Ecological Resource Consultants, Inc.
35715 US Hwy. 40, Suite D204 ~ Evergreen, CO ~ 80439 ~ (303) 679-4820

Upper Swan River Restoration Concept Plan

April 24, 2012

Prepared for:

Blue River Watershed Group

BRWG
Blue River Watershed Group

130 Ski Hill Road, Suite 110
Breckenridge, CO 80424

Prepared by:

Ecological Resource Consultants, Inc.

ERC

35715 US Hwy 40, Suite D204
Evergreen, CO 80439

ERC Project # 860-111

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1.0 INTRODUCTION

1.1 Project Background

The Blue River Watershed Group (BRWG) desires to complete a Concept Plan (Concept Plan) for restoration of the Upper Swan River from approximately 5,500 feet upstream (east) of Muggins Gulch upstream (south) to the Parkville site (herein referred to as "Project Area"). Ecological Resource Consultants, Inc. (ERC) was contracted to develop a Concept Plan for the Project Area that was compatible with the immediately downstream Swan River Restoration Plan (October 27, 2009) (herein referred to as "2009 Plan") prepared by Summit County and was developed in close coordination with current gravel operations for removing and processing the existing dredge material. A large portion of the Project Area is located on private property; however the overall Concept Plan was developed in close coordination with Summit County Open Space, the Town of Breckenridge and the US Forest Service.

The total distance of the Project Area as measured along the Swan River valley is approximately 6,665 feet located in the Swan River drainage, a major tributary of the Blue River, in Summit County, Colorado. The entire approximately 88-acre Project Area as well the downstream area subject of the 2009 Plan have been extensively disturbed from historic dredge mining activities. The stream corridor and valley bottom are relatively devoid of ecological function and the Swan River is highly degraded and channelized. As a result of the dredge material, the Swan River flows subsurface through portions of stream corridor. The project goal is to restore the channel and adjacent areas within the Project Area, returning them to a natural and functional state. Objectives for the Concept Plan included the following:

- Create a natural, stable channel based on existing and anticipated flows and sediment loads,
- Establish instream aquatic habitat including pools, riffles, glides, spawning and rearing areas and promote aquatic macroinvertebrate populations,
- Protect and enhance existing wetlands,
- Restore riparian and floodplain function and habitat by removing dredge piles within the riparian corridor, recontouring banks and establishing vegetation,
- Maintain groundwater return flows seeping into the stream,
- Improve the aesthetics of the area by creating a natural system with sufficient capacity to transport flood flows,
- Remove, regrade and cap remaining dredge piles to reduce erosion and promote upland revegetation,
- Demonstrate stream restoration techniques as a model for on-going efforts to reclaim other stream reaches degraded by historic dredge mining,
- Create a fish barrier(s) that prevents upstream migration of non-native brook trout, and
- Account for revised and appropriate road/stream crossings which provide appropriate fish habitat.

1.2 2009 Summit County Plan

One integral component of the Concept Plan was to incorporate the 2009 Plan prepared by Summit County to ensure that the two plans were generally consistent and compatible. The location of the area addressed by the 2009 Plan is immediately downstream of this proposed Project Area. The 2009 Plan provided a conceptual plan for restoration of over one mile of stream through 50 acres of land owned by Summit County and the Town of Breckenridge.

Similar to this Concept Plan, the 2009 Plan was based on the concept of creating a natural stream corridor; however design elements presented in the 2009 Plan only provide general restoration properties and do not include the level of detail in either analysis of geomorphologic characteristics or appropriate channel geometry. The 2009 Plan presents typical templates for proposed stream geometry, but lacks specific design elements including channel widths and design elevations necessary to achieve sustainable restoration.

Overall ERC found that the general concepts presented in the 2009 Plan were compatible with our restoration approach presented herein. Detailed components of ERC's Concept Plan produced as a result of our evaluation of hydrology and geomorphology can be applied to the 2009 Plan. This will ensure that both projects are implemented in a consistent and sustainable manner.

1.3 2007 Summit County Restoration Work

During the summer of 2007, Summit County and the Town of Breckenridge worked with an adjacent landowner to recreate a functioning floodplain along the Swan River just downstream of the 2009 Plan project area. This work included removal of approximately 8,000 cubic yards of unprocessed gravel from the previously dredged site, pulling down artificially steepened piles to create an undulating and natural appearing topography, importing and spreading topsoil at an approximate depth of 6" over the site, and hydroseeding the site with native seed mix. The project, overseen by Claffey Ecological Consulting, Inc, reestablished a functioning floodplain and revegetated adjacent uplands on approximately 12 acres of public property. The location and extents of the 2007 work is depicted on Sheet 1 – Project Overview Map in the Appendix.

2.0 PROJECT AREA

2.1 Location

The Project Area is located in the Upper Swan River drainage in Summit County Colorado. It includes approximately 1.6 miles of the Swan River and surrounding valley and is immediately upstream of the 2009 Plan Project Area. The upstream and downstream coordinates for the Project Area are 39° 30' 07" North, 105° 56' 50" West and 39° 31' 06" North, 105° 57' 16" West, respectively. Combined the two projects restore the stream and its riparian corridor along approximately 2.3 continuous miles along the Swan River Valley covering over 163 total acres. A Project Area location map is provided as **Figure 1**. **Figure 2** shows the three specific reaches of the Swan River that area the subject of the 2007 Work, 2009 Plan and this Concept Plan.

Figure 1. Project Area Location Map

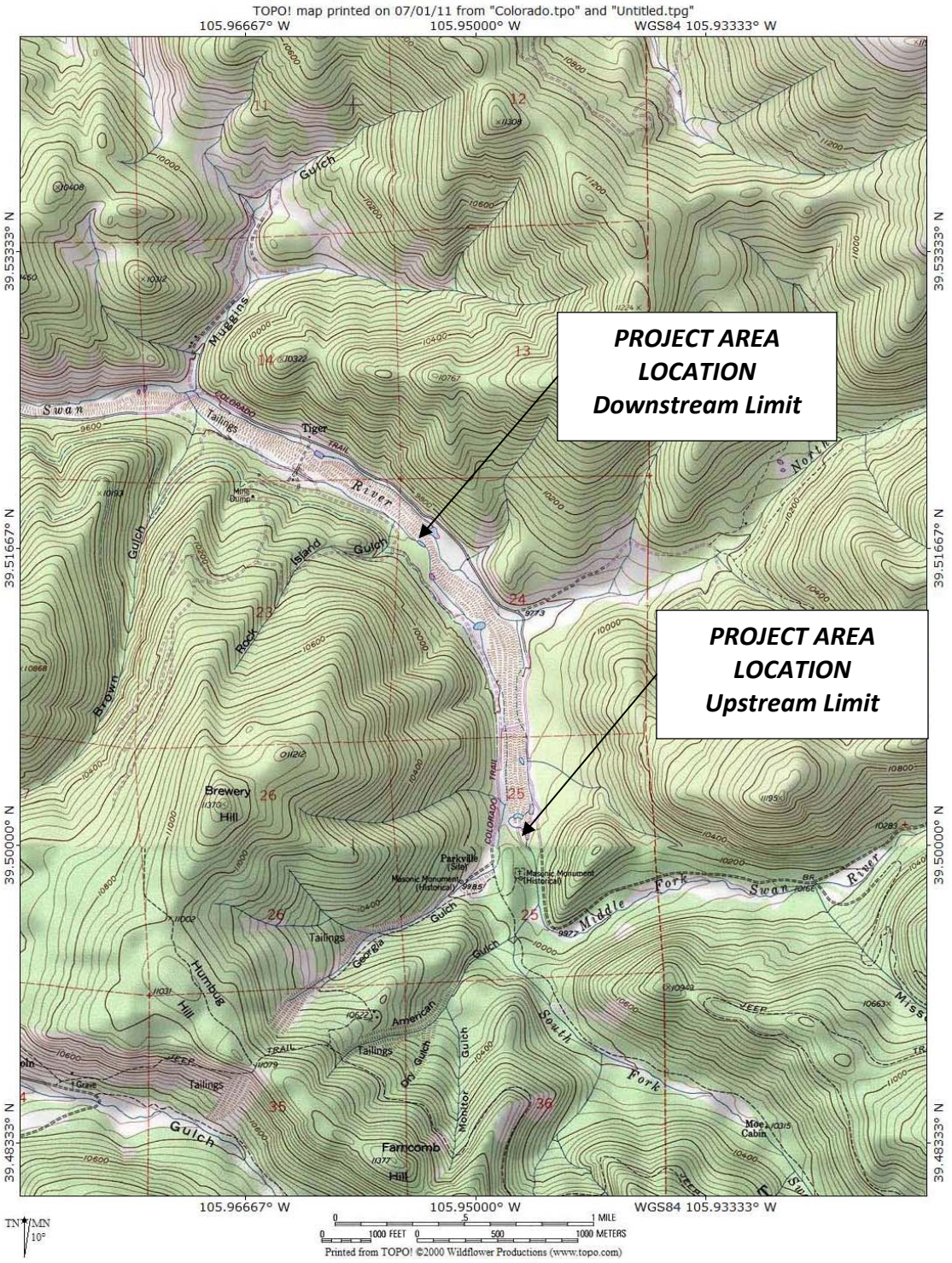
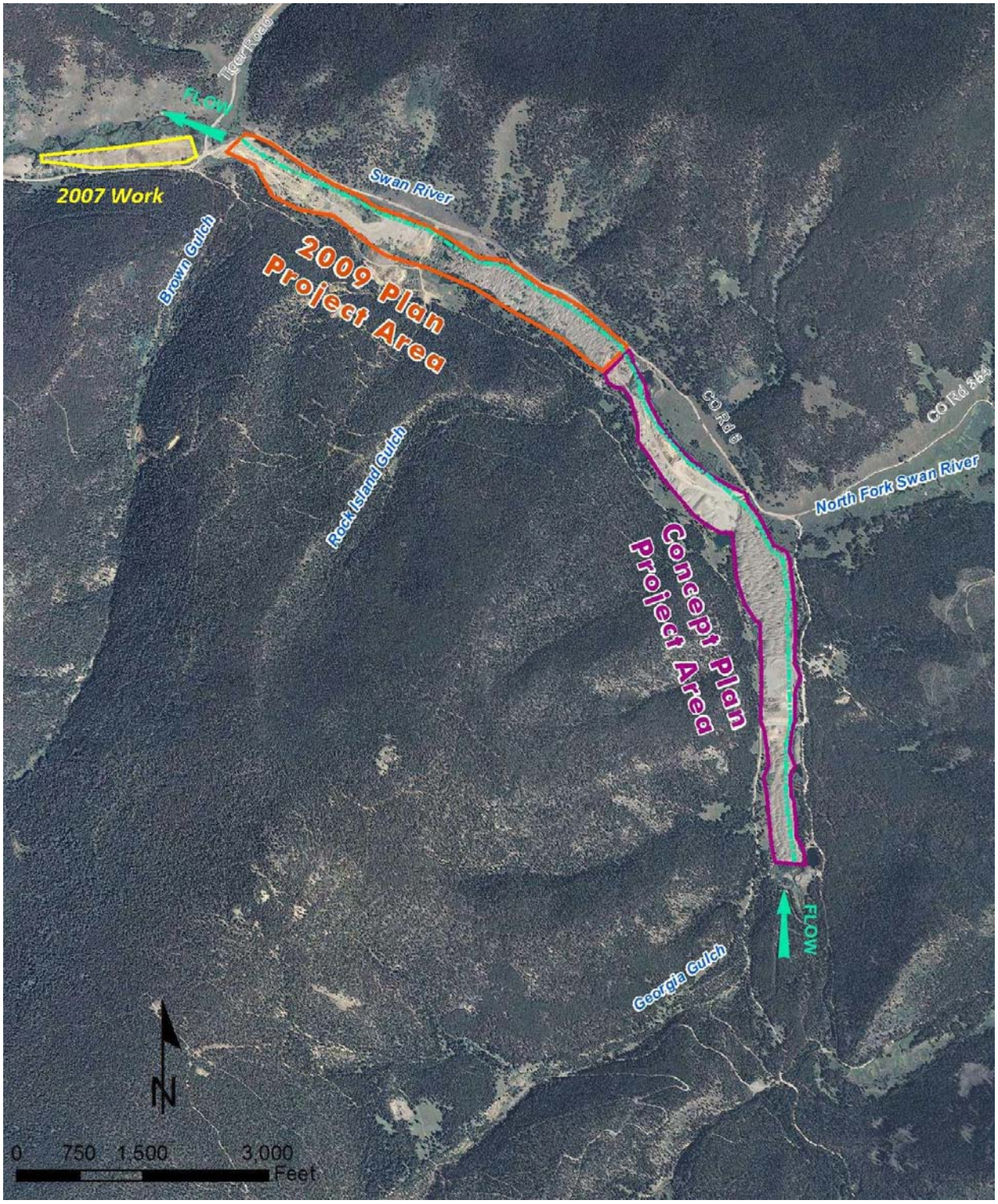


Figure 2. Swan River Project Areas Overview



2.2 Land Use

The Project Area has been historically mined using dredging techniques. Dredging was completed to an unknown depth throughout the Swan River valley as well as the nearby Blue River Valley. Dredge spoils remain on the Project Area and typically consist of sand to cobble sized materials left in piles that extend approximately 25 feet above the surrounding valley floor. The entire Project Area is practically devoid of natural vegetation and ecological function. Sporadic pockets of shrubs or young trees may exist near the existing Swan River channel or where groundwater surfaces. In portions of the Project Area, dredge material has been removed or is currently being removed and sold commercially. The stream has been channelized in large part by the dredging process and natural riparian areas are minimal to nonexistent throughout the property. Removal of the dredge material and recreation of a natural stream and riparian system are the primary focus of this Concept Plan.

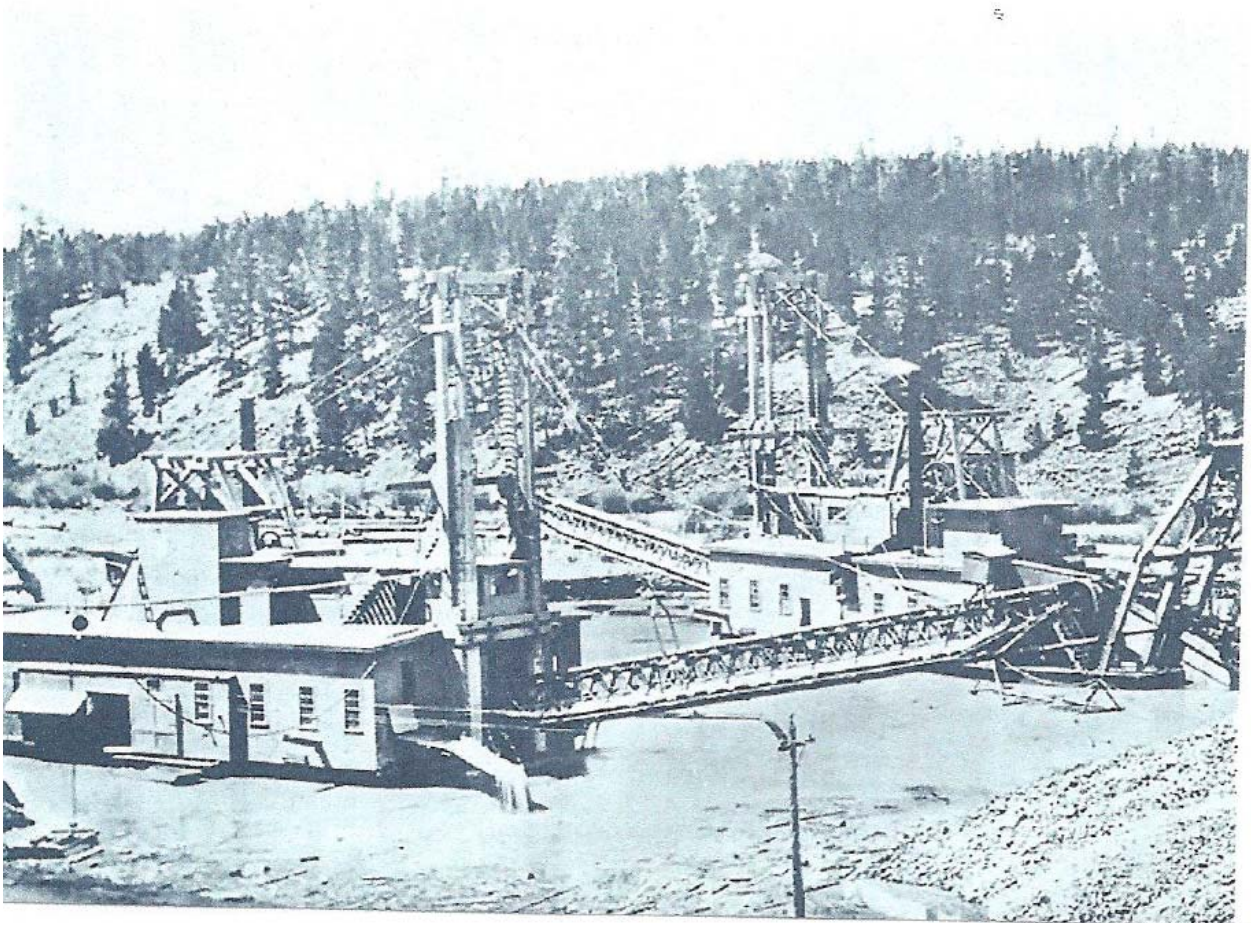


Photo 1 shows two of the dredges used in the Swan River Valley in the early 1900s.

Photo 2 shows existing dredge piles near the upstream end of the Project Area.

Photo 3 shows dredge piles and the on-going operation of removing the material. Standing water in the foreground is believed to be contact with the groundwater table.

3.0 HYDROLOGY

Estimates of flow through the Project Area were completed in order to obtain and understand the magnitude and variability of flows that can be expected. Flow data was then used to estimate appropriate channel properties and define key hydrological design parameters.

No stream gage exists on the Swan River, therefore an evaluation was performed of regional gages and results were used to estimate flows through the Project Area. Regional streamflow gages were evaluated for completeness, proximity to the Project Area and tributary drainage areas. Gages with relatively long, continuous records that are not impacted by diversions in close proximity to the Swan River basin and having tributary areas similar to the Swan River (21.9 square miles at the downstream end of the Project Area and 24.6 square miles as measured downstream of Browns Gulch) were preferred.

Four local gages were identified and evaluated. They included Keystone Gulch near Dillon (USGS Station 09047700), Snake River near Montezuma (USGS Station 09047500), Blue River at Blue River (USGS Station 09046490) and Turkey Creek near Red Cliff (USGS Station 09063400). Data on the four drainages are summarized in **Table 1**.

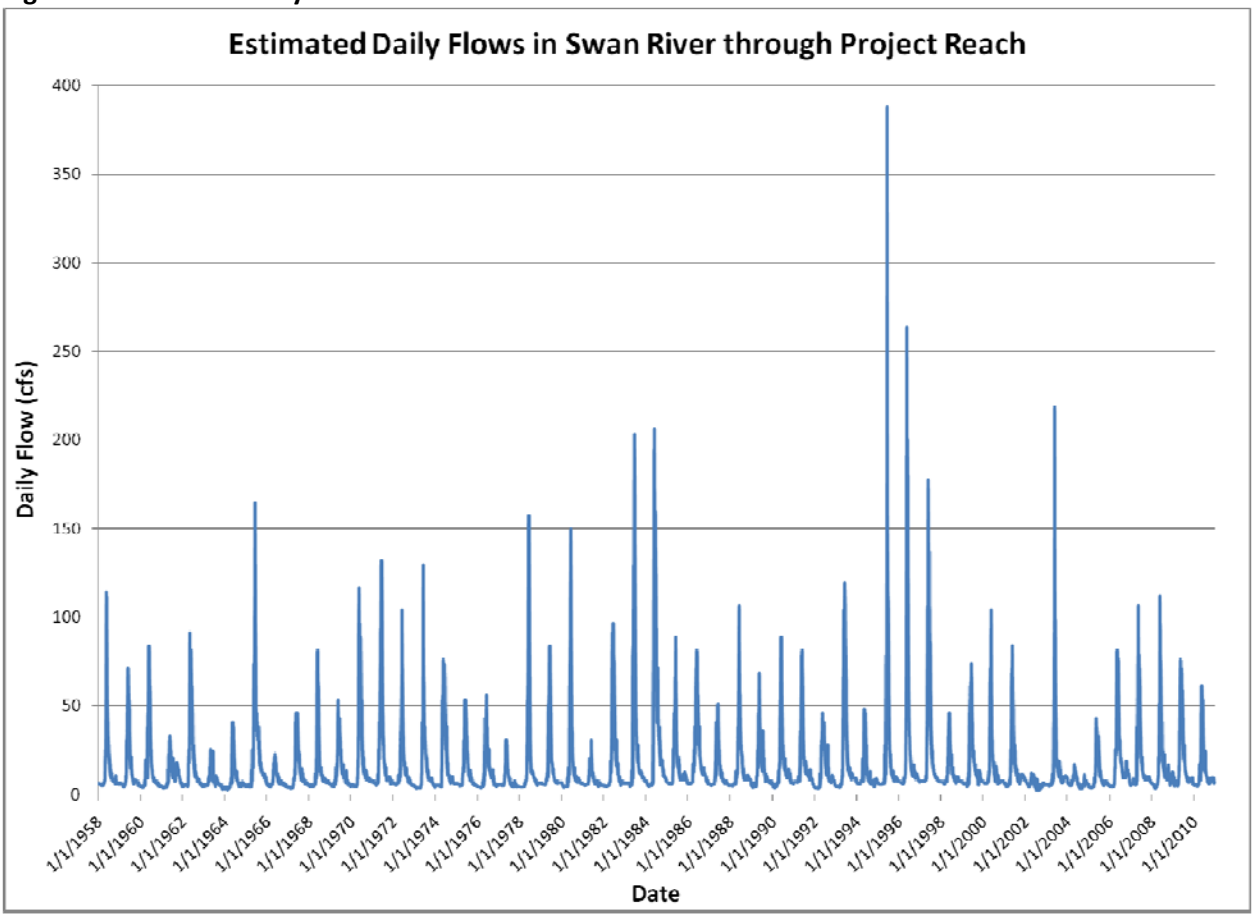
Table 1. Local Streamflow Gages

Gage	Location	Period of Record	Drainage Area	Comments
Keystone Gulch	39° 35' 40" 105° 58' 19" (6.0 miles away)	October 1957 to present	9.10 mi^2	No upstream diversions
Snake River	39° 36' 20" 105° 56' 33" (6.6 miles away)	July 1942 to September 1946, October 1951 to present	57.7 mi^2	Small upstream diversions
Blue River	39° 27' 21" 106° 01' 52" (6.0 miles away)	October 1983 to present	42.4 mi^2	Transmountain diversions upstream
Turkey Creek	39° 31' 22" 106° 20' 08" (21.0 miles away)	October 1963 to September2008	23.8 mi^2	No upstream diversions

The Blue River station was eliminated from consideration given the transmountain diversions which impact the flow records. Turkey Creek, while similar in size and basin orientation was not selected due to its distance from the site and the likely precipitation differences due to its location in the Eagle River basin. Of the remaining two, Keystone Gulch was selected as the more representative of the Swan River due to the similar drainage basin sizes and the orientation of their drainages.

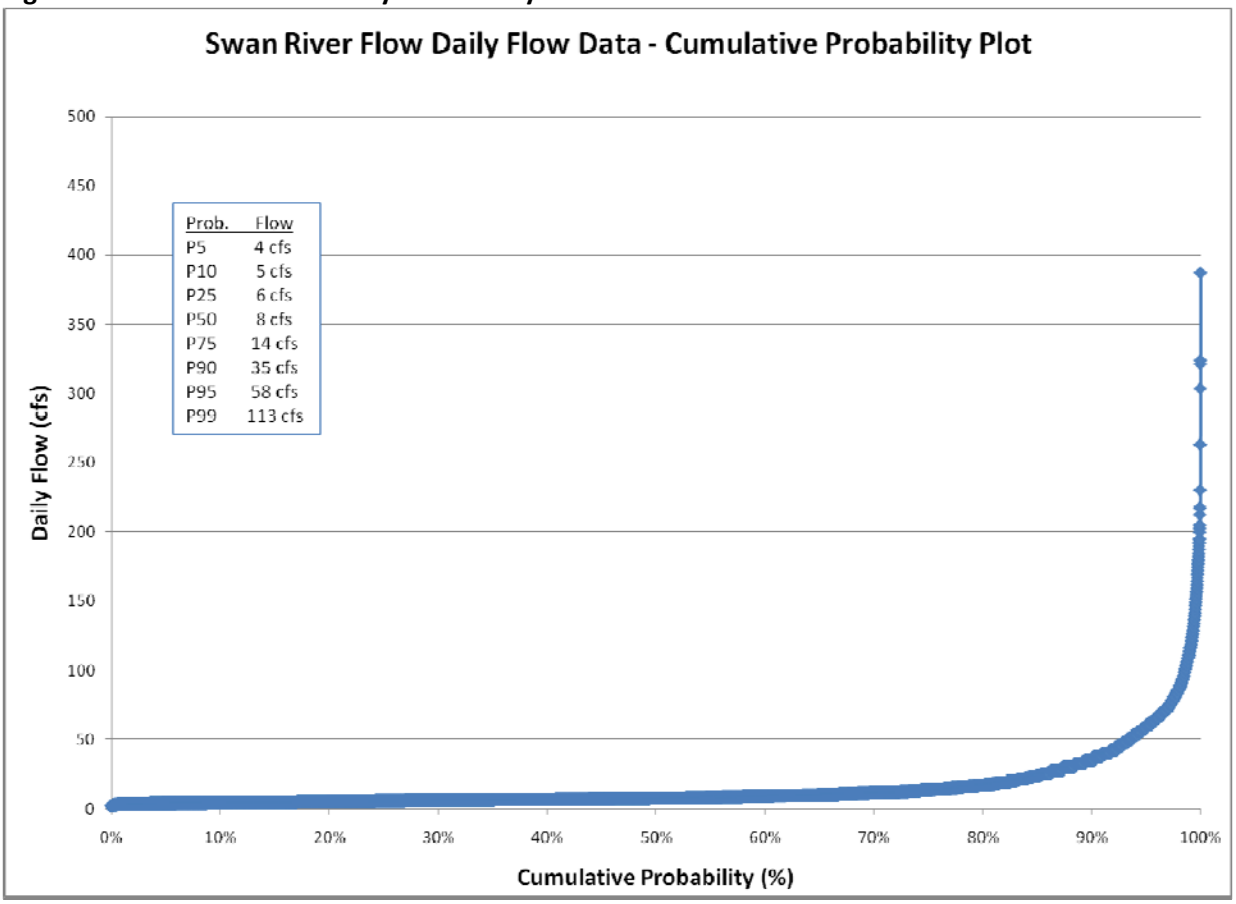
Flow estimates for the Swan River were then made based on available data from Keystone Gulch from 1958 through 2010. Daily flows measured at Keystone Gulch were multiplied by 2.53 to adjust flows from this 9.10 square mile basin to estimate daily flows at the Project Area. Estimated daily flows through the Project Area over this 53 year period of record are shown on **Figure 3**.

Figure 3. Estimated Daily Swan River Flows



As would be expected, flows show a definite seasonal trend with peak flows occurring as the result of spring runoff. Flows through the late fall and winter are typically the lowest. A cumulative probability plot of estimated daily flows was developed to quantify the percentage of times flows are less than a given flow magnitude. Results of the flow frequency analysis are shown on **Figure 4**.

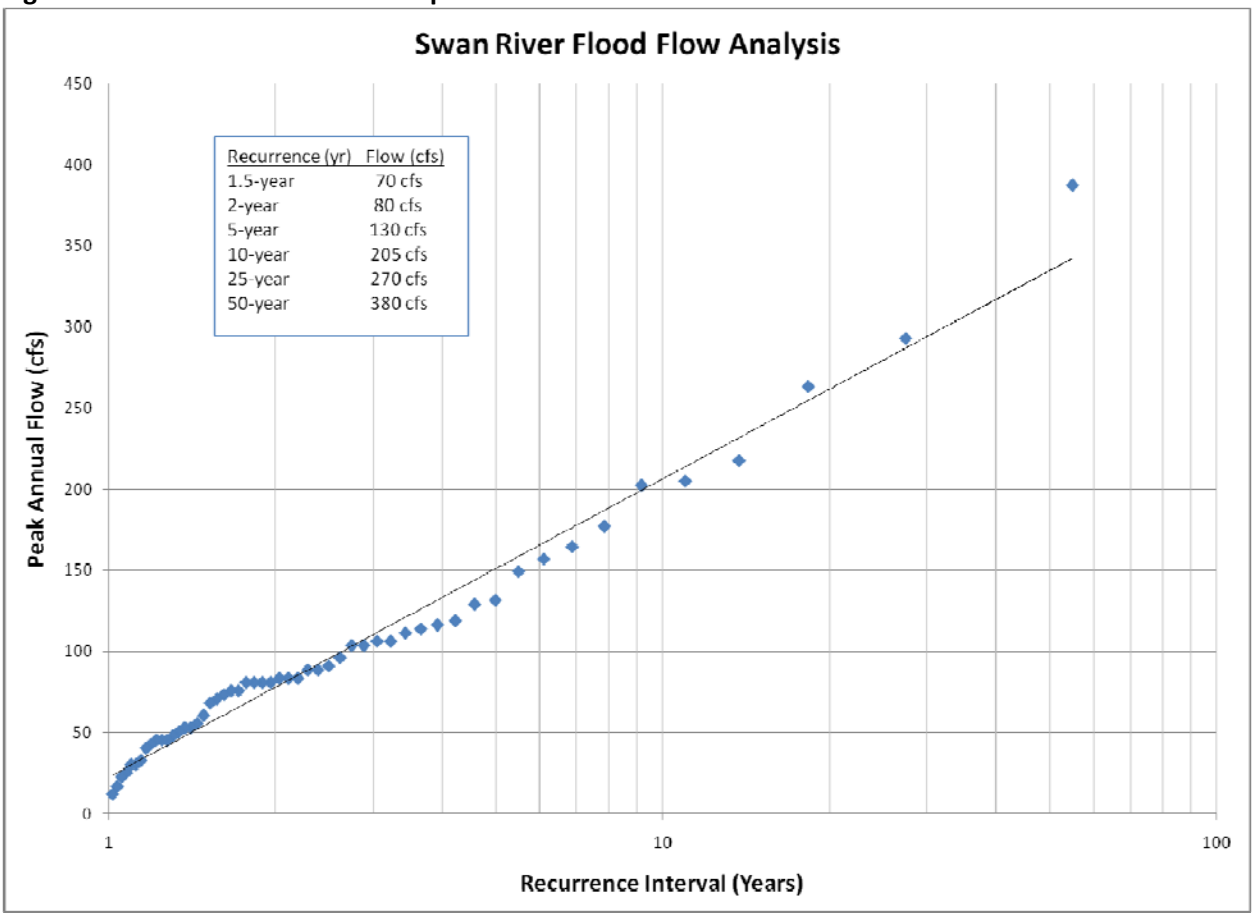
Figure 4. Cumulative Probability Plot – Daily Flows



Results indicate that 5% of the time, flows are predicted to be at or below 4 cubic feet per second (cfs). Flows are expected to be at or below 8 cfs 50% of the time and at or below 58 cfs 95% of the time. Over the 53 years flows are estimated to range from a low of approximately 2.2 cfs to a high of 390 cfs.

Peak flood flow estimates were then made at the Project Area by an analysis of peak daily flows over the 53 year period of record. Flood flow estimates were used to develop conceptual channel geometries, specifically to estimate bankfull flow. Bankfull flow was assumed to have a recurrence interval of approximately 1.5 years. For the restoration design, the bankfull flow is intended to be the point where bank vegetation will be established. Flow statistics were calculated using daily average flows rather than peak instantaneous flows as the instantaneous peak is not believed to be the flow that creates the ordinary high water mark. Peak annual flows were plotted based on data from the Keystone Gulch gage, adjusted for basin areas, using the Weibull method to produce **Figure 5**. A trendline was added and used to approximate the recurrence interval of various peak flood flows. Different recurrence interval flood flow estimates are given on the figure. Based on this information, the bankfull flow is assumed to be on the order of 70 cfs – 80 cfs. For comparison, the peak daily flow measured at the Keystone Gulch site during 2011, which was an extremely large snowpack year, was 68 cfs, which corresponds to an estimated peak flow at Swan River of approximately 175 cfs after adjustments for the basin size. The flow corresponds to an 8-9 year flood.

Figure 5. Estimated Flood Flow Frequencies



There is an inherent uncertainty in the estimate of bankfull flows at an ungaged location. As a check on the numbers presented above, peak flows were estimated based on data from the Snake River, Blue River and the Turkey Creek gage sites. At each of these locations peak flow estimates were made using peak daily flow values and using the program StreamStat. StreamStat provides flow estimates for the instantaneous 2-, 5,- 10-, 25-, 50-, and 100-, 200-, and 500-year flood values. The 1.5-year event at each location was extrapolated using probability plotting based on flows estimated by the program. Results using these different techniques at the various locations are summarized in **Table 2**.

Table 2. Comparison of Flow Estimates at Different Locations Using Different Methods

Site	Area (mi^2)	Gage Data Estimate (peak daily – cfs)	Unit Flow (cfs/mi^2)	StreamStat Estimate (peak instantaneous – cfs)	Unit Flow (cfs/mi^2)
Keystone Gulch	9.10	27	2.97	75	8.21
Blue River	42.2	118	2.80	380	8.96
Snake River	57.7	360	6.24	460	7.96
Turkey Creek	23.8	130	5.46	195	8.19
Mean	NA	NA	4.37	NA	8.33
Median	NA	NA	4.22	NA	8.20

Results indicate similar unit flows per acre at all locations when utilizing StreamStat, which is to be expected as the equations used to predict peak flood flows are based on a regional regression equation. From StreamStat results it can be concluded that the peak instantaneous 1.5-year flood event produces approximately 8.3 cfs per square mile. Greater variability was obtained based on the evaluation of stream gage data. These results range from 2.80 cfs per square mile to 6.24 cfs per square mile with mean and median values of approximately 4.3 cfs per square mile. The lowest flow per unit area was calculated at the Blue River site. As there are transmountain diversions from this system, values calculated based on gage data most likely underestimate peak flows in a natural system.

The Keystone Gulch gage analysis, which was used to estimate daily flows at the project site, produced the second lowest unit flow estimate which was approximately 1.3 cfs per square mile less than the mean and median values. This suggests that bankfull flow estimates based on the Keystone Gulch gage may underestimate actual conditions for the 1.5 year-peak daily flow. Using the median value of 4.22 from the four stations, the peak daily 1.5-year flow at the downstream end of the project site (21.9 square miles) would be approximately 93 cfs which is approximately 15% to 35% greater than the 70-80 cfs estimate for bankfull flow presented above. Estimates from StreamStat are significantly higher and would suggest 1.5-year peak instantaneous flows of approximately 180 cfs.

As the results above suggest, bankfull flow estimates are not certain values and should be verified prior to final design. Additional field verification will include a survey of cross sections at downstream locations by the US Forest Service and additional survey and hydraulic modeling in a reference section downstream of the North Fork (See Section 5.1) by ERC as part of the design. Final bankfull flow estimates to be used in the detailed design will be determined as part of these analyses. Detailed hydraulic modeling of the full proposed channel will also be completed during final design to ensure compatibility between bankfull flows, ultimate channel profiles and channel cross sections.

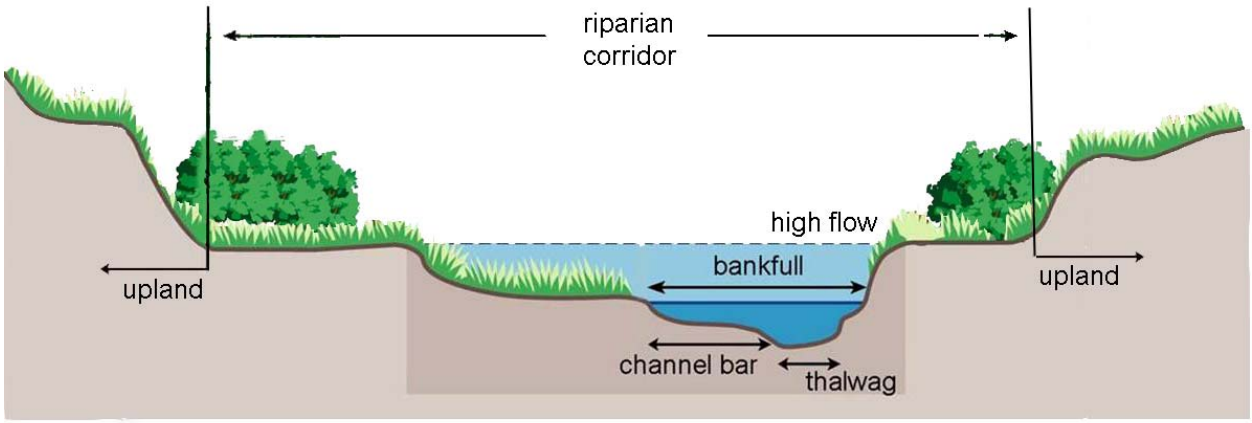
4.0 CONCEPTUAL RESTORATION DESIGN

4.1 Natural Restoration Concept

A natural based restoration approach was taken for all proposed improvements, whenever possible. The guiding principle of ERC's natural restoration approach is that a restored stream system should mimic a natural channel in appearance and function. Recreating the natural form and function within the stream system will allow lost balance and ecologic benefits to be restored. Like a natural channel, restoration was approached with a design that will allow the stream to migrate in response to flow and sediment loads, but is intended to maintain its basic form without significant aggradation or degradation. This approach, rather than a structural approach to restoration, is of the utmost importance to this project so that the restored resources function holistically and recreate the desired natural characteristics throughout the Project Area.

As part of this approach, design concepts considered improvements to the channel and the connection between the stream and adjacent lands. Improvements recommended as part of this Concept Plan include an appropriately sized channel to convey typical and bankfull flow events, a riparian corridor and transitions into upland areas. A schematic showing the relationship between the stream and adjacent lands considered in this Concept Plan is presented in **Figure 6**.

Figure 6. Schematic of Stream and Adjacent Lands in a Natural System



Natural stream improvements are sustainable, provide natural resource benefits, promote active recreation such as angling and passive recreation such as bird watching and relaxing, and result in a stream corridor that is aesthetically pleasing. ERC's restoration approach incorporates features that would be found in an undisturbed ecosystem and is based on fundamental geomorphologic and reference reach principles. For the project setting, natural restoration includes features such as riffles, bend pools, glides, instream habitat, stable vegetated banks and riparian and upland vegetation. Structural stream control features such as rock weirs, arches, jetties and vanes that are common to many stream projects, yet are not natural features, were not considered as part of this natural design approach.

4.2 Aquatic Environment

The aquatic environment will be the life-blood of the restored Swan River local ecosystem providing forage, protection, spawning and rearing habitat for fish and other aquatic species as well as the hydrological regime to maintain a riparian community. Many factors contribute to the quality of an aquatic ecosystem. Water quality is probably the single most influential component. Water quality elements such as temperature, pH, dissolved oxygen and suspended solids can determine the productivity of a stream system. From an aquatic standpoint, historic mining activities through the Project Area have left the Swan River relatively devoid of natural features. Slow moving deep pool habitat, steeper, oxygenated riffle sections, slack backwater areas and gravel spawning beds are all important habitat typical of western streams. Instream cover (rocks, undercut banks, logs and debris) and overhead vegetation are imperative to support healthy macroinvertebrate and fish populations. These characteristics are not present through the Project Area and are the focus of the instream portions of the Concept Plan.

Specifically of concern is preservation of a known nearly pure genetic strain of the native Colorado River cutthroat trout (*Oncorhynchus clarkia pleuriticus*) (CRCT) located on upstream tributaries. The Forest Service has expressed a desire to restore this entire area, including both project sites with CRCT through elimination of existing non-native brook trout (*Salvelinus fontinalis*) and creation of fish movement barriers. CRCT is designated as a special status species by the states of Colorado, Utah and Wyoming. Today, remaining CRCT populations are primarily limited to small headwater streams and lakes within their historic range. The US Department of Agriculture Forest Service 2005 Range-Wide Status of CRCT states that approximately 21,386-miles of stream habitat were identified as having the potential of being historically occupied by CRCT, of which about 13,615 are in Colorado. Currently CRCT occupy only about 1,359 miles of stream in Colorado, of which 46-miles is located in the Blue River Hydrologic Unit Code (HUC) 14010002. Of the total existing CRCT habitat the study further states that only 12.4% is considered excellent in Colorado. Therefore the restoration of excellent CRCT habitat is a basic principle of this Concept Plan.

The Concept Plan focuses on creating an aquatic environment that provides a healthy, diverse and self-sustaining trout fishery as well as specific habitat requirements for CRCT. Young (1995) determined most lotic CRCT populations reside in streams with average daily flows of less than 30 cfs where stream gradients usually exceeded 4% and elevations exceed 7,500 feet. As defined by the US Fish and Wildlife Service's Habitat Suitability Indexes (HSI, February 1982), optimal CRCT riverine habitat can be characterized by clear, cold water; a silt-free rocky substrate in riffle-run areas; an approximately 1:1 pool-to-riffle ratio, with areas of slow, deep water; well-vegetated stream banks; abundant instream cover; and relatively stable water flow, temperature regimes, and stream banks. Cover and overwintering habitat are recognized as essential components of trout streams. Cover for adult trout consists of areas of obscure stream bottom in areas of water greater than 15 centimeters deep with a low velocity less than 15 centimeters per second. These basic principles will be the fundamental guidelines for developing the instream aquatic environment as part of the Concept Plan.

An initial objective of this project was to provide a fish barrier structure to eliminate the migration of downstream brook trout and facilitate isolation of the upper Swan River Basin for CRCT habitat. Through discussions with the US Forest Service and project proponents throughout the development of this plan it was decided that the fish barrier would ideally be located at an existing road crossing within the limits of the 2009 Plan area. As a result a fish barrier was not included as part of this Concept Plan.

5.0 CHANNEL MORPHOLOGY

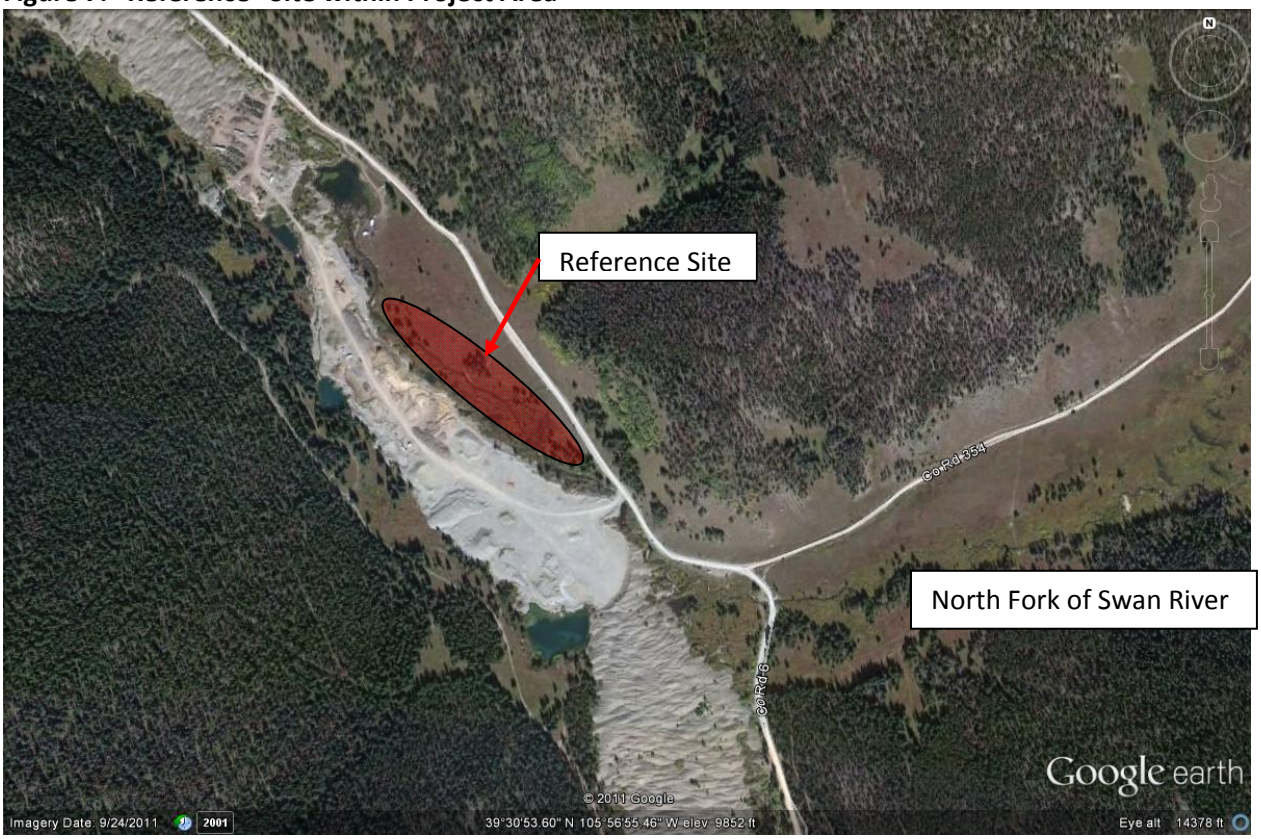
One of the key components of the restoration design was establishing the appropriate geometry for the restored stream. Appropriate channel widths were estimated based on standard geomorphologic principles and verified by review of "reference" conditions identified within the Project Area. Appropriate channel planform was estimated based on typical properties for the anticipated stable stream type following the Rosgen Classification system (Rosgen 1996).

5.1 Bankfull Channel Width

The approximate width for the restored channel was estimated based on observed relationships relating basin area to bankfull width (Leopold 1994), (Rosgen 1996). For the Project Area, bankfull width is the width of the channel where it first starts to overflow into its floodplain. As indicated above, the Swan River through the Project Area has a total tributary area of approximately 22 square miles. Standard regional geomorphologic curves suggest that for this sized basin the active channel should be on the order of 25 - 30 feet wide with a mean depth of approximately 1.5 to 2.0 feet at riffle sections.

Observations of sections of the stream that are currently properly functioning were used as a check against the values estimated using the basin area/width geomorphologic relationships. For this assessment the stretch of the Swan River downstream from the confluence with the North Fork of the Swan River was evaluated. The location of this "reference" site is shown on **Figure 7**.

Figure 7. "Reference" Site within Project Area



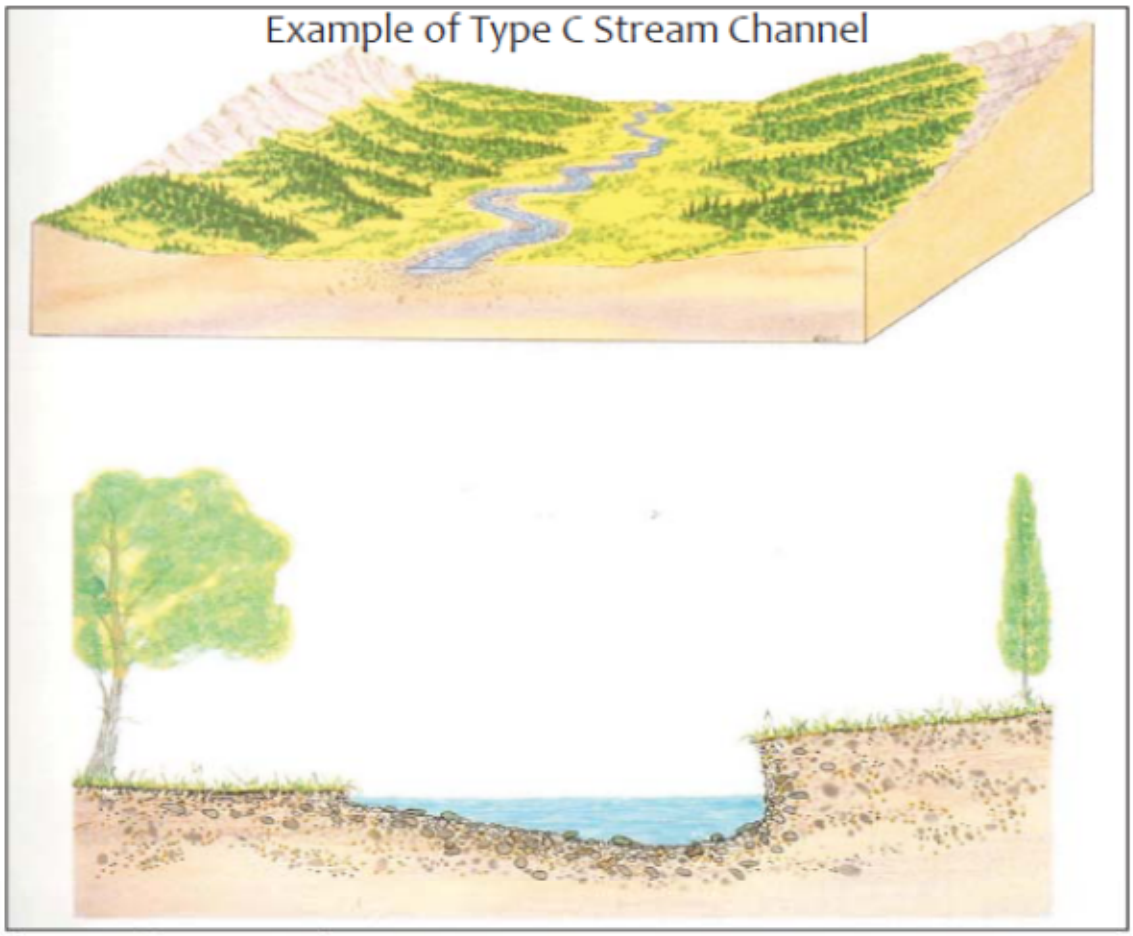
While this section of stream may or may not have been impacted in the past, it is currently functioning well with stable channel cross sections and profiles and a healthy riparian area. As discussed in more detail below, the stream through the reference site is generally straighter than typical for this type of a valley, which generally relates to narrower cross sections.

Existing bankfull channel widths were measured at five locations within this reference area. All bankfull measurements ranged from 20 – 25 feet. Measured bankfull widths are at the lower end of the widths estimated based on standard geomorphologic data, which, when coupled with the generally straight alignment of this section indicates a good relationship between estimated and measured widths. As part of future detailed design, channel widths should be evaluated further as part of detailed hydraulic modeling, however for this conceptual level work it is believed that bankfull channel widths in riffles should be approximately 25 feet and depths of 2 feet were utilized.

5.2 Channel Planform

Channel planform, or shape as observed from above, was estimated based on the stream type that is assumed to be appropriate through the Project Area. As part of this assessment other regional streams were evaluated and it was found, as would be expected, that a majority of healthy streams in this area are single thread systems. Given this and the broad, terraced valleys observed in other segments of the Swan River, ERC believes that a Rosgen Cb Stream Type is appropriate. A Type Cb stream is a single thread channel alluvial stream. It typically includes a meandering planform with point bars and riffle/pool sequences and has a broad, defined floodplain.

Figure 8. Schematic of Typical Type C Stream



Typical published values for stream sinuosity, slope, meander wavelength and entrenchment for Type Cb3 and Cb4 streams are given on **Table 3**.

Table 3. Typical Type Cb Stream Properties

Category	Criteria
Channel Slope	2 % - 3.99%
Pool Spacing	5-7 Times Bankfull Width
Width/Depth Ratio	> 12
Entrenchment Ratio	>2.2
Sinuosity	>1.2

Meander lengths and mean radii of curvature can be approximated from channel width. A mean channel width of 25 feet relates to a meander length of approximately 280 feet and a radius of curvature of approximately 60 feet (Leopold 1992).

The conceptual planform view for the restored stream section was developed based on these general guidelines. By design, not all sections of the proposed stream exactly fit within the criteria of a typical

Type C stream due to the desire to provide variability in the stream geometry, as one finds in natural stream systems. The proposed stream planform can be seen on **Sheet 2**. A summary of the average properties measured from the proposed Concept Plan is given on **Table 4**.

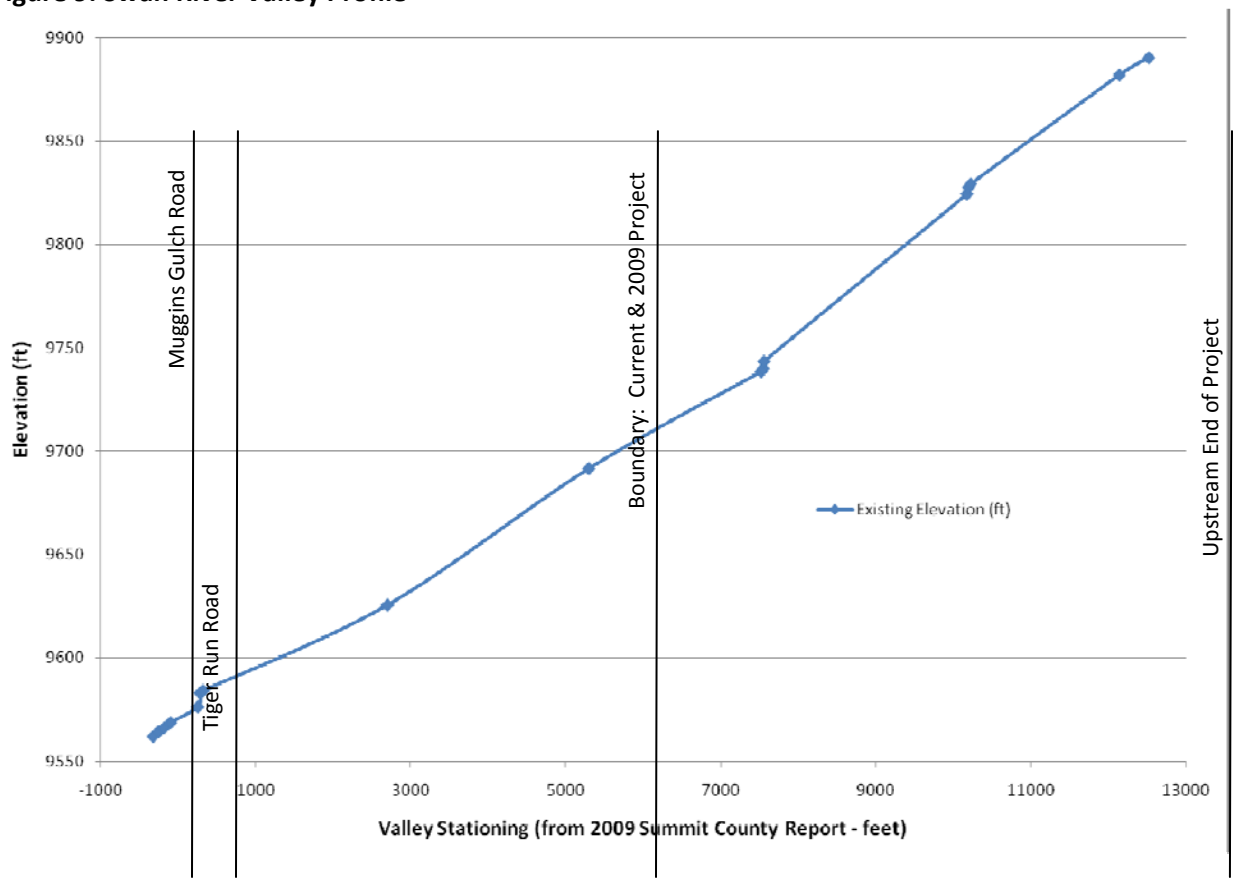
Table 4. Characteristics of Conceptual Level Restoration

Category	Value
Valley Length (ft)	6,800
Stream Length (ft)	8,300
Stream Sinuosity	1.22
Number of Bend Pools	47
Average Pool Spacing	177 (7 bankfull widths)
Riffle Bankfull Width (ft)	25
Riffle Bankfull Depth (ft)	2
Width/Depth Ratio	12.5
Channel Slope	2.3%
Floodprone Depth (ft)	4
Floodprone Width (ft)	> 100
Entrenchment Ratio	>4

5.3 Stream Profile

A profile of the existing stream was developed. The effort was limited by the fact that detailed topographic mapping of the Project Area is not available. In order to approximate the profile, ERC completed a limited site survey which included selected point locations along the existing stream channel, at all existing stream crossings, at select locations where groundwater intercepts the surface and at the upstream and downstream ends of the Project Area. This limited survey allows for a preliminary level understanding of the desired channel gradients across the Project Area. Results showing the existing stream profile, including both areas part of this Concept Plan and the 2009 Plan are shown on **Figure 9**. The stationing used to generate the profile is taken along the valley, rather than along the stream centerline. The intersection of Tiger Run Road and the Swan River following the alignment presented in the 2009 Plan was used to establish the 0+00 station. Key locations are identified on the profile.

Figure 9. Swan River Valley Profile



Overall the profile extends from the existing stream channel downstream of the Muggins Gulch road crossing upstream approximately 380 linear feet beyond the upstream extent of this Project Area boundary for a total of nearly 13,000 linear feet. The average valley slope across this surveyed area is 2.57% and the approximate valley slope across the Project Area included as part of this Concept Plan is approximately 2.78%. Slopes include drops at road crossings which contribute a significant portion of the overall drop.

6.0 CONCEPTUAL DESIGN COMPONENTS

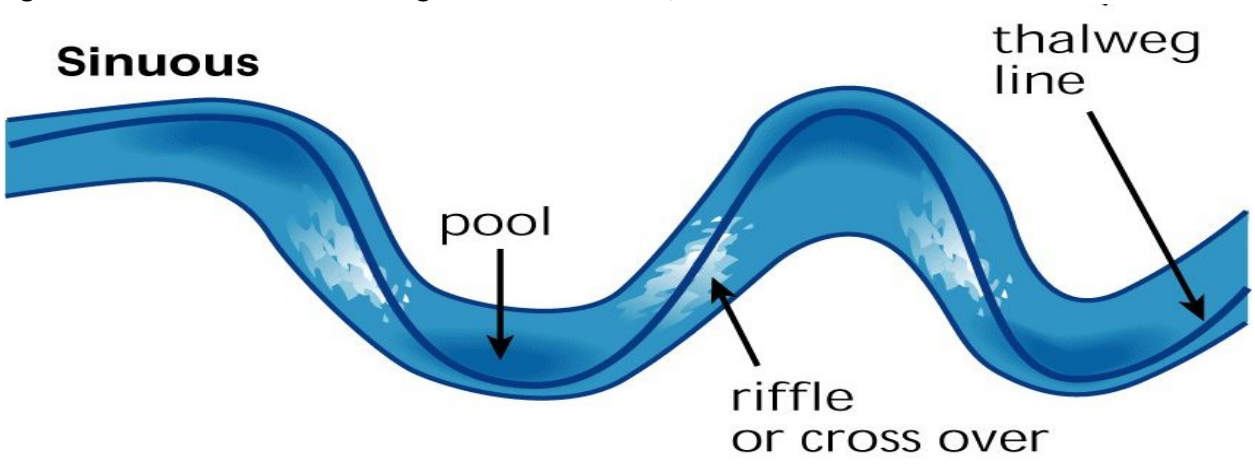
The main elements of the enhancement design include creating a natural, meandering channel, providing quality instream habitat, stabilizing banks utilizing bioengineering techniques, creating a native riparian terrace and reclaiming upland areas. Methods used to achieve these improvements are discussed in this section of the report.

6.1 Channel Form

Sheets 2 of the Concept Plan shows the plan and profile of the proposed concepts. A key element of the proposed channel design is creating a meandering pattern that is in balance with the natural hydrograph. The proposed channel takes on an alignment that is generally meandering through the valley. It has an overall sinuosity of 1.22 and follows a non uniform route to achieve the type of diversity that is observed in natural streams. The straightest section of the planned stream is downstream of the

confluence with the North Fork of the Swan River. This section of the stream is proposed to remain in its current alignment. While straighter than a typical Type Cb stream this section of the stream was found to be functioning well with stable banks and established riparian vegetation along the stream corridor. Another section from approximately station 51+00 to 61+00 on the Concept Plan has been designed straighter than a typical Type Cb stream in order to maximize available usable land at the request of the current landowner.

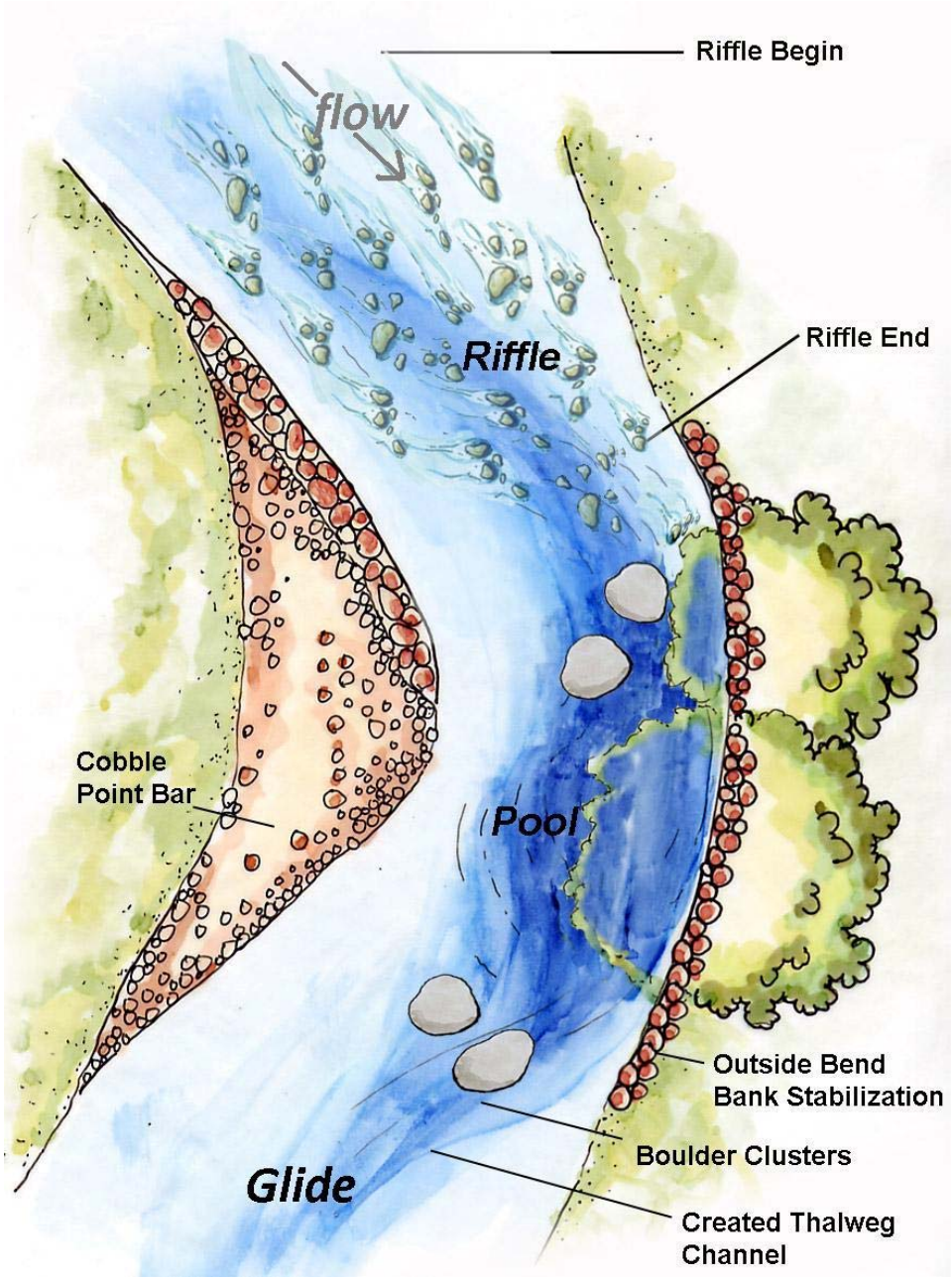
Figure10. Schematic of Meandering Channel with Riffle/Bend Pools



Type Cb stream are dominated by repeating riffle/bend pool complexes and point bars. Riffles are the steeper sections of the stream and generally located upstream from larger channel bends. Riffles are characterized by larger substrate material and swift flows. Pools are located downstream of riffles and are typically at or near the more pronounced bends in the stream. The higher flow velocity of the riffle sections provide energy required to continually scour the pools maintaining quality pool habitat. Glides are located between pools and riffles and generally have a mild adverse slope leading from the end of a pool up to the start of the next riffle. Glides have a well-defined thalweg that contain flow to a defined channel during low flow periods. Schematic templates depicting typical geometries of riffle, pool and glide cross sections are presented on **Sheet 3** of the Concept Plan.

Native material will be used to line all portions of the channel. Stability calculations were performed to estimate rock sizes required for each of the different zones within the stream. For these calculations rounded rock and a required factor of safety of 1.5 for mobilization at bankfull conditions were assumed. Recommended rock sizing for the various portions of the channel for this conceptual level design are summarized on **Sheet 3** of the Concept Plan.

Figure11. Schematic of Riffle/Pool Complex



6.2 Bank Stabilization

Stabilizing the newly constructed channel banks will be important in maintaining water quality and sustaining the constructed channel. The long-term goal of the restoration work is to create a condition where bank stability is achieved through vegetation. During initial vegetation establishment, however, additional stabilization measures are needed. Restoration concepts are therefore to provide adequate

native vegetation along the stream corridor yet supplement this with additional, temporary stabilization measures.

Different levels of stabilization are expected to be required for different shear stresses. In straight sections of the channel and along inside bends, stresses will be relatively low and stabilization requirements will be less. Along outside bends stresses will be highest and additional stabilization measures will be warranted. Two different stabilization concepts were developed to meet these different requirements.

For both conditions, the key to relieving stresses on the banks is allowing flood flows to access its floodplain where flows can then spread out over a larger area. For this reason all banks should be constructed to the bankfull elevation and riparian terraces immediately adjacent to the stream should be gently sloped back towards the channel. This general configuration will allow for the dissipation of energy and activation of the floodplain.

As was observed in the reference area, existing stream banks consisting of a combination of cobbles, gravels and fine material with healthy stands of riparian vegetation were stable at all locations observed. This natural condition should be replicated in the constructed banks. Both levels of bank protection proposed therefore utilize a cobble toe and riparian vegetation. In both cases the riparian terrace area behind the banks are planned to be sloped back to the stream at a 2% grade. Mineral soil should be placed along these banks at a minimum depth of 12 inches and it should be seeded using native riparian grasses. A temporary erosion control fabric should be used to cover the soil and protect it during vegetation establishment. This soil, seed and erosion control fabric is designed to extend for 50 feet on both sides of the channel. Biolog check structures will be installed along the banks perpendicular to flow to help minimize flow velocities that could be encountered during vegetation establishment when the banks are the most susceptible to erosion. The biolog is biodegradable and intended to provide protection only during the initial establishment period.

The same general concept is recommended for both types of bank stabilization. Given the higher stresses that will occur along outside bends, additional protection will be required. Brush layering using native willows (*Salix spp.*) is planned along outside bends. Willows stakes should be harvested locally, properly prepared and layered with a density of six per linear foot of bank. Two staggered rows of #5 native willow shrubs (with fully developed rootballs) will be planted behind the bank to provide additional root mass. This larger sized potted material is recommended to provide more immediate rootmass reinforcement as well as increased survival rate. Typical details of the two proposed bank stabilization techniques are provided on **Sheet 3** of the Concept Plan.

The Concept Plan anticipates approximately 3,300 linear feet of outside bend bank stabilization and 13,300 linear feet of straight section and inside bend bank stabilization.

6.3 Riparian Corridor

Riparian corridors refer to the entire ecosystem connected to the stream consisting of the physical channel, banks, wetlands and transitional vegetation communities The Concept Plan has developed a riparian corridor that is approximately 2-3 times the bankfull width, averaging a minimum of 50 feet on

either side of the channel edge. This width provides a flood prone area that is consistent with the intended channel type.

Evaluation of aerial photographs, literature review and professional judgment of regional wetland/riparian habitats indicated that prior to significant land disturbance (i.e., dredge operations), the Project Area likely contained suitable elevation, geomorphic setting and climate for montane willow riparian shrubland.

These riparian systems, which are found throughout the region, are located along streams and drainages and typically occur as mosaic of vegetative communities that may be tree or herb dominated in areas but contain diverse shrub components throughout. The hydroperiod for these habitats is highly dependent on snowmelt and geomorphology which largely control the frequency, timing, duration and depth of flooding (Laubhan 2004). The systems consist of temporarily, seasonally and intermittently flooded shrublands comprised of broad-leaved deciduous willow dominated species in the midstory canopy (Lemly and Joe Rocchio 2009) and an understory of herbaceous species including a mix of grasses, forbs, sedges and rushes. These corridors are some of the most biologically diverse habitats having a consistent source of water and providing structural habitat diversity utilized by a wide variety of wildlife.

Photo examples of PEM/PSS riparian corridor reference condition for Summit County. Photos depict ideal riparian characteristics incorporated into the Concept Plan.

This Concept Plan focuses first on establishing a deeply rooted and dense groundcover dominated by native riparian herbaceous species that are typical to the region such as Nebraska sedge (*Carex nebrascensis),* beaked sedge (*Carex utriculata*), rushes (*Juncus spp*.), common spikerush (*Eleocharis palustris*), fowl managrass *(Glyceria striata),* bluejoint (*Calamagrostis canadensis*), mountain brome (*Bromus marginatus*), streambank wheatgrass (*Elymus laceolatus*), western wheatgrass (*Pascopyrum smithii*) and/or alpine timothy (*Phleum alpinum*). The intent is to quickly establish a groundcover to stabilize soil, minimize establishment of invasive species and promote long-term successional development. To facilitate complete ground coverage and seed bank development the entire riparian corridor would be seeded with specialized riparian seed mix that promotes species diversity, contains

locally native species that germinate rapidly and provides complete groundcover over a wide variety of hydrologic conditions.

Second, strategically placed riparian plantings are proposed along the length of the new channel to provide not only bank stability but also increased biomass and structural habitat for the fishery and terrestrial wildlife. Additionally, riparian vegetation provides biomass to the stream (leaf-litter), overhead cover (shading) and increases bug life (terrestrial and aquatic, such as caddis).
Typically, this type of riparian system includes a dense midstory of native shrubs including a variety of tall willows such as Geyer's willow (Salix geyeriana), narrowleaf willow (*Salix exigua*) or park willow (*Salix monticola*), intermixed with serviceberry (*Amelanchier alnifolia*), shrubby cinquefoil (*Pentafloides floribunda*) or thinleaf alder (*Alnus incana*). Overstory tree species are not dominant in these riparian shrub communities but may include canopy stands of blue spruce (*Picea pungens*) or quaking aspen (*Populus tremuloides*).

Riparian plantings are proposed in two general forms, (1) those associated with outside bend bank stabilization (described in **Section 6.2**) and (2) riparian planting pockets. The Concept Plan presents the creation of 50 distinct riparian planting pockets. Preliminary riparian planting pocket locations are shown schematically on **Sheet 2** of the Concept Plan and typical details of the pockets are shown on **Sheet 3**. These details and layouts were used to determine material quantities and estimate costs. It is intended, however, that exact location, size and shape of the pockets will be determined in the final design and as part of final field layout.

Riparian planting pockets are intended to create an island effect or a diverse plant community in a relatively small space, as compared to spacing individual species at greater distances. In ecological literature, this type of island habitat has a much higher functional value resulting from increased structural complexity. Significantly more bird species will utilize this type of habitat when compared to an isolated shrub or tree. In addition, the islands typically look more visually natural as compared to an isolated planting. The riparian planting pockets are also typically more successful because they act as a natural windbreak, preventing drying out from wind/sun exposure and are significantly easier to maintain during establishment periods.

Each riparian planting pocket should consist of an approximately 25 foot diameter (approximately 500 square foot) irregularly shaped circle or oval formed along the general contour of the stream channel edge. The pocket will be excavated to a depth of 2 feet, approximately 14 #5 native shrubs installed at 6 foot on-center spacing and one ball-and burlap blue spruce tree or aspen clump, backfilled with topsoil and covered with a 3 inch mulch layer. During the establishment period (2-3 years), the pocket should also be surrounded by wooden snow fencing to increase protection of the pocket from wind, wildlife predation and providing minor shading. Routine watering of the entire riparian planting pocket would be required during the establishment period.

6.4 Aquatic Micro-Habitat

The Concept Plan incorporates 47 aquatic micro-habitat features, one within each glide section of the proposed channel. Because the proposed channel will be constructed through completely barren land, many instream habitat features that commonly exist in established channels will not be present. While the Concept Plan focuses primarily on creating instream habitat diversity in the form of riffles-pools-glides and vegetated banks, additional non-structural micro-habitat features have been included to

further increase aquatic habitat complexity, diversity and instream biomass. The Concept Plan incorporates two types of aquatic micro-habitats; (1) boulder clusters and (2) log spurs (large woody debris). These features will be placed in pool and/or glide sections where velocities are low and water is slightly deeper and are intended for habitat cover only and not intended for bank stability or grade control.

(1) Boulder clusters would consist of two to four larger irregularly shaped boulders (2 foot to 3 foot diameter) placed in close proximity creating localized scour holes. Boulders are placed in configuration at differing elevations and spacing to create a diversity of water depths and velocities across the spectrum of typical stream flows.

(2) Log spurs, or what is commonly referred to as large woody debris (LWD), is common in many established rocky mountain streams creating fish habitat and biological diversity. Water flowing over and under LWD during high flow events can result in localized scour pockets or holes for cover habitats for fish. Such features can also trap smaller wood, branches leaves and organic matter that add to the complexity and diversity of aquatic life. These features would generally consist of one or more logs with a minimum diameter of 1 foot (with or without the rootwad intact) buried into stream channel bank protruding downstream, resting on the bottom of the channel, below the bankfull elevation. The incorporation of these log spurs or LWD are not intended as a structural component of the channel or bank stability but rather as ways to increase instream habitat.

6.5 Growth Media (Topsoil)

Re-establishing a more natural ecosystem over more than 50-acres in what currently is now barren waste cobble requires extensive amounts of growth media (topsoil). Detailed analysis of the particle size and or quantity has not been completed within the dredge on the Project Area. The Concept Plan currently calls for upwards of 13,900 cubic yards of growth media for uplands and over another 30,740 cubic yards for the riparian corridor. The purchase and import of this quantity of growth media has been estimated at approximately $1.34-million dollars or almost 33% of the total project cost based on an assumed unit cost of $30 per cubic yard. While a high quality topsoil or growth media is essential for the successful long-term establishment of natural vegetation, many options may exist to produce or amend lesser quality materials and obtain the required benefits at a lower cost. The composition of topsoil generally consists of upwards of 45% fine grain mineral particles with less than 5% organic material/nutrients and the remaining 50% comprised of water and air. Substantial cost savings can be incurred by simply amending salvaged fine grained mineral soils during processing of the dredge. Fine grained mineral soils can be amended with wood chips, biosolids and manufactured fertilizers, humates and mycorrhizal inoculations. Understanding of soil conditions, in particular soil texture, pH, salts, percent organic matter and nutrients is critical to the performance of the soil mixture and ultimately the success of the restoration.

As part of the Concept Plan, the costs provided assume the purchase and import of a fine grained growth media and a single application of manufactured fertilizer/humates and mycorrhizal. Future design efforts will need to evaluate more thoroughly the availability and suitability of onsite materials in order to develop a more cost effective growth media solution.

6.6 Upland Planting

The Concept Plan depicts upwards of 34.5-acres of upland area that will be reclaimed. These areas will consist of temporary storage areas of dredge material or spoil areas. These areas should graded to varying and undulating landforms based on material quantities. Generally upland areas should be graded to form naturally appearing varying landforms with stable slopes and capped with a minimum of 3 inches of unconsolidated growth media. All grading should create a smooth transition into both the riparian corridor and the existing natural uplands. The initial focus of the Concept Plan is to re-vegetate the upland areas with an appropriate native mountain big sagebrush community. These vegetation communities in the area are dominated by a midstory of species such as big sagebrush (*Artemisia tridentate),* rabbitbrush (*Chrysothamnus sp.*) and buffaloberry (*Shepherdia canadensis*). Understory vegetation can include Rocky Mountain fescue (Festuca saximontana), Indian ricegrass (Oryzopsis hymenoides), mountain brome (*Bromus marginatus),* western wheatgrass (*Pascopyrum smithii) or* Canada wildrye (*Elymus Canadensis).* Initial re-vegetation will need to quickly stabilize soils, increase soil biomass and prevent invasive weed establishment. Once the understory grassland community is well established future restoration efforts can focus on developing a more diverse vegetation community which includes shrubland and forest species based on final topography and landforms. The cost estimate provided associated with upland planting zones includes grading, soil placement, soil amendments seeding and mulching of the initial grassland community and does not include establishment of shrubland or forest.

6.7 Stream and Groundwater Interface

Currently through the Project Area the Swan River is both a gaining and losing stream over individual sections. At some locations surface flows are evident even during times of low flow while the stream is dry with all flows going subsurface at other locations. One of the most important aspects of the planned stream restoration will be to ensure that flow is maintained at the surface and not allowed to go subsurface in the dredge material.

Two techniques are recommended to maintain surface flows. The first and most important is lowering the channel elevation so that it intercepts the local groundwater table. While there is not an existing groundwater monitoring program for the Project Area, groundwater levels can be inferred at many locations based on observed surface water. Given the high permeability of dredge material, water would drain from surface depressions that do not intercept the groundwater table. Given the tendency for surface water in the stream to go subsurface, it can also be inferred that the existing stream intercepts groundwater at locations where consistent surface flow is observed. Locations where the surface is currently believed to intercept groundwater are also identified by the existing lake surfaces shown on Sh**eets 1 and 2**. As no topographic mapping exists for the Project Area, elevations of many of these locations are unknown. ERC did however, survey elevations at some of the presumed groundwater expressions.

Moving forward it is also recommended that a program be initiated to identify the groundwater level at additional locations throughout the Project Area. Groundwater levels should be surveyed and monitored throughout the hydrologic cycle to assess seasonal and temporal groundwater fluctuations that could impact the desired stream elevations for the final restoration design.

The second technique that will be utilized to maintain surface flows is to create a layer below the channel bed that has relatively low permeability. This will be accomplished using natural materials. The low permeability zone is designed to be constructed using a combination of finer material mixed with

the smaller portion of dredge material to create a substrate with lower vertical permeability than the surrounding dredge rock. This finer material will help to inhibit vertical migration of the water, maintaining flows at the surface. If the channel is set at an elevation that intercepts the groundwater and fine material underlies the stream, water will remain at the surface. The lower permeability material layer is designed to extend below the active channel and under a portion of the riparian area for a total width of 75 feet. A 1.5 foot thick layer, consisting of a mixture of 3 inch minus material with 20% of the material passing the #200 sieve (fines) is included for this conceptual level design. A typical stream cross section including this low permeability layer is shown on **Sheet 3**.

6.8 Road Crossings

Two road crossings were included as part of this Concept Plan. The downstream crossing is located at the downstream extent of the project reach for the private residence (currently the access to the gravel operation) and the upper crossing is Parkville Road (or Georgia Pass Road). As part of the restoration both crossings should be designed to facilitate fish passage and conveyance of large flood events with minimal interruption to sediment transport. Relatively large, single cell crossings provide the best conveyance and were assumed for these crossings.

As part of the Concept Plan, both existing crossings were assumed to be replaced with a 30 foot long bridge section that will span the bankfull channel width. It is anticipated that different bridge standards can be used at the two crossings given that one is a private crossing and one is public, however for this conceptual level evaluation a uniform cost was assumed for both crossings. As part of final design it is recommended that the size of these crossings be checked for fish passage using software such as FishXing, lengths be confirmed with road design standards and flow hydraulics be evaluated with input from the land owners on design criteria for flows and crossing slopes that match the final stream profile.

6.9 Existing Open Water Features

Several existing open water features exist throughout the Project Area. These areas are non-naturally formed from dredge operations consisting of excavated pits filled with exposed groundwater or impoundments of the existing Swan River. These open water areas vary in depth from a few feet to upwards of possibly 20 feet. Vegetation of these open water features is generally limited to a narrow fringe along the ordinary high water mark. Preservation, enhancement or creation of additional such areas are subject to Colorado water law and US Army Corps of Engineers (USACE) jurisdiction and will require additional consideration during final planning. If determined appropriate such features can be incorporated into the uplands areas.

6.10 Compatibility with the 2009 Plan

As indicated in the project objectives, compatibility between this Concept Plan and the 2009 Plan prepared by Summit County was evaluated. Many of the concepts presented in the two plans are generally very similar and would allow for a direct integration of the projects:

- Both projects utilize concepts of natural verses structural restoration
- Both projects propose a similar channel sinuosity
- Both projects propose a riparian zone adjacent to the stream
- Both projects propose a transition to upland areas outside of the riparian zone

These main concepts will be easily carried from one project area to the other.

Specific data presented in this Concept Plan include items such as specific channel widths, overall stream profiles and concepts for creation of riffle/bend pools that are beyond the level of detail provided in the 2009 Plan. As this Concept Plan presents detail that the 2009 Plan does not, there is not a disconnect in terms of compatibility, rather just a disconnect in level of detail. We believe that the more detailed concepts presented in this report can be applied to the 2009 Plan area. It is likely that minor adjustments based on physical differences such as total flow area, slopes and other items such as road crossings and fish barriers will be needed for the 2009 Plan area based on more detailed analysis; however it is anticipated that a more detailed design on the lower reach will result in a general continuation of the concepts presented herein.

6.11 Muggins Gulch Road Crossing

Summit County has expressed interested as part of the 2009 Plan to reconfigure the Tiger Road and Muggins Gulch Road crossings of the Swan River. The preliminary concept for this reconfiguration is to ultimately have only one crossing of the Swan River by improving the existing Muggins Gulch Road crossing (2009 Plan identified as Option #2 New Box culvert at Muggings Gulch Road), create a new spur from Muggins Gulch Road to Tiger Road (on the north side of the Swan River)(2009 Plan identified as Proposed Muggins Gulch Road Re-alignment Option #1) and remove/reclaim the existing Tiger Road crossing (not identified on the 2009 Plan). The new improved Muggins Gulch Road crossing should be designed to act as the single fish barrier along the overall project area, eliminating upstream fish movement and preservation of CRCT habitat. A vertical barrier concept is recommended. Further design efforts are required for this reconfiguration and fish barrier.

6.12 Riparian Corridor Conservation Easement

Summit County and the US Forest Service have been working with private landowners within the Project Area (both as part of the 2009 Plan and the Concept Plan) to develop a public access conservation easement along the proposed stream channel and riparian corridor. At this point the easement is only preliminary and will need to be finalized in the future. For the purposes of the Concept Plan the preliminary easement has identified and was assumed to extend approximately 75’ on either side of the proposed channel centerline.

7.0 PROJECT COST ESTIMATES

Cost estimates were developed for the individual elements of the overall Concept Plan. As the improvements presented herein are conceptual in nature, all costs should be considered budgetary level costs. More detailed costs can be developed as part of the final design for improvements as they occur. Costs contained in this Concept Plan are based on 2012 prices. Estimates were generated from material costs, discussions with contractors, costs for completed stream improvement projects and engineering judgment.

Unit construction costs were prepared for each specific Concept Plan improvement. A table summarizing itemized costs for each improvement type is shown on **Table 5**.

Major assumptions included in the cost estimates are provided below:

1. Mining activities will include excavation of the dredge material to the approximate subgrade elevation.

2. Restoration costs include final excavation of the stream channel and fine grading at all areas.

3. An 18 inch thick low permeability underliner constructed with fines and larger material will be applied for a 75 foot wide area under the stream and riparian areas.

4. Appropriate sized gravel and cobble will be used to create channel beds and banks. It is assumed that this material will be available on site and provided at no cost to the project.

5. 12 inches of mineral soil will be utilized in the riparian corridor within 50 feet on each side of the stream.

6. 3 inches of mineral soil will be utilized within the all upland areas.

7. Road crossings would be accomplished with 30 foot long bridge sections.

8. Straight sections of the restored channel and inside channel bends will include appropriately sized cobble toes with 50 foot wide riparian areas. These riparian areas will have 12 inches of mineral soil and will be covered with a biodegradable erosion control fabric. Biologs will be placed along the banks perpendicular to flow to help dissipate overbank flow that may occur during vegetation development.

9. Outside bends of the restored channel will include the same material as straight sections and inside bends. Brush layering will be added along the outside banks and two rows of #5 shrubs planted at 5 foot centers will be included in the riparian zone adjacent to outside bends.

10. 50 riparian planting pockets will be dispersed throughout the riparian corridor. Riparian plating pockets will include approximately 37 cubic yards of mineral soil, 14 #5 shrubs and one balled and burlapped tree per pocket.

11. Upland area reclamation includes seeding, soil amendments and mulched and crimped.

12. Temporary irrigation and weed control including minor maintenance will be required and is included in the project costs.

13. Monitoring will be required by the US Army Corps of Engineers and is included in the costs.

14. Water Control identified in the cost estimate will need further evaluation and is highly dependent on restoration sequencing and unknown groundwater elevations. Since dredge removal operations are assumed to leave the surface at Concept Plan subgrade elevations, groundwater may be exposed for final restoration work in some areas. The cost estimate has assumed a lump sum cost to adequately manage water during restoration construction of the entire project. This cost will need to be further refined based on specific restoration items and groundwater elevations.

15. Costs for mobilization and demobilization were assumed at 5% of construction.

16. Costs for survey and construction management were assumed at 5% of construction.

17. A contingency of 10% of construction costs was included in the estimate.

18. Final Design-Build level plans are not included in the cost estimate. Final Design-Build Plans to be completed under separate budget combining 2009 plan and 2012 Plan.

Based on this budgetary level estimate and the assumptions presented above, it is anticipated that the total cost to complete the full restoration of this area is approximately **$4,335,370.00**.

Table 5. Budgetary Level Project Cost Estimates

Item	Unit	Quantity	Unit Cost	Sub-Total
STREAM IMPROVEMENTS				$2,114,350.00
Excavation - 125 Foot Stream and Riparian Zone	Cubic Yard	32200	$6.00	$193,200.00
Material Sorting & Placement - Fine Material Mixture for Subgrade	Cubic Yard	23100	$8.00	$184,800.00
Fine Grading for Riparian Zone	Acre	17.5	$4,000.00	$70,000.00
Fine Grading - Active Channel	Linear Foot	8300	$12.00	$99,600.00
Material Supply, Sorting and Placement - Material Sizes for Channel Bed and Banks	Cubic Yard	17210	$8.00	$137,680.00
Instream Habitat - Construct Riffle/Bend Pool Sequences	Each	47	$1,000.00	$47,000.00
Instream Micro Habitat Features per Each Sequence	Each	47	$500.00	$23,500.00
Riparian Topsoil along 100 foot Riparian Corridor	Cubic Yard	30740	$30.00	$922,200.00
Erosion Control Fabric along 100 foot Riparian Corridor	Square Foot	913000	$0.35	$319,550.00
Bank Stabilization - Outside Bend Vegetation (Brush Layering and Shrubs)	Linear Foot	3300	$31.00	$102,300.00
Temporary Fencing - Outside Bends	Linear Foot	3630	$4.00	$14,520.00
RIPARIAN AND UPLAND PLANTING ZONES				$895,720.00
Riparian Area Seeding	Acre	17.5	$2,500.00	$43,750.00
Riparian Planting Pockets	Each	50	$2,590.00	$129,500.00
Temporary Fencing - Riparian Planting Pockets	Linear Foot	3930	$4.00	$15,720.00
Upland Area Fine Grading	Acre	34.5	$2,000.00	$69,000.00
Upland Topsoil	Cubic Yard	13900	$30.00	$417,000.00
Upland Seeding	Acre	34.5	$3,500.00	$120,750.00
Weed Control, Irrigation and Minor Maintenance	Lump Sum	1	$100,000.00	$100,000.00
MISCELLANEOUS ITEMS				$1,070,900.00
Stream/Road Crossings (assumes 30 Foot Span)	Each	2	$150,000.00	$300,000.00
Spoils Piles Grading and Reclamation	Cubic Yard	32200	$3.00	$96,600.00
Water Control	Lump Sum	1	$125,000.00	$125,000.00
Construction BMPs	Lump Sum	1	$25,000.00	$25,000.00
Monitoring	Lump Sum	1	$40,000.00	$40,000.00
Project Permitting	Lump Sum	1	$25,000.00	$25,000.00
Construction Mobilization/Demobilization (5% of Construction Subtotal)	Lump Sum	1	$177,900.00	$177,900.00
Construction Survey & Management (5% of Construction Subtotal)	Lump Sum	1	$177,900.00	$177,900.00
Contingency (10% of Construction Subtotal)	Lump Sum	1	$355,900.00	$355,900.00
CONSTRUCTION SUBTOTAL				$3,558,670.00
TOTAL				$4,335,370.00

Assumptions:

Assumes mining activities produce the rough subsurface grade elevations for all areas
Detailed stream grading assumed to be part of project costs
Materials, except mineral soil, assumed to be available on site at no cost
Final Design-Build level plans are not included

8.0 REFERENCES

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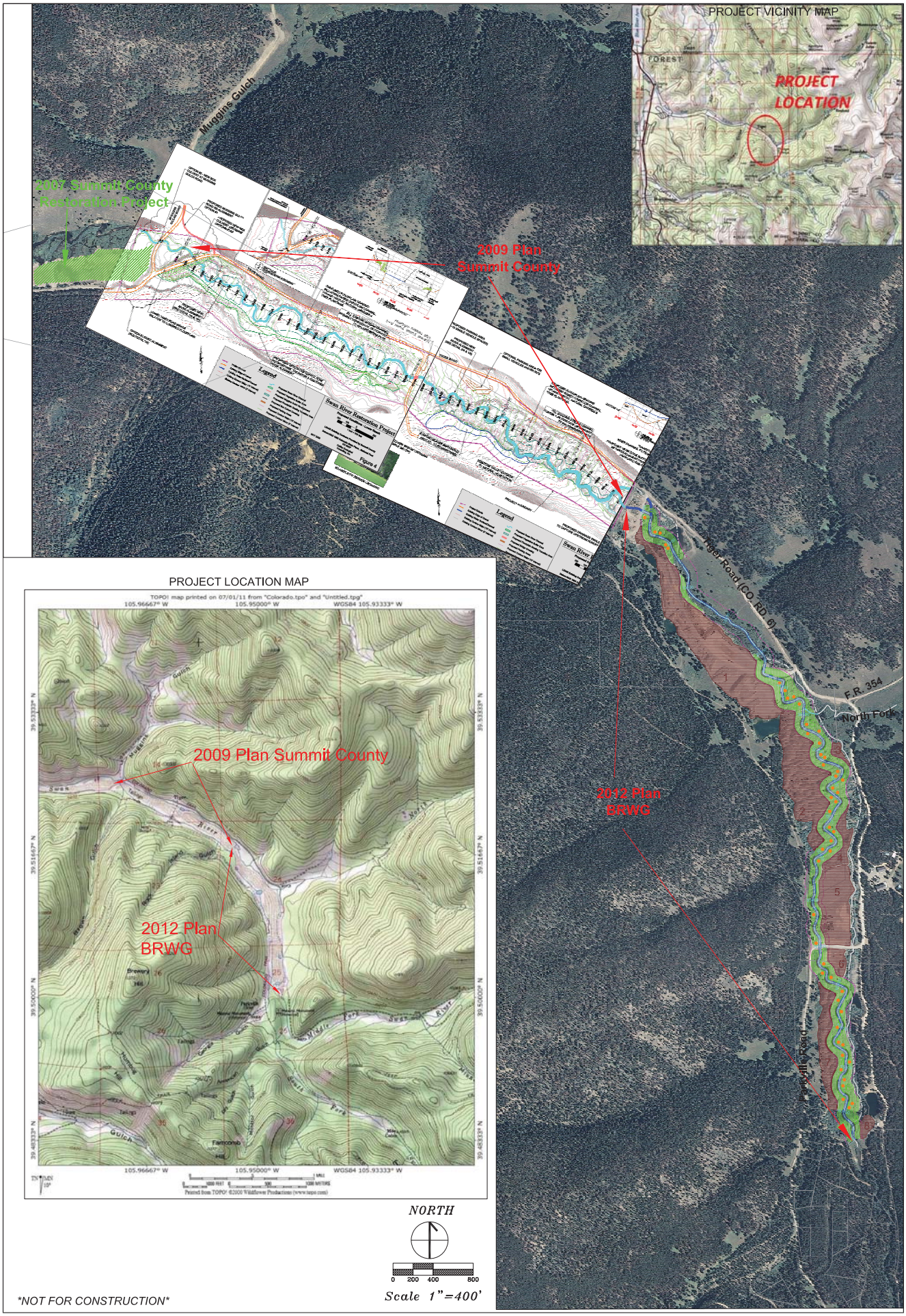
APPENDIX – CONCEPT PLAN

Note: The following Concept Plan Sheets 1, 2 and 3 have been reduced in size for the report. Refer to the attached full size Concept Plan Sheets:

- *BRWG Concept Plan SH1 3-5-12.PDF*
- *BRWG Concept Plan SH2 3-5-12.PDF*
- *BRWG Concept Plan SH3 3-5-12.PDF*



Ecological Resource Consultants, Inc.
35715 US Highway 40, Suite D204
Evergreen, CO 80439
(303) 679-4820

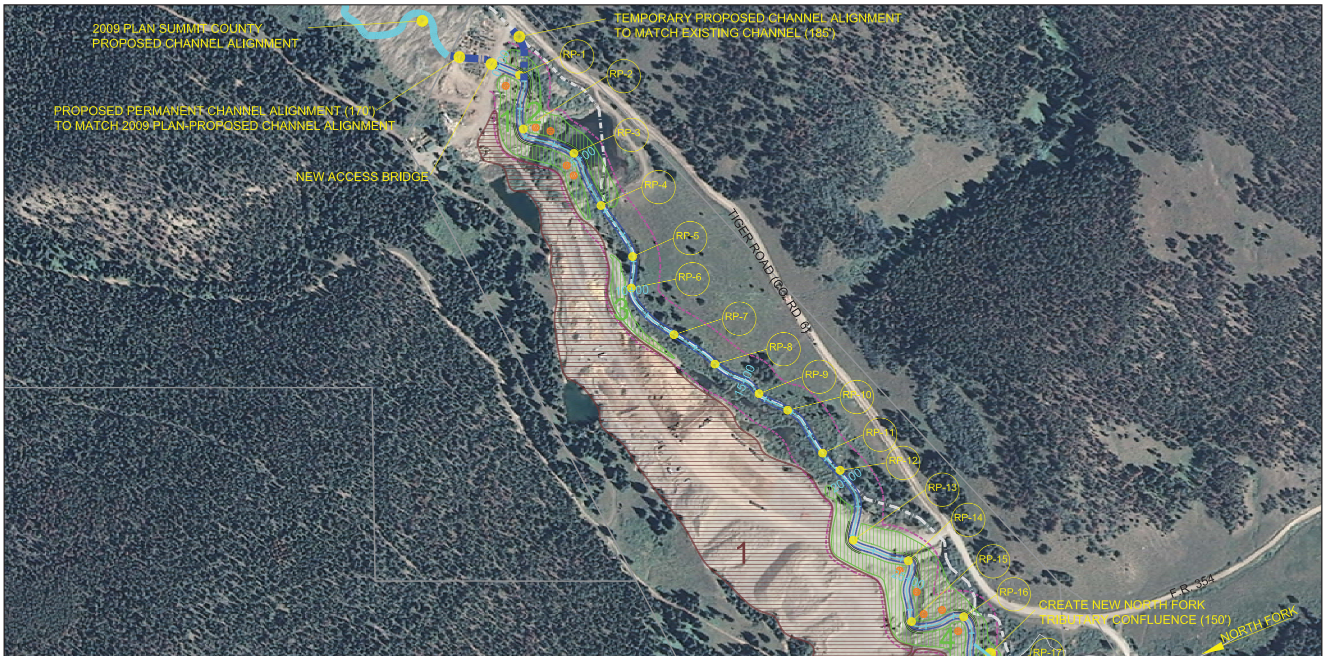
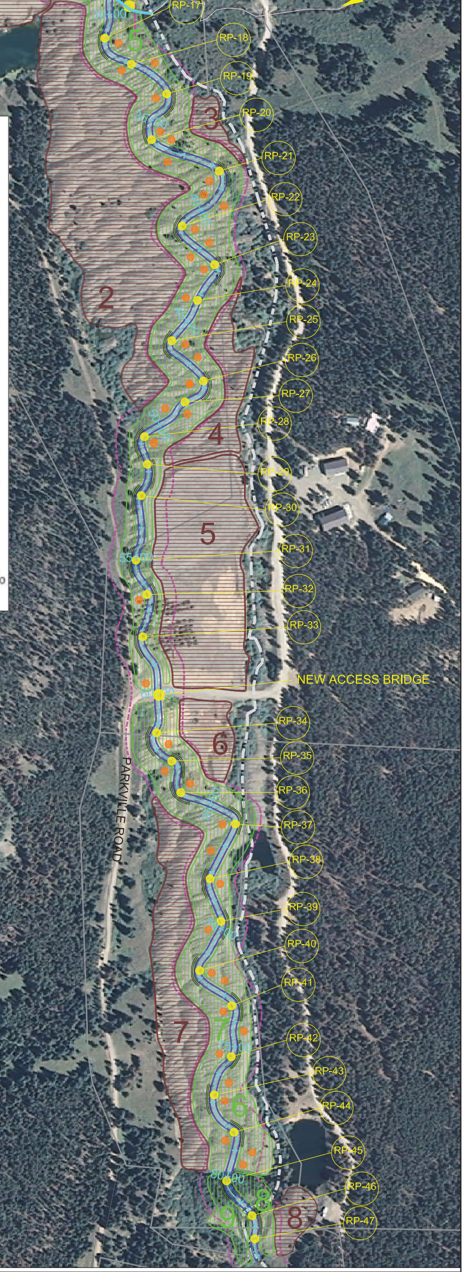
Designed By: ERC
Drawn By: ERC
Date: 7/1/2011
Project No.: 906-111
File Path:

Revision No:
Revision Date:
Approved By:
Comments:

Blue River Watershed Group
Upper Swan River Restoration Project

Concept Plan
Project Overview Map

SHEET
1



2009 PLAN SUMMIT COUNTY
PROPOSED CHANNEL ALIGNMENT
TEMPORARY PROPOSED CHANNEL ALIGNMENT
TO MATCH EXISTING CHANNEL (185')
PROPOSED PERMANENT CHANNEL ALIGNMENT (170')
TO MATCH 2009 PLAN-PROPOSED CHANNEL ALIGNMENT
NEW ACCESS BRIDGE
TIGER ROAD (CO. RD. 6)
F.R. 354
CREATE NEW NORTH FORK
TRIBUTARY CONFLUENCE (150')
NORTH FORK
PARKVILLE ROAD
NEW ACCESS BRIDGE
RP-1
RP-2
RP-3
RP-4
RP-5
RP-6
RP-7
RP-8
RP-9
RP-10
RP-11
RP-12
RP-13
RP-14
RP-15
RP-16
RP-17
RP-18
RP-19
RP-20
RP-21
RP-22
RP-23
RP-24
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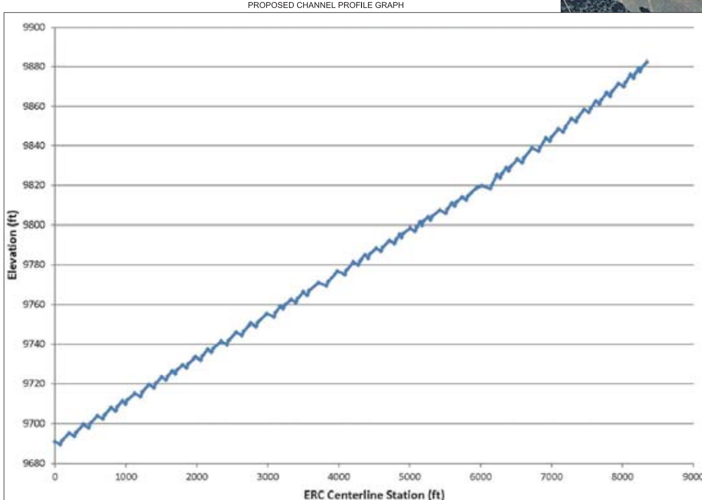
RP-32
RP-33
RP-34
RP-35
RP-36
RP-37
RP-38
RP-39
RP-40
RP-41
RP-42
RP-43
RP-44
RP-45
RP-46
RP-47

TABLE 1. PROPOSED CHANNEL PROFILE

Station	Feature ID	Elevation (feet AMSL)
0	match at U/S culvert	[illegible]
75	Pool 1	[illegible]
100	Riffle End 1	[illegible]
[illegible]	Riffle Beginning 1	[illegible]
275	Pool 2	[illegible]
[illegible]	Riffle End 2	[illegible]
400	Riffle Beginning 2	[illegible]
475	Pool 3	[illegible]
500	Riffle End 3	[illegible]
600	Riffle Beginning 3	[illegible]
675	Pool 4	[illegible]
700	Riffle End 4	[illegible]
[illegible]	[illegible]	[illegible]

PROPOSED CHANNEL PROFILE GRAPH



LEGEND

- Property Lines (Summit County GIS)
- Existing Stream Channel (7,710')
- 5+00 Proposed Channel Centerline and Station (8,300')
- Proposed Channel Bankfull Edge
- Bend Pool Bank Stabilization (33 @ 100' Each)
- RP-3 Proposed Riffle-Pool Features (ID# & Location) (47)
- Proposed Riparian Corridor (17.5 AC)
  - 1 = 1.0 AC
  - 2 = 1.0 AC
  - 3 = 0.5 AC
  - 4 = 4.5 AC
  - 5 = 2.5 AC
  - 6 = 2.5 AC
  - 7 = 4.5 AC
  - 8 = 0.5 AC
  - 9 = 0.5 AC
- Proposed Riparian Planting Pocket (50)
- Proposed Upland Restoration (34.5 AC)
  - 1 = 14.5 AC
  - 2 = 8.0 AC
  - 3 = 0.5 AC
  - 4 = 1.5 AC
  - 5 = 3.0 AC
  - 6 = 5.5 AC
  - 7 = 1.0 AC
  - 8 = 0.5 AC
- Anticipated Preliminary Public Conservation Easement (~75' From Channel Centerline)

NORTH

0 100 200 400

Scale 1"=200'

NOT FOR CONSTRUCTION

Ecological Resource Consultants, Inc.
35715 US Highway 40, Suite D204
Evergreen, CO 80439
(303) 679-4820

Designed By:	ERC
Drawn By:	ERC
Date:	4-24-12
Project No.:	860-111
File Path:	

Revision No.:
Revision Date:
Approved By:
Comments:

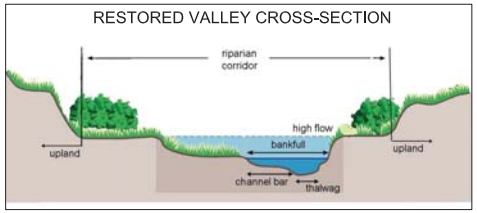
Blue River Watershed Group
Upper Swan River Restoration Project

Concept Plan
Plan View

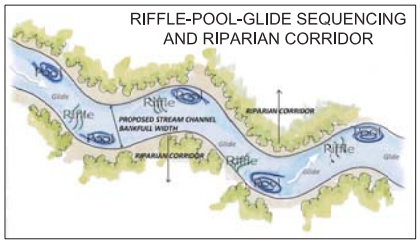
SHEET 2

RESTORATION CONCEPT TEMPLATES

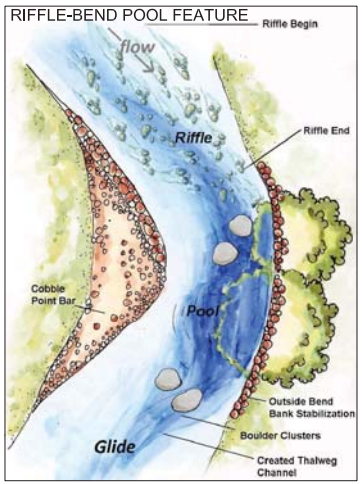
RESTORED VALLEY CROSS-SECTION

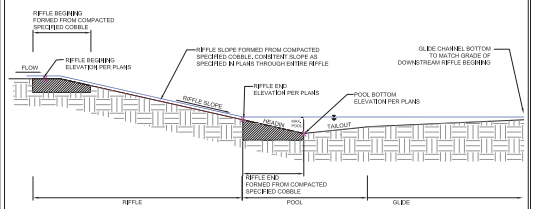


RIFFLE-POOL-GLIDE SEQUENCING AND RIPARIAN CORRIDOR

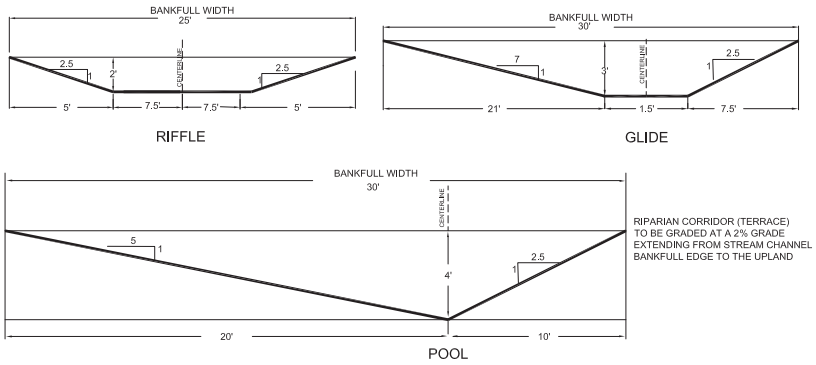


RIFFLE-BEND POOL FEATURE

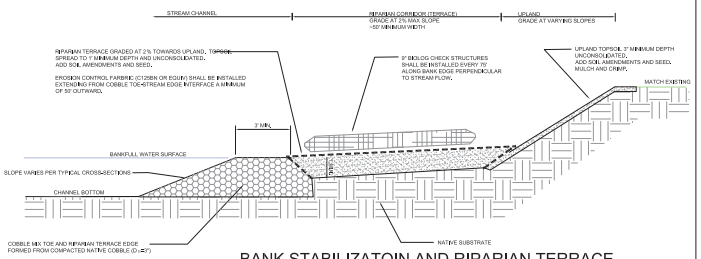




RIFFLE-POOL-GLIDE SEQUENCE
TYPICAL PROFILE SECTION~NTS

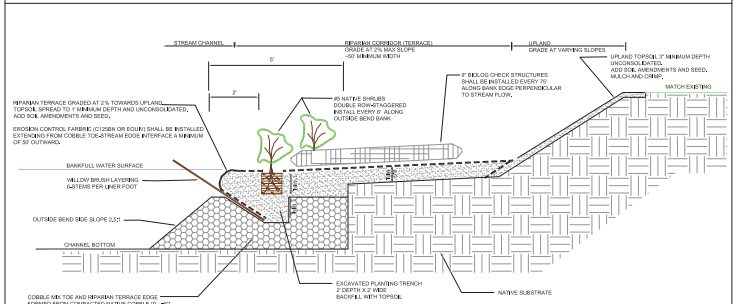


STREAM CHANNEL CROSS-SECTIONS (NTS)

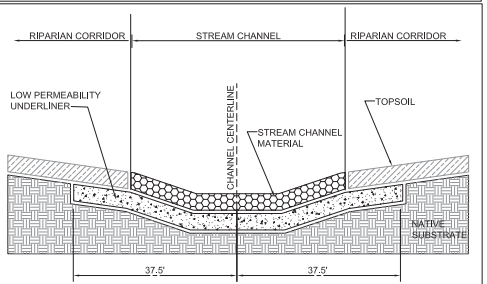


RIPARIAN PLANTING POCKET (NTS)

BANK STABILIZATOIN AND RIPARIAN TERRACE
STRAIGHT SECTIONS AND INSIDE BENDS (NTS)



BANK STABILIZATION AND RIPARIAN TERRACE
OUTSIDE BENDS (NTS)



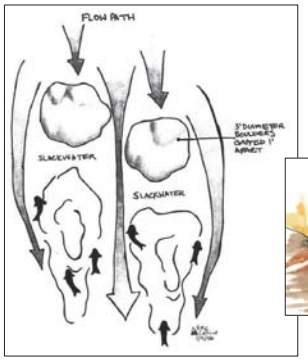
LOW PERMEABILITY UNDERLINER MINIMUM THICKNESS OF 1.5'
EXTEND 37.5' OUTWARD FROM CHANNEL CENTERLINE ALONG ENTIRE STREAM LENGTH

MATERIAL SPECIFICATION

LOW PERMEABILITY UNDERLINER: 3" MINUS MATERIAL WITH MINIMUM 20% PASSING THE #200 SIEVE FINES

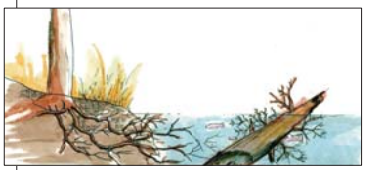
STREAM CHANNEL MATERIALS	D50 (COBBLE MIX)
RIFFLES:	4"
RIFFLE SIDE SLOPES:	6"
OUTSIDE BENDS:	9"
POOL AND GLIDE ARMOR:	1"
NON RIFFLE/NON OUTSIDE BEND BANKS:	3"

LOW PERMEABILITY UNDERLINER
AND MATERIAL SPECIFICATIONS



BOULDER HABITAT CLUSTERS

AQUATIC MICRO-HABITAT FEATURES



LARGE WOODY DEBRIS

NOT FOR CONSTRUCTION

SHEET 3

Concept Plan
Typical Details

Blue River Watershed Group
Upper Swan River Restoration Project

Revision No.:
Revision Date:
Approved By:
Comments:

Designed By: JBC
Drawn By: JBC
Date: 4-24-12
Project No.: 3664-11
File Path:

Ecological Resource Consultants, Inc.
35715 US Highway 40, Suite D204
Evergreen, CO 80439
(303) 679-4820