Forest Road BMP Upgrade Monitoring Report

2003-2005

USDA Forest Service

Lake Tahoe Basin Management Unit

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EXECUTIVE SUMMARY

This report summarizes a three-year monitoring program which evaluated the effectiveness of LTBMU's Forest Road BMP Retrofit Program. The monitoring program goals include:

- Evaluating BMP effectiveness at stream crossings utilizing Forest Service Region-5's Best Management Practices Evaluation Program (BMPEP) protocols.
- Assessing the change in risk of sediment transport as a result of BMP implementation using Water Quality Risk Assessment Protocols (WQRAP).
- Developing an estimate of sediment loads before and after BMP implementation utilizing the Water Erosion Prediction Project (WEPP) erosion and runoff prediction model.

BMPEP

Road surface, drainage and slope protection evaluations determined that 93% (49 of 52) of road surface, drainage and slope protection upgrades were effective. Diminished effectiveness resulted from various plugged cross-drains and ditches. Sedimentation and any negative effects on beneficial use were minor and only affected the stream near the crossings. Stream crossings evaluations determined that all 52 stream crossing upgrades were effective in preventing plugging and reducing diversion potential, throughout the project area. Side cast material evaluations determined that 85% (44 of 52) of the sites were rated effective with regard to side cast material. All 8 problem areas were the result of placing vegetative debris from downed trees into stream channels of SEZ's. It should be noted that recreational users are likely responsible for disposing of the debris from wind-blown downed trees which were blocking the road, prior to planned removal by Forest personnel.

WQRAP

Basin wide BMP upgrades reduced the connected length of WQRAP roads from 17.4 to 8.9 miles. An additional 1.8 miles of connected road were mapped between 2003 and 2005 which were not evaluated during the pre-project inventory of 1998. Of the total 152 road miles evaluated, 10.7 miles (7%) are considered hydrologically connected to surface water bodies and present some level of water quality risk. The most common causes of moderate to high risk evaluations are attributed to long connected road lengths, steep road gradients and close proximity of roads to SEZ's.

WEPP

Modeled results indicate that upgrades to the road system resulted in an increase in predicted erosion from 52.8 to 53.6, tons. However this overall predicted increase in erosion is a result of the model results for paving road 16N73 within the Watson Creek watershed, increasing predicted erosion 10.7 tons. This result is believed to an inaccurate portrayal of on the ground conditions as a result of this BMP, and will be subject to field verification this field season. Even with this anomalous result included, overall sediment yield decreased from 23.4 to 10.5 tons. If the result from road 16N73 is removed from the analysis, overall sediment yield is predicted to decrease from 23.4 to 2.2 tons. Road improvements within Ward Creek and Watson Creek alone, accounted for 11.3 tons of the reduced sediment yield.

Heavenly Ski Area

Upgrades to 17.9 miles of system roads resulted in a reduction of connected length of water quality risk segments from 2.42 to 2.3 miles. Overall however, high risk mileage increased from 1.3 to 1.53 miles. The increase in high risk mileage occurred on road 12N40 in the Heavenly Creek Watershed.

Recommendations

Results of the roads BMP upgrades indicates the program overall has been effective at reducing the risk of road-borne sediment migration to water bodies in the Lake Tahoe Basin. However, the following recommendations should be considered by monitoring and engineering staff for future implementation, maintenance and monitoring of forest road upgrades.

- LTBMU staff should maintain better documentation of road BMP planning and design in order to identify the source of ineffective implementation procedures or project specifications, and consistently kept in one location for monitoring access.
- LTBMU engineering and monitoring staff should conduct follow-up field evaluations for the following sites to determine requirements for additional upgrades, maintenance, and monitoring:
    - The four road crossings rated as ineffective for road surface, drainage and slope protection from BMPEP evaluations.
    - The eight sites from BMPEP evaluations, where vegetation debris blocking roads was disposed in stream channels, to determine if sidecast material is causing disruption in channel flows and mitigation is required.
    - All high and moderate risk road segments (including those that WEPP identified as relatively high sediment yield producers).

- The WEPP model should be used as a planning and design tool for future BMP upgrades.
- The WEPP model results should be verified with on-site follow-up monitoring when paved roads cause erosion to be over-predicted.
- In order to reduce errors introduced into the WEPP model, monitoring staff need to ensure that field technicians are trained to identify and record data that are subjective in nature.
- Forest Service engineering standards should be incorporated into all design specifications for future BMP upgrades to roads within the Heavenly Ski Area; and the design specifications should be reviewed by Forest Service staff prior to implementation.
- Heavenly Ski Area roads design specifications should be re-evaluated after BMP upgrades have been implemented according to Forest Service Standards.
- Native surface road BMPs need constant maintenance. Efforts for future monitoring and maintenance of BMPs should be focused on areas of highest risk.
- It is recommended that monitoring data and WEPP analysis developed by the LTBMU, relative to the production of road born sediment, be considered and utilized during the development and refinement of the Tahoe Basin TMDL model.

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1.0 INTRODUCTION

Eroded sediment from unpaved roads is the leading source of potential pollution from forested lands. (West, 2002) Eroded sediments play a significant role in lowering Lake Tahoe's water clarity. Because Best Management Practices (BMPs) have proven effective in reducing hydraulic conveyance of road-borne sediments, BMP retrofits (such as grading, rolling grade dips, and relocating roads away from SEZ's) have been applied to Forest roads as part of the Lake Tahoe Basin Management Unit's (LTBMU) Forest Roads BMP Retrofit Program. The primary goals of the BMP Retrofit Program are to:

- Decommission or obliterate unnecessary roads.
- Convert selected roads to trails.
- Upgrade Forest roads with appropriate BMPs.

All LTBMU roads were inventoried and prioritized in 1998 using a water quality risk assessment protocol (Derrig et al., 1998). Between 1999 and 2004, the LTBMU installed BMP retrofits on approximately 154 miles of roads and decommissioned another 100 miles. This report summarizes a three-year monitoring program which evaluated the effectiveness of LTBMU's Forest Road BMP Retrofit Program. The monitoring program goals include:

- Evaluating BMP effectiveness at stream crossings utilizing Forest Service Region-5's Best Management Practices Evaluation Program (BMPEP) protocols.
- Assessing the change in risk of sediment transport as a result of BMP implementation using Water Quality Risk Assessment Protocols (WQRAP).
- Developing an estimate of sediment loads before and after BMP implementation utilizing the Water Erosion Prediction Project (WEPP) erosion and runoff prediction model.

The monitoring approach and protocols are documented in the Roads Monitoring Plan (Norman, 2004). Post-project monitoring occurred in 2003, 2004 and 2005, evaluating 46, 47 and 41 miles, respectively. This report outlines a comparison between post-project data and all pre-project data. This evaluation also included 11 miles of Heavenly Valley Ski Resort roads, which is located in Appendix-A.

2.0 STUDY AREA

The Lake Tahoe Basin Management Unit contains 45 watersheds. The Forest maintains 221 miles of road within 42 of these watersheds, 20 of these watersheds have had road upgrades on a total 154 road miles (Table 2.1, and Figure 2.1). Watersheds range in size from 1,924 acres in Heavenly Creek to 8,460 acres in Ward Creek Frontal.

The LTBMU Engineering Department has also decommissioned approximately 100 road miles, 96.5 of which are in the studied watersheds. The majority of road decommissioning took place within north shore watersheds including:

- Burton Creek-Lake
- Forest-Dollar Creek Frontal

- Tahoe Vista-Griff Creek Frontal
- Watson Creek-Carnelian Frontal.

Road to trail conversions in the study watersheds total 7 miles.

3.0 METHODS

Pre-project data were collected using a qualitative water quality risk inventory in 1998. The objectives of the 1998 inventory were to document conditions and prioritize BMP retrofits and road decommissioning. Post-project monitoring was more data intensive than the pre-project inventory. The following three methods were used to collect and analyze data:

- Region 5 Best Management Practices Evaluation Program (BMPEP) for stream crossings.
- Water Quality Risk Assessment Protocols (WQRAP).
- Modeling erosion and sediment yield with Water Erosion Protection Project (WEPP).

3.1 BMPEP Ratings

BMPEP protocols were developed by the USDA, Forest Service, Region 5, in agreement with the California State Water Quality Control Board (USDA, FS, 2002). These protocols are generally applied to timber, roads, recreation, fuels reduction, construction and range. Selected protocols which focus on qualitative assessment of BMP's implemented near stream crossings are:

- E08, Road surface, drainage and slope protection
- E09, Stream crossings
- E11, Control of side cast material

Evaluations utilizing these protocols were conducted at perennial stream crossings within the roads monitored. Road surface, drainage, and slope protection protocol (E08) was used to evaluate erosion control, stability of road slope surfaces and spoil disposal areas on road segments draining directly to the stream crossing. Stream crossing protocol (E09) was used to evaluate the degree to which the general guidelines for location and design of roads were followed and also evaluates stability of road slope surfaces and spoil disposal areas. The side-cast material protocol (E11) was used to evaluate fill or other material along the road at stream crossings. Some procedures vary with each form, but a common standard approach was used (USDA FS, 2002).

During BMP implementation a variety of questions are asked which determine if the BMP was constructed according to project plans and specifications. To determine the effectiveness of BMP's, an additional data set was collected to determine if beneficial uses were impaired and, if so, to what extent, duration, and degree. Protocol E08, for example, addresses the degree of surface erosion present using the following classifications:

- Little or no evidence of rilling.
- Some rills present on <10% of the road segment or were present but do not leave road surface.
- >10% of surface length has rills 2" deep and 20' in length, which continue off the road surface.

Scores are given for each dataset and summarized for both implementation and effectiveness. Evaluations are scored using an algorithmic rule set embedded in the database. This rule set was developed by Region 5 Hydrologists for rating the results of each inquiry as outlined in Table 3.1.

3.2 Water Quality Risk Assessment Protocol (WQRAP) Ratings

Pre-project WQRAP ratings were used to assess qualitatively the risk of sediment transport and water quality impairment for selected LTBMU roads. After the installation of BMP retrofits, post-project WQRAP ratings were repeated each year (2003 to 2005) to determine if water quality risk had changed.

The 1998 pre-project WQRAP data were collected using a field form developed by the LTBMU Engineering Department, and were subsequently recorded into an Excel database. Post-project monitoring used the same field form, however, in 2004 and 2005 monitoring staff also used a Trimble GeoXT GPS Datalogger to better establish exact physical characteristics. These data were exported into shape files and maintained in ArcGIS and Excel files. WQRAP was used to evaluate the following three types of road segment:

- Road segments at stream crossings.
- Road segments hydrologically connected to stream environmental zones (SEZ).
- Road segments in non-stream environmental zones (Non-SEZ).

Road segments at stream crossings are defined as culverts, pipe arches, bridges or fords, which have a discernible stream channel above and below the crossing, and those that cross wet meadow areas even if they do not necessarily have a discernible channel upstream. Stream crossings were evaluated based on the following characteristics:

- Connected length, which is the length of road segment hydrologically connected to a surface water body through rills, gullies, overland flow or drainage ditches.
- Crossing condition (structure crushed or dented, evidence of erosion or ponding around crossing).
- Diversion potential and diversion distance (defined as the road distance diverted runoff would travel).
- Road surface type and grade.

SEZ segments are defined as segments of road that pass within 450 feet (137 meters) of a meadow, stream or lake, or road segments that pass through an SEZ but have no distinct crossing. Non-SEZ segments are defined as segments of road that are greater than 450 feet from a meadow, stream, or lake, and/or segment having a chronic erosion feature such as rill or gully erosion. SEZ and Non-SEZ segments are evaluated for the following characteristics:

- SEZ or Non-SEZ.
- Connected length.
- Road surface type and grade.
- Presence/absence of chronic erosion features.

Each road segment is assigned a risk score as outlined in Tables 3.1 and 3.2.

3.3 Water Erosion Prediction Program Modeling (WEPP)

Potential erosion and sediment yield from hydrologically connected road segments were modeled with the online version of WEPP (WEPP Forest Erosion Predictor), specifically Road Batch. Model parameters used are listed in Table 3.3. Important characteristics and limitations of WEPP Road Batch, are outlined as follows:

- Its best use is as a comparative tool between different road designs. It is not an exact numeric predictor.
- It is designed to predict runoff and potential sediment yield from forest roads, compacted landings, compacted skid trails, and compacted foot, cattle or off-road vehicle trails (Elliot et al., 1999).
- It models surface erosion from roads but does not model mass failures such as slumps and slope failures from fillslopes and cut slopes.
- It has an inherent error of plus or minus 50% for high traffic roads (Elliot et al., 2000).
- It generates results as annual mean values for modeled climates. For the purpose of this analysis, 30 years of data obtained from the Cligen weather generator was utilized. Cligen is stochastic weather prediction model, maintained by the USDA, Agricultural Research Service and US Forest Service.
- It has 13 input variables: climate, soil texture, percent rock, road design, road surface, traffic level, road grade, road length, road width, fill gradient, fill length, buffer gradient and buffer length (Table 3.3). Several of these parameters can change as a result of retrofits.
- It assumes that the ground cover of fill slopes is 50%, consequently, fillslopes are erodible in the model.
- It assumes that buffers have 100% ground cover equal to that of a 20-year forest.

4.0 RESULTS

This section outlines data collected using BMPEP, WQRAP, and modeling of erosion and sediment yield with WEPP Road Batch.

Results for watersheds within the management of Heavenly Mountain Ski Area are reported separately in Appendix-A, as the Ski Area implemented its own road improvements which followed standards different that that used by the USFS.

4.1 BMPEP Ratings

BMPEP evaluations were conducted at 52 stream crossings in 11 watersheds between 2003 and 2005. Forty eight of the 52 evaluations (92%) for road surface, drainage and slope protection (E08) are rated effective at preventing sediment transport to a waterbody. Of the four rated ineffective, two are in Blackwood Creek Watershed and one is in Glenbrook Creek Watershed and one is in Bliss Creek-SHC-SK-Watershed. All 52 of the evaluations (100%) for stream crossings (E09) are rated effective. Forty-four of 52 evaluations (85%) for side-cast material (E11) are rated effective, however, the cause of the 8 ineffective ratings are not attributable to the BMP upgrades program. These results are summarized in Table 4.1, and the reasons for less than 100% effectiveness of the E08 and E11 evaluations are discussed below.

Road surface, drainage and slope protection (E08)

Causes of ineffective ratings at four crossings are as follows:

- Blackwood Creek Watershed-Road 1503
  - 1503 Crossing 8 (1503CR08), 72" CMP on the Middle Fork of Blackwood Creek
    - Evidence of erosion of inboard ditch around wing wall at inlet transports sediment to the channel.
  - 1503 Crossing 14 and 15 (1503CR14 and 1503CR15), Two 30" CMP's on seasonal streams.
    - Sediment and/or debris were observed blocking a 24" cross-drain, an 18" cross-drain; and 340 feet of the inboard ditch caused by slumping at the 24" cross-drain.

- Bliss Creek-Secret Harbor Creek-Skunk Harbor Watershed-15N67
  - 15N67 Crossing 1 (15N67CR01), Perennial stream.
    - Evidence of erosion from the fillslope entering the channel from non-functional drainage ditch and road sloped away from the ditch.

- Glenbrook Creek Watershed-14N33
  - 14N33 Crossing 6(14N33CR06), 18"CMP Arch on an intermittent stream.
    - Evidence of sediment from the fillslope entering an intermittent stream channel.

Control of side cast material (E11)

As stated previously, the following eight ineffective evaluations are not attributable to problems with BMP upgrades. Ineffective ratings were due to evidence of side cast material in channel. It is believed that recreational users are likely responsible for moving vegetative debris blocking the road prior to planned removal by Forest personnel. Descriptions of the 8 crossings are as follows:

- Blackwood Creek Watershed-Road 15N38
  - 15N38 Crossing 7 (15N38CR07), Hardened ford on ephemeral stream.
  - 15N38 Crossing 16 (15N38CR16), Hardened ford on ephemeral stream.
- Bliss Creek-Secret Harbor Creek-Skunk Harbor Watershed-15N67
  - 15N66A Crossing 5 (15N66ACR05), 12" CMP Arch on a perennial stream .
    - Material diverted the stream into the road way for approximately 30 feet down stream.
- Glenbrook Creek Watershed-14N33
  - 14N33 Crossing 1 (14N33CR01), 16" CMP on perennial stream.
    - Branches caused aggrading stream due to trapped sediments.
- Third Creek Watershed-17N89
  - 17N89 Crossing 1 (17N89CR01), 16" CMP on perennial stream.
- Ward Creek Watershed-15N62
  - 15N62 Crossing 11 (15N62CR11), Native ford.
  - 15N62 Crossing 15 (15N62CR15), 36" CMP on ephemeral stream.
  - 15N62 Crossing 20 (15N62CR20), hardened ford.

4.2 WQRAP Ratings

This section discusses water quality risk assessment ratings associated with road segments connected to a channel that have the potential to deliver eroded sediment to the channel.

4.2.1 WQRAP Assessment

Pre-project surveys determined that 17.4 miles of the total 154 miles of system roads were hydrologically connected to channels or other surface water bodies. Post-project monitoring showed that total connected lengths of road were reduced to 8.9 miles by retrofits (Table 4.2.1). The total connected length of low risk segments decreased from 3.1 to 2.0 miles. The total connected length of moderate risk segments decreased from 9.9 to 5.2 miles. The total connected length of high risk segments decreased from 4.4 to 1.6 miles.

Post-project monitoring included some roads, which received BMP upgrades that had not been included in the pre-project inventory. As a result, 12 road miles were evaluated that were not surveyed in the pre-project inventory. Within these 12 miles, 1.8 miles were determined to be hydrologically connected to stream channels and still present some level of risk to water quality. Of these 1.8 miles, low risk segments totaled 0.2 miles; moderate risk segments totaled 1.6 miles; and high risk segments totaled less than 0.1 miles. With the addition of these new water quality risk segments, currently 10.7 miles of the inventoried 152 miles are considered hydrologically connected to channels (Table 4.2.2).

4.2.2 WQRAP Watershed Summary

Tables presented in Tables B1 thru B4 in Appendix B, summarize the change in water quality risk by watershed between pre-project and post-project monitoring. Water quality risk of newly mapped road segments is included. Roads which currently exhibit the most significant risk under WQRAP assessment are as follows:

- Third Creek watershed, Road 17N85
- Burke Creek watershed, Roads 13N82 & 14N32
- Logan House Frontal watershed, Road 14N33
- Skyland-Cave Rock-Lincoln Creek Frontal, Road 13N78

4.3 WEPP Modeling

Predicted erosion and sediment yield rates determined by modeling with WEPP Road Batch, were used to compare the effectiveness of upgrades to a subset of the upgraded forest roads. A total of 3 miles of hydrologically connected and upgraded road segments within 12 watersheds were modeled. Because monitoring staff were just beginning to utilize the WEPP model in 2003, data collection to include WEPP input parameters was only conducted on a small number of the roads monitored in 2003. The majority of roads monitored in 2003 were not included in the WEPP analysis. Table 3.3 describes the input variables necessary to run the WEPP model and more detailed WEPP results are located in Tables 4.3.1 through 4.3.3 and Appendix-C (raw data and watershed/road specific narrative).

Surface erosion and sediment yield from these roads were modeled for both the pre-project and post-project condition. From Table 3.3, the input variables most often adjusted as a result of BMP upgrades were #8 (road horizontal length) and #4 (road design), as a result of installation of water bars and other flow diversion structures. In some cases, #5 (road surface) and #13 (buffer horizontal length) were also adjusted.

As can be seen from examining the parameters in Table 3.3, consistency between crews and measurement techniques is essential for valid pre and post comparisons. In preparing the data for this analysis, it was noted that road gradients were frequently measured as different, when it is very unlikely that this parameter changed as a result of management actions. Therefore it was assumed that gradient was the same for both the pre and post condition, with the most recent measurement considered to be the most accurate.

Predictions from the WEPP model are presented as average rates of annual erosion and sediment yield, based on a 30-year historic precipitation regime. The WEPP model predicted an increase in erosion from 52.8 tons to 53.6 tons per year, while sediment yield decreased from 23.4 tons to 10.5 tons (Table 4.3.1 and 4.3.2). Since these results did not seem to match up with the reduction of hydrologically connected road segments of the WQRAP ratings, a closer look at the WEPP results presented in Appendix C was taken to determine why overall erosion was predicted to increase.

The WEPP model predicts high increases in runoff from a paved road surface (as opposed to native surface roads), which can result in high increases in predicted erosion. The following is an excerpt from the WEPP website:

> "Paving a road greatly decreases road surface erosion, but increases the runoff. Increased runoff from the road surface can cause increased erosion on fillslopes, ditches, and flow paths leading from the road to the forest. Sediment eroded on the fillslopes is more likely to be transported to streams with the increased runoff from a paved road. Paved roads show the best benefit on outsloped roads, or roads with armored ditches with minimal buffers."

The model may not have adequate mechanisms for accurately evaluating the degree to which road designs that include drainage and dissipation structures may dissipate and infiltrate road runoff from a paved road. The overall increase in erosion from all roads modeled in the WEPP analysis can primarily be attributed to the influence of the predicted changes in one road (paving of 16N73 in the Watson Creek watershed). Erosion is predicted to increase from 8 tons per year to 21 tons per year on 16N73, as a result of the road paving causing an increase in runoff. However, sediment yield is predicted to decrease, because of an increase in buffer length (from .3 meters to 7 and 10 meters). If the results for 16N73 are taken out of the comparison, total erosion from all other roads is predicted to decrease from 44.8 tons to 32.6 tons per year. Modeled erosion from newly mapped segments not identified in 1998, totaled 3.2 tons and sediment yield totaled 0.6 tons (Table 4.3.3).

In aggregate, 33 of the 40 road segments modeled have a low erosion potential (<1 ton) whereas 6 of the 40 road segments modeled have a moderate erosion potential (>2 tons and <10 tons) and 1 of the roads segments modeled (Road 16N73) has a high erosion potential (>10 tons). Additionally, 37 of the 40 road segments modeled have a low potential sediment yield (< 2 tons), whereas two of the road segments (14N32 and 16N87) modeled have a moderate potential sediment yield (>1 ton and <5 tons). Road 16N73, has a high potential sediment yield (>5 tons/yr). These results are illustrated in Figures 4.1 and 4.2).

Key findings of WEPP modeling include:

- 83% of the modeled roads have low potential for erosion and 93% pose a low potential for sediment yield.
- The only road with a high potential for erosion (>10 tons/year) and sediment yield (>5 tons/yr) is 16N73. This road should be re-evaluated through field visits during spring runoff, and after thunderstorm events, to determine if road paving and upgrades are adequately managing flows.
- Modeling results reinforce the significance of wide riparian buffers in reducing and preventing road-borne sediment from reaching a surface water body.

5.0 CONCLUSIONS

5.1 BMPEP

Road surface, drainage and slope protection (E08) evaluations determined that 93% (49 of 52) of road surface, drainage and slope protection upgrades were effective. Diminished effectiveness resulted from various plugged cross-drains and ditches. Sedimentation and any negative effects on beneficial use were minor and only affected the stream near the crossings. These concerns were submitted to the Engineering Department for resolution in a comprehensive list of 2005 road-related issues. As of the writing of this report, not all of these concerns have been addressed.

Stream crossings evaluations (E09) determined that all 52 stream crossing upgrades were effective in preventing plugging and reducing diversion potential, throughout the project area.

Side cast material evaluations (E11) determined that 85% (44 of 52) of the sites were rated effective with regard to side cast material. All 8 problem areas were the result of placing vegetative debris from downed trees into stream channels of SEZ's. It should be noted that recreational users are likely responsible for disposing of the debris from wind-blown downed trees which were blocking the road, prior to planned removal by Forest personnel.

5.2 WQRAP

Basin wide BMP upgrades reduced the connected length of WQRAP roads from 17.4 to 8.9 miles. An additional 1.8 miles of connected road were mapped between 2003 and 2005 that were not evaluated during the pre-project inventory of 1998. Of the total 152 road miles evaluated, 10.7 miles (7%) are considered hydrologically connected to surface water bodies and present some level of water quality risk. The most common causes of moderate to high risk evaluations are attributed to long connected road lengths, steep road gradients and close proximity of roads to SEZ's. Roads with the above characteristics which represent the most significant risk under WQRAP assessment are as follows:

- Third Creek watershed, Road 17N85
- Burke Creek watershed, Roads 13N82 & 14N32
- Logan House Frontal watershed, Road 14N33
- Skyland-Cave Rock-Lincoln Creek Frontal, Road 13N78

These roads should be considered in follow-up assessments, in order to establish site specific conditions and remedies.

5.3 WEPP - Road Batch

Modeling with WEPP is used as a comparative tool for evaluating the effectiveness of road upgrades. Modeled results indicate that upgrades to the road system resulted in an increase in erosion from 52.8 to 53.6, tons but sediment yield decreased from 23.4 to 10.5 tons. Road 16N73 within the Watson Creek-Carnelian Frontal is primarily responsible for the predicted increase in erosion of 10.7 tons, due to predicted increases in runoff from paved roads. However, overall sediment yield decreased from 23.4 to 10.5 tons. Road improvements within Ward Creek and Watson Creek accounted for 11.3 tons of the reduced sediment yield.

Many of the reductions in sediment yield resulted from BMP upgrades aimed at reducing the connected length of hydrologically connected segments. Segment length was decreased by installing rolling dips, water bars, or cross-drains. These upgrades can be rendered ineffective, however, on roads with grades that exceed approximately 21%. Future assessments should consider excessive road grades in determining appropriate BMP's.

Though there was a significant reduction in predicted sediment yield, roads which still have moderate to high erosion potential should be evaluated through follow-up field assessments to determine whether predicted erosion and sediment transport is occurring, and if so, can these be mitigated through additional treatment measures (Table 5.1 and Figure 5.1.a. and 5.1.b). This is particularly true for paved road segments, in which the WEPP model may be drastically overestimating sediment erosion potential from this treatment measure.

Table 5.1: Roads recommended for additional review to determine if more BMP's are required to reduce erosion and sediment yield potential.

	Moderate Risk Roads	**High Risk Roads**
Erosion Potential	13N78, 13N80, 13N82, 13N82A,14N32,16N86, 16N87	16N73
Sediment Yield Potential	14N32 and 16N87	16N73

5.4 Heavenly Ski Area

The following outlines the key findings for forest roads within the Heavenly Ski Area. The analysis of Heavenly Ski Area roads is addressed further in Appendix-A.

Upgrades to 17.9 miles of system roads resulted in a reduction of connected length of water quality risk segments from 2.42 to 2.3 miles. Low water quality risk roads decreased from 0.07 to less than 0.03 miles; moderate risk mileage decreased from 1.05 to 0.74 miles; and high risk mileage

increased from 1.3 to 1.53 miles. The increase in high risk mileage occurred on road 12N40 in Heavenly Creek.

However, despite this small decrease in water quality risk segments, WEPP modeling of these segments predicts erosion increased from 2.6 tons to 5.8 tons/yr and sediment yield increased from 1.3 tons to 3.8 tons. Increased erosion and sediment yield occurred in each of the watersheds except Bijou Creek. Roads within the Heavenly Creek watershed had the highest increases in erosion and sediment yield. Erosion and sediment increased by 3.2 tons and 2.5 tons respectively and primarily occurred on road 12N40, which has segments with connected lengths of 300 meters and is located within the SEZ. The input variables that changed that resulted in this increase are design designation and road grade.

6.0 RECOMMENDATIONS

Results of the roads BMP upgrades indicates the program overall has been effective at reducing the risk of road-borne sediment migration to water bodies in the Lake Tahoe Basin. However, the following recommendations should be considered by monitoring and engineering staff for future implementation, maintenance and monitoring of forest road upgrades.

- LTBMU staff should maintain better documentation of road BMP planning and design in order to identify the source of ineffective implementation procedures or project specifications, and consistently kept in one location for monitoring access.

- LTBMU engineering and monitoring staff should conduct follow-up field evaluations for the following sites to determine requirements for additional upgrades, maintenance, and monitoring:

    - The four road crossings rated as ineffective for road surface, drainage and slope protection from BMPEP evaluations.

    - The eight sites from BMPEP evaluations, where vegetation debris blocking roads was disposed in stream channels, to determine if sidecast material is causing disruption in channel flows and mitigation is required.

    - All high and moderate risk road segments (including those that WEPP identified as relatively high sediment yield producers).

- The WEPP model should be used as a planning and design tool for future BMP upgrades.

- In order to reduce errors introduced into the WEPP model, monitoring staff need to ensure that field technicians are trained to identify and record data that are subjective in nature.

- Forest Service engineering standards should be incorporated into all design specifications for future BMP upgrades to roads within the Heavenly Ski Area; and the design specifications should be reviewed by Forest Service staff prior to implementation.

- Heavenly Ski Area roads design specifications should be re-evaluated after BMP upgrades have been implemented according to Forest Service Standards.

- Native surface road BMPs need constant maintenance. Efforts for future monitoring and maintenance of BMPs should be focused on areas of highest risk.

And finally, the Lahonton Regional Control Board is currently spearheading an effort to develop a watershed TMDL model for the Lake Tahoe Basin. As stated in the introduction of this report, sediment produced by forest roads is a potential source of sediment impacting forest watersheds. This report provides an assessment of the relative risk and magnitude of water-borne sediments produced by roads in forest watersheds and the relative change in sediment load after implementation of BMP upgrades. The results of this report and future LTBMU monitoring data can be used as a tool to help predict sediment load and response to scheduled BMP upgrades. It is recommended that monitoring data and WEPP analysis developed by the LTBMU, relative to the production of road born sediment, be considered and utilized during the development and refinement of the Tahoe Basin TMDL model.

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FIGURES

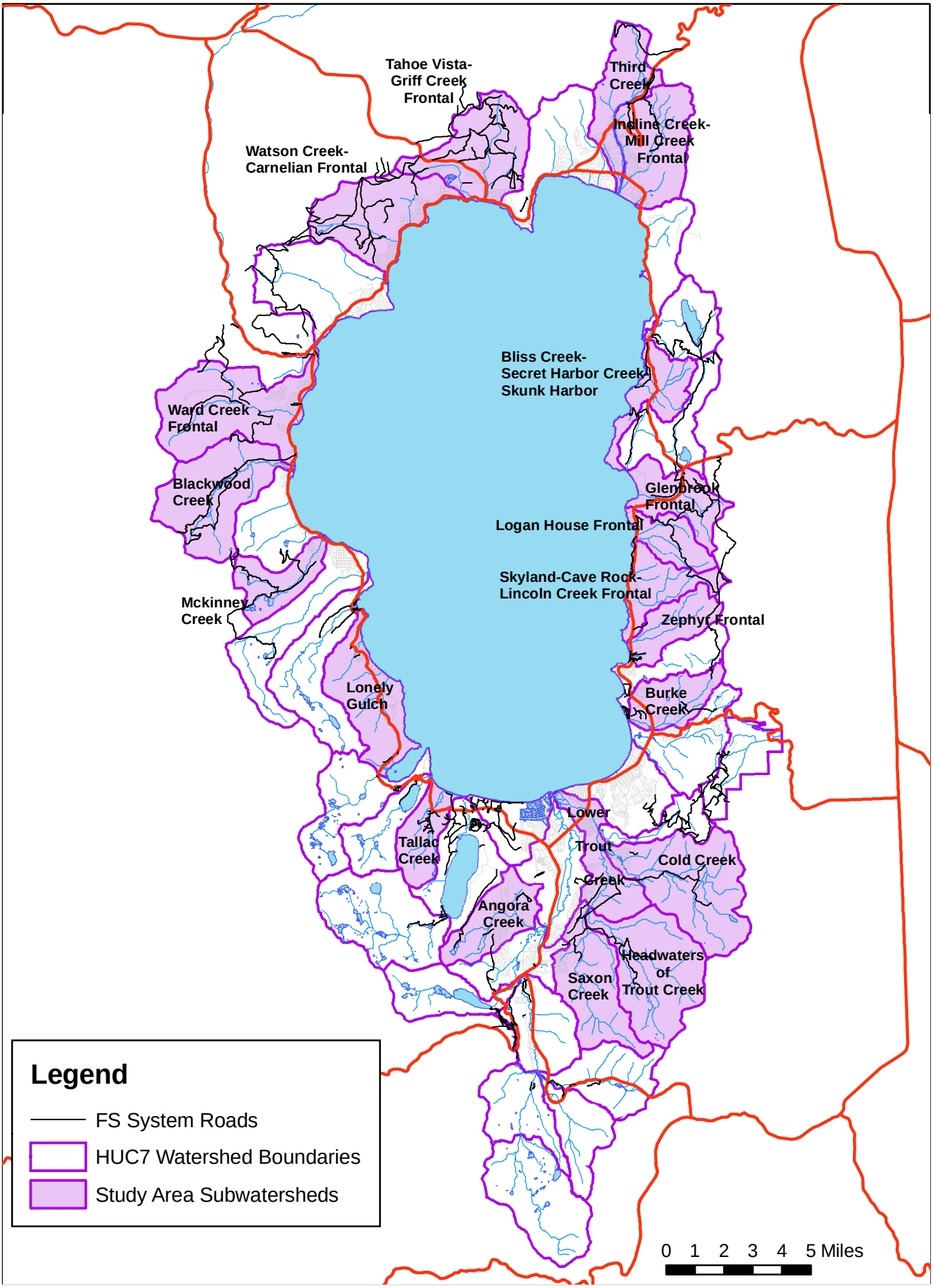

Figure 2.1 Study Watersheds

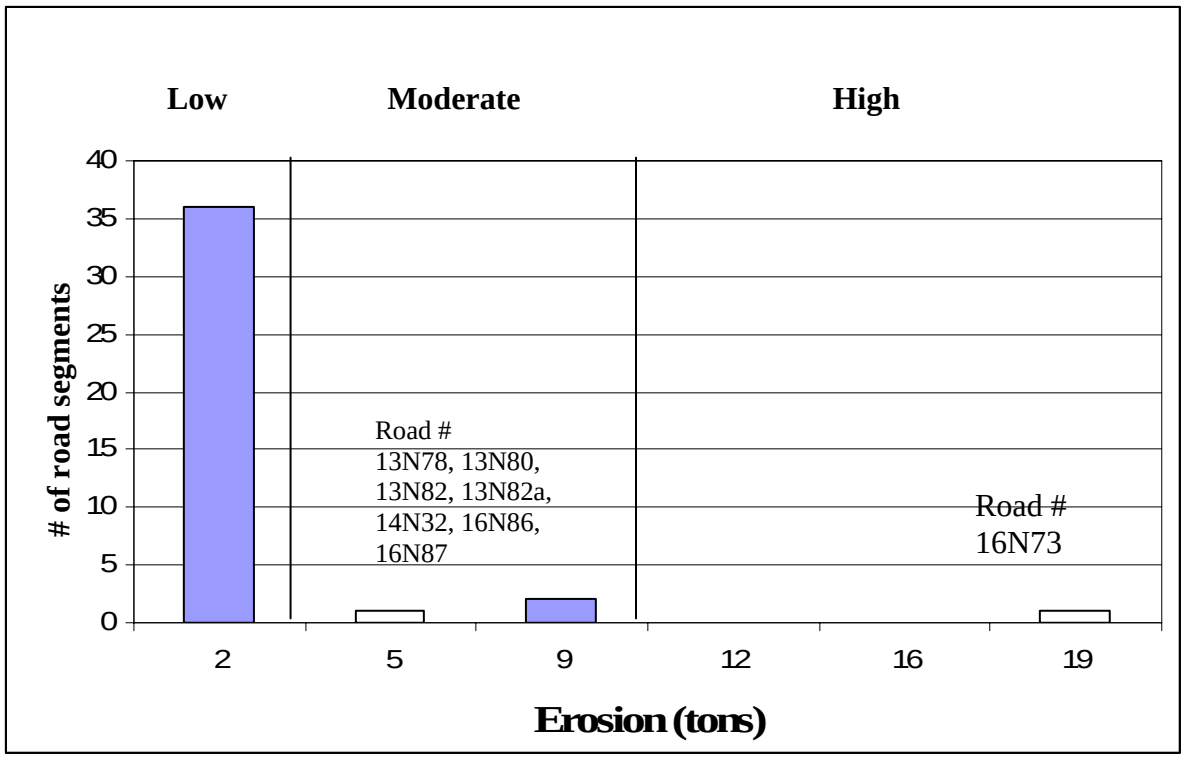

Figure 4.1: Histogram of erosion in estimated tons per year from roads. Low, moderate, and high delineate ranges of erosion rates used to prioritize more in depth evaluation.

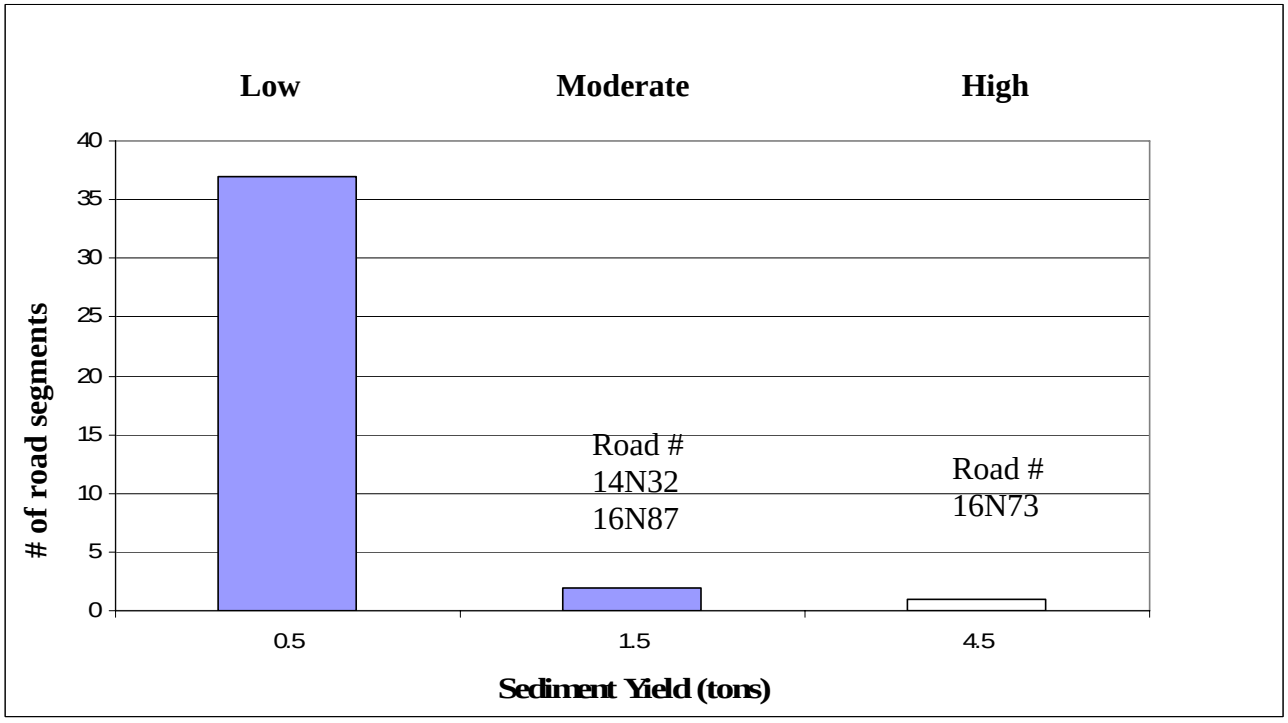

Figure 4.2: Histogram of sediment yield in estimated tons per year from roads. Low, moderate, and high delineate ranges of sediment yield rates used to prioritize more in depth evaluation.

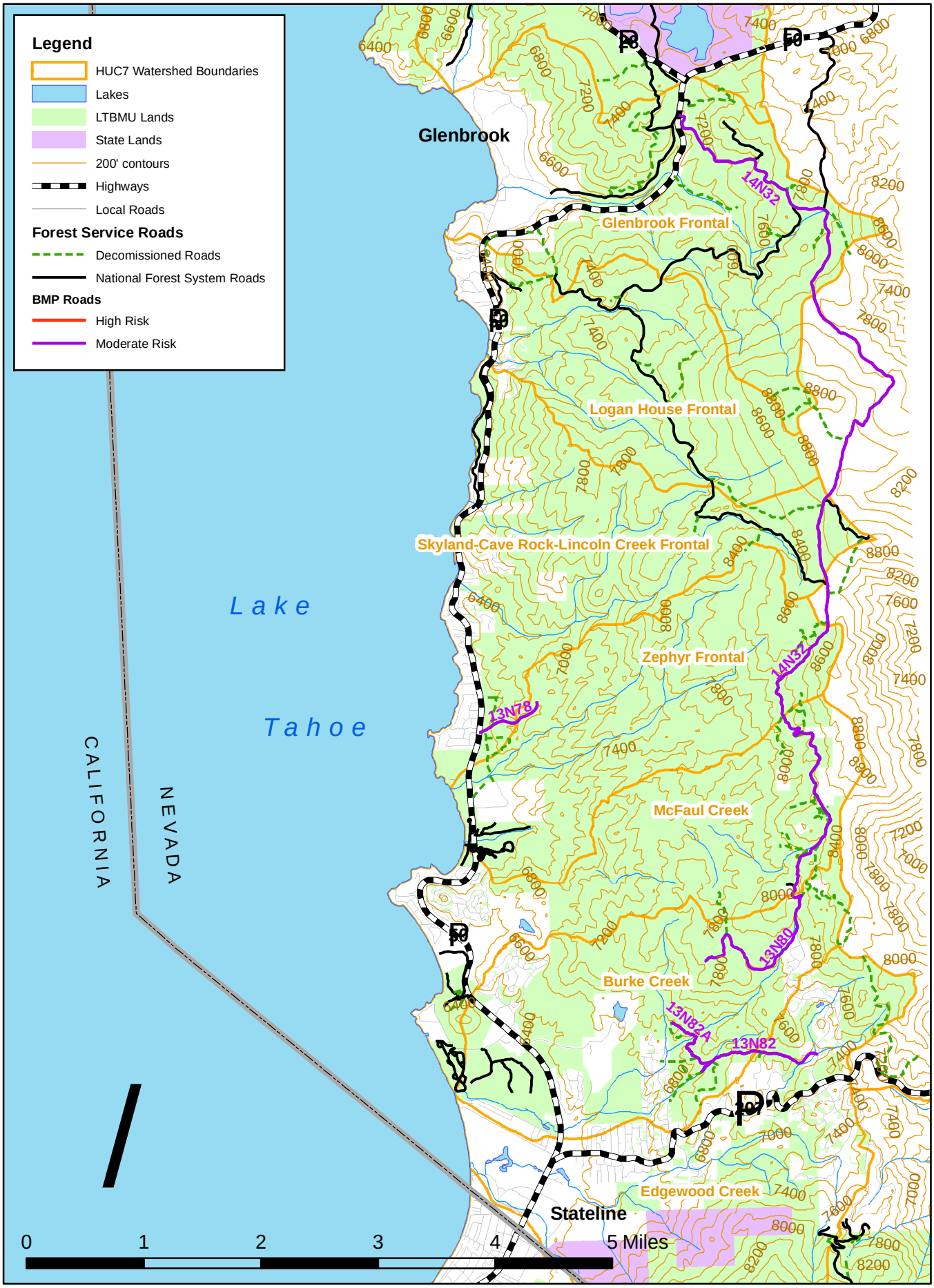

Figure 5.1a Moderate Risk Roads

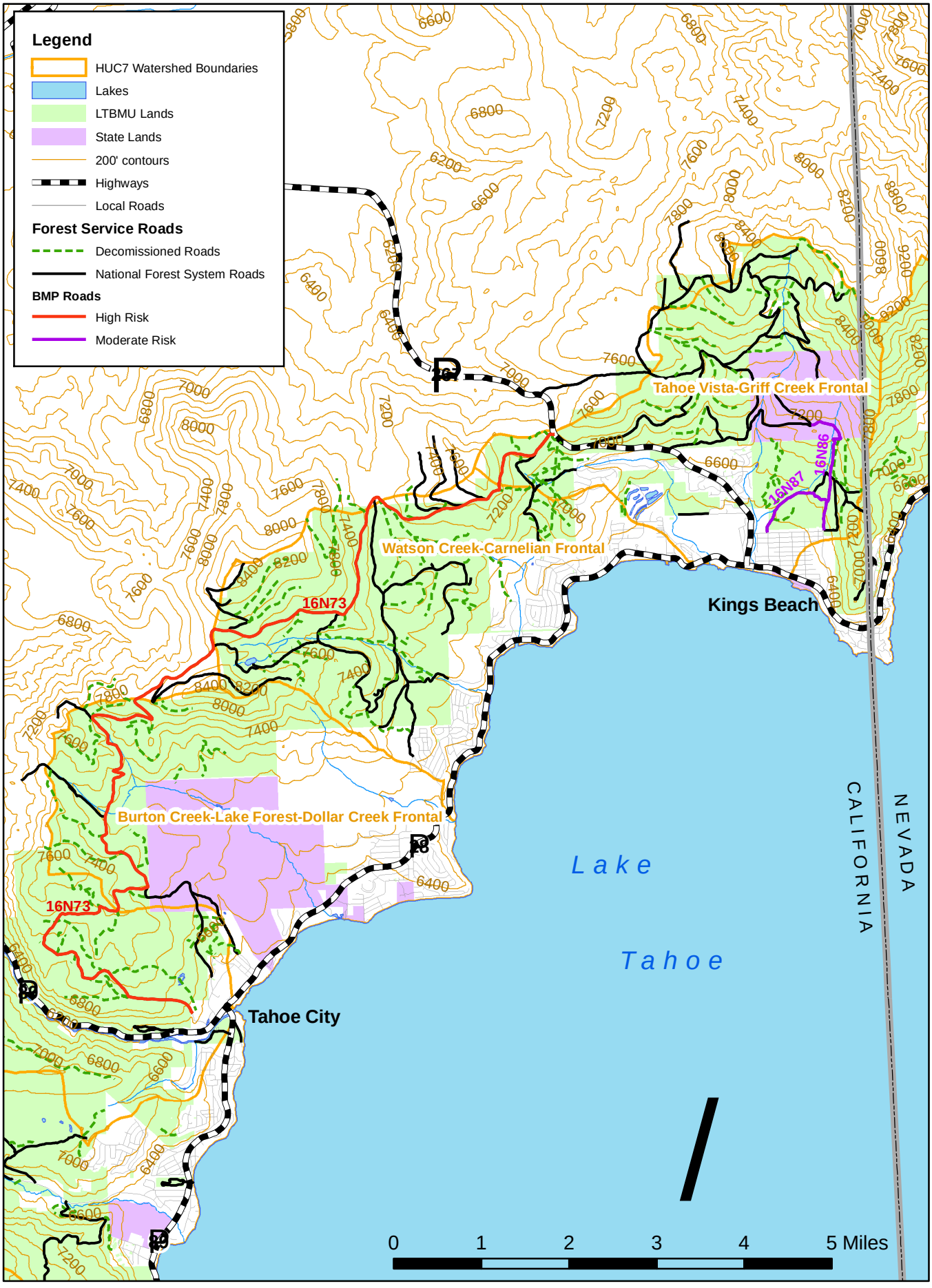

Figure 5.1b High Risk Roads

TABLES

Table 2.1: Study Watersheds Characteristics of watersheds and roads within each watershed.

Watershed	Area	Shore	Upgraded System Roads	Decommissioned Roads	Road to Trail
	acres		miles	miles	miles
[1,3,6]Angora Creek	3,694	South	5	0.8	
[1,5]Blackwood Creek	7,138	West	13	7.1	
[1,3,6]Bliss Creek-Secret Harbor Creek-Skunk Harbor	3,036	East	3	0.7	
[1,4]Burke Creek	2,985	East	3	3.2	
[2,4,8]Cold Creek	8,175	South	6	13.1	0.3
[1.4,6]Glenbrook Frontal	3,526	East	8	5.1	
[1,5]Headwaters of Trout Creek	7,499	South	6	2.2	
[1,5]Incline Creek-Mill Creek Frontal	5,701	South	3	1.3	2.2
[1,5]Logan House Frontal	2,396	East	4	2.4	
[1,3,6]Lonely Gulch	5,504	West	2		
[1,5,6]Lower Trout Creek	3,525	South	5	13.2	0.3
[1,3]McKinney Creek	3,059	West	7	0.3	
[1,5]Saxon Creek	5,397	South	4	0.7	1.7
[1,4]Skyland-Cave Rock-Lincoln Creek Frontal	3,165	East	5	2.9	
[1,4]Tahoe Vista-Griff Creek Frontal	6,300	North	23	17.2	
[1,,6]Tallac Creek	2,933	South	5		
[1,5]Third Creek	3,865	North	4	0.5	2.2
[1,4]Ward Creek Frontal	8,460	West	13	4.1	
[2,3]Watson Creek-Carnelian Frontal	6,471	North	22	14.1	
[1,4]Zephyr Frontal	2,878	East	2	1.7	
Total			**154**	**96.5**	**6.7**

1. Part of 1998 survey. 2. Not part of 1998 survey. 3. Surveyed in 2005. 4. Surveyed in 2004. 5. Surveyed in 2003. 6. Upgrades have not been completed.

Table 3.1: Water Quality Risk Scores for Individual Road Features.

Connected Length	Score
not connected	0
<91 meters (100 yds)	5
91-275 meters (100-300 yds)	15
>275 meters (300 yds)	35
Road Grade	
<5%	0
6-10%	10
>10%	20
Surface Type	
Gravel or paved	0
Native	10
[1]Inlet Condition	
Good	0
Poor	10
[1]Diversion Distance	
No diversion potential	0
<23 meters	5
23-91 meters	10
>91 meters	25
[2]SEZ or NON-SEZ	
NON-SEZ	0
SEZ	20
[2]Chronic Erosion Feature	
None	0
Present	15

1. Applies to crossings only.
2. Applies to SEZ's and Non-SEZ's only.

Table 3.2: Overall Water Quality Risk Score for Road Segments at crossings, in SEZ's, and Non-SEZ's.

Risk Category	Total Score (X)
High	X>60
Moderate	X=25-60
Low	X<25

Table 3.3: WEPP Parameters

	Input Variable	Notes
1	Climate	WEPP has many climate stations from which to choose but there is only one in the Lake Tahoe Basin. Therefore, representative climates were developed with Clignen for each watershed. Thirty years of climate were used to run the model.
2	Soil Texture	There are four options: clay loam, loam, sandy loam, and silt loam. Information for soil textures in the project area was compiled from the *Soil Survey Tahoe Basin Area California and Nevada*
3	Percent rock	Rock fragments in WEPP are considered rocks in the soil. To maintain comparability between treatments, percent rock remained at 0.
4	Road Design *	The model has four options: insloped, bare ditch (ib); insloped rocked ditch (iv); outsloped, unrutted (ou); and outsloped, rutted (or).
5	Road Surface *	WEPP options include: native, graveled, or paved.
6	Traffic Level	WEPP options for traffic level include: High, Low, and No Traffic. Roads with year-round traffic or logging roads with high use are considered High. Roads with low recreational use during dry conditions are modeled as Low (this setting is typical of most roads on the Lake Tahoe Basin Management Unit). Where vegetation has grown in one-half or more of the road, No Traffic is assigned. All roads were modeled as low traffic.
7	Road Gradient (%)	Refers to the slope of the road between drainage points. Gradient was measured in the field with a clinometer. WEPP has constraints between 0.1 and 40%.
8	Road horizontal length *(meter)	Refers to the length of road between drainage points. WEPP allows a range between 1 and 300 meters.
9	Road horizontal width (meter)	WEPP has three definitions for outsloped roads, rutted; outsloped roads, unrutted; and insloped roads. Road width is considered to be the width of the entire road. WEPP allows a range between 0.3 and 100 meters.
10	Fillslope slope (%)	WEPP requires a range between 0.1% and 150%.
11	Fillslope horizontal length (meter)	WEPP requires a range between 0.3 and 100 meters
12	Buffer gradient (%)	Refers to the gradient of the buffer, the area between the road and a stream, meadow, spring, or lake. WEPP allows a range between 0.1 and 100 percent.
13	Buffer Horizontal length (meter)	Refers to the horizontal length of the buffer, the area between the road and a stream, meadow, spring, or lake. WEPP allows a range between 0.3 and 300 meters.

** Input variables number 4 & 8 are most likely to change as a result of retrofits.*

Table 4.1: Summary of BMPEP evaluations by watershed

Watershed	Number of Crossings Evaluated	E08 Road surface, drainage and slope protection	E09 Stream crossings	E11 Control of side-cast material
		Number of Effective Evaluations	Number of Effective Evaluations	Number of Effective Evaluations
Blackwood Creek	17	15	17	15
Bliss Creek-Secret Harbor Creek-Skunk Harbor	6	5	6	5
Glen Alpine Creek, Taylor Creek, Tallac Creek	1	1	1	1
Glenbrook Creek	6	5	6	5
Griff Creek	4	4	4	4
Lonely Gulch	1	1	1	1
McKinney Creek	1	1	1	1
Third Creek	6	6	6	5
Trout Creek	3	3	3	3
Ward Creek	6	6	6	3
Watson Creek	1	1	1	1
Total	**52**	**49 (92%)**	**52 (100%)**	**44 (85%)**

Table 4.2.1: Comparison between connected segments of Pre-project and Post-Project inventories. System roads represent the total mileage of roads inventoried.

		Pre-Project				Post Project				Change			
Shore of Lake Tahoe	**System Roads**	**Low**	**Med.**	**High**	**Total**	**Low**	**Med.**	**High**	**Total**	**Low**	**Med.**	**High**	**Total**
	Miles	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**
North	54.0	0.3	3.3	2.7	**6.3**	0.2	1.2	0.2	**1.7**	-0.1	-2.1	-2.4	**-4.6**
East	26.0	0.2	1.4	0.9	**2.5**	0.3	1.2	1.2	**2.7**	0.1	-0.2	0.3	**0.1**
South	26.0	0.5	0.6	0.0	**1.1**	0.3	0.6	0.0	**0.9**	-0.2	0.0	0.0	**-0.2**
West	34.0	2.1	4.5	0.9	**7.5**	1.2	2.2	0.3	**3.7**	-0.9	-2.3	-0.6	**-3.8**
Total	**140.0**	**3.1**	**9.9**	**4.4**	**17.4**	**2.0**	**5.2**	**1.6**	**8.9**	**-1.1**	**-4.6**	**-2.8**	**-8.5**

L=Low water quality risk, M=Moderate Water Quality Risk, H=High Water Quality Risk, T=Total
1 Mileage of roads does not include roads under the management of Heavenly Valley Ski Area (Appendix A).

Table 4.2.2: Connected length of roads including newly mapped roads.

		Post Project				Newly Mapped 2003-2005				Current Condition			
Shore of Lake Tahoe	**System Roads**	**Low**	**Med.**	**High**	**Total**	**Low**	**Med.**	**High**	**Total**	**Low**	**Med.**	**High**	**Total**
	Miles	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**
North	54	0.2	1.2	0.2	**1.6**	0.0	0.3	0.0	**0.3**	0.2	1.5	0.2	**2.0**
East	31	0.3	1.2	1.2	**2.7**	<0.1	0.3	0.0	**0.4**	0.3	1.6	1.2	**3.0**
South	34	0.3	0.6	0.0	**0.9**	<0.1	0.8	<0.1	**0.9**	0.3	1.4	0.0	**1.8**
West	32	1.2	2.2	0.3	**3.7**	0.1	0.1		**0.1**	1.3	2.3	0.3	**3.8**
Total	**152**	**2.0**	**5.2**	**1.6**	**8.9**	**0.2**	**1.6**	**<0.1**	**1.8**	**2.2**	**6.8**	**1.7**	**10.7**

L=Low water quality risk, M=Moderate Water Quality Risk, H=High Water Quality Risk T=Total
0.1 miles =0.05 to 0.09 miles and <0.1 miles = 0.01 to 0.04 miles.
Total mileage includes actual value

Table 4.3.1: WEPP Road Batch Results Totals by Watershed.

Watersheds	Total Erosion Tons			Total Sediment Yield Tons		
	Pre-project	Post project	Change	Pre-project	Post project	Change
Angora Creek	0.0	<0.1	<0.1	0.0	<0.1	<0.1
Bliss-Secret Harbor-Skunk Harbor	1.8	0.1	-1.7	0.1	<0.1	-0.1
Burke Creek	15.0	16.6	1.6	3.3	2.7	-0.6
Lonely Gulch	0.1	0.8	0.7	<0.1	0.2	0.2
McKinney Creek	0.1	0.0	-0.1	<0.1	0.00	>-0.1
Skyland-Cave Rock-Lincoln Creek	5.8	8.6	2.8	0.4	0.1	-0.3
Tahoe Vista-Griff Creek	5.4	5.2	-0.2	1.8	1.6	0.2
Tallac Creek	0.8	0.5	-0.3	0.8	0.5	-0.3
Ward Creek	12.3	0.2	-12.1	7.6	0.1	-7.5
Watson Creek-Carnelian Front	11.0	21.7	10.7	9.2	5.4	-3.8
Zephyr Frontal	**0.6**	**0.1**	**-0.5**	**0.1**	**<0.1**	**>-0.1**
Grand Total	**52.8**	**53.6**	**0.8**	**23.4**	**10.5**	**-12.9**

0.1 tons =0.05 to 0.09 tons and <0.1 tons = 0.01 to 0.04 tons.
Total tonnage includes actual values

Table 4.3.2: WEPP Road Batch Results. Values are average rates of annual erosion and sediment yield from roads within each watershed. Changes in erosion and sediment yield are due to road upgrades.

Watershed/Road	Erosion			Sediment Yield		
	Pre-project	Post-project	Change	Pre-project	Post-project	Change
	Tons	Tons	Tons	Tons	Tons	Tons
Angora Creek						
12N30	**0.0**	**<0.1**	**<0.1**	**0.0**	**<0.1**	**<0.1**
Bliss-Secret Harbor-Skunk Harbor						
1566	1.6	0.0	-1.6	<0.1	0.0	>-0.1
1566A	0.2	0.1	-0.1	0.1	<0.1	0.0
15N67	<0.1	<0.1	>-0.1	<0.1	0.0	>-0.1
Watershed Total	**1.8**	**0.1**	**-1.7**	**0.1**	**<0.1**	**-0.1**
Burke Creek						
13N20	0.8	0.2	-0.6	0.1	0.1	>-0.1
13N80	1.7	2.5	0.8	1.3	0.6	-0.7
13N82	5.0	3.0	-2.0	0.8	0.1	-0.7
13N82A	0.5	1.0	0.5	0.3	0.5	0.2
14N32	7.1	9.9	2.8	0.8	1.3	0.6
Watershed Total	**15.0**	**16.6**	**1.6**	**3.3**	**2.7**	**-0.6**
Lonely Gulch						
1330	**0.1**	**0.8**	**0.7**	**<0.1**	**0.2**	**0.2**
McKinney Creek						
14N40	**0.1**	**0.0**	**-0.1**	**<0.1**	**0.00**	**>-0.1**
Skyland-Cave Rock-Lincoln Creek						
13N78	5.3	8.5	3.2	<0.1	<0.1	0.00
14N33	0.5	0.1	-0.4	0.4	<0.1	-0.3
Watershed Total	**5.8**	**8.6**	**2.8**	**0.4**	**0.1**	**-0.3**
Tahoe Vista-Griff Creek						
16N52	0.0	<0.1	<0.1	0.0	<0.1	<0.1
16N55	0.9	0.1	-0.8	0.2	0.01	-0.2
16N56	0.0	0.0	0.0	0.0	0.0	0.0
16N56B	0.0	0.0	>-0.1	<0.1	0.0	>-0.1
16N66	1.3	0.0	-1.3	0.9	0.0	-0.9
16N68	1.7	0.0	-1.7	0.0	0.0	0.0
16N86	0.6	0.3	-0.4	0.2	<0.1	-0.1
16N87	0.0	3.9	3.9	0.0	1.3	1.3
16N93	0.1	0.0	-0.1	0.1	0.0	-0.1
16N98	0.5	0.7	0.3	0.3	0.1	-0.2
16N99	0.2	0.1	>-0.1	0.1	0.1	>-0.1
Watershed Total	**5.4**	**5.2**	**-0.2**	**1.8**	**1.6**	**0.2**
Tallac Creek						
1307B	0.0	0.5	0.5	0.0	0.5	0.5
1393		0.0	0.0		0.0	0.0
1394	0.8	<0.1	-0.7	0.7	0.0	-0.7
1396	0.1	0.0	-0.1	0.1	0.0	-0.1
Watershed Total	**0.8**	**0.5**	**-0.3**	**0.8**	**0.5**	**-0.3**
Ward Creek						
15N35	3.0	0.0	-3.0	2.3	0.0	-2.3

15N60	2.4	<0.1	-2.4	0.8	<0.1	-0.8
15N60A	0.1	0.0	-0.1	0.04	0.0	>-0.1
15N62	6.0	0.1	-5.9	4.0	<0.1	-4.0
16N48	0.9	<0.1	-0.8	0.4	<0.1	-0.4
Watershed Total	**12.3**	**0.2**	**-12.1**	**7.6**	**0.1**	**-7.5**
Watson Creek-Carnelian Front						
16N49	0.1	0.0	-0.1	0.1	0.0	-0.1
16N50	0.4	0.8	0.4	0.2	0.2	0.0
16n71	0.2	0.0	-0.2	0.2	0.0	-0.2
16N73	8.0	20.9	12.9	6.7	5.2	-1.6
16N74	0.3	<0.1	-0.3	0.3	<0.1	-0.2
16N75	1.9	<0.1	-1.9	1.8	0.0	-1.8
Watershed Total	**11.0**	**21.7**	**10.7**	**9.2**	**5.4**	**-3.8**
Zephyr Frontal						
13N42	0.6	0.0	-0.6	0.1	0.0	-0.1
13N78	0.0	0.1	0.1	0.0	<0.1	<0.1
Watershed Total	**0.6**	**0.1**	**-0.5**	**0.1**	**<0.1**	**>-0.1**
Grand Total	**52.8**	**53.6**	**0.8**	**23.4**	**10.5**	**-12.9**

0.1 tons =0.05 to 0.09 tons and <0.1 tons = 0.01 to 0.04 tons.
Total tonnage includes actual values

Table 4.3.3 : WEPP Data - Includes current erosion and sediment yield sum of the post project rates in table 4.4 and erosion and sediment yield from newly mapped segments. Only roads with newly mapped segments are shown.

Watershed/Road	Erosion			Sediment Yield		
	Newly mapped	Post-project	Current	Newly mapped	Post-project	Current
	Tons			Tons		
Angora Creek						
12N30		<0.1	<0.1		<0.1	<0.1
Bliss-Secret Harbor-Skunk Harbor						
1566	0.0	<0.1	<0.1	0.0	<0.1	<0.1
1566A	0.1	0.1	0.2	0.1	<0.1	0.1
15N67	<0.1	<0.1	<0.1	0.0	<0.1	<0.1
Watershed Total	**0.1**	**0.1**	**0.2**	**0.1**	**0.0**	**0.1**
Burke Creek						
13N20		0.2	0.2		0.1	0.1
13N80	<0.1	2.5	2.5	<0.1	0.6	0.6
13N82		3.0	3.0		0.1	0.1
13N82A		1.0	1.0		0.5	0.5
14N32		9.9	9.9		1.3	1.3
Watershed Total	**0.0**	**16.6**	**16.6**	**0.0**	**2.7**	**2.7**
Lonely Gulch						
1330		**0.8**	**0.8**		**0.2**	**0.2**
McKinney Creek						
14N40	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Skyland-Cave Rock-Lincoln Creek						
13N78		8.5	8.5		0.0	0.0
14N33	0.2	0.1	0.3	0.0	0.0	0.1
Watershed Total	**0.2**	**8.6**	**8.8**	**0.0**	**0.1**	**0.1**
Tahoe Vista-Griff Creek						
16N52	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
16N54	0.1		0.1	<0.1		<0.1
16N55		0.1	0.1		<0.1	<0.1
16N56		<0.1	<0.1		<0.1	<0.1
16N56B		0.0	0.0		0.0	0.0
16N66	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
16N68		0.0	0.0		0.0	0.0
16N86	2.7	0.3	3.0	0.5	0.0	0.5
16N87		3.9	3.9		1.3	1.3
16N92		<0.1	<0.1	<0.1		<0.1
16N93		0.0	0.0		0.0	0.0
16N98		0.7	0.7		0.1	0.1
16N99		0.1	0.1		0.1	0.1
Watershed Total	**2.9**	**5.2**	**8.0**	**0.5**	**1.6**	**2.1**
Tallac Creek						
1307B		0.5	0.5		0.5	0.5
1393		0.0	0.0		0.0	0.0
1394		<0.1	<0.1		<0.1	<0.1
1396		0.0	0.0		0.0	0.0
Watershed Total		**0.5**	**0.5**		**0.5**	**0.5**
Ward Creek						

15N35			0.0			0.0
15N60		<0.1	<0.1		<0.1	<0.1
15N60A		0.0	0.0		0.0	0.0
15N62		0.1	0.1		<0.1	<0.1
16N48		<0.1	<0.1		<0.1	<0.1
Watershed Total		**0.2**	**0.2**		**0.1**	**0.1**
Watson Creek-Carnelian Front						
16N49		0.0	0.0		0.0	0.0
16N50		0.8	0.8		0.2	0.2
16n71		0.0	0.0		0.0	0.0
16N73		20.9	20.9		5.2	5.2
16N74		<0.1	<0.1		<0.1	<0.1
16N75		<0.1	<0.1		0.0	0.0
Watershed Total		**21.7**	**21.7**		**5.4**	**5.4**
Zephyr Frontal						
13N42		0.0	0.0		0.0	0.0
13N78		0.1	0.1		<0.1	<0.1
Watershed Total		**0.1**	**0.1**		**0.0**	**0.0**
Overall Total	**3.2**	**53.6**	**56.8**	**0.6**	**10.5**	**11.1**

0.1 tons =0.05 to 0.09 tons and <0.1 tons = 0.01 to 0.04 tons.
Total tonnage includes actual values

APPENDICIES

Appendix A: Results of Roads of Maintained by Heavenly Valley Ski Area.
Appendix B: Water Quality Risk Assessment Data Summary.
Appendix C: WEPP Inputs and Results.
Appendix D: Water Quality Risk Assessment Form.

Appendix-A

Heavenly Ski Area Roads

Introduction

Heavenly Valley Ski Area maintains and manages Forest Service roads within its permitted area including 18 miles of system roads and 12 miles of decommissioned roads. These roads have not been maintained or upgraded according to Forest Service standards. Consequently, the roads within the jurisdiction of the ski area are being analyzed. The following data inventory is used to predict relative water quality risk by determining the current interconnectedness of roads and estimating erosion via WEPP computer modeling.

Water Quality Risk

Heavenly Valley Ski Area encompasses parts of four watersheds, including Dagget Creek, which lies outside the boundaries of the Lake Tahoe Basin Management Unit. Watersheds range in size from 652 acres to 4,289 acres. (Table A.1).

Table A.1 Heavenly Valley Ski Area Watersheds and Roads. Inventories were completed in 1998 and 2004.

Watershed	Area	System Roads	Decommissioned Roads
	Acres	Miles	Miles
Bijou Frontage	3,763	2.7	3.8
Dagget Creek	652	4.7	2.1
Edgewood Creek	4,289	1.9	1.4
Heavenly Valley Creek	1,924	8.6	4.5
Total		**17.9**	**11.8**

Pre-project monitoring documented 2.5 miles of connected road and post project monitoring documented 2.2 miles, a decrease of 0.3 miles (Table A.2). Although there was an overall decrease in total low to moderated risk road segments (0.5 miles), there was also an increase in high risk road segments (0.2 miles). This increase in high risk road miles occurred on road 12N40 in the Heavenly Creek watershed. Results are summarized by road and watershed in Table A.2.

Table A.2 Water Quality Risk Results for Roads under the administration of Heavenly Valley Ski Area. Data was collected in 1998 and 2004. Mileage represents miles of connected length of low, moderate, and high risk roads.

	Pre-project			Post project			Change			
Watershed/Road	**L**	**M**	**H**	**L**	**M**	**H**	**L**	**M**	**H**	**T**
	Miles	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**	**Miles**
Bijou Creek										
12N40		0.4						-0.4		-0.4
12N40A		<0.1			<0.1			<0.1		<0.1
Watershed Total		**0.4**			**0.0**			**-0.4**		**-0.4**
Dagget Creek										
13N52		0.2			0.3			0.1		0.1
13N52B		<0.1						<-0.1		<-0.1
13N53E		0.1			<0.1			<0.1		<0.1
Watershed Total		**0.2**			**0.3**			**0.1**		**0.1**
Edgewood Creek										
[1]13N82		**0.3**			**0.0**			**-0.3**		**-0.3**
Heavenly Creek										
12N40	<0.1		1.2		0.1	1.4	<0.1	0.1	0.2	0.3
12N40E	<0.1	0.1		0	0.2		<0.1	0.1		0.1
13N52		0.3	0.1		0.2	0.1		-0.1	0.0	-0.1
13N52H		0.1		<0.1			0.0	-0.1		0.0
Watershed Total	**0.1**	**0.4**	**1.3**	**0.0**	**0.4**	**1.5**	**0.0**	**0.0**	**0.2**	**0.2**
Total	**0.07**	**1.05**	**1.3**	**0.03**	**0.74**	**1.53**	**-0.31**	**-0.31**	**0.23**	**-0.11**

L=Low water quality risk, M=Moderate Water Quality Risk, H=High Water Quality Risk T= Total
0.1 miles =0.05 to 0.09 miles and <0.1 miles = 0.01 to 0.04 miles.
Actual mileage is shown in totals.

WEPP: Road Batch

The increase in high risk road miles resulted in a corresponding increase in model erosion yield from 2.6 tons to 5.8 tons, with an increase in estimated sediment yield to adjacent streams from 1.3 tons to 3.8 tons. Results are listed by road and watershed in Table A.3

Table A.3 Results of WEPP modeling of roads within Heavenly Valley Ski Area. Results are based on best available data. Values are average annual amounts.

Watershed/Road	Erosion			Sediment Yield		
	Pre-project	Post project	Change	Pre-project	Post project	Change
	tons	tons	tons	tons	tons	tons
Bijou Creek						
12N40A	<0.1	0.0	<-0.1	<0.1	0.0	<-0.1
12N40E	<0.1	0.0	<-0.1	<0.1	0.0	0.0
12N40	<0.1	0.0	<-0.1	<0.1	0.0	<-0.1
Watershed Total	**0.1**	**0.0**	**-0.1**	**0.1**	**0.0**	**-0.1**
Dagget Creek	<0.1	0.0	0.0	<0.1	0.0	0.0
13N52	0.1	0.2	<0.1	0.1	0.1	0.0

13N52B	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
13N52E	0.1	0.0	-0.1	<0.1	0.0	<-0.1
Watershed Total	**0.2**	**0.2**	**0.0**	**0.1**	**0.1**	**<-0.1**
Edgewood	<0.1	0.0	0.0	<0.1	0.0	0.0
13N82	**0.3**	**0.5**	**0.2**	**0.2**	**0.2**	**<0.1**
Heavenly Creek	<0.1	0.0	0.0	<0.1	0.0	0.0
12N40	0.7	4.7	4.0	0.6	3.3	2.8
12N40E	<0.1	0.1	0.1	<0.1	0.0	0.0
13N52	1.3	0.3	-0.9	0.4	0.2	-0.2
13N52H	<0.1	0.0	<-0.1	<0.1	0.0	<-0.1
Watershed Total	**2.0**	**5.1**	**3.1**	**1.0**	**3.5**	**2.5**
Total	**2.6**	**5.8**	**3.2**	**1.3**	**3.8**	**2.5**

0.1 tons =0.05 to 0.09 tons and <0.1 tons = 0.01 to 0.04 tons.
Total tonnage includes actual values

This increase in erosion and sediment yield is predicted primarily on road 12N40 in the Heavenly Creek watershed. Erosion increased from 2 tons to 5 tons; and sediment yield increased from 1 ton to 3 tons.

Summary

Moderate and high risk road segments equal 2.2 miles, which result in a predicted erosion rate of 5.8 tons per year and a corresponding sediment yield of 3.8 tons. Road 12N40 accounted for 3 of the 3.8 tons of road sediment yield within the resort. Road 12N40s high sediment yield can be attributed chiefly to three individual road segments. These segments all have a connected length of 300 meters and relatively short buffer lengths of from 20 to 55 meters. Road conditions need reevaluation by Heavenly Ski Area staff to determine BMP's which would reduce sediment yield and water quality risk.

Appendix A-Heavenly WEPP Data

	Segment	Run number	Design	Surface, traffic	Road grad (%)	Road length (m)	Road width (m)	Fill grad (%)	Fill length (m)	Buff grad (%)	Buff length (m)	Rock cont (%)	Average annual rain runoff (mm)	Average annual snow runoff (mm)	Average annual sediment leaving road (kg)	Average annual sediment leaving buffer (kg)	Year	Watershed
12N40A	12N40ACR01_98	1	Outsloped, rutted	native low	10	30	4	0.1	0.3	5	0.3	0	15	48	25	19	1998	Bijou
12N40E	12N40ESEZ01	2	Outsloped, unrutted	native low	0.1	100	4	45	0.3	2	10	0	0	0	16	0	1998	Bijou
12N40	12N40SEZ01	3	Outsloped, unrutted	graveled low	2	120	4	45	0.3	50	0.3	0	14	11	29	24	1998	Bijou
13N52B	13N52BCR01	4	Outsloped, unrutted	native low	5	50	3	45	1	0.1	0.3	0	8	16	8	4	2004	Dagget Creek
13N52	13N52CR01_98	5	Outsloped, unrutted	native low	6	300	4	50	1	0.1	0.3	0	10	24		47	1998	Dagget Creek
13N52	13N52CR01L	6	Outsloped, unrutted	native low	5	300	4	50	1	0.1	0.3	0	9	21	61	40	2004	Dagget Creek
13N52	13N52CR01R	7	Outsloped, unrutted	native low	1	30	4	50	1	0.1	0.3	0	8	13	5	3	2004	Dagget Creek
13N52	13N52CR02	8	Outsloped, unrutted	native low	10	80	4	45	2	8	10	0	1	0	30	3	2004	Dagget Creek

Appendix A-Heavenly WEPP Data

	Segment	Run number	Design	Surface, traffic	Road grad (%)	Road length (m)	Road width (m)	Fill grad (%)	Fill length (m)	Buff grad (%)	Buff length (m)	Rock cont (%)	Average annual rain runoff (mm)	Average annual snow runoff (mm)	Average annual sediment leaving road (kg)	Average annual sediment leaving buffer (kg)	Year	Watershed
13N52E	13N52ECR01	9	Insloped, vegetated or rocked ditch	native low	18	40	3	50	1	20	20	0	2	1	33	8	2004	Dagget Creek
13N82	13N82CR01L_98	10	Insloped, bare ditch	native low	6	45	4	1	1	5	1	0	12	39	38	23	1998	Edgewood Creek
13N82	13N82CR01L	11	Insloped, bare ditch	native low	8	70	4	1	1	5	1	0	13	45	123	64	2004	Edgewood Creek
13N82	13N82CR01R_98	12	Insloped, bare ditch	native low	10	70	4	1	1	5	1	0	13	45	158	75	1998	Edgewood Creek
13N82	13N82CR01R	13	Insloped, bare ditch	native low	4	65	4	1	1	5	1	0	12	43	44	32	2004	Edgewood Creek
13N82	13N82SEZ01	14	Insloped, bare ditch	native low	8	75	4	6	4	10	20	0	3	2	135	19	2004	Edgewood Creek
12N40	12N40CR01L_98	15	Insloped, vegetated or rocked ditch	native low	2	5	4	45	2	0.1	0.3	0	8	11	1	0	1998	Heavenly Creek
12N40	12N40CR01R_98	15	Insloped, vegetated or rocked ditch	native low	8	50	4	45	2	0.1	0.3	0	14	46	26	23	1998	Heavenly Creek

Appendix A-Heavenly WEPP Data

	Segment	Run number	Design	Surface, traffic	Road grad (%)	Road length (m)	Road width (m)	Fill grad (%)	Fill length (m)	Buff grad (%)	Buff length (m)	Rock cont (%)	Average annual rain runoff (mm)	Average annual snow runoff (mm)	Average annual sediment leaving road (kg)	Average annual sediment leaving buffer (kg)	Year	Watershed
12N40	12N40CR01	16	Insloped, vegetated or rocked ditch	native low	2	40	4	45	2	0.1	0.3	0	13	42	9	7	2004	Heavenly Creek
12N40	12N40CR02_98	17	Insloped, vegetated or rocked ditch	graveled low	8	100	4	45	2	0.1	0.3	0	20	24	100	87	1998	Heavenly Creek
12N40	12N40CR02	18	Outsloped, unrutted	native low	2	250	4	45	0.3	2	50	0	0	0	41	0	2004	Heavenly Creek
12N40E	12N40ESEZ01	19	Outsloped, unrutted	native low	2	250	4	45	0.3	2	50	0	0	0	41	0	2004	Heavenly Creek
12N40	12N40SEZ02	20	Outsloped, unrutted	native low	5	300	4	30	5	20	55	0	0	0	60	0	1998	Heavenly Creek
12N40	12N40SEZ02	21	Outsloped, unrutted	native low	5	300	4	30	5	20	55	0	0	0	60	0	2004	Heavenly Creek
12N40	12N40SEZ03	22	iv	native low	12	300	4	45	2	50	20	0	10	33	1,671	1,416	1998	Heavenly Creek
12N40	12N40SEZ03	23	Insloped, vegetated or rocked ditch	native low	12	300	4	45	2	50	20	0	10	33	1,671	1,416	2004	Heavenly Creek
12N40	12N40SEZ06	24	ou	native low	4	300	4	45	1	15	20	0	0	0	60	0	1998	Heavenly Creek

Appendix A-Heavenly WEPP Data

	Segment	Run number	Design	Surface, traffic	Road grad (%)	Road length (m)	Road width (m)	Fill grad (%)	Fill length (m)	Buff grad (%)	Buff length (m)	Rock cont (%)	Average annual rain runoff (mm)	Average annual snow runoff (mm)	Average annual sediment leaving road (kg)	Average annual sediment leaving buffer (kg)	Year	Watershed
12N40	12N40SEZ06A	25	or	native low	5	300	4	45	1	15	20	0	7	25	853	485	2004	Heavenly Creek
13N52	13N52CR02L_98	26	Outsloped, unrutted	native low	4	30	4	45	2	8	10	0	0	0	6	0	1998	Heavenly Creek
13N52	13N52CR02R_98	27	Outsloped, unrutted	native low	4	85	4	45	2	8	10	0	0	0	17	1	1998	Heavenly Creek
13N52	13N52CR03	28	Outsloped, unrutted	native low	12	40	4	45	1	0.1	0.3	0	12	34	22	14	2004	Heavenly Creek
13N52	13N52CR04	29	Outsloped, unrutted	native low	8	100	4	0.1	0.3	0.1	0.3	0	10	33	30	15	2004	Heavenly Creek
13N52	13N52SEZ01	30	Insloped, bare ditch	native low	8	175	4	45	5	20	30	0	5	9	681	220	1998	Heavenly Creek
13N52	13N52SEZ01	31	Outsloped, unrutted	native low	13	160	4	45	5	20	10	0	2	0	99	21	2004	Heavenly Creek
13N52	13N52SEZ02	32	Insloped, bare ditch	native low	2	40	4	50	1	35	0.3	0	14	47	9	9	1998	Heavenly Creek
13N52	13N52SEZ02	33	Insloped, vegetated or rocked ditch	native low	12	30	4	50	1	35	0.3	0	15	48	16	16	2004	Heavenly Creek
13N52	13N52SEZ03	34	Insloped, vegetated or rocked ditch	native low	10	50	4	20	5	35	20	0	5	3	35	23	2004	Heavenly Creek
13N52H	13N52HCR01L_98	35	Outsloped, unrutted	native low	1	75	4	45	1	0.1	0.3	0	8	13	12	7	1998	Heavenly Creek

APPENDIX-B

WQRAP Watershed Summary

North Shore Results

Overall, upgrades to roads in watersheds on the north shore of Lake Tahoe reduced 4.6 miles of connected road segments from 6.3 miles to 1.7 miles in the following manner:

Table 4.2.1 Connected length of road segments

- Connected length of low risk segments was reduced from 0.3 to 0.2 miles.
- Connected length of moderate risk segments was reduced from 3.3 miles to 1.2 miles.
- Connected length of high risk segments was reduced from 2.7 miles to 0.2 miles.

Table 4.2.2

- Despite these improvements, there are still 1.5 miles of moderate risk and 0.2 miles of high risk road segments and 0.2 miles of low risk road segments within Incline Creek-Mill Creek Frontal Tahoe Vista-Griff Creek Frontal, Third Creek and Watson Creek.

Results of water quality risk analysis for north shore watersheds are located in Table B.1.

Table B-1: North Shore- Results of Water Quality Risk Analysis. Mileage is the total connected length of roads within each watershed.

		Pre-project				Post-project				Change			
Watershed	**Road**	**L**	**M**	**H**	**T**	**L**	**M**	**H**	**T**	**L**	**M**	**H**	**T**
		Miles				**Miles**				**Miles**			
Incline Creek-Mill Creek Frontal	17N89	0.1	0.3		**0.4**	0.1	0.1		**0.2**	<0.1	-0.2		**-0.2**
	17N91	<0.1	0.3	0.6	**0.9**		<0.1		**<0.1**	-<0.1	-0.3	-0.6	**-0.9**
Watershed Total		**0.1**	**0.6**	**0.6**	**1.3**	**0.1**	**0.1**	**0.0**	**0.2**	**>-0.1**	**-0.5**	**-0.6**	**-1.1**
Tahoe Vista-Griff Creek Frontal	16N52	0.0	0.2		**0.2**	<0.1			**<0.1**	>-0.1	-0.2		**-0.2**
	16N54		0.1		**0.1**		<0.1		**<0.1**		>-0.1		**>-0.1**
	16N55	0.1	0.2	0.3	**0.5**	<0.1	0.1		**0.1**	0.0	-0.1	-0.3	**-0.5**
	16N56					<0.1			**<0.1**	<0.1			**<0.1**
	16N56B		<0.1		**<0.1**				**0.0**		>-0.1		**-0.02**
	16N66		0.2		**0.2**	<0.1			**<0.1**	<0.1	-0.2		**-0.1**
	16N68								**0.0**				**0.0**

	16N73A								**0.0**				**0.0**
	16N86		0.1		**0.1**		<0.1		**<0.1**		>0.1		**>-0.1**
	16N87						0.1		**0.1**		0.1		**0.1**
	16N92						<0.1		**<0.1**		<0.1		**0.04**
	16N93			0.3	**0.3**				**0.0**			-0.3	**-0.3**
	16N98								**0.0**				**0.0**
	16N99	0.1	0.03		**0.1**	0.04			**<0.1**	>-0.1	>-0.1		**>-0.1**
Watershed Total		**0.2**	**0.7**	**0.5**	**1.4**	**0.1**	**0.3**	**0.0**	**0.4**	**>-0.1**	**-0.4**	**-0.5**	**-1.0**
Third Creek	17N85		0.7	0.5	**1.2**		0.4	0.2	**0.6**	0.0	-0.3	-0.3	**-0.5**
	17N91		0.0						**0.0**	0.0		0.0	**0.0**
Watershed Total			**0.7**	**0.5**	**1.2**		**0.4**	**0.2**	**0.6**	**0.0**	**-0.3**	**-0.3**	**-0.5**
Watson Creek-Carnelian Frontal													
	16N49		<0.1		**0.0**				**0.0**	0.0	0.0	0.0	**0.0**
	16N50			0.1	**0.1**		<0.1		**0.1**	0.0	0.1	-0.1	**0.0**
	16N71			0.1	**0.1**		0.0		**0.0**	0.0	0.0	-0.1	**-0.1**
	16N73	<0.1	1.1	0.6	**1.7**		0.3		**0.3**	>-0.1	-0.8	-0.6	**-1.4**
	16N74	<0.1	0.2		**0.3**	<0.1	<0.1		**0.1**	>-0.1	-0.2	0.0	**-0.2**
	16N75		0.0	0.3	**0.3**				**0.0**	0.0	0.0	-0.3	**-0.3**
Watershed Total		**0.1**	**1.3**	**1.1**	**2.4**	**<0.1**	**0.4**	**0.0**	**0.4**	**>-0.1**	**-0.9**	**-1.1**	**-2.0**
Grand Total		**0.3**	**3.3**	**2.7**	**6.3**	**0.2**	**1.2**	**0.2**	**1.7**	**-0.1**	**-2.5**	**-2.1**	**-4.6**

L=Low water quality risk, M=Moderate Water Quality Risk, H=High Water Quality Risk T= Total
0.1 miles =0.05 to 0.09 miles and <0.1 miles = 0.01 to 0.04 miles.
Total mileage includes actual value and results in total values and may be different then summation in table.

East Shore Results

Connected length of roads in watersheds on the east shore of Lake Tahoe increased from 2.5 miles to 2.7 miles (0.2 miles) in the following manner:

- Connected length of low risk segments increased from 0.2 miles to 0.3 miles.
- Connected length of moderate risk segments was reduced from 1.4 miles to 1.2 miles.
- Connected length of high risk segments increased from 0.9 miles to 1.2 miles (Table B.2).
    - The increase occurred on Road 13N82 in Burke Creek watershed and 13N78 in Skyland-Cave Rock-Lincoln Creek Frontal.
      Within Burke Creek the 0.18 mile, high risk segment is located at the south entrance of 14N32. This segment was also rated as high risk in 1998. This SEZ segment is rated high risk due to the location of the road adjacent to

an SEZ and the long connected length of 975-ft (325 yards). This segment has been paved and the ditch and fill slope is lined with rock for the entire length of the segment. The rating of this segment, utilizing the current methodology which only factors in slope and connected length, will not change without relocating the road. It is believed that the erosion and sediment transport potential has been greatly reduced by the installed BMP's. However, because of the steep gradient and long connected length the runoff potential from this road still remains high. BMP's in this section will need to be maintained and monitored to ensure BMP failures do not occur, particularly after large storm event.

Within Skyland-Cave Rock-Lincoln Creek Frontal the non-SEZ segment on 13N78 remains high risk to water quality; this is a steep segment (slope=20%) with a long connected length (0.18 miles) and gullies present. In 1998 this segment was judged to not be connected to a waterbody; however in 2004 it was determined that runoff from this segment reaches a drop drain on the highway below.

There are still 1.2 miles of moderate risk road segments within each of the east shore watersheds and 1.2 miles of connected high risk segments combined within Burke Creek, Logan House Frontal, and Skyland-Cave Rock-Lincoln Creek Frontal.

Table B.2: East Shore - Water Quality Risk Analysis. Mileage equals total connected length of roads within each watershed.

		Pre-project				Post project				Change			
Watershed	**Road**	**L**	**M**	**H**	**T**	**L**	**M**	**H**	**T**	**L**	**M**	**H**	**T**
		Miles				**Miles**				**Miles**			
Bliss Slaughterhouse -Skunk Harbor	1566		0.1	0.2	**0.3**	0.1	0.0		**0.1**	0.1	-0.1	-0.2	**-0.2**
	1566A	0.1	0.2		**0.2**	<0.1	<0.1		**<0.1**	>-0.1	-0.1		**-0.2**
	15N67		<0.1		**0.0**	0.0	<0.1		**<0.1**		>-0.1		**>-0.1**
Watershed Total		**0.1**	**0.3**	**0.2**	**0.5**	**0.1**	**<0.1**		**0.1**	**<0.1**	**-0.3**	**-0.2**	**-0.4**
Burke Creek	13N20	<0.1	0.1		**0.1**	<0.1	0.2		**0.2**	0.0	0.2		**0.1**
	13N80	<0.1	0.2	0.1	**0.3**	<0.1	0.1		**0.1**	0.0	-0.1	-0.1	**-0.1**
	13N82			0.1	**0.1**			0.4	**0.4**			0.3	**0.3**
	14N32			0.2	**0.2**			0.2	**0.2**			0.0	**0.0**
Watershed Total		**<0.1**	**0.2**	**0.3**	**0.6**	<0.1	**0.3**	**0.6**	**0.9**	**0.0**	**0.1**	**0.3**	**0.3**
Glenbrook	14N32	<0.1	0.2	0.2	**0.4**		0.2	0.0	**0.2**	>-0.1	0.0	-0.2	**-0.2**
	14N33	0.1	0.1	0.2	**0.4**	0.1	0.1		**0.3**	<0.1	0.0	-0.2	**-0.2**
	14N47		0.1	0.1	**0.2**		<0.1		**<0.1**		-0.1	-0.1	**-0.1**
	1451		0.1		**0.1**		0.1		**0.1**		>-0.1		**>-0.1**
Watershed Total		**0.1**	**0.5**	**0.4**	**1.1**	**0.1**	**0.4**	**0.0**	**0.6**	**<0.1**	**-0.1**	**-0.4**	**-0.5**
Logan House Frontal	**14N33**	**<0.1**	**0.2**		**0.2**	**0.1**	**0.1**	**0.4**	**0.5**	**<0.1**	**-0.1**	**0.4**	**0.3**
Skyland-Cave Rock-Lincoln Creek Frontal	13N78							0.2	**0.2**			0.2	**0.2**
	14N33		0.1		**0.1**		0.2		**0.2**		0.1		**0.1**
Watershed Total		**0.0**	**0.1**	**0.0**	**0.1**	**0.0**	**0.2**	**0.2**	**0.4**	**0.0**	**0.1**	**0.2**	**0.3**

Zephyr Frontal	13N42		0.1		**0.1**		0.1		**0.1**		0.0		**<0.1**
	13N78						0.1		**0.1**		0.1		**0.1**
Watershed Total			**0.1**		**0.1**		**0.2**		**0.2**		**0.1**		**0.1**
Grand Total		**0.2**	**1.4**	**0.9**	**2.5**	**0.3**	**1.2**	**1.2**	**2.7**	**0.1**	**-0.2**	**0.3**	**0.2**

L=Low water quality risk, M=Moderate Water Quality Risk, H=High Water Quality Risk T= Total
0.1 miles =0.05 to 0.09 miles and <0.1 miles = 0.01 to 0.04 miles.
Actual mileage for <0.1 mile has been accounted for in total mileage and results in total values being different then summation in table.

South Shore Results

Connected length of roads in watersheds on the south shore of Lake Tahoe decreased from 1.1 miles to 0.9 miles (0.2 miles) in the following manner:

- Low risk segments decreased from 0.5 miles to 0.3 miles.
- Moderate risk segments remained at 0.6 miles.

Moderate risk roads segments within Angora Creek, Headwaters of Trout Creek, Lower Trout Creek, Saxon Creek, and Tallac Creek total 0.6 miles (Table B.3).

Table B.3: South Shore - Water Quality Risk Analysis. Mileage equals total connected length of roads within each watershed.

		Pre-project			Post project			Change		
Watershed	**Road**	**L**	**M**	**T**	**L**	**M**	**T**	**L**	**M**	**T**
		Miles			**Miles**			**Miles**		
Angora Creek	**12N30**	**0.1**		**0.1**	**0.0**	**<0.1**	**<0.1**	**-0.1**	**<0.1**	**0.0**
Headwaters of Trout Creek	1201	0.1	0.1	**0.1**	0.1	0.1	**0.2**	<0.1	0.0	**<0.1**
	12N01D		0.1	**0.1**		0.1	**0.1**		<0.1	**<0.1**
Watershed Total		**0.1**	**0.1**	**0.2**	**0.1**	**0.2**	**0.3**	**0.0**	**0.0**	**0.1**
Lower Trout Creek	**12N08**	**0.0**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**>-0.1**	**0.1**
Saxon Creek	1201			**0.0**			**0.0**			**0.0**
	12N01A		0.2	**0.2**		0.3	**0.3**		0.1	**0.1**
	12N08			**0.0**	<0.1		**<0.1**	<0.1		**<0.1**
Watershed Total		**0.0**	**0.2**	**0.2**	**<0.1**	**0.3**	**0.3**	**0.0**	**0.1**	**0.1**
Tallac Creek	1394b		<0.1	**<0.1**	<0.1		**<0.1**	0.0	>-0.1	**0.0**
	1394	0.1	0.1	**0.2**	0.1		**0.1**	>-0.1	-0.1	**-0.1**
	1395	0.0		**0.0**	0.0		**0.0**			**0.0**
	1396	0.2	0.1	**0.2**	<0.1	<0.1	**<0.1**	-0.2	-0.1	**-0.2**
Watershed Total		**0.3**	**0.2**	**0.5**	**0.1**	**<0.1**	**0.1**	**-0.1**	**-0.2**	**-0.3**
Grand Total		**0.5**	**0.6**	**1.1**	**0.3**	**0.6**	**0.9**	**-0.2**	**0.0**	**-0.2**

L=Low water quality risk, M=Moderate Water Quality Risk, H=High Water Quality Risk T= Total
0.1 miles =0.05 to 0.09 miles and <0.1 miles = 0.01 to 0.04 miles.
Actual mileage for <0.1 mile has been accounted for in total mileage and results in total values being different then summation in table.

West Shore Results

Connected length of roads in watersheds on the west shore of Lake Tahoe decreased from 7.5 to 3.7 miles 3.8 miles in the following manner:

- Low risk segments decreased from 2.1 miles to 1.2 miles.
- Moderate risk segments decreased from 4.5 miles to 2.2 miles.
- Connected length of high risk segments was reduced from 0.9 miles to 0.3 miles (Table B.4).

Remaining connected high risk segments total 0.3 miles. All segments are located on forest service road 15N38 in Blackwood Creek. All other west shore watersheds have a combined total of 2.2 miles of connected moderate risk road segments.

Table-B.4: West Shore - Water Quality Risk Analysis. Mileage equals total connected length of roads within each watershed.

		Pre-project				Post-project				Change			
Watershed	**Road**	**L**	**M**	**H**	T	**L**	**M**	**H**	**T**	**L**	**M**	**H**	**T**
		Miles				**Miles**				**Miles**			
Blackwood Creek	1503	1.4	2.6		**3.9**	0.8	1.4		**2.2**	-0.6	-1.2		**-1.7**
	15N37	0.0	0.2		**0.2**	<0.1	0.1		**0.2**	<0.1	-0.1		**>-0.1**
	15N38	0.2	0.7	0.1	**1.1**	0.2	0.3	0.3	**0.8**	>-0.1	-0.4	0.1	**-0.3**
	15N41	0.1	0.5	<0.1	**0.7**				**0.0**	-0.1	-0.5	>-0.1	**-0.7**
Watershed Total		1.7	4.0	0.2	**5.9**	1.0	1.8	0.3	**3.2**	-0.7	-2.1	0.1	**-2.7**
Lonely Gulch	**1330**		<0.1		**0.0**		0.0		**0.0**		<0.1		**<0.1**
McKinney Creek	**14N40**	0.0	0.1		**0.1**	0.0	<0.1		**0.0**		-0.1		**-0.1**
Ward Creek Frontal	15N60		0.2	0.1	**0.3**		0.1		**0.1**		-0.1	-0.1	**-0.2**
	15N60A	0.1	0.0		**0.1**	<0.1	<0.1		**0.0**	<0.1	<0.1		**>-0.1**
	15N62	0.3	0.2	0.6	**1.1**	0.1	0.1		**0.3**	-0.1	-0.1	-0.6	**-0.8**
	16N48				**0.0**	0.1	0.1		**0.1**	0.1	0.1		**0.1**
Watershed Total		**0.4**	**0.4**	**0.7**	**1.5**	**0.2**	**0.3**	**0.0**	**0.5**	**-0.1**	**-0.1**	**-0.7**	**-0.9**
Grand Total		**2.1**	**4.5**	**0.9**	**7.5**	**1.2**	**2.2**	**0.3**	**3.7**	**-0.9**	**-2.3**	**-0.6**	**-3.8**

L=Low water quality risk, M=Moderate Water Quality Risk, H=High Water Quality Risk T= Total
0.1 miles =0.05 to 0.09 miles and <0.1 miles = 0.01 to 0.04 miles.
Actual mileage for <0.1 mile has been accounted for in total mileage and results in total values being different from table summation.

APPENDIX-C

WEPP Modeling Results

North Shore

Tahoe Vista-Griff Creek Frontal

Modeled erosion decreased from 5.4 tons to 5.2 kg and sediment yield decreased from 1.8 tons to 1.6 tons (1, Table 4.3.1). Pre-project monitoring found 17 segments with a combined connected length of 0.9 miles (1,395 meters). Of these 17 segments, 8 had a connected length greater than 60 meters. Post-project monitoring found 36 segments with a connected length of 0.8 miles (1,340 meters). Of these 36 segments, 3 had a connected length greater than 60 meters.

Nine new segments with a connected length of 0.3 miles were mapped on 5 roads during post project monitoring (Table 4.3.3). These mapped segments added an additional 2.9 tons of erosion and 0.5 tons of sediment yield. Current erosion and sediment yield from the Tahoe Vista-Griff Creek Frontal equals 8 tons and 2.1 tons respectively.

Watson Creek-Carnelian Frontal

Modeled erosion increased from 11 tons to 21.7 tons and sediment yield decreased from 9.2 tons to 5.4 tons (Table 4.3.1). The increased erosion occurred on 16N73 and the WEPP model likely over-estimated erosion as noted above.

East Shore

Bliss-Secret Harbor-Skunk Harbor

Modeled erosion decreased from 1.8 tons to 0.1 tons and sediment yield decreased from 0.1 tons to <0.1 tons (Table 4.3.3). Reductions were made in the following manner:

- There were 13 segments with a combined connected length of 0.6 miles (988 meters) in 1998; and in 2005 there were 11 segments with a connected length of 0.2 miles (266 meters).

- In 1998, a 0.2 mile (287 meter) segment on 1566 accounted for 1.6 tons (1,417 kg) of the 1.8 tons (1,644 kg) or 86% of the total erosion. Upgrades eliminated this source of erosion and sediment yield by disconnecting it from Lake Tahoe.

In 2005, 5 new segments with a combined connected length of 0.1 miles were mapped on roads 15N66A, 1566, and 15N67 (Table 4.3.3). Average annual erosion and sediment yield from these segments was less than 0.1 tons. With the newly mapped segments, current erosion and sediment yield in Bliss-Secret Harbor-Skunk Harbor equals 0.2 tons and 0.1 ton respectively.

Burke Creek

Modeled erosion increased from 15 tons to 16.6 tons and sediment yield decreased from 3.3 tons to 2.7 tons (Table 4.3.3). Reductions were made in the following manner:

Pre-project monitoring identified 21 connected segments with a combined connected length of 1.2 miles. Ten of the 21 segments had a connected length greater than 60 meters. Post project monitoring identified 7 connected segments with a connected length of 0.9 miles (1,450 meters); and each had a connected length greater than 60 meters.

In 2004, 3 new segments with a combined connected length of 80 meters were mapped on road 13N80. Average annual erosion and sediment yield from these segments are less than 0.1 tons (Table 4.3.3). With the newly mapped segments, current erosion and sediment yield in Burke did not change and remained at 16.6 tons and 2.7 tons respectively (Tables 4.3.2 and 4.3.3).

Skyland-Cave Rock-Lincoln Creek Frontal

Modeled erosion increased from 5.8 tons to 8.6 tons and sediment yield decreased from 0.4 tons to 0.1 tons (Table 4.3.2). The increase in erosion occurred on road 13N78 and is due to an increase in mapped road grade from 15% to 20%. This may be a result of observational bias between the two inventories. All other variables remained the same, including connected length which was 0.2 miles (300 meters).

In 2004, 14 new segments with a combined connected length of 0.3 miles were mapped on road 14N33. Average annual erosion and sediment yield from these segments was 0.2 tons and 0.0 tons respectively (Table 4.3.3). With the newly mapped segments, current erosion and sediment yield in Skyland-Cave Rock-Lincoln Creek equaled 8.8 tons and 0.1 tons respectively (Tables 4.3.2 and 4.3.3).

Forest Service road 13N78 poses a moderate risk of erosion (Figures 1 and 2).

Zephyr Frontal

Modeled erosion decreased from 0.6 tons to .1 tons and sediment yield decreased from 0.1 tons to <0.1 tons. In 1998, there was one connected segment on 13N42, which accounted for 100% of the modeled erosion and sediment yield. Upgrades disconnected this segment, thereby eliminating it as a source of erosion and sediment yield. Four segments on road 13N78 with a connected length of 0.2 miles were found to be connected in 2004. These segments were not connected in 1998.

South Shore

Angora Creek

Average annual erosion and sediment yield increased from 0 tons to <0.1 tons and from 0 tons to <0.1 tons respectively. The increase is due to 2 segments on road 12N30 with a combined connected length of <0.1 miles (32 meters). There were no connected segments on road 12N30 in 1998.

Tallac Creek

Modeled erosion decreased from 0.8 tons to 0.5 tons and sediment yield decreased from 0.8 tons to 0.5 tons (Table 4.3.3). Significant reductions were realized on roads 1393, 1394, and 1396, but erosion and sediment yield increased on 1307B.

Forest Service road 1307B accounted for over 96% of total erosion and sediment yield in Tallac Creek. The increase is due to an increase in connected length from 23 meters to 150 meters. However, the WEPP model may have overestimated erosion and sediment yield for this road, which is paved and has a buffer length of 10 meters.

West Shore

Lonely Gulch

Modeled erosion increased from 0.1 tons to 0.8 tons and sediment yield increased from <0.1 tons to 0.2 tons (Table 4.3.3). One segment on road 1330 accounts for all the erosion and sediment yield in this water shed. Connected length increased from 32 meters to 65 meters causing the increase in erosion and sediment yield. WEPP may have over-estimated erosion and sediment yield, as the road is paved and the buffer is 10 meters (Elliot, 2004).

McKinney Creek

Erosion and sediment yield decreased from 0.1 tons to 0 tons and from <0.1 tons to 0 tons respectively. (Table 4.3.3). Only Road 14N40 to Buck Lake was evaluated. Upgrades to this road do not extend north of the lake. This is the only road that the Forest Service has maintained in the McKinney Creek Watershed. One segment accounts for the erosion and sediment yield. A decrease in connected length from 0.1 miles to <0.1 miles accounts for the reductions in erosion and sediment yield.

Ward Creek

Modeled erosion decreased from 12.3 tons to 0.2 tons and sediment yield decreased from 7.6 tons to 0.1 tons (Table 4.3.3). Reductions were made in the following manner:

- The number of connected segments decreased from 48 segments to 25 segments and connected length was reduced from 2.0 miles in 1998 to 0.4 miles.
    - The remaining connected segments are on roads 15N60, 15N60A, 15N62, and 16N48.
    - These segments account for the remaining erosion and sediment yield.
- Decommissioning of road 15N62 eliminated 0.1 miles of the connected length (3% of 1998 total); 26 kg of average annual erosion (<1% of 1998 total); and 22 kg of sediment yield in 1998 (<1% of 1998 total).
- Road to trail conversion on 15N35 and 15N60 eliminated 0.4 miles of connected length (22% of 1998 total); 3.4 tons (3,051 kg) of erosion (25% of 1998 total); and 2.5 tons (2,308 kg) of sediment yield (32% of 1998 total).
- Upgrades disconnected 0.2 miles (300 meters) of road on 15N62 (9% of 1998 total); eliminated 4.0 tons (3,615 kg) of erosion (30% of 1998 total); and eliminated 3.0 tons (2,754 kg) of sediment yield (38% of 1998 total).

Appendix C-WEPP Data

Angora Creek

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
12n30sez01a	iv	graveled low	15	22	4	5	0.3	5	2	0	9	7	13	7	2005; was mapped as 12N30CR01 in 1998
12n30sez01c	ib	native low	2	10	4	1	0.3	1	15	0	0	0	1	0	

Bliss-Secret Harbor-Skunk Harbor

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
1566ACR02-left	or	graveled low	2	18	4	20	2	20	1	0	13	7	7	5	1998
15n66acr02-left	or	native low	2	22	4	20	2	20	1	0	9	12	4	3	2005
1566ACR02-right	or	graveled low	2	41	4	20	2	20	1	0	22	11	19	16	1998
15n66acr02-right	or	native low	3	35	4	20	2	20	1	0	11	17	8	7	2005
1566ACR03	iv	graveled low	3	14	4	38	1	30	1	0	17	7	8	6	1998
15n66acr03-left	iv	native low	1	2	4	38	1	30	1	0	1	1	0	0	2005
15n66acr03-right	iv	native low	3	35	4	38	1	30	1	0	13	21	9	8	2005
1566ACR04-left	ou	graveled low	4	46	4	35	3	35	1	0	8	3	17	12	1998
15n66acr04-left	ou	graveled low	6	40	5	64	3	64	10	0	1	0	18	6	2005
1566ACR04-right	ou	graveled low	4	64	4	35	3	35	1	0	8	3	24	17	1998
15n66acr04-right	ou	graveled low	5	65	5	64	3	64	10	0	1	0	26	8	2005
1566ASEZ01	ou	graveled low	4	246	4	6	1	15	1	0	2	1	92	21	1998
15n66asez01a	ou	graveled low	6	21	4	6	1	15	1	0	2	1	7	2	2005
15n66asez02b	iv	graveled low	14	45	4	40	2	17	3	0	10	5	83	50	New in 2005

Bliss-Secret Harbor-Skunk Harbor-Continued															
WEPP Inputs											WEPP Outputs				Comments
Segment	Road Design	Surface, traffic	Road grade (%)	Road length (m)	Road width (m)	Fill grade (%)	Fill length (m)	Buffer grade (%)	Buffer length (m)	Rock (%)	Average annual rain runoff (mm)	Average annual snow runoff (mm)	Average annual erosion (kg)	Average annual sediment yield (kg)	
1n566asez02c	ou	native low	6	28	4	40	1	17	2	0	1	1	6	2	New in 2005
15n66asez03	ou	graveled low	6	35	4	60	2	60	20	0	0	0	12	1	New in 2005
1566CR04-left	ou	native low	2	18	4	35	3	35	1	0	5	4	4	2	1998
1566cr04-left	ou	native low	0.1	1	4	35	3	35	1	0	3	1	0	0	2005
1566CR04-right	ou	native low	5	73	4	35	3	35	1	0	8	6	20	14	1998
1566CR04-right	ou	native low	0.1	25	4	35	3	35	1	0	3	1	4	2	2005
1566NON01	ib	Native Low	5.00	287	3	0.1	0.3	15	150.0		1	0	1417	14	1998; not connected in 2005
1566NON02	ib	Native Low	3.00	23	3	0.1	0.3	15	150.0		0	0	7	0	1998; not connected in 2005
1566SEZ01	ou	Native Low	1	77	3	20	1	9	6	0	0	0	5	0	1998; not connected in 2005
1566SEZ02	ib	native low	0.1	35	4	0.1	0.3	0.1	0.3	0	1	4	0	0	New in 2005
15N67CR01-left	ou	native low	5	46	4	45	1	45	2	0	6	4	13	7	1998
15n67cr01-left	ou	graveled low	4	10	4	45	1	45	2	0	3	1	3	1	2005
15N67CR01-rigth	ou	native low	6	35	4	45	1	45	2	0	7	5	11	7	1998
15n67cr01-right	ou	graveled low	8	10	4	45	1	45	2	0	6	2	4	2	2005
15n67sez02	ou	native low	10	25	4	20	1	22	12	0	0	0	10	0	New in 2005
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Appendix C-WEPP Data

Burke Creek															
WEPP Inputs											WEPP Outputs				Comments
Segment	Road Design	Surface, traffic	Road grade (%)	Road length (m)	Road width (m)	Fill grade (%)	Fill length (m)	Buffer grade (%)	Buffer length (m)	Rock (%)	Average annual rain runoff (mm)	Average annual snow runoff (mm)	Average annual erosion (kg)	Average annual sediment yield (kg)	
13N20CR01L_98	ib	native high	5	15	4	45	1	5	1	0	13	36	17	11	1998
13N20CR01L	iv	native low	11	50	4	1	1	5	1	0	16	75	58	39	2004
13N20CR01R_98	ib	native high	5	85	4	45	1	1	1	0	19	76	544	307	1998
13N20CR01R	iv	native low	8	20	4	1	1	1	1	0	11	44	7	4	2004
13N20CR02_98	ib	native high	5	15	4	45	1	5	1	0	13	36	17	11	1998
13N20CR02L	iv	native low	3	10	4	1	1	5	1	0	7	23	2	1	2004
13N20CR02R	iv	native low	2	5	4	1	1	5	1	0	4	7	1	0	2004
13N20CR03_98	ib	native high	4	25	4	45	1	5	1	0	16	50	31	24	1998
13N20CR03L	iv	native low	6	15	4	1	1	5	1	0	10	36	4	2	2004
13N20CR03R	iv	native low	10	25	4	1	1	5	1	0	13	54	13	9	2004
13N20NON01	ib	native low	2	3	4	1	1	5	1	0	2	2	1	0	2004; not connected in 1998
13N20SEZ01_98	ib	native high	2	300	4	5	5	3	75	0	2	3	1,225	25	1998
13N20SEZ01b	iv	native low	3	40	4	1	1	11	40	0	0	0	8	1	2004
13N20SEZ01c1	ou	native low	3	40	2	1	1	4	20	0	0	0	5	0	2004
13N20SEZ01c10	ou	native low	3	40	2	1	1	4	20	0	0	0	5	0	2004
13N20SEZ01c11	ou	native low	3	40	2	1	1	4	20	0	0	0	5	0	2004
13N20SEZ01c3	ou	native low	3	40	2	1	1	4	20	0	0	0	5	0	2004
13N20SEZ01c4	ou	native low	3	40	2	1	1	4	20	0	0	0	5	0	2004
13N20SEZ01c5	ou	native low	3	40	2	1	1	4	20	0	0	0	5	0	2004
13N20SEZ01c6	ou	native low	3	40	2	1	1	4	20	0	0	0	5	0	2004
13N20SEZ01c7	ou	native low	3	40	2	1	1	4	20	0	0	0	5	0	2004
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Burke Creek-continued

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
13N20SEZ01c8	ou	native low	3	40	2	1	1	4	20	0	0	0	5	0	2004
13N20SEZ01c9	ou	native low	3	40	2	1	1	4	20	0	0	0	5	0	2004
13N20SEZ02_98	ib	native high	2	300	2	5	5	3	75	0	2	3	613	12	1998
13N20SEZ02	iv	native low	4	200	2	1	1	5	1	0	15	92	83	71	2004
13N20SEZ02b	iv	native low	2	300	1	1	1	2	30	0	4	25	23	6	2004
13N20NON01_98	ib	native high	5	120	4	45	1	3	75	0	1	0	1,039	3	1998; not connected in 2004
13N80CR1R_98	ib	native high	5	5	4	45	1	5	1	50	12	14	5	2	1998; not connected in 2004
13N80CR1L_98	ib	native high	2	7	4	45	1	5	1	50	15	24	5	3	1998; not connected in 2004
13N80CR02A_98	ib	native high	5	13	4	45	1	5	1	50	21	50	18	12	1998
13N80CR02B_98	ib	native high	5	17	4	45	1	5	1	50	24	60	28	20	1998
13N80CR02R	ou	native low	20	5	1	1	1	5	1	50	7	15	1	0	2004
13N80CR03_98	ib	native high	5	50	4	45	1	5	1	50	32	96	219	174	1998
13N80CR03L	ou	native low	15	20	1	1	1	5	1	50	5	9	3	1	2004
13N80CR04L_98	ib	native high	10	5	4	45	1	5	1	50	12	15	9	3	1998
13N80CR04L	ou	native low	6	5	1	1	1	5	1	50	2	1	1	0	2004
13N80CR04R_98	ib	native high	8	65	8	45	1	5	1	50	35	104	1,573	956	1998
13N80CR04R	ou	native low	8	30	1	1	1	5	1	50	3	2	4	0	2004
13N80CR05L	ou	native low	3	25	1	1	1	5	1	50	1	0	2	0	New in 2004
13N80CR05R	ou	native low	3	5	1	1	1	5	1	50	1	0	0	0	New in 2004
13N80SEZ01_98	ib	native high	8	50	4	15	4	1	1	50	29	81	462	217	1998
13N80SEZ01a	ib	native none	10	50	3	15	4	1	1	50	21	77	89	48	2004

Burke Creek-continued																
WEPP Inputs												WEPP Outputs				Comments
Segment	Road Design	Surface, traffic	Road grade (%)	Road length (m)	Road width (m)	Fill grade (%)	Fill length (m)	Buffer grade (%)	Buffer length (m)	Rock (%)	Average annual rain runoff (mm)	Average annual snow runoff (mm)	Average annual erosion (kg)	Average annual sediment yield (kg)	
13N80SEZ01b	ib	native low	6	30	3	4	15	10	15	50	2	2	23	4	2004
13N80SEZ01b	ou	native low	3	3	1	1	1	5	1	50	1	0	0	0	2004
13N80SEZ01c	ib	native low	10	40	4	5	20	10	15	50	3	4	108	18	2004
13N80SEZ01c	ou	native low	3	20	1	15	10	30	20	50	1	0	2	0	2004
13N80SEZ01d	ib	native low	12	70	4	45	10	10	20	50	6	11	527	88	2004
13N80SEZ01e	ib	native low	20	50	4	45	5	20	50	50	2	0	439	19	2004
13N80SEZ01f	ib	native low	18	50	4	45	15	20	55	50	2	0	394	22	2004
13N80SEZ01g	ib	native low	12	30	4	45	15	1	1	50	19	44	122	61	2004
13N80SEZ01h	ib	native low	5	10	4	45	15	1	1	50	11	18	13	8	2004
13N80SEZ01i	ib	native low	18	50	4	45	15	1	1	50	22	62	438	197	2004
13N80SEZ01j	ib	native low	30	25	4	45	10	1	1	50	19	47	166	55	2004
13N80SEZ02_98	ib	native high	5	90	4	45	1	1	1	50	34	108	739	483	1998
13N80SEZ02	ou	native low	15	10	2	45	1	1	1	50	13	31	4	2	2004
13N80SEZ02b	ou	native low	15	25	2	45	1	1	1	50	13	31	10	4	2004
13N80SEZ03_98	ib	native high	10	105	4	45	1	20	3	50	33	96	2,682	1,590	1998
13N80SEZ03	ou	native low	5	25	1	45	1	20	3	50	1	0	2	1	2004
13N80SEZ03a	ou	native low	5	30	1	45	1	25	10	50	0	0	3	0	2004
13N80SEZ03b	ou	native low	5	25	1	1	1	1	1	50	1	0	2	0	2004
13N80SEZ03c	ou	native low	5	50	1	5	5	1	1	50	2	1	5	1	2004
13N80SEZ06	ib	native low	6	50	1	10	15	1	1	50	17	51	22	12	New in 2004
13N82SEZ01_98	ib	native high	25	188	4	45	1	10	20	50	18	46	18,669	1,679	1998
13N82SEZ02	ib	native none	25	300	2	1	1	7	50	2	4	17	7,546	167	2004
13N82ACR01L_98	ib	native high	15	75	4	45	1	5	1	2	22	83	1,934	837	1998
13N82ACR01L	ib	native none	18	140	2	1	1	5	1	2	19	103	1,338	535	2004
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Burke Creek-continued

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
13N82ACR01R_98	ib	native high	15	50	4	45	1	5	1	2	20	74	917	337	1998
13N82ACR01R	ib	native none	12	140	2	1	1	5	1	2	19	102	811	363	2004
14N32SEZ04_98	ib	native high	18	275	4	15	4	5	25	50	0.8	1.9	2,232	271	1998
14N32SEZ04	iv	paved high	12	300	4	15	4	5	25	50	1.3	5.2	1,774	377	2004

Lonely Gulch

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
1330CR01	ib	paved low	5	32	4	0.1	0.3	8	10	0	12	22	53	16	1998
1330CR01	ib	paved low	7	65	4	0.1	0.3	8	10	0	29	99	695	215	2005

McKinney Creek

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
14n40sez02	ib	native low	0.1	35	3	35	0.3	35	3	0	3	11	0	0	2005, Not connected in 1998
14N40SEZ03	ib	NATIVE low	1	182	3	0.1	0.3	2	20	0	10	26	66	21	1998
14N40SEZ04	ib	native low	0.1	15	3	0.1	0.3	2	20	0	0	0	0	0	2005
14n40cr09-left	ib	native low	0.1	16	3	0.1	0.3	0.1	0.3	0	6	32	0	0	New in 2005
14n40cr09-right	ib	native low	0.1	43	3	0.1	0.3	0.1	0.3	0	6	25	0	0	New in 2005

Skyland-Cave Rock-Lincoln Creek

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
14N33CR05L	iv	native low	10	3	4	1	1	5	1	2	2	2	1	0	New in 2004
14N33CR05R	iv	native low	11	18	4	1	1	1	1	2	11	44	9	4	New in 2004
14N33SEZ09_98	ib	native high	5	150	4	45	1	5	1	0	19	82	1,535	1,072	1998
14N33SEZ09	iv	native low	3	50	4	15	8	12	28	10	1	0	12	4	2004
14N33SEZ11	iv	native low	4	60	4	15	8	12	24	10	2	2	23	9	Part of 14N33SEZ09 in 2004
14N33SEZ12	iv	native low	5	60	4	15	8	12	25	10	2	2	28	11	Part of 14N33SEZ09 in 2004
14N33SEZ13	iv	native low	5	70	4	15	1	12	2	2	15	73	30	28	Part of 14N33SEZ09 in 2004
14N33SEZ14	iv	native low	4	35	4	15	1	10	30	2	0	0	8	1	New in 2004

Skyland-Cave Rock-Lincoln Creek-continued

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
14N33SEZ15	iv	native low	5	35	4	15	1	10	8	2	5	11	11	6	New in 2004
14N33SEZ16	iv	native low	7	45	4	15	1	13	5	2	9	32	24	19	New in 2004
14N33SEZ17	iv	native low	7	20	4	15	1	13	30	2	0	0	6	0	New in 2004
14N33SEZ18	iv	native low	8	20	4	15	1	13	30	2	0	0	7	0	New in 2004
14N33SEZ19	iv	native low	6	35	4	15	1	13	40	2	0	0	11	1	New in 2004
14N33SEZ20	iv	native low	6	30	4	15	1	15	10	2	4	5	10	5	New in 2004
14N33SEZ21	iv	native low	9	30	4	15	1	15	15	2	2	1	15	6	New in 2004
14N33SEZ22	iv	native low	9	40	4	15	1	11	35	2	0	0	24	1	New in 2004
14N33SEZ23	iv	native low	9	40	4	15	1	22	20	2	3	2	26	12	New in 2004
14N33SEZ24	iv	native low	9	40	4	15	1	11	40	2	0	0	24	1	New in 2004
14N33SEZ25	iv	native low	6	35	4	15	1	9	50	2	0	0	11	0	New in 2004
13N78NON1_98	ib	native high	15	300	4	45	1	15	300	2	0.1	0	1,869	7	1998
13N78NON01	ib	native low	20	300	5	1	1	15	300	2	0	0	15,196	4	2004

Appendix C-WEPP Data

Tahoe Vista-Griff Creek Frontal															
WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
16N52CR01L	or	native low	4	20	4	4	4	4	4	25	3	8	6	1	2004
16N52CR01R	or	native low	4	30	4	4	4	4	4	25	5	18	11	4	2004
16N52SEZ01	ou	native low	5	40	4	20	5	10	5	25	1	0	11	1	New in 2004
16N54CR01	or	native low	6	30	4	4	4	4	4	17	4	17	23	7	New in 2004
16N54SEZ01	ou	native low	5	30	4	15	5	15	40	17	0	0	8	0	New in 2004
16N54SEZ02	ou	native low	5	30	4	15	5	15	40	17	0	0	8	0	New in 2004
16N55CR01L	ou	paved low	6	50	4	4	4	4	4	25	1	1	0	0	2004
16N55CR01R	ou	paved low	3	50	4	4	4	4	4	30	0	0	0	0	2004
16N55CR02L	ou	paved low	2	10	4	4	4	4	4	30	0	0	0	0	2004
16N55CR02R	ou	paved low	3	30	4	4	4	4	4	30	0	0	0	0	2004
16N55CR04R_98	ib	native high	6	114	4	45	2	3	4	22	36	234	5,085	1,585	1998
16N55SEZ01	ib	native high	6	78	4	45	2	3	50	25	1	2	1,894	17	1998
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Tahoe Vista-Griff Creek Frontal-continued															
WEPP Inputs											WEPP Outputs				Comments
Segment	Road Design	Surface, traffic	Road grade (%)	Road length (m)	Road width (m)	Fill grade (%)	Fill length (m)	Buffer grade (%)	Buffer length (m)	Rock (%)	Average annual rain runoff (mm)	Average annual snow runoff (mm)	Average annual erosion (kg)	Average annual sediment yield (kg)	
16N55SEZ01A	ou	native low	7	40	4	45	5	30	70	25	0	0	14	1	2004
16N55SEZ01B	ou	native low	7	30	4	45	5	30	70	25	0	0	10	1	2004
16N55SEZ01C	ou	native low	7	30	4	45	5	30	70	25	0	0	10	1	2004
16N56BCR01L_98	ib	native high	8	20	4	45	2	2	1	22	29	152	153	77	1998
16N56BCR01R_98	ib	native high	5	20	4	45	2	2	1	22	29	150	71	43	1998
16N56CR01	ou	graveled low	2	10	4	4	4	4	4	22	0	0	3	0	2004
16N66CR01L_98	ib	native high	3	25	4	45	2	2	1	22	32	178	52	37	1998
16N66CR01L	ou	paved low	2	20	4	4	4	4	4	22	0	0	0	0	2004
16N66CR01R_98	ib	native high	7	115	4	45	2	2	1	22	55	331	6,569	3,436	1998
16N66CR01R	ou	paved low	3	40	4	4	4	4	4	22	0	0	0	0	2004
16N66CR02L_98	ib	native high	7	105	4	45	2	2	1	22	54	326	5,352	2,774	1998
16N66CR02R_98	ib	native high	2	25	4	45	2	2	1	22	31	176	36	26	1998
16N66SEZ01	ou	native low	7	50	4	45	5	30	30	22	0	0	17	3	New in 2004
16N66SEZ02	ou	native low	6	50	4	20	5	10	20	22	0	0	15	0	New in 2004
16N68SEZ02_98	ib	native high	9	160	4	45	1	5	50	22	5	16	17,985	364	1998, not connected in 2004
16N86CR01_98	ib	native high	8	60	4	45	2	2	1	22	47	283	1,892	850	1998
16N86CR01	ou	native high	10	25	4	4	4	4	4	22	1	2	42	2	2004
16N86CR02_98	ib	native high	7	35	4	45	1	2	5	22	15	68	398	81	1998
16N86CR02	ib	native high	10	25	4	4	4	4	4	3	3	11	190	8	2004
16N86NON01	iv	native high	21	155	5	5	10	30	50	25	4	8	11,214	420	New in 2004
16N86SEZ01_98	ib	native high	5	100	4	45	3	5	100	22	0	0	2,519	6	1998
16N86SEZ03A	iv	native low	20	20	4	1	1	20	35	25	0	0	22	0	2004
16N86SEZ03B	iv	native low	20	20	4	1	1	20	35	25	0	0	22	0	2004
16N86SEZ03C	iv	native low	20	20	4	1	1	20	35	25	0	0	22	0	2004
16N86SEZ03D	iv	native low	20	20	4	1	1	20	35	25	0	0	22	0	2004
16N86SEZ03E	iv	native low	20	20	4	1	1	20	35	25	0	0	22	0	2004
16N86SEZ03F	iv	native low	20	20	4	1	1	20	35	22	0	0	22	0	2004
16N86SEZ04A	iv	native low	6	30	4	1	1	23	70	25	0	0	9	0	2004
16N86SEZ04B	iv	native low	6	20	4	1	1	23	70	25	0	0	6	0	2004
16N86SEZ04C	iv	native low	6	20	4	1	1	23	70	25	0	0	6	0	2004
16N86SEZ04D	iv	native low	6	20	4	1	1	23	70	25	0	0	6	0	2004
16N87CR01	ib	native high	11	200	4	4	4	4	4	25	16	93	11,589	1,605	2004; not connected in 1998
16N87SEZ01A	iv	native high	10	95	4	15	15	35	20	25	7	17	948	377	2004; not connected in 1998
16N87SEZ01B	iv	native high	10	60	4	15	15	35	20	25	5	8	323	118	2004; not connected in 1998
16N87SEZ01C	iv	native high	10	60	4	15	15	35	20	25	5	8	323	118	2004; not connected in 1998
16N87SEZ01D	iv	native high	10	60	4	15	15	35	20	25	5	8	323	118	2004; not connected in 1998
16n92CR01L	or	graveled low	6	30	4	4	4	4	4	22	4	4	15	4	New in 2004
16N92CR01R	or	graveled low	4	40	4	4	4	4	4	22	5	6	16	6	New in 2004
16N93SEZ01	ib	native high	1	300	4	5	2	2	4	18	39	292	988	744	1998
16N98CR01_98	ib	native high	7	93	4	45	2	2	1	22	53	316	4,102	2,084	1998
16N98CR01	ib	native high	15	75	4	4	4	4	4	25	12	54	2,978	191	2004
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Tahoe Vista-Griff Creek Frontal-continued

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
16N99CR01L_98	ib	native high	4	55	4	45	3	2	3	15	26	156	519	241	1998
16N99CR01R_98	ib	native high	3	35	4	45	3	2	3	25	22	106	119	62	1998
16N99CR01	ou	native low	15	35	4	4	4	4	4	15	2	4	50	3	2004
16N99SEZ01	ib	native high	2	55	4	15	5	35	20	15	10	24	116	69	1998
16N99SEZ01	ib	native high	2	55	4	15	20	35	5	15	6	20	64	46	2004
16N99SEZ01A	ou	native high	8	20	4	15	20	35	5	15	2	2	21	6	2004
16N99SEZ01B	ou	native high	8	20	4	15	20	35	5	15	2	2	21	6	2004
16N99SEZ01C	ou	native high	8	20	4	15	20	35	5	15	2	2	21	6	2004
16N99SEZ01D	ou	native high	8	20	4	15	20	35	5	15	2	2	21	6	2004

Tallac Creek

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
1307BSEZ01	ib	paved low	1	23	4	10	1	10	1	0	22	84	0	0	1998
1307BSEZ01	ib	paved low	3	150	4	10	1	10	1	0	47	183	437	413	2005
1393cr01	iv	graveled low	0.1	30	6	5	1	33	7	0	0	0	0	0	2005, Not connected in 1998
1394CR01	ib	paved low	4	114	6	30	1	30	0.3	0	52	198	649	643	1998
1394cr01	ib	paved low	0.1	55	6	30	1	30	0.3	0	22	87	2	1	2005
1394CR02-left	iv	paved low	2	36	6	25	0.3	20	7	0	12	30	1	1	1998; not connected in 2005
1394CR02-right	iv	paved low	3	114	6	25	0.3	20	7	0	25	100	33	32	1998
1394CR02-right	iv	paved low	0.1	90	6	25	0.3	20	7	0	2	9	12	7	2005
1394bcr01	iv	paved low	0.1	75	6	5	1	5	0.3	0	23	85	0	0	2005, Not connected in 1998
1396CR01	iv	paved low	3	137	6	5	1	5	3	0	35	145	33	31	1998
1396cr01	iv	paved low	0.1	33	6	5	1	5	3	0	1	6	0	0	2005
13N96CR02-left	iv	paved low	1	32	6	20	1	5	2	0	20	74	2	2	1998; not connected in 2005
13n96CR02-right	iv	paved low	2	55	6	20	1	5	2	0	27	110	5	4	1998; not connected in 2005
1396CR03-left	iv	paved low	2	82	6	20	1	5	2	0	33	133	10	9	1998
1396CR03-left	iv	paved low	0.1	12	6	20	1	5	2	0	0	2	0	0	2005
1396CR03-right	iv	paved low	2	91	6	20	1	5	2	0	34	140	13	12	1998; not connected in 2005

Appendix C-WEPP Data

Ward Creek															
WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
15N35CR01_98	ib	native low	3	300	4	45	1	1	1	18	14	62	645	530	1998; road to trail conversion
15N35NON02_98	ib	native low	10	250	4	1	1	20	1	35	20	77	2,340	1,732	1998; road to trail conversion
15N35SEZ01_98	ou	native low	4	40	4	1	1	30	1	18	8	10	10	4	1998; road to trail conversion
15N60ACR01L_98	ib	native low	1	20	4	45	1	1	1	13	11	31	3	3	1998; road to trail conversion
15N60ACR01R_98	ib	native low	4	55	4	45	1	1	1	13	15	52	42	29	1998; road to trail conversion
15N60ACR02L_98	ib	graveled low	1	32	4	45	1	1	1	13	14	16	6	6	1998; road to trail conversion
15N60ACR02R_98	ib	graveled low	1	23	4	45	1	1	1	13	13	13	5	4	1998; road to trail conversion
15n60Acr02	ou	native none	1	1	1	1	1	1	1	13	0	0	0	0	2004
15N60CR01L_98	ib	native low	8	24	4	45	1	1	1	35	16	45	23	13	1998
15N60CR01-left	iv	native low	6	25	4	1	1	5	1	35	15	44	7	6	2004
15N60CR01R_98	ib	native low	8	37	4	45	1	1	1	35	18	54	52	29	1998
15N60CR01-right	iv	native low	5	15	4	1	1	5	1	35	13	30	4	2	2004
15N60SEZ01_98	ib	native low	8	225	4	1	1	20	30	35	9	22	1,444	539	1998
15N60SEZ02_98	ib	native low	9	170	4	1	1	45	75	18	5	4	838	190	1998
15N60SEZ02A	ib	native low	5	30	3	1	1	5	50	18	0	0	11	0	2004
15N60SEZ02B	ib	native low	5	25	3	1	1	5	50	18	0	0	8	0	2004
15N60SEZ02C	ib	native low	5	25	3	1	1	5	50	18	0	0	8	0	2004
15N62CR01L_98	ib	native low	1	19	4	45	1	1	1	35	14	37	4	3	1998, decomissioned
15N62CR01R_98	ib	native low	2	41	4	45	1	1	1	35	17	54	14	11	1998, decomissioned
15N62CR03L_98	ib	native low	1	23	4	45	1	1	1	35	15	42	4	4	1998, decomissioned
15N62CR03R_98	ib	native low	1	22	4	45	1	1	1	35	14	41	4	4	1998, decomissioned
15N62CR06L_98	ib	native low	4	200	4	45	1	1	1	60	25	82	614	490	1998
15N62CR06R_98	ib	native low	4	110	4	45	1	1	1	60	25	78	195	151	1998
15N62CR07_98	ib	native low	2	45	4	45	1	1	1	35	17	56	15	13	1998
15n62cr09L	ou	native none	14	25	3	45	3	1	1	35	11	17	14	6	2004; not connected in 1998
															PAGE 11

Ward Creek-continued

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
15n62cr09R	ou	native none	7	45	3	45	3	1	1	35	7	7	12	5	2004; not connected in 1998
15N62CR10L_98	ib	native low	5	25	4	45	1	1	1	35	16	45	14	10	1998
15N62CR10R_98	ib	native low	5	85	4	45	1	1	1	35	19	66	142	100	1998
15N62CR11L_98	ib	native low	1	39	4	45	1	1	1	35	16	53	6	8	1998
15N62CR11R_98	ib	native low	5	69	4	45	1	1	1	35	19	64	95	66	1998
15n62cr11	ou	native low	4	8	1	45	1	5	1	35	2	0	1	0	2004
15N62CR12L_98	ib	native low	1	27	4	45	1	1	1	35	15	46	6	5	1998
15N62CR12R_98	ib	native low	5	30	4	45	1	1	1	35	17	49	20	13	1998
15N62CR13_98	ib	native low	1	50	4	45	1	1	1	18	14	51	11	9	1998
15n62cr13a		native low	3	15	4	1	1	1	1	18	10	24	3	1	2004
15N62CR14L_98	ib	native low	2	6	4	45	1	1	1	35	7	10	1	0	1998
15N62CR14R_98	ib	native low	2	22	4	45	1	1	1	35	15	41	6	4	1998
15N62CR15L_98	ib	graveled low	3	5	4	45	1	1	1	35	6	3	1	0	1998
15N62CR15R_98	ib	graveled low	3	84	4	45	1	1	1	35	17	22	45	37	1998
15n62cr15	ou	native low	5	15	4	45	1	1	1	35	8	11	4	2	2004
15N62CR16_98	ib	graveled low	3	15	4	45	1	1	1	35	12	11	4	3	1998
15n62cr17	or	native low	2	35	4	1	1	1	1	35	16	50	7	5	2004; not connected in 1998
15n62cr18	ou	native low	4	10	4	1	1	1	1	35	6	7	3	1	2004; not connected in 1998
15N62CR20L_98	ib	graveled low	1	10	4	45	1	1	1	35	9	7	2	1	1998
15N62CR20R_98	ib	graveled low	1	115	4	45	1	1	1	35	14	21	25	22	1998
15n62cr20	ou	native low	3	35	4	1	1	1	1	35	5	5	9	2	2004
15N62CR21L_98	ib	native low	1	4	4	45	1	1	1	35	5	4	1	0	1998; not connected in 2004
15N62CR21R_98	ib	native low	2	17	4	45	1	1	1	35	14	34	4	3	1998; not connected in 2004
15N62CR22L_98	ib	native low	3	29	4	45	1	1	1	35	16	48	11	8	1998
15N62CR22R_98	ib	native low	1	15	4	45	1	1	1	35	13	31	3	2	1998
15n62cr22	ou	native low	3	10	4	1	1	1	1	35	5	5	2	0	2004
15N62CR23L_98	ib	native low	1	36	4	45	1	1	1	35	16	52	6	7	1998

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Ward Creek-continued															
WEPP Inputs											WEPP Outputs				Comments
Segment	Road Design	Surface, traffic	Road grade (%)	Road length (m)	Road width (m)	Fill grade (%)	Fill length (m)	Buffer grade (%)	Buffer length (m)	Rock (%)	Average annual rain runoff (mm)	Average annual snow runoff (mm)	Average annual erosion (kg)	Average annual sediment yield (kg)	
15N62CR23R_98	ib	native low	1	36	4	45	1	1	1	35	16	52	6	7	1998
15N62CR24L_98	ib	native low	1	18	4	45	1	1	1	18	11	30	4	2	1998
15n62cr24L	ou	native low	2	20	4	1	1	1	1	18	4	3	4	1	2004
15N62CR24R_98	ib	native low	1	19	4	45	1	1	1	18	12	32	4	2	1998
15n62cr24R	ou	native low	2	20	4	1	1	1	1	18	4	3	4	1	2004
15N62NON01_98	ib	native low	11	300	4	1	1	30	1	35	20	79	3,610	2,751	1998; not connected in 2004
15N62SEZ01_98	ib	native low	5	235	4	1	1	15	75	35	3	4	884	121	1998
15n62sez01	ou	native low	4	125	4	45	5	25	50	35	0	0	33	7	2004
16N48CR01L	ou	graveled low	1	40	4	45	1	5	1	35	6	2	10	5	2004; not connected in 1998
16N48CR01R	ou	graveled low	1	25	4	45	1	5	1	35	6	2	6	3	2004; not connected in 1998
16N48CR02_98	ib	native low	2	50	4	45	1	1	1	35	17	58	18	15	1998
16N48CR02	iv	graveled low	4	20	3	45	1	5	1	35	14	14	4	4	2004
16N48CR03L_98	ib	native low	5	22	4	45	1	1	1	35	15	42	12	8	1998
16N48CR03L	iv	graveled low	4	7	3	45	1	5	1	35	8	5	1	1	2004
16N48CR03R_98	ib	native low	1	15	4	45	1	1	1	35	13	31	3	2	1998
16N48CR03R	iv	graveled low	3	12	3	45	1	5	1	35	11	10	2	2	2004
16N48CR04L_98	ib	native low	5	155	4	45	1	1	1	35	19	71	448	337	1998
16N48CR04L	iv	graveled low	4	10	3	45	1	5	1	35	10	8	2	1	2004
16N48CR04R_98	ib	native low	3	20	4	45	1	1	1	35	14	39	6	4	1998
16N48CR04R	iv	graveled low	3	8	3	45	1	5	1	35	9	6	1	1	2004
16N48SEZ01_98	ib	native low	8	105	4	1	1	15	75	35	2	0	357	15	1998
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Appendix C-WEPP Data

Watson Creek-Carnelian Frontal

WEPP Inputs											WEPP Outputs				Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
16N49SEZ01	ib	native Low	3	73	3	0.1	0.3	0.1	0.3	0	17	68	109	81	1998
16N73CR01L	ou	graveled low	5	182	5	0.1	0.3	0.1	0.3	0	14	14	82	39	1998
16N73CR01R	ou	graveled low	4	146	5	0.1	0.3	0.1	0.3	0	13	13	66	29	1998
16N73CR02	ou	native low	9	300	5	0.1	0.3	0.1	0.3	0	14	52	187	105	1998
16N73CR04	ou	native low	4	21	5	0.1	0.3	0.1	0.3	0	11	38	7	3	1998
16N73CR05	ou	native low	4	21	5	3	0.3	0.1	0.3	0	13	39	7	4	1998
16N73CR06L	ou	native low	1	21	5	0.1	0.3	0.1	0.3	0	9	29	6	2	1998
16N73CR07	ou	native low	2	56	5	0.1	0.3	0.1	0.3	0	10	31	16	6	1998
16N73CR08	ou	graveled low	8	98	5	0.1	0.3	0.1	0.3	0	17	18	62	35	1998
16N73CR10L (sez03 in 06)	ib	native low	2	85	5	0.1	0.3	0.1	0.3	0	16	68	42	34	1998
16N73CR10R(sez03 in 06)	ib	native low	4	70	5	0.1	0.3	0.1	0.3	0	17	69	87	62	1998
16N73CR11	ib	native low	10	105	3	0.1	0.3	0.1	0.3	0	20	73	362	262	1998
16N73CR12	ib	native low	13	30	3	0.1	0.3	0.1	0.3	0	18	66	46	22	1998
16N73SEZ01	iv	graveled Low	12	300	4	35	1	0.1	0.3	0	27	32	3,668	3,404	1998
16N73SEZ10	ib	native Low	13	123	4	35	1	0.1	0.3	0	22	74	2,629	2,096	1998
16N73SEZ1a	iv	paved Low	6	180	5	0.1	0.3	8	7	0	45	191	3,655	1,877	2004
16N73SEZ1b	iv	paved Low	8	265	5	0.1	0.3	1	10	0	44	189	15,284	2,804	2004
16N74cr01L	ib	native low	1	18	4	0.1	0.3	0.1	0.3	0	13	55	3	2	1998
16N74cr01r	ib	native low	2	141	4	0.1	0.3	0.1	0.3	0	16	68	93	77	1998
16N74CR02	ib	native low	3	32	4	0.1	0.3	0.1	0.3	0	16	63	11	8	1998
16N74CR02	ou	paved low	8	20	4	0.1	0.3	0.1	0.3	0	38	149	0	0	2004
16n74cr03L	ib	native low	3	46	4	0.1	0.3	0.1	0.3	0	17	66	20	15	1998
16n74cr03r	ib	native low	1	27	4	0.1	0.3	0.1	0.3	0	15	60	4	3	1998
16n74cr04L	ib	native low	5	87	4	0.1	0.3	0.1	0.3	0	18	70	146	107	1998
16N74cr04R	ib	native low	3	55	4	0.1	0.3	0.1	0.3	0	17	67	28	21	1998
16N74CR04	iv	paved low	8	25	4	5	10	11	7	0	5	2	8	3	2004
16n74sez01	iv	Graveled Low	4	45	4	3	0.3	3	0.3	0	19	67	22	20	2004
16N71CR01	ou	graveled low	8	30	4	1	35	0.1	0.3	0	2	0	15	0	1998
16N71SEZ01	ou	graveled Low	11	137	4	35	1	0.1	0.3	0	19	17	208	143	1998
16N71SEZ01a	ou	paved Low	12	32	4	35	1	0.1	0.3	0	39	126	0	0	2004
16N71SEZ01b	ou	paved Low	10	22	4	35	1	0.1	0.3	0	36	110	0	0	2004
16N71SEZ01c	ou	paved Low	12	13	4	35	1	0.1	0.3	0	39	126	0	0	2004
16n50SEZ1	ib	native Low	8	91	3	10	0.3	15	7	0	12	35	695	221	1998
16n50sez01b	iv	Graveled Low	10	85	3	10	0.3	15	7	0	11	33	329	176	2004

Appendix C-WEPP Data

Zephyr Frontal WEPP Results.

WEPP Inputs												WEPP Outputs			Comments
Segment	**Road Design**	**Surface, traffic**	**Road grade (%)**	**Road length (m)**	**Road width (m)**	**Fill grade (%)**	**Fill length (m)**	**Buffer grade (%)**	**Buffer length (m)**	**Rock (%)**	**Average annual rain runoff (mm)**	**Average annual snow runoff (mm)**	**Average annual erosion (kg)**	**Average annual sediment yield (kg)**	
13N42SEZ01_98	ib	native low	6	150	4	45	1	5	25	0	5	10	506	58	1998
13N42SEZ01	ou	paved low	2	100	6	4	1	5	15	0	0	0	0	0	2004
13N78SEZ01a	ou	native low	8	75	4	15	1	25	8	2	2	0	29	6	2004; not connected in 1998
13N78SEZ01b	ou	native low	8	75	4	15	1	25	8	2	2	0	29	6	2004; not connected in 1998
13N78SEZ01c	ou	native low	8	75	4	15	1	25	8	2	2	0	29	6	2004; not connected in 1998
16N75SEZ01	ib	native Low	3	300	4	35	1	0.1	0.3	0	15	69	1,733	1,610	1998
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APPENDIX-D

WQRAP Assessment Form

Evaluator:

Location: **Date:**

Road #: Mile post at beginning of section:
7.5 min quad: Watershed:
T: R: Sec #: ¼:

Stream Crossing

Culvert Characteristics

Crossing type: CMP CMP pipe arch sp pipe arch ob pipe arch bridge ford (P CPS G NS)

Dia (in): Pipe Arch (width/height): Inlet type: P F M W V

Condition: good poor % dent/crushed: Describe:

Is erosion visible on downstream fill slope? Y N high moderate low Describe:

Is there evidence of ponding or fill overtopping? Y N Describe:

Stream Characteristics

Stream Type: perennial intermittent ephemeral Channel width:

Diversion potential: Y N Diversion distance: Direction of diversion: right left

Flow path: inboard ditch surface (include rills) gully/rills tire rut

Receiving feature/exit point: xing xdrain waterbar cross flow/hillslope surface other:

Hillslope gradient:

Signs of hillslope instability or erosion: Y N Describe:

Road Characteristics

Road Template: insloped outsloped crowned flat alternating concave

Surface type: paved chip seal gravel native Slope position: ridge mid valley

Feature at end of segment (lft): grade change xdrain xing waterbar cross-flow other

Feature at end of segment (rt): grade change xdrain xing waterbar cross-flow other

Connected: Y N Length connected: left / right

Road Grade (%): left / right

Flow path (lft): inboard ditch surface gully/rills tire rut N/A

Flow path (rt): inboard ditch surface gully/rills tire rut N/A

Does the flow path bypass drainage features? Y N Describe:

Special Notes, Sketches, etc.

Stream Environmental Zone Proximity

Road Characteristics

Segment length: Avg. distance from stream: Range:

Road Template: inslope outsloped crowned flat alternating concave

Slope position: ridge mid valley

Surface type: paved/chip seal gravel native

Connected: Y N Steam Wetland Steam type: perennial intermittent ephemeral

Length connected: Road Grade (%):

Flow path: inboard ditch surface (including rills) gully/rills tire rut

Receiving feature/exit point: xing xdrain waterbar cross flow/hillslope surface other:

Entrance: directly into water course fill slope hillslope
Hillslope gradient (%):

Did a gully form at drainage point? Y N Gully length:

Are there multiple drainage points? Y N Describe:

Does the flow path bypass drainage features? Y N Describe:

Special Notes, Sketches, etc.

Non-Stream Environmental Zone Proximity

Road Charateristics

Segment length:

Road Template: insloped outsloped crowned flat alternating concave

Slope position: ridge mid valley

Surface type: paved/chip seal gravel native

Connected: Y N Steam Wetland Steam type: perennial intermittent ephemeral

Length connected: Road Grade (%):

Flow path: inboard ditch surface (including rills) gully/rills tire rut

Receiving feature/exit point: xing xdrain waterbar cross flow/hillslope surface

other:

Entrance: directly into water course fill slope hillslope

Hillslope gradient (%):

Did a gully form at drainage point? Y N Gully length:

Are there multiple drainage points? Y N Describe:

Does the flow path bypass drainage features? Y N Describe:

Special Notes, Sketches, etc.