Heavenly Mountain Resort
Mitigation and Monitoring Plan
Annual Report

October 2008 – October 2009


Prepared For:

TAHOE REGIONAL PLANNING AGENCY

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April 30, 2010

David Landry
Senior Planner
Tahoe Regional Planning Agency
128 Market Street
Stateline, Nevada 89449

Dear Mr. Landry,

Please find the enclosed Heavenly Mountain Resort (Heavenly) Mitigation and Monitoring Plan Annual Report (Annual Report) prepared by ENTRIX, Inc., in conformance with the requirements of the Heavenly Mountain Resort Master Plan Amendment, approved April 25, 2007. The Annual Report is comprehensive, including the results of all applicable mitigation monitoring activities completed at Heavenly Mountain Resort between October 2008 and October 2009. The time period was chosen to encompass the 2008-2009 ski season and the 2009 construction season.

The report is organized into three levels of detail enabling the reader to choose between a broad overview and specific areas of focus. The ***first tier*** is an overview of Heavenly's compliance status during the monitoring period, and consists of Table 1, which provides a list of each mitigation measure, its applicability to and status during the October 2008-2009 time period, and whether Heavenly was in compliance with the mitigation measure. The summary table provides a roadmap to the more detailed presentations of the report.

The ***second tier*** is the body of the Annual Report which contains a moderate level of detail in describing the monitoring and compliance status. For each mitigation measure, this presentation provides a summary of the requirement, activities conducted during the monitoring period that trigger the mitigation measure, and Heavenly's compliance status. The body of the report also directs readers to the appendices, where the greatest level of detail is provided.

The ***third tier***, the most detailed tier, includes the appendices at the end of the Annual Report. The appendices contain monitoring reports for individual mitigation measures prepared by subject matter specialists. Individual reports include monitoring efforts covering BMP effectiveness, restoration, water quality, water use, biology, noise, boundary management, and employee housing.

We recommend that paper copies of the Annual Report be made available for public review at the Tahoe Regional Planning Agency offices, the USDA Forest Service Lake Tahoe Basin Management Unit Supervisor's Office (LTBMU), and the Lahontan Regional Water Quality

Control Board South Lake Tahoe Office. This document should also be posted on the Tahoe Integrated Information Management System (TIIMS) website.

Should you require additional information or have questions regarding this document and its contents, please contact Chris Donley of ENTRIX, Inc. at 530-542-0201 x 205

Sincerely,

Daniel R. Tormey, Ph.D., P.G.
Project Manager

Chris M. Donley, P.E.
Local Implementation/Project Manager

CC: Bud Amorfini, Lahontan Regional Water Quality Control Board
Sue Norman, USDA Forest Service, LTBMU
Andrew Strain, Heavenly Mountain Resort

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EXECUTIVE SUMMARY

On April 25, 2007, the Tahoe Regional Planning Agency's Governing Board unanimously approved Heavenly Mountain Resort's 2006 Master Plan Amendment. This annual report summarizes monitoring and evaluation activities conducted at Heavenly Mountain Resort (Heavenly) between October 2008 and October 2009 as a result of the implementation of the Mitigation and Monitoring Plan contained in the approved Master Plan Amendment.

The Mitigation and Monitoring Plan consists of planning measures, construction measures, operations and maintenance measures, and management response to monitoring and evaluation. The content of each measure is developed to mitigate potentially adverse effects from the implementation of Heavenly's Master Plan Amendment. As Heavenly implements the Master Plan Amendment, they must meet each applicable measure and utilize monitoring and evaluation results to adapt the measures if necessary.

Monitoring and evaluation is conducted by Heavenly, the Tahoe Regional Planning Agency, the USDA Forest Service, Lahontan Regional Water Quality Control Board, and local and county offices. Heavenly employs the services of ENTRIX, Inc, Resource Concepts, Inc., J.C. Brennan, Hauge Brueck Associates, and Integrated Environmental Restoration Services, Inc. to conduct monitoring in their field of expertise. The annual report contains a summary of the results of the monitoring and evaluation.

Heavenly has complied with all applicable measures with the exception of partial compliance with measures 7.4-4, 7.5-12, 7.5-13, and 7.5-23 for which it has developed plans to ensure full compliance. Table 1-1 summarizes the measures contained in the MMP, their relevance to the time period of interest, and Heavenly's compliance.

CHAPTER 1
INTRODUCTION

Heavenly Mountain Resort is located on the south shore of Lake Tahoe within El Dorado and Alpine Counties of California and Douglas County of Nevada (Figure 1-1). Land ownership is shared between the United States Department of Agriculture Forest Service (Forest Service) and Heavenly. Heavenly operates on National Forest lands through a special use permit, renewed in 2002 for a period of 40 years.

A Mitigation and Monitoring Plan (MMP) was first adopted during the approval of the 1996 Heavenly Master Plan. The MMP was revised based on measures that have been completed, measures that are no longer necessary, and new measures that are required to reduce potential impacts from implementation of the Master Plan Amendment. The amended Master Plan describes the long-range development plans for Heavenly Mountain Resort. An EIS/EIR/EIS was prepared in support of the Master Plan, and contained environmental mitigation conditions, monitoring and reporting requirements.

The MMP requires Heavenly's continued compliance with existing local, regional, state, and national regulatory programs both in and out of the Tahoe Basin (Heavenly, 2007). The MMP also contains planning measures, construction measures, operations and maintenance measures, and management responses to monitoring and evaluation. Table 1-1 summarizes the measures contained in the MMP, their relevance to the time period of interest, and Heavenly's compliance.

The MMP is conducted through the work of numerous agencies and private consultants including Heavenly, Tahoe Regional Planning Agency (TRPA), the USDA Forest Service, ENTRIX, Inc (ENTRIX), Resource Concepts, Inc. (RCI), J.C. Brennan, Hauge Brueck Associates (Hauge Brueck), and Integrated Environmental Restoration Services, Inc. (IERS). The period of October 2008 to October 2009 was chosen for the Annual Report in order to include the 2008-2009 ski season and the 2009 summer construction season.

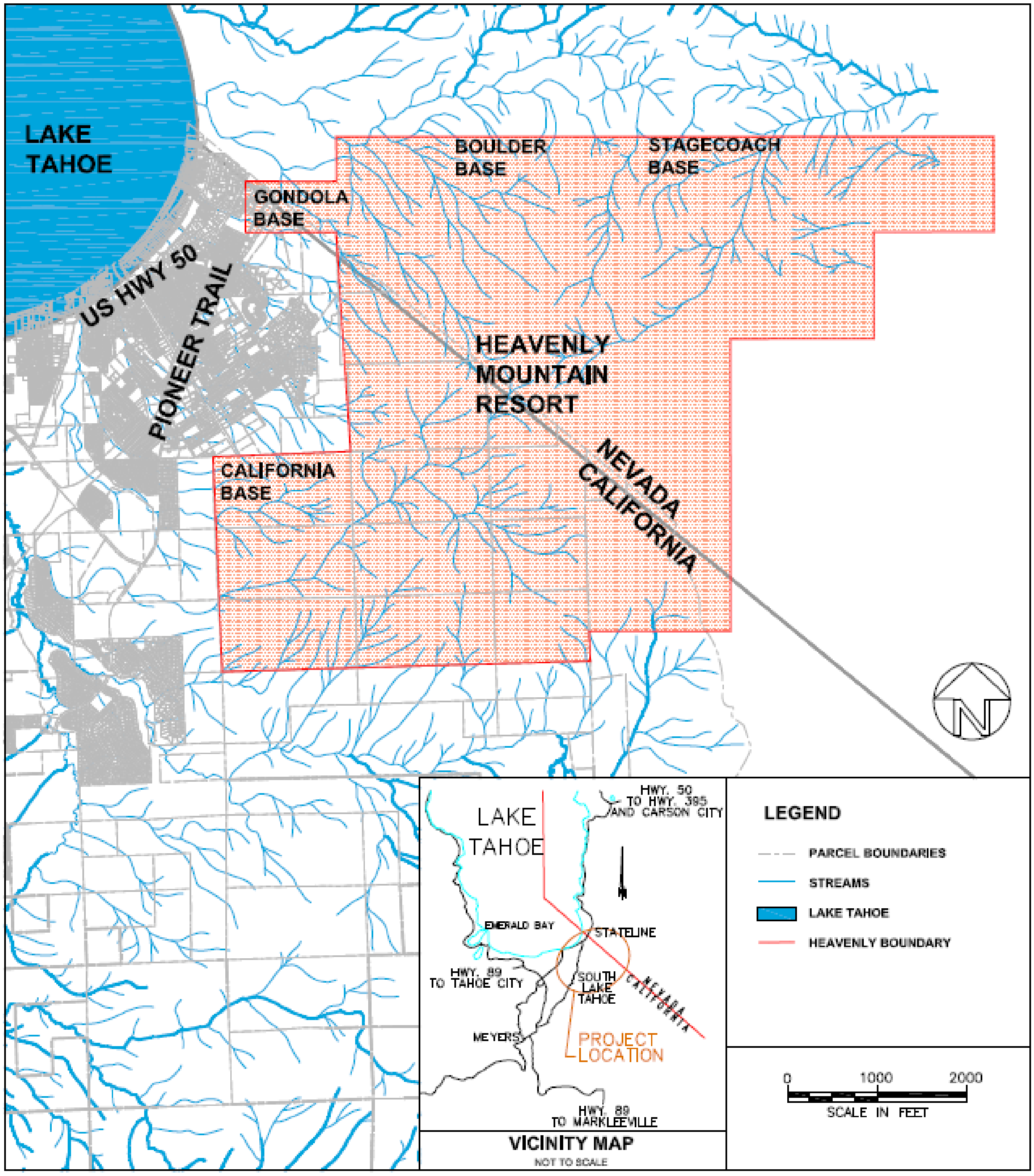

Figure 1-1. Location of Heavenly Mountain Resort (Heavenly 2007)

Table 1-1 Summary of Mitigation and Monitoring Plan Measures

Measure Number	Measure	2008-2009 Applicability	October 2009 Status	Discussed in Current Report	Compliance/ Non-compliance
Planning Measures					
7.3-1	Obtain Summer Day Use PAOT Allocations	None	Project Specific	No	N/A
7.3-2	TRPA Mitigation Monitoring Activities	All Projects and Operations	Complete	Yes	Yes
7.3-3	Design and Site the Proposed Gondola Mid-Station Restaurant to Minimize Visibility From Off-Site Views	None	Not Built	No	N/A
7.3-4	Design and Site the Proposed Angel's Roost Communications Site to Minimize Visibility From Off-Site View	None	Not Built	No	N/A
7.3-5	Reduce Visibility of the Skiways 1 and 2 Trails Through Reduction in Cleared Areas and Retention of Vegetation	Construction Completed in 2007-2008 with final TRPA inspection occurring in 2009	Completed	No	Yes
7.3-6	Design and Site the Proposed Sand Dunes Lodge to Minimize Visibility From Off-Site Views	None	Not Built	No	N/A
Construction Measures					
7.4-1	Revised Construction Erosion Reduction Program	All Projects and Operations	Ongoing	Yes	Yes
7.4-2	Construct Infiltration Facilities	CWE Worklist	Ongoing	Yes	Yes
7.4-3	(Water-1) Control Runoff for Existing Facilities	All Projects and Operations	Ongoing	Yes	Yes
7.4-4	(Water-2) Meet Water Quality Standards	All Projects and Operations	Ongoing	Yes	Partial
7.4-5	(Water-3) Implement Adaptive Ski Run Prescriptions	Tubing Hill	Ongoing	Yes	Yes

N/A - Not applicable in 2008-2009 Annual Report

Measure Number	Measure	2008-2009 Applicability	October 2009 Status	Discussed in Current Report	Compliance/ Non-compliance
7.4-6	(Water-4) Control Runoff due to Future Construction and Long-Term Operation Facilities	All Projects and Operations	Ongoing	Yes	Yes
7.4-7	Avoid Disturbance to SEZ or Restore/Create SEZ	None	Complete	Yes	Yes
7.4-8	Avoid Disturbance to Wetlands or Restore/Create Wetlands	None	Project Specific	No	N/A
7.4-9	(SEZ-3) Restore Future Disturbed SEZs to Meet MP 96 Mitigation Measure 7.4-3 Requirements	None	Project Specific	No	N/A
7.4-10	(SEZ-4) Restore Future Disturbed Jurisdictional Welands and Waters to Meet MP 96 Mitigation Measure 7.4.4 Requirements	None	Project Specific	Yes	Yes
7.4-11	(SEZ-5) Restore Disturbed SEZs due to Construction of Phase I Projects to Meet MP 96 Mitigation Measure 7.4-3 Requirements	Edgewood Creek Watershed Restoration	Partially Complete	Yes	Yes
7.4-12	(SEZ-6) Restore Jurisdictional Wetlands and Waters Disturbed Due to Construction of Phase I Projects to Meet MP 96 Mitigation Measure 7.4-4 Requirements	None	Project Specific	No	Yes
7.4-13	TRPA Land Coverage Mitigation	Planning for the Gondola Lodge	Ongoing	Yes	Yes
7.4-14	Reduce and Control Fugitive Dust	Summer Operations	Ongoing	Yes	Yes
7.4-15	Minimize Removal/Modification of Deciduous Trees, Wetlands, and Meadows	None	Project Specific	No	N/A
7.4-16	(BIO-2) Active Raptor and Migratory Bird Nest Site Protection Program	All Projects	Ongoing	Yes	Yes

N/A - Not applicable in 2008-2009 Annual Report

Measure Number	Measure	2008-2009 Applicability	October 2009 Status	Discussed in Current Report	Compliance/ Non-compliance
7.4-17	Monitor and Protect Northern Goshawk	All Projects	Ongoing	Yes	Yes
7.4-18	Prohibit Skier Access on Management Prescription 9 Lands	Winter Operations	Ongoing	Yes	Yes
7.4-19	Evaluate and Monitor Known Archeological Resources Within Comstock Logging Historic District	No Significant Changes	Ongoing	Yes	N/A
7.4-20	Identify and Protect Undiscovered Archaeological Resources	All Projects	Ongoing	Yes	Yes
7.4-21	Protect the Tahoe Rim Trail	None	Not Built	No	N/A
7.4-22	Secure Adequate Water Capacity Prior to Development	Proposed Gondola Lodge	Planning Stages	Yes	Yes
7.4-23	Secure Adequate Sewer Capacity Prior to Development	Proposed Gondola Lodge	Planning Stages	Yes	Yes
Operations and Maintenance Measures					
7.5-1	Revised Cumulative Watershed Effects Restoration Program	Summer Operations	Ongoing	Yes	Yes
7.5-2	Revised Collection/Monitoring Agreement - Heavenly and Forest Service	All Projects and Operations	Ongoing	Yes	Yes
7.5-3	Maintain Water Rights Balance	All Operations	Ongoing	Yes	Yes
7.5-4	Maintain Water Flows in Heavenly Valley Creek	All Operations	Ongoing	Yes	Yes
7.5-5	Maintain Summertime Flows in Heavenly Valley Creek	All Operations	Ongoing	Yes	Yes
7.5-6	Maintain Water Flows in Daggett Creek	All Operations	Ongoing	Yes	Yes
7.5-7	Maintain Compliance with Water Entitlements	All Operations	Ongoing	Yes	Yes
7.5-8	Reduce Vehicle Emissions	All Operations	Ongoing	Yes	Yes
7.5-9	Snow Grooming Noise Mitigation Methods	Winter Operations	Ongoing	Yes	Yes

N/A - Not applicable in 2008-2009 Annual Report

Measure Number	Measure	2008-2009 Applicability	October 2009 Status	Discussed in Current Report	Compliance/ Non-compliance
7.5-10	Snowmobile Noise Mitigation Methods	Winter Operations	Ongoing	Yes	Yes
7.5-11	Snow Removal Noise Mitigation Methods	Winter Operations	Ongoing	Yes	Yes
7.5-12	Snowmaking Noise Mitigation Methods for Base Areas	Winter Operations	Ongoing	Yes	Partial
7.5-13	Snowmaking Noise Mitigation Methods for Upper Mountain Areas	Winter Operations	Ongoing	Yes	Partial
7.5-14	(Noise-1) Limit hours of Snowmaking operation and use fan gun technology for the proposed Skyline Trail Snowmaking	None	Not Built	No	N/A
7.5-15	Rock Busting Noise Mitigation Methods	None	Not Built	No	N/A
7.5-16	(Noise-5) Restrict Hours of Ampitheater Operations	None	Not Built	No	N/A
7.5-17	Expanded Bus/Shuttle Access	All Operations	Ongoing	Yes	Yes
7.5-18	Discourage Use of Automobiles	All Operations	Ongoing	Yes	Yes
7.5-19	Implement the Coordinated Transportation System (CTS)	All Operations	Ongoing	Yes	Yes
7.5-20	Reduce Traffic on U.S. Highway 50 at Echo Summit	All Operations	Ongoing	Yes	Yes
7.5-21	Protect Tahoe Draba Populations within Heavenly Mountain Resort	All Operations	Project Specific	Yes	Yes
7.5-22	(VEG 1-A) Tahoe Draba Long-Term Conservation Strategy	All Operations	Ongoing	Yes	Yes
7.5-23	(VEG 1-B) Minimize Loss/Degradation of Sensitive Plant Species	All Operations	Ongoing	Yes	Partial
7.5-24	(VEG 1-C) Noxious Weed Management	All Projects and Operations	Ongoing	Yes	Yes
7.5-25	(VEG 3) Late Seral/Old Growth Forest Enhancement	None	Ongoing	Yes	Yes

N/A - Not applicable in 2008-2009 Annual Report

Measure Number	Measure	2008-2009 Applicability	October 2009 Status	Discussed in Current Report	Compliance/ Non-compliance
7.5-26	Restrict Vehicle Traffic within the Heavenly Ski Resort MP96 Development Area Description	All Operations	Ongoing	Yes	Yes
7.5-27	Monitor and Protect Nesting and Fledgling Bird Species	None	Not Built	No	N/A
7.5-28	Compliance with Design Review Guidelines Section 7 Exterior Lighting Standards and Code of Ordinances	None	Project Specific	No	N/A
7.5-29	Building and Site Design	None	Project Specific	No	N/A
7.5-30	Maintain Timber Thinning Practices	All Operations	Ongoing	Yes	Yes
7.5-31	Compliance with Existing Health and Safety Practices	All Operations	Ongoing	Yes	Yes
7.5-32	Avalanche Safety Practices	All Operations	Ongoing	Yes	Yes
7.5-33	Provide Employee Housing	All Operations	Ongoing	Yes	Yes
7.5-34	Ensure Adequate Police/Sheriff/Fire Capacity	All Operations	Ongoing	Yes	Yes
Management Response to Monitoring and Evaluation					
7.6-1	Soil and Water Quality	All Projects and Operations	Ongoing	Yes	Yes
7.6-2	Traffic and Parking	All Operations	Ongoing	Yes	Yes
7.6-3	Late Seral/Old Growth Enhancement	All Operations	Ongoing	Yes	Yes

N/A - Not applicable in 2008-2009 Annual Report

CHAPTER 2
PLANNING MEASURES

Introduction

A majority of the planning measures are addressed within individual Tahoe Regional Planning Agency permits. Table 2-1 provides an update to last season's (October 2007 to October 2008) project list. A few of the projects listed were completed but had yet to receive final inspections for revegetation and Best Management Practices (BMPs).

Table 2-1: Update on Projects Constructed during the 2007-2008 Construction Season

Project	TRPA Permit #	Status as of October 2009
Skiways Glade	20070104	Completed in 2008
Powderbowl Glade	20070104	Completed in 2008
Skyline Trail Re-grade	20050412	Complete*
Lakeview Water System (Phase 1)	Qualified Exempt Maintenance	Partially Completed, Tank removal and road decommissioned scheduled in 2010
California Lodge Best Management Practices (Phase 3)	BMPP2008-0013	Complete*
Adult Ski School Lift Replacement	ESRP2008-0327	Completed, TRPA agreed to design changes that promote and encourage vegetation growth.
Mid-Station Road Re-Grade	20070105	Completed in 2008
Adventure Peak Zipline	20070105	Complete*
Stagecoach Trail Snowmaking	Outside of TRPA Jurisdiction, Forest Service Permit Acquired	Completed in 2008
Olympic Chairlift Replacement	20050411	Partially Complete, the North Bowl Chair replacement is not currently on Heavenly's capital projects funding list.

* The construction is complete. Revegetation and BMPs have not received final inspections.

Between October 2008 and October 2009, the following on-mountain improvements were completed:

Table 2-2: Ongoing Projects during the 2008-2009 Construction Season

Project	TRPA Permit #	Status as of October 2009
Tubing Lift	ERSP2008-1018	Completed in December*
Gondola Lodge	ERSP2009-3571 (Draft)	Preliminary Planning

* The construction is complete. Revegetation and BMPs have not received final inspections, but are expected to occur during 2010.

7.3-1 Obtain Summer Day Use Person at One Time (PAOT) Allocations

Prior to construction of new summer day use facilities, Heavenly needs to obtain TRPA approval for the additional calculated persons at one time (PAOT).

There were no new summer day use facilities constructed during the 2008-2009 season. Therefore, no additional PAOT allocations were applied for or granted.

7.3-2 TRPA Mitigation Monitoring Activities

This measure describes the Mitigation and Monitoring Agreement that Heavenly must enter into with TRPA.

Heavenly, TRPA, and ENTRIX entered a three-party monitoring agreement in January 2008. Heavenly also provides funding to TRPA to conduct all review related to the MMP. This monitoring agreement was renewed through the 2010 calendar year.

7.3-5 (Scenic-6) Reduce Visibility of the Skiways 1 and 2 Trails through Reduction in Cleared Areas and Retention of Vegetation

This measure identifies specific requirements for Skiways Glades. Skiways 1 should be gladed to 50 percent retention of vegetation. Skiways 2 had to be realigned and gladed with 25 percent cleared area and 75 percent vegetation retention.

The Skiways Glades project was completed and inspected during the 2009 construction season (TRPA Permit 20070104). The design and implementation facilitated the requirements of measure 7.3-5.

Conclusion

Heavenly complied with all applicable planning measures during the 2008-2009 construction season. Project specific measures such as 7.3-3, 7.3-4 and 7.3-6 have yet to be constructed and will be discussed in future MMP annual reports.

CHAPTER 3
CONSTRUCTION MEASURES

Introduction

The construction measures contained in the MMP are designed to limit the environmental impacts both during and following the construction of new projects at Heavenly. Resource Concepts Inc. (RCI) assists Heavenly in developing their BMPs and conducts on-mountain monitoring of temporary construction BMPs and permanent BMPs for all of Heavenly's capital projects and Cumulative Watershed Effects (CWE) projects. For the second year in a row Integrated Environmental Restoration Services (IERS), along with Heavenly staff, helped to develop restoration treatments and monitoring plans for disturbed areas during construction and previously constructed CWE projects.

7.4-1 Revised Construction Erosion Reduction Program

The Revised Construction Erosion Reduction Program (CERP) is intended to minimize the rate of soil loss related to construction activities at Heavenly. The CERP has been upgraded from a mitigation measure to a design feature of each construction project through the Master Plan Amendment.

Similar to last season, Heavenly contracted with RCI and IERS to ensure effective BMPs and restoration treatments were designed and implemented in each of their construction projects during the 2009 construction season. RCI performed inspection on both permanent and construction BMPs for implementation and effectiveness. Permanent BMP implementation resulted in 90% of the sites evaluated. Of these implemented permanent BMP's 91% of the BMP's were effective. Temporary BMP implementation resulted in 90% compliant and scored a value of 93% for effectiveness. Recommendations moving forward include increased coordination and communication for prompt responses to BMP repairs and/or retrofits, and reviewing monitoring methods with the Forest Service for past and current roadways. Continual monitoring and prioritizing of BMP maintenance and installation sustains BMP effectiveness. RCI's 2009 BMP Effectiveness Monitoring Report is contained in Appendix I. The IERS Restoration and Monitoring 2009 Summary Report is contained in Appendix II.

7.4-2 Construct Infiltration Facilities

This measure states that all new projects contributing to impervious surface shall be designed to infiltrate the 20-year, 1-hour storm.

All infiltration facilities are designed to infiltrate the 20-year, 1-hour storm. Permanent BMPs for the Olympic Express Chairlift were completed during the 2009 construction season. Improved design and construction modifications to the Zipline Base Station that including elevating the deck, preventing concentrated runoff and an open deck design negating the need for proposed infiltration dry wells at the rear corner. Final inspection has not occurred at this site. The CWE Project and Work List percentage of projects completed increased from 63% in 2008 to 86% in 2009. Additional details and results can be found in RCI's BMP Effectiveness Monitoring Report in Appendix I. In addition, both the Tubing Lift and proposed Gondola Lodge were designed to infiltrate storm water runoff.

7.4-3 Control Runoff for Existing Facilities

This measure requires Heavenly to install BMPs at all lodges, parking areas, and ski lifts and requires compliance with the Lahontan Updated Waste Discharge Permit for completion of the California Base BMP Retrofit project.

The 1997 CWE list is completed and Heavenly is completing the retrofit installation of permanent BMPs at all lodges, parking areas, and ski lifts. In October 2008, Heavenly completed the BMP retrofit project for the California Base Parking Lot. Though in place, the treatment system is still going through troubleshooting procedures for sampling storm events. Storm frequency sampling, sampling quantities and results are being fine tuned. Once the treatment system is operational and providing valid results, the effective removal of permitted constituents by the treatment system will be validated. A list of BMPs completed during the 2009 construction season is available in Appendix A-1, page 1 of the BMP Effectiveness Annual Report. RCI's BMP Effectiveness Report can be found in this document listed as Appendix I. For more information with regards to the projects completed, please refer to Appendix III for the 2009 CWE work list (projects to be constructed in 2009).

BMPs have been designed for the Stagecoach Base and will be installed as part of the Stagecoach Redevelopment Project. The design was approved by Douglas County, under their stormwater management standards, in the fall of 2008. This area is outside both the TRPA and USDA Forest Service jurisdictions and has yet to be constructed.

7.4-4 (WATER-2) Meet Water Quality Standards

To meet water quality standards, several items are identified in the Master Plan Amendment's MMP. These measures include implementing and maintaining the CWE Restoration Program, implementing the revised CERP, implementing the revised Environmental Monitoring Program, installation of BMPs at all facilities and parking lots, installation of a monitoring site on Daggett Creek, and prohibiting grooming on ski trails deficient of adequate snow cover.

During the 2009 construction season, Heavenly implemented the maintenance phase of the CWE Restoration Program and also continued to implement the Revised CWE Restoration Program. Each year RCI and IERS help Heavenly utilizes adaptive management practices to prioritize maintenance and restoration projects. A list of projects completed during the 2009 construction season is located in Appendix III. Two projects from the 2009 list were not completed during the 2009 construction season and were moved to the 2010 CWE Work List. The two projects include: the remediation of existing infiltration trenches that are no longer effective at the Gondola Top Station, and the improvement of soil cover and stabilization of minor rilling at the Groove Upper Terminal. Detailed information concerning maintenance, monitoring, and implementation of CWE projects is located in Appendices I and II.

Heavenly also continues to implement the revised CERP and install BMPs at all facilities as discussed previously.

The Environmental Monitoring Program that has been ongoing since 1991, continued through the 2008 and 2009 season. Water quality monitoring was conducted monthly between October 1, 2008 and September 30, 2009 and weekly during spring runoff at six sites. Three storm samples were collected at the California Parking Lot water quality monitoring site.

New more stringent water quality parameters took effect during the 2008-2009 water year at the California Parking Lot site. Permit conditions stated that once the BMP Retrofit Project and treatment system were in place at the California Parking Lot, more stringent water quality standards would become effective. With these new standards in place, Heavenly reported non-compliance violations with regards to turbidity, suspended solids, total nitrogen, total phosphorus, chloride, oil and grease, and iron levels at the California Parking Lot site. Once fully operational and reliable, automatic samplers at the California Parking Lot treatment system will aid in determining the effectiveness of the parking lot BMPs and in adjusting treatment options to the type and level of constituents measured. Phosphorus, chloride and iron were also in violation at the two Heavenly Valley Creek sites. Results were reported to Lahontan, the Forest Service, and the TRPA according to the requirements of the Environmental Monitoring Program.

The phosphorus exceedence violations are likely attributable to high basin-wide background levels. The reference site at Hidden Valley Creek exhibited a similar trend with regards to phosphorus levels and this watershed is minimally affected by human development. Although there were violations of the Lahontan permit, overall water quality results for permitted constituents were below, equal to or within 15% of the previous years results. Low flows associated with another dry season, along with the maintenance of existing BMP implementation improved and or kept the monitoring results within range of last season's values. See Appendix IV for further discussion and results from the Environmental Monitoring Program. The Lahontan Water Quality Board staff is considering changes to the monitoring and reporting protocols. Heavenly is working with IERS to develop both a short and long term sustainability plan addressing nutrient loading and exceedences. By reducing soil erosion, nutrient loading should also reduce in the waterway samples. Project specific sites and ski runs test plots are proposed for the summer of 2010 with regards to prevention and sustainability in terms of soil erosion.

Heavenly has installed a flow monitoring station at Daggett Creek and RCI is collecting data at this site. Compliance with water use permits is discussed in Chapter 4. The Nevada Department of Environmental Quality (NDEP) does not require any water quality samples. Appendix V contains the Daggett Creek Flow Monitoring report provided by RCI.

Heavenly requires 12" minimum compacted snow over all obstacles before grooming with snow cats is allowed. This policy protects soil and water resources along with preventing significant damage to snowcats.

7.4-5 (WATER-3) Implement Adaptive Ski Run Prescriptions

This measure requires all new ski runs to be re-vegetated according to the ski trail prescriptions in the Easy Street Run Hazard Reduction Program. It also calls for the evaluation of existing ski trails to determine if the prescription would be appropriate.

With the help of IERS, Heavenly is actively restoring and monitoring each construction area using site-specific soil function improvement and revegetation prescriptions. See Appendix II for detailed information for each project area. The only project constructed in 2009 was the Tubing Lift, though additional performance monitoring occurred on all the projects implemented in 2008. Since the tubing lift was completed in mid December, final restoration treatments have yet to be implemented. Additional information on implementation of adaptive ski run prescription is contained in the BMP Effectiveness Annual Report in Appendix I. Restored areas continue to undergo post-construction monitoring. Monitoring results are contained in IERS Restoration and Monitoring 2009 Summary Report in Appendix II.

7.4-6 (WATER-4) Control Runoff Due to Future Construction and Long-Term Operation Facilities

Both broad and project-specific measures are identified for Heavenly to comply with the MMP. Each new project is to have permanent and temporary BMPs as part of its design and construction. New snowmaking should be underground, with certain exceptions. A formal BMP maintenance program shall be continued. Additionally, the Gondola Mid-Station Road shall have primary uses of limited operations associated with Gondola start-up and shutdown and emergency evacuation.

The Tubing Lift was the only significant project built during 2009. The majority of work instead focused on the maintenance of temporary and permanent BMPs. Two projects that were not completed in 2008 (the Olympic Express Chairlift and the Adventure Peak Zipline) were scheduled for completion during 2009. The Olympic Express Chairlift BMPs were completed. Design changes at the Adventure Peak area prevent concentrated runoff flows from the zipline deck. The improved design does not warrant further BMPs. Confirmation of existing soil cover and the improved design are scheduled for review in 2010. The 2010 Annual CWE Project and Work List can be found in Appendix V. All permanent BMPs are designed and maintained to infiltrate at least the 20-year, 1-hour storm. All monitoring of BMP effectiveness and maintenance is performed by RCI as part of the Environmental Monitoring Program. The annual report results are contained in Appendix I.

No new snowmaking equipment was installed in 2009. Snowmaking equipment installed along the Stagecoach Trail in 2008, used revegetation and soil function improvement as BMPs consistent with infiltrating the 20-year, 1-hour storm. This project will continue to undergo monitoring.

The mid-station road, completed in 2008, remains in use only for emergency evacuation and limited daily operations associated with gondola start-up and shut down.

7.4-7 Avoid Disturbance to Stream Environmental Zones (SEZ) or Restore/Create SEZ

This measure identifies specific areas for restoration as well as project-specific SEZ protection components.

All required SEZ restorations have been completed by Heavenly. Heavenly also avoids disturbance to SEZs through its CWE planning process and prioritizes BMP installation and maintenance in areas that could have an impact on SEZs.

Heavenly has completed the 7.65 acres of restoration identified in the Edgewood Creek Watershed Assessment and Restoration Plan through their 2007 Lower Edgewood Restoration Project. Heavenly has also restored 8.75 acres of the Edgewood Bowl and North Bowl areas in 2006 and 2007, and will be working with the TRPA to finalize these projects through inspections.

The restoration of 1.10 acres of SEZ at the Upper Shop was completed in 2006 and continues to be maintained by Heavenly and monitored by RCI.

7.4-8 Avoid Disturbance to Wetlands or Restore/Create Wetlands

This measure requires that Heavenly perform a wetland delineation, avoid development in wetlands, and obtain a Section 404 permit from the United States Army Corps of Engineers (USACE) if development in wetlands is necessary.

There were no plans to develop within or near wetlands during the past construction season. As outlined in the Master Plan Amendment, Heavenly is avoiding disturbance to wetlands through implementation of the mitigation measures listed in 7.4-3.

7.4-9 (SEZ-3) Restore Future Disturbed SEZs to Meet MP 96 Mitigation Measure Requirements

A number of project-specific mitigation measures for avoiding disturbance to SEZs are identified in the MMP.

There were no in-basin or out-of-basin restoration projects implemented during 2009.

7.4-10 (SEZ-4) Restore Future Disturbed Jurisdictional Wetlands and Waters to Meet MP 96 Mitigation Measure Requirements

This measure requires that any project implemented by Heavenly will be located off jurisdictional wetlands and that Sky Meadows Deck and Boulder Operations be relocated off wetlands. If development within the wetlands cannot be avoided, Heavenly is required to obtain a Section 404 permit from the USACE and comply with all requirements set forth in the permit. Additionally, any tree removal activity needed for ski lifts or trails will be conducted in a fashion that does not disturb wetlands.

There were no projects implemented during 2009 that trigger this measure. This measure will be implemented when the Powderbowl Lodge is built and the Sky Meadows Deck is relocated.

7.4-11 (SEZ-5) Restore Disturbed SEZs Due to Construction of Phase I Projects to Meet MP 96 Mitigation Measure Requirements

This measure is both project-specific and for ongoing summer operations. It specifically provides guidelines towards the design of Skiways Trail, the Edgewood Creek restoration projects, summer road usage, vegetation removal near SEZs, tree removal for lift construction, and permitting.

Generally, Heavenly hand prunes vegetation near SEZs and removes trees over the snow. Where summer roads are not well defined, roped boundaries are erected each summer by Heavenly to protect SEZs and restored areas. At the beginning of each field season, summer employees are required to attend a mandatory orientation about vehicle operation on summer roads and the presence of BMPs in order to protect sensitive areas on the mountain.

As discussed previously, Heavenly's portion of the Edgewood Creek Watershed Assessment and Restoration Plan is complete and is awaiting final inspection from TRPA.

7.4-12 (SEZ-6) Restore Jurisdictional Wetlands and Waters Disturbed due to Construction of Phase I Projects to Meet MP 96 Mitigation Measure 7.4-4 Requirements

This measure requires that any phase I project implemented by Heavenly will be located off jurisdictional wetlands. If development within the wetlands cannot be avoided, Heavenly is required to obtain a Section 404 permit from the USACE and comply with all requirements set forth in the permit. Additionally, any tree removal activity needed for construction will be conducted in a fashion that does not disturb wetlands.

During 2009, there were no projects implemented that triggered this measure.

7.4-13 TRPA Land Coverage Mitigation

To utilize available land coverage within the Heavenly project area, TRPA must make appropriate relocation findings included in the Code of Ordinances and BMPs must be installed and maintained as outlined in the CERP.

Heavenly has 434,580 square feet of available banked land coverage and proposes coverage relocation findings required by the 2007 Master Plan Amendment when applying for individual permits.

7.4-14 Reduce and Control Fugitive Dust

During project construction, Heavenly employees and contractors are required to implement mitigation measures to minimize the generation and transport of fugitive dust. These measures may include the use of chemical dust suppressants and/or water on unpaved roads, grading and excavated areas, as well as cleaning onsite paved roadways daily in order to remove excess dirt and mud.

RCI monitors the effectiveness of Heavenly's dust control measures during their temporary and permanent BMP inspections. Though water trucks were used routinely, dust control remained an issue during the late summer months. RCI noted that compacted road base placed in specific areas prevented rutting and was an effective measure in reducing dust. More information on dust control is located in Appendix I.

7.4-15 Minimize Removal/Modification of Deciduous Trees, Wetlands, and Meadows

Before any construction project Heavenly must have a qualified biologist conduct a vegetation survey and identify all deciduous trees, wetlands, and meadows located within or adjacent to the proposed construction corridor. Heavenly is then required to implement a final engineered alterative that avoids the loss or degradation of the identified riparian or wetland communities. If these communities are unable to be avoided, Heavenly must mitigate for the impacts.

There were no projects located in areas that contained deciduous trees, wetlands, and meadows during 2009.

7.4-16 (BIO-2) Active Raptor and Migratory Bird Nest Site Protection Program

This measure requires that before construction activities, a migratory bird nest site survey will be conducted to identify any active raptor nest sites within the project area. During initial construction activities, a Forest Service biological monitor is required to be onsite to evaluate if any migratory bird nests are within 100 feet of the construction corridor. If any nests are found, the biological monitor will stop construction and consult with the Forest Service and TRPA staff within 24 hours to determine the next appropriate actions.

Hauge Brueck is approved by the Forest Service to conduct raptor and migratory bird nest surveys. Surveys conducted in 2009 did not detect any active raptor or migratory bird nests within the survey area. Spotted owl protocol states that if there has been no detection for two consecutive years, it can be assumed that the results are accurate for an additional two years without performing additional surveys. A review of the surveyed results can be found in the 2009 Biological Survey Results Summary located in Appendix VII.

7.4-17 Monitor and Protect Northern Goshawk

Any projects that propose to affect or are within half a mile of any suitable northern goshawk habitat are required to have pre-construction surveys completed for northern goshawks. All surveys will be in accordance with the most recent Forest Service Region 5 protocol. Additionally, Heavenly Mountain Resort is required to fund updated northern goshawk habitat maps at 5-year intervals throughout the life of the Master Plan Amendment. These maps will be used when conducting any pre-construction surveys.

Hauge Brueck is approved by the Forest Service to conduct northern goshawk surveys. Both dawn acoustical and broadcast surveys were conducted using the updated habitat map generated by the Forest Service for the environmental analysis of the Master Plan Amendment. While 2009 surveys did not detect any active raptor or migratory bird nests within the surveyed area, due to findings in the past it is recommended that the surveys continue. Results from the surveys are contained in the 2009 Biological Survey Results Summary located in Appendix VII.

7.4-18 Prohibit Skier Access on Management Prescription 9 Lands

This measure requires that Heavenly Mountain Resort prohibits skier access from the gondola mid station.

Heavenly stations employees at the Gondola mid station to explain to skiers and riders that there is one more stop and deters them from skiing from the mid station. If guests with skis or snowboard equipment stop at the mid station, Heavenly employees require them to leave their equipment on a rack near the gondola that can be monitored.

The mid station is also a physical barrier to accessing skiable terrain. It is an elevated platform with a 10-15 foot drop to the ground. The stair leading to an area below the mid station are roped off and marked "For Authorized Personnel Only." Heavenly is therefore in compliance with this measure and is prohibiting skier access from the mid station. Detailed information on Heavenly's Boundary Management policies can be found in Appendix VIII.

7.4-19 Evaluate and Monitor Known Archaeological Resources within Comstock Logging Historic District

Prior to construction activities, a qualified professional must formally evaluate the project area for the National Register of Historic Places (NRHP). The LTBMU Heritage Resources staff keeps a record of possible historic sites at Heavenly Mountain Resort.

Conversations with LTBMU Heritage Resources staff revealed that evaluations of archeological resources sites within the Comstock Logging Historic District occurred before 2007. Evaluations concluded that all sites but one (the Flume Site) were eligible for the NRHP (Mayer, 2010). Monitoring of these eligible sites occurred throughout 2009. No significant changes were documented during this monitoring period (Mayer, 2010). Furthermore, no projects were implemented within the Comstock Logging Historic District in 2009. The LTBMU Heritage Resources staff keeps a record of possible historic sites at Heavenly Mountain Resort. There were no proposed projects located within the Comstock area in 2009.

7.4-20 Identify and Protect Undiscovered Archaeological Resources

The LTBMU Heritage Resources staff will spot-check any proposed construction areas in consultation with the appropriate State Historic Preservation Office. If previously undiscovered resources are discovered during construction, all activity will be put on hold until the LTBMU Heritage Resources staff for either California or Nevada assess it for eligibility to the NRHP, compliance with TRPA Code Section 29, and/or (in the event of a prehistoric or ethnographic find) for Native American values.

LTBMU Heritage Resources staff has prepared a comprehensive list of historical sites within the Heavenly boundary. Surveys are done prior to choosing locations for projects. Employees receive training prior to project commencement on the protocol for an encounter with possible archaeological resources.

In 2009, to assist in project scoping and field study, a general meeting at the offices of Heavenly Mountain Resort and a site visit focusing on the Gondola's Area of Potential Effects (APE) was conducted (Lindström and Blom 2009). Heritage concerns were addressed by project archaeologist Susan Lindström and John Maher, Heritage Resource Coordinator for the USFS-LTBMU. A surface archaeological reconnaissance was conducted by Devin Gonzales Blom and Susan Lindström from October 26th through 29th, 2009.

Three project areas were surveyed prior to 2009 and include the Gondola project area, the Snow Beach project area, and the Galaxy Pod project area. No heritage resources were encountered in either the Gondola or the Snow Beach project areas and no additional surveys were conducted in 2009 (Lindstrom and Blom 2009). However, in the Galaxy Pod project area, supplemental field studies were required, to include: (a) additional archaeological reconnaissance, (b) updates of existing archaeological site records, and (c) site boundary flagging. Ten archaeological sites were inventoried, and included 9 sites that had been previously recorded. One new site recording was carried out along extended segments of the "Old Mott Canyon/Daggett Creek Road" (Lindstrom and Blom 2009).

Two road segments were discovered as extensions of a Comstock-era wood haul road which was first recorded by S&S in 1992, as leading downward from the Mott Canyon area to the upper reaches of the South Fork of Daggett Creek (Lindstrom and Blom 2009). These new heritage resources have been recorded on State of Nevada IMACS archaeological site records in accordance with established guidelines. Updates to these forms were completed. Copies of this report and accompanying site records have been forwarded to the USFS-LTBMU for their review and processing. An additional copy has been placed on file with Nevada State Museum, which maintains the archaeological inventory for the State of Nevada (Lindstrom and Blom 2009).

7.4-21 Protect the Tahoe Rim Trail

In order to protect the Tahoe Rim Trail (TRT) and allow for its continued used during construction of resort facilities, Heavenly Mountain Resort is required to rope off any hazardous areas within or adjacent to the TRT, prohibit construction of permanent structures which may block the use of the trail, as well as inform the public of any potential closures along the TRT.

There were no projects implemented within the vicinity of the TRT during 2009.

7.4-22 Secure Adequate Water Capacity Prior to Development

Prior to development, Heavenly Mountain Resort is required to complete a detailed analysis of on-site water and sewer requirements of the project. South Tahoe Public Utility District (STPUD) and Kingsbury General Improvement District (KGID) will review the analysis and determine if water and sewer system collection and treatment capacity will be available to meet the expansion needs.

There were no projects implemented during 2009 that increased water demand supplied by STPUD or KGID.

7.4-23 Secure Adequate Sewer Capacity Prior to Development

Heavenly will obtain adequate sewer capacity prior to development of new on mountain facilities requiring sewer units. Heavenly generally uses the sewer capacity outline in the Master Plan of 1996. This capacity will be monitored to ensure that it will meet the requirements of the facilities outlined in the Master Plan Amendment of 2007.

During 2009, there were no new facilities implemented that require additional sewer capacity. Although it has not been constructed yet, STPUD has approved the sewer requirements for the proposed Gondola Lodge. Reserve capacity exists for future projects with both STPUD and Douglas County Sewer Improvement District (DCSID) through KGID.

Conclusion

During construction, measures of the MMP are implemented during each project. Heavenly maintained compliance with these measures during the planning, design, construction, and post-construction phases of each project in 2008-2009.

CHAPTER 4
OPERATION AND MAINTENANCE MEASURES

Introduction

The operation and maintenance measures contained in the MMP govern both summer and winter activities necessary to run Heavenly Mountain Resort. While construction measures are project-specific, operation and maintenance measures encompass daily resort operations. These ongoing measures are usually related to either summer or winter activities.

7.5-1 Revised Cumulative Watershed Effects Restoration Program

The preparation of a Cumulative Watershed Effects (CWE) Analysis was required by TRPA guidelines for ski area expansion and was completed in 1991. The CWE Analysis identified areas that produced relatively greater than background erosion and sedimentation levels. Those areas were prioritized for rehabilitation and restoration treatments. Because all of the remedial CWE projects were completed under the 1997 CWE Restoration Program, the revised CWE focuses on long-term maintenance of facility BMPs, road and ski trail projects, site specific and localized needs, and improved implementation and effectiveness monitoring (Heavenly, 2007).

Each year Heavenly prioritizes CWE projects for both maintenance and implementation. RCI is responsible for BMP implementation and effectiveness monitoring. Results from these monitoring efforts show increased improvement and are contained in Appendix I. The status of this program is ongoing. Appendix III contains a list of CWE projects proposed during the 2009 construction season. Eighteen of the twenty-one projects were completed in 2009. The remaining three projects were rolled over and are included in the 2010 CWE project list. Appendix V contains the list of proposed CWE projects planned for 2010.

7.5-2 Revised Collection/Monitoring Agreement – Heavenly and Forest Service

The Revised Collection/Monitoring Agreement between Heavenly and the Forest Service commenced in 2005 after adaptive management was used to make changes to the original monitoring agreement. The Collection/Monitoring Agreement requires Heavenly to conduct water quality monitoring, effective soil cover monitoring, BMP effectiveness monitoring, riparian condition monitoring, and condition and trend monitoring. Water quality and BMP effectiveness monitoring are conducted annually, while effective soil cover and riparian monitoring are conducted based on specific work plans approved by the Forest Service. Condition and trend monitoring is conducted every 5 years through the preparation of a comprehensive report. The next comprehensive report will be prepared in 2011.

The Environmental Monitoring Program continues to be funded by Heavenly, but has been implemented by ENTRIX and RCI since 2005. Heavenly renewed their contract with ENTRIX and RCI to complete water quality monitoring and BMP effectiveness monitoring in January 2008.

The Revised Collection/Monitoring Agreement between Heavenly and the Forest Service remains in place, however, it now provides funding for Forest Service oversight and review of all water quality and BMP-related monitoring.

Water quality monitoring was conducted monthly between October 1, 2008 and September 30, 2009 and weekly during spring runoff at the six sites specified in the 2005 Revised Environmental Monitoring Program. Storm events were also sampled at the California Parking Lot compliance site. Results were reported to Lahontan and the Forest Service in quarterly and annual reports.

The results from BMP effectiveness monitoring are also reported quarterly and annually and have been discussed previously. The effective soil cover program and riparian condition monitoring for 2009 can be found in the 2008/2009 Environmental Monitoring Program Annual Report found in Appendix IV.

An aerial photo analysis was performed in 2009 to determine effective soil cover on existing ski runs. Late in the summer of 2009, ground-truthing using California Native Plant Society's Vegetation Rapid Assessment Protocol was conducted. While this methodology was comprehensive, it was not detailed enough to address the effective soil cover objectives. During 2009-2010, Heavenly, the Forest Service, Entrix and IERS are developing an alternative measurement system.

Stream riparian studies were conducted during 2009. Data from these studies were compared to data collected in 2006. Comparisons were made to address whether or not Heavenly mountain operations are affecting stream health. Specific reaches and creek details can be found in chapter 5 of the 2008/2009 Environmental Monitoring Program Annual Report (Appendix IV). For the many of the reaches, the channel health remained similar to findings found in 2006. Stream health measurement changes occurred, but may be associated with ephemeral stream morphology and observer subjectivity.

7.5-3 Maintain Water Rights Balance

This measure specifies that Heavenly shall implement a water use/water rights monitoring program to estimate the quantity of water supplied by each source and where the water is used.

Heavenly has installed all necessary meters to conduct the water use monitoring program and has prepared an annual water use/water balance report. The Water Use Report for the 2008-2009 season contains detailed records on water used for snowmaking. The total amount of water used for snowmaking during the 2008-2009 ski season was 148.03 million gallons (454.45 acre-feet). The majority of water for snowmaking was purchased from KGID and STPUD (114.29 million gallons), while the rest was obtained from the California and East Peak Lake reservoirs (33.74 million gallons). Results show that a net of 8.3 million gallons of in-basin water were transferred out of basin during the 2008-2009 snowmaking season. Preliminary data from the 2010 water balance report indicates that water was reversed with approximately 10 million gallons returned in to the basin. New meters were installed in the summer of 2009 to enhance the monitoring system. Results from the new meters readings won't be available until the 2009-2010 water balance report is finalized next year. The 2008-2009 water use/water balance report is contained in Appendix IX.

Besides snowmaking, water usage for the remaining operations of Heavenly are distributed either from small wells or purchased from STPUD or KGID. All purchased water supplied by outside utility providers has been provided in compliance with their approved water rights or similar permits. The sources and use of water between October 1, 2008 and September 30, 2009 are as follows:

- California Main Lodge: Water for the lodge is supplied by STPUD. No consumption data is provided by STPUD. Annual flat fee charges for STPUD water are based on the size of the water meter.

- Lakeview Lodge/Snow Beach Community Water System: Water for these facilities is supplied by an underground well. The estimated consumption for the period is 486,000 gallons (1.49 acre-feet).

- Sky Deck Barbeque and Bathrooms: Water for these facilities is supplied by an underground well. The estimated consumption for the period is 432,000 gallons (1.33 acre-feet).

- Adventure Peak (Top of Gondola/Gondola Mid-Station): Water for these facilities is supplied by an underground well. The estimated consumption for the period is 1,122,000 gallons (3.44 acre-feet).

- Boulder Lodge: Water for the lodge is supplied by KGID. Estimated consumption for the period based on water invoices from KGID is 242,050 gallons (0.74 acre-feet).

- Stagecoach Lodge: Water for the lodge is supplied by KGID. Estimated consumption for the period based on water invoices from KGID is 272,000 gallons (0.84 acre-feet).

- East Peak Lodge: Water for this facility is supplied by an underground well. The State of Nevada has allocated 1.2 acre-feet (approximately 391,000 gallons) annually of consumptive water rights for the well that serves the lodge. The meter has been repaired since the last reporting period and reported an estimated consumption of 787,000 gallons (2.42 acre-feet) for the 2008-2009 time frame. Because this amount is above the state allocation, an adjustment to this water allocation has been requested from the existing pool of unused water rights.

7.5-4 Maintain Water Flows in Heavenly Valley Creek

This measure requires a water use/water rights monitoring program specific to the California Reservoir.

As reported in both the 2007-2008 and 2008-2009 water use/water balance reports, Heavenly attempts to maintain flows into and out of the California reservoir in balance continuously to ensure that water rights are not exceeded. During 2008-2009, the presence of snow made obtaining data and fixing broken meters difficult. During winter months, the balance of flows had to be estimated. The new meters discussed previously should allow for continuous monitoring and balance of flows into and out of the California reservoir for the 2009-2010 season.

7.5-5 Maintain Summertime Flows in Heavenly Valley Creek

This measure does not allow the use of water from Heavenly Valley Creek for irrigation in the summer and requires water use balance for the California Reservoir.

Heavenly does not directly take water from Heavenly Valley Creek for summer irrigation. As reported in the 2008-2009 water use/water balance report, flows into and out of the California reservoir are maintained in balance continuously to ensure that water rights are not exceeded. Another recommendation in the water balance report is to use summer time irrigation water to balance out the winter snow making transfer.

7.5-6 Maintain Water Flows in Daggett Creek

The MMP specifies that Heavenly shall install a flow gauge at East Peak Lake, monitor input via precipitation and output from East Peak Lake, and maintain release rates that satisfy water right permit 50525.

The water rights permit is based on snow making usage as opposed to maintaining flows in Daggett Creek. The permit states that 0.5 cfs of water can be used from November through March for snow making operations. Data from the Daggett Creek suggests that the East Peak Lake Dam is operated to satisfy usage rates that are established in the water rights permit. There are a number of inputs to determine this value such as precipitation in, stream flows out of the dam, water pumped out of the reservoir used for snow making and water pumped into the reservoir. Appendix V contains a report prepared by RCI on Daggett Creek flow data. The Nevada Division of Water Resources will meet with Heavenly to discuss simplifying the methodology of calculating a usage value that is easier to obtain and replicate year to year.

7.5-7 Maintain Compliance with Water Entitlements

Similar to measure 7.5-3, Heavenly shall implement a water use/water rights monitoring program and comply with existing California, Nevada, and local provider water restrictions on an annual basis.

Heavenly complied with all applicable water rights in 2008 and 2009 and prepared a water use/water rights report which is contained in Appendix I. The East Peak well became operational in the spring of 2009. The new well's purpose was to secure an additional source of water and reduce the need for the water transfer across watersheds. The East Peak well was partially operational during the 08-09 season and on-line for the entire 09-10 snowmaking season. The 09-10 well influence results won't be reported until next years report.

7.5-8 Reduce Vehicle Emissions

Heavenly is to work with responsible agencies to implement a mitigation package that will reduce the potential increase of ambient carbon concentrations. The mitigation package includes using contributions to development of best available control technologies and using these technologies for construction, expansion and improvement of the bus system, and improved parking management. In addition, Heavenly shall consider offering skiers/riders the option of both a morning and afternoon half-day lift ticket to reduce peak parking hour traffic.

To mitigate the resort's contribution to carbon emissions, Heavenly is implementing a carbon mitigation package that is largely centered on reducing vehicular traffic. Heavenly uses low emission vehicles for both transit and operations. The entire fleet of Heavenly snowmobiles has 4-stroke engines. Heavenly also uses state-of-the-art snowcats with Tier 3 California Air Resources Board (CARB) engines. The emissions from Tier 3 snowcats are the cleanest available on the market.

During the ski season, Heavenly provides free shuttle service between all base areas and lodging facilities. They discourage vehicular travel to the gondola by only offering paid parking. Employees can buy subsidized monthly bus passes. Heavenly contributed to the start up and operation of the Coordinated Transit System (CTS) and continues to contribute the 20% required local match for Capital Vehicle Replacement Grants from the Federal Transit Administration. Since 2005, all new and replacement buses on the BlueGo system have been low emission, alternative fuel vehicles.

Due to the national economy, there was a reduction in the number of skier visits at Heavenly Mountain Resort from the previous year. As a result there was a reduction of vehicles during peak traffic times. Heavenly currently offers skiers and riders half-day afternoon lift tickets.

7.5-9 Snow Grooming Noise Mitigation Methods

This measure states that Heavenly shall not groom slopes within 85 feet of a Plan Area Statement (PAS) boundary.

Heavenly did not operate snow-grooming equipment within 85 feet of the PAS boundary during the 2008-2009 ski season. This was confirmed by Heavenly Mountain Operations manager, and there were no complaints received from nearby residents. Five newer and quieter snowcats, with the best available technology (Tier 3), were acquired by Heavenly prior to the 2008-2009 season replacing older machinery.

7.5-10 Snowmobile Noise Mitigation Methods

This measure encourages snowmobile noise reduction through proper fleet maintenance, replacing 2-stroke snowmobiles with 4-stroke snowmobiles, and operation of snowmobiles away from PAS boundaries.

Heavenly's entire fleet of 45 snowmobiles consists of 4-stroke technology. Studies have shown that 4-stroke engines reduce noise levels by 10 dBA when compared to 2-stroke engines (Bollard

& Brennan, Inc., 2001). Heavenly also maintains their fleet regularly and keeps documentation on all maintenance.

Snowmobile use is concentrated in flat areas on the upper mountain and not near PAS boundaries. Snowmobiles are operated during the daytime to have the least effect on the Community Noise Equivalent Level (CNEL), though there is no formal noise measurements conducted. Additionally, no known complaints were filed with the local jurisdiction, Heavenly, TRPA, or the Forest Service.

7.5-11 Snow Removal Noise Mitigation Methods

To reduce noise created from the snow removal process; this measure states that Heavenly should minimize nighttime snow removal and attempt to construct noise barriers along the perimeters of parking lots using snow.

While no formal noise measurements are conducted to determine snow removal operations' effect on the CNEL, no known complaints were filed with the local jurisdiction, Heavenly, TRPA, or the Forest Service. Additionally, Heavenly's snow removal plan calls for constructing barriers on the perimeter of the California Base, Boulder, and Stagecoach parking lots. Additionally, Heavenly's snow removal plan calls for constructing barriers on the outskirts of the California Base, Boulder, and Stagecoach parking lots. ENTRIX visited lots after snow removal on February 25, 2008 and documented snow removal plans were followed. Snow is removed, early in the morning prior to opening for the public, from areas furthest from adjacent houses first and pushed towards the houses to build noise barriers.

7.5-12 Snowmaking Noise Mitigation Methods for Base Areas

This measure calls for a reduction of CNELs at the base areas to 1982 values or TRPA PAS noise standards, whichever is less, through the implementation of snowmaking technology.

The CNEL is measured annually at each base area by j.c. brennan and associates. Results for the 2008-2009 season are contained in the Heavenly Ski Resort Master Plan Noise Monitoring Survey located in Appendix X.

At this time, Heavenly has not finished converting the California Base snowmaking system from louder air/water nozzle guns to quieter fan guns. The California Base has a continuous noise meter which recorded sound levels during the ski season on both snowmaking and non-snowmaking days (from November 5th through March 5th). The CNEL value was identical to the value recorded during the 07-08 season (62.4 dBA). The CNEL values recorded at the monitoring location still exceeded the 55 dBA standards for PAS 085 and 087. The CNEL measured on days without snowmaking increased from the previous season by 1.5 dBA. Because this monitoring site is located near the intersection of Keller Road and Saddle Road, one of the primary noise sources includes traffic. Since CNEL levels are exceeded on both snowmaking and non-snowmaking days, the consultant recommended moving the site for the noise meter to eliminate the sound of traffic on Keller and Saddle Roads, which is the probable cause of the exceedance. The monitoring site was relocated in the fall of 2009. Results from the new monitoring location will be provided in next year's report.

Short-term CNEL measurements were taken at Boulder and Stagecoach during snowmaking operations in December 2008. At Boulder, average noise measurements were above the permitted CNEL standard for the plan area statement. Heavenly is utilizing the best available low energy/low noise snowmaking technology in all new snowmaking installations consistent with the master plan. Tower mounted gun technology was used for the Stagecoach Trail snowmaking system. Heavenly is continuing to replace air/water nozzle guns with low noise equipment throughout the entire mountain.

Heavenly has actively pursued several of the mitigation measures for noise reduction at base areas listed in the Master Plan Amendment; however, the measured CNELs are not meeting the scheduled reductions, therefore, this measure is listed as partially compliant.

7.5-13 Snowmaking Noise Mitigation Methods for Upper Mountain Areas

This measure calls for a reduction of existing noise levels where new snowmaking facilities would result in new PAS noise impacts.

The remote measurement for plan area 080 conducted in December 2008 during a full array of fan gun operations on the upper mountain did not detect any audible noise from snowmaking operations. These noise measurements were conducted at “Party Rock” noise measurement site 7 located on Figure 1 in Appendix X.

However, noise measurements from the remote measurement location for plan area 095 (Noise Measurement Site 6) were conducted during a full array of Ratnik air/water nozzles and resulted in a short term exceedance. These measurements were conducted southeast of Liz’s and Canyon trails and both measuring locations have GPS coordinates. The locations can be found on Figure 1 in Appendix X. During the time of measurement, approximately 10 Ratnik guns were in use. The snowmaking operation recorded a noise value of 79 dB Leq. This value exceeds the noise level criteria for plan area 095.

Heavenly is partially in compliance with this mitigation measure. As snowmaking equipment is replaced with new low energy/low noise technology, noise levels are expected to decrease.

7.5-14 (NOISE-1) Limit Hours of Snowmaking Operation and Use of Fan Gun Technology for the Proposed Skyline Trail Snowmaking

This measure limits snowmaking on Skyline Trail to daytime hours due to the current CNEL of 78dB.

There was no snowmaking along the Skyline Trail in 2008-2009. This measure is not applicable at this time.

7.5-15 Rock Busting Noise Mitigation Methods

In order to mitigate the impact to a less than significant level, Heavenly must control the number, size and location of "rock busting" blasts (to meet PAS noise standards). Heavenly is to continue to implement Rock Busting Noise Mitigation measure from the 1996 Master Plan.

There were limited activities in 2009 that required using rock busting. None of these activities drew complaints. It is recommended that a schedule and table be established to monitor and track rock busting activities in the future.

7.5-16 (NOISE-2) Restrict Hours of Amphitheater Operations

This measure restricts the hours of concert nose to the daytime and early evening hours and restricts the concerts to less than 6 hours.

The amphitheater has yet to be constructed. As of 2009, this measure is not yet applicable.

7.5-17 Expanded Bus/ Shuttle Access

To encourage bus and shuttle transportation, Heavenly is to implement the Coordinated Transportation System (CTS) and provide incentives for employees and patrons to use ski shuttle buses.

Heavenly continues to be a leading operator in the CTS system providing operating revenues and local match revenue for capital equipment purchases during the 2008-2009 season. No free parking was available at the gondola and free shuttle service between base areas was readily available during the 2008-2009 ski season. Employees are encouraged to use the free shuttles because employee parking is limited at the Gondola base area and prohibited on weekends, peak weekends and holiday periods at the California base area. Appendix XI has the shuttle schedule and route brochure distributed by Heavenly for the 2008-2009 season.

Additionally, Heavenly is monitoring and collecting feedback about the use of shuttles through their annual employee survey. Heavenly expands the bus system with additional vehicles (between 18-24 vehicles) during peak weekends and holiday periods. During normal mid-week periods, 9-10 vehicles are used. The number of shuttle buses that are in use every day is tied to business volume forecasts. Resort guests are randomly surveyed on a daily basis during the ski season except for the first and last two weeks of the season.

Riders are asked to rate the timeliness of the bus system. Answers to the survey along with ridership numbers are used by Heavenly to ensure that an adequate number of shuttle vehicles are in use to respond to the guests needs. Graphical results from the 2008-2009 Employee Housing and Transportation Survey are located in Appendix XII.

Ridership numbers for Heavenly's free shuttle service are included in Table 4-1. These numbers are well below last year's values because of the economic down turn and lower skier visits.

Table 4-1: Ridership Numbers for Heavenly Shuttles

2008-2009	322,486*

* includes operation of employee shuttles by transit contractor

7.5-18 Discourage Use of Automobile

To meet this measure, Heavenly is to discourage the use of automobiles as the primary mode of access to the Gondola.

Heavenly runs free shuttle service to and from all of their facilities. See Appendix X for the 2008-2009 bus schedules and encompassing map. The bus system also makes stops at employee housing. Free parking at the Gondola is not provided. Heavenly has implemented the TRPA Employer Trip Reduction Ordinance by encouraging employees to rideshare, carpool and offering subsidized bus passes to employees for public transit.

7.5-19 Implement the Coordinated Transportation System

This measure states that Heavenly shall continue to implement their portion of the ongoing air quality and traffic mitigation measures contained in the CTS Memorandum of Understanding (MOU).

Heavenly has implemented all measures identified in the Master Plan Amendment and continues to implement its share of the CTS by offering free shuttle service in the summer and paying a fair share of costs associated with operating and maintaining the fleet of buses.

7.5-20 Reduce Traffic on U.S. Highway 50 at Echo Summit

Heavenly is to implement programs that encourage charter bus trips, air travel via Reno, and travel to the basin during off-peak periods to mitigate the possible increase of traffic on Echo Summit.

Heavenly continues to use marketing incentives to help reduce traffic at Echo Summit. Heavenly's marketing team attends ski shows and expos annually in Los Angeles and the Bay Area to promote ski packages that include group transportation discounts. Heavenly also provides page on their website dedicated to organizing and promoting bus trips and offers discount lift tickets to patrons of these services.
(http://www.skiheavenly.com/plan_your_trip/groups/bus_trips/)

The California Department of Transportation performs annual traffic counts at various locations on their state highways. The Mitigation Level identified in the MMP is "Non-degradation of peak hour traffic at U.S. Highway 50 and Echo Summit". The closest location to Echo Summit was at milepost 65.62, Echo Lake Road, with a peak hour vehicle count of 1,900 in 2008. This vehicular traffic number is the exact same value reported in 2007. While all traffic at Echo Summit is not attributable to Heavenly's operations, the average daily vehicle count at milepost 65.62 can be utilized to assist in assessing the effectiveness of Heavenly's efforts.

7.5-21 Protect Tahoe Draba Populations within Heavenly Mountain Resort

Six specific measures to protect Tahoe draba populations are identified for implementation in the MMP: surveys, fencing, avoidance, rock removal, monitoring, and an interpretive program.

During the 2008-2009 time period, Heavenly complied with all applicable measure for the protection of Tahoe draba populations. Tahoe draba surveys occurred prior to projects located within potential draba habitat. Surveys were preformed prior to the construction and planning of both the Tubing Lift and proposed Gondola Lodge. No draba populations were found during these studies.

Final design at the Adventure Peak Zipline area sited summer walkways to avoid sensitive plant populations. Signs educate trail users about the presence of sensitive plants and encourage them to stay on designated trails.

The Powderbowl lodge project has not yet begun.

Every summer, Heavenly places interpretive signs about Tahoe draba along well-used driving and hiking routes to alert employees and visitors. Mandatory summer employee orientation includes a section on Tahoe draba and habitat protection.

7.5-22 (VEG 1-A) Tahoe Draba Long-Term Conservation Strategy

In addition to Measure 7.5-20: Protect Tahoe Draba Populations within Heavenly Mountain Resort, research is being conducted on Tahoe draba ecology through a Memorandum of Understanding (MOU) between the Forest Service Humboldt-Toiyabe National Forest, Forest Service LTBMU, Mount Rose Limited Partnership, Heavenly Valley Limited Partnership, and the TRPA.

Continual studies occurred during the summer of 2009 in conjunction with the 2010 CWE work list. Survey data was collected; however, both data and results are not yet available as the research is ongoing. Hauge Brueck is actively working with the LTBMU on surveying protocol and reporting.

7.5-23 (VEG 1-B) Minimize Loss/Degradation of Sensitive Plant Species

To protect sensitive plants at Heavenly, projects must be surveyed prior to construction and buffers must be placed around sensitive plants species. Facilities should also be sited to avoid riparian and old growth habitats.

Qualified field biologists from Hauge Brueck conducted sensitive plant surveys at each of the project sites listed below prior to construction and planning. The following sensitive plant surveys were performed:

- Galaxy Test Wells – September 24, 2008
- Dipper Patrol Rebuild (Construction in 2009) – September 24, 2008
- Tubing Hill (Constructed in 2009) – August 18, 2009

- Gondola Lodge (Planned Construction in 2010) – August 18, 2009

During the summer of 2008, Forest Service botanists found one potential new site of the sensitive plant species Galena Creek rock cress (*Arabis rigidissima*). Heavenly implemented a 100 foot buffer around the sensitive plant area during project construction. While upheld during project implementation, the buffer was not maintained during general maintenance operations. It appears that this population was extirpated, although additional visits are needed during the summer months to confirm (Gross, 2010). Assuming additional surveys prove this statement and finding, Heavenly is in partial compliance with this measure. It is recommended that Heavenly coordinate with the USFS prior to commencing work on maintenance issue projects.

7.5-24 (VEG 1-C) Noxious Weed Management

To prevent the spread of noxious weeds, Heavenly must develop and implement a long-term integrated weed management plan, use clean vehicles and materials for construction and stage them in weed-free areas, monitor new construction for 3 years, and implement an annual employee orientation and training program.

In coordination with the Forest Service, Heavenly has implemented a noxious weed management plan found within the EIR/EIS/EIS to stop the spread of noxious weeds. Equipment used for construction projects must be washed prior to entering Heavenly's property. All revegetation and erosion control materials are certified and inspected to be free of noxious weeds. IERS specifies special native seed mixes that are weed free to be used for revegetation efforts (Appendix II).

Employees are trained to identify the three most prevalent species of noxious weeds, tall whitetop, Canada thistle, and bull thistle, which have previously been found within the Heavenly boundary. Heavenly also has an independent weed monitoring program in areas that mulch and wood chips are applied .As part of Heavenly's post-project monitoring, sites are inspected for noxious weed infestations. There were no site specific noxious weed surveys performed in 2008-2009 due to the lack of projects constructed.

7.5-25 Late Seral/Old Growth Forest Enhancement

To mitigate for any projects that involve the removal of late seral/old growth suitable habitat, Heavenly must enhance or restore twice the area to late seral/old growth characteristics.

Heavenly enhanced/restored a stand of forest equal to twice the area proposed for removal in the Master Plan Amendment. The enhanced forest was restored during the Fall of 2007 and is located in the High Meadows area and is undergoing monitoring by the Forest Service every five years for success. The next monitoring report will be conducted in 2012. The Forest Service documentation certifying of completion of this task is located in Appendix XIII.

7.5-26 Restrict Vehicle Traffic within the Heavenly Ski Resort MP 96 Development Area

Vehicular traffic during summer access must be restricted to existing roads only.

At the beginning of the summer, Heavenly employees undergo a mandatory comprehensive training session on summer road use and BMP awareness which includes an educational session on the environmental resources on the mountain. Each employee is required to comply with the summer driving rules.

Heavenly restricts access to the mountain through locked gates with combination locks that change monthly. Only trained Heavenly employees have access through these gates. Non-Heavenly drivers of vehicles with official business on the mountain must first receive an orientation about summer road use, agree to comply with all on-mountain access policies and procedures, and obtain a special pass to access the mountain. Heavenly keeps detailed information about these permits which must be renewed each season. Heavenly escorts are provided to anyone not familiar with the road system or their destination. If the driver or vehicle is found to not be in compliance, Heavenly reserves the right to escort them off of the mountain, and to not issue them future passes. Upon entering each locked gate, a sign is posted alerting travelers to stay on designated roads, obey a 10 mph speed limit, and be alert for potential wildlife crossings. In areas where designated roads are not clear, roped boundaries are erected and stay in place for the duration of the summer. The boundary ropes are maintained throughout the summer.

7.5-27 Monitor and Protect Nesting and Fledgling Bird Species

This measure specifies allowable dates for summer concerts at the Gondola top station.

There were no concerts held at Heavenly in 2008 or 2009.

7.5-28 Compliance with Design Review Guidelines Section 7 Exterior Lighting Standards and Code of Ordinances

This measure requires that all exterior lighting be designed to comply with TRPA Design Review Guidelines Section 7 and Code of Ordinances Exterior Lighting Standards Section 30.8.

No projects that included lighting were constructed in 2008-2009.

7.5-29 Building and Site Design

All newly constructed or renovated buildings must comply with both TRPA and Forest Service design standards.

No permanent buildings were constructed in 2008-2009. Planning for the Gondola Lodge will comply with both TRPA and Forest Service design standards.

7.5-30 Maintain Timber Thinning Practices

Heavenly must work with the Forest Service to determine areas that require timber thinning as established by the LTBMU Land and Resource Management Plan. Practices should help prevent catastrophic wildfire but be consistent with management criteria for maintenance and enhancement of wildlife values.

As needed, Heavenly and Forest Service vegetation management specialists review thinning and hazard reduction needs. During 2008 and 2009 no thinning needs were identified by the Forest Service for treatment, however, this is an on-going measure. When areas are identified for thinning, timber thinning practices will be consistent with the Forest Service management criteria.

7.5-31 Compliance with Existing Health and Safety Practices

This measure requires Heavenly to regularly update and utilize their Hazardous Materials Business Plan, Hazardous Waste and Substance Potential Spill Emergency Plan, and Hazardous Waste Training Program and provide appropriate employee training. Heavenly fully complies with this measure.

Heavenly maintains updated copies of the following health and safety plans or practices as required by other laws:

- Hazardous Materials Business Plan
- Spill Prevention Control and Countermeasures Plan
- Injury and Illness Prevention Plan
- Hazardous Waste Handling Training
- Heavenly Emergency Response Plan
- Blood-borne pathogen training for specific departments

7.5-32 Avalanche Safety Practices

This measure addresses the issue of unexploded ordnances used for avalanche control. The Heavenly avalanche safety team is to document the locations of unexploded ordinances throughout the winter and locate the ordnances during periods of snowmelt for proper disposal.

Heavenly operates avalanche control and snow safety procedures in accordance with the Forest Service Operations and Avalanche Plan. The plan includes an approved procedure to safely dispose of unexploded ordnance. The 2008-2009 plan is on file with the Forest Service. In addition, Heavenly is licensed annually for the storage and use of explosives in connection with reducing avalanche hazards. Specific personnel are individually trained and licensed in the use of avalanche safety explosives. This plan is reviewed and updated annually as needed.

7.5-33 Provide Employee Housing

Heavenly must assist in providing employee housing by collecting information through an employee housing survey and supporting affordable housing through development, purchase, or sponsorship of existing programs.

The 2008-2009 Heavenly maximum employment levels (1,421 employees) are below the 1996-1997 levels (1,607 employees) indicated in the MMP; therefore, no additional mitigation is required. In 2008-2009, Heavenly provided 100 beds of employee housing on the California side, and 26 beds on the Nevada side. Heavenly also has an employee housing assistance program that matches workers with available housing. Heavenly also participates in the South

Lake Tahoe Housing task force. An employee housing survey is conducted annually and is contained in Appendix L. Results from the survey indicate that the majority of employees are satisfied with their housing situation and are paying affordable rents.

7.5-34 Ensure Adequate Police/Sheriff/Fire Capacity

No significant effects on local law enforcement are expected to result from the implementation of the Master Plan Amendment and no specific mitigation level is required.

Heavenly utilizes in-house security to monitor and respond to the majority of on-mountain issues. If Heavenly anticipates need additional security, they hire police to assist this special events or holidays.

Heavenly communicates regularly with city and county fire departments to ensure response time and coordinate resolution of aid issues. First response mutual aid agreements are in place between adjoining fire departments. Heavenly complies with all fire district regulations during the design and implementation of new on-mountain facilities.

Conclusion

Compliance with the operations and maintenance portion of the MMP is an ongoing process. Heavenly complied with the MMP through careful planning and implementation, utilizing industry experts, and educating employees. Heavenly is in compliance with all of the Operation and Maintenance measures.

CHAPTER 5
MANAGEMENT RESPONSE TO MONITORING AND EVALUATION

Introduction

Heavenly's response to monitoring and evaluation is as important as the monitoring and evaluation itself. This portion of the MMP is to encourage adaptive management through collaboration between Heavenly and relevant interested agencies and parties.

7.6-1 Soil and Water Quality

To comply with measure 7.6-1, the results of various monitoring reports on soil and water quality are contained in this report. Heavenly's response to these reports is integral in achieving environmental improvements. Within 60 days of receiving completed monitoring reports, Heavenly, Forest Service, Lahontan, and TRPA will collaborate as necessary to develop an action plan based on monitoring results.

Heavenly has employed ENTRIX in a three-party contract with the TRPA to implement water quality monitoring services. For the 2009 water year (from September 2008 through October 2009) ENTRIX provided Quarterly Reports to Lahontan, the Forest Service, and the TRPA in fulfillment of the monitoring and reporting requirements set forth in the Lahontan permit. Quarterly reports were submitted on the following dates: January 30, May 1, August 1, and November 1 of 2009. An Annual Report for the 2009 water year was submitted on February 16, 2010. This report incorporated the results from each of the quarterly reports into one comprehensive report. The agencies provided feedback for each report and changes were implemented as necessary. Due to the close working relationship of Heavenly staff and field monitors, Heavenly often responds to field directives and corrections immediately before reports need to be issued.

Total phosphorus, chloride and iron exceedances were reported at the two sampling sites along Heavenly Valley Creek. These three parameters were also exceeded at the reference site and are not likely due to Heavenly resort operations. New standards for the California Parking Lot compliance site were implemented during the 2008-2009 water year. Due to these new standards all of the measured constituents were above permitted levels. However these values were less than or equal to values reported during the previous year. Chloride levels at the California Parking Lot compliance site remain well above back ground and permitted levels. Heavenly recently purchased a new sensor that has been added to their spreaders truck for the 2009-2010 season. The new sensor gages road conditions and temperature to the control the least amount of deicer needed for success. It also reports the volume of deicer applied more accurately. Reducing the deicer applied to the roadways should help reduce chloride levels detected in the runoff. Heavenly has also installed automatic samplers in the California Parking Lot in order to better assess the effectiveness of the recently installed stormwater treatment system. Troubleshooting of the automatic samplers is ongoing. Fall inspections found sediment in the outlet bays which should be free of all debris. Once analytical results have been obtained, they will be included in quarterly and annual reports that are made available to Lahontan, TRPA, and the Forest Service. New monitoring reporting requirements are being considered by the Regional Water Quality Board staff.

BMP effectiveness monitoring is conducted by RCI. RCI submits quarterly and annual reports adhering to the same deadlines to appropriate agencies. These reports are an appendix to the quarterly and annual water quality monitoring reports. RCI's annual report summarizes findings and trends reported throughout the summer season. The annual report also lists recommendations to improve implementation and effectiveness findings in future monitoring seasons. Feedback and comments from each of the agencies, is also incorporated into Heavenly's operational and BMP practices. The overall monitoring goal is to always be in compliance with BMP installation and maintenance with all involved parties being in agreement. The BMP Effectiveness Annual Report is located in Appendix I.

The final piece of adaptive management is the work and Restoration and Monitoring Annual Report completed by IERS. IERS utilizes the results from BMP effectiveness monitoring as well as their own tests and observations done at Heavenly and designs restoration plans for on-mountain project construction areas. 2009 marked the third year of this new approach towards planning, implementing, and monitoring large-scale mountain improvement projects at Heavenly. This was the third season that Heavenly operations personnel implemented intensive soil and vegetation restoration treatments. Heavenly's operations staff and construction project managers continue to build on lessons learned. As part of the adaptive management approach, items that address success criteria will be re-defined yearly based on the past season's information collected. Two of the criteria that have shown a decreasing trending are plant cover and total Kjeldalh nitrogen (TKN). It is still too early to determine if there are immediate concerns regarding both of these criteria, but continued testing and various restoration treatments are planned for the following season in order to gain further knowledge and draw conclusions.

The 2008 projects that were not completed were winterized. In 2009, these projects were completed and continue to be monitored. The tubing lift construction began in the fall of 2009, but not all of the restoration treatments were completed. The project was winterized and scheduled to be completed per specifications in 2010. (IERS, 2010).

Pre-treatment monitoring data from most project sites indicate insufficient soil nutrient levels, low to no cover by appropriate vegetation, and high erosion rates/sediment yields. This suggests that appropriate treatment actions have great potential to improve on current conditions (IERS, 2009 and 2010).

Completion of restoration treatments remains a challenge due to the fact that projects typically start late in the field season. Performance monitoring data suggests there is an overall improvement and decrease in erosion potential on all six restoration sites monitored. There were no observable erosion issues found, except from the Stagecoach site. Rilling was evident though it originated from outside of the project area and continued into the project area. Monitoring data from clearing projects found no measurable changes that affect erosion and coverage. Besides modifying success criteria, IERS recommends that there should be continuous and scheduled communication between Heavenly staff and IERS to improve results. Additional schedules, checklists, and the protection of sensitive resources should be incorporated during restoration projects. Lastly, IERS will test irrigation methods to minimize usage during the 2010 field season. The goal is to minimize erosion while restoring soil function and coverage with sustainable vegetation. Detailed results and further discussions from the IERS reports are located in Appendix II.

Though this task is currently ongoing, Heavenly is presently in compliance. Agency and public responses to this annual report during the 60-day comment period will be assessed and integrated into an action plan if necessary. Implementation of any action plan items will be discussed in the following year's annual report.

7.6-2 Traffic and Parking

Heavenly is to prepare a parking monitoring report at the end of each ski season that includes the following:

- *Days during which overflow parking was used on Ski Run Boulevard, South Benjamin Drive, and Galaxy Bowl and any days when overflow parking was full.*

- *The number of parking spaces used at Galaxy Bowl each day this area was used for overflow parking.*

- *An explanation regarding any days during which these overflow parking areas were filled.*

The monitoring reports are to be shared with the TRPA, Douglas County, El Dorado County, and the City of South Lake Tahoe and posted on the appropriate websites, not limited to the Heavenly website. Based on the results of the monitoring reports, an action plan will be devised by Heavenly and interested parties within 60 days.

During the 2008-2009 ski season, Heavenly staff monitored the use of overflow parking areas. Results are shown in Table 5-1. The asterisk denotes that the offsite parking area(s) was filled on those dates. N/A denotes that the site was non-applicable and not in use on the day in question. Holiday weekends impacted offsite parking the most. Weekends that include: New Years Eve, Martin Luther King Day, and Presidents Day filled most of the offsite parking areas.

Table 5-1: Overflow Parking Area Use

Dates of Use:	Parking Locations: Lower Ski Run	Upper Ski Run	South Benjamin	Galaxy Bowl	Keller	Saddle
12/27/2008	105*	100	25*	**N/A**	**N/A**	**N/A**
1/1/2009	105*	100	25*	60	110*	17
1/2/2009	105*	60	25*	40	**N/A**	**N/A**
1/3/2009	105*	100	25*	25	110*	25
1/4/2009	105*	100	**N/A**	**N/A**	75	**N/A**
1/17/2009	105*	100	25*	**N/A**	50	**N/A**
1/18/2009	105*	75	**N/A**	**N/A**	**N/A**	**N/A**
1/24/2009	75	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
2/14/2009	105*	20	25*	55	**N/A**	**N/A**
2/21/2009	105*	100	25*	20	110*	**N/A**
2/22/2009	105*	100	**N/A**	**N/A**	75	**N/A**
3/7/2009	100	25	25*	15	**N/A**	**N/A**
3/21/2009	45	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
3/28/2009	40	**N/A**	25*	**N/A**	**N/A**	**N/A**

To assess Heavenly compliance with the mitigation measure to reduce vehicle traffic, data was gathered from Nevada Department of Transportation (NDOT) and the California Department of Transportation (CalTrans) on average annual daily traffic (AADT) on US Highway 50 and Kingsbury Grade. Sites were chosen to represent major points of access to Heavenly. Sites are displayed in Figure 5-1. AADT values from 2006 through 2008 for each site are shown in Table 5-2.

Compared with the previous year, the 2008 values were less than or equal to traffic totals at all of the major access points to Heavenly Mountain Resort. With limited data, it is hard to draw finite conclusions or trends. That being said, the 2008-2009 season was affected by the financial crisis and resulted in lower skier visits. Future Annual Monitoring Reports will provide more data allowing for a comparative analysis.

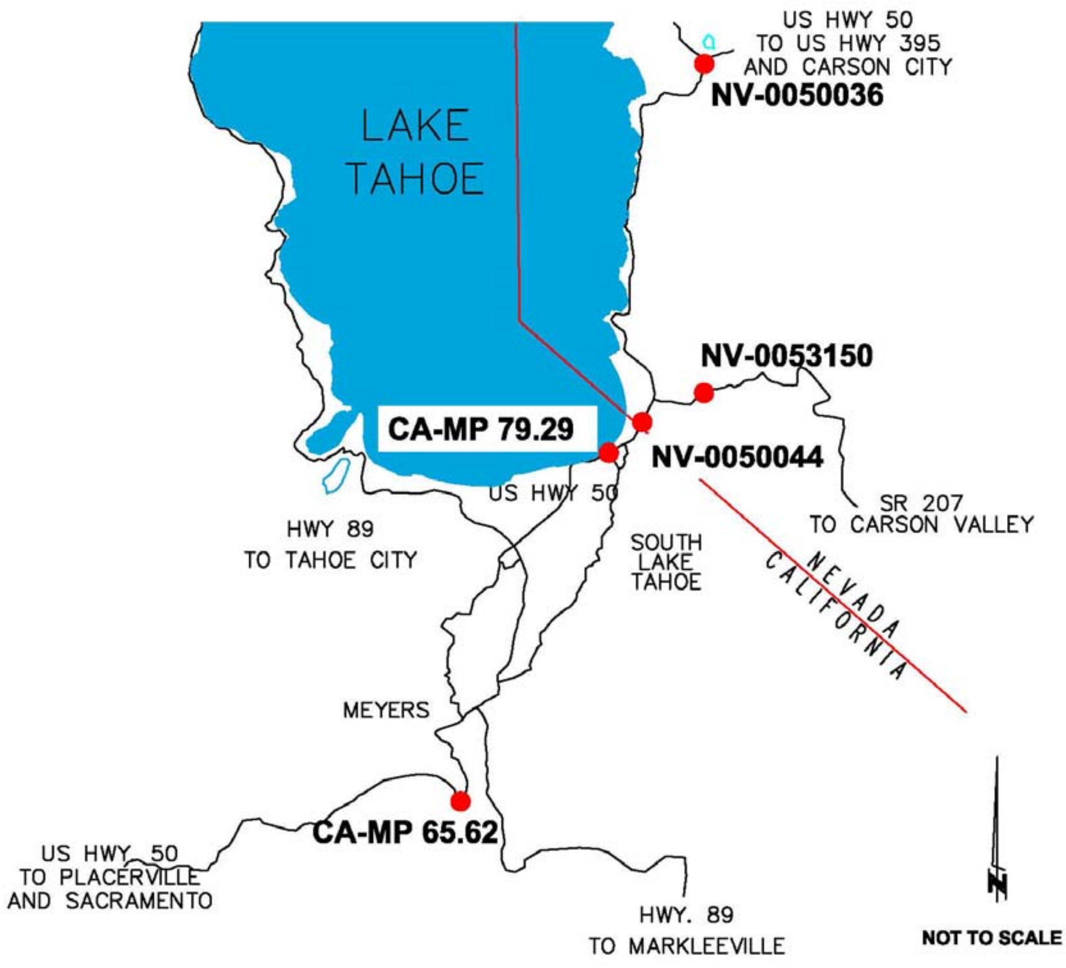

Figure 5-1. Location of Traffic Count Sites.

Table 5-2: Traffic Data on US Highway 50 and State Route 207

State - Station	Location	AADT 2006	AADT 2007	AADT 2008
NV - 0050036	US-50, 0.4 miles West of SR-28 at MP 12	10,900	11,000 [1]	10,000
NV - 0053150	SR-207 (Kingsbury Grade) 0.5 miles East of US-50	12,100	12,000	11,000
NV - 0050044	US-50, 300' East of the NV-CA State line	26,500	25,000	25,000
CA - MP 79.29	US-50 at the intersection of Ski Run Blvd. [2]	32,500	32,500	31,500
CA - MP 65.62	US-50 at the intersection of Echo Lakes Road [3]	9,000	9,000	8,900

[1] Data Adjusted or Estimated

[2] Annual Average Daily Traffic (Back AADT) Traveling West Bound

[3] Annual Average Daily Traffic (Ahead AADT) Traveling East Bound

NDOT Data - http://www.nevadadot.com/trina/

CalTrans Data - http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/index.htm

7.6-3 Late Seral/Old Growth Enhancement

Monitoring is required every 5 years for any forest enhanced or restored under the mitigation measure 7.5-25 described in Chapter 4 of this report.

All work for the forest restored under this measure was completed in 2007. Monitoring will be completed in 2012 and will be evaluated to assess potential triggers that may elicit a management response.

Conclusion

Heavenly works closely with subject-area expert consultants and their own employees to immediately respond to potential problems. This allows changes to be quickly implemented and makes adaptive management more effective. Because Heavenly is so involved in the process, the results of each report usually do not trigger an action plan as action has already been taken to resolve any issues.

The feedback from agencies and interested parties generated from this report should be a valuable tool in assessing any response Heavenly has already implemented and creating new solutions for ongoing problems.

CHAPTER 6
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Appendix I

2008-2009 BMP Effectiveness Annual Report

Heavenly Mountain Resort
BMP Effectiveness Monitoring

Annual Report - 2009

February 12, 2010

Prepared For:

ENTRIX Inc.
1048 Ski Run Blvd.
South Lake Tahoe, California 96150

Prepared By:

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Heavenly Mountain Resort BMP Effectiveness Monitoring

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INTRODUCTION

The following report summarizes the results of the BMP Effectiveness Monitoring at Heavenly Mountain Resort (Heavenly) for the 2009 construction season. It has been prepared by Resource Concepts, Inc. (RCI) to comply with the *Lahontan Regional Water Quality Control Board Waste Discharge Requirements (Board Order R6T-2003-0032)* requiring submittal of an annual monitoring report for the period. The BMP Effectiveness Monitoring is a component of the Environmental Monitoring Program as set forth in the 1996 Master Plan and the approved Master Plan Amendment (2007).

Best Management Practices (BMPs) are structural and non-structural measures used to reduce soil movement, control surface runoff, and improve runoff water quality. BMPs at Heavenly Mountain Resort are applied to facilities (buildings, utilities, parking lots, etc.), roads, ski runs, and construction projects. They are generally categorized as either Permanent or Temporary BMPs:

- Temporary BMPs are used during short-term construction and maintenance projects and are removed upon project completion.
- Permanent BMPs are used on a long-term basis to control contaminant sources or treat runoff, and require on-going maintenance to be effective.

Monitoring was conducted per the BMP component of the *Revised Environmental Monitoring Program*. Key components of the program include:

- Evaluation forms that focus on implementation and effectiveness consistent with the USDA Forest Service, Region 5, BMP Evaluation Program (Region 5 BMPEP),
- Monitoring frequency for Permanent BMPs: post-construction, 1-year post-construction, 3-, 6-, and 9-year post-construction,
- Monitoring frequency for Temporary BMPs for on-going construction projects: biweekly during construction and after precipitation events, and
- ACCESS database software to manage monitoring results.

BMPs are monitored for both implementation and effectiveness. BMP <u>implementation</u> concerns whether plans/specifications are adequate for resource protection, and if improvements are constructed according to design. BMP <u>effectiveness</u> is determined from observed erosion and sediment transport at sites evaluated.

2009 RESPONSES TO 2008 ANNUAL REPORT

In the past, BMP Effectiveness Monitoring Annual Reports (2004 through 2008) have provided recommendations for improving planning, implementation, effectiveness and monitoring of Temporary and Permanent BMPs at Heavenly. In keeping with the adaptive management approach, Heavenly has used these results and recommendations to improve the BMP retrofit and maintenance program. The following section summarizes the Resort's response to the 2008 annual report recommendations.

Planning

For the past few years, Heavenly's annual work list has included BMP construction and maintenance items identified through the previous year's BMP Effectiveness Monitoring. Table 1 (Appendix A) lists the 2009 BMP projects initiated based on recommendations made in 2008. Eighteen of twenty-one priority projects were completed in 2009. The remaining three projects and any new items identified in 2009 are being included in the recommendations for future projects.

As noted in the 2008 annual report, the sets of existing road segment data were separately developed under the CWE program and the LTBMU road-monitoring program. Because these monitoring efforts had different objectives and GPS technology was fairly new, the data sets do not correlate well and would be difficult to use effectively for road maintenance tracking or planning. RCI initiated monitoring in 2009 to reestablish the inventory based on the LTBMU data collected in 1998 and 2004/2005 and was unsuccessful in verifying segment locations by GPS. As previously noted, though road maintenance is ongoing at the resort, an effective system for tracking these efforts has yet to be developed.

The Revised Construction Erosion Reduction Plan (CERP) has proved a useful tool for identifying appropriate BMPs for projects without detailed sets of plans and specifications. The 2008 report recommends that the CERP be amended to add new techniques and incorporate results of the BMP monitoring program. The CERP is currently being updated to reflect evolving BMPs.

Permanent BMPs

Using the adaptive management approach, observations and recommendations made in 2005 through 2008 were used to identify specific projects, incorporate general recommendations, and improve the BMP program at Heavenly. A summary of past recommendations for Permanent BMPs and how they were addressed in 2009 is included in Tables 2 and 3 (Appendix A).

Temporary BMPs

Heavenly has continued to respond to the recommendations for implementation and effectiveness of Temporary construction BMPs developed through the BMP Effectiveness Monitoring program. A summary of past recommendations for Temporary BMPs and how they were addressed in 2009 is included in Tables 4 and 5 (Appendix A).

Monitoring

The BMP Effectiveness Monitoring Program has been reviewed each year to identify possible improvements consistent with an adaptive management approach. The dust control database created in 2008 was used this year to evaluate each site and make recommendations for improvements. Last year's annual report also recommended working on developing alphanumeric identifiers for more consistent naming conventions in the database, but no additional action has been taken. In 2008, RCI initiated road monitoring to document road segments that had received BMP additional maintenance such as aggregate base surfacing or drainage stabilization but correlation with the road inventory and a maintenance plan has yet to be established.

2009 MONITORING RESULTS AND DISCUSSION

Permanent BMPs

In 2009, sixty-five (65) Permanent BMPs evaluations were performed by RCI at fifty-three (53) different sites. The most common type of evaluation was 1-, 3- and 6-year post-construction monitoring to follow up on the performance of Permanent BMPs installed during previous years. Several sites with Permanent BMPs were evaluated more than once during 2009 to follow up on work as it was completed by Heavenly.

Implementation

Results for implementation of Permanent BMPs monitored in 2009 showed that BMPs were fully "implemented" at 90% of the sites evaluated. Scores show significant improvement from 2004 and 2005 when the project was initiated. In 2009, projects that scored less than fully "implemented" occurred primarily when BMPs were not fully completed at the one-year evaluation. Follow up measures are included in the 2010 recommendations section of this report and detailed in Table 2 in Appendix A for Permanent BMP implementation.

As noted in the 5-Year Comprehensive Report, some older structures have BMPs that are inadequate or need reconstruction to restore effectiveness. The revised monitoring program "Needs Assessments" have been conducted on the facilities constructed prior to 2000. To date, 69 sites have been evaluated using the "Needs Assessment" protocol. The majority of the "Needs Assessment" monitoring was completed in 2008; there were no new evaluations in 2009. The four most common needs identified have been increased cover, increased armoring, reduced soil compaction, and improved infiltration/treatment (20-yr 1-hour event).

Many infiltration areas have been constructed with wooden boards for borders, per design guidelines. Equipment and vehicles can shift the boards allowing gravel to spread out from the infiltration area. In 2009, wood borders were removed from several infiltration areas and replaced with rock borders (four to eight inch diameter rock). The rocks were keyed into the soil to ensure solid placement and prevent movement. These sites will be revisited next year to determine the effectiveness of the rock versus the wood borders.

Water bars are been routinely implemented on access roads throughout the Resort. However, typical cross drainage construction is not consistent with Forest Service design guidelines that emphasize angled structures, rolling dips, and outlet protection. Criteria for evaluating implementation may need to be reviewed and adjusted for unique conditions at the Resort, where roads serve for both summer maintenance access and ski trails, or where steep road gradients and bedrock restrict opportunities for grading.

Effectiveness

Effectiveness scoring for 2009 documented 91% of the sites had "effective" Permanent BMPs. Scores continue to show a significant increase from commencement of the BMP effectiveness monitoring program. Projects that scored less than fully "effective" were typically due to soil cover less than 70%, 3 to 6 years after construction using older soil stabilization techniques.

Heavenly has continued to act on observations and recommendations in past annual reports for improving Permanent BMPs. As previously noted, effective soil cover has typically scored the lowest of the six categories evaluated for effectiveness. Effective soil cover scores have improved in 2007 through 2009 compared to 2004 through 2006, primarily related to post construction monitoring results for projects in the last three years which have used the soil decompaction and wood chip incorporation, per the new revegetation specifications.

Similarly, follow up monitoring on infiltration BMP retrofit projects has demonstrated improved scores with the site specific installations completed. In general, infiltration BMPs have held up well over the three-year period. Regular maintenance is still recommended for infiltration areas, especially removal of accumulated sediment on an as needed basis.

Three and six year post construction monitoring indicates the long-term effectiveness of stabilization with geotextile fabric is poor on steep slopes, unless revegetation is also successful. Proactively in 2009, Heavenly has revisited the BMPs at these locations and is utilizing a combination of incorporated woodchips and rock check dams for slope stabilization.

Recommendations, reevaluation and future work suggested for Permanent BMPs in 2010 are included in Table 3 in Appendix A. Monitoring results and input from Heavenly's maintenance staff have generated the following guidelines to improve Permanent BMP effectiveness at the resort:

1. On steep slopes, rock armored channels routing runoff from drip lines to infiltration areas are more effective than trenches;

2. Rock borders are more durable than wood boards around infiltration areas;

3. Constructed drainage channels to infiltration areas on steep slopes need to be well-defined low points to intercept runoff. Otherwise, new channels erode around rocks and may deposit sediment outside the infiltration area; and

4. After three years, wood chip and pine needle mulch has needed refurbishing. Mulches should be reapplied and incorporated into the soil, which may be more effective. Sites with steep slopes may need refurbishment on shorter intervals than three years.

Temporary BMPs

Temporary BMPs were routinely used for construction projects at Heavenly and multiple construction sites were evaluated in 2009. Each site was evaluated several times depending on the length of time between construction start and completion dates. The monitoring frequency for construction projects is biweekly and after precipitation events. A total of 42 separate Temporary BMP evaluations were conducted by RCI in 2009.

Implementation

Temporary BMP implementation scores were 90% fully "implemented" in 2009. Scores that were less than "fully implemented" were primarily related to the early season inspection of staging areas on the mountain. Scores for these sites improved to fully "implemented" by the second inspection of the season after Heavenly staff responded to initial BMP monitoring results.

Temporary BMP implementation at staging areas improved during 2009 at the Resort. However, Temporary BMPs need to be implemented for each staging area before materials need to be stockpiled so that evaluations can show compliance from the beginning of the construction season. When "minor departures" from successful implementation were noted for the evaluations, Heavenly staff was contacted and reacted promptly to correct issues identified. Recommendations for implementation of Temporary BMPs in 2010 are detailed in Table 4 in Appendix A.

Effectiveness

Temporary BMP effectiveness scored "effective" for 93% of the evaluations performed in 2009. Scores less than fully "effective" were due to the initial inspection at the start of the construction season for typical staging areas on the mountain. Scores for these sites improved to fully "effective" by the second inspection of the season after Heavenly staff responded to BMP effectiveness monitoring results.

Heavenly has responded to recommendations for improved Temporary BMPs and most of the 2009 projects had detailed erosion control plans that were well implemented. Post rain event inspections showed that Temporary BMPs successfully prevented storm water from discharging sediment to SEZs. Recommendations for increasing Temporary BMP effectiveness are included in Table 5 in Appendix A.

A review of scoring for individual categories shows that dust control remains an ongoing concern especially on road switchbacks and in high traffic construction access areas. Though water trucks were routinely used, effectiveness decreased during the late summer months. A subjective review of the roads on the mountain shows that compacted road base is effective in reducing dust as well as rutting, which should be incorporated in future planning for road BMP upgrades and maintenance.

2009 CONCLUSIONS AND RECOMMENDATIONS FOR 2010

Results of the BMP Effectiveness Monitoring during 2009 generated the following conclusions and recommendations with respect to BMPs at Heavenly.

Planning

Heavenly has proactively used the results of the BMP Effectiveness Monitoring Program to improve planning for BMPs at the Resort. Planning should continue to utilize the monitoring results to assist with identifying and prioritizing BMP maintenance and retrofit projects. Recommendations for future improvements and maintenance are summarized in Table 6 and were developed from the 2009 monitoring results and review of the "Needs Assessment" database. This summary has typically been used by Heavenly Mountain Resort to develop the Annual CWE Work List.

The CERP has proved a useful tool for identifying appropriate Temporary and Permanent BMPs, particularly for projects without detailed sets of plans and specifications. Consistent with the adaptive management approach, the CERP document should evolve based on results of the monitoring program. New BMP techniques should be added and others updated based on the implementation and effectiveness results obtained over the past few years.

Planning measures could still be improved for road maintenance activities. Heavenly continued to work on maintaining access roads and road BMPs throughout the 2009 season. An additional planning measure suggested is to review methods to identify, prioritize, and document road maintenance BMPs, in coordination with the monitoring program.

Implementation

The resort is utilizing the on-going monitoring program to identify and prioritize BMP installation and maintenance projects. That effort should continue for both Temporary and Permanent BMPs and be expanded for road maintenance. During 2009, Heavenly completed 86% of the projects on the 2009 Annual CWE Project and Work List compared to 63% were completed in 2008. Continued communication between design professionals, field personnel, and agency representatives has increased success in implementing Temporary and Permanent BMPs.

Implementation improves when BMP requirements for each project, both Temporary and Permanent, are familiar to field personnel. Heavenly has experienced field personnel that can successfully implement BMPs, particularly Temporary BMP installations (fiber rolls, silt fence, exclusion fence) and revegetation practices (soil amendment, seedbed preparation, seeding, and mulching). Heavenly should continue to provide training to all new personnel in BMP "awareness" and implementation.

Effectiveness

Successful BMP effectiveness is tied to both implementation and technology. Heavenly has a long-term commitment to environmental improvement through both planning and regulatory means. Heavenly has improved the effectiveness of BMPs by implementing new projects and practices, which are reflected in the monitoring results.

In the past, soil cover achieved the lowest scores for effectiveness, but these scores have improved for recent projects using new approaches for tree removal, soil conditioning, revegetation, and rock riprap slope stabilization. Continued monitoring of these techniques will provide data on long-term effectiveness.

Heavenly has prioritized BMP installation and maintenance in areas where disturbance connects directly to SEZs and storm drains. These areas present the greatest water quality risk and, correspondingly, are locations where BMPs should be the most effective. Future planning should continue to emphasize this priority.

The effectiveness of road-related BMPs could be improved with better coordination regarding objectives and methods for road BMP maintenance. BMP design and methods may need adaptation to summer roads that also act as winter ski trails.

Monitoring

The BMP Effectiveness Monitoring Program as revised in 2004 has provided useful information for evaluating the BMPs at Heavenly. Results should continue to be incorporated in planning measures consistent with an adaptive management approach. RCI offers the following recommendations for future monitoring:

- In 2010, past and current road monitoring methods should be reviewed to confirm that results would be useful in identifying existing needs, as well as tracking the performance of BMP implementation and effectiveness;

- There is a continued need for prompt coordination throughout the construction season to ensure that Heavenly can schedule maintenance work in a timely manner. Heavenly staff has responded promptly to repair or retrofit BMPs with less than fully “implemented” or fully “effective” scores in the past;

- To increase coordination with Heavenly and facilitate timely BMP repair and maintenance, three meetings with Heavenly and the monitoring team during the year would be helpful. These meetings are suggested to take place:

    - Pre-season to review the past year’s recommendations and Heavenly’s schedule for completing the CWE work list;

    - Mid-season to review implementation and effectiveness of projects completed and any new BMP maintenance work identified during monitoring; and

    - Shortly before the grading deadline to identify what activities are still on going and what has been completed. A discussion of the sites that have been or need to be winterized would be included.

Appendix A-1

Table 1. Priority BMP Projects Completed in 2009

Location	Treatment
Big Easy Lift	Infiltration trenches were replenished, drip line were protected and effective soil cover was increased
Adventure Peak Events Area	Mulch was applied to specified depth for events area; wood chips were incorporated in areas with compacted soils
Upper Vehicle Maintenance Shop*	Gully was stabilized on ski trail above SEZ restoration site; effectiveness will be monitored in 2010
Lakeview Water System	Installation of replacement water tank and water lines.
Lakeview Lodge BMPs	Drip line protection and soil cover was improved on south side of building
Mombo Meadows Trail*	Repair broken snow making hydrant; restore and stabilize soils in affected area
Blue Angel Chutes/Upper Mombo Trail*	Water bar repairs were completed.
Top of Tram Station BMPs	Rilling was stabilized at northwest corner of the building.
First Ride Lift	Infiltration trench was extended under downspout areas and soil cover was improved.
Gondola Mid Station*	Soil cover was improved and slope stabilized below passenger unloading deck.
Mott Canyon Lift Upper and Lower* Terminals	Drip line infiltration trenches were installed at both terminals
Top of Dipper Ski Patrol Station*	Existing ski patrol station was removed and replaced with new building, including drip line trenches
North Bowl Express Lower Lift Terminal and Access Road	Switchback was stabilized on the access road adjacent to creek bank
Olympic Express Lift	Drip line infiltration trenches were installed at top and bottom stations
Olympic Express Lift Line Towers	Effective cover was improved with mulch application around towers
East Peak Pumphouse*	Infiltration BMPs were installed; soil cover was provided on barren areas not used for summer operations
Comet Express Lift Base Station	Drip line infiltration trenches were replenished
Dipper Express Lift Base Station	Drip line infiltration trenches were replenished; maintenance vehicle parking areas were delineated; effective soil cover was improved on all other disturbed areas, including underneath chair parking rail

*Site to be evaluated in 2010

Table 2. Permanent BMP Implementation – Recommendations and Responses

Observations/Recommendation	Responses/Actions in 2009
Revegetation specifications needed to be updated to present standards in the Lake Tahoe Basin. (2004-2005)	Revegetation specifications in the construction projects were site-specific and consistent with present standards. Projects included: Covered Surface Lift at Top of Gondola, Upper Maintenance Shop, and Lakeview Water System.
Design of facilities to treat or infiltrate the 20-yr 1-hour event needed to be site-specific (2004-2005). Infiltration areas should be flat bottomed, filled with sufficient gravel or drain rock and bordered with rocks (4 to 8 inch diameter).	Maintenance and reconstruction of infiltration facilities was implemented at the following number of sites: 36 in 2006, 4 in 2007, 7 in 2008 and 27 in 2009. Dripline trenches were renewed if appropriate or relocated to intercept roof runoff. Reconstructed infiltration areas were constructed with flat bottoms and bordered with rock. Heavenly staff documented the calculated volumes and facility construction at each structure.
Trench settlement can be prevented by compaction and mounding. (2004-2005)	Trench soil compaction for the Lakeview Water System was conducted per specification to 90% standard proctor density (2008 and 2009). Mounding was not feasible given the soil stabilization/revegetation treatments prescribed. Trench settlement was not observed in 2009. No trench settlement was observed for the Stagecoach Snowmaking project completed in 2008.
Use fiber rolls for long-term slope stabilization as well as temporary erosion control. (2004-2005)	Permanent fiber roll installation was used in 2009 construction projects: Lakeview Water System, East Peak Lodge Grading Area, and Covered Surface Lift at Top of Gondola. With current revegetation practices, permanent fiber rolls are placed at the toe of slope rather than mid-slope.
Gravel and riprap specifications should include: sizing, gradation, angularity and geotextile installation underneath. (2006)	Riprap used in 2009 projects was installed with geotextile behind it and projects include the Covered Surface Lift at Top of Gondola.
Geotextile fabric installation for slope stabilization must address anchor trenches at fabric edges, overlaps, and appropriate anchor intervals for lined channels and steep slopes. (2006)	Geotextile fabric for slope stabilization was not used for any new installations 2009. In 2009, geotextile fabric at the East Peak Well was no longer adequately anchored. Typically, geotextile fabric is not effective without maintenance.
New prescriptions for soil amendments and revegetation need better coordination regarding timing, accessibility, and materials availability. (2007)	Improved coordination was observed between designers and Heavenly staff. Various types and sources of materials were explored for wood chip mulch and soil amendments. Where possible Heavenly reused materials (soil, rock, wood chips, etc.) generated on-site. Site-specific soil amendment depth was identified and coordinated in the field with IERS. Accessibility was considered in project design.
Waterbars should be elongated and installed at an angle to the direction of traffic. (2009)	Waterbars were installed throughout the mountain but were parallel to the direction of traffic. Waterbars at Skyline Trail were constructed at the end of 2008 but were not installed at an angle.
Road base should be applied in areas with steep slopes, water quality concerns (proximity to SEZ/stream crossings), and high traffic areas where rutting and dust may be a problem. (2009)	Areas with compacted road base were monitored subjectively through out the mountain. Additional monitoring will be conducted in 2010.

Table 3. Permanent BMP Effectiveness – Recommendations and Responses

Observations/Recommendation	Responses/Actions in 2009
Soil cover was not typically achieved with straw mulch after the first construction season. (2004-2005)	Heavenly continued to use different types of mulch on 2009 construction projects to meet effective soil cover objectives, including wood chip mulch and pine needle mulch.
Revegetation develops minor deficiencies after construction that requires on-going correction for several years to provide effective soil cover. (2004-2005)	Several sites were revisited with spot seed and mulch application. Wood chip mulch or gravel, rather than revegetation, continues to appear more effective for high traffic areas.
Fabric installed on steep slopes often slides down in small sections, even anchored securely during installation. Geotextile needs continuing maintenance if vegetation is not established. (2006)	Fabric installed in 2008 remained securely anchored in 2009 at Edgewood Upper Gully and Powderbowl, Patsy's, and Northbowl Lower Terminals.
Projects using wood chip mulch and soil amendments appear to provide longer lasting effective cover, particularly in high traffic areas. Heavenly will continue spot treatments at facility sites where barren areas occur. (2006)	Sites where wood chip and pine needle mulch were used in 2006 but not incorporated into the soil needed refurbishing particularly in high traffic areas and steep slopes. Sites include Patsy's, Gunbarrel and Olympic Upper Terminals.
Sediment from outside the project area has the potential to impair the long-term effectiveness of SEZ restoration and soil stabilization projects unless follow-up work is performed. (2007)	Follow-up stabilization work performed as a result of post-construction evaluations in 2009 at Upper Maintenance Shop and Northbowl SEZ Restoration.
Wood borders for infiltration areas and trenches are often caught and pulled out by equipment in the winter, particularly in areas alongside roadways. Rock borders keyed into the soil are a more stable option to prevent movement of gravel. (2009)	Rock borders were installed on new infiltration areas and maintenance work included replacing wood borders with rock where needed (Sky Bathrooms, Powderbowl Upper and Lower Terminals, Canyon Lower Terminal).

Table 4. Temporary BMP Implementation – Recommendations and Responses

Observations/Recommendation	Responses/Actions in 2009
BMPs should not be disassembled prematurely, because vegetation may take several seasons to be established. Specifically, plans did not specify clearly that fiber rolls were to remain after construction. (2004-2005)	Construction project winterization included removal of sediment fence (which presents a skier hazard and does not typically last through the winter) and replacement with fiber rolls in locations where long-term stabilization was desired while vegetation was being established. Projects included Lakeview Water System, and Covered Surface Lift at Top of Gondola.
Place BMPs prior to construction, thereby ensuring readiness for summer storms or winter closures. (2004-2005)	BMPs were in place prior to initiation of each 2009 construction project. Focus should continue on installation prior to initiation for small maintenance projects and staging areas, where no plans have been prepared, but BMPs are to be installed per the CERP.
Clean out and repair BMPs after a runoff event. (2004-2005)	On-going for all projects.
Maintain BMPs through the life of the project, again to ensure readiness for summer storms or winter closures. (2004-2005)	On-going for all projects. Temporary BMPs were in place during the precipitation events and winterization measures were implemented prior to snowfall. Sediment fence needs maintenance throughout the construction season.
Temporary BMPs may concentrate runoff to a discharge point (sediment fence, fiber rolls, temporary division swales, temporary culverts, and stream diversion). Provide energy dissipation and stabilization at the point where the temporary BMPs terminate. (2006)	Sediment barriers were used at the Lakeview Water System, East Peak Grading Area and Covered Surface Lift at Top of Gondola
If a construction project initially proposed for a single season must be extended over the winter, winterization plans should be appended to the design documents. (2006)	Projects extended to 2010 include East Peak Grading Area, Covered Surface Lift at Top of Gondola and Lakeview Water System.
Maintenance of sediment fence can be reduced by using proper T-Posts for support and adequate burial of fabric edges, particularly for longer-term projects. Project designs need to allow alternative fencing at sites with substantial rock or limited access. (2007)	Proper sediment fence installations were typically observed in 2009. Fiber rolls were substituted in areas with substantial rock and limited access. Despite proper installation wind damaged sediment fence required repeated maintenance.
Dust control for soil stockpiles on the mountain can be improved. If water is unavailable from the snowmaking system, stockpiles need to be covered with plastic sheeting. (2007)	Projects utilizing improved dust control methods for soil stockpiles in 2009 included: Covered Surface Lift at Top of Gondola and Lakeview Water System.
Location of sediment barriers (silt fence or fiber rolls) shown on project plans needs to be parallel to the slope or with energy dissipaters along the flow line and at discharge points. (2008)	Sediment barriers were shown on the plans for the Covered Surface Lift at Top of Gondola and Lakeview Water System.
Staging areas should have Temporary BMPs in place before materials are stockpiles on site. (2009)	Staging areas at Boulder Parking Lot, East Peak Borrow Area, and Sky Base Staging Area scored “not implemented” for the first evaluation. By the following evaluation, all staging areas were clearly delineated and protected with Temporary BMPs.

Table 5. Temporary BMP Effectiveness – Recommendations and Responses

Observations/Recommendation	Responses/Actions in 2009
Disturbance outside construction limits.	Construction limits were generally well defined and disturbance was kept within the limits.
Exposed soils with potential for sediment delivery to SEZ.	Sediment barriers were generally installed and routinely maintained. Vehicle traffic near SEZs has a higher potential for water quality impacts during construction and Temporary BMP plans need to be especially robust.
Dust control measures for stockpiles are more effective when snowmaking water is available to wet down soils. Plastic sheeting is less effective and is difficult to keep anchored in windy conditions, but may be the only option in some areas.	No projects were completed in 2009 in especially windprone areas so alternatives to plastic sheeting were not required. Stockpiles were covered at Covered Surface Lift at Top of Gondola, Lakeview Water System and Upper Maintenance Shop.
Sediment fence is effective in containing excavated stockpiled soils. If stockpiles are larger than initially anticipated, the fence must be extended.	Stockpiles were generally contained with sediment fence and in several locations sediment fence was extended to fully contain the stockpile.
Despite proper installation, burial of fabric edges does not always prevent wind from pulling the fabric out, and metal mesh backing does not always prevent holes and blowing fabric. Prompt inspection and repair of sediment fence is almost always needed after windy conditions.	Heavenly inspected sediment fence at ongoing construction projects after wind storms; any damage was promptly repaired.

Table 6. Site-Specific Recommendations For 2010 BMP Projects

Location	Treatment
Priority Projects for Follow Up Maintenance (2010)	
Boulder Lift Lower Terminal	Install infiltration trenches and improve effective cover (2009).
Boulder Lift Upper Terminal	Install infiltration trenches and improve effective cover (2009).
Gondola Top Station	Refurbish existing infiltration basin and improve drainage to maintain effectiveness (2007).
Groove Upper Terminal	Improve soil cover to stabilize bare slope (2009).
Lakeview Water System	Remove old tank. Decommission old tank site and road to tank. (2009).
Olympic Express Lift Lower Terminal	Stabilize area with bare soil below access road to terminal (2009).
Upper Vehicle Maintenance Shop	Review gully stabilization on ski trail above SEZ restoration site (2009).
Zip Line Base Station	Confirm effectiveness of existing soil cover and add cover beneath operator's booth (2007).
Out of Tahoe Basin BMP Needs (2010 to 2011, Low Priority)	
East Peak Grading Area	Complete drainage and stabilization measures initiated for the area between Comet and Dipper Lift Lower Terminals (2009).
East Peak Lodge	Stabilize driplines and drainage swales near foundation of building (2007).
East Peak Well (New)	Stabilize slope between road and well house (2009).

Appendix II

2008-2009 Restoration and Monitoring Annual Report

Heavenly Mountain Resort Restoration and Monitoring 2009 Summary Report

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Integrated Environmental Restoration Services

April 26, 2010

INTEGRATED ENVIRONMENTAL
RESTORATION SERVICES, INC

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Executive Summary

Does replacing a chairlift or clearing a new ski run increase runoff and erosion? Can restoration treatments provide self sustaining sediment source control without ongoing maintenance? Heavenly Mountain Resort has begun to implement an adaptive management-based approach to planning, implementing, and monitoring construction and restoration projects that will enable them to answer a number of these important questions. This approach has been supported by the League to Save Lake Tahoe, the USDA Forest Service - Lake Tahoe Basin Management Unit, the Tahoe Regional Planning Agency, and the Lahontan Regional Water Quality Control Board and is an integral part of Heavenly's recent Master Plan Amendment EIR.

This report describes how adaptive management is being used to plan, implement, monitor and continually improve specific projects at Heavenly. Projects completed under this program to date include lift replacement, zip line construction, road construction and removal, ski run clearing, waterline and snowmaking line installation, run widening, regrading, and re-alignment. In total, 261,385 square feet of erosion control and/or restoration treatments have been implemented at Heavenly between 2007 and 2009 as part of this program (see Table 1). For each project, goals and success criteria have been defined, performance monitoring has been conducted using simulated rainfall and a suite of soil and vegetation measurements, and management responses have been developed based on the results of monitoring. Despite much discussion about adaptive management in the Lake Tahoe Basin, this program is the only known multi-year example of adaptive management actually being applied to improve the sediment source control effectiveness of on-the-ground restoration projects in the Lake Tahoe Basin.

Performance monitoring results from six restoration projects indicate overall improvements in most measured parameters and substantial decreases in erosion potential within 1-2 years of treatment. However, both plant cover and soil TKN (total Kjeldahl nitrogen) decreased at nearly all sites following treatment. While neither of these trends are cause for immediate concern, several hypotheses will be tested to develop a more complete understanding of how sites at Heavenly respond to various types of restoration treatment. For the two run clearing/glading projects, performance monitoring results indicate no measurable changes to most key parameters that affect erosion potential and slight increases in total cover when compared to uncleared conditions.

Table 1. Restoration treatment summary, 2007-2009.

Project	Treatment Area (ft^2)
Olympic Lift	104,224
Heavenly Flyer	10,514
Mid Station Road	9,940
Skyline Trail	27,964
Lakeview Lodge Water System	34,726
Stagecoach Snowmaking	74,017
TOTAL	**261,385**

Across all projects, initial monitoring results suggest that restoration treatments have substantially reduced erosion potential and ski run clearing/glading projects have been implemented while protecting the ecological elements and processes responsible for erosion protection. This information is of great value in this region and beyond, as little monitoring of restoration treatment effectiveness has been conducted in high elevation (above 8000 ft) settings with poorly developed soils, particularly those derived from decomposed granite. The Heavenly restoration and monitoring program is demonstrating a new model for land management, one that rethinks and tests assumptions about project outcomes. This program also helps to develop new restoration treatment techniques, expand understanding of treatment effectiveness, define and refine appropriate success criteria, and shares this information to support similar efforts throughout the region.

Chapter 1: Overview

Introduction

This report describes the three years of restoration treatments and monitoring results for nine mountain improvement projects at Heavenly Mountain Resort (Figure 1). These projects were approved as part of Heavenly Mountain Resort's 2007 Master Plan Amendment. Integrated Environmental Restoration Services (IERS) principal Michael Hogan began working with Heavenly in 2006 to facilitate an agreement between Heavenly, the USDA Forest Service - Lake Tahoe Basin Management Unit (LTBMU), and the League to Save Lake Tahoe that bridged the gap between the interests of all parties. This agreement laid out a framework for setting clear goals, defining "success" in quantitative terms, developing low-maintenance and effective treatment strategies, and directly measuring the results of project implementation. This framework follows the basic principles of adaptive management (described below).

IERS has been working with Heavenly since 2006 to set goals and objectives, define success criteria, develop soil and vegetation treatment specifications, conduct pre-treatment (baseline) and post-treatment (performance) monitoring, and oversee implementation activities. The five projects implemented in 2007 were: Olympic Lift Replacement, Heavenly Flyer Construction (Zip Line), Mid Station Road Restoration, North Bowl Ski Run Clearing, and Orion II Ski Run Clearing (Figure 1). Three additional projects were implemented in 2008: Skyline Trail Regrade, Lakeview Lodge Water System Improvements, and Stagecoach Snowmaking. IERS conducted performance monitoring for all of these projects in 2009 to measure whether each project had a net impact on soil, vegetation, or runoff and sediment transport. In 2009, the Tubing Lift project was constructed. Pre-treatment monitoring results and restoration treatments for this project are described in this report.

Chapter 1 describes the overall site characteristics, lists overall program goals, describes how "success" is defined and measured, and provides a general description of the restoration techniques and monitoring methods employed. **Chapters 2 and 3** describe project-specific objectives, success criteria, monitoring results, and treatment elements implemented for each project. Projects are grouped into one of these two chapters, depending on whether or not performance monitoring has been completed yet. **Chapter 2** covers projects with only pre-treatment monitoring results. **Chapter 3** covers projects with both pre-treatment and performance monitoring results. **Chapter 4** summarizes conclusions and recommendations, and includes literature cited.

Results for each project are presented in the following format:

- Overview – description of the type of project, associated impacts to soil and vegetation, and timing of both treatments and monitoring
- Site Description – description of the geographic location, physical conditions and ecological characteristics of each project site Objectives and Success Criteria – description of specific objectives and success criteria by which each project is being evaluated
- Restoration Treatments – summary of specific soil and vegetation restoration treatments implemented at each project site

- Monitoring Results – graphical summary of monitoring results
- Management Response – comparison of monitoring results to project success criteria summarizing what worked, what did not, and what (if any) management actions should be taken to achieve project success criteria as well as improve future projects

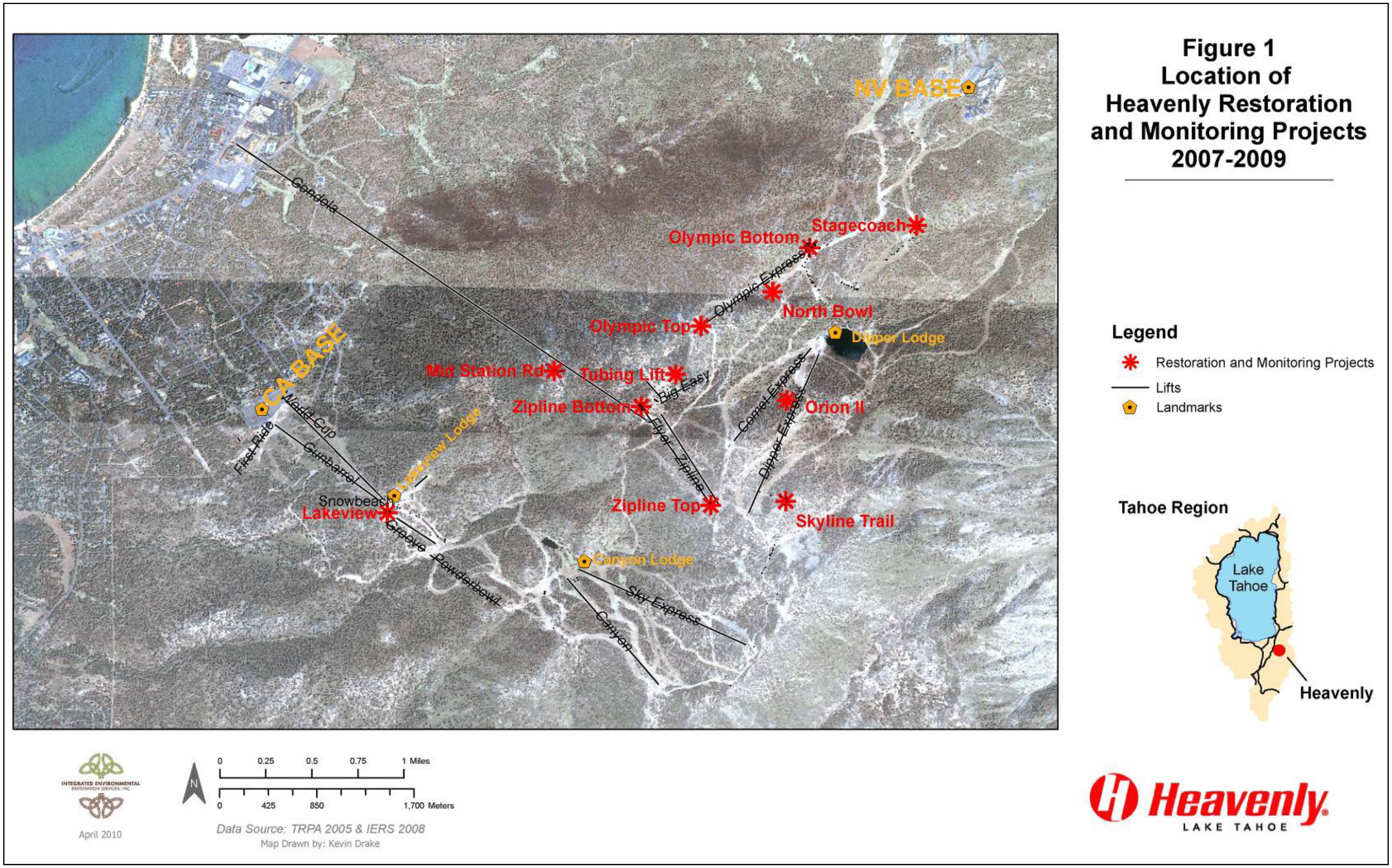
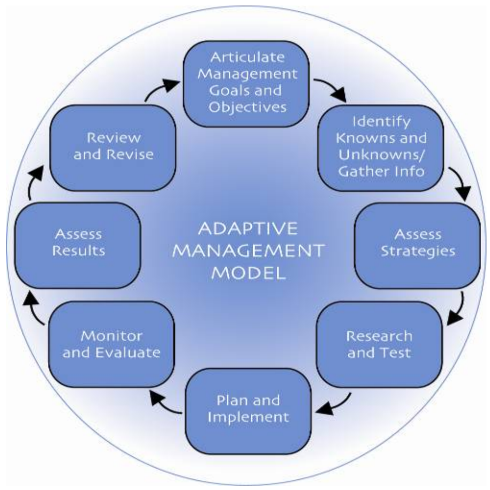


Figure 1. Locations of restoration projects at Heavenly Mountain Resort.

Adaptive Management Overview

The Heavenly Valley Master Plan Amendment EIR of 2007 included an innovative approach to project implementation known as adaptive management. For many years in the Lake Tahoe Basin, projects have been designed to comply with regulations. In that attempt to comply is embedded the assumption that compliance measures actually attain the goals that they are designed to attain. However, a majority of the BMPs currently approved for a specific project have not been tested or measured for performance in the type of situation or conditions to which they are being applied. In fact, most permanent BMPs are based on output from models, such as the Universal Soil Loss Equation. Thus we have made little progress toward either understanding or improving performance on many of the standard and accepted BMPs. Heavenly has departed from this approach and while the adaptive management system being employed assures compliance, this approach is being used to investigate the actual performance of both standard and newly developed BMPs in order to assure a higher level of environmental performance and cost-effectiveness. Below is a brief description of the adaptive management model being employed at Heavenly.



The concept of adaptive management[1] has been applied for centuries under a number of different names. Physical engineers have used this approach since the first structure or bridge was constructed to continually learn from 'failures' and successes to improve designs. In the realm of applied science, including restoration and erosion control, adaptive management has not, until recently, been widely embraced. This effort at Heavenly Mountain Resort is one of the first truly adaptively-managed projects in the Lake Tahoe Basin.

Adaptive management has a dual nature. First, adaptive management is a philosophical approach toward resource management that acknowledges that we do not completely understand the system that we are working with. It acknowledges that we will proceed with a project or program using existing information while we gather the knowledge that we lack. Second, adaptive management is a structured decision-making process designed to increase knowledge and understanding. That process includes the following components, usually addressed in a stepwise fashion:

1. **Articulate management goals and objectives –** Goals have been set for the entire program with clear objectives and success criteria defined for each project.

[1] The adaptive management approach being applied at Heavenly has been pioneered by the California Alpine Resorts Environmental Cooperative (CAREC) and is described in greater detail in the Sediment Source Control Handbook, which is available at: www.IERStahoe.com or www.sbcouncil.org

2. **Identify "knowns and unknowns"/gather information –** Heavenly's restoration and monitoring program provides a practical framework for translating "knowns," "unknowns," assumptions and ideas into hypotheses to be tested in the context of new projects. In this manner, Heavenly is able to utilize proven and/or promising treatment approaches while addressing research needs and filling information gaps.
3. **Assess strategies –** Monitoring results from past projects are used as the basis for developing treatment strategies for new projects that are most likely to achieve project objectives and success criteria.
4. **Research and tests –** Test plots are incorporated into project-scale treatments whenever possible to test assumptions and fill information gaps identified in step 2 in order to expand Heavenly's toolkit of effective restoration treatments.
5. **Plan and implement –** All treatments are monitored by IERS staff during implementation in order to ensure that treatments are implemented according to plan and to document as-built conditions to support monitoring and continual improvement.
6. **Monitor and evaluate –** Quantitative, defensible monitoring is conducted before construction and one year following treatment to evaluate treatment effectiveness relative to pre-defined success criteria.
7. **Assess results –** Monitoring data are analyzed, summarized and reported annually (in this report). Management responses are recommended to address treatments that did not meet the project objectives and success criteria. These results are shared with regulatory agencies as well as other regional stakeholders.
8. **Review and revise –** This final and critical step in the adaptive management cycle involves continual reassessment and improvement of treatment practices by incorporating information gained through monitoring into future projects and treatments. This step also includes refinement of success criteria if suggested by new knowledge or understanding.

Overall Site Description

Heavenly Mountain Resort (Heavenly) is a ski resort located on the east slope of the central Sierra Nevada Mountains in the Carson Range on the southeast side of the Lake Tahoe Basin. Heavenly spans Nevada and California and has approximately 650 acres of ski runs, 30 ski lifts, 35 structures, and approximately 30 miles of roads within the resort boundary.

Soils are derived from granitic parent material and deposits of decomposed granite rock including quartz, monzonite, and granodiorite. Heavenly is predominantly located within a mixed conifer forest, with some of the upper reaches of the resort within a Western White Pine Series vegetation type (Sawyer and Keeler-Wolf, 1995). Elevations range from 6,225 ft above mean sea level (AMSL) in the Heavenly Village to 10,400 ft AMSL at the top of the Sky Express.

The environment varies from densely forested at the lower elevations to open and exposed slopes at the higher elevations. The overstory is dominated by red fir (*Abies magnifica*), whitebark pine (*Pinus albicaulis*), Western white pine (*Pinus monticola*), lodgepole pine (*Pinus contorta*), and mountain hemlock (*Tsuga mertensiana*). Native plants dominate the understory in undisturbed areas and include pinemat manzanita (*Arctostaphylos nevadensis*) and huckleberry oak (*Quercus vacciniifolia*). Native grasses and forbs are also present. At the higher elevations, plant cover is sparser and large areas of bare soil exist. Ski runs and other disturbed and revegetated areas tend to be dominated by non-native fescue (*Festuca trachyphylla*).

Overall Program Goals

Treatment Goals

- To implement projects that result in no net increase in runoff or sediment transport
- To implement sediment source control treatments that are either self-sustaining (as measured by sustainability indices, discussed below) OR are accompanied by a plan for ongoing maintenance and management to maintain treatment effectiveness
- To develop and demonstrate an applied adaptive management program for development, management and maintenance activities in upper watersheds

Monitoring Goals

- To quantitatively assess whether projects result in no net increase in runoff or sediment transport
- To identify and quantify indices of long-term ecosystem sustainability to the greatest extent possible
- To use monitoring data to determine the cost-effectiveness of restoration techniques
- To use monitoring data to improve effectiveness of future treatments

Defining and Measuring Success

Defining Success Criteria

A project without a clearly defined target will not reach that target. The purpose of success criteria is, among other things, to minimize the condition described in the old adage: "If you don't know where you're going, any road will get you there." Success criteria are a set of numerical values or other specific descriptors of the target future condition of an area that are measured or observed in the field to determine whether goals and objectives have been achieved. Success criteria must be explicitly linked to project goals and objectives if they are to be valid and useful. Success criteria are most often defined as a range of acceptable values with upper or lower thresholds rather than a single numeric target in order to account for variability in natural systems and confidence in the accuracy of different measurement and analysis methods. Success criteria should reflect realistic and appropriate targets that are based on measured data whenever possible.

Success criteria are also subject to adjustment or change in some cases, especially when new elements are encountered such as the use of new techniques, ecosystems not previously worked in, or other novel situations where the outcome is not assured. At the same time, even in new situations, success criteria are based on a 'best guess' outcome that is derived from previous work. Adjustments may be required if, through careful monitoring, one discovers that the targets set are unattainable, unrealistic and/or not accurate indicators of goal or objective attainment. However, adjusting or changing success criteria must be done in a well substantiated, carefully considered manner. Defensible reasoning must be presented to support success criteria adjustment with new criteria presented based on monitoring data, rather than simply a desire to change the criteria.

Using Success Criteria within Adaptive Management

In the context of applied adaptive management, unmet success criteria serve as "trigger points" for actions or "management responses". Success criteria are also adjusted when monitoring and field reality clearly suggest that criteria are unrealistic or physically unattainable. A pre-defined management response represents a commitment by the project owner or manager to take action to achieve the project goals if the success criteria are not met or to review and revise the criteria themselves if justified. Potential management responses should be defined during project planning and directly linked to success criteria and monitoring. Additional management responses may also be developed after project implementation and monitoring are complete, once the sources of the problem and potential solutions are more clearly understood. Management responses can take the form of an on-the-ground action (re-mulching and/or re-seeding a bare area, for instance) or in some cases, refining the success criteria themselves so that they reflect the most realistic and appropriate targets possible.

The success criteria developed in 2008 have been refined based on recent data collected at Heavenly and analysis of variability inherent in each type of measurement (see Appendix A for an overview and justification of refinements to success criteria). Over time, the success criteria presented in this report will continue to be refined based on the results of monitoring both treatment and reference areas at Heavenly and other similar sites. In this way, success criteria become more representative of the system in which we are working and provide a framework for comparing our initial understanding about that system to what we are learning from ongoing field measurements. Thus, initial success criteria reflect our best understanding of the system and system response to treatment at the outset of the project.

Little monitoring of restoration treatment effectiveness has been conducted in high elevation (above 8,000 ft) settings with poorly developed soils, particularly those derived from decomposed granite. Heavenly's adaptive management-based restoration and monitoring program is a rare but sorely needed opportunity to help fill important information gaps and provide a quantitative, defensible basis for defining success for restoration in high-elevation settings at Heavenly and throughout the region.

Developing Appropriate Management Responses

Management responses are developed for each success criteria during project planning in order to describe the types of responses that could be deployed to address unmet success criteria. When a specific success criterion is not met, it "triggers" an action, and that action should be based on information gathered through quantitative monitoring, qualitative observations and field experience, which is not always available during project planning. Effective management responses should be directly linked to goals and objectives. Given the primary program goal at Heavenly of "no net increase in runoff or sediment transport," the scale and intensity of a given management response should be commensurate with the level of certainty that runoff or sediment yield has actually increased. Success criteria for Heavenly projects are based on both direct measurements and indirect indices of erosion potential. For instance, rainfall simulation provides a direct measurement of erosion potential whereas all other monitoring parameters included as success criteria serve as indices or indicators of erosion potential and longer-term sustainability of sediment source control treatments. Even the various types of plant cover measurements are intended to be indicators of erosion potential, rather than any sort of direct measurement of erosion.

The various forms of monitoring have been carefully constructed to allow a range of information of various importance or 'weight'. While all of the monitoring information offers useful information, not all may be equally useful to determine a trigger point. Greater weight, for instance, is put on the rainfall simulation-derived sediment yield results than on other indirect indices of erosion when evaluating the overall functional condition and erosion risk of a site and the need for a particular type of management response. For example, if the criteria for plant cover or soil organic matter are not met but the criteria for sediment yield and total cover are met, monitoring results would indicate that the overall project outcome is aligned with the project objective (no net increase in runoff or sediment transport) but that further monitoring and/or observations to evaluate the longer-term trajectory of soil organic matter and vegetation response may be needed. Alternatively, if measured sediment yield slightly exceeds the success criterion but available monitoring data suggests that the difference in sediment yield is within the range of natural variability measured at Heavenly, the success criterion may be revised to account for the range of natural variability.

Success criteria, monitoring, and management responses are used to determine and ensure that site conditions are trending in the intended direction. Since we are working with complex and dynamic natural systems that we do not fully understand, an unmet success criterion does not always warrant a treatment action. The type, scale and intensity of management responses should be proportionate with the relative erosion risk level of a particular site, which requires integration and interpretation of a range of ecological variables (which are manifested as success criteria). In the context of applied adaptive management, success criteria and management responses provide a useful framework for translating goals into measurable targets, stating and testing assumptions, increasing both flexibility and accountability in project implementation, and ultimately improving the success of erosion control and restoration efforts over time.

Methods and Materials

Restoration Treatment Techniques and Materials

Full Soil and Vegetation Restoration Treatment

Full soil and vegetation restoration treatment includes the following: soil loosening with amendments and/or topsoil, fertilizer, native seed, and mulch applications. These materials and techniques represent an integrated treatment approach that aims to restore key functions of the soil-vegetation system in a cost-effective manner in order to provide low-maintenance, sustainable sediment source control. This combination of treatment elements is also affectionately referred to as the "Full Hogan."

Soil Amendments

Soil amendments, such as wood chips, tub grindings, and compost, are used to add organic matter and nutrients to the soil. When organic matter is incorporated into disturbed soil, it improves the infiltration and water holding capacity of the soil. Organic matter is also necessary to create a soil environment in which a robust microbial community can develop while establishing long-term nutrient cycling that, over time, supports native vegetation. Each amendment serves a different purpose in restoring soil function. Soils are tested prior to treatment to determine the types and quantities of amendments most appropriate for a given site.

Amendments are applied to the soil surface in an even layer before tilling. Soil amendments were generally applied at depths of approximately 3 to 5 inches at Heavenly restoration treatment areas, depending on site conditions, treatment goals and amendment type. Four types of soil amendments were used in Heavenly restoration treatments from 2007 - 2009:

- Full Circle Integrated Tahoe Blend Zero Compost, consisting of 100% composted coarse wood overs ranging in size from 3/8" to 3"
- Wood chips, generated on-site at Heavenly
- "Boulder Lodge Blend", consisting of aged wood chips and pine needles from Heavenly's "Compost Your Combustibles" Program
- Decomposed wood shavings, consisting of well-aged wood shavings from a nearby firewood operation in Meyers. Supplies of this amendment were limited, and it was only used at the Olympic Lift Bottom area.

Figure 2. Soil amendments – wood chips and compost.

Soil Loosening (Tilling)

Soil loosening is used to remove compaction from dense soil and to incorporate amendments into the soil before fertilizing, seeding, and mulching. Soil loosening tends to increase infiltration rates, thereby decreasing runoff and associated sediment transport (Grismer and Hogan 2005). Soil loosening also allows plant roots to penetrate more easily into the soil, therefore allowing them greater access to water and nutrients while helping to stabilize the soil. All soil loosening treatments at Heavenly have been implemented using the bucket of a full sized excavator (or a backhoe in a few cases) to till soil and incorporate amendments. Soil tilling is conducted in a manner that mixes the subsurface material with the amendments (such as wood chips or compost) and leaves the subsurface irregular or "scalloped" (i.e. rough, not smooth; Figure 3 and Figure 4).

Figure 3. Tilling/scalloping with full-sized excavator

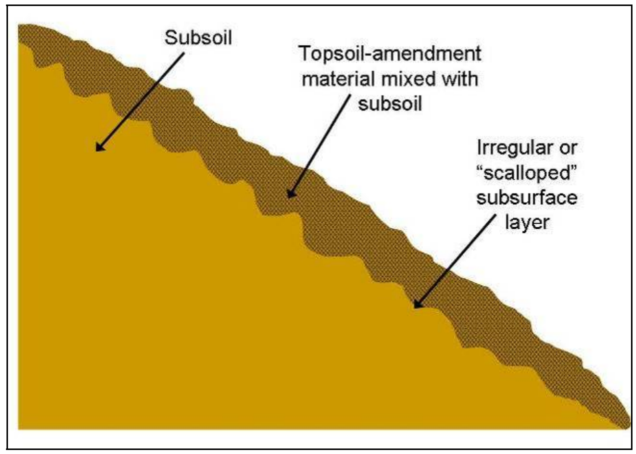


Figure 4. Result of tilling/scalloping

Fertilizer

Fertilizer is typically added to support short-term plant growth while carbon-rich soil amendments, such as wood chips or composted coarse-overs, are broken down by soil microbes and provide more available nutrients in the long-term to support plant growth. Biosol (6-1-3) is an organic, slow-release fertilizer, and was the only fertilizer used at the 2007-2009 restoration treatment areas. The nutrients present in Biosol are released much more gradually than with most other commercial fertilizers, providing a longer-term source of nutrients to support establishment of native perennial species while reducing the potential for leaching into groundwater. Biosol is applied to the soil surface and incorporated into the top 1 inch of the soil using a rake.

Seed

Figure 5. Applying and raking seed.

Two native upland seed mixes were developed for Heavenly projects (Table 2 and Table 3). In addition, a mesic mix was developed for a wetter area on Patsy's Trail for the Lakeview Lodge project (Table 4). Seed selection is important in any restoration project; however, it is important to note that many sites where vegetation and topsoil have been removed are not capable of supporting robust vegetation. Therefore, seeding should always be a part of a larger process of soil re-capitalization. The other treatments described in this section (tilling, soil amendments, mulch) are an integral part of establishing a sustainable soil and vegetation community that provides long-term sediment source control. Native perennial species with deep root systems were specifically selected because they provide a high level of soil stabilization. Grasses, which dominate the seed mix, have the densest root system of the herbaceous species and are the first to establish in the natural successional process that eventually leads to a mature tree and shrub-dominated community. Seeding is an integral part of full soil restoration, which includes soil loosening, incorporation of amendments into the soil, fertilizer application, and mulch. Seed is applied to the soil and raked lightly to ¼ inch below the surface.

Table 2. Heavenly Upland Seed Mix

Species (Common Name)	Species (Botanical Name)	Pure Live Seed (%)
Squirreltail	*Elymus elymoides*	46%
Blue wildrye	*Elymus glaucus*	11%
Mountain brome (Mokelumne or El Dorado)	*Bromus carinatus*	29%
Antelope bitterbrush	*Purshia tridentata*	6%
Greenleaf manzanita	*Arctostaphylos patula*	6%
Sulphur flower buckwheat	*Eriogonum umbellatum*	2%

Table 3. Lakeview Upland Seed Mix

Species (Common Name)	Species (Botanical Name)	Pure Live Seed (%)
Squirreltail	*Elymus elymoides*	48%
Western needlegrass	*Achnatherum occidentale*	2%
Mountain brome (Mokelumne or El Dorado)	*Bromus carinatus*	20%
Antelope bitterbrush	*Purshia tridentata*	10%

Species (Common Name)	Species (Botanical Name)	Pure Live Seed (%)
Sulphur flower buckwheat	*Eriogonum umbellatum*	8%
Slender wheatgrass (Revenue)	*Elymus trachycaulus*	12%

Table 4. Lakeview Moist Site Seed Mix

Species (Common Name)	Species (Botanical Name)	Pure Live Seed (%)
Tufted hairgrass	*Dechampsia caespitosa*	20%
Meadow barley	*Hordeum brachyantherum*	20%
Baltic rush	*Juncus balticus*	10%
Nebraska sedge	*Carex Nebraska*	15%
Rocky mountain iris	*Iris missouriensis*	20%
Purple monkeyflower	*Mimulus lewisii*	5%
Sierra larkspur	*Delphinium glaucum*	10%

Table 5. Stagecoach Upland Seed Mix

Species (Common Name)	Species (Botanical Name)	Pure Live Seed (%)
Squirreltail	*Elymus elymoides*	52%
Mountain brome (Mokelumne or El Dorado)	*Bromus carinatus*	20%
Antelope bitterbrush	*Purshia tridentata*	20%
Sulphur flower buckwheat	*Eriogonum umbellatum*	8%

Mulch

Mulch is a protective layer of material, spread on the soil surface, that can serve to decrease erosion and sediment transport, decrease evaporation of water from the soil, and contribute to long-term nutrient cycling. Mulches commonly used for erosion control in the Sierra Nevada include pine needles, wood shreds, and rice straw. However, pine needles and wood shreds have proven to be far more durable and effective at reducing sediment transport than rice straw when applied consistently over treated areas. At sites in the Lake Tahoe Basin, a consistent cover of pine needle mulch has been shown to reduce

Figure 6. Aged pine needles were applied as mulch at several projects.

sediment yield by as much as 50% compared to adjacent, partially-treated areas with little mulch (Grismer et al. 2008). Pine needles and wood chips/shreds are the only mulches that were used at Heavenly restoration treatments in 2007 and 2008.

Monitoring Methods

Before a discussion of individual methods, it is important to understand sampling during field data collection and to understand how an area is selected for monitoring.

Monitoring Area Selection

Monitoring areas were selected at each project based on the type and magnitude of impacts to soil and vegetation (disturbance and restoration) that were expected, construction plans, and coordination with Heavenly operations personnel. In general, the more complex the project, the greater the level of monitoring effort required to adequately characterize the impacts of the project on runoff and sediment transport (i.e. erosion). Within the general area of interest, a smaller, but representative area is chosen for the monitoring described below.

Monitoring Data Collection: Sampling versus Whole Area Measuring

We define monitoring within an adaptive management context as measurements to detect change in a system or system attributes over time. Monitoring is an attempt to understand specific system attributes and to see how they change. Plant cover, soil nutrients, erosion potential are all attributes that we attempt to measure. However, it's usually impossible to count every plant or blade of grass in an area or to measure all of the soil nutrients. So we take what we hope are representative samples of those attributes. We measure small subsets of the overall system of interest and we hope to get a representative understanding of the overall system. Unfortunately, natural systems can be extremely variable. Statistics help us to understand whether our measurements are accurate or not. In taking samples, there are a number of places where 'error' occurs and thus, we develop our success criteria with a margin of error or a 'plus or minus' factor. This error is cumulative and comes from measurement instruments themselves, the observers, the statistical methodology and laboratory processes, among other things. While we would like to have a sense that numbers represent precise reality, they are, after all, an approximation. Our intent is to develop numbers that we have a certain confidence in. So when we list that plant cover in one area is 10% and in another area it is 15%, the difference is likely to be from the potential 'error' that we've discussed and not a real difference. While this sounds like an excuse for numerical inaccuracy, we are really stating that we can be confident within set limits. Further; we are really looking for trends in the data that reflect trends in the attribute of interest.

Rainfall Simulation

The rainfall simulator is a custom-designed monitoring tool used to simulate natural rainfall events and directly measure infiltration, runoff, and erosion rates from disturbed, treated, and reference areas. The rainfall simulator "rains" on a square plot from a height of 3.3 feet (Figure 7 and Figure 8). The rate of rainfall is controlled (typically 4.7 inches per hour) and runoff is collected from a trough at the bottom of a 6.5 ft^2 frame that has been pounded into the ground. The volume of water collected is measured, and then the volume of infiltration is calculated by subtracting the volume of runoff from the total volume of water applied to the plot. If runoff is not observed during the first 30-45 minutes, the simulation is stopped. The average steady state infiltration rate is calculated from three simulation frames and the collected runoff samples are then analyzed for steady state sediment yield (referred to as "sediment yield" throughout this report). Often times, post-treatment simulations were conducted outside the pre-treatment monitoring area to capture a range of the varied treatment applied during restoration. The pre-treatment data was used as a comparison for all post-treatment simulations at a particular site and is presented next to the post-treatment data for each plot.

A cone penetrometer is used to record the depth to refusal (DTR) surrounding the runoff frames before and after rainfall simulations. Soil moisture is also measured in each runoff frame before and after rainfall simulations. After rainfall simulation, the wetting depth is measured at nine locations within the frame to determine how deeply water has infiltrated into the soil column.

Three simulations were conducted at each site pre-treatment in an effort to account for the widely varying soil hydrologic properties within a site. Sediment yields can vary by thousands of lbs/acre/in at a single site, but are more commonly are within a one hundred lbs/acre/in of each other. This variability, along with collection and analysis variability were accounted for in determining the sediment yield success criteria. Infiltration rates, while still variable for the same reasons mentioned above, are generally with 0.5-1 in/hr of each other within a particular site.

Figure 7. Rain drops are generated from more than 800 hypodermic needles on the rainfall simulator.

Figure 8. Rainfall simulation in action at the Gunbarrel Top Terminal Slope monitoring area.

Rainfall simulation was conducted at the Olympic lift project, the Lakeview Lodge project (except Patsy's trail in 2008), the Stagecoach project, the Tubing Lift project, Mid Station Road, Heavenly Flyer top, and North Bowl. Rainfall simulation was not conducted at

Heavenly Flyer bottom due to the presence a rare plant and the high concentration of rocks at the site.

Runoff Simulation

The runoff simulator is a custom-designed tool used to induce surface runoff (such as spring snowmelt). Like the rainfall simulator, this tool is used to directly measure infiltration, runoff and erosion rates from disturbed, treated and reference areas. Runoff simulation was conducted at Skyline Patsy's Trail at the Lakeview Lodge project. Runoff frames are often easier to install than rainfall frames in rocky or highly compacted areas. The runoff simulator is a 3.3 feet wide PVC pipe with 50 evenly spaced holes that are one-sixteenth inches in diameter (Figure 9).

Figure 9. The runoff simulator at the Skyline trail. The PVC pipe is visible just below the boulder and the collection frame is at the bottom of the photo.

Figure 10. The runoff simulator and test area post-simulation at the Lakeview Lodge Patsy's Trail monitoring site. The PVC pipe is visible at the top of the photo and the collection frame is at the bottom.

When water is pumped though the pipe and exits the holes, an even flow of water across the entire width of the pipe is produced, thereby simulating snowmelt runoff through sheet flow. Snowmelt can produce a significant amount of runoff and sediment, which can lead to severe erosion problems. The application rate ranges from 2.5 to 5.9 in/hr. A collection trough is installed 6.6 feet down slope from the runoff pipe and all runoff is collected. The same measurements and samples are collected for the runoff simulator as for the rainfall simulator.

Soil and Site Physical Conditions

Penetrometer Depth to Refusal (DTR)

Penetrometer DTR is measured along transects. Penetrometer DTR measurements are used as a surrogate for soil density. A cone penetrometer with a ½ inch diameter tip is pushed straight down into the soil until a maximum pressure of 350 pounds per square inch is reached (Figure 11 and Figure 12). The depth at which that pressure is reached is recorded as the depth to refusal (DTR). The depths are marked in 3 inch increments and can be read to the nearest 1 or 2 inches.

Penetrometer DTRs can only be compared at similar soil moisture levels, because DTR increases with increasing soil moisture. DTRs are not presented if soil moisture levels are not comparable between years.

Soil Moisture

A hydrometer is used to measure volumetric soil moisture content adjacent to the penetrometer readings at a depth of 4.7 inches (Figure 13).

Solar Exposure

Solar radiation measurements are taken using a Solar Pathfinder (Figure 14). Solar input affects evaporation rates and soil temperature, which may affect time of seed germination, germination rate, rate of plant growth, and soil microbial activity. It is an important variable to consider when monitoring plant growth and soil development.

Figure 11. Cone penetrometer dial, showing pressure applied in pounds per square inch.

Figure 12. Conducting cone penetrometer readings along transects.

Figure 13. Conducting soil moisture readings along transects.

Figure 14. Solar pathfinder in use.

Cover

Cover point monitoring is a statistically defensible method of measuring foliar plant cover and ground cover. Cover is measured along randomly located transects using a metal rod with a laser pointer mounted 3.3 feet high. After the rod is leveled in all directions, the button on the laser pointer is depressed and two cover measurements are recorded (Figure 15 and Figure 16):

- the first hit cover
- the ground hit cover

The first hit cover is the first vegetation intercepted by the laser and measures the foliar cover by plant leaves or stems. The first hit vegetation is moved aside and the ground hit cover is identified. Ground hit cover is litter, mulch, basal (or rooted) plant cover, rocks, woody debris, or bare ground.

Figure 15. Cover pointer in use along transects.

Figure 16. Cover pointer rod with first hit cover and ground cover hit by the laser. The laser pointer hits are circled in red. The first cover hit is a native grass and the ground hit cover is pine needle mulch.

Basal and foliar plant cover is recorded by species and organized into four categories: lifeform, perennial/annual/woody, native/alien, and seeded/volunteer. Each species is classified based on whether it is native to the Tahoe area, and whether it was seeded during treatment. Ocular estimates of species composition are recorded.

Cover point monitoring was conducted at the 80% confidence level in most cases. For areas dominated by bare soil, dozens of transects can be required to reach the 80% confidence level. In these cases, 10 transects were recorded.

Soil Nutrient Analysis

Successful revegetation and soil treatments require adequate nutrient capital in the soil. Readily available sources of nitrogen, sufficient organic matter, and a robust microbial community are necessary to support vigorous and self-sustaining vegetation. Previous studies of soil nutrient levels at revegetation sites throughout the Tahoe area found that high plant cover was associated with high levels of total nitrogen (Claassen and Hogan 2002). Total Kjeldahl nitrogen (TKN) and organic matter are used as indicators of soil condition in this study.

Soil sub-samples are collected from a depth of 0-12 inches following the removal of the mulch layer (Figure 17). Three soil sub-samples are combined and sieved to remove any material larger than 0.08 inches in diameter, then sent to A&L Laboratories (Modesto, CA) for S3C nutrient suite, TKN, and organic matter analysis.

Like soil hydrologic properties, soil nutrient levels can vary widely, even within a small area. Three sub-samples are collected for each sample sent to the lab to help account for some of this natural variability. In addition to the natural variability, each nutrient value is accurate to a certain degree, depending on the analysis method used at the laboratory. The organic matter lab analysis is accurate within 20%, while TKN lab analysis is accurate to within 8%. The success criteria developed for organic matter and TKN reflect the variability encountered during the soil sample collection and analysis process.

Figure 17. Soil sub-sample collection.

Chapter 2: Projects with Pre-Treatment Monitoring Only

Tubing Lift Construction Project

Overview

The tubing lift project includes the installation of a covered surface lift, clearing trees and boulders to accommodate new ski school teaching areas (low-angle ski runs) and tubing lanes, and installation of a new underground snowmaking line on existing unpaved roads (Figure 18). The proposed project encompasses a range of site conditions including existing unpaved roads, expansive low-slope areas with very sparse vegetation and mulch cover ("beach-like" conditions), and forested areas further upslope. Soil and vegetation impacts associated with construction include tree clearing, trenching for snowmaking piping, and soil compaction in designated vehicle and equipment travel paths and staging areas. No mass grading was conducted. Construction of the lift and lanes occurred during the fall of 2009. Pre-treatment soil and vegetation monitoring was conducted in the fall of 2009, just before construction began.

Site Description

Tubing Lift

The tubing lift was constructed in a mostly open area with some Western white pine (*Pinus monticola*) and a sparse understory of pinemat manzanita (*Arctostaphylos nevadensis*), buckwheat (*Eriogonum sp.*), penstomen (*Penstemon sp.*), and Western needlegrass (*Achnatherum occidentale*; Figure 19). No non-native species were observed. Most of the granitic parent material soil was bare; however, there was a sparse mulch cover by pine needles near the forested areas. There were some medium to large rocks that are visible above the surface. Excavation observed during pre-treatment monitoring indicated that many of the rocks were large boulders with the majority of their mass below the surface. The site is gently sloped (10 degrees), faces 181 degrees south, and had a summer solar exposure of 86%. The site elevation is approximately 9,150 feet AMSL.

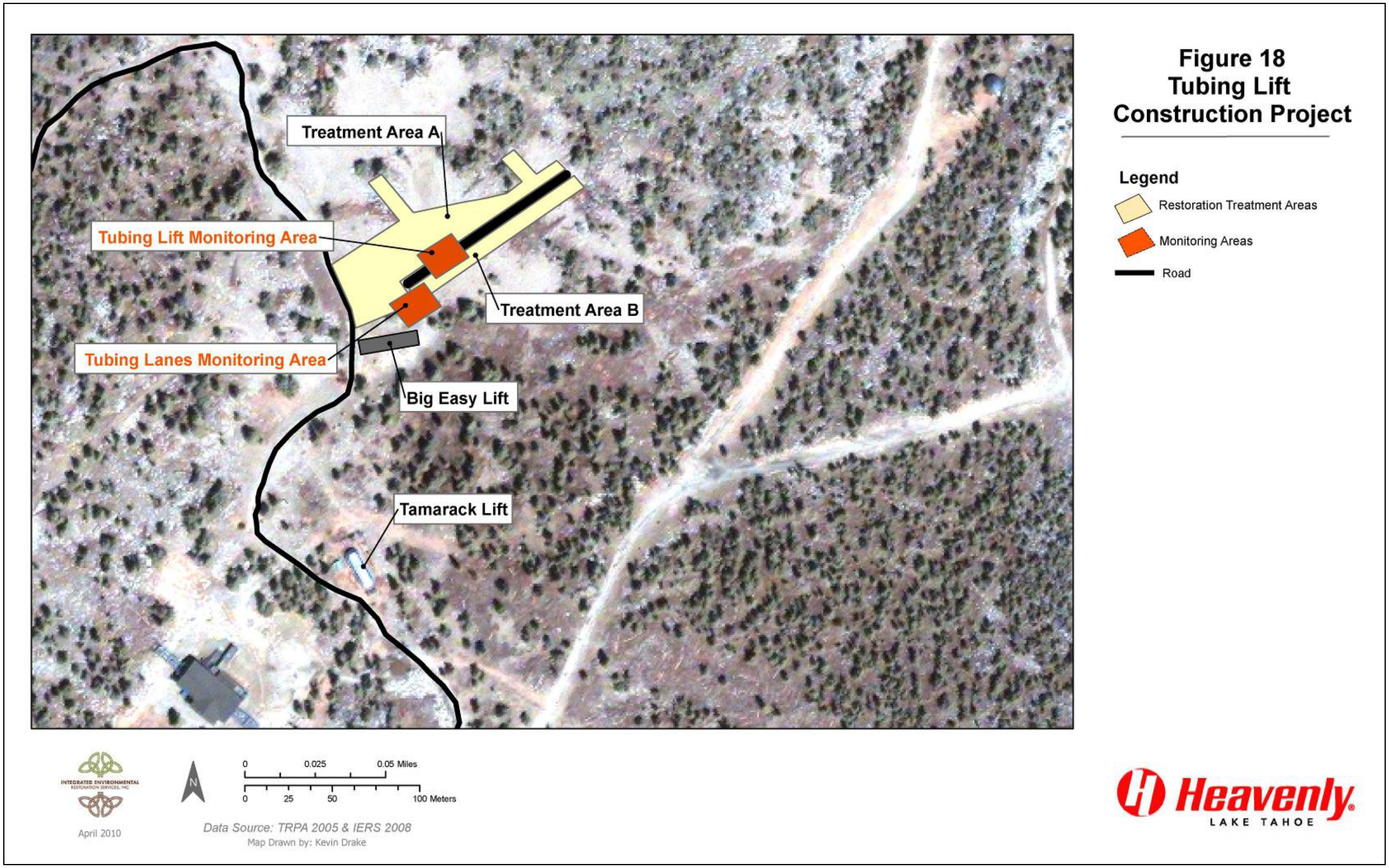


Figure 18. Tubing Lift Construction Project Map.

Tubing Lanes

The tubing lanes were constructed in an open area with very few Western white pine (*Pinus monticola*) and a very sparse understory of pinemat manzanita (*Arctostaphylos nevadensis*), buckwheat (*Eriogonum sp.*), penstomen (*Penstemon sp.*), and Western needlegrass (*Achnatherum occidentale*; Figure 20). No non-native species were observed. Most of the soil was bare; however, there was a very sparse mulch cover by pine needles near the forested areas. There were some medium to large rocks that are visible above the surface. The site is gently sloped (10 degrees), faces 181 degrees south, and had a summer solar exposure of 91%. The site elevation is approximately 9,150 feet AMSL.

Figure 19. Tubing Lift, before construction, 2009

Figure 20. Tubing Lanes, before construction, 2009

Objectives and Success Criteria

Treatment Objective

- no net increase in runoff and/or sediment transport as a result of lift and lane installation

Monitoring Objective

- to quantitatively assess whether lift construction and run clearing resulted in a net change in runoff and/or sediment transport

Success Criteria

The following success criteria will be used to determine whether run construction treatments achieved project treatment goals following construction (Table 6). The success criteria are based on the following indicators: sediment yield, infiltration rate, penetrometer depth to refusal (DTR, used as an index for soil density), total cover, plant cover, organic matter, and visual erosion assessment. A success criterion for TKN was not used in 2009, as discussed in Appendix B. In addition to evaluating short-term treatment success, these indicators represent key information needed to assess the likelihood of long-term sustainability of the soil-plant system, which is the key to long-term sediment source control.

Table 6. Tubing Lift Success Criteria and Management Responses.

	Tubing Lift / Lanes	Management Response
Sediment Yield (lbs / acre / in)	Not greater than 100 lbs/acre/in higher than pre-treatment levels	Soil loosening with amendments and/or mulching
Infiltration Rate (in / hr)	Not greater than 0.8 in/hr lower than pre-treatment levels	Soil loosening with amendments
Penetrometer Depth (inches)	Not greater than 4 inches shallower than pre-treatment level	Soil loosening, amendments
Total Cover (%)	70% or greater	Mulching and/or seeding
Plant Cover	10% or greater	Seeding and/or targeted, short-term irrigation
Organic Matter (%)	Not greater than 1.5 percentage points less than pre-treatment level	Additional amendments and soil loosening
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	Identify causes of erosion. Develop and implement site-specific management response plan.

Pre-Treatment Monitoring

Infiltration and Sediment Yield

At the tubing lift line, there was no runoff, and therefore, no sediment production (Figure 21). At the tubing lane, the average steady state sediment yield was 56 lbs/acre/in. The higher sediment yield at the lane was most likely not related to the shallower penetrometer DTR measured on transects at the tubing lane (Figure 22). Shallower penetrometer DTRs can lead to less infiltration and higher sediment yields in some cases. The penetrometer DTR measured within the rainfall frames did not reflect the transect measurements at the tubing lane. At the lift line, the penetrometer DTR within the frame was 10.2 inches, compared to 10.8 inches at the lift lane. For comparison, typical native or treated sites have sediment yields less than 100 lbs/acre/in. The infiltration rate was 4.1 in/hr at the tubing lane and 4.7 in/hr at the lift line.

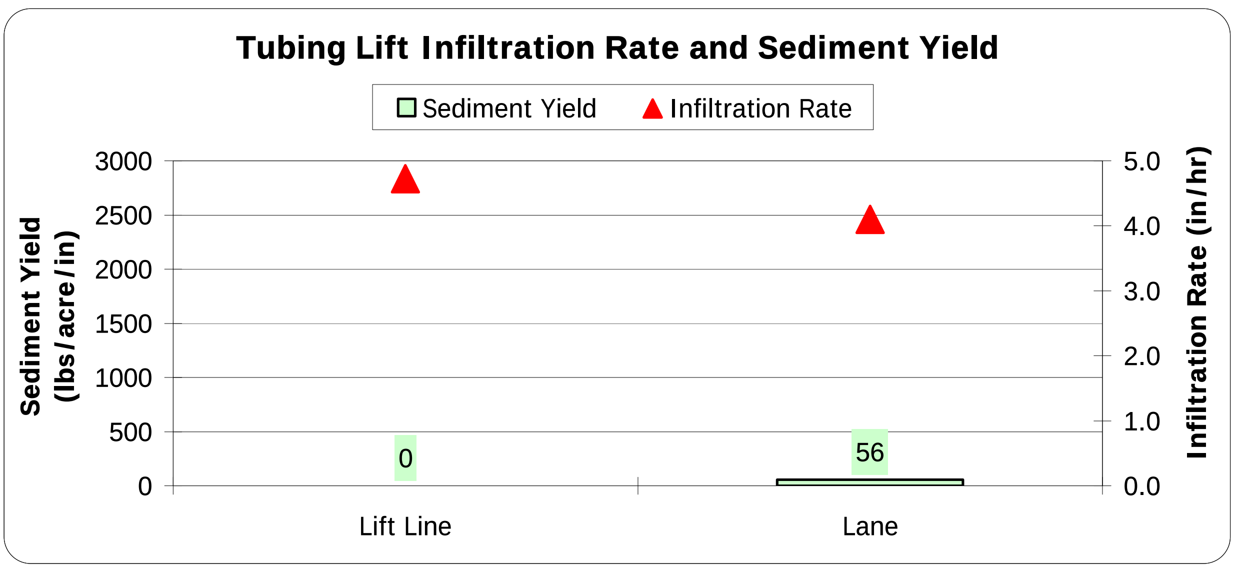


Figure 21. Tubing Lift Infiltration Rate and Sediment Yield. The lift line had a sediment yield of zero and an infiltration rate of 4.7 in/hr, while the lane had a sediment yield of 56 lbs/acre/in and an infiltration rate of 4.1 in./hr.

Penetrometer DTR

The penetrometer DTR at the lift line was 11.1 inches, compared to 3.6 inches at the tubing lane (Figure 22).

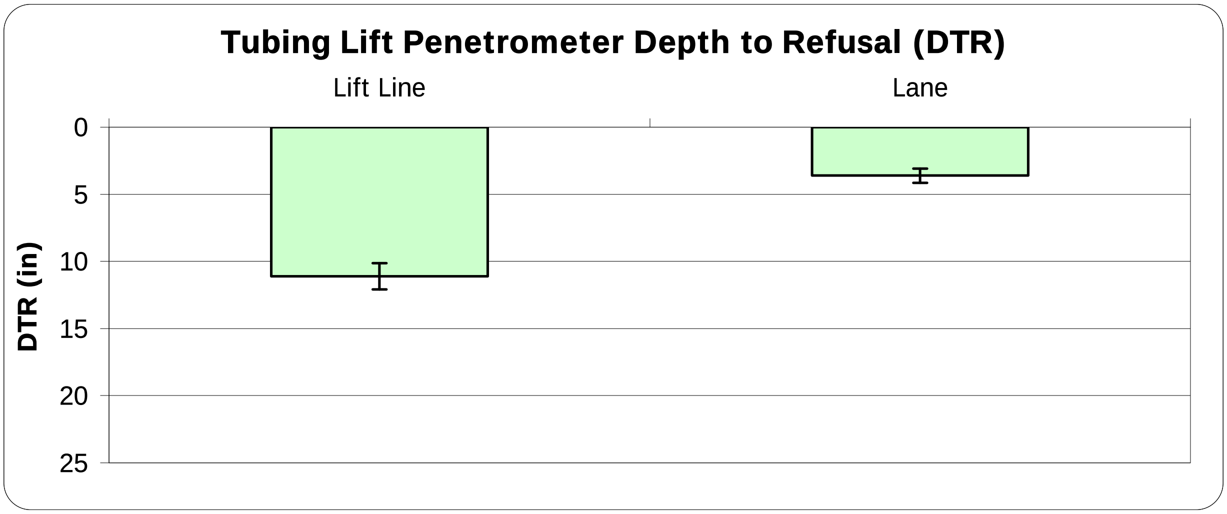


Figure 22. Tubing Lift Penetrometer Depth to Refusal (DTR). The penetrometer DTR at the lift line was 11.1 inches, compared to 3.6 inches at the lane. The error bars denote one standard deviation above and below the mean.

Total Cover and Plant Cover

Total cover at the tubing lift line (10%) was similar to the total cover (9%) at the tubing lane (Figure 23). Both had high proportions of bare soil: 90% at the lift line and 89% at the tubing lane. Understory plant cover (not including canopy cover) was 1% at both the tubing lift line and the tubing lane (no graph).

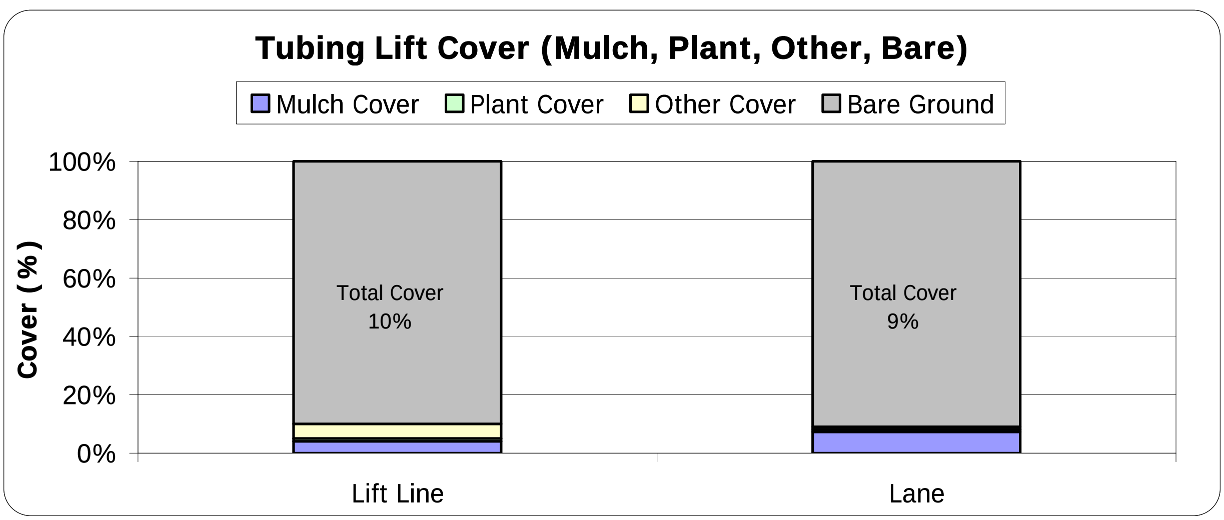


Figure 23. Tubing Lift Cover (Mulch, Plant, Other, Bare). Total plant cover at the lift line was 10%, compared to total cover at the tubing lane, which was 9%.

Soil Nutrients

Organic matter content at the tubing lift line was 1.3%, compared to 0.8% at the tubing lane (Figure 24). Total Kjeldahl nitrogen (TKN) at the tubing lift line was 349 ppm, compared to 247 ppm at the tubing lane.

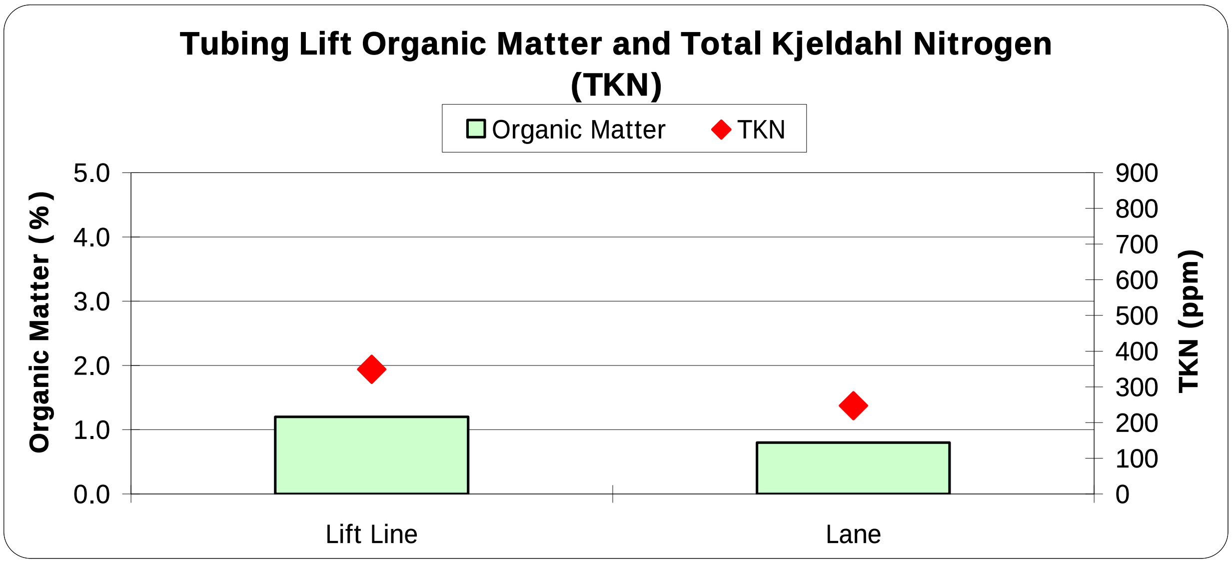


Figure 24. Tubing Lift Organic Matter and Total Kjeldahl Nitrogen (TKN). At the tubing lift line, organic matter content was 1.3% and TKN was 349 ppm. At the tubing lane, the organic matter content was 0.8% and the TKN was 247 ppm.

Visible Erosion Assessment

Pine needle movement and presence in depressions, which can sometimes be an indicator of erosion, was observed at both the tubing lift line and the tubing lane. Pine needle movement can also result from wind erosion. No sediment deposition was observed on the upslope side of the pine needles, suggesting that wind transport was the likely mechanism for pine needle movement. No other signs of erosion were present.

Restoration Treatments

The tubing lift consists of two preliminary treatment areas (Figure 18, Figure 25, Figure 26, Figure 27, and Figure 28, and Table 7). In 2009, construction of the tubing lift and associated snowmaking lines was not completed until mid-December and restoration treatments were not implemented. During construction of the tubing lift, wood chips were applied to provide soil surface protection in designated vehicle travel areas. In Area A (north side of lift), which was especially compacted, wood chips were tilled into the soil once construction was completed. Disturbed soil areas on both sides of the lift (A and B) were then mulched with pine needles to fully winterize the site. Restoration treatments are planned to be completed as per specifications in 2010.

Table 7. Tubing Lift Treatment Matrix

		Treatment Area	
		A	B
Amendments	Type	WC	n/a
	Depth (in)	4	n/a
Tilling	Depth (in)	12*	n/a
Mulch	Type	PNM*	WC/PNM*
	Depth (in)	2*	4/2*

Key

WC = wood chips, PNM = pine needle mulch, * = not verified in field

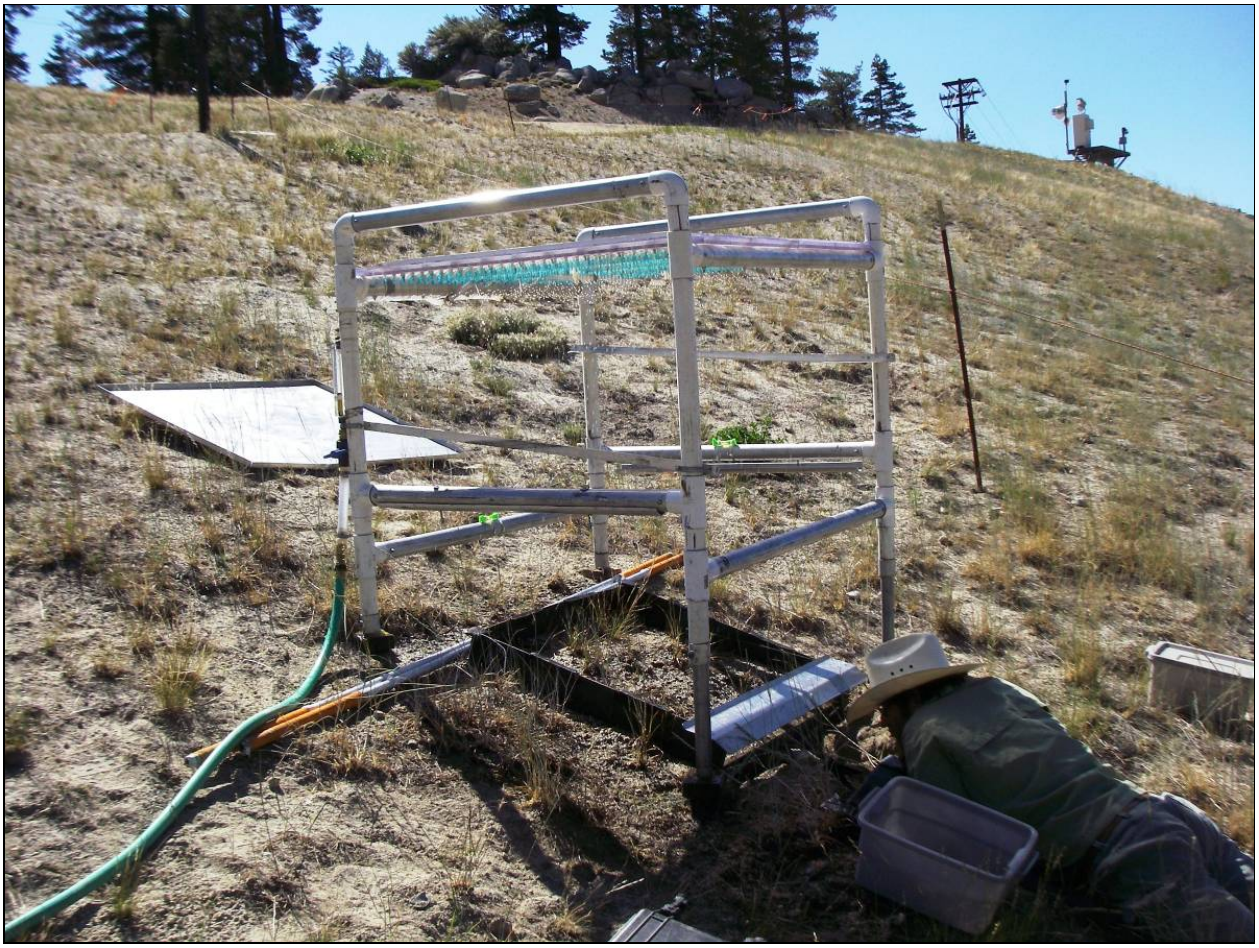
Figure 25. Tubing lift, treatment area A, near start of construction, August 2009.

Figure 26. Tubing lift, treatment area A, with wood chips covering soil during construction, October 2010.

Figure 27. Tubing lift, snowmaking lateral covered in wood chips during construction, treatment area A, October 2009.

Figure 28. Tubing lift, access road winterized with wood chips (tilled) and pine needle mulch after construction, December 2010.

Chapter 3: Projects with Performance Monitoring



North Bowl Ski Run Clearing and Glading Project

Overview

The North Bowl ski run clearing and glading project included the creation of three new ski runs (S8, S9, and S10) near the Olympic Lift. Rather than more traditional smooth grading run construction techniques, clearing and glading methods were implemented. To minimize impacts to soil and vegetation, the clearing and glading were during spring 2008, while snow was on the ground,. Run S8 was cleared: all trees in the run alignment were hand felled, removed by helicopter, and the stumps were flush cut with chain saws. Runs S9 and S10 were gladed, meaning that selected patches of trees were removed to minimize tree removal and create a more natural skiing experience. The same methods were used for glading as for clearing. Clearing and glading are being used as an alternative to smooth grading, which tends to have substantial impacts on soils, vegetation, and erosion potential (Grismer and Hogan, 2005; Burt and Rice, 2009). Soil and vegetation monitoring was conducted on the cleared run, S8, in summer 2008. Additional monitoring, including simulated rainfall monitoring, was conducted in early summer 2009.

Site Description

Cleared Run

The cleared run was cut in a forested area with lodgepole pine (*Pinus contorta*) and Western white pine (*Pinus monticola*; Figure 30). There is no canopy cover and very little vegetation exists. No non-native species were observed. Large boulders, ranging from one to five feet in diameter, and tree stumps that are one to two feet tall are scattered throughout the cleared area. Tree branches from the glading process were left on the run, and are up to 15 feet long. Rills and gullies were present at the toe of the ski slope, where it meets the access road. The soil derived is from granitic parent material. Little vegetation was present in the cleared area. The site is moderately sloped (20 degrees), faces 52 degrees northeast, and had a summer solar exposure of 73-79%. The site elevation is approximately 9,025 feet AMSL.

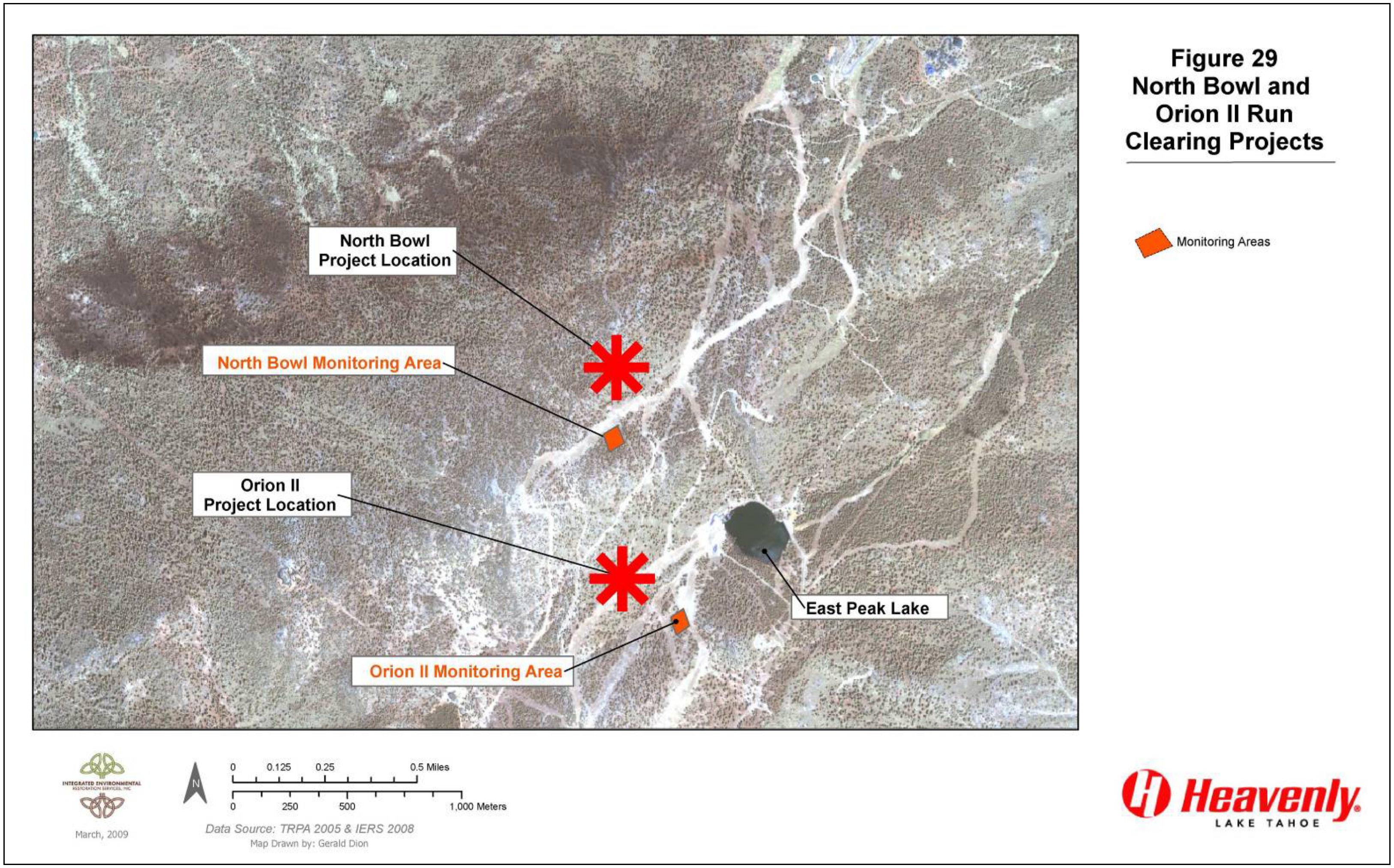


Figure 29. North Bowl Ski Run Clearing and Glading Project Map.

Uncleared Reference

The uncleared reference site is adjacent to the cleared run. The dominant trees are lodgepole (*Pinus contorta*) and western white pine (*Pinus monticola*) and the area contained many large boulders, ranging from one to five feet in diameter (Figure 31). No erosion was observed in the reference area, but animal disturbance was seen throughout. Little understory vegetation was present and no non-native species were observed. The slope, aspect, and elevation are identical to that of the cleared run. The solar exposure at the reference area ranges from 29-35% during the summer months.

Figure 30. North Bowl cleared ski run, 2008.

Figure 31. North Bowl uncleared reference site, 2008.

Objectives and Success Criteria

Treatment Objectives

- no net increase in runoff and/or sediment transport as a result of ski run clearing and glading

Monitoring Objectives

- to quantitatively assess whether run construction resulted in a net change in runoff and/or sediment transport

Success Criteria

The following success criteria will be used to determine whether run construction treatments achieved the project treatment goals following construction (Table 8). The success criteria are based on the following indicators: sediment yield, infiltration rate, penetrometer depth to refusal (DTR, used as an index for soil density), total cover, plant cover, organic matter, total, and visual erosion assessment. A success criterion for TKN was not used in 2009, as discussed in Appendix B. In addition to evaluating short-term treatment success, these indicators represent key information needed to assess the likelihood of long-term sustainability of the soil-plant system, which is the key to long-term sediment source control.

Table 8. North Bowl Cleared Ski Run Success Criteria Evaluation.

	Cleared Run Success Criteria	Cleared Run Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 100 lbs/acre/in higher than pre-treatment levels	× Success Criterion Not Met*
Infiltration Rate (in/hr)	Not greater than 0.8 in/hr lower than pre-treatment levels	√ Success Criterion Met
Penetrometer Depth (inches)	Not greater than 4 inches shallower than pre-treatment level	√ Success Criterion Met**
Total Cover (%)	Not greater than 15 percentage points below pre-clearing level	√ Success Criterion Met**
Organic Matter (%)	Not greater than 1.5 percentage points less than pre-treatment level	√ Success Criterion Met**
TKN (ppm)	TKN not used as a metric for measuring success	n/a, see Appendix B
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	√ Success Criterion Met
*See call out box in Figure 35 for discussion of sediment yield measurements **Evaluated in 2008		

Performance Monitoring

Photo monitoring was conducted at the North Bowl ski run clearing project in 2007 and 2008. In 2008, soil and vegetation monitoring and simulated rainfall were conducted at the cleared run (S8) and at the reference area. However, due to inconclusive results from hydrophobic conditions, it was conducted again in 2009. Hydrophobicity occurs when mulch or soil is resistant to absorbing water. Hydrophobic conditions are common in many areas in late summer after dry, hot weather has persisted for several weeks. The result of rainfall in hydrophobic conditions is illustrated in the following schematics (Figure 32, Figure 33, and Figure 34). Most of the water applied via rainfall or runoff simulation at a hydrophobic site never reaches the soil surface and flows directly to the collection trough through the mulch. Lateral water flow through pine needle mulch to the collection trough results in artificially low infiltration rates. Since hydrophobic conditions were present at North Bowl at the time of monitoring in 2008 and rainfall simulation was actually measuring lateral flow and not infiltration and erosion processes, the runoff samples collected were not sent to the lab for analysis. Rainfall simulation was conducted earlier in the 2009 season (June) so that hydrophobic conditions were avoided.

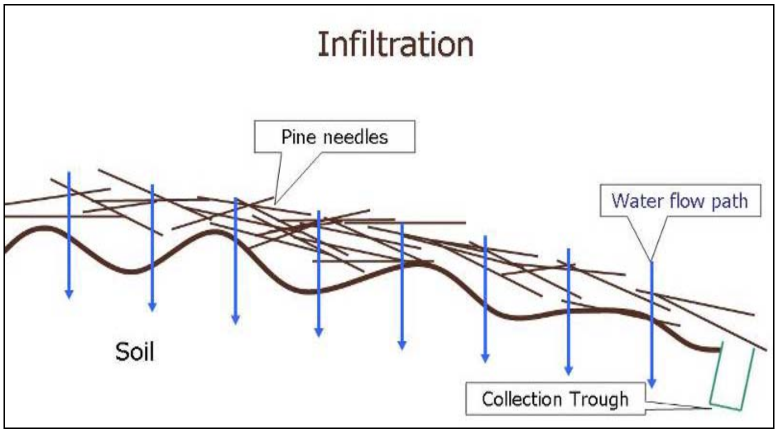


Figure 32. Water infiltrating through pine needle mulch into soil.

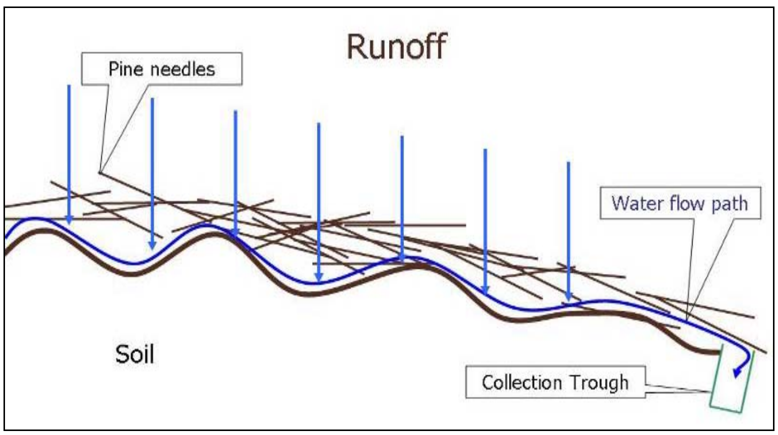


Figure 33. Water penetrating the pine needle mulch and running off after reaching the soil. There is no infiltration into the soil. Runoff is then captured in the collection trough.

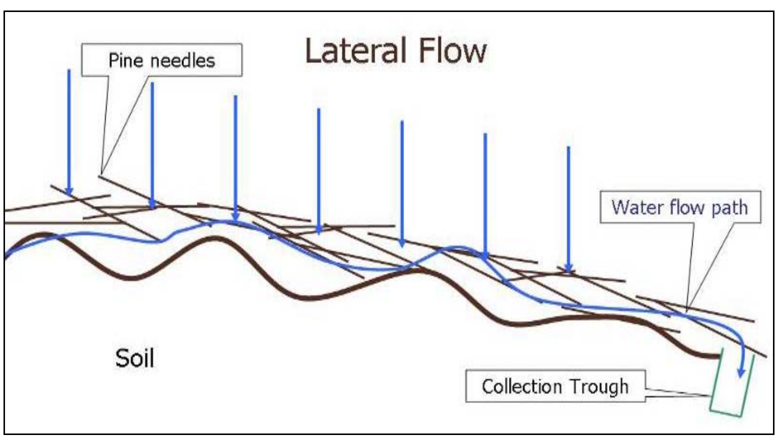


Figure 34. Water flowing laterally through pine needle mulch into collection trough. The water does not reach the soil surface; therefore, it is not known whether the water can infiltrate into the soil.

Infiltration and Sediment Yield

The sediment yield at the North Bowl cleared run (177 lbs/acre/in) was 743% higher than the sediment yield at the uncleared run (21 lbs/acre/in, Figure 35). The success criterion, which requires the cleared run sediment yield to be no more than 100 lbs/acre/in higher than the uncleared run sediment yield, was not met. See the call out box next to Figure 35 for more information on this difference in sediment yields.

The infiltration rate was similar at the cleared run (4.0 in/hr), compared the uncleared run (3.9 in/hr). The success criterion for infiltration rate, which states the infiltration rate can be no more than 0.8 in/hr lower than the pre-treatment infiltration rate, was met.

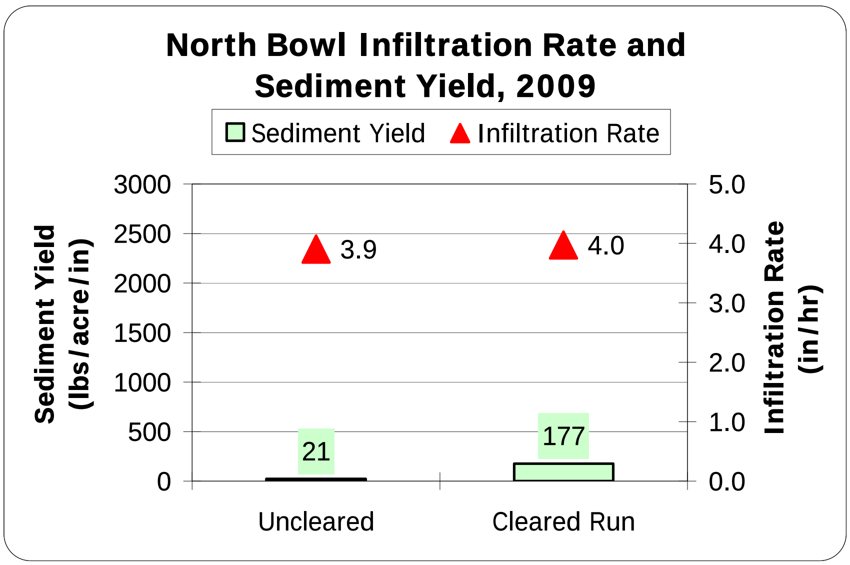


Figure 35. North Bowl Infiltration Rate and Sediment Yield, 2009. The sediment yield at the North Bowl cleared run (177 lbs/acre/in) was 743% higher than the sediment yield at the uncleared run (21 lbs/acre/in). The infiltration rate was similar at cleared run (4.0 in/hr) and the uncleared run (3.9 in/hr).

A Closer Look

Why did the cleared run plot have a higher sediment yield than the uncleared run plot?

One explanation for the higher sediment yield at the cleared run may be the lower duff/litter depth within the rainfall simulation frames. The average duff/litter depth at the uncleared plot frames was 1 inch, compared to 0.25 inches at the cleared run frames. Sediment yield has been shown to increase with decreasing mulch cover (Schnurrenberger et al. 2008). One limitation of rainfall simulation is that it is difficult to install the frames in areas with woody material larger than the frame. Removal of the woody material would substantially disturb the area to be measured, therefore areas without large pieces of woody material, which generally have less duff/litter are chosen. Preferential placement of frames in areas with a lower duff/litter depth may have resulted in artificially high sediment yields at this site.

Penetrometer DTR

Penetrometer DTRs were similar between the cleared run (9.5 inches) and the reference area without clearing (8.8 inches; Figure 36). The success criterion for penetrometer states that the DTR at the cleared run has to be no more than 4.0 inches shallower the DTR at the reference area. Since the DTR at the cleared run was 0.7 inches deeper than at the reference area, the success criterion was met.

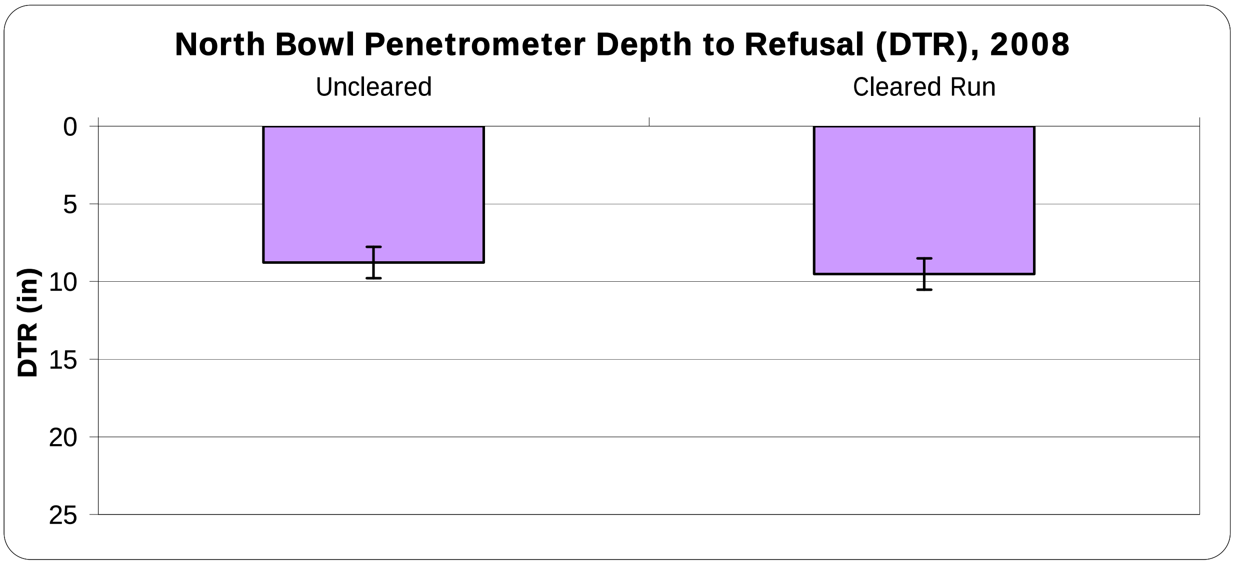


Figure 36. North Bowl Penetrometer Depth to Refusal (DTR), 2008. Penetrometer DTRs were similar between the cleared run (9.5 inches) and the reference area without clearing (8.8 inches). The error bars represent one standard deviation above and below the mean.

Total Cover

Total cover at the cleared run (98%) was 9 percentage points higher than the total cover (89%) at the uncleared run (Figure 37). The difference in total cover at the cleared run compared to the uncleared run can be accounted for by the difference in mulch cover at the cleared run (84%) compared to the uncleared run (76%). The cleared run most likely had higher mulch cover because branches from the removed trees were left on the ground. The success criterion for total cover, which states that the total cover at the cleared run must be no more than 15 percentage points less than the total cover at the reference area, was met.

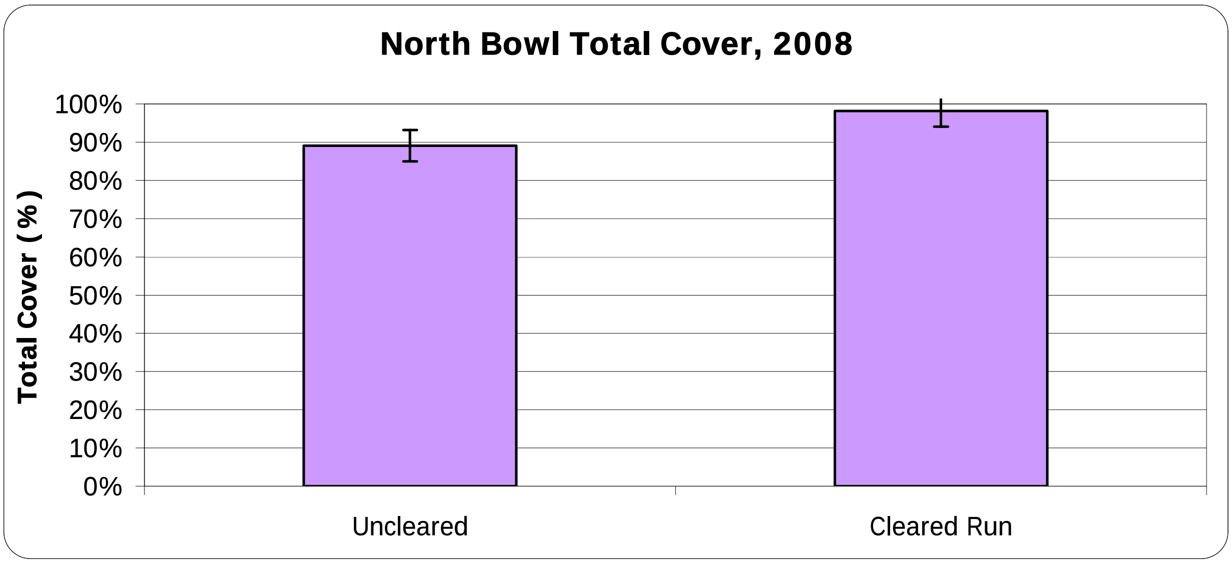


Figure 37. North Bowl Total Cover, 2008. The cleared run had slightly more mulch cover and less bare soil than the uncleared run. The error bars represent one standard deviation above and below the mean.

Soil Nutrients

The organic matter content for soil at the cleared run and the unlceared reference area were both 3% (Figure 38). The success criterion, which states that the cleared run organic matter content must be no more than 1.5 percentage points lower than that of the reference area level, was met. The TKN for the cleared run (672 ppm) was 157 ppm lower than the TKN the uncleared run (829 ppm). A success criterion for TKN was not used in 2009, as discussed in Appendix B.

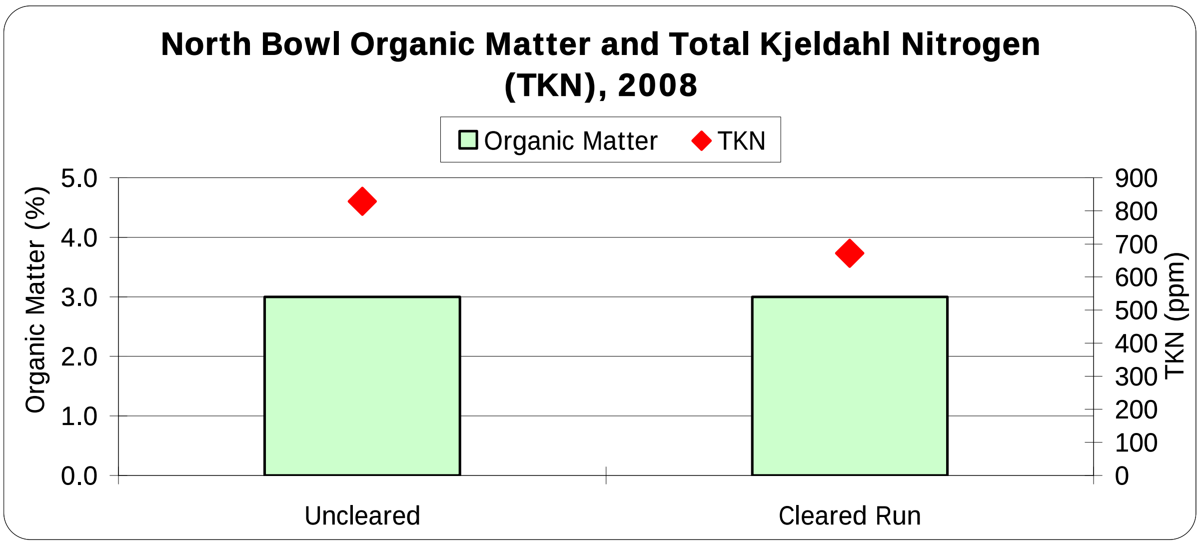


Figure 38. North Bowl Organic Matter and Total Kjeldahl Nitrogen (TKN), 2008. The organic matter content for the cleared run and the reference area was 3%. The TKN for the cleared run was 157 ppm or 19% lower than the TKN for the uncleared run.

Visible Erosion Assessment

Pine needle movement, which is sometimes an indicator of erosion, was observed at the cleared run. No sediment deposition was observed on the upslope side of the pine needles, suggesting that wind transport was the likely mechanism for pine needle movement. No other signs of erosion were present. The success criterion, which states that no visible signs of rills, gullies, sediment transport, or sediment deposition can be present, was met.

Management Response

Most of the success criteria were met for the North Bowl site. Monitoring results indicate an infiltration rate similar to the uncleared reference plot, a low to moderate sediment yield, a similar soil density (as measured by cone penetrometer) to the uncleared reference plot, a high total cover, and adequate nutrient levels that were similar to those at the uncleared reference run. A closer look at the unmet success criterion for sediment yield is necessary, as the primary project objective is no net increase in sediment yield from run clearing (Table 9). As discussed in the call out box next to Figure 35, the higher sediment yield measured at the cleared run is likely a result of preferential placement of rainfall simulation frames in areas with lower duff/litter layers. The measured sediment yield is still low to moderate compared to other sites. Additionally, other key indicators of erosion potential (total cover, infiltration rate, soil density) measured at this site suggest that the cleared run has very low erosion potential and that this project has achieved the project objective of no net increase in runoff or sediment transport. Therefore, visual erosion assessment is recommended on a yearly basis (and during or immediately after rain events) to identify and address any erosion problems that may occur. Additionally, annual photo monitoring is recommended to visually document changes in understory vegetation that may result from creating gaps in the tree canopy.

Table 9. North Bowl Management Responses for Unmet Success Criterion.

	Unmet Success Criterion	Management Response
Cleared Run	Sediment Yield	Visual erosion assessment
Cleared Run	n/a	Photo monitoring

Orion II Ski Run Clearing Project

Overview

The Orion II ski run clearing project includes the creation of a new ski run to connect the Orion ski run with the Upper Dipper Return run near the base of the Dipper Express Chairlift. To minimize impacts to soil and vegetation, the clearing occurred during spring 2008, while snow was on the ground. Upper Dipper Return was cleared: all trees in the run alignment were hand felled, removed by helicopter, and the stumps were flush cut with chain saws. Much like the North Bowl ski run projects, clearing is being used as an alternative to smooth grading, which tends to have substantial impacts on soils, vegetation, and erosion potential (Grismer and Hogan, Burt and Rice, 2009). The impacts to soil and vegetation were monitored in 2008. The cleared run was sampled again in 2009, to verify the 2008 findings of shallower penetrometer DTR depths at the cleared run.

Site Description

Cleared Run

This cleared run was cut in a forested area with lodgepole pine (*Pinus contorta*) and Western white pine (*Pinus monticola*; Figure 40). There is no canopy cover and little understory vegetation was present in the cleared area. No non-native species were observed. Large rocks, tree branches, and stumps were scattered throughout the cleared area. The soil is derived from granitic parent material. The site is moderately sloped (19 degrees), faces northwest, and had a summer solar exposure of 68-79%. The site elevation is approximately 8,922 feet AMSL.

Uncleared Reference

This reference site is in a forested area adjacent to the cleared run with lodgepole pine (*Pinus contorta*) and Western white pine (*Pinus monticola;* Figure 41). There is no canopy cover in the area sampled, but variable canopy cover in the surrounding areas. Very little understory vegetation exists. No non-native species were observed. The soil is derived from granitic parent material with approximately 40% coarse fragments greater than 0.5 inches in diameter. The site is moderately sloped (21 degrees), faces northwest, and has a summer solar exposure of 74-86%. The site elevation is approximately 8,964 feet AMSL.

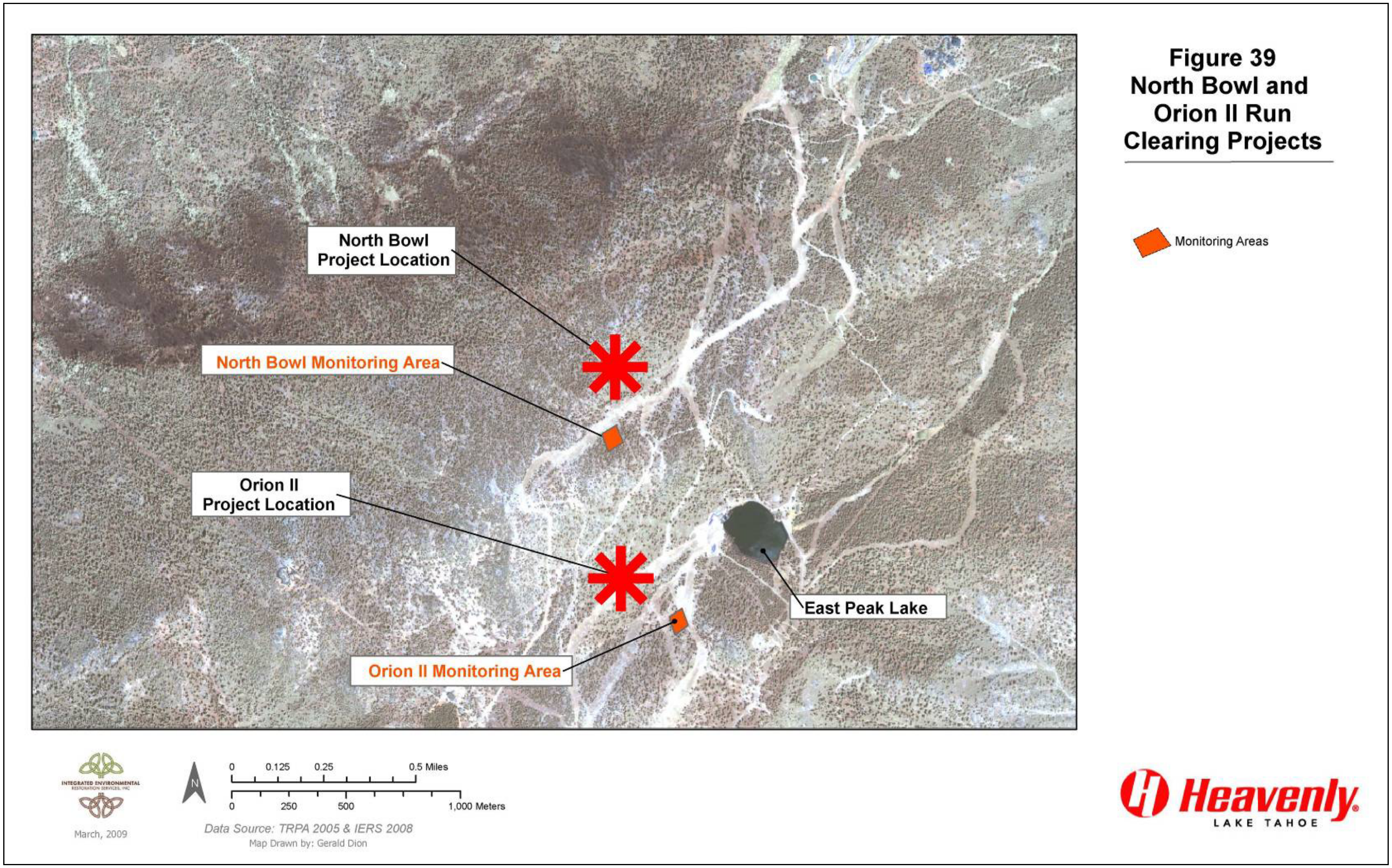


Figure 39. Orion II Ski Run Clearing Project Map.

Figure 40. Orion II run cleared area.

Figure 41. Orion II uncleared reference area. The cleared run is visible just in front of the truck.

Objectives and Success Criteria

Treatment Objectives

- no net increase in runoff and/or sediment transport as a result of ski run clearing

Monitoring Objectives

- to quantitatively assess whether run construction resulted in a net change in runoff and/or sediment transport

Success Criteria

The following success criteria are being used to determine whether run construction treatments achieved the project treatment goals in 2008, one year following construction (Table 10). The success criteria are based on the following indicators: penetrometer depth to refusal (DTR, used as an index for soil density), total cover, organic matter, and visual erosion assessment. A success criterion for TKN was not used in 2009, as discussed in Appendix B. In addition to evaluating short-term treatment success, these indicators represent key information needed to assess the likelihood of long-term sustainability of the soil-plant system, which is the key to long-term sediment source control.

Table 10. Orion II Ski Run Success Criteria Evaluation.

	Cleared Run Success Criteria	Cleared Run Success Criteria Evaluation
Penetrometer Depth (inches)	Not greater than 4 inches shallower than pre-treatment level	√ Success Criterion Met
Total Cover (%)	Not greater than 15 percentage points below pre-clearing level	√ Success Criterion Met*
Organic Matter (%)	Not greater than 1.5 percentage points less than pre-treatment level	√ Success Criterion Met*
TKN (PPM)	TKN not used as a metric for measuring success	n/a, see Appendix B
Visual Assessment	No visible signs of erosion including rilling, gullying, or other sediment transport and deposition.	√ Success Criterion Met
*Evaluated in 2008		

Performance Monitoring

Photo monitoring was conducted for the Orion II ski run clearing project in 2007 and 2008 (Figure 42, Figure 43, Figure 44, and Figure 45). In 2008, some soil and vegetation monitoring was conducted at the cleared run and at a nearby uncleared area that was used as a reference area. In 2009, penetrometer monitoring was conducted at the cleared run and at the uncleared reference area to provide more insight into the 2008 penetrometer results.

Figure 42. Orion II Ski Run Clearing Project, before clearing, 2007, as seen from the top of the Olympic Lift.

Figure 43. Orion II Ski Run Clearing Project, after clearing, 2008, as seen from the top of the Olympic Lift.

Figure 44. Orion II Ski Run Clearing Project, after clearing, 2008, looking down at East Peak Lake. Cleared ski run in foreground.

Figure 45. Orion II Ski Run Clearing Project, after clearing, 2007, as seen from the bottom of Dipper Lift.

Penetrometer DTR

In 2008, the penetrometer DTR at the cleared run, 8.8 inches, was 2.7 inches shallower than the DTR at the reference run without clearing, 11.5 inches (Figure 46). In 2009, the penetrometer DTR at the cleared run was 9.2 inches, which was 2.3 inches shallower than the DTR at the reference run without clearing. The success criterion, which states the cleared run DTR should be no more than 4 inches shallower than the reference area, was met.

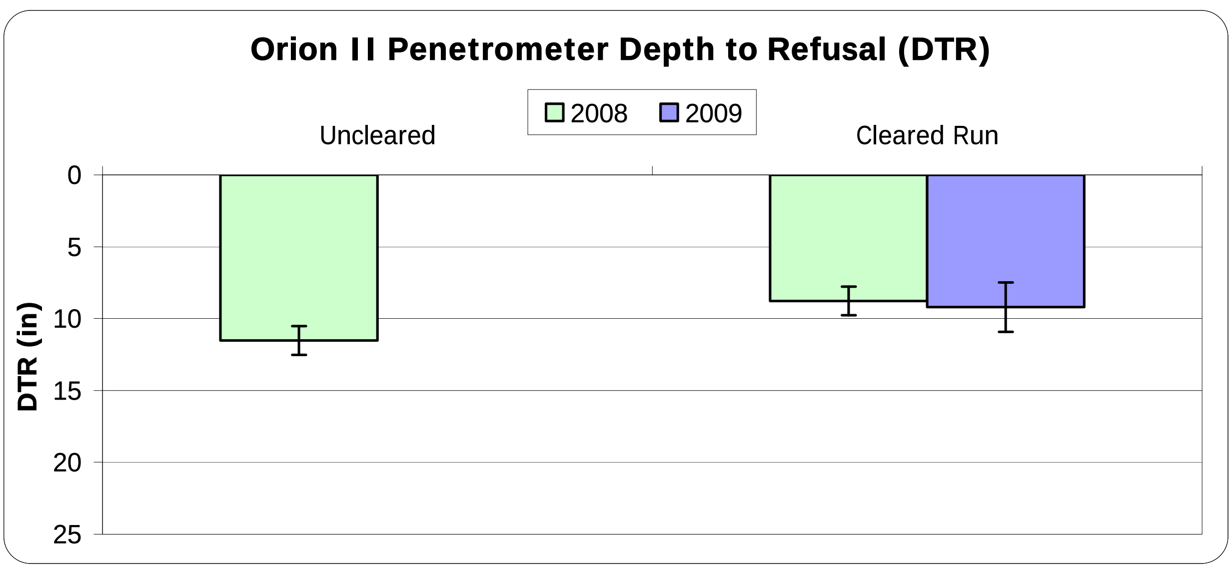


Figure 46. Orion II Penetrometer Depth to Refusal (DTR). The penetrometer DTR at the cleared run, was 2.7 inches shallower than the DTR at the uncleared run in 2008 and 2.3 inches uncleared run in 2009. The error bars denote one standard deviation above and below the mean.

Cover

The total cover at the cleared run (96%) was 14 percentage points higher than the total cover at the uncleared run (82%, Figure 47). The total cover composition was different at each plot. The cleared run had a high proportion of mulch, while the uncleared run had a high proportion of rocks. The success criterion for total cover, which states that total cover at the cleared run should be not more than 15 percentage points below that of the reference area, was met.

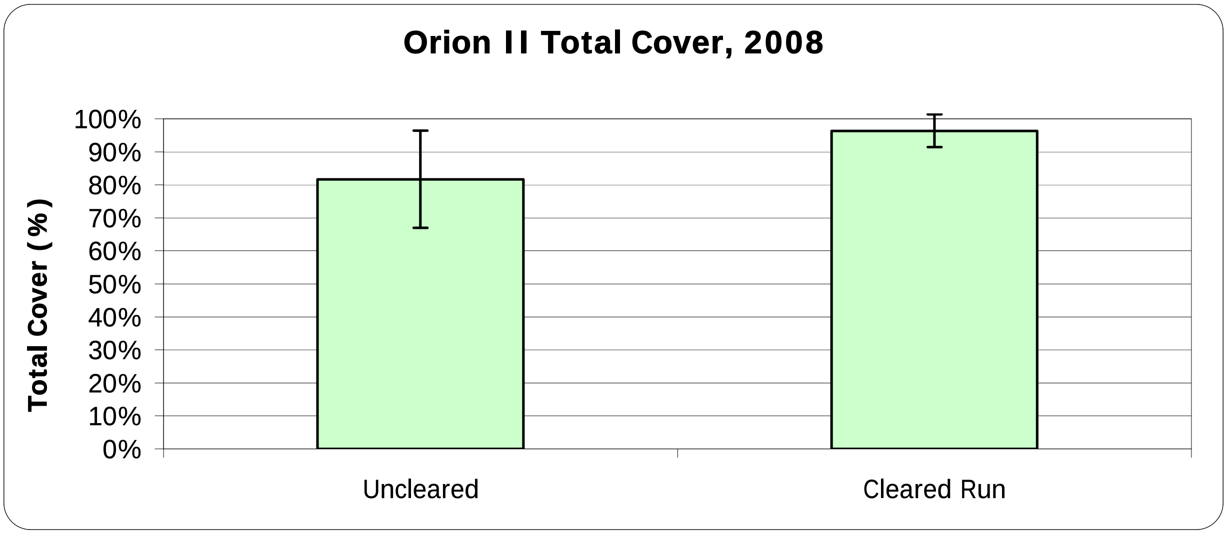


Figure 47. Orion II Total Cover, 2008. The total cover at the cleared run (96%) was 14 percentage points or 17% higher than the total cover at the uncleared run (82%). The error bars denote one standard deviation above and below the mean.

Soil Nutrients

Organic matter levels were similar at the cleared run (2.9%) compared to the reference area (2.8%; Figure 48). The success criterion for organic matter, which states that the organic matter at the cleared run has to be no more than 1.5 percentage points less than at the reference area, was met. TKN levels were 87 ppm or 11% lower at the cleared run (670 ppm) compared to the reference area (757 ppm; Figure 48). A success criterion for TKN was not used in 2009, as discussed in Appendix B.

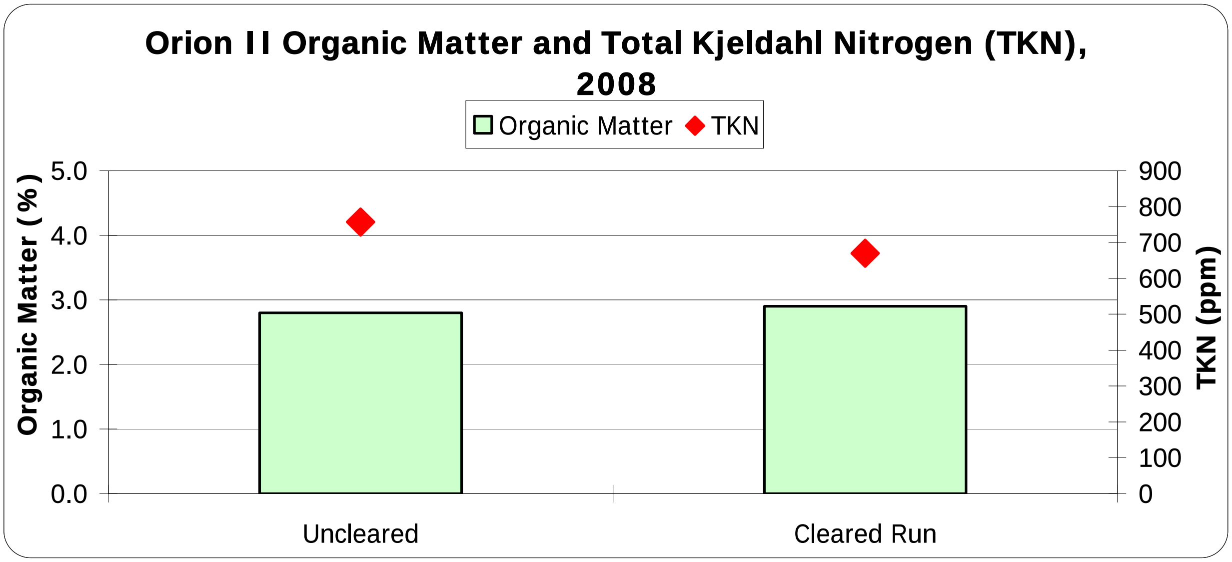


Figure 48. Orion II Organic Matter and Total Kjeldahl Nitrogen (TKN), 2008. Organic matter levels were similar at the cleared run (2.9%) compared to the reference area (2.8%) TKN levels were lower at the cleared run (670 ppm) compared to the reference area (757 ppm).

Visible Erosion Assessment

Pine needle movement, which is sometimes an indicator of erosion, was observed at both the reference area and at the cleared run in 2008 and 2009. No sediment deposition was observed on the upslope side of the pine needles, suggesting that wind transport was the likely mechanism for pine needle movement. No other signs of erosion were present. The success criterion, which states that no visible signs of rills, gullies, sediment transport, or sediment deposition can be present, was met.

Management Response

All of the success criteria were met for the Orion site, indicating that the project outcome was aligned with the primary project objective of no net increase in sediment yield from run clearing. Monitoring results indicate a sediment yield and infiltration rate similar to the uncleared reference plot, a similar soil density (as measured by cone penetrometer) to the uncleared reference plot, a high total cover, and adequate nutrient levels that were similar to those at the uncleared reference run. Visual erosion assessment is recommended on a yearly basis in order to identify and remedy any small erosion problems before they become larger problems (Table 11). Visual observation is recommended during and immediately after rain events, to ensure that erosion is not occurring. Annual photo monitoring is also recommended to document changes in understory vegetation that may occur due to increased solar exposure from reduction in tree canopy.

Table 11. Orion II Management Responses for Unmet Success Criterion

	Unmet Success Criterion	Management Response
Cleared Run	n/a	Visual erosion assessment
Cleared Run	n/a	Photo monitoring

Olympic Lift Replacement Project

Overview

The Olympic Lift Replacement Project, completed in 2007, included the replacement of the existing lift towers in addition to the top and bottom lift terminals. Disturbances to soil and vegetation associated with this project included re-grading segments of ski runs, soil compaction from heavy equipment, and trenching for utility lines. Restoration treatments were partially implemented in 2007 and completed in 2008. Performance monitoring was conducted in 2009. There are three treatment plots at the top terminal and five treatment plots at the bottom terminal. Three monitoring areas, which are within the treatment areas, have also been established for this project – one at the top terminal and two at the bottom terminal. All restoration treatment and monitoring areas are described in detail below and are shown on the project map (Figure 49).

Site Description

Olympic Lift Bottom

Olympic lift bottom is a disturbed area that encompasses the current bottom lift terminal and a portion of the Olympic Downhill ski run that funnels to the lift terminal (Figure 49, Figure 50, and Figure 51). This site is at an elevation of 8,561 feet AMSL on rocky soil derived from granitic parent material and faces northeast. Before treatment, non-native plants were present. The surrounding vegetation includes an overstory of red fir (*Abies magnifica*), whitebark pine (*Pinus albicaulis*), and Western white pine (*Pinus monticola*), with an understory of pinemat manzanita (*Arctostaphylos nevadensis*). The treatment area is dominated by a non-native fescue (*Festuca trachyphylla*). The tree canopy cover is less than 10%, the solar exposure is 70%, and the slope angle is 20 degrees. Rills and gullies caused by water erosion were observed throughout the site pre-treatment. In 2009, post-treatment, tire tracks were found on skiers left side of the Bottom A slope. Pine needle movement was evident throughout and may have been a result of water erosion or animal disturbance. Trash was found scattered through the area.

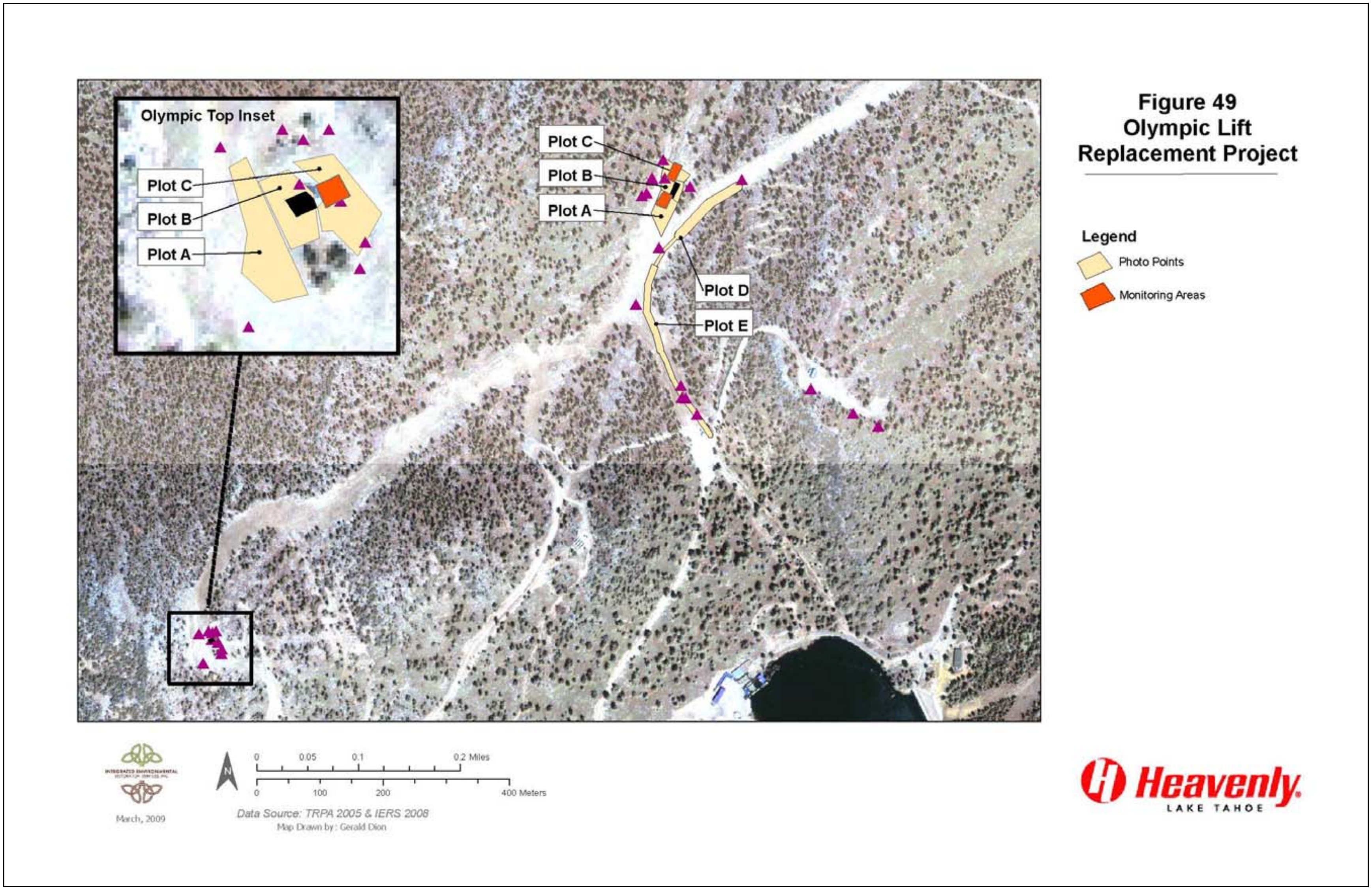


Figure 49. Olympic Lift Replacement Project Map.

Figure 50. Olympic Lift Bottom, Olympic Downhill ski run, pre-treatment, 2007.

Figure 51. Olympic Lift Bottom, old bottom terminal, pre-treatment, 2007.

Olympic Lift Top

Olympic lift top is a disturbed area surrounding the top lift terminal (Figure 49, Figure 52, and Figure 53). It is at an elevation of 9,445 ft AMSL on granitic parent material and faces north. The surrounding vegetation includes lodgepole pine (*Pinus contorta*), whitebark pine (*Pinus albicaulis*), and native grasses. Vegetation in the treatment area includes of Western needlegrass (*Achnatherum occidentale*) and lodgepole pine. Also present was a non-native grass species, quackgrass (*Elymus trachycaulus*). There is no tree canopy cover and the solar exposure is 99%.

Figure 52. Olympic Lift top, pre-treatment, 2007.

Figure 53. Olympic Lift top, pre-treatment, 2007.

Objectives and Success Criteria

Treatment Objectives

- no net increase in runoff and/or sediment transport as a result of lift terminal replacement and associated site grading
- to establish an appropriate, self-sustaining, native plant communities
- no evidence of erosion caused by lift terminals (i.e. concentrated runoff or dripping)

Monitoring Objective

- to quantitatively assess whether treatments resulted in a net change in runoff and/or sediment transport following lift terminal replacement

Success Criteria

The following success criteria are being used to determine whether implemented treatments achieved the treatment goals of the project in 2009, one year following completion of treatments (Table 12). The success criteria are based on the following indicators: sediment yield, infiltration rate, penetrometer depth to refusal (DTR, used as an index for soil density), total cover, plant cover, organic matter, and visual erosion assessment. A success criterion for TKN was not used in 2009, as discussed in Appendix B. In addition to evaluating short-term treatment success, these indicators represent key information needed to assess the likelihood of long-term sustainability of the soil-plant system, which is the key to long-term sediment source control.

Table 12. Olympic Lift Success Criteria Evaluation.

	Success Criteria	Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 100 lbs/acre/in higher than pre-treatment levels	Top:* √ Criterion Met A:** √ Criterion Met C:*** √ Criterion Met
Infiltration Rate (in/hr)	Not greater than 0.8 in/hr lower than pre-treatment levels	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met
Penetrometer Depth (inches)	Not greater than 4 inches shallower than pre-treatment level	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met
Total Cover (%)	70% or greater	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met
Total Plant Cover (%)	10% or greater	Top: × Criterion Not Met A: × Criterion Not Met C: × Criterion Not Met
Organic Matter (%)	Not greater than 1.5 percentage points less than pre-treatment level	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met
TKN (ppm)	TKN not used as a metric for measuring success	n/a, see Appendix B
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition. No erosion resulting from runoff or dripping from foundations or decks.	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met

*Top = Olympic Lift Top
**A = Olympic Lift Bottom, Treatment Area A
***C = Olympic Lift Bottom, Treatment Area C

Restoration Treatments

Olympic Lift Bottom

The Olympic Lift Bottom consists of five individual treatment areas (Figure 49, Table 13, Figure 54, Figure 55, Figure 56, Figure 57, Figure 58, and Figure 59). In 2007, treatments in many of these areas were started, but not completed. In 2008, treatments in all areas were completed in accordance with project specifications. Soil and vegetation treatment specifications varied slightly among the different areas, depending on site conditions and planned future use. However, treatments in all areas were to include the following elements of full soil restoration: soil amendments, tilling, organic fertilizer, seed, and mulch. Temporary irrigation was also applied in several of these treatment areas to encourage rapid seed germination. Table 13 details the specific treatment elements implemented at each treatment area. The type of disturbance associated with each treatment area is described briefly below:

- Treatment Area A – re-graded ski run upslope of lower lift terminal
- Treatment Area B – saddle where lower lift terminal was replaced
- Treatment Area C – re-graded ski run down slope of lower lift terminal
- Treatment Area D – removed/treated section of Olympic Traverse Road
- Treatment Area E – disturbed area along utility line trench

Table 13. Olympic Lift Bottom Treatment Matrix.

		Treatment Area				
		A	B	C	D	E
Amendments	Type	WC, FCZ, DWS	WC	WC, FCZ	WC, FCZ	WC, DWS
	Depth (in)	4	4*	4	4	4
Tilling	Depth (in)	15	10	12	12	20
Fertilizer	Type	Biosol 6-1-3	Biosol 6-1-3*	Biosol 6-1-3	Biosol 6-1-3*	Biosol 6-1-3*
	Rate (lbs/acre)	2,000	2,000*	2,000	2,000*	2,000*
Seed	Mix	Heavenly upland mix*	Heavenly upland mix*	Heavenly upland mix*	Heavenly upland mix*	Heavenly upland mix*
	Rate (lbs/acre)	87*	87*	87*	87*	87*
Mulch	Type	PNM	PNM	PNM	PNM	PNM
	Depth (in)	1	1	1	1	1
Irrigation	Frequency/ Duration	yes – unknown	yes – unknown	no	yes – unknown	no
Treatment Area	Square Feet	16,915	7,805	9,713	24,441	30,437

Key
WC = wood chips
FCZ = Full Circle Integrated Tahoe Blend Zero (composted coarse overs)
DWS = decomposed wood shavings
PNM = pine needle mulch
* = not verified in field

Figure 54. Olympic lift bottom, treatment area A, pre-treatment, 2007.

Figure 55. Olympic lift bottom, treatment area A, post-treatment, 2008.

Figure 56. Olympic lift bottom, treatment area A, post-treatment, 2009.

Figure 57. Olympic lift bottom, treatment area B, pre-treatment, 2007.

Figure 58. Olympic lift bottom, treatment area B, post-treatment, 2008.

Figure 59. Olympic lift bottom, treatment area B, post-treatment, 2009.

Olympic Lift Top

The Olympic lift top area consists of three individual treatment areas surrounding the upper Olympic lift terminal (Figure 49, Table 14, Figure 60, Figure 61, Figure 62, Figure 63, Figure 64, and Figure 65). Soil and vegetation treatments for areas A and C included the following treatment elements: soil amendments, tilling, organic fertilizer, seed, and mulch. Area B was mulched to provide soil protection, rather than full restoration treatment, as this skier down ramp area is continually impacted by grooming and foot traffic. Rock slope protection was used to stabilize the cut slope between the lift terminal and treatment area C, as soil and vegetation-based treatments were unlikely to be successful due to steep slope angles, poorly developed soils, and likelihood of ongoing disturbance. Since the area near the top of Olympic Lift serves as a popular viewpoint for hikers in the summer, Heavenly constructed a foot trail between treatment areas A and B, fenced off the treatment areas, and posted educational signage to keep visitors from disturbing the recently treated revegetation areas (Figure 65). These treatment area protection measures proved to be very effective during summer 2008. These treatments were partially implemented in 2007 and completed in 2008.

- Treatment Area A – flat parking area above lift terminal
- Treatment Area B – fill slope (skier down ramp) surrounding upslope side of lift terminal
- Treatment Area C – fill slope below lift terminal

Table 14. Olympic Lift Top Treatment Matrix.

		Treatment Area		
		A	B	C
Amendments	Type	WC, FCZ	n/a	WC, FCZ
	Depth (in)	4	n/a	4
Tilling	Depth (in)	12	n/a	10
Fertilizer	Type	Biosol 6-1-3	n/a	Biosol 6-1-3
	Rate (lbs/acre)	2,000	n/a	2,000
Seed	Mix	Heavenly upland mix	n/a	Heavenly upland mix
	Rate (lbs/acre)	87	n/a	87
Mulch	Type	PNM	WC	PNM
	Depth (in)	1	2	1
Irrigation	Frequency/Duration	yes – unknown	n/a	yes – unknown
Treatment Area	Square Feet	5,165	4,196	5,552

Key
WC = wood chips
FCZ = Full Circle Integrated Tahoe Blend Zero (composted coarse overs)
DWS = decomposed wood shavings
PNM = pine needle mulch

Figure 60. Olympic lift top, pre-treatment, 2007.

Figure 61. Olympic lift top, post-treatment, 2008.

Figure 62. Olympic lift top, pre-treatment, 2007.

Figure 63. Olympic lift top, post-treatment, 2008.

Figure 64. Olympic lift top, post-treatment, 2009.

Figure 65. Olympic lift top, treatment area protection.

Performance Monitoring

Post-treatment monitoring was conducted at one plot at Olympic top and two plots at Olympic bottom. The pre-treatment data from the sole pre-treatment monitoring plot at the Olympic bottom was compared to both post-treatment plots and therefore appears twice on each graph.

Infiltration and Sediment Yield

The post-treatment sediment yield at the Olympic lift top (334 lbs/acre/in) was 67% lower than the pre-treatment sediment yield (1,019 lbs/acre/in, Figure 66). The post-treatment sediment yield at the Olympic lift bottom A (14 lbs/acre/in) was 88% lower than the pre-treatment sediment yield (113 lbs/acre/in).

The post-treatment sediment yield at the Olympic lift bottom C (264 lbs/acre/in) was 151 lbs/acre/in or 133% higher than the pre-treatment sediment yield (113 lbs/acre/in). The post-treatment sediment yield may have been affected by the hydrophobic conditions observed at Frame 1. Simulations that take place under hydrophobic conditions cannot be compared to those under typical summer conditions, as observed in Frames 2 and 3 (see callout next to Figure 66 for more information). When the Frame 1 sediment yield is removed from the average, the post-treatment sediment yield (20 lbs/acre/in) is 93 lbs/acre/in or 82% lower than the pre-treatment sediment yield (113 lbs/acre/in). The success criterion, which states that the sediment yield must be no more than 100 lbs/acre/in higher than the pre-treatment sediment yield, was met for all three plots.

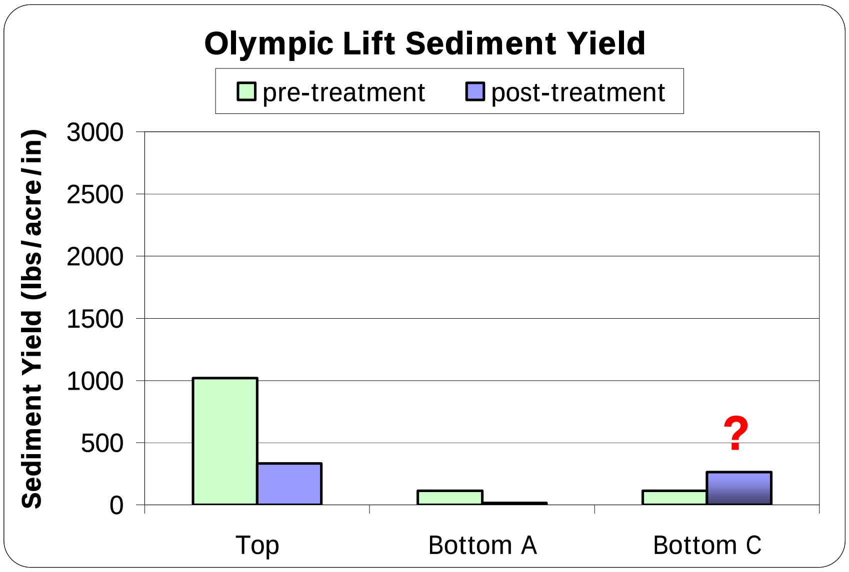


Figure 66. Olympic Lift Sediment Yield. Sediment yield decreased by 67% from 1,019 to 334 lbs/acre/in at the top and by 88% from 113 to 14 lbs/acre/in at bottom A. Sediment yield increased by 151 lbs/acre/in or 133% at bottom C from 113 to 264 lbs/acre/in (see callout next to this graph).

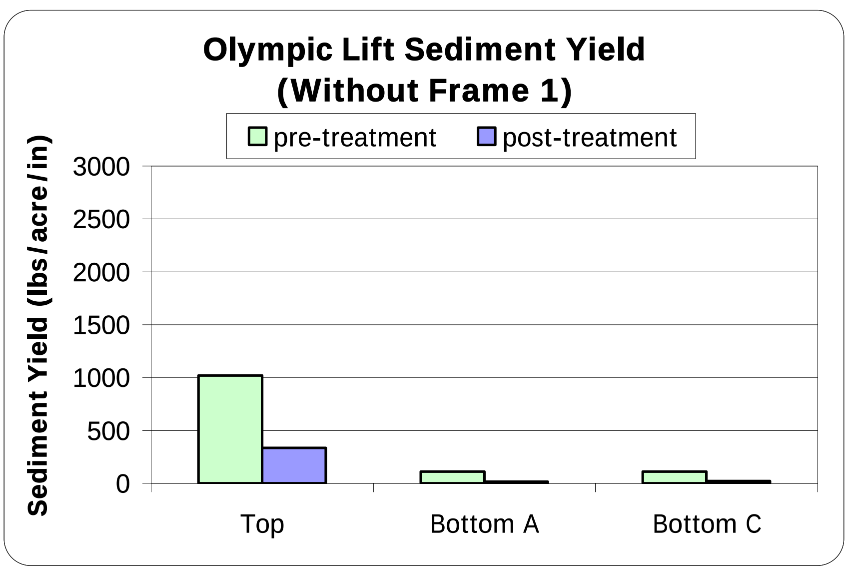


Figure 67. Olympic Lift Sediment Yield. After Frame 1 was removed from bottom C (see sidebar), the sediment yield decreased by 82% from 113 lbs/acre/in to 20 lbs/acre/in.

A Closer Look

Why did the sediment yield increase post-treatment at Bottom C?

Three frames were included in the sediment yield average:

Frame 1: 751 lbs/acre/in
Frame 2: no runoff
Frame 3: 40 lbs/acre/in

It was noted during the simulation that slight hydrophobic conditions may have been present at Frame 1.

The depth of water penetration with in the rainfall frame in Frame 1 was 1 inch, compared to 10 inches for Frame 2 and 9 inches for Frame 3. The shallow wetting depth at Frame 3 is consistent with the hydrophobic observation.

Shallow wetting depths can also be a result of compacted soil. Penetrometer depths within each frame were:

Frame 1: 9 inches
Frame 2: 13 inches
Frame 3: 11 inches

The similarly high penetrometer depths for each frame indicate that compaction did not lead to the higher sediment yield. Data collected under hydrophobic conditions cannot be compared to those collected under non-hydrophobic conditions. Figure 67 shows bottom C results without the Frame 1 sediment yield.

The average infiltration rate at the Olympic lift top post-treatment (3.6 in/hr) was 0.4 in/hr or 13% lower than the infiltration rate pre-treatment (3.2 in/hr, Figure 68). The average infiltration rate at the Olympic lift bottom A post-treatment (4.6 in/hr) was 44% higher than the infiltration rate pre-treatment (3.2 in/hr).

The average infiltration rate at the Olympic lift bottom C post-treatment (4.3 in/hr) was 34% higher than the infiltration rate pre-treatment (3.2 in/hr). When Frame 1 (hydrophobic result) was removed from the average, the post-treatment (4.7 in/hr) infiltration rate was 47% higher than the pre-treatment infiltration rate (3.2 in/hr).

The success criterion, which states that the post-treatment infiltration rate must be no more than 0.8 in/hr lower than the pre-treatment infiltration rate, was met for Olympic lift top, bottom A, and bottom C.

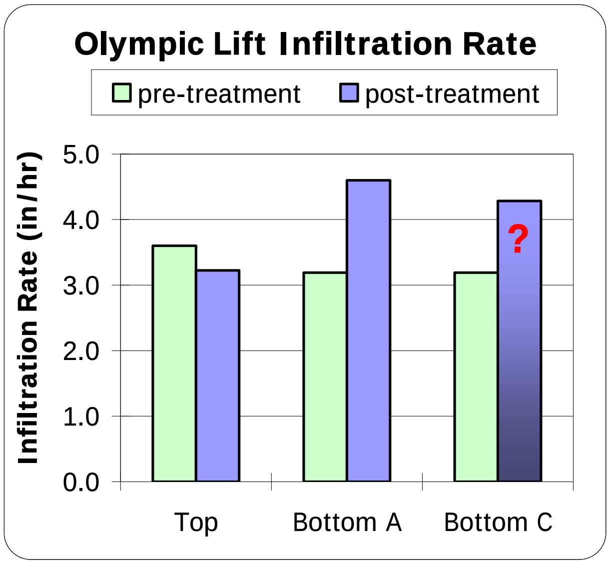


Figure 68. Olympic Lift Infiltration Rate. The average infiltration rate at the Olympic lift top decreased by 0.4 in/hr post-treatment. The average infiltration rate post-treatment at the Olympic lift bottom exhibited a 34-44% increase.

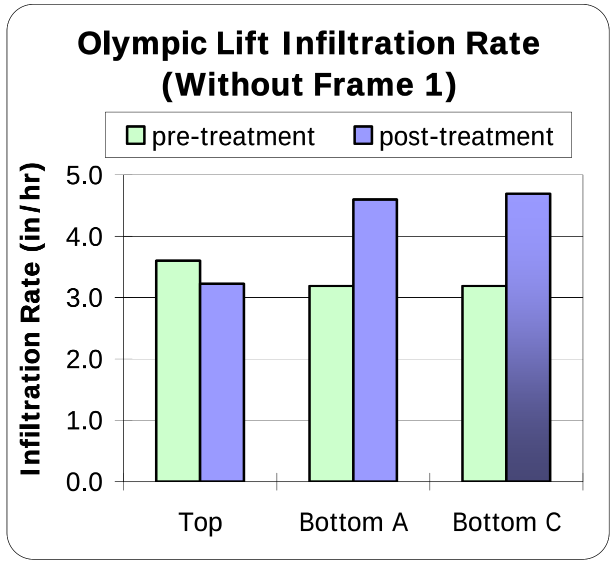


Figure 69. Olympic Lift Infiltration Rate without Frame 1. When Frame 1 (hydrophobic result) was removed from the average, the post-treatment (4.7 in/hr) infiltration rate was 47% higher than the pre-treatment infiltration rate (3.2 in/hr).

Penetrometer Depth to Refusal (DTR)

The post-treatment penetrometer DTR at the Olympic lift top (6 inches) was 1.3 inches shallower than the pre-treatment DTR (7.3 inches; Figure 70). The post-treatment penetrometer DTR at the Olympic lift bottom A (5.7 inches) was 1.5 inches shallower than the pre-treatment DTR (4.2 inches). The post-treatment penetrometer DTR at the Olympic lift bottom C (12.3 inches) was 8.2 inches deeper than the pre-treatment DTR (4.2 inches). The success criterion, which states that the post-treatment DTR must be no more than 4.0 inches shallower than the pre-treatment DTR, was met for all plots.

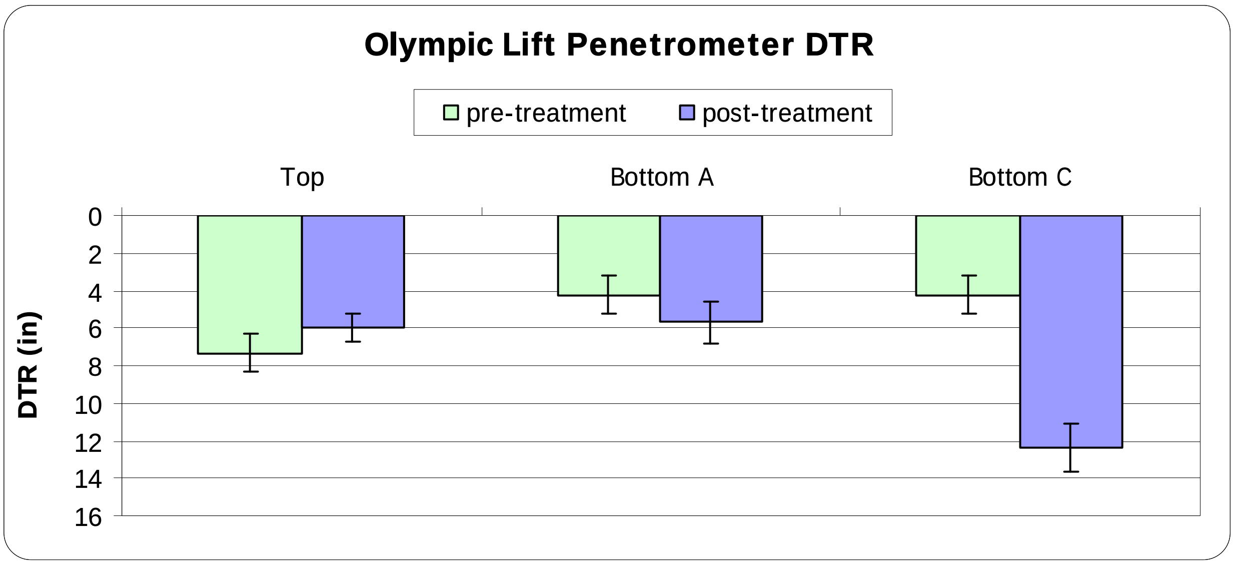


Figure 70. Olympic Lift Penetrometer DTR. The penetrometer DTR at the Olympic lift top was 1.3 inches shallower post-treatment. The penetrometer DTR at the Olympic lift bottom was 1.5 to 8.2 inches deeper post-treatment. The error bars denote one standard deviation above and below the mean.

Total Cover

The post-treatment total cover at the Olympic lift top (98%) was 78% higher than the pre-treatment total cover (55%; Figure 71). The post-treatment total cover at the Olympic lift bottom A (96%) was 75% higher than the pre-treatment total cover (55%). The post-treatment total cover at the Olympic lift bottom C (83%) was 51% higher than the pre-treatment total cover (55%). The success criterion, which states that the post-treatment total cover must be greater than 70%, was met for all plots.

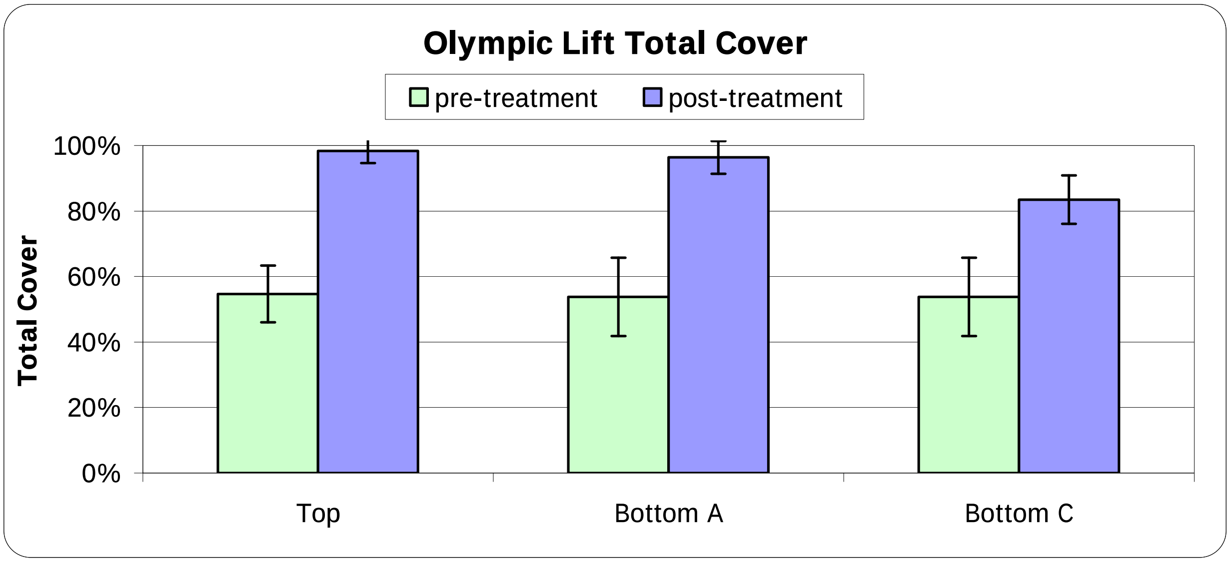


Figure 71. Olympic Lift Total Cover. The post-treatment total cover increased by 51-78% post-treatment and the total cover for all plots was 83% or greater. The error bars denote one standard deviation above and below the mean.

Plant Cover

The post-treatment plant cover at the Olympic Lift top (5%) was similar to the pre-treatment total cover (3%, Figure 72). The plant cover was dominated by grasses that were not mature enough to be identified.

The post-treatment total cover at the Olympic lift bottom A and C was 0%, compared to 15% pre-treatment at both plots. Ocular estimates indicated that there was approximately 2% cover by native plants at both Olympic bottom A and C that was not captured during cover point monitoring. This indicates that native plants are beginning to establish. Although the plant cover was higher before restoration treatments, it was dominated by non-native species, which may not provide long-term protection against erosion when compared to deep-rooting native perennial grasses. The success criterion, which states that the post-treatment plant cover be at least 10%, was not met for the Olympic plots.

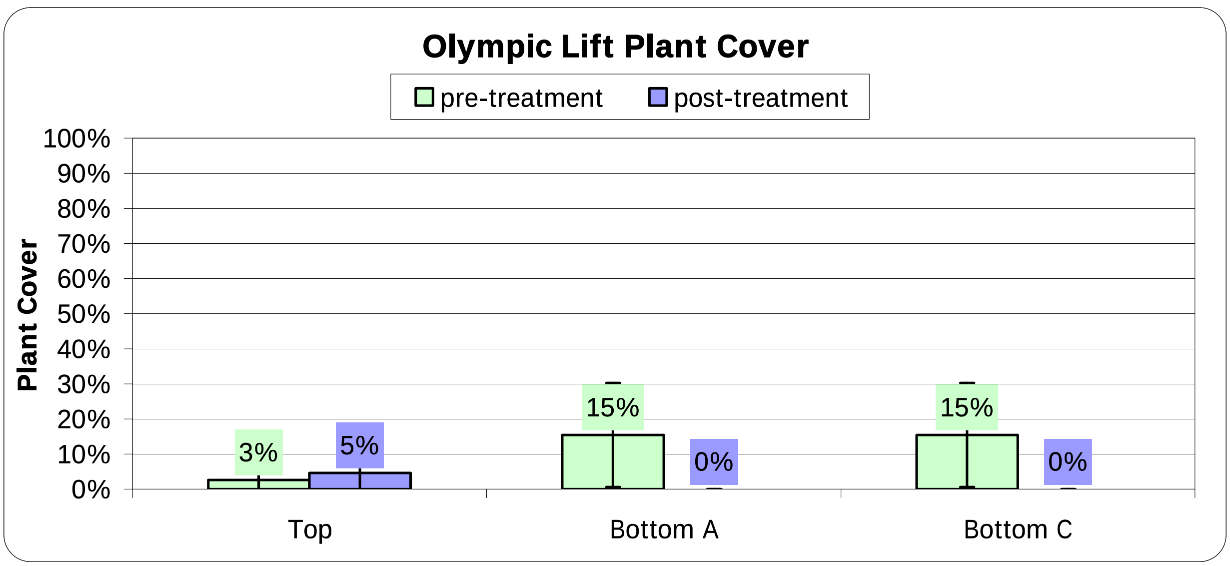


Figure 72. Olympic Lift Plant Cover. The post-treatment plant cover at the Olympic Lift Top (5%) was similar to the pre-treatment total cover (3%). The post-treatment total cover at the Olympic Lift Bottom A and C was 0%, compared to 15% pre-treatment. The error bars denote one standard deviation above and below the mean.

Soil Nutrients

Organic Matter

The post-treatment organic matter at the Olympic lift top (1.5%) was 114% higher than the pre-treatment organic matter (0.7%, Figure 73). The post-treatment organic matter at the Olympic lift bottom A (1.9%) was similar to the pre-treatment organic matter (1.4%). The post-treatment organic matter at the Olympic lift bottom C (1.1%) was similar to the pre-treatment organic matter (1.4%). The success criterion, which states that the post-treatment organic matter content must be no more than 1.5 percentage points lower than the pre-treatment organic matter, was met for all plots.

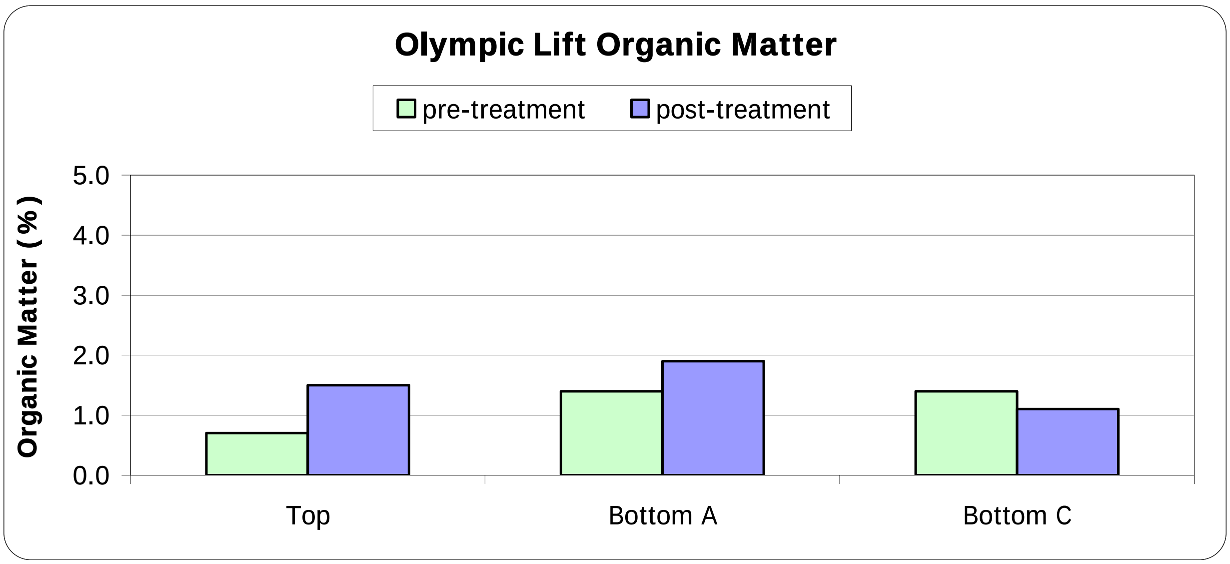


Figure 73. Olympic Lift Organic Matter. The organic matter at the Olympic lift top increased by 114% post-treatment, while at bottom A it increased by 36% post-treatment. The pre- and post-treatment organic matter contents at the Olympic lift bottom C were similar.

Total Kjeldahl Nitrogen (TKN)

The post-treatment TKN at the Olympic lift top (192 ppm) was 175 ppm or 56% lower than the pre-treatment TKN (467 ppm, Figure 74). The post-treatment TKN at the Olympic lift bottom A (176 ppm) was 589 ppm or 77% lower than the pre-treatment TKN (765 ppm). The post-treatment TKN at the Olympic lift bottom C (120 ppm) was 645 ppm or 84% lower than the pre-treatment TKN (765 ppm). A success criterion for TKN was not used in 2009, as discussed in Appendix B.

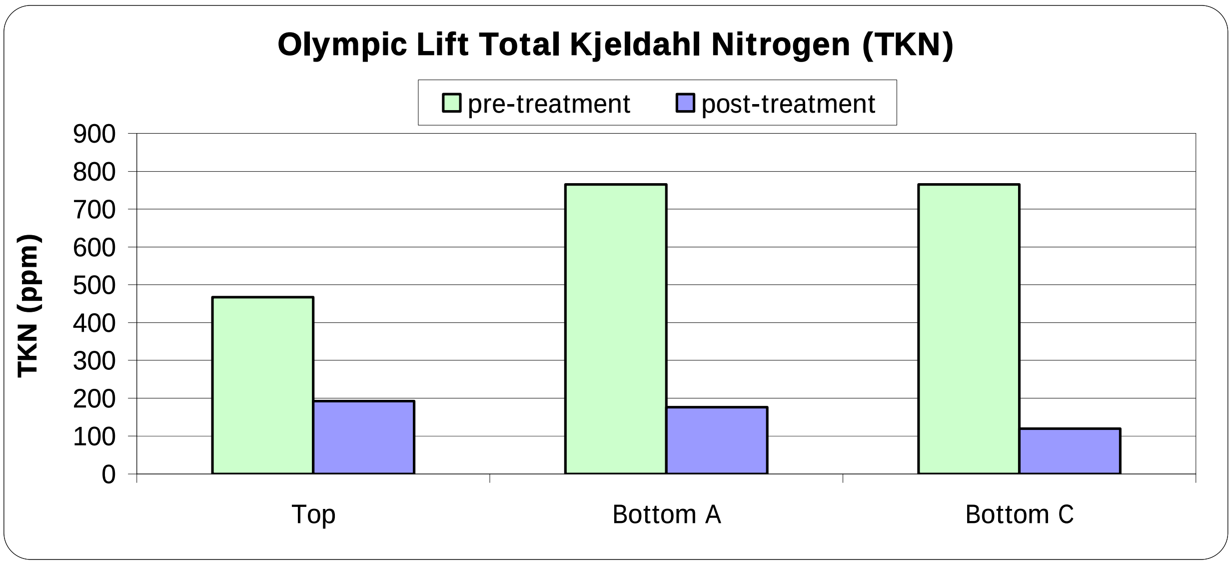


Figure 74. Olympic Lift Total Kjeldahl Nitrogen (TKN). The post-treatment TKN decreased by 56% to 84% at the Olympic lift plots.

Visual Erosion Assessment

At Olympic lift bottom A, tire tracks were observed on skier's left of the slope. Animal disturbance and pine needle movement, which is sometimes an indicator of erosion, were observed at both bottom A and bottom C. No sediment deposition was observed on the upslope side of the pine needles, suggesting that wind transport may be the mechanism for pine needle movement. No other major evidence of erosion was present at Olympic lift top or bottom. The criterion, which states that no visible signs of rills, gullies, sediment transport, sediment deposition, or erosion from dripping foundations or decks can be present, was met for all plots.

Management Response

Most of the success criteria were met for the Olympic Lift Replacement project, indicating that the project outcome was aligned with the primary project objective of no net increase in runoff or sediment yield (Table 9). Monitoring results indicate high infiltration rates, low sediment yield, low soil density (as measured by cone penetrometer) and high total cover.

The criterion for plant cover was not met at any of the Olympic lift plots. Additionally, the TKN was relatively low and lower than pre-treatment at all of the plots. Soil TKN and plant cover tend to be closely related. High-carbon soil amendments, which were used at this site, tend to reduce available nitrogen during decomposition, which can limit plant growth for several years. Another year of cover monitoring is recommended to better understand the long term trajectory for plant cover. If monitoring in 2010 indicates increasing trends, follow up treatments may not be necessary. However, if measurable plant cover is not present in 2010, treatment actions such as additional fertilizing, seeding and/or irrigation will be necessary to expedite vegetation establishment.

Visual erosion assessment is recommended on a yearly basis in order to identify and address any small problems before they become larger problems. Specifically, the vehicle tracks that were observed at Olympic A should be closely watched throughout the season, particularly during and immediately after rain events, to ensure that the tracks are not concentrating surface runoff and causing erosion. Additional mulching and/or soil loosening may be necessary if the tire tracks become an erosion problem. Additionally, it is recommended that Heavenly expand efforts to minimize disturbance of treatment areas by installing temporary fencing and/or signage and communicating the locations of sensitive treatment areas to operations staff.

Table 15. Olympic Lift Management Responses for Unmet Success Criterion.

	Unmet Success Criterion	Management Response
Top	Plant Cover	Cover monitoring
Top	n/a	Photo monitoring
Top	n/a	Visual erosion assessment
Bottom	Plant Cover	Cover monitoring
Bottom	n/a	Photo monitoring
Bottom	n/a	Visual erosion assessment
Bottom	n/a	Treatment area protection (fencing, signage, etc)

Heavenly Flyer Construction Project

Overview

The Heavenly Flyer Construction Project includes the installation of top and bottom terminals for a new zip line. Disturbances associated with this project included soil compaction from heavy equipment and some vegetation removal. There are two distinct treatment and monitoring areas: Heavenly Flyer bottom and Heavenly Flyer top. Each restoration treatment and monitoring area is described in detail below and is shown on the project map (Figure 76).

Heavenly Flyer Bottom

Heavenly Flyer Bottom was a relatively undisturbed area before treatment that encompasses the bottom lift terminal construction area (Figure 75). It is at an elevation of 9,151 feet AMSL on rocky soil derived from granitic parent material and faces southeast. The Heavenly Flyer bottom site is an open high elevation conifer forest dominated by white bark pine (*Pinus albicaulis*) with some Western white pine (*Pinus monticola*). The understory includes pinemat manzanita (*Arctostaphylos nevadensis*), and native forbs and grasses. A rare plant, Carson range rockcress (*Arabis rigidissima var. demota*), was present. The tree canopy cover is less than 5%, the solar exposure is 81%, and the slope angle is 15 degrees.

Figure 75. Heavenly Flyer bottom, pre-treatment, 2007.

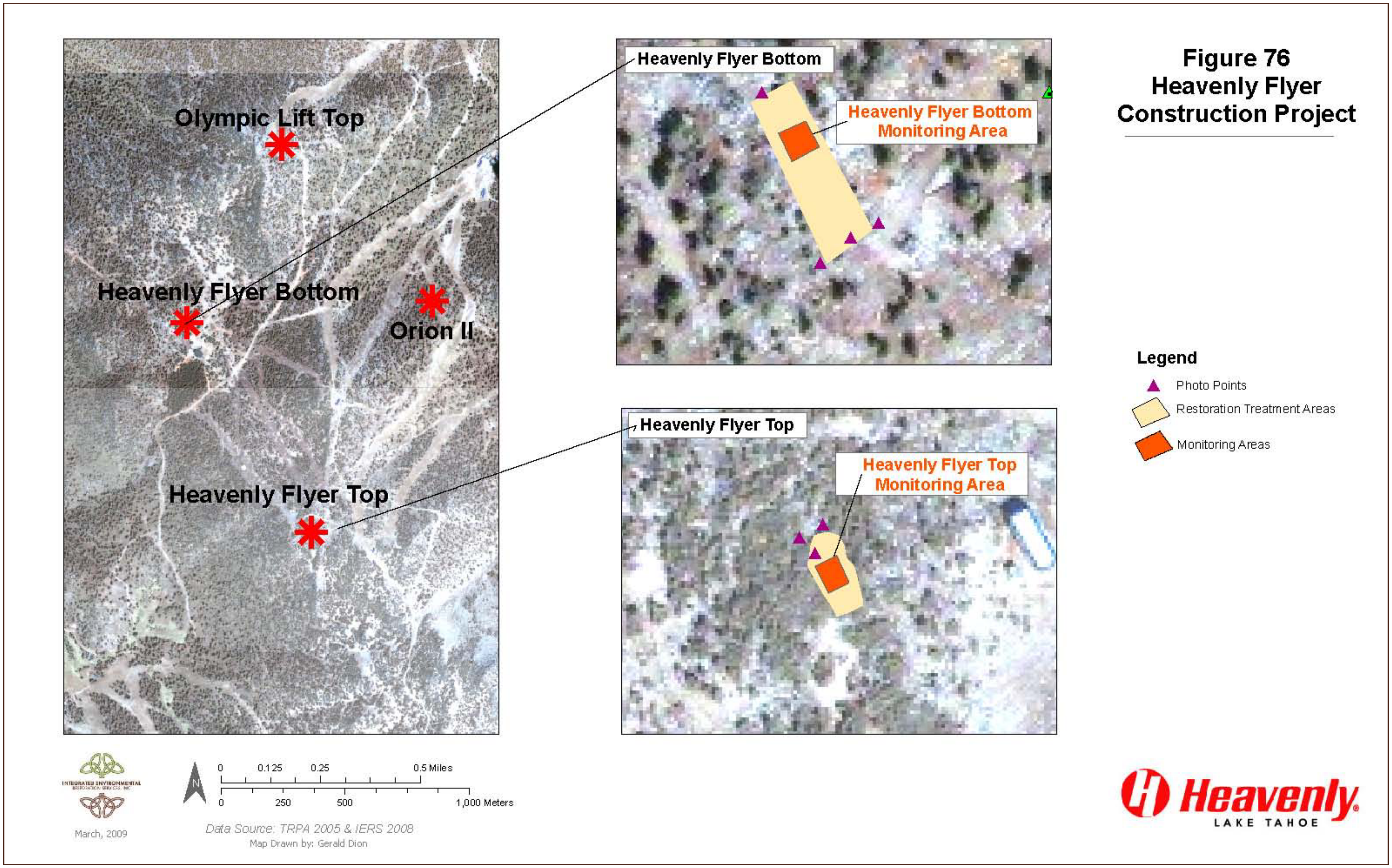


Figure 76. Heavenly Flyer Construction Project Map.

Heavenly Flyer Top

Heavenly Flyer top was a relatively undisturbed before treatment area that encompasses top lift terminal construction area (Figure 77). It is at an elevation of 9,395 feet AMSL on rocky soil derived from granitic parent material and faces north. The Heavenly Flyer top site is dominated by white bark pine (*Pinus albicaulis*) and has a thick layer of pine needle duff. The tree canopy cover is approximately 13%, the solar exposure is 44%, and the slope angle is 15 degrees.

Figure 77. Heavenly Flyer Top, pre-treatment cover point monitoring, 2007.

Objectives and Success Criteria

Treatment Objectives

- no net increase in runoff and/or sediment transport as a result of lift terminal replacement and associated site grading
- to establish an appropriate, self-sustaining, native plant community
- no evidence of erosion caused by zip line deck and foundations (i.e. concentrated runoff or dripping)

Monitoring Objective

- to quantitatively assess whether treatments resulted in a net change in runoff and/or sediment transport following construction of zip line terminals

Success Criteria

The following success criteria were used to determine whether implemented treatments achieved the treatment goals of the project (Table 16). The success criteria are based on the following indicators: sediment yield, infiltration rate, penetrometer depth to refusal (DTR, used as an index for soil density), total cover, plant cover, organic matter, and visual erosion assessment. A success criterion for TKN was not used in 2009, as discussed in Appendix B.

In addition to evaluating short-term treatment success, these indicators represent key information needed to assess the likelihood of long-term sustainability of the soil-plant system, which is the key to long-term sediment source control.

Table 16. Heavenly Flyer Success Criteria Evaluation.

	Success Criteria	Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 100 lbs/acre/in higher than pre-treatment levels	Top:* √ Criterion Met Bottom:** n/a
Infiltration Rate (in/hr)	Not greater than 0.8 in/hr lower than pre-treatment levels	Top: √ Criterion Met Bottom: n/a
Penetrometer Depth (inches)	Not greater than 4 inches shallower than pre-treatment level	Top: √ Criterion Met Bottom: √ Criterion Met
Total Cover (%)	70% or greater	Top: √ Criterion Met Bottom: √ Criterion Met
Total Plant Cover (%)	10% or greater	Top: × Criterion Not Met Bottom: × Criterion Not Met
Organic Matter (%)	Not greater than 1.5 percentage points less than pre-treatment level	Top: √ Criterion Met Bottom: √ Criterion Met
TKN (PPM)	TKN not used as a metric for measuring success	n/a, see Appendix B
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition. No erosion resulting from runoff or dripping from foundations or decks.	Top: √ Criterion Met Bottom: √ Criterion Met
*Top = Heavenly Flyer top **Bottom = Heavenly Flyer bottom		

Restoration Treatments

Heavenly Flyer Top and Heavenly Flyer Bottom

The Heavenly Flyer top and bottom areas each consist of a single, contiguous treatment area encompassing the area of disturbance from the construction of the zip line terminals (Figure 78, Figure 79, Figure 80 and Figure 81). Soil and vegetation treatments for each area included all elements of full soil and vegetation treatment: soil amendments, tilling, organic fertilizer, seed, and mulch (Table 17). In 2007, amendments were incorporated into the soil via hand tilling at both treatment areas and fertilizer and seed were applied. However, no pine needle mulch was applied. In 2008, both treatment areas were completed by applying additional seed and pine needle mulch. Additionally, temporary irrigation was used to encourage seed germination and plant establishment. Specific treatments implemented for the top and bottom areas are detailed below (Table 17).

Table 17. Heavenly Flyer Top and Bottom Treatment Matrix.

		Top	Bottom
Amendments	**Type**	WC, FCZ	WC, FCZ
	Depth (in)	4 (2" each)	4 (2" each)
Tilling	**Depth (in)**	11	8
Fertilizer	**Type**	Biosol 6-1-3*	Biosol 6-1-3*
	Rate (lbs/acre)	2,000*	2,000*
Seed	**Mix**	Heavenly upland mix*	Heavenly upland mix*
	Rate (lbs/acre)	87*	87*
Mulch	**Type**	PNM	PNM
	Depth (in)	1	1
Irrigation	**Frequency/Duration**	No	No
Treatment Area	**Square Feet**	2,412	7,521

Key
WC = wood chips
FCZ = Full Circle Integrated Tahoe Blend Zero (composted coarse overs)
PNM = pine needle mulch
* = not verified in field

Figure 78. Heavenly Flyer top, during construction, 2007. Pre-treatment conditions (very dense thicket of pine) were difficult to photograph.

Figure 79. Heavenly Flyer top, post-treatment, 2007.

Figure 80. Heavenly Flyer bottom, pre-treatment, 2007.

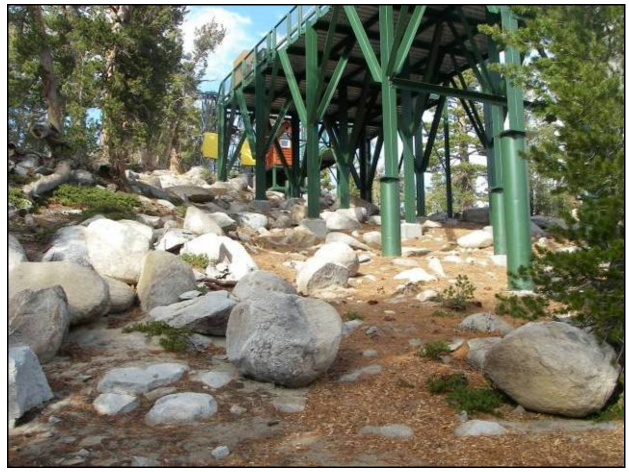


Figure 81. Heavenly Flyer bottom, post-treatment, 2008.

Performance Monitoring

Infiltration and Sediment Yield

The post-treatment sediment yield at the Heavenly Flyer top (40 lbs/acre/in) was nearly the same as the pre-treatment sediment yield (34 lbs/acre/in, Figure 82). The success criteria, which states that the post-treatment sediment yield cannot be more than 100 lbs/acre/in higher than the pre-treatment sediment yield, was met.

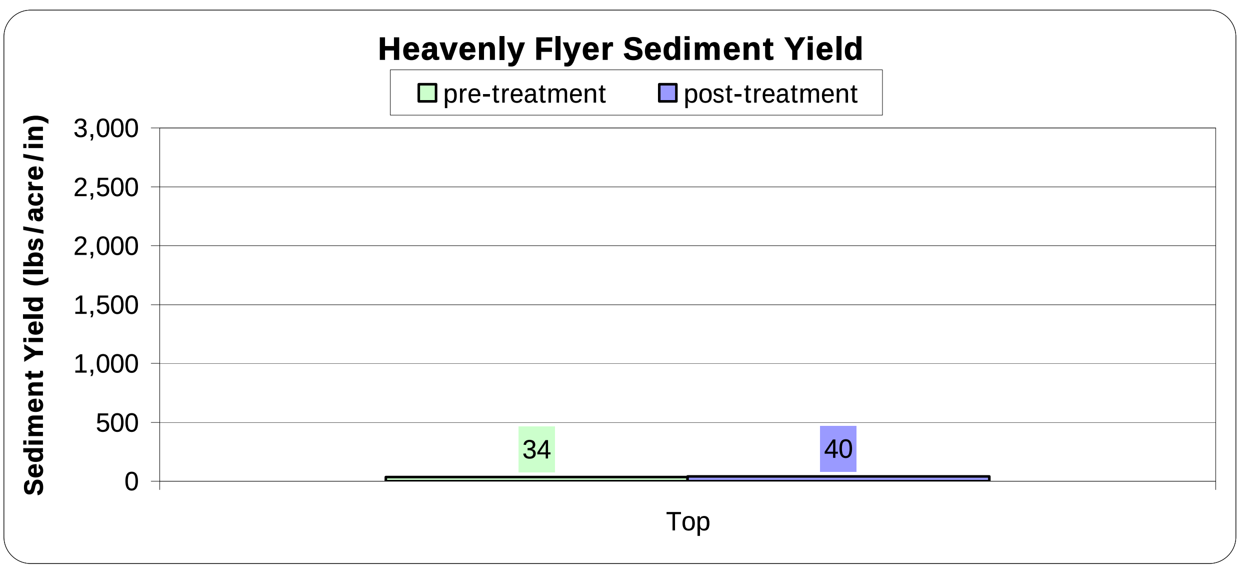


Figure 82. Heavenly Flyer Sediment Yield. The sediment yield was 34 lbs/acre/in pre-treatment, compared to 40 lbs/acre/in post-treatment.

The average infiltration rate at the Heavenly Flyer post-treatment (4.3 in/hr) was similar to the average infiltration rate pre-treatment (4.4 in/hr, Figure 83). The success criterion, which states the post-treatment infiltration rate can not be more than 0.8 in/hr lower than the pre-treatment infiltration rate, was met.

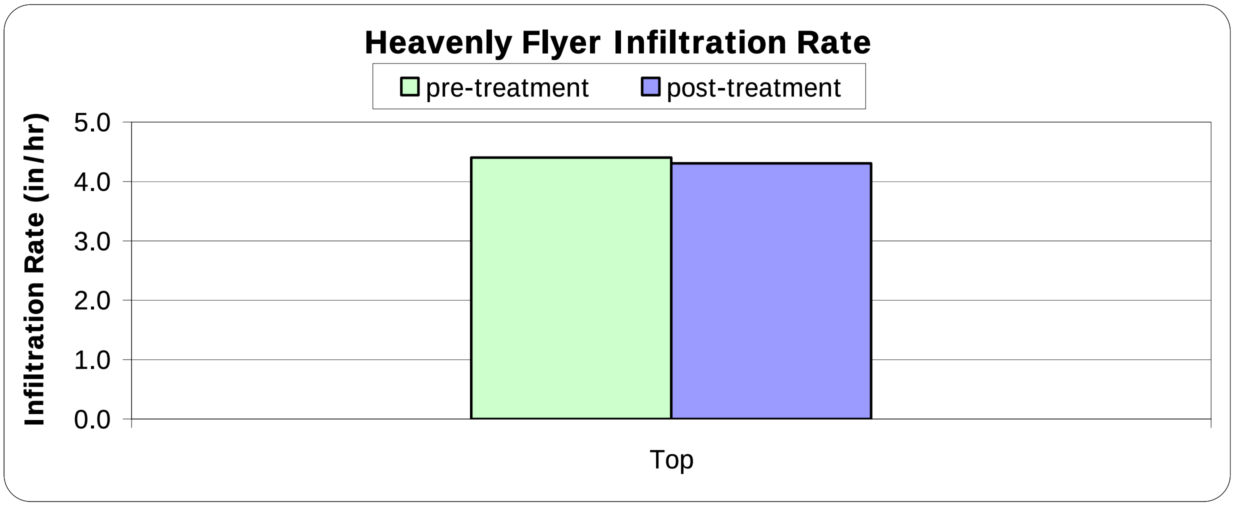


Figure 83. Heavenly Flyer Infiltration Rate. The infiltration rate was 4.4 in/hr pre-treatment, compared to 4.3 in/hr post-treatment.

Penetrometer Depth to Refusal (DTR)

The penetrometer DTR at the Heavenly Flyer top post-treatment (13.3 inches) was similar to the DTR pre-treatment (11.4 inches; Figure 84). The penetrometer DTR at the Heavenly Flyer bottom post-treatment (14.0 inches) was 6.8 inches deeper than the DTR pre-treatment (7.2 inches). The success criterion, which requires the post-treatment DTR to be no more than 4.0 inches shallower than the pre-treatment DTR, was met.

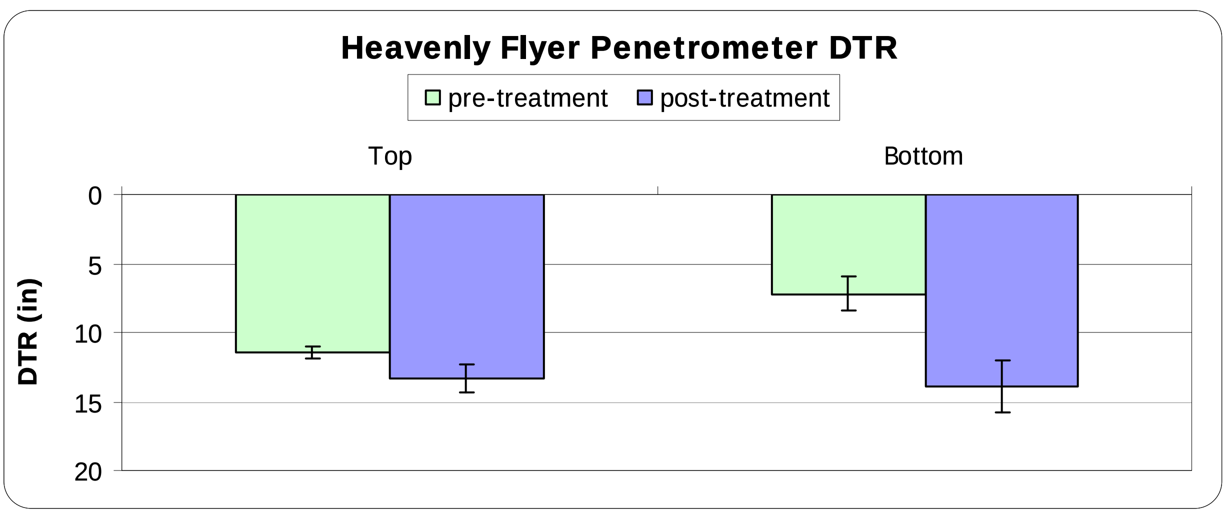


Figure 84. Heavenly Flyer Penetrometer Depth to Refusal (DTR). The penetrometer DTR was similar pre- and post-treatment at the Heavenly Flyer Top. The DTR was 6.8 inches deeper post-treatment at the Heavenly Flyer Bottom. The error bars denote one standard deviation above and below the mean.

Total Cover

At the Heavenly Flyer top, the total cover post-treatment (98%) was the same as the total cover pre-treatment (98%, Figure 85). The cover composition changed from 58% mulch and 40% rocks/sand/gravel to 92% mulch and 6% rocks/sand/gravel. At the Heavenly Flyer bottom, the total cover post-treatment (88%) was 30% higher than the total cover pre-treatment (68%). Mulch cover increased from 42% to 72% following treatment. The success criterion, which is 70% total cover or greater, was met at both the Heavenly Flyer top and bottom.

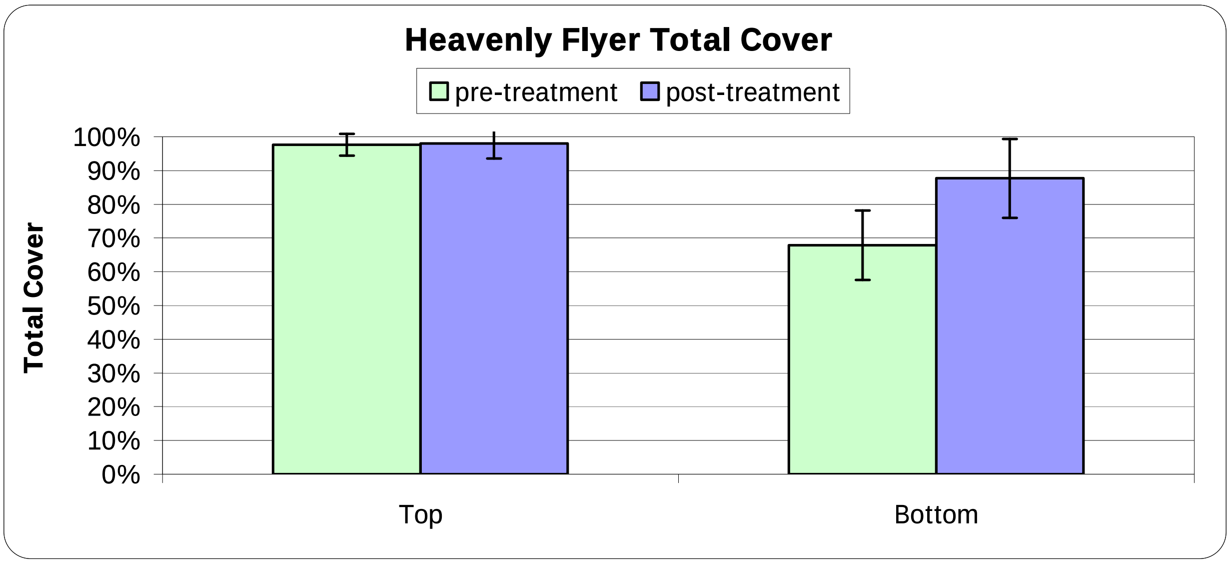


Figure 85. Heavenly Flyer Total Cover. Total cover was similar pre- and post-treatment at the Heavenly Flyer top, and increased by 30% at the bottom. The error bars denote one standard deviation above and below the mean.

Plant Cover

The post-treatment plant cover at Heavenly Flyer top (0%) was similar to the pre-treatment plant cover (1%; Figure 72). The post-treatment plant cover at the Heavenly Flyer bottom was 0%, compared to 12% pre-treatment. Ocular estimates indicated that there were trace amounts of cover by native plants (and one unknown species) at both plots that were not captured during cover point monitoring. This indicates that native plants are beginning to establish. The success criterion, which requires that post-treatment plant cover be at least 10%, was not met for either plot.

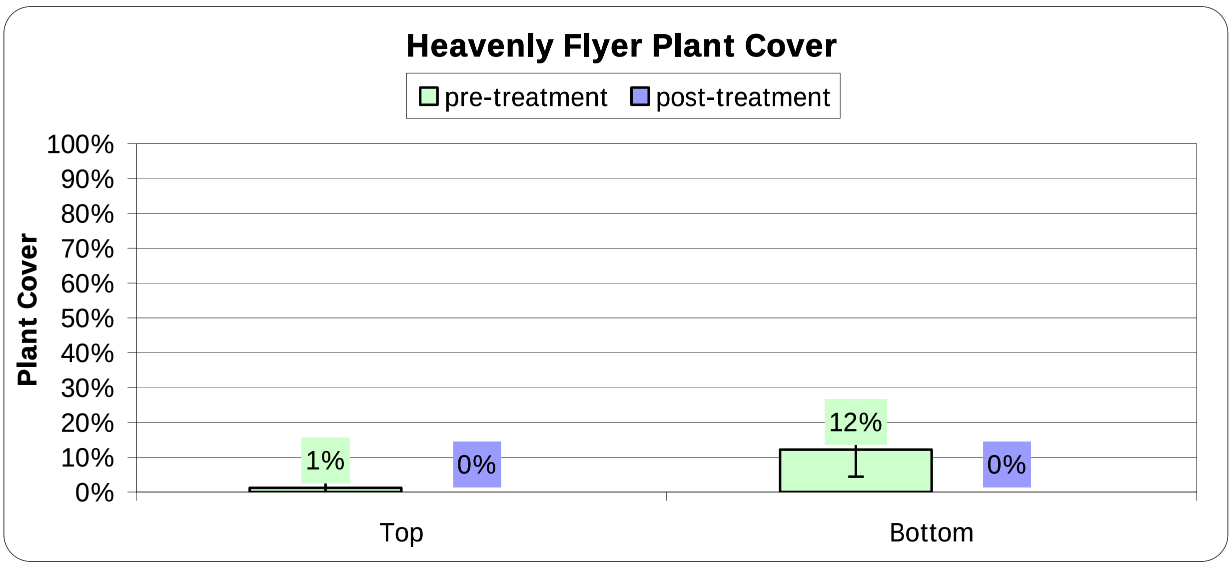


Figure 86. Heavenly Flyer Plant Cover. Plant cover was similar pre- and post-treatment at the Heavenly Flyer top, and decreased from 12% to zero at the bottom. The error bars denote one standard deviation above and below the mean.

Soil Nutrients

Organic Matter

At the Heavenly Flyer top, the post-treatment organic matter (2.2%) was similar to the pre-treatment organic matter (2.1%; Figure 87). At the Heavenly Flyer bottom, the organic matter increased by 161% from 1.8% to 4.7%. The success criterion, which states that the post-treatment organic matter must be no more than 1.5 percentage points lower than the pre-treatment organic matter, was met for both the Heavenly Flyer top and bottom.

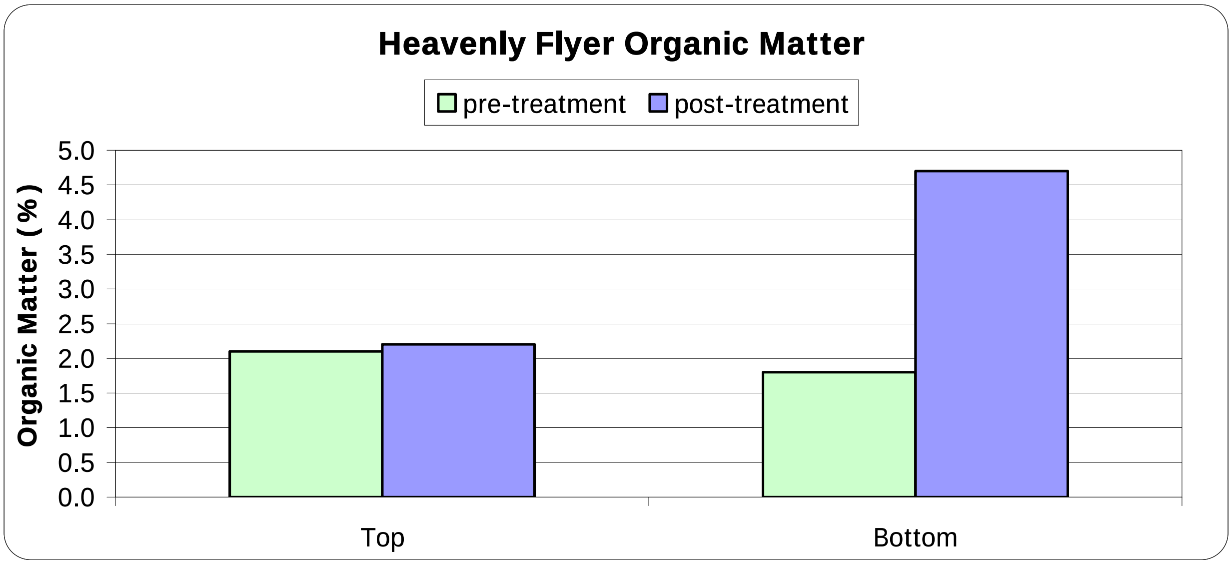


Figure 87. Heavenly Flyer Organic Matter. At Heavenly Flyer Top, organic matter content was similar pre- and post-treatment. At the Heavenly Flyer Bottom, it increased by 161% post-treatment.

Total Kjeldahl Nitrogen

At the Heavenly Flyer top, the post-treatment TKN (523 ppm) was 26% lower than the pre-treatment TKN (703 ppm; Figure 88). At the Heavenly Flyer bottom, the post-treatment TKN (682 ppm) was 34% lower than the pre-treatment TKN (448 ppm). A success criterion for TKN was not used in 2009, as discussed in Appendix B.

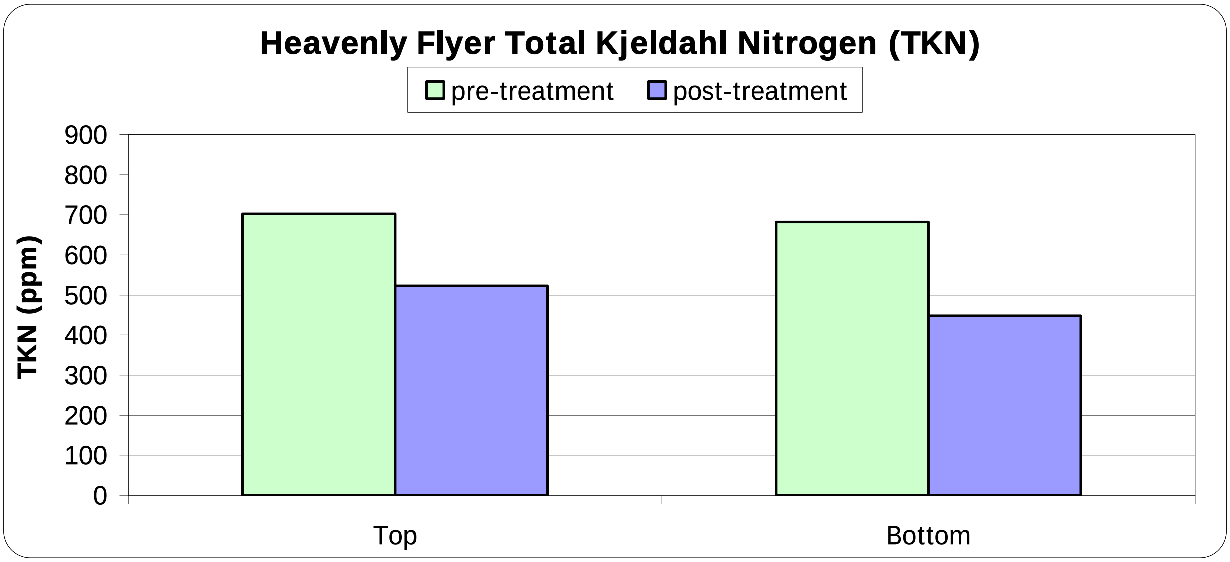


Figure 88. Heavenly Flyer Total Kjeldahl Nitrogen (TKN). At the Heavenly Flyer top, the TKN decreased by 26% post-treatment. At the Heavenly Flyer bottom, the TKN decreased by 34% post-treatment

Visual Erosion Assessment

At the Heavenly Flyer top, no major erosion problems were evident. Rodent activity and selective browsing of the native grasses were observed. At the Heavenly Flyer bottom, the area underneath the platform showed evidence of minor splash disturbance from water dripping from the platform. Although foot traffic disturbance was not evident, employees were observed walking from the lodge to the platform through the treatment area. The criterion, which states that no visible signs of rills, gullies, sediment transport, sediment deposition, or erosion from foundations or structures can be present, was met.

Management Response

Most of the success criteria were met for the Heavenly Flyer site, indicating that the project outcome was aligned with the primary project objective of no net increase in runoff or sediment yield. Monitoring results indicate high infiltration rates, low sediment yields, low soil density (as measured by cone penetrometer), and high total cover.

The criterion for plant cover was not met at any of the Heavenly Flyer plots. Additionally, the TKN decreased at both plots. Soil TKN and plant cover tend to be closely related. High-carbon soil amendments such as aged wood chips, which were used at this site, tend to reduce available nitrogen during decomposition, which can limit plant growth for several years. Therefore, rather than recommending immediate treatment action, another year of monitoring is recommended to better understand the long term trajectory for plant cover. If monitoring in 2010 indicates increasing plant cover, follow up treatments may not be necessary. However, if no measurable plant cover is present again in 2010, treatment actions such as fertilizing, seeding and/or irrigation will be necessary to help achieve success criteria and to ensure the long-term sustainability of sediment source control treatments at the site.

Visual erosion assessment is also recommended on a yearly basis in order to identify any small problems before they become larger problems. Specifically, the dripping from the platform should be closely watched throughout the season, particularly during and immediately after rain events, to ensure that drip lines are not causing erosion. Additionally, it is recommended that Heavenly expand efforts to minimize disturbance of the treatment area at the bottom plot by installing temporary fencing and/or signage and communicating the locations of sensitive treatment areas to staff, who were observed walking through the treatment area between the lodge to the platform. If this is expected to continue to be used as a walking trail for Heavenly staff, a trail should be formalized in order to protect restoration treatment areas. The top plot is adequately signed and roped off.

Table 18. Heavenly Flyer Management Responses for Unmet Success Criteria.

	Unmet Criterion	Management Response
Bottom	Plant Cover	Cover monitoring
Bottom	n/a	Visual erosion assessment
Bottom	n/a	Photo monitoring
Top	Plant Cover	Cover monitoring
Top	n/a	Visual erosion assessment
Top	n/a	Photo monitoring

Mid Station Road Project

Overview

Mid Station Road is an unpaved access road that leads from the top of the gondola to the gondola mid station. The road is only used for limited summer and emergency access. As part of the Mid Station Road Project, a portion of the road near the mid station was realigned in 2008 and the abandoned segment of the road was removed and treated to restore the soil and vegetation community (Figure 89, Figure 90, and Figure 91). The treatment area is at an elevation of 9,142 feet AMSL. The soil is derived from granitic parent material and the site faces west to southwest. Vegetation is not present in the planned treatment area. Rills and gullies, which were formed by water erosion, were present on the road surface before treatment. The surrounding area has many large rocks and is dominated by white bark pine (*Pinus albicaulis*). There is no tree canopy cover in the treatment area, the solar exposure is 77%, and the slope angle is 9 degrees.

Figure 89. Mid Station Road, pre-treatment, 2007.

Figure 90. Mid Station Road, pre-treatment with monitoring transects, 2007.

Figure 91. Mid Station Road Project Map.

Objectives and Success Criteria

Treatment Objectives

- no net increase in runoff and/or sediment transport as a result of road construction and partial removal/restoration of existing road segment
- to establish an appropriate, self-sustaining, native plant community in the existing road segment to be removed/treated

Monitoring Objective

- to quantitatively assess whether treatments resulted in a net change in runoff and/or sediment transport from the site following road construction and partial removal/restoration of existing road segment

Success Criteria

The following success criteria will be used to determine whether project implementation achieved the project treatment goals (Table 19). The success criteria are based on the following indicators: sediment yield, infiltration rate, penetrometer depth to refusal (DTR, used as an index for soil density), total cover, plant cover, organic matter, and visual assessment. A success criterion for TKN was not used in 2009, as discussed in Appendix B. In addition to evaluating short-term treatment success, these indicators represent key information needed to assess the likelihood of long-term sustainability of the soil-plant system, which is the key to long-term sediment source control in treated areas.

Table 19. Mid Station Road Success Criteria Evaluation.

	Success Criteria	Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 100 lbs/acre/in higher than pre-treatment levels	√ Criterion Met
Infiltration Rate (in/hr)	Not greater than 0.8 in/hr lower than pre-treatment levels	√ Criterion Met
Penetrometer Depth (inches)	Not greater than 4 inches shallower than pre-treatment level	√ Criterion Met
Total Cover (%)	70% or greater	√ Criterion Met
Total Plant Cover (%)	10% or greater	× Criterion Not Met
Organic Matter (%)	Not greater than 1.5 percentage points less than pre-treatment level	√ Criterion Met
TKN (PPM)	TKN not used as a metric for measuring success	n/a, see Appendix B
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	√ Criterion Met

Restoration Treatments

In 2008, vehicle traffic was excluded from the abandoned segment of the Mid Station Road and soil and vegetation restoration treatments were implemented to functionally remove the road and restore the area to surrounding undisturbed conditions. The abandoned road segment was divided into two treatment areas, one upslope of the realigned road (area A) and one down slope of the realigned road (area B; Figure 91). The treatment for area A included all elements of full soil and vegetation treatment: soil amendments, tilling, organic fertilizer, seed, and mulch. The treatment for area B included soil amendments, tilling, and mulch. Area B's treatment is intended to maximize infiltration, thereby reducing runoff and erosion, but did not including seeding or fertilizer. This treatment area has a low slope angle and is surrounded by mature forest; therefore, it presented a low-risk opportunity to test a lower-intensity treatment. The lower-intensity treatment was focused on optimizing soil conditions and relying on natural seed cast from the surrounding vegetated areas to assist in reestablishing vegetation. The specific treatment elements implemented at each treatment area are detailed in Table 20.

Table 20. Mid Station Road Treatment Matrix.

		Treatment Area	
		A	**B**
Amendments	**Type**	WC	WC
	Depth (in)	4	4
Tilling	**Depth (in)**	18	16
Fertilizer	**Type**	Biosol 6-1-3	n/a
	Rate (lbs/acre)	2,000	n/a
Seed	**Mix**	Heavenly upland mix	n/a
	Rate (lbs/acre)	50	n/a
Mulch	**Type**	PNM	PNM
	Depth (in)	1-2	1-2
Irrigation	**Frequency/Duration**	No	no
Treatment Area	**Square Feet**	5,815	4,125

Key
WC = wood chips
PNM = pine needle mulch
* = not verified in field

Figure 92. Mid Station Road, treatment area A, pre-treatment with monitoring transects, 2007.

Figure 93. Mid Station Road, treatment area A, post-treatment, 2008.

Figure 94. Mid Station Road, treatment area A, post-treatment, 2009.

Figure 95. Mid Station Road, treatment area B, post-treatment, 2008.

Performance Monitoring

Infiltration and Sediment Yield

The post-treatment sediment yield at the Mid Station Road (1,543 lbs/acre/in) was 48% or 735 lbs/acre/in higher than the pre-treatment sediment yield (808 lbs/acre/in, Figure 96). The post-treatment sediment yield may have been affected by the animal disturbance found at Frame 3, which produced a sediment yield of 4,504 lbs/acre/in, compared the 24 lbs/acre/in at Frame 1, and no runoff at Frame 2. Although animal disturbance is typical in mountain environments, the effects of the disturbance are generally not measured during pre- or post- treatment rainfall simulation. This disturbance was discovered after the simulation. When the Frame 3 sediment yield is removed from the average, the post-treatment sediment yield (12 lbs/acre/in) is 99% lower than the pre-treatment sediment yield (808 lbs/acre/in). This result, without Frame 3, met the success criterion, which states the post-treatment sediment yield must no more than 100 lbs/acre/in higher than the pre-treatment sediment yield.

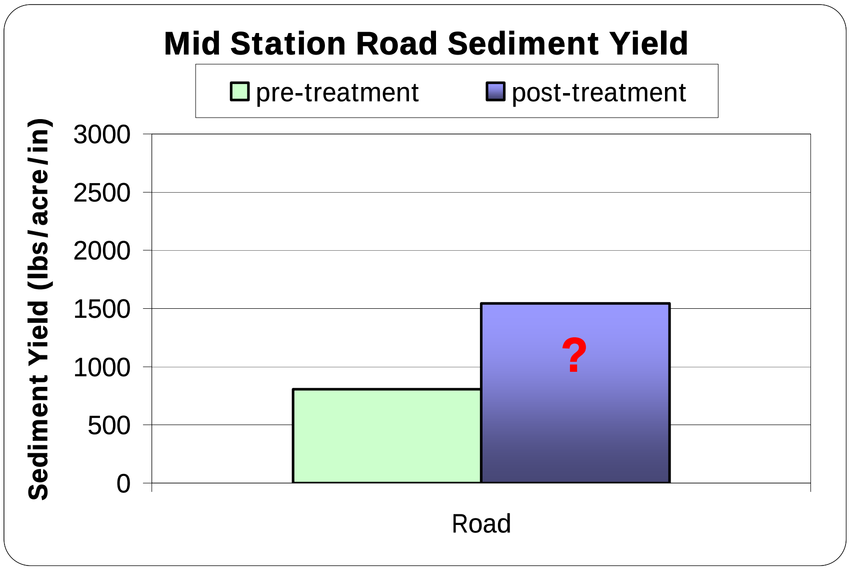


Figure 96. Mid Station Road Sediment Yield. The post-treatment sediment yield 48% or 735 lbs/acre/in higher than the pre-treatment sediment yield.

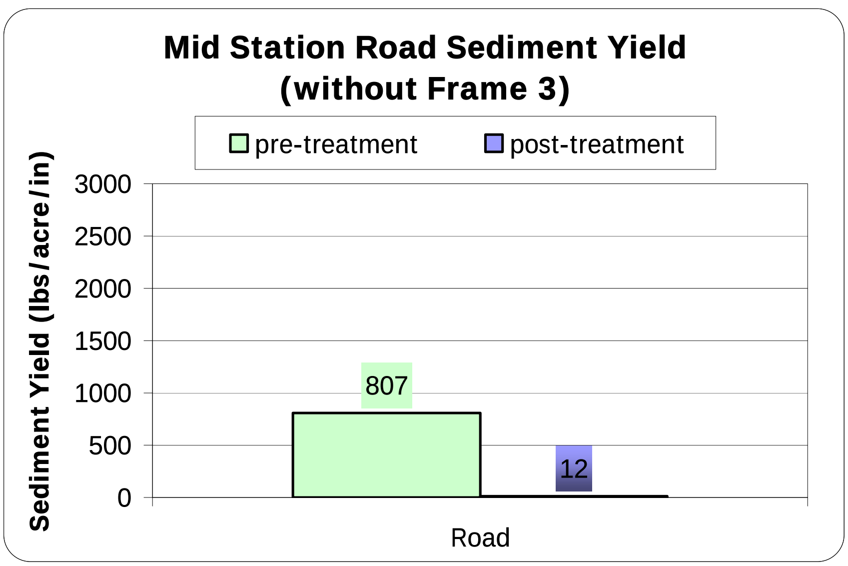


Figure 97. Mid Station Road Sediment Yield. When the Frame 3 outlier was removed, the post-treatment sediment yield was 99% lower compared to the pre-treatment sediment yield.

A Closer Look

Why is the sediment yield higher post-treatment?

This result is the average of three simulations.

Frame 1: 24 lbs/acre/in
Frame 2: no runoff
Frame 3: 4,604 lbs/acre/in

The high sediment yield at Frame 3 was most likely a result of the animal disturbance. Evidence of burrowing by a small rodent was observed in the frame immediately after the simulation.

If the Frame 3 outlier were removed, the sediment yield would be 12 lbs/acre/in, a reduction of 63 times compared to pre-treatment (808 lbs/acre/in).

The average infiltration rate at the Mid Station Road post-treatment (4.4 in/hr) was 2 times higher than pre-treatment (2.1 in/hr; Figure 98). Examining the infiltration rates by frame will aid in understanding why the infiltration rate was highest for the post-treatment simulations, which had the highest sediment yield before the outlier was removed. Generally, high sediment yields are linked with low infiltration rates. The Frame 1 infiltration rate was 4.3 in/hr (sediment yield: 24 lbs/acre/in), the Frame 2 infiltration rate was 4.7 in/hr (no runoff or sediment), and the Frame 3 infiltration rate was 4.2 in/hr (sediment yield: 4,604 lbs/acre/in). The Frame 1 and Frame 3 infiltration rates were very similar even though the sediment yields varied widely. This may be because the relatively small animal disturbance area produced a majority of the sediment, but did not cover a large enough area to reduce the overall infiltration rate. The success criterion, which states the post-treatment infiltration rate must be no more than 1.5 in/hr lower than the pre-treatment infiltration rate, was met.

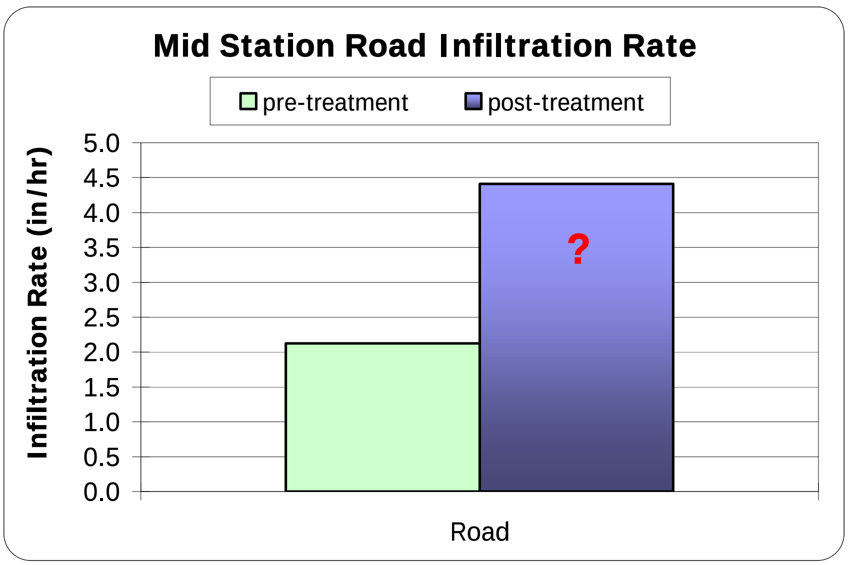


Figure 98. Mid Station Road Infiltration Rate. The average infiltration rate post-treatment 2 times higher than the pre-treatment infiltration rate.

A Closer Look

Why is the post-treatment infiltration rate so high when the sediment yield was also high?

Infiltration rates by frame indicate that Frame 1, which produced little sediment, had nearly the same infiltration rate as Frame 3, which had the highest sediment yield.

Frame 1: 4.3 in/hr (24 lbs/acre/in)

Frame 2: 4.7 in/hr (no runoff)

Frame 3: 4.2 in/hr (4,604 lbs/acre/in)

The high sediment yield in Frame 3 was a result of a small area of disturbed, loose soil rather than lack of infiltration throughout the frame.

Penetrometer DTR

The depth to refusal at Mid Station Road post-treatment (10.4 inches) was 9.4 inches deeper than the pre-treatment DTR (1.0 inches; Figure 99). The success criterion, which dictates that the penetrometer DTR can be no more than 4.0 inches shallower than the pre-treatment DTR, was met.

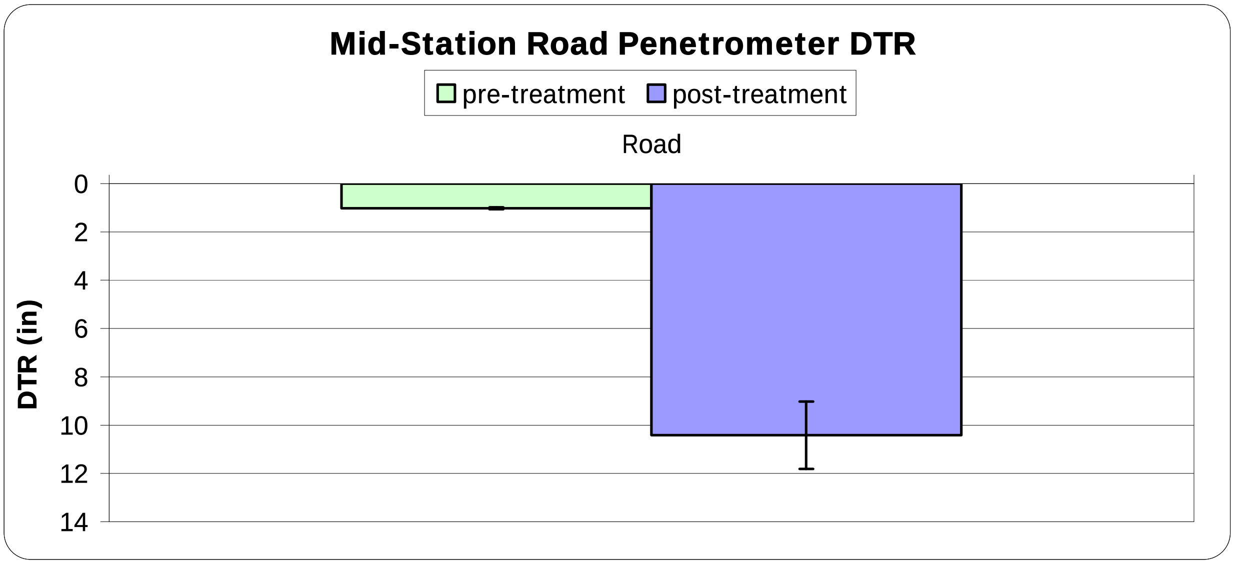


Figure 99. Mid Station Road Penetrometer Depth to Refusal (DTR). The depth to refusal at Mid Station Road post-treatment was 10 times shallower than the pre-treatment. Error bars denote one standard deviation above and below the mean.

Total Cover

At Mid Station Road, the total cover post-treatment (88%) was 159% higher than the total cover pre-treatment (34%, Figure 100). The mulch cover increased by 252% from 25% to 88%. The success criterion, which states the total cover must be greater than 70% post-treatment, was met.

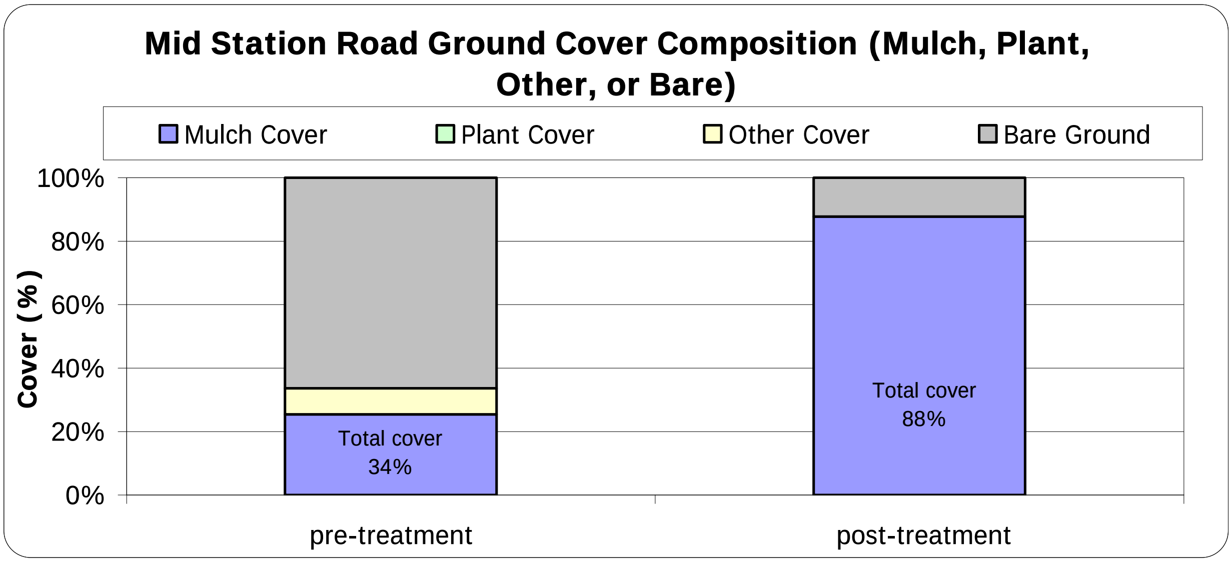


Figure 100. Mid Station Road Total Cover. At Mid Station Road, the total cover post-treatment was greater than 70% and 159% higher than pre-treatment total cover.

Plant Cover

Plant cover did not change and remained at zero post-treatment; therefore the criterion of 10% plant cover or greater was not met (no graph).

Soil Nutrients

Organic Matter

At Mid Station Road, the post-treatment organic matter (0.9%) was similar to the pre-treatment organic matter (0.6%; Figure 101). The success criterion, which states that the post-treatment organic matter must no more than 1.5 percentage points below the pre-treatment organic matter content, was met.

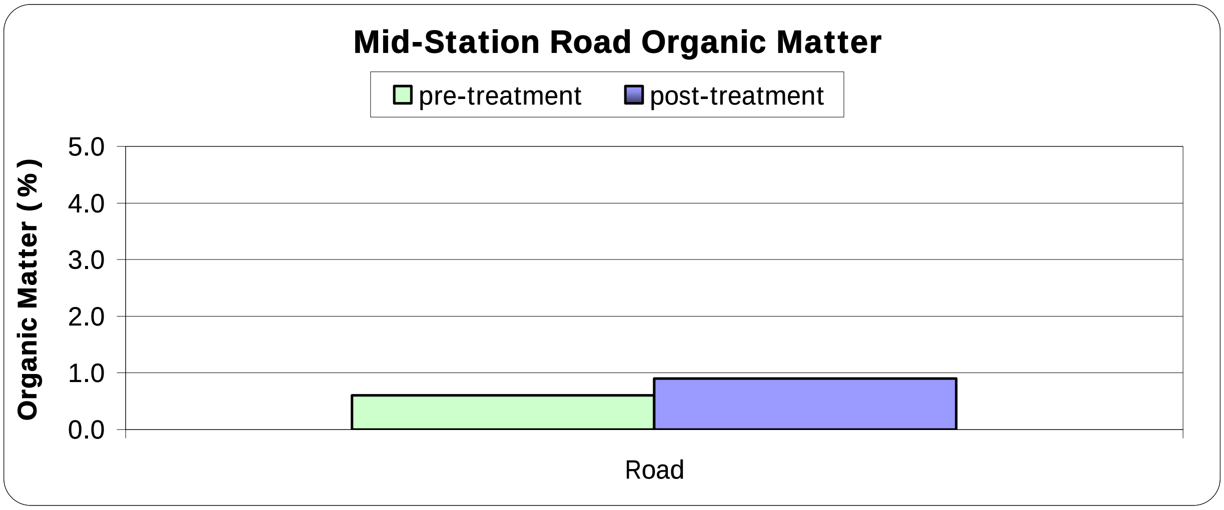


Figure 101. Mid Station Road Organic Matter. The post-treatment organic was similar to the pre-treatment organic matter.

Total Kjeldahl Nitrogen

At Mid Station Road, the post-treatment TKN (182 ppm) was 40% or 122 ppm lower than the pre-treatment TKN (304 ppm; Figure 102). A success criterion for TKN was not used in 2009, as discussed in Appendix B.

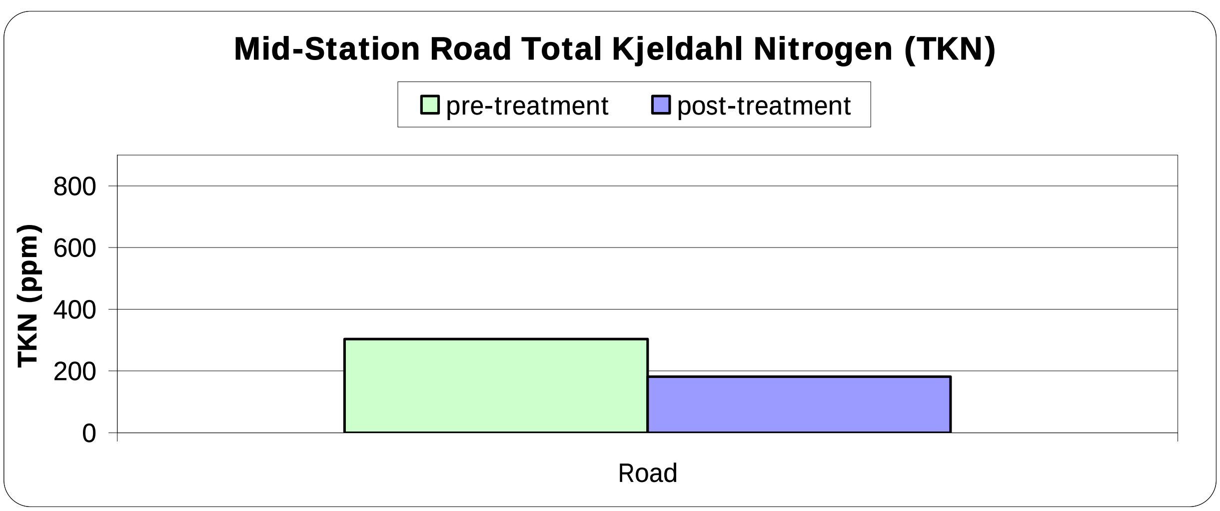


Figure 102. Mid Station Road Total Kjeldahl Nitrogen (TKN). The post-treatment TKN was 40% lower than the pre-treatment TKN.

Visual Erosion Assessment

At the Mid Station Road, pine needle mulch movement was observed. Pine needle movement can be an indicator of water erosion; however, in this case, it was likely a result of rodent activity. No other signs of erosion were observed. The criterion, which states that no visible signs of rills, gullies, sediment transport, or sediment deposition can be present, was met.

Management Response

Most of the success criteria were met for the Mid Station Road site, indicating that the project outcome was aligned with the primary project objective of a no net increase in sediment yield. Monitoring results suggest high infiltration rates, low sediment yield, low soil density (as measured by cone penetrometer), and high total cover. However, the success criterion for plant cover was not met and the TKN was low. Soil TKN and plant cover tend to be closely related. High-carbon materials, such as aged wood chips, which were used as a soil amendment at this site, tend to reduce available nitrogen during decomposition, which can limit plant growth for several years. Rather than recommending immediate treatment action, another year of cover monitoring is recommended to better understand the long term trajectory for plant cover. If monitoring in 2010 indicates increasing trends in plant cover, follow up treatments may not be necessary. However, if no measurable vegetation is present in 2010, treatment actions such as fertilizing or seeding (irrigation may not be a practical option at this site) may be necessary to help achieve success criteria.

Visual erosion assessment is recommended on a yearly basis in order to identify and address any small erosion problems before they become larger problems, particularly during and immediately after rain events. Annual photo documentation is also recommended.

Table 21. Mid Station Road Management Responses for Unmet Criterion.

	Unmet Criterion	Management Response
Road	Plant Cover	Cover monitoring
Road	n/a	Visual erosion assessment
Road	n/a	Photo monitoring

Skyline Trail Re-Grade Project

Overview

The Skyline Trail Re-grade Project consisted of re-grading, widening, and realigning the Skyline trail ski run to achieve a more consistent slope throughout the length of the trail. There are two distinct monitoring areas on the Skyline Trail: road cut and road shoulder. In addition, one area near the bottom of the Dipper chairlift, the Dipper bottom slope, was also monitored pre-treatment. Large rocks removed during grading at Skyline Trail were placed at the Dipper bottom. Post-treatment monitoring was not conducted at the Dipper bottom, as there were a sufficient number of large rocks to cover the entire area and soil restoration treatments were not necessary. The Skyline Trail Re-grade project map shows the locations of treatment and monitoring areas associated with this project (Figure 103).

Site Description

Cut Slope

The cut slope, as the name implies, is a slope created from the construction the Skyline Trail (Figure 104, Figure 105, Figure 106, and Figure 107). It is very steep (approximately 33 degrees) and exhibited evidence of wind and water erosion pre-treatment. Rills were visible throughout the slope and pine needle movement from water erosion was apparent. Located at approximately 9,600 feet AMSL on an east-facing slope, it is in an exposed area that has greater than 90% solar exposure in the summer months. The soil is derived from granitic parent material and has a low proportion of rocks. Little vegetation is present at this high elevation site. Whitebark pine (*Pinus albicaulis*) are present with an understory of penstemon (*Penstemon sp.)* and buckwheat (*Eriogonum sp.*). Tahoe draba (*Draba asterophora var. asterophora*), a rare native plant, is present in the surrounding area.

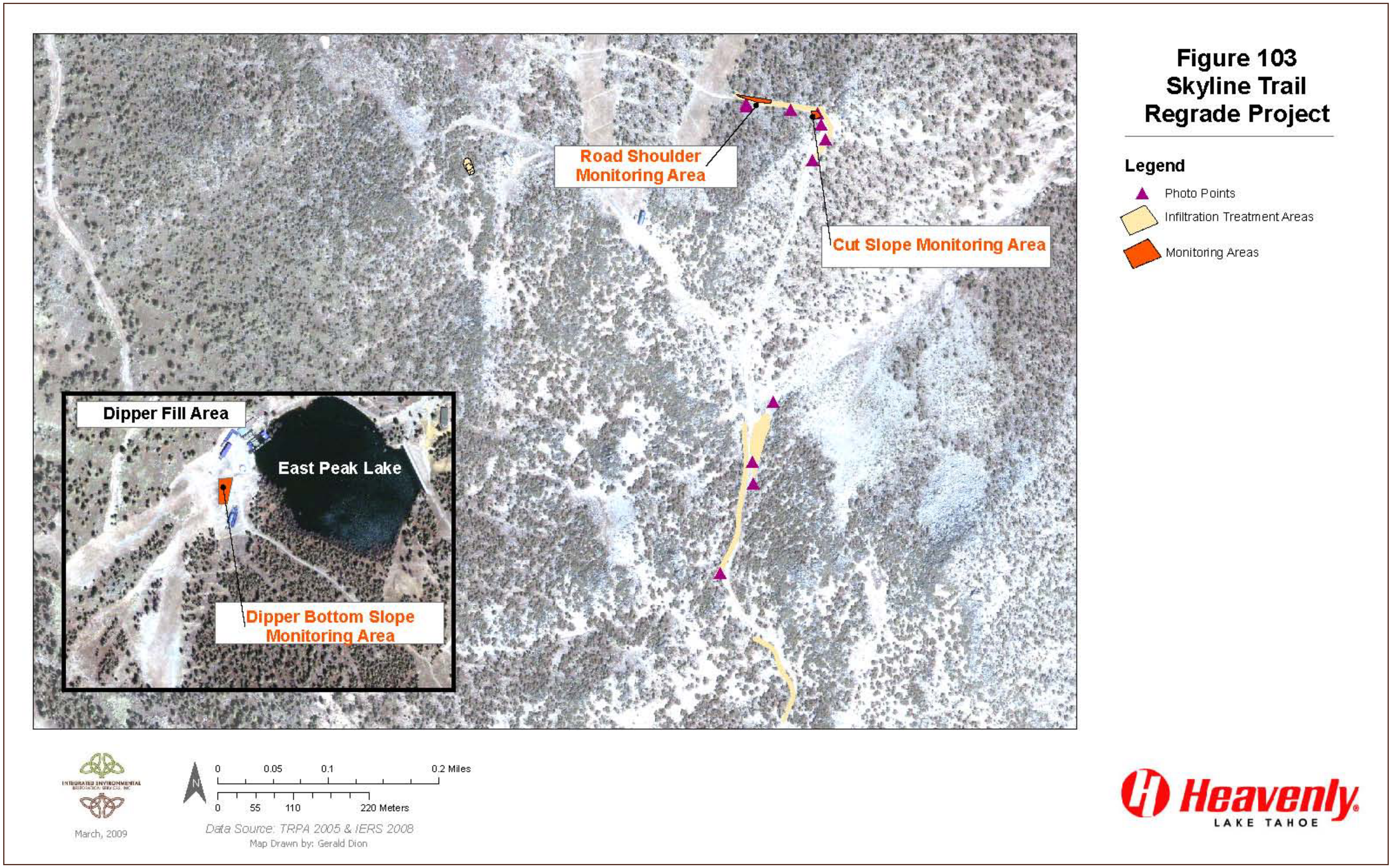


Figure 103. Skyline Trail Re-Grade Project Map.

Figure 104. Skyline Trail cut slope, pre-treatment, 2008.

Figure 105. Skyline Trail cut slope, post-treatment, 2009.

Figure 106. Skyline Trail cut slope and road shoulder, pre-treatment, 2008

Figure 107. Skyline Trail cut slope and road shoulder, post-treatment, 2009

Road Shoulder

The road shoulder treatment area is located along the same road as the cut slope, just downhill at approximately 9,580 feet AMSL (Figure 108 and Figure 109). Pre-treatment, it was a very disturbed area, with evidence of foot traffic and tire tracks. Both rills and gullies were present. The area is gently sloped at approximately 8 degrees, faces west, and has a summer solar exposure of greater than 90%. The soil is derived from granitic parent material and has a low proportion of rocks. No vegetation was present within the sampling area and little vegetation is present in the surrounding area at this high elevation site, especially in the understory. Trees that are present include whitebark pine (*Pinus albicaulis*) and mountain hemlock (*Tsuga mertensiana*). Tahoe draba (*Draba asterophora var. asterophora*), a rare native plant, is present in the surrounding area.

Figure 108. Skyline Trail road shoulder monitoring area, pre-treatment, 2008.

Figure 109. Skyline Trail road shoulder monitoring area, post-treatment, 2009.

Dipper Bottom Slope

The Dipper bottom slope is located near the bottom terminal of the Dipper chairlift in a disturbed area (Figure 110 and Figure 111). Pre-treatment, there was evidence of water erosion, including rills and a drainage gully with sedimentation. There was also disturbance from small and large animals, including burrowing and grazing. This area is frequented by deer and coyotes, as feces were present throughout the site. The site is located on a west-facing slope at an elevation of 8,636 feet AMSL. The solar exposure for this gently sloped site (6 degrees) is greater than 95% during the summer because no canopy cover is present. The soil is derived from granitic parent material with approximately 40% composition by rocks greater than 0.5 inches in diameter. Species present in the surrounding area include greenleaf manzanita (*Arctostaphylos patula*), tobacco brush (*Ceanothus velutinus*), red fir (*Abies magnifica*), and Western white pine (*Pinus monticola*). There were three invasive species present within the monitoring area: common sheep sorrel (*Rumex acetosella*), creeping bentgrass (*Agrostis stolonifera*) and orchard grass (*Dactylis glomerata*). A mix of approximately 50% native species and 50% non-native species of forbs and shrubs were present. The high proportion of non-native species may be attributed to the straw mulch present at the site. Non-native seeds are often present in straw. A few native shrubs and tree seedlings were also present in the plot.

Figure 110. Skyline Trail Dipper bottom slope monitoring area, pre-treatment, 2008.

Figure 111. Skyline Trail Dipper bottom slope, pre-treatment, 2008.

Figure 112. Skyline Trail Dipper bottom slope, pre-treatment, 2008.

Figure 113. Skyline Trail Dipper bottom slope, after rock application, 2009.

Objectives and Success Criteria

Treatment Objectives

- no net increase in runoff and/or sediment transport as a result of the trail widening, re-aligning, and grading
- no net increase in runoff and/or sediment transport as a result of rock placement at the bottom of the Dipper chairlift

Monitoring Objective

- to quantitatively assess whether treatments resulted in a net change in runoff and/or sediment transport following the trail modification

Success Criteria

The following success criteria will be used to determine whether treatments achieved the treatment goals of the project one year following construction (Table 22). The success criteria are based on the following indicators: sediment yield, infiltration rate, penetrometer depth to refusal (DTR, used as an index for soil density), total cover, and visual erosion assessment.

Table 22. Skyline Trail Success Criteria Evaluation.

	Success Criteria	Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 100 lbs/acre/in higher than pre-treatment levels	√ Criterion Met
Infiltration Rate (in/hr)	Not greater than 0.8 in/hr lower than pre-treatment levels	√ Criterion Met
Penetrometer Depth (inches)	Not greater than 4 inches shallower than pre-treatment level	√ Criterion Met
Total Cover (%)	70% or greater	√ Criterion Met
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	√ Criterion Met

Restoration Treatments

The primary areas that were affected by grading and trail improvement activities as part of the Skyline Trail project were road shoulders and cut slopes. Rock slope protection was used to stabilize cut slopes, as soil and vegetation-based treatments were unlikely to be successful due to steep slope angles, poorly developed soils, and the high elevation nature of the project area. Infiltration strips (4-8 feet wide) were constructed in all roadside areas where the road is outsloped and concentrated road runoff has the potential to cause erosion down slope. Infiltration strips were created by "tucking" 2-3 inches of wood chips into the soil using the teeth on the bucket of a full size excavator. This treatment loosened the soil to a depth of approximately 6 inches and incorporated a portion of the wood chips into the soil. This left some wood chips on the surface to function as mulch/surface protection and roughened the soil surface. The overall goal of this treatment type is to slow down and infiltrate runoff from the road surface. This treatment was also implemented in the upper portion of the Milky Way ski run, which is adjacent to Skyline Trail and was also disturbed during re-grading. Some segments of road shoulder infiltration strips with low mulch cover were mulched with pine needles in spring 2009 by Heavenly operations staff. Lastly, spoil materials (primarily large rocks) generated during the re-grading of Skyline Trail were placed near the bottom of the Dipper Lift. No soil and vegetation treatments were implemented in this area, as the spoil materials were composed of primarily large boulders and did not require revegetation to stabilize.

Table 23. Skyline Trail Treatment Matrix.

Amendments	**Type**	WC, BLB
	Depth (in)	3
Tilling	**Depth (in)**	6
Fertilizer	**Type**	n/a
	Rate (lbs/acre)	n/a
Seed	**Mix**	n/a
	Rate (lbs/acre)	n/a
Mulch	**Type**	WC, BLB
	Depth (in)	0-1
Irrigation	**Frequency/Duration**	n/a
Treatment Area	**Square Feet**	27,964
Key WC = wood chips BLB = Boulder Lodge Blend (well-aged wood chips and pine needles)		

Figure 114. Infiltration strip in upper segment of Skyline Trail.

Figure 115. Infiltration strip and rock slope protection in lower segment of Skyline Trail.

Figure 116. Upper portion of the Milky Way ski run.

Figure 117. Dipper fill area after construction.

Performance Monitoring

Pre-treatment monitoring was conducted at the Skyline Trail cut slope and road shoulder and at the bottom of the Dipper chairlift (Arst, Drake. 2009). Post-treatment monitoring was conducted solely at the Skyline Trail road shoulder. The rock slope protection treatments applied at the Skyline Trail cut slope and the Dipper chairlift did not require post-treatment monitoring because soil restoration treatments were not conducted.

Infiltration and Sediment Yield

The post-treatment sediment yield at the Skyline Trail road shoulder (1,140 lbs/acre/in) was 86% lower than the pre-treatment sediment yield (8,386 lbs/acre/in, Figure 118). The success criterion, which states that the post-treatment sediment yield must be no more than 100 lbs/acre/in higher than the pre-treatment sediment yield, was met.

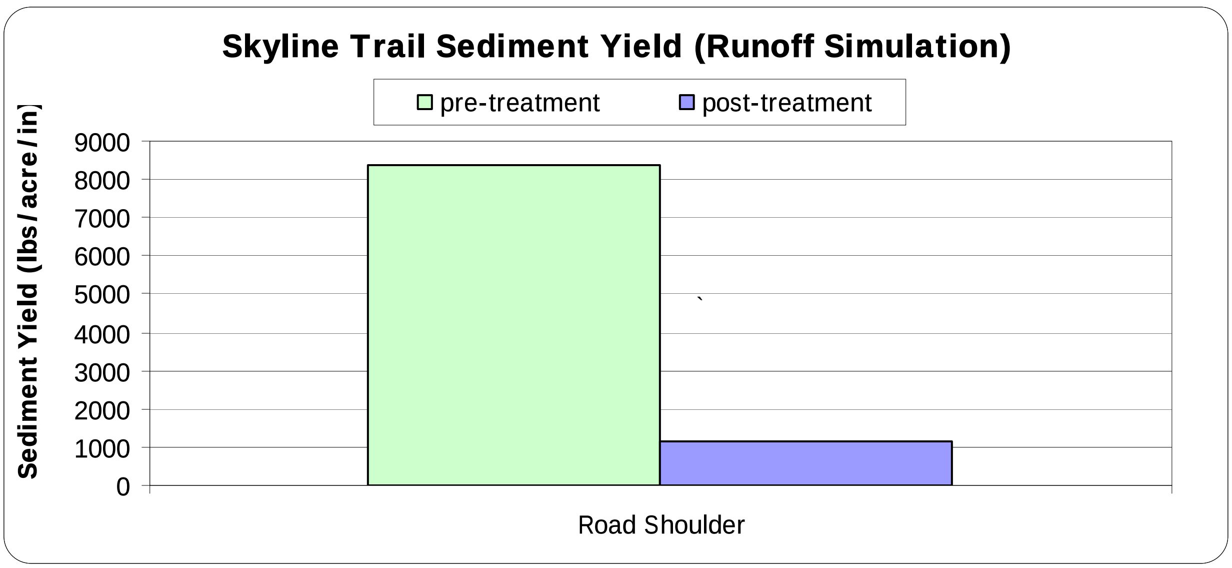


Figure 118. Skyline Trail Sediment Yield (Runoff Simulation). Sediment Yield decreased by 86% post-treatment. Note the different scale for this runoff simulation graph (max of 9,000 lbs/acre/in versus max of 3,000 lbs/acre/in for the rainfall simulation graphs).

The post-treatment average infiltration rate at the Skyline Trail cut slope (4.0 in/hr) was similar to the pre-treatment average infiltration rate (3.8 in/hr; Figure 119). The success criterion, which states the post-treatment infiltration rate must be no more than 1.5 in/hr lower than the pre-treatment infiltration rate, was met.

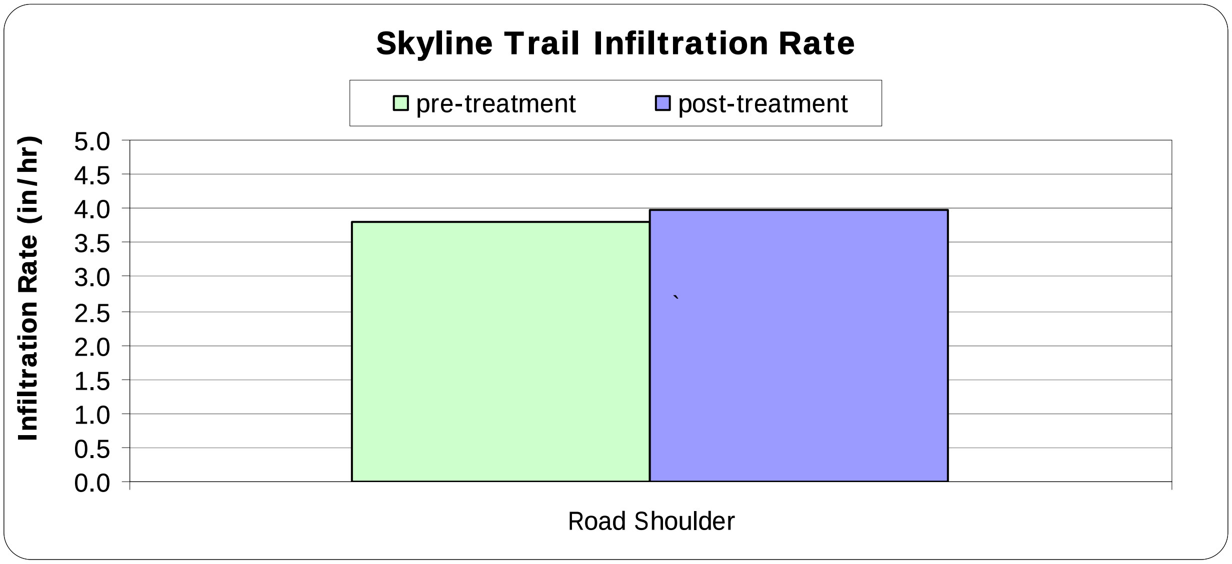


Figure 119. Skyline Trail Infiltration Rate. The pre- and post-treatment infiltration rates were similar.

Penetrometer Depth to Refusal (DTR)

The post-treatment penetrometer DTR at the Skyline Trail road shoulder (9.8 inches) was 7 inches deeper than the pre-treatment DTR (2.8 inches, Figure 120). This meets the criterion, which states that the post-treatment penetrometer DTR must be no more than 4.0 inches shallower than the pre-treatment penetrometer DTR.

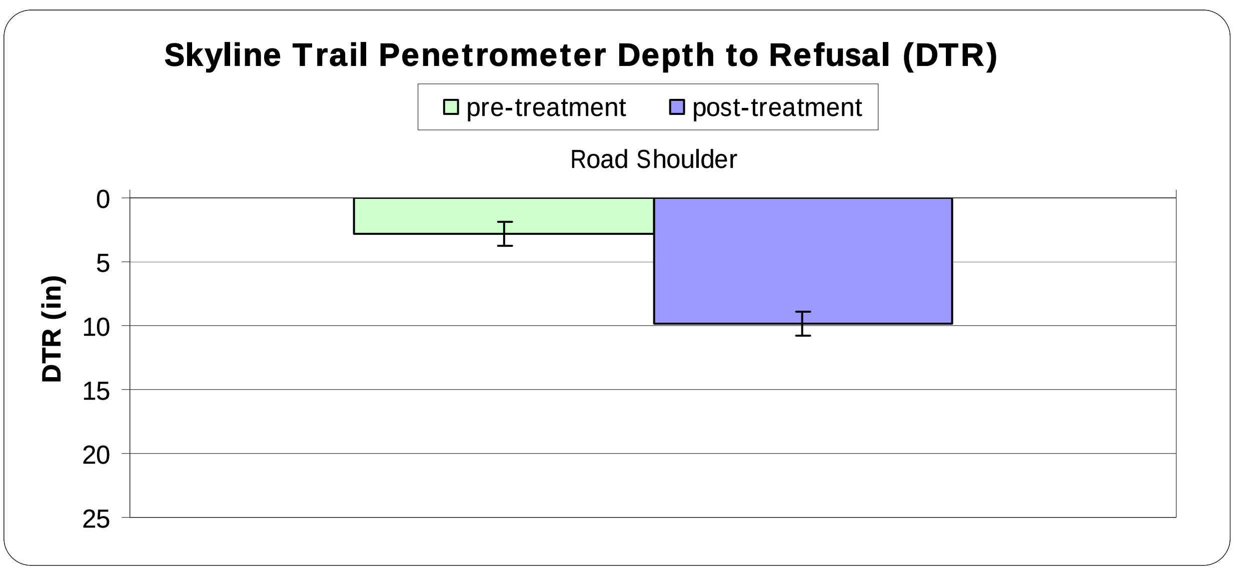


Figure 120. Skyline Trail Penetrometer Depth to Refusal (DTR). The post-treatment DTR was 7 inches deeper than the pre-treatment DTR. The error bars denote one standard deviation above and below the mean.

Total Cover

The post-treatment total cover at the Skyline Trail road shoulder (100%) was approximately 1900% greater than the pre-treatment ocular estimate of total cover (5%; Figure 121). The criterion, which states that the post-treatment total cover must be greater than 70%, was met.

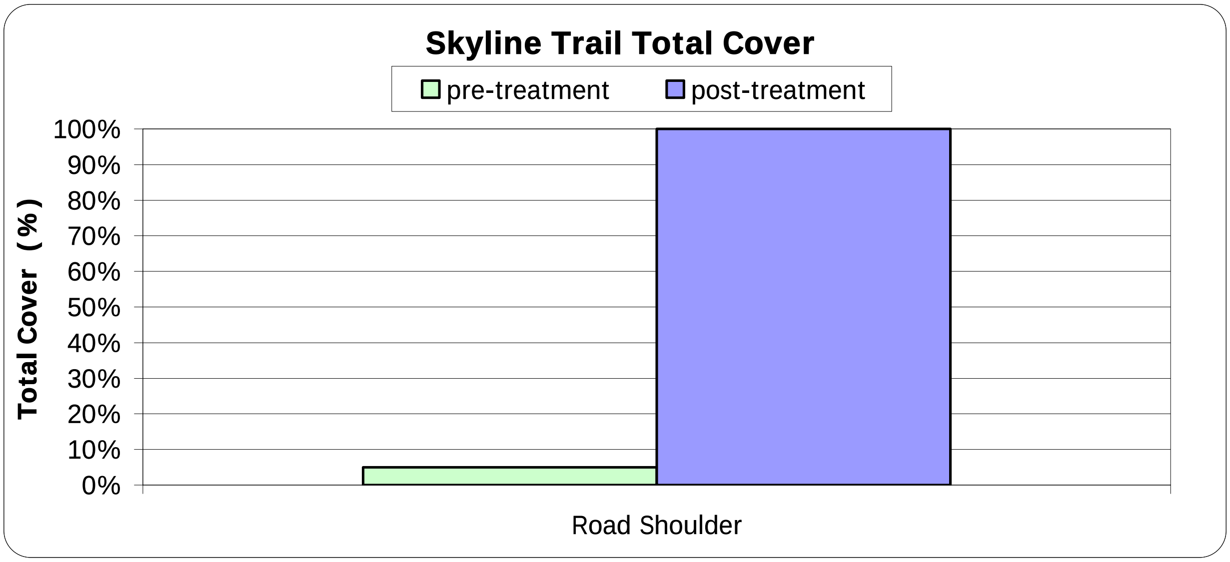


Figure 121. Skyline Trail Total Cover. Total cover improved to 100% post-treatment. The pre-treatment total cover is an ocular estimate.

Visual Erosion Assessment

At the road shoulder, tire tracks were observed in the monitoring area. During monitoring, a dog walked through the entire shoulder area. It appears that road shoulders in this area also function as summer hiking trails. Evidence of rodent activity was also observed. No other signs of erosion were present at this site, or the road cut site or Dipper bottom slope site. The success criterion, which states that no visible signs of rills, gullies, sediment transport, or sediment deposition can be present, was met.

Management Response

All of the success criteria were met for the Skyline Trail site, indicating that the project outcome was aligned with the primary project objective of no net increase in runoff or sediment transport. Monitoring results indicate increased infiltration rates, decreased sediment yields, lower soil density (as measured by cone penetrometer), and higher total cover.

Annual visual erosion assessment is recommended for the road shoulder infiltration strips, as these areas are expected to be impacted by both vehicles and foot traffic. Road shoulder infiltration strips are expected to require annual targeted maintenance (e.g. re-mulching, soil loosening) to maintain their intended function of slowing and infiltrating runoff from outsloped road surfaces. Incorporation of wood chips into the soil is intended to increase microbial activity and make these treatment areas fairly resilient to disturbance; however, continual disturbance by vehicles and foot traffic will quickly reduce their functional life. It is recommended that Heavenly expand efforts to minimize disturbance of these relatively-sensitive treatment areas by communicating their locations and intended functions to operations staff. During routine inspections of road shoulder infiltration strips, Heavenly staff should have mulch (preferably wood chips) on hand to re-apply mulch in bare areas and a pick mattock to loosen compacted soil areas (particularly tire tracks).

	Unmet Criterion	Management Response
Road Shoulder	n/a	Visual erosion assessment
Road Shoulder	n/a	Targeted maintenance (mulching, soil loosening, etc.)
Road Shoulder	n/a	Photo monitoring

Lakeview Lodge Water System Improvement Project

Overview

The Lakeview Lodge Water System Improvement Project includes a range of improvements to the water infrastructure near the Lakeview Lodge at the top of the tram. The project includes removal of the existing water tank, construction of a new water tank, and construction of new underground waterlines to tie into existing infrastructure. Construction activities are primarily taking place in previously disturbed areas. Trenching was the primary impact to soil and vegetation during the 2008 construction season. Seven treatments and three monitoring areas were established at this project in 2008 (Figure 122). In 2010, the second phase of the Lakeview Lodge Water System Improvement Project is planned to be implemented, which will include the following elements: removal of the existing water tank and restoration of the associated access road, and completion of an ADA trail from Lakeview Lodge to the top of the tram.

Site Description

Gun Barrel Top Terminal Slope

The Gun Barrel top terminal slope (Gun Barrel top slope) is a disturbed slope with a summer road that switchbacks through it (Figure 123 and Figure 124). The site is located on a northeast facing slope at an elevation of 8,303 feet AMSL. The site is moderately sloped (14 degrees), does not have any canopy cover, and a solar exposure of greater than 95% during the summer months. The soil is derived from granitic parent material with a low proportion of rocks greater than 0.5 inches in diameter. Conifers surround the area, which is dominated by red fir (*Abies magnifica*), Jeffrey pine (*Pinus jeffreyi*), and Western white pine (*Pinus monticola*). Greenleaf manzanita (*Arctostaphylos patula*) dominates the understory in the surrounding area. The monitoring area contains a variety of native and non-native forbs and grasses, with a few native shrub and tree seedlings. None of the non-native species are classified as invasive or noxious.

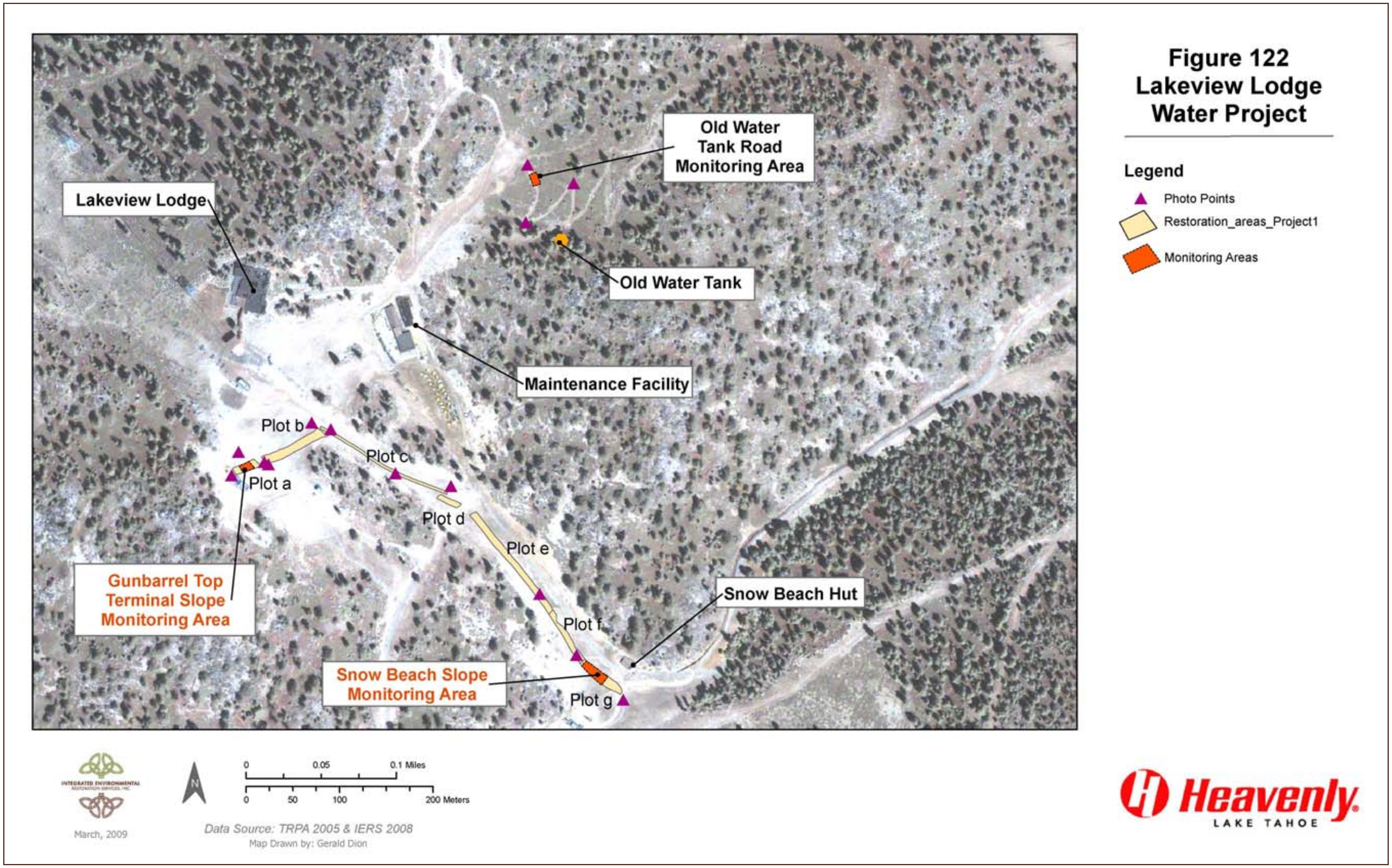


Figure 122. Lakeview Lodge Water System Improvement Project Map.

Figure 123. Gun Barrel top terminal slope monitoring area, pre-treatment, August 2008.

Figure 124. Gun Barrel top terminal slope, pre-treatment, August 2008. Water line installation area is between the T-stakes.

Old Water Tank Road

The old water tank road is an unpaved road that will be restored after the water tank is removed in 2010 (Figure 125 and Figure 126). Most of the road faces north-northwest at an elevation of approximately 8,261 feet AMSL. The road is gently sloped in mostly places, approximately 6 degrees. There is no canopy cover and the solar exposure is about 90% during the summer months. The solar exposure is lower at the southern part of the road near the existing water tank. The soil is derived from granitic parent material with a low proportion of rocks greater than 0.5 inches in diameter. Conifers surround the area, which is dominated by red fir (*Abies magnifica*), Jeffrey pine (*Pinus jeffreyi*), and Western white pine (*Pinus monticola*). Greenleaf manzanita (*Arctostaphylos patula*) dominates the understory, which also contain a variety of native forbs and grasses.

Figure 125. Old Water Tank Road, pre-treatment, looking downhill from the water tank site.

Figure 126. Old Water Tank Road, pre-treatment, looking uphill at the water tank

Patsy's Trail

Patsy's Trail is the ski run directly above the Snow Beach area (Figure 127 and Figure 128). The conditions vary from dry in some of the lower areas to wet in the upper areas. The slope faces 130 degrees east and the slope angle is moderate at 10 degrees. The approximate elevation is 8,096 feet AMSL and the solar exposure is 90% during the summer months. There is no canopy cover, but the surrounding area is dominated by Jeffrey pine (*Pinus jeffreyi*) and red fir (*Abies magnifica*). A mix of native and non-native plant forbs and grasses were present; however, three non-native invasive plants were also found at this site: orchard grass (*Dactylis glomerata*), curly dock (*Rumex crispus*), and woolly mullein (*Verbascum thapsus*).

Figure 127. Patsy's Trail, looking up from the Snow Beach area, pre-treatment, 2008.

Figure 128. Patsy's Trail, looking down at the Snow Beach area, pre-treatment, 2008.

Objectives and Success Criteria

Treatment Objectives

- no net increase in runoff and/or sediment transport as a result of the waterline installation, the old water tank removal, or the new water tank construction
- to establish an appropriate, self-sustaining, native plant community
- no evidence of erosion from any of the waterline or water tank installation activities

Monitoring Objective

- to quantitatively assess whether treatments resulted in a net change in runoff and/or sediment transport following the trail modification

Success Criteria

The following success criteria were used to determine whether treatments achieved the project treatment goals (Table 24). The success criteria are based on the following indicators: sediment yield, infiltration rate, penetrometer depth to refusal (DTR, used as an index for soil density), total cover, plant cover, organic matter, and visual erosion assessment. A success criterion for TKN was not used in 2009, as discussed in Appendix B. In addition to evaluating short-term treatment success, these indicators represent key information needed to assess the likelihood of long-term sustainability of the soil-plant system, which is the key to long-term sediment source control.

Table 24. Lakeview Project Success Criteria Evaluation.

	Success Criteria	Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 100 lbs/acre/in higher than pre-treatment levels	GB:* √ Criterion Met PT:** √ Criterion Met
Infiltration Rate (in/hr)	Not greater than 0.8 in/hr lower than pre-treatment levels	GB:√ Criterion Met PT:√ Criterion Met
Penetrometer Depth (inches)	Not greater than 4 inches shallower than pre-treatment level	GB:√ Criterion Met PT:√ Criterion Met
Total Cover (%)	70% or greater	GB:√ Criterion Met PT:√ Criterion Met
Total Plant Cover (%)	10% or greater	GB:× Criterion Not Met PT:× Criterion Not Met
Organic Matter (%)	Not greater than 1.5 percentage points less than pre-treatment level	GB:√ Criterion Met PT:√ Criterion Met
TKN (PPM)	TKN not used as a metric for measuring success	n/a, see Appendix B
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition	GB:√ Criterion Met PT:√ Criterion Met
*GB=Gun Barrel top slope **PT=Patsy's Trail		

Restoration Treatments

The Lakeview Lodge Water System Improvement Project consists of seven individual treatment areas (Table 25, Figure 122, Figure 129, Figure 130, Figure 131, Figure 132, Figure 133, Figure 134, Figure 135, Figure 136, Figure 137, and Figure 138). Soil and vegetation treatment specifications varied slightly among these areas, depending on site conditions and planned future use. Additionally, treatment elements were varied to test a few different treatment types. Treatments in areas A, B, and G included the following elements of full soil restoration: soil amendments, tilling, organic fertilizer, seed, and mulch. Treatments in areas C, D, E, and F were less intensive, and included mulch or soil loosening with mulch. These areas include road shoulders and other areas that are expected to be subject to future or ongoing disturbance and where full soil and vegetation restoration treatments would have a low probability of success.

- Treatment Area A – trench line on Gun Barrel Top Terminal Slope
- Treatment Area B – trench line on Gun Barrel Top Terminal Slope
- Treatment Area C – trench line on road shoulder
- Treatment Area D – utility box installation area

- Treatment Area E – trench line down Patsy's Trail
- Treatment Area F – trench line down Patsy's Trail
- Treatment Area G – trench line down Patsy's Trail

Table 25. Lakeview Project Treatment Matrix.

		Treatment Area						
		A	B	C	D	E	F	G
Amendments	Type	WC, FCZ	WC	n/a	n/a	n/a	BLB	BLB
	Depth (in)	4 (2" of each)	4	n/a	n/a	n/a	4	4
Tilling	Depth (in)	18	14	n/a	n/a	n/a	14	12
Fertilizer	Type	Biosol 6-1-3	Biosol 6-1-3*	n/a	n/a	n/a	n/a	Biosol 6-1-3*
	Rate (lbs/acre)	2,000	2,000*	n/a	n/a	n/a	n/a	2,000*
Seed	Mix	Lakeview upland mix	Lakeview upland mix	n/a	n/a	n/a	n/a	No
	Rate (lbs/acre)	50	50	n/a	n/a	n/a	n/a	0
Mulch	Type	PNM	PNM	WC	WC	WC	BLB	BLB and PNM
	Depth (in)	1	1	2	2	4	1	1
Irrigation	Frequency/ Duration	yes - unknown	no	n/a	no	no	no	No
Treatment Area	Square Feet	2,449	7,033	4,697	1,558	10,057	3,928	5,004

Key: WC = wood chips, BLB = Boulder Lodge Blend (well-aged wood chips and pine needles), FCZ = Full Circle Integrated Tahoe Blend Zero (composted coarse overs), PNM = pine needle mulch, * = not verified in field

Figure 129. Treatment area A, pre-treatment, August 2008.

Figure 130. Treatment area A, post-treatment, August 2008.

Figure 131. Treatment area A, post-treatment, August 2009.

Figure 132. Treatment area B, pre-treatment, August 2008.

Figure 133. Treatment area B, post-treatment, September 2008.

Figure 134. Treatment area B, post-treatment, August 2009.

Figure 135. Treatment areas E, F and G, pre-treatment, August 2008.

Figure 136. Treatment areas E, F and G, post-treatment, October 2008.

Figure 137. Treatment areas E, F and G, post-treatment, August 2009. Heavy machinery tracks are visible.

Figure 138. Treatment areas E, F and G, post-treatment, October 2009.

Performance Monitoring

Infiltration and Sediment Yield

Rainfall Simulation

The pre-treatment sediment yield at the old water tank road was 2,314 lbs/acre/in (Figure 139). Post-treatment infiltration and sediment yield monitoring will be conducted in 2010 after the old water tank is removed.

The post-treatment sediment yield at Patsy's Trail (19 lbs/acre/in) was 98% lower than the pre-treatment sediment yield (1,154 lbs/acre/in). Although runoff simulation was conducted pre-treatment and rainfall simulation was conducted post-treatment, the success criterion can easily be evaluated without a directly comparing the two methods. The post-treatment sediment yield was lower than all but one plot (Olympic bottom A) measured in 2009, indicating it is one of the most successful restoration treatments and the criterion has been met.

The post-treatment sediment yield at the Gun Barrel top slope (280 lbs/acre/in) was 143% higher than the pre-treatment sediment yield (115 lbs/acre/in). This increase was a result of the strange runoff substance collected at Frame 1 (see the call out box next to Figure 139 for details). Without Frame 1 included, the post-treatment sediment yield was zero at the Gun Barrel top slope and the success criterion, which states that the post-treatment sediment yield must be no more than 100 lbs/acre/in higher than the pre-treatment sediment yield, was met (Figure 140).

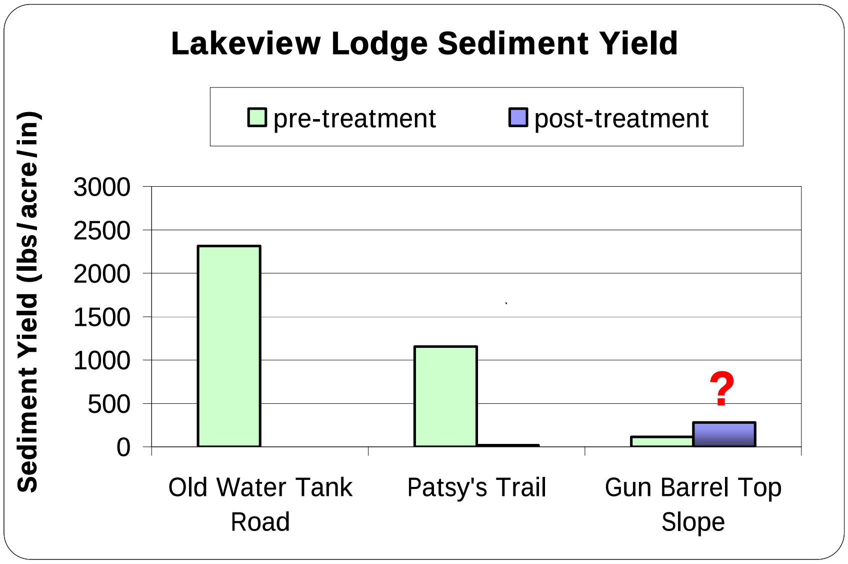


Figure 139. Lakeview Lodge Sediment Yield. Sediment yield at the Gun Barrel top slope increased by 143% (from 115 to 280 lbs/acre/in) when Frame 1 was included. The post-treatment sediment yield at Patsy's trail was 19 lbs/acre/in, a 98% reduction. Runoff simulation was conducted at Patsy's Trail pre-treatment, while rainfall simulation was conducted post-treatment.

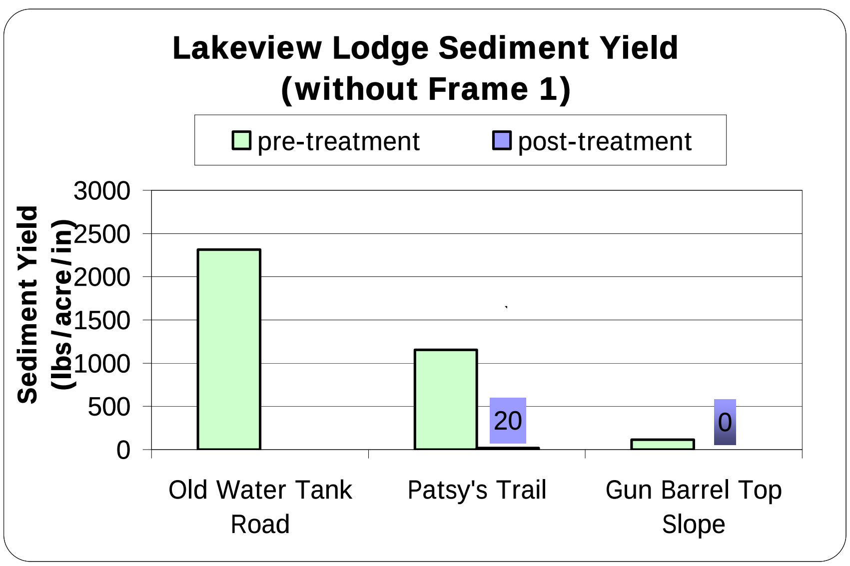


Figure 140. Lakeview Lodge Sediment Yield (Without Frame 1). Sediment yield at the Gun Barrel top slope decreased from 115 lbs/acre/in to zero when frame 1 was removed from the average. Runoff simulation was conducted at Patsy's Trail pre-treatment, while rainfall simulation was conducted post-treatment.

A Closer Look

Why did sediment yield increase post-treatment at the Gun Barrel top slope?

Three frames were included in the sediment yield average:

Frame 1: 839 lbs/acre/in
Frame 2: no runoff
Frame 3: no runoff

Frame 1 produced a highly cohesive gelatinous substance while filtering to determine sediment yield that has not been observed before (see photo below of filtered sample). Consultation with University of Davis faculty did not help to identify the substance.

Without this frame included in the average, the post-treatment sediment yield was zero, a decrease of 115 lbs/acre/in from pre-treatment.

The pre-treatment infiltration rate at the old water tank road was 3.7 in/hr (Figure 141).

The post-treatment infiltration rate at Patsy's Trail (4.6 in/hr) was 130% higher than the pre-treatment infiltration rate (2.0 in/hr). Although it is difficult to compare the pre-treatment runoff simulation to the post-treatment rainfall simulation, Patsy's Trail is considered to have met the success criterion. The post-treatment infiltration rate (4.6 in/hr) was 2% lower than the maximum possible infiltration rate (4.7 in/hr) for rainfall simulation.

The post-treatment infiltration rate at the Gun Barrel top slope (4.7 in/hr) was 18% higher than the pre-treatment infiltration rate (4 in/hr). Removal of Frame 1 from the infiltration rate did not change the average. The success criterion, which states the post-treatment infiltration rate must be no more than 0.8 in/hr lower than the pre-treatment infiltration rate, was met.

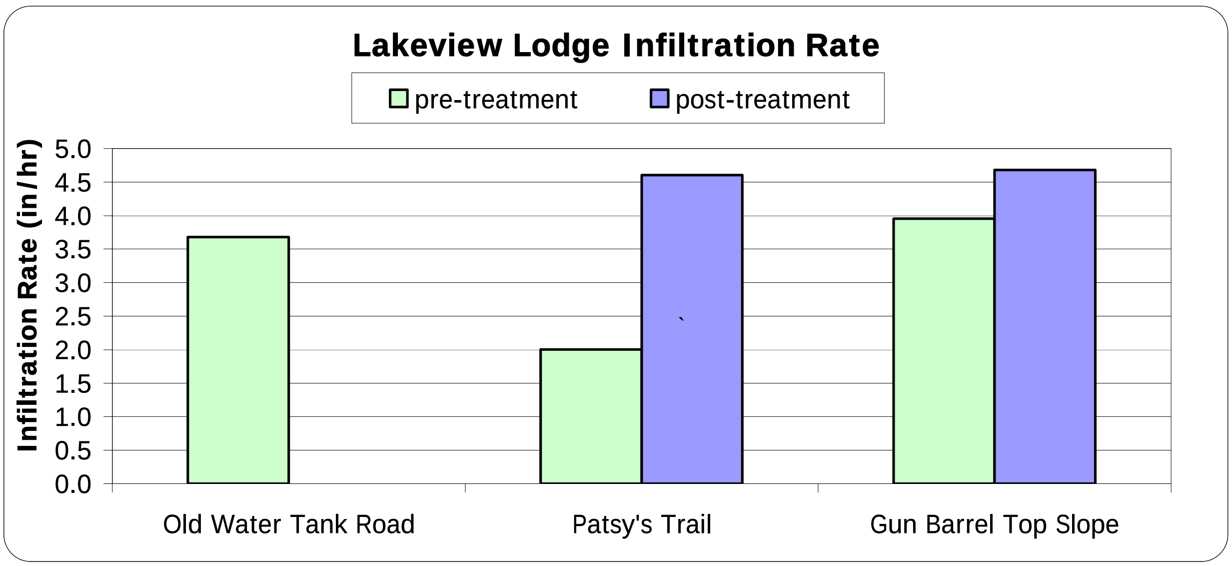


Figure 141. Lakeview Infiltration Rate (Rainfall Simulation). The infiltration rate at the Gun Barrel top slope increased by 18% post-treatment, while the infiltration rate at Patsy's Trail increased by 130% post-treatment. Runoff simulation was conducted at Patsy's Trail pre-treatment, while rainfall simulation was conducted post-treatment.

Penetrometer Depth to Refusal (DTR)

The pre-treatment penetrometer DTR at the old water tank road was 2.0 inches (Figure 142). The post-treatment penetrometer DTR at Patsy's trail (6.4 inches) was 5.1 inches deeper than the pre-treatment DTR (1.3 inches). The post-treatment penetrometer DTR at the Gun Barrel top slope (15.1 inches) was 12.1 inches deeper than the pre-treatment penetrometer DTR (3.0 inches). The success criterion, which states the post-treatment DTR cannot be more than 4.0 inches shallower than the pre-treatment DTR, was met.

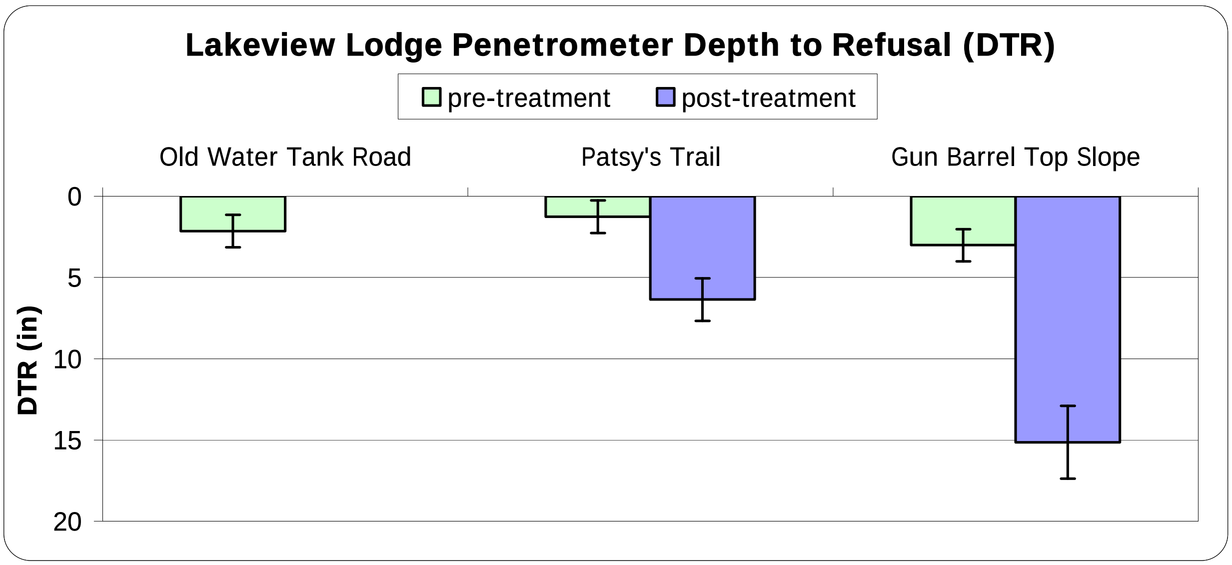


Figure 142. Lakeview Penetrometer Depth to Refusal (DTR). Penetrometer DTR increased post-treatment at Patsy's Trail and Gun Barrel top slope by 5.1-12.1 inches. Post-treatment measurements were not taken at the old water tank road. Error bars represent one standard deviation above and below the mean.

Total Cover

The pre-treatment total cover at the old water tank road was 48% (Figure 143). The total cover consisted of 11% cover by mulch and 36% cover by gravel/rocks. The post-treatment total cover at Patsy's Trail (79%) was 58% higher than the pre-treatment total cover (50%). The mulch cover, which increased from 33% to 76%, accounted for most of the gain in total cover. The post-treatment total cover at the Gun Barrel top slope (95%) was 228% higher than the pre-treatment total cover (29%). The mulch cover increased from 24% to 95% post-treatment. The success criterion, which states that the total cover must be greater than 70%, was met for both plots.

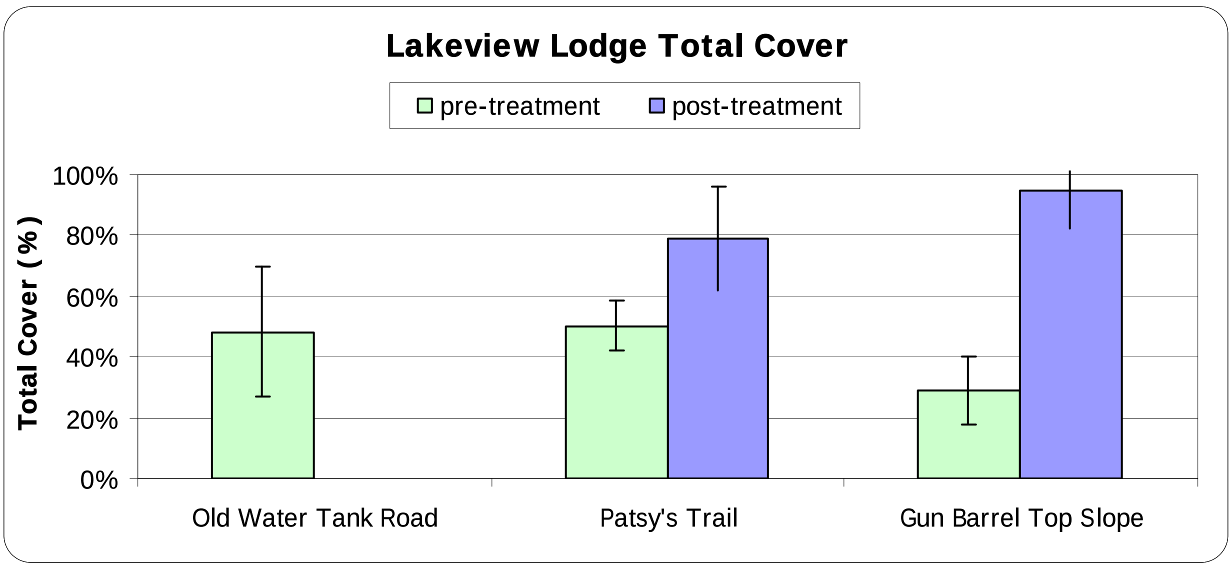


Figure 143. Lakeview Lodge Total Cover. Total cover increased by 58-228% post-treatment at Patsy's Trail and the Gun Barrel top slope. Post-treatment measurements were not taken at the old water tank road. The error bars denote one standard deviation above and below the mean.

Plant Cover

The pre-treatment plant cover was 5% at the old water tank road (Figure 144). The post-treatment plant cover at Patsy's Trail (2%) was 91% lower than the pre-treatment plant cover (22%). The post-treatment plant cover at the Gun Barrel top slope (9%) was 36% lower than the pre-treatment plant cover (14%). The success criterion, which states the post-treatment plant cover must be at least 10%, was not met for either plot.

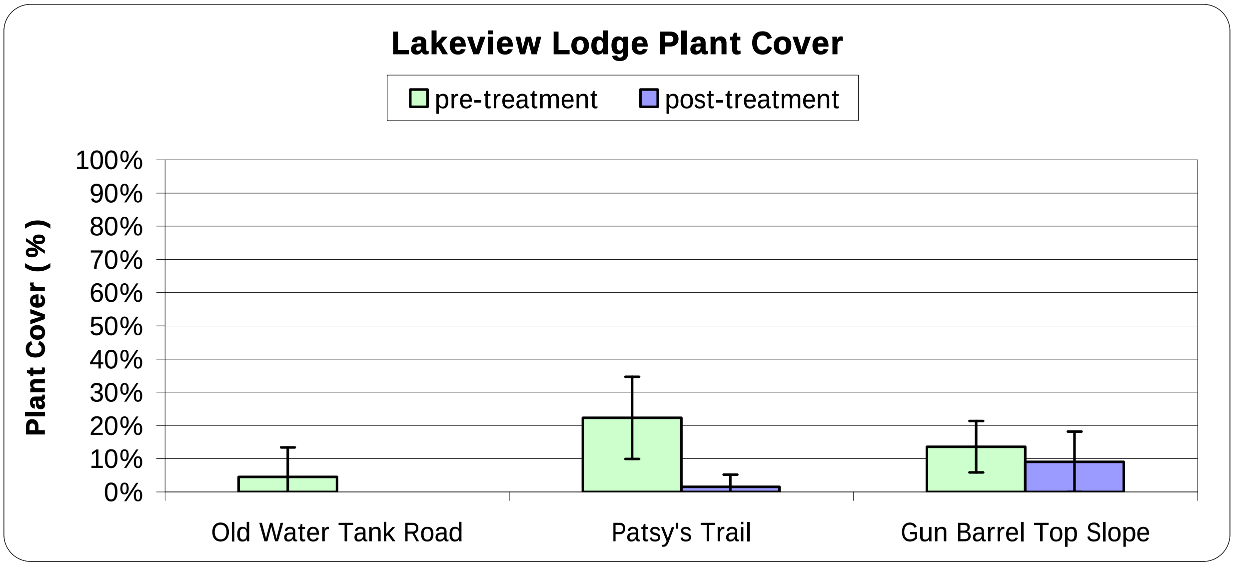


Figure 144. Lakeview Lodge Plant Cover. Plant cover decreased at both sites following treatment post-treatment. Post-treatment measurements were not taken at the old water tank road. The error bars denote one standard deviation above and below the mean.

Soil Nutrients

Organic Matter

The pre-treatment organic matter content at the old water tank road was 2.3% (Figure 145). The post-treatment organic matter content at Patsy's Trail (1.6%) was similar to the pre-treatment organic matter content (1.5%). The post-treatment organic matter content at the Gun Barrel top slope (1.4%) was 36% or 0.8 percentage points lower than pre-treatment organic matter content (2.2%). The criterion, which states that the post-treatment organic matter content must be no more than 1.5 percentage points lower than the pre-treatment organic matter content, was met for both Patsy's Trail and the Gun Barrel top slope.

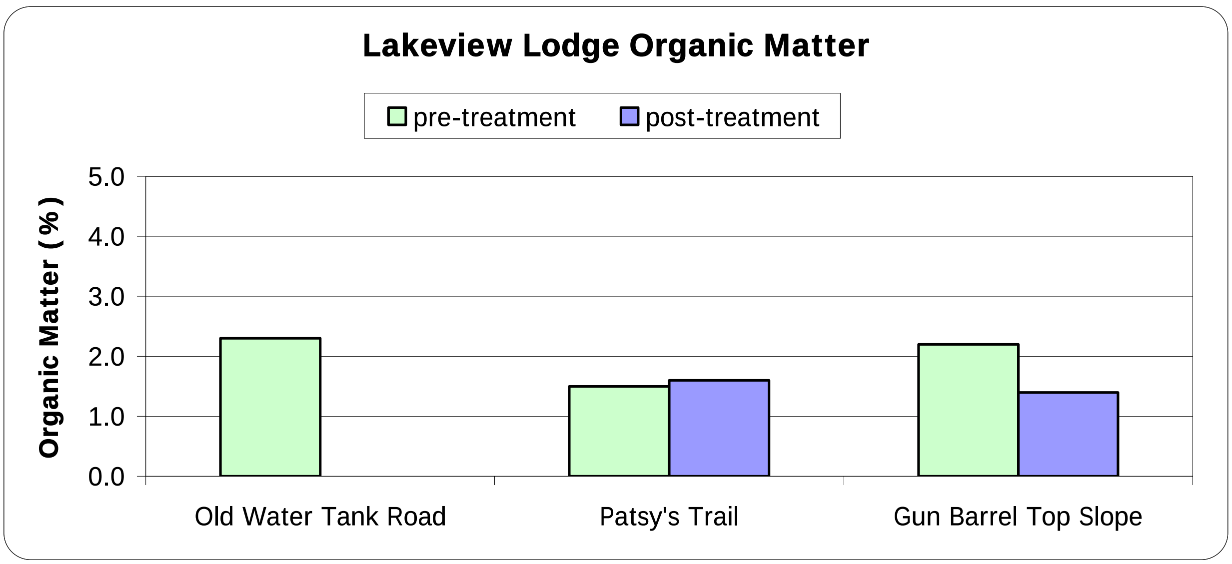


Figure 145. Lakeview Organic Matter Content. At Patsy's Trail, organic matter content did not change markedly pre- and post-treatment, while it decreased by 0.8 percentage points at the Gun Barrel top slope. Post-treatment measurements were not taken at the old water tank road.

Total Kjeldahl Nitrogen

The pre-treatment TKN at the old water tank road was 600 ppm (Figure 146). The post-treatment TKN at Patsy's Trail (368 ppm) was 30% lower than the pre-treatment TKN (523 ppm). The post-treatment TKN at the Gun Barrel top slope (257 ppm) was 64% percent lower than the post-treatment TKN (721 ppm). A success criterion for TKN was not used in 2009, as discussed in Appendix B.

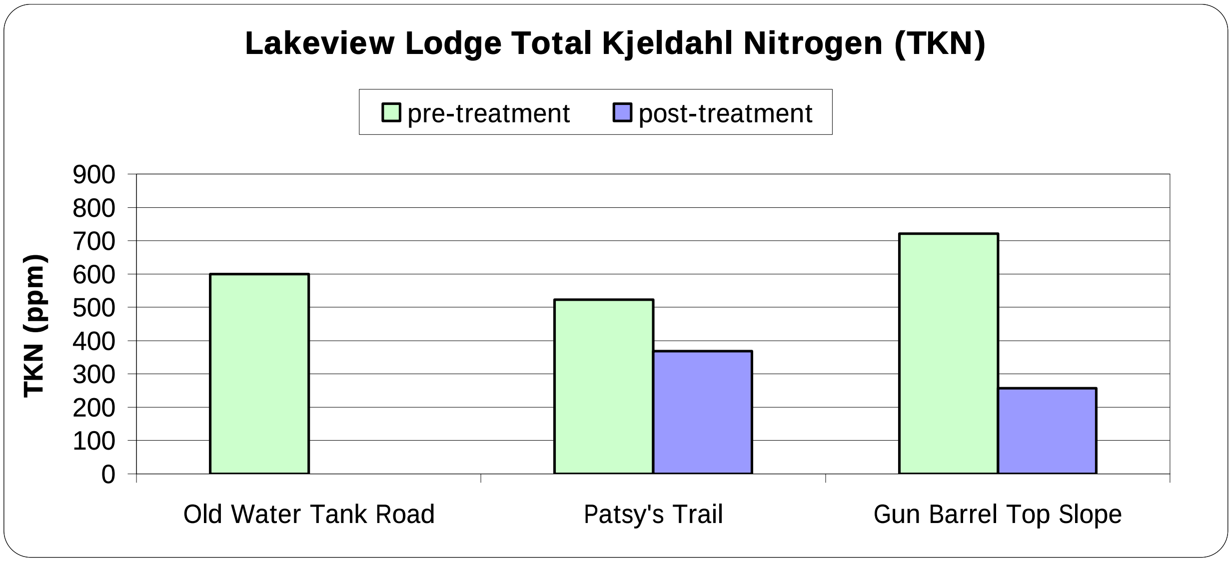


Figure 146. Lakeview Lodge Total Kjeldahl Nitrogen (TKN). TKN decreased by 30-64% at Patsy's Trail and the Gun Barrel top slope. Post-treatment measurements were not taken at the old water tank road.

Visual Erosion Assessment

At the old water tank road, there was water erosion in the form of rilling and evidence of disturbance by rodents in 2008 and 2009.

At Patsy's Trail in August 2009, heavy machinery tracks were observed as well as small bare areas created by burrowing animals in the monitoring plot (Figure 137). The area was treated again in fall 2009, and no further disturbances were observed. Therefore, the criterion, which states that no visible signs of rills, gullies, sediment transport, or sediment deposition can be present, was met.

At the Gun Barrel top slope, there was evidence of water erosion in 2008, including rills and gullies on the slope. Some of the water erosion is a likely result of the irrigation routinely applied to this slope. Off Highway Vehicle (OHV) tire tracks were observed on this slope in 2008, as well as disturbance by small burrowing animals. Pine needle movement, grazing, and rodent activity were observed at the Gun Barrel plot in 2009, however there were no other signs of erosion in 2009. No sediment deposition was observed on the upslope side of the pine needles, suggesting that wind transport was the likely mechanism for pine needle movement.

Management Response

Most of the success criteria were met for the Lakeview Lodge project, indicating that outcome was generally aligned with the primary project objective of a no net increase in runoff and sediment yield. Monitoring results indicate high infiltration rates, low sediment yield, low soil density (as measured by cone penetrometer), and high total cover. However, the criterion for plant cover was not at either site. Additionally, the TKN decreased at both sites following treatment. Soil TKN and plant cover tend to be closely related. High-carbon soil amendments such as aged and composted wood chips, which were used as soil amendments at these sites, tend to reduce available nitrogen during decomposition, which can limit plant growth for several years. Therefore, rather than recommending immediate treatment action, another year of monitoring is recommended to better understand the long term trajectory for plant cover. If monitoring in 2010 indicates increasing trends in plant cover, follow up treatments may not be necessary. However, if plant cover decreases or no plant cover is present in 2010, treatment actions such as fertilizing, seeding and/or irrigation will be necessary to help achieve success criteria. Although the plant cover was higher before restoration treatments, many non-native species were present, which may provide less long-term protection against erosion compared to deep-rooting native perennial grasses.

Patsy's Trail was re-treated after post-treatment monitoring occurred in 2009; therefore, further penetrometer monitoring is recommended in 2010 to ensure that a tilling depth comparable to the 2009 treatment was achieved. Cover monitoring for 2010 is also recommended since the re-treatment will affect the total cover.

Visual erosion assessment is recommended on a yearly basis to identify small problems before they become larger problems and develop appropriate treatment responses. Additional assessment can be particularly useful during and immediately after rain events, as evidence of erosion is difficult to observe even several days after a rain storm, particularly on decomposed granite soils. It is recommended that Heavenly expand efforts to minimize disturbance of treatment areas by installing temporary fencing and/or signage and communicating the locations of sensitive treatment areas to operations staff.

Table 26. Lakeview Lodge Management Responses for Unmet Success Criteria.

	Unmet Criterion	Management Response
Patsy's Trail	Plant Cover	Cover monitoring
Patsy's Trail	n/a	Visual erosion assessment
Patsy's Trail	n/a	Photo monitoring
Patsy's Trail	n/a	Penetrometer monitoring
Patsy's Trail	n/a	Treatment area protection (fencing, signage, etc)
Gun Barrel Top Slope	Plant Cover	Cover monitoring
Gun Barrel Top Slope	n/a	Photo monitoring
Gun Barrel Top Slope	n/a	Visual erosion assessment

Stagecoach Snowmaking Project

Overview

The Stagecoach snowmaking project includes the installation of a snowmaking line that runs from the top of the Stagecoach Lift down the Stagecoach ski run and along the shoulder of Nevada Trail. The snowmaking line includes both above-ground and below-ground segments. The below-ground segments were installed on unpaved roads and the above-ground segments were installed along the edge of a cleared ski run (Stagecoach) with large boulders and a dense shrub understory. Soil impacts associated with this project included trenching for snowmaking pipes, soil compaction, and vegetation disturbance in temporary vehicle and equipment travel paths and staging areas. Three different treatments areas were implemented and three monitoring areas were established at this project site in 2008. These treatment areas and monitoring areas are described in detail below and are shown on the project map (Figure 149).

Site Description

Upper Slope

The upper slope is located on the edge of a cleared ski run (Figure 147 and Figure 148). The site faces 30 degrees northeast and has a moderate slope of 16 degrees. The approximate site elevation is 8,362 feet AMSL. The canopy cover is 5% and the solar exposure ranges from 82 to 86% during the summer months. The soil is derived from granitic parent material with a low proportion of rocks greater than 0.5 inches in diameter. The surrounding area is dominated by red fir (*Abies magnifica*) and Western white pine (*Pinus monticola*), while the ski slope is mostly greenleaf manzanita (*Arctostaphylos patula*) with some chinquapin (*Chrysolepis sempervirens*). Non-native species were not observed in this area.

Figure 147. Stagecoach snowmaking upper slope, pre-treatment, October, 2008.

Figure 148. Stagecoach snowmaking upper slope, during treatment, October, 2008.

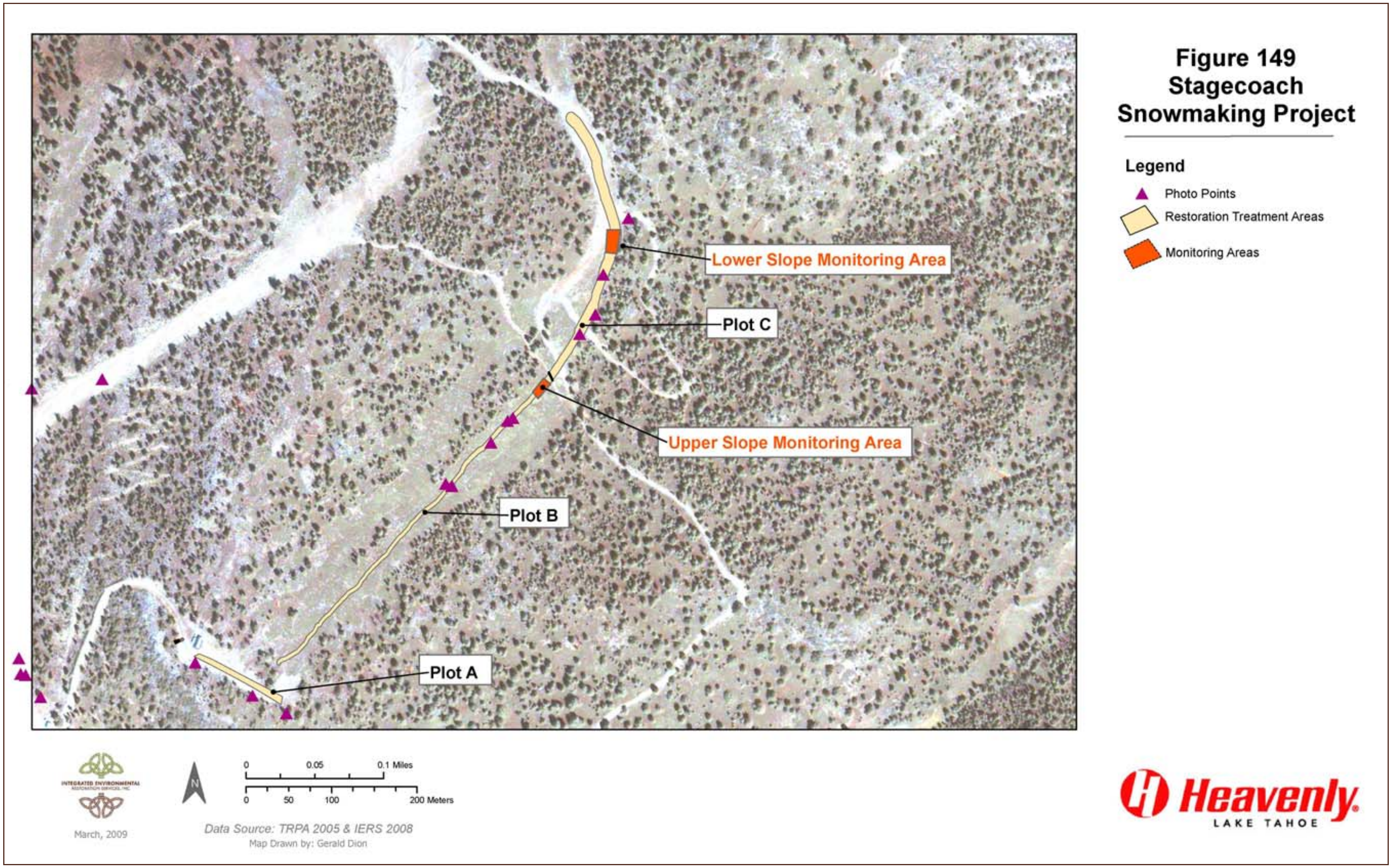


Figure 149. Stagecoach Snowmaking Project Map.

Lower Slope

The lower slope is located on the edge of a cleared ski run (Figure 150 and Figure 151). The site faces north and has a slope of 24 degrees. The approximate site elevation is 8,224 feet AMSL. There is no canopy cover and the solar exposure ranges from 55 to 70% during the summer months. The soil is derived from granitic parent material with a low proportion of rocks greater than 0.5 inches in diameter. The surrounding forested area is dominated by red fir (*Abies magnifica*), white fir (*Abies concolor*) and Western white pine (*Pinus monticola*), while the ski slope has pinemat manzanita (*Arctostaphylos nevadensis*) Western white pine, and some native grasses and forbs. Non-native species were not observed in this area.

Figure 150. Stagecoach snowmaking lower slope monitoring area, pre-treatment, August, 2008.

Figure 151. Stagecoach Snowmaking lower slope monitoring area post-treatment, November, 2008.

Objectives and Success Criteria

Treatment Objectives

- no net increase in runoff and/or sediment transport as a result of the snowmaking line installation
- to establish an appropriate, self-sustaining, native plant community
- no evidence of erosion from any of the snowmaking line installation activities

Monitoring Objective

- to quantitatively assess whether treatments resulted in a net change in runoff and/or sediment transport following the snowmaking line installation

Success Criteria

The following success criteria were used to determine whether treatments achieved the project treatment goals (Table 27). The success criteria are based on the following indicators: sediment yield, infiltration rate, penetrometer depth to refusal (DTR, used as an index for soil density), total cover, plant cover, organic matter, and visual erosion assessment. A success criterion for TKN was not used in 2009, as discussed in Appendix B. In addition to evaluating short-term treatment success, these indicators represent key information needed to assess the likelihood of long-term sustainability of the soil-plant system, which is the key to long-term sediment source control.

Table 27. Stagecoach Snowmaking Line Success Criteria Evaluation.

	Stagecoach Success Criteria Evaluation	Stagecoach Success Criteria
Sediment Yield (lbs/acre/in)	Not greater than 100 lbs/acre/in higher than pre-treatment levels	U*:√ Criterion Met L**:√ Criterion Met
Infiltration Rate (in/hr)	Not greater than 0.8 in/hr lower than pre-treatment levels	U:√ Criterion Met L:√ Criterion Met
Penetrometer Depth (inches)	Not greater than 4 inches shallower than pre-treatment level	U:√ Criterion Met L:√ Criterion Met
Total Cover (%)	70% or greater	U:√ Criterion Met L:√ Criterion Met
Total Plant Cover (%)	10% or greater	U:× Criterion Not Met L: × Criterion Not Met
Organic Matter (%)	Not greater than 1.5 percentage points less than pre-treatment level	U:√ Criterion Met L:√ Criterion Met
TKN (PPM)	TKN not used as a metric for measuring success	n/a, see Appendix B
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	U:√ Criterion Met L:× Criterion Not Met

*U=Upper slope
**L=Lower Slope

Restoration Treatments

The Stagecoach Snowmaking project consists of three treatment areas – A, B, and C (Figure 152, Table 28, Figure 153, Figure 154, Figure 155, Figure 156, Figure 157, Figure 158, Figure 159, Figure 160). Areas A and C include unpaved roads, road shoulders and other previously disturbed areas where below-ground snowmaking segments were constructed. Due to the soil disturbance associated with trenching and the general lack of ecological "capital" in areas A and C, full soil and vegetation restoration treatments were implemented to rebuild a self-sustaining soil and vegetation community. The full restoration treatment included the following elements: soil amendments, tilling, organic fertilizer, seed, and mulch. Area B is a cleared ski run where above-ground snowmaking was constructed. The run clearing activities left the topsoil and understory vegetation relatively intact; therefore, treatments were less intensive at area B than those implemented in areas A and C. The treatment at area B was designed to remove soil compaction and replace vegetation disturbed in the equipment travel corridor. Additionally, equipment travel was deliberately limited to a very narrow corridor in order to minimize impacts to soil and vegetation during construction.

Table 28. Stagecoach Snowmaking Treatment Matrix.

		Treatment Area		
		A	**B**	**C**
Amendments	**Type**	WC, BLB	n/a	WC, BLB
	Depth (in)	4	n/a	4*
Tilling	**Depth (in)**	20	14	18*
Fertilizer	**Type**	Biosol 6-1-3*	Biosol 6-1-3*	Biosol 6-1-3*
	Rate (lbs/acre)	1,000*	1,000*	1,000*
Seed	**Mix**	Stagecoach upland mix*	Stagecoach upland mix*	Stagecoach upland mix*
	Rate (lbs/acre)	25*	25*	25*
Mulch	**Type**	PNM, WC*	PNM*	PNM*
	Depth (in)	1*	1*	1*
Irrigation	**Frequency/Duration**	No	no	no
Treatment Area	**Square Feet**	5,111	6,009	2,969

Key
WC = wood chips
BLB = Boulder Lodge Blend (well-aged wood chips and pine needles)
PNM = pine needle mulch
* = not verified in field

Figure 152. Stagecoach Snowmaking, treatment area B, pre-treatment, August 2008.

Figure 153. Stagecoach Snowmaking, treatment area B, during construction, September 2008.

Figure 154. Stagecoach Snowmaking, seeding at treatment area B, November 2008.

Figure 155. Stagecoach Snowmaking, treatment area B, October 2009.

Figure 156. Stagecoach Snowmaking, treatment area C, pre-treatment, August 2008

Figure 157. Stagecoach Snowmaking, treatment area C, post-treatment, November 2008.

Figure 158. Stagecoach Snowmaking, treatment area C, post-treatment, August 2009.

Figure 159. Stagecoach Snowmaking, treatment area C (roadside), pre-treatment, August 2008

Figure 160. Stagecoach Snowmaking, treatment area C (roadside), post-treatment, October 2009.

Performance Monitoring

Infiltration and Sediment Yield

The post-treatment sediment yield at the Stagecoach upper slope (61 lbs/acre/in) was 103% or 31 lbs/acre/in higher than the pre-treatment sediment yield (30 lbs/acre/in; Figure 161). The post-treatment sediment yield at the lower slope (91 lbs/acre/in) was 20% or 15 lbs/acre/in higher than the pre-treatment sediment yield (76 lbs/acre/in). The success criterion, which states that the post-treatment sediment yield should be no more than 100 lbs/acre/in higher than the pre-treatment sediment yield, was met for the upper and lower slope.

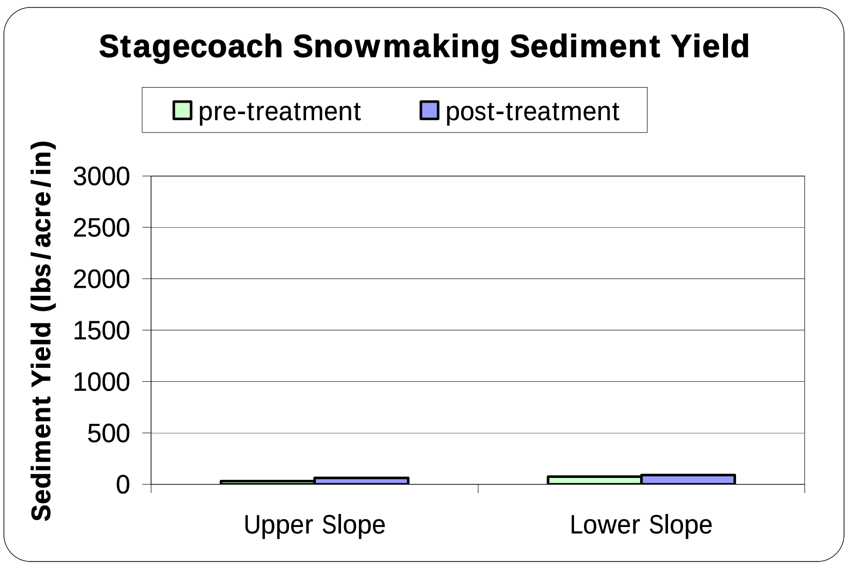


Figure 161. Stagecoach Snowmaking Sediment Yield. Sediment yield increased by 20% to 103% post-treatment. All sediment yields were under 100 lbs/acre/in.

A Closer Look

Although the criterion was met for the Stagecoach lower slope, a closer look at the data reveals an interesting trend.

	Frame DTR (in)	Sediment Yield (lbs/acre/in)
Frame 1	1.7	179
Frame 2	4.9	94
Frame 3	7.6	No runoff

The frame with the shallowest penetrometer DTR (measured within the rainfall frame) had the highest sediment yield, while the frame with the deepest DTR did not produce any runoff or sediment. Had all three rainfall frames been placed in the same area as Frame 1 (skiers left of the lower slope), the criterion for the lower slope would not have been met.

The post-treatment infiltration rate at the Stagecoach upper slope (4.1 in/hr) was similar to the pre-treatment infiltration rate (4.5 in/hr; Figure 162). The post-treatment infiltration rate at the Stagecoach lower slope (4.0 in/hr) was similar to the pre-treatment infiltration rate (4.2 in/hr). The success criterion, which states the post-treatment infiltration rate must be no more than 0.8 in/hr lower than the pre-treatment infiltration rate, was met at both plots.

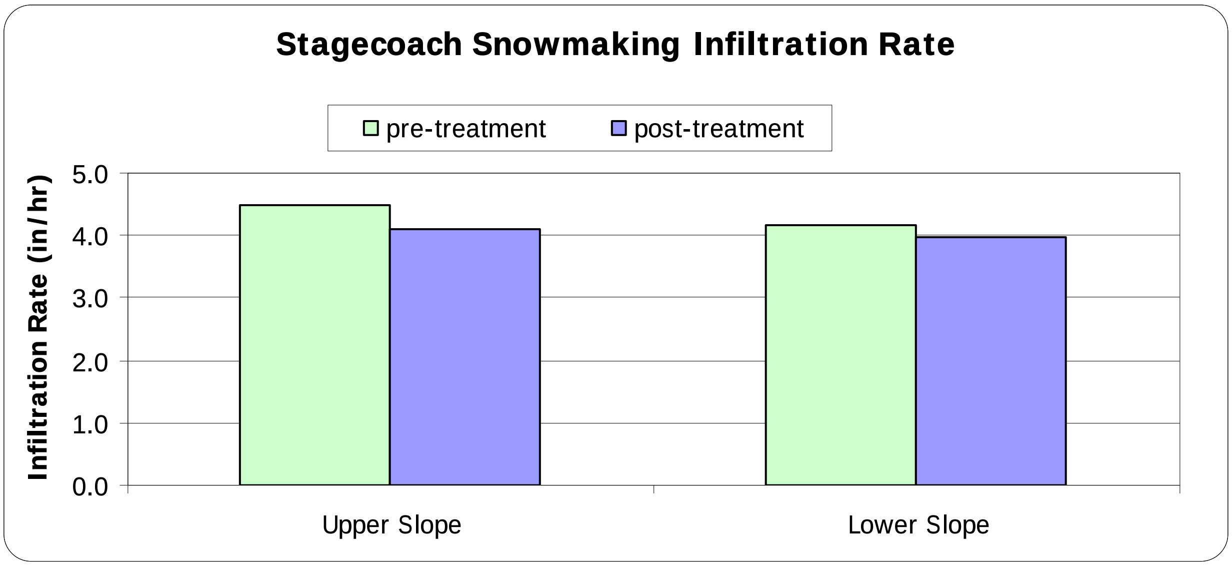


Figure 162. Stagecoach Snowmaking Infiltration Rate. Infiltration rates were similar pre- and post-treatment. Post-treatment infiltration rates were above 4.0 in/hr.

Penetrometer Depth to Refusal (DTR)

The post-treatment penetrometer DTR at the Stagecoach upper slope (15.1 inches) was 1.6 inches deeper than the pre-treatment DTR (13.5 inches; Figure 163). The post-treatment DTR at the Stagecoach lower slope (14.1 inches) was 5.3 inches deeper than the pre-treatment DTR (8.8 inches). At the lower slope, the penetrometer DTRs were inconsistent between skier's left and right of this slope, with skier's left having shallower penetrometer DTRs. This resulted in a high standard deviation (8 inches) for the penetrometer measurements and the large range of sediment yields among the three rainfall frames (Figure 161). The success criterion, which states that the post-treatment DTR cannot be more than 4.0 inches shallower that the pre-treatment DTR, was met for both plots. However, had the penetrometer DTR been measured separately at the skier's left area at the lower slope, the criterion would not have been met for skier's left.

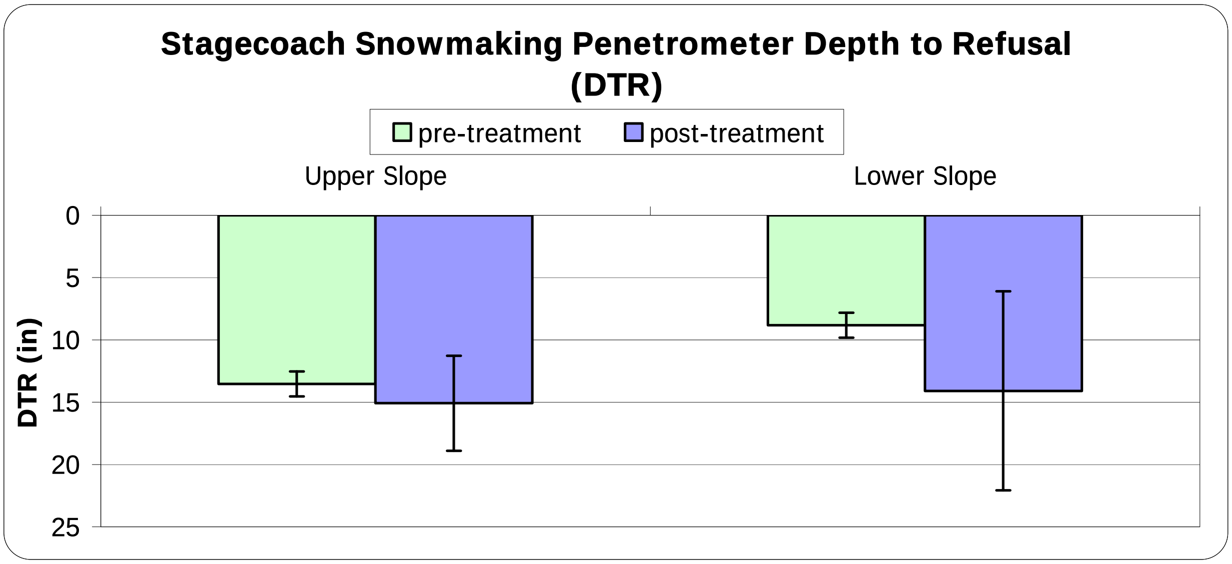


Figure 163. Stagecoach Penetrometer Depth to Refusal (DTR). Penetrometer DTRs increased by 1.6 and 5.3 inches post-treatment. Error bars denote one standard deviation above and below the mean.

Total Cover

The post-treatment total cover at the Stagecoach upper slope (96%) was similar to the pre-treatment total cover (95%; Figure 164). The post-treatment total cover at the Stagecoach lower slope (93%) was nearly double the pre-treatment total cover (47%). The success criterion, which states that the post-treatment total cover must be greater than 70% post-treatment, was met for both plots.

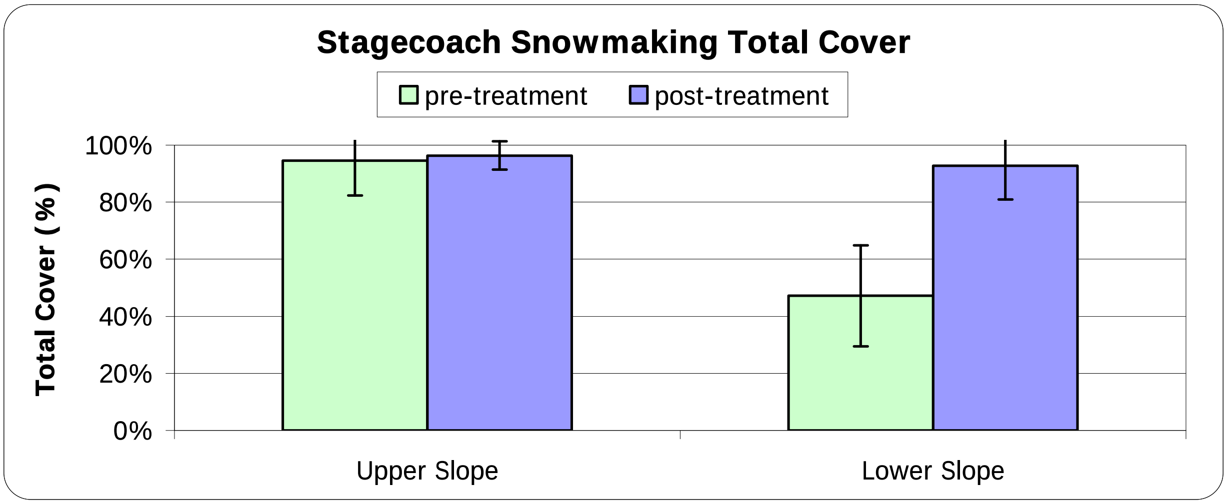


Figure 164. Stagecoach Snowmaking Total Cover. Total cover was above 90% for both plots post-treatment. Error bars denote one standard deviation above and below the mean.

Plant Cover

The plant cover at the Stagecoach upper slope decreased from 49% pre-treatment to zero post-treatment. The plant cover at the Stagecoach lower slope decreased from 3% to zero post-treatment. The success criterion, which states that the post-treatment plant must be 10% or greater, was not met for either plot.

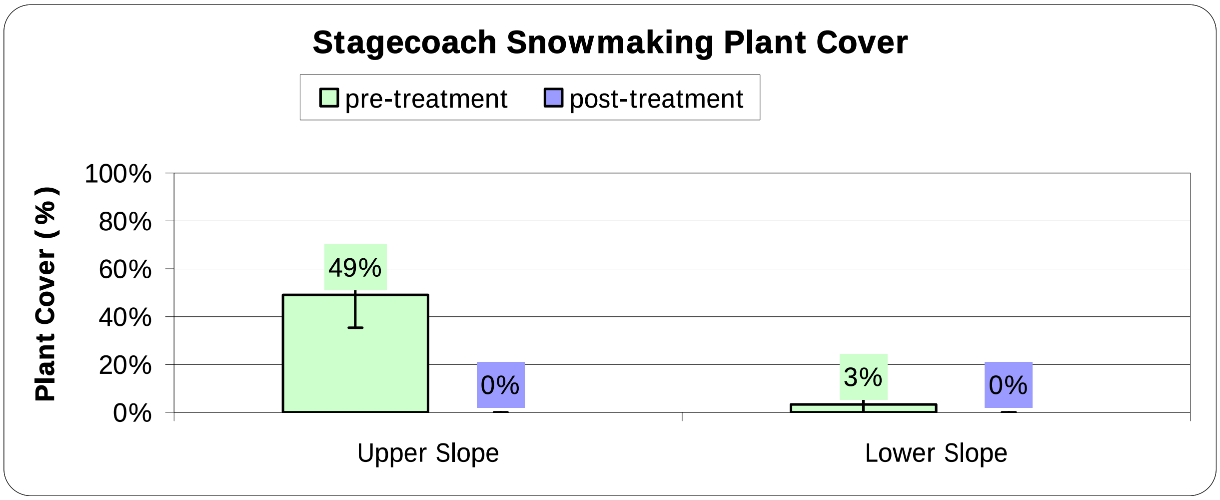


Figure 165. Stagecoach Snowmaking Plant Cover. Plant cover decreased to zero at both plots post-treatment. The error bars denote one standard deviation above and below the mean.

Soil Nutrients

Organic Matter

The post-treatment organic matter content at the Stagecoach upper slope (1.8%) was 46% or 1.5 percentage points lower than the pre-treatment organic matter content (3.3%; Figure 166). The post-treatment organic matter content at the Stagecoach lower slope (2.8%) was 12% higher than the pre-treatment organic matter content (2.5%). The success criterion, which states the post-treatment organic matter content must be no more than 1.5 percentage points lower than the pre-treatment organic matter content, was met for both the upper slope and the lower slope.

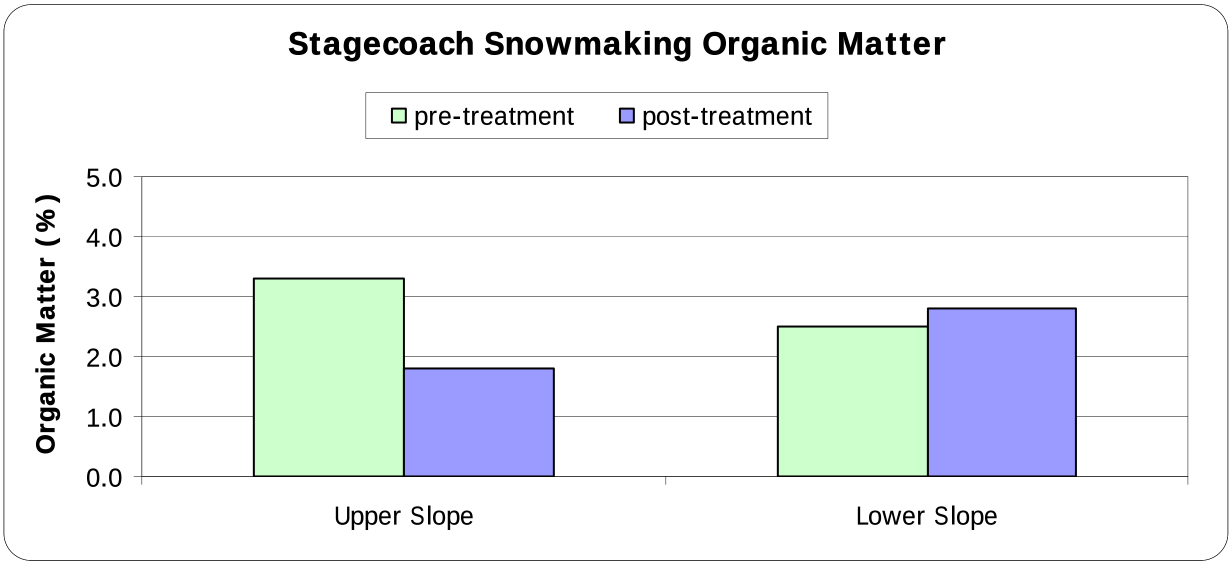


Figure 166. Stagecoach Organic Matter. Organic matter content declined by 46% at the upper slope, and increased by 12% at the lower slope.

Total Kjeldahl Nitrogen

The post-treatment TKN at the Stagecoach upper slope (324 ppm) was 60% or 484 ppm lower than the pre-treatment TKN (808 ppm; Figure 167). The post-treatment TKN at the Stagecoach lower slope (310 ppm) was 39% or 198 ppm lower than the pre-treatment TKN (508 ppm). A success criterion for TKN was not used in 2009, as discussed in Appendix B.

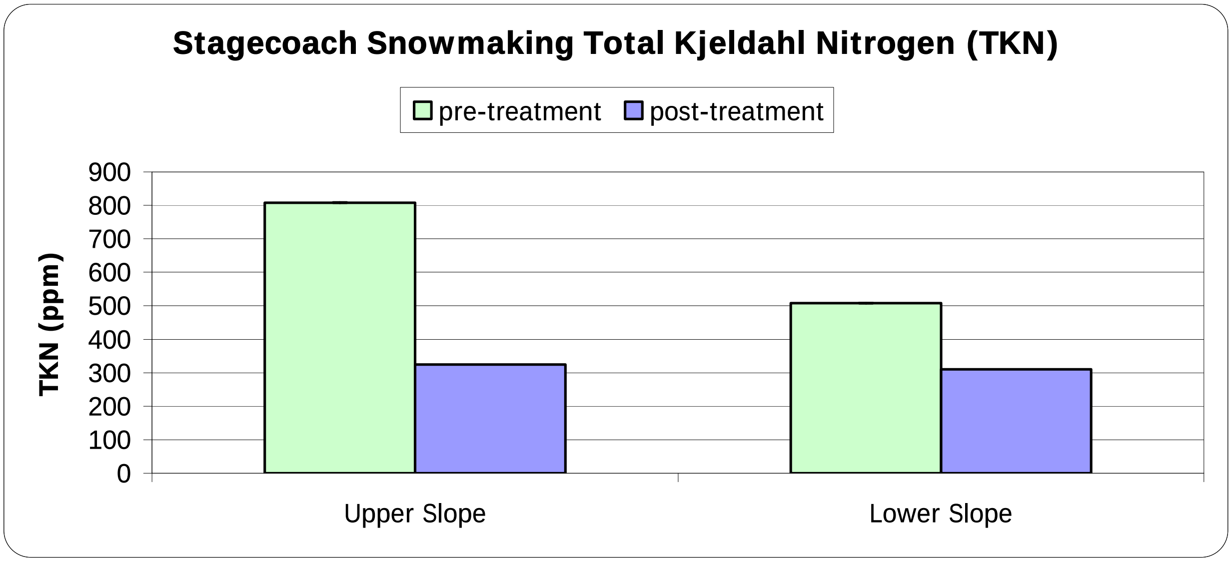


Figure 167. Stagecoach Snowmaking Total Kjeldahl Nitrogen (TKN). The TKN decreased by 39% to 60% at the Stagecoach upper and lower plots.

Visual Erosion Assessment

At the upper slope, a little pine needle movement was observed and rodent disturbance was apparent. No sediment deposition was observed on the upslope side of the pine needles, suggesting that wind transport was the likely mechanism for pine needle movement. At the lower slope, a rill that originated in the untreated area continued into the treated area, the dissipated. Rodent activity was also observed at the lower slope, where raised areas of bare soil were present. No other signs of erosion were present. The criterion, which states that no visible signs of rills, gullies, sediment transport, or sediment deposition can be present, was met for the upper slope, but was not met for the lower slope.

Management Response

Most of the success criteria were met for the Stagecoach project, indicating that the project achieved the primary project objective of a no net increase in runoff or sediment yield. Monitoring results indicate higher infiltration rates, lower sediment yield, lower soil density (as measured by cone penetrometer), and higher total cover following treatment. However, the criterion for plant cover was not met at either the upper or lower plot and decreased TKN levels were measured. Soil TKN and plant cover tend to be closely related and TKN decreased at both plots post-treatment. Although nutrient-rich topsoil and duff at these sites was removed prior to trenching and re-applied after backfilling trenches, tilling the topsoil deeply into the soil profile likely resulted in reduced nutrient concentration and, therefore, lower TKN measured in soil samples. In future projects where topsoil salvage and reuse is used, it is recommended that topsoil is mixed into the top 4-6 inches of soil after deeper loosening is completed. Additionally, since most of the organic matter and nutrients in high elevation decomposed granite soil are concentrated in a relatively thin and fragile topsoil/duff layer, some of which is often lost during removal/replacement, soil amendment additions are recommended to supplement the salvaged topsoil on similar projects in the future. Rather than recommending immediate treatment action to increase vegetation cover, another year of cover monitoring is recommended to better understand the long term trajectory for plant cover. If monitoring in 2010 indicates an increasing trend in plant cover, follow up treatments may not be necessary. However, if measurable plant cover is not present in 2010, treatment actions such as fertilizing, seeding and/or irrigation will be necessary to help achieve success criteria.

Although the penetrometer and sediment yield success criteria were met for the lower slope, consistently low penetrometer measurements (less than 2 inches) were recorded on the skier's left portion of the treatment area. The rainfall frame in this part of the treatment area produced the highest sediment yield, which was 58% higher than the average pre-treatment sediment yield. Further penetrometer monitoring is recommended on the skier's left portion of the slope and within the area of disturbance above the monitoring plot to determine the scope of the problem. If widespread compaction is found, further tilling may be necessary. Any additional management responses will be determined following the penetrometer monitoring.

Lastly, visual erosion assessment and photo point monitoring is recommended on a yearly basis. Continued observation of a rill that originated in the untreated area of the ski run and continued into the lower slope treatment area is necessary during and immediately after rain events. It is important to ensure that the rill is not expanding and that the treated area is infiltrating the concentrated water from the rill. It is recommended that Heavenly expand efforts to minimize disturbance of the lower slope plot by installing fencing and signage, particularly due to its close proximity to the Tahoe Rim Trail.

Table 29. Stagecoach Management Responses for Unmet Success Criteria.

	Unmet Criterion	Management Response
Upper Slope	Plant Cover	Cover monitoring
Upper Slope	n/a	Photo monitoring
Upper Slope	n/a	Visual erosion assessment
Lower Slope	Plant Cover	Cover monitoring
Lower Slope	Visual Erosion Assessment	Visual erosion assessment (assess rill observed in 2009)
Lower Slope	n/a	Penetrometer monitoring to assess shallow DTRs on skier's left (possible retreatment depending on monitoring results)
Lower Slope	n/a	Photo monitoring

Chapter 4: Conclusions, Management Responses and Recommendations

Conclusions

Overall Process

2009 marked the third year of a new approach to planning, implementing, and monitoring large-scale mountain improvement projects at Heavenly with a focus on minimizing runoff and erosion. Heavenly's operations staff continued to demonstrate greater competence and commitment to proactive project planning, implementation, treatment documentation, and treatment area protection. Completion of restoration treatments associated with larger mountain improvement projects during a single field season is still a challenge at Heavenly, as many projects begin later in the season than anticipated due to permitting. However, Heavenly staff, in cooperation with IERS, have been able to adapt to changing circumstances effectively.

Figure 168. Jim Larmore checks tilling depth with a cone penetrometer.

Restoration Projects

Over three years, a total area of 261,385 ft^2 or 6 acres was restored at six project sites. Combined performance monitoring data from the six sites indicate overall improvements in ecological function and decreases in erosion potential. Compared to pre-treatment conditions, restoration treatments resulted in:

- 67% - 133% decrease in sediment yields
- 18% - 110% increase in infiltration rates
- 50% - 940% increase in penetrometer depth to refusal
- 30% - 1900% increase in total cover
- 12% - 161% increase in soil organic matter
- No observable erosion issues, except at Stagecoach where a rill that originated outside of the treatment area flowed into the treatment area.

Across nearly all restoration projects, both plant cover and soil TKN decreased following treatment. Some decreases in plant cover are attributable to vegetation removal during soil tilling treatments and the time required for vegetation to re-establish. Low plant cover is also common on projects that use high-carbon soil amendments such as wood chips, as availability of nitrogen and other nutrients are reduced during decomposition of wood chips. While neither of these trends are cause for immediate concern, they will require further investigation in order to develop a more complete understanding of how sites at Heavenly respond to various types of restoration treatments.

Ski Run Clearing Projects

Monitoring data from both run clearing projects (Orion II and North Bowl) suggest that low-impact clearing and glading treatments – helicopter logging with hand felling and stump cutting – resulted in no measurable changes to most key parameters that affect erosion potential. When compared to uncleared conditions, clearing and glading treatments resulted in:

- No measurable change in sediment yields
- No measurable change in infiltration rates
- No measurable change in penetrometer depth to refusal
- No measurable change in total cover
- No measurable change in soil organic matter
- No observable erosion issues

Success Criteria

Applied adaptive management assumes that a revision or adjustment of success criteria will take place where data and field observations support that adjustment. Initial success criteria often serve as a working hypothesis which can be changed when data warrants and where a defensible argument can be made for that change. Thus, as part of the adaptive management process and as reflective of a greater understanding of soil and ecosystem processes at Heavenly, the 2008 success criteria were revised based on the information gained from the results of the 2009 monitoring (Table 31 in Appendix A). Previously, the success criteria metrics were defined to be within a certain *percent* of the pre-treatment level. While this can be useful in the middle ranges of the measurements, it not realistic or indicative of an actual change when comparing values in the low ranges of each measurement. A more accurate, reasonable, and useful set of success criteria were defined by an actual discrete range of numerical *valuse*. These values were developed by analyzing Heavenly data, comparing it to a large database and refining accordingly, with each adjustment supported by data. Application and refinement of success criteria is at the core of applied (versus conceptual) adaptive management. More detailed discussion on success criteria refinement and justification can be found in Appendix A.

Recommendations

Overall Process

- Continue weekly conference calls between IERS and Heavenly operations staff during field season
- Closer coordination between Heavenly staff and IERS monitoring crew to ensure that monitoring plots are delineated with a complete understanding of both planned treatments (for pre-treatment monitoring) and implemented treatments (performance monitoring)

Restoration Projects

- Develop a schedule and checklist for annual erosion assessment and photo documentation for all restoration projects (use Summary of Management Responses, below, as a starting point)
- Develop a maintenance plan for road shoulder infiltration strips along Skyline Trail, which are likely to require spot mulching and targeted loosening to address ongoing disturbance
- Identify sensitive treatment areas that are in close proximity to trails or regular foot traffic and implement measures to minimize disturbance (signage, fencing, etc)
- As part of the adaptive management process (see Adaptive Management Overview section at the beginning of this document), incorporate test areas into selected future restoration projects to evaluate:
    - Effects of amendment concentration (combination of amendment application depth and tilling depth) on soil nutrients, infiltration rate, and plant growth
    - Effects of fertilizer application rate on soil nutrients and plant growth
    - Effects of mulch type and depth on sediment yield
    - Effects of different irrigation regimes on plant establishment (year 1), plant growth over time, and species composition
- Continue to revise success criteria as more data and information becomes available
- Discuss strategy to minimize use of irrigation in 2010 field season through testing of alternative treatments to control erosion and restore soil function
- Expand use and understanding of standardized measurement protocols to ensure consistent application rates for seed and fertilizer (such as 5-gallon buckets marked with volumes that correspond to seed or fertilizer weight)
- Continue to work with IERS to use and refine treatment documentation forms (see Heavenly Revegetation Treatment Log, Appendix C). Documentation of specific treatments is critical to improving treatment effectiveness.

- Develop a plan for a long-term source of soil amendments that considers future on-mountain sources (tied to fuel reduction projects and other tree clearing activities), minimizing hauling (import and export) and long-term storage/staging
- Track restoration treatment costs and compare to results of monitoring to determine cost-effectiveness of various treatments

Ski Run Clearing Projects

- Develop a schedule and checklist for annual erosion assessment and photo documentation for ski run clearing and glading projects (use Summary of Management Responses, below, as a starting point)

Summary of Management Responses by Project

The following table summarizes recommended management responses to be completed by either Heavenly staff or IERS in 2010 for each project and site (Table 30).

Table 30. Summary of management responses by project and site

Project/Site	Unmet Criterion	Management Response	Who	When
North Bowl Cleared Run	Sediment Yield	Visual erosion assessment	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events
North Bowl Cleared Run	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010
Orion II Cleared Run	n/a	Visual erosion assessment	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events
Orion II Cleared Run	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010
Olympic Lift Top	Plant Cover	Cover monitoring	IERS Staff	August, 2010
Olympic Lift Top	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010

Project / Site	Unmet Criterion	Management Response	Who	When
Olympic Lift Top	n/a	Visual erosion assessment	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events
Olympic Lift Bottom	Plant Cover	Cover monitoring	IERS Staff	
Olympic Lift Bottom	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010
Olympic Lift Bottom	n/a	Visual erosion assessment	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events
Olympic Lift Bottom	n/a	Treatment area protection (fencing, signage, etc)	Heavenly Staff	Directly following spring 2010 snowmelt
Heavenly Flyer Bottom	Plant Cover	Cover monitoring	IERS Staff	August, 2010
Heavenly Flyer Bottom	n/a	Visual erosion assessment	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events
Heavenly Flyer Bottom	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010
Heavenly Flyer Top	Plant Cover	Cover monitoring	IERS Staff	
Heavenly Flyer Top	n/a	Visual erosion assessment	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events
Heavenly Flyer Top	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010
Mid Station Road	Plant Cover	Cover monitoring	IERS Staff	August, 2010
Mid Station Road	n/a	Visual erosion assessment	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events

Project / Site	Unmet Criterion	Management Response	Who	When
Mid Station Road	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010
Skyline Trail Road Shoulder	n/a	Visual erosion assessment	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events
Skyline Trail Road Shoulder	n/a	Targeted maintenance (mulching, soil loosening, etc.)	Heavenly staff	After spring 2010 snowmelt, soil loosening only in low soil moisture conditions
Skyline Trail Road Shoulder	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010
Lakeview Lodge Patsy's Trail	Plant Cover	Cover monitoring	IERS Staff	August, 2010
Lakeview Lodge Patsy's Trail	n/a	Visual erosion assessment	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events
Lakeview Lodge Patsy's Trail	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010
Lakeview Lodge Patsy's Trail	n/a	Penetrometer monitoring	IERS Staff	When soil moisture levels are comparable to 2009 levels (June-October, 2010)
Lakeview Lodge Patsy's Trail	n/a	Treatment area protection (fencing, signage, etc)	Heavenly Staff	Directly following spring 2010 snowmelt
Lakeview Lodge Gun Barrel Top	Plant Cover	Cover monitoring	IERS Staff	August, 2010
Lakeview Lodge Gun Barrel Top	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010

Project/Site	Unmet Criterion	Management Response	Who	When
Lakeview Lodge Gun Barrel Top	n/a	Visual erosion assessment	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events
Stagecoach Upper Slope	Plant Cover	Cover monitoring	IERS Staff	August, 2010
Stagecoach Upper Slope	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010
Stagecoach Upper Slope	n/a	Visual erosion assessment	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events
Stagecoach Lower Slope	Plant Cover	Cover monitoring	IERS Staff	August, 2010
Stagecoach Lower Slope	Visual Erosion Assessment	Visual erosion assessment (assess rill observed in 2009)	IERS or Heavenly Staff	Directly following spring 2010 snowmelt and after rain events
Stagecoach Lower Slope	n/a	Penetrometer monitoring to assess shallow DTRs on skier's left (possible retreatment depending on monitoring results)	IERS Staff	When soil moisture levels are comparable to 2009 levels (June-October, 2010)
Stagecoach Lower Slope	n/a	Photo monitoring	IERS or Heavenly Staff	During visual assessment if erosion is observed and August, 2010

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Appendix A

Redefining Success Criteria

Success criteria need to reviewed and often, especially in new study areas, re-defined to ensure that they reflect current available data as well as defensible levels of achievement. The 2008 success criteria were revised based on the information gained from the results of the 2009 monitoring (Table 31). Previously, the success criteria metrics were defined to be within a certain percent of the pre-treatment level. This type of metric is best for the middle ranges of the measurements; however, it can be very misleading for the low ranges of each measurement. For example, the Olympic bottom pre-treatment organic matter content was 1.4%, while the post-treatment content was 1.1%. These values are very close and well within the range of natural variability that can occur at a site. However, the post-treatment organic matter was 21% lower that the pre-treatment organic matter, which didn't strictly meet the 2008 criterion of within 20%. In another case, the Stagecoach upper slope sediment yield was 30 lbs/acre/in, compared to 61 lbs/acre/in post-treatment. Although this is an increase of approximately 100%, the sediment yields are both very low and indicative of low potential for erosion. Further, the range of 30 lbs/acre/in is within an expected range of variability between rainfall frames. Using the 2008 criterion for sediment yield, this plot did not meet the criterion, although its erosion potential was low. The 2009 criteria are better defined to account for both measurement error and natural variability within a site. Each criterion had been modified to include a limit in the applicable units rather than a percent relative to the pre-treatment level.

To determine appropriate upper and/or lower value for success criteria for each parameter, an analysis of all the 2009 monitoring data from Heavenly was conducted. The standard deviation of measurement types for which data was available (sediment yield, infiltration rate, etc) at each plot was calculated. In some cases, such as for penetrometer measurements, the standard deviation at each plot was based on 50 or more readings at each plot. In other cases, such as for sediment yield, the standard deviation was based on just three simulations at each plot. For the soil parameters (TKN and organic matter), only one composite sample is typically collected for each plot, therefore a standard deviation could not be calculated. The maximum standard deviation for a particular measurement across all sites and plots was chosen as the success criteria limit and assumed to be representative of the maximum natural and sampling variability at Heavenly. These standard deviation calculations are based on a relatively small dataset; therefore, further refinements will likely be necessary as additional data is collected.

Table 31. Comparison of previous and re-defined success criteria.

	Previous Success Criteria (2008)	Redefined Success Criteria (2009)
Sediment Yield (lbs/acre/in)	Not greater than 10% above pre-treatment level	Not greater than 100 lbs/acre/in higher than pre-treatment levels
Infiltration Rate (in/hr)	Not greater than 10% below pre-treatment level	Not greater than 0.8 in/hr lower than pre-treatment levels
Penetrometer Depth (inches)	Not greater than 2 inches above pre-treatment level	Not greater than 4 inches shallower than pre-treatment level
Total Cover (%)	70% or greater	70% or greater
Total Plant Cover (%)	Not greater than 10% below pre-treatment level	10% or greater
Organic Matter (%)	Not greater than 20% below pre-treatment level	Not greater than 1.5 percentage points less than pre-treatment level
TKN (ppm)	Not greater than 20% below pre-treatment level	Not greater than 100 ppm less than pre-treatment level
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition. No erosion resulting runoff or dripping from foundations or decks.	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition. No erosion resulting runoff or dripping from foundations or decks.

The sediment yield criterion was adjusted to be less than the maximum standard deviation, based on professional judgment and the results of hundreds of simulations in the Lake Tahoe area. The maximum standard deviation was greater than 200 lbs/acre/in; however, an outlier in the dataset skewed the standard deviation upward. Instead, 100 lbs/acre/in was chosen as a reasonable and representative limit for this criterion.

To determine the success criterion for TKN and organic matter, a dataset was used from a north Lake Tahoe site with soil derived from volcanic parent material. The same calculations were conducted to determine the maximum standard deviation, but adjustments were made for the granitic soil at Heavenly. The magnitude of variation in granitic soils tends to be less than that of volcanic soils; therefore, the maximum standard deviations were adjusted to be lower for Heavenly.

A different approach was used for the total and plant cover success criteria for the restoration projects. A threshold was set for each type of cover, rather than setting criteria based on the pre-treatment cover levels. A criterion based on pre-treatment levels might state the post-treatment total cover is required be no more than 15 percentage points less than the pre-treatment total cover. If the pre-treatment total cover were 15%, then a total cover of zero would meet the criteria. Cover is a key factor in erosion control; therefore, the criteria were re-defined to reflect a cover threshold that would to reflect an appropriate level of erosion reduction potential. For total cover, a threshold of 70% was set and for plant cover, a threshold of 10% was set. Both of these thresholds were determined based on a large dataset from the Lake Tahoe area and were adjusted to be appropriate for Heavenly.

The cover success criteria for the ski run clearing/glading projects remained as comparisons to pre-treatment levels, as it was important to demonstrate that the tree removal did not change the existing (pre-treatment) conditions. The maximum standard deviation was calculated, as explained above, and used to determine the success criteria.

The previous success criteria from 2008 and the revised success criteria are presented for each project and site in the following tables (Table 32, Table 33, Table 34, Table 35, Table 36, Table 37, Table 38, and Table 39).

Table 32. North Bowl Cleared Ski Run Success Criteria Evaluation.

	North Bowl Cleared Run 2008 Success Criteria	North Bowl Cleared Run 2008 Success Criteria Evaluation	North Bowl Cleared Run Revised Success Criteria (2009)	North Bowl Cleared Run Revised Success Criteria Evaluation (2009)
Sediment Yield (lbs/acre/in)	Not greater than 10% above pre-clearing level	× Success Criterion Not Met	Not greater than 100 lbs/acre/in higher than pre-treatment levels	× Success Criterion Not Met
Infiltration Rate (in/hr)	Not greater than 10% below pre-clearing level	√ Success Criterion Met	Not greater than 0.8 in/hr lower than pre-treatment levels	√ Success Criterion Met
Penetrometer Depth (inches)	Not greater than 2 inches above pre-clearing level	√ Success Criterion Met*	Not greater than 4 inches shallower than pre-treatment level	√ Success Criterion Met*
Total Cover (%)	Not greater than 10% below pre-clearing level	√ Success Criterion Met*	Not greater than 15 percentage points below pre-clearing level	√ Success Criterion Met*
Organic Matter (%)	Not greater than 20% below pre-clearing level	√ Success Criterion Met*	Not greater than 1.5 percentage points less than pre-treatment level	√ Success Criterion Met*
TKN (ppm)	Not greater than 20% below pre-clearing level	√ Success Criterion Met*	TKN not used as a metric for measuring success	n/a
Visual Assessment	No visible signs of erosion including rilling, gullying, or other sediment transport and deposition.	√ Success Criterion Met	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	√ Success Criterion Met

*Measurements taken in 2008, not 2009.

Table 33. Orion II Ski Run Success Criteria Evaluation.

	Orion II Cleared Run 2008 Success Criteria	Orion II Cleared Run 2008 Success Criteria Evaluation	Orion II Cleared Run Revised Success Criteria	Orion II Cleared Run Revised Success Criteria Evaluation
Penetrometer Depth (inches)	Not greater than 2 inches above pre-clearing level	x Success Criterion Not Met	Not greater than 4 inches shallower than pre-treatment level	√ Success Criterion Met
Total Cover (%)	Not greater than 10% below pre-clearing level	√ Success Criterion Met*	Not greater than 15 percentage points below pre-clearing level	√ Success Criterion Met*
Organic Matter (%)	Not greater than 20% below pre-clearing level	√ Success Criterion Met*	Not greater than 1.5 percentage points less than pre-treatment level	√ Success Criterion Met*
TKN (PPM)	Not greater than 20% below pre-clearing level	√ Success Criterion Met*	TKN not used as a metric for measuring success	n/a
Visual Assessment	No visible signs of erosion including rilling, gullying, or other sediment transport and deposition.	√ Success Criterion Met	No visible signs of erosion including rilling, gullying, or other sediment transport and deposition.	√ Success Criterion Met

*Evaluated in 2008

Table 34. Olympic Lift Success Criteria Evaluation.

	Olympic Lift 2008 Success Criteria	Olympic Lift 2008 Success Criteria Evaluation	Olympic Lift Revised Success Criteria	Olympic Lift Revised Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 10% above pre-treatment level	Top*: √ Criterion Met A**: √ Criterion Met C***: √ Criterion Met	Not greater than 100 lbs/acre/in higher than pre-treatment levels	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met
Infiltration Rate (in/hr)	Not greater than 10% below pre-treatment level	Top: × Criterion Not Met A: √ Criterion Met C: √ Criterion Met	Not greater than 0.8 in/hr lower than pre-treatment levels	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met
Penetrometer Depth (inches)	Not greater than 2 inches above pre-treatment level	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met	Not greater than 4 inches shallower than pre-treatment level	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met
Total Cover (%)	70% or greater	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met	70% or greater	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met
Total Plant Cover (%)	Not greater than 10% below pre-treatment level	Top: √ Criterion Met A: × Criterion Not Met C: × Criterion Not Met	10% or greater	Top: × Criterion Not Met A: × Criterion Not Met C: × Criterion Not Met
Organic Matter (%)	Not greater than 20% below pre-treatment level	Top: √ Criterion Met A: √ Criterion Met C: × Criterion Not Met	Not greater than 1.5 percentage points less than pre-treatment level	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met
TKN (ppm)	Not greater than 20% below pre-treatment level	Top: × Criterion Not Met A: × Criterion Not Met C: × Criterion Not Met	TKN not used as a metric for measuring success	n/a
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition. No erosion resulting runoff or dripping from foundations or decks.	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition. No erosion resulting runoff or dripping from foundations or decks.	Top: √ Criterion Met A: √ Criterion Met C: √ Criterion Met

*Top = Olympic Lift Top
**A = Olympic Lift Bottom, Treatment Area A
***C = Olympic Lift Bottom, Treatment Area C

Table 35. Heavenly Flyer Success Criteria Evaluation.

	Heavenly Flyer 2008 Success Criteria	Heavenly Flyer 2008 Success Criteria Evaluation	Heavenly Flyer Revised Success Criteria	Heavenly Flyer Revised Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 10% above pre-treatment level	Top: × Criterion Not Met Bottom: n/a	Not greater than 100 lbs/acre/in higher than pre-treatment levels	Top:√ Criterion Met Bottom: n/a
Infiltration Rate (in/hr)	Not greater than 10% below pre-treatment level	Top:√ Criterion Met Bottom: n/a	Not greater than 0.8 in/hr lower than pre-treatment levels	Top:√ Criterion Met Bottom: n/a
Penetrometer Depth (inches)	Not greater than 2 inches above pre-treatment level	Top:√ Criterion Met Bottom:√ Criterion Met	Not greater than 4 inches shallower than pre-treatment level	Top:√ Criterion Met Bottom:√ Criterion Met
Total Cover (%)	70% or greater	Top:√ Criterion Met Bottom:√ Criterion Met	70% or greater	Top:√ Criterion Met Bottom:√ Criterion Met
Total Plant Cover (%)	Not greater than 10% below pre-treatment level	Top: × Criterion Not Met Bottom:× Criterion Not Met	10% or greater	Top: × Criterion Not Met Bottom:× Criterion Not Met
Organic Matter (%)	Not greater than 20% below pre-treatment level	Top:√ Criterion Met Bottom:√ Criterion Met	Not greater than 1.5 percentage points less than pre-treatment level	Top:√ Criterion Met Bottom:√ Criterion Met
TKN (PPM)	Not greater than 20% below pre-treatment level	Top:× Criterion Not Met Bottom:× Criterion Not Met	TKN not used as a metric for measuring success	n/a
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition. No erosion resulting runoff or dripping from foundations or decks.	Top:√ Criterion Met Bottom:√ Criterion Met	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition. No erosion resulting runoff or dripping from foundations or decks.	Top:√ Criterion Met Bottom:√ Criterion Met

Table 36. Mid Station Road Success Criteria Evaluation.

	Mid Station Road 2008 Success Criteria	Mid Station Road 2008 Success Criteria Evaluation	Mid Station Road Revised Success Criteria	Mid Station Road Revised Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 10% above pre-treatment level	√ Criterion Met	Not greater than 100 lbs/acre/in higher than pre-treatment levels	√ Criterion Met
Infiltration Rate (in/hr)	Not greater than 10% below pre-treatment level	√ Criterion Met	Not greater than 0.8 in/hr lower than pre-treatment levels	√ Criterion Met
Penetrometer Depth (inches)	Not greater than 2 inches above pre-treatment level	√ Criterion Met	Not greater than 4 inches shallower than pre-treatment level	√ Criterion Met
Total Cover (%)	70% or greater	√ Criterion Met	70% or greater	√ Criterion Met
Total Plant Cover (%)	Not greater than 10% below pre-treatment level	√ Criterion Met	10% or greater	× Criterion Not Met
Organic Matter (%)	Not greater than 20% below pre-treatment level	√ Criterion Met	Not greater than 1.5 percentage points less than pre-treatment level	√ Criterion Met
TKN (PPM)	Not greater than 20% below pre-treatment level	× Criterion Not Met	TKN not used as a metric for measuring success	n/a
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	√ Criterion Met	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	√ Criterion Met

Table 37. Skyline Trail Success Criteria Evaluation.

	Skyline Trail 2008 Success Criteria	Skyline Trail 2008 Success Criteria Evaluation	Skyline Trail Revised Success Criteria	Skyline Trail Revised Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 10% above pre-treatment level	√ Criterion Met	Not greater than 100 lbs/acre/in higher than pre-treatment levels	√ Criterion Met
Infiltration Rate (in/hr)	Not greater than 10% below pre-treatment level	√ Criterion Met	Not greater than 0.8 in/hr lower than pre-treatment levels	√ Criterion Met
Penetrometer Depth (inches)	Not greater than 2 inches above pre-treatment level	√ Criterion Met	Not greater than 4 inches shallower than pre-treatment level	√ Criterion Met
Total Cover (%)	70% or greater	√ Criterion Met	70% or greater	√ Criterion Met
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	√ Criterion Met	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	√ Criterion Met

Table 38. Lakeview Project Success Criteria Evaluation.

	Lakeview 2008 Success Criteria	Lakeview 2008 Success Criteria Evaluation	Lakeview Revised Success Criteria	Lakeview Revised Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 10% above pre-treatment level	GB*: √ Criterion Met PT**: √ Criterion Met	Not greater than 100 lbs/acre/in higher than pre-treatment levels	GB: √ Criterion Met PT: √ Criterion Met
Infiltration Rate (in/hr)	Not greater than 10% below pre-treatment level	GB:√ Criterion Met PT:√ Criterion Met	Not greater than 0.8 in/hr lower than pre-treatment levels	GB:√ Criterion Met PT:√ Criterion Met
Penetrometer Depth (inches)	Not greater than 2 inches above pre-treatment level	GB:√ Criterion Met PT:√ Criterion Met	Not greater than 4 inches shallower than pre-treatment level	GB:√ Criterion Met PT:√ Criterion Met
Total Cover (%)	70% or greater	GB:√ Criterion Met PT:√ Criterion Met	70% or greater	GB:√ Criterion Met PT:√ Criterion Met
Total Plant Cover (%)	Not greater than 10% below pre-treatment level	GB:× Criterion Not Met PT:× Criterion Not Met	10% or greater	GB:× Criterion Not Met PT:× Criterion Not Met
Organic Matter (%)	Not greater than 20% below pre-treatment level	GB:× Criterion Not Met PT:√ Criterion Met	Not greater than 1.5 percentage points less than pre-treatment level	GB:√ Criterion Met PT:√ Criterion Met
TKN (PPM)	Not greater than 20% below pre-treatment level	GB:× Criterion Not Met PT:× Criterion Not Met	TKN not used as a metric for measuring success	n/a
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	GB:√ Criterion Met PT:√ Criterion Met	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition	GB:√ Criterion Met PT:√ Criterion Met

*GB=Gun Barrel top slope
**PT=Patsy's Trail

Table 39. Stagecoach Snowmaking Line Success Criteria Evaluation.

	Stagecoach 2008 Success Criteria	Stagecoach 2008 Success Criteria Evaluation	Stagecoach Revised Success Criteria	Stagecoach Revised Success Criteria Evaluation
Sediment Yield (lbs/acre/in)	Not greater than 10% above pre-treatment level	U*: × Criterion Not Met L**: √ Criterion Met	Not greater than 100 lbs/acre/in higher than pre-treatment levels	U:√ Criterion Met L:√ Criterion Met
Infiltration Rate (in/hr)	Not greater than 10% below pre-treatment level	U:√ Criterion Met L:√ Criterion Met	Not greater than 0.8 in/hr lower than pre-treatment levels	U:√ Criterion Met L:√ Criterion Met
Penetrometer Depth (inches)	Not greater than 2 inches above pre-treatment level	U:√ Criterion Met L:√ Criterion Met	Not greater than 4 inches shallower than pre-treatment level	U:√ Criterion Met L:√ Criterion Met
Total Cover (%)	70% or greater	U:√ Criterion Met L:√ Criterion Met	70% or greater	U:√ Criterion Met L:√ Criterion Met
Total Plant Cover (%)	Not greater than 10% below pre-treatment level	U:× Criterion Not Met L: × Criterion Not Met	10% or greater	U:× Criterion Not Met L:× Criterion Not Met
Organic Matter (%)	Not greater than 20% below pre-treatment level	U:× Criterion Not Met L:√ Criterion Met	Not greater than 1.5 percentage points less than pre-treatment level	U:√ Criterion Met L:√ Criterion Met
TKN (PPM)	Not greater than 20% below pre-treatment level	U:× Criterion Not Met L: × Criterion Not Met	TKN not used as a metric for measuring success	n/a
Visual Assessment	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	U:√ Criterion Met L:× Criterion Not Met	No visible signs of erosion including rotational failures, rilling, gullying, or other sediment transport and deposition.	U:√ Criterion Met L:× Criterion Not Met
*U=Upper slope **L=Lower Slope				

Appendix B

A Closer Look at TKN

In order to help determine whether the soil contains adequate nutrients to support a robust microbial and vegetation community, we have measured a range of soil macro and micro nutrients, pH, total nitrogen (using the total Kjeldahl nitrogen (TKN) analysis method), and total organic matter. The macro and micro nutrient measurements are used as screens, however, seldom suggest deficiencies; therefore, TKN and organic matter content are used as an indicator of soil fertility. Since most of the plant-available nutrients in soil, especially nitrogen, are associated with soil organic matter, and since nitrogen is the nutrient used in the highest amount by plants, these two common measurements are expected to provide useful information. We also expect them to track one another. That is, as organic matter increases, we would expect TKN to increase as well.

Since many of the treatments at Heavenly included nitrogen addition in the form of either woody amendments (woodchips), fertilizer, or both, we would expect to see an increase in TKN after treatment. The consistent decline of TKN post-treatment compared to pre-treatment at the restoration sites was unexpected. Further investigation into the lack of correlation is needed to help in understanding the cause of this seeming anomaly. We will continue to measure both TKN and OM until we can either find an explanation or find that TKN is not a reliable indicator of nutrient availability.

Here, we put forth a couple possible explanations for the decrease:

- Nitrogen is contained in un-decomposed woody material (1-20% N). Any large woody pieces were sieved out during soil sample processing and were not captured in the TKN values from the lab.
- N may be locked up or bound in recalcitrant organic compounds that the Kjeldahl digest does not break down

Although we do not yet fully understand the decline in TKN at some of the restoration sites, it is important to continue to further our knowledge and understanding of why the two analysis method outputs don't track. Continued sampling is necessary, and other analysis methods need to be compared to the current method. We will continue to attempt to correlate plant growth with OM and total nitrogen and will determine whether TKN is an appropriate analysis method for total nitrogen. TKN was not used as a success criterion metric as initially intended, the data first needs to be understood before being used as a metric.

Appendix C

Heavenly Mountain Resort
Revegetation Treatment Log

Project Name	
Site Name and Description	
Project Foreman	
Project Staff	
Start Date	
Completion Date	

Treatment Tracking

	Area Name	Area Name	Area Name	Area Name
Treatment Area (ft^2)				
Tilling Method (backhoe, ex, etc)				
Tilling Depth (inches)				
Amendment[2] Type(s) and Source(s)				
Amendment Depth (inches)				
Fertilizer Type (typically Biosol)				
Fertilizer Rate (lbs/acre)				
Seed Mix Name (from seed tag)				
Seed Rate (lbs/acre)				
Mulch[3] Type(s) and Source(s)				
Mulch Depth (inches)				
Mulch Surface Coverage (%)				
Irrigation Schedule, Duration and Frequency				
Irrigation Wetting Depth (inches)				

TREATMENT NOTES

[2] **Amendments** are those materials that are incorporated into the soil via tilling.
[3] **Mulches** are those materials that are applied to the soil surface (after completion of tilling, fertilizer and seeding, if applicable)

As-Built Map

<u>As-Built Map Checklist</u>

- ✓ Treatment areas (labeled A, B, C...)
- ✓ Photo points showing location and direction (labeled 1,2,3...)
- ✓ Features such as roads, trails, lifts, utilities (snowmaking, hydrants), other landmarks (such as signs)
- ✓ North arrow and an arrow indicating direction of slope/fall line

Appendix III

2009 CWE Work List

HEAVENLY MOUNTAIN RESORT
2009 ANNUAL CWE PROJECT & WORK LIST
January 28, 2009

Project #	Source*	Location	Treatment
Watershed: CA-1 Heavenly Valley Creek			
1	M	Big Easy Lift	Replenish infiltration trenches, drip line protection and effective soil cover
2	M	Zipline Base Station	Install drip line infiltration trenches
3	M	Adventure Peak Events Area	Complete mulch application to specified depth for events area; incorporate wood chips in areas with compacted soils
4	M	Gondola Top Station	Refurbish or reconstruct existing infiltration facilities that are no longer effective
5	M	Groove Upper Terminal	Improve soil cover to stabilize minor rilling on trail northwest of unloading area.
6	M	Upper Vehicle Maintenance Shop	Stabilize gully on ski trail above SEZ restoration site; check condition of parking area re-surfacing following snow melt and refurbish if necessary
7	M	Replace and relocate Top of Tram water tank and lines	Complete installation of replacement water tank and water lines; remove and restore existing improvements consistent with plans
8	M	Lakeview Lodge BMPs	Improve drip line protection and soil cover on south side of building
9	M	Mombo Meadows Trail	Repair broken snow making hydrant; restore and stabilize soils in affected area
10	M	Blue Angel Chutes/Upper Mombo Trail	Complete water bar repairs per specified plans
Watershed: CA-6 Bijou Park Creek			
11	M	California Main Lodge Adult Ski School Surface Lift	Install infiltration trenches
12	M	Top of Tram Station BMPs	Stabilize rilling at northwest corner of the building.
13	M	First Ride Lift	Extend infiltration trench under downspout areas and improve soil cover.
Watershed: CA-7 Unnamed			
14	M	Gondola Mid Station	Improve soil cover and stabilize slope below passenger unloading deck.

Watershed: NV-1 Mott Canyon Creek			
15	B	Mott Canyon Lift	Install drip line trenches at top and bottom stations
16	B	Top of Dipper Ski Patrol Station	Remove and replace existing ski patrol station with new building, including drip line trenches
Watershed: NV-3 Edgewood Creek			
16	M	North Bowl Express Lower Lift Terminal and Access Road	Stabilize access road switchback adjacent to creek bank.
17	M	Olympic Express Lift	Install drip line trenches at top and bottom stations
18	M	Olympic Express Lift Line Towers	Evaluate and improve effective cover around towers
Watershed: NV-2 + 5 Daggett Creek			
19	B	East Peak Pumphouse	Install infiltration BMPs; provide soil cover on barren areas not use for summer operations
20	B	Comet Express Lift Base Station	Replenish drip line trenches
21	B	Dipper Express Lift Base Station	Replenish drip line trenches; delineate maintenance vehicle parking areas; provide effective soil cover on all other disturbed areas, including underneath chair parking rail
Resort Wide			
22	M	Resort-Wide	Install and maintain closure signs on Ellie’s Swing Trail, Betty’s Return Trail , Powderbowl tower road, Lower Cal Trail below Hellwinkle’s trail, East Peak Dam Road and West Round-a-bout
23	M	Resort-Wide	Develop process to identify and treat priority areas with long-term soil cover needs on ski runs. Soil amendments may be considered as part of the treatment. Note: This replaces the treatment listed in previous Annual CWE Work Lists as “Reseed and fertilize degenerating grassy areas on +/- 1/5th of ski runs (all runs are reviewed/reseeded over 5 years)”
24	M	Resort-Wide	Inspect and restore all areas damaged affected by winter resort operations, including hydrants & pipe failures, and areas affected by snowcat operations; document areas treated
25	M	Resort-Wide	Erect and maintain vehicles barriers and/or fences to prevent unauthorized vehicle access off of designated summer roads and facility parking areas
26	M	Resort-Wide	Inspect and maintain all drainage structures.

27	M	Base Areas	Erect and maintain vehicle barriers and/or fences to prevent unauthorized vehicle access from base areas
***Source Codes**			
	M B M MMP	Maintenance Needed Project need determined from BMP Effectiveness Monitoring Master Plan Development Project Master Plan Monitoring & Mitigation Plan Requirement	

Appendix IV

2008-2009 Environmental Monitoring Program Annual Report

Heavenly Mountain Resort
Ongoing Collection/Monitoring Agreement
Annual Report for the 2008/2009 Water Year

Prepared for:

Heavenly Mountain Resort
Post Office Box 2180
Stateline, NV 89449

Prepared by:

Entrix, Inc.
1048 Ski Run Boulevard
South Lake Tahoe, CA 96150

February 16, 2010

Date: 02/16/10

California Regional Water Quality Control Board
Lahontan Region
2501 Lake Tahoe Boulevard
South Lake Tahoe, CA 96150

Facility Name: Heavenly Mountain Resort

Address: Post Office Box 2180
Stateline, Nevada 89449

Contact Person: Andrew Strain

Job Title: VP of Planning and Government Affairs

Phone: (775) 586-2313 direct line

Email: **astrain@vailresorts.com**

WDR/NPDES Order Number: R6T-2003-00032

WDID Number: 6A090033000

Type of Report (circle one)**:** Monthly Quarterly Semi-Annual **Annual** Other

Month(s) (circle applicable month(s)*)**:** JAN FEB MAR APR MAY JUN JUL AUG SEP **OCT** NOV DEC

***Annual Reports** (circle the first month of the reporting period)

Year: Water Year 2009: October 1, 2008 – September 30, 2009

Violation(s)? (Please check one): ____________**NO** _______X_____ **YES***

***If YES is marked complete a-g (Attach Additional information as necessary)**

a) Brief Description of Violation:

1. Heavenly Valley Creek station HV-C2, the Below Patsy's site exceeded annual averages for Total Phosphorus, Chloride, and Iron.

2. Heavenly Valley Creek station HV-C3, the Property Line station exceeded annual averages for Total Phosphorus, Chloride and Iron.

3. Bijou Park Creek station HV-C4, the CA Parking Lot site exceeded annual averages for Turbidity, Suspended Sediment, Total Nitrogen, Total Phosphorus, Chloride, Oil and Grease, and Iron.

b) Section(s) of WDRs/NPDES Permit Violated:

Board Order No R6T-2003-0032, WDID NO.6A090033000
Section I.A.1 on page 19 and Section I.B.1 on page 20

c) Reported Value(s) or Volume:

HV-C2: Total Phosphorus - 0.023 mg/L, Chloride-1.25 mg/L, & Iron - 0.18 mg/L
HV-C3: Total Phosphorus -0.021 mg/L, Chloride- 1.27 mg/L, & Iron - 0.09 mg/L
HV-C4: Turbidity – 88.74 NTU, Suspended Sediment – 168.0 mg/L,
Total Nitrogen – 0.878 mg/L, Total Phosphorus – 0.307 mg/L,
Chloride - 119.79 mg/L, Oil and Grease – 3.95 mg/L, & Iron - 3.44 mg/L

d) WDRs/NPDES Limit/Condition:

Maximum concentrations for discharge to surface waters in the Lake Tahoe Hydrologic Unit:
Turbidity: 20 NTU
Total Nitrogen: 0.5 mg/L
Total Phosphorus: 0.10 mg/L
Chloride: 3.0 mg/L
Oil and Grease: 2.0 mg/L
Total Iron: 0.50 mg/L
Total Dissolved Solids: 65mg/L (90th Percentile for Lake Tahoe Receiving Water Limits)

Maximum concentrations for discharge to surface waters in the Heavenly Valley Creek watershed:
Total Dissolved Solids: 60 mg/L
Total Nitrogen: 0.19 mg/L
Total Phosphorus: 0.015 mg/L
Chloride: 0.15 mg/L
Total Iron: 0.03 mg/L

e) Date(s) and Duration of Violation(s):

Water Year 2009 (October 1, 2008 –September 30, 2009)

f) Explanation of Cause(s):

Heavenly Valley Creek- Total Phosphorus, Chloride, and Iron were exceeded at both creek sites (HV-C2 and HV-C3). These parameters were also exceeded at similar values at the Hidden Creek reference site (HV-H5): 0.029 mg/L, 1.02 mg/L, and 0.18 mg/L respectively. Therefore the exceedances are likely not entirely due to Heavenly Resort operations

Bijou Park Creek- New standards in place for the Bijou Park Creek site (HV-C4) resulted in non-compliance exceedances for each of the constituents. All of these values were similar or less than the previous year's data. Turbidity, Total Phosphorus, and Oil and Grease levels were all skewed upward from the three storm event samples collected. Total Nitrogen levels are less than last year's annual average and may be attributed to the third year of a drought cycle and less vegetation uptake of nutrients. Chloride levels remain fairly high and are most likely due to the application of salt at the Base Lodge parking area. Chloride levels were highest during storm events and during spring runoff sampling. The exact causes of high Iron levels are unknown, but a known iron rich spring upstream of the sampling site is most likely the cause and mentioned in the general permit.

g) Corrective Action(s) (Specify actions taken and a schedule for actions to be taken)

Bijou Park Creek: Additional water quality treatment facilities are in place at the California Main Lodge and at the intersection of Saddle and Wildwood Roads above the Bijou Park Creek sampling point. The additional facilities are consistent with the waste discharge requirements. Additional monitoring will continue to take place in the California Parking Lot to ensure efficiency of the new system. Once trouble shooting with the automatic samplers is complete, the system in its entirety can be graded on performance. With consistent water quality results from the automatic samplers, further decisions with regards to meeting the new water quality standards can be made. It may be the case that additional treatment options are needed to meet the new water board standards. Heavenly is also investigating alternative deicer methods to address the Chloride issue.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision following a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my knowledge of the person(s) who manage the system, or those directly responsible for data gathering, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

If you have any questions or require additional information, please contact Andrew Strain at the number provided above.

Sincerely,

Signature:___________________________________

Name: Andrew Strain

Title: Vice President of Planning and Governmental Affairs

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CHAPTER 1 – INTRODUCTION

This annual report is submitted in partial fulfillment of monitoring and reporting requirements set forth in the Lahontan Regional Water Quality Control Board Order R6T-2003-0032. It summarizes monitoring and evaluation activities conducted at Heavenly Mountain Resort (Heavenly) during 2008/2009 water year as a result of the implementation of the Water Quality and Best Management Practices Monitoring Program. This program is a component of the Heavenly Mountain Resort Master Plan (Heavenly 1996) and the Heavenly Mountain Resort Master Plan Amendment (Heavenly 2007).

Heavenly Mountain Resort is located on the south shore of Lake Tahoe within El Dorado and Alpine Counties of California and Douglas County of Nevada (Figure 1.1). Land ownership is shared between the U.S.D.A. Forest Service (USDA Forest Service) and Heavenly. Heavenly operates on National Forest lands through a special use permit, renewed in 2002 for a period of 40 years.

The Water Quality and Best Management Practices Monitoring Program was initiated at Heavenly in 1995 in conjunction with the completion of the Heavenly Mountain Resort Master Plan (Heavenly 1996). The need for such a monitoring program was established during preparation of a Cumulative Watershed Effects (CWE) Analysis required by Tahoe Regional Planning Agency (TRPA) guidelines for ski area expansion. Implementation of the monitoring program was a condition of the Master Plan approval by the USDA Forest Service and TRPA. An amendment to the Heavenly Mountain Resort Master Plan approved by TRPA on April 25, 2007, is currently being implemented by Heavenly in collaboration with Lahontan Regional Water Quality Control Board (Lahontan), the USDA Forest Service, and TRPA. Modifications resulting from the Master Plan Amendment include incorporating all monitoring into a single report that was submitted May 15, 2009 to the TRPA, USDA Forest Service, and Lahontan. This monitoring report is on an ongoing schedule due yearly. The requirements of the 2008/2009 Annual Water Quality and Best Management Practices Monitoring Report remain the same following approval of the Master Plan Amendment.

The Master Plan represents a comprehensive twenty-year development plan for Heavenly Mountain Resort. Master Plan and Master Plan Amendment implementation objectives of Heavenly, TRPA, and the USDA Forest Service regarding protection of the environment include (Heavenly 1996):

- Making optimal use of the natural attributes of the site without creating a significant impact on the environment (Heavenly);
- Restoring the health of sub-watersheds and other natural resource values disturbed by past activities (Heavenly);
- Protecting the environmental quality of the area (USDA Forest Service);
- Providing a quality ski resort with ski runs and other disturbed areas stabilized to reduce the potential for soil erosion (USDA Forest Service);
- Improving the visual quality of the area (USDA Forest Service); and
- Providing for long-term preservation and restoration of Stream Environment Zones (TRPA).

Implementation of the Collection/Monitoring Agreement between Heavenly and the USDA Forest Service (Monitoring Program) will provide data sufficient to determine compliance with agency water quality standards and validate the efficiency of management practices in protecting against adverse cumulative watershed effects.

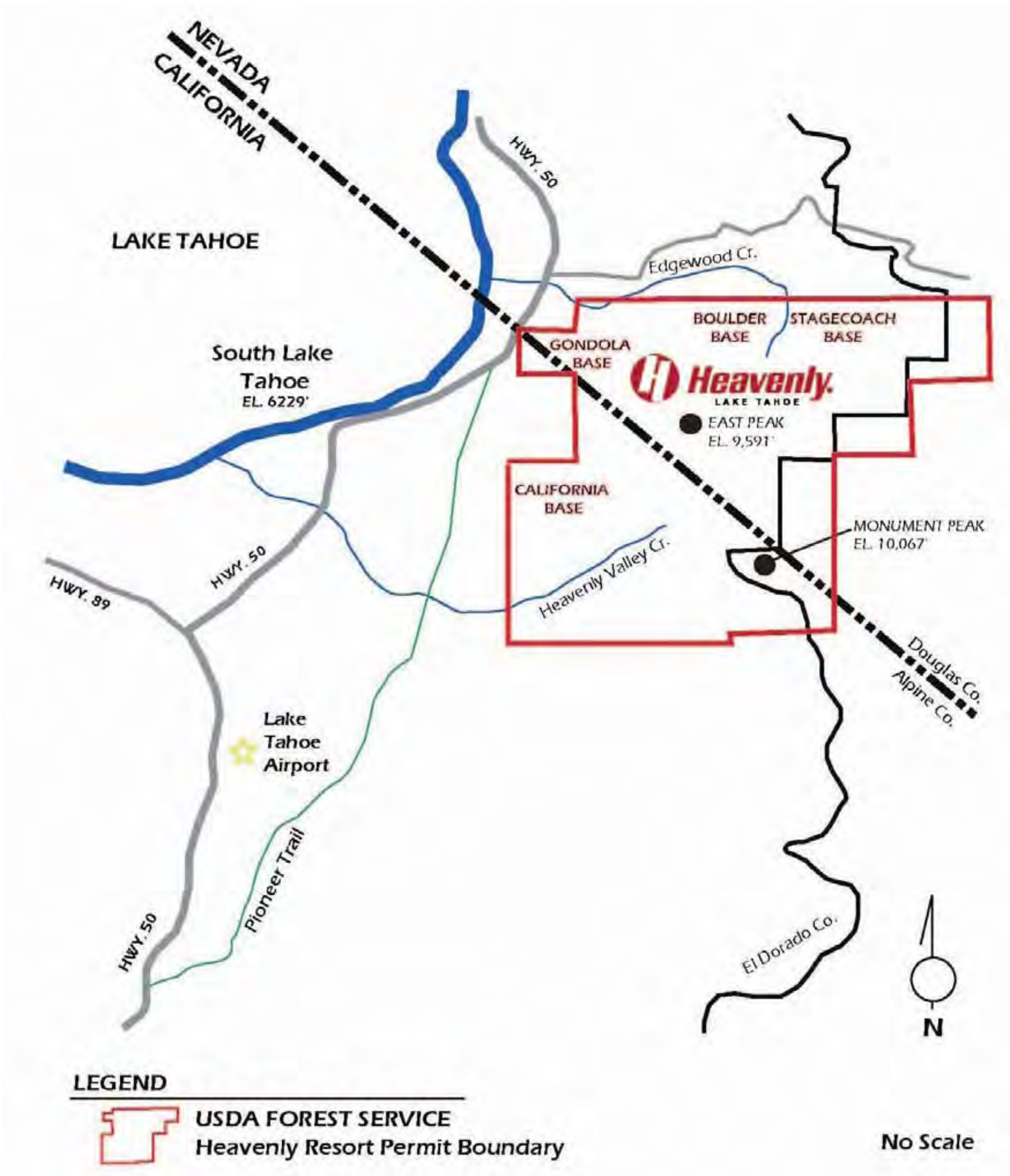

Figure 1.1. Location of Heavenly Mountain Resort (Heavenly 2007)

Environmental Monitoring Program

The overall objective of the Environmental Monitoring Program is to evaluate and monitor water quality and overall ecological health of Heavenly creeks and watersheds while satisfying California, Nevada, and TRPA regulatory water quality requirements. The Environmental Monitoring Program is made up of five major components (Heavenly 1996):

- Water quality monitoring to comply with regulatory monitoring requirements;
- Soil cover monitoring to gain understanding of how to prevent soil loss and protect water quality;
- Monitoring to determine BMP effectiveness under the various conditions at the ski area;
- Riparian condition monitoring to determine riparian area response to Heavenly Mountain Resort activities; and,
- Overall watershed condition and trend monitoring.

The Effective Soil Cover Workplan was modified in 2008, and the Monitoring and Riparian Condition Monitoring Plans was modified in 2005 in coordination with the Lake Tahoe Basin Management Unit (LTBMU). The Water Quality Monitoring Program was reviewed in 2005 and 2006 by the LTBMU and Lahontan to determine the need to modify sample locations. One of the revisions to the Monitoring Program implemented in water year 2006 was the exclusion of water quality site 43-HV-C1A, (Sky Meadows on Heavenly Valley Creek). No monitoring occurred at station 43-HV-C1A in water year 2008 in accordance with the environmental monitoring program as updated by the Heavenly Master Plan Amendment (2007) and as recommended in the 2006 annual report.
The Heavenly Master Plan was amended in 2007, and there are additional mitigation and monitoring requirements contained in the 2007 Heavenly Master Plan EIS/EIR/EIS which are not relevant to Lahontan standards and regulations. The first comprehensive annual report encompassing the mitigation and monitoring required by the Master Plan Amendment was submitted on May 15, 2009 to the TRPA and was made available to other interested agencies and parties. The second comprehensive mitigation and monitoring report will be submitted on May 14, 2010.

Monitoring Plan

The Environmental Monitoring Program Plan is in Chapter 7 of the 2005 Draft Master Plan Amendment. The Monitoring Program was designed to satisfy the requirements of Lahontan Board Order No. 6-91-36. The Monitoring Plan addresses the five components stated above. Key plan requirements are summarized here.

Water Quality Monitoring

The waste discharge requirements, monitoring, and reporting program were updated by Lahontan Board Order No. R6T-2003-0032 in 2003. Currently, the Monitoring Program includes water quality monitoring at 6 stations. Sampling occurs monthly except during the spring snowmelt period when sampling occurs weekly or when flows are too low to measure. Results and discussion are to be reported to Heavenly, TRPA, and Lahontan in this annual report. Additionally, water quality sampling results are reported quarterly to Lahontan as required by Order No. 6-91-36.
Several constituents are identified in the Monitoring Program for sampling at each of the stations. The following primary list of constituents is monitored at each station:

- Discharge

- Specific Conductivity
- Turbidity
- Suspended Sediment
- Total Nitrate/Nitrite as Nitrogen
- Total Kjeldahl Nitrogen
- Dissolved Orthophosphate
- Total Phosphorus
- Dissolved Phosphorus
- Chloride
- Total Iron

The following secondary list of constituents is typically monitored only during storm events at stations associated with parking lots:

- Oil and Grease
- Total Petroleum Hydrocarbons
- Ammonia
- Total Lead

Effective Soil Cover Monitoring

The Monitoring Program includes soil cover monitoring to determine requirements and effectiveness of various soil covers under different slopes and conditions. Monitoring examines the effectiveness of past and current projects. Soil cover monitoring conducted from 1995 to 2003 was based on the use of random transects at elevations greater then 7,000 ft. The results were reported in the 2003 Comprehensive Report. Collection of the data was too time-intensive, making it difficult to obtain data for the entire resort and the 2003 Comprehensive Report recommended that the measurements be discontinued. The report also recommended development of new protocol. A new general methodology was developed in 2005 by ENTRIX and approved by the USDA Forest Service.

In the 2007 Annual Report and later in the 2008 Effective Soil Cover Workplan, a new protocol was presented that combined the California Native Plant Society's (CNPS) Vegetation Rapid Assessment Protocol (VARP) and the establishment of permanent photo points. After discussions with the USDA Forest Service, it was determined that Heavenly and the USDA Forest Service will share the cost of one over-flight in July or August of 2009. The flight will produce a 1:8,000 resolution infrared aerial photo of the entire mountain and will be used along with Geographic Information Systems (GIS) and sufficient field verification (i.e. ground-truthing) to produce an accurate picture of the soil cover at Heavenly. This new detailed methodology was implemented in 2009, and is discussed in Chapter 3.

BMP Effectiveness Monitoring

The Monitoring Program includes BMP monitoring to determine the effectiveness of the BMPs in preventing soil erosion and protecting water quality under various conditions. Based on recommendations contained in the 2003 Comprehensive Report, the USDA Forest Service designed and implemented a new BMP monitoring strategy modeled after Region 5's Best Management Practices Effectiveness Program (BMPEP) protocols (USDA Forest Service 2002). The BMP monitoring program is currently being implemented by Resource Concepts Inc. (RCI) and is presented in Chapter 4.

Riparian Condition Monitoring

The Monitoring Program includes riparian and channel condition monitoring, as well as macro-invertebrate monitoring which includes the following objectives:

- Determine which, and by how much, various creek parameters fluctuate between monitoring periods
- Evaluate the impacts of Heavenly management practices on riparian system health

In 2003, the USDA Forest Service made a number of recommendations to improve channel condition monitoring. These recommendations are reflected in the Riparian Conditions Monitoring Plan developed by ENTRIX in 2005. The revised plan was implemented in 2006 and most recently in 2009. Channel condition monitoring occurred in all monitoring reaches and is discussed in Chapter 5. Macro-invertebrate monitoring occurred in 2006 and 2007 and will not occur again until 2010 and 2011.

Condition and Trend Monitoring

Condition and trend evaluations will be conducted on each of the data elements of the monitoring program both individually and cumulatively to gauge overall watershed condition, trends, and to determine if ski area management activities are improving. These evaluations are evaluated in 5-year intervals in Comprehensive Reports. The last Comprehensive Report was submitted in 2006, and the next one is due in 2011.

CHAPTER 2 – WATER QUALITY

Station Descriptions

For the 2008/2009 water year, a set of water quality parameters were measured at six stations on four creeks to determine the effects of ski area development on background conditions (Table 2.2). Stations and sampling rationale are given in Table 2.1. Approximate locations of stations are shown in Figure 2.1.

Table 2.1. Heavenly Valley Mountain Resort Monitoring Program Water Quality Stations

Station ID	Station Name	Rationale
HV-C2	Heavenly Valley Creek Below Patsy's and Groove Lifts	Characterize water quality in Heavenly Valley Creek draining developed ski area
HV-C3	Forest Service Property Line	Characterize water quality in Heavenly Valley Creek leaving National Forest Lands below Heavenly Mountain Resort
HV-C4	Heavenly California Base Parking Lot	Characterize water quality in Bijou Park Creek below California Main Lodge and parking area
HV-E1	Edgewood Creek Above Boulder Parking Lot	Characterize water quality in Edgewood Creek above Boulder parking lot and below ski runs
HV-E2	Edgewood Creek Below Boulder Parking Lot	Characterize water quality at Edgewood Creek below Boulder parking lot
HV-H5	Hidden Valley Creek Baseline Station	Characterize water quality in creek draining a similar, but mostly undeveloped watershed

Precipitation Summary

Precipitation for the year is shown in Figure 2.2. Data was taken from the National Resource Conservation Service, National Water and Climate Center website (http://www.wcc.nrcs.usda.gov). This graph represents accumulated precipitation and snow water content measured at SNOTEL Station 19L24S ("Heavenly Valley"), operated by the USDA Natural Resource Conservation Service. This station is located in the upper watershed of Heavenly Valley Creek near Sky Meadows, the former HV-C1A monitoring station at latitude 38° 56' N, longitude 119° 54' W, and elevation 8,850 ft.

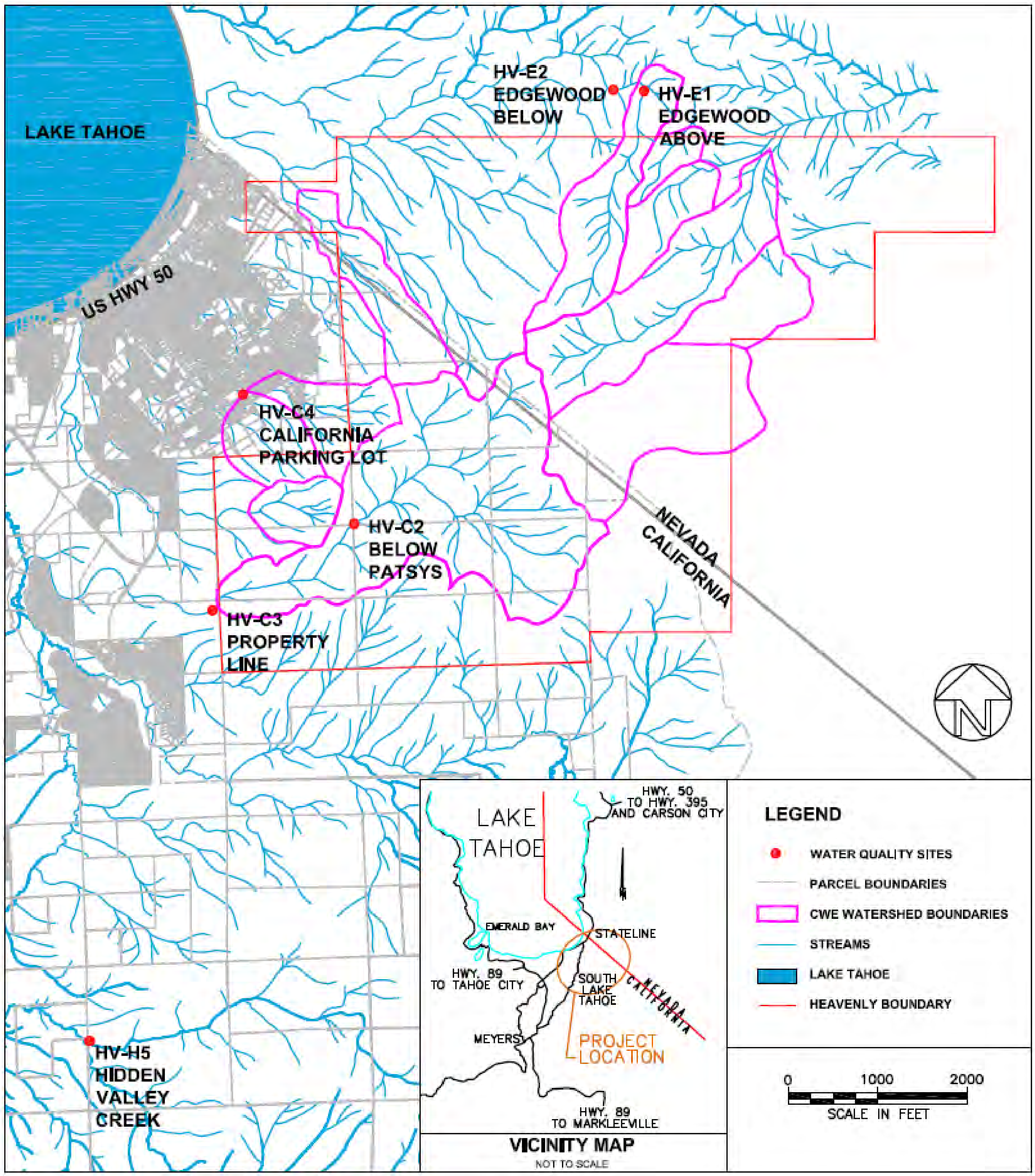

Figure 2.1. Approximate location of water quality sampling sites (Mapquest 2009) (USDA Forest Service 2001).

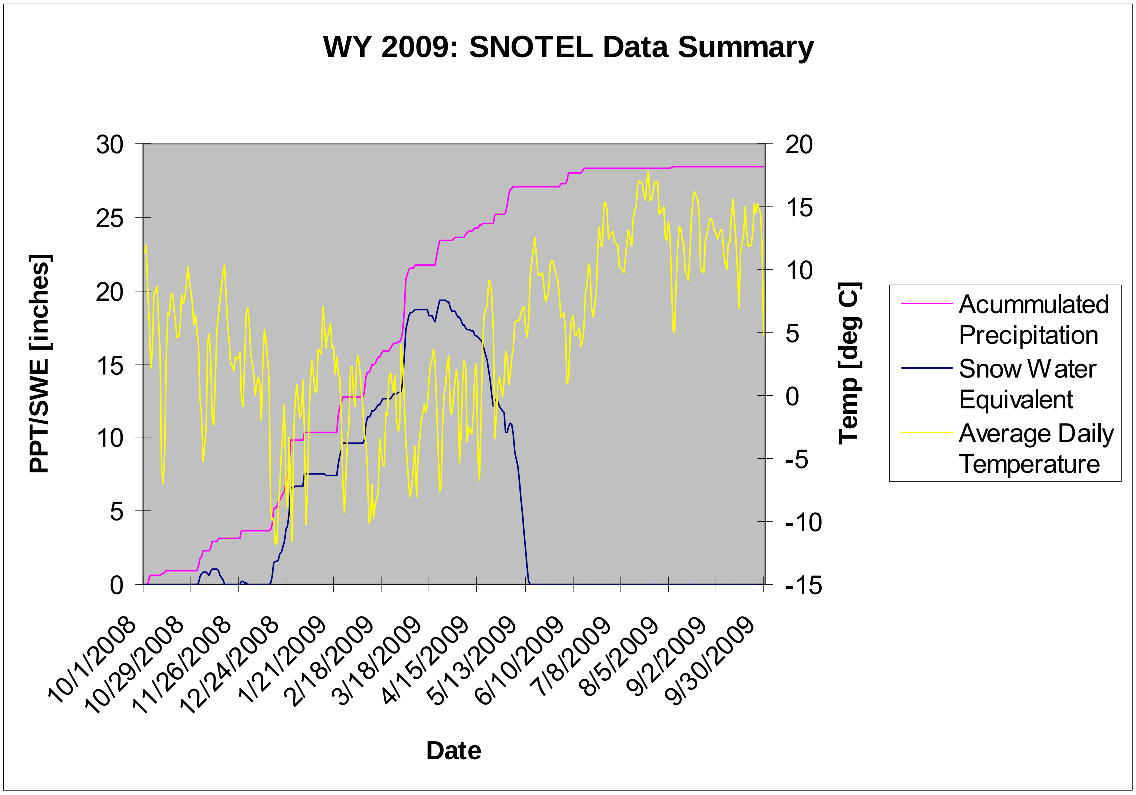

Figure 2.2. SNOTEL weather graph for water year 2009.

Sampling Frequency and Analysis

A total of 74 samples were collected during the 2008/2009 water year. Six of these samples were collected during storm events. Three storm event samples were taken at the California Parking Lot Station (HV-C4), and one storm sample each from Hidden Creek (HV-H5), Upper Edgewood (HV-E1) and Lower Edgewood (HV-E2). All stations were sampled weekly during spring runoff and monthly during baseflow conditions, as flow levels permitted. Table 2-2 provides a summary of sampling and analyses for the 2008/2009 water year.

Analyses for specific conductivity, turbidity, suspended sediment, nitrate/nitrite, total Kjeldahl nitrogen, total nitrogen, total phosphorus, soluble reactive phosphorus, and dissolved phosphorus were performed by High Sierra Water Lab located in Truckee, CA. Analyses for iron, lead, oil and grease, and chloride were performed by Western Environmental Testing Laboratory (WETLab) in Reno, NV. Analytical results by station are provided in Appendix A.

Table 2.2. Summary of Sampling and Analysis Conducted at Heavenly Mountain Resort for the 2008/2009 Water Year.

Station ID	Station Name - abbreviated	Number Samples	Constituents*
HV-C2	Heavenly Below Patsy's	14	Full suite
HV-C3	Heavenly at Property Line	14	Full suite
HV-C4	California Parking Lot-Bijou Park Creek	17	Full suite, oil, grease, TPH, Fe, Pb, Cl
HV-E1	Edgewood Creek Above	5	Full suite
HV-E2	Edgewood Creek Below	9	Full suite
HV-H5	Hidden Valley Creek	15	Full suite

*Full suite = Discharge, specific conductivity, turbidity, suspended sediment, nitrate/nitrite, TKN, total nitrogen, total phosphorus, soluble reactive phosphorus. Storm and quarterly samples are included in the "full suite" count. Storm and quarterly sampling may also include chloride and iron as additional constituents.

Results and Discussion

Discharge

The rate of stream flow was measured using a Marsh-McBirney meter at all sites except HV-C2 where flow was calculated from stage values in Parshall flumes. The Heavenly Valley (HV-C2 and HV-C3) and Hidden Valley Creek (HV-H5) stations exhibited peak streamflow discharge values in mid-May. The Bijou Park Creek station (HV-C4) exhibited peak streamflow discharge during the February and March sample dates and a slight rise again in, mid-May. The peak flows from Heavenly Valley Creek (HV-C2 and HV-C3) were slightly higher than 2008 measurements, while Bijou Creek (HV-C4) reported a discharge peak below what was reported in 2008. Hidden Valley Creek (HV-H5) peaked approximately three weeks sooner with a higher discharge than last year's values.

The peak streamflows at the Edgewood Creek sites (HV-E1 and HV-E2) occurred at the beginning of May. These values are less than the reported peaks of 2008. Occasionally samples from the lower Edgewood site (HV-E2) reported discharge values higher than the upper sampling site (HV-E1). Edgewood Creek is known to have tributaries adding flow to the downstream site from surrounding neighborhoods. In addition, below the Boulder parking area the creek is established in a small ravine which collects groundwater recharge from the adjacent hillside slopes. During storm events the discharge values are in reverse order. The upper site (HV-E1) shows a higher discharge value than the lower site (HV-E2). This is most likely the result of the Boulder Parking Lot Treatment System installed in 2005 attenuating flow as it runs downstream to the lower site. In addition, the Lower Edgewood Creek Stream Environment Restoration Project completed in 2007, created plunge pools to increase retention time contributing to the attenuation.

The 2009 water year was a below average winter for precipitation. This marks the third consecutive year of similar precipitation totals. While precipitation values were slightly higher than last year, the snow water equivalent peak measurement was lower. Above average temperatures in March and April again fueled the mid-May peak discharge values at a majority of the sam pling lo cations. (See Figure 2.2) Figures 2-3, 2-4, a nd 2-5 are hydrographs representing all six sampling stations.

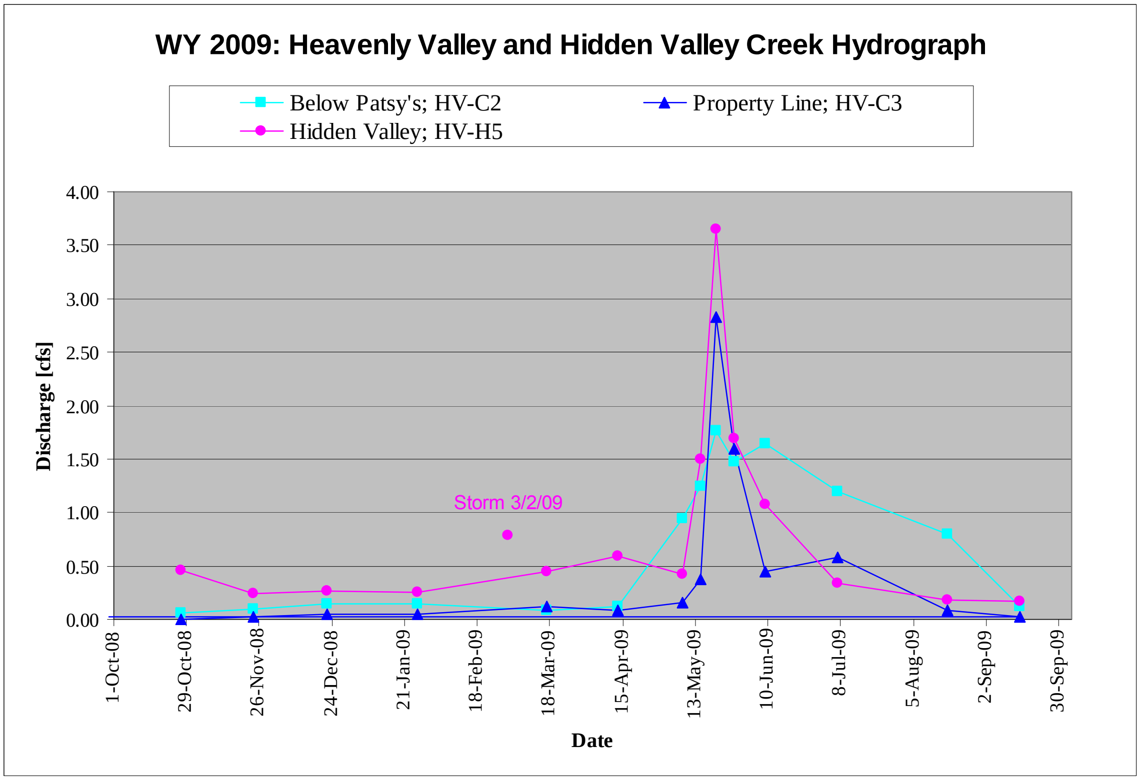

Figure 2.3. Hydrographs for Heavenly Valley and Hidden Valley Creeks during water year 2009. The two Heavenly Valley Creek monitoring sites are depicted in shades of blue. The one Hidden Valley Creek monitoring site is depicted in magenta.

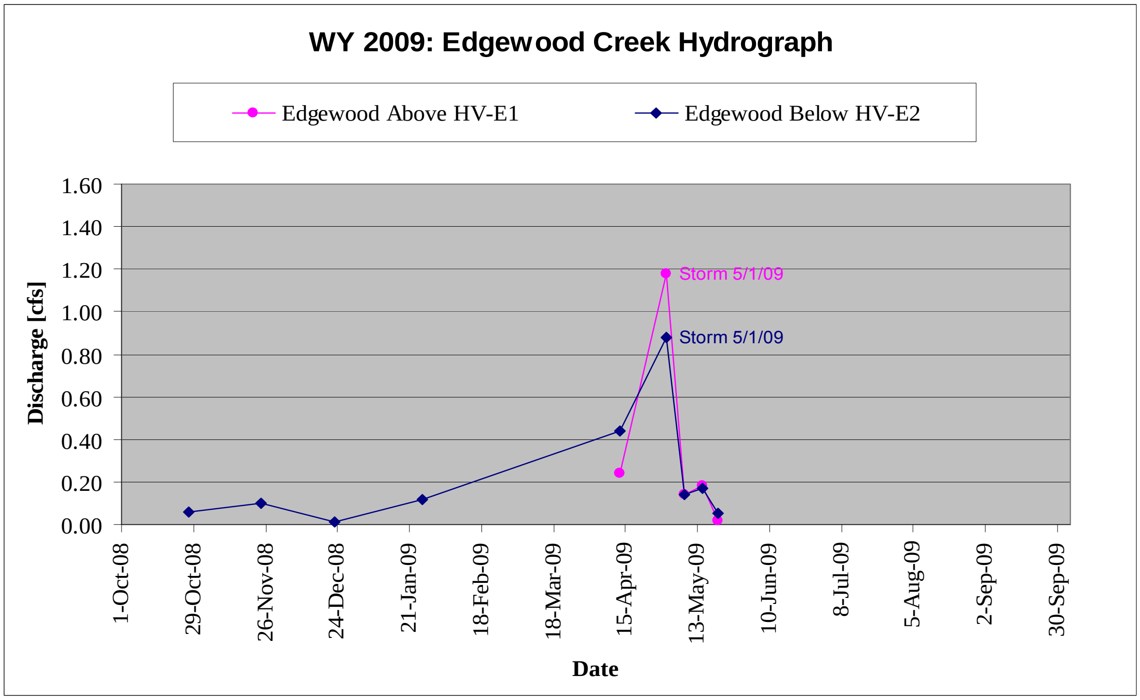

Figure 2.4. Hydrographs for Edgewood Creek during water year 2009.

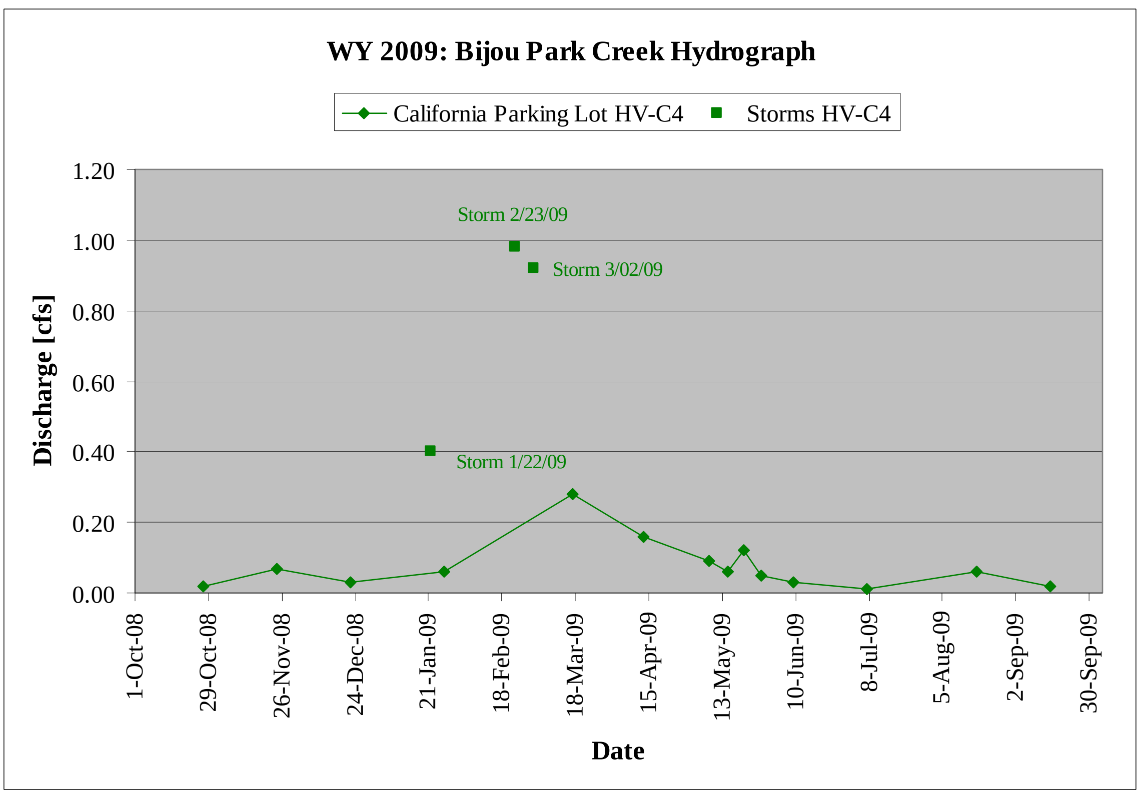

Figure 2.5. Hydrograph for Bijou Park Creek during water year 2009.

Annual Load Estimates

Table 2.3 presents the annual load values calculated from flow-weighted concentration data for total nitrogen, total phosphorus, and suspended sediments at Heavenly Valley Creek's Property Line station and the Hidden Valley Creek baseline station for water year 2009. Annual load values are calculated from flow-weighted concentration data for constituents. The previous Total Maximum Daily Load (TDML) for sediment at Heavenly Valley Creek was 58 tons/year (based on a five-year rolling average). The newly calculated five year average from 2005 to 2009 is shown in Table 2.4 and equals 15 tons/year. This new rolling average is considerably lower than 58 tons/year and is mostly likely associated with below average precipitation and flows the past three seasons. In addition, this lower rolling average value could also be attributed to BMP implementation and effectiveness through out the watershed. Although compliance is not determined until the Comprehensive Report, which will include water years 2006-2011, Heavenly continues to be below the TMDL standard for suspended sediment. The last comprehensive report found that Heavenly was in compliance for the TMDL standard during that monitoring period.

The method used to calculate annual load values is based on constituent concentrations, discharge, and days between samples. This is the same method that has been used in previous annual reports. Storm data was not used in load calculations. The 2009 water year can be considered a below average precipitation year. As such, the annual load values are considerably lower than in 2006, but fairly similar to 2007, which was also a dry year. Values for total phosphorus and suspended sediment are similar to values calculated in 2008. The total nitrogen levels are relatively high for lower discharge values. Because the calculation is weighted on discharge and days between samples, it seems that spring runoff is driving the Hidden Valley total nitrogen levels higher.

Table 2.3. Annual load values at Heavenly Valley Creek Property Line and Hidden Valley Creek Stations.

Year	Discharge m^3/yr	Total N kg/yr	Total P kg/yr	Suspended Sediment tons/yr
Property Line (HV-C3)				
2009 174,91	8	14	4	1
Hidden Valley Creek (HV-H5)				
2009 415,12	3	51	12	2

Table 2.4. Five Year Rolling Average of Suspended Sediment for Heavenly Valley Creek Property Line and Hidden Valley Creek Stations.

Year	Property Line (HV-C3) Suspended Solids (tons/year)	Hidden Valley Creek (HV-H5) Suspended Solids (tons/year)
2005 33		25
2006 39		34
2007 1		3
2008 1		2
2009 1		2
5 Year Rolling Average	15 (tons/year) 13.2	(tons/year)

Heavenly Valley and Hidden Valley Creeks

Summary Statistics for Water Quality Constituents: Water Year 2009

The statistical summary for Heavenly Valley and Hidden Valley Creeks for water year 2009 is contained within Tables 2.5 through 2.7, while raw data is referenced in Appendix A. Annual average standards that were exceeded by the stations on Heavenly Valley Creek were also exceeded by the Hidden Valley Creek reference station. Therefore, the exceedances are likely due to background conditions unrelated to operation of Heavenly. Total phosphorus, chloride and total iron all exceeded the standard annual averages. Although the results for some of the exceedances are higher on Heavenly Valley Creek when compared with those of Hidden Valley Creek, the standard deviations of these numbers show that the difference is statistically insignificant in almost all cases.

The concentration of Total Suspended Sediment (TSS) at Heavenly Valley and Hidden Valley Creeks fell well below the State Standard of 60mg/L at the 90th percentile. The Below Patsy's (HV-C3) and Property Line station (HV-C3) TSS values were below the value of the Hidden Valley Creek reference station (HV-H5), suggesting that resort operations have no impact or a less than significant impact on TSS concentrations.

Lahontan's standard for total nitrogen, 0.19 mg/L, is the sum of the total nitrite/nitrate plus total Kjeldahl nitrogen. Both stations (HV-C2 and HV-C3) on Heavenly Valley Creek exhibited annual averages below the standard. The Below Patsy's (HV-C2) and Property Line station (HV-C3) total nitrogen values were similar to that of the reference station, Hidden Valley Creek (HV-H5), suggesting that resort operations have no impact or a less than significant impact on total nitrogen concentrations.

Annual averages for total phosphorus are required to be below the 0.015 mg/L Lahontan standard. Both stations on Heavenly Valley Creek exhibited levels that exceeded the standard. Average values for these stations are as follows: Below Patsy's (HV-C2) 0.023 mg/L, and Property Line (HV-C3) 0.021 mg/L. The reference station on Hidden Valley Creek (HV-H5) also exceeded the annual average standard at 0.029 mg/L. Although vegetation removal at the resort could contribute to phosphorus levels, the levels are below that of the primarily forested and relatively undeveloped watershed of Hidden Valley Creek. It appears that Heavenly is achieving a reduction in soil erosion through their implementation of BMPs.

The chloride standard of 0.15 mg/L was also exceeded by all stations on Heavenly Valley and Hidden Valley Creeks. Below Patsy's (HV-C2) and Property Line (HV-C3) exhibited annual averages of 1.25 mg/L, and 1.27 mg/L, respectively. By comparison the reference station on Hidden Valley Creek (HV-H5) exhibited a chloride value of 1.04 mg/L. Causes for high chloride levels are unknown. The application of salt in the watershed upstream is a possible cause, but does not explain the high background concentrations. The chloride levels at the sample site Below Patsy's (HV-C2) could be attributed to application of sodium chloride on nearby terrain parks on the mountain. The Property Line site (HV-C3) is downstream of the Below Patsy's site and could be affected by salt application on terrain parks also. The maximum chloride level measured at Hidden Valley Creek (HV-H5) was 2.3 mg/L on 10/27/08. Chloride results are similar to values in previous water years and is it not entirely understood why the reference watershed has higher background values. There is no evidence or knowledge of salt or deicers being used in this remote relatively undisturbed watershed. The high value sampled from the reference station at Hidden Valley Creek (HV-H5) may indicate relatively high background concentrations. Heavenly is investigating practices that will reduce chloride in runoff such as alternative deicers, application practices, and deicer storage. If the reference station (HV-H5) continues to exhibit high chloride levels further management measures and implementation at resort sites may still not meet the water board standard.

Iron was the third constituent to be exceeded by all stations. The iron standard is 0.03 mg/L. Below Patsy's (HV-C2) and Property Line (HV-C3) had average values of 0.18 mg/L, and 0.09 mg/L respectively. The reference station on Hidden Valley Creek (HV-H5) exhibited 0.18 mg/L. The high value in the reference station may indicate high background concentrations. Groundwater below the Heavenly Tram was sampled on December 9, 2008 to investigate whether background iron concentrations exceeded the standard. This sample produced an iron level of 0.046 mg/L, which exceeded the standard. Further augmenting the possibility that iron levels are naturally high in Lake Tahoe groundwater is U.S. Geological Survey (USGS) data for Basin streams from 1991 through 2003 (USGS 2000). Data from streams such as Ward Creek, Blackwood Creek, Logan Creek, and First Creek, among others, demonstrate exceedances of the iron standard on a regular basis. Though this data ceased to be collected after 2003, it offers some insight on background iron levels in the Lake Tahoe Basin. Iron levels measured in water year 2009 were similar to values in previous water years.

Table 2.5. Below Patsy's Water Year 2009 Statistical Summary.

Table 2.5	Exceedances of California Lake Tahoe Receiving Water Limits and Water Year 2009 Summary Statistics for Below Patsy's (HV-C2)								
	Q (cfs)	Turbidity (NTU)	TSS (mg/L)	S Cond (mmhos)	Total Phos (mg/L)	SRP (mg/L)	Total Nitrogen (mg/L)	Chloride (mg/L)	Iron (mg/ L)
CA State Standard		-	60.00 -		0.015 -		0.19	0.15	0.03
# Samples	14	14	14 14		14 14		14	4	4
Min 0.06		0.40	0.27	27.30	0.015 0.001		0.09	0.82	0.08
Max 1.76		3.00	7.60	82.80	0.300 0.006		0.21	1.80	0.28
Mean	0.70	1.12	2.41	49.67	0.023 0.003		0.15	1.25	0.18
Std Error	0.66	0.68	2.17	19.38 0.006		0.002	0.04	0.48	0.08
90th Per	-	-	5.12	-	-	-	-	-	-

Table 2.6. Property Line Water Year 2009 Statistical Summary.

Table 2-6	Exceedances of California Lake Tahoe Receiving Water Limits and Water Year 2009 Summary Statistics for Property Line (HV-C3)								
	Q (cfs)	Turbidity (NTU)	TSS (mg/L)	S Cond (mmhos)	Total Phos (mg/L)	SRP (mg/L)	Total Nitrogen (mg/L)	Chloride (mg/L)	Iron (mg/L)
CA State Standard		- 60.00 - 0.015				-	0.19	0.15	0.03
# Samples	14	14 14 14 14				14 14		4	4
Min 0.02		0.32	0.27	32.20	0.014	0.001 0.0		0.85 0.07	
Max 2.83		1.60	4.80	50.20	0.030 0.006		0.12	1.70	0.12
Mean 0.46		0.79	1.86	41.83	0.021 0.004		0.06	1.27	0.09
Std Error	0.80	0.37 1.48 5.		40 0.005		0.002	0.04	0.44	0.02
90th Per	-	-	3.6	- -		- -		- -	

Table 2.7. Hidden Valley Creek Water Year 2009 Statistical Summary.

Table 2.7	Exceedances of California Lake Tahoe Receiving Water Limits and Water Year 2009 Summary Statistics for Hidden Valley Creek (HV-H5)								
	Q (cfs)	Turbidity (NTU)	TSS (mg/L)	S Cond (mmhos)	Total Phos (mg/L)	SRP (mg/L)	Total Nitrogen (mg/L)	Chloride (mg/L)	Iron (mg/L)
CA State Standard		-	60.00	-	0.015	-	0.19	0.15	0.03
# Samples	15	15	15	15	15	15	15	5	5
Min	0.17	0.50	0.40	20.50	0.019	0.002	0.05	0.40	0.03
Max	3.65	6.10	11.20	62.00	0.046	0.017	0.23	2.30	0.44
Mean	0.80	1.42	3.00	44.57	0.029	0.008	0.12	1.02	0.18
Std Error	0.92	1.45	3.13	15.62	0.008	0.003	0.06	0.77	0.17
90th Per	-	-	6.56	-	-	-	-	-	-

Bijou Park Creek (California Parking Lot)

Summary Statistics for Water Quality Constituents: Water Year 2009

The California Parking Lot site (HV-C4), is sampled for compliance with California state effluent standards for urban runoff and water quality objectives for maximum concentrations for discharge to surface waters, as stated in Lahontan Board Order No. R6T-2003-0032. Prior to November 30, 2008 effluent limits for discharge at this site were regulated under the permit as maximum concentrations for discharge to land treatment values. The new standards were reduced by approximately a factor of ten compared to the land treatment values (see Table 2.8). Proposed, constructed, and implemented improvements to the California Base parking lot dictated by the Lahontan permit triggered these more stringent objectives. California State effluent standards and exceedances are outlined in Table 2.9, while raw data is referenced in Appendix A.

Table 2.8. Lake Tahoe Hydrologic Unit Surface Runoff Effluent Limits

Constituent Units		Maximum Concentrations for Discharge to Land Treatment [1]	Maximum Concentration for Discharge to Surface Waters [2]
Total Nitrogen	mg/L as N	5.0	0.5
Total Phosphorus	mg/L as P	1.0	0.1
Total Iron	mg/L	4.0	0.5
Turbidity NTU		200	20
Oil and Grease	mg/L	40	2

[1] The effluent limits for discharge to land were effective for discharges from the California Base area on December 31, 2004.

[2] The effluent limits for discharge to surface waters shall be effective for discharges from the California Base area on November 30, 2008.

The annual average for total nitrogen for the station at Bijou Park Creek (HV-C4) was recorded at 0.878 mg/L. This value exceeds the newly adopted maximum concentration of 0.5 mg/L.

The highest calculated value (the sum of nitrate, nitrite and total Kjeldahl nitrogen) was recorded during the February 23, 2009 storm event at 3.043 mg/L. Only four of the thirteen samples collected were below the annual average. The 2009 annual average value is less than the previous four years annual average for total nitrogen. However non-compliance results from this value because of the new lower imposed standard. Plant uptake and decay may explain seasonal spikes throughout the year for nitrogen readings, but it doesn't explain the relatively high background readings. Another possible factor could be the fact that the Tahoe basin experienced the third consecutive below average precipitation and this trend may be contributing to less vegetation undergrowth and nutrient uptake.

The total phosphorus annual average for the Bijou Park Creek station (HV-C4) was 0.307 mg/L. This value exceeds the standard of 0.1 mg/L. The total phosphorous measurement on October 27, 2008 is likely due to sampling error and was not included in the annual statistical data. Only five of the total sixteen samples collected were above the standard. Storm sampling spikes of 0.93 mg/L and 2.717 mg/L pushed the annual average well above the standard. If these two readings, along with the sample error reading, are ignored the new annual average would be 0.066 mg/L and below the new imposed standard. Phosphorus and nitrogen constituents can vary with plant uptake and subsequent vegetation removal, however the 2009 annual average is lower than the reported averages for the past three water years.

The annual average standard of 0.5 mg/L for total iron was exceeded for the Bijou Park Creek (HV-C4) 2009 water year. The 2009 annual average was 3.44 mg/L. Of the nine samples collected, none were below the Lahontan standard. The 2009 annual average was less than the previous four water years. These relatively high iron readings are likely attributed to naturally occurring iron in the soils and nearby springs, as noted in the general permit (Section 12 California Base Area Runoff, page 6). An additional test was performed in December 2008 to test iron levels in and around the parking lot. The iron concentration from the tram sump water measured 0.046 mg/L, while the iron concentration at the parking lot outlet was 12 mg/L. The increase in iron concentration indicates that something in or on the California Parking Lot is contributing iron to the groundwater, which then enters Bijou Park Creek as surface water at the intersection of Saddle and Wildwood.

The 2009 annual average for turbidity at the Bijou Park Creek station (HV-C4) was 88.74 NTU. This value well exceeded the newer standard of 20 NTU. Only three of the seventeen samples collected exceeded the Lahontan standard. All three of these exceedances occurred during storm sampling (1/22/09, 2/23/09, and 3/2/09), and were collected during the three highest flows measured in 2009. The highest turbidity reading was 978 NTU and these three readings skewed the data set well above the standard. If these storm values are removed from the data set, the new annual average would be 9.68 NTU and below the measured standard. During larger storm events surface water and increased flow in the creek can stir up and mobilize particulates that would account for these higher readings.

The 2009 annual average for oil and grease at the Bijou Park Creek station (HV-C4) was 3.95 mg/L. This value is in exceedance of the Lahontan standard of 2.0 mg/L. Six of the seventeen samples collected were above the new standard. The three largest readings were all collected during a storm event and skewed the data in an upward trend (11.0 mg/L, 31.0 mg/L and 5.4 mg/L). If these storm samples are neglected the new annual average value is 1.41 mg/L and below the water quality standard. With both the California Parking Lot and the treatment system at the intersection of Saddle Road and Wildwood Road in place these values are lower than reported values in previous years. Also laboratory detection limits are being reported at a lower value (<1.0) than in prior years. Continued monitoring and trouble shooting the treatment systems should provide better data and further understanding of these values.

The suspended sediment 2009 annual average at the Bijou Park Creek (HV-C4) station was measured at 168 mg/L. This value too exceeds the new Lahontan standard of 65 mg/L for the 90th percentile for receiving waters into Lake Tahoe (page 22 of the Board Order Number R6T-2003-0032). Only three of the seventeen samples collected exceeded the new standard, and all three of these violations occurred during storm water sampling (1/22/09, 2/23/09 and 3/2/09). The highest value recorded equaled 823.23 mg/L and skewed the annual average above the Lahontan limit. If the three storm events are neglected, the new annual average is 7.97 mg/L and half of the standard value. Increase suspended sedimentation is likely the cause of increased nutrient loading (nitrogen and phosphorous). These constituents are known to adhere to suspended sediments. The addition of two treatment systems above the sampling location has decreased this value from previous years (prior to 2008). Continued monitoring and regular maintenance of the treatment systems should stabilize this value in the coming quarters and years.

The annual average standard of 3.0 mg/L for chloride, for receiving waters of Lake Tahoe (Table 3 of the Board Order Number R6T-2003-0032), was exceeded for this site (HV-C4). The annual average for chloride reported a value of 119.79 mg/L. The highest level of chloride was measured during a rain on snow event that occurred on February, 23, 2009. As depicted by the hydrograph, the discharge was the highest recorded at this site during the 2009 water year. The chloride concentration was measured at 430 mg/L, skewing the average towards a higher value. If all three storm events are neglected and the average is recalculated the new annual average is 87 mg/L. This value too exceeds the water board standard. Excess chloride is most likely due to deicer application that includes sodium chloride. Applications to the California Base Lodge Parking area and surrounding city roads helps to prevent ice build up and ensure public safety. While most of the measured values for chloride were high, summer measurements occurred when no deicers were applied to the California Base Lodge Parking area or surrounding area. For example, no deicers were applied to the California Parking Lot in July of 2009 when chloride concentrations were measured at 76 mg/L. It is possible that deicer residuals from the previous season had accumulated and were flushed during summer thunderstorms. With the installation of automatic samplers at the influents and effluent locations of the California Parking Lot treatment system, Heavenly should be better able to determine whether chloride originates from the resort application, city road application, or occurs naturally. Heavenly is actively investigating practices that will reduce chloride in runoff such as alternative deicers, application practices, and deicer storage.

Single value non-compliance values are discussed in the pertinent quarterly report and are displayed in Appendix A.

Table 2.9. Exceedances of CA Standards and Water Year 2009 Summary Statistics for HV-C4.

Table 2.9	Exceedances of California Effluent Standards and Water Year 2009 Summary Statistics for Bijou Park Creek (HV-C4) below California Parking Lot												
	Q (cfs)	Tur-bidity (NTU)	TSS (mg/L)	S Cond (mmhos)	Total Phos (mg/L)	SRP (mg/L)	NO_2/ NO_3 (mg/L)	TKN (mg/L)	Total N (mg/L)	Chlor-ide (mg/L)	Oil/ Grease (mg/L)	Total Iron (mg/L)	Total Lead (mg/L)
CA State Standards		20.0	65	N/A	0.10	N/A	N/A	N/A	0.5	3.0	2	0.5	N/A
# Non-compliance		3	3		5				13	16	6	9	
% Non-compliance		18%	18%		31%				76%	94%	35%	100%	
# Samples	17	17	17	17	16	16	17 17		17 17		17	9	17
Min 0.01		4.80	2.40	283.00	0.041	0.001	0.038	0.097	0.28	0.4	1.0	1.5	<0.010
Max	0.98	978.00	823.33	1368.00	2.717	0.014	0.590	3.005	3.04	430.0	31.0	6.8	<0.010
Mean 0.20		88.74	75.97	492.24	0.307	0.006	0.332	0.546	0.88	119.8	3.95	3.4	-
Std Error	0.30	243.49	201.55	271.65	0.681	0.004	0.173	0.764	0.69	99.3	7.41	1.63	-
90th Percent-ile Value	-	-	168.00	-	-	-	- -		- -		-	-	-

Edgewood Creek

Summary Statistics for Water Quality Constituents: Water Year 2009

Although Edgewood Creek is located in Nevada, outside of Lahontan jurisdiction, Edgewood Creek data is included for compliance with the Master Plan Amendment because it is within TRPA's jurisdiction. The Edgewood Creek sites are sampled for compliance with the Nevada Department of Environmental Protection (NDEP) standards. Data are summarized in Tables 2.10 and 2.11, while raw data is referenced in Appendix A. The annual average standard for total nitrogen was met at both stations during water year 2009.

The not to exceed standards for total phosphorus was exceeded at the Edgewood Above station (HV-E1) on April 13, 2009. The reason for the high levels is unknown, but may be caused by surface flows mobilizing nutrients during spring runoff. Levels decreased later in the season, even with higher flows.

The not to exceed standards for turbidity and suspended sediment, were exceeded at the Edgewood Below station (HV-E2) on April 13, 2009. The not to exceed standards for turbidity, suspended sediment, and total phosphorus were exceeded again on May 1, 2009. The occurrence of these exceedances correlates with the peak of Edgewood Below station's hydrograph and, therefore, the highest flows in water year 2009. The May 1st sample date was collected during a storm event. Because the levels of the constituents trended downward after this storm event and as the season progressed, the initially high values could have resulted from the spring flush and sediment transport of the constructed plunge pools from the 2007 restoration project. As vegetation continues to mature, the restoration project should control temporary spikes in turbidity and suspended sediments along with the phosphorus that usually accompanies these constituents.

Table 2.10. Exceedances of Standards and Water Year 2009 Summary Statistics for HV-E1.

Table 2.10	Exceedances of State (NDEP) Standards and Water Year 2009 Summary Statistics for Edgewood Creek (HV-E1) Above Boulder parking lot									
	Q (cfs)	SC (mmhos)	Turbidity (ntu)	SS (mg/L)	NO_2/ NO_3 (mg/L)	TKN (mg/L)	TN (mg/L)	TP (mg/L)	SRP (mg/L)	DP (mg/L)
NDEP Standards[1]	N/A	N/A	10.00	25.00	N/A	N/A	0.6 [2]	0.10	N/A	N/A
# Noncompliance			0	0				1		
% Noncompliance			0%	0%				20%		
# Samples	5	5	5	5	5	5	5	5	5	-
Min	0.02	57.10	14.00	2.00	0.001	0.08	0.1	0.03	0.001	-
Max	1.18	74.10	6.50	20.77	0.003	0.19	0.2	0.12	0.005	-
Mean	0.35	65.88	3.14	8.02	0.002	0.13	0.1	0.06	0.003	-
Std Err	0.44	27.52	2.40	7.92	0.001	0.07	0.1	0.04	0.002	-

[1]NDEP Standards are from the Nevada Administrative Code (NAC) Chapter 445A.1915. All listed numbers are standards for single values no greater than a given parameter unless otherwise noted.
[2]Annual Average

Table 2.11. Exceedances of Standards and Water Year 2009 Summary Statistics for HV-E2.

Table 2.11	Exceedances of state (NDEP) Standards and Water Year 2009 Summary Statistics for Edgewood Creek (HV-E2) below Boulder parking lot									
	Q (cfs)	SC (mmhos)	Turbidity (NTU)	SS (mg/L)	NO_2/ NO_3 (mg/L)	TKN (mg/L)	TN (mg/L)	TP (mg/L)	SRP (mg/L)	DP (mg/L)
NDEP Standards[1]*	N/A	N/A	10.00	25.00	N/A	N/A	0.6 [2]	0.10	N/A	N/A
# Noncompliance			2	2				1		
% Noncompliance			22%	22%				11%		
# Samples	9	9	9	9	9	9	9	9	9	-
Min	0.01	81.30	0.65	1.20	0.019	0.06	0.1	0.02	0.001	-
Max	0.80	145.40	22.00	82.00	0.770	0.34	0.4	0.14	0.005	-
Mean	0.22	113.93	6.16	16.47	0.041	0.19	0.2	0.05	0.003	-
Std Err	0.27	40.96	7.20	24.91	0.020	0.11	0.1	0.04	0.002	-

[1]NDEP Standards are from the Nevada Administrative Code (NAC) Chapter 445A.1915. All listed numbers are standards for single values no greater than a given parameter unless otherwise noted.
[2]Annual Average

Conclusions and Recommendations

The 2009 water year was the third consecutive year of below average precipitation. The water quality pattern was very similar to trends in the previous years, however with the new stricter standards implemented on Bijou Creek the number of non-compliance exceedances increased. Heavenly's operations are consistent with meeting water quality objectives and there is an overall water quality improvement trend. For the most part water quality results were at, below or within 15 % of the 2008 values. Some of the constituents of non-compliance in this year's monitoring are attributable to background conditions. The reference stream that is unaffected by Heavenly operations in a primarily forested watershed also exceeded specific standards. Other problem constituents are actively being addressed by Heavenly's completion of CWE projects. The following sections include a summary of the monitoring program and the 2009 findings for each creek and any applicable recommendations.

Heavenly Valley Creek

Annual average standards for phosphorus, chloride, and iron were exceeded by both stations on Heavenly Valley Creek (HV-C2 and HV-C3). The same standards were also exceeded at the Hidden Valley Creek reference station (HV-H5). These exceedances may not be attributable to Heavenly resort operations and could be a background characteristic of the watersheds. Similar to the findings of 2006, 2007, and 2008 data indicate that water quality in Heavenly Valley Creek is now similar to, or better than the reference creek. Specifically, turbidity, total nitrogen, and suspended sediment, met the applicable standards and were similar to or better than the levels detected at Hidden Valley Creek. And, while the phosphorus and iron levels at Below Patsy's (HV-C2) and Property Line (HV-C3) exceeded the standards, the annual average for these constituents levels were lower than the data collected at the reference site (HV-H5). The improved water quality is likely attributable to the watershed treatments conducted by Heavenly. Chloride exceedances were less than last year's values at both sampling sites and may be affected by mountain operation of snow condition enhancement. It should be noted that chloride values at the reference site (HV-H5) have been above the water board annual standard since 2005. While snow enhancement may be increasing the chloride readings, mountain operations is not the sole cause for these higher measurements.

The Below Patsy's site (HV-C2) is valuable in assessing the effects of upper mountain management on water quality. The Property Line site (HV-C3) is the TMDL compliance point and will continue to be valuable to monitoring protocol. Heavenly Valley Creek continues to be well within the TMDL limits for suspended solids and all other permitted constituents.

California Parking Lot / Bijou Creek

Water quality results from the Bijou Creek sampling site (HV-C4) have been approximately equal to or lower than last years results. This trend is exemplified as BMP improvement projects and retrofits were completed. However, newly implemented standards at this sampling site location have led to exceedances for each of the permit constituents. The 2009 water year is the first full year where all BMPs for the California Base were installed and operational. A small portion of the California Parking Lot was retrofit with storm treatment vaults that have functioned since November 2007. The majority of the California Parking Lot runoff is now treated by large vaults which were installed in 2007, but were not treating water until the filter media cartridges were installed on April 15, 2008. The final piece of the treatment system at the intersection of Saddle and Wildwood Roads, just above the sampling site, became operational on October 24, 2008. In addition to sampling the historical surface water site, three additional sites associated with the automatic samplers, one at each of the two inlets and one at the outlet, are sampled during storm events.

Troubleshooting of the automatic samplers is on going. This fall an inspection of the treatment vault systems found sediment in the outlet bay, which should be free of all debris. The exact entry point of the sediment source is unknown, but one possibility is that there are not proper seals on the manhole lids allowing sediment to fall into the system after treatment. Replacing and ensuring a seal on each of the manhole lids is the first step towards trouble shooting the system. The next step is to thoroughly clean out all sediment from the treatment system. Once this experiment is in place, a decision can be interpreted from the results. Assuming that this methodology works, the next step will be collecting storm event data. These data sets will be used to refine and fine tune the samplers to collect water samples through the duration of storm at various points on the hydrograph. The samplers may also help Heavenly isolate the source of exceedances such as iron and chloride.

Total nitrogen values from the past few water years remain right around 1 mg/L, almost twice the new standard limit of 0.5 mg/L. Now that both treatment systems are in place, monitoring shall continue at this site. If this trend or value remains well above the standard further investigation into nitrogen removal should be looked into to meet compliance standards. The next Comprehensive Report (2011) should review the possibility and feasibility of further nitrogen treatment/removal. Possible additional treatments may include the use of different filter media cartridges to increase nitrogen removal, or the use of some sort of coagulant for nitrogen removal.

To address the on-going chloride exceedances, Heavenly has investigated alternative deicers and deicer application and storage practices. Magnesium chloride was examined, but found to be both a human health and safety risk and an environmental hazard (Transportation Research Board 1991 and Chambers 2008). Already banned in Aspen, Colorado, magnesium chloride has been found to have adverse effects on the life cycles of micro- and macro-invertebrates (Lewis 1999). Calcium magnesium acetate (CMA) was also examined, but was found to be prohibitively expensive and required in greater quantities (Transportation Research Board 1991). With the current available research, the combination of sodium chloride and sand or cinders is the least harmful to the environment and water quality. Research has shown that applying deicers before predicted storms and pre-wetting the deicing agents during application increases effectiveness and reduces the amount of deicers required. Along with implementing the aforementioned application practices, Heavenly has been testing the reduction of salt to cinder ratio. Monitoring of chloride at both the compliance point and with the automatic sampler locations will continue in 2010.

Edgewood Creek

The treatment system, completed in 2005, was constructed to collect and treat runoff originating from the Boulder Parking Lot and Lodge that flows into Edgewood Creek. Additional stream improvements and creek restoration occurred in 2006 and 2007. As vegetation associated with these restoration efforts matures, additional nutrient uptake and subsequent water quality should improve. The next Comprehensive Report (2011) will evaluate these improvements with regards to water quality. For 2010 the current monitoring protocol will continue with an increased effort in collecting more samples.

CHAPTER 3 – EFFECTIVE SOIL COVER

Introduction

Vegetation and other organic and inorganic soil cover materials are known to reduce the potential erosivity of soil particles, increase percolation, and reduce runoff rates. The construction of ski trails and access roads requires the removal of vegetation and other obstacles (boulders, tree stumps, etc.) thereby reducing the effective soil cover (ESC). Efforts to stabilize disturbed areas by increasing effective soil cover or increasing the infiltration rate has resulted in reduction of erosion rates, thereby decreasing sediment and nutrient input into adjacent streams, and ultimately Lake Tahoe.

Background and Objectives

Evaluation of effective soil cover focuses on types and percentages of cover, and identification of erosion features. Evaluation of ESC by a survey of fixed plots and random transects was undertaken by the United States Department of Agriculture (USDA) Forest Service from 1995 through 2003. Findings from these evaluations, summarized in the 2003 Comprehensive Monitoring Report, indicated that there has been a 21 percent increase in effective soil cover on ski runs at the resort since 1991 (USDA Forest Service 2003). This increase is resulting from a resort wide estimated total percent cover from 49 percent in 1991 and 69 percent in 2003 (USDA Forest Service 2003). However, in many cases transect data was either not statistically significant or did not adequately address the original monitoring objectives. Issues with record keeping, such as mitigation practices, data collection, such as data sheets, and inconsistent data collection, along with database management made processing and analyzing data cumbersome and time-intensive (USDA Forest Service 2003).

A revised methodology was developed by ENTRIX in the Effective Soil Cover Plan (ENTRIX 2005). The revised monitoring plan adopted conclusions and recommendations from the 2003 Comprehensive Monitoring Report and greatly simplified ESC evaluation objectives. Primary objectives of the revised methodology are:

1. Determine if changes in cover result in changes in runoff and sediment volume from ski runs and other project infrastructure.
2. Evaluate utilization of soil amendments/treatments to increase infiltration capacity for those areas resistant to revegetation efforts, or where revegetation is ineffective.

The revised methodology intended to use data derived from remote sensing (originally IKONOS satellite imagery) with limited ground-truthing. No successful evaluations were conducted in 2006 or 2007, although the revised methodology was attempted. In general, suitable satellite images or aerial photographs were either not available for the necessary spatial or temporal periods, and/or pixel resolution was not sufficient for soil cover analysis.

In the 2007 Annual Report and later in the 2008 Effective Soil Cover Workplan, a new protocol was presented that combined the California Native Plant Society's (CNPS) Vegetation Rapid Assessment Protocol (VRAP) and the establishment of permanent photo points.

After discussions with the USDA Forest Service, it was determined that the CNPS VRAP method should support an aerial survey, rather than being the only data collected. Heavenly and the USDA Forest Service agreed to share the cost of an over-flight in 2009. The flight produced a 1:8,000 resolution infrared aerial photo of the entire mountain and was used along with Geographic Information Systems (GIS) and sufficient field verification (i.e. ground-truthing) to produce an accurate picture of the soil cover at Heavenly.

Due to inclement weather conditions and scheduling of the aerial flyover, only half of the field verification was completed using the CNPS VRAP methodology. Therefore, this effective soil cover report is an interim report. Field verifications from 2009 and 2010 will be considered the "baseline" for ESC under the new protocol. Over-flights to take infrared photographs will occur approximately every five years. Both these measurements, conducted over time, will show trends which will be analyzed in order to meet the ESC study objectives.

Monitoring Methods

An infrared aerial flyover of Heavenly Mountain Resort was conducted by 3DiWest in conjunction with the USDA Forest Service in July of 2009. The aerial photograph acquisition was coordinated with the USDA Forest Service. The next shared purpose over-flight will occur in approximately 5 years (July or August 2014).

The aerial photographs were used to characterize and map soil cover along and near projects facilities (including ski runs). Mapping was completed using Arc-Geo Information Systems (GIS). Once the images were combined into a representative map covering Heavenly Mountain Resort, a ratio of bare soil verses vegetation was deduced using Arc GIS. This ratio will be used in conjunction with field verifications to extrapolate the effective soil cover in other areas on Heavenly. This will allow for a more efficient and less time consuming way of reporting the general ESC of Heavenly Mountain Resort, by only using the aerial flyover images and limited field information. After baseline studies performed in 2009 and 2010, a comparative analysis will be conducted in five year intervals with a focus on explaining areas resistant to establishing effective soil cover.

The methods used to conduct field verification were derived from the VRAP developed by the California Native Plant Society (CNPS 2004). The VRAP is a semi-quantitative method of vegetation and habitat sampling (CNPS 2004). Quantitative vegetation and site data recorded include, but are not limited to: topography, soil, rock and litter (size and percent cover), vegetation association and alliance, and vegetation cover (by percent cover, stratum and species) (Sawyer and Keeler-Wolf 1995). These data are not based on established test plots, but on a broader scale unit that is appropriate for the vegetation type found on the landscape. VRAP allows enough flexibility to respond to site-specific attributes of the areas, combined with enough quantitative observation to allow comparison between years. These measurements will be conducted over time, and trends will be analyzed to meet the ESC study objectives. The VRAP method was augmented with the establishment of permanent photo points to better track variability over time. A biologist with experience in botany and soil cover analysis made judgments while conducting the VRAP measurements

In 2009, ten sites were selected on Heavenly Mountain Resort in order to ground-truth the aerial images. Sites were selected as a representative sample of ski run slopes, aspects, and soil types, as well as the erosion control treatment methods applied up to the present. The ten selected sites are outlined in Table 3-1.

Table 3.1. Ten Selected Effective Soil Cover Monitoring Locations

Landscape Unit*	Ski Run Name	Aspect	Ski Run Difficulty	Treatment
3	Gunbarrel	Northwest	Black	Hand racking in seed
6	Groove	Southeast	Green	Rock lined channel between roads
11	Ellie's Swing	North	Blue	Decommissioned road-tilling, mulch, amendments, revegetation
14	Edgewood Meadow	Northeast	Blue	Riparian/Wetland
16	Boulder Chute	North	Blue	Re-seeding
17	Lower Olympic	Northeast	Blue	Revegetation Treatments
18	Cloud Nine	Northeast	Blue	"Lop and Scatter" and Easy Street
24	Double Down/ Lower High Roller	Northwest	Black	Bottom of run has test plots
25	Lower Cal Trail	Southwest	Blue	Decommissioned Road, no treatment
23	Rope Tow Area near Big Easy and Gondola	Southeast	Green	Easy Street Treatment

*Landscape Units from ENTRIX, Inc. 2008 Workplan (ENTRIX 2008).

A field team, which included one biologist with experience in botany and soil cover estimation, visited five of the ten field verification sites on October 20 and 21, 2009. At each of the sites visited, the field crew established a photo point (or points) to enhance comparison of site attributes between measurement periods. Establishment of permanent photo points at selected runs would allows for semi-quantitative assessment of effective soil cover over time. Each photo point was located at a fixed point (GPS location and permanent marker). All photos were from a landscape perspective and the bearing of the camera in relation to the slope was recorded. The area of the photograph was recorded using a long tape measure for length and camera zoom information for width. Recording effective soil cover (i.e., live and dead vegetative cover, substrate, etc.) erosion features, and any mitigation work performed in the area, was the primary focus of the field of view. Photo documentation considered the elements outlined in the Standard Operating Procedure (SOP) 4.2. 1.4. *Stream Photo Documentation Procedure* (SWRCB 2001). In the future, field crews will visit the established photo points every year to take updated photos documenting the vegetation and reassess the ESC.

The size of the landscape unit was estimated as an area that received a certain type of treatment to abate erosion. Boundaries of the landscape units were also defined by "stands", which are the basic physical unit of vegetation in a landscape (CNPS 2004). Stands are defined by two main unifying characteristics, composition and structural integrity. Compositional integrity means that throughout a site, the combination of species is similar (CNPS 2004). A stand is therefore differentiated from adjacent stands by a discernable boundary of changing dominant vegetation types (CNPS 2004). Structural integrity means that a site has a setting that presents similar horizontal and vertical spacing of plant species (CNPS 2004). Additionally, for an area of vegetated ground to meet the requirements of a stand, it must be homogenous; therefore, all boundaries were defined by homogenous vegetation types (CNPS 2004).

After photo documentation and boundary establishment, the field crew assessed the site's soil cover using the CNPS field form. A copy of the field form used during onsite verification can be seen in Figure 3.1. The field crew took notes on their observations at each of the sites and filled out the CNPS field form as detailed as possible. After the field data was collected, it was recorded into a Microsoft Excel database.

In the summer of 2010, the remaining five field verification sites will be assessed based on the methodology above. During field activities in 2010 ENTRIX will incorporate, to the extent relevant, other studies of soil cover and erosion conducted within the basin. ENTRIX will contact Michael Hogan at Integrated Environmental Restoration Services in order to include some of his study sites on Heavenly into the field verification efforts. All ten verification sites will be revisited, reassessed, and photographed annually beginning in 2011 for the duration of the 5-year Mitigation and Monitoring Plan. Percentages of effective soil cover and eroded areas for each site will be recorded and reported annually along with qualitative observations made by the field crew. In 2015 another aerial flyover will be conducted over the Project area in coordination with the USDA Forest Service.

CALIFORNIA NATIVE PLANT SOCIETY - VEGETATION RAPID ASSESSMENT FIELD FORM
(Revised Sept. 20, 2004)

For Office Use:	Final database #:	Final vegetation type name:	Alliance___ Association

I. LOCATIONAL/ENVIRONMENTAL DESCRIPTION

Polygon/Stand #:	Air photo #:	Date:	Name(s) of surveyors:
___	___	___	___

GPS waypoint #: _________ GPS name: ______________ GPS datum: (NAD 27) _______ Is GPS within stand? Yes / No

If No, cite from GPS point to stand, the distance ______(in meters) and bearing ______(in degrees) GPS Error: ±_____ ft / m

UTM field reading: UTME ___ ___ ___ ___ ___ ___ UTMN ___ ___ ___ ___ ___ ___ ___ UTM zone: ____________

Elevation: _________ ft / m Photograph #'s: ______________________________

Topography: convex____ flat____ concave____ undulating____ | top____ upper____ mid____ lower____ bottom____

Geology: _______ Soil Texture: _______ Rock: %Large____ %Small ____ %Bare/Fine: ____ %Litter: ____ %BA Stems: ____

Slope exposure (circle one and/or enter actual °): NE______ NW______ SE______ SW______ Flat__ Variable__

Slope steepness (circle one and enter actual °): 0°__ 1-5° _____ 5-25°_____ > 25°_____ Upland or Wetland/Riparian (circle one)

Site history, stand age, and comments: ______________________________

Type/ Level of disturbance (*use codes*): ____/____ ____/____ ____/____ ____/____ ____/____ ____/____ ____/____ ____/____

II. VEGETATION DESCRIPTION

Field-assessed vegetation alliance name: ______________________________

Field-assessed association name (optional): ______________________________

Size of stand: <1 acre___ 1-5 acres___ >5 acres___ Adjacent alliances: ______________________________

Tree: T1 (<1" dbh), T2 (1-6" dbh), T3 (6-11" dbh), T4 (11-24" dbh), T5 (>24" dbh), T6 multi-layered (T3 or T4 layer under T5, >60% cover)

If Tree, list 1-3 dominant overstory spp.: ______________________________

Shrub: S1 seedling (<3 yr. old), S2 young (<1% dead), S3 mature (1-25% dead), S4 decadent (>25% dead)

Herbaceous: H1 (<12" plant ht.), H2 (>12" ht.) Desert Palm/Joshua Tree: 1 (<1.5" base diameter), 2 (1.5-6" diam.), 3 (>6" diam.)

Desert Riparian Tree/Shrub: 1 (<2ft. stem ht.), 2 (2-10ft. ht.), 3 (10-20ft. ht.), 4 (>20ft. ht.)

% Overstory Conifer/Hardwood Tree cover: ____/____ Shrub cover: _____ Herbaceous cover: _____ Total Veg cover:_____

Overstory Conifer/Hardwood height: ____/____ Tall Shrub/Low Shrub height: ____/____ Herbaceous height: _____

Height classes: 01=<1/2m 02=1/2-1m 03=1-2m 04=2-5m 05=5-10m 06=10-15m 07=15-20m 08=20-35m 09=35-50m 10=>50m

Species (List up to 12 major species), Stratum, and Approximate % cover: (Jepson Manual nomenclature please)

Stratum categories: T=tall, M=medium, L=low; *% cover intervals for reference*: <1%, 1-5%, >5-15%, >15-25%, >25-50%, >50-75%, >75%

Strata	Species	% cover		Strata	Species	% cover

Major non-native species - With % cover: ______________________________

Unusual species: ______________________________

III. PROBLEMS WITH INTERPRETATION

Confidence in identification: (L, M, H) _____ Explain ______________________________

Other identification problems (describe): ______________________________

Polygon is more than one type: (Yes, No) _______ (Note: type with greatest coverage in polygon should be entered in above section)

Other types: ____________ ____________ ____________

Has the vegetation changed since air photo taken? (Yes, No) _____ If Yes, how? What has changed (write N/A if so)? ______

Figure 3.1. CNPS Vegetation Rapid Assessment Field Form, 2004.

Results

An aerial flyover was conducted by 3DiWest in July 2009. Infrared photographs from the flyover were transmitted to the USDA Forest Service and ENTRIX, Inc. in October 2009. A composite map of the Heavenly Mountain aerial photos is shown in Figure 3.2. The composite map has been modified to represent the area of Heavenly Mountain Resort that is subject to effective soil cover monitoring. The colored area of the map approximates the boundary of Heavenly Mountain Resorts operations. From this composite map, land cover was broken down into four types: 1. shadow, 2. tree/shrub, 3. mix, and 4. bare ground. Area of these land types (in both square feet and acres) is summarized in Table 3.2.

Table 3.2. Land Cover Types and Associated Areas within the Boundary of Heavenly Mountain Resort Operations.

Number	Land Cover Type	Area (Square Feet)	Area (Acres)
1 Shado	w	51,559,916	1,183.65
2 Tree/Sh	rub	146,747,952	3,368.87
3 Mix		33,194,162	762.03
4 Bare	Ground	108,758,126	2,496.74

Field verification of five of the ten chosen field verification sites was conducted on October 20 and 21, 2009. Sites visited during this monitoring period included: Gunbarrel, Edgewood Meadow, Groove, Boulder Chute, and Lower Olympic. A summary of results from the field verification efforts conducted in 2009 are presented in Table 3.3. Due to field efforts being conducted in the late fall, early snow cover made it difficult to properly identify vegetation. Therefore, monitoring efforts were focused on disturbed areas lower in elevation. Hazardous road conditions, due to increased snow depth on the roadways, prevented higher elevation field verification. Sites such as Ellie's Swing were inaccessible by vehicle. Despite early snowfalls, the field crew was able to identify vegetation species with medium to high confidence at these lower sites.

Table 3.3. Field Verified ESC Sites and Associated Characteristics.

Landscape Unit	Ski Run Name	Slope Exposure	Topography	Geology	Soil Texture	Slope Steepness	Dominant Veg.	Secondary Veg.	% Rock/Litter	% Veg	% Bare
3 Gunbarrel		NW 310°	Concave, top part of the ski run	Decomposed Granite	Coarse to Medium Sand	>25°	*Thinopyrm intermedium* (Wheatgrass)	*Ceanothus velutinus var. hookeri* (Tobacco Brush)	15% 70%		15%
6 Groove		SE 140°	Concave, Bottom of Run	Decomposed Granite	Coarse Sand	>25°	*Thinopyrm intermedium* (Wheatgrass)	*Festuca brevipila* (Hard Fescue)	11% 47%		42%
14	Edgewood Meadow	NE 10°	Flat, bottom part of the run	Mixed alluvium	Moderately fine silty clay loam	>25°	*Stipa spp.* (Neddle Grass)	*Salix spp.* (Willow)	20% 80%		0%
16	Boulder Chute	NE 20°	Concave, bottom part of the ski run	Decomposed Granite	Medium Sand	>25°	*Arctostaphylos nevadensis*(Pinemat Manzanita)	*Salix spp.* (Willow)	45% 30%		25%
17	Lower Olympic	NE 40°	Flat, Mid-Lower part of the ski run	Decomposed Granite	Medium Sand	>25°	*Thinopyrm intermedium* (Wheatgrass)	*Festuca brevipila* (Hard Fescue)	28% 52%		20%

Discussion and Conclusions

The objectives of the Effective Soil Cover monitoring, taken from the 2008 Workplan, are as follows:

1. Maintain and restore soils with favorable infiltration characteristics and diverse vegetative cover to absorb and filter precipitation and to sustain favorable conditions of stream flows.
2. Determine if changes in cover result in changes in runoff and sediment volume from ski runs and other project infrastructure.
3. Evaluate utilization of soil amendments/treatments to increase infiltration capacity for those areas resistant to revegetation efforts, or where revegetation is ineffective.

In their 2003 Comprehensive Monitoring Report, the USFS concluded that the method of detailed transect measurement did not meet the monitoring objective. Similarly, the use of the air photo analysis combined with ground-truthing, while providing useful information regarding the overall soil cover, does not effectively meet these monitoring objectives.

ENTRIX recommends a more focused approach, one that relies on infiltration measurements and improvements such as are reported in the Master Plan monitoring. In the 2010 annual report, we will provide the remainder of the ground-truthing sites that were not accessible in 2009, and we will incorporate the infiltration work that so far has primarily been conducted by Mike Hogan. Visiting verification sites during this period of time should result in accurate observations of effective soil cover and identifications of blooming vegetation. Results and conclusions from all effective soil cover monitoring will be discussed in the 2010 Annual Report. We anticipate that, in that annual report, we will recommend a change from comprehensive ESC monitoring to more focused, area-specific work.

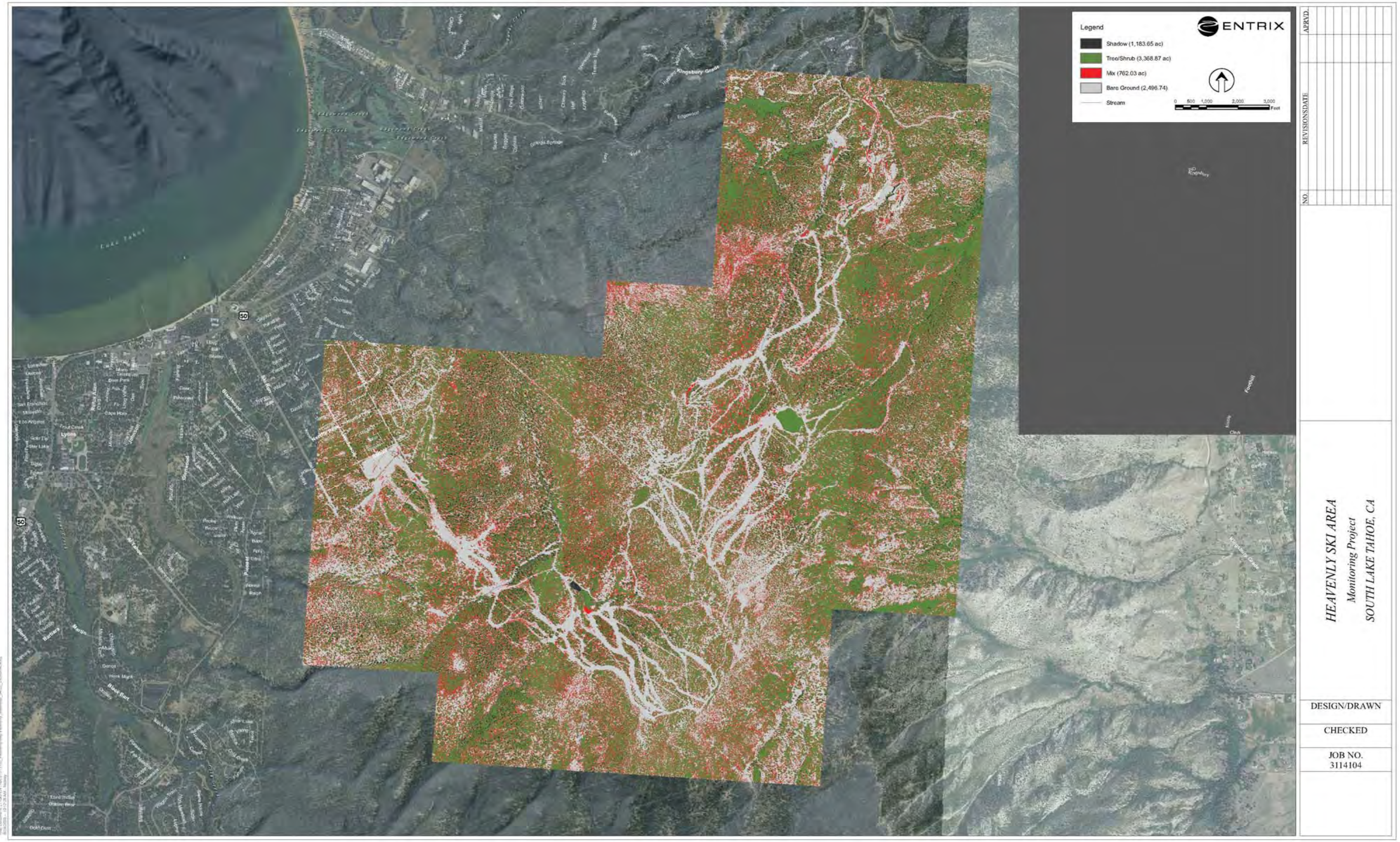

Figure 3.2. Composite Map of the Heavenly Mountain Aerial Photos, Highlighting the Heavenly Mountain Resort's Operational Area, Broken Down by Land Cover Types

Chapter 4 – Best Management Practices (BMP) Implementation and Monitoring

BMP monitoring was completed by Resources Concepts Inc. (RCI) and is included in Appendix B.

CHAPTER 5 – RIPARIAN CONDITION SUMMARY

Introduction

This chapter discusses the stream channel monitoring activities that were conducted in June and July 2009 in accordance with the *Work Plan for Riparian Condition Monitoring* (Work Plan) (ENTRIX 2005). Comprehensive monitoring of all the riparian conditions sites is conducted every three years, and was last conducted in 2006. The monitoring objective is to assess the effectiveness of erosion control measures and restoration activities on stream health. Monitoring is conduced to characterize stream and riparian conditions along selected stream reaches within the Heavenly Mountain Resort (Resort) area and reference reaches unaffected by Resort activity. The monitoring data is used in conjunction with data from previous monitoring events to assess potential alterations of stream and riparian conditions and, if changes are encountered, determine whether the alterations are associated with operations at the Resort. During years when the comprehensive monitoring is not conducted, those locations downstream of new restoration sites are monitored. This occurred in 2007 and 2008 downstream of the stream restoration project on Edgewood Creek in order to evaluate the effectiveness of the project.

The monitoring involves the collection of geomorphology and riparian data along 8 stream reaches that are located within or downstream of the Resort area (project-affected reaches on Heavenly Valley Creek) and 2 stream reaches located upstream of the Resort area (reference reaches on Hidden Valley Creek). The project reaches are used to evaluate potential effects of Resort operations on stream health and the reference reaches are used to characterize undisturbed conditions for comparison with selected project reaches. The monitoring follows the protocols and methods outlined in the United States Department of Agriculture Forest Service (USFS) *Stream Condition Inventory Technical Guide: Pacific Northwest Region, Version 5.0* (USFS Technical Document) (2005). The SCI method was developed to collect intensive and repeatable data from stream reaches to monitor conditions over time. In this chapter, potential changes in stream and riparian conditions are evaluated by comparing the monitoring data collected in 2009 with the data collected in 2006.

The SCI methodology also includes benthic macro-invertebrate (BMI) sampling which was conducted in 2006 and 2007 on Heavenly Valley and Hidden Valley Creeks in support of bioassessment monitoring required by the 2003 Heavenly Valley Creek Total Maximum Daily Load (TMDL) Bioassessment Monitoring Plan. The next scheduled BMI sampling will occur in 2010 and 2011, and is not discussed further in this report.

The following sections provide a description of the survey reaches and monitoring locations, an overview of the methods and data collected during the monitoring activities, and a discussion of the monitoring results. In general, channel conditions in the project-related reaches have stayed relatively constant since 2006, or improved. Reference reaches in Hidden Valley Creek show more adverse effects between 2006 and 2009, in part owing to relatively low flows in these reaches, and in part to natural variability occurring in the watershed.

Monitoring Locations

The project-related monitoring locations consist of three project reaches along Heavenly Valley Creek (HVC-1 through HVC-3), two project reaches on Edgewood Creek (EC-1 and EC-2), two project reaches on Daggett Creek (DC-1 and DC-2), and one project reach on Mott Creek (MC-

1). The background, or reference monitoring sites consist of two reference reaches on Hidden Valley Creek (HVC-1 and HVC-2). The survey locations are shown in Figures 5.1 and 5.2.

The project reaches on Heavenly Valley Creek are located within California and were established by the USFS in 2001. HVC-1 is situated in the vicinity of Sky Meadows between the snowmaking pond and the 90-degree bend in the creek immediately downstream of the Sky Express Chair. HVC-2 extends downstream of the culverts near Patsy's Chair to immediately upstream of the steep boulder field situated beyond the ski area boundary. HVC-3 extends downstream from the USFS boundary to immediately upstream of Powerline Trail.

The project reaches on Edgewood Creek, Daggett Creek, and Mott Creek are located in Nevada and were established by ENTRIX and the USFS in 2006. Reach EC-1 (Upper Edgewood) on Edgewood Creek is located upstream of the stream restoration project completed in 2006 along the proposed alignment for the new North Bowl Express Lift and is used to monitor the stream restoration project in that area. Reach EC-2 (Lower Edgewood) extends downstream from the Boulder Lodge parking past the Edgewood Below water quality site and is used to monitor the stream restoration project completed in 2007. Along Daggett Creek, DC-1 (Upper Daggett) is located downstream of the dam outlet culvert and DC-2 (Lower Daggett) is located downstream of DC-1 under the Galaxy chairlift. Finally, monitoring location MC-1 on Mott Creek is located downstream of the Tahoe Rim Trail creek crossing.

The two reference reaches are located on Hidden Valley Creek in California and were established by the USFS in 2001. These two reference reaches are used for comparison with the project reaches on Heavenly Valley Creek. HDVC-1 (Upper Hidden Valley Creek) is located in the upper watershed, upstream of the Resort area, and is used as a reference site for project reach HVC-1. HDVC-2 (Lower Hidden Valley Creek) extends from the confluence with Trout Creek to approximately 270 meters (m) upstream and is used as a reference site for project reach HVC-3.

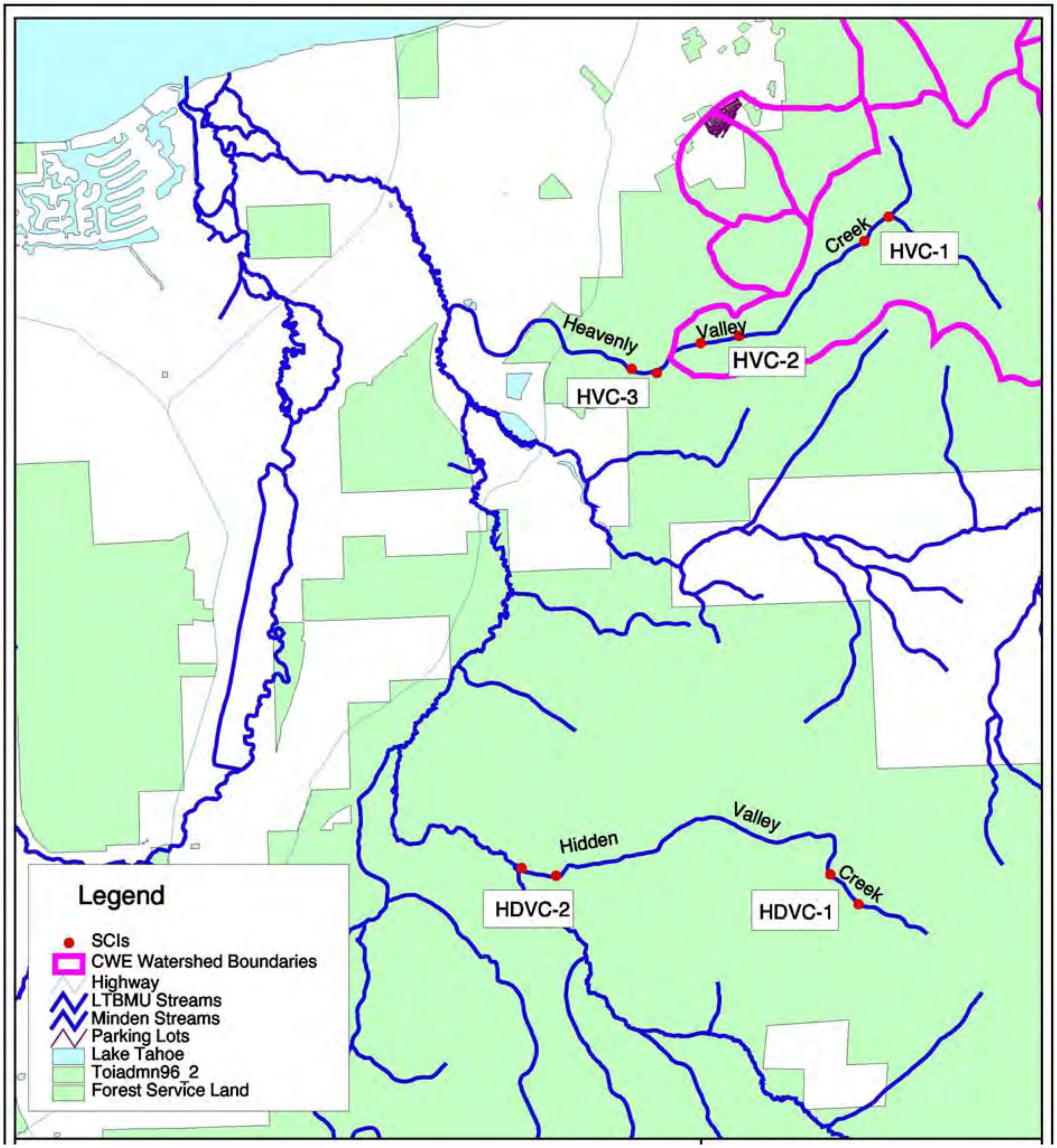

Figure 5.1. Historical SCI monitoring sites in California. (USFS 2001)

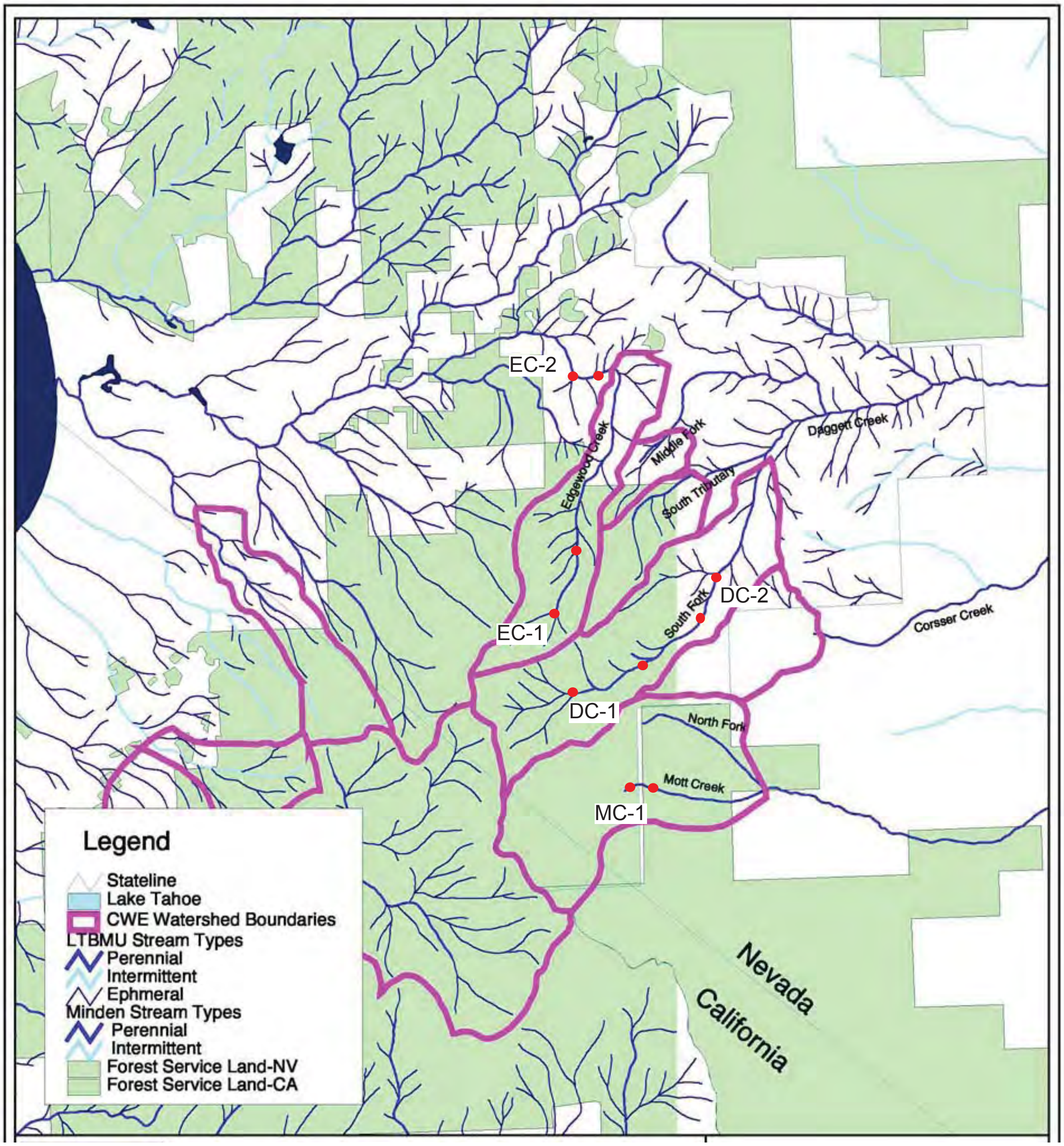

Figure 5.2. **Newly Established SCI monitoring creeks and their watersheds in Nevada**. (USFS 2001)

Monitoring Methods

As outlined in the *Work Plan for Riparian Condition Monitoring* (ENTRIX 2005), the monitoring activities conducted in June and July 2009 involved the collection of geomorphology and riparian data in accordance with the USFS SCI methodology (USFS 2005). The monitoring activities involved the collection of the following data:

- Particle Size Distribution: The objective of this measurement is to detect the status and change of streambed particle size distribution. Measurements were conducted in the four riffles within each survey reach that were sampled for macro-invertebrates during the previous sampling years. At each riffle location, measurements were collected from the streambed along ten equally spaced transects that were oriented perpendicular to stream flow. Ten particles were selected along each transect using the blind touch method and were measured using a gravelometer.

- Large Woody Debris (LWD) / Total Wood: The objective of this measurement is to characterize the abundance of woody debris within each survey reach. The monitoring involved inventorying and counting all LWD that was that was longer than one-half the bankfull width and located within a portion of the bankfull width of the channel.

- Bankfull Stage: The objective of this measurement is to identify bankfull stage in order to determine the associated channel characteristics such as bankfull width, bankfull depth, and bankfull width-to-depth ratio. Bankfull stage was determined based on various indicators including change in bank slope, vegetation, changes in sizes of bank materials, and water stains or lichen lines on substrate. Bankfull stage was measured at the upstream end of each survey reach, along the particle size distribution transects, cross-section locations, and width-to-depth/entrenchment locations.

- Cross-Section: The objective of this measurement is to establish permanent monitoring sites to evaluate change in channel geometry over time. Three cross-sections were established along each of the 10 monitoring reaches. The cross-sections were located within fast water habitats and were oriented perpendicular to flow. At each cross-section, headpins were established along the left and right streambanks and a measuring tape was run horizontally across the channel from the left bank monument to the right bank monument. Ground surface and water surface elevations along each of the cross-sections were measured using either an Auto-level or a Recon Total Station. Elevations were recorded at breaks in slope, at bankfull stage, and at the waters edge. The cross-sections were surveyed from the left bank headpin (designated as Station 0) across to the right bank headpin. All elevations were recorded as relative to the left bank headpin which was assigned an elevation of “0”. Photographs of each cross-section were taken after completion of the surveying activities.

- Water Surface Gradient/Bed Profile: The objective of this measurement is to determine the water surface gradient (or bed profile) in percent slope. During the monitoring, water surface slope, if flow was present, or streambed slope (along the thalweg), if channel was dry, was measured at each of the three cross-sections within each survey reach for the longest possible distance in order to represent the average gradient of the reach. Measurements were collected using either an Auto-level or a Recon Total Station.

- Width-to-Depth Ratio: The width-to-depth ratio is defined as the ratio of bankfull surface width to the mean depth of the bankfull channel. The objective of this measurement is to characterize stream morphology and aquatic habitat. The width-to-depth ratio was calculated using the survey data for each of the three cross-sections along each survey reach as well as at five additional locations (in fast water and straight sections of the channel) within each survey reach. At each location the bankfull stage was identified and a measuring tape was stretched between the bankfull stages on each bank to determine the bankfull width. The mean bank full depth was determined by collecting approximately ten bankfull depth measurements along each measurement transect to determine the approximate bankfull width along the entire monitoring reach.

- Entrenchment Ratio: Entrenchment ratio is defined as the ratio of floodprone width (as measured at twice the maximum bankfull depth) to bankfull width. The objective of this measurement is to quantify channel confinement. The entrenchment ratio was calculated using the survey data for each of the three cross-sections along each survey reach as well as at five additional locations (in fast water and straight sections of the channel) within each survey reach. At each location the bankfull stage was identified and a measuring tape was stretched between the bankfull stages on each bank to determine the bankfull width. The floodprone width was measured using double the maximum bankfull depth and pulling tape across the channel until the tape reached the banks on either side.

- Habitat Type: Habitat types were classified along entire reaches in order to describe the spatial distribution and characteristics of fast and slow water habitat units. Fast water (riffles and runs) and slow water (pools) are important core attributes because they are the base stratification of habitats that support aquatic life. The habitat types were measured and described based on stationing that was established along each survey reach.

- Pools: The objectives of pool measurements include quantifying the number of pools in each survey reach, determining the range of residual pool depths within the survey segment, and documenting whether wood is a factor in pool formation. Residual pool depth was measured to characterize pools because it reduces the variability in pool depths that result form differences in the stage. In order to be considered a pool, water velocity must be slow or not moving. The feature must occupy most of stream width and include the thalweg. Backwater and side water pools were not measured. Other criteria include: the length of pool must be greater than wetted width, the depth must be greater than non-pools, and the maximum depth is more than twice pool tail depth. At each pool the depth at the deepest point was measured along with the pool tail crest depth.

- Pool Tail Surface Fine Sediment: This measurement was taken along with the residual pool depths at each identified pool along each reach. The objective of this measurement is to quantify the percentage of fine sediment less than 2 millimeters on the pool tail substrate. Measurements were taken at each pool tail using a grid designed by the USFS. The grid is a 14-inch square frame with 49 line intersections and one corner, totaling 50 intersecting points. Three random tosses of the grid were done at each pool tail, space allowing. If the pool tail was too narrow, only one toss was made. Within the area where the grid fell, the survey crew counted and recorded the number of grid intersections lying above substrate 2 millimeters or less. Each counted intersection represents 2% fines. The amount of intersects counted were multiplied by two to reveal a percentage of fines within the pool tail.

- Streambank Stability: The objective of this measurement is to calculate streambank stability for each reach. Streambank stability is a measure of cover that protects sterambanks against erosion. During field activities, streambank stability was measured along the entire length of a monitoring reach, at equally spaced intervals. Observations on streambank cover were recorded using a 1, 2, 3 number system as follows: 1 = stable, 2= vulnerable, and 3= unstable. Stable streambanks were identified as having 75% or more cover of living plants and/or other stability components that are not easily eroded (such as rocks and logs). Stable banks also show no indicator of instability (like erosion). Vulnerable banks have 75% or more cover, but have one or more instability indicators. Unstable banks have less than 75% cover and have instability indicators. Unstable streambanks are often bare, or nearly bare, composed of particle sizes too small or uncohesive to resist erosion at high flows.

- Stream Shading: The objective of this measurement is to determine the average canopy cover in each monitoring reach. Stream shading was measured at the same 50 equally spaced transects used to assess streambank stability. At each of the 50 transects, stream shading was measured using a Solar Pathfinder. The Solar Pathfinder was oriented to the south at approximately 0.3 meters above the water surface. Looking at the reflection of the sky in the Solar Pathfinder dome along the August sun path, the field crew was able to add up the shaded sections to yield the percent shade for each transect.

- Streamshore Water Depth: Streamshore water depth was only measured in channels that had water gradients (or bed gradients) of less than 2%. Measurements were collected at each of the 50 equally spaced transects along the entire channel reach, on each bank. At each transect and each bank, the water depth was measured at the waters edge. If the bank angle was equal to or less than 90 degrees, the water depth was measured using a measuring tape. If the bank angle was greater than 90 degrees the bank shore depth was recorded as zero.

- Streambank Angle: Bank angle is the measure of the dominant angle of the streambank between the bottom of the bank and the bankfull stage. Measurements were collected at the same 50 transects used to assess streambank stability and stream shading. At each transect, each bank was measured for an angle using a clinometer.

- Aquatic Fauna: Aquatic fauna was documented if observed along any of the reaches.

Results

This section presents the results of the 2009 monitoring activities and a comparison with the 2006 monitoring results.

Heavenly Valley Creek

Sky Meadows (HVC-1)

The Sky Meadows Reach (HVC-1) is the upper most monitoring site on Heavenly Valley Creek and was established by the USFS in 1996. This stretch of creek is known to be a perennial reach that falls under the “C” type channel as described by the Rosgen classification system. A “C” type channel is described as a low gradient, meandering, riffle/ pool, alluvial channel with broad, well-defined floodplains (Rosgen 1996).

The 2006 and 2009 monitoring results for this reach are presented in Table 5.1. During the 2009 survey, all SCI measurements were collected along this reach since the mean water surface gradient is less than 2% with surface flow present at the time of monitoring. The monitoring data collected in 2009 is similar to the data collected in 2006 with the exception of the following:

- Total Wood – in 2009 a total of 54 pieces of LWD were present along this reach in comparison with 10 pieces of LWD recorded in 2006;
- Mean Entrenchment Ratio – the mean entrenchment ratio calculated using the 2009 data is 5.7 in comparison with 3.96 in 2006;
- Mean Residual Pool Depth – the mean residual pool depth recorded in 2009 was 18.1 cm in comparison with 9.1 in 2006;
- Percent Stable Banks – the percent of stable banks recorded in 2009 was 96% in comparison with 40% in 2006; and,
- Percent Vulnerable Banks – the percent of vulnerable banks recorded in 2009 was 4% in comparison with 60% in 2006.

In general stream conditions have improved since 2006, with deepening pools, more stable banks, and less vulnerable banks. The amount of woody debris has also increased. The 2006 and 2009 cross section profiles for the three cross-sections (XS-1 through XS-3) situated within this reach are presented in Figures 5.3 – 5.5. There is very little change in the cross sections between 2006 and 2009. The right bank headpin at cross section one (XS-1) and both headpins at cross section three (XS-3) had been buried by fallen and decaying meadow vegetation and the left bank headpin at cross section two (XS-2) was buried by an eroding bank. These headpins were located using a metal detector prior to commencing the cross section surveys.

Table 5.2 presents each cross sections associated bankfull width, width-to-depth ratio, and entrenchment ratio. Bankfull widths and width-to-depth ratios at each cross- section have changed slightly since 2006. Entrenchment ratios since 2006 have increased at all cross-sections since 2006.

Table 5.1. Results from the 2009 and 2006 SCI for the Sky Meadows Reach.

Reach Name	Year	Reach No.	Dominant Pebble Class (secondary axis in mm)	Total Wood	Mean Bankfull Width (m)	Mean Width to Depth Ratio	Mean Entrenchment Ratio	Mean Water Surface Gradient (%)	Mean Pool Length (m)	Mean Residual Pool Depth (cm)	Mean Percent Fines	Percent Stable Banks	Percent Vulnerable Banks	Mean Shading (%)	Mean Bank Angle (deg)	Mean Shore Depth (cm)
Sky Meadows	2006 HDV	C-1	Gravel 16-32	10 1.6		8.34	3.96	1.12	1.52	9.1 80		40	60	36.5	106.5	5.86
Sky Meadows	2009 HDV	C-1	Gravel 11-16	54	1.3	4.2 5.7 1.23			1.9	18.1 64		96	4	30	94.3	5.84

Table 5.2. 2006 and 2009 Cross Section Bankfull Widths, Width-to-Depth Ratios and Entrenchment Ratios

Bankfull	Widths		
Year XS-1		XS-2	XS-3
2006 1.53		1.52	1.49
2009 1.53		1.55	1.52

Width-t	o-Depth Ratio		
Year XS-1		XS-2	XS-3
2006 6.65		8.44	8.76
2009 6.58		6.46	8.44

Entrenc	hment Ratio		
Year XS-1		XS-2	XS-3
2006 6.2		16.6	9
2009 14.6		13.5	46

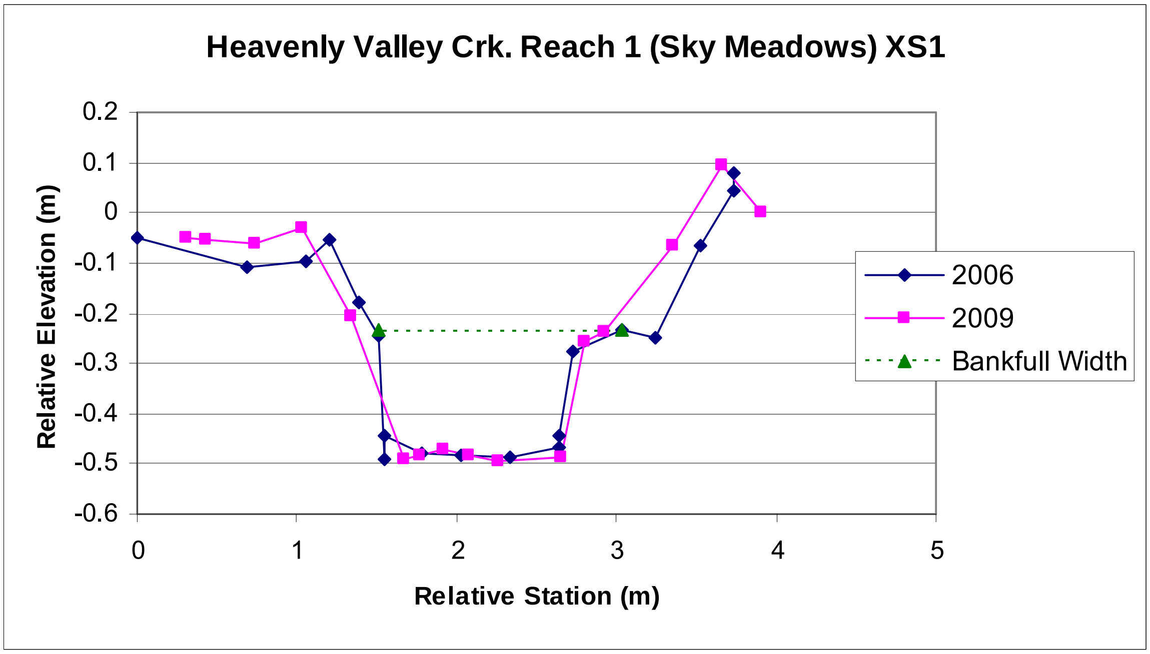

Figure 5.3. Permanent Cross Section number 1 (XS-1) HVC-1, Sky Meadows, along Heavenly Valley Creek.

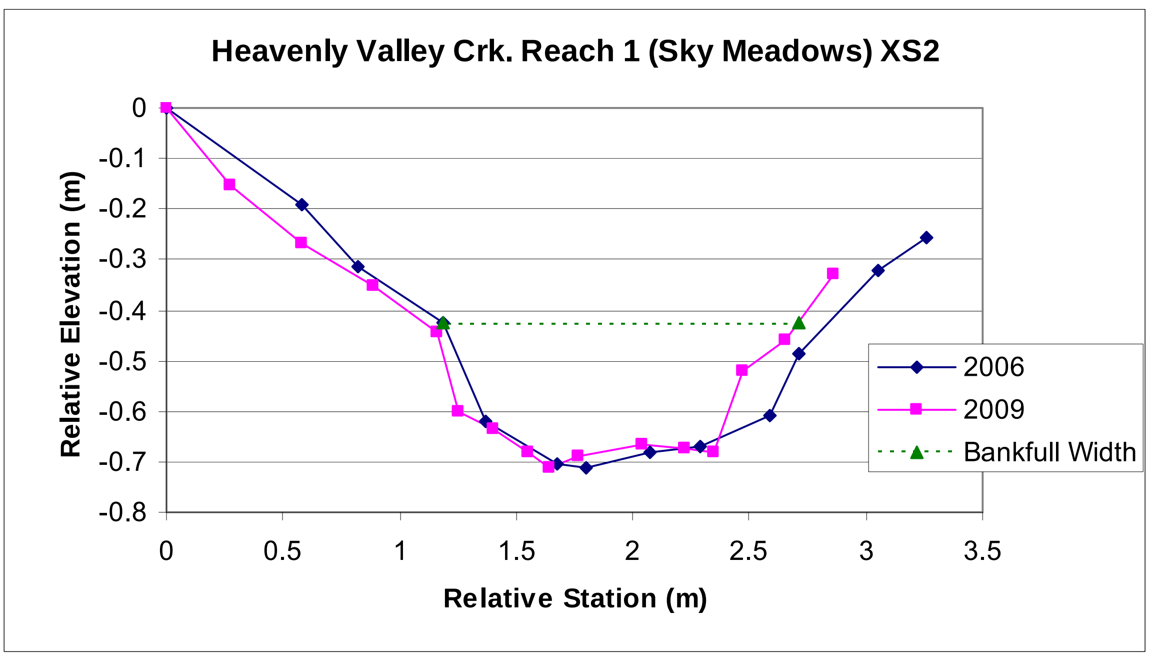

Figure 5.4. Permanent Cross Section number 2 (XS-2) for HVC-1, Sky Meadows, along Heavenly Valley Creek.

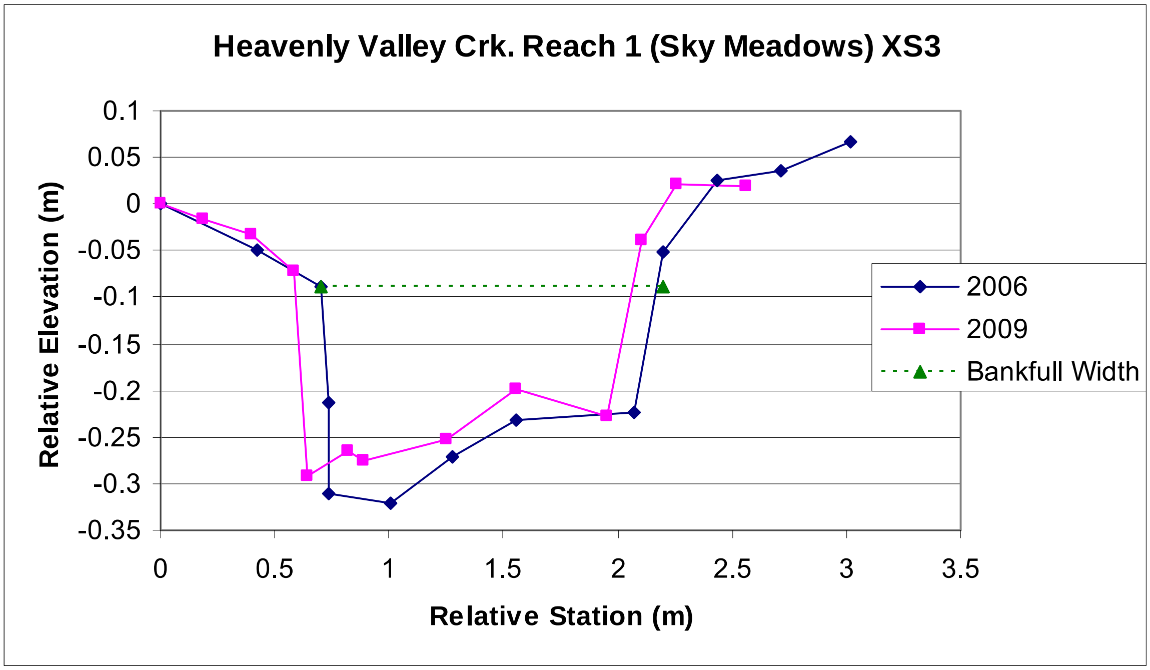

Figure 5.5. Permanent Cross Section number 3 (XS-3) for HVC-1, Sky Meadows, along Heavenly Valley Creek.

Below Patsy's (HVC-2)
HVC-2, Below Patsy's is the second monitoring reach located on Heavenly Valley Creek and was established by the USFS in 1996. This reach exhibits the characteristics of a "B" type channel. A "B" type channel is generally described as a moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools, stable banks and a stable profile.

Table 5.3 presents the results for the SCI evaluations completed in 2006 and 2009 for this project reach. Bank angle and stream shore depth were not recorded in either 2006 or 2009 because this reach has a water surface gradient of greater than 2%. All other measurements were recorded, as the creek was flowing during field efforts. Most of the data collected in 2009 is different to the 2006 data and includes the following:

1. Total Wood – In 2006, 57 pieces of wood were counted in the Below Patsy's Reach. In 2009 270 pieces of wood were counted during the SCI survey.

2. Mean Bankfull Width – In 2009 the mean bankfull width across the entire reach was 1.3. In 2006 it was measured at 2.04.

3. Mean Pool Length – The mean pool length measured in 2009 was 1.8 meter, while in 2006 the mean pool length was measured at approximately 2.86 meters.

4. Mean Residual Pool Depth – In 2006 the mean residual pool depth was approximately 11 centimeters but had risen to 18.5 in 2009.

5. Percent Fines – The percent pool tail fines increased from 13.33 in 2006 to 63.1 in 2009.

6. Percent Stable/Vulnerable Banks – In 2006 the percent of stable and vulnerable banks was ranked at 50% stable and 50% vulnerable. In 2009 the percent of banks ranked at 83% stable and 17% vulnerable.

In general channel conditions have improved since 2006. Permanent cross-sections for Below Patsy's, HVC-2, are graphed in Figures 5.6 – 5.8. The cross sections show very little change between 2006 and 2009. These cross-sections are graphed and presented with the cross-sections surveyed in 2006. All cross-sections are graphed from rebar monuments. Elevation and station measurements are graphed relative to the left bank rebar stake. The base of the rebar stake on the left bank is the zero, zero point.

Table 5.4 presents each cross sections associated bankfull width, width-to-depth ratio, and entrenchment ratio. All measurements have changed slightly since 2006. Each graph shows the bankfull width associated with that cross section. The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

Table 5.3. Results from 2006 and 2009 SCI for Below Patsy's Reach.

Reach Name	Year	Reach No.	Dominant Pebble Class (secondary axis in mm)	Total Wood	Mean Bankfull Width (m)	Mean Width to Depth Ratio	Mean Entrenchment Ratio	Mean Water Surface Gradient (%)	Mean Pool Length (m)	Mean Residual Pool Depth (cm)	Percent Fines	Percent Stable Banks	Percent Vulnerable Banks	Mean Shading (%)	Mean Bank Angle (deg)	Mean Shore Depth (cm)
Below Patsy's	2006	HVC-2	Gravel 32-64	57 2.04		6.33	4.03	5	2.86	10.9728 13.33		50	50	73.01	N/A	N/A
Below Patsy's	2009	HVC-3	Gravel 22.6-32	270 1.3		4	3.87	8	1.8	18.5	63.1	83	17	75	N/A	N/A

Table 5.4. 2006 and 2009 Cross Section Bankfull Widths, Width-to-Depth Ratios and Entrenchment Ratios

Bankfull	Widths	
Year XS-1	XS-2	XS-3
2006 1.55	2.04	1.68
2009 1.34	1.86	1.77

Width-t	o-Depth Ratio		
Year XS-1		XS-2	XS-3
2006 3.60		4.43	7.00
2009 3.44		4.77	6.10

Entrenchment Ratio			
Year	XS-1 XS-2 XS-3		
2006 6.8		12	15.4
2009 10.1		14	15.5

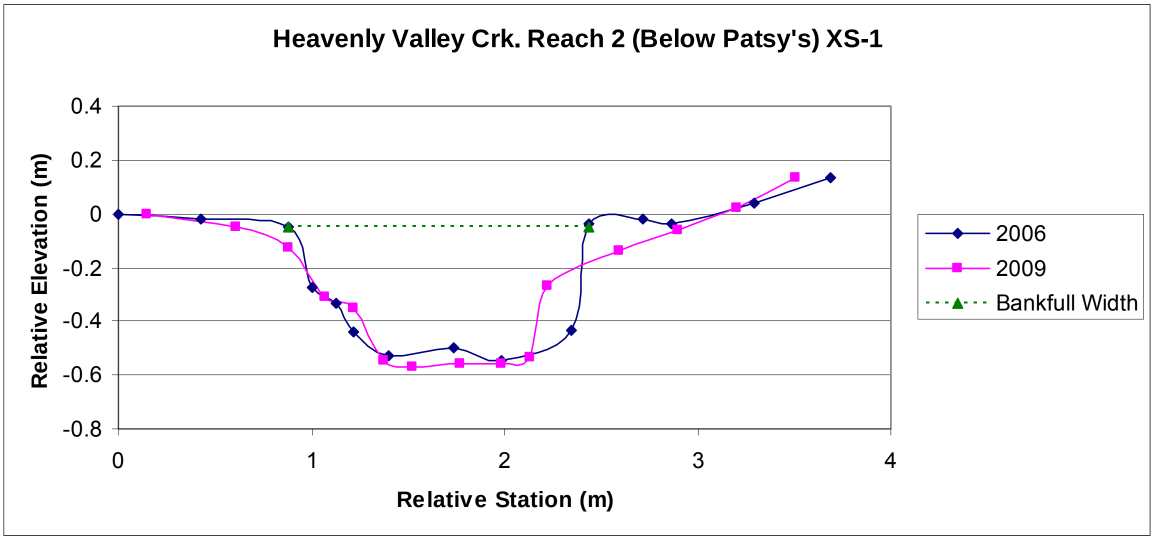

Figure 5.6. Permanent Cross Section number 1 (XS-1) for HVC-2, Below Patsy's, along Heavenly Valley Creek

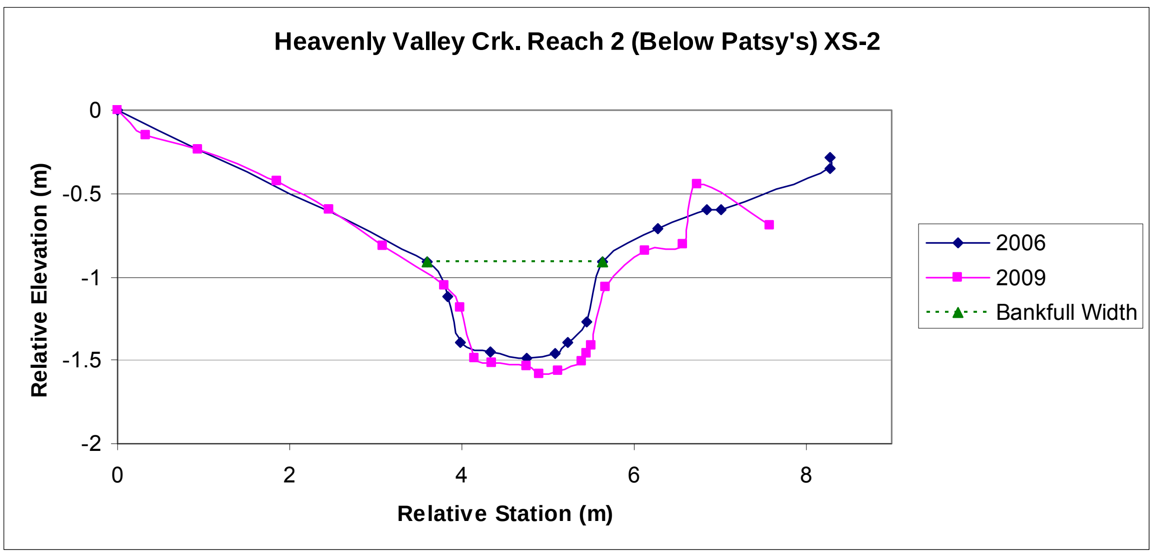

Figure 5.7. Permanent Cross Section number 2 (XS-2) for HVC-2, Below Patsy's, along Heavenly Valley Creek

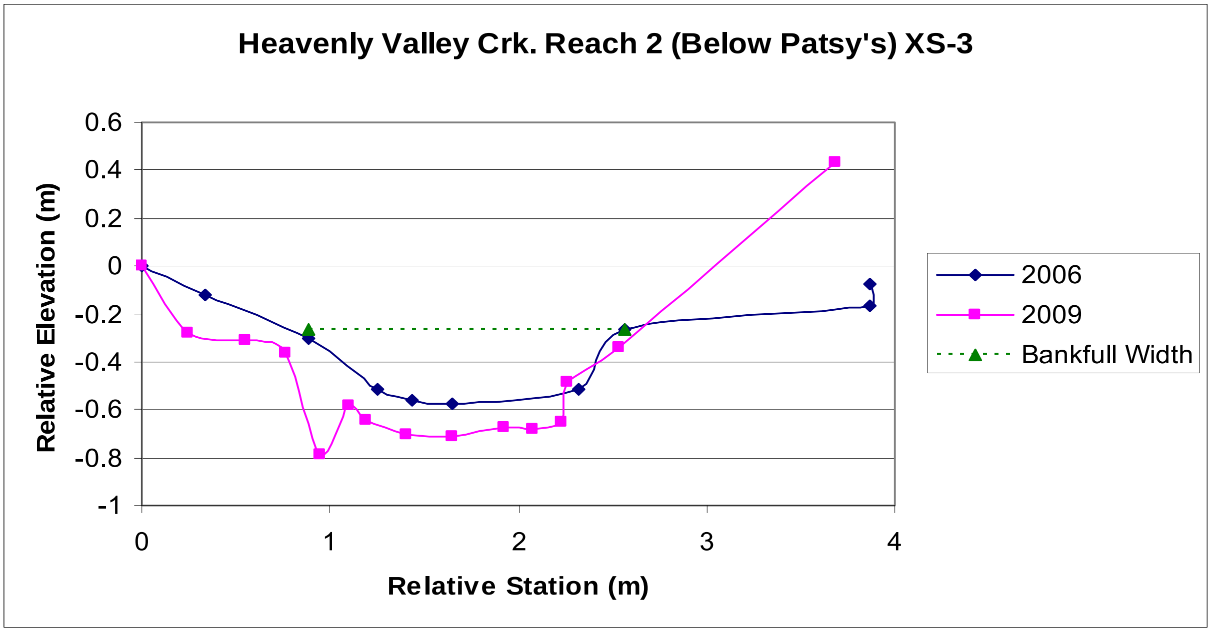

Figure 5.8. Permanent Cross Section number 3 (XS-3) for HVC-2, Below Patsy's, along Heavenly Valley Creek.

Property Line (HVC-3)

The HVC-3 reach was established in 2001, downstream of Heavenly Ski Resort's boundaries to show temporal changes in channel morphology resulting from cumulative impacts. This reach exhibits "A" type channel characteristics (Rosgen, 1996). An "A" type channel is generally described as a steep, entrenched, cascading, stream that is high energy and transports debris associated with depositional soils. In 2006, the classification was changed from a "B" type channel. Although there are some attributes to fit both types (such as stable banks and moderate entrenchment), the classification was changed to an "A" type channel due to the steepness of the reach.

Table 5.5 presents the results for the SCI evaluations completed in 2006 and 2009 for this project reach. Bank angle and stream shore depth were not recorded in either 2006 or 2009 because this reach has a water surface gradient of greater than 2%. It is unknown why field measurements for total wood were not completed in 2006. All other measurements were recorded, as the creek was flowing during field efforts. Most of the data collected in 2009 is similar to the 2006 data except for the following measurements:

1. Mean Entrenchment Ratio – The mean entrenchment ratio for the entire project reach in 2006 was 1.85 and in 2009 the mean entrenchment ratio was calculated at 3.4.

2. Mean Residual Pool Depth – The mean residual pool depth in 2006 was approximately 4.6 centimeters. In 2009 the mean residual pool depth changed increased to 18.47 centimeters.

3. Percent Fines – The percent pool tail fines in 2006 was calculated at 25%. In 2009 the percent pool tail fines increased to 71%.

Table 5.5. Results from 2006 and 2009 SCI for Property Line Reach

Reach Name	Year	Reach No.	Dominant Pebble Class (secondary axis in mm)	Total Wood	Mean Bankfull Width (m)	Mean Width to Depth Ratio	Mean Entrenchment Ratio	Mean Water Surface Gradient (%)	Mean Pool Length (m)	Mean Residual Pool Depth (cm)	Percent Fines	Percent Stable Banks	Percent Vulnerable Banks	Mean Shading (%)	Mean Bank Angle (deg)	Mean Shore Depth (cm)
Property Line	2006	HVC-3	Gravel 16-32	N/C	2.89	13.44	1.85 5.9		3.51	4.572	25	52	48	83.64	N/A	N/A
Property Line	2009	HVC-3	Gravel 11-16	111	2.41	11.1	3.4 4.7		2.92	18.47	71	57	43	87	N/A	N/A

Table 5.6. 2006 and 2009 Cross Section Bankfull Widths, Width-to-Depth Ratios and Entrenchment Ratios

Bankfull Widths			
Year	XS-1 XS-2 XS-3		
2006 1.96		2.53	1.98
2009 1.74		2.13	1.92

Width-to-Depth Ratio			
Year XS-1		XS-2	XS-3
2006 7.84		14.88	6.39
2009 7.57		15.21	6.00

Entrenchment Ratio			
Year XS-1		XS-2	XS-3
2006 13		27.3	5.5
2009 8.7		7	7.3

This location shows general improvement, although the percentage of fines in pools is greater in 2009 compared to 2006. Permanent cross sections for Heavenly Valley Creek's Property Line reach, HVC-3, are graphed and presented in Figure 5.9 – 5.11. The cross sections show very little change between 2006 and 2009. These cross sections are graphed and presented with the cross sections surveyed in 2006. All cross sections are graphed from rebar monuments. Elevation and station measurements are graphed relative to the left bank rebar stake. The base of the rebar stake on the left bank is the zero, zero point.

Table 5.6 presents each cross-sections associated bankfull width, width-to-depth ratio, and entrenchment ratio. Bankfull widths and width-to-depth ratios at each cross-section have changed slightly since 2006. Entrenchment ratios since 2006 have decreased at cross sections one (XS-1) and two (XS-2), and increased at cross section three (XS-3). The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

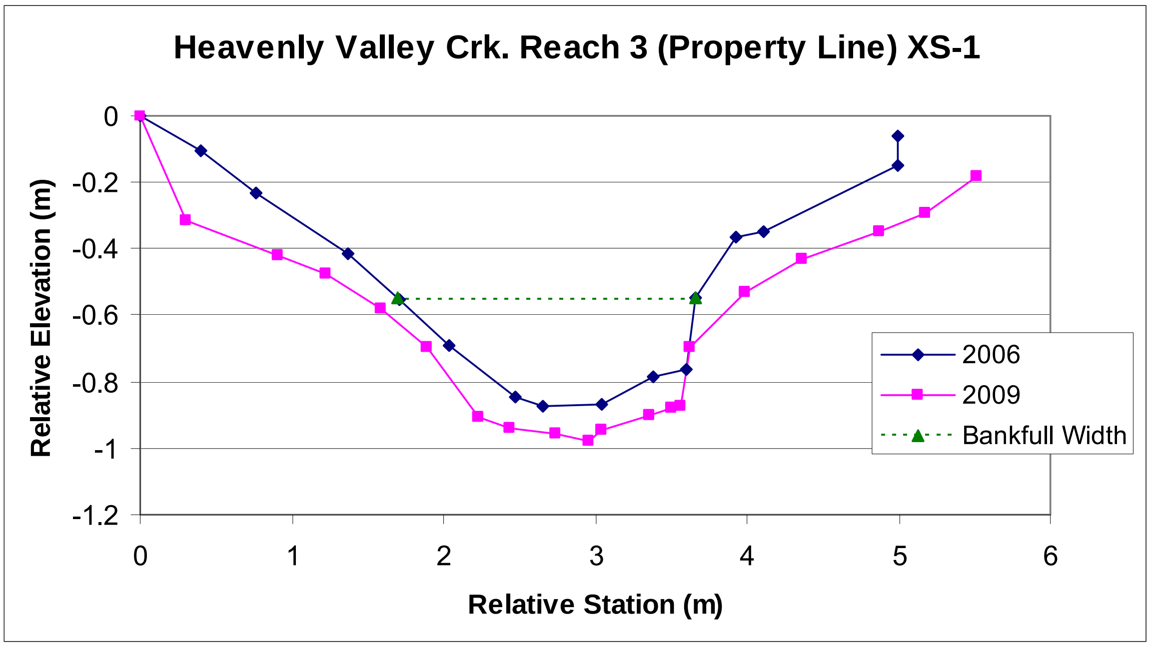

Figure 5.9. Permanent Cross Section number 1 (XS-1) for HVC-3, Property Line, along Heavenly Valley Creek.

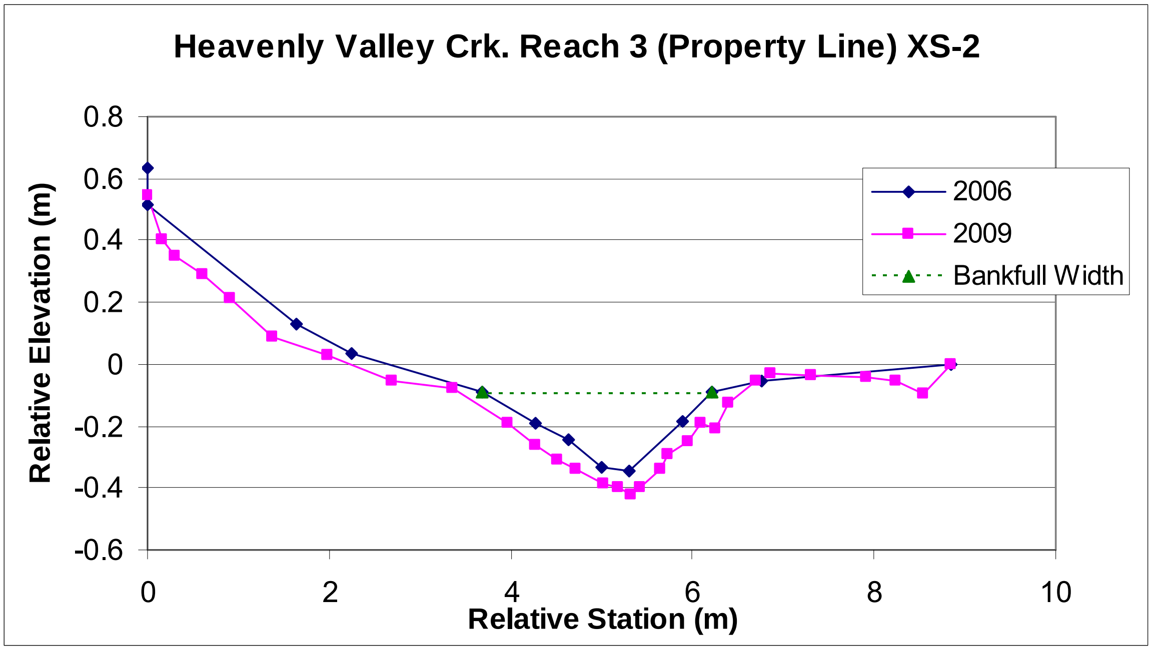

Figure 5.10. Permanent Cross Section number 2 (XS-2) for HVC-3, Property Line, along Heavenly Valley Creek.

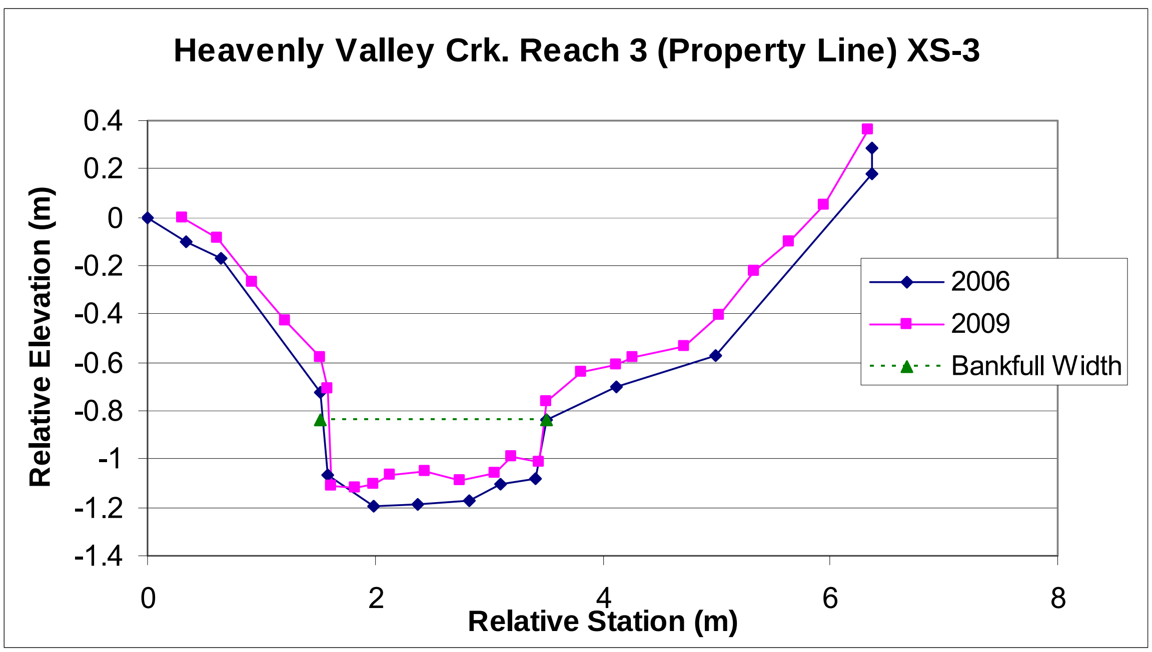

Figure 5.11. Permanent Cross Section number 3 (XS-3) for HVC-3, Property Line, along Heavenly Valley Creek.

California Reference Reaches

Upper Hidden Creek (HDVC-1)

The Upper Hidden reach is located in the headwaters area of Hidden Valley Creek. This is the highest monitoring reach on Hidden Valley Creek. Established in 1996, HDVC-1 is a reference reach undisturbed by ski resort activities, and is comparable to the Sky Meadows reach on Heavenly Valley Creek. Both reaches are similar in terms of watershed size, geology, soils, and slope. Using the Rosgen channel classification method, the Upper Hidden reach currently exhibits the characteristics of "C" type channels (Rosgen 1996). A "C" type channel is generally described as a low gradient, meandering, point bar, riffle/pool alluvial channel with broad, well-defined floodplains (Rosgen 1996).

Table 5.7 presents the results for the SCI evaluations completed in 2006 and 2009 at the reference reach. The channel was dry in 2006 when field efforts were conducted. Therefore a full SCI could not be completed. Mean pool length, mean residual pool depth, and percent fines were not measured in 2006. In 2009, the creek was flowing during field efforts. Therefore a full SCI was conducted at this reach. The water surface gradient in 2006 is the bed profile, as no water was flowing in the channel. Bank angle and stream shore depth were recorded because this reach has a water surface gradient (and/or the bed profile) of less than 2%. Most of the data collected in 2009 is different than the 2006 data owing to the dry channel in 2006, and includes the following:

1. Total Wood – The total wood increased from 2006 to 2009 by 21 pieces.
2. Mean Bankfull Width – The mean bankfull width for the entire project reach in 2006 was calculated at 2.64 meters. In 2009 the mean bankfull width decreased to 1.3 meters
3. Mean Width to Depth Ratio – The mean width-to-depth ratio decreased from 47.55 in 2006 to 16.3 in 2009.
4. Mean Entrenchment Ratio – The mean entrenchment ratio increased from 3.38 in 2006 to 7.38 in 2009.
5. Mean Water Surface Gradient – The water surface gradient increased from 2006 (0.61) to 2009 (1.53).
6. Percent Stable/Vulnerable Banks – The percent stable banks increased from 2006 from 55% to 86% while the percent vulnerable banks decreased from 45% to 14%.

The reference (background) reach showed more adverse change than the project reaches, with a greater amount of vulnerable banks. Table 5.8 presents each cross-sections associated bankfull width, width-to-depth ratio, and entrenchment ratio. Cross section two (XS-2) was not identified in 2006 or 2009. Bankfull widths and width-to-depth ratios at each cross section have increased since 2006. Entrenchment ratios since 2006 have decreased at cross sections one (XS-1) and two (XS-2).

Table 5.7. Results from 2006 and 2009 SCI for Upper Hidden Reach

Reach Name	Year	Reach No.	Dominant Pebble Class (secondary axis in mm)	Total Wood	Mean Bankfull Width (m)	Mean Width to Depth Ratio	Mean Entrenchment Ratio	Mean Water Surface Gradient (%)	Mean Pool Length (m)	Mean Residual Pool Depth (cm)	Percent Fines	Percent Stable Banks	Percent Vulnerable Banks	Mean Shading (%)	Mean Bank Angle (deg)	Mean Shore Depth (cm)
Upper Hidden	2006 HVC-1		Gravel 8-16	22	2.64	47.55	3.38 0.61		N/A	N/A	N/A	55	45	57.5	128	2.55
Upper Hidden	2009 HVC-1		Gravel 8-11	43	1.3	16.3	7.38	1.53 8.75 20.6			34	86	14	51	115	3.3

Table 5.8. 2006 and 2009 Cross Section Bankfull Widths, With-to-Depth Ratios and Entrenchment Ratios

Bankfull Widths			
Year XS-1*		XS-2	XS-3
2006 0.93		N/A	1.39
2009 1.37		N/A	2.29

* XS-1 calculations for 2006 are based on the 2001 USFS Data

Width-to-Depth Ratio			
Year XS-1*		XS-2	XS-3
2006 4.43		N/A	7.32
2009 6.52		N/A	15.27

Entrenchment Ratio			
Year XS-1*		XS-2	XS-3
2006 12		N/A	17.8
2009 10.9		N/A	9.8

Cross sections for the reference reach, Upper Hidden (HDVC-1), are graphed in Figures 5.12 – 5.13. Like in 2006, only two of three cross-sections were located during the stream assessment in 2009 (cross sections one and three). Only the buried left bank rebar monument was located for cross section one (XS-1) in 2006. In 2009, both monuments were located for cross section one (XS-1). Cross section one (XS-1) in 2006 was aligned perpendicular to the current stream flow but, since the right bank monument was never found, the alignment is different from the 2001 and 2009 cross sectional graphs

Cross section two (XS-2) was not surveyed in 2006 or 2009 because the buried rebar monuments could not be found. During 2009 field efforts, the field crew approximated the location of both cross-section two monuments from descriptions and measurements recorded by the USFS in 2001. As cross section two (XS-2) in 2009 was estimated, no graph will appear in this report. During the next round of SCI monitoring in 2012, it is recommended that the field crew install permanent monuments at the approximate location of cross section two (XS-2), as based on the field notes from the USFS in 2001, and from the field notes taken by ENTRIX in 2009. Both monuments were found at cross section three (XS-3) in 2009.

Cross sections one (XS-1) and three (XS-3) surveyed in 2001, 2006, and 2009 are graphed from rebar monuments. 2001 data is included in these graphs to illustrate the wrong alignment chosen in 2006 at cross section one (XS-1). Elevation and station measurements are graphed relative to the left bank rebar stake. The base of the rebar stake on the left bank is the zero, zero point.

Each graph shows the bankfull width associated with that cross section. The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

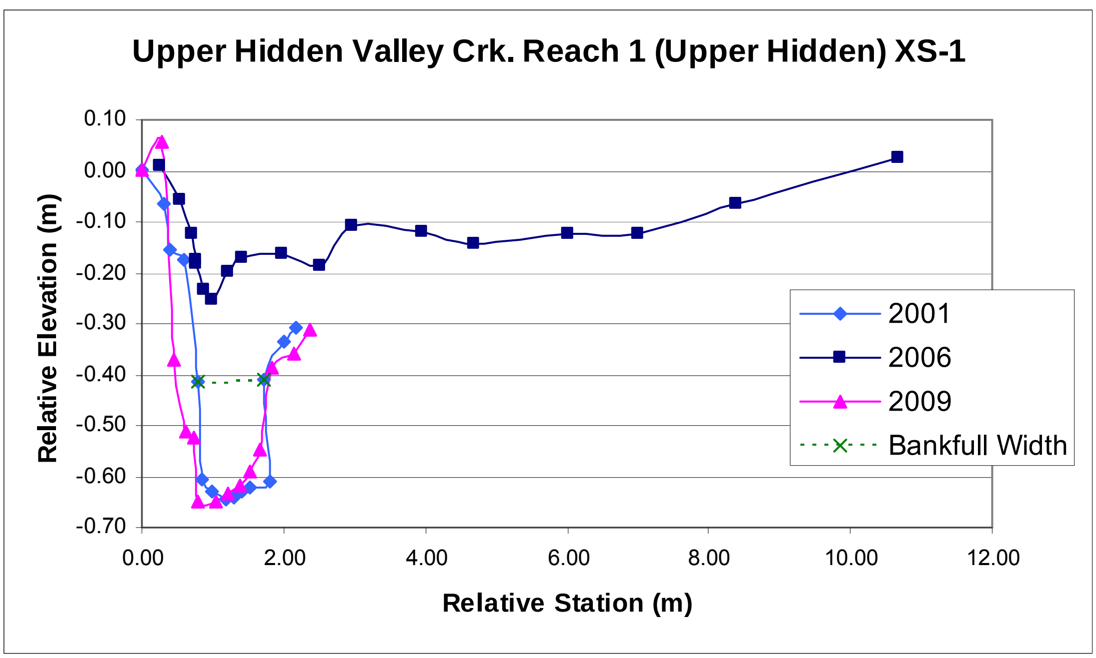

Figure 5.12. Permanent Cross Section number 1 (XS-1) for HDVC-1, Upper Hidden, along Hidden Valley Creek.

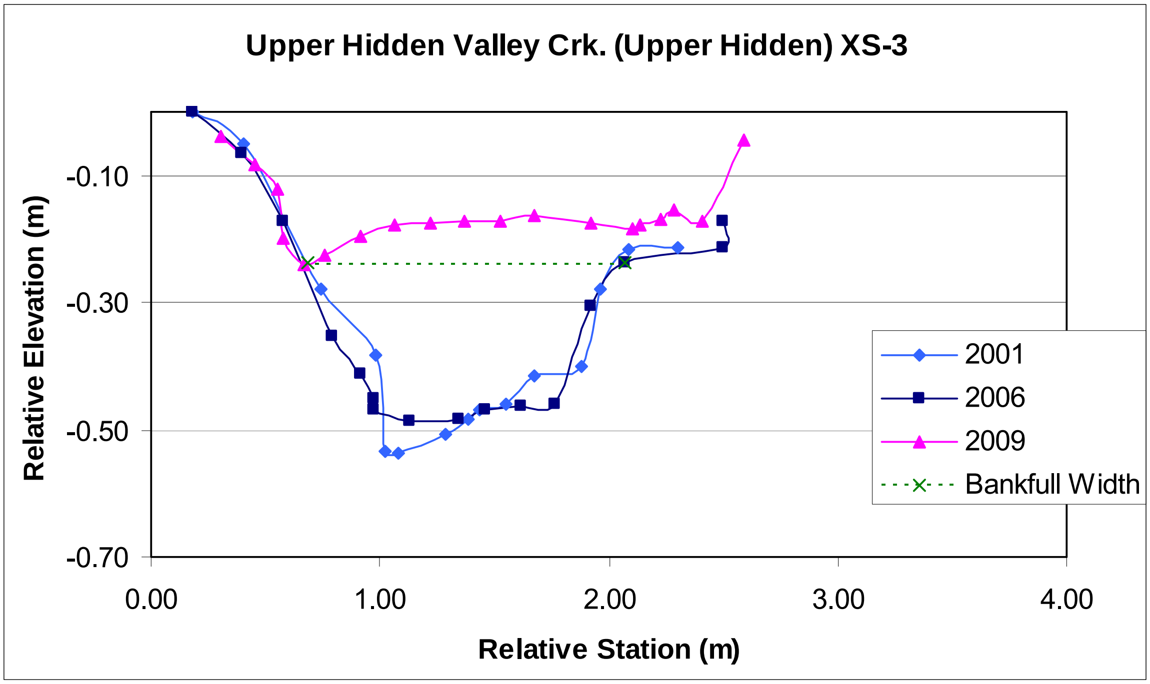

Figure 5.13. Permanent Cross Section number 3 (XS-3) for HDVC-1, Upper Hidden, along Hidden Valley Creek.

Lower Hidden Creek (HDVC-2)
The HDVC-2 reach was established in 2001 as a reference site to HVC-3 (Property Line). Similar to the HVC-1 and HDVC-1 comparison this is an only indirect comparison. Both reaches have similar gradient, canopy covers, adjacent streamside vegetation types, elevation, and bankfull widths. However, Heavenly Valley and Hidden Valley creeks have dissimilar flow regimes, since the discharge in Heavenly Valley Creek is influenced by the Sky Meadows dam, while Hidden Valley Creek flows unobstructed.

This reach exhibits "A" type channel characteristics (Rosgen, 1996). An "A" type channel is generally described as a steep, entrenched, cascading, stream that is high energy and transports debris associated with depositional soils. In 2006, the classification was changed from a "B" type channel. Although there are some attributes to fit both types (such as stable banks and moderate entrenchment), the classification was changed to an "A" type channel due to the steepness of the reach.

Table 5.9 presents the results for the SCI evaluations completed in 2006 and 2009 for this project reach. Bank angle and stream shore depth were not recorded in either 2006 or 2009 because this reach has a water surface gradient of greater than 2%. All other measurements were recorded, as the creek was flowing during field efforts. Total wood was not counted in the 2006 field efforts for unknown reasons. Most of the data collected in 2009 is different than the 2006 data including the following measurements:

1. Dominant Pebble Class – The dominant pebble class increased from sand to 22.6-16.

2. Mean Width-to-Depth Ratio – The mean width-to-depth ratio for the entire reference reach in 2006 was 12.92. In 2009 the mean width-to-depth ratio decreased to 9.2.

3. Mean Entrenchment Ratio – The mean entrenchment ratio increased from 1.81 in 2006 to 7.65 in 2009.

4. Mean Pool Length – The mean pool length increased from 2.13 meters to 6.1 meters from 2006 to 2009.

5. Percent Fines – The percent pool tail fines have increased from 37% in 2006 to 41.6% in 2009.

These differences between the 2009 and 2006 data are discussed in the next section of this report (Discussion).

Permanent cross sections for the lower reach of Hidden Valley Creek (Lower Hidden), HVC-3, are graphed and presented in Figures 5.14 – 5.16. These cross sections are graphed and presented with the cross sections surveyed in 2006. All cross sections are graphed from rebar monuments. Elevation and station measurements are graphed relative to the left bank rebar stake. The base of the rebar stake on the left bank is the zero, zero point.

Table 5.10 presents each cross sections associated bankfull width, width-to-depth ratio, and entrenchment ratio. Bankfull widths and width-to-depth ratios at each cross section have changed slightly since 2006. Entrenchment ratios since 2006 have increased at all cross sections. Each graph shows the bankfull width associated with that cross section. The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

Table 5.9. Results from 2006 and 2009 SCI for Lower Hidden Reach

Reach Name	Year	Reach No.	Dominant Pebble Class (secondary axis in mm)	Total Wood	Mean Bankfull Width (m)	Mean Width to Depth Ratio	Mean Entrenchment Ratio	Mean Water Surface Gradient (%)	Mean Pool Length (m)	Mean Residual Pool Depth (cm)	Percent Fines	Percent Stable Banks	Percent Vulnerable Banks	Mean Shading (%)	Mean Bank Angle (deg)	Mean Shore Depth (cm)
Lower Hidden	2006	HDVC-2	Sand <2	N/C	2.87	12.92	1.81	9.37 2.13		7.9248	37	63	37	87.28	N/A	N/A
Lower Hidden	2009	HDVC-2	Gravel 22.6-16	48	2.86	9.2	7.65 8.63		6.1265	7.07	41.6	77	23	88	N/A	N/A

Table 5.10. 2006 and 2009 Cross Section Bankfull Widths, Width-to-Depth Ratios and Entrenchment Ratios

Bankfull Widths			
Year XS-1		XS-2	XS-3
2006 1.25		1.72	2.99
2009 1.37		1.95	2.74

Width-to-Depth Ratio			
Year XS-1		XS-2	XS-3
2006	15.63 8.60	11.96	
2009 17.13		6.50	9.45

Entrenchment Ratio			
Year XS-1		XS-2	XS-3
2006 10.32		8.50	2.80
2009 14.10		13.80	7.80

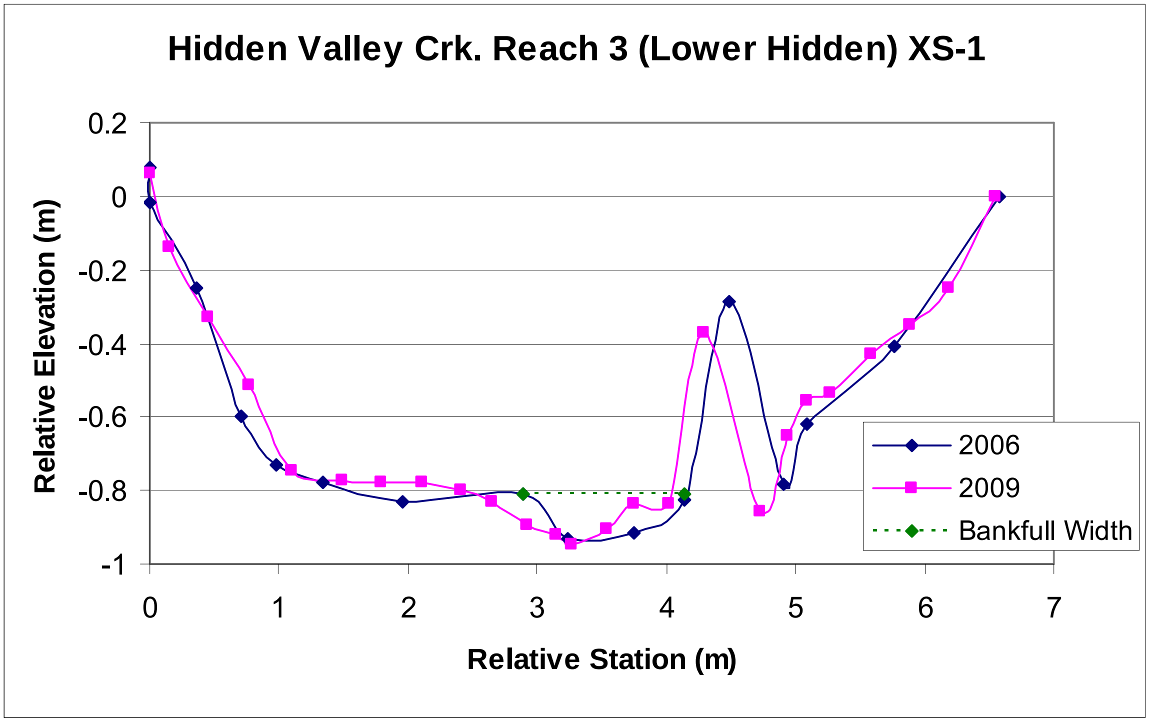

Figure 5.14. Permanent Cross Section number 1 (XS-1) for HDVC-2, Lower Hidden, along Hidden Valley Creek.

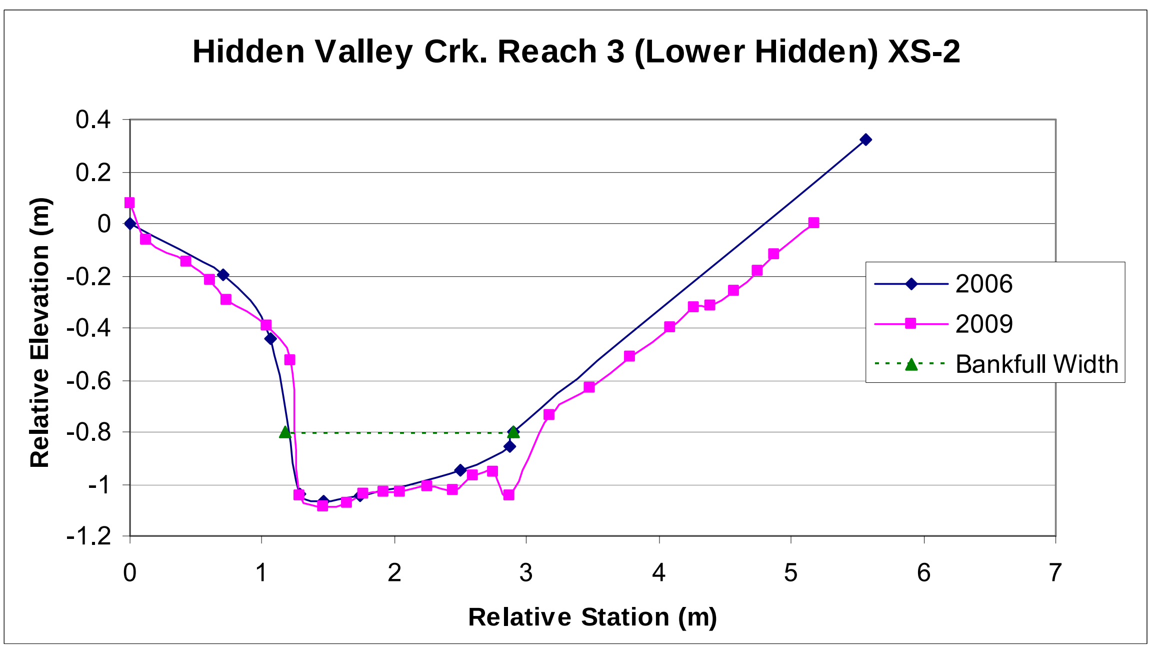

Figure 5.15. Permanent Cross Section number 2 (XS-2) for HDVC-2, Lower Hidden, along Hidden Valley Creek.

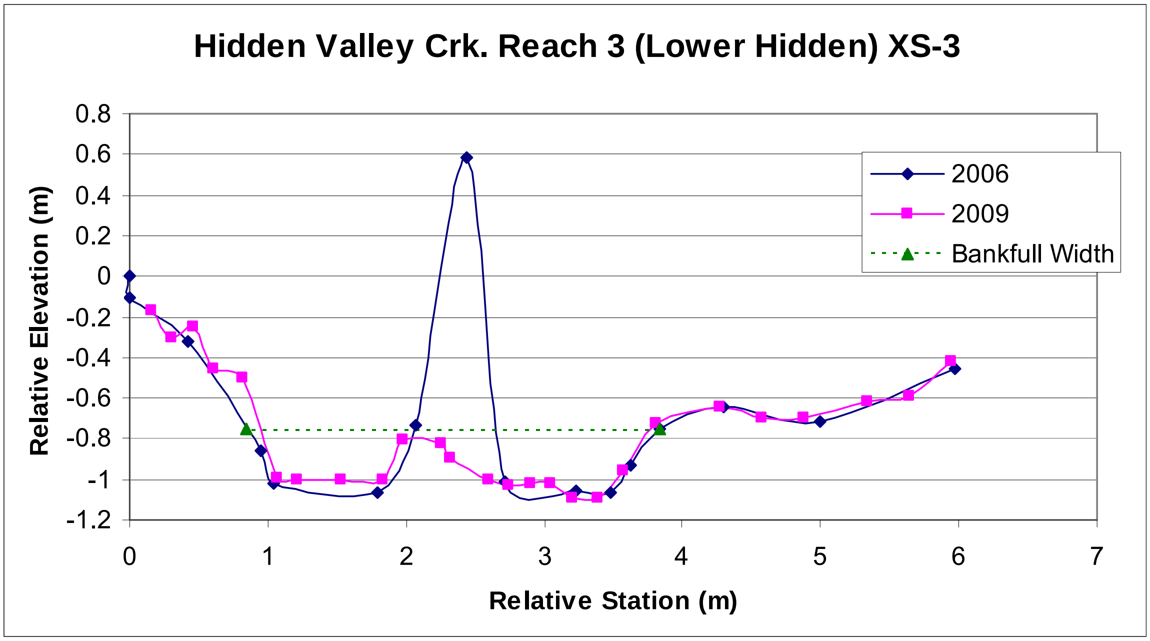

Figure 5.16 Permanent Cross Sections number 3 (XS-3) for HDVC-2, Lower Hidden, along Hidden Valley Creek.

Nevada Project Reaches

Upper Edgewood Creek (EC-1)

The Edgewood Creek watershed has been t he location of multiple restoration p rojects. The restoration project in the portion of Edgewood Creek inclu ding riparian monitoring site EC-1 is referred to as the North Bowl Rest oration Stream En vironment Project. Phase 1 of the North Bowl Restoration Strea m Environ ment Project, consisting of the downstream two-t hirds of t he project, was completed in 2006. Ot her activities in 2006 included gabion structure s added as gully improvements upst ream of the North Bowl Restoration Stream Environment Project and best management practices installed on the road that descends from Boulder Parking Lot along Edgewood Creek. Phase 2 of the North Bowl Restoration Stream Environment Project, which contains rip arian monitoring site EC-1, was completed in the summer of 2007. Phase 2 involved the installation of more gabion structur es, strategic placement of large woody debris, and vegetat ion establishment. For a more t horough asse ssment, please reference the Final Edgewood Watershed Assessment and Enhancement Plan: Upper Ed gewood Creek (Swanson 2006).

Reach one of Edgewoo d Creek, know as Upp er Edgewoo d (EC-1), was dry at th e time of stream condition analysis. Therefore, a full SCI could not be completed. The USFS SCI protocol version 5.0 provides meas ures of channel morph ology most applicable to low gradie nt streams (USFS 2005). Because this reach is a high gra dient strea m only a lo ngitudinal b ed profile (Figu re 5.17) an d cross se ction analysis (Figures 5.18 – 5.20) were cond ucted. The three permanent cross sections exte nd across the entire valley floor width and were selected in 2006 as to avoid construction disturbance.

The EC-1 reach exhibit s characteristics of an “Aa+” type channel u sing the Rosgen channe l classification method (Rosgen 1996). It is very steep (>10 percent), somewhat entrenched, and confined. The channel resembles a gully and has a step/pool morphology resulting from the large number of downed trees in the channel (Rosgen 1996).

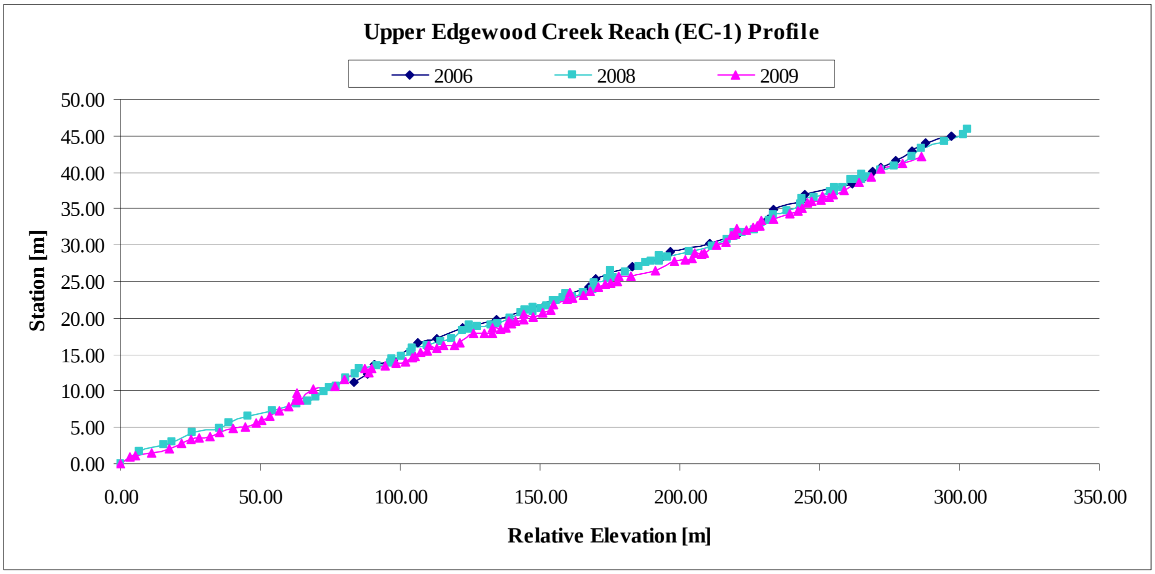

Figure 5.17. Bed profile of reach EC-1, Upper Edgewood, along Edgewood Creek.

Established in 2006, the profile was taken along the entire reach length along the dry bed. Elevation and station measurements are graphed relative to the downstream end of the reach. The downstream end of the reach is point zero, zero. The profile of the Upper Edgewood Reach shows a fairly uniform slope throughout the surveyed reach. The profile also indicates that there may have been some channel degradation since last surveyed in 2008. The survey conducted in 2009 shows the bed profile being slightly lower than in 2008.

Permanent cross sections for Edgewood Creek's Upper Edgewood reach, EC-1, are graphed and presented in Figure 5.8. EC-1 is a high energy and high sediment system due to steep channel slope and narrow channel cross sections. Established in 2006, all cross sections are graphed from rebar monuments. Elevation and station measurements are graphed relative to the left bank rebar stake. The top of the rebar stake on the left bank is the zero, zero point. Table 5.6 presents each cross sections associated bankfull width, width-to-depth ratio, and entrenchment ratio. Bankfull widths and width-to-depth ratios at each cross section have changed slightly since 2006. Entrenchment ratios since 2006 have decreased at cross section one (XS-1) and two (XS-2), and increased at cross section three (XS-3) since 2006. The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

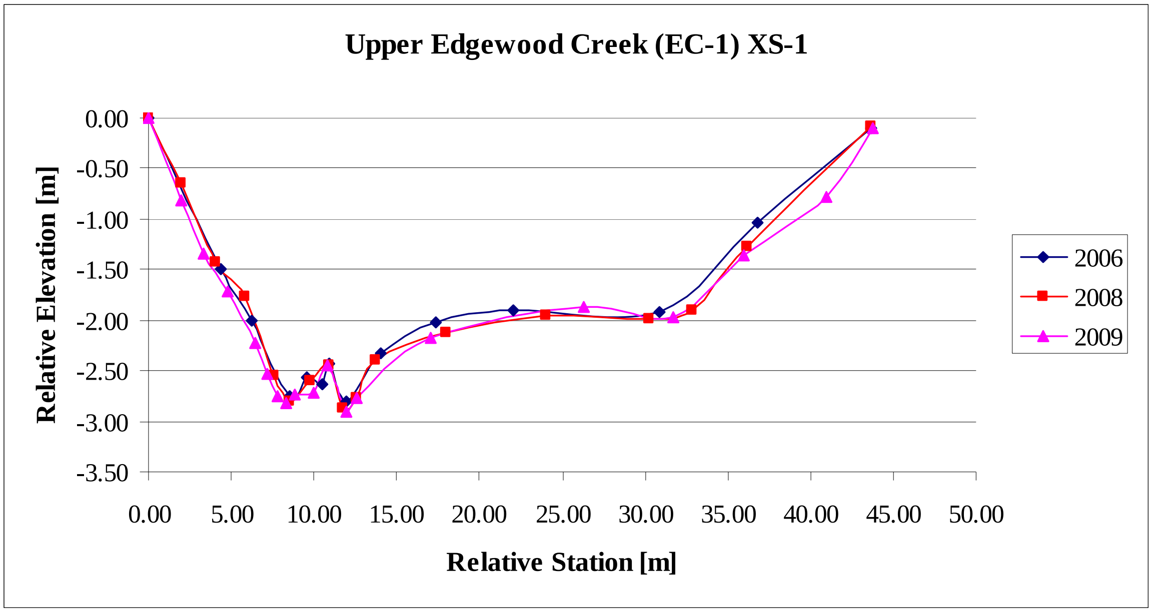

Figure 5.18. Permanent Cross Section number 1 (XS-1) for EC-1, Upper Edgewood, along Edgewood Creek.

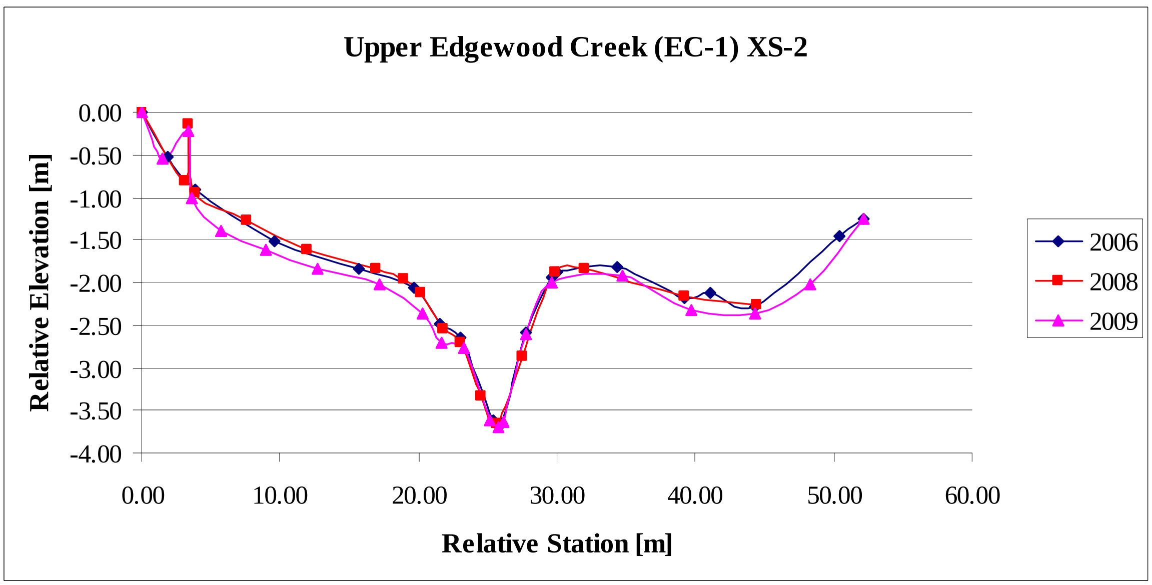

Figure 5.19. Permanent Cross Section number 2 (XS-2) for EC-1, Upper Edgewood, along Edgewood Creek.

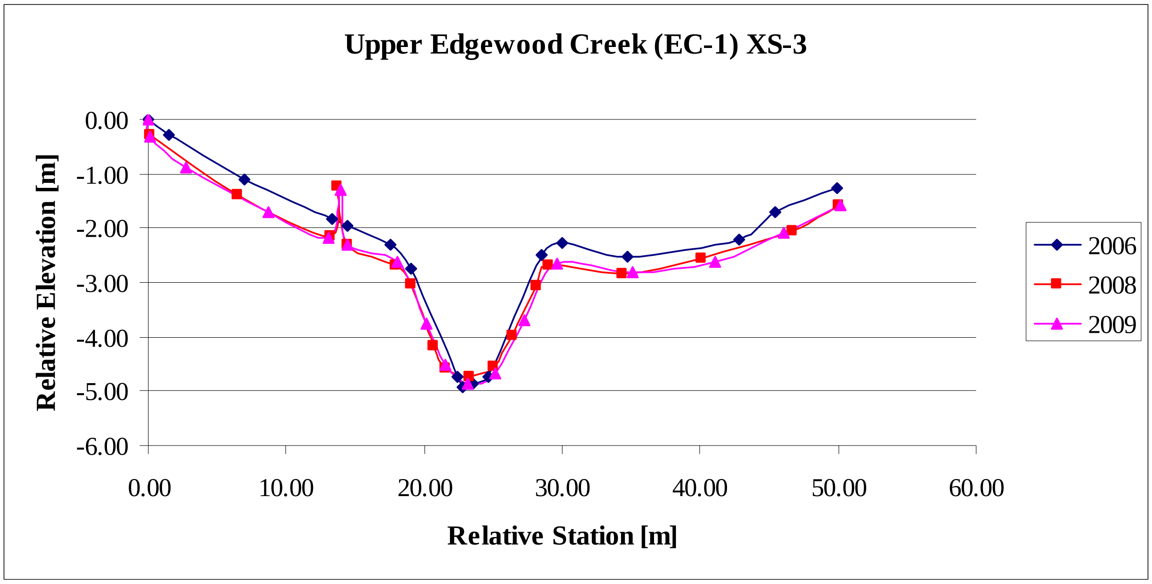

Figure 5.20. Permanent Cross Section number 3 (XS-3) for EC-1, Upper Edgewood, along Edgewood Creek.

Lower Edgewood Creek (EC-2)

Lower Edg ewood exhi bits charact eristics of a "G" t ype channel usin g the Rosgen channel classification method. "G" channel types typi cally have very high bank erosion rates and a high sediment su pply. Channel degradation and side slope rejuve nation processes are a lso typical (Rosgen 1996). Edgewood Creek below Boulder Parking Lot also u nderwent restoration in 2007. These restoration activities included repair of a headcut by constructing plunge pools and riparian planting. The re storation of Lower Edgewood Creek occurred directly upstre am of EC-2, incorporating the upstream cross-section of t he riparian monitoring site. A vau lt treatment system was installed in the Boulder parking lot in 2005.

Table 5.11 presents th e results for full SCI evaluations co mpleted in 2009 and compared to results from 2006 and 2 008 for EC-2. A pebb le count was not completed because all sediment was less than 8 mm. T he dominant pebble class is assumed to be sand. There we re no pools as defined by the USFS SCI protocol, theref ore the me an pool length, mean r esidual pool depth, and percent fines were not measured. Most of the data collected in 2009 is similar to the 2006 data excluding the following measurements:

1. Percent Stable/Vulnera ble Banks – Since 20 06, the per cent of sta ble banks have increased from 60% to 100%.

Table 5.12 presents ea ch cross se ctions a ssociated bankf ull width, width-to-depth ratio, and entrenchment ratio for 2006, 2008 and 2009. All three m easurements have cha nged slightly since 2006 and 2009, most notably the entren chment ratios at cross sections on e (XS-1) an d two (XS-2). The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

Table 5.11. Results from 2006, 2008 and 2009 SCI for Lower Edgewood Reach.

Reach Name	Year	Reach No.	Dominant Pebble Class (secondary axis in mm)	Total Wood	Mean Bankfull Width (m)	Mean Width to Depth Ratio	Mean Entrenchment Ratio	Mean Water Surface Gradient (%)	Mean Pool Length (m)	Mean Residual Pool Depth (cm)	Percent Fines	Percent Stable Banks	Percent Vulnerable Banks	Mean Shading (%)	Mean Bank Angle (deg)	Mean Shore Depth (cm)
Lower Edgewood	2006 E	C-2	N/A	N/A	1.6	4.6	15.2	3.9 N/A		N/A	N/A	60	40	92.13	111	2.97
Lower Edgewood	2008 E	C-2	N/A	N/A	1.4	3.5	15.1	4.5 N/A		N/A	N/A	67	33	92.64	108	1.84
Lower Edgewood	2009 E	C-2	N/A	N/A	1.1	5.2	15.2	4.3 N/A		N/A	N/A	100	0	95	113	1.7

Table 5.12. 2006, 2008 and 2009 Cross Section Bankfull Widths, Width-to-Depth Ratios and Entrenchment Ratios

Bankfull Widths			
Year X	S-1	XS-2	XS-3
2006 0	98	0.91	1.76
2008 0	70	0.79	2.65
2009 1	56	0.70	2.65

Width-to-Depth Ratio			
Year XS-1		XS-2	XS-3
2006 12.25		1.82	9.26
2008 17.50		1.30	5.20
2009 39.00		1.11	5.41

Entrenchment Ratio			
Year XS	-1	XS-2	XS-3
2006	75.50 81	.40 33.60	
2008	77.90 89	.10 24.40	
2009 35	.10	107.90	24.50

Permanent cross sections for Edgewood Creek's Lower Edgewood reach, EC-2, are graphed and presented in Figures 5.21 – 5.23. The most upstream cross section, (cross section three, XS-3), had to be relocated in 2008 due to restoration activities destroying the permanent monument. The new location is directly below the rock grade control structure constructed as part of the Lower Edgewood Restoration Project completed in 2007. Established in 2006 and 2008, all cross sections are graphed from rebar monuments. Elevation and station measurements are graphed relative to the left bank rebar stake. The top of the rebar stake on the left bank is the zero, zero point.

Each graph shows the bankfull width associated with that cross section. The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

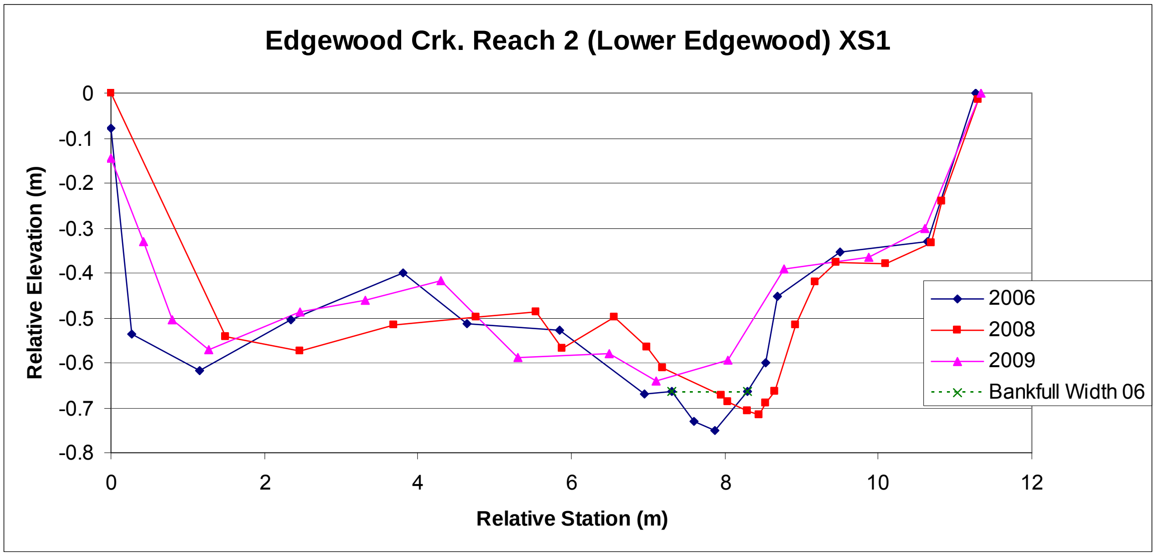

Figure 5.21. Permanent Cross Section number 1 (XS-1) for EC-2, Lower Edgewood, along Edgewood Creek.

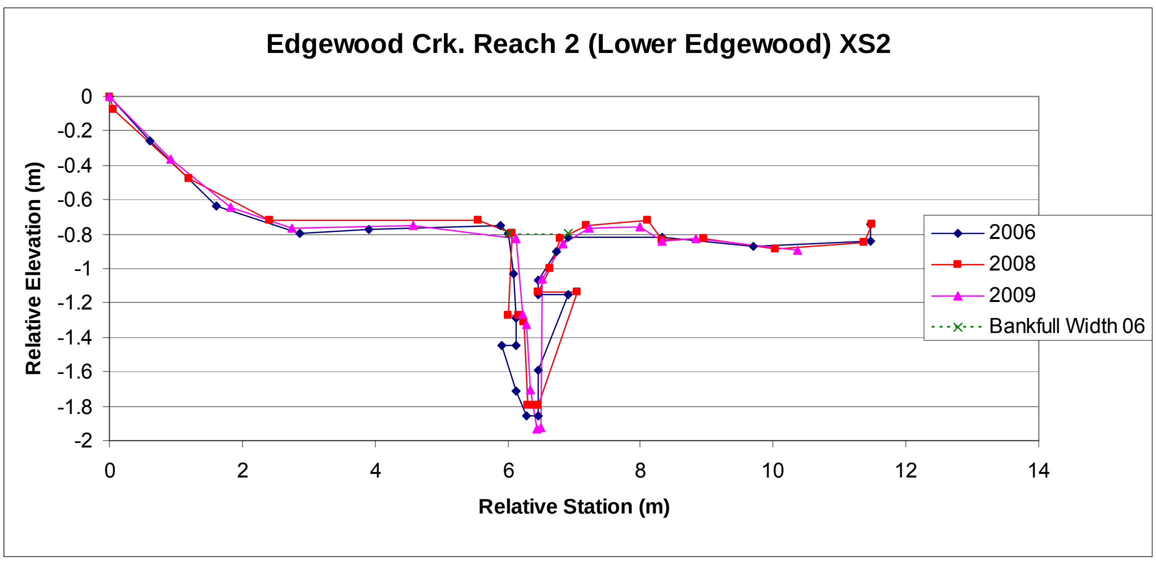

Figure 5.22. Permanent Cross Section number 2 (XS-2) for EC-2, Lower Edgewood, along Edgewood Creek.

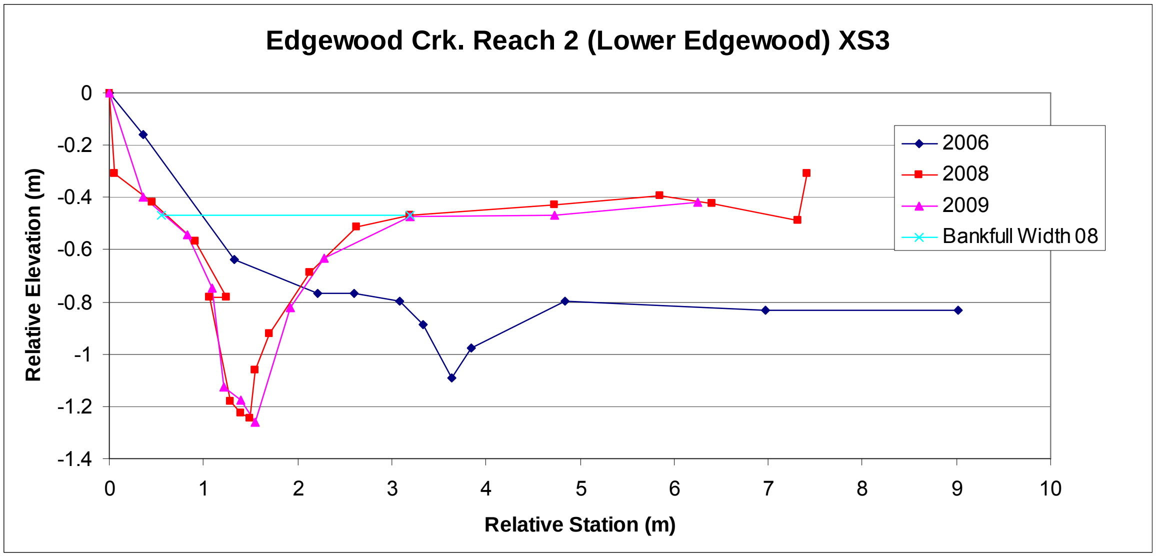

Figure 5.23. Permanent Cross Section number 3 (XS-3) for EC-2, Lower Edgewood, along Edgewood Creek.

Upper Daggett Creek (DC-1)

The DC-1 reach exhibits characteristics of an "Aa+" type channel using the Rosgen classification method. An "Aa+" type channel is generally described as a very steep, deeply entrenched torrent stream with the capacity of debris transport (Rosgen 1996). This reach is steep (>10 percent), well entrenched, and is highly confined. Typical characteristics include a step/pool morphology with chutes and waterfalls (Rosgen 1996).

Table 5.13 presents the results for full SCI evaluations completed in 2009 and compared to 2006 for DC-1. Both mean bank angle and mean shore depth could were not measured in 2006 and 2009 due to the channel's steepness (over a 2% water gradient). Most of the data collected in 2009 is similar to the 2006 data excluding the following measurements:

1. Entrenchment Ratio – The mean entrenchment ratio for the entire project reach in 2006 was 6.05. In 2009 the mean entrenchment ratio increased to 14.7.

2. Mean Residual Pool Depth – The mean residual pool depth increased from 7.0 centimeters in 2006 to 34.7 centimeters in 2009.

3. Percent Stable/Vulnerable Banks – The percent stable banks increased from 2006 at 70% to 2009 at 100%.

4. Percent Mean Shading – The mean percent shading decreased from 86.23% in 2006 to 51% in 2009.

Table 5.14 presents each cross sections associated bankfull width, width-to-depth ratio, and entrenchment ratio. Bankfull widths and width-to-depth ratios at each cross section have changed slightly since 2006. Entrenchment ratios since 2006 have increased at all three cross sections. The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

Table 5.13. Results from 2006 and 2009 SCI for Upper Daggett Reach.

Reach Name	Year	Reach No.	Dominant Pebble Class (secondary axis in mm)	Total Wood	Mean Bankfull Width (m)	Mean Width to Depth Ratio	Mean Entrenchment Ratio	Mean Water Surface Gradient (%)	Mean Pool Length (m)	Mean Residual Pool Depth (cm)	Mean Percent Fines	Percent Stable Banks	Percent Vulnerable Banks	Mean Shading (%)	Mean Bank Angle (deg)	Mean Shore Depth (cm)
Upper Daggett	2006	DC-1	Gravel 8-16	29	1.2984	4.9	6.05	>10% 1.79		7.0	69.13	70	30	86.23	N/A	N/A
Upper Daggett	2009	DC-1	Gravel 8-11	49	1	3.7	14.7	>10% 2.1		34.7	74	100	0	51	N/A	N/A

Table 5.14. 2006 and 2009 Cross Section Bankfull Widths, Width-to-Depth Ratios and Entrenchment Ratios

Bankfull Widths			
Year XS-1		XS-2	XS-3
2006 4.27		2.38	1.49
2009 4.51		2.44	1.49

Width-to-Depth Ratio			
Year XS-1		XS-2	XS-3
2006 6.89		5.06	4.03
2009 7.39		5.30	4.38

Entrenchment Ratio			
Year XS-1		XS-2	XS-3
2006 2.5		17.4	27.7
2009 6		23.8	38.3

Permanent cross sections for Daggett Creek's Upper Daggett reach, DC-1, are graphed and presented in Figures 5.24 – 5.26. All cross sections are graphed from rebar monuments. Elevation and station measurements are graphed relative to the left bank rebar stake. The top of the rebar stake on the left bank is the zero, zero point.

Each graph shows the bankfull width associated with that cross section. The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

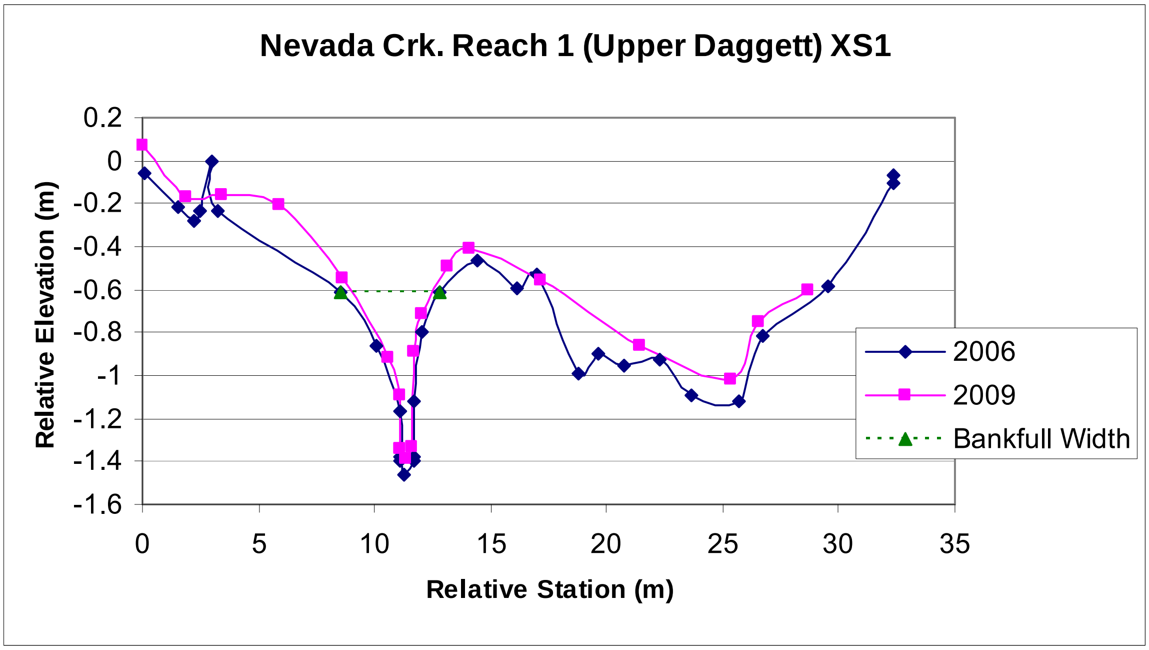

Figure 5.24. Permanent Cross Section number 1 (XS-1) for DC-1, Upper Daggett, along Daggett Creek.

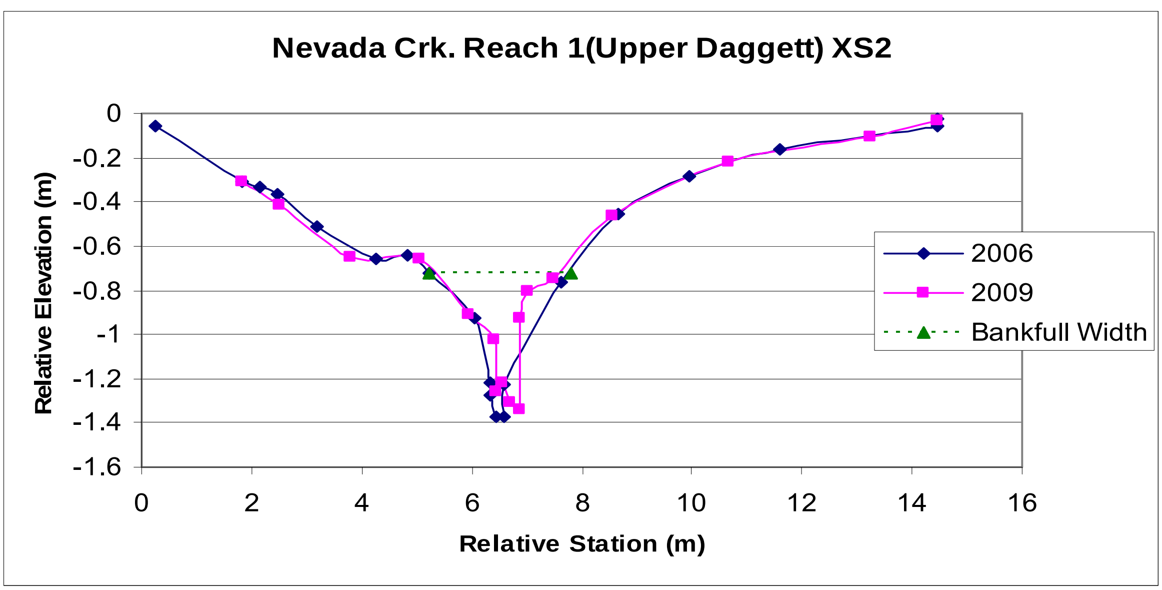

Figure 5.25. Permanent Cross Section number 2 (XS-2) for DC-1, Upper Daggett, along Daggett Creek.

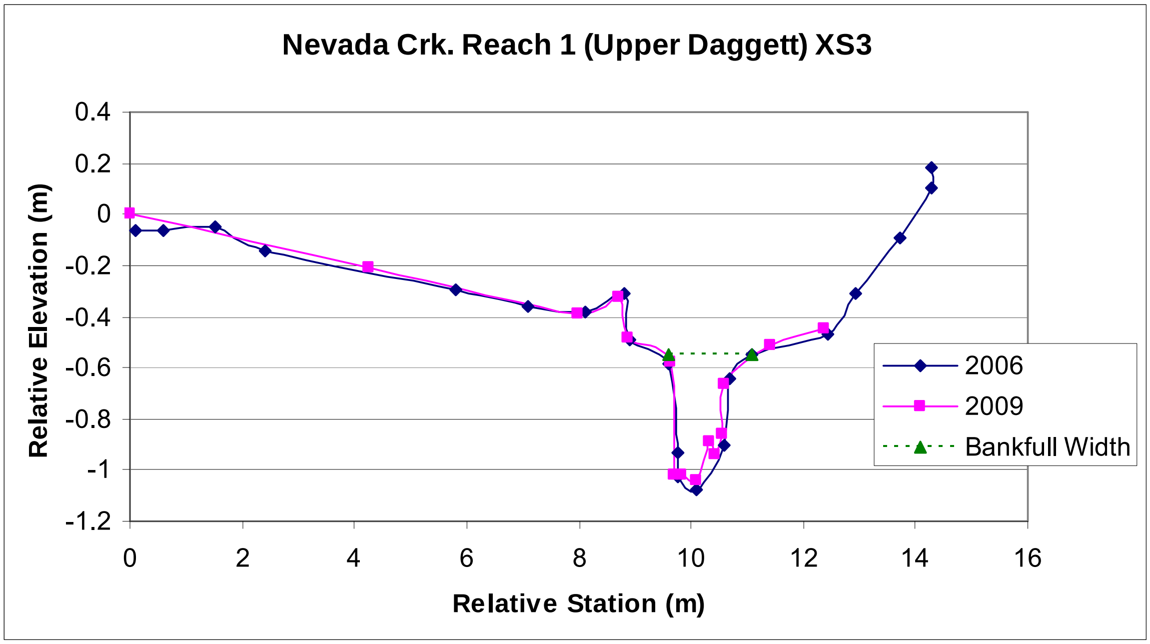

Figure 5.26. Permanent Cross Section number 3 (XS-3) for DC-1, Upper Daggett, along Daggett Creek.

Lower Daggett Creek (DC-2)
Lower Dagg ett exhibits characteristics of an "A" type channel. It is similar to an “Aa+” typ e channel in terms of several channel characterist ics, yet its lower channel slope results in an “A” classification (Rosgen 1996).

Table 5.15 presents the results for SCI evaluati ons completed in 2009 and compared to results from 2006 for DC-2. Mean bank angle and stream shore depth were not completed per protocol as the water surface gra dient is grea ter than 2%. No pools were identified in 2006. Therefore no measurements were recorded fo r mean pool length, mean residual pool depth and percent fines in 200 6. Most of the data collected in 2009 is sim ilar to the 2 006 data excluding the following measurements:

1. Total Wood – Increased from 15 pieces counted in 2006 to 24 pieces counted in 2009.

2. Percent Mean Shading – The mean percent shading in the project reach decreased from 60.72% to 32% from 2006 to 2009.

Table 5.16 presents ea ch cross se ctions a ssociated bankf ull width, width-to-depth ratio, and entrenchment ratio. Bankfull widt hs and width-to-depth ratios at each cross section have changed slightly since 2006. Entrenchment ratios since 2006 have increased at all three cross sections. The slight diff erences in t he cross se ctional areas, and chan ges associated with the graphs will be discussed in the next section of this report (Discussion).

Table 5.15. Results from 2006 and 2009 SCI for Lower Daggett Reach.

Reach Name	Year	Reach No.	Dominant Pebble Class (secondary axis in mm)	Total Wood	Mean Bankfull Width (m)	Mean Width to Depth Ratio	Mean Entrenchment Ratio	Mean Water Surface Gradient (%)	Mean Pool Length (m)	Mean Residual Pool Depth (cm)	Percent Fines	Percent Stable Banks	Percent Vulnerable Banks	Mean Shading (%)	Mean Bank Angle (deg)	Mean Shore Depth (cm)
Lower Daggett	2006	DC-2	Gravel 8-16	15	0.94793	10.62	5.7 8.1		N/A	N/A	N/A	92	8	60.72	N/A	N/A
Lower Daggett	2009	DC-2	Gravel 8-11	24	0.98	10.16	9 7.2		2.1	40.2	89	100	0	32	N/A	N/A

Table 5.16. 2006 and 2009 Cross Section Bankfull Widths, Width-to-Depth Ratios and Entrenchment Ratios

Bankfull Widths			
Year XS-1		XS-2	XS-3
2006 0.95		1.36	1.53
2009 0.69		0.94	1.53

Width-to-Depth Ratio			
Year XS-1		XS-2	XS-3
2006 4.13		6.80	8.50
2009 3.43		9.44	7.65

Entrenchment Ratio			
Year XS-1		XS-2	XS-3
2006 7.6		13	18.2
2009 13.2		18.6	27.5

Permanent cross sections for Daggett Creek's Lower Daggett reach, DC-2, are graphed and presented in Figures 5.27 – 5.29. Established in 2006, all cross sections are graphed from rebar monuments. Elevation and station measurements are graphed relative to the left bank rebar stake. The top of the rebar stake on the left bank is the zero, zero point. Each graph shows the bankfull width associated with that cross section. The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

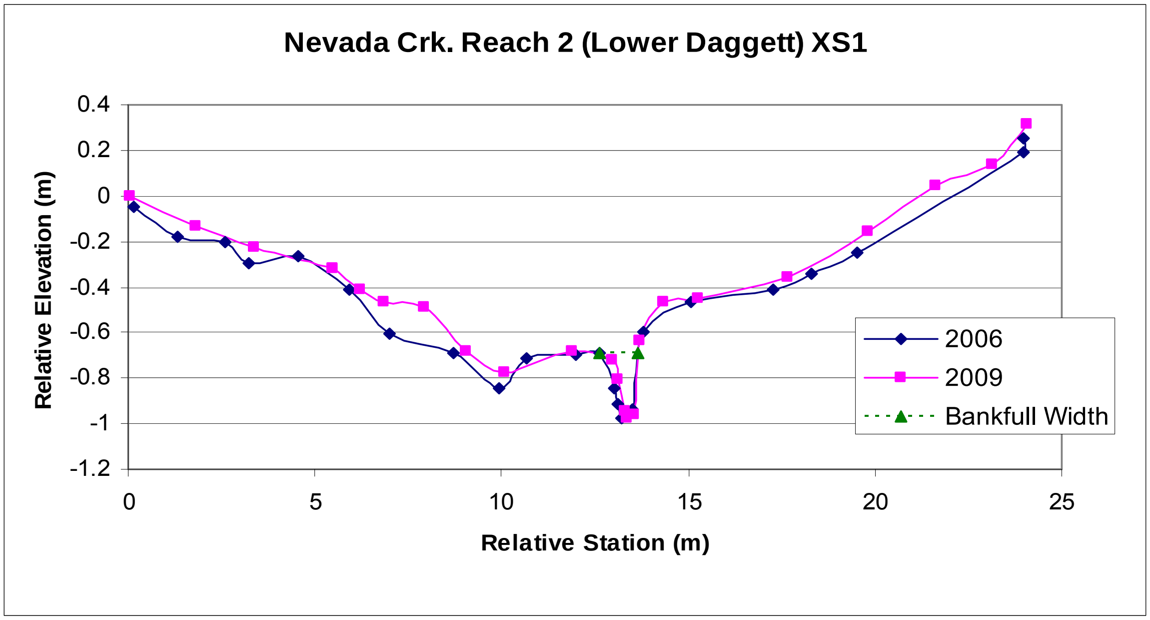

Figure 5.27. Permanent Cross Section number 1 (XS-1) for DC-2, Lower Daggett, along Daggett Creek.

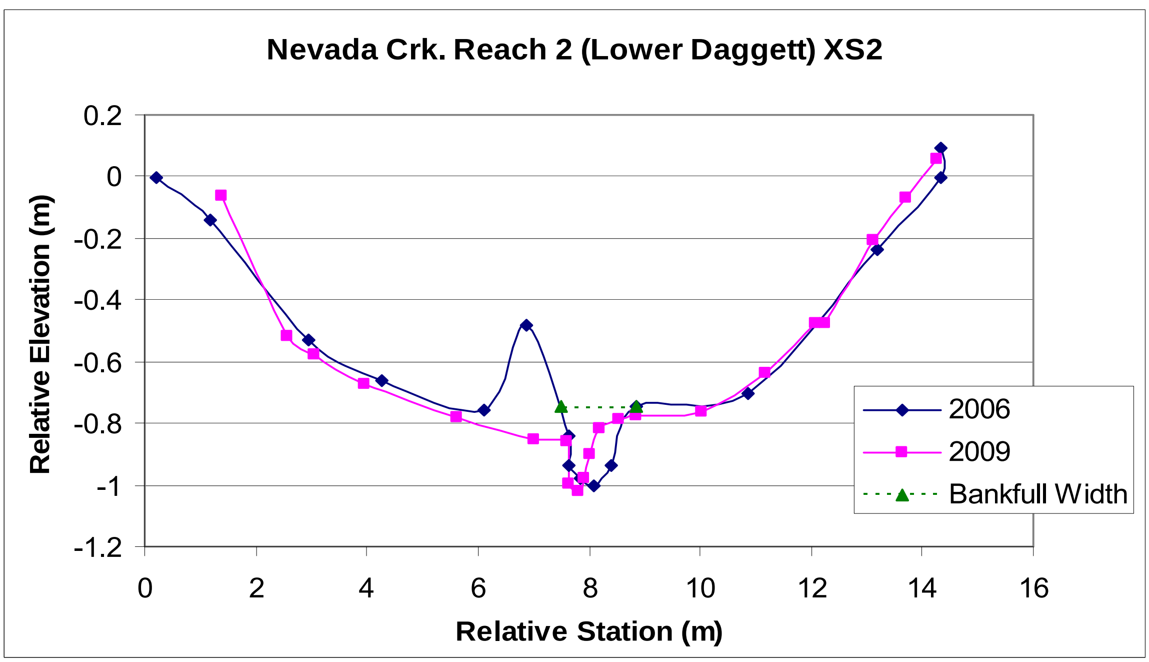

Figure 5.28. Permanent Cross Section number 2 (XS-2) for DC-2, Lower Daggett, along Daggett Creek.

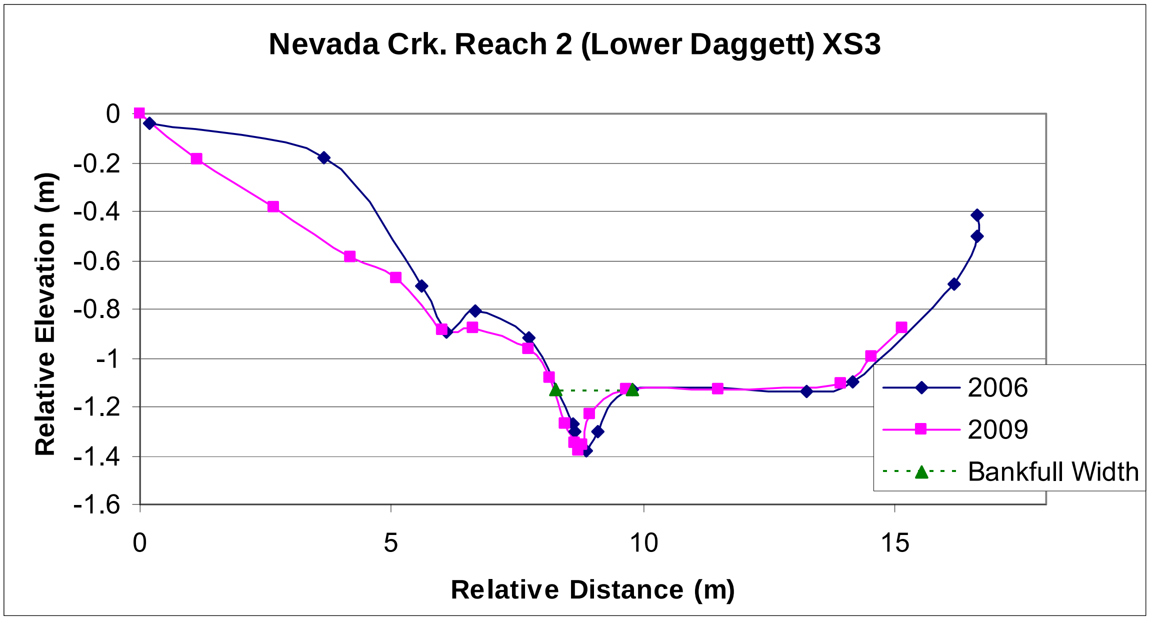

Figure 5.29. Permanent Cross Section number 3 (XS-3) for DC-2, Lower Daggett, along Daggett Creek.

Mott Creek (MC-1)

The MC-1 reach exhibits characteristics of an "Aa+" type channel using the Rosgen classification method. It is very steep (>10 percent), well entrenched, and is highly confined. Typical characteristics include step/pool morphology with chutes and waterfalls (Rosgen 1996).

Table 5.17 presents the results for the full SCI evaluation completed in 2009 for MC-1. At the time of in 2009 monitoring, Mott Creek was dry. Therefore not all of the SCI protocol could be completed. Pools and riffles could not be properly identified due to the lack of water; therefore no pool measurements or pebble counts occurred in 2009. In 2006 no pools as defined by the SCI protocol were identified. Mean bank angle and stream shore depth were not measured in 2006 or 2009 per protocol as the gradient was larger than 2%. Most of the data collected in 2009 is similar to the 2006 data excluding the following measurements:

1. Total Wood – The amount of total wood increased from 36 pieces in 2006 to 65 pieces in 2009.

2. Percent Stable/Vulnerable Banks – The percent stable banks decreased from 100% in 2006 to 77% in 2009.

Table 5.18 presents each cross sections associated bankfull width, width-to-depth ratio, and entrenchment ratio. Bankfull widths at all three cross sections have increased slightly since 2006. Width-to-Depth ratios at cross section two (XS-2) and cross section three (XS-3) have increased since 2006. Cross section one's (XS-1) width-to-depth ratio has decreased slightly since 2006. Entrenchment ratios since 2006 have increased at cross sections one (XS-1) and decreased at cross sections two (XS-2) and three (XS-3). The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

Table 5.17. Results from 2006 and 2009 SCI for Mott Creek Reach.

Reach Name	Year	Reach No.	Dominant Pebble Class (secondary axis in mm)	Total Wood	Mean Bankfull Width (m)	Mean Width to Depth Ratio	Mean Entrenchment Ratio	Mean Water Surface Gradient (%)	Mean Pool Length (m)	Mean Residual Pool Depth (cm)	Percent Fines	Percent Stable Banks	Percent Vulnerable Banks	Mean Shading (%)	Mean Bank Angle (deg)	Mean Shore Depth (cm)
Mott Canyon	2006	MC-1	Gravel 16-32	36	3.6	14.23	2.35 8.1		N/A	N/A	N/A	100	0	25.72	N/A	N/A
Mott Canyon	2009	MC-1	N/A	65	4.5	11.7	2.03	N/A N/A		N/A	N/A	77	22	24	N/A	N/A

Table 5.18. 2006 and 2009 Cross Section Bankfull Widths, Width-to-Depth Ratios and Entrenchment Ratios

Bankfull Widths			
Year	XS-1	XS-2	XS-3
2006	3.20	3.93	4.31
2009	4.60	5.04	5.41

Width-to-Depth Ratio			
Year	XS-1	XS-2	XS-3
2006	5.61	11.23	15.39
2009	6.05	10.50	9.84

Entrenchment Ratio			
Year	XS-1	XS-2	XS-3
2006	1.70	5.80	5.20
2009	1.90	5.00	3.50

Established in 2006, all three cross sections are graphed from rebar monuments. Elevation and station measurements are graphed relative to the left bank rebar stake. The top of the rebar stake on the left bank is the zero, zero point. Permanent cross sections for Mott Creek, MC-1, are graphed and presented in Figure 5.12.

Each graph shows the bankfull width associated with that cross section. The slight differences in the cross sectional areas, and changes associated with the graphs will be discussed in the next section of this report (Discussion).

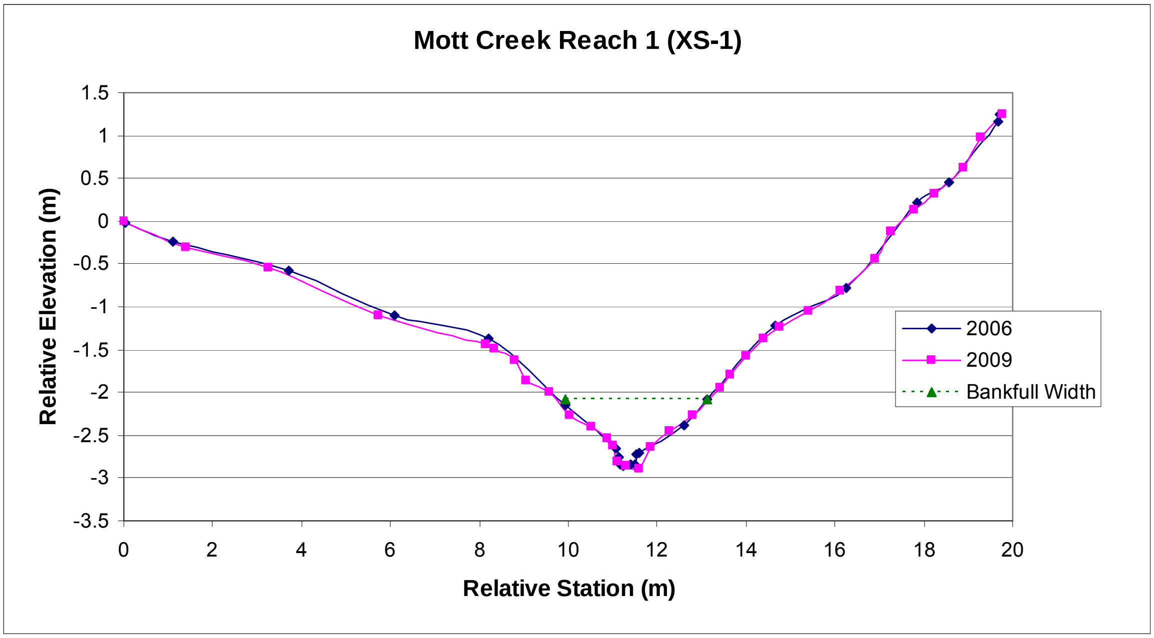

Figure 5.30. Permanent Cross Section number 1 (XS-1) for MC-1, Mott Canyon along Nevada Creek.

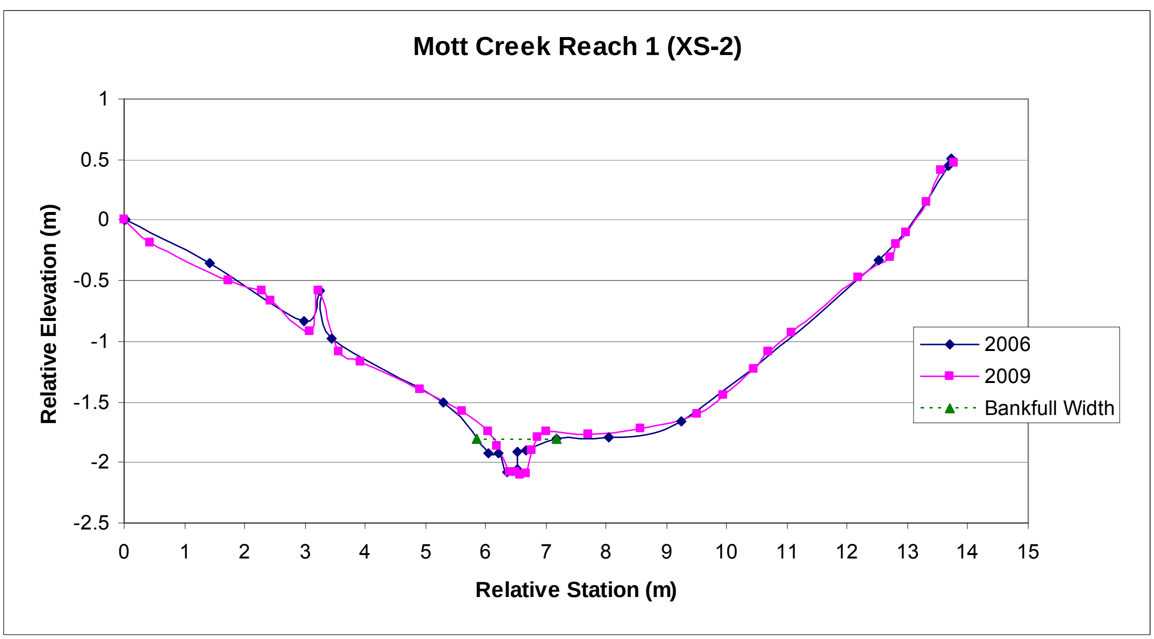

Figure 5.31. Permanent Cross Section number 2 (XS-2) for MC-1, Mott Canyon along Nevada Creek.

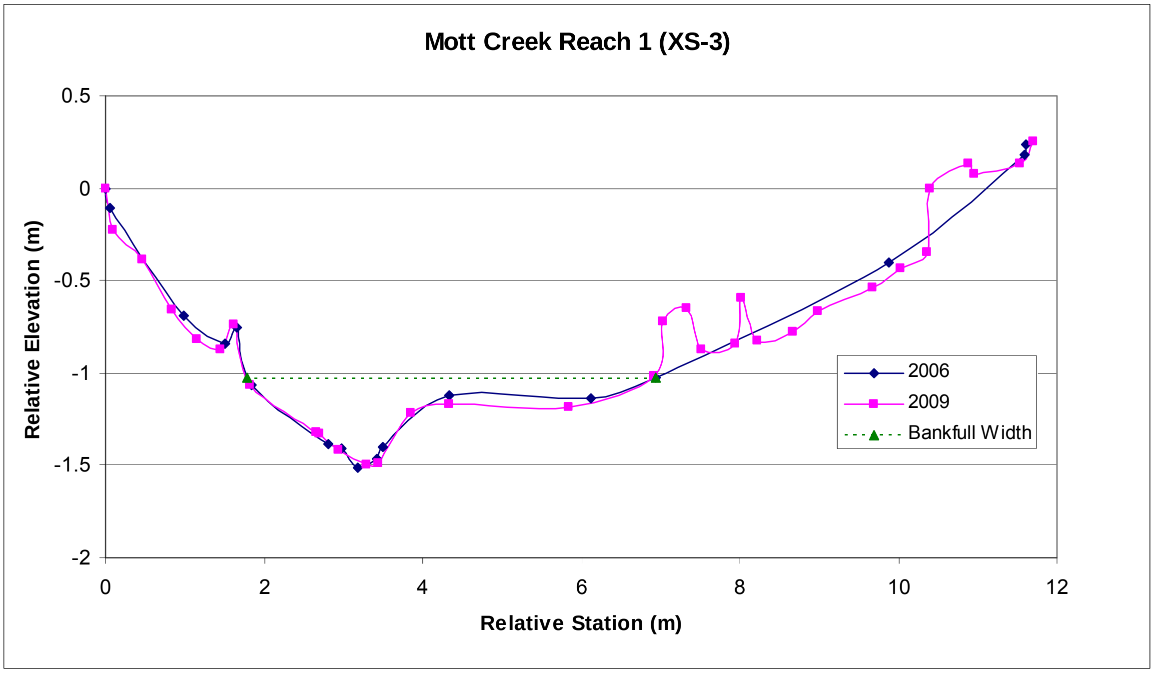

Figure 5.32. Permanent Cross Section number 3 (XS-3) for MC-1, Mott Canyon along Nevada Creek.

Discussion

Overall Summary of Stream and Riparian Conditions

This section of the report discusses the changes that have occurred in each of the reaches between 2006 and 2009. The most noticeable changes that have occurred in the majority of the monitoring reaches include:

1. Total Wood
2. Entrenchment Ratio
3. Residual Pool Depths
4. Percent Stable/Vulnerable Banks

In 2006, wood in the channel was counted using a slightly different methodology. Wood that was counted was considered not only by the length (longer than one-half the bankfull width), and location (had to be within a portion of the bankfull width of the channel), but also by diameter. Surveyors in 2006 counted only the pieces of wood with diameters at least as round as one-half the bankfull width. In 2009, surveyors following the USFS SCI protocol did not take into account wood diameter when counting. Therefore, the majority of reaches in 2009 had significantly higher wood numbers than in 2006. However, based on our observations of a greater amount of downed trees in the area, the amount of woody debris is higher than in 2006. In general this condition is beneficial as the wood can enhance channel stability and habitat complexity.

Entrenchment ratio is another measurement which has changed in many reaches since 2006. As stated in the Methods section of this report, entrenchment ratio is defined as the ratio of floodprone width (as measured at twice the maximum bankfull depth) to bankfull width. Floodprone width can be a subjective measurement, especially when the floodprone width is long. In areas where the floodprone width is more than 20 feet, the floodprone width was estimated. Therefore, it is expected that the entrenchment ratio differs slightly between 2006 and 2009 (based on subjectivity). Inspection of the channel cross sections indicates very little change at the project reaches, and based on this the true channel entrenchment has changed little from 2006 to 2009. In general, project-related channel reaches are very similar between 2006 and 2009 and indicate relatively stable conditions.

Residual pool depths at many of the monitoring reaches show increases from 2006 to 2009. A contributing factor to this beneficial effect is the amount of pools identified during habitat classification. More pools were identified in almost every reach in 2009 than in 2006. When measurements were taken in 2006, water flows were higher than in 2009. 2006 had a yearly (based on a water year October 1 – September 30) average precipitation of 42.6 inches (Snotel 2009). The average precipitation was only 28.4 inches in water year 2009 (Snotel 2009). Pools were identified on the on basis of three key criteria: 1. Flow (slow or no velocity during summer low flows), 2. Morphology (hydraulic control at the pool tail, usually a concave longitudinal profile, and, 3. Dimension (length is greater than the wetted width, depth is greater than non-pools, and the maximum depth is more than twice the pool tail depth). Therefore, in a dry year when flows are lower, there is a greater likelihood of encountering pools during monitoring. Inspection of the channel cross sections indicates that in most reaches, there was a true, albeit small, increase in pool depths.

The percent of stable banks increased in most reaches since 2006. This beneficial condition may be due to more vegetation growth at the reaches since 2006. Another contributing factor may include increased amount of debris covering the banks of the monitoring reaches. Large woody debris and rocks/ boulders are considered stabilizers in the USFS SCI protocol. Woody debris in the majority of monitoring reaches has increased since 2006. This is a possible indicator of more trees becoming downed along the channels.

In general, the reference reaches (Upper Hidden and Lower Hidden) show more adverse effects between 2006 and 2009, in part owing to relatively low flows in these reaches, and in part to natural variability occurring in the watershed.

The four measurements above represent wide-spread changes across all of the different monitoring reaches. A discussion on each individual reach and how it's changed since 2006 is provided below. Since there are only two reference reaches (Upper Hidden and Lower Hidden), they are discussed in relation to the project reaches they most resemble.

Sky Meadows (HVC-1) and Upper Hidden Creek (HDVC-1)
The major changes that have occurred at the Sky Meadows project reach include:

1. Total Wood
2. Mean Entrenchment Ratio
3. Mean Residual Pool Depths
4. Percent Stable/Percent Vulnerable Banks

In 2001, due to ski area management, much of the woody debris had been removed from this disturbed reach (USFS 2001). Since 2001, accumulation of wood within HDVC-1 has increased leading to benefits of increased channel and habitat complexity. This can be seen in the differences in total wood found in the channel between 2006 and 2009. Total wood is significantly higher in 2009 from 2006. In addition to natural woody debris accumulation in the reach, the protocol used in the 2006 monitoring was slightly different than what was used in 2009. This could be a contributing factor for the larger numbers in total wood between the monitoring years.

The mean entrenchment ratio has also increased since 2006. However, inspection of the cross sections indicate very little change in channel width or depth; the primary change is in the definition of the floodprone width at each area. Therefore, much of the change in entrenchment ration appears to be due to observer subjectivity (as discussed in the introduction of this section) rather than a true change to the channel morphology.

The increase in percent stable banks in this project reach since 2006 may be due to more vegetation along the banks of this reach, as well as more woody debris.

The morphology of HVC-1 cross sections surveyed in 2009 is similar to 2006 conditions, although slight changes in morphology are present. These slight changes are due to natural fluctuations in the creek. The channel exhibits evidence of lateral channel migration that is natural for alluvial meadow like channels, whereby bank erosion on one side of the channel is offset by sediment fill on the other. The buried monuments at all stations and the changes in channel shape at all cross sections are evidence of this migration. Average bed elevations are similar at cross sections one (XS-1) and two (XS-2) between 2006 and 2009, which indicates that the channel is not aggrading, degrading, or widening. There is slight aggrading shown in cross section three (XS-3), although the change is less than 0.5 meter on average.

The reference reach Upper Hidden (HDVC-1) was established to be a comparison stream to Sky Meadows (HVC-1). Both channels exhibit characteristics of a “C” type channel. However, the reaches are dissimilar in that the project is known to be a perennial reach while the reference reach is thought to be non-perennial. Since there is no known discharge rates available for the reference reach (due to the remoteness of the site), the flows are not known.

The major changes that have occurred at this reference reach since 2006 include:

1. Total Wood
2. Mean Bankfull Width
3. Mean Width to Depth Ratio
4. Mean Entrenchment Ratio
5. Mean Water Surface Gradient
6. Percent Stable/Vulnerable Banks

Changes in total wood, mean entrenchment ratio and percent of stable/vulnerable banks are discussed generally in the introduction of this section. Since all of these measurements at the reference reach have also increased since 2006, it is not likely that Heavenly Mountain Resort Operations are causing these changes in the project reach (Sky Meadows).

The mean bankfull width and mean width-to-depth ratio are both significantly higher in 2009 than in 2006. This may be an indication of bank erosion occurring at this reach. Channels of the "C" stream type can be significantly altered when the cumulative effects of changes in bank stability, watershed condition, or flow regime exceed the channel stability threshold (Rosgen 1996).

Cross sectional data indicates that a flushing of small gravel size sediment into the reference reach has caused a distinct change in channel morphology, especially in bankfull characteristics. The mean bankfull width is almost half of what it was in 2006, indicating that sediment has been building up in the channel since 2006. Differences in shore depth also echoes possible sediment flush occurring at the reference reach.

Cross section one (XS-1) shows a slight difference in channel morphology between 2001 and 2009. The channel profile for 2006 appears to have been inaccurately measured. This may be due to an unfound monument at cross section one (XS-1) during 2006 field efforts. In 2009 both monuments were located at cross section one (XS-1). Therefore, the 2006 data is being compared only to the 2001 data. The slight changes in profile from 2001 indicate that natural lateral channel migration is occurring.

Cross section three (XS-3) shows aggradation is occurring. The channel morphology has changed significantly since the survey in 2001 and 2006. The channel profile shows that between 2001 and 2006 surveys, the channel morphology hardly changed. In 2009 however, the channel bed has risen approximately 0.30 meters. The changes in channel morphology at cross section three (XS-3) may indicate that sediment may transport is occurring. Future monitoring in 2012 will provide additional insight into the channel's response to the possible sediment transport.

In general, channel changes at the reference reach have been greater, and adverse, compared to the project reaches. This may be in part due to the reference reach becoming ephemeral during the monitoring period, and likely having lower flow to maintain healthy channel conditions. Future monitoring in 2012 will provide additional insight into the channel's response to sediment transport occurring at the reach. Additional monitoring will reveal if the channel is currently in a state of adjustment, and should not be used as an analog for Heavenly Valley Creek or, if the channel returns to stable condition, can continue to be used as a reference reach.

Below Patsy's (HVC-2)

The major changes that have occurred at the Below Patsy's project reach between 2006 and 2009 include:

1. Total Wood
2. Mean Bankfull Width
3. Mean Entrenchment Ratio
4. Mean Pool Length
5. Mean Residual Pool Depth

6. Percent Fines

7. Percent Stable/Vulnerable Banks

Changes in total wood, mean entrenchment ratio, mean residual pool depth and percent of stable/vulnerable banks are discussed generally in the introduction of this section. Since there are no reference reaches that directly correspond to this year or studied reach, it is not clear whether any Heavenly Mountain Resort Operations are causing these minor changes in the project reach (Below Patsy's).

The profiles from 2009 show signs of improvement from the 2006 profiles. Channel beds in all three cross sections have become slightly deeper. The rise in fine sediment in pool tails throughout the reach since 2006, however, may be an indicator that the channel is showing signs of degradation. It is likely that accumulation of fines is a reflection of low flows since the last monitoring, and that higher flows would scour the channel of these materials.

Discharges in Heavenly Valley Creek are influenced by the Sky Meadows Dam, located downstream of the Sky Meadow's monitoring reach. Examination of cross section two (XS-2) shows that the channel morphology has remained similar between 2006 and 2009. The slight flow reduction could affect channel morphology, but the data indicate that any effect is slight.

Property Line (HVC-3) and Lower Hidden (HDVC-2)

The major changes that have occurred at the Property Line project reach between 2006 and 2009 include:

1. Mean Entrenchment Ratio

2. Mean Residual Pool Depth

3. Percent Fines

All three measurements that have changed significantly since 2006 may be due to channel deepening occurring along the monitoring reach. Cross section one (XS-1) and two (XS-2) of the project reach also indicate net deepening since 2006. Both profiles show that the channel has become deeper than it was in 2006, although only slightly. The thalweg in 2006 at cross-section one was at approximately -0.83 relative elevation. In 2009 the thalweg at cross-section one was at approximately -1.0 relative elevation. The thalweg at cross section two (XS-2) changed by -0.1 meter between 2006 and 2009. Cross section three (XS-3), however, indicates net deposition since 2006. The thalweg at cross section three (XS-3) is shallower in 2009 compared to 2006 by approximately 0.2 meter.

Hidden Valley Creek's Lower Hidden reach, HDVC-2, was established in 2001 as a reference site to HVC-3 (Property Line). Both channels exhibit Rosgen "A" type channel characteristics (Rosgen, 1996). This pair of channels makes for a good comparison between a project reach and a reference reach because both reaches have similar gradient, canopy covers, adjacent streamside vegetation types, elevation, and bankfull widths. The major changes that have occurred at this reference reach since 2006 include:

1. Dominant Pebble Class

2. Mean Width-to-Depth Ratio

3. Mean Entrenchment Ratio

4. Mean Pool Length

5. Percent Fines

The reference reach is exhibiting more significant changes in measurements between 2006 and 2009 than the project reach. This indicates that there are natural processes that are causing morphology changes in the creeks around the basin. Like the project reach, the reference reach has had increases in the mean entrenchment ratio and percent fines.

Cross section one (XS-1) and cross section two (XS-2) exhibit little channel morphology change since 2006. The thalwegs at both cross sections are the same for both 2006 and 2009. The slight changes that are present in both cross sections are due to natural processes that are occurring in the creek. Slight changes are also seen in the project reach (Property Line), and are therefore most likely due to natural creek processes.

The most significant change for the cross section three (XS-3) profile, is the absence of a large pile of woody debris located approximately at relative station 2.0. This bump in the channel profile in 2006 was due to a large woody debris pile located in the channel. Since 2006, this pile has diminished in size. The 2009 cross section three (XS-3) channel profile shows a slight bump around station 2.0. The woody debris pile most likely washed out downstream during a high flow event that occurred sometime over the last three years.

Upper Edgewood Creek (EC-1)

After undergoing extensive stream restoration efforts, Upper Edgewood Creek Reach shows no increased degradation from previous resort management activities. This reach shows either unchanged or slightly improved conditions. Continued documented observations will allow for analysis of the effects of the North Bowl Stream Environment Restoration.

The USDA Forest Service SCI protocol version 5.0 provides measures of channel morphology most applicable to low gradient streams (USDA Forest Service 2005). Because most of the reaches evaluated for the Heavenly Monitoring Program are moderate to high gradient streams, not all reaches are suitable for full SCI evaluations. Upper Edgewood, EC-1, should continue with cross section and longitudinal bed profile analysis only.

Restoration completed in 2007 repaired the largest headcuts, which can be seen in the comparison between the 2006 and 2008/2009 profiles. The 2008 and 2009 profiles have a more consistent slope with fewer sharp changes. Some of the step pool morphology was retained from pre-restoration, but the gabions and downed logs in the restored reach provide hard points that should resist down cutting at the most vulnerable points.

The restoration projects completed in 2006 and 2007 should stop or reverse the downcutting and widening of the channel over time. Very little change is observable in all three cross sections. While the early signs point to success, further surveys are necessary to determine the effects of the North Bowl Stream Environment Restoration Project.

Lower Edgewood Creek (EC-2)

After undergoing extensive restoration efforts, Lower Edgewood Creek Reach shows no increased degradation from previous resort management activities. This project site shows either unchanged or slightly improved conditions. Recovery at EC-2 has slowly progressed since the restoration in 2007. Continued documented observations will allow for analysis of the effects of the Lower Edgewood Creek Stream Environment Restoration and the installation of the Edgewood Vault in the Boulder Parking Lot.

The only major change that has occurred since 2006 is the decreased percentage of vulnerable banks in this project reach. In 2006, 40% of the banks observed were considered vulnerable. By 2009, all banks were recorded as stable. This is most likely due to the increased amount of vegetation within the project reach due to restoration activities.

Lower Edgewood Creek's channel morphology is highly influenced by dense riparian vegetation that supplies a large amount of wood to the channel which creates complex channel morphology. The plot for cross section two (XS-2) illustrates banks along the reach being undercut in 2006 and 2008. In 2009, the undercut banks are no longer visible. The graph also indicates that the channel has become narrower since 2009.

Cross section one (XS-1) shows that bed deposition occurred between 2008 and 2009, perhaps due to low flows in 2009 causing sediment buildup in the reach. Since the dominant substrate in EC-2 is sand, it is easily mobilized during low, slow moving flows. Sediment in transport will eventually build up in areas of extremely low, to no flow areas, such as eddies caused by undercut banks.

In 2008, cross section three (XS-3) also showed undercutting along the left bank. This is the most upstream cross section, located directly downstream of the last constructed plunge pool in the Lower Edgewood Restoration Project. In the 2009 section, the undercut bank is no longer visible. This is in accordance with what is occurring in the downstream cross sections. One of the goals of the restoration project was to stop flows from creating headcuts, and therefore reducing the amount of vulnerable banks in the reach. This was achieved by way of slowing flows by creating plunge pools and planting more riparian vegetation. The 2009 data indicates that the restoration project is heading towards success, especially since the number of vulnerable banks has decreased to zero since 2006. Additionally, the cross section profiles show a decrease in undercut banks, meaning that the reach has become more stable. Despite 2009 evidence of improved stream health, future years of monitoring will help confirm the beneficial effects of the restoration.

Upper Daggett Creek (DC-1)

The major changes that have occurred at the Upper Daggett project reach between 2006 and 2009 include:

1. Entrenchment Ratio
2. Mean Residual Pool Depth
3. Percent Stable/Vulnerable Banks
4. Percent Mean Shading

Mean entrenchment ratio, residual pool depth and percent stable/vulnerable banks changes are discussed in the introduction to this section. The percent of mean shading at this project reach has decreased since 2006. This may be a result of trees along the project reach being downed due to natural causes. It was noted that there were more downed trees observed during the 2009 field efforts, than during 2006. This is evident in the amount of total wood recorded in

2006 and 2009. 49 pieces of wood were counted within the bankfull width of this project reach in 2009. In 2006, only 29 pieces were counted. The increase may be due to observer variability, or it may be due to more trees being downed in the area.

The high entrenchment ratio of the channel may be indicative of channel incisement in response to the flows from the East Peak Reservoir. Over-steepening of the banks due to the channel incision could result in future channel widening. As the channel incises, the banks will become more unstable and eventually erode away, causing the channel to widen. More analysis is necessary to determine if this channel response is a result of resort management.

Between 2006 and 2009, little to no changes in entrenchment have occurred at each of the cross sections. Cross section one (XS-1) shows hardly any change in the channel bed since 2006. The banks on either side of the channel have risen since the last monitoring period. Changes in banks may be the result of increased downed wood or vegetation along the banks at cross section one (XS-1).

Lower Daggett Creek (DC-2)

The major changes that have occurred at the Lower Daggett project reach between 2006 and 2009 include:

1. Total Wood
2. Percent Mean Shading

Total wood in the bankfull width of the project reach may be inversely related to the mean percentage of shading in the reach. As the total number of wood increases, the percent shading will decrease. This is event in this project reach. The amount of wood counted in the channel has increased since 2006. Inversely, the mean percent shading has decreased almost by half since 2006.

The higher width to depth ratio of lower Daggett Creek compared to upper Daggett Creek may indicate that the influence of the flow releases at the reservoir are diminished downstream as the channel becomes less incised. This is evident in both the 2006 and 2009 data. More analysis and monitoring are necessary to determine if resort management activities is the cause of the channel response.

Cross section one (XS-1) shows small changes between 2006 and 2009, most notably the change in bank elevations. This may be the result of vegetation debris or downed wood accumulation along the banks because the bed morphology in cross section one (XS-1) appears not to have changed. The largest change between monitoring periods at cross section 2 (XS-2) is the absence of a pronounced rise in elevation change at the right top of bank. This jump in the data was most likely due to a log or other natural debris that has since been dissipated or moved. Cross section two (XS-2) also exhibits narrowing of the channel most likely due to incising from the high flows regulated by the upstream reservoir. Cross section 3 (XS-3) shows little bed morphology changes since 2006. The right bank has decreased in elevation. The cause may be from movement of woody debris on the bank, or bank aggradations.

Mott Creek (MC-1)

The major changes that have occurred at the Mott Creek project reach between 2006 and 2009 include:

1. Total Wood

2. Percent Stable/Vulnerable Banks

The total counted wood in the bankfull width of the project reach has increased since 2006. This may be due to more trees being downed in the project area. Downed trees appeared to have been from natural causes. The field crew did not make any observations that trees had been cut due to Heavenly Mountain Resort's Operations.

The percentage of stable banks decreased from 2006. In 2006 all banks were classified as stable. In 2009 only 77% of the banks were identified as stable. This change is most likely due to the creek being dry during field activities in 2009. The lack of water might have destroyed some of the vegetation that was along the banks during the 2006 field efforts when the channel was flowing. Vegetation is one of the major attributes to a stable channel. Therefore the lack of vegetation due to the lack of water lead to some banks being identified as unstable which were previously stable.

Cross section profiles for Mott Creek show little to no change in reach morphology between monitoring periods. Cross section three (XS-3) indicates the presence of debris along the left bank that was not present in 2006. Woody debris shown in the profile is concurrent with the increase in total wood counted at the site since 2006. The potential for noticeable channel adjustment in Mott Creek is low due to the sediment-poor nature of the steep, confined channel.

Other than some minor changes in measurements between 2006 and 2009 the Mott Creek reach appears to be a stable channel unaffected by resort management activities. Further monitoring of this reach when it is flowing is needed to indicate if any changes to the many measurements not recorded in 2009 have occurred.

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APPENDIX A – RAW DATA FOR WATER QUALITY CONSTITUENTS, WATER YEAR 2008/2009

Table A-1:		Heavenly Mountain Resort water year 2009 water quality monitoring data from station HV-C2, Heavenly Valley Creek below Patsy's Chair. This station is located just beyond ski area development within this watershed at an elevation of 8,000 feet.												
Date	**Time**	**Discharge (cfs)**	**Specific Conductivity (mmhos)**	**Turbidity (ntu)**	**Suspended Sediment (mg/L)**	**Total Nitrite/Nitrate (mg/L)**	**Total Kjeldahl N (mg/L)**	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Soluble Reactive P (mg/L)**	**Chloride (mg/L)**	**Total Iron (mg/L)**	**Average Temperature (Deg C)**	**Precipitation (in)**
Lahontan Standards [1]		N/A	N/A N/A		**60**	N/A	N/A	**0.19**	**0.015**	N/A	**0.15**	**0.03**	N/A	N/A
Fourth Quarter-2008														
081027	1110	0.06	66.4	0.68	0.60	0.061	0.045	0.106	0.015	0.001	**1.80**	**0.075**	7.3	0.0
081124	1112	0.10	82.8	0.40	0.40	0.067	0.038	0.105	**0.017**	0.005	-	-	3.1	0.0
081222	1120	0.15	77.5	0.64	0.27	0.078	0.040	0.118	**0.021**	0.006	-	-	-0.7	0.6
First Quarter-2009														
090126	1105	0.15	75.7	0.63	0.40	0.048	0.038	0.086	**0.030**	0.006	-	-	-8.7	2.1
090317	1100	0.08	64.1	0.85	0.50	0.032	0.150	0.182	**0.019**	0.005	**1.50**	**0.18**	0.9	0.0
Second Quarter-2009														
090413	1100	0.12	49.6	0.76	1.20	0.052	0.089	0.141	**0.030**	0.002	-	-	2.0	0.1
090508	1100	0.94	38.0	3.0	7.6	0.062	0.146	**0.208**	**0.028**	0.004	-	-	6	0
090515	1100	1.25	36.5	1.70	5.60	0.043	0.116	0.159	**0.029**	0.002	-	-	5.9	0
090521	1105	1.76	32.3	1.80	4.00	0.035	0.165	**0.200**	**0.018**	0.003	-	-	9.5	0
090528	1100	1.47	33.5	1.40	3.20	0.032	0.112	0.144	**0.021**	0.002	**0.87**	**0.28**	10.7	0
090609	1100	1.64	27.3	0.81	2.40	0.018	0.114	0.132	**0.018**	0.001	-	-	6.11	0
Third Quarter-2009														
090707	1120	1.2	35.0	0.90	2.40	0.044	0.097	0.141	**0.020**	0.003	**0.82**	**0.2**	10.2	0
090818	1050	0.8	38.5	1.25	2.80	0.053	0.070	0.123	**0.027**	0.002	-	-	14.2	0
090915	1050	0.12	38.2	0.80	2.40	0.033	0.169	**0.202**	**0.030**	0.001	-	-	7	0
Annual Summary	**Minimum**	0.06	27.30	0.40	0.27	0.018	0.038	0.086	0.015	0.001	0.82	0.08	-	-
	Maximum	1.76	82.80	3.00	7.60	0.078	0.169	0.208	0.030	0.006	1.80	0.28	-	-
	Average	**0.70**	**49.67**	**1.12**	**2.41**	**0.047**	**0.099**	**0.146**	**0.023**	**0.003**	**1.25**	**0.18**	**-**	**-**
	Std Error	0.66	19.38	0.68	2.17	0.016	0.048	0.039	0.006	0.002	0.48	0.08	-	-
	90th Percentile		-	-	5.12	-	-	-	-	-	-	-	-	-

[1] Standards are annual averages for the receiving waters of Trout Creek. For suspended sediment, standards are for streams tributary to Lake Tahoe. Suspended sediment concentrations shall not exceed a 90th percentile value of 60 mg/L.

Table A-2:	Heavenly Mountain Resort water year 2009 water quality monitoring data from station HV-C3, Heavenly Valley Creek at the Property Line. This station is located just above the Forest Service property line and subdivision development at an elevation of 6,620 feet.													
Date	**Time**	**Discharge (cfs)**	**Specific Conductivity (mmhos)**	**Turbidity (ntu)**	**Suspended Sediment (mg/L)**	**Total Nitrite/Nitrate (mg/L)**	**Total Kjeldahl N (mg/L)**	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Soluble Reactive P (mg/L)**	**Chloride (mg/L)**	**Total Iron (mg/L)**	**Average Temperature (Deg C)**	**Precipitation (in)**
Lahontan Standards [1]		N/A	N/A N/A		**60**	N/A	N/A	**0.190**	**0.015**	N/A	**0.15**	**0.03**	N/A	N/A
Fourth Quarter-2008														
081027	1230	0.03	48.4	0.50	0.60	0.002	<0.035	0.002	0.015	0.001	**1.70**	**0.070**	7.3	0.0
081124	1210	0.05	45.2	0.32	0.40	0.001	<0.035	0.001	0.014	0.005	**-**	**-**	3.1	0.0
081222	1330	0.05	45.1	0.54	0.40	0.002	<0.035	0.002	**0.020**	0.003	**-**	**-**	-0.7	0.6
First Quarter-2009														
090126	1205	0.12	43.0	0.71	0.27	0.001	0.043	0.044	**0.023**	0.003	-	-	-8.7	2.1
090317	1228	0.09	42.4	0.65	0.40	0.001	0.041	0.042	**0.017**	0.006	**1.60**	**0.09**	0.9	0.0
Second Quarter-2009														
090413	1210	0.16	42.9	0.32	1.20	0.001	0.073	0.074	**0.0185**	0.004	-	-	2.0	0.1
090508	1215	0.37	39	1.1	2.60	0.005	0.073	0.078	**0.018**	0.005	-	-	6	0
090515	1225	2.83	37.6	1.10	2.80	0.006	0.087	0.093	**0.025**	0.001	-	-	5.9	0
090521	1205	1.6	35.0	1.60	4.80	0.008	0.111	0.119	**0.0285**	0.004	-	-	9.5	0
090528	1155	0.45	36.9	1.2	3.60	0.007	0.091	0.098	**0.019**	0.003	**0.93**	**0.12**	10.7	0
090609	1220	0.58	32.2	0.91	2.40	0.004	0.061	0.065	**0.019**	0.001	-	-	6.11	0
Third Quarter-2009														
090707	1400	0.09	39.2	0.86	2.20	0.003	0.068	0.071	**0.019**	0.006	**0.85**	**0.07**	10.2	0
090818	1212	0.03	48.5	0.45	0.80	0.004	0.061	0.065	**0.023**	0.003	-	-	14.2	0
090915	1115	0.02	50.2	0.83	3.60	0.001	0.088	0.089	**0.030**	0.004	-	-	7	0
Annual Summary	**Minimum**	0.02	32.20	0.32	0.27	0.00	0.04	0.001	0.014	0.001	0.85	0.07	-	-
	Maximum	2.83	50.20	1.60	4.80	0.01	0.11	0.119	0.030	0.006	1.70	0.12	-	-
	Average	**0.46**	**41.83**	**0.79**	**1.86**	**0.003**	**0.072**	**0.060**	**0.021**	**0.004**	**1.27**	**0.09**	**-**	**-**
	Std Error	0.80	5.40	0.37	1.48	0.00	0.02	0.038	0.005	0.002	0.44	0.02	-	-
	90th Percentile		**-**	**-**	3.6	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

[1] Standards are annual averages for the receiving waters of Trout Creek. For suspended sediment, standards are for streams tributary to Lake Tahoe. Suspended sediment concentrations shall not exceed a 90th percentile value of 60 mg/L.

Table A-3: Heavenly Mountain Resort water year 2009 water quality monitoring data from station HV-C4, Bijou Park Creek below California Parking Lot. This station is located 1/4 miles below the culvert outlet draining the parking lot off of Wildwood Avenue at an elevation of 6,530 feet.

Date	Time	Discharge (cfs)	Specific Conductivity (mmhos)	Turbidity (ntu)	Suspended Sediment[1] (mg/L)	Total Nitrite/ Nitrate (mg/L)	Total Kjeldahl N (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Soluble Reactive P (mg/L)	Chloride[1] (mg/L)	Oil and Grease (mg/L)	Total Iron (mg/L)	Total Lead (mg/L)	Dissolved Ammonia NH4 (mg/L)	Temp (C)	pH	TPH (mg/L)	Average Temperature (Deg C)	Precipitation (in)
Lahontan Standards[2]		N/A	N/A	**20.0**	**65**	N/A	N/A	**0.5**	**0.1**	N/A	**3.0**	**2.0**	**0.5**	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fourth Quarter-2008												.								
081027	1140	0.02	400.0	4.8	6.00	0.042	1.156	1.198	**4.993** [3]	4.883	**58.0**	**2.5**	**2.1**	<0.0025	0.003	-	-	ND	7.3	0.0
081124	1140	0.07	362.0	9.3	3.20	0.292	0.266	0.558	0.041	0.006	**59.0**	<1.5	-	<0.010	0.084	-	-	ND	3.1	0.0
081222	1230	0.03	630.0	9.1	9.60	0.240	0.225	0.465	0.042	0.004	**160.0**	**2.4**	-	<0.010	0.065			ND	-0.7	0.6
First Quarter-2009																				
090122 [4]	0845	0.40	902.0	350.0	230.00	0.286	1.780	**2.066**	**0.930**	0.003	**280.0**	**11.0**	**3.3**	<0.010	0.036	-	-	ND	3.1	0.0
090127	1120	0.06	590.0	9.8	2.40	0.468	0.296	**0.764**	0.062	0.001	**150.0**	<1.5	-	<0.010	0.112	-	-	ND	-10.1	0.0
090223 [4]	0930	0.98	1368.0	978.0	823.33	0.038	3.005	**3.043**	**2.717**	0.002	**430.0**	**31.0**	**4.6**	<0.010	0.023	-	-	ND	0.8	0.4
090302 [4]	0930	0.92	284.0	45.0	126.67	0.056	0.220	0.276	**0.404**	0.007	**74.0**	**5.4**	**4.6**	<0.010	0.004	-	-	ND	1.0	1.4
090317	1140	0.28	420.0	19.0	24.00	0.226	0.358	**0.584**	**0.104**	0.002	**110.0**	1.1	**2.6**	<0.010	0.048	-	-	ND	0.9	0.0
Second Quarter-2009																				
090413	1130	0.16	388.0	8.41	7.91	0.328	0.282	**0.610**	0.100	0.013	**90.0**	<1.0	**2.5**	<0.010	0.106	-	-	ND	2.0	0.1
090508	1145	0.09	395.0	11.0	9.20	0.477	0.227	**0.704**	0.054	0.012	**91.0**	<1.0	-	<0.010	0.105	-	-	ND	6	0
090515	1130	0.06	441.0	10.0	9.60	0.519	0.315	**0.834**	0.085	0.006	**110.0**	<1.0	-	<0.010	0.099	-	-	ND	5.9	0
090521	1135	0.12	433.0	10.1	6.00	0.494	0.206	**0.700**	0.069	0.009	**100.0**	<1.0	-	<0.010	0.116	-	-	ND	9.5	0
090528	1125	0.05	431.0	11.2	6.40	0.493	0.220	**0.713**	0.057	0.011	**100.0**	1.1	**6.8**	<0.010	0.099	-	-	ND	10.7	0
090609	1130	0.03	392.0	9.15	8.80	0.455	0.332	**0.787**	0.080	0.014	**94.0**	**2.6**	-	<0.010	0.102	-	-	ND	6.11	0
Third Quarter-2009																				
090707	1200	0.01	363.0	10.00	8.00	0.590	0.173	**0.763**	0.061	0.002	**76.0**	<1.0	**3.0**	<0.010	0.077			ND	10.2	0
090818	1120	0.06	286.0	8.75	7.20	0.343	0.124	0.467	0.055	0.005	**54.0**	<1.0	-	<0.010	0.048			ND	14.2	0
090915	1150	0.02	283.0	4.92	3.20	0.296	0.097	0.393	0.050	0.003	0.4	<1.0	**1.5**	<0.010	0.069			ND	7	0
Annual Summary	**Min**	0.01	283.00	4.80	2.40	0.038	0.097	0.276	0.041	0.001	0.44	1.00	1.50	0.00	0.00	-	-	-	-	-
	Max	0.98	1368.00	978.00	823.33	0.590	3.005	3.043	2.717	0.014	430.00	31.00	6.80	0.00	0.12	-	-	-	-	-
	Mean	**0.20**	**492.24**	**88.74**	**75.97**	**0.332**	**0.546**	**0.878**	**0.307**	**0.006**	**119.79**	**3.95**	**3.44**	**-**	**0.07**	**-**	**-**	**-**	**-**	**-**
	Std Error	0.30	271.65	243.49	201.55	0.173	0.764	0.686	0.681	0.004	99.34	7.41	1.63	-	0.04	-	-	-	-	-
	90th Percentile		-	-	**168.00**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ND=Non-detect

[1] Chloride standards are from Table 3, LRWQCB WDID No. 6A090033000 (Lake Tahoe Receiving Water Limits). Total Dissolved Solids shall not exceed the 90th percentile.

[2] Standards are maximum concentration for discharge to surface waters, effective November 30, 2008. Suspended Sediment Limits based on the 90th Percentile of receiving waters to Lake Tahoe.

[3] The phosphorus level measured on 10/27/08 was likely due to a sampling error and will not be included in annual statistics.

[4] Storm Event

Table A-4:	Heavenly Mountain Resort water year 2009 water quality monitoring data from station HV-H5, Hidden Valley Creek baseline station. This station is located just above the confluence with Trout Creek, at an elevation of 6,680 feet.													
Date	**Time**	**Discharge (cfs)**	**Specific Conductivity (mmhos)**	**Turbidity (ntu)**	**Suspended Sediment (mg/L)**	**Total Nitrite/Nitrate (mg/L)**	**Total Kjeldahl N (mg/L)**	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Soluble Reactive P (mg/L)**	**Chloride (mg/L)**	**Total Iron (mg/L)**	**Average Temperature (Deg C)**	**Precipitation (in)**
Lahontan Standards[1]		N/A	N/A	**20**	**60**	N/A	N/A	**0.19**	**0.015**	N/A	**0.15**	**0.03**	N/A	N/A
Fourth Quarter-2008														
081027	1445	0.46	56.8	0.57	0.40	0.005	0.154	0.159	**0.025**	0.006	**2.3**	**0.03**	7.3	0.0
081124	1350	0.24	57.8	0.50	0.40	0.001	0.056	0.057	**0.019**	0.010	**-**	**-**	3.1	0.0
081222	1520	0.26	59.8	0.65	0.40	0.003	0.049	0.052	**0.024**	0.008	**-**	**-**	-0.7	0.6
First Quarter-2009														
090126	1405	0.25	59.4	0.98	1.20	0.011	0.072	0.083	**0.032**	0.009	-	-	-8.7	2.1
090302 [2]	1130	0.79	52.8	6.10	4.80	0.013	0.220	**0.233**	**0.042**	0.017	<1.0	**0.44**	1.0	1.4
090317	1406	0.45	62.0	0.83	0.40	0.008	0.097	0.105	**0.027**	0.011	<1.0	0.10	0.9	0.0
Second Quarter-2009														
090413	1330	0.590	60.0	0.99	1.40	0.018	0.149	0.167	**0.021**	0.009	-	-	2.0	0.1
090508	1410	0.42	42.3	2.20	4.40	0.012	0.141	0.153	**0.025**	0.008	-	-	6	0
090515	1400	1.5	31.9	1.70	5.60	0.010	0.150	0.160	**0.030**	0.010	-	-	5.9	0
090521	1335	3.65	22.1	2.50	11.20	0.008	0.205	**0.213**	**0.046**	0.007	-	-	9.5	0
090528	1330	1.69	20.5	1.80	7.20	0.003	0.148	0.151	**0.031**	0.005	**0.41**	**0.27**	10.7	0
090609	1345	1.08	22.0	0.74	1.20	0.001	0.072	0.073	**0.022**	0.002	-	-	6.11	0
Third Quarter-2009														
090707	1540	0.34	29.9	0.64	3.20	0.001	0.061	0.062	**0.026**	0.008	**0.40**	**0.08**	10.2	0
090818	1405	0.18	40.5	0.60	2.00	0.010	0.046	0.056	**0.024**	0.008	-	-	14.2	0
090915	1400	0.17	50.8	0.55	1.20	0.009	0.063	0.072	**0.035**	0.008	-	-	7	0
Annual Summary	**Minimum**	0.17	20.50	0.50	0.40	0.001	0.046	0.052	0.019	0.002	0.40	0.03	-	-
	Maximum	3.65	62.00	6.10	11.20	0.018	0.220	0.233	0.046	0.017	2.30	0.44	-	-
	Average	**0.80**	**44.57**	**1.42**	**3.00**	**0.008**	**0.112**	**0.120**	**0.029**	**0.008**	**1.02**	**0.18**	**-**	**-**
	Std Error	0.92	15.62	1.45	3.13	0.005	0.058	0.060	0.008	0.003	0.77	0.17	**-**	**-**
	90th Percentile		**-**	**-**	6.56	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

[1] Standards are annual averages for the receiving waters of Trout Creek. For Suspended Sediment, standards are for streams tributary to Lake Tahoe. Suspended Sediment concentrations shall not exceed a 90th

[2] Storm Event

Table A-5:		Heavenly Mountain Resort water year 2009 water quality monitoring data from station HV-E1, Edgewood Creek above Boulder Parking Lot. This station is located in Edgewood Bowl above the learn-to-ski center, at an elevation of 7,280 feet.											
Date	**Time**	**Discharge (cfs)**	**Specific Conductivity (mmhos)**	**Turbidity (ntu)**	**Suspended Sediment (mg/L)**	**Total Nitrite/Nitrate (mg/L)**	**Total Kjeldahl N (mg/L)**	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Soluble Reactive P (mg/L)**	**Dissolved P(mg/L)**	**Average Temperature (Deg C)**	**Precipitation (in)**
NDEP Standards[1]		N/A	N/A	**10**	**25.00**	N/A	N/A	**0.6 [2]**	**0.1**	N/A	N/A	N/A	N/A
Fourth Quarter-2008													
no samples taken; low flow or no flow													
First Quarter-2009													
no samples taken; low flow or no flow													
Second Quarter-2009													
090413	1520	0.24	74.1	6.5	20.77	0.002	0.191	0.19	**0.118**	0.001	-	2.0	0.1
090501 [3]	1500	1.18	63.3	4.5	11.33	0.003	0.191	0.19	0.077	0.003	-	6	0
090508	1545	0.14	57.1	1.8	3.2	0.001	0.084	0.09	0.031	0.002	-	5.9	0
090515	1515	0.18	64.8	1.5	2.00	0.002	0.109	0.11	0.025	0.004	-	9.5	0
90521	1500	0.02	70.1	1.4	2.8	0.001	0.094	0.10	0.027	0.005	-	10.7	0
Third Quarter-2009													
no samples taken; low flow or no flow													
Annual Summary	**Minimum**	0.02	57.10	1.40	2.00	0.001	0.084	0.09	0.025	0.001	0.00	-	-
	Maximum	1.18	74.10	6.50	20.77	0.003	0.191	0.19	0.118	0.005	0.00	-	-
	Average	**0.35**	**65.88**	**3.14**	**8.02**	**0.002**	**0.134**	**0.14**	**0.056**	**0.003**	**-**	**-**	**-**
	Std Error	0.44	27.52	2.40	7.92	0.001	0.072	0.07	0.043	0.002	-	-	-

[1] NDEP Standards are from the Nevada Administrative Code (NAC) Chapter 445A.1915. All listed numbers are standards for single values no greater than a given parameter unless otherwise noted.
[2] Annual Average
[3] Storm Sample

Table A-6:	Heavenly Mountain Resort water year 2009 water quality monitoring data from station HV-E2, Edgewood Creek below Boulder Parking Lot. . This station is located 1/4 mile below the parking lot, underneath the power lines at an elevation of 7,120 feet.											
Date	**Time**	**Discharge (cfs)**	**Specific Conductivity (mmhos)**	**Turbidity (ntu)**	**Suspended Sediment (mg/L)**	**Total Nitrite/Nitrate (mg/L)**	**Total Kjeldahl N (mg/L)**	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**Soluble Reactive P (mg/L)**	**Dissolved P (mg/L)**	**Average Temperature (Deg C)**	**Precipitation (in)**
NDEP Standards[1]		N/A	N/A	**10.0**	**25.0**	N/A	N/A	**0.6 [2]**	**0.1**	N/A	N/A	N/A	N/A
Fourth Quarter-2008													
081027	1555	0.06	128.2	0.7	1.2	0.019	0.064	0.083	0.018	0.001	-	7.3	0.0
081124	1505	0.10	125.4	3.1	9.2	0.040	0.162	0.202	0.016	0.003	-	3.1	0.0
081223	0935	0.01	127.5	1.4	5.6	0.042	0.114	0.156	0.019	0.001	-	-0.7	0.6
First Quarter-2009													
090126	1605	0.12	145.4	1.8	2.4	0.077	0.109	0.186	0.033	0.001	-	-8.7	2.1
Second Quarter-2009													
090413	1500	0.44	113.4	**15.0**	**28.2**	0.054	0.331	0.385	0.088	0.003	-	2.0	0.1
090501 [3]	1440	0.88	81.3	**22.0**	**82.0**	0.042	0.339	0.381	**0.141**	0.003	-	6	0
090508	1522	0.14	87.3	5.6	8.4	0.03	0.143	0.173	0.036	0.003	-	5.9	0
090515	1500	0.17	102.5	3.5	6.8	0.031	0.240	0.271	0.044	0.005	-	9.5	0
090521	1445	0.05	114.4	2.4	4.4	0.035	0.178	0.213	0.034	0.005	-	10.7	0
Third Quarter-2009													
no samples taken; low flow or no flow													
Annual Summary	**Minimum**	0.01	81.30	0.65	1.20	0.019	0.064	0.083	0.016	0.001	0.000	-	-
	Maximum	0.88	145.40	22.00	82.00	0.077	0.339	0.385	0.141	0.005	0.000	-	-
	Average	**0.22**	**113.93**	**6.16**	**16.47**	**0.041**	**0.187**	**0.228**	**0.048**	**0.003**	**-**	**-**	**-**
	Std Error	0.27	40.96	7.20	24.91	0.020	0.109	0.119	0.042	0.002	-	-	-

[1] NDEP Standards are from the Nevada Administrative Code (NAC) Chapter 445A.1915. All listed numbers are standards for single values no greater than a given parameter unless otherwise noted.

[2] Annual Average

[3] Storm Sample

APPENDIX B – BMP EFFECTIVENESS MONITORING
(See Appendix I)

APPENDIX C – ANNUAL WORK LIST
(See Appendix VI)

HEAVENLY MOUNTAIN RESORT
2010 ANNUAL CWE PROJECT & WORK LIST
February 4, 2010

Project #	Source*	Location	Treatment
Watershed: CA-1 Heavenly Valley Creek			
1	M	Gondola Top Station	Refurbish existing infiltration basin and improve drainage to maintain effectiveness.
2	M	Groove Upper Terminal	Improve soil cover to stabilize steep slope and redirect runoff to channel and infiltration area.
3	P	Lakeview Water System	Remove old tank. Decommission old tank site and road to tank.
4	M	Upper Vehicle Maintenance Shop	Confirm effectiveness of stabilization work on gully above SEZ restoration site.
5	M	Zipline Base Station	Confirm effectiveness of existing soil cover and add cover beneath operator's booth.
Watershed: NV-3 Edgewood Creek			
6	B	Boulder Lift Upper Terminal	Install infiltration areas and improve effective cover around terminal.
7	B	Boulder Lift Upper Terminal	Install infiltration areas and improve effective cover around terminal.
8	P	Olympic Express Lift Lower Terminal	Stabilize area with bare soil below access road to terminal.
Watershed: NV-2 + 5 Daggett Creek			
9	P	East Peak Grading Area	Complete drainage and stabilization measures initiated for the area between Comet and Dipper Lift Lower Terminals.
10	B	East Peak Lodge	Stabilize driplines and drainage swales near foundation of building.
11	M	East Peak Well	Stabilize slope between road and well house.
Resort Wide			
12	M	Resort-Wide	Install and maintain closure signs on Ellie's Swing Trail, Betty's Return Trail, Powderbowl tower road, Lower Cal Trail below Hellwinkle's trail, East Peak Dam Road and West Round-a-bout
13	M	Resort-Wide	Develop a process to treat priority areas with long-term soil cover needs on ski runs and to identify and perform road maintenance needs. Note: This replaces the treatment listed in previous Annual CWE Work Lists as "Reseed and fertilize degenerating grassy areas on +/- 1/5th of ski runs

			(all runs are reviewed/reseeded over 5 years)"
14	M	Resort-Wide	Inspect and restore all areas damaged affected by winter resort operations, including hydrants & pipe failures, and areas affected by snowcat operations; document areas treated.
15	M	Resort-Wide	Erect and maintain vehicles barriers and/or fences to prevent unauthorized vehicle access off of designated summer roads and facility parking areas.
16	M	Resort-Wide	Inspect and maintain all drainage structures.
17	M	Base Areas	Erect and maintain vehicle barriers and/or fences to prevent unauthorized vehicle access from base areas.
***Source Codes**			
	M B P MMP	Maintenance Needed Project need determined from BMP Effectiveness Monitoring Master Plan Development Project Master Plan Monitoring & Mitigation Plan Requirement	

Appendix D – Summary of Deicer Application and Recovery in Water Year 2008/2009

Appendix D
Summary of Deicer Application and Recovery for Water Year 2009

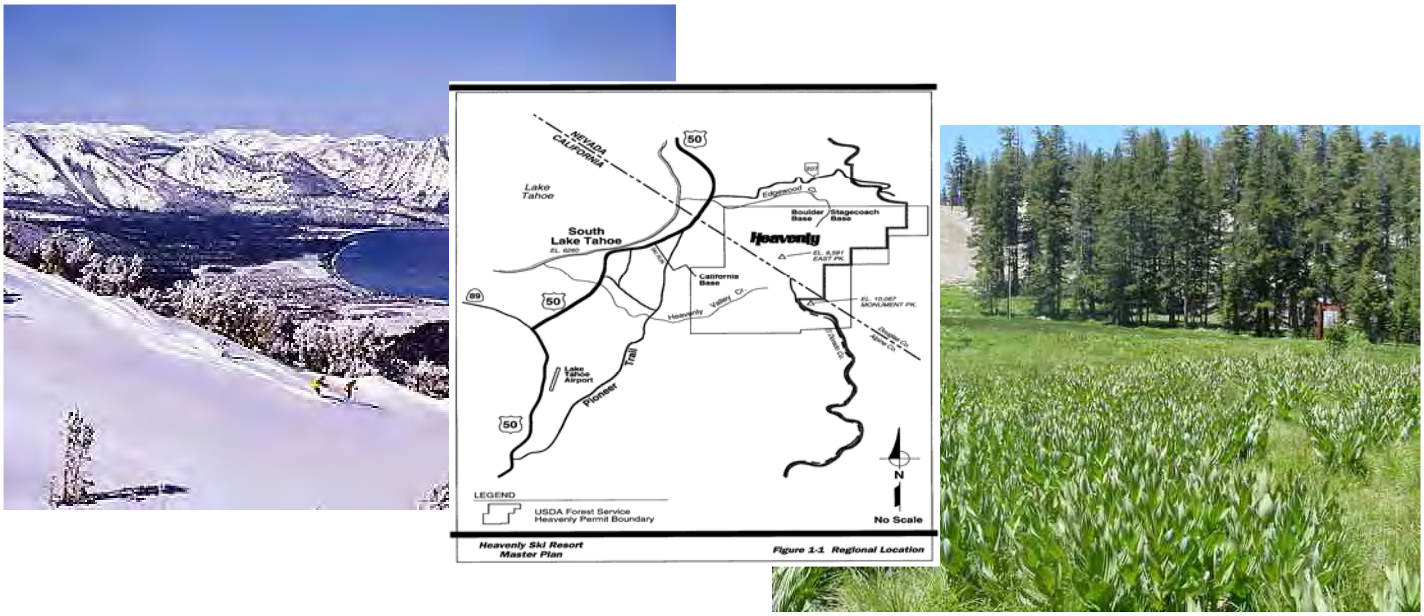
Monthly Breakdown for WY 2009		
Month/Year	**Total Amount of Deicers and Abrasives Applied (lbs)**	**Total Amount of Deicers and Abrasives Recovered (lbs)**
Oct-08	0	0
Nov-08	0	0
Dec-08	5,220	0
Jan-09	3,800	0
Feb-09	3,800	0
Mar-09	4,500	11,980
Apr-09	0	0
May-09	0	0
Jun-09	0	0
Jul-09	0	50,880
Aug-09	0	0
Sep-09	0	0

Summary for WY 2009	
Deicers and Abrasives Applied (lbs)	**17,320**
Deicers and Abrasives Recovered (lbs)	**62,860**
Percent Recovered [1]	**363%**

[1] This value is above and beyond 100%, because sweeping accounts for all particles collected off of the roadway. Vehicular traffic adds additional material that is collected.

APPENDIX E – EFFECTIVE SOIL COVER WORKPLAN

Heavenly Mountain Resort
Effective Soil Cover Workplan
2008



Prepared by:

Entrix, Inc.
1048 Ski Run Boulevard
South Lake Tahoe, CA 96150

June 30, 2008

Resource Interest:

Soil Cover, Soil Conditions, Fine Sediment (<20 micron), Slope Stability, Sediment Influx to Lake Tahoe

Management Goals and Objectives:

1. Maintain and restore soils with favorable infiltration characteristics and diverse vegetative cover to absorb and filter precipitation and to sustain favorable conditions of stream flows.

Monitoring Objective(s):

1. Determine if changes in cover result in changes in runoff and sediment volume from ski runs and other project infrastructure.

2. Evaluate utilization of soil amendments/treatments to increase infiltration capacity for those areas resistant to revegetation efforts, or where revegetation is ineffective.

Project Nexus:

According to the results of the Bailey Land Capability Classification (1974), most of Heavenly Mountain Resort's land is classified as High Hazard for erosion (Class 1A). Construction, operation, and maintenance of ski runs, roads, and other infrastructure can therefore lead to excessive erosion. Operations on volcanic soils can lead to erosion of fine (<20 micron) soils that are of particular concern to water clarity in Lake Tahoe.

Monitoring Methods:

These methods are derived from the Vegetation Rapid Assessment Protocol (VRAP) Developed by the CNPS (CNPS 2004). The VRAP is a semi-quantitative method of vegetation and habitat sampling. Quantitative vegetation and site data recorded include, but are not limited to: topography, soil, rock and litter (size and percent cover), vegetation association and alliance (following Sawyer and Keeler-Wolf 1995), and vegetation cover (by percent cover, stratum and species). These data are not based on established test plots, but on a broader scale unit that is appropriate for the vegetation type found on the landscape. This judgment is made by the experienced practitioner conducting the measurements. This method allows enough flexibility to respond to site-specific attributes of the areas, combined with enough quantitative observation to allow comparison between years. The method is augmented with the establishment of permanent photo points to better track variability over time. The measurements will be conducted over time, and the trends will be analyzed to meet the ESC study objectives.

1. In 2008, approximately twenty-five sites will be selected on Heavenly Mountain Resort. Sites will be selected to include a representative sample of ski run slopes,

aspects, and soil types, as well as the erosion control treatment methods applied up to the present. See Appendix A for preliminary list of selected sites.

2. A permanent photo point or points will be selected and established at each site and its coordinates will be recorded using a GPS unit. Surveyors will visit the established photo points annually to reassess the effective soil cover (ESC) as described in step 3 below, and to take an updated photo.

3. A survey team, which must include at least one biologist with experience in botany and soil cover estimation, will visit each established photo point and perform the ESC field analysis on one landscape unit (between ¼ acre and 1 acre in size). Initially, the size of the landscape unit will be estimated as an area that received a certain type of treatment to abate erosion. The field crew will finalize the boundaries of each selected site in the field using visual boundaries of soil cover types and practical boundaries of the photo point.

4. The survey crew will assess the site's soil cover using the field form, Appendix B. They will also take a photo from the established photo point, recording the bearing of the camera towards the slope. The area of the photograph will be recorded using a long tape measure for length and camera zoom information for width.

5. The data will be recorded into a Microsoft Excel database. The sites will be revisited, reassessed, and photographed annually for the duration of the 5-year Mitigation and Monitoring Plan. Percentages of effective soil cover and eroded areas for each site will be recorded and reported annually along with qualitative observations made by the field crew.

6. Using the physical characteristics of the ski run and the applied treatment types, the results for the twenty-five selected sites can be extrapolated to other areas on Heavenly. A comparative analysis will be conducted, with a focus on explaining areas resistant to establishing effective soil cover.

Reporting

The ESC Report will be included in the Annual Report of the year it is completed. The contents of the report will include a description of methods, results, and discussion. The discussion will focus on observed trends and their significance with respect to project related effects. The report will identify areas resistant to vegetation efforts and propose additional efforts that could improve revegetation. The report will also include recommendations for future monitoring and management.

Schedule

ESC and photo point monitoring will occur in July 2008.

The results of the ESC and photo point monitoring will be summarized in the annual report in February 2009.
Subsequent ESC and photo point monitoring will occur either annually during the summers of 2009, 2010, 2011, and 2012 or once, at the culmination of the five-year Mitigation and Monitoring Plan.

Literature Cited

California Native Plants Society (CNPS). 2004. California Native Plant Society - Vegetation Rapid Assessment Protocol CNPS Vegetation Committee. Revised September 20, 2004. Available at: http://www.cnps.org/cnps/vegetation/pdf/rapid_assessment_protocol.pdf

Sawyer, J.O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society. Sacramento, California.

State Water Resources Control Board, 2001. Stream Photo Documentation Procedure. Standard Operating Procedure 4.2.1.4.

APPENDIX A

Sites Selected for Analysis

Landscape Unit	Ski Run Name
1	First Ride
2	World Cup
3	Gunbarrel
4	Pistol
5	Powderbowl
6	Groove
7	Pioneer Poma
8	Waterfall
9	Upper Mombo
10	Lower Ridge
11	Ellie's Swing
12	Liz's
13	Ellie's
14	Edgewood Meadow
15	North Bowl or Bohemain Grove
16	Boulder Chute
17	Lower Olympic
18	Cloud Nine
19	The Pines
20	Gondola Line
21	Cascade
22	Easy Street
23	Rope Tow Area near Big Easy and Gondola
24	Double Down/ Lower High Roller
25	Lower Cal Trail
26	Sky Canyon*

*Sky Canyon will be substituted if construction is occuring on any site or if the vegetation specialist deems it necessary

APPENDIX B

Field Form

HEAVENLY MOUNTIAN RESORT - VEGETATION RAPID ASSESSMENT FIELD FORM

Landscape Unit:	Ski Run Name:	Map Number:	Date:	Time:	Surveyors Names:

Description of photo point location:	Photo Point Marker (rebar?, nail, cap color?)

Camera Zoom:	Sample Area Width (ft):	Sample Area Length (ft):	Total Sample Area (sq ft)
GPS waypoint #:	GPS name:	GPS datum:	GPS Error: (± ft/m)

Elevation (ft):	Photograph #'s:

Topography: convex____ flat____ concave____ undulating____	Slope Exposure (circle or enter actual exposure): NE____ NW____ SE____ SW____ Flat__ Variable__

Slope Steepness (circle or enter actual exposure):
0º__ 1-5º _____ 5-25º_____ > 25º_____ Upland or Wetland/Riparian (circle one)

Geology:	Soil Texture:	TRPA Land Capability	TRPA Soil Type (see map)

Site history, disturbance, and comments:

Existing manmade erosion features (circle or list):
Water bars Downed Timber Drain Rock Rock Lined Channel Grass Lined Swale
Revegetation EC Blanket Coir logs/Wattles Gabions Mulch Other ____________________
Comments:

Existing signs of erosion (gullies or rills)	Approximate Area (sq ft)

Rock (% cover):
Bedrock ____ >12" diameter ____ 6"-12" diameter ____ 3"-5" diameter ____ 3/4"-3" diameter ____

Duff Cover (%)	Litter Cover (%)	Large Downed Wood (%)	Total Organic Matter (%)

Tree (Circle Avg. dbh): T1 (<1" dbh), T2 (1-6" dbh), T3 (6-11" dbh), T4 (11-24" dbh), T5 (>24" dbh), T6 multi-layered
If Tree, list 1-3 dominant overstory spp.:

Shrub: S1 seedling (<3 yr. old), S2 young (<1% dead), S3 mature (1-25% dead), S4 decadent (>25% dead)

Herbaceous: H1 (<12" plant ht.), H2 (>12" ht.)

Conifer Cover (% overstory)	Shrub Cover (%)	Herbaceous Cover (%)	Mosses/ Lichens (%)
Overstory Conifer height:	Tall Shrub height	Low Shrub height	Herbaceous height

Height classes: 01=<1/2m 02=1/2-1m 03=1-2m 04=2-5m 05=5-10m 06=10-15m 07=15-20m 08=20-35m 09=35-50m 10=>50m

Species (List up to 12), Stratum, and Approximate % cover: (Jepson Manual nomenclature please)
Stratum category: T=tall, M=med, L=low; *% cover intervals for reference:* <1%, 1-5%, >5-15%, >15-25%, >25-50%, >50-75%, >75%

Strata	Species	% cover	Strata	Species	% cover

Major non-native species and % cover:

Unusual species:

Sum of Percentages of Rock, Organic Matter, and Vegetation Cover:

Confidence in identification: (L, M, H)	Explain:

Other identification problems (describe):

APPENDIX F – FACILITIES AND WATERSHED AWARENESS

The facilities and awareness letter was submitted June 15th, 2009.

Heavenly
LAKE TAHOE

June 15, 2009

Mr. Bud Amorfini
Environmental Scientist
State of California Regional Water Quality Control Board Lahontan Region
2501 Lake Tahoe Boulevard
South Lake Tahoe, CA 96150

Dear Mr. Amorfini:

HEAVENLY SKI RESORT UPDATED WASTE DISCHARGE REQUIREMENTS BOARD ORDER NO. R6T-2003, WDID NO. 6A090033000 – VERIFICATION OF FACILITIES AND WATERSHED AWARENESS TRAINING

This letter verifies the 2009 Facilities and Watershed Awareness training that was held at Heavenly Mountain Resort on June 8, 2009. A copy of the agenda and attendance list is attached.

Thank you for attending the meeting and speaking on behalf of your organization. Please contact me at (775) 586-2313 if you have further questions.

Sincerely,

Andrew Strain

Andrew Strain
Vice President of Planning & Governmental Affairs

/as

Enclosures

cc: Mike Guarino, USDA Forest Service Lake Tahoe Basin Management Unit

P.O. Box 2180
Stateline NV 89449
775/586-7000
www.skiheavenly.com

Appendix V

2008-2009 Daggett Creek Monitoring

March 17, 2010

Sent Via E-mail

Mr. Andrew Strain
HEAVENLY MOUNTAIN RESORT
P.O. Box 2180
Stateline, Nevada 89449

Re: Daggett Flow for the 2009 Water Year

Dear Mr. Strain:

Resource Concepts, Inc., periodically downloads the data and maintains the gauge on Daggett Creek. Data was downloaded from the gauge twice during the 2009 water year (on June 2 and October 27). Figures 1 and 2 are graphs of the pressure transducer readings and the corresponding estimated discharge.

The gauge on Daggett Creek consists of a pressure transducer mounted in a perforated pipe at a confined natural section of Daggett Creek installed in 2004. When we check the gauge, RCI also makes stream discharge measurements to develop a relationship between pressure, depth, and stream discharge. Lower base flow is typically too shallow for a propeller type discharge meter, so a portable 60 degree v-notch weir is used to measure flow. For higher flows, we use a Swoffer (propeller type) flow meter to measure discharge. A rating curve has been developed from the in-stream measurements collected from 2005 through 2009 to estimate discharge from the pressure transducer readings recorded by the gauge.

As noted in previous reports, the pressure transducer gauge provides a relative indication of water depth in Daggett Creek below East Peak Lake. However, the correlation to discharge is not very accurate particularly in the range of 0.1 to 0.4 cfs. This is primarily due to the minimal flow depth and irregular cross section of the natural stream channel. If more accurate in-stream discharge measurements are needed, a permanent cross section (flume or V-notch weir) and a barometric pressure adjusted pressure transducer could be installed. However, this would require disturbance of the stream channel for construction and would still present maintenance concerns during the winter months.

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340 N. Minnesota Street • Carson City, NV 89703
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ZEPHYR COVE OFFICE
P.O. Box 11796 • Zephyr Cove, Nevada 89448
office: 775-588-7500 • fax: 775-589-6333

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Please feel free to contact me with any comments or questions.

Sincerely,

Jill Sutherland

Jill Sutherland, P.E.
Project Manager

Attachments

Figure 1. Daggett Creek Transducer Readings 2009

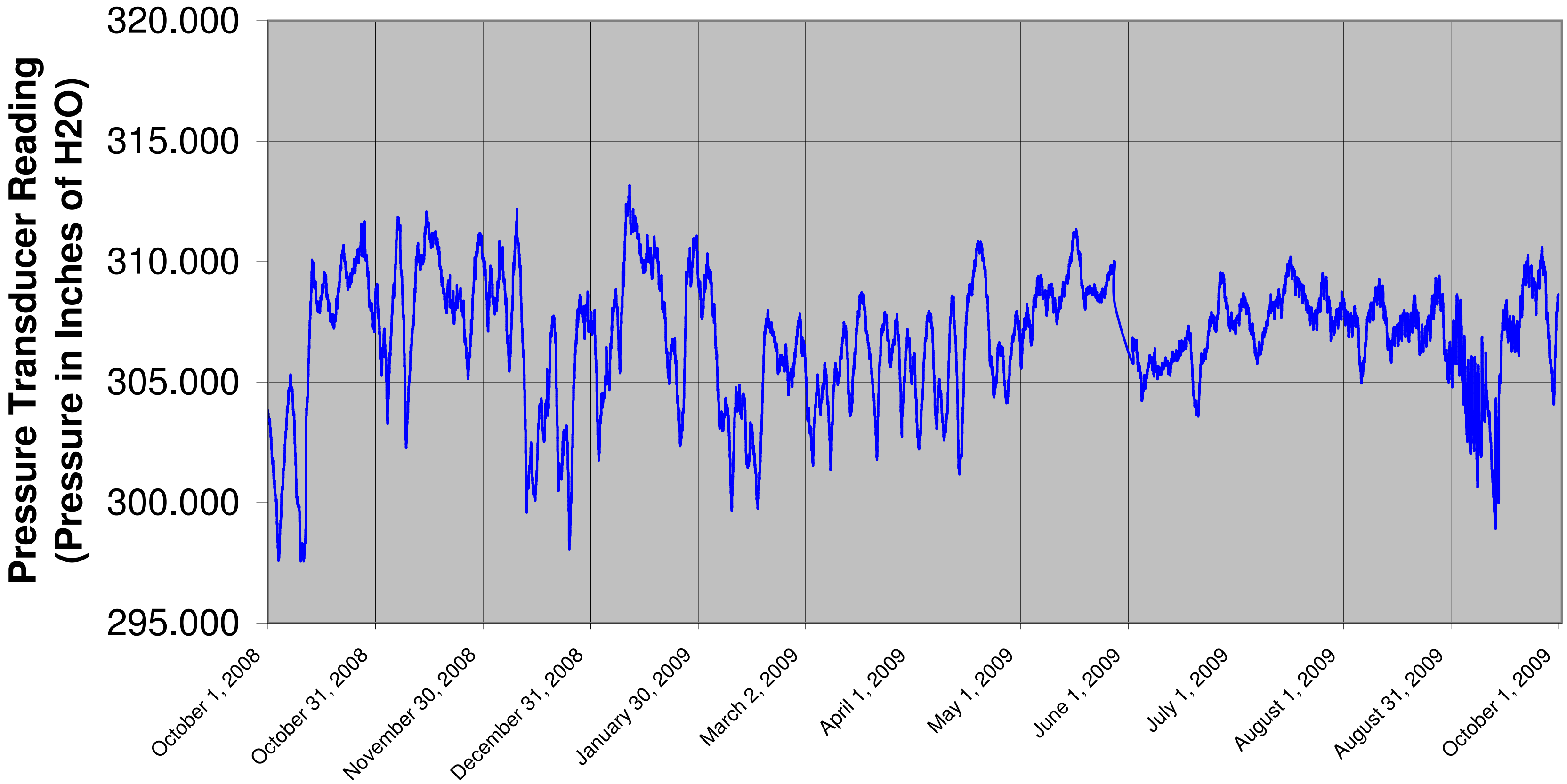
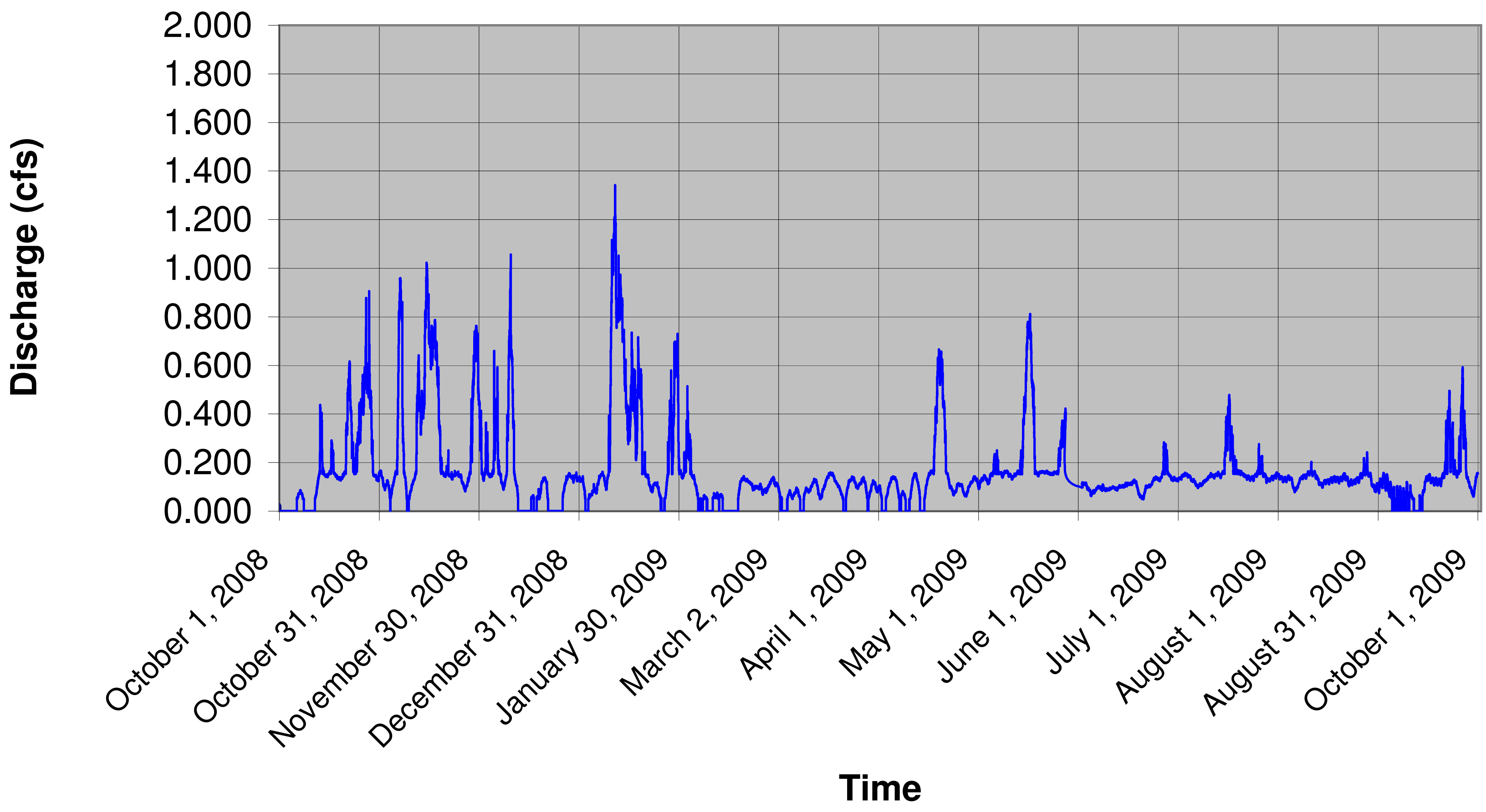


Figure 2. Daggett Creek Estimated Discharge 2009



Appendix VI

2010 CWE Work List

HEAVENLY MOUNTAIN RESORT
2010 ANNUAL CWE PROJECT & WORK LIST
February 4, 2010

Project #	**Source***	**Location**	**Treatment**
Watershed: CA-1 Heavenly Valley Creek			
1	M	Gondola Top Station	Refurbish existing infiltration basin and improve drainage to maintain effectiveness.
2	M	Groove Upper Terminal	Improve soil cover to stabilize steep slope and redirect runoff to channel and infiltration area.
3	P	Lakeview Water System	Remove old tank. Decommission old tank site and road to tank.
4	M	Upper Vehicle Maintenance Shop	Confirm effectiveness of stabilization work on gully above SEZ restoration site.
5	M	Zipline Base Station	Confirm effectiveness of existing soil cover and add cover beneath operator's booth.
Watershed: NV-3 Edgewood Creek			
6	B	Boulder Lift Upper Terminal	Install infiltration areas and improve effective cover around terminal.
7	B	Boulder Lift Upper Terminal	Install infiltration areas and improve effective cover around terminal.
8	P	Olympic Express Lift Lower Terminal	Stabilize area with bare soil below access road to terminal.
Watershed: NV-2 + 5 Daggett Creek			
9	P	East Peak Grading Area	Complete drainage and stabilization measures initiated for the area between Comet and Dipper Lift Lower Terminals.
10	B	East Peak Lodge	Stabilize driplines and drainage swales near foundation of building.
11	M	East Peak Well	Stabilize slope between road and well house.
Resort Wide			
12	M	Resort-Wide	Install and maintain closure signs on Ellie's Swing Trail, Betty's Return Trail, Powderbowl tower road, Lower Cal Trail below Hellwinkle's trail, East Peak Dam Road and West Round-a-bout
13	M	Resort-Wide	Develop a process to treat priority areas with long-term soil cover needs on ski runs and to identify and perform road maintenance needs. Note: This replaces the treatment listed in previous Annual CWE Work Lists as "Reseed and fertilize degenerating grassy areas on +/- 1/5th of ski runs

			(all runs are reviewed/reseeded over 5 years)”
14	M	Resort-Wide	Inspect and restore all areas damaged affected by winter resort operations, including hydrants & pipe failures, and areas affected by snowcat operations; document areas treated.
15	M	Resort-Wide	Erect and maintain vehicles barriers and/or fences to prevent unauthorized vehicle access off of designated summer roads and facility parking areas.
16	M	Resort-Wide	Inspect and maintain all drainage structures.
17	M	Base Areas	Erect and maintain vehicle barriers and/or fences to prevent unauthorized vehicle access from base areas.
***Source Codes**			
	M B P MMP	Maintenance Needed Project need determined from BMP Effectiveness Monitoring Master Plan Development Project Master Plan Monitoring & Mitigation Plan Requirement	

Appendix VII

2008-2009 Biological Survey Results Summary

HAUGE BRUECK
ASSOCIATES

www.haugebrueck.com

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NEVADA
P 775-588-4700
F 775-588-4704
P.O. Box 10291
310 Dorla Court, Suite 209
Zephyr Cove, NV 89448

30 December 2009

Mr. Andrew Strain
Heavenly Mountain Resort
P.O. Box 2180
Stateline, NV 89449

SUBJECT: HEAVENLY MOUNTAIN RESORT 2009 BIOLOGICAL SURVEY RESULTS SUMMARY

Dear Mr. Strain,

In preparation for future construction and implementation of projects, Hauge Brueck Associates LLC has performed wildlife surveys in suitable habitat within the Special Use Permit Boundary in 2009. Surveys for both northern goshawk and California spotted owl were completed to protocol. A summary of each species surveys is provided below:

California Spotted Owl

Methods: Surveys were conducted and completed in potentially suitable habitat within and surrounding the project area. Surveys were conducted according to the United States Forest Service "Protocol for Surveying for Spotted Owls in Proposed Management Activity Areas and Habitat Conservation Areas" (March 12, 1991, Revised February 1993). The survey points used for the 2007 and 2008 field season were utilized again in 2009 to provide continuity of data collected. Data sheets for 2009 surveys are attached to this letter.

Results: No auditory or visual detections of California spotted owls were documented within the survey area during 2009.

Northern Goshawk

Methods: Surveys were conducted and completed in suitable habitat within and adjacent to the project area for northern goshawk based on the updated habitat map generated by the US Forest Service for the environmental analysis of the Master Plan Amendment. In 2009, both dawn acoustical and broadcast survey methods were utilized and were completed to protocol. All surveys were conducted according to "Survey Methodology for Northern Goshawks in the Pacific Southwest Region, U.S. Forest Service" (14 May 2002). Data sheets for 2009 dawn acoustical and broadcast surveys are submitted with this letter.

Results: No auditory or visual detections of northern goshawk were documented within the survey area in 2009.

The completion of the 2009 field surveys for northern goshawk and California spotted owl results in meeting the two-year protocol for these species. Based on Appendix A of the California spotted owl survey protocol, since no detections were documented, and the two year protocol was met, "the negative results may be considered accurate for two additional years without conducting additional surveys." The two-year timeline starts on the last day of the last survey, which would be 17 August 2009. Therefore, if implementation of the project would commence prior to 17 August 2011, no further surveys for California spotted owl would be necessary. However, if construction does not commence prior to this date, two-year protocol surveys must be conducted. The northern goshawk protocol does not include any discussion as to validity of surveys for any duration of time after protocol has been met. However, since northern goshawks have been detected in previous years, it is recommended surveys for northern goshawks are continued to determine if goshawks are nesting within the special use permit boundary.

If you should have any questions regarding the surveys performed for the 2009 season, please do not hesitate to contact me at (775) 588-4700.

Regards,

Garth Alling
Senior Planner/Biologist

Enclosures

CC: Shay Zanetti , USFS LTBMU
Ted Thayer, TRPA
Chris Donneley, Entrix

Appendix VIII

Boundary Management

BOUNDARY MANAGEMENT

A. In perimeter areas, where it is likely for the skiing public to ski out of the patrolled area, Heavenly shall utilize a gated boundary system consisting of the following elements:

1. Gates are located in areas people have traditionally gone through in order to reach an area out-of-bounds.

2. Appropriate signage will be placed at the gates, informing users this is true backcountry access. Heavenly will place signs indicating that no patrolling of the area will occur, no hazards will be marked, no avalanche control work will be done and searches may or may not be conducted due to hazardous conditions. Skiers who enter the Backcountry areas will do so knowingly and will accept full responsibility for property loss, injury, and/or death. They may also be cited by local authorities and charged for the cost of their rescue.

3. Gated entries will have two vertical steel posts through which a skier must pass. A steel bar will hang horizontally from one post and be held against the other by a steel spring. For someone to enter the area they must pull the bar in front of them and as they pass through, the bar will automatically close behind them. The bar will be height adjustable to allow it to remain waist-high for a normal adult. The intent in doing this is to require a physical action beyond merely going through the posts to enter the area.

4. Due to the fact that this experience would be the same as any other backcountry experience, Heavenly will rarely “close” access into the terrain. The only time that these gates would be closed is when Heavenly staff is actively performing avalanche control with explosives in the adjacent permit area. Other than this special situation, the gate itself would never be locked or signed “closed”. Heavenly has no way of ascertaining the hazards that exist on a day-to-day basis in that terrain.

5. "Closed Ski Area Boundary, Exit Through Gates Only" signage will be placed along perimeter ropes. These signs are placed at appropriate intervals so that individuals would have the opportunity to read the warning and not cross under the ropes. The signage will indicate that some routes may access private property.

6. Heavenly will position signs in populated areas of the resort warning of skiing outside of the defined (roped) boundary. These signs clearly state that skiing under a rope boundary carries the potential of a citation by the appropriate law enforcement, cost of search (if any), removal of their pass and the forfeiture of any future opportunity to possess a Heavenly pass.

7. Heavenly will provide and maintain counters at each of the gates for the entire ski season. Gate use will be monitored weekly and reported to Forest Service monthly.

8. Heavenly will continue to assist county search and rescue efforts when requested.

B. Heavenly will install and maintain three gates. These gates will be monitored on a daily basis throughout the winter season to ensure signage is in place, the gates are functioning properly and that they are at the appropriate height. The gates are installed at the following locations:

1. Fire Break
   This gate is located to the north of the top of Olympic Chair. It accesses terrain locally termed "The Palisades".

2. Raley's Gulch
   This gate is located off of California Trail at the start of Maggie's Canyon.

3. Fulstone Canyon
   This gate is located above the existing Gate "A" of Killebrew Canyon.

It controls access to the area directly to the south and east of Killebrew Canyon.

Appendix IX

2008-2009 Water Use Balance Report

Heavenly Mountain Resort

Water Use Report, 2008-9 Season

Heavenly Mountain Resort is furnishing this report on water usage during the 2008-9 season as per the terms of the existing master plan agreement.

Snowmaking Water Usage

The Heavenly Mountain Resort snowmaking system consumed a total of 148.03 million gallons of water during the 2008-9 season to cover a total of 317 acres of terrain. The distribution of water sources and water consumption is described below:

Total Snowmaking Water Use--California	63.33	million gallons
Total Snowmaking Water Use--Nevada	84.70	million gallons
Net Total Snowmaking Water Use	148.03	million gallons
Water Supplied in California	73.69	million gallons
Water Used in California	63.33	million gallons
Net Surplus (flow out of California)	10.36	million gallons
Water Supplied in Nevada	74.34	million gallons
Water Used in Nevada	84.70	million gallons
Net Deficit (Flow into Nevada)	-10.36	million gallons
Water Supplied In Basin	73.69	million gallons
Water Used in Basin	82.01	million gallons
Net Surplus (flow out of Basin)	-8.32	million gallons
Water Supplied Out of Basin	74.34	million gallons
Water Used Out of Basin	66.02	million gallons
Net Deficit (flow into Out of Basin)	8.32	million gallons
Water Purchased--STPUD	70.69	million gallons
Water Purchased--KGID	43.60	million gallons
TOTAL WATER PURCHASED	114.29	million gallons

Table 1 provides a breakdown of water usage between California and Nevada, along with the net transfer of water between the States.

Table 1...2008-2009 Water Usage Summary--Inter State Transfers					
Pumping Region	**MG used**	**In California**		**In Nevada**	
		% of acre-ft	**Water (MG)**	**% of acre-ft**	**Water (MG)**
Cal Base	17.9	100%	17.9	0%	0.0
Cal Dam	39.1	100%	39.1	0.0%	0.0
E. Peak	91.0	7%	6.3	93%	84.7
Total	**148.0**		**63.3**		**84.7**
Water Supply- (Purchased + Recharge)			**73.7**		**74.3**
InterState Water Transfer			**-10.4**		**10.4**

Table 2 provides a breakdown of water usage between in-basin and out of basin regions, along with the net inter-basin transfer of water. This table also provides a breakdown of Nevada water use within 4 water right quadrants as listed below (see Attachment 6 for graphical representation):

Table 2...2008-2009 Water Usage Summary--Inter Basin					
Pumping Region	**MG used**	**In Basin**		**Out of Basin**	
		% of acre-ft	**Water (MG)**	**% of acre-ft**	**Water (MG)**
Cal Base	17.9	100%	17.9	0%	0.0
Cal Dam	39.1	100%	39.1	0%	0.0
E. Peak--CA	6.3	0%	0.0	100%	6.3
Total California	**63.3**		**57.0**		**6.3**
Quadrant A	0.0	12.0%	10.2		
Quadrant B				58%	49.1
Quadrant C				13%	10.6
Quandrant D		18%	14.8		
Total Nevada	**84.7**		**25.0**		**59.7**
TOTAL SNOWMAKING	**148.0**		**82.0**		**66.0**
Water Supply			**73.7**		**74.3**
Inter Basin Water Transfer			**8.3**		**-8.3**

Quadrant A - Within Tahoe Basin and south of the southern boundary of section 25, 26, 27 T. 13 N. R 18 E. and section 30 T. 13. N., R. 19 E.

Quadrant B - Outside of Tahoe Basin and south of the southern boundary of section 25, 26, 27 T. 13 N. R 18 E. and section 30 T. 13. N., R. 19 E.

Quadrant C - Outside of Tahoe Basin and North of the southern boundary of section 25, 26, 27 T. 13 N. R 18 E. and section 30 T. 13. N., R. 19 E.

Quadrant D - Within Tahoe Basin and North of the southern boundary of section 25, 26, 27 T. 13 N. R 18 E. and section 30 T. 13. N., R. 19 E.

The following attachments provide documentation and calculations procedures used in determining these values:

Attachment 1….Map of Existing Meter Locations
Attachment 2….Meter Readings
Attachment 3….Schematic of Water Transfers and Calculation Procedures
Attachment 4….California Snowmaking Trails
Attachment 5….Nevada Snowmaking Trails
Attachment 6….Nevada Water Right Quadrants

Calculation Procedures

Water allocation calculations for Heavenly Mountain Resort are complicated by the fact that snowmaking occurs in both Nevada and California, as well as inside and outside the TRPA boundary. While the snowmaking piping distribution system for the entire resort is interlinked, there are 3 basic sub-regions:

1. Cal Base — This region consists of the acreage on the California side falling below Cal Dam. All of this region falls within the State of California and within the Tahoe Basin.

2. Cal Dam — This region consists of acreage on the California side that is above Cal Dam. All of this region falls within the State of California and within the Tahoe Basin.

3. East Peak — This region consists of acreage above and below East Peak Lake. The region is predominantly in Nevada, though some trails serviced at the top fall inside California. A majority of this terrain is out of the Tahoe Basin, but 25% lies inside the Basin.

Attachment 3 provides a schematic of pumping operations, meter readings, and the calculation procedure for interstate water transfers. These calculations consist of performing a water balance between the STPUD and KGID supplies, water entering and exiting reservoirs, and a flowmeter installed on the existing transfer line between the Cal Dam and East Peak systems .

The interstate water transfer calculation is further complicated by the fact that a portion of the East Peak system services terrain in California. This issue is more of a factor for determining inter-basin transfers, since the snowmaking pipelines frequently cross the TRPA boundary. Heavenly has installed a multitude of in-line meters in an attempt to track these transfers, but has had little success with these meters for a number of reasons including:

- Most of these meters are installed in remote vaults in rocky environments with no power or heat. These vaults are typically buried under 10 or more feet of snow during the winter and often flood in the spring due to poor mountain drainage and high rates of melt.

- The snowmaking water pipelines are unlined steel and subject to rust and slag formation. With the high velocity frequently experienced in snowmaking pipelines, this rust and slag is often carried downstream and either clogs or damages the meters.

- The meters are inaccessible during the winter months so that if a malfunction occurs, it is not known until late spring/early summer.

A revised methodology has been developed to track inter-basin water usage without using these chronically unreliable meters. This methodology involves calculating the total water usage within the 3 major sub-regions (Lower Cal, Cal Dam, and East Peak) and then allocating water proportionally based on snowmaking terrain within that region that falls inside and outside the Tahoe basin. Since different trails require different design depths of snow, the allocation is based on the trail acreage x design depth for each trail, as detailed in Attachments 4 and 5. The same methodology is used to allocate East Peak water between California and Nevada.

The trail data provided in Attachments 4 and 5 indicate that 7% of the East Peak design acre-ft of snow coverage occurs in California, while 93% occurs in Nevada. Therefore, 7% of the total 91.0 MG used for snowmaking in the East Peak sub-region is calculated to fall in California (6.3 MG) while 93% is calculated to fall in Nevada (84.7 MG). Of this 84.7 MG of East Peak water that is used in Nevada, 29.5% of the design acre-ft of snow production occurs within the Tahoe Basin, while 70.5% occurs outside the basin. Therefore 29.5% of the 84.7 million gallons of water used in this sub-region are calculated to be used within the Basin (25.0 MG) while 70.5% are calculated to be used outside the basin (59.7 MG). Tables 1 and 2 summarize these calculations.

Revised Operating Procedures

The calculations indicate that a net of 8.3 million gallons of in-basin water was transferred out of basin during the 2008-2009 snowmaking season. Several improvements are in process to minimize this transfer of inter-basin water in the future:

1. New meters have been installed that will provide more accurate and timely record keeping, along with the ability to adjust water sources to better balance water use

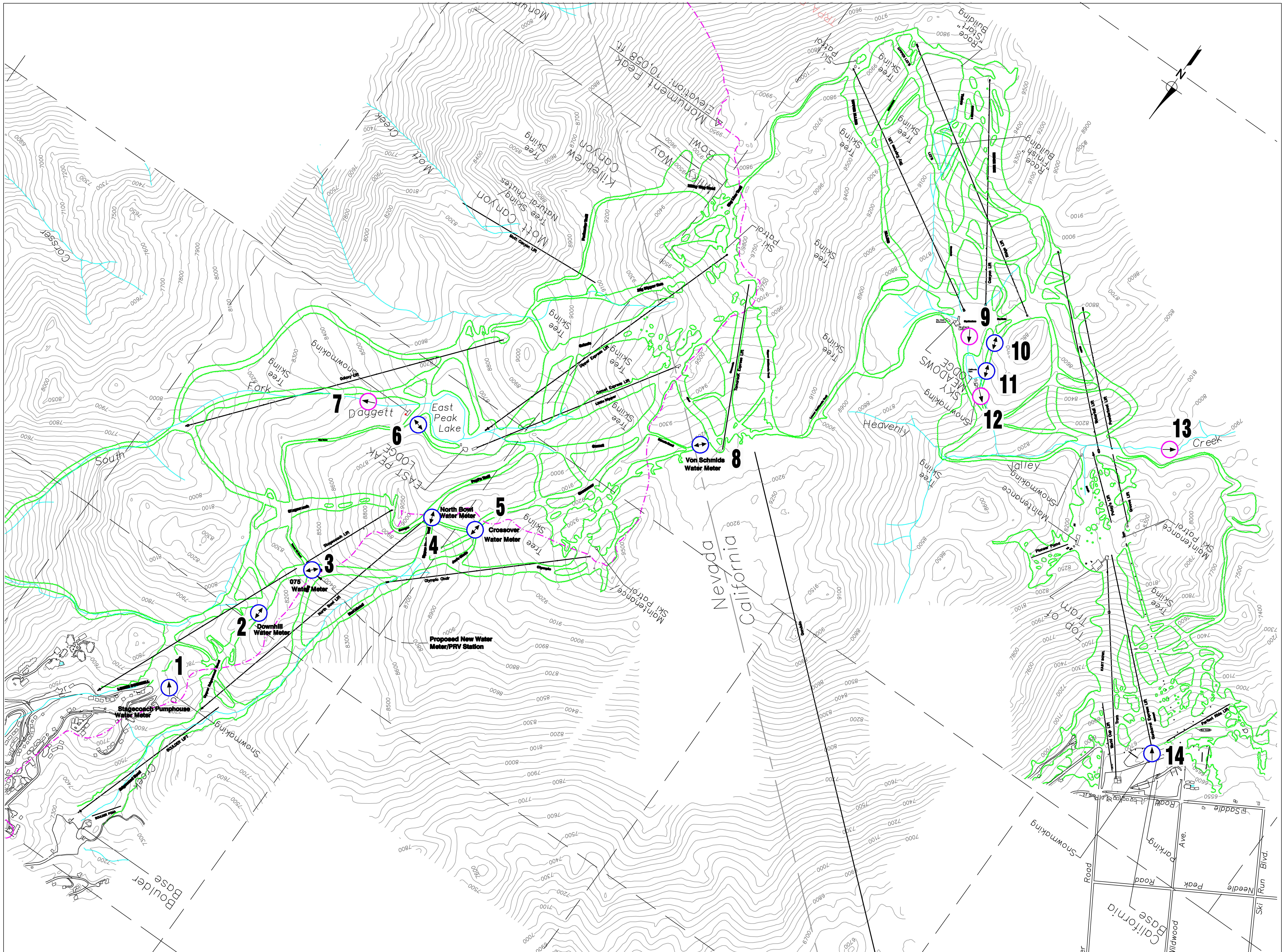
2. The East Peak well is an out of basin source that was not operational for the entire season. This should in the future reduce the need to transfer water out of the basin

3. Summer irrigation efforts will be utilized where possible to balance out water transfers after the snowmaking season is completed.

4. Interim reporting is being developed to assist the snowmaking operators in evaluating water balance during the season. This will allow the operators to select sources that will help balance withdrawal and consumption within the various subregions.

Respectfully Submitted,

Scott Barthold, PE
Sno.matic Controls and Engineering, Inc.



REVISIONS				
No.	DATE	DESCRIPTION	DRAWN BY	APP'D BY

NOTES / LEGEND

- Water Meter Single Direction Measurement
- Water Meter Bi Direction Measurement
- Pipe Meter
- Stream Water

DRAFT

FOR REVIEW ONLY, NOT FOR CONSTRUCTION

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CLIENT

HEAVENLY SKI RESORT

PROJECT TITLE

HEAVENLY SNOWMAKING SYSTEM

DRAWING TITLE

Master Plan Map
Metering Stations
-

Designed by: S. Barthold	Approved by: -
Project no.: 149.1	Drawn by: J. Wilkinson
Date: 5/19/03	Scale: 1" = 800'-0" D SIZE
Drawing no.: Heavenly updated map1.dwg	Sheet no.: __ - __

Attachment 2…Meter Readings

2008-2009 Snowmaking Water Meter Readings

	Ca Base	Ca Base	Ca Dam New Meter by road		Ca Dam Old Meter Down		Cal Dam Uphill		Von Schmidt's	
	Back Flow	Water Cooler	Reverse	Forward	Rev	Forward	Forward	Reverse	Rev	Fwd
7/14/2008	338,713,000	80,134,900			41,573,000	10,440,700	140,459,500	5,556,200	63,455,000	45,731,000
10/7/2009	436,450,000	80,134,900	1,207,000	290,000	21,686,000	1,917,000	new meter	new meter	20,488,000	49,525,600
Total	**70,688,992**	**0**			**-19,887,000**	**-8,523,700**	**#VALUE!**	**#VALUE!**	**20,488,000**	**3,794,600**
	Water from STPUD	Water from STPUD	Out of Dam	To Dam	To Dam	Out of dam dn hill	System	To Dam	To California	To Nevada
					Via World Cup/Face	snowmaking-low	snowmaking high	via Round-a-bout	assume meter	not used, close,
					not used	not used	plus water to E Pk	should be insigr	reset	but calculated
								not used		value used

East Peak		North Bowl		Crossover		075		Way Home		KGID
Fwd	Rev	Fwd	Rev	Fwd	Rev	Fwd	Rev	Fwd	Rev	Stagecoach
708,221,000	60,399,000	316,520,000	113,531,000	20,488,000	49,525,600	158,000,000	55,031,000	64,806,500	99,940,000	137,058,000
781,857,000	138,339,000	322,984,000	113,580,000	185,000,000	257,253,000	195,190,000	68,722,000	68,934,500	99,929,000	137,058,000
77,940,000	**73,636,000**	6,464,000	**49,000**	164,512,000	**207,727,400**	**37,190,000**	**13,691,000**	**4,128,000**	**-11,000**	**43,601,000**
Into System	Into Pond	To Comet	To Downhill	To Olympic	To Steve's Road	To E.P. Lake	To Lower MT.	To Boulder	(drain only)	(purchase records)
48.0 MG	**30.4 MG**	not used	not used	not used	not used		(drain only)	not used	not used	
(Intellution Records used)							not used			

Water Pumped into Cal Dam		**52,788,100**	Intellution Data
Water Pumped from E Peak Well		**25,741,276**	

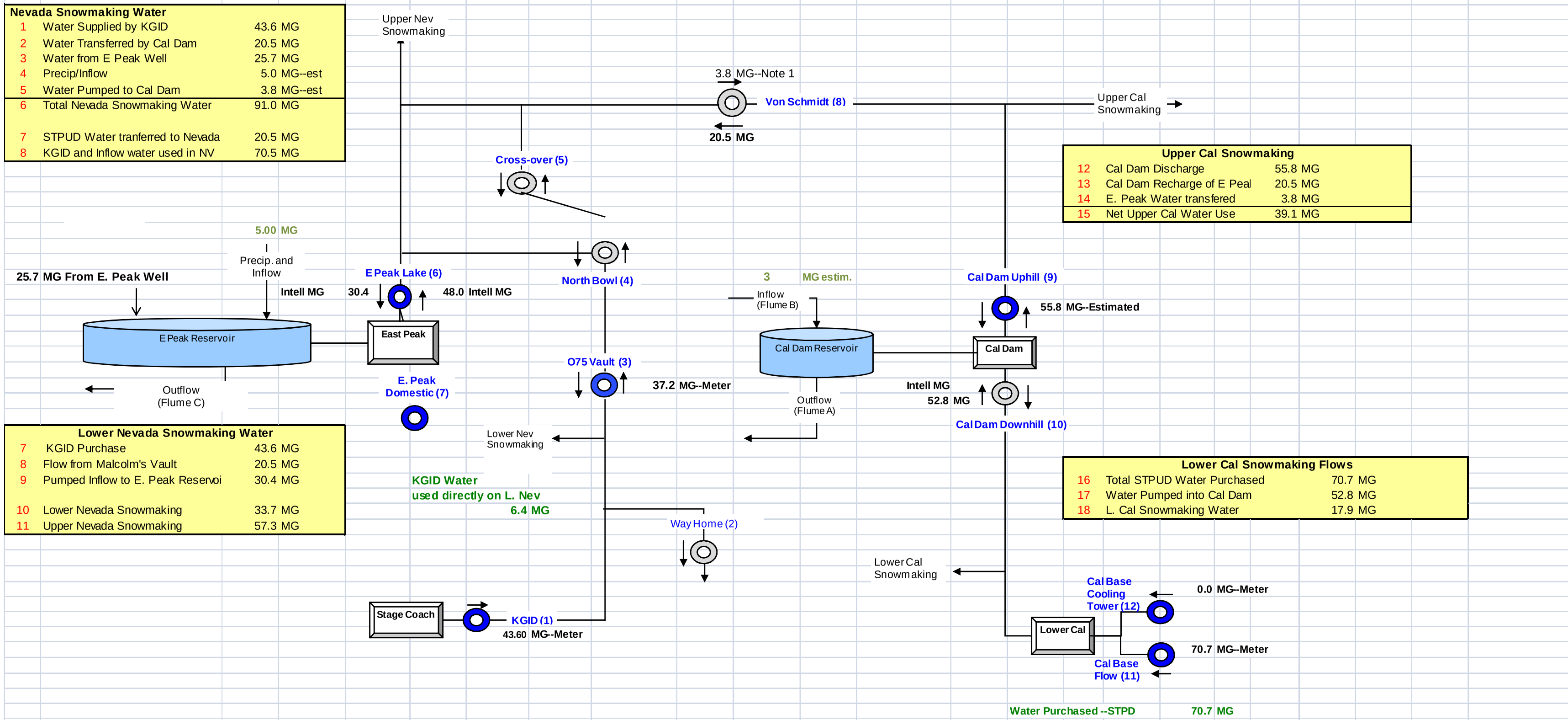
Note: Indicates Value used in Calculations

Attachment 3---Schematic

Attachment 3

Heavenly Mountain Resort Snowmaking Water Usage
2008-2009 Water Transfers

Nevada Snowmaking Water		
1	Water Supplied by KGID	43.6 MG
2	Water Transferred by Cal Dam	20.5 MG
3	Water from E Peak Well	25.7 MG
4	Precip/Inflow	5.0 MG--est
5	Water Pumped to Cal Dam	3.8 MG--est
6	Total Nevada Snowmaking Water	91.0 MG
7	STPUD Water tranferred to Nevada	20.5 MG
8	KGID and Inflow water used in NV	70.5 MG



Upper Cal Snowmaking		
12	Cal Dam Discharge	55.8 MG
13	Cal Dam Recharge of E Peal	20.5 MG
14	E. Peak Water transfered	3.8 MG
15	Net Upper Cal Water Use	39.1 MG

Lower Nevada Snowmaking Water		
7	KGID Purchase	43.6 MG
8	Flow from Malcolm's Vault	20.5 MG
9	Pumped Inflow to E. Peak Reservoi	30.4 MG
10	Lower Nevada Snowmaking	33.7 MG
11	Upper Nevada Snowmaking	57.3 MG

Lower Cal Snowmaking Flows		
16	Total STPUD Water Purchased	70.7 MG
17	Water Pumped into Cal Dam	52.8 MG
18	L. Cal Snowmaking Water	17.9 MG

Calculation Notes

1 Provided by Purchase Records from KGID
2 Based on Von Shmidt meter reading.
3 Obtained from Well pumping records
4 Estimated recharge
5 Based on Von Shmidt meter reading.
6 Total Water used in NV = what flows in (KGID, E Pk Well, Recharge, water from Cal Dam)-what flows out (transfer to Cal Dam)

7 Provided by Purchase Records from KGID
8 Based on Von Shmidt meter reading.
9 From Inttellution flow records
10 Water in (KGID purchase) - water into reservoir (water supplied to E. Peak- water supplied by Cal Dam)=water used on Lower Nevada
11 Upper Nevada = Total Nevada - Lower Nevada

12 Cal Dam Discharged assumed to equal recharge plus water pumped into Cal Dam (flowmeter not functioning)
13 Based on Von Shmidt meter reading.
14 Based on Von Shmidt meter reading.
15 Water pumped from Cal Dam - Cal Dam water transferred to E. Peak+ E. Peak water transferred to Cal Dam = Water used on Upper Cal

16 Purchase records from STPUD
17 From Intellution flowmeter value
18 Lower Cal usage = STPUD purchase (supply)-water transferred to Cal Dam

ATTACHMENT 4---CALIFORNIA SNOWMAKING ACREAGE

2007 Master Plan Amendment Trail #	1996 Master Plan Trail #	Trail Name	2007 Master Plan Amendment Snowmaking Action (1)	Length (feet)	Width (feet)	Acreage (acres)	Acre ft. (3)	Sub Region
California In Basin…. 'pod' trails								
B1	1	EAST BOWL -THE FACE	EXISTING	3,220	220	16.3	81.3	Cal Base
B2	2	GUNBARREL	EXISTING	2,030	175	8.2	40.8	Cal Base
D1	5	WORLD CUP	EXISTING	1,000	260	6.0	16.1	Cal Base
E1	7	PATSY'S	EXISTING	1,730	200	7.9	21.4	Cal Dam
G1	9	MAGGIES	EXISTING	5,210	80	8.4	22.7	Cal Dam
G2	10	CAT TRACK	EXISTING	1,070	40	1.0	2.7	Cal Dam
G5	13	MOMBO MEADOWS	EXISTING	1,190	170	4.1	11.1	Cal Dam
G6	14	MOMBO	EXISTING	1,700	25	1.0	2.6	Cal Dam
G7	14	LOWER MOMBO	EXISTING	1,200	90	2.5	6.7	Cal Dam
H9	23	CANYON - SKY CANYON	EXISTING	2,400	128	6.1	16.5	Cal Dam
H10	24	JACKPOT (RUSUTSU)	EXISTING	1,860	125	4.3	11.6	Cal Dam
H11	26	HIGH ROLLER (STEAMBOAT)	EXISTING	1,430	130	3.3	8.9	Cal Dam
I1	25	LIZ'S	EXISTING	4,630	100	9.6	25.9	Cal Dam
I3	27	UPPER ELLIE'S / ELLIE'S	EXISTING	4,490	130	12.4	49.6	Cal Dam
K1	30	PERFECT RIDE (WEST BOWL)	EXISTING	1,260	300	8.7	23.4	Cal Base
*L1	31	LOWER SKI SCHOOL	EXISTING	500	200	2.3	6.2	Cal Base
M1	32	CHILDRENS SKI CENTER	EXISTING	390	100	0.9	2.4	Cal Base
N1	33	PIONEER PLATTER PULL	EXISTING	700	150	2.4	6.5	Cal Dam
O1	34	LEARN TO SKI CENTER	EXISTING	400	150	1.4	3.7	Cal Dam
*GG1	29	(UPR.) CALIFORNIA TRAIL	EXISTING	2,900	145	7.4	20.0	E. Peak
**GG2	29A	SAM'S DREAM	EXISTING - UNBUILT	1,430	130	4.3	17.1	E. Peak
*GG3	29B	TAMARACK RETURN	EXISTING	650	50	0.7	2.0	E. Peak
*GG6	82	CASCADE	EXISTING	2,800	125	8.0	32.1	E. Peak
*HH1	81	EASY STREET (1/2)	EXISTING	740	200	3.4	9.2	E. Peak
HH2	81	EASY STREET II (1/2)	RETAIN	300	300	2.1	5.6	
B3	3	PISTOL	REMOVE	1,220	130	0.0	0.0	
B4	4	WEST BOWL	REMOVE	2,040	100	0.0	0.0	
E2	8	GROOVE	EXISTING	1,640	100	3.8	10.2	Cal Dam
G3	11	SWING TRAIL	NO ACTION	1,190	30	0.0	0.0	
G4	12	WATERFALL	RETAIN	760	200	3.5	17.4	
G8	15	POWDERBOWL	RETAIN	1,540	100	3.5	14.1	
G9	NC	NEW - POWDERBOWL 2 (Gladed)	NEW	1,640	50	1.9	5.1	
H1	17	WOODS TRAIL	NO ACTION	2,960	25	0.0	0.0	
H2	18	BETTY'S SWING	NO ACTION	1,080	30	0.0	0.0	
H3	19	RIDGE BOWL	NO ACTION	1,400	100	0.0	0.0	
H4	19	RIDGE CHUTE	NO ACTION	860	50	0.0	0.0	
H5	20	HIGH ROLLER (BETTY'S RUN)	RETAIN	3,680	150	12.7	63.4	
H6	20	DOUBLE DOWN (BETTY'S BOWL)	RETAIN	400	180	0.0	0.0	
H7	21	LOWER BETTY'S	RETAIN	710	50	0.0	0.0	
H8	22	BETTY'S CUTOFF	NO ACTION	570	130	0.0	0.0	
H12	NC	NEW - BETTY'S CUTOFF	NO ACTION	600	150	0.0	0.0	
H13	NC	NEW - BETTY'S ESCAPE	NO ACTION	250	60	0.0	0.0	
I2	27	ELLIE'S SWING - EXTENSION	RETAIN	2,740	70	3.4	9.2	
I4	NC	NEW - SKIWAYS 1 (GLADED)	NO ACTION	3,089	50	0.0	0.0	
I5	NC	NEW - SKIWAYS 2 (GLADED)	NO ACTION	2,982	50	0.0	0.0	
GG5	64	49ER	RETAIN	1,710	40	1.6	6.3	
California In-Basin..non 'pod' transport trails								
1	6	ROUND-A-BOUT	EXISTING	17,000	40	15.6	42.1	Cal Base
2	16	RIDGE RUN	EXISTING	1,200	60	1.7	4.5	Cal Dam
3	16	LOWER RIDGE RUN	EXISTING	4,610	155	15.9	42.9	Cal Dam
5	29	CALIFORNIA TRAIL	EXISTING	6,010	50	5.5	14.9	Cal Dam
5A	NC	NEW- CAL. TRAIL ALTERNATIVE	NEW	1,800	40	1.7	4.5	
10	67	VON SCHMIDT'S (1/4)	RETAIN	1,050	50	1.2	3.3	
**11	83	VON SCHMIDT'S - MEADOW	RETAIN	600	300	4.1	11.1	
1	6	ROUND-A-BOUT - REALIGNMENT	NEW	1,691	40	1.6	4.2	
4	28	SKYLINE TRAIL	RETAIN	3,100	54	2.8	7.6	
12	NC	NEW - MAGGIES CANYON (GLADED)	NO ACTION	1,890	150	0.0	0.0	
In Basin Total--Master Plan						**212.8**	**706.7**	
In Basin Total--Cal Base Existing						**57.9**	**212.4**	
In Basin Total--Cal Dam Existing						**91.2**	**262.3**	
In Basin Total--E. Peak Existing						**0.0**	**0.0**	
California Out of Basin 'pod' trails								
V4	54	BIG DIPPER (1/5)	EXISTING	1,080	150	3.7	10.0	E Peak
V8	58	ORION'S (1/2)	EXISTING	1,820	200	8.4	22.6	E Peak
*V10	72	METEOR (1/2) - (GLADED)	EXISTING - UNBUILT	970	130	2.9	7.8	
**V11	75	METEOR II (1/3) - (GLADED)	REMOVE	500	100	0.0	0.0	
V7	57	DIPPER BOWL (1/2)	NO ACTION	680	450	0.0	0.0	
GG4	61	SAND DUNES	RETAIN	1,610	80	3.0	8.0	
V1	51	MILKY WAY BOWL (2/3)	NO ACTION	1,800	900	0.0	0.0	
V3	53	DIPPER KNOB	RETAIN	1,730	30	1.2	3.2	
Out of Basin Total--Master Plan						**17.9**	**48.4**	
Out of Basin Total--Cal Base Existing						**0.0**	**0.0**	
Out of Basin Total--Cal Dam Existing						**0.0**	**0.0**	
Out of Basin Total--E. Peak Existing						**12.1**	**32.6**	
California Total--Master Plan						**230.8**	**755.1**	
California Total--Existing						**161.1**	**507.3**	
Cal Base Total Existing						**57.9**	**212.4**	
Cal DamTotal Existing						**91.2**	**262.3**	
E Peak Total Existing						**12.1**	**32.6**	
Cal Base Existing---% In Basin						**100%**	**100%**	
Cal Dam Existing---% In of Basin						**100%**	**0%**	
E Peak Existing---% In Basin						**0%**	**0%**	

ATTACHMENT 5---NEVADA SNOWMAKING ACREAGE

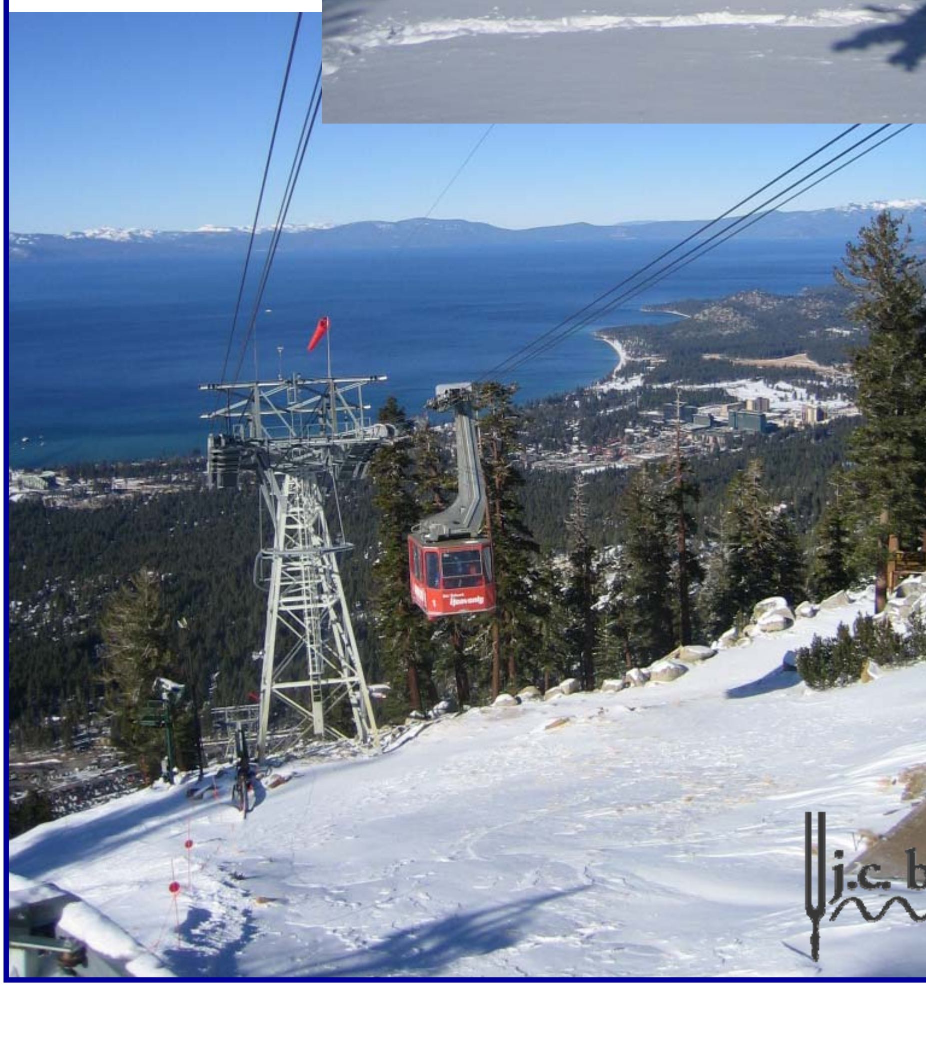
2007 Master Plan Amended Facilities - Snowmaking at Buildout

2007 Master Plan Amendment Trail #	Trail Name	2007 Master Plan Amendment Snowmaking Action (1)	Acreage (acres)	Acre ft. (3)
Nevada In Basin 'pod' trails				
Q1	BOULDER (EDGEWOOD) BOWL	EXISTING	17.2	68.9
S1	OLYMPIC DOWNHILL (3/5)	EXISTING	15.5	41.8
X1	BOULDER SKI SCHOOL	EXISTING	2.8	7.6
*HH1	EASY STREET (1/2)	EXISTING	3.4	9.2
S2	BOULDER CHUTE (O75)	RETAIN	2.7	11.0
S3	NORTH BOWL	RETAIN	7.8	38.9
S4	UPPER NORTH BOWL	RETAIN	4.2	21.0
S8	NEW - NORTH BOWL 2	NEW	5.1	13.8
S9	NEW - NORTH BOWL 3 (Gladed)	NEW	8.1	22.0
S10	NEW - NORTH BOWL 4 (Gladed)	NEW	7.8	21.2
HH2	EASY STREET II (1/2)	NO ACTION	2.1	5.6
	(wasn't on snowmaking plan)			
Nevada In Basin non 'pod' transport trails				
9	STEVE'S	EXISTING	0.5	1.4
10	VON SCHMIDT'S (1/4)	RETAIN	1.2	3.3
NV In Basin Total--Master Plan			**78.5**	**265.5**
NV In Basin Existing Total (all E. Peak)			**39.4**	**128.8**
Nevada Out of Basin 'pod' trails				
R2	(UPPER) STAGECOACH	EXISTING	4.2	16.6
S1	OLYMPIC DOWNHILL (2/5)	EXISTING	10.3	27.9
S5	CROSSOVER	EXISTING	6.7	18.1
V4	BIG DIPPER (4/5)	EXISTING	14.8	40.0
V6	ORION'S BELT	EXISTING	1.1	2.9
V8	ORION'S (1/2)	EXISTING	8.4	22.6
V9	LOWER ORION'S	EXISTING	2.9	7.8
*V10	METEOR (1/2) - (GLADED)	EXISTING - UNBUILT	2.9	7.8
W3	LITTLE DIPPER	EXISTING	10.4	52.2
W4	COMET	EXISTING	14.2	38.3
Z1	NEW - WELLS FARGO 1	NEW	5.4	14.5
Z2	NEW - WELLS FARGO 2	RETAIN	8.3	22.4
Z3	NEW - WELLS FARGO 3	NEW	11.4	30.7
Z4	NEW - WELLS FARGO 4	RETAIN	12.8	34.6
Z5	NEW - WELLS FARGO 5	NEW	2.8	7.5
Z7	NEW - WELLS FARGO 7	NEW	6.9	18.7
R1	STAGECOACH	EXISTING	12.4	49.6
R3	NEW - STAGECOACH 2	NO ACTION	7.1	35.6
R4	NEW - STAGECOACH 3	NO ACTION	0.0	0.0
R5				
S6	PONDEROSA (BONANZA BOWL)	RETAIN	4.0	15.9
S7	EAST PEAK	RETAIN	3.9	15.8
U1	PERIMETER	RETAIN	13.5	36.4
U2	GALAXY	RETAIN	10.1	27.3
U3	NEW - GALAXY 1	NEW	8.7	23.4
U4	NEW - GALAXY 2	NEW	2.7	7.3
V5	LOWER BIG DIPPER	RETAIN	3.7	9.9
V12	NEW - ORION'S II	NEW	3.4	9.3
W1	ARIES	RETAIN	1.3	3.4
W2	JACK'S	NEW	3.0	8.0
*HH3	SILVER SPUR	NO ACTION	0.5	1.4
Necada Out of Basin Non 'pod' transport trails				
7	LOWER WAY HOME	EXISTING	5.2	14.1
8	PEPI'S	EXISTING	4.0	10.8
10	VON SCHMIDT'S (1/2)	EXISTING	2.4	6.5
14	NEW - GALAXY ACCESS	NEW	6.4	17.3
15	NEW - SCORPION	NEW	6.3	17.1
6	NEW - NEVADA TRAIL (WAY HOME)	NEW	5.9	16.0
16	NEW - FARGO TO GALAXY	NEW	1.1	2.9
NV-Out of Basin Total MP			**229.1**	**690.8**
NV Out of Basin Existing Total (all E. Peak)			**97.0**	**307.5**
		Acreage total by Quandrant		
			% of Total Acreage	
Nevada Total--Master Plan			**307.6**	**956.3**
Nevada Total--Existing			**136.4**	**436.3**
% In Basin--Existing			**29%**	**30%**
% Out of Basin			**71%**	**70%**
Grand Total--2007 Master Plan			**538.4**	**###**
		Cal Base Total	**57.9**	**212.4**
		% in CA	**100%**	**100%**
		% In Basin	**100%**	**100%**
		Cal DamTotal	**91.2**	**262.3**
		% in CA	**100%**	**100%**
		% in Basin	**100%**	**100%**
		E. Peak Total	**148.5**	**468.9**
		% in CA	**8%**	**7%**
		E. Peak in CA	**12.1**	**32.6**
		% of E. Peak in CA-in I	**0%**	**0%**
		E. Peak in NV	**136.4**	**436.3**
		% of E. Peak in NV-in I	**29%**	**30%**

Appendix X

2008-2009 Master Plan Noise Monitoring Survey

Heavenly Ski Resort
Master Plan Noise Monitoring Survey
2008-2009 Ski Season



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I INTRODUCTION

j.c. brennan & associates, Inc. is providing a final report on the noise monitoring and analysis of noise measurement data collected during the 2008/2009 snowmaking operations at Heavenly. The noise measurements and analysis of data are required as a condition of approval for the Heavenly Master Plan EIS/EIR. This is the twelfth annual analysis of snowmaking noise.

The previous noise analyses for the 2007/2008, 2006/2007, 2005/2006, and 2004/2005 ski seasons were prepared by j.c. brennan & associates, Inc. The five noise analyses for the 1999/2000, 2000/2001, 2001/2002, 2002/2003, 2003/2004 ski seasons were prepared by Bollard & Brennan, Inc. The three noise analyses for the 1996/97, 1997/98, and 1998/99 ski seasons were prepared by Brown-Buntin Associates, Inc (BBA).

The conditions of approval for the Heavenly Master Plan EIS/EIR are aggressive, and include instituting a comprehensive noise monitoring program, the replacement of older and louder air/water nozzles with quiet model snowmaking equipment, sound control devices for snowmaking equipment, and participation with the snowmaking industry in the research and development of quiet snowmaking equipment and sound control devices for snowmaking equipment. The current technology considers quiet snowmaking equipment to be fan guns, and based upon noise measurement data collected for the various types of snowmaking equipment, fan guns are generally 15 dBA quieter than traditional air/water nozzles.

Since the 1996/1997 ski season, Heavenly committed to the installation of a permanent noise monitoring site at the base of the ski area near the California lodge, and to establishing the existing snowmaking noise levels at the Boulder Base and Stagecoach Base. Refer to Figure 1 for locations of noise monitoring sites.

According to the previous snowmaking noise reports, during the 1996/1997 ski season some quiet snowmaking equipment was installed and used at the California Base facilities. However, the use of quiet equipment was limited. During the 1997/1998 ski season, additional quiet snowmaking equipment was introduced into the fleet of snowmaking operations. During the 1998/1999 snowmaking operations, no additional quiet snowmaking equipment was implemented. Based upon review of the log of snowmaking activities provided by Heavenly, fan guns were used in both the lower and upper locations of the California Base during the 1999/2000 - 2003/2004 ski seasons. During the 2008/2009 ski season, fan guns were used extensively on the lower portion of the California Base area. Based upon the snowmaking logs, there was limited use of air/water nozzles on the lower portion of the California side as an effort to reduce overall snowmaking noise levels. Currently, air/water nozzles are only used on the Round About trail of the lower portion of the California face.

Figure 1
Heavenly at Tahoe Ski Resort
Project Site and Noise Measurement Locations

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II PURPOSE AND NEED

The purpose and need for the Annual Noise Monitoring Report, is to address the attainment of performance standards contained within the Heavenly Master Plan and to address progress toward attainment of the TRPA noise level criteria.

TRPA Criteria

The Tahoe Regional Planning Agency (TRPA) has adopted Environmental Thresholds for the Lake Tahoe Region. The noise standards, or Thresholds as they are commonly referred to, are numerical Community Noise Equivalent Level (CNEL)[1] values for various land use categories and transportation corridors.

As a form of zoning, the TRPA has divided the Lake Tahoe Region into more than 175 separate Plan Areas. Boundaries for each of the Plan Areas have been established based upon similar land uses and the unique character of each geographic area. For each Plan Area, a Statement is made as to how that particular area should be regulated to achieve regional environmental and land use objectives. As a part of each Statement an outdoor CNEL standard is established based upon the Thresholds. Table 1 shows the existing CNEL standards for the Heavenly Plan Areas and adjacent Plan Areas.

Table 1
Plan Area Statement (PAS) CNEL Criteria

PAS	Description	CNEL Criterion
087	Heavenly Valley California	55 dBA
085	Lakeview Heights (Location of California Base noise monitoring location)	55 dBA
094	Glenwood	50 dBA
095	Trout/Cold Creek	50 dBA
086	Heavenly Valley Nevada	55 dBA
082	Upper Kingsbury	55 dBA
080	Kingsbury Drainage	50 dBA
088	Tahoe Village	55 dBA

[1] For an explanation of these terms, see Appendix A: "Acoustical Terminology"

III COMPLIANCE REPORTING

III.1 Snow Grooming Noise

III.1a Master Plan Mitigation Methods

The Master Plan mitigation methods for snow grooming operations are to maintain an 85 foot setback from Plan Area boundaries that are adjacent to Heavenly. Operations of snow grooming equipment would not exceed Plan Area noise standards with a minimum of 85 feet of separation.

III.1.b Master Plan Milestone/Product

Snow grooming machines are not operated within 85 feet of PAS boundaries. Portions of the fleet are replaced continually with newer technology equipment

III.1c Responsible Party

Heavenly is responsible for educating snow groomers to maintain the 85 foot setback.

III.1d PAS Criteria

PAS 080 – 50 dB CNEL
PAS 082, 085, 086, 087, 088 – 55 dB CNEL
PAS 095, PAS 121 – 45 dB CNEL

III.1.e Results of Reporting and Determination of Compliance

To be included in ENTRIX compliance report.

III.2 Snowmobile Noise

III.2.a Master Plan Mitigation Methods

Replace all snowmobiles with 4-stroke technology. This would ensure that snowmobiles would comply with the 82 dBA single event noise level standard.

III.2.b Master Plan Milestone/Product

Snowmobile equipment is maintained and operated within 85 feet of PAS boundaries. Portions of the fleet are replaced with new equipment.

III.2.c Responsible Party

Heavenly is responsible for replacing the fleet of snowmobiles with 4-stroke technology machines.

III.2.d Criteria

The TRPA single event noise level standard for snowmobiles is 82 dBA Lmax, at a distance of 50 feet.

III.2.e Results of Reporting and Determination of Compliance

Heavenly staff reported in 2008 that all snowmobiles in the fleet are 4-stroke engine technology. Therefore, this is in compliance with the TRPA thresholds.

III.3 Snow Removal Noise

III.3.a Master Plan Mitigation Methods

Mitigation methods for snow removal noise impacts are to minimize nighttime snow removal operations, and by constructing noise barriers along the perimeters of the parking lots. At the California Base area, the upper parking lot should be cleared first, and clearing of the lower parking lot should be conducted during the daytime and evening hours.

III.3.b Master Plan Milestone/Product

Snow removal equipment is operated consistent with the measures listed above.

III.3.c Responsible Party

Heavenly is responsible for operating snow removal equipment consistent with the measures listed above.

III.3.d Criteria

PAS 080 – 50 dB CNEL
PAS 082, 085, 086, 087, 088 – 55 dB CNEL
PAS 095, PAS 121 – 45 dB CNEL

Results of Reporting and Determination of Compliance

To be provided in ENTRIX compliance report.

III.4 Snowmaking California Base Area Noise

III.4.a Master Plan Mitigation Methods

1. Use of fans in place of air/water nozzles or air/water guns which are low noise;
2. Re-direction of nozzles and fans to minimize noise exposures at PAS boundaries;
3. Reduction in the numbers of nozzles and/or fans;
4. Use of setbacks to reduce noise exposures at PAS boundaries;
5. Use of noise reduction housings for air/water nozzles;
6. Use of barriers at low-mounted air/water nozzles;
7. Reduction in snowmaking activities at nighttime;
8. Sponsor research into reducing noise produced by snowmaking. This may include support of industry-wide research activities, specific studies concerning nozzle design sponsored directly by Heavenly, and the study of alternatives in placement of guns and fans at Heavenly.

III.4.b Master Plan Milestone/Product

Heavenly has installed the long-tem noise monitoring station at the California Base area. The annual noise monitoring occurs from November 1, and generally through March 31st, depending on the snowmaking activities. Heavenly has completely replaced the air-water snowmaking nozzles at the base of California with fan guns. Heavenly has not implemented items 4 through 8 listed above.

III.4.c Responsible Party

Heavenly is responsible for implementing the mitigation measures.

III.4.d PAS Criteria

PAS 080 – 50 dB CNEL
PAS 082, 085, 086, 087, 088 – 55 dB CNEL
PAS 095, PAS 121 – 45 dB CNEL

III.4.e Results of Reporting and Determination of Compliance

1996/1997 - 2007/2008 Snowmaking Noise Levels Summary:

Please see previous j.c brennan & associates, inc., and Bollard & Brennan, Inc. reports for details on the analysis of past snowmaking seasons. The results of previous noise monitoring surveys are provided in Tables 2 and 3.

2008/2009 Snowmaking Noise Levels Summary:

The ski season during the 2008/2009 spanned a total of 140 days. Continuous snowmaking noise level measurements were conducted between November 5, 2008 and March 5, 2009 at the permanent noise monitoring site, located at the Tahoe Seasons Resort (PAS 085). The monitoring site is located on the northeast corner of the intersection of Keller Rd. and Saddle Rd., with a direct line of sight to the California Base snowmaking operations. Due to the decrease of CNEL noise levels associated snowmaking operations and the continued conversion to fan guns, the current noise monitoring location is reaching the limitations of its usefulness. Traffic noise from the intersection of Keller Rd. and Saddle Rd. is affecting the overall measured noise levels.

The equipment used for the noise level measurements was a Larson Davis Laboratories (LDL) Model 820 precision integrating sound level meter which was calibrated with an LDL Model CAL 200 acoustical calibrator.

During the 2008/2009 ski season the Heavenly continued the log of snowmaking operations, also noting the use and location of snowmaking equipment, during the hours of operation when snowmaking activity occurred. Upon review of the snowmaking activities log provided by Heavenly snowmaking personnel, the measured CNEL values during snowmaking activities was determined at the noise monitoring location. Noise associated with snowmaking activities was a function of the number and location of snowmaking nozzles and/or fans guns in operation. Table 2 summarizes the previous twelve years of snowmaking levels at the Tahoe Seasons Resort (PAS 085), as well as the 2008/2009 season.

Table 2 Summary of Measured Noise Levels at the Tahoe Seasons Resort (Average Measured CNEL Values, Year 2008-2009) Noise Monitoring Site GPS Coordinates (38° 56' 17.43" N - 119° 56' 18.43" W)					
Year	CNEL on Days with Snowmaking	CNEL on Days without Snowmaking	CNEL During Measurement Period	Total # of Monitoring Days	Total # of Snowmaking Days
1996/1997	74.1 dBA	61.7 dBA	71.6 dBA	--	--
1997/1998	73.5 dBA	61.8 dBA	70.2 dBA	--	--
1998/1999	73.0 dBA	62.0 dBA	69.5 dBA	--	--
1999/2000	74.3 dBA	62.0 dBA	73.0 dBA	141	101
*2000/2001	74.1 dBA	60.0 dBA	72.2 dBA	140	89
*2001/2002	73.9 dBA	60.3 dBA	72.1 dBA	145	93
*2002/2003	72.0 dBA	63.1 dBA	68.3 dBA	150	61
*2003/2004	67.4 dBA	62.3 dBA	65.7 dBA	104	56
*2004/2005	65.3 dBA	61.5 dBA	63.1 dBA	149	51
*2005/2006	61.0 dBA	60.9 dBA	61.4 dBA	151	41
*2006/2007	63.7 dBA	58.1 dBA	62.6 dBA	149	75
*2007/2008	62.4 dBA	58.2 dBA	61.6 dBA	140	62
***2008/2009**	**62.4 dBA**	**59.7 dBA**	**61.2 dBA**	**119**	**75**
*The 2000/2001 - 2007/2008 measurement site was moved to the ground level of the Tahoe Seasons Resort. Previously this site was located at the roof-top of the Tahoe Seasons Resort. **Year 2003-2004 Heavenly began Fan Gun Technology**					

The average measured CNEL value at the 2008/2009 monitoring site was 62.4 dBA when snowmaking operations occurred. This was identical to the 2007/2008 season. As shown in Table 2, the average measured CNEL during the 2008/2009 season was 1.5 dBA CNEL greater than during the 2007/2008 ski season, on days when snowmaking operations did not occur.

Average daily measured noise level was 62.4 dBA CNEL when snowmaking operations occurred. This level exceeds the 55 dBA CNEL standards for PAS 085 and PAS 087. In addition, the measured CNEL values on days without snowmaking operations also exceeded the 085 and 087 Plan Area CNEL standards. However, one of the primary noise sources is traffic on Keller Road and Saddle Road, and is not completely indicative of snowmaking activities at Heavenly. The data indicates that when snowmaking occurs, the noise levels associated with snowmaking are equal to the noise when snowmaking does not occur. To put this in perspective, two equal amounts of sound energy would result in a 3 dBA increase (59 dBA + 59 dBA = 62 dBA). Figures 2 through 6 graphically show the results of the noise monitoring, as they compare to the TRPA CNEL criterion of 55 dBA for PAS 085 and 087.

Based upon revisions to the methods for tracking daily snowmaking operations over the past seven ski seasons, a more detailed analysis of snowmaking noise levels can be conducted. Specifically, the snowmaking database has incorporated specific information on the type of snowmaking equipment which is operating (air/water nozzles or fan guns), number of each type of snowmaking gun, and the geographic array of snowmaking equipment on the mountain.

Snowmaking can occur over a significant portion of the California side of the mountain. In addition, the array of snowmaking at the California Base can include air/water nozzle and fan-gun type snowmaking equipment. The fan-guns have been found to produce noise levels which are a minimum of 10 dBA and closer to 20 dBA less than the traditional air-water nozzle guns, such as Ratnik and Omicron brand snowmaking nozzles. Table 3 summarizes the last eight years of CNEL values for varying types of snowmaking operations.

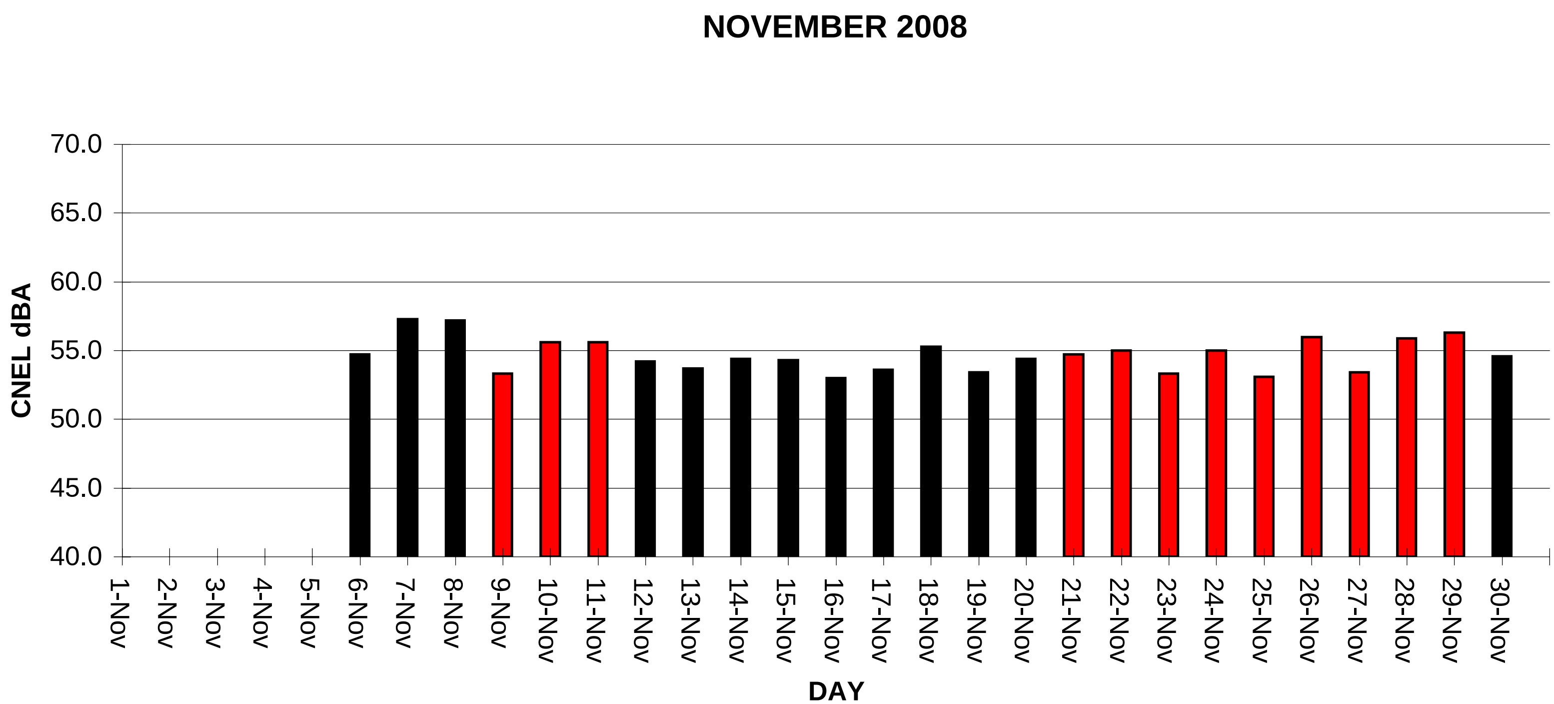
Table 3
Summary of Measured Noise Levels at the Tahoe Seasons Resort
Based upon Varying Arrays of Snowmaking Operations at the California Base

Year	Days with Lower Snowmaking Only	Days with Upper Snowmaking Only	Days with Lower Air/Water Nozzles Only	Days with Upper Air/Water Nozzles Only	Days with Lower Fan-Guns Only
	Arithmetic Average CNEL				
2001-2002	74.7 dBA	63.7 dBA	72.2 dBA	63.7 dBA	NA[2]
2002-2003	73.0 dBA	63.0 dBA	NA[3]	62.8 dBA	NA[2]
2003-2004	61.7 dBA	60.9 dBA	NA[3]	60.3 dBA	61.1 dBA
2004-2005	64.1 dBA	60.3 dBA	66.1 dBA	NA[1]	NA[2]
2005-2006	63.4 dBA	57.6 dBA	NA[3]	NA[1]	63.4 dBA
2006-2007	65.4 dBA	60.2 dBA	NA[3]	59.3 dBA	65.2 dBA
2007-2008	60.6 dBA	61.2 dBA	NA[3]	62.0 dBA	60.1 dBA
2008-2009	**64.3 dBA**	**58.1 dBA**	**NA[3]**	**63.3 dBA**	**63.4 dBA**

[1]NA - No snowmaking occurred with strictly Upper Air-Water Nozzles operating.
[2]NA - No snowmaking occurred with strictly Fan Guns operating.
[3]NA - No snowmaking occurred with strictly Lower Air-Water Nozzles Only

Figure 2
Nov-08
Heavenly California Base Area Snowmaking Noise Monitoring

Annual Snowmaking Report
Summary of CNEL
November-08



NO SNOWMAKING

SNOWMAKING

CNEL Criterion 55 dBA

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Figure 3
Dec-08
Heavenly California Base Area Snowmaking Noise Monitoring

Annual Snowmaking Report
Summary of CNEL
December-08

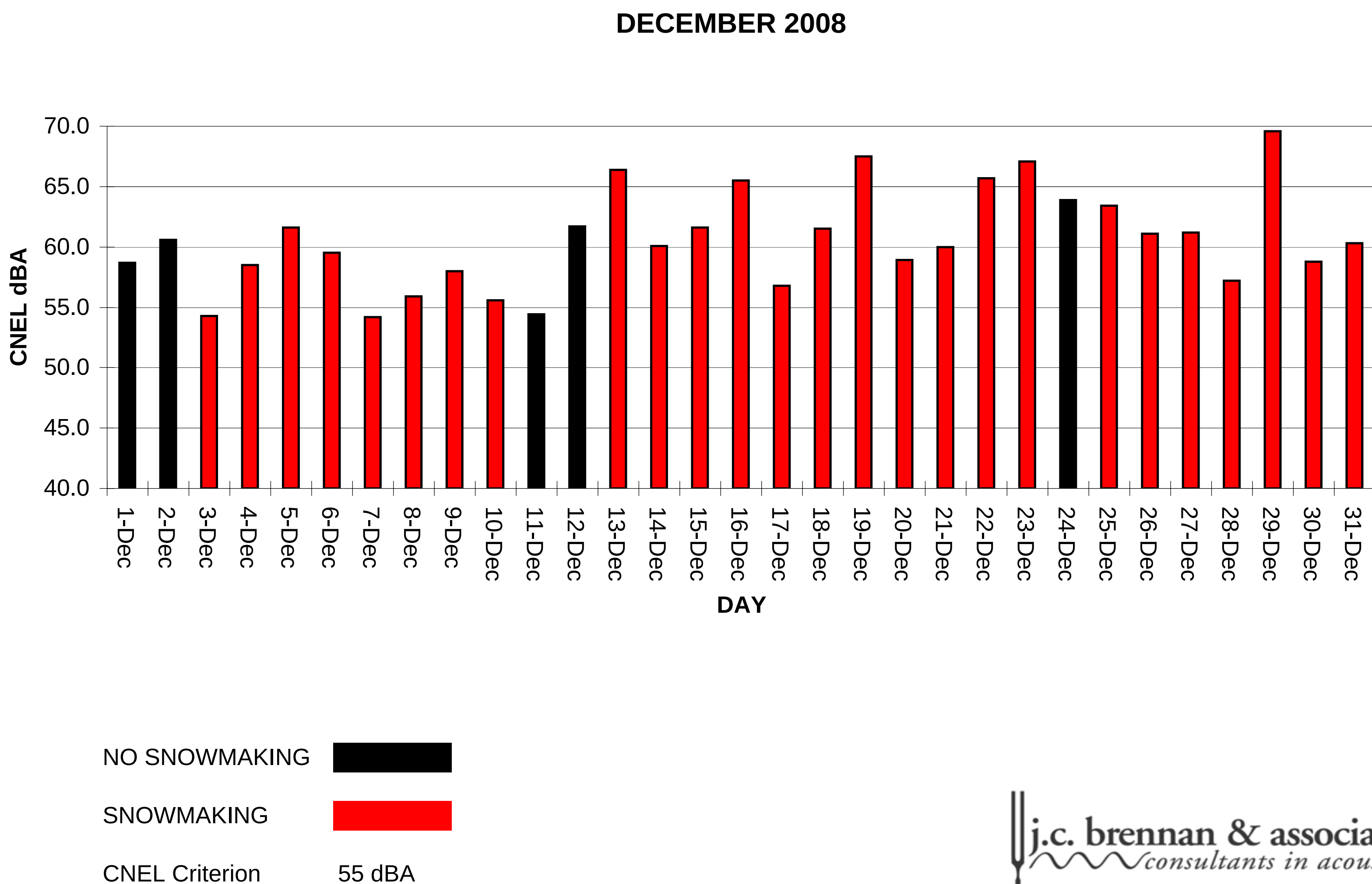

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Figure 4
Jan-09
Heavenly California Base Area Snowmaking Noise Monitoring

Annual Snowmaking Report
Summary of CNEL
January-09

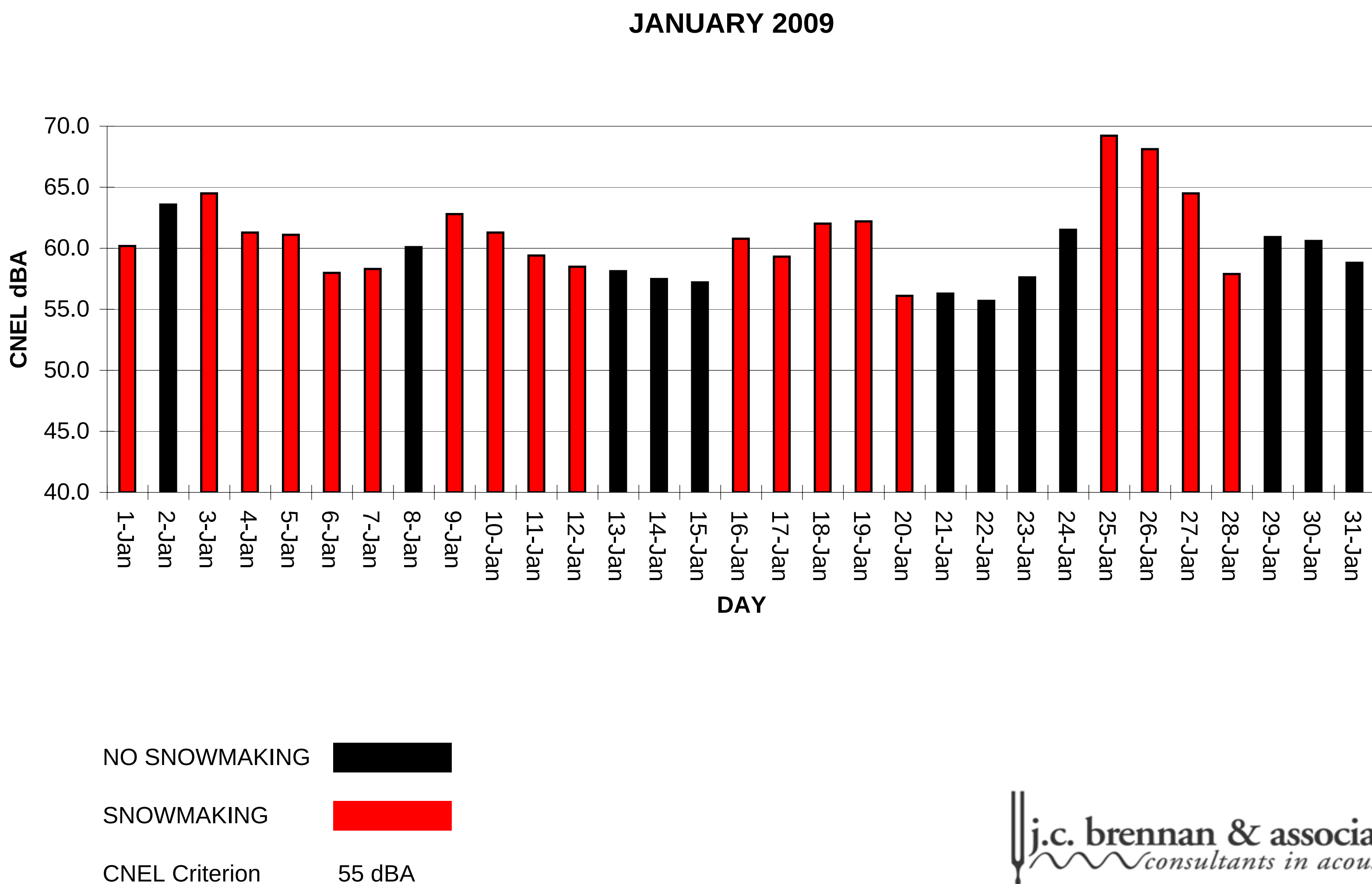

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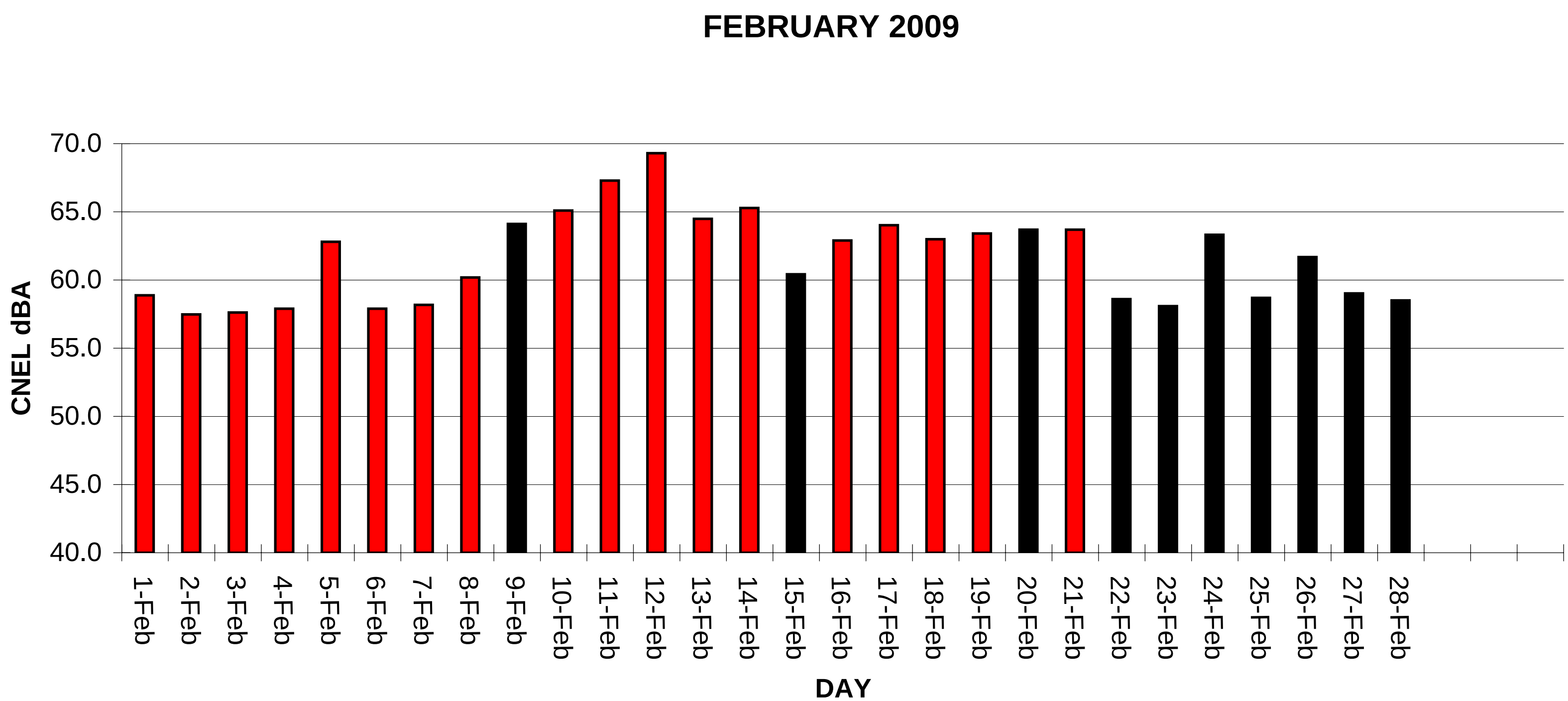
Figure 5
Feb-09
Heavenly California Base Area Snowmaking Noise Monitoring

Annual Snowmaking Report
Summary of CNEL
February-09



NO SNOWMAKING

SNOWMAKING

CNEL Criterion 55 dBA

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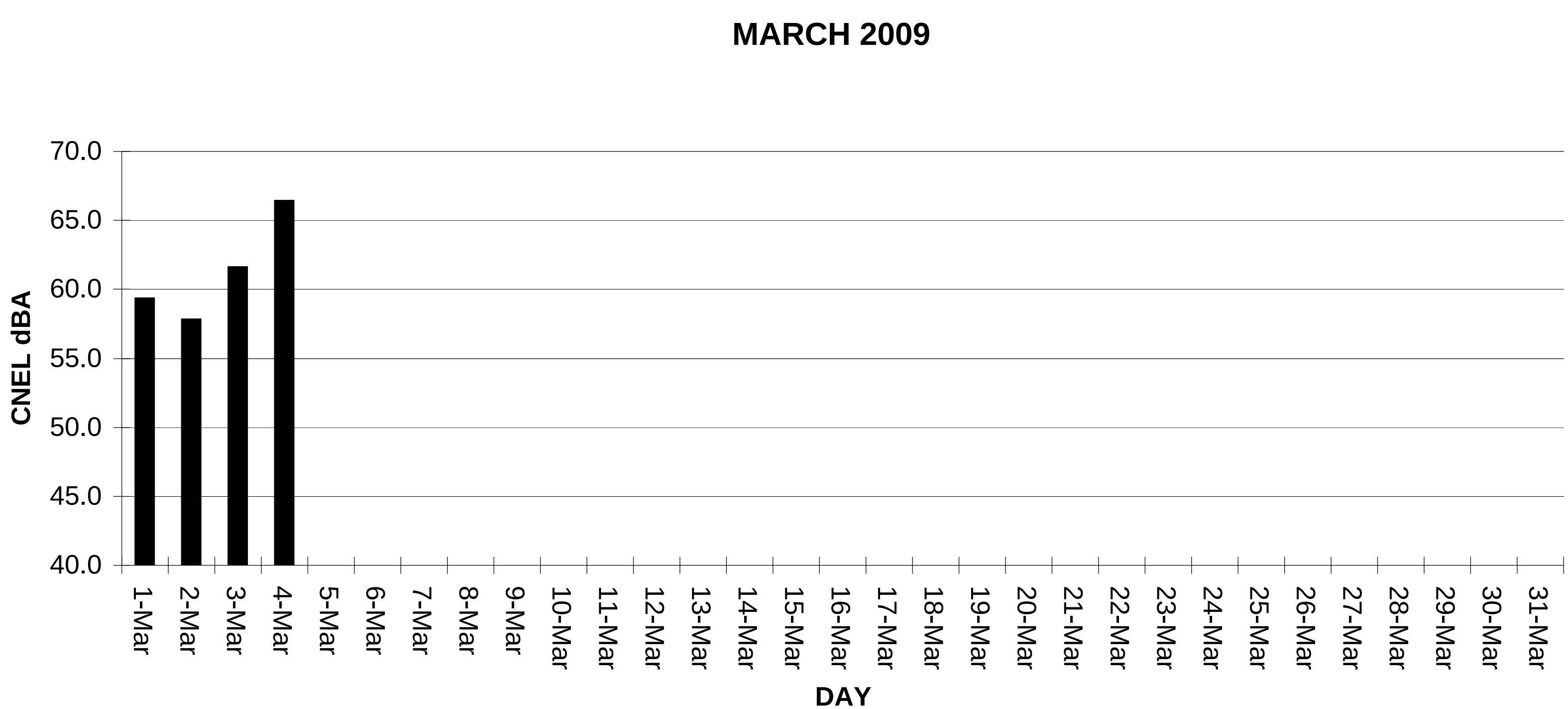
Figure 6
Mar-09
Heavenly California Base Area Snowmaking Noise Monitoring

Annual Snowmaking Report
Summary of CNEL
March-09



NO SNOWMAKING

SNOWMAKING

CNEL Criterion 55 dBA

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The CNEL values shown in Table 3 for the 2008/2009 ski season indicate a fairly substantial increase in noise levels associated with lower snowmaking operations over the 2007/2008 ski season. However, in review of the data, there were only 6 days (all in February), when only the lower snowmaking operations occurred. During one of those days, there were 38 air/water nozzles operating on the lower portion of the mountain, which resulted in a CNEL of 69.3 dBA. This single day resulted in a significant increase in noise over the 2007-2008 ski season. However, the trend in snowmaking noise levels remains in a downward trend since the noise monitoring has begun..

Fan Gun Noise Levels

Heavenly has nearly completed the process of converting the California Base snowmaking operations to the use of fan-guns. The types of fan guns which Heavenly is currently using include SMI Super Polecat. Noise level measurements were conducted on each of these three snowmaking guns on March 24, 2003. The results indicate that noise levels associated with the fan guns are approximately 22 dBA to 25 dBA less than a typical Omicron Whisper Gun or Ratnik Single air/water snowmaking nozzle.

Assuming that the lower California snowmaking fleet could be converted to fan gun technology or other low noise technology air/water nozzles, it is expected that a minimum noise level reduction of 10 dBA can be achieved. During the 2008/2009 ski season, Heavenly reported consistent use of air/water nozzles for snowmaking at the lower portion of the California side along the Round About trail. As the upper mountain converts to fan guns, it is expected that additional reductions in snowmaking noise levels can be realized.

However, the determining factors on overall noise from the snowmaking system include the types of snowmaking equipment, the number of air/water nozzles or fans operating at any time, and the total hours of operations. If fan gun technology is not capable of producing the amount of snow that the air/water nozzles produce, then snowmaking operations may require an increase in the number of fan guns operating at any one time and/or an increase in hours of operation.

III.5 Snowmaking at Boulder Base Area Noise

III.5.a Master Plan Mitigation Methods

1. Use of fans in place of air/water nozzles or using air/water nozzles which are low noise;
2. Re-direction of nozzles and fans to minimize noise exposures at PAS boundaries;
3. Reduction in the numbers of nozzles and/or fans;
4. Use of setbacks to reduce noise exposures at PAS boundaries;
5. Use of noise reduction housings for air/water nozzles;
6. Use of barriers at low-mounted air/water nozzles;
7. Reduction in snowmaking activities at nighttime;
8. Sponsor research into reducing noise produced by snowmaking. This may include support of industry-wide research activities, specific studies concerning nozzle design sponsored

directly by Heavenly, and the study of alternatives in placement of guns and fans at Heavenly.

9. At the Stagecoach and Boulder Bases, Heavenly will strive to replace all air/water nozzles with fans.

III.5.b Master Plan Milestone/Product

During the 2008/2009 ski season, Heavenly has conducted short-term noise monitoring at the Boulder Base area. The noise monitoring occurs for short periods of time since the snowmaking only occurs for between 2 and 4 days per year. Heavenly anticipates replacing the air/water nozzles after complete replacement of nozzles with fan guns on the entire California face. Heavenly is investing in low noise technology fan gun and air/water nozzles and anticipates this is the next area for replacement of noisy air/water nozzles. Heavenly has not implemented any of the other mitigation measures listed above.

III.5.c Responsible Party

Heavenly is responsible for implementing the mitigation measures.

III.5.d PAS Criteria

PAS 080 – 50 dB CNEL
PAS 082, 085, 086, 087, 088 – 55 dB CNEL
PAS 095, PAS 121 – 45 dB CNEL

III.5.e Results of Reporting and Determination of Compliance

Short-term noise level measurements of snowmaking operations were conducted during the 2008/2009 ski season at the Boulder Base on December 24, 2008. Measured noise levels at this location were approximately 67 dBA Leq during snowmaking operations. Measurements were also conducted at the corner of Jack Circle and Bonnie Court. The measured noise levels were approximately 65 dB Leq. These levels are identical to the 2007/2008 ski season. The results of the ambient noise measurements for the 2008/2009 ski season and previous ski seasons are shown in Table 4. The predicted CNEL value at the Boulder Base is 73 dBA. The predicted CNEL value at the Jacks Circle location is 71 dBA.

Table 4 Ambient Noise Level Measurements Boulder Base Area					
Year	Date	Measured Sound Level, Leq			
		Boulder Base Site 1	Corner of Jack Cir. and Bonnie Ct. Site 2		
			Measured	Measured for Master Plan	
1999-2000	December 14, 1999	70 dBA	63 dBA	65 dBA	
2000-2001	December 14, 2000	73 dBA	65 dBA		
2001-2002	NA[1]	NA[1]	NA		
2002-2003	February 4, 2003	71 dBA	53 dBA		
2003-2004	December 8, 2003	60 dBA	NA[1]		
2004-2005	December 3, 2004	66 dBA	58 dBA		
2005-2006	December 13, 2005	71 dBA	64 dBA		
2006-2007	December 28, 2006	68 dBA	63 dBA		
2007-2008	December 31, 2007	67 dBA	65 dBA		
2008-2009	December 24, 2008	67 dBA	65 dBA		

[1]Snowmaking operations did not occur at this location during this season.
Boulder Base GPS Coordinates (38° 58.3' 3.98" N - 119° 53' 25.81"W)
Jack Circle/Bonnie Ct. GPS Coordinates (38° 58' 5.14" N – 119° 53' 34.76" W)

Currently, the snowmaking operations are out of compliance with the TRPA criteria.

III.6 Snowmaking at Stagecoach Base Area Noise

III.6.a Master Plan Mitigation Methods

1. Use of fans in place of air/water nozzles or air/water guns which are low noise;
2. Re-direction of nozzles and fans to minimize noise exposures at PAS boundaries;
3. Reduction in the numbers of nozzles and/or fans;
4. Use of setbacks to reduce noise exposures at PAS boundaries;
5. Use of noise reduction housings for air/water nozzles;
6. Use of barriers at low-mounted air/water nozzles;
7. Reduction in snowmaking activities at nighttime;
8. Sponsor research into reducing noise produced by snowmaking. This may include support of industry-wide research activities, specific studies concerning nozzle design sponsored directly by Heavenly, and the study of alternatives in placement of guns and fans at Heavenly.
9. At the Stagecoach and Boulder Bases, Heavenly will strive to replace all air/water nozzles with fans.

III.6.b Master Plan Milestone/Product

During the 2008/2009 ski season, Heavenly has conducted short-term noise monitoring at the Stagecoach Base area. The noise monitoring occurs for short periods of time since the snowmaking only occurs for between 2 and 4 days per year. Heavenly anticipates replacing the air/water nozzles after complete replacement of nozzles with fan guns on the entire California face. Heavenly has not implemented any of the mitigation measures listed above.

III.6.c Responsible Party

Heavenly is responsible for implementing the mitigation measures.

III.6.d PAS Criteria

This area is located outside of the TRPA area of influence.

III.6.e Results of Reporting and Determination of Compliance

Short-term noise level measurements of snowmaking operations were conducted during the 2008/2009 ski season at three locations of the Stagecoach Base, on December 17, 2008. The noise levels during snowmaking operations were 78 dBA Leq at 460 Quaking Aspen, 65 dBA Leq at the entrance to the Eagle Nest, and 55 dBA Leq at the entrance to the Ridge. The average hourly noise levels at the Quaking Aspen location conducted for the development of the Master Plan were between 82 dBA and 92 dBA Leq in 1996. The results of the ambient noise measurements for the 2008/2009 ski season and previous ski seasons are shown in Table 5.

Table 5 Ambient Noise Level Measurements Stage Coach Base Area					
Year	Date	Measured Sound Level, L_{eq}			
		460 Quaking Aspen Rd. Site 3		Entrance to The Ridge Site 4	Eagles Nest Site 5
		Measured	Measured for Master Plan		
1999-2000	December 4, 1999	87 dBA	82-92 dBA	62 dBA	78 dBA
2000-2001	December 11, 2000	86 dBA		56 dBA	72 dBA
2001-2002	November 30, 2001	57 dBA		55 dBA	59 dBA
2002-2003	February 2, 2003	83 dBA		--	70 dBA
2003-2004	December 8, 2003	87 dBA		58 dBA	74 dBA
2004-2005	November 30, 2004	81 dBA		58 dBA	68 dBA
2005-2006	December 5, 2005	81 dBA		63 dBA	73 dBA
2006-2007	December 18, 2006	88 dBA		62 dBA	72 dBA
2007-2008	December 20, 2007	82 dBA		60 dBA	68 dBA
2008-2009	December 17, 2008	78 dBA		55 dBA	65 dBA

Quaking Aspen GPS Coordinates (38° 57’ 37.52” - 119° 53’ 16.57” W)
Entrance to Ridge GPS Coordinates (38°57’ 46.68” N - 119° 56’ 3.68” W)
Eagles Nest GPS Coordinates (38° 57’ 35.04” N - 119° 53’ 23.63” W)

Using the data collected on December 17, 2008 shown in Table 5, a 24 hour CNEL was calculated for each of the three locations at the Stage Coach Base Area. With continuous snowmaking operations, 24 hour operations at Eagle Nest resulted in a 71 dBA CNEL. The 24 hour operations at 460 Quaking Aspen resulted in a CNEL of 84 dBA. The 24 hour operations at the entrance to The Ridge resulted in a 61 dBA CNEL.

III.7 Snowmaking Upper Mountain Noise

III.7.a Master Plan Mitigation Methods

In order to reduce overall snowmaking noise the levels, Heavenly shall use fan guns or other similar noise reduction measures for all new snowmaking areas. In addition, where new snowmaking is placed adjacent to existing ski trails with snowmaking, Heavenly shall convert the existing air/water snowmaking nozzles with fan guns or use other similar noise reduction measures to maintain or reduce existing noise levels in that area.

III.7.b Master Plan Milestone/Product

Snowmaking noise from the upper mountain areas is monitored and evaluated from the California

Base Area permanent noise monitor, and through Remote Plan Area monitoring. The analysis to date indicates that upper mountain snowmaking does not exceed the ambient noise when snowmaking is not occurring. New snowmaking installations are fan guns.

III.7.c Responsible Party

Heavenly is the responsible party.

III.7.d PAS Criteria

PAS 080 – 50 dB CNEL
PAS 082, 085, 086, 087, 088 – 55 dB CNEL
PAS 095, PAS 121 – 45 dB CNEL

III.7.e Results of Reporting and Determination of Compliance

See the reporting for the California Base Area. The following provides results of the Remote Plan Area Noise Measurements

j.c. brennan & associates, Inc., conducted noise level measurements of snowmaking operations at two remote Plan Area locations December 18, 2008. The noise measurement locations included "Party Rock" (Noise Measurement Site 7) located within Plan Area 080, and the second noise measurement location was in Plan Area 095 adjacent to the ski area boundary, and southeast of Liz's and Canyon Runs (Noise Measurement Site 6). The noise level measurements were conducted to determine if snowmaking operations would exceed the applicable standards.

The noise measurements for Plan Area 080 were conducted during a full array of fan gun operations at the base of the Von Schmidt's Lodge. The results of the noise measurements and field observations were that the snowmaking operations were not audible. The noise measurements for Plan Area 095 were conducted during a full array of Ratnik air/water nozzles operating along the traverse above Liz's Run and Sky Express Chair. The full array of air/water guns was approximately 10 Ratnik guns. The snowmaking operations resulted in a noise level of 79 dB Leq.

GPS coordinates for the Remote Plan Area measurements sites are as follows:

Party Rock (38° 56' 27.63" N - 119° 56' 1.35" W);
Liz's / Canyon Run (38° 54' 47.5" N - 119° 54' 43" W).

Currently, the noise levels exceed the noise level criteria at the top of Sky Chair area (PAS 095). Noise levels do not exceed the Plan Area 080 criteria.

III.8 Rock Busting Noise

III.8.a Master Plan Mitigation Methods

Rock busting generally occurs through the use of explosives and blasting. Control the number, size and location of Rock Busting blasts.

III.8.b Master Plan Milestone/Product

None

III.8.c Responsible Party

Heavenly is the responsible party.

III.8.d PAS Criteria

PAS 080 – 50 dB CNEL
PAS 082, 085, 086, 087, 088 – 55 dB CNEL
PAS 095, PAS 121 – 45 dB CNEL

III.8.e Results of Reporting and Determination of Compliance

Heavenly has not contacted j.c. brennan & associates, Inc. to conduct noise measurements of blasting or rock busting. It is assumed that this activity has not occurred.

III.9 Amphitheater Operations Noise

III.9.a Master Plan Mitigation Methods

Restrict hours of concert noise to the daytime and early evening hours. This is consistent with the hours of operations assumed for the amphitheater noise study. In addition, concerts should not extend more than 6 hours in duration.

III.9.b Master Plan Milestone/Product

Heavenly has conducted a concert simulation and amphitheater noise study.

III.9.c Responsible Party

Heavenly is the responsible party

III.9.d PAS Criteria.

PAS 080 – 50 dB CNEL

PAS 082, 085, 086, 087, 088 – 55 dB CNEL
PAS 095, PAS 121 – 45 dB CNEL

III.9.e Results of Reporting and Determination of Compliance

No concerts have occurred to date.

Appendix A

Acoustical Terminology

Acoustics	The science of sound.
Ambient Noise	The distinctive acoustical characteristics of a given space consisting of all noise sources audible at that location. In many cases, the term ambient is used to describe an existing or pre-project condition such as the setting in an environmental noise study.
Attenuation	The reduction of an acoustic signal.
A-Weighting	A frequency-response adjustment of a sound level meter that conditions the output signal to approximate human response.
Decibel or dB	Fundamental unit of sound, A Bell is defined as the logarithm of the ratio of the sound pressure squared over the reference pressure squared. A Decibel is one-tenth of a Bell.
CNEL	Community Noise Equivalent Level. Defined as the 24-hour average noise level with noise occurring during evening hours (7 - 10 p.m.) weighted by a factor of three (+5 dB for TRPA calculations) and nighttime hours weighted by a factor of 10 (or +10 dB) prior to averaging.
Frequency	The measure of the rapidity of alterations of a periodic signal, expressed in cycles per second or hertz.
Ldn	Day/Night Average Sound Level. Similar to CNEL but with no evening weighting.
Leq	Equivalent or energy-averaged sound level.
Lmax	The highest root-mean-square (RMS) sound level measured over a given period of time.
L(n)	The sound level exceeded a described percentile over a measurement period. For instance, an hourly L50 is the sound level exceeded 50% of the time during the one hour period.
Loudness	A subjective term for the sensation of the magnitude of sound.
Noise	Unwanted sound.
Peak Noise	The level corresponding to the highest (not RMS) sound pressure measured over a given period of time. This term is often confused with the "Maximum" level, which is the highest RMS level.
RT_{60}	The time it takes reverberant sound to decay by 60 dB once the source has been removed.
Sabin	The unit of sound absorption. One square foot of material absorbing 100% of incident sound has an absorption of 1 sabin.
Threshold of Hearing	The lowest sound that can be perceived by the human auditory system, generally considered to be 0 dB for persons with perfect hearing.
Threshold of Pain	Approximately 120 dB above the threshold of hearing.
Impulsive	Sound of short duration, usually less than one second, with an abrupt onset and rapid decay.
Simple Tone	Any sound which can be judged as audible as a single pitch or set of single pitches.

Appendix B
2008-206
Heavenly Snowmaking Monitoring

Annual Snowmaking Report
Summary of CNEL
November-08

Day	CNEL dB	Snow	Nevada Upper A	Nevada Upper F	Nevada Lower A	Nevada Lower F	California Upper A	California Upper F	California Lower A	California Lower F	California Base F	California York	
1-Nov	0.0												
2-Nov	0.0												
3-Nov	0.0												
4-Nov	0.0												
5-Nov													Set up Meter
6-Nov	54.7	N											
7-Nov	57.3	N											
8-Nov	57.2	N											
9-Nov	53.3	Y	80	4									
10-Nov	55.6	Y	76	5									
11-Nov	55.6	Y	75	5									
12-Nov	54.2	N											
13-Nov	53.7	N											
14-Nov	54.4	N											
15-Nov	54.3	N											
16-Nov	53.0	N											
17-Nov	53.6	N											
18-Nov	55.3	N											
19-Nov	53.4	N											
20-Nov	54.4	N											
21-Nov	54.7	Y	88	10				1					
22-Nov	55.0	Y	70	7									
23-Nov	53.3	Y	88	10				1					
24-Nov	55.0	Y	82	10				1					
25-Nov	53.1	Y	60										Downloaded Meter during the 11:00 hr
26-Nov	56.0	Y	72	10									
27-Nov	53.4	Y	76	11				1					
28-Nov	55.9	Y	80	12				1					
29-Nov	56.3	Y	44	12									
30-Nov	54.6	N											

CNEL Average	
No Snowmaking	54.8
Snowmaking	54.9
Total	54.9

# of No Snowmaking Days	13
# of Snowmaking Days	12
Total Days of Monitoring	25

* A- Air Nozzles
F- Fan Guns

No Snowmaking Log Available
Snowmaking
Meter Downtime/Incomplete Data

j.c. brennan & associates
consultants in acoustics

Appendix B
2008-206
Heavenly Snowmaking Monitoring

Annual Snowmaking Report
Summary of CNEL
December-08

Day	CNEL dB	Snow	Nevada Upper A	Nevada Upper F	Nevada Lower A	Nevada Lower F	California Upper A	California Upper F	California Lower A	California Lower F	California Base F	California York	
1-Dec	58.7	N											
2-Dec	60.6	N											
3-Dec	54.3	Y	80	11				1					
4-Dec	58.5	Y	82	10				1		7			
5-Dec	61.6	Y	86	10				1		11			
6-Dec	59.5	Y	66	10				2		11			
7-Dec	54.2	Y	52	10				3		2			
8-Dec	55.9	Y	54	11				3					
9-Dec	58.0	Y	68	10				3		8			
10-Dec	55.6	Y	16	3				20					
11-Dec	54.4	N											
12-Dec	61.7	N											
13-Dec	66.4	Y					50	3		7			
14-Dec	60.1	Y	32	4			40	3		7			
15-Dec	61.6	Y	20	4			60	3		7			
16-Dec	65.5	Y	24	7			58	3		2			
17-Dec	56.8	Y	40	7			24			3			
18-Dec	61.5	Y	16	7	24		38	2		3			
19-Dec	67.5	Y	36	3	24		40	1		3			
20-Dec	58.9	Y	10		6		4			3			
21-Dec	60.0	Y	36	6			36						
22-Dec	65.7	Y	26	6			28	2		5			
23-Dec	67.1	Y	36	5			2	2	40	7			Meter uploaded during the 2:00 hr
24-Dec	63.9	N											Christmas Eve
25-Dec	63.4	Y		6	26		32						
26-Dec	61.1	Y		1	40		14			1			
27-Dec	61.2	Y		2	32	2	24			3			
28-Dec	57.2	Y		4			26						
29-Dec	69.6	Y		5			14						
30-Dec	58.8	Y	12	18	12	2	36			9			
31-Dec	60.3	Y	14	16	12	2	36			9			

CNEL Average	
No Snowmaking	60.9
Snowmaking	62.8
Total	62.6

# of No Snowmaking Days	5
# of Snowmaking Days	26
Total Days of Monitoring	31

* A- Air Nozzles
  F- Fan Guns

No Snowmaking Log Available
Snowmaking
Meter Downtime/Incomplete Data

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Appendix B
2008-206
Heavenly Snowmaking Monitoring

Annual Snowmaking Report
Summary of CNEL
January-09

			Nevada				California						
		Snow	Upper		Lower		Upper		Lower		Base	York	
Day	CNEL dB		A	F	A	F	A	F	A	F	F		
1-Jan	60.2	Y	4	11	12		18	1					
2-Jan	63.6	N											
3-Jan	64.5	Y	32	10	12		10	2	24	22			
4-Jan	61.3	Y	2	7	12		26	2	20	22			
5-Jan	61.1	Y	2	14	14		50	2		16			
6-Jan	58.0	Y		8			32	2					
7-Jan	58.3	Y		2									
8-Jan	60.1	N											
9-Jan	62.8	Y					36	1		18			
10-Jan	61.3	Y		4			30	16		16			
11-Jan	59.4	Y		4	14		40						
12-Jan	58.5	Y		4			34						
13-Jan	58.1	N											
14-Jan	57.5	N											
15-Jan	57.2	N											
16-Jan	60.8	Y	8				52						
17-Jan	59.3	Y	14	2			44						
18-Jan	62.0	Y	16	8		1	50	2		9			
19-Jan	62.2	Y		6			50			7			
20-Jan	56.1	Y		3		1	50						
21-Jan	56.3	N											No Log Available
22-Jan	55.7	N											
23-Jan	57.6	N											
24-Jan	61.5	N											
25-Jan	69.2	Y			16		2	10	48	10			
26-Jan	68.1	Y			4	1	22		24	27			Meeter Downloaded During 11:00am hr
27-Jan	64.5	Y		4		1	12		28	29			
28-Jan	57.9	Y						64		5			
29-Jan	60.9	N											
30-Jan	60.6	N											
31-Jan	58.8	N											

CNEL Average	
No Snowmaking	59.6
Snowmaking	62.8
Total	61.9
# of No Snowmaking Days	12
# of Snowmaking Days	19
Total Days of Monitoring	31

* A- Air Nozzles
F- Fan Guns

No Snowmaking Log Available
Snowmaking
Meter Downtime/Incomplete Data

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Appendix B
2008-206
Heavenly Snowmaking Monitoring

Annual Snowmaking Report
Summary of CNEL
February-09

			Nevada				California					
		Snow	Upper		Lower		Upper		Lower		Base	York
Day	CNEL dB		A	F	A	F	A	F	A	F	F	
1-Feb	58.9	Y					50			2		
2-Feb	57.5	Y					40	4				
3-Feb	57.6	Y					48	1				
4-Feb	57.9	Y	4	1			56	1				
5-Feb	62.8	Y	4				66					
6-Feb	57.9	Y	4	8			74			14		
7-Feb	58.2	Y	4				66	2				
8-Feb	60.2	Y	4				58	2		8		
9-Feb	64.1	N										
10-Feb	65.1	Y	2	8			66			12		
11-Feb	67.3	Y	2	8		1	30		38	12		
12-Feb	69.3	Y		8		1			38	12		
13-Feb	64.5	Y				1		3		19		
14-Feb	65.3	Y				1		3		19		
15-Feb	60.4	N										
16-Feb	62.9	Y								12		
17-Feb	64.0	Y								14		
18-Feb	63.0	Y								21		
19-Feb	63.4	Y								13		
20-Feb	63.7	N										
21-Feb	63.7	Y								15		
22-Feb	58.6	N										
23-Feb	58.1	N										
24-Feb	63.3	N										
25-Feb	58.7	N										
26-Feb	61.7	N										
27-Feb	59.0	N										
28-Feb	58.5	N										

CNEL Average	
No Snowmaking	61.2
Snowmaking	63.6
Total	62.9
# of No Snowmaking Days	10
# of Snowmaking Days	18
Total Days of Monitoring	28

* A- Air Nozzles
F- Fan Guns
No Snowmaking Log Available
Snowmaking

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Appendix B
2008-206
Heavenly Snowmaking Monitoring

Annual Snowmaking Report
Summary of CNEL
March-09

			Nevada				California					
		Snow	Upper		Lower		Upper		Lower		Base	York
Day	CNEL dB		A	F	A	F	A	F	A	F	F	
1-Mar	59.3	N										
2-Mar	57.8	N										
3-Mar	61.6	N										
4-Mar	66.4	N										
5-Mar												
6-Mar												
7-Mar												
8-Mar												
9-Mar												
10-Mar												
11-Mar												
12-Mar												
13-Mar												
14-Mar												
15-Mar												
16-Mar												
17-Mar												
18-Mar												
19-Mar												
20-Mar												
21-Mar												
22-Mar												
23-Mar												
24-Mar												
25-Mar												
26-Mar												
27-Mar												
28-Mar												
29-Mar												
30-Mar												
31-Mar												

CNEL Average	
No Snowmaking	62.6
Snowmaking	#DIV/0!
Total	62.6
# of No Snowmaking Days	4
# of Snowmaking Days	0
Total Days of Monitoring	4

* A- Air Nozzles
F- Fan Guns

No Snowmaking in March 2008

Meter Downloaded During 3:00 Hour

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2008-206

Heavenly Snowmaking Monitoring

CNEL Summary

CNEL Averages						
	November	December	January	February	March	Average for Measurment Period
Total	54.9	62.6	61.9	62.9	62.6	61.6
Snowmaking	54.9	62.8	62.8	63.6	0.0	62.4
No Snowmaking	54.8	60.9	59.6	61.2	62.6	59.7

	November	December	January	February	March	Total
# of Snowmaking Days	12	26	19	18	0	75
Total Days of Monitoring	25	31	31	28	4	119

Annual Snowmaking CNEL (dB)	**55.5**

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Appendix XI

2008-2009 Shuttles and Routes Schedule

RED ROUTE 10

		MINUTES PAST THE HOUR	
1	Stateline Transit Center / Gondola (Departure)	:00	:30
32	Forest Suites Resort (Bellamy Ct.)	:01	:31
48	Shops at Heavenly Village (Heavenly Village Way)	:01	:31
46	Applebee's / Park Tahoe Inn (U.S. Hwy 50)	:02	:32
18	Holiday Inn Express (U.S. Hwy 50)	:02	:32
23	Lake Tahoe Vacation Resort (Ski Run Blvd.)	:05	:35
24	Tahoe Beach & Ski Club (U.S. Hwy 50)	:08	:38
25	Lakeland Village (U.S. Hwy 50)	:10	:40
26	Lakeshore Lodge & Spa (Bal Bijou Rd.)	:11	:41
27	Best Western Timber Cove Lodge (U.S. Hwy 50)	:13	:43
28	Inn by the Lake (Fremont Ave.)	:15	:45
42	Safeway (U.S. Hwy 50)	:16	:46
30	Super 8 Motel (U.S. Hwy 50)	:18	:48
22	Fantasy Inn (U.S. Hwy 50)	:20	:50
21	Quality Inn (U.S. Hwy 50)	:22	:52
47	Heavenly Gondola (U.S. Hwy 50)	:24	:51
1	Stateline Transit Center / Gondola (Arrival)	:25	:55

ORANGE ROUTE 11

#	Stop	MINUTES PAST THE HOUR		
1	Stateline Transit Center / Gondola (Departure)	:00	:20	:40
32	Forest Suites Resort (Bellamy Ct.)	:02	:22	:42
48	Shops at Heavenly Village (Heavenly Village Way)	:02	:22	:42
19	7-Eleven (Pioneer Trail)	:05	:25	:45
20	Americana Village (Pioneer Trail)	:07	:27	:47
44	Pioneer Trail / Wildwood Ave	:08	:28	:48
31	Ski Run Blvd. / Pioneer Trail	:09	:29	:49
	CALIFORNIA LODGE (Arrival)	:15	:35	:55
	CALIFORNIA LODGE (Departure)	:20	:40	:00
37	Inn at Heavenly (Ski Run Blvd.)	:26	:46	:06
44	Pioneer Trail / Aspenwald Rd.	:32	:57	:12
20	Pioneer Trail / across from Americana Village	:34	:54	:14
19	Pioneer Trail / across from 7-Eleven	:35	:55	:14
47	Heavenly Gondola (U.S. Hwy 50)	:37	:57	:17
1	Stateline Transit Center / Gondola (Arrival)	:38	:58	:18

GREEN ROUTE 12

		MINUTES PAST THE HOUR			
1	Stateline Transit Center / Gondola (Departure)	:55	:10	:25	:40
32	Forest Suites Resort (Bellamy Ct.)	:56	:11	:26	:41
3	Harrah's East Retail Entrance	:00	:15	:30	:45
4	MontBleu Resort Casino & Spa	:05	:20	:35	:50
45	U.S. Hwy 50 / Visitor Center	:07	:22	:37	:52
40	Kingsbury Transit Center	:07	:22	:37	:52
5	Lakeside Inn and Casino	:08	:23	:38	:53
6	Horizon Casino Resort	:11	:26	:41	:56
7	Harveys Bus Center	:14	:29	:44	:59
1	Stateline Transit Center / Gondola (Arrival)	:17	:32	:47	:02

GOLD ROUTE 13

		MINUTES PAST THE HOUR	
24	Tahoe Beach & Ski Club (Departure) (U.S. Hwy 50)	:23	:53
25	Lakeland Village / Howard Johnson (U.S. Hwy 50)	:24	:54
26	Lakeshore Lodge & Spa (Bal Bijou Rd.)	:25	:55
27	Best Western Timber Cove Lodge (U.S. Hwy 50)	:27	:57
28	Inn by the Lake (Fremont Ave.)	:29	:59
29	Bavarian Village (Herbert Ave.)	(Upon Request)	
30	Super 8 Motel (U.S. Hwy 50)	:33	:03
23	Lake Tahoe Vacation Resort (Ski Run Blvd.)	:35	:05
43	Ski Run Blvd. / U.S. Hwy 50	:35	:05
33	Alder Inn (Ski Run Blvd.)	:37	:07
34	Discount Ski (Ski Run Blvd.)	:37	:07
35	Across from Rainbow Mountain (Ski Run Blvd.)	:38	:08
36	Black Bear Inn (Spruce Ave.)	:39	:09
36	Deerfield Lodge (Ski Run Blvd.)	:39	:09
31	Pioneer Trail / Ski Run Blvd.	:40	:10
	CALIFORNIA LODGE (Arrival)	:45	:15
	CALIFORNIA LODGE (Departure)	:47	:17
37	Inn at Heavenly (Ski Run Blvd.)	:49	:19
24	Tahoe Beach & Ski Club (Arrival) (U.S. Hwy 50)	:52	:22

PURPLE ROUTE 14

		MINUTES PAST THE HOUR		
	BOULDER LODGE (Departure)	:03	:23	:43
	STAGECOACH LODGE	:10	:30	:50
41	The Ridge Resorts		:33	
	BOULDER LODGE (Arrival)	:20	:40	:00

BLUE ROUTE 15

#	Stop	MINUTES PAST THE HOUR		
1	Stateline Transit Center / Gondola (Departure)	:00	:20	:40
32	Forest Suites Resort (Bellamy Ct.)	:02	:22	:42
48	Shops at Heavenly Village (Heavenly Village Way)	:02	:22	:42
47	Heavenly Gondola (U.S. Hwy 50)	:03	:23	:43
7	Harveys Bus Center (Stateline Ave.)	:05	:25	:45
2	Embassy Suites	:08	:28	:48
3	Harrah's East Retail Entrance	:11	:31	:51
4	MontBleu Resort & Casino & Spa	:14	:34	:54
6	Horizon Casino Resort	:17	:37	:57
45	U.S. Hwy 50 / Visitor Center	:21	:48	:01
40	Kingsbury Transit Center	:22	:49	:02
5	Lakeside Inn and Casino	:23	:43	:03
38	Mott Canyon Tavern (S.R. 207)	:25	:45	:05
	BOULDER LODGE - (Arrival)	:33	:53	:13
	BOULDER LODGE - (Departure)	:40	:00	:20
	STAGECOACH LODGE - (Arrival)	:52	:12	:32
	STAGECOACH LODGE - (Departure)	:00	:20	:40
39	Scotty's Hardware (S.R. 207)	:10	:30	:50
1	Stateline Transit Center / Gondola (Arrival)	:18	:38	:58

YELLOW ROUTE 16

#	Stop	MINUTES PAST THE HOUR		
1	Stateline Transit Center / Gondola (Departure)	:00	:20	:40
32	Forest Suites Resort (Bellamy Ct.)	:01	:21	:41
48	Shops at Heavenly Village (Heavenly Village Way)	:01	:21	:41
10	Stateline Lodge (Manzanita Ave.)	:03	:23	:43
9	Big Pines Mtn. House (Manzanita Ave.)	:04	:24	:44
8	Tahoe Queen & Tahoe Villa North (Manzanita Ave.)	:05	:25	:45
11	7 Seas Motel (Manzanita Ave.)	:05	:25	:45
12	Rodeway Inn (Pine Blvd.)	:07	:27	:47
13	Best Tahoe West Inn (Pine Blvd.)	:08	:28	:48
14	Best Western Station House Inn (Pine Blvd.)	:09	:29	:49
15	Royal Valhalla Motor Lodge (Lakeshore Dr.)	:10	:30	:50
16	Heavenly Inn (Park Ave)	:12	:32	:52
17	Park Tahoe Inn (Park Ave)	:12	:32	:52
18	Holiday Inn Express (U.S. Hwy 50)	:14	:34	:54
47	Heavenly Gondola (U.S. Hwy 50)	:16	:36	:56
1	Stateline Transit Center / Gondola (Arrival)	:17	:37	:57

Times listed are departure times.
Buses only stop at designated bus stops.
No flag stops or deviations allowed.

Important Information

These times are approximate and may vary due to road conditions, weather, traffic conditions and other unforeseen circumstances.
BlueGO assumes no responsibility for acts or omissions of others, or for lost or stolen or damaged baggage or other personal articles, or for personal items left behind.
Time tables shown are approximate and not guaranteed. Passengers should allow extra time for delays.

If you have any questions about BlueGO Heavenly Ski Shuttles, please call:

(530) 541-7149 or (530) 541-7548

www.bluego.org

FOR ADDITIONAL MOUNTAIN RESORT INFORMATION CONTACT:

Heavenly Mountain Resort
(775)586-7000 skiheavenly.com

Information updated as ski or weather conditions change.

Heavenly is proud to be among the family of

VAIL RESORTS
EXTRAORDINARY RESORTS
EXCEPTIONAL EXPERIENCES

premier mountain resorts.

Vail. Beaver Creek. KEYSTONE
BRECKENRIDGE SKI RESORT Heavenly LAKE TAHOE ROCKRESORTS

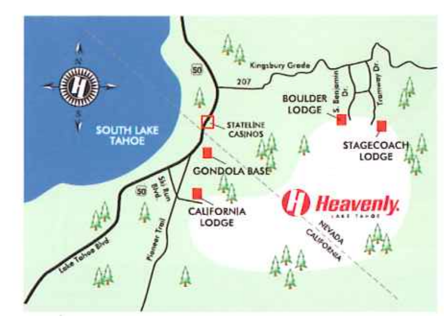
CLEAN FUEL VEHICLE

Heavenly is a proud partner with the Tahoe Regional Planning Agency, Tahoe Transportation District and South Tahoe Area Transit Authority known as BlueGO. Together we are working to replace the bus fleet with new clean-fuel technology vehicles. The new vehicles will not only improve air quality and reduce congestion in South Lake Tahoe, but it will directly improve the the water quality and clarity of Lake Tahoe.

Heavenly is pleased to be associated with a select group of corporate and event partners. Together We're Better.

The Official Vehicle of Heavenly	The Official Communications Provider to Heavenly	The Official Car Rental Company of Heavenly
The Official Sports Beverage of Heavenly	The Official Card of Heavenly	The Official Coffee of Heavenly
The Official Soft Drink of Heavenly	The Official Natural Energy Source of Heavenly	The Official Sock of Heavenly

VAIL RESORTS 100% POWERED BY WIND
NATIONAL FOREST FOUNDATION



Heavenly
LAKE TAHOE

2008 - 2009 SKI SHUTTLE RIDERS GUIDE

BLUE GO

EFFECTIVE FRIDAY, NOVEMBER 21, 2008

BLUEGO HEAVENLY SKI SHUTTLE

The BlueGO Heavenly Ski Shuttle service is comprised of seven routes (red, green, yellow, gold and orange for California and blue and purple for Nevada). The shuttles pick up at each of the shuttle stops according to the shuttle timetables listed for each route color. The time tables are in service from 8:00am - 2:00pm. After 2:00pm the shuttles make continuous loops from the Gondola and California / Nevada base lodges to expedite guest return to their lodging properties.

Please allow extra time when riding shuttles during holidays and Saturdays, as the shuttles are in peak demand during these high-use periods. Shuttles also need extra time during inclement weather, as visibility and slippery road conditions require extra caution and slower speeds.

Look for the white BlueGO Heavenly Ski Shuttle stop signs to board the shuttles.

GONDOLA SHUTTLE OPERATION

In the event the gondola is not operating (due to mechanical or weather issues), the yellow, green and red routes will go to the California Lodge.

At the end of the day, be sure to board a shuttle with the correct colored sign. Shuttles display colored signs near their entry doors or displayed overhead on the designation sign.

If you have any questions about
BlueGO Heavenly Ski Shuttles, please call:

(530) 541-7149 or (530) 541-7548

www.bluego.org

For comments, concerns, questions or suggestions regarding BlueGO transit services please contact John Andoh, BlueGO Transit Administrator by calling: (775) 589-5284, writing to: South Tahoe Area Transit Authority, 128 Market Street, Stateline, NV 89449, fax to: (775) 588-4527 or emailing: jandoh@trpa.org.

ATM

Transit services are provided by Area Transit Management, Inc under contract to the South Tahoe Area Transit Authority and Heavenly Mountain Resort.

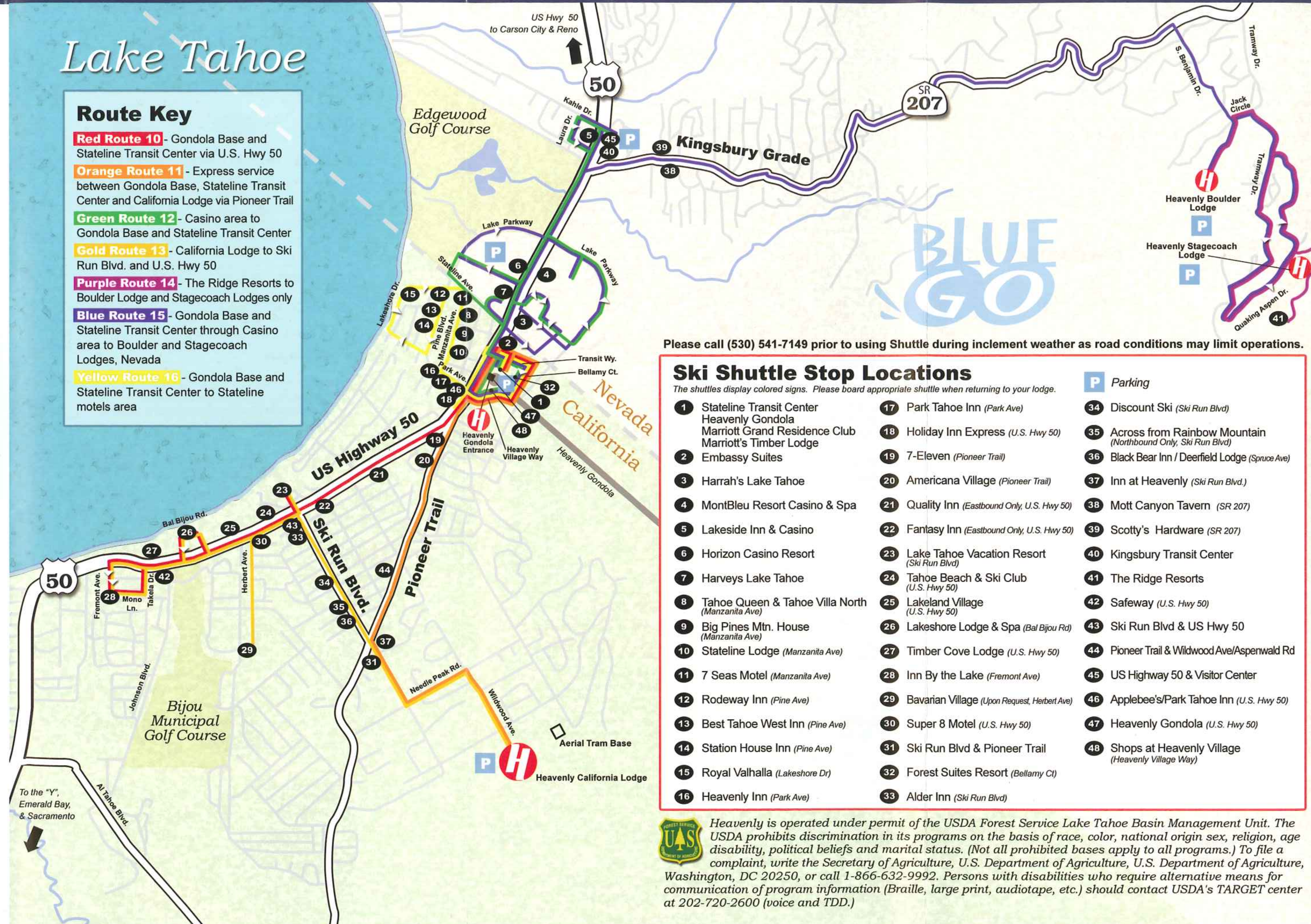
FOR ADDITIONAL MOUNTAIN RESORT INFORMATION CONTACT:

Heavenly Mountain Resort

(775) 586-7000 skiheavenly.com

Information updated as ski or weather conditions change.

Heavenly
LAKE TAHOE



Route Key

- **Red Route 10** - Gondola Base and Stateline Transit Center via U.S. Hwy 50
- **Orange Route 11** - Express service between Gondola Base, Stateline Transit Center and California Lodge via Pioneer Trail
- **Green Route 12** - Casino area to Gondola Base and Stateline Transit Center
- **Gold Route 13** - California Lodge to Ski Run Blvd. and U.S. Hwy 50
- **Purple Route 14** - The Ridge Resorts to Boulder Lodge and Stagecoach Lodges only
- **Blue Route 15** - Gondola Base and Stateline Transit Center through Casino area to Boulder and Stagecoach Lodges, Nevada
- **Yellow Route 16** - Gondola Base and Stateline Transit Center to Stateline motels area

Please call (530) 541-7149 prior to using Shuttle during inclement weather as road conditions may limit operations.

Ski Shuttle Stop Locations

The shuttles display colored signs. Please board appropriate shuttle when returning to your lodge.

1. Stateline Transit Center
   Heavenly Gondola
   Marriott Grand Residence Club
   Marriott's Timber Lodge
2. Embassy Suites
3. Harrah's Lake Tahoe
4. MontBleu Resort Casino & Spa
5. Lakeside Inn & Casino
6. Horizon Casino Resort
7. Harveys Lake Tahoe
8. Tahoe Queen & Tahoe Villa North *(Manzanita Ave)*
9. Big Pines Mtn. House *(Manzanita Ave)*
10. Stateline Lodge *(Manzanita Ave)*
11. 7 Seas Motel *(Manzanita Ave)*
12. Rodeway Inn *(Pine Ave)*
13. Best Tahoe West Inn *(Pine Ave)*
14. Station House Inn *(Pine Ave)*
15. Royal Valhalla *(Lakeshore Dr)*
16. Heavenly Inn *(Park Ave)*
17. Park Tahoe Inn *(Park Ave)*
18. Holiday Inn Express *(U.S. Hwy 50)*
19. 7-Eleven *(Pioneer Trail)*
20. Americana Village *(Pioneer Trail)*
21. Quality Inn *(Eastbound Only, U.S. Hwy 50)*
22. Fantasy Inn *(Eastbound Only, U.S. Hwy 50)*
23. Lake Tahoe Vacation Resort *(Ski Run Blvd)*
24. Tahoe Beach & Ski Club *(U.S. Hwy 50)*
25. Lakeland Village *(U.S. Hwy 50)*
26. Lakeshore Lodge & Spa *(Bal Bijou Rd)*
27. Timber Cove Lodge *(U.S. Hwy 50)*
28. Inn By the Lake *(Fremont Ave)*
29. Bavarian Village *(Upon Request, Herbert Ave)*
30. Super 8 Motel *(U.S. Hwy 50)*
31. Ski Run Blvd & Pioneer Trail
32. Forest Suites Resort *(Bellamy Ct)*
33. Alder Inn *(Ski Run Blvd)*
34. Discount Ski *(Ski Run Blvd)*
35. Across from Rainbow Mountain *(Northbound Only, Ski Run Blvd)*
36. Black Bear Inn / Deerfield Lodge *(Spruce Ave)*
37. Inn at Heavenly *(Ski Run Blvd.)*
38. Mott Canyon Tavern *(SR 207)*
39. Scotty's Hardware *(SR 207)*
40. Kingsbury Transit Center
41. The Ridge Resorts
42. Safeway *(U.S. Hwy 50)*
43. Ski Run Blvd & US Hwy 50
44. Pioneer Trail & Wildwood Ave/Aspenwald Rd
45. US Highway 50 & Visitor Center
46. Applebee's/Park Tahoe Inn *(U.S. Hwy 50)*
47. Heavenly Gondola *(U.S. Hwy 50)*
48. Shops at Heavenly Village *(Heavenly Village Way)*

P *Parking*

Heavenly is operated under permit of the USDA Forest Service Lake Tahoe Basin Management Unit. The USDA prohibits discrimination in its programs on the basis of race, color, national origin sex, religion, age disability, political beliefs and marital status. (Not all prohibited bases apply to all programs.) To file a complaint, write the Secretary of Agriculture, U.S. Department of Agriculture, U.S. Department of Agriculture, Washington, DC 20250, or call 1-866-632-9992. Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET center at 202-720-2600 (voice and TDD.)

Appendix XII

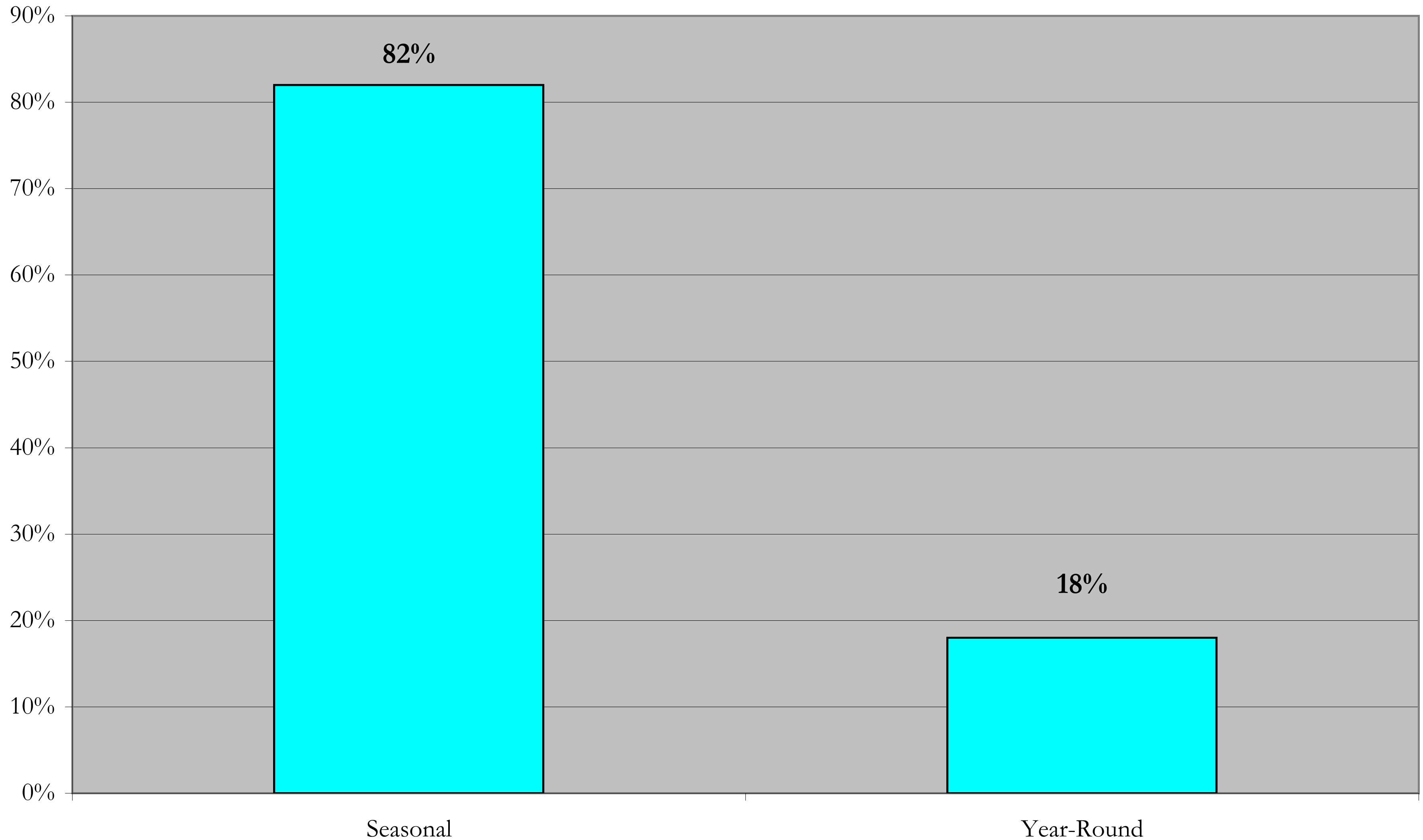
2008-2009 Employee Survey Results

2008-2009 Heavenly Employee Survey

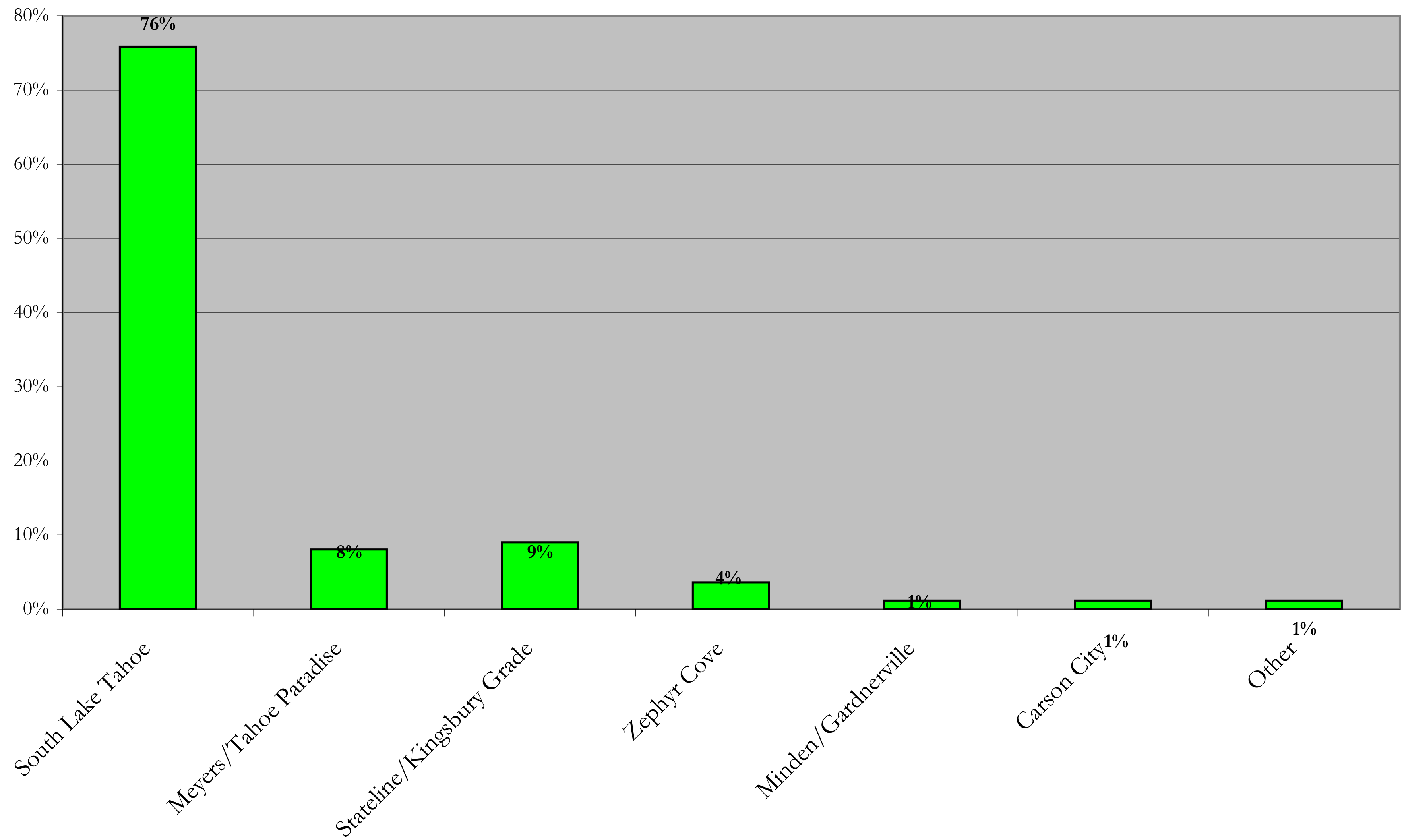
	2008-2009 Survey Master	Total Number of Suvey(s) = 609	Survey #
1	**Employment Classification**	**498**	Seasonal
		111	Year-Round
2	**Current Residence**	**334**	House
		41	Duplex
		21	Triplex
		48	Townhouse or Condo
		115	Apartment
		13	Mobile Home
		21	Employee Housing
		16	Other
3	**Own/Rent**	**115**	Own
		494	Rent
4	**Where?**	**462**	South Lake Tahoe
		49	Meyers/Tahoe Paradise
		55	Stateline/Kingsbury Grade
		22	Zephyr Cove
		7	Minden/Gardnerville
		7	Carson City
		7	Other
5	**How many people?**	**66**	1
		155	2
		133	3
		121	4
		62	5
		72	6 or more
6	**How many bedrooms**	**38**	0 (Studio)
		71	1
		173	2
		236	3
		70	4
		18	5
		3	6 or more
7a	**Renters payment:**	**72**	less than $299
		177	300-499
		116	500-699
		59	700-899
		37	900-1099
		42	more than 1,100
		9	Not Applicable

	2008-2009 Survey Master	Total Number of Suvey(s) = 609	Survey #
7b	**Owners payment:**	**11**	less than $399
		1	400-599
		8	600-799
		12	800-999
		10	1,000-1,199
		50	more than 1,200
		2	Not Applicable
8	**Satifisied w/ housing situation?**	**241**	Very Satisfied
		190	Somewhat Satisfied
		110	Neutral
		40	Somewhat Unsatisfied
		28	Very Unsatisfied
9	**Housing availability in community?**	**78**	Very Good
		223	Good
		217	Neutral
		73	Poor
		18	Very Poor
10	**Rate the cost of housing.**	**73**	Very Good
		211	Good
		200	Neutral
		99	Poor
		20	Very Poor
11	**Have a Car?**	**373**	Yes
		219	No
12	**How do you get to work?**	**258**	Drive
		50	Get a Ride with Someone in a Car or Truck
		128	Ride the Bus
		50	Walk/Bike
		8	Other
13	**Bus or Van from Carson/G-Ville?**	**30**	Yes
		11	No
14	**How much would you pay for service #13?**	**23**	$0. I would not take it if I had to pay anything for it
		12	$5.00 per round trip
		0	$10.00 per round trip

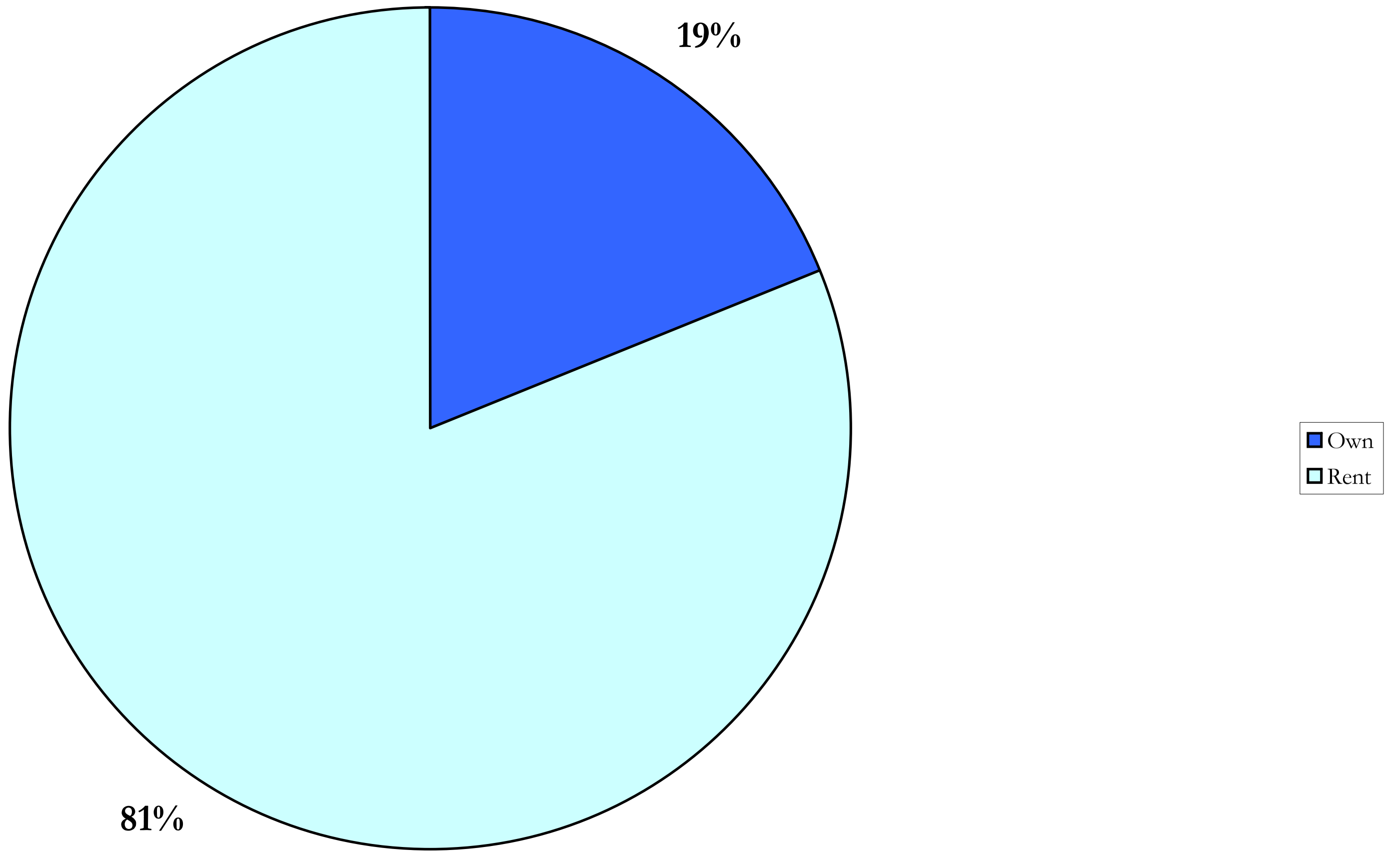
What is your current employment classification?



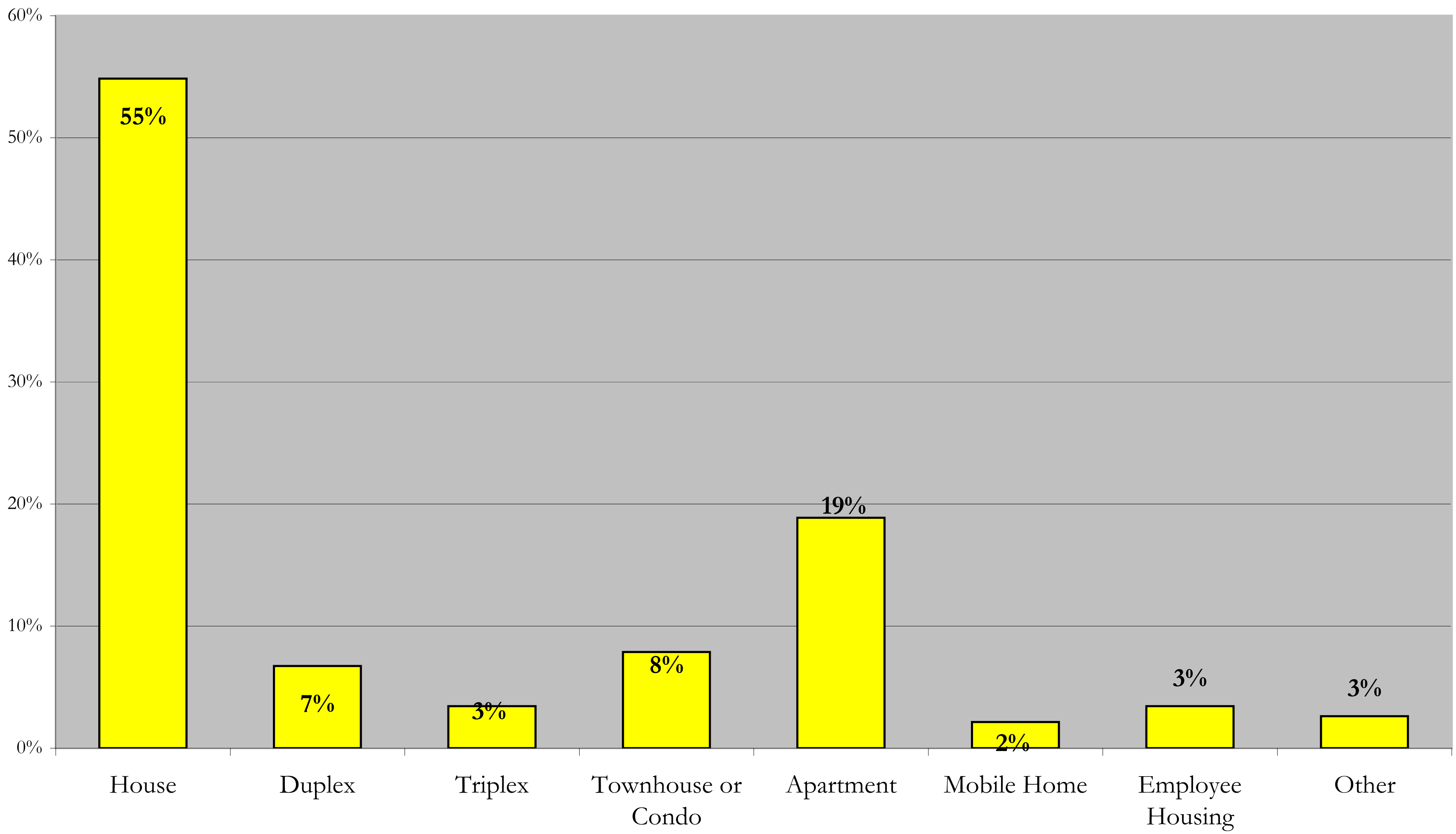
Where do you live?



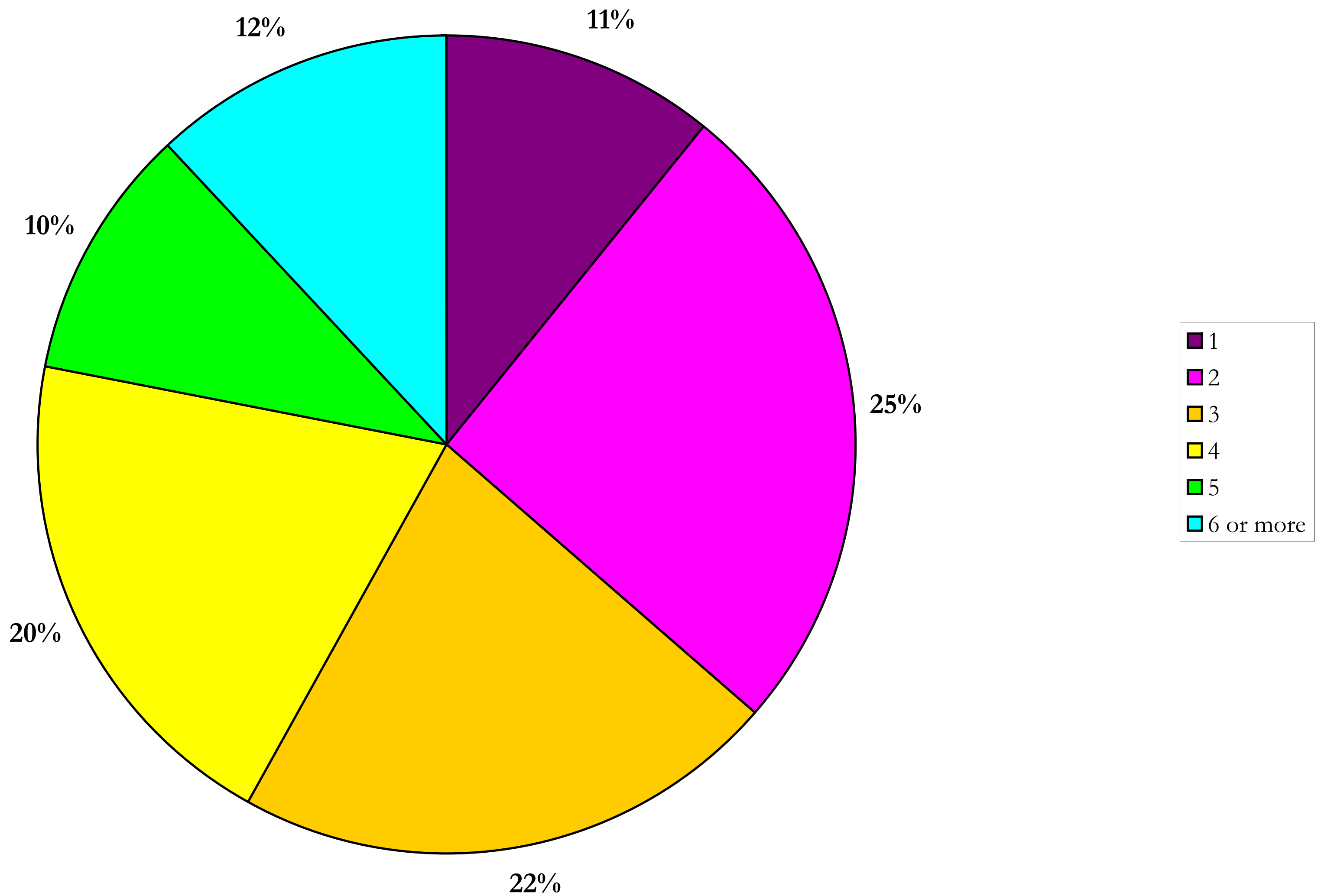
Do you own or rent your current residence?



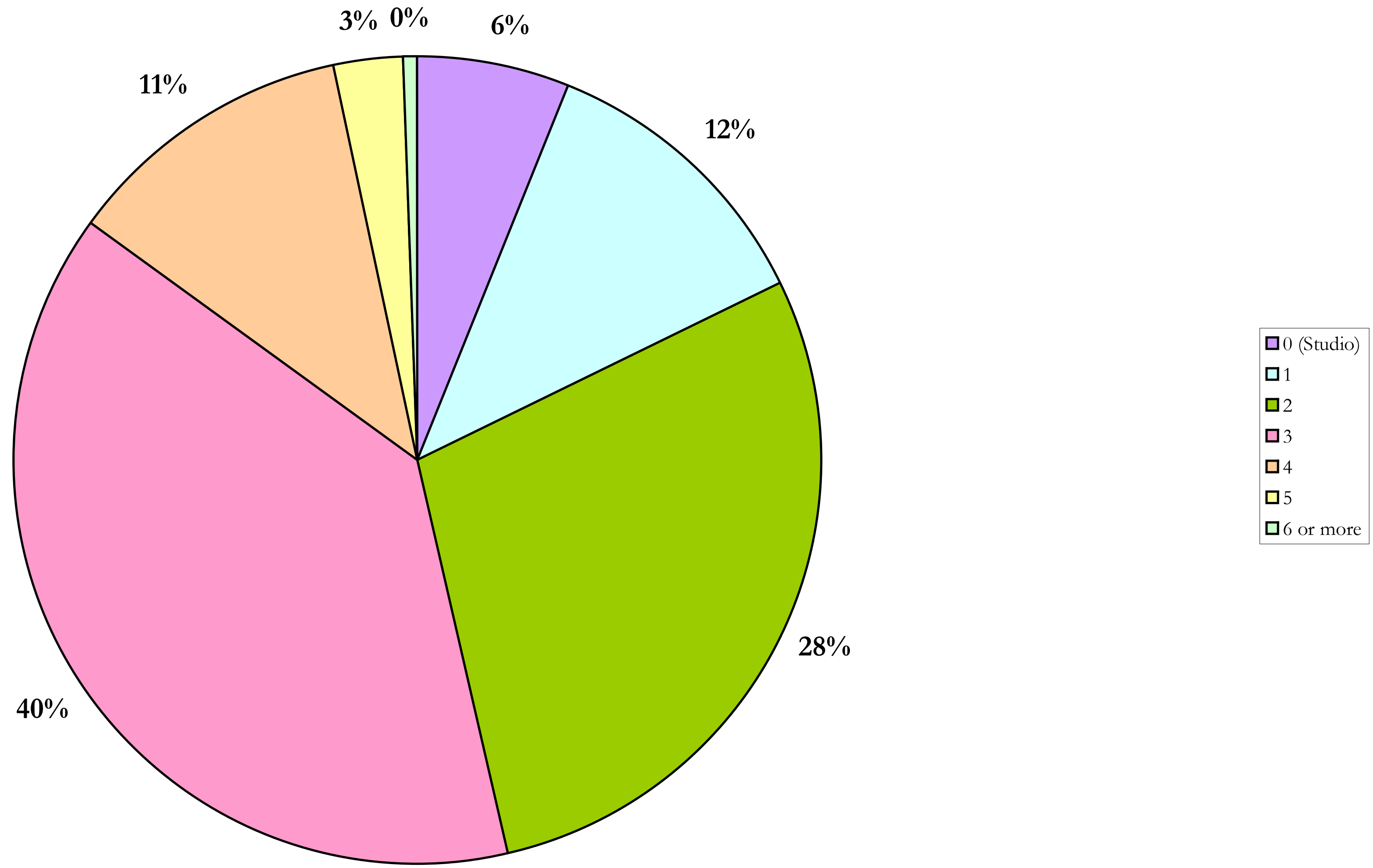
Which of the following categories best describes your current residence?



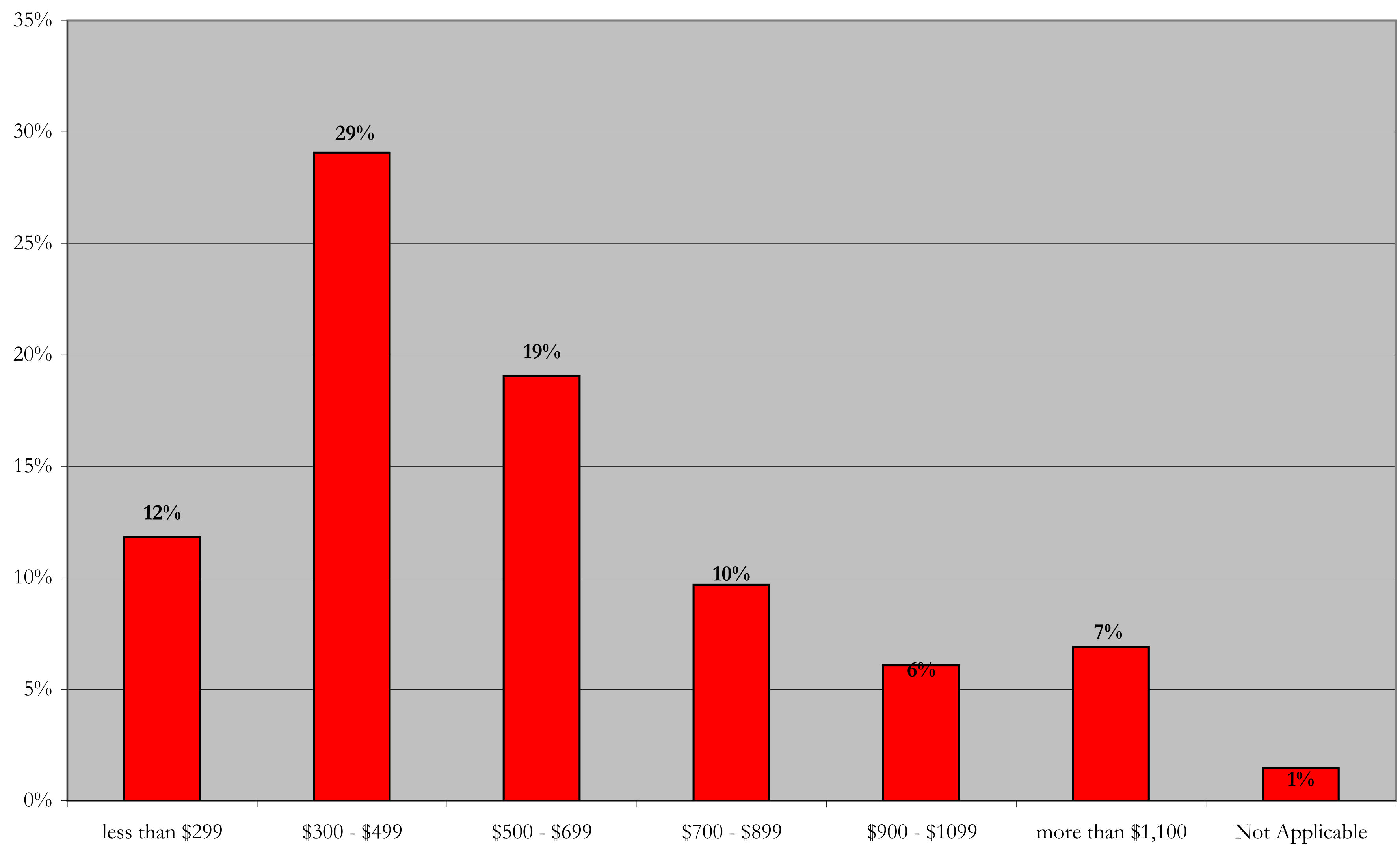
How many people including yourself live in your household?



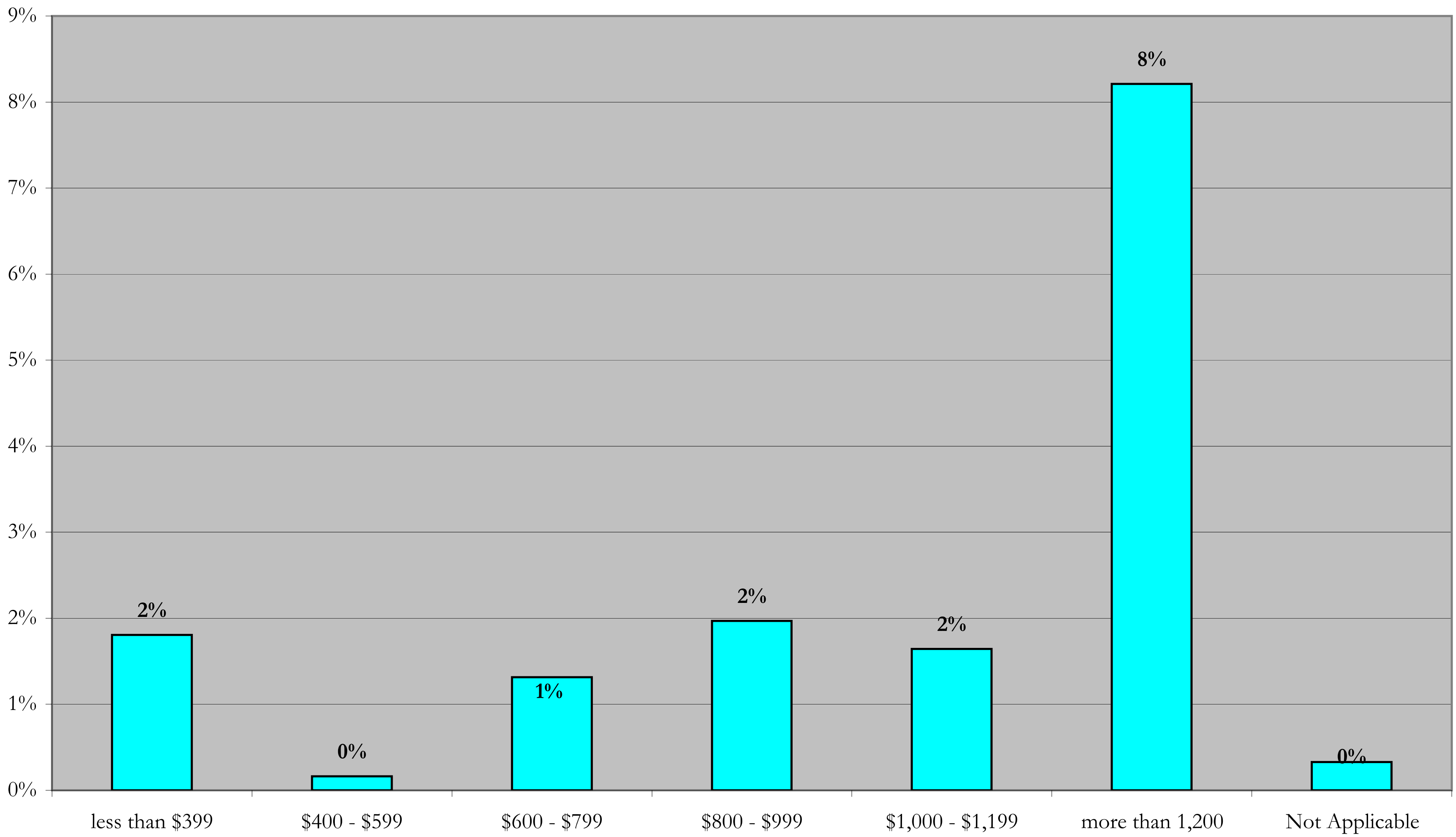
How many bedrooms are in your current residence?



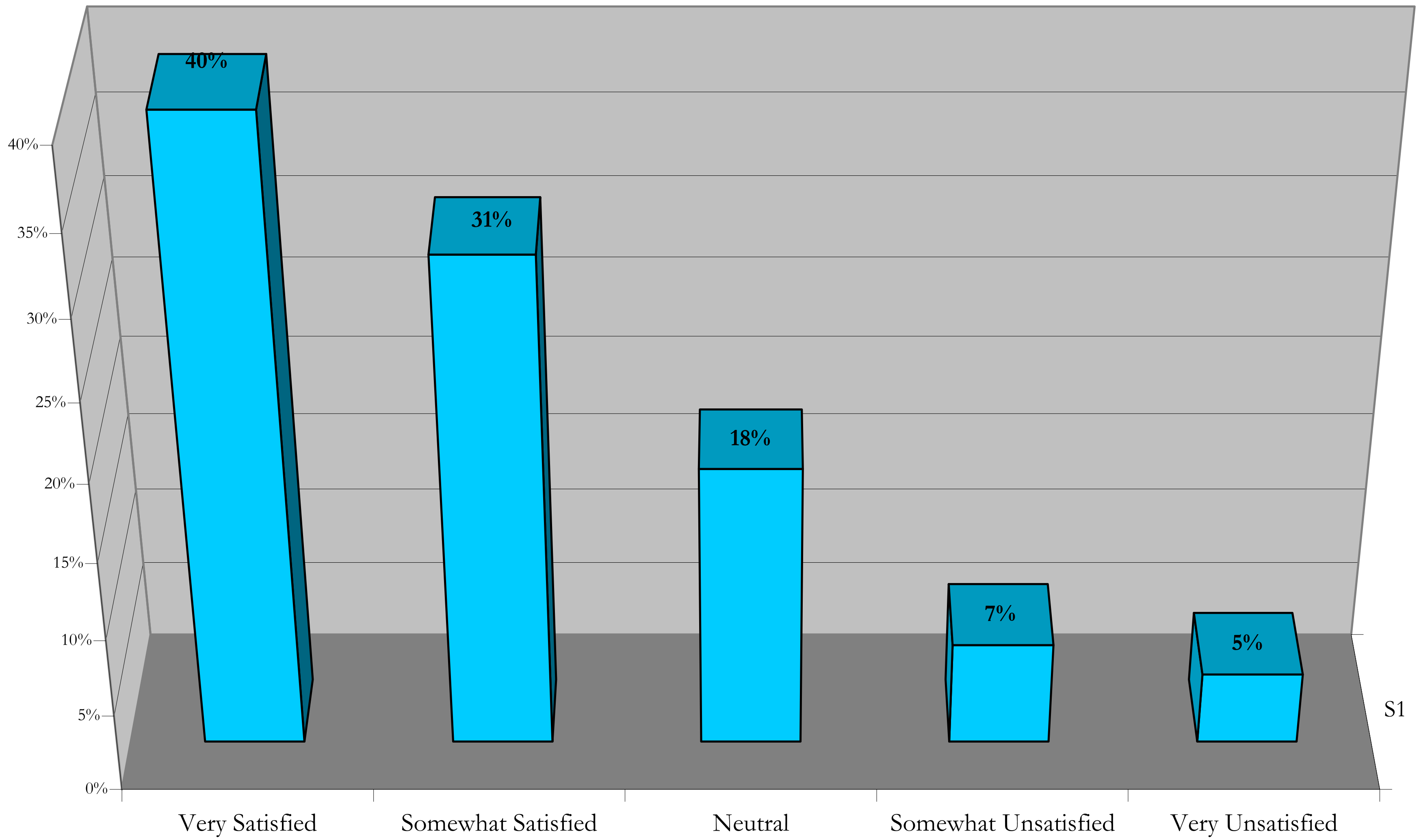
How much do *you* currently pay for monthly rent?



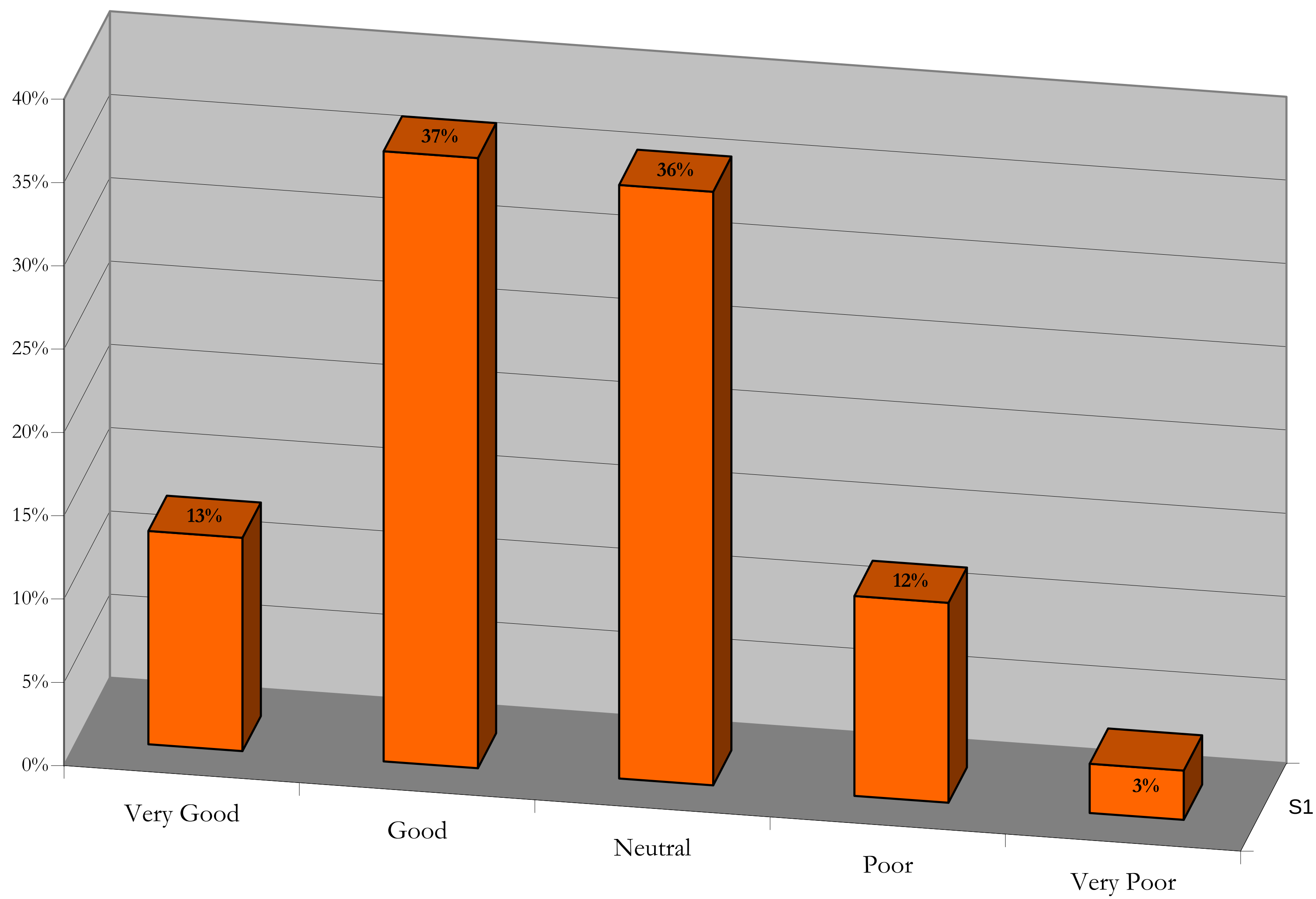
How much is *your* current monthly mortgage payment on your residence?



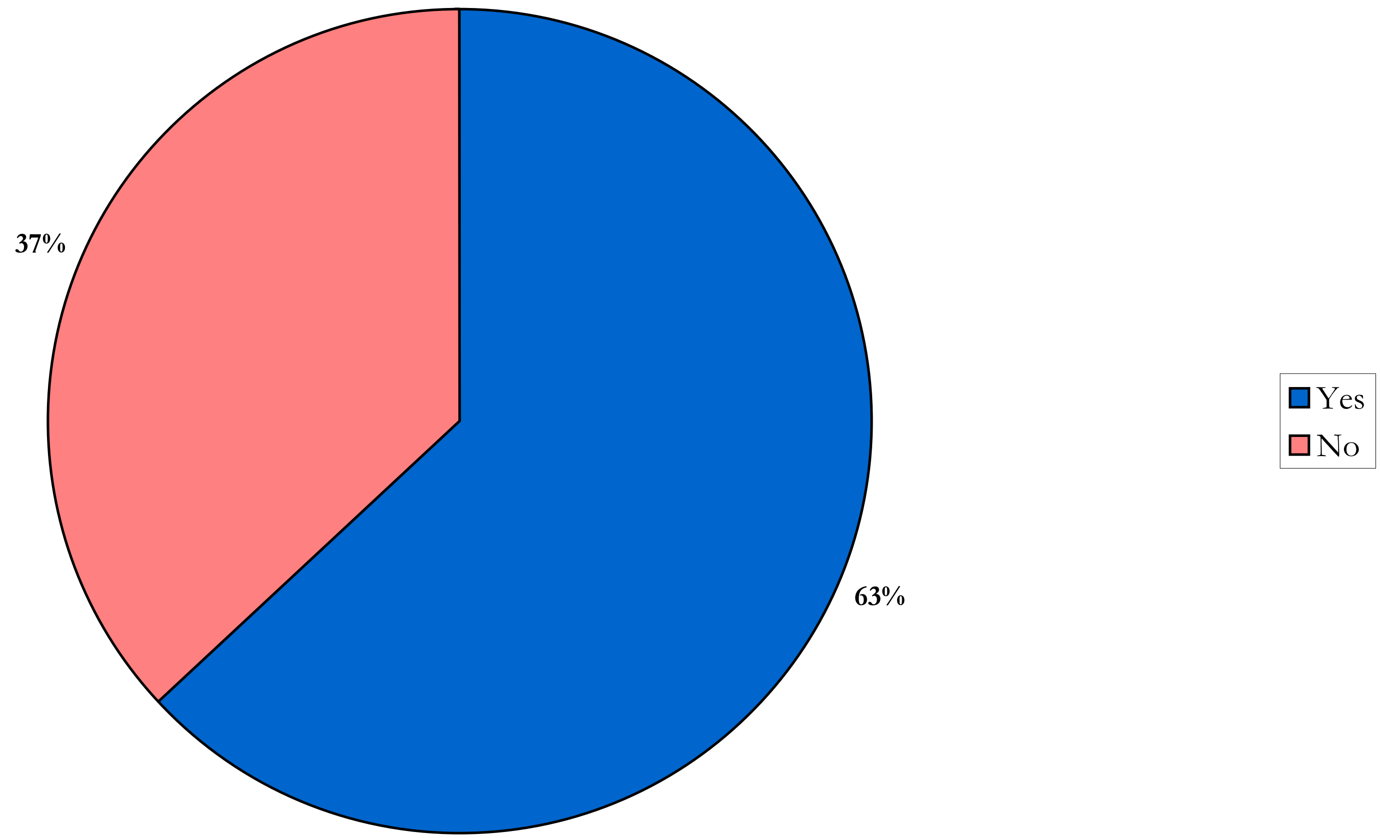
How satisfied are you with your existing housing situation?



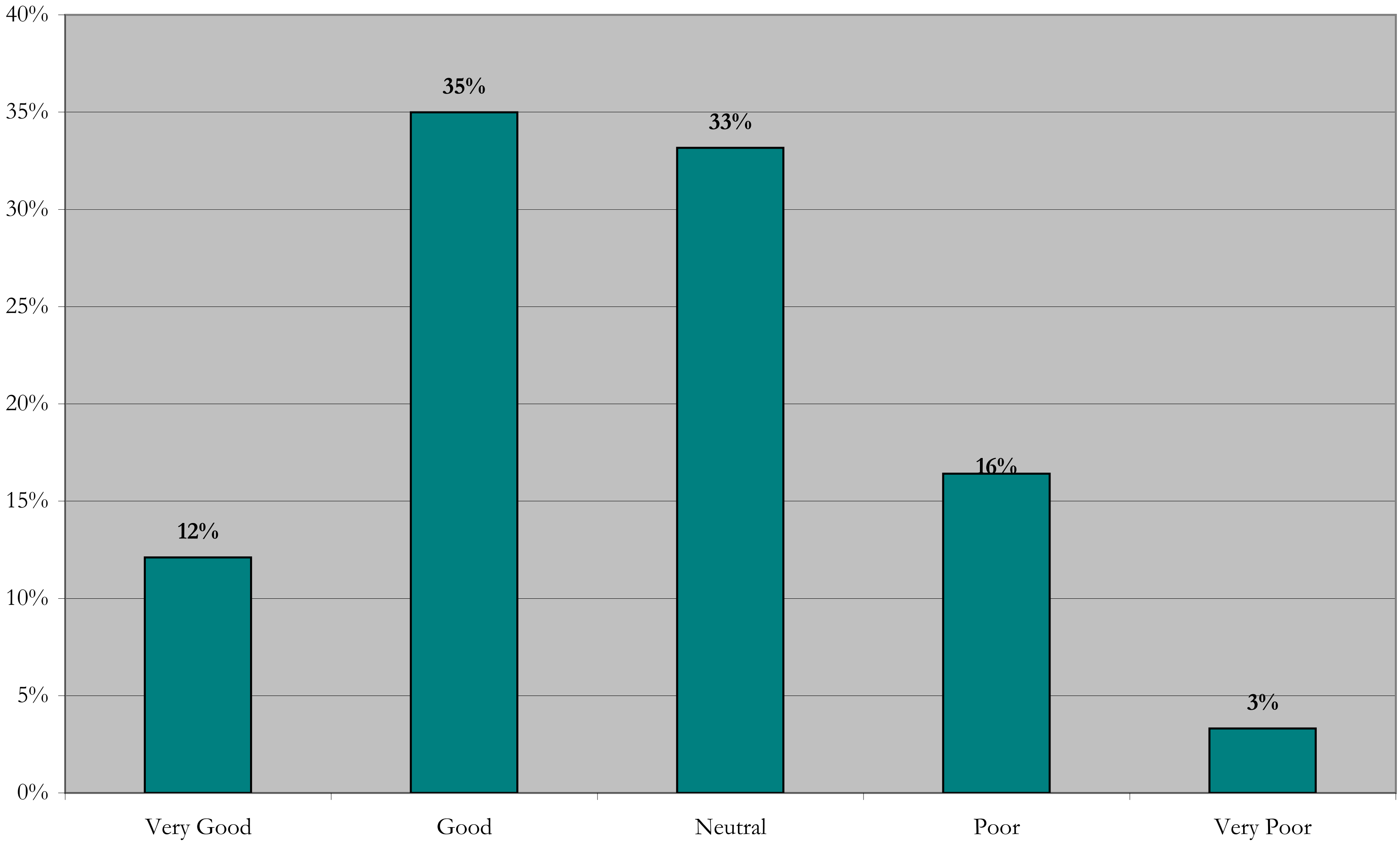
How would you rate the availability of housing in your community?



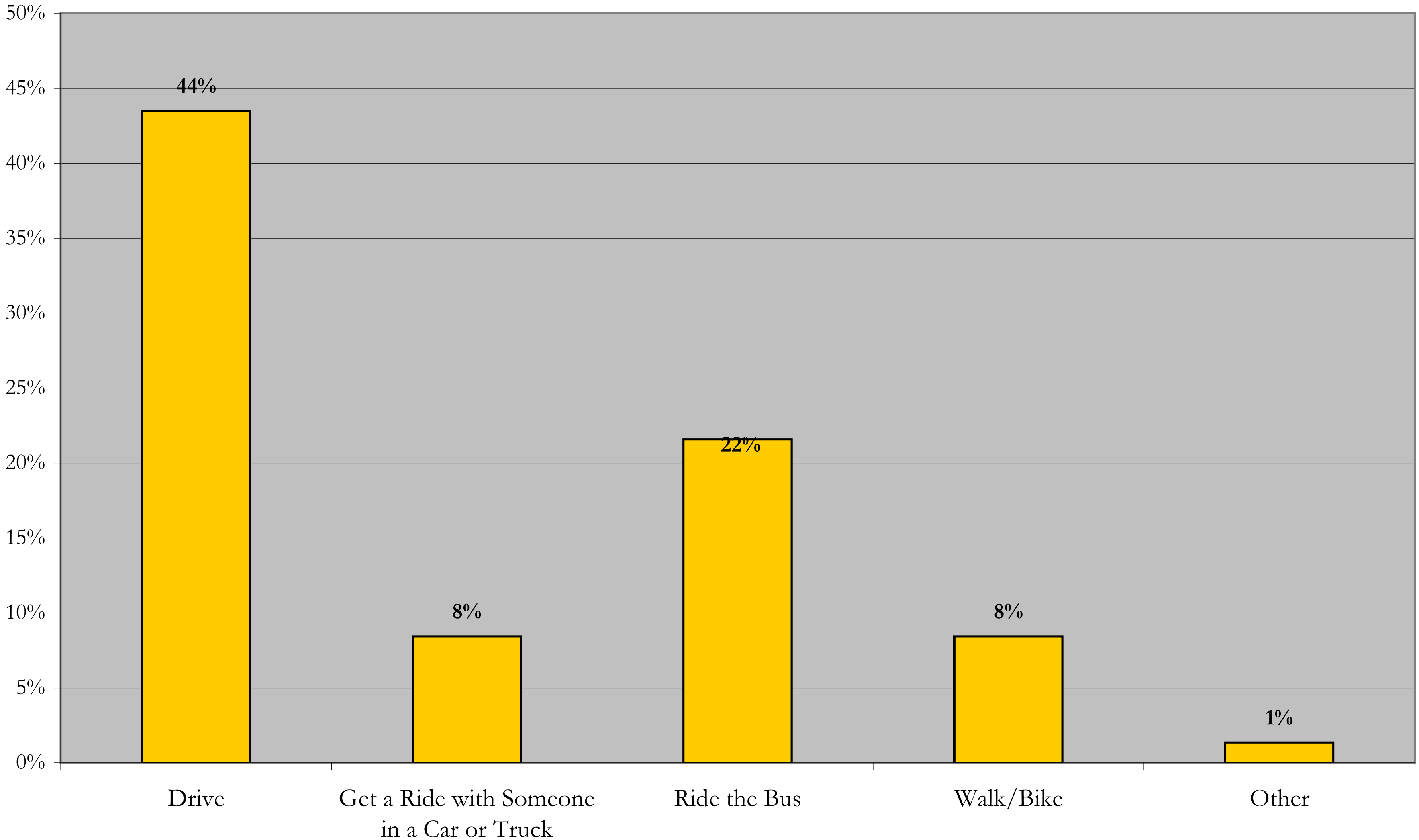
Do you have a car?



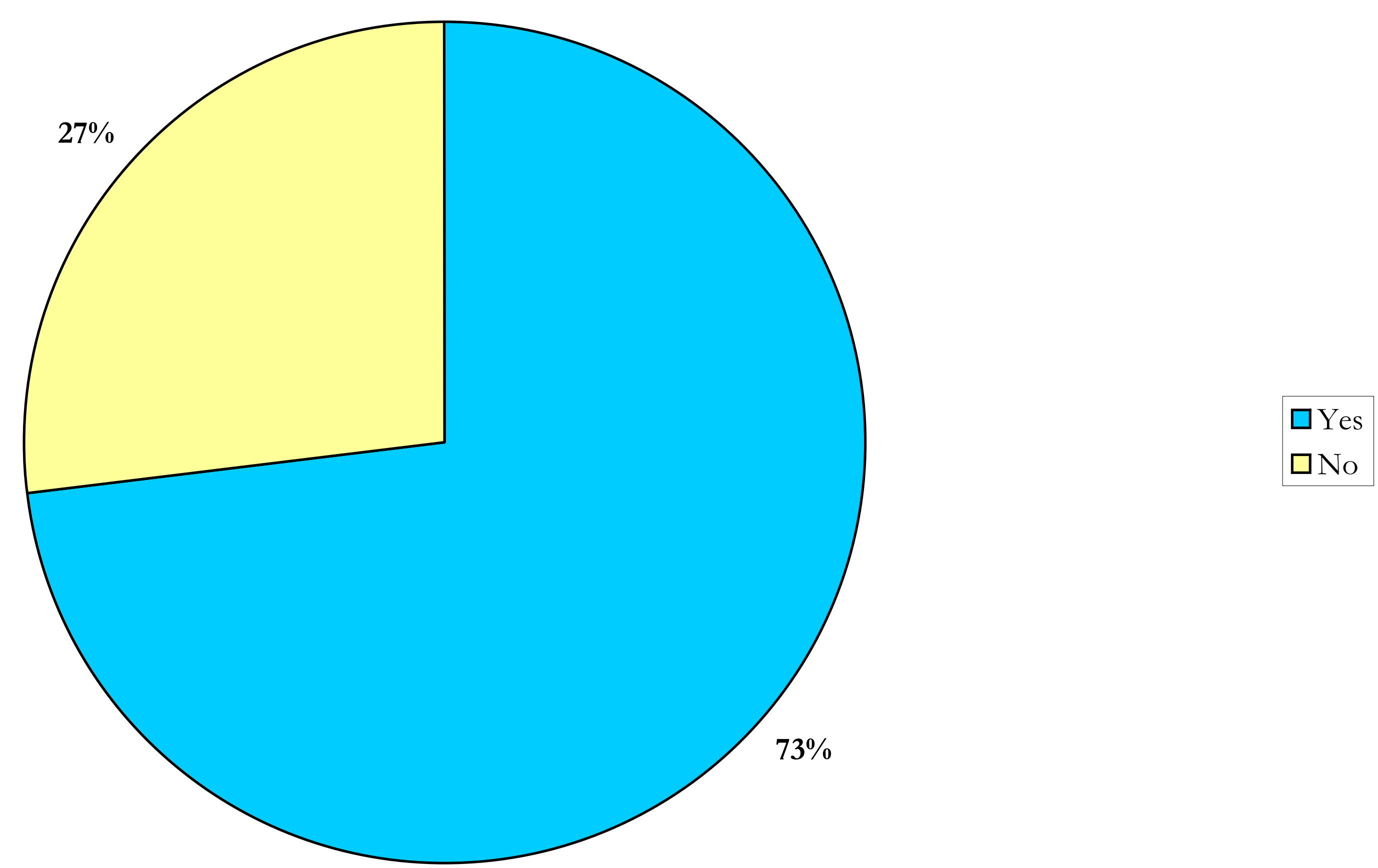
How would you rate your cost of housing?



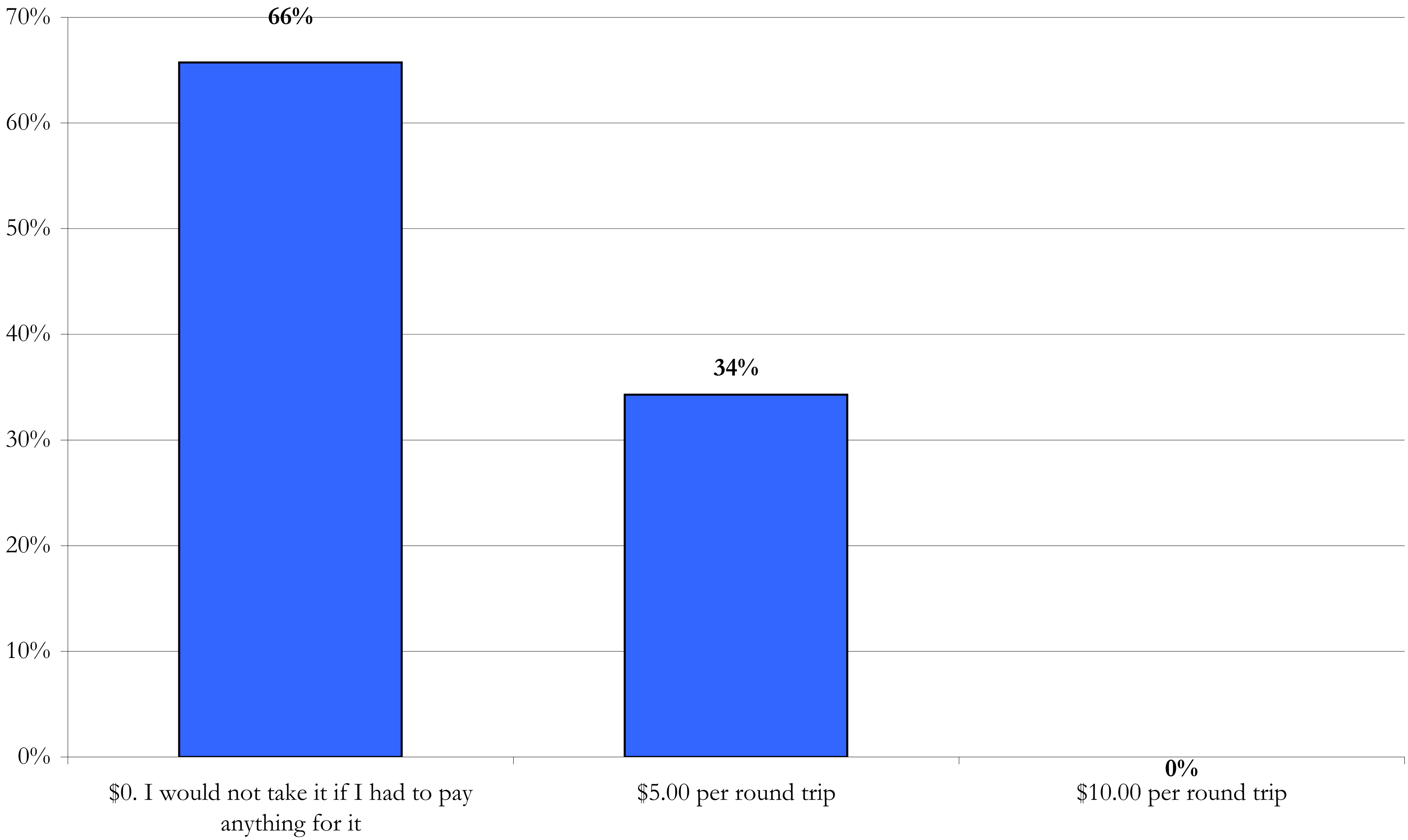
How do you normally get to work?



Would you be willing to take a small bus or van service to and from work if the arrival and departure times worked for your schedule?



How much would you be willing to pay for the service?



Appendix XIII

Letter of Completion for Old Growth Forest

United States Department of Agriculture **Forest Service** **Lake Tahoe Basin Management Unit**

35 College Drive
South Lake Tahoe, CA 96150
530 543-2600

File Code:
Date: March 19, 2009

Andrew Strain
Heavenly Mountain Resort
PO Box 2180
Stateline, NV 89449

Dear Andrew,

The High Meadows stand identified for hand thinning to improve long-term habitat conditions for northern Goshawk per the Heavenly Master Plan Amendment was treated in the fall of 2007. All contract work was completed and accepted per the contract requirements on December 6 2007. I will fax you the signed copies of the Certificate of Final Inspection and the Contract Release for this project for your records. If you have questions, please give me a call at (530) 543-2687.

Sincerely,

SCOTT PARSONS
Contracting Officer's Representative

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE **CERTIFICATE OF FINAL INSPECTION** *(Reference FSH 6309.31)*	CONTRACT NUMBER **AG-9A63-C-08-0015** UNIT **LTBMU** PROJECT **South Shore hand Thin 2007**
TO: **Matthew Gagnon** **CONTRACTING OFFICER**	NAME AND ADDRESS OF CONTRACTOR **Central Valley Forestry** **18985C Road 256** **Exeter, CA 93221**

I hereby certify that the final inspection of the work under the above contract was made on 12-6-07.

The last day on which work was performed was 12-6-07 after which no calendar days should be charged against time. All materials have been furnished, all the work has been performed, and all the construction required by the contract in accordance with its terms has been completed.

A copy of the inspection report is enclosed.

Enclosure(s)

SIGNATURE	TITLE	DATE
Robert Guebard	Contracting Officer's Representative	12-6-0'

FS-6300-5 (11/79)

Matthew 12-10-07

FS-6300-16 (11/00)

USDA - Forest Service **CONTRACT RELEASE** *(Reference FSH 6309.11)*	CONTRACT NUMBER AG-9A63-C-08-0015 UNIT LTBMU PROJECT South Shore Hand Thin 2007
TO: Matthew Gagnon CONTRACTING OFFICER	NAME AND ADDRESS OF CONTRACTOR Central Valley Forestry 18985C Road 256 Exeter, CA 93221

In consideration of the receipt of final payment in the amount of $ 84,385.00 the undersigned hereby releases the United States of America from any and all obligations arising under this contract and any modifications thereof except as reserved below.

Reservations:
none

12/10/07
Date (mm/dd/yyyy)

Central Valley Forestry
Contractor

By [signature]

Title Owner

Microsoft Word 2000