Vail 2010 Flood Assessment

January 27, 2011

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Introduction

A significant flood event occurred within the Town of Vail in June of 2010. Flows on Gore Creek above Red Sandstone were determined to be 2,260 cfs which is just shy of the 100 year return event of 2,310 cfs. However, the upper basin likely experienced flows greater than the 100 year event. The USGS is currently finalizing data for the upper Gore Creek basin; provisional data for Booth Creek shows that flows reached 472 cfs, which is greater than the 500-year return flows at Booth (460 cfs), Pitkin (380 cfs) and Bighorn (340 cfs) Creeks. All of the southern aspect tributaries upstream of Booth Creek are anticipated to have had approximately 500-year flood events. Gore Creek likely experienced greater than 100-year return flows upstream of Middle Creek.

The most significant flood impacts occurred on Booth Creek, Pitkin Creek and Bighorn Creek. These three tributaries experienced significant channel widening (erosion of both banks) and scour and deposition of the channel bed. These three tributaries have headwaters along the Gore Range Divide with elevations greater than 13,000 feet. Bighorn Creek has reaches that scoured to bedrock through over 4 feet of alluvium. Other south aspect tributaries upstream of Black Gore Creek likely experienced similar events, but were not investigated. Middle Creek also experienced flooding, but not as significant channel scouring, likely due to the slightly lower elevations of the upper basin. Tributaries with northern aspects or lower basin elevation elevations had large runoff events, but did not experience significant channel alterations. Black Gore Creek only experienced 225 cfs discharge which is less than a 10 year return flood.

The Water Year 2010 snowpack was below average. Significant flooding on southern aspect tributaries with high elevation upper basins may be indicative of a cold spell in late spring followed by extreme solar gain and rapid snow melting. 1986 was a similar water year condition with below average snow pack by the beginning of May, followed by a quick, high magnitude runoff. Pitkin Creek exceeded its 500 year return flow of 380 cfs in 2003 (408 cfs) and exceeded its 50 year flow of 260 in 1985 (265 cfs). This many anomalies out of 25 years may simply be outliers. However, shifts towards earlier runoff peaks and higher magnitudes, especially occurring with below average snowpack, may be indicative of larger scale climate variability. As outliers, the appropriate response to these discrete events may be to simply repair damage. If these “outliers” occur more regularly, planning and preventative maintenance may be a more necessary response.

Gore Creek Assessment

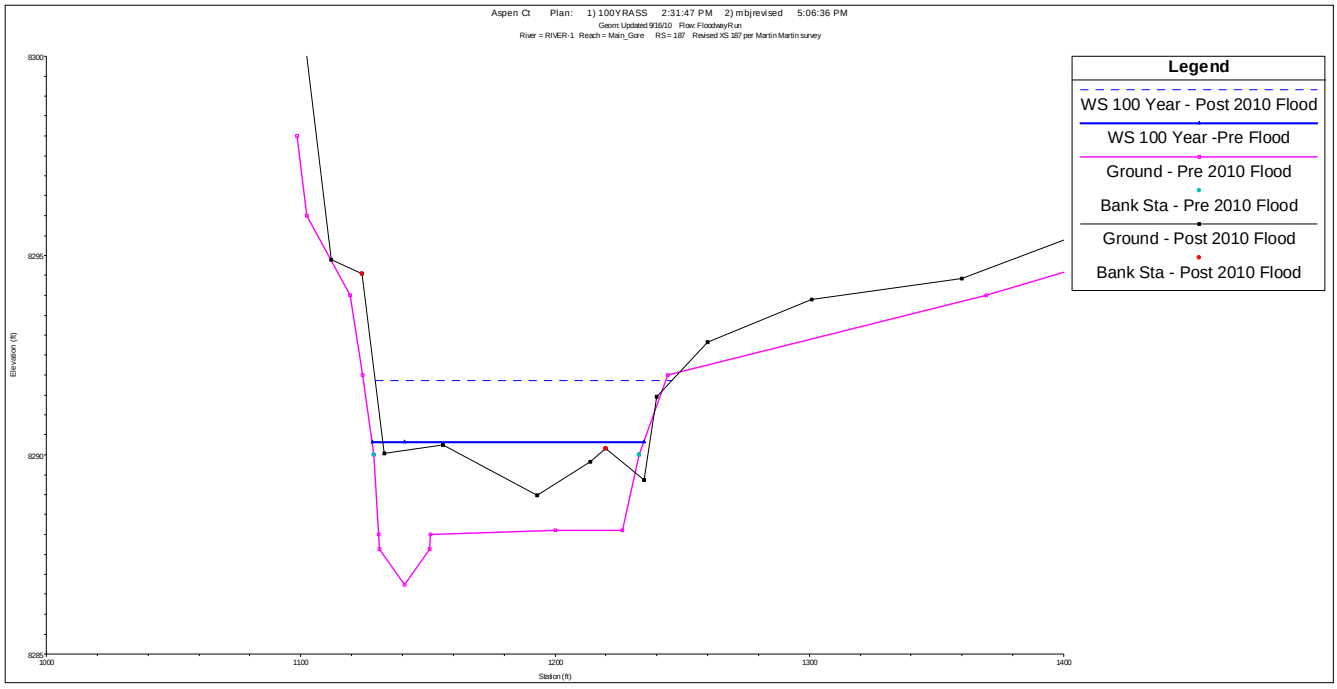
Extensive aggradation (reach wide deposition) occurred in Gore Creek from increased supplies of sediment; evidenced by 4 feet deep deposits on gravel bars within the main channel of Gore Creek. Similar aggradation occurred in the lower Booth, Pitkin and Bighorn tributaries. The confluences of these tributaries with Gore Creek occur on steep alluvial fans. Alluvial fans form where the canyon mouths open and the sediment transport capacity of the canyon creeks rapidly reduces. Alluvial fans are natural, ongoing depositional areas; in Vail, the alluvial fans are also prime development land. The natural process of an alluvial fan is to deposit and perch (raise above adjacent land elevation) a channel, and then, during a significant flow event, the creek will avulse (significant migration by cutting a new channel in low land) and repeat the process of deposition and perching. Bighorn Creek is significantly perched at the apex of the alluvial fan; the creek is at the top of the hill. Pitkin and Booth Creek are also perched, but on more of a slope with low ground generally to the West. Middle Creek runs along the toe of the alluvial fan; however, the fan is steep with numerous overflow channels. The development encroachment on these fans has created a scenario where the channels are prevented

(through maintenance such as clearing log jambs) from the natural avulsion (significant migration) process necessary to absorb the sediment supply from the upstream canyon. The encroaching development further perches the creek channels on the alluvial fans and delivers more significant sediment loads to the main channel of Gore Creek.

The main channel of Gore Creek is in an alluvial floodplain that tends to aggrade the sediment supply by the point bar and cut bank meandering of a single channel. In some areas where Gore Creek is overwhelmed by sediment supply, some channel braiding and island forming may be evident. Although more subtle than avulsions on an alluvial fan, meandering requires migration of the river channel. The alluvial floodplain of Gore Creek has also been significantly encroached by development reducing the available migration corridor. A natural channel response to encroachment and limited migration is aggradation and widening of the main channel. Extensive aggradation also reduces the channel flood capacity and increases overbank flooding.

Unfortunately, significant aggradation has occurred throughout the main channel of Gore Creek and may impact channel conveyance and base flood elevations as determined by FEMA. A very detailed flood study of Gore Creek was performed in 1994 - 1996 including survey of the channel bottom. A 2010 resurvey of these locations has shown up to 4 feet of channel aggradation (Figure 1). Preliminary flood modeling of the existing channel conditions shows increases in the predicted base flood elevations of up to 2 feet.

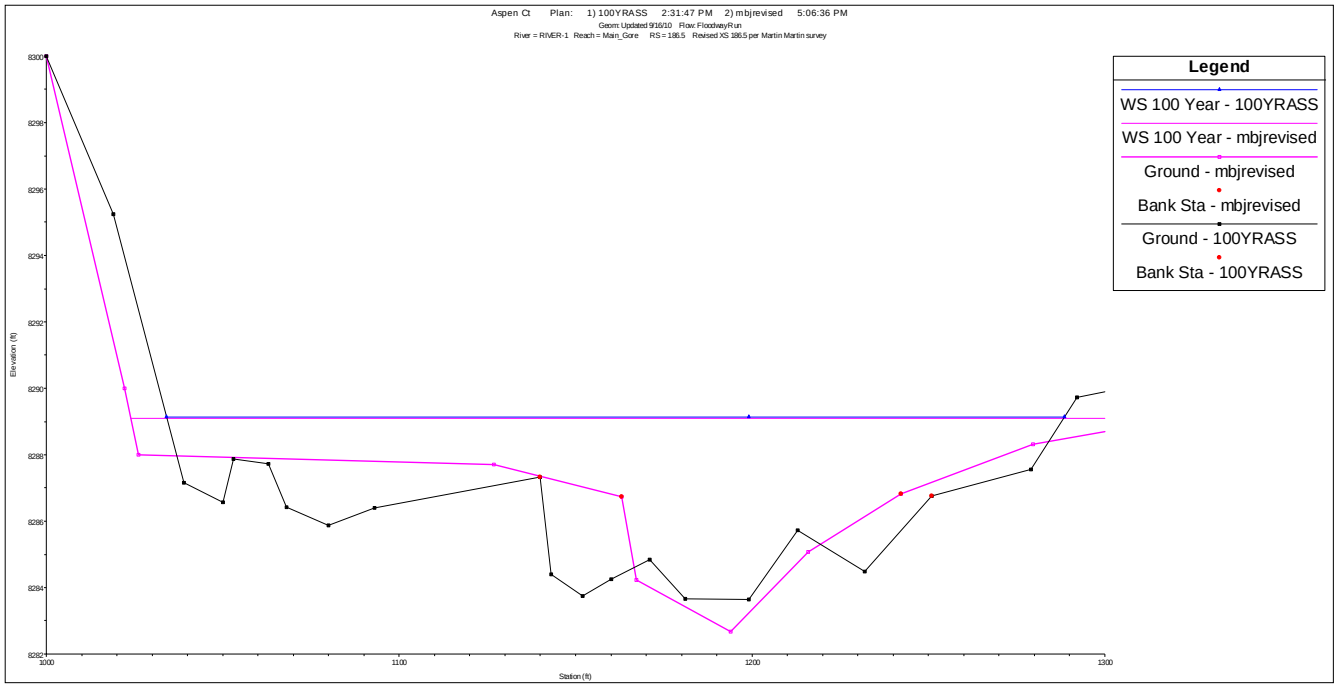
Figure 1. 1994 vs 2010 survey upstream of Aspen Court showing over 3 feet of aggradation.



The necessary and natural processes of channel aggradation and subsequent channel migration are beginning to conflict with adjacent development. Loss of channel capacity is the first indication, and significant loss of land would be the unabated long term result of this conflict. The south bank upstream of Aspen Court has eroded over 43 feet since 1994 and the channel has filled up to 4 feet (Figure 2). In areas where increasing flood elevations or potential channel migration threatens structures, channel maintenance may be a necessary course of action. Channel maintenance may come in the form of stabilizing banks, removing sediments, or offsetting structures and creating openspaces where the channel can migrate.

Fortunately, existing building offsets, intact riparian fringes, and open spaces have allowed for some migration of the main channel of Gore Creek. A long undeveloped segment of valley floor is intact downstream of East Vail to approximately Booth Creek. This openspace (Katsos) is very critical in absorbing the large sediment loads generated from Bighorn and Pitkin Creeks. The opportunity for sediments to aggrade in the Katsos reach reduces the amount that is transported downstream into the more developed areas of Vail. Similarly, another moderate sized riparian zone exists in the middle of the Racket Club condominiums, Upstream of Bighorn Creek. This area deposits sediments coming from upper Gore Creek and Black Gore Creek before the large sediment inputs of Bighorn and Pitkin Creeks. Booth Creek deposits largely occur along the Vail Golf Course channel.

Figure 2. 1994 vs 2010 survey upstream of Aspen Court showing 43 feet of left bank erosion.



Tributary Assessment

The migration process of tributaries is more erratic and less predictable. Tributaries are becoming more and more perched as berming and flood wall building have responded to channel aggradation and overbank flooding. In an attempt to keep the tributaries in their current alignments (between property lines and road crossings) future maintenance of the tributaries may need to be performed. Maintenance may include periodic removal of sediments and repair of channel banks. Bighorn, Pitkin and Booth Creeks have required removal of sediments at culverts this year. Bighorn is the most significantly perched channel and overbank flooding in 2010 was significant. Landowners have built floodwalls (during summer 2010) at the top of bank along Bighorn Creek. Bighorn Creek will likely require removal of large boulder deposits upstream of Bighorn Road to reduce potential for avulsion and/or overbank flooding. Pitkin Creek is significantly perched upstream of I-70 and has eroded to a very thin berm along the top of bank. This berm would likely require stabilization to prevent a future avulsion. Booth Creek has experienced significant channel widening and bed aggradation and will likely require removal of sediments to reduce overbank flooding potential. Maintenance of channels is a long-term commitment that Vail must consider in order to mitigate the natural channel response to development

encroachment and confinement of the creek channels.

Improved management of the riparian corridor may also lead to fewer long-term problems. Local areas where the native riparian understory has been replaced by shallow rooting turf grass consistently showed accelerated loss of river bank. Best management practices to improve the riparian zone would greatly reduce flooding, the loss of land due to flooding, and non-point source pollution due to sediment loading. Mature trees and turf grasses do not have the root depth and density to hold bank material. As well, areas with too narrow a band of riparian shrubs do not have the density to hold the bank together; the channel pulls the bank materials out from behind this narrow band and the willows collapse into the bank. A robust riparian corridor is critical to reducing land loss and facilitating sediment transport during flood flow events.

RiverRestoration staff rapidly assessed damage resulting from the 2010 flood at over 58 assessment sites throughout Vail, Colorado (Appendix A). The 2010 flood event had relatively insignificant structural damage; however, multiple instabilities have resulted from the flood. If the flood had persisted for just a couple more days, it is our opinion that the structural damage would have been a magnitude (10 times) greater. Aspen Court was the only bridge completely lost to the flood; however, 8 additional crossings have been compromised and likely could not sustain another flood event. Most of the tributaries are perched above adjacent roads, development and infrastructure; overbank flooding and channel cutting occurred on these tributaries, laying the path for future floods to be more damaging. Massive sediment deposits have occurred in Gore Creek and tributaries, changing erosion patterns and reducing flood capacity. A number of channel instabilities should be repaired before the next flood event (see Appendix B for a detailed list of priorities). More detailed assessment is required to determine the specific repair method and the cost thereof.

Figure 3. Typical channel aggradation in East Vail

Deposition in the main channel of Gore Creek has likely been exacerbated by adjacent landuse. The encroachments on the Bighorn Creek, Pitkin Creek and Booth Creek tributaries and development on the alluvial fans has prevented channel migration and deposition on those fans. Material may be more readily transported into Gore Creek that would otherwise deposit on the alluvial fans. Similarly, the land use encroachments of Gore Creek have reduced the main channel's ability to absorb new sediments by migrating and eventually aggrading the valley floor.

A map of all 141 assessment points is included in Appendix A along with descriptions of the 58 assessment sites. A shapefile of all assessment points is included with this report. Within the 58 assessment areas a total of 61 specific projects were identified (Appendix B). Out of the 61 projects six priority sites were evaluated for conceptual designs. The following sections contain descriptions of the work to be completed at each site with opinions of cost. Detailed conceptual plans and opinions of cost are presented in Appendix C.

1. Heathers at Vail, Black Gore Drive Flood Mitigation

Downstream of the Interstate 70 Bridge over Gore Creek is a broad alluvial fan with bifurcating channels. The fan is less steep than other local tributaries and multiple perennial flow paths exist. Dense residential property has been developed on the fan island between the two main channels. Prior to 2010, the right (north) channel conveyed more significant flow and the left (south) channel had lesser conveyance. A number of bifurcating flow paths connects the right and left channels across the fan. The fan is anticipated to be a significant deposition zone and significant morphology and changes in channels are expected after significant flood events.

During the 2010 flood, a pre-existing debris bridge over the right (north) channel reduced conveyance and created a large sediment plug. Subsequently, the left (south) channel widened, cut and eroded with the increased discharge. The left channel is likely perched at a higher elevation and more overbanking of flood flows likely occurred from this south channel. The right channel was deprived of sediment at the debris plug and widened and eroded the toe of the channel at a sharp right turn. Bank collapse occurred due to toe erosion behind Heatherwood Condo Building. Sand bagging on the bank may have been in response to super-elevation flows at the corner, bank collapse or a combination.

Overall, the channels functioned ideally in 2010 to minimize flood damage to the structures. The debris bridge and sediment plug formation routed more water in the left (south) channel and prevented more significant damage that may have occurred without the increased left channel capacity. Both the right and left channels will likely have increased flood capacity after removal of the sediment plug.

A detailed cost analysis is presented in Appendix C with the sketch plan. Recommendations actions and opinion of costs are:

- Remove Sediment Plug at head of Right (north) channel
- Excavate cobbles at left channel of left (south) channel island and place in right channel of island.
- Biostabilize right bank of left channel
- Reduce grade control at downstream end of left channel (check for utility crossing).
- Stabilize toe of right channel behind Heatherwood
- Mimic or replace debris bridge for plug re-formation during future flood events.
- Cost Opinion: $47,000

2. Bighorn Creek culvert under Spruce Way and Columbine Dr. stabilization

The Spruce Way and Columbine Way crossings over Bighorn Creek are in critical condition, meaning that they may significantly fail with the repeat of a flood event similar to the 2010 event. Bighorn Creek experienced a significant flood event in 2010 that is evidenced by: 4 feet of aggraded deposits at the confluence with Gore Creek; significant channel cutting and widening downstream of Bighorn Road; deposit of boulder sized material and significant overbank flooding upstream of Bighorn Road; scour to bedrock and channel degradation of over 4 feet upstream of Interstate 70 to Columbine Way; significant deposition upstream of Columbine Way.

Previously, on June 1, 2003, the Bighorn Creek culverts under Interstate 70 failed and caused significant flooding. Much of the flooding was likely due to infiltration and piping of ground water around the culvert that built a reservoir of mud and debris. The massive size and quantity of rock material that moves through the Bighorn Creek culverts can compromise the metal culverts and create rips where groundwater can infiltrate. The I-70 CMP culvert was replaced with a 72 in. CMP with 6 inches of concrete floor to protect the metal of the culvert from being ripped by rock material transporting through the culvert.

The Columbine Way culvert has been highly compromised by rock transporting through. The rips in the culvert are likely creating paths for groundwater to pipe and infiltrate beneath the culvert. The channel cutting downstream of the culvert outlet has destabilized the channel; however, a natural grade control of boulders remains downstream of the outlet which helps keep a pool at the outlet and reduces the groundwater gradient across the culvert. This grade control is very unstable and loss of the grade control (simply by a boulder shifting) may significantly increase the hydraulic gradient of ground water across the Columbine Way culvert, increasing infiltration and piping and may eventually compromise the integrity of the road.

The Spruce Way metal culvert has not been significantly ripped; however significant erosion at the head and the outlet has caused pooling of water around the culvert ends. This pooling may eventually lead to ground water infiltration and piping around the culvert and collapse similar to the 2003 I-70 culvert. Similar to Columbine Way, a natural boulder grade control pools water at the outlet and helps reduce the groundwater gradient across the culvert. The solution to limiting ground water outside of the culvert at Spruce Way is to install head walls; however, the culvert floor should also be bedded with 6 inches of concrete to prevent the eventual ripping of the culvert, and to ensure culvert longevity similar to the expected life of the head walls.

Headwalls at Spruce Way are an immediate solution, but in our opinion not a long term solution to the broader problems in Bighorn Creek. Furthermore, installation of headwalls on the existing pipe will likely require road closure and repair. It is our opinion that the cost and complications of in-situ head walls, coupled with in-situ concrete flooring of the culvert, will be similar to costs for completely replacing the culvert, wherein a superior product may be achieved.

Detailed cost estimates and sketch plans are included in Appendix C. Recommended actions, and cost opinions, for Columbine Way and Spruce Way over Bighorn Creek, in approximate order of priority, are:

1) Temporary stabilize grade control outlet at Columbine Way with rock and grout: $8,000

2) Temporary stabilize grade control outlet at Spruce Way with rock and grout: $8,000
3) Replace culvert at Spruce Way with a concrete box structure (4’ x 6’)with concrete wing/head walls and permanent grade control: $129,000
4) Replace culvert at Columbine Way with a concrete box structure (4’ x 6’) with boulder wing walls and permanent grade control: $104,000

3. Bighorn Park bank stabilization, spillway, inlet, and Christopher Sewell Bridge

The design rational for the bank stabilization, inlet repair, and low flow spillway replacement at Bighorn Pond (pond) is intended to protect the pond from capture during future flood events less than a 100-year event. Construction of approximately 120 feet of crib walls along the south bank downstream of the Christopher Sewell Bridge (pedestrian bridge) restores the bank line prior to the flooding events of 2010 while increasing the bank elevation to reduce future over-bank flooding. Construction of approximately 50 feet of boulder retaining wall upstream of the pedestrian bridge would restore the bank line to a pre-2009 position and reduce the advancing channel migration. Replacing the existing spillway weir is designed to improve outflow capacity of the pond to be sized with inlet capacity.

The design of crib walls for bank stabilization, rather than riprap or boulder bank stabilization, offers a location to waste some sediment which has aggraded the channel over 2 feet since 1994. The crib structures are designed with a boulder toe to reduce channel migration into the pond bank. These crib structures require dense vegetation installation as part of the stabilization and long term function of the bank. Design of a boulder retaining wall upstream of the Christopher Sewell Bridge is meant to reconstruct a pre-2010 bank location while providing toe stability and reduce the migration of the channel into the south abutment.

The existing inlet culvert immediately downstream of the pedestrian bridge, which was damaged during the 2010 flood, will be replaced. The inlet culvert configuration dimensions and elevations will not be modified, other than the addition of a gate. The gate will allow for some inlet control during flood events and maintenance periods.

Re-sizing of the low flow spillway has been performed to offer increased conveyance capacity during high stream flow events while maintaining the existing low flow pond surface elevations. The current capacity of the existing weir coupled with the vertical standpipe is insufficient (less than 5 cfs) to convey the combined stream flow obtained from the two inlet culverts (approximately 10 cfs) at Bighorn Pond. Furthermore, the existing weir was compromised during flooding in 2010 and has significant leakage around its end. A compound radial spillway was designed for increased conveyance, groundwater cutoff, and improved aesthetics.

Damage from the 2010 flood event on Christopher Sewell Bridge was extensive. The south abutment was almost completely undermined and is supported by only a few small boulders without adequate subgrade. It is RiverRestoration's opinion that the abutment was not originally designed to adequate scour depth. The top of the abutment footer is at elevation 8516.5 feet and poured unevenly on native subgrade ground consisting of sand, gravel and cobble. The abutments may have been away from the main channel at the time of installation; however, the thalweg of the channel is now at the south abutment. Scour resulting from the 2010 flood went below elevation 8513.0 feet at the south abutment. The poorly consolidated subgrade material has eroded from under the entire abutment, extending up to six feet behind the face of the abutment.

After dewatered inspection, our recommended alternative is to rebuild the bridge and design new alignments, abutments, and spans to function with a mobile channel bed. However, we understand that Owners may seek a lower cost alternative, and furthermore, the perilous existing condition may result in collapse of the bridge after spring runoff 2011. Therefore, it is reasonable to attempt to stabilize the south abutment in place. We have provided a design to inhibit scour around the abutment, train the flow along the channel banks and resist the ongoing migration of the channel. In addition, concrete fill would be placed in the voids beneath the abutment. This alternative does not permanently rectify the fundamental design flaw of the original abutment and therefore should be considered a temporary fix. The longevity of the temporary fix is unknown and should be monitored. Detailed cost estimates and sketch plans are included in Appendix C. Cost Opinion: $53,000.

South abutment Christopher Sewell Bridge inspected December 6, 2010, Vail, CO

4. Booth Creek upstream of I-70

While the data is still being reviewed, preliminary information indicates that Booth Creek experienced an approximate 500-year flood event in June of 2010 when compared to the flows outlined in the Flood Insurance Study for Eagle County, Colorado and Incorporated Areas (FEMA, 2007). As previously indicated there have been a number of large flood events on Gore Creek Tributaries over the last 25 years. Many factors can impact a basin's hydrology including changes in forest health or composition, wildfires, urbanization, and climate variability. It is difficult to know if these recent large events are indicative of large scale changes as described above, if they are simply outliers, or if the hydrology presented in the FEMA report is inaccurate. The mapped 100-year floodplain for Booth Creek may not represent the actual flood hazard in this area. This mapping should be reviewed by the floodplain administrator and any necessary adjustments to floodplain management should be made.

Given these uncertainties the Town of Vail must weigh the costs of designing and constructing facilities capable of handling these larger events versus the cost incurred from cleaning and repairing the existing facilities after these events. Gore Creek and its tributaries are a dynamic system that is constantly changing in response to the basin's climate, hydrology, geology, ecology and human impacts. As a result future events of this magnitude should be expected, although challenging to predict. The design presented below is intended to accommodate events similar to the 2010 runoff.

During this most recent event, significant channel widening and down cutting and associated erosion and periodic deposition occurred in Booth Creek. Significant loss of land occurred most significantly in areas where the riparian zone was thinned and replaced with grasses. Significant overbank flooding and deposits and other damage were sustained at the tennis courts, in the playground, on the bike path culvert and along the frontage road.

Booth Creek flows through a large, moderate gradient, alluvial fan with intermittently perched channel. Overbank flooding occurred throughout the channel but flows mostly returned to the main channel. Approximately 200 feet upstream of the bike path culvert (originally installed for U.S. Highway 6), overbank flooding did not return to the main channel and damaged the tennis courts and frontage road with deposits and erosion. Ground water upwelling or offsite flows are suspect for flooding west of tennis courts and damage to the playground area.

The scoured channel may actually have greater flow capacity post flood and should be studied in detailed for existing hydraulic conveyance. The oversized culvert has opportunity for modifications that may improve capacity and maintenance access. The localized overbanking may be mitigated with offset berms and defined flow channels routing through the playground, around the park and along the frontage road, and possibly back to the main channel.

Significant erosion of the Frontage Road drainage swales occurred as a result of overbank flows from Booth Creek. These flows likely overwhelmed the culverts under Bald Mountain Rd., flowed across the Frontage Rd. causing significant erosion at the edge of the pavement. These roadside swales were designed to drain a relatively small area along the side of the Frontage Road. The channel improvements to Booth Creek will reduce the likelihood that the roadside swales will have to handle these types of floods but will not completely eliminate them. The Town must weigh the costs of improving these roadside swales versus restoring them to their original condition and maintaining them after future flood events. Similar decisions must be made regarding the drainage facilities near the tennis court. The sketch plans presented below should be sufficient to handle flows similar to those in

2010 while limiting damage. The Town may choose to implement all or just a portion of these plans.

Detailed costs and sketch plans are included in Appendix C. Recommended measures include:

- Reduce boulder grade control at I-70 inlet (WP46; photo221; coordinate with USGS gage rating).
- Clear bike path culvert debris (performed 2010).
- Modify bike path culvert with maintenance access and possible trash racks.
- Remove cobble deposits from bike path culvert to upstream approx 200 feet (between WP44 and WP47; photo218).
- Create right offset levee (between WP48 and WP 49 and WP 50).
- Channel overflow ditch to North Frontage Road and berm along tennis courts.
- Create groundwater drainage at west end of tennis courts. Evaluate flood capacity, floodplain limits and floor elevations for existing channel upstream of tennis courts.
- Modify channel capacity as needed.
- Bio-stabilize as needed and widen riparian zone where possible.
- Improve frontage road drainage swales underneath I-70.
- Cost Opinion: $331,000

5. Middle Creek upstream of I-70

Middle Creek's peak flow during the 2010 runoff was 71 cfs; less than the 10-year event. Middle Creek's steeper alluvial fan is subject to debris flow events in addition to flood events. When unconstrained, alluvial fans such as this will frequently modify their flow paths to accommodate large quantities of sediment and debris. As the functioning channel becomes clogged new flow paths develop in new directions. Development on the Middle Creek alluvial fan has significantly restricted its natural function. Debris flows typically are assumed to have two to three times larger discharge volumes than the 100-year flood event, which for Middle Creek would be 280 to 420 cfs. While mitigation efforts for these events may be warranted, they require significant engineering and construction. The sketch plan presented below is intended to address issues related to flood damage and flood conveyance and is not intended to protect against debris flows.

Middle Creek experienced overbank flooding and isolated bank erosion in June of 2010. Middle Creek flows in the longest possible planform as it traverses a very steep alluvial fan. The channel is perched and overbank channels have numerous high gradient overbank paths. Debris jambs could lead to avulsion which is exacerbated by the perched condition. The Bell Tower was apparently constructed with designed drainage, flood and mud and debris mitigation and controls; however, Building "C" of the condos appears to block or modify one of the Bell Tower mitigation drainages and does not appear to have designed flood mitigation specific to the condos. It is also suspect that Middle Creek was realigned to its current perched position during construction of the Bell Tower. Erosion of the road fill slope at the switchback did not appear significant; the boulder toe appeared to be in place. However this area should be bio-stabilized. Additionally, erosion should be monitored and the as-built designs of the retaining walls should be evaluated for designed scour depth.

Upstream of the Bell Tower there is a boulder grade control structure and the stream is somewhat super elevated. This configuration could force flows over the left bank. Reduction of the grade control and regarding of the channel through this reach would reduce the risk of overbank flows. Construction of small vegetated berms at strategic locations along the left bank will further reduce flooding. The overflow channels to the northeast of the Bell Tower should be evaluated for their hydraulic capacity and modified as necessary.

Similar to Booth Creek the mitigation plans outlined for Middle Creek are designed to handle a flood event similar to 2010. The mapped 100-year floodplain for Middle Creek may not represent the actual flood hazard in this area. This mapping should be reviewed by the floodplain administrator and any necessary adjustments to floodplain management should be made. Additionally the Town should review the flood and debris flow mitigation plans for the properties located on the alluvial fan to ensure that the development of these properties meets land use code. This process may identify other changes that need to be made such as modifying the land use code to restrict development on active alluvial fans. Once these reviews are made the Town and adjacent property owners must weigh the costs of implementing the mitigation design versus the cost of cleanup and repair after a large event.

Detailed costs and sketch plans are presented in Appendix C. Recommended measures include:

- Bio-stabilize road embankment fill across from gage station.
- Reduce boulder grade control at peak of alluvial fan.
- Construct small vegetated berms as necessary.
- Review permitted flood mitigation for building construction, especially for the Bell Tower.

- Evaluate alternative paths for overflow channel.
- Construct drainage collection and return channel at edge of parking lot (WP16).
- Cost Opinion: $212,000.

6. Gore Creek East Vail Channel Maintenance

Significant deposition and channel changes have occurred in the main branch of Gore Creek. In early September 2010, Martin & Martin surveyed the Aspen Court area in preparation of rebuilding the bridge and provided us with cross-section information at the same locations as the cross-sections in the effective FEMA model for Gore Creek as surveyed between 1994 and 1996.

As part of the Aspen Court Bridge Replacement, RiverRestoration used the survey provided by Martin & Martin to run a revised 100-year event on Gore Creek with channel geometry representing existing conditions. Cross-sections 187, 186.5, and 185 were modified to reflect this existing channel geometry. The cross-sections associated with the Aspen Court bridge were left unchanged (effective) in the model to exemplify that any change in water surface elevation would be due to the existing conditions of the channel deposition.

Comparing the pre- and post-event channel geometry at XS 187 shows a large amount of channel aggradation, up to 4 feet in some locations. The loss of channel conveyance area caused a rise in the predicted base flood elevation of 1.55 feet. XS 186.5 has also morphed since the effective model survey in 1995; showing channel aggradation with 40 feet of left bank erosion. Viewing XS 185 in cross-section shows the formation of a large gravel bar in the center of the channel caused by deposition of materials. The water surface elevation was raised 0.63 feet at XS 185. Approximately 3,500 cubic yards of material has been deposited between 600' above to 300' below the bridge alignment.

There are likely other areas, concentrated in East Vail, that have effective base flood elevations impacted by the significant aggradation. We recommend that survey and subsequent hydraulic analysis be repeated at: XS 187 - XS 189, XS 198 - XS 200, XS 201.5 - XS 204.7, and XS 214.5 – XS 215. Repeated survey will be the basis for evaluating existing conditions and recommending channel modification measures.

Restoration measures are expected to be concentrated around exporting deposits from the channel. Deposition in the main channel of Gore Creek has likely been exacerbated by adjacent landuse. The encroachment on the Bighorn Creek, Pitkin Creek and Booth Creek tributaries and development on the alluvial fans has prevented channel migration and deposition on those fans. Material may be transported into Gore Creek that would otherwise deposit on the alluvial fans. Similarly, the land use encroachments of Gore Creek have reduced the main channel's ability to absorb new sediments, migrate and eventually aggrade the valley. Therefore, mechanical maintenance of the channel may be the most cost effective alternative for maintaining base flood elevations.

We estimate the magnitude of sediments impacting base flood elevations to be 10,000 cubic yards. Attached is a budget cost opinion for surveying, designing, permitting and removing sediments from the channel. More specific opinions of costs, and the rationale for project locations would come from detailed study modeling.

Detailed costs and sketch plans are presented in Appendix C. Recommended measures include:

- Survey cross-sections.
- Hydraulic Analysis of Gore Creek
- Develop Modification/Restoration plan.

- Channel Modification/Excavation and Restoration.
- Cost Opinion: $619,000.

Summary

In June of 2010 the Town of Vail experienced significant flooding due to rapid snowmelt. Flows on Gore Creek through the Town of Vail are estimated to be close to the 100 year return flood event and isolated tributary flows were in excess of the 500 year return flood determined by FEMA. This event caused significant deposition and channel changes to the main branch of Gore Creek, and washed out the bridge crossing at Aspen Court. In response to this event the Town of Vail requested that RiverRestoration provide an evaluation of the resulting systemic instabilities beyond the obvious damage identified by the Town of Vail.

This report identifies 58 locations that were compromised by the flooding. A geomorphic assessment was performed at each project location. The resulting flood damage was evaluated and potential impacts to habitat and any destabilized structures were also identified. General restoration measures and associated cost opinions were developed for each of the 58 sites for planning purposes. Appendix A provides a summary of each evaluation location. Six priority projects were identified for sketch plan development and detailed cost opinions. Four of these projects are located on tributary streams (Booth Creek, Middle Creek, Bighorn Creek) and two are located on Gore Creek (Heathers & Gore Creek Channel Conveyance). The sketch plans and detailed costs are presented in Appendix C.

As these flood mitigation projects are implemented we urge the Town of Vail to consider all other functions of the stream beyond flood conveyance. Colorado's water resources are increasing in value and it is prudent for the Town of Vail to maximize the values associated with Gore Creek and its tributaries. In addition to flood conveyance, rivers and streams provide critical riparian and aquatic habitat as well as recreational opportunities (both passive and active). One way of ensuring that development in the Town of Vail is compatible with the natural functions and benefits of the streams flowing though it is to develop a Stream Management Plan. This document would guide land use decisions and project implementation for the greatest benefit to the streams as well as the community. The document could provide guidelines for riparian setbacks, recreational opportunities, stormwater management, riparian habitat conservation and enhancement, and aquatic habitat restoration.

Currently the Town's Development Standards have limited detailed regarding Best Management Practices (BMPs) or the use of Low Impact Design (LID), which are directly related to river function. The Stream Management Plan could provide detailed guidance on which BMPs or LID approaches are appropriate for Gore Creek's unique environment and character. The Stream Management Plan would ideally balance Stormwater, Riparian Habitat, Land Use, Construction BMPs, Recreation, Aquatic Habitat, and Flood Plain Management to maximize the sustainability and vitality of Gore Creek and its tributaries.

APPENDIX A

TOWN OF VAIL 100-YEAR FLOOD ASSESSMENT

RIVER RESTORATION.ORG

TOWN OF VAIL

Town of Vail Boundary

N

0 0.5 1 2 Miles

Legend

- Vail 100-Year Flood Assessment Points
- Streams
- INTERSTATE 70
- Town of Vail Roads
- TOV_town_property

Vail 2010 Flood Assessment
Appendix A
January 12, 2011

Prepared By:

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Vail 2010 Flood Assessment
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Flood Assessment Point:	**West Vail Gore Trail**
GPS Coordinates:	lat="39.6157" lon="-106.4377"
Direction to Assessment Point:	South Frontage road to head west to dead end at Gore Trail. Walk approximately 500 feet downstream
Project Priority:	High X Moderate Low
Description of Damage:	Erosion of channel toes, both banks. Collapse of bike path sub grade.
Structures:	Gore Trail Bike Path
Geomorphic Description:	This reach is significantly channelized between the fill slopes of the bike path and Bellflower drive as well as fill from residential developments. Construction of the boulder wall fill slopes apparently was not keyed into the bed of the channel and lacks footer rock at scour depth. Instead the toes appear to be backfilled grouted cobble and riprap. The grouted toes have failed in many locations exposing the footer rocks. Footer rocks have shifted and the upper banks have collapsed as a result. The channel is likely responding to over-encroached banks.
Habitat Considerations:	Lack of riparian zone. NPS from native sediments and traction sand.
Measures:	Bench Left Bank and clear toe for channel capacity. Reinforce right channel toe. Plant riparian shrubs to increase the bank mass along Gore Trail and Bellflower Drive. Encourage landowners to plant robust riparian buffers. Install barriers to capture sediments from snow stockpiles at dead end of South Frontage Road.
Cost Range Opinion:	$60K-$100K
Photographs:	• Aug 18th #52, 53, 54, 55, 56, 57

Flood Assessment Point:	**Kinnickinnick Bridges**
GPS Coordinates:	RR.org1GPS 59-60 59lat="39.617991205304861" lon="-106.43276408314705" 60lat="39.620284494012594" lon="-106.42809863202274"
Direction to Assessment Point:	South Frontage road head west to dead end at Gore Trail.
Project Priority:	High Moderate X Low
Description of Damage:	East Kinnickinnick Bridge abutment armor is adequate. The West Bridge has some failed grouted boulders at the left abutment.

Structures:	Kinnickinnick Bridge West and East
Geomorphic Description:	This reach is characterized by a steep boulder channel that is confined between South Frontage road and residential developments.
Habitat Considerations:	
Measures:	Monitor toe stability at the Bridges.
Cost Range Opinion:	$0K-$1K
Photographs:	• Aug 18th #1, 2, 3, 4, 5, 6

Flood Assessment Point:	**Stephens Park**
GPS Coordinates:	lat="39.621640685945749" lon="-106.42569093033671"
Direction to Assessment Point:	Adjacent to West Vail Frontage road. Town of Vail dog park.
Project Priority:	High: Moderate: X Low:
Description of Damage:	There are four areas with significant flood damage. 1.) The beach access area on river right. This area is planned for improvements to be constructed fall 2010. 2.) The upper bank fill material on river left is eroding for approximately 30 feet. This erosion is localized to the outside of the river bend and will compromise the paved pathway at the top of the bank. 3.) Upstream of the pedestrian bridge on river left the bank is eroding for approximately 50 feet. Two large pine trees will likely fall into the river in the near future. No structures are compromised. 4.) Downstream of the pedestrian bridge on river right the upper fill material has eroded. No structures are compromised at this area. In addition to these four sites there was erosion of the soft pathway on the interior floodplain bench on river right.
Structures:	Pedestrian bridge and pathways.
Geomorphic Description:	Upstream of Stephens Park the channel is constricted between the frontage road and a bedrock outcrop. After the outcrop, the channel opens and an Island formed on left and Stephens park is likely fill of remnant islands and channel braiding. Around the park area the channel makes a shallow radius left to right bend. Erosion of the upper bank fill material has occurred on the outside of theses bends. The toe of the banks appear stable with large boulder material or fractured bedrock. The right point bar is native material. Loss of under story vegetation has likely exacerbated erosion. The channel may tend to braid in this section without fill and stabilization.
Habitat Considerations:	Loss of the under story vegetation has resulted to decreased bank stability and root mass.
Measures:	Implement the Stephens Park Bank Stabilization Project.

	Monitor erosion on the outside of the bends. Continued erosion on the cut banks of the bends may require a biodegradable coir fabrics with staking of willows/dogwoods. Facilitate bank access and detour random trampling with thorny shrub plantings. Monitor interior cut channels on point bar.
Cost Range Opinion:	$1K-$5K
Photographs:	• River left bank erosion • river left erosion, large trees • river right erosion

Flood Assessment Point:	**Gore Creek Downstream of Elliot Bridge**
GPS Coordinates:	
Direction to Assessment Point:	From South Frontage Road drive south on Elliot Road. Deposits are located downstream of the Elliot Road Bridge in front of the Oldest Cabin in Vail.
Project Priority:	High Moderate Low X
Description of Damage:	Significant channel deposition and change in channel morphology.
Structures:	South frontage road at top of bank on river right.
Geomorphic Description:	Significant cobbles have deposited forming a lateral bar on river left. Downstream of the deposits the channel is constricted between the South Frontage road fill slope and a bedrock outcrop. The backwater effect from this constriction decreased the transport capacity and significant bedload deposits of cobble material dropped out forming a lateral bar on river left. This deposition may decrease channel flood capacity.
Habitat Considerations:	The lateral bar has pushed the thalweg to the right side of the channel. This may exacerbate erosion of the right bank fill slope. Large boulders are in place at the toe, however the fill material may erode and eventually compromise the stability of the fillslope of the south frontage road. Refreshed gravel/cobble bars provide good spawning habitat.
Measures:	Monitor lateral bar growth, thalweg, and erosion of the river right bank. Monitoring may recommend the future need for erosion control fabrics and plantings to protect the fill slope. In-channel excavation of the cobble deposits may be necessary if erosion increases or deposition causes upstream flood issues. .
Cost Range Opinion:	$0K-$1K
Photographs:	• Cobble deposits • Aug11_012

Flood Assessment Point:	**West Vail Roundabout Bridge Downstream**
GPS Coordinates:	
Direction to Assessment Point:	From the West Vail exit roundabout drive south to Bridge and look downstream.
Project Priority:	High Moderate Low X
Description of Damage:	Erosion of the fill material on river right for approximately 50 feet. Toe of channel is stabilized with large boulders.
Structures:	Possible buried utilities
Geomorphic Description:	The river is confined by a steep fillslopes on left and a retaining wall on right for South Frontage road. The fill slope is reportedly for utility coverage. There are no vegetation or fabrics to hold the left fill slope. The fine bank materials are eroding, potentially reducing cover on utilities.
Habitat Considerations:	NPS sediments from bank erosion.
Measures:	Monitor erosion of fillslope. Monitoring of the fillslope may recommend willow/dogwood pole planting augmentation, or possible placement of riprap and boulders at toe of fill slope.
Cost Range Opinion:	$10K-$20K
Photographs:	• Bank erosion at the abutment • Downstream river left bank erosion

Flood Assessment Point:	**South Frontage Road Fillslope Erosion**
GPS Coordinates:	RR.org1pt2 lat="39.628552235662937" lon="-106.41873680055141
Direction to Assessment Point:	From the West Vail exit roundabout drive east on South Frontage road for approximately 100 feet.
Project Priority:	High Moderate Low X
Description of Damage:	Erosion of the fill material on river right for approximately 150 feet. Toe of channel is stabilized with large boulders.
Structures:	South Frontage Road
Geomorphic Description:	The river right is confined by a steep fillslope from South Frontage road. There are no vegetation or fabrics to hold the slope. The fine bank materials are eroding.
Habitat Considerations:	NPS sediments from bank erosion.
Measures:	Monitor erosion of right fillslope. Monitoring of the fillslope may recommend willow/dogwood pole planting augmentation, or possible placement of riprap.
Cost Range Opinion:	$0K-$1K
Photographs:	• Fill slope erosion

Flood Assessment Point:	**Downstream Gore Creek Drive at Condos**
GPS Coordinates:	RR.org1pt3 lat="39.628682406619191" lon="-106.41736778430641"
Direction to Assessment Point:	From West Wail exit roundabout drive east on South Frontage road, drive south for approximately 0.25miles.
Project Priority:	High Moderate Low X
Description of Damage:	Erosion of bank on river left and a large tree fallen across the channel.
Structures:	none
Geomorphic Description:	Bank erosion of cobble and fine materials on the river left bank has exposed the rootmass of several large trees. One large tree has fallen across the channel. The channel is widening with river left bank failure. Local hydraulics are partial split flow from a cobble island where the thalweg is located on river left. There is some trampling of the bank on river right from residents.
Habitat Degradations:	NPS sediments from bank erosion. Loss of mature vegetation.
Measures:	Cut and remove large tree fallen across the channel. Monitor for future fallen trees across the channel. Install boulders toe stability to protect tree root erosion on river left. Thorny vegetate informal bank access areas and densely vegetate understory native shrubs for root mass and bank stability in the riparian area.
Cost Range Opinion:	$2K-$4K
Photographs:	• large fallen tree across the channel • left bank erosion • left bank erosion • left bank erosion and fill slope

Flood Assessment Point:	**West Gore Creek Drive Bridge**
GPS Coordinates:	
Direction to Assessment Point:	From South Frontage road, drive south on West Gore Creek Drive.
Project Priority:	High Moderate Low X
Description of Damage:	Erosion of fine bank materials downstream of the bridge may cause collapse of a large pine tree on river left. Small mammals digging into the bank exacerbate the erosion.
Structures:	Gore Creek Drive Bridge and in-channel utility crossing appear stable.
Geomorphic Description:	Small mammal wildlife making homes in the bank have likely reduced the vegetation cover exacerbating erosion caused during the flood.

Habitat Considerations:	NPS sediments from bank erosion.
Measures:	Monitor stability or cut large tree to prevent damage to the road. Leave stump in place for root mass bank protection and augment with boulders. Monitor small mammals digging into the bank near the bridge abutments. May need to augment mammal holes with boulders.
Cost Range Opinion:	$2K-$4K
Photographs:	• Left bank erosion and small mammal home

Flood Assessment Point:	**Matterhorn Circle Bridge**
GPS Coordinates:	
Direction to Assessment Point:	From South Frontage road turn south onto Matterhorn Circle.
Project Priority:	High: X; Moderate: ; Low:
Description of Damage:	Erosion of both left and right bank fill material and the toe of the right bridge abutment. Fine materials have washed out from behind the grouted boulders on the river right abutment protection. The toe of the river right abutment has eroded under the spread footer. Erosion of fine bank materials has occurred upstream of the bridge on river right, and downstream of the bridge on river left. Some erosion has occurred on the upstream and downstream edge of the left abutment. Significant bank fill has compromised trees and riparian vegetation. Downstream bank erosion on river left may cause two large pine trees to fall into the river. The pedestrian bridge upstream appears to have stable channel protection.
Structures:	Bridge, pipe crossing, and buried utilities
Geomorphic Description:	The river takes a left turn, the bridge is located just downstream of the apex in the bend where maximum scour will occur on river right. The loss of under story vegetation coupled with the steep bank from the road encroaching the channel has likely exacerbated erosion of the left bank.
Habitat Considerations:	NPS sediments from bank erosion. Loss of vegetation.
Measures:	Remove the two large trees. Reduce the slope of the left bank opening up an interior floodplain. Install erosion control blankets and plantings on river left. Protect the abutments by grouting cobble and boulders.
Cost Range Opinion:	$20K-$40K
Photographs:	• River right abutment scour • Upstream river right bank erosion • Downstream right abutment erosion

	• Upstream left abutment erosion • Downstream left abutment erosion • Downstream river left bank erosion, two trees

Flood Assessment Point:	**Donovan Park Tennis Courts**
GPS Coordinates:	RR.org1pt 5-8 5lat="39.633822022005916" lon="-106.40819672495127" 6lat="39.636298371478915" lon="-106.4064942765981" 7lat="39.636624343693256" lon="-106.40594450756907" 8lat="39.636624259874225" lon="-106.40594677068293"
Direction to Assessment Point:	From the Matterhorn Circle bridge head east on the Gore Creek Trail bike path.
Project Priority:	High Moderate Low X
Description of Damage:	Pedestrian and fishing recreation has trampled the bank in local areas exacerbating erosion. The narrow riparian buffer and steep slope from the bike path increases the potential for bank erosion.
Structures:	Bike Path
Geomorphic Description:	The channel is encroached by the bike path resulting to loss of riparian vegetation and reduced bank stability. The channel has been channelized from development encroachments.
Habitat Considerations:	NPS sediments from bank erosion. Loss of vegetation. Development encroachment.
Measures:	Monitor erosion. Monitoring may recommend augmenting the bank willow/dogwood pole plantings and possible placement of riprap. Landscape measures may be necessary to designate bank access.
Cost Range Opinion:	$4K-$8K
Photographs:	• Bank access • Pedestrians and bank access • Looking at path and fill slope • Looking at slope and channel

Flood Assessment Point:	**West Haven Circle Bridge**
GPS Coordinates:	
Direction to Assessment Point:	From Cascade village drive to West Haven Bridge.
Project Priority:	High Moderate Low X
Description of Damage:	Some winnowing of fine materials behind boulder

	stabilization at the abutments. Large boulders in the channel appear stable. No scour noticeable at the mid-channel pier.
Structures:	Bridge
Geomorphic Description:	The Bridge is located at the cross over between a left to right bend in the river. Large boulders naturally deposit in this area to form a riffle. The construction of the bridge moved these boulders. The pier of the bridge splits flow, the thalweg is located on river right of the pier.
Habitat Considerations:	Good in-stream habitat with pocket pools.
Measures:	Monitor for future scour of bridge abutments and pier.
Cost Range Opinion:	$0K-$1K
Photographs:	•

Flood Assessment Point:	**Cascade Skier Bridge**
GPS Coordinates:	
Direction to Assessment Point:	Gore Creek trail bike path upstream of Cascade village.
Project Priority:	High Moderate Low X
Description of Damage:	Debris jam creates navigation hazard for watercraft recreation.
Structures:	Bridge
Geomorphic Description:	Upstream of the bridge the reach has been channelized and is confined between South Frontage road on river right, and the bike path cutslope on river left.
Habitat Considerations:	Downstream of the bridge an island splits flow allowing for greater flood flow conveyance and a wider riparian corridor.
Measures:	Post in-stream navigation hazard warning signs upstream of the bridge. Periodically check debris for cross channel strainers, or altering the flow conveyance under the bridge.
Cost Range Opinion:	$2K-$4K
Photographs:	• Looking at debris jam downstream of bridge

Flood Assessment Point:	**Channelized Reach between WWTP and Cascade Village**
GPS Coordinates:	RR.org1pt9, RR.org1pt10 9lat="39.640001831576228" lon="-106.39953654259443" 10lat="39.640768943354487" lon="-106.39678543433547"
Direction to Assessment Point:	Downstream of the Wastewater Treatment Plant

Project Priority:	High Moderate X Low
Description of Damage:	Upper bank fill material erosion.
Structures:	Parking lot, and bike path.
Geomorphic Description:	This reach has been channelized and is confined between a steep fillslope for the South Frontage Road and fill for a parking lot. The lack of under story vegetation and bank root mass may exacerbate the failure of mature pine trees. The channel trend is to migrate north and restore the natural bend.
Habitat Considerations:	Continued erosion of fillslope materials will lead to bank failure and loss of the riparian vegetation. Continued loss of riparian vegetation will compromise the stability of the fill slope.
Measures:	Install biodegradable erosion control fabrics and plant native shrubs to increase the bank rootmass. Monitor future erosion of the fillslope. Future fallen mature trees are likely and will need to be removed from the channel.
Cost Range Opinion:	$1K-$4K
Photographs:	• Looking at mature tree about to fall into river • Looking at eroding fill slope

Flood Assessment Point:	**WWTP Bridges**
GPS Coordinates:	
Direction to Assessment Point:	At the Wastewater Treatment Plant there are two bridges. A newly constructed road bridge, and the bike path/pedestrian bridge.
Project Priority:	High Moderate X Low
Description of Damage:	No significant flood damage. Some of the riprap under the right abutment of the road bridge have mobilized.
Structures:	Bridges
Geomorphic Description:	This reach has been channelized and is confined between a steep fillslope and the bikepath. The channel has grade control structures, and the toe of the banks are stable with boulders and large cobbles.
Habitat Considerations:	Buffer discharge from storm water culvert on river left bank.
Measures:	Monitor bridge abutments for future scour.
Cost Range Opinion:	$0K-$1K
Photographs:	• Aug 11 #61, looking at right abutment • Aug 11#62, looking at culvert

Flood Assessment Point:	**Forest Road Bridge**
GPS Coordinates:	
Direction to Assessment Point:	Upstream of the Wastewater Treatment Plant
Project Priority:	High Moderate Low X
Description of Damage:	Erosion of cobble and bank materials. River right repaired, however hydroseed not spouting at time of assessment. Failed silt fence.
Structures:	Bridge
Geomorphic Description:	Downstream of the bridge the reach has been channelized and there are several grade control structures. Upstream of the bridge large cobble deposits form a mid-channel bar.
Habitat Considerations:	
Measures:	Augment riprap under the bridge at the abutments. Monitor scour at the abutments and migration of cobble bar. Monitoring may recommend fabrics under the riprap to hold fine bank materials. Install willow stakes between riprap.
Cost Range Opinion:	$1K-$4K
Photographs:	• Aug 11 #63, repaired abutment • Aug 11 #64, looking downstream at deposits

Flood Assessment Point:	**Lionshead Deposition Reach**
GPS Coordinates:	RRorg1GPS #11, GPS #12 11lat="39.641890609636903" lon="-106.39089949429035" 12lat="39.641872001811862" lon="-106.39087183400989"
Direction to Assessment Point:	Between Lionshead skier bridge and Forest Road Bridge.
Project Priority:	High Moderate Low X
Description of Damage:	Cobble deposits and channel aggradation are forming lateral bars that put pressure on the bank.
Structures:	Bike Path
Geomorphic Description:	This reach is characterized by lateral bars. Bedrock outcrops protect the banks, however there are sections where robust riparian vegetation is critical for bank stability.
Habitat Considerations:	There are several natural features that provide good in-stream habitat. Bedrock outcrops form deep pools and undercuts that provide good fish cover. Cobble bars form spawning habitat and diversity of niche habitat for macroinvertebrates.

	Several locations are denuded from fishing/pedestrian traffic random trampling the bank.
Measures:	Monitor bank stability and robust riparian vegetation. Designate bank access areas. Future monitoring of the riparian vegetation will be necessary to ensure the bank root mass is sufficient to hold the channel in its current alignment. Shifting of cobble bars and loss of understory shrubs could result to erosion of the banks and compromise the bike path.
Cost Range Opinion:	$5K-$10K
Photographs:	• Bedrock outcrop • Bedrock and undercut bank • Cobble bars and robust riparian vegetation • Random trampling of bank • Random trampling of bank

Flood Assessment Point:	**Lionshead Wetland Pedestrian Bridge**
GPS Coordinates:	
Direction to Assessment Point:	
Project Priority:	High Moderate Low X
Description of Damage:	Groundwater piping is eroding materials behind the left bridge abutment.
Structures:	Pedestrian Bridge
Geomorphic Description:	Groundwater draining from the wetland is piping fine bank material from behind the left abutment of the pedestrian bridge. The toe of the abutment is stable.
Habitat Considerations:	NPS from bank erosion.
Measures:	Monitor piping of structural fill material under the abutment, and bank stability. Future monitoring may recommend the installation of drainpipes around the abutment.
Cost Range Opinion:	$0K-$1K
Photographs:	• Looking at left abutment and groundwater piping.

Flood Assessment Point:	**Gore Trail Park Area Upstream of Lionshead**
GPS Coordinates:	RRorg1GPS #13 lat="39.643221236765385" lon="-106.38500173576176"
Direction to Assessment Point:	Adjacent to bike path upstream of Lionshead village
Project Priority:	High Moderate Low X

Description of Damage:	Erosion of right bank, loss of picnic area.
Structures:	No structures, however park area with picnic tables.
Geomorphic Description:	Local hydraulics against the outside of the bend are eroding the right cut bank. Coupled with pedestrian traffic and loss of vegetation the bank has eroded to steep bare soil.
Habitat Considerations:	Non-point source pollution from bank erosion. Loss of riparian habitat.
Measures:	Install boulder steps to a boulder platform at the right toe to facilitate pedestrian traffic and stabilize the bank. The steep bank limits potential for terraced seating. Install shrubs and herbaceous plantings at upper bank. Potential for an overlook wall and patio area to enhance the picnic area.
Cost Range Opinion:	$20K-$40K
Photographs:	• Aug 11 photo #81, 82, 83

Flood Assessment Point:	**Main Vail Bridge**
GPS Coordinates:	RR.org1GPS #16 lat="39.640782941132784" lon="-106.37797376140952"
Direction to Assessment Point:	Main Vail exit drive south around roundabout to Gore Creek.
Project Priority:	High Moderate Low X
Description of Damage:	Erosion of left bank fill material may cause collapse of mature pine trees.
Structures:	No structural damage.
Geomorphic Description:	The toe is stable with boulders, however erosion of the fine materials on the bank have exposed roots of mature pine trees.
Habitat Considerations:	Non-point source pollution from bank erosion. Loss of mature pine trees. Discharge from a small stormpipe saturates the bank upstream of the left abutment and is causing bank failure.
Measures:	Build the left bank with toe boulders to stablize mature trees. Backfill with cobbles and native soil encapsulated in a coir erosion control fabrics. Plant with willows. Install buffer area for stormwater return.
Cost Range Opinion:	$10K-$20K
Photographs:	• Aug 11 photo #87, 88, 89

Flood Assessment Point:	**Gore Creek International Bridge to Covered Bridge**

GPS Coordinates:	
Direction to Assessment Point:	
Project Priority:	High Moderate Low X
Description of Damage:	Localized areas of the bank are eroding from random trampling of the bank coupled with narrow to none existent native riparian shrubs.
Structures:	Pedestrian bridge and commercial developments.
Geomorphic Description:	Channelized section confined between developments. There are several grade control structures and hard access points.
Habitat Considerations:	Local random trampling of the bank at the Bridges.
Measures:	Encourage land owners to plant a robust riparian corridor to protect the bank. Prune brush or remove deposits at culverts as needed.
Cost Range Opinion:	$1K-$4K
Photographs:	• Aug 18th #42, 43, 44

Flood Assessment Point:	**Vail Whitewater Park**
GPS Coordinates:	
Direction to Assessment Point:	International Bridge Vail Village
Project Priority:	High Moderate Low X
Description of Damage:	Loss of veneer rock on Pedestrian and International Bridge
Structures:	Bridge.
Geomorphic Description:	Hardened channel confined by boulder toes and bridge abutments
Habitat Considerations:	Impediment of channel processes.
Measures:	Monitor toe erosion. Replace veneer pieces. Monitor inflatable bladders for function and remove debris.
Cost Range Opinion:	$0K-$1K
Photographs:	• 111_0729/ IMGP2179.jpg; IMGP2180.jpg ; IMGP2181.jpg; IMGP2182.jpg; IMGP2183.jpg IMGP2184.jpg

Flood Assessment Point:	**Gore Creek Upstream of Covered Bridge**
GPS Coordinates:	Deposit = 39°38'27.87"N; 106°22'21.45"W Tree= 39°38'27.41"N; 106°22'20.71"W

Direction to Assessment Point:	Exit 1-70 Main Vail; head 0.4 miles east on South Frontage Road; head south on Vail Valley Blvd turn west on Promenade 0.1 mile to Mill Creek confluence.
Project Priority:	High Moderate Low X
Description of Damage:	Localized erosion throughout banks
Structures:	Left bank of channel property; bridge
Geomorphic Description:	Deposits in the channel upstream of Mill Creek confluence and the Covered Bridge put pressure on left bank toe. Thalweg at toe of left bank may eventually cause erosion. Insignificant scour at bridge abutments.
Habitat Considerations:	Non-point source pollution from bank erosion.
Measures:	Monitor erosion of the left bank and increasing center bar deposits. Install shrubs and herbaceous plantings to increase bank root mass. Designate bank access to reduce random trampling. Install replacement conifers.
Cost Range Opinion:	$1K-$4K
Photographs:	• 115_0804/IMGP2347.jpg; IMGP2348.jpg; IMGP2349.jpg; IMGP2350.jpg; IMGP2351.jpg

Flood Assessment Point:	**Gore Creek Near of Vail Valley Blvd Bridge**
GPS Coordinates:	Tree= 39°38'28.28"N; 106°22'17.84"W Tree=39°38'29.26"N; 106°22'15.12"W
Direction to Assessment Point:	Exit 1-70 Main Vail; head 0.4 miles east on South Frontage Road; head south on Vail Valley Blvd to Gore Creek, walk trail on north side of river upstream and downstream.
Project Priority:	High Moderate Low X
Description of Damage:	Localized erosion throughout banks
Structures:	Bridge. No minor scour around abutments of road bridge. Some loss of riprap at right abutment. Retaining wall: loss of tree may undermine gabion basket retaining wall upstream of bridge. Path downstream of Bridge: repaired after flood.
Geomorphic Description:	The channel flows around the Mill Creek alluvial fan. Upstream of the bridge the channel is pushed to the north at the toe of a steep terrace. Downstream of the bridge there is a broad interior floodplain. The right bank is the alluvial fan with 2 major tributary channels and a number of smaller springs and flow paths.
Habitat Considerations:	Non-point source pollution from bank erosion. Potential loss of mature pine trees.
Measures:	Monitor erosion of the banks and cantilevered trees. Install shrubs and herbaceous plantings to increase bank root mass, esp at park. Designate bank access at park and along trail.

	Plant new generation of conifer trees. At upstream of bridge, some channel work may realign boulders to reduce erosion at tree.
Cost Range Opinion:	$4K-$10K
Photographs:	• 115_0804/IMGP2352.jpg; IMGP2353.jpg; IMGP2354.jpg; IMGP2355.jpg; IMGP2356.jpg; IMGP2357.jpg; IMGP2358.jpg; IMGP2359.jpg; IMGP2360.jpg

Flood Assessment Point:	**Gore Creek Downstream of Vail Manor Bridge**
GPS Coordinates:	Deposit=39°38'23.57"N; 106°22'1.99"W
Direction to Assessment Point:	Exit 1-70 Main Vail; head 0.9 miles east on South Frontage Road; Park at Ford Park parking lot, walk trail on north side of river downstream 0.4 miles.
Project Priority:	High Moderate Low X
Description of Damage:	Center channel deposits creating toe scour on both banks downstream of bridge
Structures:	Bridge. No significant scour around abutments of pedestrian bridge. Some loss of riprap at right abutment.
Geomorphic Description:	Cobble/gravel deposits downstream of the bridge split flow and push the thalweg on river right and river left bank. Fine bank materials are eroding causing several mature pine trees to cantilever and eventually collapse into the channel. Random trampling of the right bank exacerbates erosion.
Habitat Considerations:	Non-point source pollution from bank erosion. Potential loss of five mature pine trees.
Measures:	Monitor erosion of the banks and cantilevered trees (2 right, 1 left). Install shrubs and herbaceous plantings to increase bank root mass. Designate bank access. Plant new generation of conifer trees. Improve storm water rundowns.
Cost Range Opinion:	$4K-$10K
Photographs:	• 115_0804/IMGP2361.jpg; IMGP2362.jpg; IMGP2363.jpg; IMGP2364.jpg;IMGP2365.jpg

Flood Assessment Point:	**Betty Ford Alpine Gardens**
GPS Coordinates:	RR.org1GPS #17 lat="39.638815876096487" lon="-106.36610733345151"
Direction to Assessment Point:	There are trails that access the river bank throughout the area. The bike path/pedestrian bridge connect north and south trails.

Project Priority:	High Moderate Low X
Description of Damage:	Random trampling of right bank. Cobble deposits in main channel may increase overbank flooding.
Structures:	No structural damage to pedestrian bridge.
Geomorphic Description:	Boulder grade control structure located at the pedestrian bridge appears stable. Cobble/gravel deposits downstream of the bridge split flow and push the thalweg on river right bank. Fine bank materials are eroding causing several mature pine trees to cantilever and eventually collapse into the channel. Random trampling of the right bank exacerbates erosion.
Habitat Considerations:	Non-point source pollution from bank erosion. Potential loss of five mature pine trees.
Measures:	Monitor erosion of the banks and fallen trees across the river. Install shrubs and herbaceous plantings to increase bank root mass. Designate bank access. Plant new generation of pine trees.
Cost Range Opinion:	$4K-$10K
Photographs:	• Aug 11 photo #96, 97, 98, 99, 102

Flood Assessment Point:	**Nature Center**
GPS Coordinates:	RR.org1GPS 18-21 lat="39.639660604298115" lon="-106.36311608366668" lat="39.639919940382242" lon="-106.36139184236526" lat="39.640437522903085" lon="-106.36008569039404" lat="39.640348590910435" lon="-106.35904314927757"
Direction to Assessment Point:	There are trails that access the left river bank throughout the Nature Center area. The paved path can be accessed from Vail Valley Drive (Vail Golf Course), just upstream of the Nature Center.
Project Priority:	High Moderate Low X
Description of Damage:	Erosion of left bank causing collapse of paved path and mature pine trees.
Structures:	Paved path
Geomorphic Description:	Local hydraulics on the outside of the bend at the apex point are eroding cobble and finer material. The bank has eroded and is undermining the paved path. Sand bags are staked to protect the bank.
Habitat Considerations:	Non-point source pollution from bank erosion. Random trampling of the bank throughout the nature center causes loss of shrubs and herbaceous cover.
Measures:	Install boulders with pole plantings to stabilize the outside of the bend. Patch and repair paved path. Plant thorny shrubs to detour random trampling the banks throughout the Nature

	Center area.
Cost Range Opinion:	$14K-$30K
Photographs:	• Aug 11th #113; 114; 115; 116;117

Flood Assessment Point:	**Golf Course Downstream Path**
GPS Coordinates:	
Direction to Assessment Point:	Below the #14? Tee Box along cart path
Project Priority:	High Moderate Low X
Description of Damage:	Left bank erosion at apex of point bar. Temporarily stabilized with dumped boulders
Structures:	Cart Path; tree
Geomorphic Description:	Advancing pointbar downstream of channelized reach erodes left cut bank into terrace material. Cart path cut into terrace at top of bank. Large conifer trees help hold bank.
Habitat Considerations:	Non-point source pollution from bank erosion and loss of the riparian vegetation have degraded stream health functions.
Measures:	Monitor erosion, monitor tree root stability. Evaluate point bar for other channels. Install willow/dogwood pole plantings between the riprap boulders on river left to increase the bank mass. A repaired structure may redefine the thalweg and stabilize the toe of the bank.
Cost Range Opinion:	$21K-$44K
Photographs:	• Aug31/IMG_0270.jpg; IMG_0271.jpg; IMG_0272.jpg; IMG_0273.jpg

Flood Assessment Point:	**Golf Course Channelized Reach**
GPS Coordinates:	RR.org1GPS 22, 24-25 22lat="39.641814166679978" lon="-106.3532461412251" 24lat="39.642828125506639" lon="-106.34814290329814" 25lat="39.643014539033175" lon="-106.34701101109385"
Direction to Assessment Point:	Reach along South Frontage Road between Ford Park and the bend in the river at the Golf Course.
Project Priority:	High Moderate Low X
Description of Damage:	Several local areas where erosion of the left bank has caused loss of riparian vegetation and is eroding the maintained areas of the Golf Course. A few areas are eroding the upper bank fill material on river right.
Structures:	South Frontage Road; Golf Course

Geomorphic Description:	Gore Creek has been channelized in this reach between South Frontage Road and the Golf Course. Several grade control structures are installed and appear stable. There is one grade control structure that has failed and repair of left bank erosion is evident; the river is braiding and widening in this area. Both the left and right bank have a very narrow band of riparian vegetation. There are a few local areas where erosion of fill material on river right may compromise the road if the slope is not stabilized.
Habitat Considerations:	Non-point source pollution from bank erosion and loss of the riparian vegetation have degraded stream health functions.
Measures:	Install willow/dogwood pole plantings between the riprap boulders on river right to increase the bank mass. Install biodegradable coir fabrics with shrub plantings and mature trees to restore a minimum 15' wide riparian band on river left. Alternatives should be evaluated at the failed grade control structure; the channel wants to naturally braid however may continue to erode land on the Golf Course; a repaired structure may redefine the thalweg and stabilize the toe of the bank.
Cost Range Opinion:	$4K-$10K
Photographs:	• Aug 11th #125; 126; 127; photo 125 is braiding area and failed grade control structure.

Flood Assessment Point:	**Vail Valley Blvd Bridge**
GPS Coordinates:	RR.org1GPS #23 lat="39.642157824710011" lon="-106.3521493691951"
Direction to Assessment Point:	From South Frontage Road drive there is a snow storage site/pull-out area upstream of Vail Valley Drive Bridge.
Project Priority:	High Moderate Low X
Description of Damage:	Some riprap boulders have rolled exposing the fabric at the abutments under the Bridge.
Structures:	Bridge
Geomorphic Description:	Hydraulics under the bridge have eroded fine materials.
Habitat Considerations:	Non-point source pollution from erosion and traction sand sediments. Loss of riparian vegetation.
Measures:	Monitor for scour under the bridge and stability of riprap placed at the abutments. Future conditions may recommend augmentation of riprap at the abutments.
Cost Range Opinion:	$0K-$1K
Photographs:	• Aug 11th #123 left abutment • Aug 11th #124 traction sand and eroding bank.

Flood Assessment Point:	**Golf Course Diversion Structure**
GPS Coordinates:	RR.org1GPS 52-55 52lat="39.642947567626834" lon="-106.33767901919782" 53lat="39.64329575188458" lon="-106.33815988898277" 55lat="39.643433969467878" lon="-106.33861351758242"
Direction to Assessment Point:	Vail Golf Course
Project Priority:	High X Moderate Low
Description of Damage:	Grade Control Structure for water diversion.
Structures:	Grouted boulder diversion headding structure
Geomorphic Description:	This reach has been channelized with a series of grade control structures. Boulders have moved at cross vane structures, some causing localized bank erosion. The headding structure for the water diversion has experienced significant scour that has lead to failure. Footer boulders have rolled creating an undercut of grouted boulders are bridged. The bridge is forming a sieve that may be extremely hazardous to in-stream navigation.
Habitat Considerations:	
Measures:	Coordinate with owner of the diversion structure and repair/replace the structure. Post warning signs for in-stream recreation.
Cost Range Opinion:	$40K-$60K
Photographs:	• Aug 16th #47; 48; 49 • Aug 18th #15; 16; 17; 18

Flood Assessment Point:	**Golf Course Bridge Upstream of Bathrooms**
GPS Coordinates:	RR.org1GPS 30 lat="39.64541444554925" lon="-106.33020655252039"
Direction to Assessment Point:	Vail Golf Course
Project Priority:	High X Moderate Low
Description of Damage:	Significant scour on river right exposing the spread footer of the abutment. Deep scour hole beneath bridge approximately 4 feet lower than bottom of footer elevation Erosion of fine bank materials around the river left abutment.
Structures:	Pedestrian/cart bridge
Geomorphic Description:	Bridge is located at cross over location between two meander bends. Heavy bank armor at upstream right appears to have been placed in emergency fashion (previous to 2010). Boulders from the upstream right armor have

	created scour at the right abutment and center channel.
Habitat Considerations:	NPS pollution of sediments from bank erosion.
Measures:	Place riprap around footer of right abutment. Reshape upstream right armor to reduce adverse hydraulics on right abutment.
Cost Range Opinion:	$25K-$50K
Photographs:	• Aug 11th #136; 137; 138; 139 • Aug 16th #37

Flood Assessment Point:	**Golf Course Bike Path Bridge**
GPS Coordinates:	RR.org1GPS 28 lat="39.64525661431253" lon="-106.33198569528759"
Direction to Assessment Point:	South of Golf Course Bathrooms.
Project Priority:	High Moderate Low X
Description of Damage:	River left bank is eroding for approximately 10', left wing wall is exposed. Sewer line crossing scoured to concrete casing. Casing broken and pipe is exposed.
Structures:	Pedestrian/cart bridge
Geomorphic Description:	Massive deposition upstream of bridge. Significant channel stabilization efforts impact channel realignment
Habitat Considerations:	Non-point source pollution from bank erosion and loss of the riparian vegetation.
Measures:	Repair bank erosion to protect golf path. Repair/replace sewer line and armor. Monitor.
Photographs:	• Aug 11th #128; 129; 130

Flood Assessment Point:	**Golf Course Bridge 3rd Downstream**
GPS Coordinates:	RR.org1GPS 27 lat="39.644486820325255" lon="-106.33324231021106"
Direction to Assessment Point:	Vail Golf Course
Project Priority:	High Moderate Low X
Description of Damage:	River right approach/abutment fill has been eroded with sandbags protecting the upper fill. Spread footer appears buried.
Structures:	Pedestrian/cart bridge
Geomorphic Description:	Area is in a straight section between two meander bends.
Habitat Considerations:	
Measures:	Flow fill behind abutment at upper loss of right approach backfill. Monitor loss of material from behind right

	abutment. Low land adjacent to right approach may allow for a boardwalk approach with restored wetland areas.
Cost Range Opinion:	$1K-$4K
Photographs:	• Aug 11th #131; 132; 133 • Aug 16th #38; 39

Flood Assessment Point:	**Golf Course Bridge 5th Downstream**
GPS Coordinates:	
Direction to Assessment Point:	First pedestrian bridge north of channelized reach on the Vail Golf Course.
Project Priority:	High: Moderate: X Low:
Description of Damage:	River left bank is eroding for approximately 20', left wingwall is exposed.
Structures:	Pedestrian/cart bridge
Geomorphic Description:	There are several grade control structure in this reach. The channel takes a left to right bend just downstream of the pedestrian bridge. Local hydraulics on the left bank are eroding the bank.
Habitat Considerations:	Non-point source pollution from bank erosion and loss of the riparian vegetation.
Measures:	Install biodegradable coir mats with shrub plantings to increase the bank root mass.
Photographs:	

Flood Assessment Point:	**Aspen Court Bike Path Bridge**
GPS Coordinates:	RR.org1GPS 42-43 42lat="39.645150415599346" lon="-106.32521722465754" 43lat="39.645473454147577" lon="-106.32577755488455"
Direction to Assessment Point:	South Frontage road drive south onto Aspen Drive.
Project Priority:	High: X Moderate: Low:
Description of Damage:	Bridge collapse. Over 40 feet of bank erosion on river left.
Structures:	Aspen Court pedestrian Bridge. Private land on river right (flooding and erosion).
Geomorphic Description:	Significant deposition upstream of te Aspen Court Bridge alignment. The bridge constriction likely caused a major backwater effect and significant reduction in sediment transport. Increased supply of sediment sourced from the Booth Creek tributary and the Katsos reach deposited in the main channel upstream of the bridge and increasing erosional forces on the south bank..

Habitat Considerations:	Bank erosion and loss of riparian zone. Overwide braided channel.
Measures:	Replacement of the bridge and restoration of the south bank is being implemented. Possible need to remove sediment deposits from the main channel to reduce overbank flooding. Neighborhood should be encouraged to increase riparian zone width and plantings.
Cost Range Opinion:	$150K-$350K
Photographs:	• Aug 16th #30; 31; 32; 33; 34; 35

Flood Assessment Point:	**Gore Trail Upstream of Aspen Court**
GPS Coordinates:	RR.org1GPS 48 lat="39.644568292424083" lon="-106.33332185447216"
Direction to Assessment Point:	South Frontage road drive south onto Aspen Drive.
Project Priority:	High Moderate Low X
Description of Damage:	Erosion of left bank threatens bike path and alignment.
Structures:	Gore Trail Bike Path
Geomorphic Description:	Channelized reach in a naturally braiding system. The channel is intermittently restricted from south migration by the Bike Path and armoring at the toe; and to the north by the Golf Course maintenance and armoring.
Habitat Considerations:	Bank erosion and loss of riparian zone.
Measures:	Realign bike path south and widen the riparian corridor.
Cost Range Opinion:	$10K-$40K
Photographs:	• Aug 16th #43; 44; 45; 46

Flood Assessment Point:	**Gore Creek Trail Bridge near East Vail Exit (Katsos)**
GPS Coordinates:	RR.org1GPS 32-34 32lat="39.643504712730646" lon="-106.30875055678189" 33lat="39.644553791731596" lon="-106.30963241681457" 34lat="39.645130634307861" lon="-106.31097528152168" 80 lat="39.645155696198344" lon="-106.31108265370131"
Direction to Assessment Point:	From East Vail Exit head west on Gore Creek Trail
Project Priority:	High Moderate Low X
Description of Damage:	Significant cobble deposits downstream of the pedestrian bridge may be widening the channel. Local areas of the bank are eroding causing loss of riparian vegetation. Several trees (cottonwoods on river left) may fall into the river near

	the bridge. The top of footer of the left abutment is exposed. Cobble deposits under the bridge and downstream of the bridge likely reduce the floodflow conveyance and increase scour potential at the left footer.
Structures:	Pedestrian/bike path bridge
Geomorphic Description:	Downstream of the bridge the channel has been realigned causing an adverse bend in the river. This reach is characterized by cobble deposits and braiding. The channel may be responding to the realignment by cutting into the right bank to balance the radius of curvature of the bend. The channel may also be cutting an interior channel forming a mid-channel bar. The upstream cross vane structure was stable and functioning. Upstream of the cross vane there are a few bedrock outcrops forming deep pools and good fish habitat.
Habitat Considerations:	Loss of mature trees on the river left bank, and erosion of the river right bank on the outside of the bend.
Measures:	Monitor left abutment for increased scour. Monitor channel conveyance. Monitor channel alignment changes with respect to bridge hydraulics.
Cost Range Opinion:	$1K-$4K
Photographs:	• Aug 16th #5; 6; 7; 8; 9; 10; 11; 12; 13 • Aug31/IMG_0283.jpg; IMG_0284.jpg; IMG_0285.jpg

Flood Assessment Point:	**Gore Creek Braided Channel Reach (Katsos)**
GPS Coordinates:	RR.org1GPS 35-41 35lat="39.645807975903153" lon="-106.31260489113629" 36lat="39.646197399124503" lon="-106.31334995850921" 37lat="39.646336371079087" lon="-106.315659256652" 38 N/A 39lat="39.645829014480114" lon="-106.31627591326833" 40lat="39.646683717146516" lon="-106.31806335411966" 41lat="39.646382471546531" lon="-106.31925232708454"
Direction to Assessment Point:	Gore Creek Channel Reach between East Vail exit Gore Trail Bridge and Aspen Court Bridge.
Project Priority:	High: Moderate: X Low:
Description of Damage:	GPS 36-failed cross vane structure and mature pine tree to fall into channel. GPS 37- mature pine tree fallen across channel. GPS 38- eroding left bank GPS 41- river right bank erosion with sandbags in place to protect property at top of bank.
Structures:	Retaining wall for South Frontage road is stable; GPS 40.
Geomorphic Description:	Significant aggradation throughout the reach. Many cobble

	deposit elevations approximate adjacent top of bank elevations. Channel conveyance is greatly reduced and significant lateral migration and braiding is anticipated. This reach is braiding and shifting across the valley floor. The Katsos open space allows room for the channel to shift to the south, however the Interstate-70 prevents migration to the north. The Interstate-70 fill slope is stabilized with riprap; this likely increases transport of materials to upstream of Aspen Court where deposits are significant. Lateral migration is also limited by the stabilization along the neighborhood development at Booth Creek Drive.
Habitat Considerations:	Loss of the riparian zone.
Measures:	Monitor channel migration. Preserve a wide migration corridor. Augment riparian vegetation. The large flood deposits likely will cause a shift in lateral stability of the channel. Coordinate with homeowners to bio-stabilize the bank at the neighborhood with a minimum of 15' width dense native shrubs and dogwood/willow cuttings.
Cost Range Opinion:	$20K-$40K
Photographs:	• Aug 16th #19; 20; 21; 22; 23; 24; 25; 26; 27; 28; 29

Flood Assessment Point:	**Bridge Road Bridge**
GPS Coordinates:	
Direction to Assessment Point:	
Project Priority:	High Moderate Low X
Description of Damage:	Three culverts under the bridge are filling with sediments and decrease the flood flow capacity.
Structures:	Road Bridge.
Geomorphic Description:	The channel needs to be able to convey a high load of cobbles and gravels. The three culverts decrease the transport capacity.
Habitat Considerations:	Impediment of channel processes.
Measures:	Periodically clean out the culverts.
Photographs:	• Aug 18th #45; 46; 47; 48

Flood Assessment Point:	**Glen Falls Bridge Utilities**
GPS Coordinates:	
Direction to Assessment Point:	
Project Priority:	High Moderate Low X

Description of Damage:	Utilities hanging from the bridge have compromised mounts.
Structures:	Utilities
Geomorphic Description:	Bridge crossing with hung utilities
Habitat Considerations:	N/A
Measures:	Secure utilities
Cost Range Opinion:	$2K-$4K
Photographs:	• 111_0729/IMGP2254.jpg • 111_0729/IMGP2255.jpg

Flood Assessment Point:	**Christopher Sewell Pedestrian Bridge in East-Vail**
GPS Coordinates:	RR.org1GPS 66
Direction to Assessment Point:	Exit I-70 East Vail. Drive east on Bighorn Rd. At Main Gore Drive head south, turn west onto Jupiter lane. Park at public park area.
Project Priority:	High X Moderate Low
Description of Damage:	Pedestrian bridge has scoured undermining the footer of the left abutment. Footer has settled more that 0.5 feet. Footer subgrade extremely unstable. Significant erosion downstream of the bridge on river left.
Structures:	Bridge, gas utility
Geomorphic Description:	An advancing and aggrading pointbar increases pressure on bridge aligned at apex of bend. Bridge is located on a right bend where maximum scour occurs at the left abutment. Left abutment was not designed for adequate scour depths.
Habitat Considerations:	NPS pollution from sediments and loss of riparian vegetation.
Measures:	Stabilize left abutment sub-grade. Armor abutment and scour hole. Stabilize approach bank. Improve sediment transport through reach.
Cost Range Opinion:	$30K-$60K
Photographs:	• 111_0729/IMGP2185.jpg- IMGP2186.jpg

Flood Assessment Point:	**Bighorn Pond and Spillway**
GPS Coordinates:	
Direction to Assessment Point:	Exit I-70 East Vail. Drive east on Bighorn Rd. At Main Gore Drive head south, turn west onto Jupiter lane. Park at public park area.
Project Priority:	High X Moderate Low
Description of Damage:	Left bank of Gore Creek at flow through inlets has eroded 12

	feet laterally and 1 foot vertically creating greater flood connection with Bighorn Pond. The outlet works of Bighorn Pond are overwhelmed by flood flows and the pond levee breached.
Structures:	Pond
Geomorphic Description:	The pond represents the highest gradient path for Gore Creek and may have historically been a secondary or main channel. Point bar advancement and aggradation at the inlet increase flood connection. Flood overflows at the upstream end of the pond threaten to capture the main channel of Gore Creek by headward erosion of a channel through the pond.
Habitat Considerations:	NPS pollution from sediments and loss of riparian vegetation.
Measures:	Stabilize left bank and inlet control to limit flood overtopping. Install outlet spillway to handle maximum flows through inlet pipes. Evaluate need for breakaway emergency spillway for flood flows that would overtop inlet. Improve sediment transport at inlet to reduce pointbar aggradations and advancement.
Cost Range Opinion:	$40K-$80K
Photographs:	• 111_0729/IMGP2187.jpg; IMGP2188.jpg ; IMGP2189.jpg ; IMGP2190.jpg ; IMGP2191.jpg ; IMGP2192.jpg ; IMGP2193.jpg ; IMGP2194.jpg; IMGP2195.jpg; IMGP2196.jpg; IMGP2197.jpg; IMGP2198.jpg; IMGP2199.jpg; IMGP2200.jpg; IMGP2201.jpg; IMGP2202.jpg; IMGP2203.jpg; IMGP2204.jpg; IMGP2205.jpg; IMGP2206.jpg; IMGP2207.jpg; IMGP2208.jpg; IMGP2209.jpg; IMGP2210.jpg; IMGP2211.jpg

Flood Assessment Point:	**Heathers at Vail**
GPS Coordinates:	rr.org2 WP32-39 32lat="39.625383289530873" lon="-106.27955781295896" 33lat="39.625485213473439" lon="-106.2791913561523" 34lat="39.625627622008324" lon="-106.27887586131692" 35lat="39.625767515972257" lon="-106.2786694150418" 36lat="39.625917971134186" lon="-106.27830530516803" 37lat="39.626127853989601" lon="-106.27878609113395" 38lat="39.625902883708477" lon="-106.27937173470855" 39lat="39.625631310045719" lon="-106.28030019812286"
Direction to Assessment Point:	Confluence of Gore Creek and Black Gore Creek
Project Priority:	High: X Moderate: Low:

Description of Damage:	Overbank flooding of developed condo areas. Localized bank erosion from return waters, toe scour, and channel deposition. Channel widening, plugging and new channel cutting. 33-head of split channel 34-overbank flooding 35-scour hole overbank 36-sediment plug photo 193 37-debris jamb photo 197 38- secondary debris jamb 39-toe scour, hungry water
Structures:	Condos, parking lots, utilities.
Geomorphic Description:	Downstream of the Interstate 70 Bridge over Gore Creek is a broad alluvial fan with bifurcating channels. The fan is less steep than other local tributaries and multiple perennial flow paths exist. Dense residential property has been developed on the fan island between the two main channels. Prior to 2010, the right (north) channel conveyed 70 percent of the flow and the left (south) channel had lesser conveyance. A number of bifurcating flow paths connects the right and left channels across the fan. The fan is anticipated to be a significant deposition zone and significant morphology and changes in channels are expected after significant flood events. During the 2010 flood, a pre-existing debris bridge over the right (north) channel reduced conveyance and created a large sediment plug. Subsequently, the left (north) channel widened, cut and eroded with the increased discharge. The left channel is likely perched at a higher elevation and more overbanking of flood flows likely occurred. The right channel was deprived of sediment at the debris plug and widened and eroded the toe of the channel at a sharp right turn. Bank collapse occurred due to toe erosion at WP39 behind Heatherwood Condo Building. Sand bagging WP39 may have been in response to super-elevation flows at corner, or bank collapse. Overall, the channels functioned perfectly to minimize flood damage to the structures. The debris bridge and sediment plug formation routed more water in the left (south) channel and prevented more significant damage that may have occurred without the left channel capacity. Both the right and left channels will likely have increased flood capacity after removal of the sediment plug.
Habitat Considerations:	Loss of the under story vegetation has resulted in decreased bank stability and root mass along the right bank of the left channel. This is where overbank flows returned and cut

	additional channels through the lawn. Increased native shrubs and understory would help reduce bank erosion rates.
Measures:	• Remove Sediment Plug at head of Right (north) channel • Excavate cobbles at left channel of left (south) channel island and place in right channel of island. • Biostabilize right bank of left channel • Reduce grade control at downstream end of left channel (check for utility crossing). • Stabilize toe of right channel behind Heatherwood • Mimic or replace debris bridge for plug re-formation in future flood events.
Cost Range Opinion:	$30K-$60K
Photographs:	• Looking downstream right channel sediment plug • Looking downstream left channel at split • Looking upstream right channel at debris bridge • Looking downstream right channel at Heatherwood toe scour • Aug 18th #193 Sediment plug • Aug 18th #197 Debris jamb bridge • Aug 18th #198 toe erosion and sand bagging • Aug 18th #199 1 foot channel downcutting

Flood Assessment Point:	**Buffehr Creek Upstream of I-70**
GPS Coordinates:	RRorg2 5lat="39.633822022005916" lon="-106.40819672495127" 6lat="39.636298371478915" lon="-106.4064942765981" 7lat="39.636624343693256" lon="-106.40594450756907" 8lat="39.636624259874225" lon="-106.40594677068293" 9lat="39.640001831576228" lon="-106.39953654259443" 10lat="39.640768943354487" lon="-106.39678543433547" 11lat="39.641890609636903" lon="-106.39089949429035"
Direction to Assessment Point:	I-70 Exit West Vail north to North Frontage Road. Travel east 0.6 miles to Buffehr Cr. Road
Project Priority:	High Moderate Low X
Description of Damage:	Localized erosion, exposed shallow utilities WP5- service utilities exposed in left bank erosion WP6-perched channel with left overbank channel cutting WP7-compromised grade control and head cut in channel WP8-sand bagging for flood control or repair WP9-NPS road gravel from uncontrolled drainage WP10-Drainage off switchback may exacerbate thalweg at toe of embankment, increasing erosion. Minor erosion noted at culvert inlets and outlets. Pedestrian

	bridge abutments appear stable.
Structures:	Homes, Roads
Geomorphic Description:	Buffehr Creek is steep, encroached, perched and channelized for about 0.1 miles north of North Frontage Road at the Circle Drive crossing. Upstream of Circle Drive the gradient is much flatter and a densely vegetated floodplain meadow exists for approximately 0.1. Upstream of the floodplain meadow, a pedestrian bridge crosses and the creek becomes more encroached by the road and canyon topography. The densely vegetated floodplain meadow may help to attenuate flood flows, coming out of the canyon, before they flow into the steep and encroached reach. Flows at the mouth of the canyon have been purposely diverted into the meadow (WP11).
Habitat Considerations:	Densely vegetated meadow upstream of residential development. NPS from road and stormwater erosion.
Measures:	Evaluate and stabilize service utilities downstream of Chamonix. Monitor right overbank flooding and channel cutting 50 feet upstream of Chamonix. Offset berm right overbank as necessary. Monitor channel cutting upstream of Circle Dr. and associated left bank failure. Stabilize channel grade if necessary. Repair left bank berm 50 feet upstream of Chamonix to prevent flooding of Buffehr Cr. Rd.
Cost Range Opinion:	$4K-$10K
Photographs:	• Aug 11-2010/IMG_0022.jpg; IMG_0023.jpg ; IMG_0024.jpg ; IMG_0025.jpg ; IMG_0026.jpg ; IMG_0027.jpg ; IMG_0028.jpg ; IMG_0029.jpg ; IMG_0030.jpg ; IMG_0031.jpg ; IMG_0032.jpg ; IMG_0033.jpg ; IMG_0034.jpg; IMG_0035.jpg

Flood Assessment Point:	**Red Sandstone Creek**
GPS Coordinates:	RR.org1GPS 61-62 lat="39.643216961994767" lon="-106.3964403513819" lat="39.646024229004979" lon="-106.39604397118092"
Direction to Assessment Point:	Access points are from South Frontage Road, North Frontage Road, and Red Sandstone Road;
Project Priority:	High Moderate Low X
Description of Damage:	South Frontage Road bridge has slight decay of the concrete, however the toe appears stable. North Frontage Bridge is stable with clean culverts and dense riparian vegetation. The Red Sandstone Apartments has moderate-low bank erosion exposing the left abutment. The Red Sandstone Road twin culverts are clean of sediments.
Structures:	Bridges

Geomorphic Description:	A steep and densely vegetated tributary that runs south into Gore Creek.
Habitat Considerations:	
Measures:	Monitor for scour at bridges. Monitor for vegetation growth and sediments deposition at the culverts to ensure flood flow capacity. Prune brush or remove deposits at culverts as needed.
Cost Range Opinion:	$0K-$1K
Photographs:	• Aug 18th #7; 8; 9; 10; 11; 12; 13; 14

Flood Assessment Point:	**Mill Creek Tributary**
GPS Coordinates:	RR.org1GPS 69 Lat="39.639809466898441" lon="-106.37283992953598"
Direction to Assessment Point:	From Main Gore Drive turn west onto Jupiter lane. Park at public park area.
Project Priority:	High Moderate Low X
Description of Damage:	
Structures:	Pedestrian bridge and neighborhood homes.
Geomorphic Description:	The Mill Creek tributary flows north to confluence with Gore Creek upstream of the Covered Bridge. The tributary has a high sediment load and braided upstream of the confluence. Vegetation has encroached the channel and may reduce the flood flow conveyance.
Habitat Considerations:	Local random trampling of the bank at the Bridges.
Measures:	Encourage land owners to plant a robust riparian corridor to protect the bank. Prune brush or remove deposits at culverts as needed.
Cost Range Opinion:	$0K-$1K
Photographs:	• Aug 18th #39; 40; 41

Flood Assessment Point:	**Middle Creek Downstream of I-70**
GPS Coordinates:	RRorg2 53 lat="39.643172202631831" lon="-106.38408157043159"
Direction to Assessment Point:	Exit I-70 Main Vail and head south to South Frontage Road. Drive west 0.3 miles to creek.
Project Priority:	High Moderate Low X
Description of Damage:	Localized bank erosion, clogged culverts, trampled understory. Tree (WP53)
Structures:	Buildings, road, parking lot, paths
Geomorphic Description:	Moderate gradient tributary creek flowing through alluvial fan. Not perched. Encroached by development.
Habitat Considerations:	Trampled understory vegetation, narrow riparian zone.

Measures:	Clear I-70 outlet, approximately 12 @ 2' boulders. Cut and remove log jamb debris from bike path culvert inlet. Remove debris jamb form left outlet. Cut and stabilize downstream headwall of double box culvert bike path crossing. Bio stabilize upper bank fill erosion. Discourage random trampling with thorny vegetation. Stabilize service utilities.
Cost Range Opinion:	$4K-$20K
Photographs:	• Aug 18-2010/IMG_0205.jpg ; IMG_0206.jpg ; IMG_0207.jpg ; IMG_0208.jpg ; IMG_0209.jpg ; IMG_0210.jpg ; IMG_0211.jpg ; IMG_0212.jpg ; IMG_0213.jpg ; IMG_0214.jpg ; IMG_0215.jpg ; IMG_0216.jpg ; IMG_0217.jpg ; IMG_0218.jpg ; IMG_0219.jpg ; IMG_0220.jpg ; IMG_0221.jpg ; IMG_0222.jpg ; IMG_0223.jpg ; IMG_0224.jpg ; IMG_0225.jpg ; IMG_0226.jpg ; IMG_0227.jpg ; IMG_0228.jpg ; IMG_0229.jpg ; IMG_0230.jpg ; IMG_0231.jpg ; IMG_0232.jpg ; IMG_0233.jpg ; IMG_0234.jpg ; IMG_0235.jpg ; IMG_0236.jpg ; IMG_0237.jpg ; IMG_0238.jpg ; IMG_0239.jpg

Flood Assessment Point:	**Middle Creek Upstream of I-70**
GPS Coordinates:	RRorg2 12 lat="39.646214749664068" lon="-106.38184351846576" 13lat="39.646238470450044" lon="-106.38167437165976" 14lat="39.646537452936172" lon="-106.38088370673358" 15lat="39.646686734631658" lon="-106.3805459998548"
Direction to Assessment Point:	Exit I-70 Main Vail and head north to North Frontage Road. Drive west 0.2 miles to Ma Bell Road.
Project Priority:	High: X Moderate: Low:
Description of Damage:	Localized bank erosion, overbank flooding, potential avulsion channel cutting. WP12-Right bank erosion threatens 2 mature 24 inch cottonwoods which could greatly alter main chnnel flow path if fallen. WP13 –overbank flood flow from debris jamb and superelevation WP14- overbank flows and riling from debris jamb WP15- overbank flood flow from superelevation
Structures:	Buildings, road, parking lot
Geomorphic Description:	Middle Creek flows in the longest possible planform traversing a very steep alluvial fan. The channel is perched and overbank channels have numerous high gradient overbank paths. Debris jambs could lead to avulsion. Bell tower apparently constructed with designed drainage

	mitigation and controls; however, Building "C" appears to block or modify one of the main mitigation drainages.
Habitat Considerations:	Dense riparian and understory
Measures:	Bio-stabilize road embankment fill across from gage station. Reduce boulder grade control at peak of alluvial fan. Review permitted flood mitigation for building construction, esp for the Bell Tower. Construct drainage collection and return channel at edge of parking lot (WP16).
Cost Range Opinion:	$50K-$100K
Photographs:	• Aug 11-2010/IMG_0036.jpg; IMG_0037.jpg ; IMG_0038.jpg ; IMG_0039.jpg ; IMG_0040.jpg ; IMG_0041.jpg ; IMG_0042.jpg ; IMG_0043.jpg ; IMG_0044.jpg ; IMG_0045.jpg ; IMG_0046.jpg ; IMG_0047.jpg ; IMG_0048.jpg ; IMG_0049.jpg ; IMG_0050.jpg

Flood Assessment Point:	**Spraddle Creek**
GPS Coordinates:	
Direction to Assessment Point:	
Project Priority:	High Moderate Low X
Description of Damage:	Minor riprap collapse at parking lot culvert.
Structures:	Road
Geomorphic Description:	Perched channel on alluvial fan with road cut below main channel.
Habitat Considerations:	Dense riparian vegetation and understory
Measures:	Maintain roadway ditch to serve as flood overflow conveyance. Clear deadfall and obstructing brush for 50 feet upstream of culverts where main channel is perched. Monitor groundwater seepage behind concrete lined channel.
Cost Range Opinion:	$0K-$1K
Photographs:	• Aug 18-2010/IMG_0227.jpg

Flood Assessment Point:	**Booth Creek I-70 to Gore Creek**
GPS Coordinates:	RRorg2 51lat="39.646715819835663" lon="-106.32287775166333" 52lat="39.645968489348888" lon="-106.32267700508237"
Direction to Assessment Point:	Exit I-70 East Vail. Drive west on North Frontage Road to Aspen Lane. Drive east on Booth Creek Dr.
Project Priority:	High Moderate Low X
Description of Damage:	Deposits in culvert. Downed (WP51) and exposed shallow utilities (WP52).
Structures:	Road

Geomorphic Description:	Moderate gradient tributary creek flowing through alluvial fan. Not perched.
Habitat Considerations:	Dense riparian vegetation.
Measures:	Clear culvert, stabilize utilities
Cost Range Opinion:	$2K-$10K
Photographs:	• Aug 18-2010/IMG_0222.jpg; IMG_0223.jpg ; IMG_0224.jpg ; IMG_0225.jpg ; IMG_0226.jpg

Flood Assessment Point:	**Booth Creek Upstream of I-70**
GPS Coordinates:	RRorg2 26 lat="39.648931659758091" lon="-106.32239428348839" 27 lat="39.64915000833571" lon="-106.32238539867103" 28 lat="39.649203233420849" lon="-106.32221759296954" 44 lat="39.648139318451285" lon="-106.32247474975884" 45 lat="39.647662723436952" lon="-106.32255563512444" 46 lat="39.64766213670373" lon="-106.32255747914314" 47 lat="39.648444838821888" lon="-106.32247600704432" 48 lat="39.648525305092335" lon="-106.32261950522661" 49 lat="39.648408377543092" lon="-106.32265848107636" 50 lat="39.648084081709385" lon="-106.32302351295948"
Direction to Assessment Point:	Exit I-70 East Vail. Drive west on North Frontage Road to Booth Falls rd.
Project Priority:	High X Moderate Low
Description of Damage:	Significant channel widening and down cutting and associated erosion and deposition. Significant loss of land. Significant overbank flooding and deposits in park area.
Structures:	Park, playground, bike path, tennis courts, road, homes, yards.
Geomorphic Description:	Large, moderate gradient, alluvial fan with intermittently perched channel. The channel experienced a significant flood and channel forming event in 2010. High ground water is suspect for flooding west of tennis courts.
Habitat Considerations:	Dense, well vegetated riparian zone.
Measures:	Reduce boulder grade control at I-70 inlet (WP46; photo221; coordinate with USGS gage rating). Clear bike path culvert debris (performed 2010). Modify bike path culvert with maintenance access and possible trash racks. Remove cobble deposits from bike path culvert to upstream approx 200 feet (between WP44 and WP47; photo218). Create right offset levee (between WP48 and WP 49 and WP 50). Channel overflow ditch to North Frontage Road and berm along tennis courts. Create groundwater drainage at west end of tennis courts. Evaluate flood capacity, floodplain limits and floor elevations for existing channel upstream of tennis courts. Modify channel capacity as needed. Bio-stabilize as needed and widen riparian zone where possible.

Cost Range Opinion:	$50K-$100K
Photographs:	• 115_0804/IMGP2371.jpg; IMGP2372.jpg ; IMGP2373.jpg ; IMGP2374.jpg ; IMGP2375.jpg ; IMGP2376.jpg ; IMGP2377.jpg ; IMGP2378.jpg ; IMGP2379.jpg ; IMGP2380.jpg ; IMGP2381.jpg ; IMGP2382.jpg ; IMGP2383.jpg ; IMGP2384.jpg ; IMGP2385.jpg ; IMGP2386.jpg ; IMGP2387.jpg ; IMGP2388.jpg ; IMGP2389.jpg ; IMGP2390.jpg ; IMGP2391.jpg ; IMGP2392.jpg • Aug 18-2010/IMG_0216.jpg; IMG_0217.jpg ; IMG_0218.jpg ; IMG_0219.jpg ; IMG_0220.jpg; IMG_0221.jpg

Flood Assessment Point:	**Pitkin Creek I-70 Outlet Structure**
GPS Coordinates:	
Direction to Assessment Point:	Exit I-70 East Vail. Drive east on Bighorn Rd to Pitkin Creek.
Project Priority:	High: X; Moderate: ; Low:
Description of Damage:	The channel experienced a significant flood and channel forming event in 2010. At the I-70 outlet significant scour and channel down cutting occurred. Footers of the I-70 outlet structure may be undermined. Channel material was borrowed for bank stabilization (summer 2010), further compromising channel grade stability. There is potential for downcutting and collapse of I-70 culvert similar to Bighorn Creek 2003.
Structures:	I-70
Geomorphic Description:	Excessive channel scour and loss of channel grade control
Habitat Considerations:	Increased NPS on encroached alluvial fan channel.
Measures:	Rebuild Pitkin Creek Culvert and head works. Augment grade control downstream of I-70. Stabilize scour pool at I-70 outlet.
Cost Range Opinion:	$100K-$200K
Photographs:	• Aug 18-2010/IMG_0205.jpg-IMG_0206.jpg

Flood Assessment Point:	**Pitkin Creek I-70 to Gore Creek**
GPS Coordinates:	42lat="39.642558982595801" lon="-106.30456262268126"
Direction to Assessment Point:	Exit I-70 East Vail. Drive east on Bighorn Rd to Pitkin Creek.
Project Priority:	High: ; Moderate: X; Low:
Description of Damage:	The channel experienced a significant flood and channel

	forming event in 2010. Channel downcut extends Bighorn Road to I-70. Large spruce (WP42) are undermined and bank failure evident. Channel aggradation at Bighorn Rd outlet to Gore Creek.
Structures:	Yards, Condos, Bighorn Road, Bridge Road.
Geomorphic Description:	Perched channel of alluvial fan is encroached properties and road crossings. Exacerbated erosion and deposition processes. Significant channel migration potential for un-maintained channel.
Habitat Considerations:	Increased NPS on encroached alluvial fan channel.
Measures:	Install channel grade controls. Evaluate and monitor large tree stability and potential for channel obstruction. Clear culverts and evaluate downstream deposits for flooding of Bridge Street and potential channel avulsion around Bridge Street. Clear confluence deposits as necessary top maintain channel capacity.
Cost Range Opinion:	$30K-$60K
Photographs:	• Aug 18-2010/IMG_0205.jpg; IMG_0206.jpg ; IMG_0207.jpg ; IMG_0208.jpg ; IMG_0209.jpg ; IMG_0210.jpg ; IMG_0211.jpg ; IMG_0212.jpg ; IMG_0213.jpg; IMG_0214.jpg

Flood Assessment Point:	**Pitkin Creek Trail Head Pedestrian Bridge**
GPS Coordinates:	
Direction to Assessment Point:	Exit I-70 East Vail to north. Drive east on Fall Line Drive to Pitkin Creek trail head parking. Walk upstream 100 feet.
Project Priority:	High X Moderate Low
Description of Damage:	Pedestrian bridge collapse.
Structures:	Pedestrian Bridge/
Geomorphic Description:	The channel experienced a significant flood and channel forming event in 2010. Significant channel downcutting and widening compromised a small pedestrian bridge structure, completely eroding abutments. A concrete grade control exists in the channel immediately downstream of the bridge with an un-identified purpose. The grade control was compromised and undercut.
Habitat Considerations:	Concrete in river channel.
Measures:	Modify and stabilize grade control. Install bridge abutments and reset bridge.
Cost Range Opinion:	$20K-$40K
Photographs:	• Aug 11-2010/IMG_0054.jpg

Flood Assessment Point:	**Pitkin Creek I-70 to Trail Head**

GPS Coordinates:	17lat="39.643607223406434" lon="-106.303137447685"
Direction to Assessment Point:	Exit I-70 East Vail to north. Drive east on Fall Line Drive to Pitkin Creek trail head parking. Walk upstream 100 feet.
Project Priority:	High: X; Moderate: ; Low:
Description of Damage:	Channel erosion, increased potential for overbank flooding.
Structures:	Condos
Geomorphic Description:	The channel experienced a significant flood and channel forming event in 2010. Significant channel downcutting and widening compromised a narrow embankment that protects condos from the perched channel of Pitkin Creek from flooding and channel capture. Fall Line Road culvert had deposits that should be removed to improve flood capacity. I-70 inlet channel showed signs of erosion but not significant instabilities at structures.
Habitat Considerations:	Overwide channel, NPS for bank erosion.
Measures:	Stabilize right bank at condos. Evaluate capacity of post flood channel. Monitor left bank erosion at I-70 inlet.
Cost Range Opinion:	$7K-$18K
Photographs:	• Aug 11-2010/IMG_0055.jpg; IMG_0056.jpg ; IMG_0057.jpg ; IMG_0058.jpg ; IMG_0059.jpg ; IMG_0060jpg ; IMG_0061.jpg ; IMG_0062.jpg ; IMG_0063.jpg ; IMG_0064.jpg

Flood Assessment Point:	**Bighorn Creek Bighorn Road to Gore Creek**
GPS Coordinates:	RRorg2 18lat="39.636243050917983" lon="-106.29768569022417" 19lat="39.635965693742037" lon="-106.29793765023351"
Direction to Assessment Point:	Exit I-70 East Vail to south. Drive east on Rd to east 0.7 miles.
Project Priority:	High: ; Moderate: X; Low:
Description of Damage:	Channel down cutting and widening and localized bank erosion. Some mature trees have been compromised and may threaten structures.
Structures:	Culvert, Road, Homes, Utilities
Geomorphic Description:	This is the deposition zone of a moderate steep alluvial fan. The main channel is not significantly perched and overbank flooding was not reported or evident. The channel may be significantly migrating, assisted by collapse of mature trees.
Habitat Considerations:	Deposition and riparian area well offset from development. Protect.
Measures:	Monitor stability of trees (WP18 & WP 19). Evaluate capacity of sewer line crossing Gore Creek. Monitor scour and exposure of the concrete outlet pan a Bighorn Rd. Biostabilize localized bank erosion.
Cost Range Opinion:	$6K-$14K

Photographs:	• Aug 11-2010/IMG_0065.jpg; IMG_0066.jpg ; IMG_0067.jpg ; IMG_0068.jpg ; IMG_0069.jpg ; IMG_0070.jpg ; IMG_0071.jpg ; IMG_0072.jpg ; IMG_0073.jpg ; IMG_0074.jpg ; IMG_0075.jpg

Flood Assessment Point:	**Bighorn Creek I-70 to Bighorn Road**
GPS Coordinates:	RRorg2 21lat="39.637133460491896" lon="-106.29692268557847" 22lat="39.637010497972369" lon="-106.29724664613605" 23lat="39.636853169649839" lon="-106.29714857786894" 24lat="39.63728123344481" lon="-106.29684875719249"
Direction to Assessment Point:	Exit I-70 East Vail to south. Drive east on Bighorn Rd to east 0.7 miles.
Project Priority:	High X Moderate Low
Description of Damage:	Spruce way experienced erosion around the culvert inlet and outlet, which were constructed with minimal extension and no slope retaining structures. Large material transporting through the culvert may eventually damaged the integrity of the culvert and create seepage infiltration. Bank erosion upstream of Spruce Way resulted in the emergency removal of mature conifer trees. Downstream of Spruce Way significant overbank flooding occurred (WP21), evidenced by gravel and cobble deposits. Overbank flooding originated at a location where massive boulders and debris have deposited in the main channel. Return channel may compromise utility junction (WP23). Significant right bank collapse (WP22/ photo 94). Deposition also occurred at the Bighorn Rd inlet.
Structures:	Culvert, Road, Homes, Condos
Geomorphic Description:	This is the head of a very steep alluvial fan. The main channel is perched at the crown of the fan with significant low land for long distances on either side of the channel. Development has encroached the alluvial fan and the perched channel may be aggrading (WP23). Interestingly left overbank remnant channel did not significantly connect (WP24/ photo 96), but significant overbank flooding occurred 100 feet downstream.
Habitat Considerations:	
Measures:	Stabilize grade control at outlet of Spruce Way. Biostabilize right bank. Replace Spruce Way culvert with concrete reinforced floor for transport of boulder material. Install cutoff and head walls as needed. Replace felled trees. Evaluate flood capacity of the channel. Reduce boulder debris jamb in main channel. Stabilize toe of right erosing bank. Remove deposits from Bighorn Road inlet. A left

	bank flood wall wan installed fall of 2010, monitor for performance. Monitor right bank fir trees (3@15 inch) for stability.
Cost Range Opinion:	$70K-$150K
Photographs:	• Aug 11-2010/IMG_0076.jpg; IMG_0077.jpg ; IMG_0078.jpg ; IMG_0079.jpg ; IMG_0080.jpg ; IMG_0081.jpg ; IMG_0082.jpg ; IMG_0083.jpg ; IMG_0084.jpg ; IMG_0085.jpg ; IMG_0086.jpg ; IMG_0087.jpg ; IMG_0088.jpg ; IMG_0089.jpg ; IMG_0090.jpg ; IMG_0091.jpg ; IMG_0092.jpg ; IMG_0093.jpg ; IMG_0094.jpg ; IMG_0095.jpg ; IMG_0096.jpg ; IMG_0097.jpg ; IMG_0098.jpg ; IMG_0099.jpg ; IMG_0100.jpg ; IMG_0101.jpg ; IMG_0102.jpg; IMG_0103.jpg

Flood Assessment Point:	**Bighorn Creek at Columbine Dr.**
GPS Coordinates:	RRorg2 29lat="39.639340247958899" lon="-106.29472738131881"
Direction to Assessment Point:	Exit I-70 East Vail to south. Drive east on Bighorn Rd to east 0.7 miles. Turn north of Columbine Way and travel under I-70 to trailhead parking lot.
Project Priority:	High X Moderate Low
Description of Damage:	A head cut may be destabilizing Coulmbine Way by eroding the toe of the fill slope and increasing groundwater gradients. Large material transporting through the culvert has damaged the integrity of the culvert and created seepage points. Other localized erosion upstream of Coulmbine Way.
Structures:	Culvert
Geomorphic Description:	This is the mouth of a canyon and the apex of a very steep alluvial fan. The channel experienced a significant flood and channel forming event in 2010. Downstream of Columbine Way the channel scoured through bedrock with indicator cobbles perched over 5 feet vertically. The channel is slightly perched with the I-70 underpass to the trail head parking lot being lower ground. Upstream of the parking lot there appears to be remnant channel training devices such as sheet piling and concrete walls (WP29). The purpose of the devices was not clear.
Habitat Considerations:	Fish passage or managed migration barrier. Coordinate with CDOW on cutthroat populations.
Measures:	Stabilize grade control at outlet of Columbine Way. Biostabilize fill slope at outlet. Replace Columbine Way culvert with concrete reinforced floor for transport of boulder material.
Cost Range Opinion:	$50K-$100K

Photographs:	• Aug 18-2010/IMG_0183.jpg; IMG_0184.jpg ; IMG_0185.jpg ; IMG_0186.jpg ; IMG_0187.jpg ; IMG_0188.jpg ; IMG_0189.jpg ; IMG_0190.jpg ; IMG_0191.jpg; IMG_0192.jpg

Flood Assessment Point:	**Gore Creek East Vail Channel Maintenance**
GPS Coordinates:	Downstream Lat=”39.645” Lon+”-106.324” Upstream Lat=”39.628” Lon=”-106.286”
Direction to Assessment Point:	Gore Creek from Confluence with Bighorn Creek to Aspen Court Bridge
Project Priority:	High Moderate Low X
Description of Damage:	Significant deposition, washed out bridge, flooding
Structures:	Homes
Geomorphic Description:	Significant deposition and channel changes have occurred as a result of large tributary sediment supply. Aggradation up to 4 feet. Loss of conveyance has cause rise in base flood elevations. Significant bank erosion at FEMA XS 186.5. 3500 cubic yards deposited 600’ above to 300’ below the bridge. Channel conveyance is greatly reduced and significant lateral migration is anticipated. Total 10,000 cubic yards.
Habitat Considerations:	NPS from bank erosion.
Measures:	Resurvey cross-sections perform hydraulic analysis of Gore Creek. Develop modification/restoration plan. Channel modification/extraction and restoration.
Cost Range Opinion:	$300K-$600K
Photographs:	Aug 31, 2010: IMG_0281

APPENDIX B

Vail 2010 Flood Assessment Summary Projects Table				
Appendix B				
27-Jan-11				
			Cost Range	Cost Range
Crossings	Need	Structure	$1,000	$1,000
Bighorn Creek at Columbine Dr.	4	Road	75	150
Bighorn Creek at Spruce Way	5	Road	75	150
Pitkin Creek Trail Head Pedestrian Bridge	4	Path	20	40
Pitkin Creek I-70 Outlet Structure	5	Highway	100	200
Golf Course Bridge Upstream of Bathrooms	4	Path	25	50
Matterhorn Circle Bridge	4	Road	20	40
Christopher Sewell Pedestrian Bridge in East-Vail	5	Path/Utilities	30	60
Aspen Court Bike Path Bridge	5	Path/Utilities	150	350
West Haven Circle Bridge	1	Channel	0	1
West Gore Creek Drive Bridge	2	Bridge	2	4
WWTP Bridges	1	Bridge	0	1
Forest Road Bridge	2	Bridge	1	4
Main Vail Bridge	3	Bridge	10	20
Vail Valley Blvd Bridge	1	Bridge	0	1
Golf Course Bike Path Bridge	3	Bridge	15	30
Golf Course Bridge 3rd Downstream	3	Bridge	1	4
Golf Course Bridge 5th Downstream	0	Bridge	N/A	
Gore Creek Trail Bridge near East Vail Exit (Kastos)	1	Bridge/Channel	1	4
Kinnickinnick Bridges	1	Bridge	0	1
Flood Hazard				
Heathers at Vail	5	Condos	40	80
Bighorn Creek I-70 to Bighorn Road	4	Homes/Roads	20	50
Pitkin Creek I-70 to Trailhead	3	Condos/Road	7	18
Booth Creek Upstream of I-70	4	Homes/Recreation	250	350
Middle Creek Upstream of I-70	4	Buildings/Roads	150	250
Gore Creek East Vail Channel Maintenance	4	Homes	300	600
Booth Creek I-70 to Gore Creek	3	Road/Utilities	2	10
Bridge Road Bridge	0	Bridge	N/A	
Bighorn Creek at Bighorn Road	2	Road	1	4
Red Sandstone Creek	1	Road	0	1
Buffehr Creek Upstream of I-70	1	Homes/Roads	4	10
Mill Creek Tributary	1	Buildings	0	1
Spraddle Creek	1	Road/Parking	0	1
Navigation Hazards				
Glen Falls Bridge Utilities	5	Utilities	2	4
Golf Course Diversion Structure	5	Diversion	40	60
Downstream Gore Creek Drive at Condos	2	Channel	2	4
Cascade Skier Bridge	2	Channel	2	4
Erosion Problems				
Bighorn Pond and Spillway	5	Pond	40	80
Pitkin Creek I-70 to Gore Creek	4	Channel	30	60
Bighorn Creek Bighorn Rd to Gore Creek	3	Channel	5	10
West Vail Roundabout Bridge Downstream	4	Utilities	10	20
Golf Course Channelized Reach	2	Channel	4	10
Gore Trail Park Area Upstream of Lionshead	3	Path	20	40
Gore Creek Braided Channel Reach (Katsos)	3	Channel	20	40
West Vail Gore Trail	4	Path	60	100
Golf Course Downstream Path	4	Path/Tree	21	44
Gore Creek Downstream of Vail Manor Bridge	2	Channel	4	10
Middle Creek Downstream of I-70	3	Buildings/Roads	4	20
Gore Creek Upstream of Covered Bridge	2	Channel	1	4
Gore Creek International Bridge to Covered Bridge	1	Channel	1	4
Gore Creek Downstream of Elliot Bridge	1	Channel	0	1
Stephens Park	2	Tree/Channel	1	5
Gore Creek Near Vail Valley Blvd Bridge	1	Path/Retaining Wall	4	10
Channelized Reach between WWTP and Cascade Village	2	Channel	1	4
South Frontage Road Fillslope Erosion	1	Channel	0	1
Vail Whitewater Park	1	Channel	0	1
Donovan Park Tennis Courts	1	Channel	4	8
Lionshead Deposition Reach	2	Channel	5	10
Lionshead Wetland Pedestrian Bridge	1	Channel	0	1
Betty Ford Alpine Gardens	2	Channel	4	10
Nature Center	3	Channel	14	30
Gore Trail Upstream of Aspen Court	2	Channel	10	40
		TOTAL:	**$1,608**	**$3,120**
KEY TO NEED:				
Repaired or Modified After Assessment	0			
Monitor for Changes	1			
Standard Maintenance or Vegetation Installation	2			
Sketch Design and Adaptive Management	3			
Engineering Design and Implement 3 year	4			
Engineering Design and Implement 1 year	5			

APPENDIX C

General Notes

TOWN OF VAIL
HEATHERS AT VAIL SKETCH DESIGN
PLAN VIEW

NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

RIVER RESTORATION.ORG
P.O. Box 2123
Glenwood Springs, CO 81602
www.RiverRestoration.org

Project Name and Address

TOWN OF VAIL
GORE CREEK

Project: FLOOD	Sheet: A-1
Date: 09-16-2010	
Scale: 1" = 100'	

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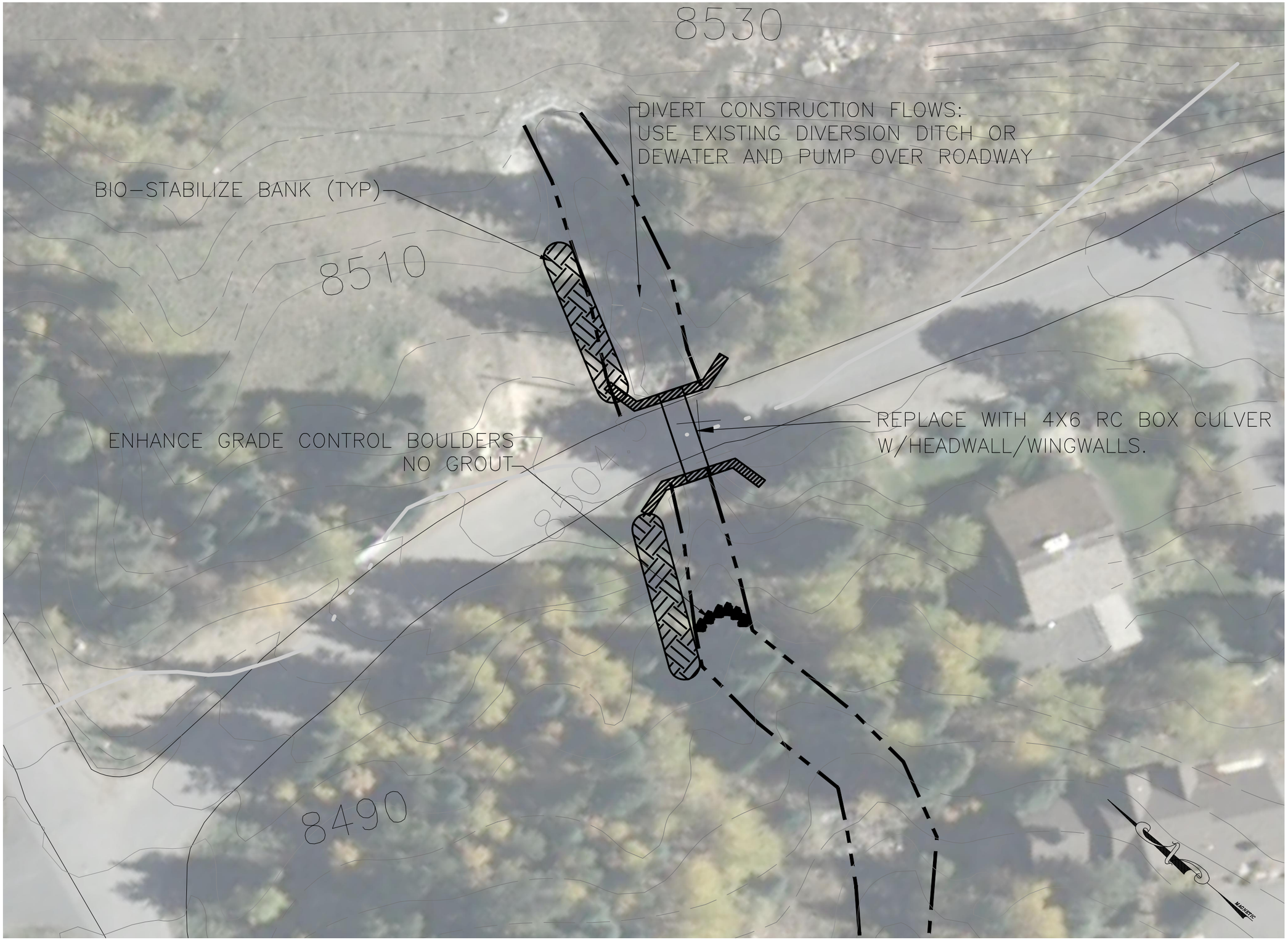
Heathers At Vail Flood Channel Stabilization Opinion of Costs Sketch Design					
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**SubTotal**
Site Setup					
Best Management practices					
Silt Fence	800	LF	$2	$1,600	
Access Repair	1	LS	$1,500	$1,500	
Plant Native Grasses	0.25	AC	$2,500	$625	
					$3,725
Biostabilize Bank					
BioStabilization	200	SY	$8	$1,600	
Topsoil	4	CY	$40	$160	
Toe Boulders	15	CY	$90	$1,350	
Shrubs	60	ea	$40	$2,400	
care of water	1	LS	$1,200	$1,200	
					$6,710
Channel Grading					
Excavation Alluvium	400	CY	$20	$8,000	
Excavation Hauloff	250	CY	$30	$7,500	
Excavation Backfill	150	CY	$10	$1,500	
Care of Water	1	LS	$1,500	$1,500	
					$18,500
PROJECT SUBTOTAL				$28,935	$28,935
25% CONTENGENCY				$7,234	
CONSTRUCTION SUBTOTAL				**$36,169**	
Lands Survey (LS)				$2,000	
Topographic Survey				$2,500	
Wetland Delineation				$500	
Lands and Easements				N/A	
Lands and Easements Processing				N/A	
Construction Bonding/Ins (3%)				$1,085	
Mob and Demob (2%)				$723	
Engineering Design				$5,425	
Permitting 404, 401				$2,400	
Permitting VAIL DRB PEC				$1,200	
Permit CDOT				$1,200	
Permitting Floodplain				$800	
Plans and Specifications for bid				$1,085	
Construction Stakeout				$362	
Construction Monitoring				$723	
Vegetation Replacement YR 2				$454	
TOTAL PROJECT COST OPINION				**$56,626**	



General Notes

TOWN OF VAIL
BIGHORN CK/SPRUCE WAY CULVERT
SKETCH DESIGN
PLAN VIEW

NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

Firm Name and Address

P.O. Box 2123
Glenwood Springs, CO 81602
www.RiverRestoration.org

Project Name and Address

TOWN OF VAIL
GORE CREEK

Project: FLOOD	Sheet: B-2
Date: 01-27-2011	
Scale: 1" = 30'	

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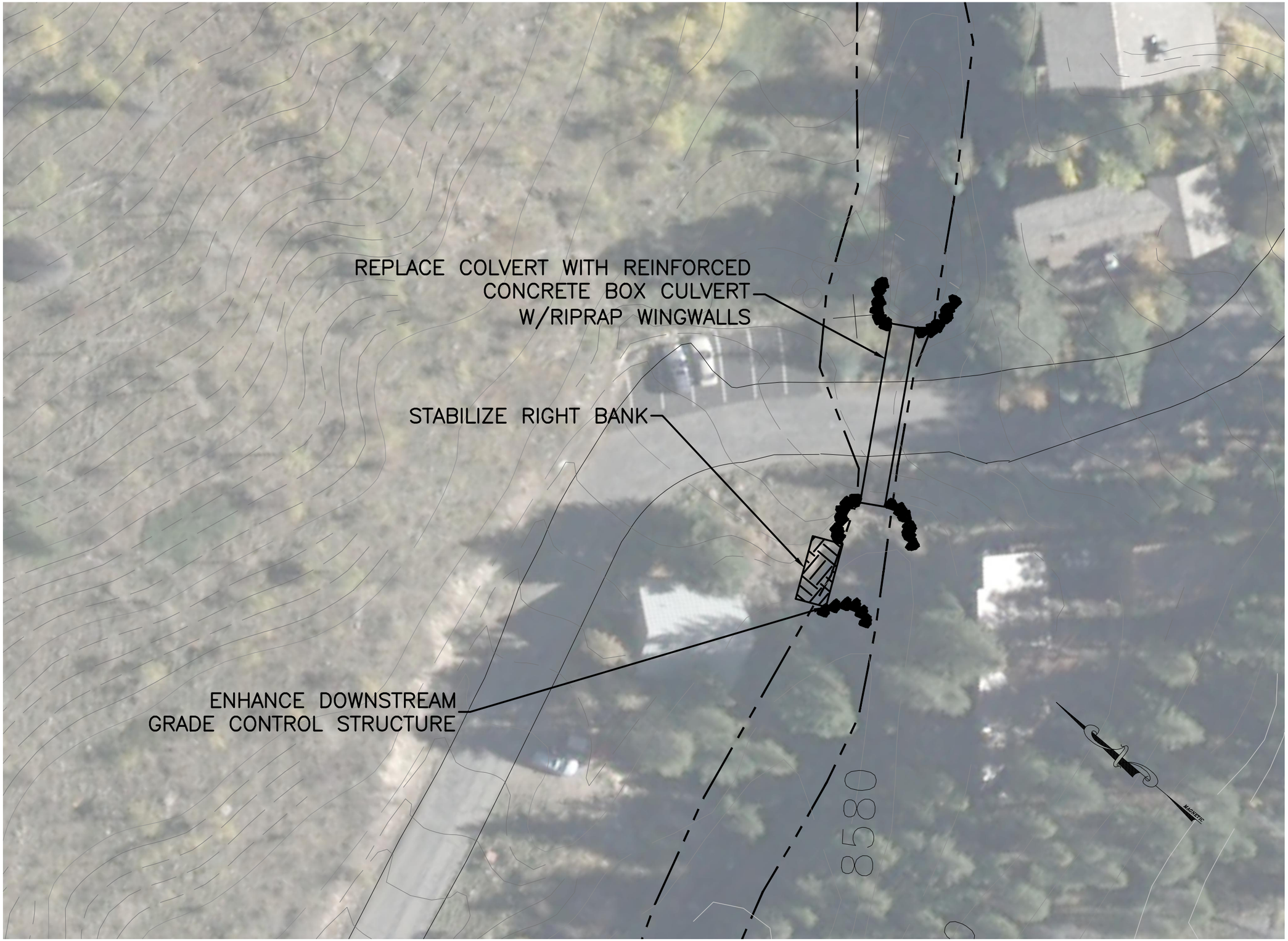
Bighorn Creek at Spruce Way Flood Channel Stabilization Opinion of Costs Sketch Design					
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**SubTotal**
Site Setup					
Best Management practices					
Silt Fence	500	LF	$2	$1,000	
Access Repair	1	LS	$1,500	$1,500	
Plant Native Grasses	0.25	AC	$2,500	$625	
					$3,125
Biostabilize Right Bank					
BioStabilization	250	SY	$8	$2,000	
Topsoil	20	CY	$40	$800	
Toe Boulders	34	CY	$90	$3,060	
Trees	3	ea	$400	$1,200	
Shrubs	100	ea	$40	$4,000	
Care of Water	1	LS	$1,500	$1,500	
					$12,560
Culvert					
Installation of Culvert	30	LF	$452	$13,560	
4x6 Box Culvert (delivered)	30	LF	$260	$9,000	
Headwalls/Wing Walls	35	CY	$600	$21,000	
Care of Water	1	LS	$1,500	$1,500	
Asphalt Cutting/ Patch/ Lining	1	LS	$4,500	$4,500	
Traffic Control	1	LS	$2,800	$2,800	
					$52,360
Grade Control Enhancement					
Excavation Alluvium	100	CY	$20	$2,000	
Excavation Hauloff	50	CY	$30	$1,500	
Excavation Backfill	50	CY	$20	$1,000	
Care of Water	1	LS	$1,500	$1,500	
					$6,000
PROJECT SUBTOTAL				$74,045	$74,045
25% CONTENGENCY				$18,511	
CONSTRUCTION SUBTOTAL				**$92,556**	
Lands Survey (LS)				$2,000	
Topographic Survey				$2,500	
Wetland Delineation				$500	
Lands and Easements				N/A	
Lands and Easements Processing				N/A	
Construction Bonding/Ins (3%)				$2,777	
Mob and Demob (2%)				$1,851	
Engineering Design				$13,883	
Permitting 404, 401				$2,400	
Permitting VAIL DRB PEC				$1,200	
Permit CDOT				$1,200	
Permitting Floodplain				$800	
Plans and Specifications for bid				$2,777	
Construction Stakeout				$926	
Construction Monitoring				$1,851	
Vegetation Replacement YR 2				$874	
TOTAL PROJECT COST OPINION				**$128,095**	



General Notes

TOWN OF VAIL
BIGHORN CK. AT COLUMBINE DR.
SKETCH DESIGN
PLAN VIEW

NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

RIVER RESTORATION.ORG
P.O. Box 2123
Glenwood Springs, CO 81602
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Project Name and Address

TOWN OF VAIL
BIG HORN CREEK

Project: FLOOD	Sheet: B-1
Date: 09-23-2010	
Scale: 1" = 30'	

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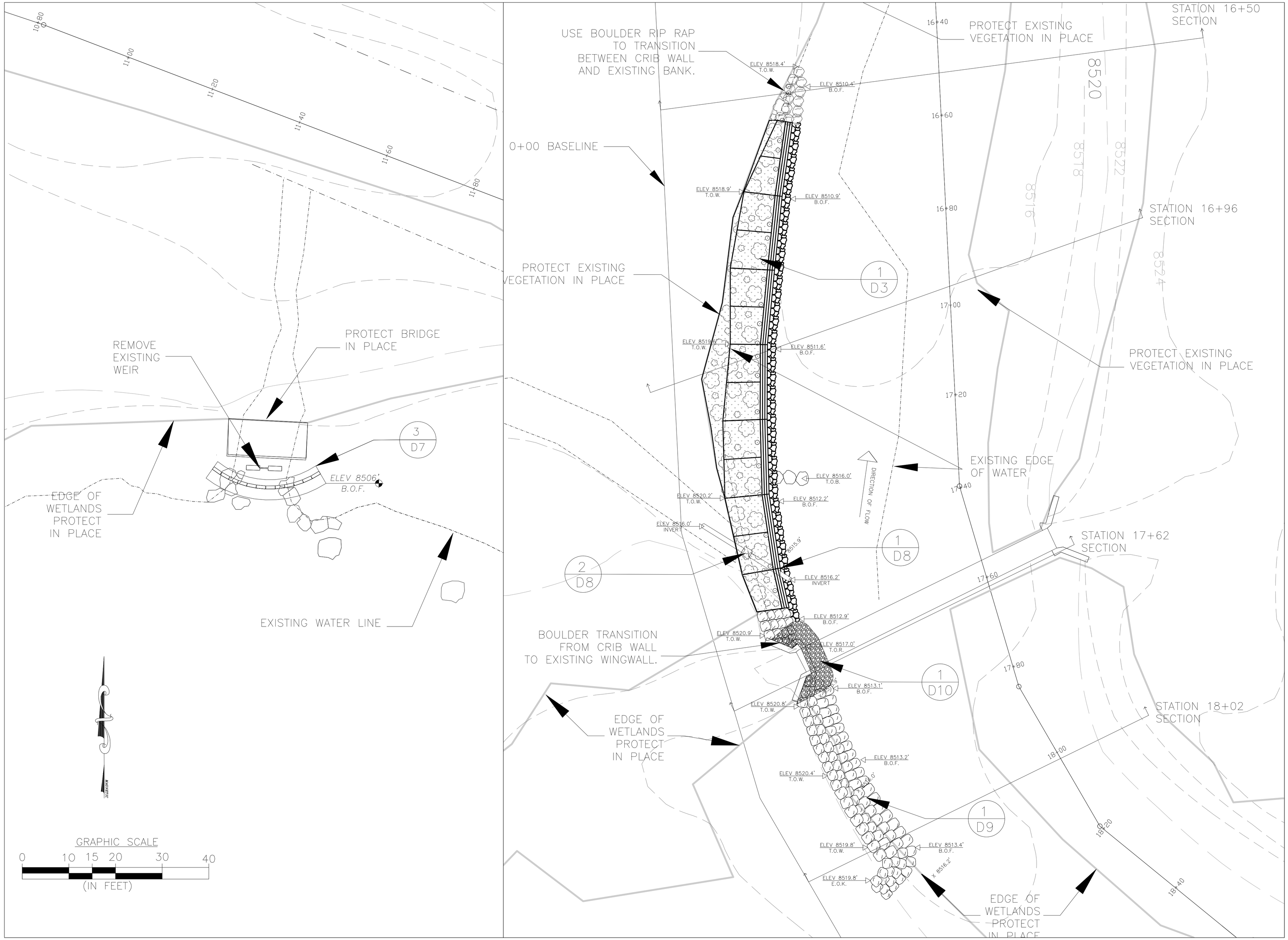
Bighorn Creek at Columbine Rd Flood Channel Stabilization Opinion of Costs Sketch Design					
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**SubTotal**
Site Setup					
Best Management practices					
Silt Fence	500	LF	$2	$1,000	
Access Repair	1	LS	$1,500	$1,500	
Plant Native Grasses	0.25	AC	$2,500	$625	
					$3,125
Biostabilize Downstream Right Bank					
BioStabilization	250	SY	$8	$2,000	
Topsoil	20	CY	$40	$800	
Toe Boulders	10	CY	$90	$900	
Trees	0	ea	$400	$0	
Shrubs	100	ea	$40	$4,000	
care of water	1	LS	$1,200	$1,200	
					$8,900
Culvert					
Installation of Culvert	35	LF	$452	$15,820	
Boulder Wing Walls	50	CY	$125	$6,250	
4x6 Box Culvert (Delivered)	35	LF	$260	$10,300	
Care of Water	1	LS	$1,500	$1,500	
Asphalt Cutting/ Patch/ Lining	1	LS	$4,500	$4,500	
Traffic Control	1	LS	$2,800	$2,800	
					$41,170
Grade Control Enhancement					
Excavation Alluvium	100	CY	$20	$2,000	
Excavation Hauloff	0	CY	$30	$0	
Excavation Backfill	100	CY	$20	$2,000	
Care of Water	1	LS	$1,500	$1,500	
					$5,500
PROJECT SUBTOTAL				$58,695	$58,695
25% CONTENGENCY				$14,674	
CONSTRUCTION SUBTOTAL				**$73,369**	
Lands Survey (LS)				$2,000	
Topographic Survey				$2,500	
Wetland Delineation				$500	
Lands and Easements				N/A	
Lands and Easements Processing				N/A	
Construction Bonding/Ins (3%)				$2,201	
Mob and Demob (2%)				$1,467	
Engineering Design				$11,005	
Permitting 404, 401				$2,400	
Permitting VAIL DRB PEC				$1,200	
Permit CDOT				$1,200	
Permitting Floodplain				$800	
Plans and Specifications for bid				$2,201	
Construction Stakeout				$734	
Construction Monitoring				$1,467	
Vegetation Replacement YR 2				$694	
TOTAL PROJECT COST OPINION				**$103,738**	



General Notes

TOWN OF VAIL
BIGHORN POND STABILIZATION
FINAL DESIGN
PLAN VIEW

APPROVED FOR CONSTRUCTION

No.	Revision/Issue	Date

RIVER RESTORATION.ORG
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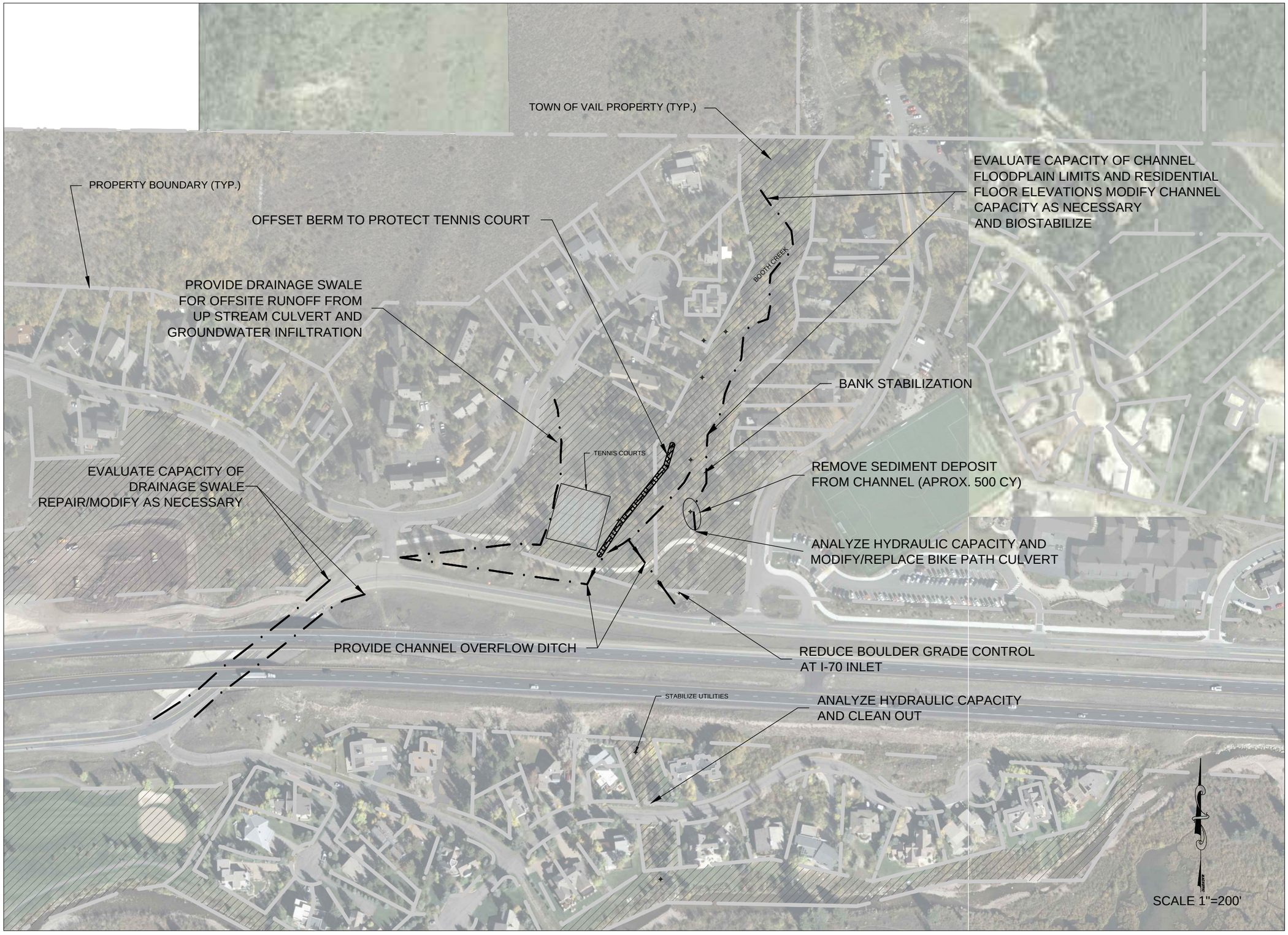
TOWN OF VAIL
GORE CREEK

Project: FLOOD	Sheet: C-1
Date: 11-23-2010	
Scale: 1" = 10'	

Bighorn Pond Stabilization Opinion of Costs Sketch Design					
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**SubTotal**
Site Setup					
Best Management practices					
Silt Fence	800	LF	$2	$1,600	
Other BMPs	1	LS	$1,500	$1,500	
Plant Native Grasses	0.25	AC	$2,500	$625	
					$3,725
Inline Water Level Control Structure					
Inline Water Lever Control Structure (5' x 12")	1	ea	$899	$899	
12' Bar Guard	1	ea	$48	$48	
Rat Guard	1	ea	$17	$17	
3' x 3' Anti Seep Collar	2	ea	$61	$122	
HDPE Culvert	20	LF	$42	$840	
Bedding Material	1	CY	$25	$25	
					$1,951
Crib Wall Bank					
Logs Installed for Cribbing	700	BF	$5	$3,500	
Erosion Control Blanket	150	SY	$4	$630	
Topsoil	20	CY	$40	$800	
Toe Boulders	40	CY	$90	$3,600	
Transition Boulders	5	CY	$90	$450	
Shrubs	90	ea	$30	$2,700	
Filter Fabric	150	SY	$4	$630	
Welded Wire	75	SY	$4	$300	
Excavation Alluvium	100	CY	$20	$2,000	
Backfill Alluvium	130	CY	$10	$1,300	
care of water	1	LS	$1,200	$1,200	
					$17,110
Diversion Plan (Crib Wall)					
Excavation Alluvium	30	CY	$20	$600	
Reinforced Visqueen	5	ea	$50	$250	
Jersey Barriers	30	LF	$5	$150	
Access	2	ea	$500	$1,000	
Turbidity Curtain	100	LF	$4	$400	
Oil Booms	100	LF	$1	$100	
					$2,500
Low-flow Spillway Replacement					
Concrete Installed	8	CY	$500	$4,000	
Bridge Stabilization	1	LS	$1,200	$1,200	
Care of Water	1	LS	$2,000	$2,000	
Unclassified Excavation	42	CY	$30	$1,260	
Unclassified Haul-Off	32	CY	$30	$960	
Toe Rock	5	CY	$90	$450	
Compacted Structural Backfill	19	CY	$45	$855	
					$10,725
Diversion Plan (Spillway Replacement)					
Sheet Piling	34	LF	$40	$1,360	
Excavation Lake bed	88	CY	$20	$1,760	
Backfill Lake Bed	88	CY	$20	$1,760	
Jersey Barriers	10	LF	$5	$50	
Access	1	ea	$500	$500	
					$5,430
PROJECT SUBTOTAL				$41,441	$41,441
10% CONTINGENCY				$4,144	
CONSTRUCTION SUBTOTAL				**$45,585**	
Lands Survey (LS)				$800	
Construction Bonding/Ins (3%)				$1,368	
Mob and Demob (2%)				$2,500	
Construction Stakeout				$900	
Construction Monitoring				$2,000	
TOTAL PROJECT COST OPINION				**$53,152**	



General Notes

TOWN OF VAIL BOOTH CREEK RESTORATION CONCEPTUAL PLAN VIEW

NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

RIVER RESTORATION.ORG
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Project Name and Address

TOWN OF VAIL
BOOTH CREEK

Project: FLOOD	Sheet: C-1
Date: 12-20-2010	
Scale: 1" = 200'	

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Booth Creek Flood Channel Stabilization Opinion of Costs Sketch Design					
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**SubTotal**
Site Setup					
Best Management practices					
Silt Fence	1000	LF	$2	$2,000	
Access Repair	1	LS	$3,000	$3,000	
Plant Native Grasses	3	AC	$2,500	$7,500	
					$12,500
Bio-stabilize Bank					
BioStabilization	250	SY	$8	$2,000	
Topsoil	4	CY	$40	$160	
Toe Boulders	15	CY	$90	$1,350	
Trees Installed and Protected	10	ea	$400	$4,000	
Shrubs Installed	200	ea	$40	$8,000	
Soil Sacks Hand Placed	40	CY	$100	$4,000	
Hand Shovel	40	CY	$100	$4,000	
					$23,510
Channel Grading					
Excavation Alluvium	750	CY	$20	$15,000	
Excavation Hauloff	500	CY	$30	$15,000	
Excavation Backfill	250	CY	$10	$2,500	
Care of Water	1	LS	$2,500	$2,500	
					$35,000
Vegetated Berms					
Soil Sacks Hand Placed	60	CY	$100	$6,000	
Shrubs	150	ea	$40	$6,000	
Hand Shovel	60	CY	$100	$6,000	
					$18,000
Drainage Return Channels					
Excavation	400	CY	$20	$8,000	
Excavation Hauloff	300	CY	$30	$9,000	
Boulder Retaining/ Grade Control	150	CY	$90	$13,500	
BioStabilization	200	SY	$8	$1,600	
Shrubs	100	ea	$40	$4,000	
18” HDPE Culvert	200	LF	$60	$12,000	
Sidewalk Repair	200	SF	$12	$2,400	
Asphalt Cutting/ Patch/ Lining	1	LS	$15,000	$15,000	
					$65,500
Right Offset Levee					
Excavation Backfill and Compaction	200	CY	$20	$4,000	
Topsoil	33	CY	$40	$1,320	
Shrubs	100	ea	$40	$4,000	
					$9,320
Modify US6 Box Culvert					
Concrete Cutting/ DEMO	200	LF	$50	$10,000	
Trash Rack	1	LS	$12,000	$12,000	
Concrete Forming	2	CY	$800	$1,600	
					$23,600
PROJECT SUBTOTAL				$187,430	$187,430
25% CONTENGENCY				$46,858	
CONSTRUCTION SUBTOTAL				**$234,288**	
Lands Survey (LS)				$3,500	
Topographic Survey				$3,500	
Wetland Delineation				$2,500	
Lands and Easements				$3,500	
Lands and Easements Processing				$3,000	
Construction Bonding/Ins (3%)				$7,029	
Mob and Demob (2%)				$4,686	
Engineering Design				$35,143	
Hydraulic Modeling				$7,500	
Permitting 404, 401				$4,686	
Permitting VAIL DRB PEC				$2,343	
Permit CDOT				$0	
Permitting Floodplain				$800	
Plans and Specifications for bid				$7,029	
Construction Stakeout				$2,343	
Construction Monitoring				$4,686	
Vegetation Replacement YR 2				$4,125	
TOTAL PROJECT COST OPINION				**$330,656**	

General Notes

TOWN OF VAIL
MIDDLE CREEK RESTORATION
CONCEPTUAL PLAN
PLAN VIEW

NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

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Project Name and Address

TOWN OF VAIL
BOOTH CREEK

Project	Sheet
FLOOD	C-1
Date: 12-20-2010	
Scale: 1" = 100'	

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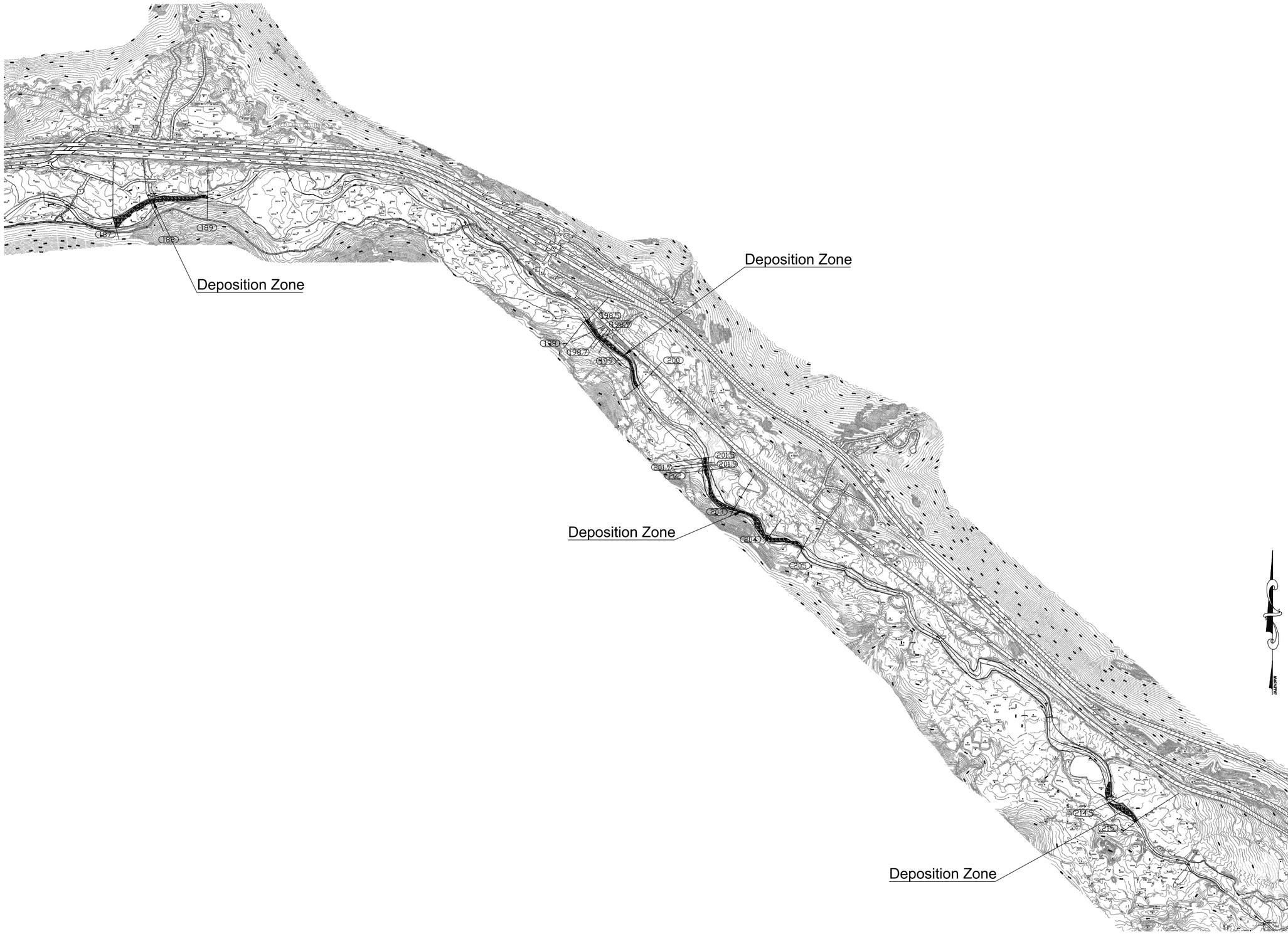
Middle Creek Flood Channel Stabilization Opinion of Costs Sketch Design					
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**SubTotal**
Site Setup					
Best Management practices					
Silt Fence	1000	LF	$2	$2,000	
Access Repair	1	LS	$3,000	$3,000	
Plant Native Grasses	1	AC	$2,500	$2,500	
					$7,500
Biostabilize Bank					
BioStabilization	200	SY	$8	$1,600	
Topsoil	4	CY	$40	$160	
Toe Boulders	15	CY	$90	$1,350	
Trees	0	ea	$400	$0	
Shrubs	100	ea	$40	$4,000	
care of water	1	LS	$1,200	$1,200	
					$8,310
Channel Grading					
Excavation Alluvium	150	CY	$20	$3,000	
Excavation Hauloff	150	CY	$30	$4,500	
Excavation Backfill	50	CY	$10	$500	
Care of Water	1	LS	$1,500	$1,500	
					$9,500
Drainage Return Channel					
Excavation	150	CY	$20	$3,000	
Excavation Hauloff	150	CY	$30	$4,500	
Boulder Retaining Wall	90	CY	$90	$8,100	
BioStabilization	200	SY	$8	$1,600	
Shrubs	100	ea	$40	$4,000	
Asphalt Cutting/ Patch/ Lining	1	LS	$4,500	$4,500	
					$25,700
Vegetated Berms					
Soil Sacks Hand Placed	40	CY	$100	$4,000	
Shrubs	100	ea	$40	$4,000	
Hand Shovel	40	CY	$100	$4,000	
					$12,000
Flood Mitigation Channel Improvements					
Excavation	500	CY	$20	$10,000	
Excavation Hauloff	150	CY	$30	$4,500	
Excavation Backfill and Compation	350	CY	$20	$7,000	
Boulder Retaining Wall	300	CY	$90	$27,000	
BioStabilization	200	SY	$8	$1,600	
					$50,100
PROJECT SUBTOTAL				$113,110	$113,110
25% CONTENGENCY				$28,278	
CONSTRUCTION SUBTOTAL				**$141,388**	
Lands Survey (LS)				$3,500	
Topographic Survey				$3,500	
Wetland Delineation				$1,000	
Lands and Easements				$3,500	
Lands and Easements Processing				$3,000	
Construction Bonding/Ins (3%)				$4,242	
Mob and Demob (2%)				$2,828	
Engineering Design				$21,208	
Hydraulic Modeling				$12,000	
Permitting 404, 401				$2,828	
Permitting VAIL DRB PEC				$1,414	
Permit CDOT				$0	
Permitting Floodplain				$800	
Plans and Specifications for bid				$4,242	
Construction Stakeout				$1,414	
Construction Monitoring				$2,828	
Vegetation Replacement YR 2				$2,175	
TOTAL PROJECT COST OPINION				**$211,865**	



General Notes

TOWN OF VAIL
CHANNEL CONVEYANCE STABILIZATION
SKETCH DESIGN
PLAN VIEW

NOT FOR CONSTRUCTION

No.	Revision/Issue	Date

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TOWN OF VAIL
GORE CREEK

Project: FLOOD	Sheet: C-1
Date: 01-27-2010	
Scale: 1" = 1000'	

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Channel Conveyance Project (5 sites) Opinion of Costs Sketch Design					
Description	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**SubTotal**
Channel Grading					
Excavation Alluvium	10000	CY	$10	$100,000	
Excavation Hauloff	8000	CY	$30	$240,000	
Excavation Backfill	2000	CY	$10	$20,000	
Care of Water	5	LS	$1,500	$7,500	
Best Management practices	5	LS	$3,800	$19,000	
Channel Access and Restoration	5	EA	$5,500	$27,500	
					$414,000
PROJECT SUBTOTAL				$414,000	$414,000
25% CONTENGENCY				$103,500	
CONSTRUCTION SUBTOTAL				**$517,500**	
Lands Survey (LS)				$2,000	
Topographic Survey				$12,000	
Wetland Delineation				$500	
Lands and Easements				N/A	
Lands and Easements Processing				N/A	
Construction Bonding/Ins (3%)				$15,525	
Mob and Demob (2%)				$10,350	
Hydraulic Modeling				$6,000	
Engineering Design				$16,000	
Permitting 404, 401				$5,000	
Permitting VAIL DRB PEC				$1,200	
Permit CDOT				$0	
Permitting Floodplain				$2,000	
Plans and Specifications for bid				$15,525	
Construction Stakeout				$5,175	
Construction Monitoring				$10,350	
TOTAL PROJECT COST OPINION				**$619,125**	