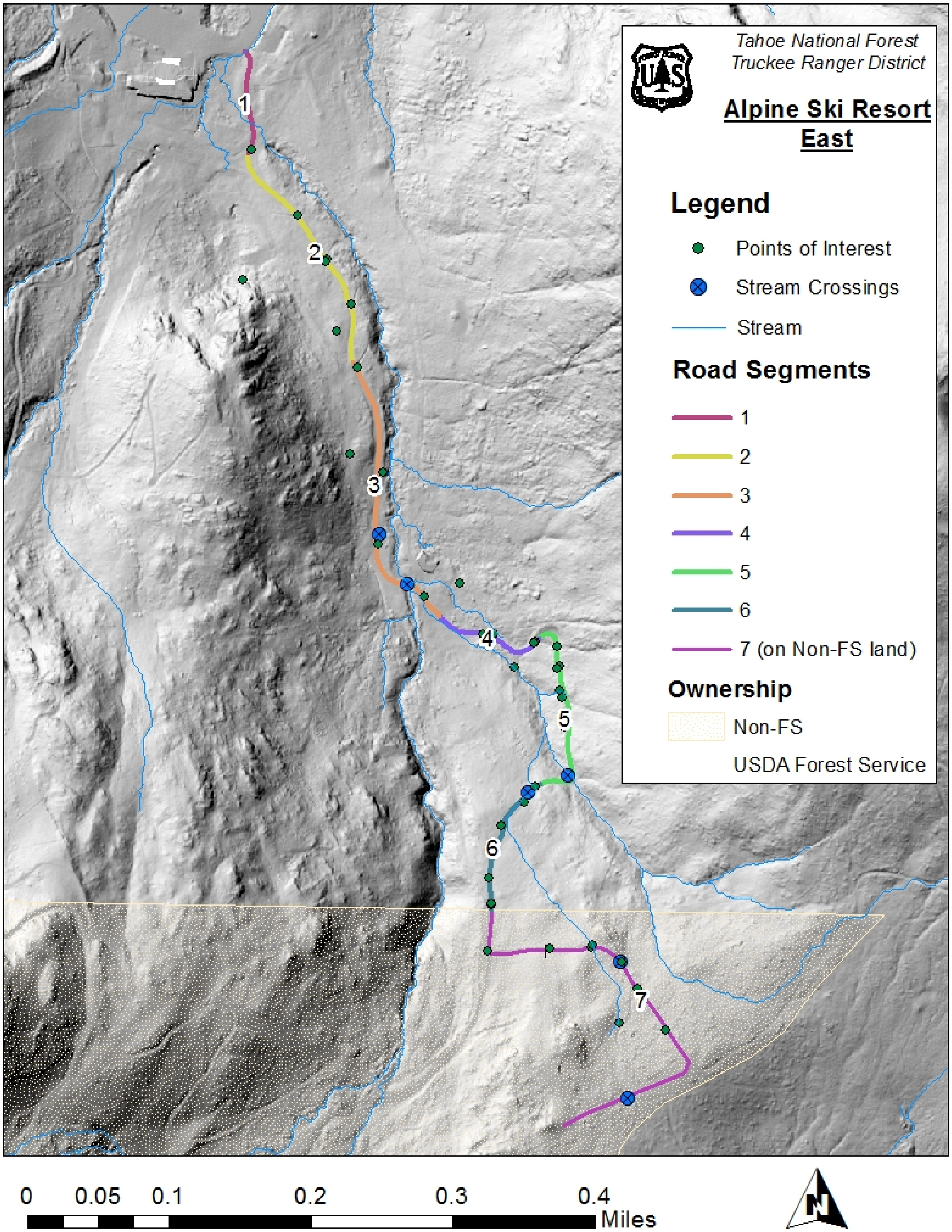
   Possible remedies include; using the two sedimentation/water retention ponds particularly for late season snow removal/melt sediment filtration. The feasibility of using these ponds for cleaning snow pile surfaces that have accumulated sediment could be considered for site remediation cleanup. Other options include annual sweeping of loose sediments/decomposed pavement. Plowing snow into designated areas to accumulate/store sediment and having a drainage filtration method at these locations as well as, annual clean-out of ditches early during the snowmelt period to prevent sediment wash from overland flow to the Bear Creek/flood plain.

2. In conjunction with the Alpine Ski Operations provide provisions for tracking quantity of sand that is applied to improve traction for wheeled vehicles.
3. In conjunction with the Alpine Ski Operations provide clean-up of existing sediment accumulation within the Bear Creek riparian zone. Address mitigations for vegetative disturbance caused from clean up. Provide a – regular scheduled monitoring of deposits to Bear Creek to provide adaptive management if reduction methods are not adequate.
4. Legacy Mitigations. The early development of Alpine Meadows resulted in development that has encroached upon the Bear Creek drainage and its tributaries. Future improvements at the site should consider possible actions that can reduce past impacts, specifically encroachment upon drainages by facilities and restoration of drainage capacity, function and riparian health.


120°14'30"W
120°14'15"W
39°10'15"N
39°10'0"N
SEGMENT 7
AREA OF PROPOSED REMEDIATION
N
0 120 240 480
Feet

Bear Creek Watershed Assessment

Alpine Meadows Ski Resort - East Assessment



Summary

Development of infrastructure to provide recreational ski use in this area has created multiple erosional features and flow paths connecting road sedimentation to nearby rivers. Many hillslopes in the area have poor vegetation and exposed soils, allowing for slope runoff to entrain large amounts of sediment. Runoff is in fact large enough to carry transported sediment and road material pass forest buffers and into channels. At higher elevations, the runoff is incising the drainage outlets deeper and farther than their original design, caring sediment downslope. If this trend continues, the runoff will continue pass forest buffers and into the nearest streams. Drainage structures appear on the road frequently, however was not design for the amount of runoff that adjacent hillslopes produce. Slope stability structures were installed as waddles, but do not contribute to the mitigation of the large runoff.

Overview of Recommendations

Remediation of the hillslopes in this area will provide the largest improvement to the amount of runoff produced here. Returning some vegetation and ground cover will slow down the detachment, transportation, and runoff of sediment downslope. Vegetation and ground cover will also increase the infiltration for runoff and slow down overland flow. The substrate of the surrounding slopes consist of rock and gravel. The addition of finer grain top soil would increase the ability for vegetation to grow.

Maintenance and improvements can be implemented to existing waterbars and leadouts. Many of the leadouts' substrate consists of bare soils, which is susceptible for further erosion and entrainment of sediment. Providing more cover over the leadout substrate will decrease erosion potential and sediment flow past the leadout into the forest buffer. Cover can be provided by vegetation or rocks.

Cutslopes are also exposed on several parts of the road. Similar to the hillslopes in this area, poor vegetation and cover is exposing bare soils to interill erosion. Increasing vegetation and cover would provide more protection from rainfall and overland flow, allowing for better slope stability. This will prevent mass movement and sediment lost from the cutslope.

Road Segment Descriptions

Segment 1: Outsloped graveled road. This road segment is nearly flat with a 7% gradient for both cut and fill slope. Vegetation is found on both and consist of small grasses. No ruts or rills. No remediation action is needed.

Segment 2: This road segment has an average 15% road gradient. Cut and fill slope have a 15% gradient.

Points of concern:

- Accumulated runoff from the road and the hillslope is large enough to cause incision in and past the leadout, allowing large amount of discharge and sediment into the adjacent stream (Figure 1). The large amount of discharge entering this leadout is contributed largely by overland flow of water from the hillside.

- The hillside is poorly vegetated, providing poor cover and exposing soils (Figure 2 and Figure 3). Water from rain and snowpack does not have proper infiltration time and immediately leaves the hillslope and flows into the road. The waterbars and leadouts are collecting this discharge.

It is recommended that the hillslopes have their surfaces roughen and revegetated to slow down overland flow and allow more time for infiltration. Armoring of the leadouts will prevent further incision.

Figure 1. Leadout incision from large amounts of discharge flowing onto road from adjacent hillslope. Discharge is large enough that it flows out of the leadout and into the nearby stream.

Figure 2. Poorly vegetated hillslopes. The lack of vegetation allows for exposed soils. Rain and overland flow are allowed to erode the surface and carry sediment downslope into adjacent roads, eventually flowing into nearby streams.

Figure 3. Poorly vegetated hillslopes. Poor vegetation is allowing for exposed soils, becoming more susceptible to erosion from rain and overland flow.

Segment 3: Outslope graveled road. 5% road gradient and an average 28% hillslope gradient.

Points of concern:

- Similar to segment 2, waterbar and leadout receive large amounts of runoff from adjacent hillslope, incising the outlet of the leadout and allowing sediment to be carried into the channel. Again, the large amount of discharge entering this leadout is contributed largely by overland flow of water from the hillside.
- The hillside is poorly vegetated, providing poor cover and exposing soils. Water from rain and snowpack does not have proper infiltration time and immediately leaves the hillslope and flows into the road. The waterbars and leadouts are collecting this discharge. Road is also built parallel and in close proximity to the stream.
- The fillslope of the road is entering the stream and allowing outslope runoff from the road to flow over the fillslope and into the stream (Figure 4). There is also a culvert with a damaged outlet that requires repair (Figure 5).
- This road segment has a bridge crossing over a perennial channel (Figure 6 and Figure 7). The bridge does not have any railing or raised lip, so any runoff that flows over the bridge can flow over the top and into the stream. Straw waddles were installed on the sides of the bridge to prevent road runoff to top over, but have failed.
- Southwest of the Chalet restaurant, there's a berm that is channelizing flow to the north, creating meandering channels through a small meadow.

Recommended actions consist of the following. Hillslope surfaces are roughen and vegetated. This will allow slower overland flow and greater infiltration time, effectively lowering the amount of hillslope runoff from entering the roads and drainage structures. The fillslope material placed in the channel along this road segment should be removed and the remaining stream bank should be armored and revegetation to minimize bank erosion to the disturbed surface. Proper side walls or lip instead of the straw waddles should be installed on the bridge to prevent road runoff from flowing over the edge and into the stream. The berm to the southeast of the Chalet should be recontoured, roughen, and revegetated to allow proper overland sheet flow to return. This will prevent focused flow paths from forming and prevent the formation of rillings and gullies on the hillslope.

Figure 4. Fillslope of road placed directly into channel.

Figure 5. Damaged culvert outlet.

Figure 6. Bridge crossing over perennial channel. Straw waddles installed to prevent water from flowing over the top of the bridge and into the channel have failed.

Figure 7. Bridge crossing over perennial channel. Straw waddles installed to prevent water from flowing over the top of the bridge and into the channel have failed.

Figure 8. Berm southeast of the Chalet restaurant. Pushing flow to the north, creating meandering channels to form in small meadow.

Segment 4: Inslope graveled road. Road gradient of 14% and hillslope gradient of 22%.

Points of concern:

- The inslope drainage ditch is collecting large amounts of runoff, causing incision in the ditch (Figure 9). Again, a large contribution to the runoff flowing in this ditch is from the hillslope.
- Poor vegetation and ground cover is exposing soils and allowing overland flow and rain to erode slope surfaces and carrying sediment downslope into the road and ditch (Figure 10).
- There is an old culvert stream crossing for a closed road that connected to the main road. The closed road is caring runoff from the slope to the top of the culvert and flowing over the outlet into the channel.
- A rolling dip structure on this segment is built where an ephemeral channel crosses the road. The outlet of the rolling tip is being scoured and incised due to the large amount of water and sediment exiting the outlet.

Recommended actions would be to provide more ground cover for hillslopes. The exposed soils and poor cover is the main contributor to the points of concern. Roughening and revegetating the hillslopes will provide more cover to the exposed soils and slow down overland sheet flow. This should provide higher infiltration rates and lower erosion. Armoring the leadouts with rock can help mitigate scour and incision of the outlet. Revegetating and installing waterbars on the closed road will increase infiltration time and lower the amount of water that will flow over the culvert. The trough of the rolling dip should filled with rocks to slow down the flow of water from the ephemeral channel, lowering the amount of energy of flow and preventing further scour and incision.

Figure 9. Inside ditch of inslope road shows scouring and rilling. Rilling continues past leadout.

Figure 10. Poorly vegetated slope looking uphill where Figure 9 was taken.

Figure 11. Ephemeral channel crossing road through trough of rolling dip.

Figure 12. Old road passing over culvert crossing. Runoff from old road flows over top of the culvert outlet and into the stream.

Road Segment 5: Outslope graveled road. Road gradient of 15%. Average hillslope gradient of 40%. No major concerns with this road except for possible old skid trail crossing into the main road may be bringing water down and onto road (Figure 12). The skid trail crossing is ~5 ft north of culvert crossing on main road. Recontour and/or addition of waterbars to skid road should divert water back to overland sheet flow.

Figure 12. Old road passing over culvert crossing. Runoff from old road flows over top of the culvert outlet and into the stream.

Segment 6: Outslope graveled road. Road gradient of 20%. Average hillslope gradient of 22%.

Point of Concerns:

- Culvert drainage is buried due to large amounts of slope runoff.
- Water maybe flowing subsurface due to rocky slope. Water flows out of surface and into a small channel parallel to road (Figure 13). It flows out and onto the road for ~20ft (Figure 14). Water may be being transported by rills that formed on the slope from road drainages uphill.
- Rolling dips/waterbars are accumulating large amounts of flow (Figure 15, 16, and 17). A majority of the water is likely coming from overland sheet flow uphill. Hillslope is rocky with poor cover and vegetation, allowing water from rainfall and snowpack to flow downhill with low infiltration rates. The large accumulated flow from the hillslope and road is scouring and incising the drainage outlets, flowing downslope and into nearby stream.
- Rilling is occurring on parts of the road, creating an inside ditch on an outslope road (Figure 16 and 17). The unnatural inside ditch accumulates more discharge and transports it to drainage outlet, scouring and incising the outlet.

The main contributor to the concerns of this segment is heavy overland flow from uphill. The hillslope is barren and consist mainly of rock with exposed soils, allowing for rainfall and snowpack runoff to flow downhill quickly without a large amount of infiltration. Increasing cover and vegetation on this slope will increase infiltration rates and lower the amount of runoff reaching the road. Reinforcing the rolling dips/waterbars will ensure proper drainage and less accumulate flow for drainage structures downhill. Armoring the outlets with rocks will lower the erosion to the outlets and the amount of sediment leaving them.

Figure 13. Small channel/ditch forming parallel to road. Water maybe permeating through small berm between road and channel.

Figure 14. Extent of runoff from small channel/ditch onto road. Runoff travels ~20ft on road.

Figure 15. Rolling dip/waterbar transporting large amounts of runoff off the road. Outlet is filled with road material and sediment, and is flowing past the outlet, downslope, towards stream.

Figure 16. Riling creating inside ditch on outslope road. Rolling dip transporting larger than normal runoff off road. Outlet is being scoured and incised due to large amount of flow.

Figure 17. Rilling creating inside ditch on outslope road. Rolling dip transporting larger than normal runoff off road. Outlet is being scoured and incised due to large amount of flow.

Segment 7: Non-Forest Service road. Average road gradient of 13%. Average hillslope gradient of 20%.

Points of Concern:

- Rolling Dip/Waterbar at the junction of two roads (one going uphill to the south, the other going uphill to the east) is catching large amounts of runoff (Figure 18). Both roads appear to allow runoff to accumulate at this point. Due to this, the outlet is being scoured and incised, with large amounts of sediment in and leaving the outlet.
- A possible intermittent channel is crossing the road without a crossing structure. The channel is incising across the road, carrying road runoff and road material into the channel. There is a waddle installed downstream of the road, but it has failed (Figure 19).
- At the top of the road, snowpack melt is collecting onto the road (Figure 20). This is likely the headwaters for the intermittent channel that flows across the lower section of this road segment. This channel is incising the hillslope from its headwaters to where it crosses the road downhill (Figure 19).

The waterbars installed on the segment of road before the road turns south/southwest into forest canopy are not fully functioning. They allow some runoff to bypass them and continue down the road, accumulating at the junction. They should be reinforced so that road runoff can be properly dispersed on the hillslope. The possible intermittent channel flowing across the road seen in Figure 19 has multiple resolutions. A proper stream crossing structure, such as a culvert, could be installed to prevent further incision of the road. This will also prevent road runoff and sediment from entering the channel. Another possibility is to recontour, roughen, and revegetate the hillslope that is being incised by the possible intermittent channel. If this is done, the accumulated runoff that serves as the headwaters will disperse to overland sheet flow. It will not be concentrated and should not cross the road in Figure 19 as a channel. Further up the road from Figure 20, snowpack melt is flowing along the road before collecting at the trough in the road. This is likely the headwaters for the intermittent channel that is rilling forming on the downslope and incises the road below at its crossing. betwee Waterbars installed up the road more can disperse the snowpack melt and prevent it from collection at the trough. Water will not accumulate large enough to create a concentrated flow path that continues to where it crosses the road downhill.

Figure 18. Looking at rolling dip at the base of a junction for two roads. This rolling dip is catching runoff from both roads. The excess flow is incising and scouring the leadout outlet, transport

Figure 17. Rilling creating inside ditch on outslope road. Rolling dip transporting larger than normal runoff off road. Outlet is being scoured and incised due to large amount of flow.

Figure 17. Rilling creating inside ditch on outslope road. Rolling dip transporting larger than normal runoff off road. Outlet is being scoured and incised due to large amount of flow.

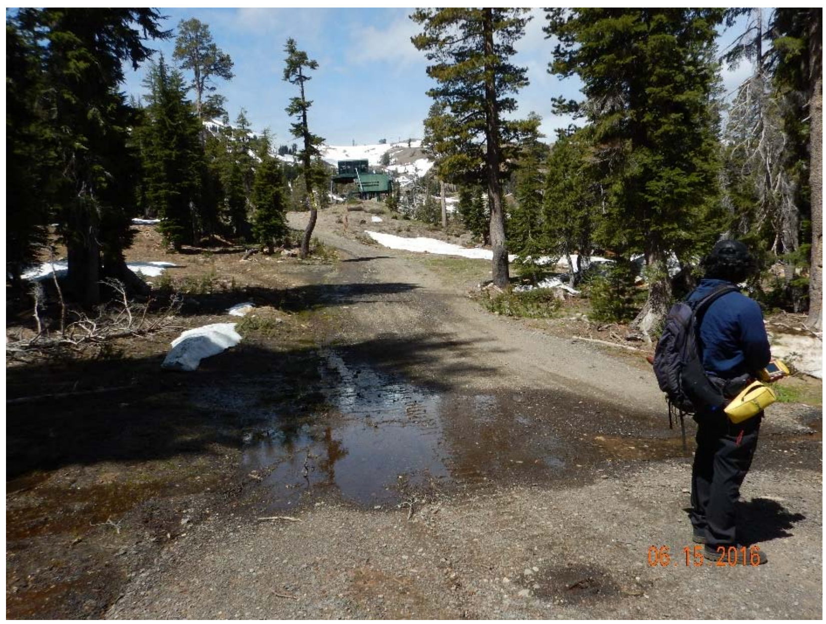
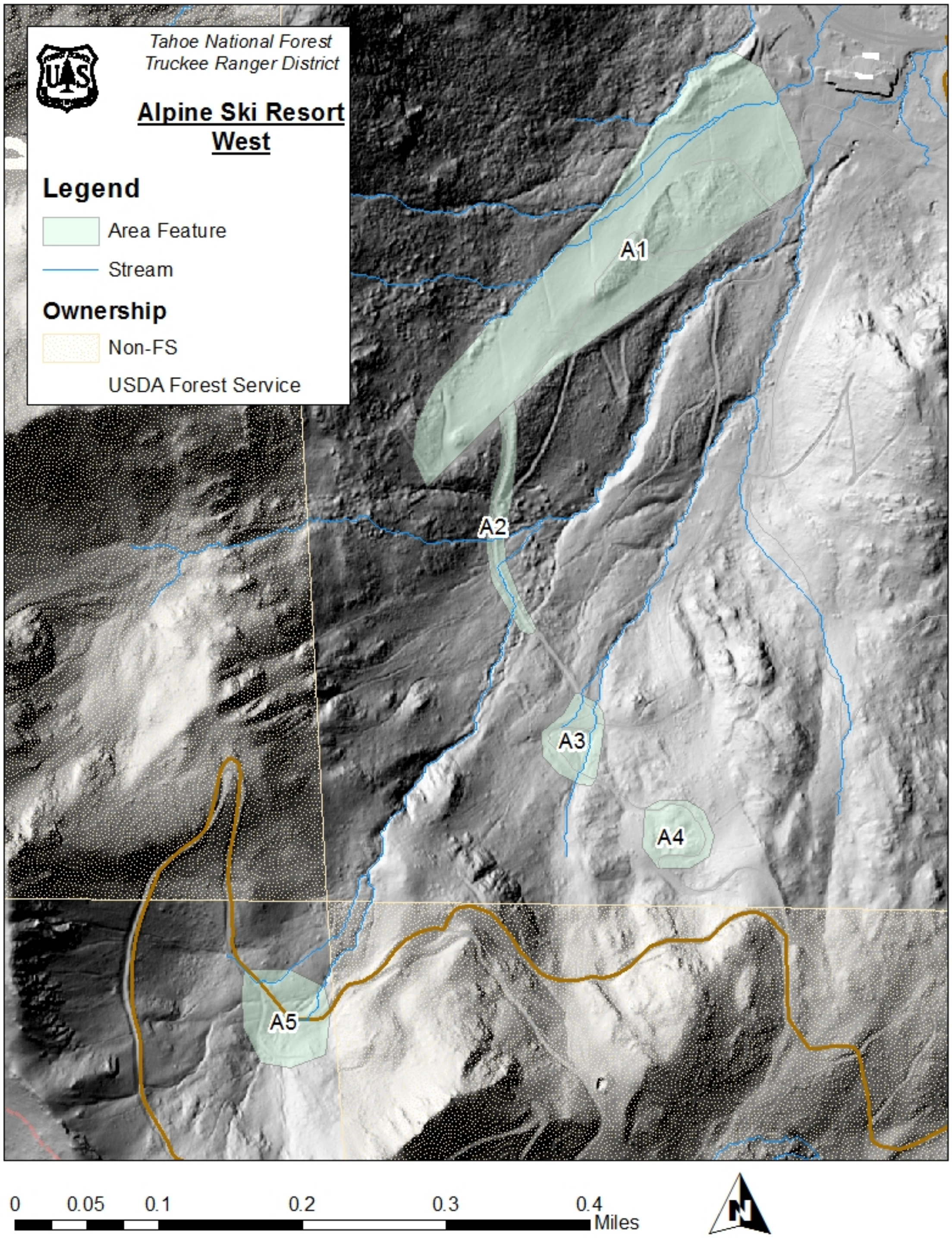


Figure 17. Rilling creating inside ditch on outslope road. Rolling dip transporting larger than normal runoff off road. Outlet is being scoured and incised due to large amount of flow.

Bear Creek Watershed Assessment

Alpine Meadows Ski Resort - West Assessment



Map 1. Overview map of Alpine Ski Resort West.

Summary

Development of infrastructure to provide recreational ski use in this area has created multiple erosional features and flow paths connecting road sedimentation to nearby rivers. Many hillslopes in the area have poor vegetation and exposed soils, allowing for slope runoff to entrain large amounts of sediment. The development of surface runoff diversions and drainages have been poor and appear to lack maintenance, creating multiple repercussions: Waterbars catch large amounts of surface runoff and form unnatural channels, accumulated surface runoff on graded slopes bypass waterbars and create deep rillings, lengths of road allow for surface runoff to accumulate to large amounts, lack of stream crossing structures allow road runoff to enter the channel directing, switch back roads divert runoff back to road downslope.

Overview of Recommendations

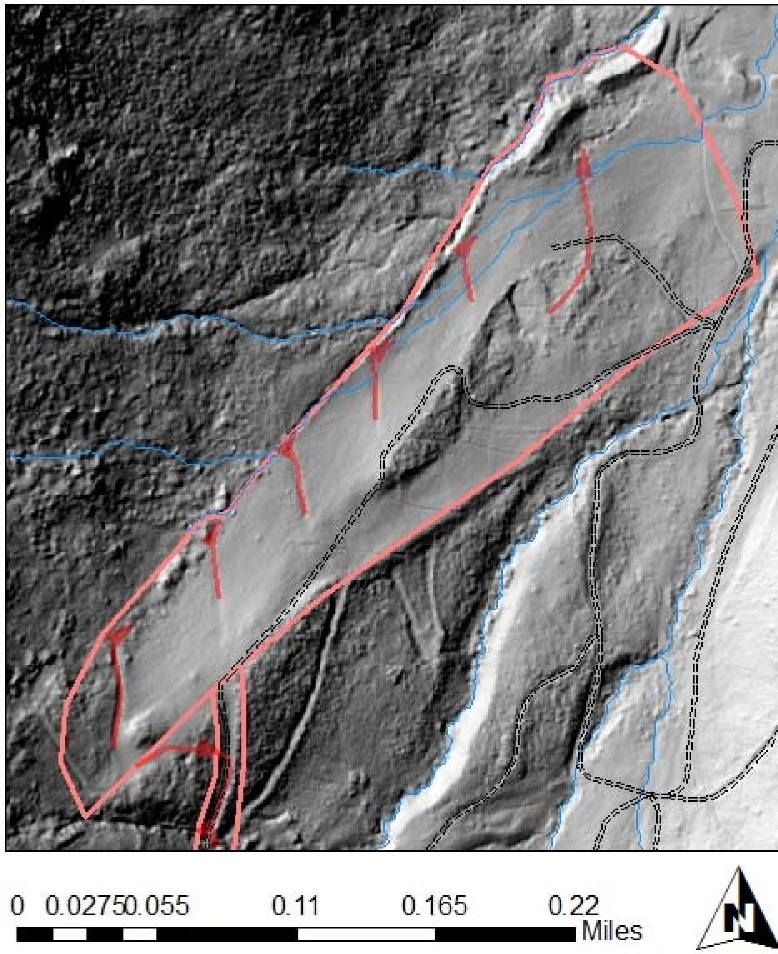
Remediation of the hillslopes will include returning top soil to rills. This should allow these areas to be revegetated and prevent further loss of top soil. The waterbars constructed across the graded slope should be reinforced for heavier runoff events to prevent accumulation of surface runoff that can potentially create more rills.

Additional waterbars and maintenance on existing waterbars is needed on nearly all the roads in this western area. It would help prevent runoff to accumulate and create enough energy to form rills and ruts in hillslopes and roads. Installing proper crossing structures such as culverts and maintaining current crossing structures will help improve water quality of the streams in this area. Currently they are unprotected from road surface runoff connectivity.

Switchbacks portions of the road should be redesigned to have road surface drainages directed away from lower segments of the road.

Area Features

Areas in the western portion of the Alpine Ski Resort have unique problems based on infrastructure established and its main use. This section will discuss these areas.



Map 2. Area Feature W1.

W1: A graded slope for a ski run. This slope is more vegetated compared to the major graded slope on the east side. However, multiple waterbars were built running across almost the entire width of the slope. They catch large amounts of runoff (Figure 1). On the northern end of the waterbars, density in vegetation increases due to larger soil moisture. Due do the large amount of captured runoff, a channel has formed on the north edge of the slope. This unnatural channel runs parallel to a natural channel, but is separated by a berm. At the southwest end of this graded slope, a road captures runoff and directs it into what may have been an ephemeral channel, but now is the headwaters for the unnatural channel. The waterbars however do not capture and slow down all surface runoff during higher flows, and excess surface runoff have created rills that are widening and removing top soil from the slope (Figure 2 and 3). There's a water tower used for storing water on this graded slope. However, it is leaking water and flowing down into the northern most water bar (Figure 4). This furthers the formation of the unnatural channel.

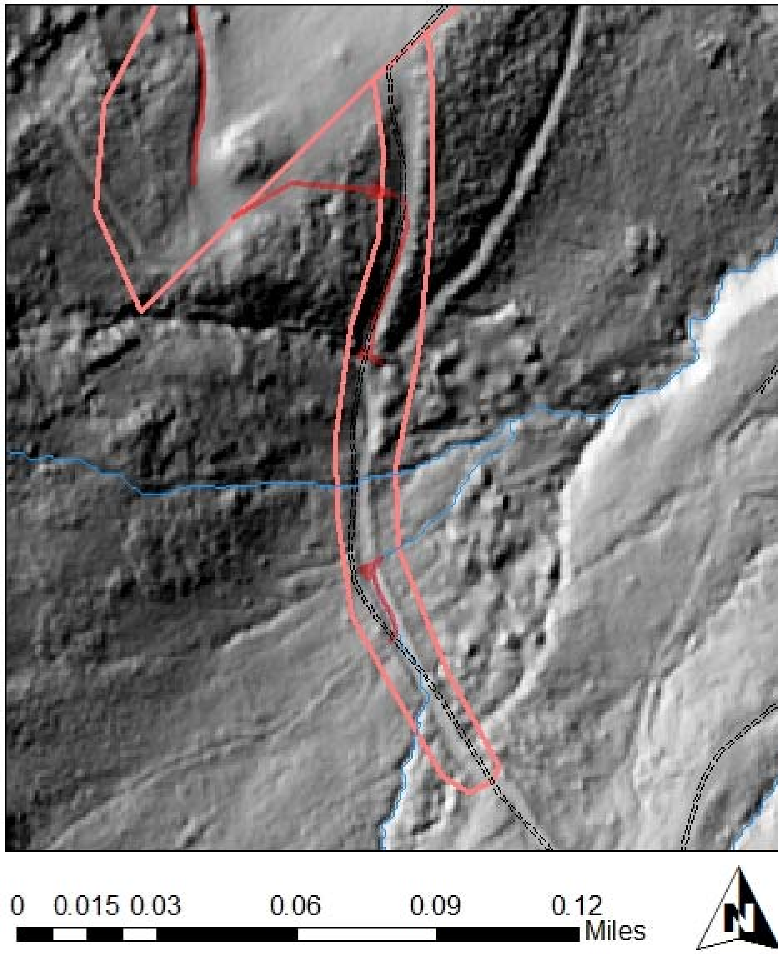
Figure 1. Northern most waterbar capturing water from water tower.

Figure 2. Rillings that have formed from large amounts of surface runoff that have bypassed waterbars.

Figure 3. Another photo of rillings that are removing top soil exposing rocky substrate.

Figure 4. Water leaking out of the base of the water tower.

Remediation: Possible resurface and roughening of graded slope to remove existing rills and reestablish a viable top soil to provide more vegetation and increase infiltration time for surface runoff. Waterbars should be reinforced and added to prevent future rills to form. The berm separating the unnatural channel with the natural channel north of this area should be removed to allow runoff to drain into a natural channel. With the other improvements, the water quality of the surface runoff should be better and create a minimal impact on overall water quality of the natural channel. This will also prevent the unnatural drainage to flow into the parking lot. The water tower should be reinforced to prevent future water leaks at the base.



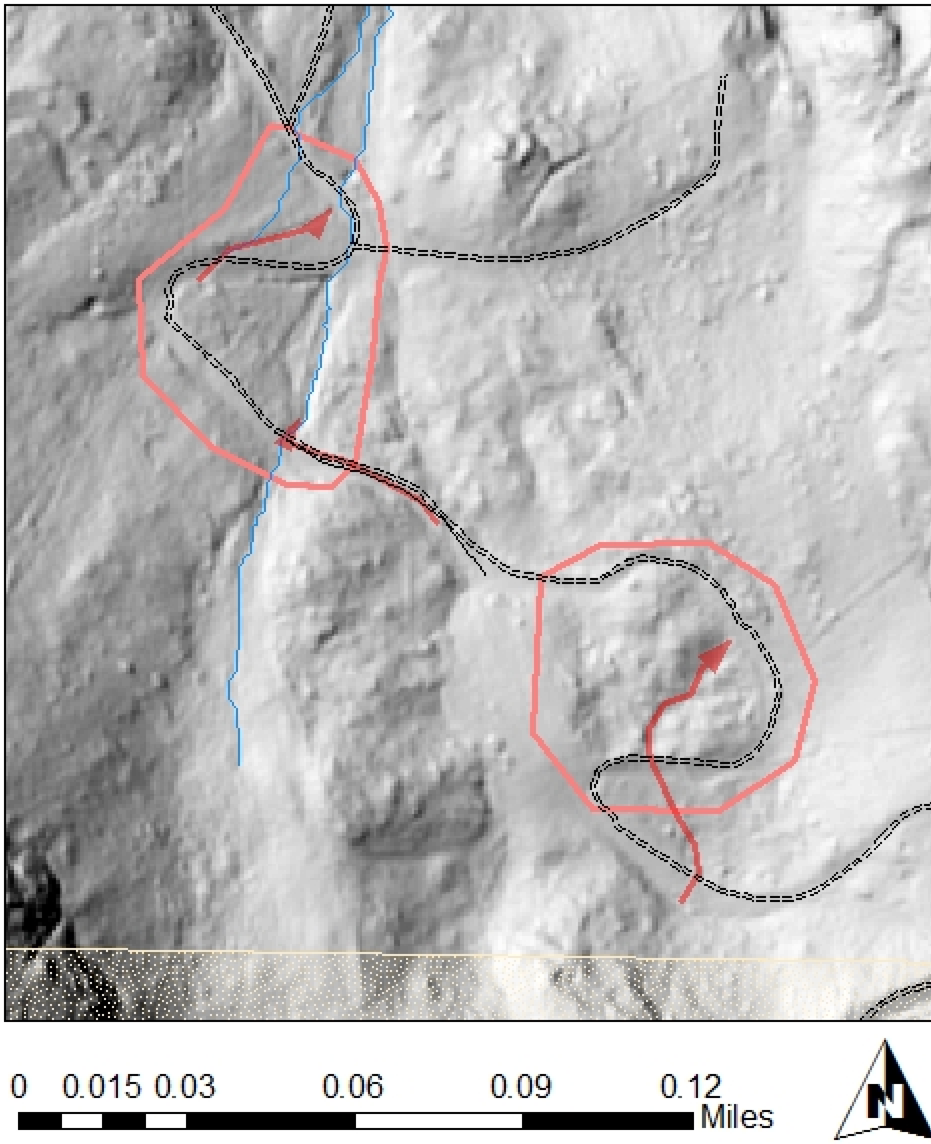
Map 3. Area Feature W2.

W2: This length of road crosses multiple ephemeral and intermittent channels without any proper stream crossing structures (Figure 5 and 6). This has allowed road runoff to directly drain into these channels and on multiple occasions allow to road to capture and redirect the stream, degrading their water quality. This road also lacks a sufficient number of road surface drainage structures to prevent large accumulations of runoff.

Figure 5. Road crossing into an intermittent channel.

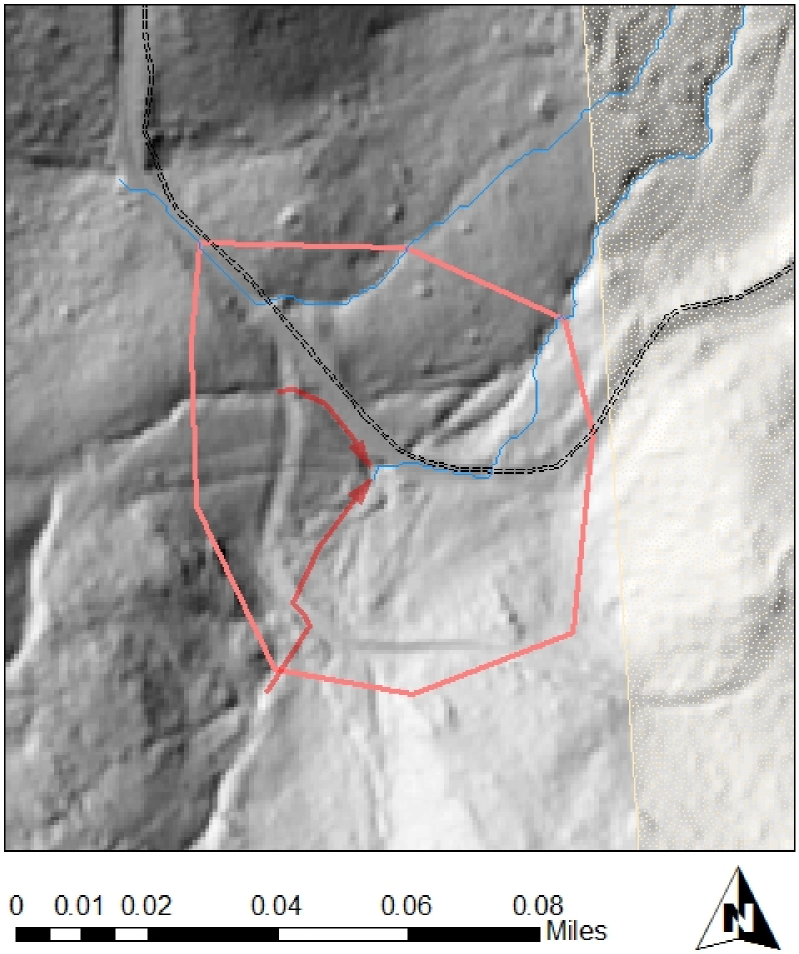
Figure 6. Road crossing into an ephemeral channel.

Remediation: Install proper crossing structures such as culverts at crossings to prevent road surface runoff connectivity to the channel. This will also prevent the road from capturing the channel and redirecting it. Maintaining existing waterbars and installing more will help prevent excess accumulation of road surface runoff which could erode the road and harm nearby water quality.



Map 4. Area Features W3 (Left) and W4 (Right).

W3, W4, and W5: These areas are similar in the nature of having the same source issue. These areas are portions of the road that switch back to prevent high road gradients. However, they were poorly designed in regards to their surface drainage systems, which directs surface runoff away from the road only to be directed back to the road at a lower elevation. Similar to W2, there are multiple points where a channel would cross road without a proper crossing structure, allowing road surface runoff the flow directly into the channel.



Map 5. Area Feature W5.

Figure 7. Diverted road surface runoff has created a channel that goes downslope to a lower portion of this switchback.

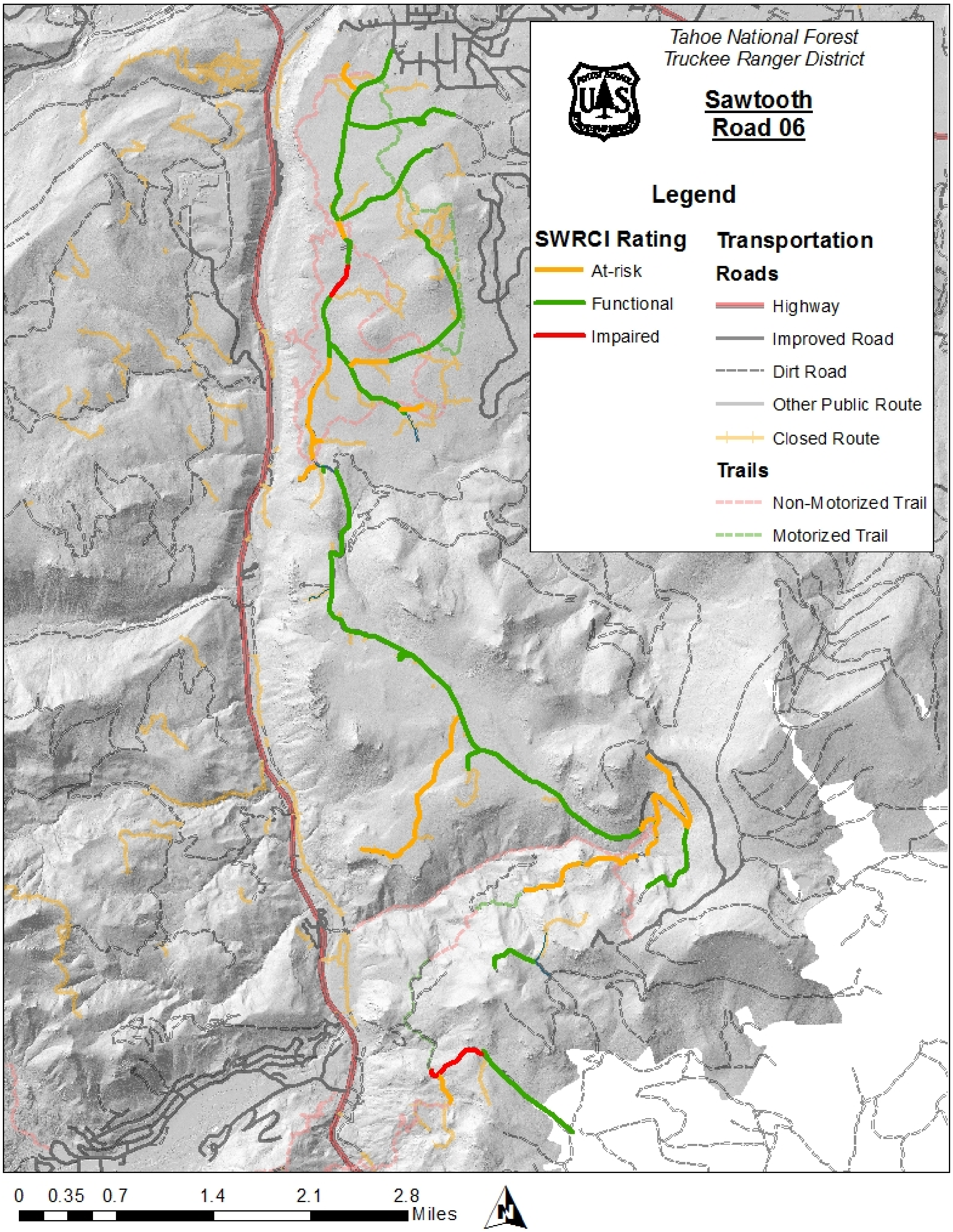
Figure 8. Road surface runoff leaving a leadout only to flow back onto road downslope.

Figure 9. Runoff from road directed downslope to another segment of the road.

Remediation: Redesign of the road and drainage structures could remediate the existing problems. Altering the road design to be insloped with a rock lined inside ditch will prevent surface runoff from flowing down slope through an outsloped manner. Leadouts for the inside ditch should be placed at the hairpin turns and directed at an angle that provides the furthest distance from the road and allows runoff to flow downslope. Crossing culverts should be installed at crossings to prevent road surface runoff from entering the channel.

Deer Creek Watershed Assessment

Sawtooth (Road 06) Road Assessment



Summary

Sawtooth road (Road 06) contains several road segments that are impacted by poor road design. Problems occur on lengths of the main 06 road as well as spur roads. The overall road gradients are relatively low (<5%). However, on segments with higher gradients (5-10%), there is more sediment collecting at leadouts. The main contributors to higher sedimentation along problematic road lengths are insufficient number of dips/waterbars and the road surface type. Dips are found ~600 ft. apart on problematic roads. On spur roads, often with native soil, waterbars are found with a similar spacing distance. Normal spacing between dips/waterbars on low gradient roads are usually 400 ft. apart. Another issue consists of native road surfaces instead of gravel. Several road segments consist of a native road surface instead of gravel. Its gravel counterparts show significantly less amount of sedimentation. Sediment on native surfaces are more susceptible to transportation from rainfall and road surface runoff.

SWRCI Rating	Total Road Lengths (ft)	Lengths (mi)
Functional	65651.8	12.4
At-Risk	33237.3	6.3
Impaired	3908.6	0.74
Total	102797.7	19.4

Proposed Action

Installation of additional dips/waterbars and dips spaced ~300 ft apart. along problematic roads should reduce the accumulation of road surface runoff and its ability to transport sediment. Adding gravel to road surfaces that are currently native will also reduce erosion and sediment transport.

Sediment Loss Modeling

Modeling of sediment loss was conducted using WEPP: Roads Batch. Graveled road is seen mainly on the Sawtooth road. Native roads are seen on the spur roads.

Table 1. Input parameters for typical graveled roads and native spur road having "At Risk "or "Impaired" SWRCI rating as inventoried under in the Sawtooth area.

Road	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
Gravel	Insloped, vegetated or rocked ditch	graveled high	7	656	18	1.13	88.56	7	1	50	975
Native	Insloped, vegetated or rocked ditch	native low	4.72	590.4	8	10.71	22.96	4.72	1	5	133

Table 2. Input parameters for typical graveled roads and native spur road with roads having “At Risk “or “Impaired” SWRCI rating in the Sawtooth area after remediation.

Road	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual sediment leaving road (lb)
Gravel	Insloped, vegetated or rocked ditch	graveled high	7	328	18	1.13	88.56	7	1	50	252
Native	Insloped, vegetated or rocked ditch	graveled low	4.72	295.2	8	10.71	22.96	4.72	1	5	17

Road length was divided by two to represent the installation of additional dips/waterbars. Surface for native roads is changed to gravel to represent the change in road surface post remediation.

Table 3. Sediment lost values before and after remediation.

	Current Conditions	Post Remediation	
Road	Average Annual Soil Loss (lbs/yr)	Average Annual Soil Loss (lbs/yr)	**Percent Reduction**
Gravel	975	504	**48.307692**
Native	133	34	**74.43609**

Table 4. Sediment lost values before and after remediation. Values were determined by dividing sediment lost values from Table 3 by their respective length of roads.

	Current Conditions	Post Remediation	
Road	Average Annual Soil Loss (lbs/ft*yr)	Average Annual Soil Loss (lbs/ft*yr)	**Percent Reduction**
Gravel	1.486280488	0.76829268	**48.3076923**
Native	0.225271003	0.05758808	**74.4360902**

Calculations for sediment loss for all length of roads found in Sawtooth was not completed as the existing conditions would remain similar.

Photos

Looking down main Sawtooth 06 road with gravel road surface. The 06 road mainly consists of gravel road surfaces.

Looking down main Sawtooth 06 road with native road surface.

Leadout from road that has collected large amounts of sediment.

Spur road with native road surface.

Culvert for ephemeral channel crossing and inside ditch relief. Scouring at outlet due to large amounts of runoff entering culvert. Consider a larger culvert replacement.

Channel formed from excess runoff from culvert in above photo. Consider additional water drainage.

89 Corridor Watershed Assessment

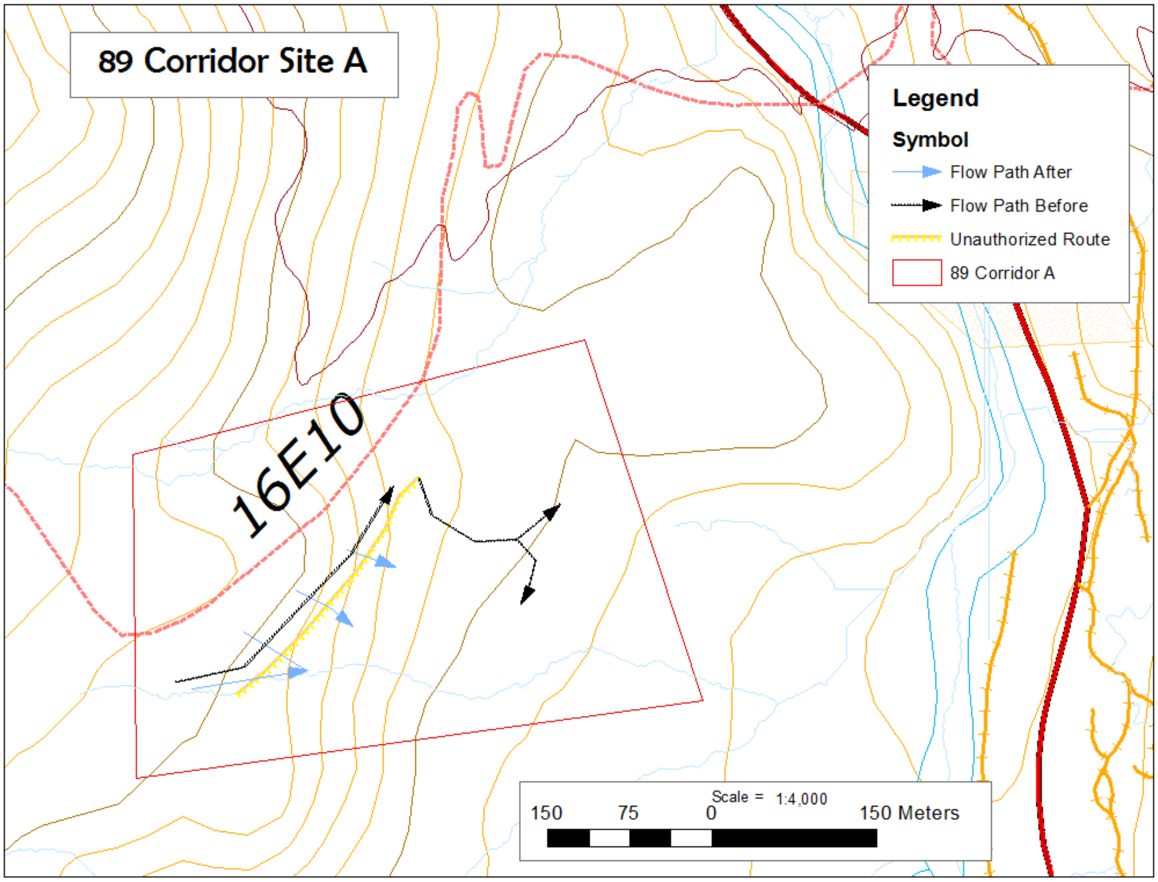
Alpine Meadow Horse Trail

1. Existing Conditions:

The Alpine Meadow Horse Trail occasionally uses an unauthorized road bed that remains from legacy construction. This road bed is approximately 860 feet long and collects drainage that would otherwise flow down slope. The road bed is eroding as is evidenced by residual rock that remains after fines are washed away. The collected drainage flows onto other trails below that are in the location of the flow path shown on the map. This occurs for approximately 1,700 feet.

2. Proposed Action:

It is proposed that the roadbed be decommissioned and at a minimum narrowed to the appropriate design trail width for horses. Restoration or minimized trail construction with adequate erosion controls and revegetation or groundcover over the trail would significantly reduce existing levels of erosion. Restoration of this area would result in decreasing the length of concentrated flow down slope and transport of sediment to the drainages below. At the most short segments of trail would transport water and overland flow would be favored over the longer length of concentrated waters.



89 Corridor Site A
Legend
Symbol
Flow Path After
Flow Path Before
Unauthorized Route
89 Corridor A
16E10
Scale = 1:4,000
150 75 0 150 Meters

89 Corridor Watershed Assessment

Campgrounds

Goose Meadow Campground:

The Goose Meadow campground is located off Hwy 89 approximately a third of the way from the town of Truckee to Tahoe City. It is directly north of the confluence of Deep Creek from the west and the Truckee River from the south. The meadow for which the campground was named lies directly north of the campground; the total combined area of the campground and meadow is 159,000 square meters. The campground is typically open to the public between the months of May (Memorial Day) and October (Columbus Day).

Goose Meadow: Natural drainage from the hillslopes west of the meadow is heavily impacted by the construction of Hwy 89. During spring runoff and storm events, water from the hillslopes runs up against Hwy 89 South and is concentrated into three culverts. These culverts have been dug approximately 18 inches below the natural ground elevations and have been trenched on their outlet side into the meadow and keeps the water channeled after it crosses Hwy 89 preventing natural re-watering of the meadow. On the east side of Hwy 89, three road curb outlets divert water captured by the road into the meadow along with large amounts of road sand creating large mounds.

Goose Meadow Campground: The campground is accessible by two roads that lead east from Hwy 89. Runoff that is captured on Hwy 89 is diverted onto these gravel access roads. Runoff stays on the road's compacted surface for a short distance, allowing it to increase in velocity and turbidity and to cause rilling of the gravel road leading into and through the campground. Points where this channeled flow exits the gravel road creates minor scouring of the native surface it crosses. These channels empty directly to the Truckee River with only a small buffer area between the campground and the Truckee River. There is also a utility corridor between the campground and the river that gets used as a trail. This area should be further assessed and remediation plans developed to reduce sediment influx into the Truckee River.

Silver Creek Campground:

The Silver Creek Campground is located off Hwy 89 approximately half way between the town of Truckee and Tahoe City. It is directly south of the confluence between Silver Creek from the west and the Truckee River from the south. The campground encompasses an area of 53,000 square meters. The campground is typically open to the public between the months of May (Memorial Day) and October (Columbus Day).

The campground has paved roads and so does not have erosion problems from the road surface. There are indications that runoff from the paved roads gets concentrated on the eastern end of the campground loops generates small amounts of sediment from the native soil on the slopes leading down to the river with minimal vegetative buffer. This area should be further assessed and remediation plans developed to reduce sediment influx into the Truckee River

On the eastern side of the campground there is an in sloped terrace with campsites accessible only by foot traffic. The inslope shape of this terrace allows it to catch and channel runoff and dump it directly into the Truckee River. This appears to have a low to moderate potential for sediment input to the river. Further assessment is needed to determine if remediation efforts can and should be made to this terrace.

Granite Flat Campground:

The Granite Flat campground is located off Hwy 89 approximate 1.5 mile south of the town of Truckee. There are no major creeks in the immediate vicinity of the campground. The campground encompasses and area of 85,000 square meters. It is along a very narrow (115 meters max) strip of land between Hwy 89 and the Truckee River. The campground is typically open to the public between the months of May (Memorial Day) and October (Columbus Day).

In all, the Granite Flat campground is not a sediment source problem site. The roads are paved. The main drainage that empties into the Granite Flat campground area enters at the southern tip of the campground and is generated by sheet flow captured by Hwy 89 and passes through a culvert. This channel has been recently remediated to prevent it from being captured by roads within the campground. In all areas where flow leaves the campground there is an adequate vegetative buffer in good shape to allow for infiltration and filtration of flood waters, and deposition of most sediment within the buffer before it reaches the Truckee River.

Prosser Creek Watershed Assessment

Prosser Creek and associated roads below Prosser dam

Introduction

The area below Prosser Reservoir and above the Truckee River has approximately nine miles of roads and trails that drain into Prosser Creek. This portion of Prosser Creek is a prime trout fishery and drains directly into the Truckee River. Reduction in the amount of sediment from the road and trail system is an important factor in reducing TMDLs in the Truckee River. The roads and trails in this area have very few drainage structures to dissipate the water energy that mobilizes sediment during and after storm events. Portions of the road system on the north side of Prosser Creek provide for recreation access and make close approaches to Prosser Creek which can lead to direct deposition of sediment to the creek.

Analysis

The analysis area was comprised of 472 acres of land managed by the USDA Forest Service that drain into this portion of Prosser Creek. Within this area 1.94 miles of forest system roads, 1.42 miles of non-system roads and 5.61 miles of user created horse trails currently exist. The roads are native surface and are generally 12 feet wide, while most of the horse trails are three feet wide with some trails using an old road system are up to 12 feet wide.

To estimate the annual sediment production from this road and trail system the WEPP: Road model was used. WEPP: Road is one in a series of the U.S.D.A. Forest Service's Internet-based computer programs based on the Agricultural Research Service's Water Erosion Prediction Project (WEPP) model. WEPP: Road allows the user to specify the characteristics of the road in terms of climate, soil, local topography, drain spacing, road design and surface condition. One of the most common forest road conditions leading to sedimentation of streams is shown in **figure 1**, where a forest road experiences erosion between cross drains. The runoff from the cross drain is routed over the fill slope and across a buffer area to the stream.

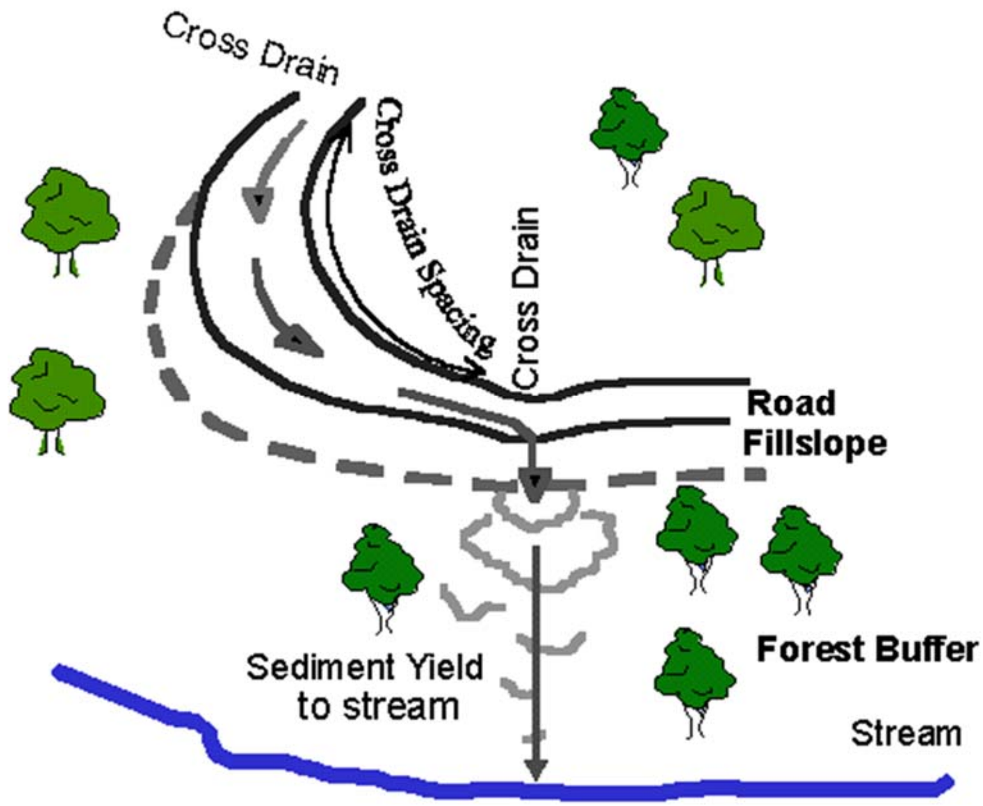


Figure 1. *Relationship of road, fillslope, forest buffer and stream for the WEPP:Road Program*

For the sediment modeling, 99 road and trail segments were identified in GIS and the characteristics of these segments was entered into the WEPP: Road model (http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/wr/wepproadbat.pl). Fifty years of climatic data from the Forest Service's Truckee Ranger station was used for climatic input. The model was then run twice. Once modeling the roads and trails with current conditions (no waterbars or dips) and then again with waterbar spacing based from the Forest Service's Timber Sale

Administration Handbook for soils with a high soil erosion hazard rating (Appendix A). A summary of the results are presented in **table 1** below.

Prosser roads and trails sediment summary	Distance	Average annual sediment leaving road (tons)	Average annual sediment entering the stream (tons)	Average annual sediment leaving road (tons)	Average annual sediment entering the stream (tons)
	Miles	current condition		with waterbars	
Horse Trails	5.61	14.06	2.07	3.56	0.49
System Roads	1.94	10.78	1.83	2.68	0.28
Non-System Roads	1.42	7.09	1.12	1.85	0.25
TOTAL	**8.97**	**31.93**	**5.01**	**8.09**	**1.02**

Table 1. *Prosser roads and trails summary*

The table shows that waterbarring all roads and trails in the analysis area would result in a 75% reduction in sediment leaving the roads and trails and an 80% reduction in sediment reaching stream channels. While the horse trails deliver the most sediment to the streams, on a per mile basis they deliver the least (see **table 2** below).

	Distance	Average annual sediment entering the stream (tons/mile)	Average annual sediment entering the stream (tons/mile)
	Miles	current condition	with waterbars
Horse Trails	5.61	0.37	0.08
System Roads	1.94	0.94	0.14
Non-System Roads	1.42	0.79	0.18

Table 2. Sediment delivery in tons per mile

Discussion

Sediment delivery from roads and trails to the streams in the Prosser area can be reduced by 80% by adding appropriately spaced waterbars to all identified roads and trails. It is proposed that 1.16 miles of system and non-system roads that are not necessary be obliterated. It is also recommended that half of the current horse trails be obliterated. At this time the Forest Service's recreation department needs to still provide input to determine which horse trails need to be retained to still serve the horse riding public. It is assumed that obliteration would in the long term reduce the sediment currently coming from these areas to natural background erosion. This would reduce sediment delivery to the Prosser Creek stream system to 0.60 tons annually. This is a reduction of 88% from current conditions and a 59% reduction from waterbarring everything.

Not considered in this analysis is the amount of sediment coming from the parking areas near Prosser Creek. Further reduction in sediment entering the stream could be accomplished by eliminating some parking areas and reducing the size of others. This could be as simple as placing boulders to limit access, as well as seeding and mulching the reclaimed areas.

References

United States Department of Agriculture, Forest Service, FSH 2409.15 Timber Sale Administration Handbook, 1989.

United States Department of Agriculture, Forest Service, Rocky Mountain Research Station and San Dimas Technology and Development Center, WEPP: Road. WEPP Interface for Predicting Forest Road Runoff, Erosion and Sediment Delivery, 1999.

United States Department of Agriculture, Forest Service, Soil Survey for Tahoe National Forest Area California, 1994.

Appendix A

Exhibit 01 gives the recommended spacing for water bars 1/ on temporary roads, tractor roads, skid trails and fire lines.
(Use these spacing guidelines for permanent roads when there is a need for drainage facilities for permanent roads)

Road, Skid Trail or Fire Line Gradient	Erosion Hazard Rating for Area 2/ 4-5 (Low)	6-8 (Medium)	9-10 (High)	11-13 (Very High)
%	(Feet)	(Feet)	(Feet)	(Feet)
1 - 6	400	350	300	250
7 - 9	300	250	200	150
10 - 14	200	175	150	125
15 - 20	150	120	90	60
21 - 40	90	70	50	30
41 - 60 3/	50	40	25	15

1/ Measure spacing’s on the slope.

2/ EHR's are based on general area around road or trail and not on the bare area of the road or trail.

3/ May require hand work instead of dozer.