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BACKGROUND

This erosion assessment implements the effective soil cover monitoring requirement of the Master Plan Amendment 2007 (MPA 07) mitigation measure 7.5-2. Mitigation measure 7.5.2 details the on-going Environmental Monitoring Program that was originally developed and implemented by the Forest Service as part of the Master Plan 1996 EIR/EIS/EIS. The Environmental Monitoring Program was subsequently updated and included in the MPA 07 and is now jointly overseen by the Tahoe Regional Planning Agency (TRPA), USDA Forest Service, and California Water Quality Control Board – Lahontan Region (Lahontan).

The effective soil cover monitoring protocols outlined in the ongoing Environmental Monitoring Program did not prove to be robust enough in past years. As a result, the erosion-focused rapid assessment methodology (described below) began to replace previous protocols in 2013 in an effort to develop a more prioritized framework for addressing watershed erosion issues. An initial summary of erosion hot spots in the CA-1 watershed was provided in the Mitigation and Monitoring Plan Annual Report (October 2012-September 2013). The erosion assessment in Sky Basin builds on a broader erosion assessment for the entire Heavenly Valley Creek watershed (CA-1) that began in 2013.

ASSESSMENT OVERVIEW

The Sky Basin erosion assessment was conducted on July 22, 2014 in the drainage area above Sky Meadows, in the upper portion of the CA-1 watershed. The assessment utilized the erosion-focused rapid assessment (EfRA) methodology described in the *Watershed Management Guidebook* (Drake et al. 2012 - http://www.ierstahoe.com/pdf/research/watershed_management_guidebook.pdf). This methodology focuses on identifying the primary sources of erosion (“hot spots”) through a simple GIS-based flow accumulation mapping exercise followed by targeted on-the-ground assessment. This approach is based on developing an understanding of water flow patterns in the watershed to address the root cause(s) of erosion issues (often a failed water bar or other concentrated drainage features) rather than using modeling and extrapolation to make statements about the theorized condition of the entire watershed. The output of the EfRA process is a matrix of field-assessed hot spots with qualitative ranking criteria, associated maps and photos. This information can be used to prioritize erosion hot spots for treatment within a watershed context. That is, hot spots with high erosion potential (or actual observed erosion) and high hydrologic connectivity to surface waters are generally ranked as higher priorities and hot spots with lower erosion potential and/or connectivity to surface water are ranked as lower priorities.

EROSION HOT SPOT RANKING CRITERIA AND SUMMARY MATRIX

- **Erosion Risk (high/medium/low – H/M/L):** combination of soil and site factors that directly influence erosion potential such as soil density/compaction, slope angle (steepness), total surface cover, and presence of flow concentration features (e.g. gully, water bar).
- **Active Erosion (Y/N):** visual evidence of erosion observed.
- **Active Deposition (Y/N):** visual evidence of sediment deposition observed.
- **Proximity to Stream/SEZ (H/M/L):** distance from hot spot to nearest ephemeral drainage, stream or SEZ (as the crow flies). Categories are: L = >500ft, M = 100-500ft, H = <100ft
- **Connectivity to Stream/SEZ (H/M/L):** likelihood of runoff and sediment from hot spot being transported to a drainage, stream or SEZ. Assessing connectivity requires basic understanding of hydrologic processes

and a keen eye in the field, yet can be somewhat subjective. In general, high connectivity is characterized by a well-defined drainage path with minimal potential for storage or infiltration (e.g. a relatively steep gully/ditch). Low connectivity is generally characterized as having broad topographic definition and little to no evidence of recent concentrated flow.

- **Overall Priority (H/M/L):** This is a synthesis of the five criteria above and provides a relative priority for treating hot spots. The most important factors considered here are the magnitude of the erosion source and the likelihood of sediment reaching Sky Meadow or Heavenly Valley Creek above the reservoir.

Note: numbering of hot spots in the matrix does not begin at 1 because it is a continuation of erosion assessment work in the CA-1 watershed that began in 2013. New hot spots are numbered sequentially from where the 2013 assessment left off. Hot spots 6, 7, and 13 were initially identified in 2013 and are included in this assessment because of their location within Sky Basin. Hot spots identified during the more recent 2014 assessment are numbered sequentially beginning with hot spot 30.

Table 1. Heavenly Erosion Hot Spot Summary Matrix (Sky Basin Drainage Area – Upper CA-1 Watershed)

Hot Spot #	Type	Erosion Risk	Active Erosion	Active Deposition	Proximity to Stream/SEZ	Connectivity to Stream/SEZ	Overall Priority	Problem Description	Treatment Recommendation(s)
6	Water Bar	H	Y	Y	L	L	L	Giant sediment plume and incising WBs downslope of road, all caused by concentrated road runoff	re-direct road runoff away from slope, then remove WBs on slope and stabilize with full restoration treatment (~15,000sf)
7	Gully	M	Y	Y	L	L	L	Road drainage to breached WB formed gully down fir-covered ski run.	maintain drainage to WB on ski run; rake out gully; apply thick mulch to lower ski run above road (~2500sf)
13	Water Bar	H	Y	Y	M	H	H	water bar draining to reservoir	install PN wattles as sediment forebay; create small infiltration swale at WB outlet (~500sf)
30	Disturbed area	L	N	Y	H	H	M	bare and poorly vegetated area under Sky Deck (~3000sf)	restoration and planting shade-tolerant meadow/riparian species
31	ski run	M	Y	Y	H	H	H	erosion from bare ski run area above road (and on road) directly to meadow below	full restoration treatment (~2500sf)
32	swale	M	Y	Y	H	H	H	rock-lined swale around Canyon base filled with sediment; sediment plume into meadow	remove sediment and rebuild rock-lined swale; install several mulch filter berms in swale; remulch lift loading areas as needed to maintain surface mulch (~500sf)
33	ski run	H	Y	Y	H	M	H	steep ski run (lower double down) with low surface cover and sparse trees; water bar near bottom of run filled with sediment and overtopped	rehab water bar and convert to infiltration swale; install several mulch berms on ski run OR cover lower portion of ski run with mulch (1500-15,000sf, depending on treatment)
34	ski run	H	Y	Y	H	H	H	steep ski run (lower ridge run/sky chute) with little surface cover and widespread erosion; several v-shaped water bars direct water to a culvert system that leads to meadow and several water bars have overtopped (causing erosion below)	rehab water bars and convert to infiltration swales; install several mulch berms on ski run OR cover ski run with mulch (2500-15,000sf, depending on treatment)
35	road	M	N	N	H	H	H	bare, compacted vehicle turnaround and access to Sky lift	maintain wood chip mulch cover on turnaround area near creek (~500sf)







Hot Spot #	Type	Erosion Risk	Active Erosion	Active Deposition	Proximity to Stream/SEZ	Connectivity to Stream/SEZ	Overall Priority	Problem Description	Treatment Recommendation(s)
								base, which is ~20ft from creek channel	
36	water bar	H	Y	Y	M	H	H	water bar draining road is causing erosion under large ski run sign, compromising power box, and contributing runoff and sediment to ski run below (lower ridge run - hot spot 34)	create spreading/infiltration area at water bar outlet and add pine needle filter berms to trap sediment (~500sf)
37	water bar	H	Y	Y	L	H	H	road drainage collects at V-shaped water bar with culvert direct to meadow; erosion along water bar (head cutting); water bar overtopped at culvert inlet, causing erosion downslope	rehab water bars and convert to infiltration swales; rake out and mulch rills (~1000sf)
38	water bar	H	Y	Y	L	H	H	road drainage directed along water bar on ski run; erosion along water bar and downslope where water bar overtopped	rehab water bars and convert to infiltration swales; also rebuild water bar on roadway; ; rake out and mulch rills on ski run (~1000sf)
39	ephemeral drainage	H	Y	Y	L	H	L	large ephemeral drainage; lots of woody debris in flow line and moderate mulch cover in surrounding areas	no action recommended
40	water bar	H	Y	Y	L	M	L	many water bars on high roller ski run above and below summer road; many have failures where they have overtopped, causing erosion downslope	rehab water bars at failure points and convert into infiltration swales through soil loosening, wood chip incorporation (~10,000-15,000sf)
41	water bar	H	Y	Y	L	H	M	ski run (upper ridge run) with ~6 eroding water bars that direct runoff into large drainage that eventually outlets at the Canyon lift base and connects to Sky Meadow; many water bars have failures.	rehab water bars at failure points and convert into infiltration swales through soil loosening, wood chip incorporation (~10,000-15,000sf)









Hot Spot #	Type	Erosion Risk	Active Erosion	Active Deposition	Proximity to Stream/SEZ	Connectivity to Stream/SEZ	Overall Priority	Problem Description	Treatment Recommendation(s)
42	stream channel	M	N	N	H	H	M	south fork of SEZ channel above Sky Meadow culvert with mostly bare soil and moderately steep slopes on both sides of channel; old decomposed jute and plastic netting observed from previous USFS erosion control efforts; generally no visible erosion from banks; channel is somewhat straight and incised but no significant head cuts or bank erosion observed	definitely potential for restoration/stabilization of banks (loosening/seeding/mulch - no fabric); approx ~5000sf of bare soil along channel
43	stream channel	M	Y	Y	H	H	M	bank erosion and sediment plume in south fork of SEZ channel above Sky Meadows culvert	bank stabilization/restoration treatment (loosening/seeding/mulch - no fabric); ~300sf
44	stream channel	M	Y	Y	H	H	M	sediment plume in south fork of SEZ channel above Sky Meadows culvert; sediment appears to have come from short section of rock-lined swale upslope of creek; no obvious bank erosion	decommission rock-lined swale, which appears to unnecessarily collect dispersed runoff from rocky slope above it (~1000sf)
45	water bar	H	Y	Y	H	H	H	very steep section of road (Hellwinkle's) is delivering sediment downslope into a fingered section of the north fork of the SEZ channel above Sky Meadows culvert; rills and gullies formed on hillside below road and above channel	stabilize rills/gullies on hillside, and address road runoff. Road options: 1) surface and/or pave road; 2) decommission road and use only for emergency access; 3) improve infiltration capacity and conduct very frequent maintenance at sediment basins along road (~1000-5000sf)
46	water bar	H	Y	Y	H	H	H	very steep section of road (Hellwinkle's) is delivering sediment downslope into a fingered section of the north fork of the SEZ channel above Sky Meadows culvert; minor rilling on hillside below road and above channel	options: 1) surface and/or pave road; 2) decommission road and use only for emergency access; 3) improve infiltration capacity and conduct very frequent maintenance at sediment basins along road (~1000-5000sf)








Hot Spot #	Type	Erosion Risk	Active Erosion	Active Deposition	Proximity to Stream/SEZ	Connectivity to Stream/SEZ	Overall Priority	Problem Description	Treatment Recommendation(s)
47	ephemeral drainage	M	Y	Y	L	H	L	large ephemeral drainage at crossing with lower Cal trail; relatively stable and well vegetated with small meadow below road crossing; evidence of flow during recent rain events but no obvious sediment transport	no action recommended
48	gully	M	Y	Y	L	M	L	well-established gully formed at downslope end of lower Cal trail; collects water from large drainage area; moderate amount of erosion and deposition observed from recent rain storm	full restoration treatment along gully (maintain general swale-like shape) to slow and infiltrate surface runoff during spring snowmelt and rain storms; installation of mulch filter berms would provide short-term benefits (~1500sf)
49	ski run	H	Y	Y	H	M	H	steep ski run (lower Ellie's) with compacted soil, moderate veg cover, and visible rilling; water bar near bottom of run filled with sediment and overtopped in several locations	rehab water bar and convert to infiltration swale; install several mulch berms on ski run OR cover lower portion of ski run with mulch (1500-15,000sf, depending on treatment)








EROSION HOT SPOT PHOTOS







Table 2. Heavenly Erosion Hot Spot Photo Summary









Hot Spot #	Photo 1	Photo 2
6		
7		
13		

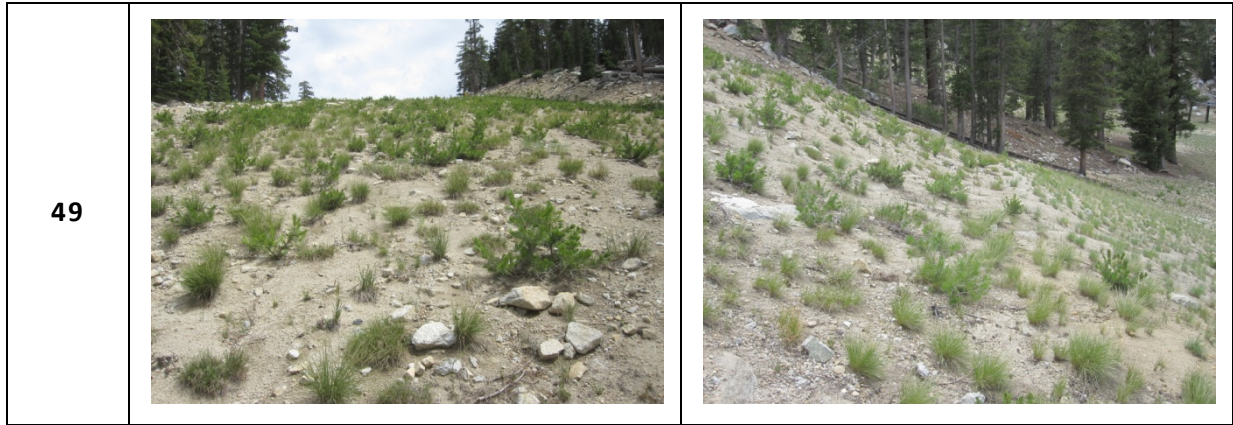
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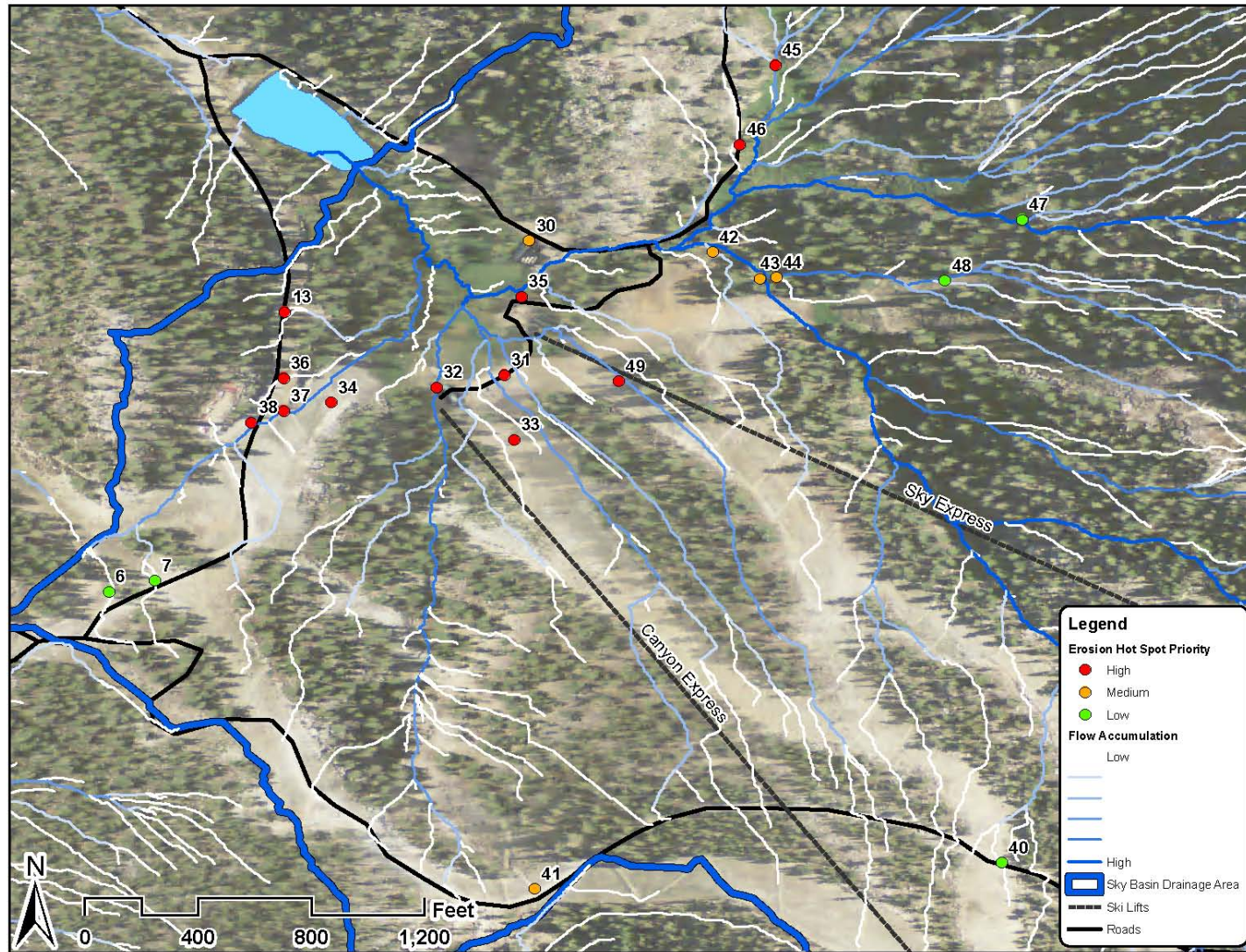
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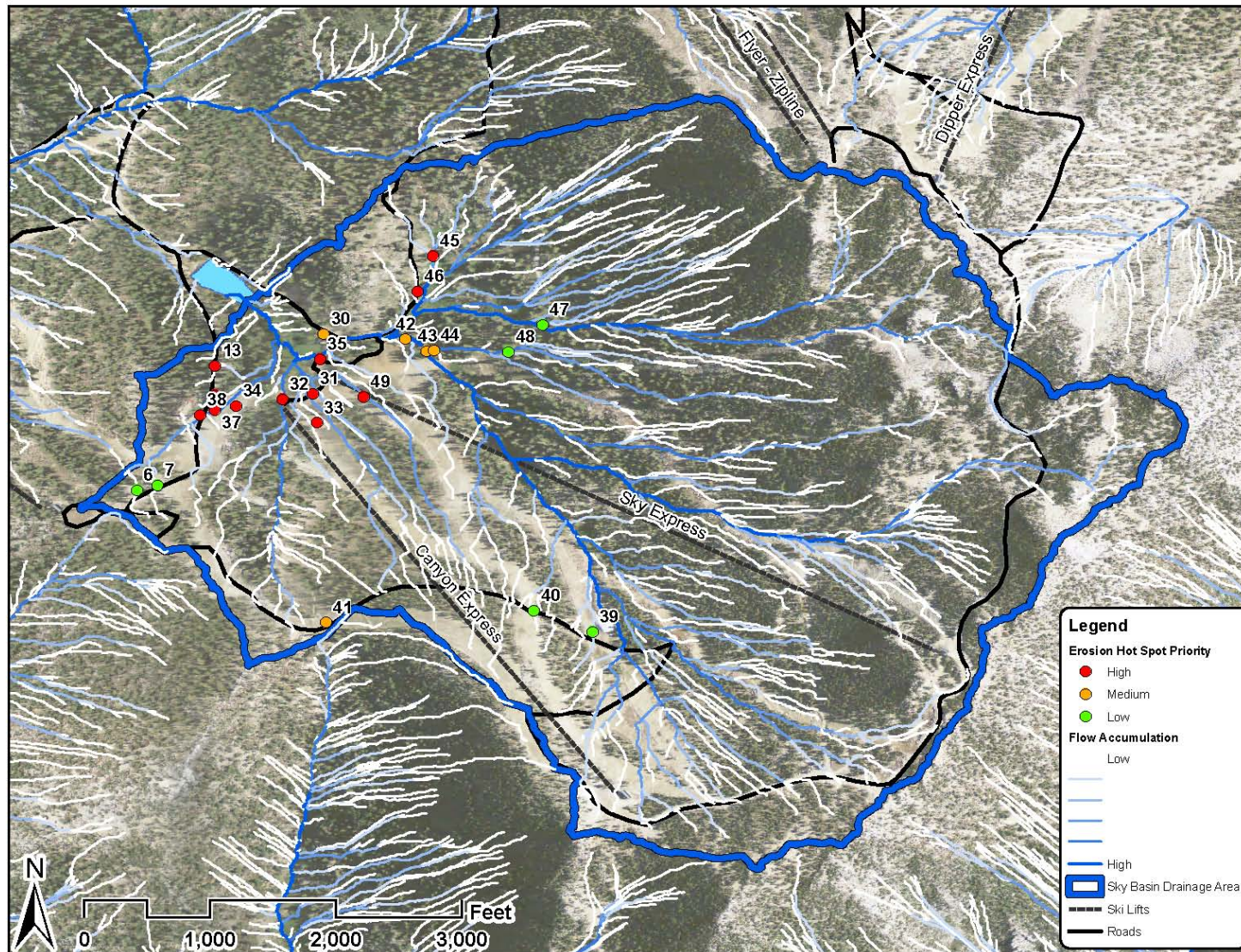
EROSION HOT SPOT MAPS

See next page.



Map Prepared by Kevin Drake, IERS, Inc. July 2014. Data Sources: Vail Corp, RCI, IERS, USGS

Figure 1. EfRA Summary Map showing hot spots in Sky Basin (CA-1).



Map Prepared by Kevin Drake, IERS, Inc. July 2014. Data Sources: Vail Corp, RCI, IERS, USGS

Figure 2. Summary Map showing hot spots in Sky Basin (CA-1), zoomed out to show entire Sky Basin drainage area.

LITERATURE CITED

Drake, K. and M. Hogan. 2012. Watershed Management Guidebook: An Outcome-Based Guide to Watershed Management. Prepared for the California State Water Resources Control Board. Available online at: http://www.ierstahoe.com/pdf/research/watershed_management_guidebook.pdf

APPENDIX 3.1-G
MOTT CANYON (WATERSHED
NV-1) EROSION ASSESSMENT



MOTT CANYON (NV-1) EROSION ASSESSMENT



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The effective soil cover monitoring protocols outlined in the ongoing Environmental Monitoring Program did not prove to be robust enough in past years. As a result, the erosion-focused rapid assessment methodology (described below) began to replace previous protocols in 2013 in an effort to develop a more prioritized framework for addressing watershed erosion issues. This assessment in the NV-1 watershed builds on erosion assessment work that began in the Heavenly Valley Creek watershed (CA-1) in 2013.

ASSESSMENT OVERVIEW

The Mott Canyon (NV-1 watershed) erosion assessment was conducted on June 24-25, 2014. The assessment utilized the erosion-focused rapid assessment (EfRA) process described in the *Watershed Management Guidebook* (Drake et al. 2012 - http://www.ierstahoe.com/pdf/research/watershed_management_guidebook.pdf). The EfRA methodology focuses on identifying the primary sources of erosion (“hot spots”) through a simple GIS flow accumulation mapping exercise followed by on-the-ground assessment. The field assessment work focused on areas where new bike trails are proposed as part of the Heavenly Epic Discovery project, with the intention of identifying areas where proposed disturbance and existing erosion “hot spots” may intersect. The EfRA approach is based on developing an understanding of water flow patterns in the watershed to address the root cause(s) of erosion issues (often a failed water bar or other concentrated drainage features) rather than using modeling and extrapolation to make statements about the theorized condition of the entire watershed. The output of the EfRA process is a matrix of field-assessed hot spots with qualitative ranking criteria, associated maps and photos. This information can be used to prioritize erosion hot spots for treatment within a watershed context. That is, hot spots with high erosion potential (or actual observed erosion) and high hydrologic connectivity to surface waters are generally ranked as higher priorities and hot spots with lower erosion potential and/or connectivity to surface water are ranked as lower priorities.

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- **Connectivity to Stream/SEZ (H/M/L):** likelihood of runoff and sediment from hot spot being transported to a drainage, stream or SEZ. Assessing connectivity requires basic understanding of hydrologic processes and a keen eye in the field, yet can be somewhat subjective. In general, high connectivity is characterized by a well-defined drainage path with minimal potential for storage or infiltration (e.g. a relatively steep

gully/ditch). Low connectivity is generally characterized as having broad topographic definition and little to no evidence of recent concentrated flow.

- **Overall Priority (H/M/L):** This is a synthesis of the five criteria above and provides a relative priority for treating hot spots. The most important factors considered here are the magnitude of the erosion source and the likelihood of sediment reaching primary drainages within the NV-1 watershed. Any erosion hot spots within the alignment of proposed bike trails automatically received a high priority (H) ranking.

Table 1. Erosion Hot Spot Summary Matrix (NV-1 Watershed)

Hot Spot #	Feature Type	Hot Spot-Proposed Trail Interaction	Erosion Risk	Active Erosion	Active Depos.	Prox to stream or SEZ	Connect. to stream or SEZ	Overall Priority	Problem Description, Notes	Mitigation Recommendations
1	water bar	Y	L	Y	Y	L	M	H	trail crosses old low-gradient water bar	remove/decommission water bar using soil restoration treatment
2	water bar	N	H	Y	Y	L	M	M	water bar overtopped (WB #4 on Orion's); heavy rilling below	rebuild water bars and create infiltration capacity on the upslope side through soil restoration treatment; rake out rills downslope; construct mulch berms or infiltration strips on ski run to prevent further erosion by slowing/disbursing flow
3	rill/gully	Y	M	Y	Y	L	M	H	rilling through depositional area below steep rocky slope where proposed beginner trail crosses	restoration treatment to stabilize rilling area below rocks
4	rill/gully	Y	H	Y	Y	L	M	H	several rills and a big gully down Aries ski run; both beg and adv trails are proposed to cross erosion paths on ski run	address source of runoff (see HS#5); stabilize ski run with full restoration treatment and/or series of infiltration strips or mulch berms
5	ski run/road	Y	M	Y	Y	L	M	H	compacted ski run/old road below Comet lift top terminal sheds water onto Aries ski run, contributing to ski run erosion issues (linked to HS #4)	create infiltration/spreading area at top of Aries ski run (before ski run steepens)
6	rill/gully	Y	M	Y	Y	L	M	H	~4 distinct large rills on ski run at proposed trail crossing	soil restoration treatment to stabilize rilling area below rocks
7	water bar	Y	H	Y	Y	L	M	H	proposed trail crossing at water bar with erosion, which collects runoff from at least 150ft of dirt road	design stable drainage crossing for trail
8	proposed trail	Y	L	N	N	L	H	H	proposed trail switchback very near dipper drainage; lots of bare soil but no visible erosion	shift trail alignment so it doesn't drain to dipper drainage

Hot Spot #	Feature Type	Hot Spot-Proposed Trail Interaction	Erosion Risk	Active Erosion	Active Depos.	Prox to stream or SEZ	Connect. to stream or SEZ	Overall Priority	Problem Description, Notes	Mitigation Recommendations
9	water bar	Y	M	Y	Y	L	M	H	proposed trail switchback at end of water bar (major depositional area)	shift trail alignment away from water bar depositional area
10	proposed trail	Y	M	Y	Y	L	H	H	proposed trail switchback very near dipper drainage with a few rills just upslope of proposed trail and connecting to dipper drainage	shift trail alignment away from dipper drainage and existing rills
11	water bar	Y	M	Y	Y	L	L	H	proposed trail switchback near water bar outlet with visible rilling	shift trail alignment away from water bar drainage area
12	road	N	L	N	N	L	M	L	old road - mitigation opportunity	decommission old road
13	proposed trail	Y	L	N	N	L	H	H	proposed trail switchback close to dipper drainage and in area with heavy Manzanita understory	shift trail alignment away from dipper drainage and out of heavily-vegetated area
14	water bar	N	H	Y	Y	L	H	M	several blown out water bars on Big Dipper ski run; mitigation opportunity - not in proposed trail alignment	rebuild water bars and create infiltration capacity on the upslope sides through soil restoration treatment; rake out rills downslope; construct mulch berms or infiltration strips on ski run to prevent further erosion by slowing/disbursing flow
15	depositional area	N	H	Y	Y	L	M	M	depositional area at lower end of dipper drainage	address erosion through source control upslope
16	drainage	Y	M	Y	Y	L	M	H	proposed trail alignment crosses defined drainage	shift proposed trail alignment (location of switchback) to avoid crossing drainage
17	road	N	M	Y	Y	L	M	L	old road to avalanche gun - mitigation opportunity	decommission old road (~8 ft avg width x 1290 ft length; northernmost 100 ft is ~20 ft width)
18	road	N	L	N	N	L	L	L	short loop/turnaround road - mitigation opportunity	decommission turnaround section of road (~12ft x 100ft)