Cardno ENTRIX

Shaping the Future

Draft

Middle Rosewood Creek Restoration Project – Area A Design Report

March 2011

Cardno ENTRIX Project No. 31228060

Prepared for

Nevada Tahoe Conservation District

Valley & Mountain Consulting

Wood Rodgers

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Prepared for

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List of Acronyms

ARS-NSL	U.S. Department of Agriculture Agricultural Research Service, National Sedimentation Laboratory
BMPs	best management practices
BSTEM	U.S. Department of Agriculture Agricultural Research Service, National Sedimentation Laboratory Bank Stability and Toe Erosion model
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
DRI	Desert Research Institute
FEMA	Federal Emergency Management Agency
ft	foot/feet
Mainstream	Mainstream Restoration, Inc.
NNHP	Nevada Natural Heritage Program
NTCD	Nevada Tahoe Conservation District
Project	Middle Rosewood Creek Restoration Project – Area A
SEZ	Stream Environment Zone
TAG	Technical Advisory Group
TRPA	Tahoe Regional Planning Agency
USFS	U.S. Department of Agriculture Forest Service
USFWS	U.S. Fish and Wildlife Service

Chapter 1

Introduction

1.1 Project Goals

The Middle Rosewood Creek Restoration Project – Area A (the Project) is intended to restore channel and riparian corridor functions, reduce future channel bed and bank erosion, provide protection from flooding, improve forest health and wildlife habitat, enhance aquatic habitat, improve fish passage, pre-treat urban stormwater, and improve fish access.

The proposed Project would prevent continued streambed and streambank erosion that generates sediment transported downstream. The proposed Project would increase the opportunities for sediment conveyed into the area to settle out and be sequestered on a functional, vegetated floodplain within the reach. These measures would reduce sediment loads to lower Rosewood Creek, Third Creek, and Lake Tahoe.

Project goal statements were developed based on the December 19, 2008 Technical Advisory Group[1] (TAG) discussion and follow-up discussions and research by the TAG members and the Project team (Valley & Mountain Consulting, ENTRIX, Inc. [now Cardno ENTRIX], and Wood Rodgers, Inc.).

A meeting with Tahoe Regional Planning Agency (TRPA) staff on March 5, 2009 provided additional clarification and hierarchy for the proposed Project goals. TRPA is charged with protecting the Lake Tahoe Basin as a national treasure for the benefit of current and future generations. The TRPA vision is a lake and environment that is clean, healthy, and sustainable for the community and future generations. The Middle Rosewood Creek Restoration Project goals are based on one of the TRPA Core Values:

> *"Environmental Protection: Serving as stewards of Lake Tahoe and attaining environmental thresholds while sustaining the ecological, social, and economic well being of the Tahoe Region."*

The Project goals, listed in priority order (high to low), are as follows:

1. Restore channel and riparian corridor functions

   Channel capacity would be reduced and floodplain connectivity would be restored relative to the existing deeply incised and oversized condition. The restoration would reconstruct a low-flow channel with (1) the appropriate size, slope, and materials to convey the bankfull flow and sediment; and (2) bank

[1] Technical Advisory Group members for the Middle Rosewood Creek Restoration Project include all the funding, planning, and regulatory agencies: Nevada Tahoe Conservation District, Washoe County, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, Nevada Division of Environmental Protection, Nevada Division of State Lands, Nevada Division of Wildlife, Nevada Department of Transportation, and the Tahoe Regional Planning Agency.

heights and overbank topography that provide for a small, but connected active floodplain throughout the entire Project reach. The restoration design is focused on creation of a stable stream channel with a connected and functioning floodplain to enhance the riparian habitat corridor through structural species diversity.

2. Improved stream water quality

The flow in the stream channel in the Project reach would reach the top of bank and overflow onto the floodplain at a frequency and duration typical of a functional stream (i.e., at least several days every couple of years). This would facilitate water quality improvement because of:

a. Reduced stream channel erosion (lower sediment and fine sediment particle production); and

b. Increased floodplain sediment, fine sediment particle, and nutrient trapping.

3. Protection from flooding

No change to the Federal Emergency Management Agency (FEMA) 500-year (0.2 percent annual chance of occurrence) floodplain boundary would result, and any change to the FEMA 100-year (1 percent annual chance of occurrence) floodplain boundary or water elevation would not increase flood hazards to existing developed property in the Project reach or in adjacent upstream/downstream reaches.

4. Improved forest health/wildlife habitat

Riparian and upland plant communities in the Project area would have lower risk of catastrophic wildfire, enhanced wildlife habitat of special significance, improved riparian species recruitment, and removal of known noxious/invasive weeds.

5. Enhanced aquatic habitat

The stream channel morphology and materials in the Project reach would be improved to enhance physical habitat for potential resident fish and benthic macroinvertebrates, such that areas now designated by TRPA as “resident marginal” would be considered “resident good” fish habitat. Additionally, improved food production in the Project area would benefit aquatic habitat downstream.

6. Improved fish passage

Stream channel characteristics in the Project reach would be modified to improve fish passage conditions and to enhance passage for potential migratory fish, such that areas now designated by TRPA as “migratory marginal” would be considered “migratory good.”

7. Pre-treated urban stormwater

Project design would be coordinated with best management practices (BMPs) to be provided by landowners and located outside the Stream Environment Zone (SEZ). These measures would pre-treat the volume of stormwater and the loads of fine sediment particles, suspended solids, nutrients, and petrochemicals. The Project would provide discharge facilities that minimize the risk of soil and stream channel erosion.

8. Improved fish access

The Project team will coordinate with project sponsors on adjacent downstream reaches (lower Rosewood Creek and Third Creek) to improve potential access for migratory fish into the Project reach from the downstream reaches.

1.2 Incorporation of Previous Studies

Stabilization of Rosewood Creek was identified in prior watershed studies as an important erosion control priority (Watershed Restoration Associates 1999, Swanson 2000). In 2005, the Nevada Tahoe Conservation District (NTCD) supervised preparation of a comprehensive geomorphic and riparian assessment of the middle reach of Rosewood Creek (Mainstream 2005). Individual restoration opportunities and an overall restoration concept for the entire middle reach of Rosewood Creek, including Area A, were presented by Mainstream Restoration, Inc. (Mainstream) based on several data sources and factors. The Mainstream 2005 analysis summarized and screened conceptual restoration approaches developed by prior studies in the area (Swanson 2000, ENTRIX 2001, Corps 2004), and presented suggestions and priorities for restoration of all portions of the middle reach of Rosewood Creek.

Based on the results of that assessment, NTCD retained the Project team to prepare a conceptual design for restoration of the middle reach of Rosewood Creek. Detailed engineering and implementation plans of specific sub-reaches (known as “areas”) were initiated, starting upstream with Area F and continuing to Area A.

Alternatives featuring various types and degrees of treatments, such as stabilization, reconstruction, and relocation within the existing floodplain, were considered during the 2005–2006 conceptual design and implementation plan phase. A Concept Plan and Implementation Plan (Valley & Mountain Consulting 2006a, 2006b) integrated data and recommendations from prior studies, new field assessments, and additional design analyses to further develop and evaluate restoration options for the entire middle reach of Rosewood Creek, including Area A. The results of this planning step were the basis for 30-percent and 50-percent design steps.

1.3 Key Terms and References

The following key terms are used in this report:

- Study area. The study area consists of the entire middle reach of Rosewood Creek from State Route 28 to the downstream side of State Route 431).

- Project area. The Project area is Area A, also referred to as "Implementation Area A," as described below.
- Implementation area. The middle reach of Rosewood Creek consists of discrete implementation areas (A though I), as presented in the *Middle Rosewood Creek SEZ Restoration, Implementation Plan* (Valley & Mountain Consulting 2006b). Implementation Area A is the subject of this report. Its boundaries are approximately 100 feet south of State Route 28 and 200 feet north of Northwood Boulevard**.**
- Project team. The Project team consists of Valley & Mountain Consulting, Cardno ENTRIX, and Wood Rodgers, Inc.

As noted above, this report incorporates the results of earlier studies. The descriptions of existing conditions are based primarily on the following documents, supplemented by additional field studies as noted:

- The *Middle Rosewood Creek Geomorphic and Riparian Assessment* was prepared by Mainstream Restoration, Inc. in November 2005. It is referenced in this report as the "Mainstream 2005" report.
- The *Middle Rosewood Creek SEZ Restoration, Concept Plan* was prepared by Valley & Mountain Consulting in April 2006. It is referenced in this report as the "Concept Plan."
- The *Middle Rosewood Creek SEZ Restoration Project, Implementation Plan* was prepared by Valley & Mountain Consulting in April 2006. It is referenced in this report as the "Implementation Plan."

Chapter 2

Hydrology

2.1 Peak Flow Estimates

Rosewood Creek does not have a long-term gaging record from which hydrological analysis can be performed. Thus, the hydrological analysis on Rosewood Creek was based on a comparison of regional flood-frequency curves from the nearby gaged watersheds of Incline, Third, First, and Wood Creeks. The Mainstream 2005 presents the initial results of this analysis (Table 2-1). Mainstream calculated the unit discharge per watershed area from these four creeks with linear regressions relating watershed area and recurrence intervals. The Project team updated the Mainstream 2005 analysis by adding several more years of peak flow data available from the Third Creek and Incline Creek gages, and by adding additional recurrence interval flows. The new results are plotted in Figure 2-1, which shows the peak annual recurrence interval against the drainage area. A comparison of the last two rows in Table 2-1 shows that updating the data with additional flow years did not appreciably change the values when compared to the Mainstream 2005 report.

In addition, the Project team compared the methodology and results of the peak flow data for this Project to those of the Third Creek Restoration Project. The Third Creek Restoration Project is located in Incline Village, Nevada, south of the Project site and near the confluence of Rosewood Creek and Third Creek. The methodology and results for the Third Creek Restoration Project are comparable to the methodology and peak flow estimates for this Project, thus providing a greater level of certainty.

The final row in Table 2-1 lists the estimated recurrence interval flows for Rosewood Creek at State Route 28 based on the watershed comparison analysis. The estimated recurrence intervals range from 3.8 cubic feet per second (cfs) at the 1.5-year flow to approximately 49 cfs at the 100-year flow.

Table 2-1 Flood Frequency Estimates for Rosewood Creek at State Route 28

Gage Name	Gage Number / Source	Period of Record (water years)	Years of Data	Watershed Area (square miles)	1.5-year (cfs)	2-year (cfs)	5-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
Incline Creek near Crystal Bay	USGS Gage 10336700	1970–1973, 1975, 1988–2009	22	6.74	22	31	61	88	131	170	215
Third Creek near Crystal Bay	USGS Gage 10336698	1970–1973, 1975, 1978–2009	32	6.05	41	56	99	130	174	208	244
Wood Creek at Mouth near Crystal Bay	USGS Gage 10336694	1970–1974, 1991–2000	10	1.97	7	10	19	27	38	47	57
First Creek near Crystal Bay	USGS Gage 10336688	1970–1974, 1991–2000	15	1.07	4	6	14	22	34	45	57
Rosewood Creek	MACTEC 2003	N/A	N/A	1.15	N/A	12	24	35	N/A	N/A	98
Rosewood Creek	Mainstream 2005	N/A	N/A	1.15	N/A	6	16	23	N/A	N/A	40–60
Rosewood Creek	This study	N/A	N/A	1.15	3.8	6	14	21	31	40	49

Notes:

cfs = cubic feet per second.
N/A = Not applicable.
USGS = U.S. Geological Survey.

Flood frequency estimates are based on a drainage basin area comparison of four adjacent watersheds with gage records, including previous (MACTEC 2003, Mainstream 2005) flood frequency estimates.

Source: Table 1 in Mainstream 2005.

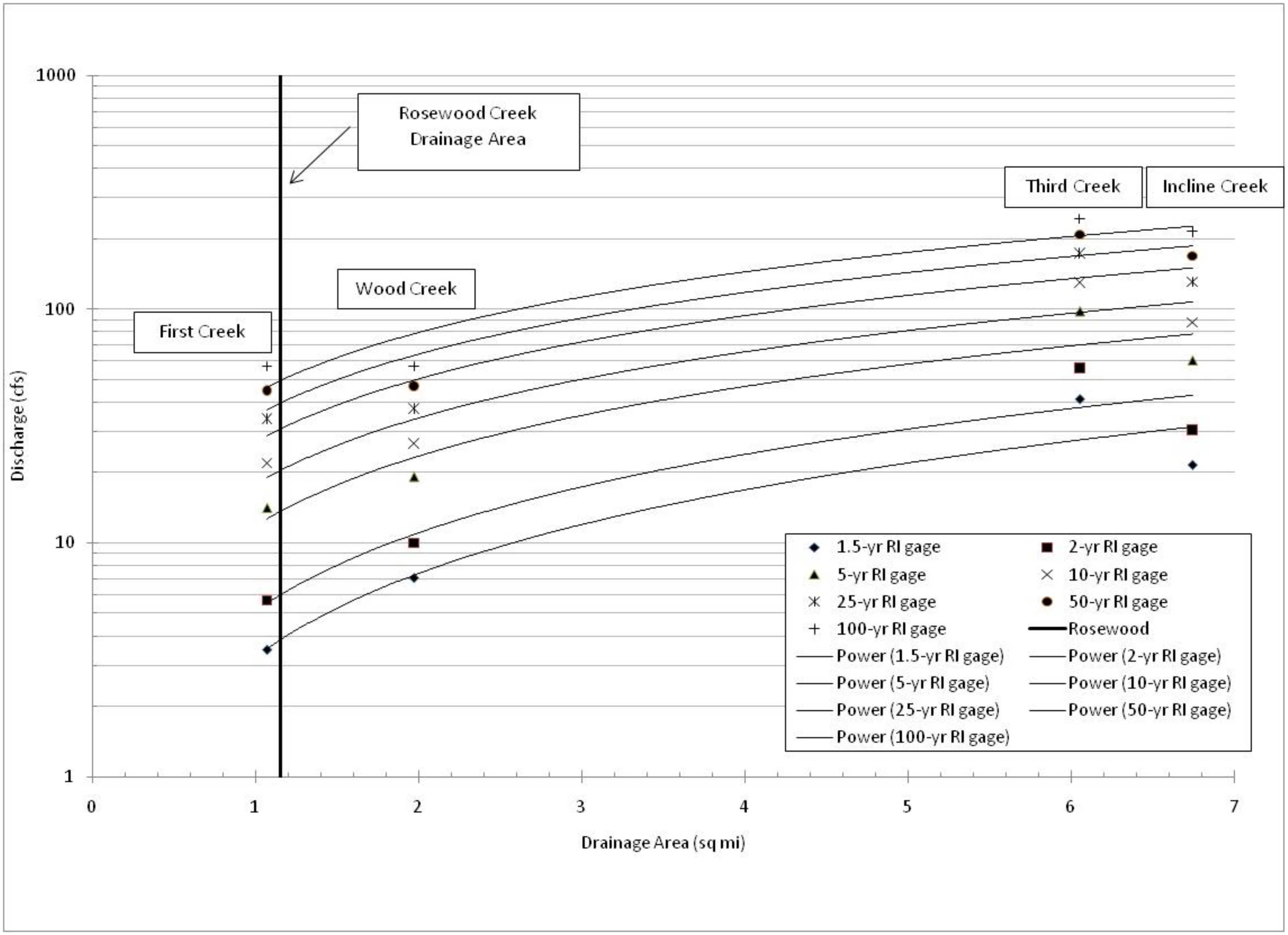

Figure 2-1. Comparison of Drainage Area and Peak Annual Recurrence Interval (RI) Flows for Gaged Streams near Rosewood Creek

2.2 Design Flows

The peak annual recurrence interval flows reported in the last row of Table 2-1 were used to guide design flows for the Project. The selected 100-year flow used in the design is 48 cfs. To ensure that the Project would not increase flood risk on adjacent properties, the Valley & Mountain Project team evaluated the 100-year flow in both the existing condition hydraulic model (to determine the existing flood extent) and proposed condition hydraulic model (to determine how the flood extent would change with the proposed design). The 100-year flow also was analyzed to determine the magnitude of shear stresses on the floodplain and channel under proposed conditions. This analysis assessed the risk of floodplain erosion and helped to identify the substrate sizes needed to construct a stable new channel. Analysis of the 100-year flow and lower magnitude flows, such as the 5- and 10-year flows, played a key role in designing the elevations and width of the new active floodplain.

In addition to the large magnitude, infrequently occurring 100-year flow, another important design flow was used to size the dimensions of the new channel. The bankfull, or channel capacity flow, often correlates approximately with the 1.5- to 2-year flow. According to Table 2-1, the 1.5-year flow for Rosewood Creek is 3.8 cfs, and the 2-year flow is 6 cfs. These statistics were derived by refining long-term gage records for the local watersheds based on several years of data collected specifically on Rosewood Creek.

As part of monitoring for the lower Rosewood Creek restoration project, pressure transducers were installed to record stage on 10-minute intervals at locations on Rosewood Creek in 2003. The site downstream of State Route 28, upstream of the confluence of Rosewood Creek with Third Creek, is closely representative of the Area A project reach. The streamflow monitoring data for 2003–2009 were made available to the project team by Rick Susfalk at the Desert Research Institute (DRI). Data from the 2008–2009 water years are largely incomplete and were excluded from our analysis. DRI measured discharge at the site downstream of State Route 28 to develop a stage/discharge rating curve for the site. Based on the DRI data, a flow of 4 cfs was exceeded in three of the five years of record, and a 6-cfs flow was exceeded in two of the five years. Conversion of the 10-minute interval readings to day time steps allowed calculation of days/year durations. Based on the DRI data, flows would exceed 4 cfs for 2.4 days/year; a 6-cfs flow would be exceeded for 0.9 days/year (Table 2-2). A channel capacity of 4 cfs was selected for the Project design. The available data indicate that this flow would result on average in an additional 1.5 days/year that the channel would overbank onto the floodplain compared to a channel capacity of 6 cfs.

Table 2-2 Exceedance of 4-cfs and 6-cfs Flows on Rosewood Creek Downstream of State Route 28

	4-cfs-Flow		6-cfs Flow	
Water Year	# 10-Minute Readings Exceeded	Days/Year	# 10-Minute Readings Exceeded	Days/Year
2003	8	0.06	4	0.03
2004	13	0.09	0	0.00
2005	0	0.00	0	0.00
2006	1704	11.83	649	4.51
2007	0	0.00	0	0.00
Average		2.4		0.9

Notes:

cfs = cubic feet per second.

The number of days per year that 4-cfs and 6-cfs flows were exceeded on Rosewood Creek downstream of State Route 28 was based on measured flow data from 2003 to 2007, provided by Rick Susfalk at the Desert Research Institute. Data from the 2008–2009 water years are largely incomplete and were excluded from our analysis.

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Chapter 3

Field Data Collection

3.1 Topographic Survey

The initial efforts of the Middle Rosewood Creek Restoration Project included a boundary survey and aerial topography of the entire middle reach study area (State Route 28 to the downstream side of State Route 431), with additional cross-sectional ground-surveys at several locations. This preliminary survey information was adequate to develop an overall concept restoration plan for the study area. It did not, however, provide adequate information to develop final design plans and construction documents required for each implementation area. As part of the final design process for Implementation Area A, detailed topographic and planimetric surveys were completed in fall 2008.

The detailed topographic and planimetric surveys were combined with the preliminary boundary survey and aerial survey to compile a complete basemap for the Project. The complete basemap includes all of the existing features in the Project area and provided the necessary information to develop design plans, HEC-RAS modeling, and construction documents.

3.2 Vegetation Community Mapping

The study area consists of discrete implementation areas (A though I), as presented in the Implementation Plan (Valley & Mountain Consulting 2006b). In addition, the study area includes three U.S. Department of Agriculture Forest Service (USFS) – Lake Tahoe Basin Management Unit parcels and proposed access and staging areas. The USFS lands are located within portions of the following areas: (1) Implementation Area C (APN 131-110-04); (2) Implementation Area F (APN 124-083-14); and (3) Implementation Area I (APN 129-021-03).

In September 2006, ENTRIX conducted a literature review and field assessment of the study area (extending from State Route 28 to its intersection with State Route 431) to assess potential terrestrial and aquatic wildlife habitat. A Mainstream plant ecologist conducted initial field surveys of the study area in late June through mid-July 2005 to characterize the riparian communities. Sensitive plant surveys were conducted as part of the riparian study and are included in the Mainstream 2005 report (Plates 1–6). Wood Rodgers also conducted a special-status plant species and invasive/noxious weed survey for Implementation Area A in 2009 and 2010 (Wood Rodgers 2009, 2010). A U.S. Army Corps of Engineers (Corps) delineation of jurisdictional wetlands and waters of the United States in the study area was conducted on September 14, 15, and 26, 2006. A jurisdictional determination was issued on January 26, 2007 (Regulatory Branch 200600942).

Database queries were submitted to the Nevada Natural Heritage Program (NNHP) and the U.S. Fish and Wildlife Service (USFWS) Reno, Nevada office to determine the potential occurrence of special-status plant species in Implementation Area A. The USFWS (February 2010) and NNHP (January 2010) have determined that no state- or federally listed threatened or endangered plant species are known to occur in the Project area. Information on state- and federally listed threatened, endangered, and candidate species; USFWS Sensitive Species; and TRPA Species of Special Interest with the potential to occur in the Project area was obtained from the TRPA, USFS, NNHP and USFWS (USBOR 2010). Based on field studies completed to date, Implementation Area A does not support any threatened, endangered, or sensitive vegetation or wildlife species.

Field studies identified two noxious weeds in the Project area. Two Priority Invasive Weed species of the Tahoe Basin were documented as occurring in the Project area, including 12 stems of teasel (*Dipsacus fullonum* – Group 1: Watch for, Report, Eradicate Immediately [present as small populations that would be eradicated]) and eight stems of bull thistle (*Cirsium vulgare* – Group 2: Manage Infestations with a Goal of Eradication [isolated populations would be targeted for eradication]) (Wood Rodgers 2010). The locations of the two invasive weed species are shown on the Project Plans (Appendix A), and treatment is addressed in the Project Special Technical Specifications (Appendix B).

3.3 Geotechnical Analysis

A geotechnical investigation (Wood Rodgers 2009, see Appendix E) was conducted for Implementation Area A that included specific bank sampling at locations representative of the proposed new channel alignment and potential grade control structures. Fifteen hand-augured exploration sites were collected and analyzed by a Wood Rodgers geologist in 2008 and 2009 to obtain soil samples from various depths down to 5 feet (ft) below the ground surface. The laboratory testing that was conducted included particle size analysis, permeability testing, and Atterberg limits. Soils were found to be composed of interfingered layers of poorly graded sand, silty sand, and clayey sand. The predominant types are interbedded with moderately to highly plastic silt and clay layers. The surface layer has a substantial amount of organic material (suitable for topsoil salvage). Several layers may contain varying amounts of gravel, cobbles, and boulders (less than 4 ft in diameter).

In addition, close coordination and sharing of geotechnical information has occurred with the U.S. Department of Agriculture Agricultural Research Service, National Sedimentation Laboratory (ARS-NSL). The ARS-NSL collected data in 2007 on the existing streambanks and streambed throughout Rosewood Creek as part of an analysis in support of the Lake Tahoe total maximum daily load process. These data were used to guide selection of parameters for bank stability modeling.

Chapter 4

Existing Conditions

4.1 Channel and Floodplain Morphology

The existing morphologic conditions of Rosewood Creek are described in the Mainstream 2005 report. The creek is in a steep, mountainous setting with a valley slope in Implementation Area A (referred to as "Reach A" in the Mainstream 2005 report) of 6 percent. The valley alluvium is largely comprised of fine-grained sand and silt particles with low cohesion. Rosewood Creek has been highly altered from its natural condition. The alterations include direct channel disturbances, such as channelization of the lower portion of the channel in Area A and modification of the channel's base level at the State Route 28 culvert, and watershed-scale alterations of hydrology and sediment loads due to urbanization of the drainage.

These alterations have led to substantial morphologic degradation of Rosewood Creek in previous decades. The negative response of the channel to the alterations is exacerbated by the steep valley slope and poorly cohesive alluvium whereby the channel flows in a high-energy environment through highly erodible bed and bank materials. For most of the reach, the channel is incised several feet into the valley alluvium. Downcutting and incision of the channel led to oversteepening of the channel's banks, resulting in bank failure and channel overwidening. The flow conveyance capacity of the existing channel is several times larger than pre-disturbance conditions. Most of the channel in Area A is completely disconnected from its former floodplain. The former floodplain is now a terrace that never receives overbank flow from the creek. At many locations, the channel is over 6 ft deep and from 20 to 30 ft wide. Incipient floodplain has formed at some locations within the entrenched channel, but in many areas, the creek still flows through narrow sections with nearly vertical banks several feet tall on both sides of the channel. Several nickpoints throughout the reach suggest that the channel is still responding to previous disturbances and that additional downcutting, overwidening, and bank collapse will continue into the future if unchecked.

4.2 Riparian Vegetation

Implementation Area A is characterized by a riparian corridor adjacent to Rosewood Creek within a Sierra mixed conifer forest community dominated by Jeffrey pine (*Pinus jeffreyi*) and white fir (*Abies concolor*). Dominant overstory riparian vegetation is provided by mountain alder (*Alnus incana* ssp. *tenuifolia*), Scouler's willow (*Salix scouleriana*), and Pacific willow (*S. lucida* ssp. *lasiandra*). A shrub layer is typically noncontiguous along the streambank, except for discrete occurrences of red osier dogwood (*Cornus sericea*), Wood's rose (*Rosa woodsii*), and Lemmon's willow (*S. lemonnii*). The herbaceous understory varies from dense cover of mesic gramionoids like small-fruit bulrush (*Scirpus microcarpus*) and sedges (*Carex* spp.) and dry graminoids like blue wildrye (*Elymus glaucus*) to an understory composed of forbs, including western brackenfern (*Pteridium aquilinum*), stinging nettle (*Urtica dioica*), and Anderson's thistle (*Cirsium andersonii*).

Although Implementation Area A is described as a "riparian community type" in the Mainstream 2005 report and is designated by TRPA as an SEZ, the channel is completely disconnected from its former floodplain through a majority of the reach. The former floodplain is now a terrace that never receives overbank flow from the creek. This results in a localized depression of groundwater levels in and adjacent to the creek. Thus, the riparian species are strongly tied to the in-channel floodplain and some low-elevation areas within the disconnected floodplain that accumulate precipitation. The alterations to the watershed hydrology and geomorphology discussed in Section 4.1 are reflected in the current vegetation composition that includes establishment of second- and third-growth forests.

Vegetation conforms to two vegetation series: the Jeffrey Pine Series and the Mountain Alder Series. Overstory health, canopy cover, and age class are variable; but most of Implementation Area A evidences some lack of riparian vegetation recruitment, senescence (aging of vegetation strands), and conifer encroachment. In general, mountain alder and willow species greater than 20 ft from the top of bank in the incised reaches tend toward senescence, while the root systems of well established older trees on the bank and in the channel are healthy due to their proximity to more consistent soil moisture. A shrub layer is typically noncontiguous along the streambank, except for discrete occurrences of redosier dogwood, Wood's rose, and Lemmon's willow. The herbaceous understory varies from dense cover of mesic and dry graminoids (drier soil conditions) to an understory composed of forbs that reflect soil moisture conditions ranging from dry to depressional area soil moisture. The Mainstream 2005 analysis of vegetation cross sections (Reaches 1, 2, 3, and 4) through Implementation Area A resulted in their characterization as an early seral (drying) riparian complex.

Within Implementation Area A, 32 special-status plant species (including TRPA Species of Special Interest) were identified by USFWS as potentially occurring (Wood Rodgers 2010). However, none of these 32 plant species were found to occur in the Project area due to range, elevation, and habitat range limitations. An Environmental Assessment prepared for the U.S. Bureau of Reclamation (Wood Rodgers 2010) documents the information in the following discussion.

Approximately 0.17 acre of jurisdictional waters of the Unites States and 1.06 acres of existing jurisdictional wetland are located in Implementation Area A. Rosewood Creek is also within a TRPA-recognized SEZ, with perennial runoff. Floodplain and SEZ in the Lake Tahoe Basin is highly valued habitat; the floodplain processes provide the potential for infiltration of storm flows when they are functional. The SEZ boundary verified by TRPA within Implementation Area A contains approximately 6.48 acres of SEZ.

4.3 Aquatics

On September 27 and 28, 2006, ENTRIX biologists walked the length of the Middle Reach of Rosewood Creek and noted specific habitat types and features. All observed wildlife was noted, and separate field notes were taken for each implementation area.

The survey involved walking from downstream to upstream within the creek as much as possible, or on the bank when dense riparian vegetation or woody debris limited access. Habitat was classified as riffle, pool, or cascade. Surveying from downstream to upstream was important as it afforded a much higher chance of spotting fishes or other aquatic organisms before they sought shelter from the survey crew. The low-flow condition prevented the use of snorkeling as a survey tool; however, a dip net was used to sample some of the deeper and more discrete units. A small amount of marginal habitat occurs within the channel in Area A (ENTRIX 2006).

No fish species were found during surveys of Implementation Area A. Based on the habitat types noted, however, the following fish species have the potential to occur in the Project area: brook trout (*Salvelinus frontalis*), rainbow trout (*Oncorhynchus mykiss*), speckled dace (*Rhinichthys osculus*), and Lahontan redside shiner (*Richardsonius egregious*). None of these species are listed as threatened or endangered. There are two known fish passage barriers in the Project area, at least one fish passage barrier upstream, and at least one fish passage barrier downstream.

4.4 Culverts

Two culverts cross under Northwood Boulevard through a thick embankment fill. On the east (left downstream view) is an arched corrugated metal pipe (CMP) culvert with a 4.5-foot (ft) span and a 2.8-ft rise. On the west (right downstream view) is a 4-ft diameter circular CMP culvert. Both of these culverts have the capacity to convey the design storm event flows shown in Table 2-1. Because of their slope, length, and outfall configuration (a small jump without a pool), however, the culverts likely represent a fish passage barrier.

State Route 28 has a single arched CMP culvert with a 6.8-ft span and 4.75-ft rise. This culvert has the capacity to convey the design storm event flows shown in Table 2-1. Given the low slope and culvert characteristics, the culvert itself is not considered to be a significant fish passage barrier. However, debris blockage at the downstream outfall (potentially related to winter snow storage in the right-of-way) may impair use of the resting pool for upstream migrants.

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Chapter 5

Existing Conditions Hydraulic Modeling

5.1 Model Set-Up and Assumptions

The Corps HEC-RAS software (version 4.0) was used to model the hydraulics of existing conditions in Rosewood Creek in Area A. The ground topography surveyed in 2008 (as described in Section 3.1) was used to create the geometry file for the model. Bed slopes within the reach range from less than 1 percent in small sections to over 10 percent in the steepest sections. The reach average slope is approximately 6 percent. Within Area A, 110 cross sections were established from downstream of State Route 28 to upstream of Northwood Boulevard, with an average spacing of 20 ft. The cross-section spacing is not intended to be dense enough to capture all of the local hydraulic changes associated with the numerous nickpoints and morphologic bedforms (e.g., step-pool features and cascades) throughout Rosewood Creek that result in rapidly varying flow conditions. To do so would have required thousands of cross sections. Instead, the cross-section spacing is dense enough to capture reach-averaged conditions. The culverts at the two roads (Northwood Boulevard and State Route 28) were included in the model.

Manning's "n" roughness values for the floodplain were determined from published literature relating vegetation type, height, and density with influence on flow resistance (Chow 1959). The channel roughness values are based on research that relates channel bed slope with flow resistance at the reach scale (Yochum and Bledsoe 2010, Montgomery and Buffington 1997). For example, in step-pool morphology, the abruptly changing flow resistances associated with high energy loss at channel steps and relatively low energy loss in pools is averaged out for the entire bedform unit. This reach averaging of flow resistance enables use of HEC-RAS to hydraulically model rapidly varying flow by essentially reducing the channel complexity to gradually varied flow. Thus, the modeled water surface elevations do not show the detail of every channel step, but they do show reach-averaged water surface elevations that can be used to evaluate reach-average conditions.

5.2 Results

The model results support the field observations that the conveyance capacity of Rosewood Creek is several times greater than its pre-disturbed condition. The 100-year event (48 cfs) results from HEC-RAS were analyzed in HEC-GeoRAS software in GIS to map flow depths and inundation extent (Figure 5-1). The mapping shows that, except for a small section of the creek in approximately the middle of the reach, the 100-year flow is entirely contained within the entrenched channel. The vast majority of the terrace (former floodplain) never receives any surface water flooding from the creek overtopping its banks. Flow depths in the channel are typically 2–3 ft and can exceed 4 ft. A longitudinal profile showing the elevation relationship of the 2-year (6 cfs) and 100-year (48 cfs) even water surface elevations and the left and right top of bank elevations is displayed in Figure 5-2. This plot reaffirms the substantial incision and overwidening the channel has experienced that has led to near confinement of the largest magnitude, most infrequent flood events. The longitudinal profile shows that the existing culverts at State Route 28 and Northwood Boulevard can adequately convey the 100-year flood without overtopping or backwatering.

The key result of the hydraulic modeling analysis of existing conditions was quantification of the extent of disconnection between the channel and its former floodplain. The vertical difference between the water surface elevation at the 100-year flow and the broader valley floor (former floodplain) is typically several feet. Field observations indicate that Rosewood Creek is developing incipient floodplain in some reaches. This floodplain is typically only from one to two channel widths wide and several feet beneath the valley floor. While this incipient floodplain will continue to develop naturally, it will do so by continuing to erode the tall, oversteepened banks, thus delivering more fine sediment to the channel that eventually will be delivered to Lake Tahoe. Since the base level of the creek in Area A at the State Route 28 culvert is a fixed elevation, the long-term evolution of the reach is likely continued bank erosion and incipient floodplain development, resulting in further disconnect with the former floodplain.

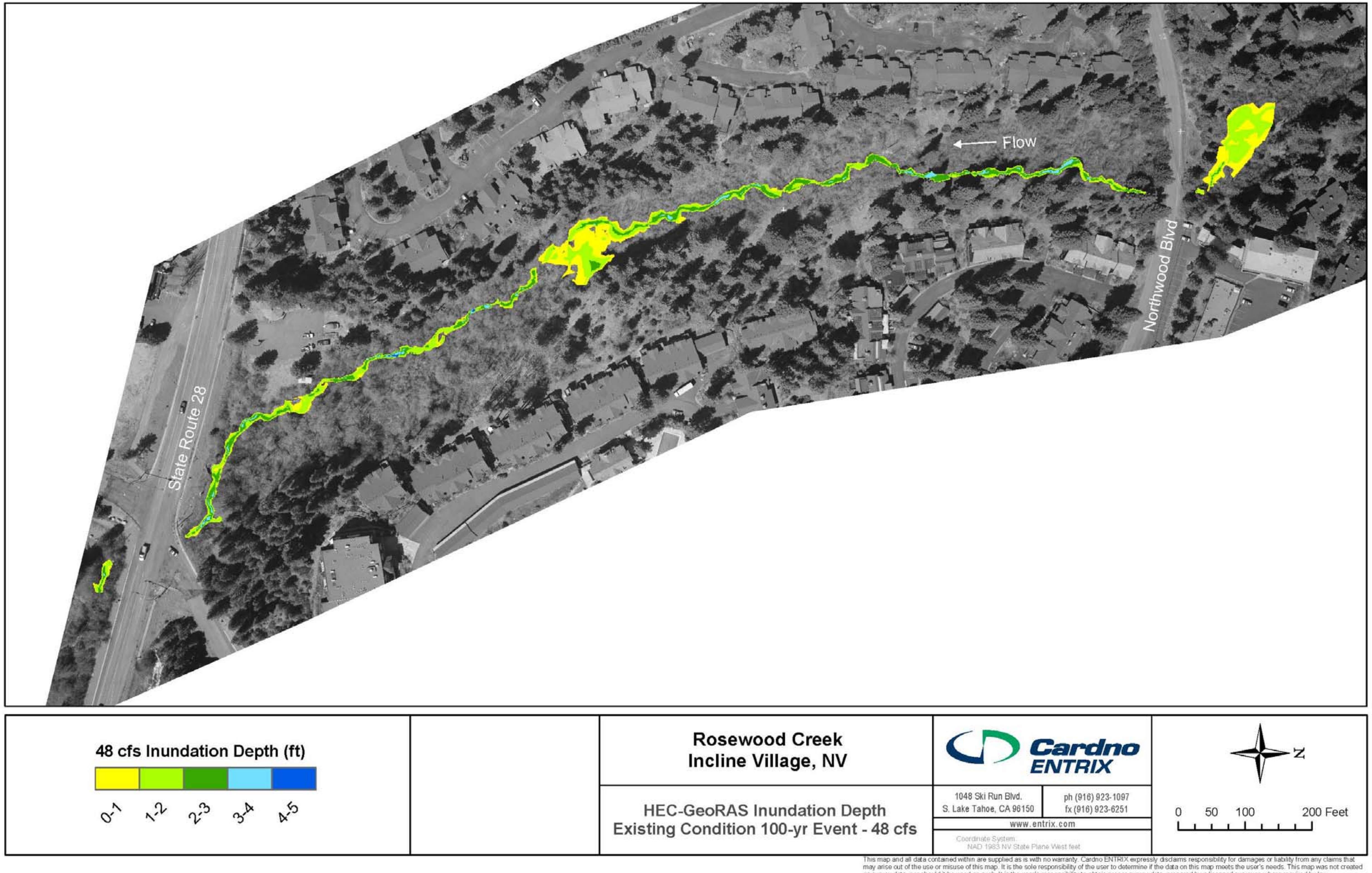

Figure 5-1. Modeled Inundation Depths at the 100-Year Recurrence Interval Event of 48 cfs under Existing Conditions

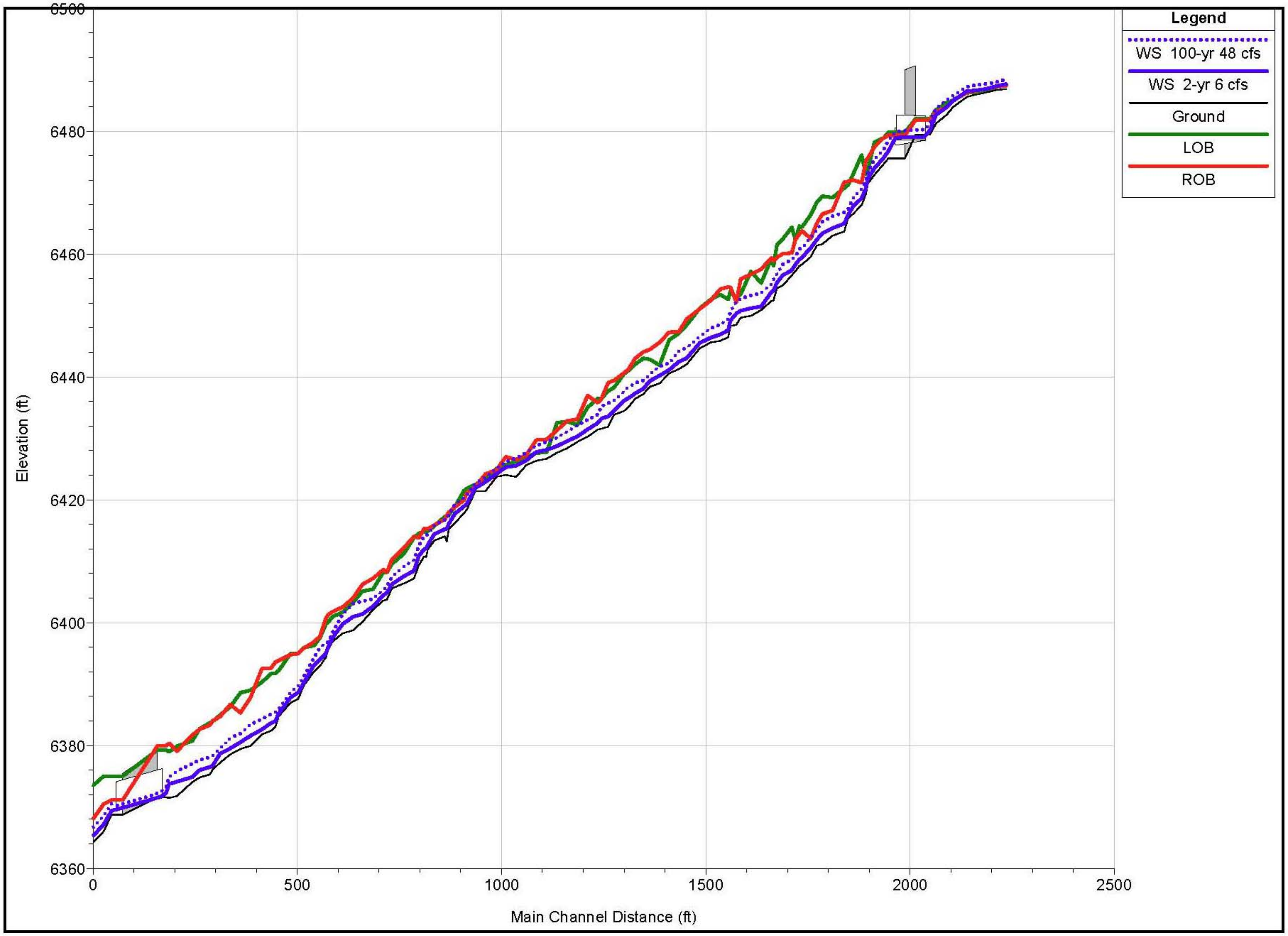

Figure 5-2. Comparison of the 2-Year (6 cfs) and 100-Year (48 cfs) Event Water Surfaces and Left and Right Top-of-Bank Elevations under Existing Conditions

Chapter 6

Restoration Design

6.1 Channel Capacity and Restoration of Floodplain Connectivity

The Project design includes several specific elements that are consistent with the Project goals of reducing channel capacity and restoring floodplain connectivity relative to the existing deeply incised and oversized condition. The restoration would reconstruct a low-flow channel with (1) the appropriate size, slope, and materials to convey the bankfull flow and sediment; and (2) bank heights and overbank topography that provide for a small, but connected active floodplain throughout the entire Project reach. The active floodplain would receive water from flows exceeding the bankfull design flow (4 cfs) and would be expected to accommodate the 5-year and 10-year flows without excessive depths, velocities, or shear stress. The proposed new channel capacity and regraded floodplain topography would result in overtopping onto the active floodplain for at least several days every couple of years, assuming that future hydrologic conditions are similar to the historical record.

The measures to raise the streambed and water surface elevation under normal seasonal flows and small to moderate flood flows would also bring up the surface elevation of major flood flows (including the 100-year event) and spread it out across portions of the existing SEZ/terrace that would be active floodplain. Therefore, the Project design must balance the primary benefits of restored channel capacity and floodplain connectivity with the commitment to prevent any adverse changes in flood hazards. The proposed changes to the low-flow channel and floodplain topography or materials were iteratively modeled during design development (see Chapter 8) to ensure that a 100-year flood event (1 percent annual chance of occurrence) would not expand the FEMA Special Flood Hazard areas to include any structures not already so mapped.

The proposed Project conditions will allow flows that exceed the 4-cfs bankfull capacity onto the active floodplain, including large flood flows. The channel is intended to experience some natural dynamics in terms of seasonal to interannual movement, transport, and sorting of bed material and changes in bed form and surface particle sizes, along with small changes in planform or bank stability for flows up to and including the 10-year peak flows. However, the overall channel position should remain within the design alignment (~<two channel widths from centerline), excessive surface erosion (e.g., rills or gullies) should not occur on the active floodplain, and the channel bed changes should not exceed the placed bed material thickness over this same range of flows.

The design includes a system of several vertical grade controls along the Project reach with the appropriate width (valley wide and across the active floodplain, respectively) at locations along the valley and channel profile to protect against the worst-case risk of scour or incision and nickpoint migration up to the 100-year flow (48 cfs). The framework provided by these grade control structures would ensure that, even if minor channel bed and bank dynamics result from moderate to large floods (i.e., 20-year to 100-year events), the effects would be localized and contained between grade control structures.

The geomorphic observations, geotechnical study, and hydraulic modeling of the Project reach indicate that the steepness of the valley slope; fine-textured, loosely consolidated soil materials; and irregular existing topography could combine to increase the risks of soil erosion on the floodplain during large storm events (i.e., 50-year to 100-year events). Therefore, the design incorporates recontouring to smooth the floodplain topography and revegetation that would improve soil cohesion and floodplain roughness without adversely routing or converging flows.

The design allows for naturally dynamic channel margins and a connected active floodplain within contiguous short sub-reaches that are each protected from instability by adjoining (upstream/downstream) valley-wide and channel grade control structures.

6.2 Defining New Channel Alignment and Profile

The restoration design proposes a relocated stream channel within the SEZ that incorporates some former channel remnants and provides a stream length and profile that is suitable for the existing valley topography. The relocated stream channel would meet the existing downstream culvert (State Route 28) at grade, and its design incorporates replacement of the upstream culverts (Northwood Boulevard) that would improve natural functions and satisfy utility constraints.

The alignment of the new channel is based on a combination of field inspection and map interpretation of the topography, remnant channel features on the abandoned floodplain (i.e., terrace), landowner knowledge of the historical channel positions, and iterative hydraulic modeling to minimize 100-year flood flow extent, depths, and velocities. The proposed alignment is generally west of the existing channel in the upstream portion of the Project reach and east of the existing channel in the downstream portion of the Project area. This alignment limits crossing of the existing channel by the new channel to one location and takes advantage of the existing abandoned floodplain (terrace) surfaces as restored SEZ. The valley is relatively narrow, particularly in the middle of the Project reach, and required iterative adjustments of proposed grading to limit maximum water depths for the 100-year flood. The topography slopes down to the east in the lower portion of the Project reach, in the headwaters of a small secondary drainage, which required iterative adjustments of the channel location and elevation to avoid excessive water depths or extent in existing wetlands.

Iterative hydraulic modeling was used to optimize the channel profile, channel alignment, and width and slope of the active floodplain in the first round of the 90-percent design. Channel profile adjustments were made to limit in-channel shear stress over the entire range of design flows, up to the 100-year event. The down-valley and cross-valley (toward the channel) slopes on the active floodplain also were refined to limit out-of-channel shear stress over the entire range of design flows, up to the 100-year event. The highest mean in-channel and active floodplain shear stresses were grouped (Table 6-1) as an initial guide to the use of specific soil types, rock sizes, vegetation, or bioengineering treatments for channel and floodplain surface stability at particular design flows (following standard permissible shear stress guidelines).

Table 6-1 Channel and Active Floodplain Guidelines for Rosewood Creek Area A

Channel Feature	Channel Type 1	Channel Type 2	Channel Type 3	Channel Type 4
In-Channel				
Highest mean shear stress for 2-, 5-, and 10-year flows (lbs/ft^2)*	1.5	2.6	3.5	5.0
Highest mean shear stress for100-year flow (lbs/ft^2)*	1.9	4.0	4.8	6.0
Active Floodplain				
Highest mean shear stress for all flows for 2-,5-, and 10-year flows (lbs/ft^2)*	0.6	1.2	2.0	3.5
Highest mean shear stress for 100-year flow (lbs/ft^2)*	1.5	2.0	2.5	3.9

lbs/ft^2 = Pounds per square feet.

The initial 90-percent design channel alignment, profile, and active floodplain slopes were further refined by additional iterative hydraulic modeling once incipient motion analyses and bank stability modeling (as described in other sections) produced target channel dimensions for each slope range. The resulting channel profile generally matches the surveyed existing valley slope (which is not constant), excavated less than 1–3 ft as needed to provide for the lowest in-channel and over-bank shear stress while maintaining channel bank heights that are appropriate for the channel type given the proposed channel slope.

6.3 Developing New Channel Cross-Section Dimensions

The size and shape of the proposed active (low-flow) channel are based on several considerations:

a. Statistical analysis of measured hydrology data from Rosewood Creek (tributary to) Third Creek and available streamflow records on neighboring watersheds that guided selection of a 4-cfs bankfull design flow (as described in Chapter 2, “Hydrology”).

b. Empirical data from a representative sub-reach (existing creek stations 10+60 through 12+00) that has reasonably stable channel condition and a functioning floodplain connection with Rosewood Creek (based on the field survey described in Chapter 3, “Field Data Collection”).

c. Iterative hydraulic modeling (at-a-station HEC-RAS) and bank stability analyses (ARS-NSL Bank Stability and Toe Erosion [BSTEM] model) to select the appropriate range of channel bed widths and bank angles that meet the target bankfull capacity (4 cfs) while limiting shear stresses on the bed and bank. The preferred conditions were selected such that rock sizes and vegetative materials consistent with natural local stable channel segments (i.e., not large rock/ riprap) would be sufficient for stability.

All of the channel types are designed to meet the bankfull design capacity of 4 cfs, but the size and shape of the proposed channel are varied to match the range of valley slopes. The channel in steeper sections (Type 4) would be narrowest and deepest. The channel in moderate sections (Types 2 and 3) would be slightly wider and shallower. The channel in the lowest slope sections (Type 1) would be the shallowest (Table 6-2 and Figure 6-1).

Table 6-2 New Channel Dimensions in Rosewood Creek Area A

Channel Feature	Channel Type 1	Channel Type 2	Channel Type 3	Channel Type 4
Channel slope range (ft/ft)	>0.03	0.03 to 0.05	0.05 to 0.07	0.07 to 0.12*
Maximum depth (ft)	0.70	0.90	0.90	1.20
Top width (ft)	3.3	3.3	3.3	2.4
Bed width (ft)	1.9	1.5	1.5	1.2
Cross-section area (ft^2)	2.0	1.9	1.9	2.2

ft = Feet.

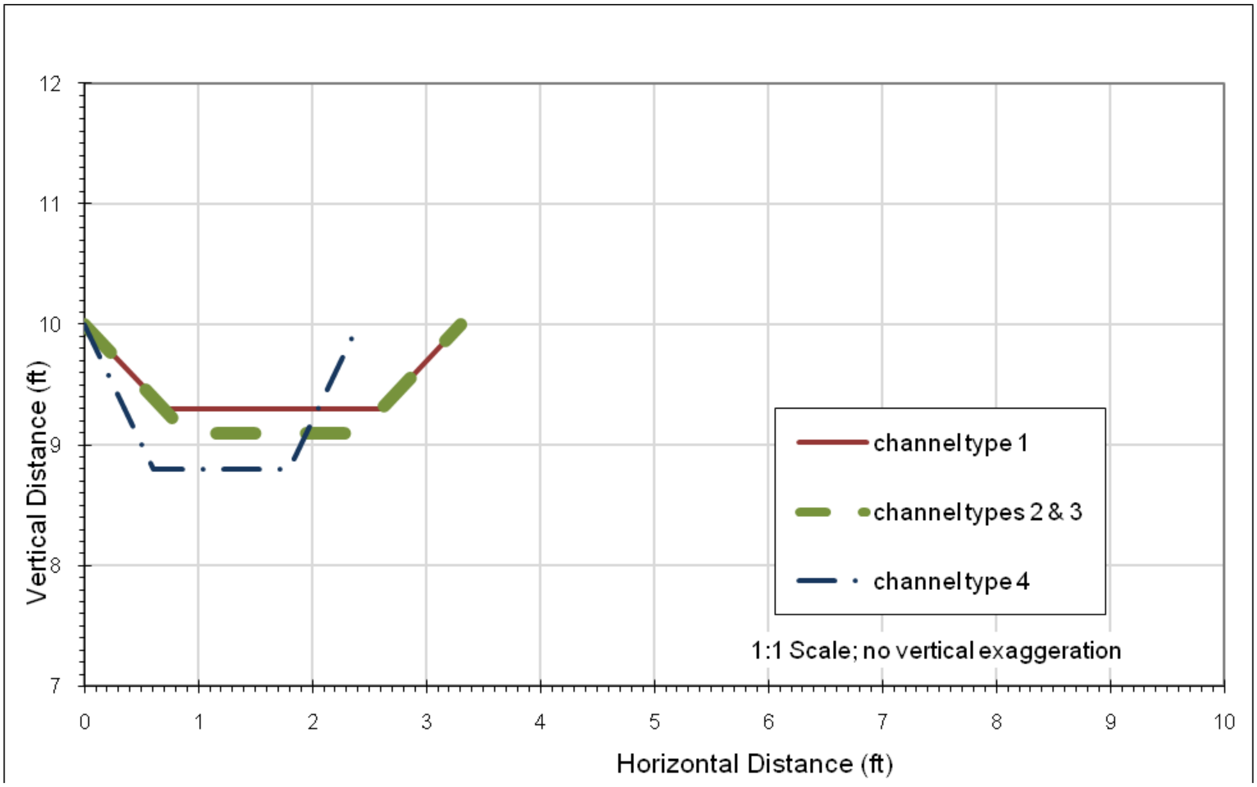

Figure 6-1 Schematic Representation of Channel Dimensions for Proposed Channel Types

6.4 Northwood Boulevard Culvert Replacement

The Project will replace the aging and poorly aligned culverts under Northwood Boulevard. The new culverts are designed to improve the stream profile, reconnect adjoining areas to the active floodplain on both sides of the road fill embankment, improve fish passage conditions, and take advantage of the opportunity to remove fill material within the SEZ on the upstream side of Northwood Boulevard.

The geotechnical investigation described in Chapter 3 (Wood Rodgers 2009; see Appendix E) indicated the approximate depth and extent of placed fill, which served as a guide to target elevations for the restored active floodplain on the upstream side of Northwood Boulevard.

The proposed culvert alignment, slope, inlet/outlet elevations, and hydraulic capacity meet several criteria, including:

a. New elevation and alignment that facilitates reconnection of remnant channels downstream on the terrace that will be reactivated as floodplain;

b. Increase hydraulic capacity to allow open-channel flow up to 48 cfs, the 100-year design flow; and

c. Reestablish more natural sediment transport continuity and fish passage conditions by installing a bottomless culvert with natural bed materials in a low flow channel.

The replacement culvert type and materials were selected to meet Washoe County Department of Public works regulations, policies, and requirements. The selected culvert is a concrete arch, open-bottom culvert. The culvert was designed to meet several requirements, including clearance between sanitary sewers (1 ft vertical clearance/separation) and open clearance (height) of the culvert (5 ft vertical from channel bottom to the top of the culvert opening).

6.5 Backfilled Existing Channel

The proposed backfilling of the existing incised channel will restore natural-appearing valley topography. The design includes some variations to help ensure that flows from major floods are not routed over the backfilled channel, limiting the potential for recapture of the existing alignment or profile.

Because the native soils of the existing oversized channel have been eroded away and transported downstream of the reach, imported earth materials, or materials excavated from onsite efforts (native backfill), will be needed to raise the existing elevation to meet the adjoining surfaces. For areas eroded deeper than approximately 1.5 ft below finished grade, the imported material composition (lithology), size distribution, and physical layering/compaction need to achieve engineering purposes for stability and restored groundwater levels and reasonable flow rates (i.e., neither restricted or accelerated). Native backfill will be screened material (to ensure that no large or organic materials are present) and will be the cut materials generated as part of the Phase 3 efforts (see Section 10.1 for discussion of the construction phasing for the Project). This native material will comprise the “middle” of the backfilled channel. The lower portions (deepest approximately 3 ft) will be comprised of an engineered fill that will not allow for porosity and will be able to be compacted to 90-percent relative compaction or higher. This lower area may also be backfilled with materials generated from Phase 1 efforts stockpiled and stored by the Contractor at an offsite location (as the Project does not provide for stockpiling of this material) in a similar manner as described above. For the areas within approximately 1.5 ft of finished grade, the imported material needs to provide suitable soil profile characteristics for revegetation success, including texture, porosity, permeability, organic material, and microorganisms.

Protection of the backfilled existing channel from possible surface erosion due to flooding is provided by the combination of topographic grading that restricts access of flood waters to these areas; the valley-wide grade control structures that are designed to function up to and including the 100-year peak flow; and the revegetated surfaces, including varied roughness targets and a range of more mesic species in areas that will be farthest from the new channel and active floodplain.

The backfilled channel will generally provide benefits to groundwater levels and flows, because it will reestablish sediments and soils with groundwater storage and transmission properties. The specifications for particle sizes, porosity, and permeability are intended to avoid restricting groundwater, similar to the existing condition in the rest of the valley. Conversely, protection of the backfilled channel alignment against locally high groundwater flow rates will be ensured by installation of perforated sheet pile to regulate (but not entirely dam/prevent) down-valley groundwater movement. The perforated sheet pile would be at least as wide as the existing incised channel, plus 10 ft on either side. It would driven down at least 5 ft below the existing channel bed, and the top of the pile would be between 2 and 3 ft below finished grade.

Given a lack of groundwater monitoring data upon which to base quantitative design, the number and location of permanent buried protection have been proposed based on professional judgment, acknowledging the expected raising of groundwater elevations in response to backfilling.

Chapter 7

Proposed Revegetation Design

7.1 Revegetation Approach

The restoration design is focused on creation of a stable stream channel with a connected and functioning floodplain to enhance the riparian habitat corridor through structural species diversity. The Project design was based on the results of bank stability modeling to guide the use of optimal soil material, bank angles, and vegetation treatments that would match various channel types for slope ranges in the reach. The proposed design would be geotechnically stable and would resist hydraulic forces by using only rock and vegetation treatments. Therefore, to the furthest extent possible, the proposed revegetation design does not include the use of erosion control blankets for initial protection. In addition, the proposed Order of Work (see the Project Special Technical Specifications in Appendix B), maximum duration of construction, and ability to use off-channel construction will provide for up to two growing seasons for revegetation to establish on the banks of the new channel, the frequently inundated floodplain, and wetlands prior to the channel being rewetted. These provisions negate the need for erosion control blankets except at tie-in locations and where the old channel and new channel are close to each other. At these locations, woody vegetation seeding, root wads, and willow staking will be used in combination with an erosion control blanket to afford a higher level of immediate short-term protection.

7.2 Revegetation Establishment and Seasoning

The Order of Work for implementation of restoration provides for a minimum of one growing season and a maximum of two complete growing seasons for revegetation to establish and provide site stability. Seasoning of the new channel will not be considered complete until revegetation establishment will provide stability to accept stream and floodplain flow and has been approved by the Engineer, Washoe County, NTCD, TRPA, Nevada Division of State Lands, and the Nevada Department of Environmental Protection.

7.3 Revegetation Types

Revegetation types have been designed based on the physical and hydraulic attributes of the new channel, new active floodplain, and backfill channel areas. The revegetation design is focused largely on providing roughness to protect both the new channel banks and the new connected floodplain. Revegetation types also include those to facilitate wetland enhancement, restoration, and creation, and to stabilize sites used for construction access and staging areas.

The proposed revegetation types, their characteristics, and the applicable areas are summarized in Table 7-1.

Table 7-1 Proposed Revegetation Types and Characteristics

Type	Description	Applicable Area
A	Wet herbaceous and riparian woody species	New channel, restored/ created/enhanced wetland, old channel backfill, restored floodplain
B	Wet herbaceous species only	Restored/ created/enhanced wetland
C	Installation of willow stakes in channel	Low on new channel bank and at toe of new channel bank
D	Installation of willow stakes in channel, with mid elevation above channel bottom and top of bank armored with root wads amid rock armor	New channel banks (particularly in steeper areas and at grade control structures)
E	Wet herbaceous and high-density riparian woody species	Valley-wide grade control structures, specific locations near old and new channel alignments
F	Mesic species site stabilization	Restored floodplain fringe
G	Mesic species site stabilization	Upland areas – miscellaneous areas outside Revegetation Type F, access and staging areas in upland
H[a]	Erosion control blanket	Channel tie-in locations, revegetation areas not subject to revegetation seasoning
I	Combinations of previously listed Revegetation Types	Channel tie in locations, and revegetation areas NOT subject to revegetation seasoning
J	Combinations of previously listed Revegetation Types	Channel tie in locations, and revegetation areas NOT subject to revegetation seasoning
K	Combinations of previously listed Revegetation Types	Channel tie in locations, and revegetation areas NOT subject to revegetation seasoning

[a] Revegetation Type H (erosion control blanket) will be applied in very specific locations. These locations include channel tie-in locations, areas where the existing channel is close to the new channel alignment, and wetland treatment areas that will be subject to immediate rewetting. At these locations, rock armoring in combination with woody vegetation seeding, root wads, and willow staking will be used in combination with an erosion control blanket to afford a higher level of immediate short-term protection.

Revegetation Types H, I, J, and K will be applied in very specific locations as indicated above. These locations include channel tie in locations, areas where the existing channel is in close proximity to the new channel alignment, and wetland treatment areas that will be subject to immediate rewetting. At these locations rock armoring, wetland sod and erosion control blanket in combination with woody vegetation seeding, root wads and willow staking will be employed afford a higher level of immediate/short term protection.

Chapter 8

Hydraulic Model Evaluation of Restoration Design

8.1 Channel Capacity and Floodplain Connectivity Performance

HEC-RAS software was used to evaluate the proposed channel and floodplain restoration design. The modeling effort had several objectives:

1. Evaluate how the design would affect the inundation depth and extent of the 100-year flow and prevent changed flood risk to nearby properties;

2. Evaluate the flow conveyance capacity of the new channel to ensure that it overbanks at the desired frequency;

3. Analyze overbanking to ensure that the lateral extent of flooding on the new floodplain is largely consistent, without major expansions and constrictions throughout the reach;

4. Assess channel shear stresses over a range of flow magnitudes to determine the size material needed to construct a stable channel in which the key framework sediment would be immobile at the highest flows;

5. Analyze floodplain shear stresses to ensure that the proposed revegetation on the floodplain can withstand the erosive energy of flood flows; and

6. Evaluate the performance of the new Northwood Boulevard culvert for both flood conveyance and fish passage.

The new design ground elevation surface generated in AutoCAD was input into the HEC-RAS model. Cross sections that spanned the entire valley width were created at approximately every 25 ft throughout the reach. The same guidelines used to determine Manning's "n" roughness values for the existing condition model were used in the proposed design model. Floodplain roughness values were based on the vegetation treatment types described in Chapter 7 and as shown on the Project Plans (Revegetation Sheets R-1 through R-4 in Appendix A), and they assumed that vegetation is at least 3–5 years established. Similar to the existing condition model, the proposed design model does not include all of the micro-detail associated with the individual bedforms in the reach. For example, all of the abrupt elevation changes of a step-pool section of channel are not included in the model because this would be impractical over such a long modeling reach. Instead, reach-averaged Manning's "n" values were assigned to the cross sections to account for the average flow resistance of the reach. Therefore, the model simulates reach-averaged conditions.

Hydraulic modeling of the proposed design was an iterative process. After each model run, the results were analyzed to evaluate design performance. The limitations of the design step highlighted by the modeling were then changed via modified proposed grading and final ground surface elevations in AutoCAD and re-run in HEC-RAS. Iterative design changes were made until the design satisfactorily met the Project objectives outlined above. Some of the major design changes related to balancing floodplain regrading with channel alignment and elevation changes until the desired channel capacity, slopes, and floodplain overbanking were achieved without 100-year floodplain boundaries, depths, or velocities of concern.

8.2 Channel Velocities and Shear Stresses

Text, Table and Graphics results to be inserted upon approval of 90-percent design by TAG.

8.3 Active Floodplain Velocities and Shear Stresses

Text, Table and Graphics results to be inserted upon approval of 90-percent design by TAG.

8.4 100-Year Floodplain Characteristics

Text, Table and Graphics results to be inserted upon approval of 90-percent design by TAG.

Chapter 9

Refinement of Channel Design Based on Hydraulic Modeling Analysis

9.1 Channel Materials and Bank Vegetation for Channel Treatment Types

The selection of channel bed and bank materials and vegetation is intended to match or mimic the naturally occurring conditions for local channels while providing adequate initial and long-term stability for the channel boundaries.

Bed material sizing for each channel type was determined by an approach that combined empirical bed material data from stable mountain streams in the channel slope ranges (Montgomery & Buffington 1997), critical grain size calculations from the HEC-RAS model of the proposed uniform channel dimension, and specific calculations of critical particle diameter. The critical particle diameter calculations used the total shear stress at the maximum channel slope of each channel type, for a channel constructed to meet the proposed standard channel dimensions for that channel type (Table 6-2).

These data informed the selection of appropriate particle size distributions, characterized by the particle diameters for key points on the target cumulative particle size distribution (which is a description of the percent of particles by weight, smaller than a specific diameter).[2] The average between the empirical stable channel d50 size and the calculated critical diameter for the maximum shear at bankfull design flow (4 cfs) was used to guide the proposed d50 (Table 9-1). The average between the empirical stable channel d84 size and the calculated critical diameter for the maximum shear at the 100-year flow (48 cfs) was use to guide the proposed d84 (Table 9-1). The largest bed particle diameter for each channel type was estimated to be the greater of either the calculated critical diameter for the maximum shear at the 100-year flow or the size of rock available at local material suppliers (TNT and Pombo) with a size class containing the d84 particle size.

The desired particle size distribution for each channel type was prescribed in the plan detail drawings and specification as the necessary mixtures (by weight) of screened particle size intervals available from regional material suppliers to achieve the bed material particle diameter cumulative distribution targets listed in Table 9-1.

[2] When sediment samples are collected and analyzed, a particle size distribution is created by calculating the cumulative percent of the sediment finer than a given grain size. At certain points on the cumulative scale, the particle size can be significant to geomorphic processes. For example, the d10 is the particle size where 10 percent of the sediment is finer than the d10 particle size. Similarly, the d50 refers to the median particle size where 50 percent of the sediment is finer than the d50 particle size and indicates the mid-point in the size distribution of particles in a sample.

Bed material thickness below finished grade was selected to be the greater of either one full channel depth or twice the diameter of the d50 particle size for each respective channel type.

Bed material width was determined to be a minimum of two channel bottom widths, or 1 foot wider than the top width on each side (maximum of the two), to allow for minor planform adjustments.

To help ensure that interstitial spaces of the placed bed material will be filled reasonably quickly and will support surface water within the channel, a layer of medium to coarse sand will be placed 6 inches below finished grade in all of the placed bed material in all channel treatment types. There is little detailed quantitative information on future sediment characteristics or supply from upstream, but observations after construction of Area F support this approach, which provides a partial filling of pore spaces at the time of construction that would be supplemented by natural processes during channel seasoning and the initial wetting of the new channel.

Table 9-1 New Channel Bed Materials by Channel Type

Channel Feature	Channel Type 1	Channel Type 2	Channel Type 3	Channel Type 4
Channel slope range (ft/ft)	>0.03	0.03 to 0.05	0.05 to 0.07	0.07 to 0.12
Median (d50) bed material particle diameter (in)	3.0	4.5	5.8	7.2
D84 bed material particle diameter (in)	6.9	9.2	11.6	14.0
Largest bed material particle diameter (in)	8.0	12.0	12.0	18.0
Smallest bed material particle diameter (in)	1.5	3.0	3.0	3.0
Minimum bed material thickness (in)	8.4	10.8	11.6	14.4

ft = Feet.
In = Inches.

Bank angles, bank soil composition, and bank treatments—including top-of-bank, bank face, and toe-of-bank vegetation, rock, or other protective materials—were determined through iterative use of the hydraulic modeling (HEC-RAS) data on proposed slopes and water stage in representative bank stability modeling with the BSTEM model.

Initial BSTEM bank stability analyses used the geotechnical characteristics of the existing native materials (from the geotechnical investigation discussed in Chapter 3) and tested whether the desired bank angles (0.5:1 or 1:1) would be stable immediately as constructed, if protected, or once vegetation had established. The results of these BSTEM scenarios indicated that, while the proposed vegetation types could provide adequate geotechnical stability for the weakly cohesive natural materials, the top-of-bank vegetation would not achieve this condition until it had matured for 2–5 years, depending on the species types and mix. Therefore, the constructed channel dimensions and shape might be vulnerable to bank failures from internal weakness during the channel seasoning or the initial year or two of active flow. Surface protections on the bank would not eliminate this small risk (primarily a risk of losing the shape and size of the desired small channel, but also the risk of a minor amount of mobilized sediment) because the driving forces were internal geotechnical properties. However, BSTEM iterations showed that lowering the bank angle (2:1) or increasing the cohesion of the bank materials could solve the initial instability. Lowered bank angles were not considered representative of the desired long-term natural channel shape and were not preferred. However, the bank heights are so low (~1 ft) that the volume of imported soil required to provide soil materials more cohesive than the native materials would not be impractical. Therefore, the selected solution to possible short-term initial geotechnical bank failures is import and placement of soil that is moderately cohesive.

The BSTEM toe erosion analyses were updated to assume the use of imported moderately cohesive material and the range of potential bank angles (0.5:1 and 1:1), with iterative analysis of bankfull flows for varied durations and over the full range of channel slopes proposed. Combinations of bank face and toe (lower one-third of the 1-ft banks) treatments were tested to ensure that neither the recommended living vegetation nor the rock material sizes would result in any toe erosion. Vegetation treatments for each of the channel types (1–4) were customized to include appropriately increasing proportions of deep-rooted, high roughness woody vegetation in the steeper areas, as indicated in Table 9-2 and discussed in Chapter 7.

Table 9-2 New Channel Bank Treatments by Channel Type

Channel Feature	Channel Type 1	Channel Type 2	Channel Type 3	Channel Type 4
Channel slope range (ft/ft)	>0.03	0.03 to 0.05	0.05 to 0.07	0.07 to 0.12[a]
Bank angle (rise: run)	1:1	1:1	1:1	0.5:1
Bank composition	Moderate/resistant silt	Moderate/resistant silt	Moderate/resistant silt	Resistant Silt
Bank face material	Live fascine	Live fascine	Live fascine	Live fascine (< 0.08 slopes); 10-inch diameter rock (>0.08 slopes)
Bank toe[b] material	Live fascine or 3.0-inch diameter gravel	6.4-inch diameter cobble (0.03–0.04 slopes); 10-inch diameter rock (0.05 slopes)	10-inch diameter rock	10-inch diameter rock
Top-of-bank vegetation[c]	Wet meadow	Wet meadow and/or woody riparian	Wet meadow and/or woody riparian	Woody riparian

Notes:

[a] Nearly all treatment areas of Channel Type 4 are between 0.07 to 0.09 channel slopes, but the bed material sizing has used worst-case slope of 0.12 as the guide for sizing bed material.

[b] The toe of the bank is only the lower 3–4 inches; if the rock treatment size diameter is larger than 4 inches, calculations assume that the remainder of rock is buried below the toe, not extending up into the rooting zone at the top of bank.

[c] Vegetation must be 2 years old for wet meadow species and 5 years old for woody riparian species to achieve full bank cohesion benefits.

9.2 Valley-Wide and Channel Grade Control Structures

The Project includes two types of grade control structures to provide a vertical and lateral stability framework: (1) valley-wide grade control features that span the 100-year floodplain (including the new channel, active floodplain, and backfilled existing channel); and (2) channel grade control features that span the new channel and active floodplain. These elements of the design would be installed largely below finished grade (except for exposure where they cross the new channel bed) and are intended to be static (immobile) at all flows up to and including the

100-year peak flow (48cfs). Engineering and geomorphic principles formed the basis for the grade control design guidelines (Table 9-3).

Table 9-3 Design Guidelines for Grade Control Structures

Width (across Valley)	Location (in Plan and Profile)	Depth below Surface (ft)	Material Sizing
Valley-Wide Grade Controls			
Larger of the following: 20 ft (horizontal/plan) from the top of existing channel bank; 20 ft (horizontal/plan) from the top of proposed channel bank; 2 ft (vertically/elevation) above 100-year flood elevation; or 10 ft (horizontal/plan) from the boundary of the 100-year floodplain (48 cfs).	At distinct changes in valley orientation and profile slope; At key locations to avoid recapture of the backfilled existing channel alignment; and Along profile to meet 0.02 slope guide for grade control spacing that provides nickpoint migration protection.	At least two particle diameters of the sized boulders but no deeper than 3 ft; and Along profile to meet 0.02 slope guide for grade control spacing that provides nickpoint migration protection.	Critical particle diameter for maximum shear stress at the 100-year peak flow (48 cfs); calculated for all grade control cross sections, selected a conservative18-inch diameter as a typical specification.
Channel Grade Controls			
Larger of the following: Twice the channel width from the outside edge of the new active floodplain (16 cfs); 4 ft (horizontal/plan) from the top of existing channel bank; or At the 5-year event flow width.	At distinct changes in channel orientation and profile slope; At key locations to avoid recapture of the backfilled existing channel alignment; and Along profile to meet 0.02 slope guide for grade control spacing that provides nickpoint migration protection.	At least two particle diameters of the sized boulders but no deeper than 3 ft; and Along profile to meet 0.02 slope guide for grade control spacing that provides nickpoint migration protection.	Critical particle diameter for maximum shear stress at the 100-year peak flow (48 cfs); calculated for all grade control cross sections, selected a conservative18-inch diameter as a typical specification.

cfs = Cubic feet per second.
ft = Feet.

The widths of the grade control structures were determined relative to the floodplain that each type protects: the valley-wide grade control widths are based on the 100-year floodplain, and the channel grade control widths are based on the active (e.g., 5-year) floodplain.

Proposed locations of the grade control structures throughout the Project reach (in plan and profile) were selected to minimize or arrest potentially destructive geomorphic changes. The initial positioning for draft 90-percent design located structures at distinct changes in the valley orientation and profile, and at key locations that would prevent flow routing toward the backfilled existing channel. The valley-wide grade controls are oriented nearly perpendicular to the anticipated floodplain flow direction, and the edges of these structures are also shaped to smoothly connect to adjoining upland topography.

The location, number, and orientation of all grade control structures were refined during 90-percent design relative to the channel profile. The performance goal was to ensure that potential vertical or lateral channel instability between structures could not propagate upstream or downstream. The method used was to project a 0.02 bed slope upstream from each proposed grade control (as a conservative estimate of the deepest potential channel profile in the event that incision was re-initiated) and then use that projected elevation as the minimum depth for the next upstream grade control feature. The grade control structure locations and spacing along the profile were adjusted so that the buried rock would not need to be greater than 3 ft at any structure while connecting at the 0.02 minimum projected slope continuously throughout the Project reach.

The rock sizing for the valley-wide and channel grade control structures is designed to resist predicted shear stresses up to the 100-year event.

The design approach for the grade control structures limits risk from future channel movement and bed erosion overall throughout the reach, but allows for some natural channel adjustments in planform and profile of the new channel between structures.

Both the channel and valley grade controls are located and designed to withstand and perform under adverse flood conditions up to the 100-year event, without any specific maintenance requirements. Inspections would be recommended after moderate to large storm events (e.g., 20-year or larger) to ensure that no unexpected damage to the buried structures occurred.

Additionally, no routine maintenance should be required for the restored channel and active floodplain between structures. The channel bed and banks are designed to be stable for flows at least as large as the 10-year peak flow event. For streamflow events greater than the 10-year peak flow, inspections would be recommended to ensure that no unexpected damage occurred. Small changes in bed and bank erosion could result for flows exceeding the 10-year peak flow and would be considered normal. The design would accommodate such dynamics for the sub-reaches between grade control structures without a requirement for maintenance or repair.

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Chapter 10

Other Features Included in the Design

10.1 Construction Phasing

A multi-year, multi-phased approach is required to allow for proper construction of the Project and the effective introduction of flows to the new channel and floodplain. The phasing of the Project also takes into account property owner concerns, along with the regulatory requirements for work within the Lake Tahoe Basin. The construction phasing of the Project is described in detail in the Order of Work (see Project Special Technical Specifications in Appendix B) and is generally described below.

Phase 1:

Phase 1 of the Project generally consists of construction of the new channel and floodplain, except for three areas where the existing and proposed channels cross or meet. In association with the new channel construction, Phase 1 will also construct all of the channel grade control structures, along with the portions of the valley-wide grade control structures within the disturbance area of Phase 1. Phase 1 efforts will further include construction of the open-bottom concrete culvert, along with revegetation of all areas disturbed during Phase 1. These efforts include establishment of project-specific BMPs to provide temporary erosion control and to provide a safe working environment for both the Contractor and the surrounding public.

The duration of Phase 1 will be one construction season. Work efforts will be initiated after seasonal high flows have diminished and will be focused on periods of historical low channel flow (August). Phase 1 work will be completed prior to the deadline for completing grading (October 15).

Phase 2:

Phase 2 of the Project generally consists of providing a seasoning period for the new channel and floodplain revegetation work performed in Phase 1. The objective of the Phase 2 time period and effort is to allow for successful plant and revegetation establishment to occur, without flows being introduced to the channel or floodplain.

The duration of Phase 2 will depend on the success of plant and revegetation establishment, and will require between one and two growing seasons after completion of the Phase 1 efforts.

Phase 3:

Phase 3 of the Project generally consists of construction of the existing and new channel tie-ins, removal of roadway fill along Northwood Boulevard, and placement of the creek flows in the new channel. The work associated with this phase will be performed through diversion of the creek (see Section 10.3). Phase 3 work also will include construction of the remainder of the valley-wide grade control structures (within the area of disturbance of Phase 3 work) and backfilling of the existing channel along with revegetation of all disturbed areas. These efforts include establishment of project-specific BMPs to provide temporary erosion control and to provide a safe working environment for both the Contractor and the surrounding public.

The duration of Phase 3 is one construction season. Work efforts will be initiated after seasonal high flows have diminished and will take place during periods of historical low channel flow (August). Phase 3 will be completed prior to the deadline for completing grading (October 15).

10.2 Staging and Access

The Contractor will need to store and stage equipment and materials in the vicinity of the Project area. Because the Project is located off county and state rights-of-way and affords no paved or covered areas for staging or access, access will be required onto private property off of the roadways. (Washoe County will attain a Right-of-Entry for all work.) Because the Project will be constructed in phases, the storage/staging and access also will be phased, with different areas and access being used for each phase. The staging and access locations have been strategically determined for each phase to avoid long-term disturbance on private or public parcels and to avoid repeat disturbance to restored/revegetated areas.

Phase 1, Storage and Staging:
Construction of the Project will require the Contractor to store both materials and equipment, along with providing parking for construction employees. These areas are to be located as close to the Project work areas as feasible, and therefore the following areas have been identified for use by the Contractor:

1. Third Creek Homeowners Association (parking lot by activity center); and

2. North side of Northwood Boulevard (where existing fill is located, on the west side of the existing creek).

In addition to these storage and staging areas, the Contractor will use a “moving” storage and staging area, which will be the general location (within the disturbance footprint) where work is occurring at that time. This area will be different on a weekly basis, as the Contractor’s work operations progress.

Each staging and storage area outside the contiguous disturbance limits will be constructed to ensure that dirt and debris do not leave the staging and storage site (through installation of a construction entrance), and each location will have adequate traffic control signage to alert local traffic in the vicinity to the presence of the storage and staging areas. Additionally, at each staging and storage area outside of the contiguous disturbance limits temporary erosion controls and construction limit fencing will be installed to provide both environmental and public safety controls.

Phase 1, Access:
The access necessary for proper construction of Phase 1 improvements will require access to both the southern and northern work areas (south and north of the existing and new channel crossing).

The southern access point will be near the intersection of State Route 28 and Northwood Boulevard, along Northwood Boulevard. This access point will be constructed in an environmentally sensitive area and requires installation of an access road that protects existing wetlands prior to access being allowed. Upon completion of the southern area of the Phase 1 efforts, the access road will be removed and the area will be restored to existing (pre-construction) conditions.

The northern access point will be west of the existing creek crossing of Northwood Boulevard. This access point will provide the Contractor with access to the northern work area of Phase 1 along with access to the open-bottom concrete culvert to be constructed for the creek crossing of Northwood Boulevard.

Each access will be constructed to ensure that dirt and debris do not leave the access site (through installation of a construction entrance), and each location will have adequate traffic control signage to alert local traffic in the vicinity to the presence of the access points.

Phase 2, Storage and Staging:
The work associated with the Phase 2 efforts is generally limited in (see Section 10.1 for a description of the Phase 2 work effort) and does not require extensive equipment or materials. To reduce project impacts, the Phase 2 storage and staging area is limited to the Third Creek Homeowners Association (parking lot by activity center).

This staging and storage area will be constructed to ensure that dirt and debris do not leave the staging and storage site (through installation of a construction entrance), and the area will have adequate traffic control signage to alert local traffic in the vicinity to the presence of the storage and staging area. Additionally, temporary erosion controls and construction limit fencing will be installed to provide both environmental and public safety controls.

Phase 2, Access:
Access for the Phase 2 work efforts will be required only by foot and only for the use of hand equipment; therefore, no formal access points are to be provided as part of the Project. Because the work associated with the Phase 2 efforts is plant and revegetation establishment, the use of motorized equipment and equipment with ground pressure is not allowed, as it would jeopardize and reduce the likelihood of revegetation establishment.

Phase 3, Storage and Staging:
Construction of Phase 3 of the Project will require the Contractor to store both materials and equipment, along with providing parking for construction employees. These areas are to be located as close to the Project work areas as feasible; therefore, the following areas have been identified for use by the Contractor:

1. Third Creek Homeowners Association (parking lot by activity center);
2. Club Tahoe parking area; and
3. Robinson parking area.

In addition to these storage and staging areas, the Contractor will use a “moving” storage and staging area, which will be the general location where work is occurring at that time. This area will vary on a weekly basis, as the Contractor’s work operations proceed.

Each staging and storage area will be constructed to ensure that dirt and debris do not leave the area (through installation of a construction entrance), and each location will have adequate traffic control signage to alert local traffic in the vicinity to the presence of the storage and staging areas. Additionally, temporary erosion controls and construction limit fencing will be installed at each area to provide both environmental and public safety controls.

Phase 3, Access:
Construction of the Phase 3 improvements will require access to both the southern and northern work areas (south and north of the existing and new channel crossing), along with another northern access point for the work to be performed north of Northwood Boulevard.

The southern access point will be west of the intersection of State Route 28 and Northwood Boulevard, through the driveway/parking area of the “Robinson” property. This location will facilitate access to the existing channel to be backfilled downstream of its crossing with the new channel.

Two access points will provide the Contractor access to the northern work area of Phase 3 south of Northwood Boulevard. The first is within the Third Creek condominium complex east of Rosewood Creek. The second is off Northwood Boulevard (to the south), west of the existing creek channel.

Access for the northern work area of Phase 3 north of Northwood Boulevard will be at the existing creek crossing of Northwood Boulevard. This access point will provide the Contractor access to the northern work area of Phase 3 (north of Northwood Boulevard) along with access for the backfill of the existing channel downstream of Northwood Boulevard and removal of the existing culverts at Northwood Boulevard.

Each access will be constructed to ensure that dirt and debris do not leave the access site (through installation of a construction entrance), and each location will have adequate traffic control signage to alert local traffic in the vicinity to the presence of the access points.

10.3 Creek Diversion/Channel Tie-Ins

Construction of the two tie-ins to the existing channel (the upstream and downstream ends of the Project) and the crossings of the existing and new channels require the flows in the creek to be diverted around these distinct construction areas. A Project-specific diversion plan has been developed (as part of the Storm Water Pollution Prevention Plan [SWPPP]) for the Project. The SWPPP (Appendix D) describes in detail all of the specific features, requirements, and construction processes to be followed that are generally as described in this section.

Diversions of the creek and constructions of the tie-ins generally will be constructed from the most downstream tie-in/diversion to the most upstream tie-in/diversion. The Contractor will not be permitted to initiate the next upstream tie-in/diversion until the Engineer, and all regulatory agencies having jurisdiction over the Project, have approved completion of the current tie-in/diversion. These approvals will provide a level of protection to reduce the risk for an effluent discharge or failure during construction. Furthermore, all of the tie-in/diversion work will be performed during periods of historically low flow (after August 1 and before October 15) to further reduce this risk.

Each channel tie-in and diversion is additionally detailed and portrayed on the Project Plans (see sheets DIV-1 through DIV-3 and TI-1 through TI-16 in Appendix A). These sheets depict the reinforcement of these tie-ins in order to provide immediate protection from bank erosion from creek flows. This level of protection is necessary as these areas of the channel will not have the seasoning allowed for plant establishment in the other areas of the new channel. Key reinforcement features of these tie-in locations include use of "clean" stone in the lower portions (up to the 16-cfs flow) and revegetation with erosion control blankets for the upper areas.

The diversions have been designed, and are specified in the SWPPP, to provide a dewatered work area for each tie-in location. This will provide the Contractor with a workable area, to allow for the most efficient construction process. Furthermore, the SWPPP specifies that the diversions have adequate capacity to provide bypass conveyance for the flows anticipated to be seen in the creek during the time period of these diversions. This information was obtained from monitoring gage data in downstream reaches of Rosewood Creek and is deemed to be slightly conservative, as the contributing watershed at the monitoring gage is larger than the contributing watershed at each of the Project diversions.

Finally, each diversion will remain in place until construction of all of the tie-ins have been completed (all three operating at one time). After acceptance of all of the tie-ins by the Engineer and regulatory agencies with jurisdiction over the Project, the flows will be introduced into the new channel at the upstream tie in, by removal of the upstream diversion. During this wetting of the new channel, water quality monitoring (turbidity) will be conducted at the downstream end of the Project to ensure that effluent standards are met. In the event that discharge occurs above the regulated constituent level, the creek will be dewatered downstream of the State Route 28 culvert and pumped into a "dirtbag" for infiltration into adjacent ground. The effluent will be observed and monitored until the effluent appears (visually) to have improved. At this time, when the effluent is within the regulated constituent limits, the dewatering will cease to be performed.

10.4 Temporary BMPs/SWPPP Measures

The Project is a complex restoration project within the highly regulated Lake Tahoe Basin. Similar to all projects of this size and type, a Project-specific SWPPP has been developed (Appendix D) that describes specific construction controls to be implemented in order to reduce the risk of an effluent discharge or other violation of the National Pollutant Discharge Elimination System requirements. In addition to the typical temporary BMPs for projects of this nature, the Project includes a detailed diversion plan for the diversion of the creek (as described in the section above and in detail in the SWPPP [Appendix D]). Standard temporary controls for the Project include the following:

- Reinforced silt fence;
- Water-filled berm;
- Gravel construction entrances;
- Coir logs and wattles;
- Inlet and sediment trap protection;
- Construction fencing; and
- Revegetation warning signs.

These items are generally depicted on the Project Plan Temporary Erosion Control Sheets (Sheets EC-1 through EC-4 in Appendix A) and are described in detail in the Project SWPPP (Appendix D).

10.5 Temporary Buried Protection

The Temporary Erosion Control Plan Sheets (Sheets EC-1 through EC-4 in Appendix D) identify several locations where "temporary buried protection" shall be installed in Phase 1. This is a temporary protection of the new channel and floodplain from effects due to the existing channel and potential high flows that could occur during Phase 2 or Phase 3. The temporary buried protection will be installed during Phase 1 of the Project and will be removed during the Phase 3 of the Project. These features involve installing sheet pile in specific locations to a depth below the existing channel flowline and to the existing ground surface. The areas to be protected in this manner are locations where the existing channel, and existing channel forces, have a potential to impact the new channel or floodplain (and revegetation) during Phase 2.

The following design criteria and guidance were used in determining the locations where the temporary buried protection would be installed:

- Locations where the existing and proposed channel are within 20 ft of one another and the existing channel planimetry is in the general direction of the new channel;
- In the vicinity of the existing secondary channel;
- Locations where Phase 1 work is within 10 ft of the existing channel;
- Upstream and downstream of new and existing channel crossings; and
- Upstream of the downstream tie-in.

Chapter 11

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Chapter 12

References

Chow, V. T. 1959. Open Channel Hydraulics. New York, McGraw-Hill Book Company.

Corps. See U.S. Army Corps of Engineers.

ENTRIX, Inc.. 2001. Geomorphic Assessment Report: Third, Incline, and Rosewood Creeks, Section 206 Aquatic Ecosystem Restoration Project. Prepared for the U.S. Army Corps of Engineers, Sacramento District, Sacramento, CA.

MACTEC Engineering and Consulting. 2003. Rosewood Creek Design Report, Rosewood Creek Stream Restoration, Washoe County, NV. Prepared for Incline Village General Improvement District, Stateline, NV.

Mainstream. See Mainstream Restoration, Inc.

Mainstream Restoration, Inc. 2005. Middle Rosewood Creek Geomorphic and Riparian Vegetation Assessment. Prepared for Nevada Tahoe Conservation District, Stateline, NV. November.

Montgomery, D. R. and J. M. Buffington. 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin 109(5): 596-611.

Swanson, M. 2000. Third and Incline Creek Watershed Assessment for Sediment Reduction: Incline and Third Creeks, Lake Tahoe Basin, NV. Prepared for the Tahoe Regional Planning Agency by Swanson Hydrology & Geomorphology.

U.S. Army Corps of Engineers (Corps). 2004. Draft Environmental Assessment. Third, Incline, and Rosewood Creek Section 206 Aquatic Ecosystem Restoration, Washoe County, NV. Sacramento, CA.

USBOR. See U.S. Bureau of Reclamation.

U.S. Bureau of Reclamation, 2010. Environmental Assessment and Finding of No Significant Impact – Rosewood Creek Restoration Implementation Area A.

Valley & Mountain Consulting. 2006a. Middle Rosewood Creek SEZ Restoration, Concept Plan. Prepared for the Nevada Tahoe Conservation District by Valley & Mountain Consulting, ENTRIX, Inc. and Wood Rodgers, Inc. April.

Valley & Mountain Consulting. 2006b. Middle Rosewood Creek SEZ Restoration Project, Implementation Plan. Prepared for the Nevada Tahoe Conservation District by Valley & Mountain Consulting, ENTRIX, Inc., and Wood Rodgers, Inc. April.

Watershed Restoration Associates. 1999. Incline Creek and Third Creek Watershed Assessment Memorandum. Presented to the Incline Village General Improvement District. Prepared by Swanson Hydrology & Geomorphology and River Run.

Wood Rodgers, Inc. 2010. Environmental Assessment, Restoration of Rosewood Creek Area A.

Wood Rodgers, Inc. 2009. Geotechnical Investigation, Restoration of Rosewood Creek Area A.

Yochum, S. and B. Bledsoe. 2010. Flow Resistance Estimation in High-Gradient Streams. Fourth Federal Interagency Hydrologic Modeling Conference, Las Vegas, NV.

Appendix A

Project Plans

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Appendix B

Project Special Technical Specifications

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Appendix C

HEC-RAS Output Data

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Appendix D

Storm Water Pollution Prevention Plan

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Appendix E

Geotechnical Report

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