# Rabbit Ears Pass
# Sediment Control Scoping Study

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# EXECUTIVE SUMMARY

This Sediment Control Scoping Study (SCSS) provides an assessment of sediment issues and potential sediment control measures for Rabbit Ears Pass along Highway 40 (US40), a major east-west highway through Colorado. Due to erosion and winter traction sanding operations, sediment controls are needed to decrease water quality impacts to near-by surface waters on, or adjacent to, Rabbit Ears Pass. The importance of Steamboat Springs as a vacation/recreation destination has increased in past decades, and created more traffic demand on the Pass as the town has grown. This has created unique travel conditions, demand patterns, and maintenance needs that differ significantly from other portions of the state because Rabbit Ears Pass provides excellent winter access to and through this region.

Public safety is paramount to Colorado Department of Transportation (CDOT), thus considerable traction sand is laid down during the winter months. Excessive sediment loading has been occurring for many years. Sedimentation is caused by both winter maintenance practices and cut-and-fill slope erosion. This material, referred to collectively as sediment, is transported into the natural environment from the Rabbit Ears Pass right-of-way by surface water runoff, depositing into streams, lakes, and wetlands. Excessive sediment loading can impair water quality, increase nuisance nutrient concentrations, reduce fish spawning habitat, and inundate wetland vegetation. This situation is largely a result of inadequate source controls and drainage problems along Rabbit Ears Pass.

Sediment controls are referred to as Best Management Practices (BMPs) under the Clean Water Act. Implementation of sediment control BMPs can reduce the amount of sediment loading in receiving waters. Additional controls and drainage improvements are required to reduce the sediment loading from Rabbit Ears Pass. The focus of this SCSS is related primarily to identifying and prioritizing problem areas and then making recommendations for (i) existing maintenance improvements, and (ii) suggestions regarding where drainage and sediment source controls that may reduce sediment loading along the Rabbit Ears Pass corridor might be sited. The project also considers some general cost estimates of various BMP recommendations. Extensive field assessment, interview with maintenance crews, and Geographic Information System (GIS)-based analysis was required to assess these needs, and this SCSS is the most comprehensive examination of Rabbit Ears Pass sediment issues.

The SCSS is a planning document that includes relevant background information, an evaluation of Rabbit Ears Pass sediment sources, identification of potentially viable BMPs and locations, and improved maintenance practices that may be used to guide development of a detailed source control strategy. Both structural and non-structural sediment control BMPs are proposed. A detailed map book and map panel index accompanies the report providing detailed information on recommended BMPs and maintenance improvements. Via field work, GIS-based analysis, and interviews with maintenance crews and project stakeholders, a great deal has been learned about the Rabbit Ears Pass to help guide sedimentation mitigation, and to help define workable mitigation solutions put forth in this SCSS. Currently, Rabbit Ears Pass has no fixed sediment source controls in place other than a temporary sediment trap that was put in by CDOT maintenance crews on the west side of the Pass. This was developed following the blow-out of a sediment laden culvert above private property that was itself partly inundated by sediment in the same event. The sediment trap has worked remarkably well, and provided the project team an excellent example of a BMP that works on the Pass.

Following this example, the strategy adopted for this planning document is focused on source control. Field studies and observations indicate that presently, the majority of sediment on and in close proximity to the Rabbit Ears Pass right-of-way is accumulated traction sand that is applied to the highway during winter maintenance operations. Annual applications currently average approximately 6,500 tons/year on Rabbit Ears Pass. About 5-10% of the residual sand may be collected annually under routine maintenance operations such as ditch cleaning, but the remaining 90-95% either remains on the shoulders of Rabbit Ears Pass, or is transported in surface water runoff to receiving waters. The area included in this SCSS is the highway shoulder and median, extending to approximately 25-feet on either side of the edge of pavement, except for the wetland/fenland area on the flatter top of the Pass see study area map). Any work beyond the highway corridor 25-foot zone will need to be addressed in a separate study.

Operational BMPs for sediment control are relatively new to the CDOT maintenance program. A significant portion of this SCSS is dedicated to maintenance practices and operations. Since the completion of Rabbit Ears Pass highway, the focus of maintenance operations has been on maintaining the highway surface. The higher level of maintenance work to meet the growing needs was not anticipated at the time of construction. Public expectations for maintaining Rabbit Ears Pass to a certain level have increased accordingly. The scenarios presented in this plan would require significant additional resources for Rabbit Ears Pass maintenance to provide the same level of service to the traveling public and adequately address the sedimentation problem. This would indicate that additional resources, as well as changes in policies and priorities, are required to meet all the needs. It is clear that maintenance forces are generally under-staffed and under-funded at the current time to adequately clean-up traction sand and sediment material as well as meeting myriad other tasks.

The goal of this SCSS is to provide an overall management strategy for the entire corridor so that one problem does not exacerbate another nor inhibit the effectiveness of various solutions. The BMPs recommended in this report are conceptual in nature, requiring engineering input prior to implementation. In various meetings held throughout the project, CDOT maintenance staff was consulted to develop additional sediment control measures and clean-up procedures that can be implemented into their current schedule. Sediment control strategies, procedures and methods are portrayed using an ArcGIS Mapbook which depicts locations where snow storage should/should not occur, areas where laying down of traction material should be limited, and recommended locations of non-structural and structural Best Management Practices (BMPs). It is intended that the Mapbook be used by CDOT maintenance staff as a reference guide when performing their winter snow removal operations. As funds become available, it is recommended that the capital construction and maintenance plan be prioritized to address the following locations:

- Steep bends near Milepost 140
- Steep bends near Milepost 145
- Large pulloff area near Milepost 146
- CDOT Maintenance Shed
- Muddy Creek Culvert near Milepost 153

These areas, discussed in Section 4.4, are those areas identified by maintenance to be among the most problematic on the Pass. To the extent feasible, these areas should be addressed first, giving preference to the maintenance shed, as it is the main concern of the U.S. Forest Service (USFS). The overall strategy of the SCSS (process and goals) put forward in this document are to capture sediment as close to the source as possible and before it leaves the site, and to implement an effective regular maintenance plan. Recommendations for BMPs, including types and locations, are identified in the text of the report and in the Mapbook. In addition to proper design, structural BMPs must also be sited, installed, and maintained appropriately in order to function effectively. The importance of proper maintenance of structural BMPs cannot be overestimated. All the recommended structural BMPs, if they are to function properly, require both time and budget commitments for maintenance in order to continue to function and to be successful over time (many structural BMPs fail due to the lack of continued support for maintaining the installed facilities).

Maintenance can use this document as a guide to address sedimentation issues on the Pass and develop a more comprehensive maintenance plan. The report contains a discussion of BMPs organized by their intent – prevention, collection, and treatment. The potential application of those BMPs has been demonstrated in the discussion of five priority problem areas. Each problem area is further broken down into enhanced and comprehensive maintenance plans. The enhanced plan is intended to present a low capital cost approach to addressing the sediment issues at the site. The comprehensive plans involve a higher capital cost, but are intended to be effective over a longer term. The Mapbook shows one potential application of BMPs to the entire project area. Again, the designs in the Mapbook are conceptual. This both allows maintenance to adapt the plans how they see fit and requires engineering input prior to capital construction. Maintenance does not have the budget to implement most the BMPs illustrated in the Mapbook, and thus cannot execute all of the recommended BMPs.

# 1.0 INTRODUCTION AND OBJECTIVES

Highway 40 (US40) is a major east-west highway through Colorado. In the area of interest, US40 passes through Steamboat Springs and continues south and east over the Continental Divide at Rabbit Ears Pass (the Pass), elevation 9,426 feet, connecting Steamboat Springs to Kremmling and Routt County to Grand County, via Jackson County. In the project area, the highway corridor is steep and/or winding in several locations, receives significant annual snowfall, and carries large traffic volumes during the winter months when weather conditions can change rapidly. Due to these conditions, driving the highway in winter can be treacherous at times. In order to maintain safe winter driving conditions along the corridor, the Colorado Department of Transportation (CDOT) applies a salt/sand mixture to the 19-mile stretch of roadway on a yearly basis. While critical for road safety, this road salt/sand can later be mobilized by rainfall and snowmelt runoff and wind, contributing to the sedimentation of adjacent water bodies, wetlands and properties.

In April 2012, CDOT contracted with AMEC Environment & Infrastructure (AMEC) to perform a Sediment Control Scoping Study (SCSS) to present conceptual level solutions to address the sediment load from applied road sand to adjacent bodies of water. The project limits for the SCSS include US40 and the adjacent impacted lands from approximately mile post 139 to 158.

Specific goals for the project were to:

- Coordinate with local stakeholders and CDOT staff to identify existing high-risk, problematic areas that contribute to the sedimentation of adjacent waterways and properties.
- Recommend additional sediment control measures that can be incorporated into current CDOT maintenance practices and schedule.
- Recommend permanent Best Management Practices (BMPs) that can be implemented as funds become available.

Coordination with CDOT, AMEC, and the U.S. Forest Service (USFS) occurred in the form of meetings and field work. Collaboration with the USFS was important for identifying local needs and concerns, particularly with wetland resources throughout the study area. Field work was performed to evaluate site-specific parameters and potential “fatal flaws” with the recommended BMPs.

## 1.1 Document Organization

The following section, Section 2, provides an overview of Rabbit Ears Pass, existing conditions, maintenance issues and challenges, and additional aspects for CDOT to consider when planning construction projects such as implementation of sediment control measures. AMEC and the CDOT maintenance crew worked together to identify and develop sediment control measures and clean-up procedures that can be implemented into their current schedule. This is termed the “Enhanced Maintenance Plan” and is described in Section 4.2. Additional BMPs were developed that can effectively be implemented at a later time as funds become available. A discussion of this “Comprehensive Construction and Maintenance Plan” is discussed in Section 4.3. Five priority areas and suggested BMPs are discussed in the “Prioritized Construction and Maintenance Plan” in Section 4.4. The menu of non-structural and structural

BMP control measures presented in Sections 3.2 and 3.3 provide the background and detailed information for many of the BMPs included in each Maintenance Plan. The reader is directed to these sections for information such as benefits, limitations, site and maintenance considerations and general design criteria for each BMP. Additionally, a discussion regarding recommendations to control sediment loads due to steep cut slopes along portions of the highway corridor is presented in Section 3.4.

To assist CDOT maintenance staff with turning this conceptual plan into on the ground implementation, the following information and sections of this SCSS are recommended for review and use:

- Section 4.2 Enhanced Maintenance Plan
- The Mapbook which depicts the entire study area, i.e. milepost 138 to the junction of US40 and Colorado State Highway 14, using high resolution aerial imagery
- The Mapbook Reference Sheet that describes various features shown in the Mapbook

It is hoped that this information, if desired, can be pulled out of the SCSS and act as a stand-alone, portable guide to BMP control measures that maintenance staff can implement to the desired level depending on time, personnel and funding available. In particular, the Mapbook can assist the user in identifying all locations requiring treatments. The Menu of BMPs in Sections 3.2 and 3.3 can also be used as supplemental information when the time comes to select the best single or combination of treatments for a particular site, depending on the resources available.

The specific sections in the Rabbit Ears Pass SCSS include the following:

- Section 1.0 Introduction and Objectives
- Section 2.0 Rabbit Ears Pass Corridor Overview
- Section 3.0 Sediment Control Options
- Section 4.0 Maintenance Plan Options
- Section 5.0 Summary and Recommendations
- Section 6.0 Acronyms
- Section 7.0 References
- Appendix A: Cost Estimates

# 2.0 RABBIT EARS PASS CORRIDOR OVERVIEW

## 2.1 Study Area and Existing Conditions

*Physical Setting*

Rabbit Ears Pass is traversed by US40 and connects Steamboat Springs to Kremmling and Routt County to Grand County, via Jackson County. US40 over Rabbit Ears Pass is a high mountain roadway that experiences significant snowfall in the winter months. The road itself is generally oriented east-west, traversing 19 miles through mountains bordering the Gore and Park Ranges (Figure 1). The west side of the Pass is significantly steeper than the rest of the Pass (Figure 2). Moving east from Steamboat Springs, and the western edge of the study area at milepost 138, the road climbs from an elevation of ~6900 feet to the western summit at ~9400 feet of elevation, between mileposts 146 and 147. In roughly 7.5 miles, the road gains ~2500 feet of elevation, resulting in road slopes as high as 7% (Figure 3). The adjacent hill slopes are generally steep, with slopes well over 100%. The Yampa Valley has a ranching history, with mixed grasses as the main vegetation cover (Figure 4a). Rising from the valley, the vegetation in the road corridor quickly changes to pine and aspen forest (Figure 4b).

Moving east, the road begins to flatten for several miles until climbing gently to the east summit of the Pass at 9426 feet of elevation. This true summit is located near milepost 154, and is also where the road crosses the continental divide. Road slopes along this section of road are in the 1% to 3% range. The composition of the vegetation changes here, as steeper hill slopes give way to flatter valleys, composed of grasses and significant wetland resources (Figure 4c).

Moving east, past the continental divide, the road grade slightly steepens as it twists its way toward the intersection of Colorado State Highway 14 and the eastern edge of the study area. Road slopes through this section range from 2% to 5%. Vegetation in the road corridor is a mix of sections of grassland valleys and pine forest.

*Hydrography*

Multiple streams and creeks are in the area, including Walton Creek, Harrison Creek, Grizzly Creek, Little Muddy Creek, and Muddy Creek, a fish bearing stream (Figure 1). Wetlands border the highway between mileposts 149 and 154. Between mileposts 151 and 152 there is a small section of Fen wetlands which are characterized by their neutral chemistry, high dissolved mineral levels, and high diversity of plant species. This section of Fens has been identified as an important resource in meetings with the USFS. Harrison and McKinnis Creeks drain the west side of the Pass. Both creeks are tributary to the Yampa River, with Harrison feeding into Lake Catamount which is a reservoir that spills into the Yampa. Muddy Creek is the major drainage on the east side of the Pass, passing under the highway near milepost 153.

*Climate*

The climate on Rabbit Ears Pass is on the colder side of mild, with generally dry summers and relatively wet winters. Orographics play a major role in local weather patterns, accounting for a dramatic increase in winter snowfall and summer thunderstorms. On the west side of the Pass, the abrupt rise of the mountains from the Yampa Valley, combined with a general west-east weather pattern creates a significant temperature and precipitation gradient. The PRISM (Parameter-elevation Regressions on Independent Slopes Model) Climate Group at Oregon State University provides spatially gridded climate data for the entire United States. Data from a PRISM cell near the intersection of the Yampa River and State Highway 131, along with two SNOTEL (SNOpack TELemetry) stations located on opposite sides of the Pass allow for the establishment of a gradient along the Pass. Figures 5 and 6 show average annual values of climate variables (precipitation and temperature), along with a conceptual elevation profile. The Yampa Valley PRISM cell shows an average annual precipitation of 22.3 inches. Average July and January temperatures are 63 degrees Fahrenheit (°F) and 16.8°F, respectively. The Rabbit Ears SNOTEL site (709) is located near milepost 147 at 9400 feet on the west summit of the Pass. Here, the average annual precipitation is nearly double that of the valley at ~45 inches. Temperatures average 52°F in July and 16°F in January. Moving further east across the study site, the Columbine SNOTEL site (408) is located on the east side of Rabbit Ears Pass at 9160 feet elevation, east of milepost 155. Average annual precipitation values fall to 38 inches, and average July and January temperatures are 59°F and 24°F, respectively.

*Winter Operations*

The application of traction material on Rabbit Ears Pass has seen a progression in the approaches used to keep the highway safe for vehicles. Winter tracking operations began with the use of Scoria, a highly vesicular volcanic rock. However, the material was only marginally effective because of its light weight and fragile nature. Heavy truck tires would blow the material off the road. Additionally, the vesicular nature means that the material is easily transported during snowmelt or storm events, appearing to float or easily saltate along the road and down into channels. In light of these deficiencies, CDOT moved to using salt. However, the salt was negatively affecting the trees along the roadway. As a result, CDOT began using a traction sand and magnesium chloride mixture. For the past couple of seasons, CDOT has used Meltdown Apex, a deicer composed of magnesium chloride and a proprietary additive that increases the effective temperature range of magnesium chloride by 12 °F. While the specific amount of material placed on the Pass depends on the winter, maintenance estimates that it puts down approximately 6500 tons of material in an average year.

*Problem Overview*

Winter tracking operations, combined with steep physical nature of the Pass have led to the buildup of traction control material along the road corridor. Piles of traction sand line the highway shoulder along steeper sections of road. While the majority of the deposition zones along the highway are primarily composed of traction sand, scoria is still prevalent throughout the system despite not having been used in 10 or more years (Figures 7a and 7b).

**Problems:**

- Winter traction material buildup along highway corridor
- Scoria is prevalent in study area
    - Lining creek channels
    - Piled in deposition zones
    - Plugging culverts
- Cut slopes along highway provide significant sediment loads

The persistence of the scoria can be seen throughout the study area, lining creek channels, piled on top of traction sand in deposition zones, and plugging culverts. Particularly, two similar blow-out events have caused consternation with local landowners. Culverts located above and adjacent to private lots had become plugged with scoria. During a high runoff event, the culverts blew out, flooding the lots below with scoria-laden water. CDOT Maintenance, in response, constructed sediment traps above and below the culvert in an attempt to abate future blowouts (Figures 8a and 8 b). These traps were constructed 3 years before a May, 2012 field visit conducted for this SCSS, and only the trap above the culvert was in need of cleaning. This action acts like a test case or pilot study, providing insight into the potential BMPs that could be implemented at other problem sites along the Pass.

While most of the sedimentation issues seen in the study area are most clearly a result of winter tracking operations, cut slopes seen all along the highway also provide a significant sediment load. These are essentially steep, unconsolidated walls of erosive bedrock that are poorly suited to vegetation (Figure 9). Field reconnaissance indicates that these cut slopes may contribute as much as 10% of the overall sediment load to road shoulder.

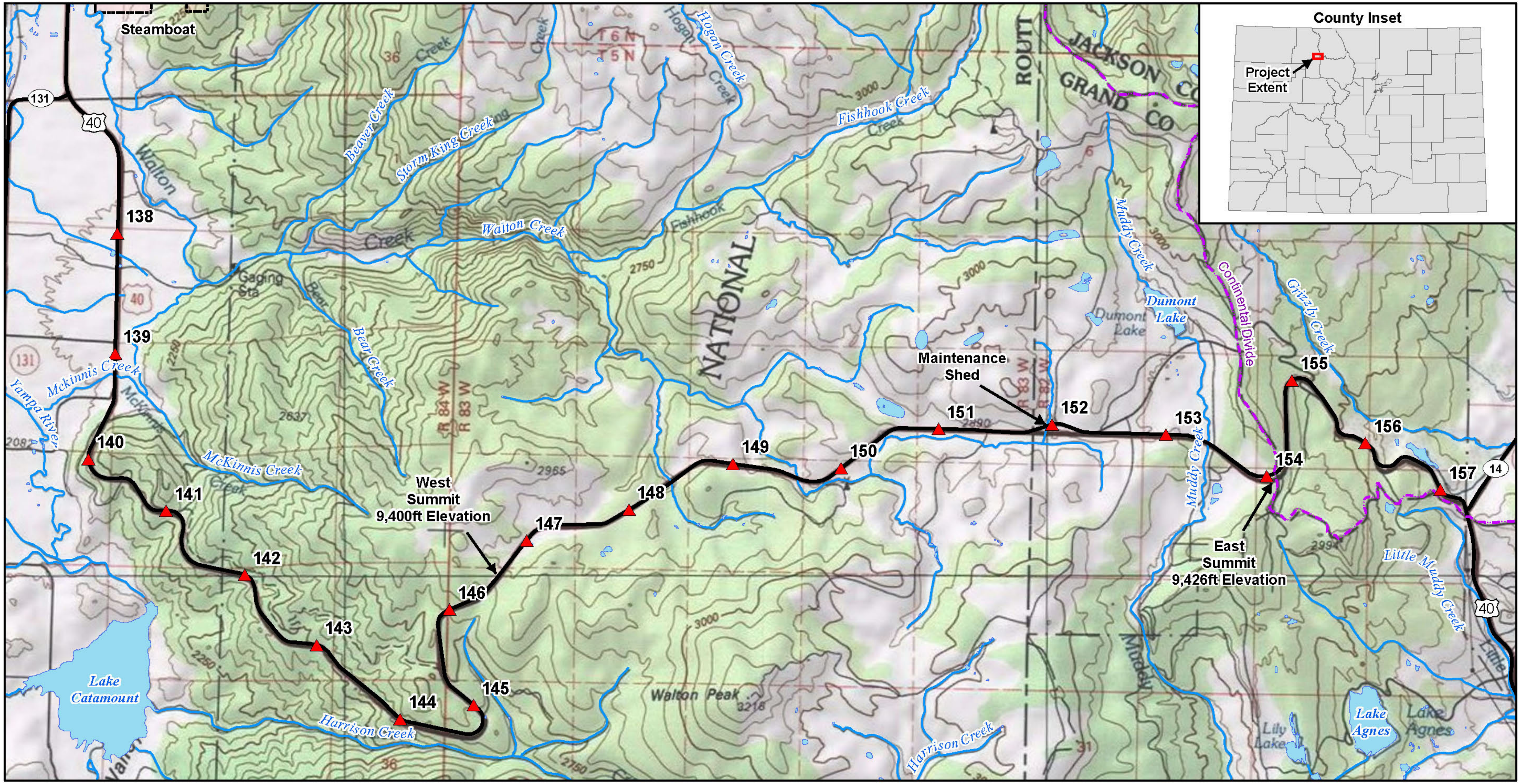



Figure 1. Study area overview showing US40 over Rabbit Ears Pass on the border of the Gore and Park Ranges of northern-central Colorado. The project study area begins on the east side of the Pass at the intersection of Colorado State Highway 14 and US40 and extends west to mile marker 138, south of the town of Steamboat Springs.

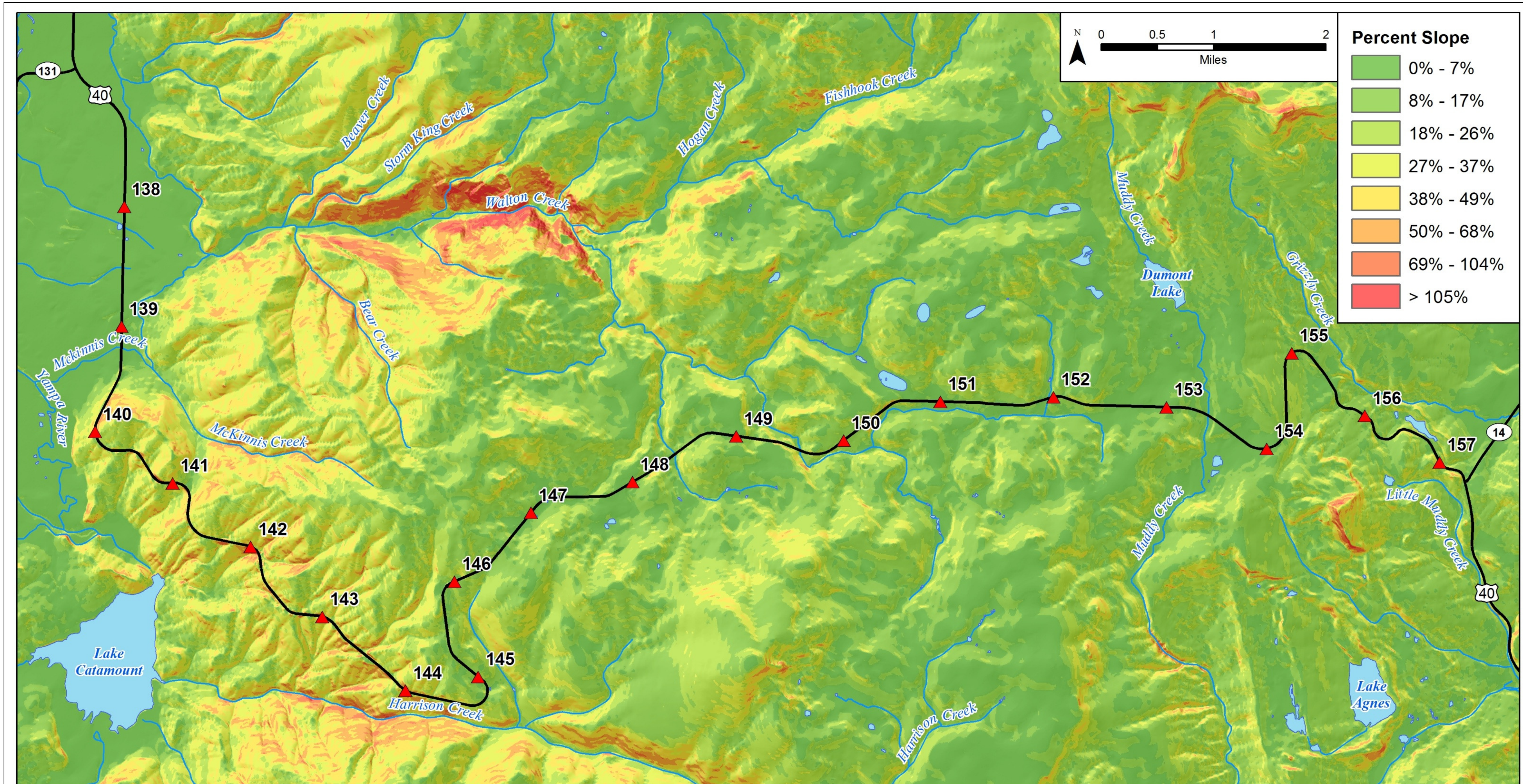



Figure 2. Terrain slopes were calculated from the 10m Digital Elevation Model (DEM). The terrain is much steeper on the west side of the Pass, or from the western summit (between mileposts 146 and 147) down to the Yampa Valley. Moving east from the western summit, the Pass is relatively flat, before steepening again in the last couple miles before the intersection of US40 and Colorado State Highway 14.

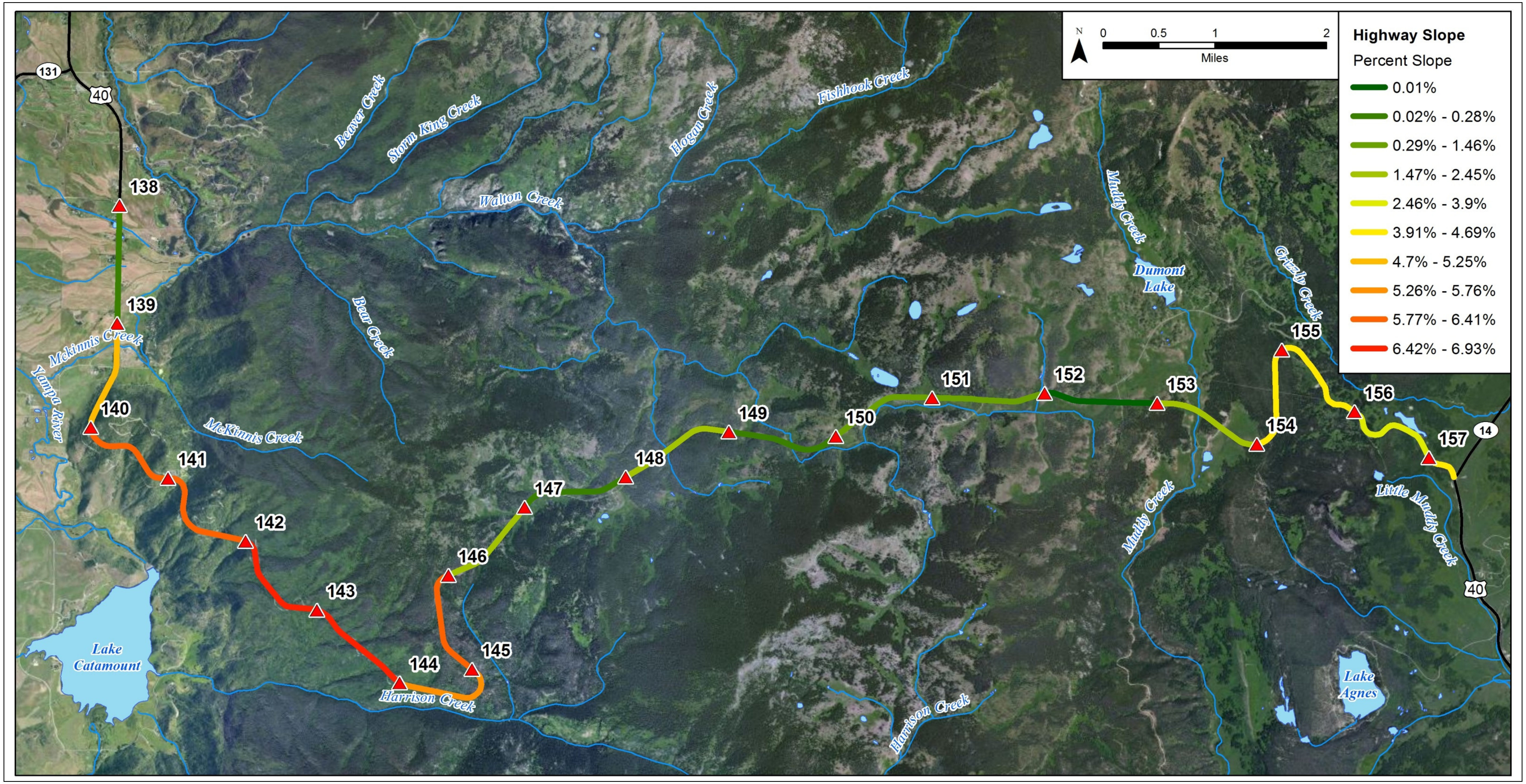



Figure 3. Road surface slopes calculated for the length of US40 included in the project area. As expected, the west side of the Pass contains the steepest road grades – a result of the gradients seen between mileposts 139 and 146.

a.) b.) c.)

Figure 4. a.) View from US40 on Rabbit Ears Pass looking across Lake Catamount and the Yampa Valley (MP143). b.) Typical forest, composed of Aspen and pine, on the west side of the forest (MP140). c.) View of wetlands typical of the flats on the Pass (MP147).

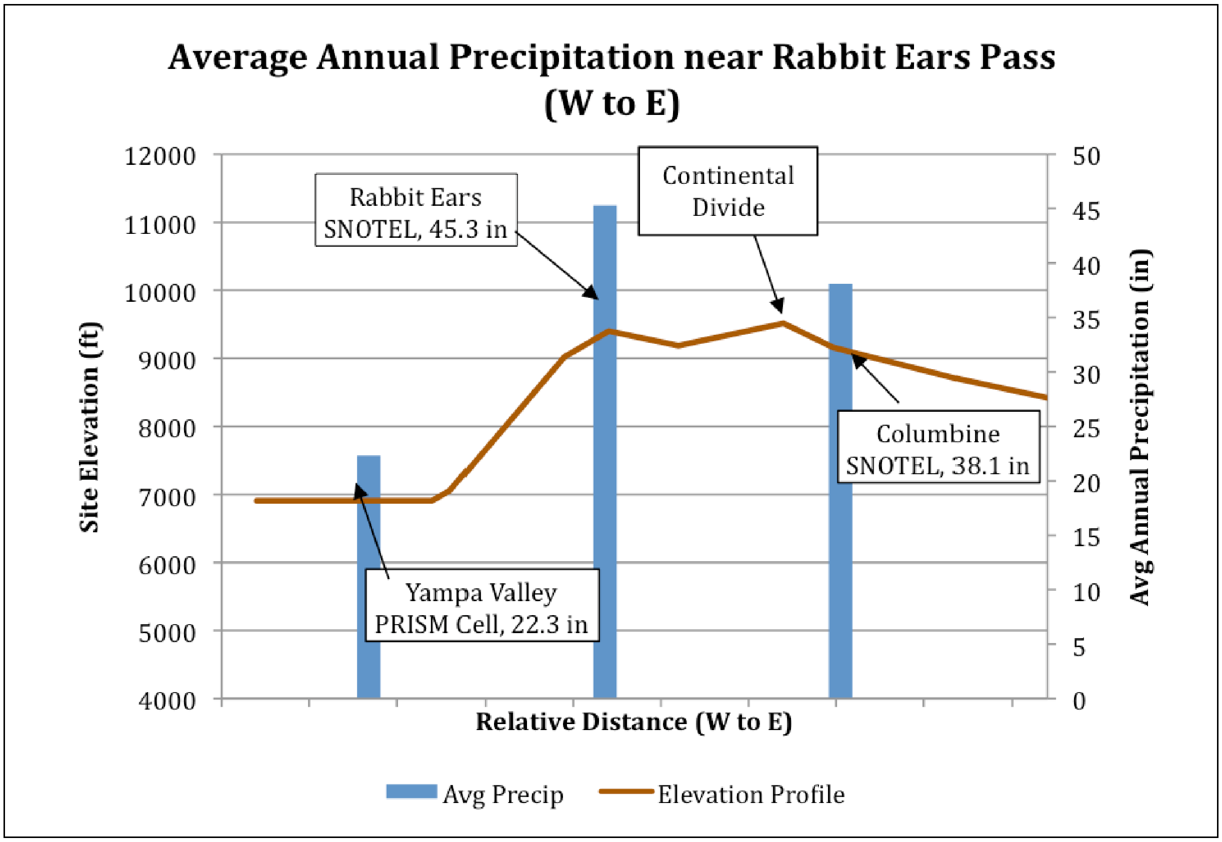



Figure 5. Graphical representation of the precipitation gradient over Rabbit Ears Pass, moving from Yampa Valley (west) to the intersection of US40 and Colorado State Highway 14 (east).

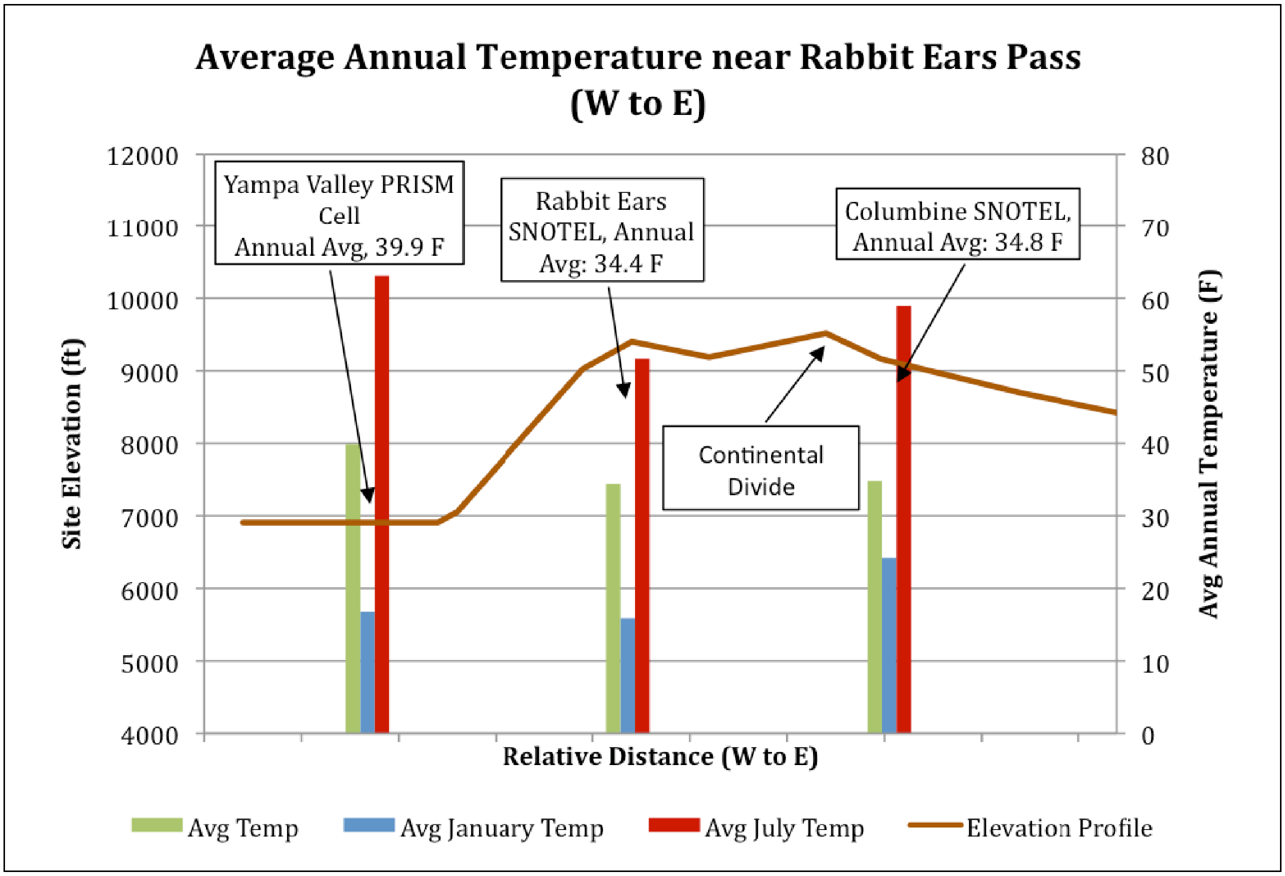



Figure 6. Graphical representation of the temperature gradient over Rabbit Ears Pass.

a.)

b.)

Figure 7. a.) Scoria, the darker material, seen in roadside deposit near milepost 140. b.) Example of traction sand building up, inhibiting vegetation growth on roadside near milepost 153. Note the partially buried culvert.

a.)

b.)

Figure 8. a.) Sediment traps placed above culvert (MP140). b.) Armored sediment traps placed below culvert outlet.

a.)

b.)

Figure 9. a., b.) Cut slopes, pervasive throughout the study area, supply a significant amount of sediment to the system (west of MP145 and east of MP140, respectively).

## 2.2 Maintenance Issues and Challenges

While the priority of the CDOT maintenance crew is to maintain a level of safety for wintertime travelers, they are also charged with managing the erosion and down slope movement of material. However, accomplishing this task is complicated by several physical and regulatory constraints present along the road corridor over US40, including:

- Managing/mitigating the erosion and subsequent transport of material located at deposition sites;
- Keeping existing culverts clear so they can continue to guide runoff as designed;
- Developing systems or best management practices that minimize the amount of seasonal maintenance required;
- Implementing BMPs in an extremely narrow road corridor;
- Controlling high amounts of precipitation;
- Establishing vegetation on unconsolidated slopes composed of traction material;
- Managing the large quantities of traction material used on the Pass

Historically, few sediment control measures have been implemented on Rabbit Ears Pass, which has led to the substantial buildup and subsequent transport of material both along and off site. As a result, much of the originally designed drainage features (culverts, ditches) have become plugged, blocked, or in many cases, completely buried in traction control material (Figure 10). Cleaning out the culverts and clearing the drainages is essential in controlling the flow of material through the study site.

**Maintenance Issues:**

- Lack of robust sediment control management program
- Limited space to implement control measures
- Climate, e.g., short growing season for revegetation, heavy snowfall
- Steep slopes with unconsolidated material and thin, nutrient-lacking soils, i.e., amendments/fertilizers necessary for establishing vegetation

Another major obstacle is the lack of manageable space in which to implement sediment control solutions along much of the Pass. CDOT is encouraged to maintain a clear zone or unobstructed, relatively flat area along the road available for safe use by wayward vehicles. The idea is to give out-of-control vehicles a chance to either recover control or stop in a safe manner. The clear zone is not a controlling criterion and is not considered an element requiring a formal design exception. It is designed to provide a range within which judgment should be exercised in making decisions (Department of Transportation (DOT)-Federal Highway Administration (FHWA), 2011). Objects or terrain features located inside of the clear zone are usually shielded, so any drainage and erosion control features implemented in areas lacking a clear zone will require a barrier. Figure 11 shows two locations where maintaining a clear zone and implementing structural sediment control solutions is difficult because of the lack of space. The clear zone for a 55 mile per hour (mph) speed limit is roughly 26 feet, measured from the edge of the white line (American Association of State Highway and Transportation Officials, 2011).

Additionally, stabilizing the cut slopes and unconsolidated deposits of traction sand adjacent to the road is a task significantly complicated by the climate and steep slopes on the Pass. Establishing vegetation on the slopes adjacent to the road is made difficult by a short growing season, unconsolidated material, and large yearly snowfall totals supplying an annual pulse of new traction material. The growing season is short and typical of high-mountain passes, generally extending from June through September. In addition, alpine soils, especially on steeper slopes, are often thin and contain few nutrients. These alpine and subalpine locations thus require soil amendments, fertilizers, and mulch in order to allow planted seeds a chance to grow (CDOT, 2002a). Referring to Figures 12 and 13, many areas of the Pass will require significant soil amendments in order to establish vegetation, while in other spots, grasses are re-establishing themselves on the slopes. Figure 12 provides examples of locations where soil amendments, in addition to an altered maintenance plan, will be required to stabilize the slope. The material is largely unconsolidated, and the slope in Figure 12b shows evidence of material being transported away from the road corridor. In Figure 13, native grasses are beginning to re-establish themselves on the slopes. Re-establishing vegetation on those slopes is key in limiting the offsite mobilization of deposited traction material.

Lastly, managing the large quantities of traction material on the Pass poses a challenge. In addition to implementing the BMPs discussed herein, options to assist with its management include exploring opportunities for reuse of the material and a possible location for alternate storage that has been discussed during project meetings. With this suite of management options, CDOT maintenance can begin to find effective solutions for decreasing the impact that increased sediment loads have historically created.

In the mountainous regions of Colorado, CDOT estimates it uses approximately 24,000 tons of traction sand annually. Maintenance estimates that they use approximately 6,500 tons of sediment per year on Rabbit Ears Pass. Because street sweepers can often reclaim a significant percentage of this material, up to 50%, there are options for reuse of this material such as for road base or as back fill for retaining walls (CDOT, 2010). Further, because costs are on the rise for traction resources and for their disposal, reuse of sand material can be a viable and cost-effective option for CDOT.

Recommended reuse options for traction sand include:

- Road base
- Bridge or retaining wall backfill
- Pipe bedding
- Aggregate for asphalt mix
- In concrete used for medians/raised islands
- Mixed with new traction sand
- Mixed with seed for vegetative cover in medians or as noise berms

Additional steps need to be conducted to determine the applicability of using traction sand from Rabbit Ears Pass for these other uses. This includes a cost/benefit analysis, whether a market exists for the resources, and aggregate specifications for the end product or use. Further, regulatory requirements for reuse of traction sand include approval from CDPHE and laboratory testing of the material for organic constituents to ensure safe levels that do not pose a health risk.

For the percentage of the traction material applied along the Pass that cannot be reclaimed and reused, the possibility of using the road cut along US40 from the old highway alignment for traction sand storage has been mentioned. However, most of this land is privately owned. Discussions should occur between all parties to determine the feasibility of using the area for this purpose. Further research is required to determine a suitable disposal location for traction sand that is recovered from the site and cannot be reused.

a.)

b.)

Figure 10. a., b.) Examples of partially buried and blocked culverts (MP140 and 145, respectively).

a.)

b.)

Figure 11. a., b.) Two locations where maintaining a 26 foot clear zone and implementing sediment control measures is not possible. Note that the channel in (a) is cutting through and re-transporting deposited traction material. (Both photos taken near MP 145)

a.)

b.)

Figure 12. a., b.) Both of these locations are examples of areas where re-establishing vegetation will require soil amendments and, where possible, maintenance should avoid burying the vegetation in snow and traction material. Note the depth to which the guardrail is buried in (a) and the erosion runnels forming in (b). (Both photos taken near MP146)

a.)

b.)

Figure 13. a., b.) In both of these locations grasses are re-establishing themselves and provide examples of the types of locations more likely to support vegetation. (Both photos taken near MP140)

## 2.3 Requirements and Additional Considerations for Plan Implementation

This section describes various aspects that CDOT should consider when implementing actions provided in this SCSS, such as permitting and process requirements associated with construction projects, or items to generally take note of such as the presence of fiber optic cable adjacent to much of the highway corridor.

**Considerations:**

- Monitor stormwater discharges during construction projects
- Comply with NEPA regulations
- Obtain appropriate permits, e.g., Section 404
- Understand presence of sensitive species and wetlands/fens
- Recognize recreational use, aesthetic values and archaeological importance of some areas
- Consider property ownership and Right of Way access
- Note the possible presence of underground utilities throughout the highway corridor

<u>Construction Permit Requirements</u>

To fulfill requirements under the Colorado Discharge Permit System (CDPS) Stormwater Construction Permit (SCP) from the Colorado Department of Public Health and Environment (CDPHE), CDOT must monitor stormwater discharges from construction projects. In addition to operating in accordance with the CDPS-SCP, a site specific Stormwater Management Plan (SWMP) must be prepared for any project involving an earth disturbance for an area greater than one acre. The intention of the SWMP is to prevent sediment from reaching receiving waters and is prepared during the design phase of the project.

Because nearly all of the requirements of the CDPS-SCP and SWMP focus on managing water quality during construction through installation of temporary BMPs, it may be necessary to clarify with CDPHE whether the more permanent, maintenance-based structures proposed herein necessitate different requirements.

<u>NEPA Process</u>

CDOT must also comply with the National Environmental Policy Act (NEPA) and environmental procedures established by the FHWA when considering construction projects. This process is in place to address the environmental impacts (wetlands, Threatened and Endangered Species, water quality, aesthetics, etc.) of a proposed federal action or any action that receives federal funds. Although not evaluated for this report, the level of NEPA requirements, if any, will need to be determined on a project specific basis through coordination with the USFS and FHWA once the details of each project are clearly identified.

<u>Wetlands and Wildlife</u>

A main concern that has been discussed throughout development of the SCSS is the presence of wetlands in the project area, especially the Fens. Fens are present approximately 0.4 miles west of milepost 152, Mapbook page 78. Other wetlands exist near the CDOT Maintenance Shed and there is a pond present in that location that is in need of dredging due to the presence of sand in the pond (Figure 14). Any construction project undertaken by CDOT that will have potential impacts to Wetlands and Waters of the United States should be addressed before construction commences. Appropriate permits such as those applicable to Section 404 Clean Water Act will need to be obtained prior to starting construction from the United States Army Corps of Engineers and Environmental Protection Agency, as necessary. This applies to both the pond, as well as the area to be reclaimed as wetlands north of the maintenance shed.

Section 404 also includes regulation of discharge of dredged (e.g. the Maintenance Shed pond), or fill material into waters of the United States.

The USFS and CDOT have discussed concerns with implementing various projects due to the presence of Boreal Toads in the study area. A large culvert has been placed to assist the Boreal Toads in navigating their breeding grounds approximately 0.25 miles west of milepost 156 (refer to Mapbook page103). Boreal Toads are listed as an endangered species by the States of Colorado and New Mexico. The presence of Lynx in the area have also been discussed, and a second culvert was installed 0.3 miles east of milepost 156 to be used as an underpass (refer to Mapbook page 106). Due to the presence of these species, consultation with the USFS, the US Fish & Wildlife Service, and the Colorado Division of Wildlife should continue throughout development and implementation of specific projects on Rabbit Ears Pass.

Recreational use, Archaeological sites and Aesthetic values

Rabbit Ears Pass is located in an area where aesthetic values are important. The highway corridor is an area that the USFS manages for Scenery, specifically as a 4.2 Scenery Management Area Prescription as designated in the 1997 Routt Land and Resource Management Plan (Forest Plan). A Forest Plan provides guidance for all resource management activities on a National Forest and is a requirement of the 1976 National Forest Management Act. The Guideline for Transportation discussed therein is to design proposed roads and trails to blend with the landscape. Due to this scenic quality designation, which also has NEPA implications, the USFS should be consulted regarding the scenery management aspects of potential erosion control projects.

The vicinity around Rabbit Ears Pass is also a popular recreational area and contains archaeological features. Fishing is popular on Muddy Creek and on portions of Walton Creek. Snowmobiles use Muddy Creek culvert as a throughway. It was mentioned at the May 15$^{th}$ scoping meeting that archaeologic lithic scatter exists near milepost 152, and possibly in other locations in the project area. CDOT should coordinate the permitting and evaluation process with the appropriate regulatory agencies pertaining to these aspects during development of the specific projects.

Property ownership and Right of Way access

An evaluation of property ownership data indicates that most of the land around Rabbit Ears Pass is National Forest System lands. Referring to Figure 15, private property abuts the highway approximately from milepost 142 through the western end of the project area. Additionally, some irrigation ditches in the area are operated and maintained by private owners with permits/leases with the USFS. In addition to gaining access from private landowners as necessary for roadside projects, CDOT will need to go through appropriate procedures to work on or utilize USFS land available to them for projects such as the erosion control measures recommended herein. The US Department of Transportation, Federal Highway Administration and USFS have agreed to a Memorandum of Understanding establishing the procedure by which USFS land may be appropriated for Interstate and highway use. CDOT should refer to the Memorandum of Understanding as a guide for working with the USFS on the proposed projects. As part of the Memorandum of Understanding, CDOT has a 300 foot easement within which to work as measured from the centerline.

Underground utilities

CDOT was able to provide as-builts for the 2003 re-route of US40 that extended east from milepost 155 (roughly) to the intersection of US40 and Colorado State Highway 14. The plans contain a note conveying that fiber optic cable, buried approximately 5 feet deep, runs roughly 6 feet off the north side of the highway for the entire project length. Plans detailing utilities along the remainder of the highway should be obtained and referenced prior to implementing any BMPs requiring excavation.

Table 1 below provides a quick reference summary of the regulatory items discussed above. The intent is for maintenance to reference this table prior to addressing the sedimentation issues discussed herein.

Figure 14. View looking north across the pond at the CDOT maintenance shed.

**Table 1. Summary of Regulatory Requirements and Considerations for Maintenance Operations on Rabbit Ears Pass**

| Project Considerations and Requirements | Description | Application Notes |
|---|---|---|
| ROW Easement | Most of the land adjacent to the road is managed by the USFS. An easement provides CDOT Maintenance 300 feet of space within which to conduct routine operations and maintenance. The easement distance is measured 150 feet each direction from the center line. | Verify that extent of disturbance is within easement limits. |
| Buried utilities | As-builts created for the 2003 re-route of US40 (between milepost 155 and Colorado State Highway 14 indicate the presence of fiber optic cable approximately 5 feet down and 6 feet off the north side of the highway. | Utilities should be field located prior to commencement of project. |
| Clear zone | The Clear Zone is a relatively flat area immediately adjacent to the road intended to provide space in which wayward vehicles can stop or regain control safely. Maintenance should avoid creating steep slopes or obstacles in this zone. For reference, in the 55 mph zones along the pass the clear zone is 26 feet, measured from the white line. | Maintenance should monitor the generation of erosion gullies in deposited sediments and be aware of slope limits when cleaning and maintaining roadside ditches. |
| Archaeological Sites | Various archaeological sites, including lithic scatters, are located along Rabbit Ears Pass. CDOT and maintenance teams should work with the USFS prior to implementing projects with ground disturbance aspects. | For ground disturbance projects located within the easement maintenance should coordinate with CDOT Environmental prior to starting work. |
| Wetlands/Wildlife | Wetlands located all along the top of the pass, including sensitive fens near milepost 152. Projects potentially impacting wetlands may require permits such as those applicable to Section 404 of the Clean Water Act. Sensitive Boreal Toad habitat is located near the installed culvert approximately 0.3 miles west of milepost 156 (see mapbook page 103). An underpass was also constructed for Lynx approximately 0.3 miles east of milepost 156 (see mapbook page 106). | Maintenance may need to coordinate with CDOT Environmental for projects that encroach upon or discharge to wetlands. |
| Construction Permits | In order to fulfill the requirements of Colorado Discharge Permit System, CDOT will need to monitor stormwater discharges from construction projects. A site specific Stormwater Management Plan (SWMP) must be prepared for any projects inovlving an earth disturbace greater than 1 acre. | Coordinate with CDOT Environmental prior to starting work for verification of SWMP requirements. |

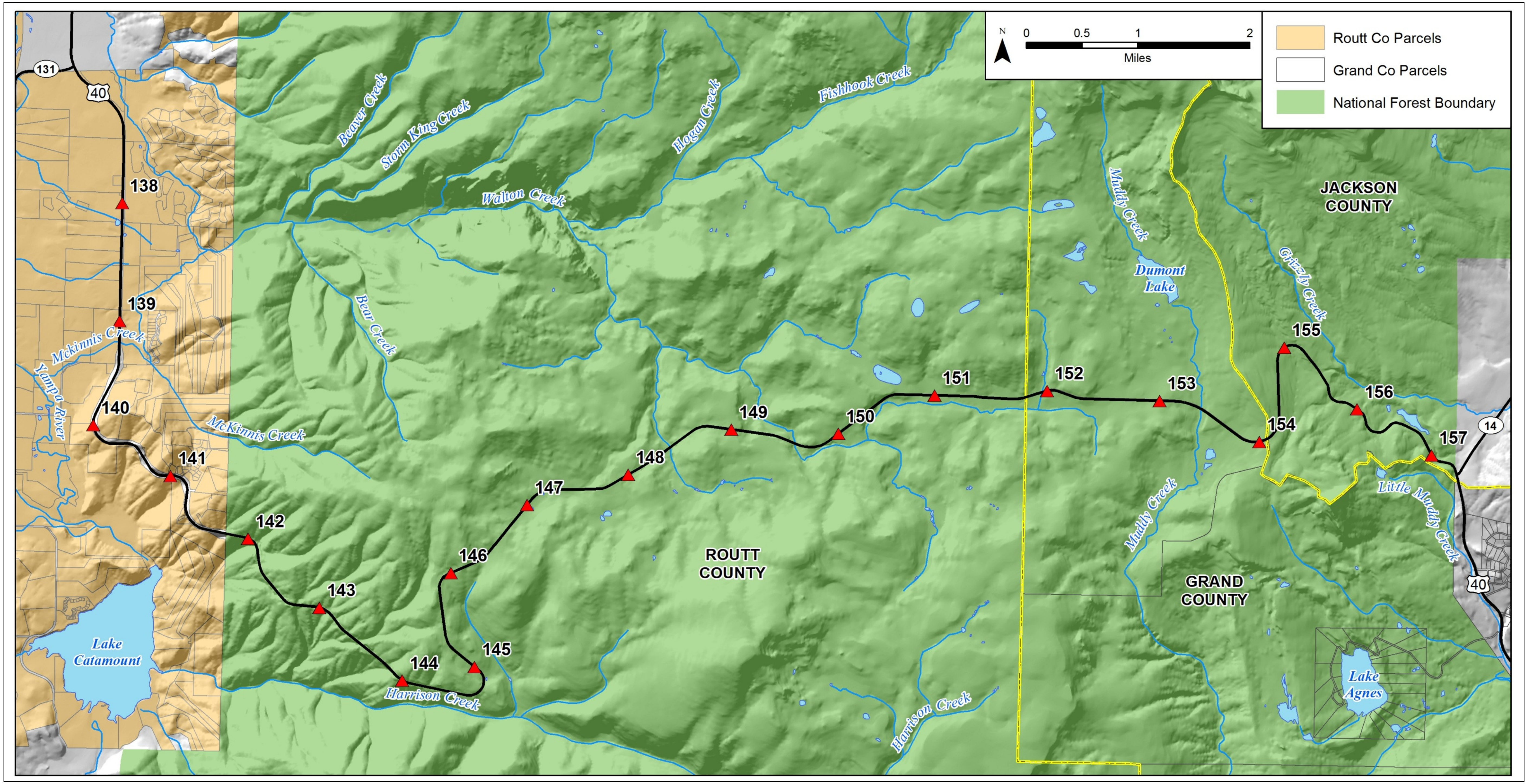



Figure 15. Private property parcels can be seen in orange in the figure above. Any roadside BMPs implemented in this zone will require permission from the owner. The green represents the national forest boundary and roadside projects in this zone will require permission from the USFS.

# 3.0 SEDIMENT CONTROL OPTIONS

The purpose of this section is to discuss the project methodology and resulting sediment control strategy, present potential non-structural and structural BMP control measures in a "Menu" format, and discuss cut slope treatment options. Once a particular maintenance strategy is decided upon, e.g., enhanced, comprehensive, or prioritized construction and maintenance plan, CDOT can refer back to this section for detailed information such as best uses for a particular BMP, site/maintenance considerations and general design criteria.

Due to the varying nature of US40 in terms of shoulder width and roadway grade, application of a single sediment control management strategy is not feasible. Therefore, a combination of measures may be necessary to best manage site-specific issues.

A goal in developing the suite of BMPs provided in the Menu of BMP control measures was to provide effective solutions to address sediment storage and transport issues in a manner that requires the least possible maintenance. Specific control measures are necessary in the cut slope locations to address sediment loading from existing slopes (rather than implications arising from the presence of winter traction material) and therefore choosing from the Menu of BMPs is not applicable. As such, recommendations for addressing the problems due to the steep cut slopes are discussed separately in Section 3.4.

Besides the previously mentioned sediment traps, no sediment control BMPs have been implemented on Rabbit Ears Pass. Those suggested in this study build off of CDOT experience gained from other high elevation sediment control plans (e.g., CDOT, 2002b; CDOT, 2002c) implemented in the state of Colorado. The general strategy, also adopted for this project, is to control and direct runoff toward traps, where the sediment can be settled out before the runoff leaves the site. An additional, critical component is the maintenance plan associated with each proposed BMP.

## 3.1 Sediment Control Assessment and Strategy

The sediment control strategy developed for this project is based on a combination of previous CDOT experience, a site tour with the Rabbit Ears maintenance team, and a field mapping effort focused on discerning the causes or sources of problem areas.

**Sediment Control Strategy:**

- Capture sediment before it leaves the site
- Implement an effective regular maintenance plan

A site tour, conducted on May 10th, 2012 helped to identify known problem areas and also to discuss practical solutions to those issues. These suggestions included the sediment traps installed in response to the previously discussed blowout event, which occurred just downhill of milepost 140.

**Field Mapping Effort:**

- Identification of:
  - Source zones
  - Flow pathways
  - Deposition areas
- Assessment of roadway hydrology and drainage design
  - Identify and map visible culverts

In order to determine the causes of the problems observed on the site visit, as well as to identify additional issues, AMEC conducted a field mapping effort. The following components were mapped with a GPS:

- Source zones: Those areas supplying sediment to the system which include cut slopes and locations where evidence exists of sediment entrainment (e.g., erosion runnels).

- Flow pathways: Flow pathways connect source zones and deposition areas and are the obvious channels and runnels forming along the road corridor.

- Deposition areas: Zones of accumulated sediments that have been entrained and subsequently deposited at various locations throughout the study area. These are associated with a decreasing energy gradient, i.e., places where blockages or a slackening of the slope result in material deposition.

In addition to mapping the flow pathways, an effort was made to assess the roadway hydrology and drainage design. Where visible, culverts were identified and mapped. However, many of the culverts were completely or mostly buried in traction material. An effort should be made to identify all buried culverts and clear them so the designed drainage can again function.

Again, the overall strategy is capturing the sediment before it leaves the site. Using various flow control tools, AMEC has developed a plan (in GIS form) that will reduce the amount of traction material leaving the road corridor. The developed plan heavily relies on establishing effective drainage and treatment through a series of ditches and sediment traps. Because of the rugged topography, this task is complicated by the need to maintain a 26' clear zone (for 55 mph zones) – a distance that is not available in many locations along the highway. Therefore, suggestions of BMPs that can be implemented within clear zones have also been provided.

A final component of the developed sediment control strategy involves the regular maintenance of any implemented structural and non-structural controls (discussed in Section 4). Ideally these efforts would take place during the snowmelt season, or shortly thereafter. As the highest energy events are likely to be summer thunderstorms, it will be important to identify any sedimentation (e.g., full traps) or structural (e.g., blown out sediment basin walls) issues before those systems are stressed to the point of failure.

The following sections discuss the BMP control measures suggested for this project. In addition to being grouped by non-structural and structural, the BMPs were also categorized according to the following types of measures:

- Preventive: measures that are designed to decrease the need for, or dependence on, many collection and/or treatment BMPs. This is accomplished by implementing BMPs designed to reduce the amount of material applied to the Pass, stabilize sediment sources, and separate clean water from contaminated runoff. Examples include training maintenance staff in improved sanding practices, revegetation projects, and bypassing clean water before it has the chance to pick up and transport traction material.

- Collection: measures implemented to capture contaminated runoff and route it towards acceptable drainage points for treatment. Examples include drainage ditches, culverts, and pan drains.

- Treatment: measures designed to reduce the amount of traction material and sediment leaving the project study area. The basic design for these features is to pond up the contaminated runoff and settle out the entrained sediment, before allowing the clean runoff to drain from the site. Examples of treatment features include sand cans and sediment basins.

A written summary for each BMP control measure follows, which as a whole act as a menu for CDOT to review and choose according to the desired outcome for a particular area. A matrix summarizing the type of control measure and whether they are structural or non-structural is presented in Table 2.

**Table 2. Summary of Non-Structural and Structural BMP Control Measures**

| | Structural | Non-structural |
|---|---|---|
| **Preventive** | Clear water diversion | Maintenance Staff Training<br>Appropriate Application Rate and Material<br>Improved Sanding Practices<br>Anti-icing/De-icing Improvements<br>Technology Updates<br>Street Sweeping<br>Cut Slope Grading<br>Revegetation |
| **Collection** | Ditches/Swales<br>Pan Drains<br>Kneewall & French/Underground Drain<br>Snow Storage/Graded Areas<br>Drainage Rundowns<br>Geo-textile Tubes<br>Vegetated Berms<br>Barriers | |
| **Treatment** | Sand Cans<br>Sediment Basins<br>Bench Traps<br>Loading Dock Traps | |

## 3.2 Menu of Non-Structural BMP Control Measures

A variety of non-structural BMPs can be implemented on Rabbit Ears Pass to act as preventive measures. The goal of these programs is to reduce the need for structural measures, e.g., through improved management practices, trainings and technology upgrades. Examples include training of maintenance personnel, implementing guidelines for sanding practices and revegetation.

**Non-Structural BMP Control Measures**

- PREVENTIVE
  - Maintenance Staff Training
  - Appropriate Application Rate and Material
  - Improved Sanding Practices
  - Anti-icing/De-icing Improvements
  - Technology Updates
  - Street Sweeping
  - Cut slope grading
  - Revegetation

Through discussions with maintenance staff it is clear that they have already put much thought into how to become more efficient and less impactful in their winter maintenance operations along Rabbit Ears Pass. For example, maintenance is testing for optimum mixtures of deicers and traction material. They have learned that vehicles will spread the sand along the highway so, for example, if they place material at the base of a slope, traffic will spread the material up the slope, lessening the need to place material all along the highway.

What follows are suggestions about additional practices or technologies maintenance can research and/or implement as time permits and funds become available.

## Maintenance Staff Training

The day-to-day operations and knowledge of the system lies within the maintenance staff. Therefore, it is critical that CDOT maintenance personnel are properly trained so they can implement new technologies, guidelines and operating procedures, in addition to performing the maintenance necessary to keep the BMP control measures functioning properly. This should occur from the top down, with managers providing direction to staff so the most effective practices are used.

A refresher course on winter maintenance and snow removal procedures should be given on an annual basis, preferably in the fall months before snow is expected. This will lay the foundation for proper protocol for new staff and act as a refresher course for long-term personnel. Additional training opportunities include computer- or simulator-based classes which use interactive software to help staff train in the decision making process (Staples, 2004).

In addition to training maintenance staff, it is recommended that environmental staff be incorporated into the construction and maintenance program. This will ensure that various plans are implemented and that environmental goals are met through enhanced communication, oversight, quality assurance, and technical assistance.

## Appropriate Application Rate and Material

With traveler safety the primary concern, a more precise application of traction materials applied to the Pass can both increase safety and reduce environmental impacts. The goal is to apply the right material, at the right place, at the right time, while maintaining the highest levels of safety. In order to accomplish this task, maintenance crews need access to accurate, real-time information, which is only possible with the most recent technology. The National Cooperative Highway Research Program has developed application rate guidelines to assist in determining the best treatments for specific environments. (For more information, see http://www.fhwa.dot.gov/research/partnership/nchrp/). Additional items include:

- Improved instrumentation to provide more precise, real-time information
    - A Road Weather Information System (RWIS), consisting of a dense network of instruments (e.g., meteorological sensors, road surface temperature instruments) would increase the knowledge of how road conditions directly relate to the observed conditions.
    - The Federal Highway Administration has also been developing a Maintenance Decision Support System (MDSS), with the goal of maximizing the efficiency with which winter operations are carried out.
- Spreaders could be calibrated at the start of each season to ensure drivers are applying the appropriate amount of material.
- Updating trucks to include hoppers and spreaders that allow drivers to switch between different materials and application rates.

- Employing the most up-to-date sanding practices
  - Use a clean sand source
  - Pre-wetted sands have to potential to cut traction material use by as much as 50% (Staples, et al. 2004). Researchers in Norway found that dry sand may be removed from the road by the passage of as few as 50 vehicles, but sand pre-wetted with hot water lasted for more than 2000 vehicles. CDOT will want to test the performance of pre-wetted sands for Colorado roads and climate. Also, new spreaders needed to be developed for the use of the sands, which may not be available in the United States. (See Staples et al., 2004 for additional information.)
  - Anti-icing is a proactive practice that involves laying down chemicals prior to snowpack formation. When applied correctly, it greatly facilitates snow removal and reduces the need for traction material. For more information, see the Federal Highway Administration's *Manual of Practice for an Effective Anti-icing Program* (http://www.fhwa.dot.gov/reports/mopeap/eapcov.htm)

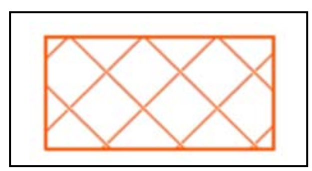
## Street Sweeping and Vacuuming

Street sweeping is already performed on Rabbit Ears Pass on an annual basis. This practice should continue, and be performed shortly after the snowmelt season (late spring most years) in order to capture the most material possible.

Subterranean sand cans, a form of inlet sediment trap, have been recommended in several locations along the pass. In order for these to be effective, maintenance will need to acquire a vacuum truck so they can be regularly cleaned.

## Slope Revegetation

Map symbol



In some locations, migration of sediment on Rabbit Ears Pass can be controlled by employing revegetation practices. In addition to providing erosion control, revegetation also provides habitat improvements and aesthetic enhancements (CDOT, 2002). The USFS was consulted to develop seed mixes or recommendations appropriate for each area identified for revegetation, with an emphasis on finding native genetic species. Most of the sites, with the exception of the wetland area at the CDOT Maintenance Shed, may be reseeded with CDOT's Native seed mix, at a rate of 20-25 lbs/acre. Table 3 provides this seed mix information, which is a diverse upland mix of varying heights consisting of sod-formers and bunchgrasses, and a mixture of perennial forbs. Success has been seen with this mix on Tennessee Pass near Leadville at the same elevation.

**Advantages**

- Erosion control and prevention
- Habitat improvements
- Aesthetic enhancements
- Stabilizes soil

**Limitations**

- Establishing vegetation may be difficult
  - Short growing season
  - High altitude
  - Thin, nutrient-lacking soils

**Table 3. Native Seed Mix**

| Common Name | Scientific Name | Rate (lbs/acre) |
|---|---|---|
| 'Garnet' Mountain Brome | Bromus marginatus | 3 |
| 'Joseph' Idaho Fescue | Festuca idahoensis | 2 |
| 'VNS' Needle and Thread | Hesperostipa comata | 3 |
| 'VNS' Prairie Junegrass | Koeleria macrantha | 1 |
| 'Arriba' Western Wheatgrass | Pascopyrum smithii | 4 |
| 'High Plains' Sandberg Bluegrass | Poa secunda ssp. sandbergii | 2 |
| 'VNS' Bluebunch Wheatgrass | Pseudoroegneria spicata ssp. spicata | 4 |
| 'VNS' Showy Goldeneye | Heliomeris multiflora | 1 |
| 'VNS' Scarlet Gilia | Ipomopsis aggregata | 1 |
| 'VNS' Lewis Flax | Linum lewisii | 1 |
| Wheat x Wheatgrass Sterile Hybrid | Triticum aestivum x Elytrigia elongata | 3 |
| | **TOTAL** | **25** |

Notes:
VNS=Variety Not Stated
Rates are for drill seeding per CDOT Standard Specification (212). Double the rate for hydroseeding and apply per 212.
Always include a soil conditioner per CDOT Standard Specification (212) for the same area to be seeded.
Spray-on Mulch Blanket (213) may be used on steep, rocky slopes in lieu of erosion control blankets (216).

Although CDOT Maintenance has indicated Rabbit Ears Pass is rarely mowed, State specifications indicate roadside mowing operations should be performed resulting in a height of six to eight inches. Because this mix contains a range of growing heights, consideration should be made whether this will present maintenance concerns.


Source: CDOT, 2002a

Because some of the area next to the CDOT Maintenance Shed would have been a wetland community prior to disturbance, this area would be more appropriately replanted with willows and other wetland graminoids. For this approximately one-half acre wetland area, the wetlands seed mix in Table 4 should be used, intermingled with willow cuttings (the mix provided in Table 4 should be used for the other area).The USFS indicates that willow cuttings have already been taken for this area and are ready to be planted once a viable plan is created amongst all interested parties. However, the particular willow species is unknown at this time.

**Table 4. Wetlands Seed Mix**

| Common Name | Scientific Name | Rate (lbs/acre) |
|---|---|---|
| 'Sourdough' Bluejoint reedgrass | Calamagrostis canadensis | 2 |
| 'Nortran' Tufted Hairgrass | Deschampsia caespitosa | 1 |
| VNS, American mannagrass | Glyceria grandis | 1 |
| VNS, Nebraska sedge | Carex nebrascensis | 2.5 |
| VNS, Beaked sedge | Carex rostrata (utriculata) | 2.5 |
| | **TOTAL** | **9** |

Because of the short growing season, high altitude, and unconsolidated nature of the traction material deposits, establishing vegetation on the steeper road shoulder sections may prove especially challenging. Further study is required to determine how revegetated areas will respond to these variables, along with the seasonal inundation of material from plow throw. Revegetation efforts can and should begin on flatter areas, but it is recommended to test the vegetation on steeper slopes before significant funds are committed to treating these areas. Working with the USFS, CDOT can develop a pilot/feasibility study to optimize treatments in the more difficult areas.

**Recommendations**

- Develop revegetation plans for various areas along the Pass with consultation from the USFS
- Begin small-scale revegetation efforts on flatter areas
- Implement pilot study on steeper slopes to determine response of vegetation to:
  - Revegetation limitations, e.g., short growing season, etc.
  - Seasonal inundation from traction material thrown by snow plows

## 3.3 Menu of Structural BMP Control Measures

A structural control measure is one that requires construction of a specific measure or structure such as a sediment basin or an earthen berm. A variety of structural control measures can be utilized on Rabbit Ears Pass including ditches, sediment traps, berms and check dams to perform preventive, collection and treatment goals. These and other options are described below. This list was developed in consultation with CDOT, literature review, and professional judgment.

For each structural BMP control measure that follows, typical information includes:

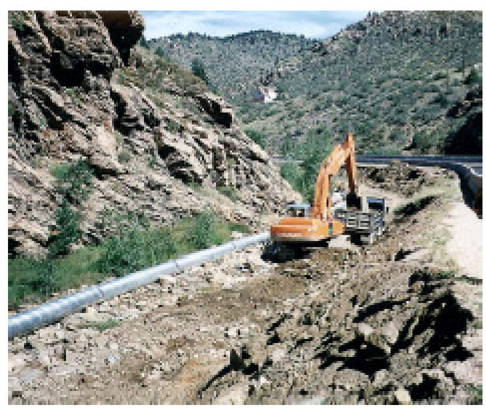
- Description: A description is given for each feature, including the type of BMP
- Site Considerations: Site-specific factors are identified that dictate use of the control measure.
- Application Guidelines: Appropriate applications of the measure are discussed.
- Maintenance Considerations: Maintenance considerations are presented.
- General Design Criteria: Standards plans from CDOT and other sources are included

**Selecting Structural BMPs**
- Establish goals for treatment, including maintenance plan, on a case-by-case basis
- Assess site conditions, e.g., physical characteristics, size constraints, environmental factors
- Decide which BMPs are unreasonable
- Establish staff availability, funding, timeframe for completion
- Adapt BMP, or suite of BMPs, to site-specific conditions

### Clear Water Diversion

**Purpose: Preventive System**
- Separates clean tributary flows from highway runoff via upstream diversions into culverts

**Description**
A clear water diversion is used to protect water quality, specifically during construction projects, by conveying clean surface water runoff around the site and discharging it downstream. For application on Rabbit Ears Pass, clear water diversions can be used in a more permanent fashion to protect source water from coming in contact with sediment-laden water by diverting upstream tributary water into culverts that pass under the highway, discharging to uncontaminated areas.


Source: CDOT, 2002a

**Application Guidelines**
Clear water diversions need to be extended far enough upstream to capture clean source water, and additionally need to consider the potential impacts to

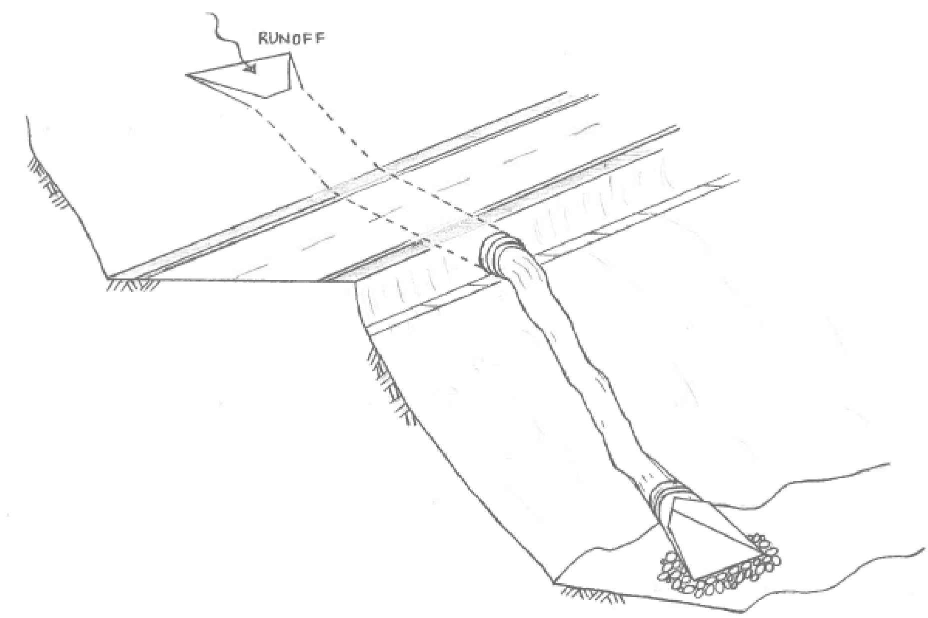
existing stream channels. These features have the benefit of limiting the amount of water passing through, and thus stressing, install structural BMPs.

**Maintenance Considerations**
Clear water diversions will need to be inspected at least on an annual basis, but more appropriately after large storm events. Inspections include checking for blockages, damages, and scour around both the inlet and outlet.

A sketch of a clear water diversions system is shown below.

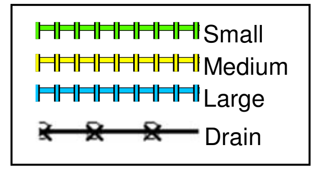
**Benefits**
- Keeps highway runoff separate from clean upstream flows
- Volume of water needing treatment is reduced

**Limitations**
- Special permits or mitigation measures may be required
- Disturbance of natural waterway during construction is likely



## Ditches/Swales

Map symbol




**Purpose: Collection System**

- Capture, control and direct runoff and traction material to specific drainage points
- Facilitate road corridor draining

**Description**

Ditches/swales can generally be used to capture, control, and direct runoff and traction material to acceptable drainage points. Additionally, establishing drainage channels in many locations along the Pass will help drain the road corridor, helping to reduce various problems, such as sheet flow on the road surface. Even though ditches are not seen as effective sediment trapping measures, the application of them along Rabbit Ears Pass due to minimal widths between the shoulder and the existing terrain may prove useful. These features are designed to conform to established drainage patterns, following the standards contained in the CDOT *Drainage Design Manual*. They are generally constructed with compacted soil and allow for a minimum freeboard of 6 inches (CDOT, 2004).

Source: TRPA, 2012

**Site Considerations**

Applying ditches/swales for controlling runoff are useful in the following types of locations:

- Naturally low topographic areas of uniform grade that are prone to erosion and where vegetation is difficult to establish.

- Areas where concentrated flows need to be collected and re-directed, e.g., at the bottom and mid-slope locations, below steep grades.

Check dams are usually installed in drainage ditches located in steep areas, containing a high sediment load. However, check dams area not recommended for the drainage ditches in this project for several reasons. In general, the road is not steep enough, nor is the sediment load high enough to warrant their inclusion. Additionally there simply is not enough shoulder space to accommodate the extra width required to install check dams. That being said, the installation of periodic armoring, made of six inch rip-rap, is recommended. Riprap, placed periodically along the bottom of the ditch and at any sharp bends, will help regulate the buildup of runoff energy. The 6 inch riprap will accumulate some sediment, but will be flushed during larger events, thus avoiding regular maintenance.

**Advantages**

- Reduces sheet flow on road surface
- Typically less expensive than curb and gutter
- Low maintenance

**Limitations**

- May require more land than curb and gutter

**Application Guidelines**

Armored drainage ditches are recommended for many locations along the highway in the study area. . Ditch capacities and sizes were estimated for two purposes: 1.) They are priced by volume of material removed, and 2.) To provide designers with a starting point from which to calculate more precise capacities. Sizes were estimated using contributing areas, slope, and ditch length, and have subsequently been symbolized on the map. The point is to ensure enough capacity is placed where required, not to prescribe a rigid treatment in a particular location. Maintenance should aim to hit the recommendations provided in the Mapbook, but not at the expense of letting an area go untreated. For a more thorough explanation of the estimation methods, interested readers are directed to the cost information in Appendix A.

In certain areas of the Pass, natural drainage channels have formed in several locations. These can serve as effective conveyance features in areas where a lack of shoulder space inhibits the construction of new features, and are referred to as drains in the Mapbook. However, these existing features will need to have their integrity regularly inspected for blockages and migrations into the road surface. Maintenance can improve the function of these features by creating small check dam-type features in the channels. This can be accomplished with the use of rip rap or erosion logs.

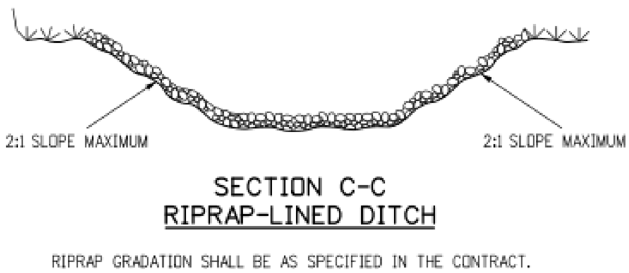
**Maintenance Considerations**

In addition to the regular inspection of pre-existing channels, maintenance of the ditches will involve annual inspection, checking for accumulations of sand and unwanted points of lateral movement, or bank erosion. Blockages that may form as a result of deposited material will need to be removed. The photo to the right shows a roadside ditch being cleaned by an excavator. Eroded areas will need to be armored in order to prevent further issues. Frequent issues are not anticipated with the drainage ditches. Maintenance should be able to fix problems as they are identified in the yearly inspection.

Source: CDOT

**General Design Criteria**

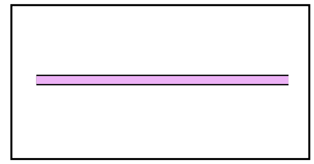
A cross section of a riprap lined ditch from the CDOT Standard Plans is shown below.




Source: CDOT Standard Plan No. M-203-2

## Pan Drains

Map symbol



### Description

Pan drains provide an effective method for directing runoff and reducing erosion to the edge of the road. By paving the edges of the road, they also help facilitate street sweeping efforts. Controlling runoff, both due to general highway runoff and melting of shoulder snow, subsequently protects the edge of the roadway. Pan drains can route runoff, both general highway runoff and snowmelt, to sediment collection structures for treatment, before runoff is directed offsite (Tahoe Regional Planning Agency (TRPA), 2012).

**Purpose: Collection System**

- Convey shoulder snowmelt and highway runoff to sediment collection structures for treatment.

### Application

As the majority of the Pass contains little should space, pan drains are recommended for much of the study area. They will require a designed capacity relative to the area they are to be installed and interface with other BMPs (e.g., frequency of drains, interface with underground traps, etc.). Pan drains require guard rail, which needs to be designed together. Conceptual representations have been made in the Mapbook that lay out where the pan drains could assist with sediment control along the Pass.

**Benefits**

- Paved shoulder can be used for snow/sand storage
- Facilitates roadway sweeping efforts
- May be less expensive to install and easier to maintain than other conveyance systems

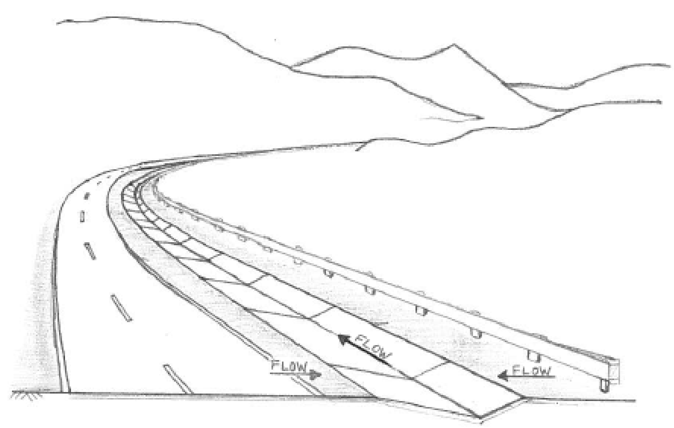
**Limitations**

- Adequate shoulder width necessary
- Volume of runoff is concentrated
- Stormwater does not infiltrate

### Maintenance Considerations

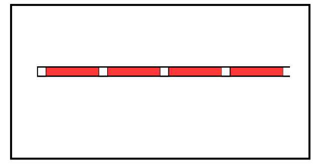
Maintenance of any installed curb is expected to be minimal. The largest consideration is armoring the existing erosion runnels to prevent further erosion and cutting into the road grade. Additionally, drivers will need to try and not push snow off the edge, when possible. Obviously, space will need to be cleared during intense storms.

A conceptual schematic showing a pan drain as part of the highway shoulder is provided below.



## Kneewall & French/Underground Drain

Map symbol



**Purpose: Collection System**

- Aids in the protection of source water by draining water underneath areas of sediment accumulation due to:
  - Traction sand thrown by snow plows
  - Cut slope erosion

**Description**

The kneewall and French drain is a collection system BMP that has been applied with success to the base of cut slopes along I-70 in Colorado. The kneewall can be constructed with jersey barrier. An underground drain is then installed between the kneewall and the base of the cut slope. This will help facilitate drainage on the cut slope, in addition to snowmelt drainage from snow thrown over the wall. The drain outlet can then be pointed to a treatment BMP (e.g., sediment basin) to clean the runoff before it leaves the site.

**Advantages**

- Controls sediment from two sources:
  - traction sand thrown by plows
  - cut slope erosion
- May help stabilize cut slopes.

**Limitations**

- Adequate shoulder width needed
- Removal of deposited sediment necessary
- Provides only limited storage space between the wall and the cut slope

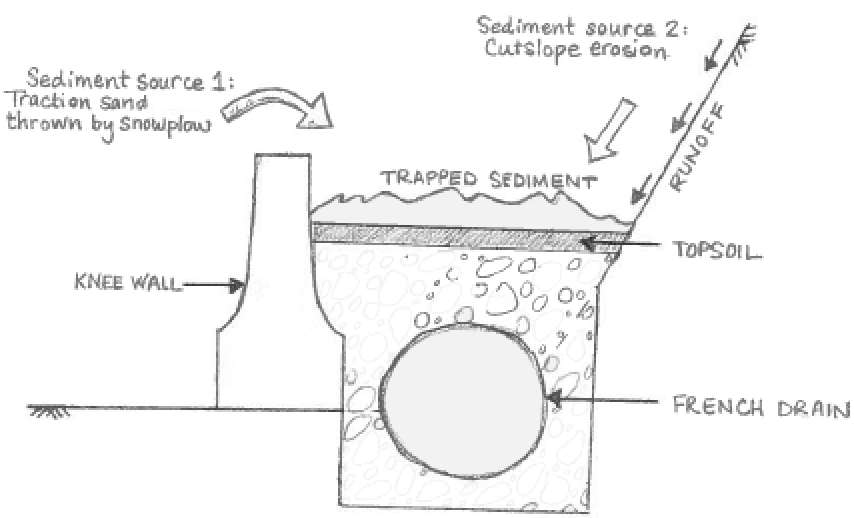
**Site Considerations**

These BMPs have been developed for application to the base of cut slopes along mountain passes.

**Maintenance Considerations**

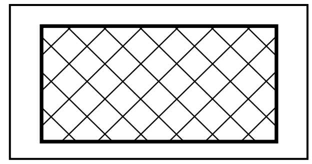
In order to maintain these features, maintenance will need to clean out deposited sediment trapped between the wall and the cut slope.

A schematic showing the kneewall and drain concept is provided below.



## Snow Storage

Map symbol



**Purpose: Collection System**

- Defined roadside areas used to contain snow contaminated with traction material
- May be dedicated roadside areas or paved, parallel storage units

### Description

Snow storage areas are relatively flat zones designed to store plowed snow and contain BMPs to treat the contaminated runoff generated from the melting snow. These areas can be constructed into the roadway, incorporating designs for capturing traction material, or they can be graded earthen areas that drain to a treatment BMP (e.g., sediment basins). Earthen areas have the advantages of being cheaper in the short term, in addition to being relatively flexible to future developments or improvements in winter operations. The construction options, such as those built on Berthoud Pass, will require less maintenance, but also lose the flexibility of the earthen options.

### Application Guidelines

Snow storage areas need to be isolated from drinking water supplies (USEPA 1988), at least 75 feet from private wells and 200 feet from community wells (TIRRS 2001). The treatment BMP should be designed to store the maximum probable meltwater volume, and both BMPs (the storage area and treatment BMP) should be easily accessed by maintenance.

### Maintenance Considerations

Maintenance for the snow storage areas is dependent upon the type of BMP installed. Both types will require annual removal of sediment, but earthen areas may require re-grading, should any erosion runnels form.

**Benefits**

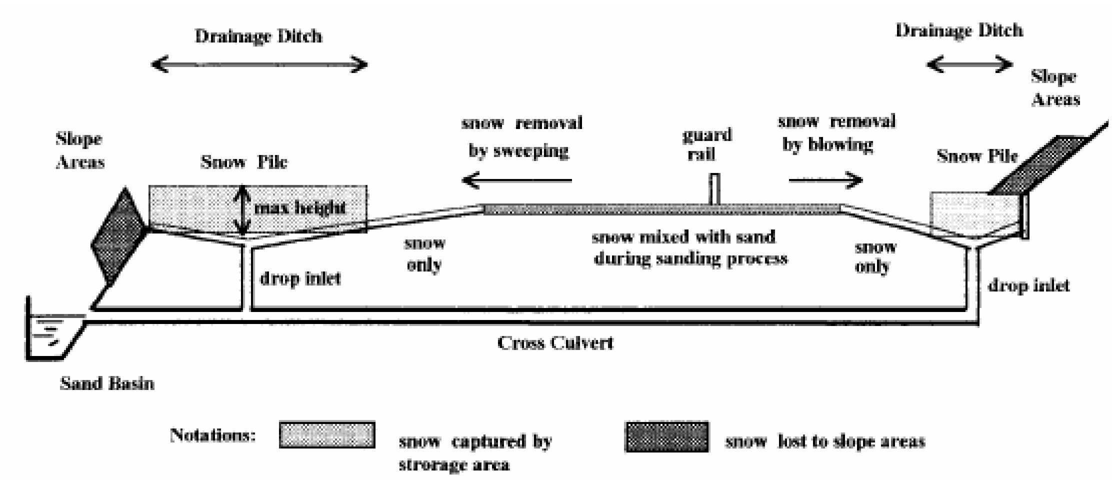
- Provide ample snow storage space, allowing maintenance to push snow to a location that can be treated for sand removal
- Can be created to fit in many roadside configurations

**Limitations**

- If not graded properly can create drainage problems
- May cause excessive routine maintenance if seasonal erosion runnels form.
- Need to be isolated from drinking water supplies
- Easy access point needed for maintenance

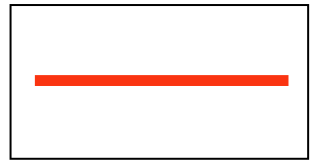
Source: Shanks, 2006

A conceptual design of snow storage areas constructed alongside the road and BMPs to capture sand is shown below (Staples, 2004). These are expensive construction projects, but the maintenance required is limited to seasonal cleanup.



## Outlet Rundowns

Map symbol



### Description

Outlet rundowns are used to prevent erosion potentially caused from runoff discharged onto a steep slope. They provide armor and protection against the head cutting caused by concentrated flows. Rundowns are generally constructed using concrete or grouted riprap that dissipates erosive energy by reducing flow velocity.

**Purpose: Collection System**

- Outlet rundowns are used to convey runoff down embankments, preventing erosion and head cutting from concentrated flows.

### Application Guidelines

Outlet rundowns are needed in several locations along the Pass, where deep erosion channels have formed along the elevated road grade. They will also be required to armor the outlets and spillways of any installed sediment traps and basins, clean water diversions, and culverts. Rundowns spilling into sediment basins will require scour protection. Those spilling into ditches will need armor placed on both banks.

### Maintenance Considerations

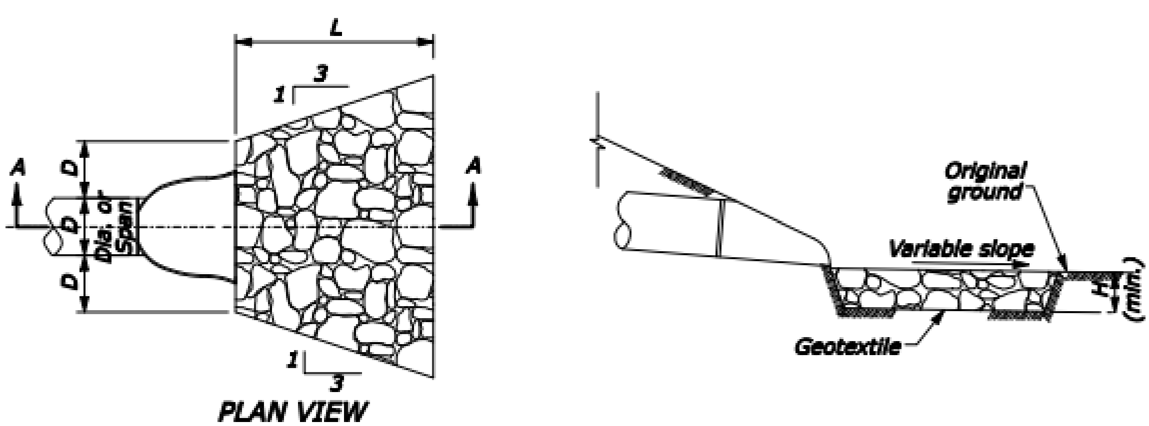
Rundowns are generally difficult to install on steep slopes so care will be required to ensure they are properly constructed. Slopes steeper than 2:1 or 3:1 may require a concrete or asphalt lining. Maintenance staff will need to inspect the features for integrity and function on an annual basis. Excess debris and sediment should be cleaned, as well as any damage to grout repaired (Urban Drainage and Flood Control District (UDFCD), 2008).

**Benefits**

- Prevent the development of erosion runnels on steep slopes
- Provide outlet protection for culverts, sediment traps, and basins

**Limitations**

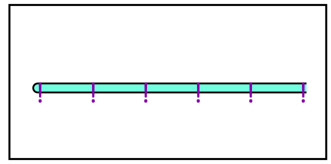
- Difficult to establish on steep slopes.




Example plans for placed riprap at culvert outlets (FHWA, Detail C251-50)

## Geo-textile Tubes

Map symbol



### Description

Geo-textile tubes are linear containers made of densely woven fabrics that can be quickly pumped full with sand slurry (e.g., water-saturated traction sand). The water then drains out, leaving a hard oval-shaped barrier. While they tend to last many years, geo-textile tubes are temporary flow direction structures, similar to berms. The main differences between berms and geo-textile tubes are their relative impermanence, and the ability to dispose or move them through the employment of heavy machinery.

**Purpose: Collection System**
- Geo-textile tubes collect and route material towards acceptable drainage points.

### Application Guidelines

For this project, geo-textile tubes can be used to provide a barrier around several of the sediment traps, especially in those locations where traps are recommended to capture sand at the down slope end of pullouts. This could provide an additional opportunity to reuse traction sand that has been cleaned out of accumulation areas.

Source: www.tensarcorp.com

### Maintenance Considerations

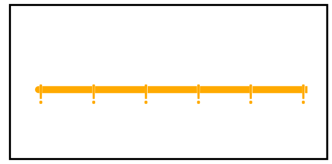
Maintenance of the geo-textile tubes is fairly limited, requiring only periodic inspection and cleanings. The tubes should be annually examined for holes. The altered drainage should be inspected to be sure additional erosion outlets have not been created and that the tubes continue to direct flow to the desired discharge point. Accumulated sediments should also be scraped out as needed.

**Advantages**
- Makes use of existing traction sand material
- Inherently flexible to drainage or sediment control design changes.
- Limited maintenance consisting of periodic inspection and cleanings

**Limitations**
- Limited lifespan as they are susceptible to UV damage
- May not be the most aesthetically pleasing solution

## Vegetated Berms

Map symbol



### Description

Vegetated Berms are constructed ridges of soil used to intercept and divert runoff toward a slope drain or sediment trap. They are generally designed to a minimum height of 18 inches with slopes 2:1 or flatter and at least 4.5 feet wide at the base. They are composed of compacted soil or coarse aggregate and stabilized with riprap for erosion protection (CDOT, 2002a).

**Purpose: Collection System**

- Divert and intercept runoff to slope drains or sediment traps/basins
- Provides a natural looking barrier for snow storage areas

### Site Considerations

Local topography, soil type, length of slope, and land use should be considered when determining appropriate locations to use berms.

### Application Guidelines

For this project, berms are generally applied as boundary features, limiting the spatial extent to which snow can be pushed or stored at particular locations, thus confining the traction material into particular areas. The area confined by the berm will need to be scraped (in many cases) and re-graded in a manner that promotes drainage to a particular point, marked by a sediment trap.

### Maintenance Considerations

Maintenance considerations for the proposed berms include regular inspection, cleaning, and repairing. Constructed berms should be inspected yearly to check for breakdowns caused by erosion. These areas will need to be stabilized to prevent further issues. Accumulated traction sand not entrained by the proposed grading will need to be periodically cleaned, though it is expected that these features can be cleaned at a less frequent time step when compared with the sediment traps. As the stored snow piles up in these locations, the berms will eventually become buried, so they will require some sort of visual marker to be placed on them, such as posts or trees.

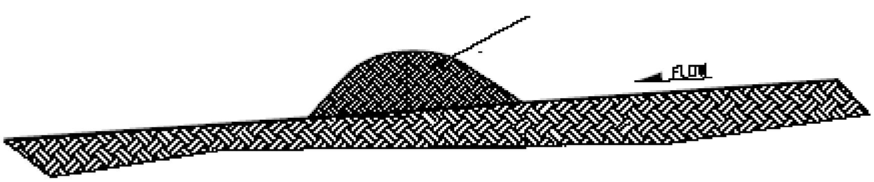
**Advantages**

- Blend into the landscape once vegetation has been established.

**Limitations**

- Contributing drainage area considerations
- Slopes should be less than 10%

A cross section of a temporary berm from the CDOT Standard Plans is shown below.

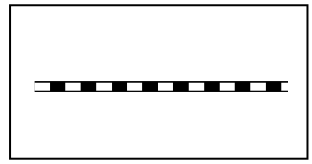



TEMPORARY BERM

Source: CDOT Standard Plan No. M-208-1

## Type 7 (Jersey) Barriers

Map symbol



**Purpose: Collection System**
- Ubiquitous concrete barriers that can be used to route runoff or provide a barrier between the road and constructed BMPs.

**Description**
Type 7 (Jersey) barriers are short, steel-reinforced, modular concrete walls designed for use as traffic barriers. They are one option to establish a barrier between the road and constructed BMPs, where maintaining an adequate clear zone is not possible.

**Application Guidelines**
For this project, Jersey barriers will be required in many locations, a result of the steep mountainous topography and numerous cut slopes. They will also serve the additional function of a flow control and direction BMP.

**Advantages**
- Commonly used for roadside projects.

**Limitations**
- May not be aesthetically pleasing.

**Maintenance Considerations**
Maintenance for the jersey barriers is expected to be minimal. They may need to be repositioned if their ability to direct flow (or traffic) is damaged by snow plows and/or traffic accidents.

Jersey barrier in use on the west side of Rabbit Ears Pass.

## Sand Cans

Map symbol

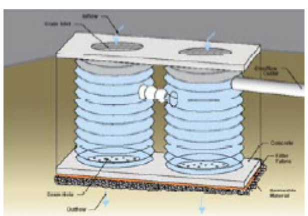
### Description

Sand cans are treatment BMPs designed to settle out sediment from incoming runoff. They are constructed with corrugated metal pipe that is inverted and modified for trapping sediment. Runoff enters the top of the can, sediments settle out, and runoff is released through an outlet located approximately one foot below the top (Staples et al., 2004). They have the advantages of being relatively cheap and easy to install, and can be used in narrow areas. While they are highly effective in trapping sediment, they require regular maintenance to ensure their function, as higher flows can entrain accumulated sediment (Caltrans, 2005).

**Purpose: Treatment System**
- Underground BMPs designed to settle out traction sand from snowmelt and runoff

### Application Guidelines

Due to the lack of shoulder space throughout much of the Pass, sand cans have been recommended in several locations along Rabbit Ears Pass. In many locations, sand cans have been recommended near culverts, and will subsequently need to be designed to interface with the existing drainage. Multiple cans can be linked together in order to increase storage (Caltrans, 2005). The photograph below and schematic above show conceptual options for the construction of the cans. Cans installed without bottoms will saturate the slope, potentially creating an instability. CDOT will want to design cans that work for the unique environments found on Rabbit Ears Pass and throughout the state of Colorado.



**Advantages**
- Constructed with cheap materials
- Relatively easy to install
- Effective at capturing sediment
- Installed underground, so there are no impacts to the viewshed and can be installed in narrow locations
- Can be cleaned with a vacuum truck

**Limitations**
- Relatively little storage space
- Require regular, diligent maintenance
- Need to excavate to install
- Requires a vacuum truck in order minimize required maintenance effort

### Maintenance Considerations

Maintenance for the cans is expected to be limited to annual cleaning. If sand cans are ultimately chosen for Rabbit Ears, maintenance has recently acquired a vacuum truck that can be used to clean out the cans.

Source: TRPA, 2012

## Sediment Basins

Map symbol

A Small
A Medium
A Large

### Description

Sediment basins are ponding areas used to settle out the suspended load, preventing downstream or offsite transport. They are created by excavating below the grade and armoring the inlet, outlet, and base. Sediment basins are usually located at points of discharge, as determined by pre-existing natural drainage patterns. General design guidelines are outlined in the CDOT *Erosion Control Guide* (CDOT, 2002a) and include metrics such as a 2:1 length to width ratio, reserving half of the total capacity as wet volume, and building to capacity to include 3,600 cubic feet ($ft^3$) per acre of contributing area.

**Purpose: Treatment System**

- Ponding areas to settle out suspended sediment before allowing runoff to leave the site

### Application

For this project, the recommended sediment traps should largely mimic those already in use between mileposts 139 and 140. Where possible, they should be placed before drainage outlets, such as culverts, in order to keep those features clear. Where the maps indicate the placement of a trap that does not drain into a culvert, the outlet will need to be armored with riprap in order to diffuse the spill energy. Basin sizes were estimated for the recommended sediment basins to both guide maintenance and generate cost estimates. This was accomplished using drainage area and presence of accumulated material along the drain line. As with the drainage ditches, the sediment traps were classified in three classes - small, medium and large. This was done to serve as a guide for maintenance, but in practice, larger traps require less frequent cleaning. Maintenance should fit what they can where they can. A more thorough explanation of the methods used to determine sizes is presented in Appendix A.

**Advantages**

- Very effective at removing traction sand from runoff
- Can be sized to fit in many locations
- Demonstrated effectiveness in mountain environments

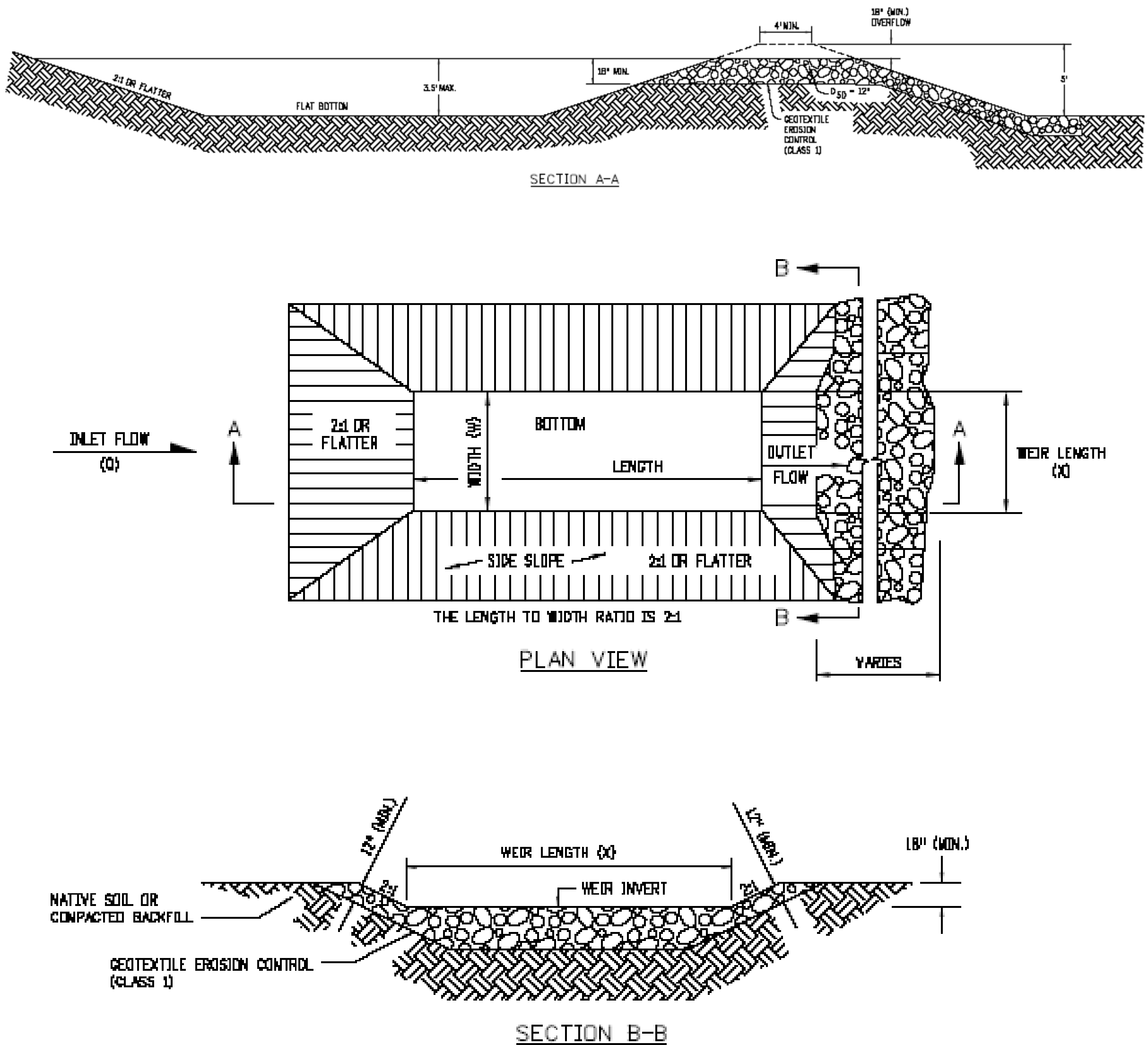
**Limitations**

- May be limited by available shoulder space
- May require frequent maintenance if subjected to high energy events

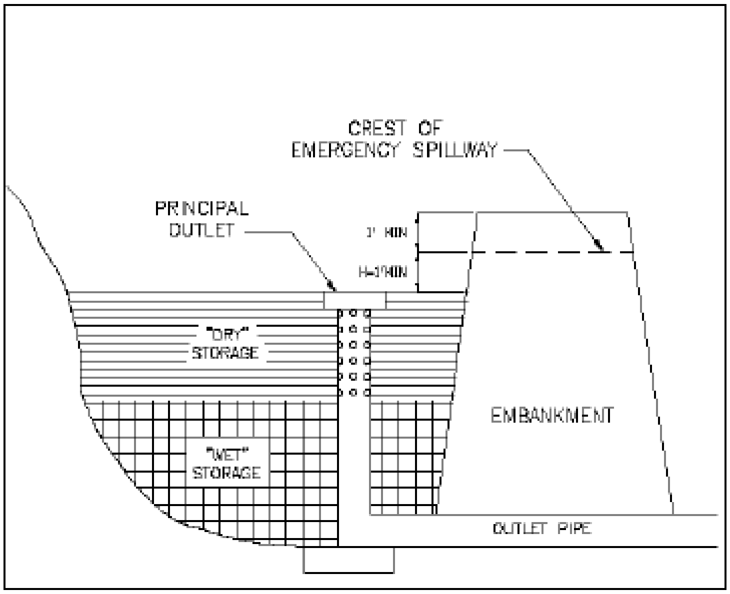
Source: CDOT, 2002a

### Maintenance Considerations

Maintenance for each trap involves yearly inspection and periodic cleaning. Ideally, Inspection and any necessary cleaning would happen post melting, but prior to the start of the summer thunderstorms. Runoff from the thunderstorms has the most potential to stress the features and entrain the deposited material. Cleaning traps prior to summer thunderstorms will greatly reduce roadside drainage issues and offsite sedimentation issues. The frequency at which these features need to be cleaned will depend on several variables, including available man hours, and the size of the basin relative to the amount of material applied. To some extent, larger basins will require less frequent cleaning. However, as previously discussed, the amount of shoulder space may be limiting in certain locations, especially along the steeper west side of the Pass. In locations with space restrictions, it may be necessary to construct a series of smaller traps in order to generate the required surface area. The general rule of thumb is to clean out the traps when they are half full, or when the amount of wet storage (roughly half the capacity) has been filled.



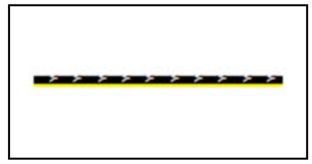

Source: CDOT Standard Plan No. M-208-1




Source: CDOT, 2002a

## Bench Traps

Map symbol



### Description

Bench traps are graded or excavated ditch-like features that are intended to capture plow throw, overland runoff, and the downslope movement of material towards waterways.

**Purpose: Treatment System**
- Bench traps are ditch-like features used to capture plow throw and/or material moving downslope, away from the road corridor.

Constructed by excavating a shelf into a hillslope, the bench trap is meant to intercept material before it moves further off site. Potential applications have been depicted in the Mapbook, but thought is required in order to determine their applicability to Rabbit Ears Pass. These features will need to be located far enough downslope to capture thrown material, but close enough to the road to allow maintenance access. During the winter months, thrown material will likely pass over buried traps – the hope is to trap material that melts out between the road and the trap after the snowmelt season.

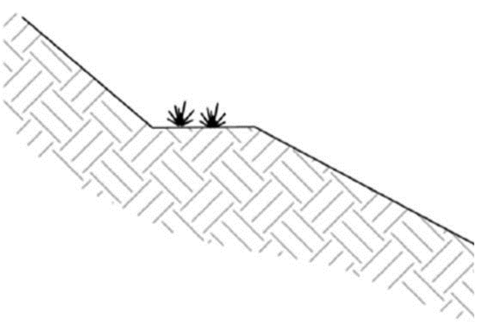
**Advantages**
- Easy to construct at a low cost.
- No clear zone issues as they are constructed away from the road.

**Limitations**
- Questionable effectiveness and durability.
- May present challenging access and cleaning issues for maintenance.

One alternative to excavating a bench trap is to apply erosion logs perpendicular to the slope, as shown below. The logs provide a similar function to the bench trap – stopping the downslope movement of material. The obvious downside is that the logs will likely require significant maintenance as a result of the volume of snow the Pass receives.

### Site Considerations

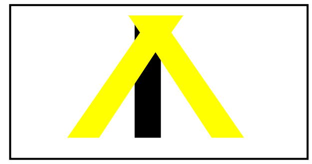
If bench traps are applied to the Pass, maintenance will need safe access to these features. One option might re-form or re-grade the features as needed. Given the question marks surrounding their long-term sustainability and difficulty to maintain, these should be considered a last choice BMP.



Modified from TRPA, 2012

## Loading Dock Traps

Map symbol



### Description

In order to simplify and reduce the amount of maintenance required, loading dock-style traps have been designed and successfully installed on mountain passes (e.g., Berthoud Pass). These traps store a large amount of material and are relatively easy to clean with the use of machinery (Caltrans, 2003).

**Purpose: Treatment System**
- Concrete traps with large storage volumes that can be easily cleaned with machinery

### Application Guidelines

Loading dock traps have been recommended in a few locations along the Pass. These traps require ample roadside space, and designs need to consider driver safety. While they are expensive to construct, they are particularly effective at trapping large amounts of sediment.
Any installed traps will require access roads in order to be cleaned with machinery.

Source: Shanks, 2006

### Maintenance Considerations

These loading dock traps should only require minimal maintenance, assuming an absence of drainage issues. They should be cleaned out and inspected on an annual basis.

**Advantages**
- Highly effective at storing sediment
- Easy to clean with a loader
- Requires minimal maintenance if designed to drain well

**Limitations**
- Need to be designed with roadside safety considerations
- Expensive to install

## Miscellaneous

## Pavestone

### Description

Pavestone, or grass pavers, are honeycomb shaped concrete blocks that allow grasses and vegetation to grow up through the holes in each block. They help stabilize the ground, supporting the weight of machinery without creating additional erosion problems. Since the forest service manages the Pass as a scenic resource, the use of these pavers will help preserve the viewshed, hiding the access road as grasses establish themselves in the interstices.

### Application Guidelines

For this project, grass pavers are proposed for the problem area associated with milepost 153, or the Muddy Creek culvert. Material moving downslope will be captured by the proposed berms. This material will need to be periodically cleaned, so the maintenance team will need to be able to access the berms with machinery. Pavers provide the ability to install a relatively durable driving surface that also allows for infiltration.

### Maintenance Considerations

Maintenance considerations for the grassy pavers will mainly involve combating the effects of annual freeze/thaw. Individual blocks, over the course of years, will be thrust up or sunk down in response to the freeze/thaw process. These blocks will need to be reset on an as needed basis.

Source: CDOT, 2002a

## 3.4 Recommended Measures to Stabilize Existing Cut Slopes

Numerous cut slopes and natural slopes exist along Rabbit Ears Pass that are not well stabilized, have little vegetation, and yield quite considerable annual loads of sediment down to the sides of US40 (Figure 9a,b). Major cut slope features were identified both in the field and on the GIS. Area estimates were made from the GIS, but must be taken with some caution due to the difficulties of attempting to measure vertical, three-dimensional features in two-dimensional GIS. Scaling up 25% to account for the relief displacement effects on vertical features in aerial photographs, the total surface area of the faces is ~1.3 million square feet. While treating the entire area would be the ideal course of action, there is potential to optimize treatments, accounting for the realities of budget constraints. Decisions could be based on factors including those faces estimated to contribute most to the sediment budget and faces likely to best respond to treatment, a task requiring further study.

**Recommendations:**
- Work with vendor to determine ideal slope for product effectiveness for each individual location

Considering that the steep slopes in this area will require sturdy reinforcement so that revegetation can take place, and that proper erosion control measures also need to be present to reduce sediment loading down the hillsides, a combination of measures should be implemented to address the cut slope issues seen around Mileposts 140 and 146. Further, the measures should be natural-looking and require minimal maintenance due to their proximity to the road and access concerns.

Conceptual level strategies to address these areas include using high performance turf reinforcement mats coupled with earth driven anchors for securing purposes such as Armormax from Propex Geotextile Systems (geotextile.com). Surficial slope stabilization is provided by securing the reinforcement geotextile matting by driving anchors into moderate to steep hillsides. The anchors offer safety and long-term design life by providing an effective tie-down mechanism to the subgrade on steep slopes, thereby preventing sloughing of near-surface soils and resisting movement. The mats prevent soil erosion and act to lock in seed and soil to establish permanent vegetation by enhancing seedling emergence. Because these systems are intended to provide a long-term design life (approximately 50 years), the UV resistance of the geotextile matting is high and is resistant to corrosion.

Source: Presto GeoWeb

Similar in concept to the anchored high performance turf reinforcement mats, another strategy to stabilize the cut slope areas include using geocell cellular confinement systems secured with a tendon anchoring system, such as Presto Geosystems Geoweb Slope Protection System (prestogeo.com). Once laid on the slope and secured, the structured network of interconnected cells are filled with topsoil, which provides a structurally stable environment for vegetation to grow. Resistance to erosive and sliding forces occurs via the systems confinement and reinforcement of the vegetated upper soil layer. A representative with Presto Geosystems indicated that such a system can prove effective along Rabbit Ears Pass, albeit costly. For the system to be successful, the top edge of the cut slope would need to be excavated back to provide a more gentle slope. This would decrease the erosive forces of sheet flow over the slope edge due to spring runoff or heavy precipitation events; thus keeping the soil in the geocells in place, and greater chances for establishment of vegetation. Additionally, proper anchoring into the bedrock would need to take place to ensure the geocells do not move down the hillside.

Cost estimates for a slope stabilization and erosion control system such as these are provided as unit costs and in the tables corresponding to costs for the areas surrounding Mileposts 140 and 146 in Appendix A. Representatives from Propex and Presto Geoweb were consulted to develop the numbers. The estimates provided are general. Refinements can be made when other variables, such as slope, material composition, and dimensions, are known.

Source: Presto GeoWeb

While these technologies have some potential, it is unclear the extent to which they have been tested in a harsh sub-alpine environment, such as that present on Rabbit Ears Pass, in addition to the feasibility of the requirements, e.g., grading back the top edge of the cut slope areas. The potential to spend budget on ineffective technology is high, generating a relatively high amount of risk as a result of unknowns associated with the slopes. Therefore, it is recommended that CDOT collaborate with the USFS to develop a cut slope pilot study in order to maximize the chances of successfully treating these difficult cut slope faces.

# 4.0 MAINTENANCE PLAN OPTIONS

## 4.1 Existing Maintenance Plan

Currently, there is not a specific maintenance plan for Rabbit Ears Pass that addresses the management of sediment, whether from natural sources (cut slopes), or due to existence of winter traction material. Cleaning efforts are generally lumped into larger projects. Historically, the strategy has been reactive, i.e., if a problem arises, it is spot treated. This is in large part due to the primary focus of maintenance: to provide a safe driving environment for motorists, specifically during the winter months. If additional resources such as personnel and funding were available, maintenance would be able to better manage sediment control issues and take a more proactive approach to increase the chances for success.

Existing maintenance practices on Rabbit Ears Pass pertaining to sediment management include:

- Addressing issues affecting offsite property owners on an as-needed basis
- Limiting traction sand application to spot treatments of observed and/or known problem areas
- Using the magnesium chloride based deicer Apex Meltdown in order to decrease the amount of traction sand applied to the Pass
- Annual street sweeping

The goal of this SCSS is to provide an overall management strategy for the entire corridor so that one problem does not exacerbate another nor inhibit the effectiveness of the variety of solutions or measures put into practice. Therefore, an enhanced maintenance plan, as described below, was developed to refine, improve, and standardize existing maintenance practices.

## 4.2 Enhanced Maintenance Plan

CDOT maintenance staff will be integral in the success of the enhanced maintenance plan, which includes tasks and BMPs that maintenance can implement prior to capital investment. This plan focuses on non-structural BMPs or softer constructed BMPs that can be implemented by maintenance. The following lists the tasks in order of priority:

1) Address priority issues that developed during the snowmelt season such as:
    - responding to catastrophic events, e.g., culvert blowout that floods a field with scoria
    - other sediment-related issues deemed priority by the maintenance staff

2) Clean up and implement non-structural BMPs to address the issues associated with the five priority areas discussed in Section 4.4

3) Implement the tasks contained in Table 5 in this order, if applicable to a certain location:
    - High to low elevation, west side of Pass (due to presence of majority of issues)
    - High to low elevation, east side of Pass
    - Top of the Pass between the two summits

Working from higher elevations toward lower elevations will prevent *upstream* issues from re-contaminating *downstream* areas that were cleaned at the beginning of the season.

**Table 5. Enhanced Maintenance Plan Tasks**

| Task | Notes/Considerations |
|---|---|
| Establish an official sediment control maintenance plan with schedules to be strictly followed by maintenance | What machinery is available to assist with sediment control? |
| Increase the frequency of sweeping efforts | ▪ Sweeping before the summer thunderstorm season will limit the transport of traction sand away from the site.<br>▪ Sweeping again in the fall, before the snow falls will create a fresh starting point for the season. |
| Inventory and document the locations and sizes of issues that will need to be addressed in the future | ▪ Size, depth, locations of deposits, formed roadside hazards, etc…<br>▪ Notes of possible remedies will be valuable – which locations can be cleaned with machinery and which will require hand labor |
| Identify, map, clean, and mark culverts | ▪ Determine which culverts are functioning and which need replacement |
| Excavate, grade, and clear obstacles from existing drainage channels | |
| Install erosion logs or rip rap check dams in existing channels | |
| Clean sand from existing deposits with shovels or available machinery | |
| Train in the latest snow removal, anti-icing, and deicing techniques | |
| Place and excavate sediment basins above culverts | |
| Install drainage rundowns and drainage outlet protection where needed | |
| Work with the USFS to discuss revegetation and slope stabilization options | |
| Document material amounts | ▪ Winter application amounts<br>▪ Summer recovery amounts |
| Establish a sediment reuse and disposal program | |

Note: These tasks are in no particular order.

## 4.3 Comprehensive Construction and Maintenance Plan

The comprehensive construction and maintenance plan includes the full suite of constructed and non-structural BMPs. As shown in Figure 16, it builds upon the enhanced maintenance plan outlined above to include capital investment and construction projects. The Mapbook produced for this project provides a conceptual representation of how structural BMPs can be implemented on the Pass. Comprehensive Construction and Maintenance Plan BMPs recommended for Rabbit Ears Pass include the following:

**Non-structural BMPs**

- Maintenance training in the latest snow removal techniques and anti-icing/deicing practices.
- Implement revegetation plans
- Updates to the sediment removal schedule, allowing for the inspection and maintenance of the installed structural BMPs
- Installation of improved forecasting and real-time weather instruments
- Development of a Maintenance Decision Support System that integrates all of the available information
- Updates for the plow trucks, including hoppers that allow for the application of different materials, GPS tracking systems, and onboard instruments that can measure and update the current road conditions

**Structural BMPs**

- Pan drains
- Underground sediment traps
- Sediment basins
- Loading dock sediment traps
- Ditch excavation
- Creation of snow storage and parallel storage areas
- Installation of culverts
- Cut slope stabilization, re-grading and treatment

Structural BMPs can be installed using the same priority structure established in the above Enhanced Maintenance Plan – starting with the priority problem areas, and subsequently working from the top down. Due to the limited amount of time and maintenance staff, the acquisition of machinery (such as a vacuum truck, loader and bulldozer) is key to being able to clean the sediment control features during the short snow-free season.

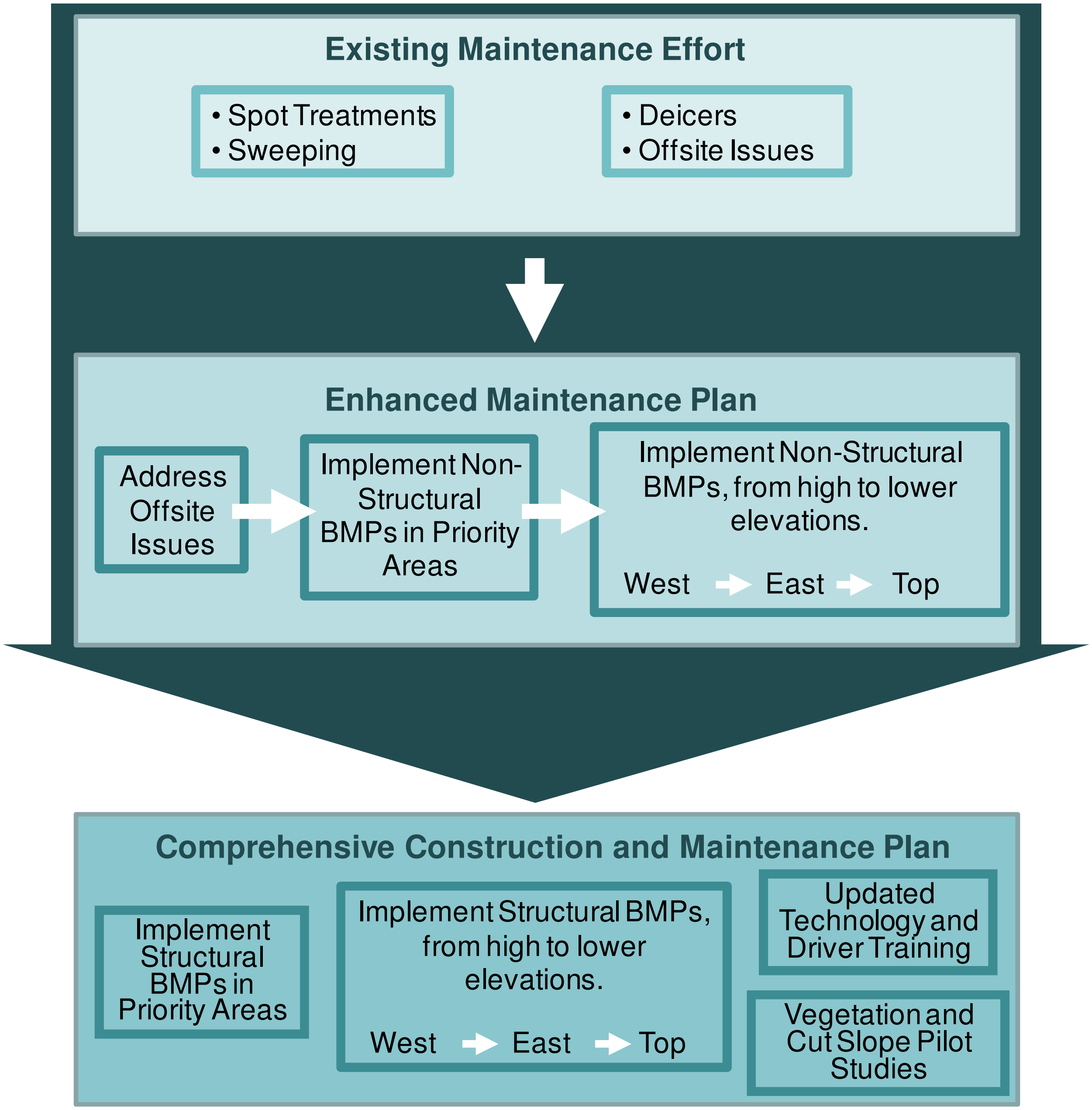



Figure 16. The maintenance effort required to address the sediment issues on Rabbit Ears Pass can be divided into stages, which when taken together, form a comprehensive maintenance plan.

## 4.4 Prioritized Construction and Maintenance Plan

**Priority Areas:**
- Steep bends near Milepost 140
- Steep bends near Milepost 145
- Large pulloff area near Milepost 146
- CDOT Maintenance Shed
- Muddy Creek Culvert near Milepost 153

With the guidance of CDOT maintenance staff, AMEC has identified several priority problem areas. These are areas with a relatively complex series of causes, involving solutions that are not as straightforward as other areas. In several instances, they supply traction material directly to open surface water. These five priority problem areas have been selected to serve as prime representative examples of sediment control recommendations being made herein. These five examples generally encompass all of the sediment control challenges presented in the study area, including use of a majority of the BMPs recommended for this project. Each are described in detail in terms of their location, the site-specific problem, and the recommended treatment(s).

Once the reader is familiar with each of these sites, problems, and the recommended solutions, they can then refer to the attached Mapbook in order to locate similar problems requiring similar treatments. The locations of the identified problem areas are presented in the attached Mapbook, in which the entire study area, i.e. milepost 138 to the junction of US40 and Colorado State Highway 14, is covered at the maximum scale of the aerial imagery available for the study site – 1:1000. The user of this report can use this high resolution data product to identify all locations requiring treatments, and then refer to the examples of recommended sediment control BMPs in order to select the best single or combination of treatments for that site, depending on the resources available.

**Steep bends near Milepost 140**

*Description*

The first problem area is located near milepost 140 and is caused by steep slopes, poor drainage, sediment loading from road cuts and a significant bend in the road (Mapbook pages 12-16). Through this area, the slope of the road is in the range of 5.5% - 6.5%. Sheet flow is an issue in this area as water flows down the steep road cuts and hill slopes above the highway. Traction material has built up on the road shoulder, filling ditches and plugging culverts. As a result, water flows across the road to the south, becoming an issue for traction as well as a transportation mechanism for stored sediment. The road shoulder on the north side of the road, east of the identified culvert, exhibits significant deposition. Erosion runnels have developed in the deposited material (Figure 17a). Compounding the situation, erosion from several road cuts is supplying additional material (Figure 17b). The south side of the road drops steeply to the valley floor. The slope is vegetated to varying degrees, but traction sand and scoria can be found deposited over the edge.

The channel on the east side of the road, wedged between the road grade and cut slope, flows north to two additional culverts. This is one of the larger cut slopes on the Pass. The channel then continues to the sediment traps installed by maintenance in response to a past blow out event (indicated on Mapbook page 12). Through this stretch, the west side of the road is mostly perched above steep slopes that extend to the valley floor. The drop-off to the valley is broken in two spots by smaller cut slopes that seem to be supporting some vegetation.

a.) b.)

Figure 17. a.) Photo showing buildup of traction material along highway on the inside of bend. Note the well-formed erosion runnels, indicating the transportation of material. These runnels lead to a culvert with a history of blowing out onto the properties below. b.) Photo illustrating the lack of space caused by the proximity of the road to cut slopes.

*Solutions*

While solution implementation is complicated by the relative lack of space along the road, several options exist that could both improve drainage and control the transport of material.

*Enhanced Maintenance Plan*

There are several BMPs maintenance can implement before capital construction funds are acquired. The recommended tasks and BMPs include:

- In order to facilitate drainage, existing drainage ditches should be cleaned out and maintained along both sides of the road (Figure 18).
- Small roughness elements such as rocks or erosion logs placed periodically in the ditch can help trap sediment.
- Riprap should be used to armor unwanted migrations of the channel towards the road.
- Clean out and mark existing culverts.
- Place erosion protection at culvert outlets.

Figure 18. Looking down (north) small natural channel, just above the implemented sediment trap near milepost 140. The channel is vegetated, providing natural roughness elements that provide some control over the flows heading towards the sediment basin.

*Comprehensive Maintenance Plan*

The sedimentation problems in this area near milepost 140 could also benefit structural BMPs recommended as part of the Comprehensive Maintenance Plan. These sediment control features are illustrated in the Mapbook and include the following:

- The prominent cut slope on the north/east side of the road should be re-graded and revegetated if possible;
- The cut slope can also be addressed through a combination of kneewall and an underground (French) drain;
- Pan drains can be used to help route flows towards treatment BMPs;
- Sand cans provide one option to treat runoff in the narrow road corridor;

- A snow storage area can be placed near mile marker 140.1;
- Excavate sediment basins, similar to those already in place. Trap size is ultimately limited by the relatively confined nature of this section of road, but maintenance should fit as big of a trap as the available space allows.
- Jersey barriers can be used to help address the sheet flow issues observed near mile marker 140.3;

In order to control the flow of runoff across the road, Type 4 (Jersey) barriers should be placed to concentrate and contain flow coming from the cut slope in the proposed ditch. On the south side of the road, a ditch should be placed to capture runoff and sediment. A small sediment basin should be placed at the end of the ditch to prevent material from being transported over the edge of the road grade.

Moving north down the road, there is a significant cut slope along the east side of the road. A similar drainage ditch and sediment basin system should be implemented along this stretch of road. Again, it is sufficient to use the established channel forming between the road surface and cut slope. These drain ditches will help concentrate and direct runoff toward the sediment basins, which will settle out the traction sand and scoria. This system will lead directly into the sediment basins already constructed by CDOT. The cut slopes along this problem area will also need treatment. Further study is required to determine which specific treatment is most appropriate for this location, but several likely options have been presented in section 4.4.

On the west side of the road, there are relatively few opportunities to control the flow of sediment. It is suspected that some of the load reaching the western edge of the road is supplied from the cut slope and subsequently transported and deposited on the edge. Installing the aforementioned BMPs on the east side will help to cut down on this supply. To the extent possible, maintenance can help this area by keeping the outlet side of the culverts clear of plowed snow. This will cut down on the amount of maintenance necessary in the summer to clean the culverts.

**Steep bends near Milepost 145**

*Description*

Moving east along US40 from milepost 145 traction material has accumulated along both sides of the road, mostly a result of plow throw and snow storage. There is a pullout located on the east side of the road which is used to store snow (refer to Mapbook pages 42-45 and Figure 19a). Traction sand deposited in this pullout area becomes entrained in the prominent erosion runnel, and travels down (south) along the highway (Figure 19b). Through this stretch, the highway is confined to the east by hill slope and exposed bedrock, thus road shoulder space is limited (Figure 20a). Traction material builds up along the road shoulder, where a channel is cutting into the deposited material (Figure 20c). The flow travels south along the road until it reaches a break in the bedrock where the material is deposited (Figure 20b). The deposition zone is quite large in area and appears to be several feet deep. Subsequent events have cut deep channels into this material, transporting it away from the road corridor. Harrison Creek is downslope from this location, and the likely destination for the transported material. Throw from the plows also contributes to the sedimentation problems in this area. Traction sand and scoria can be seen deposited up on the exposed bedrock sections, many feet above the road surface.

*Solutions*

The sediment control measures recommended for this problem area include installing ditches, confining the spatial extent of available snow storage area, excavating sediment traps, and revegetating slopes. While there is not an excess of space, BMPs can be implemented to address the sedimentation problems.

*Enhanced Maintenance Plan*

Non-structural BMPs that can be implemented in this area as part of the enhanced maintenance plan include the following:

- Culverts need to be identified, cleaned and marked;
- Traction material needs to be cleaned from both sides of the road;
- Existing ditches should be cleaned and cleared of obstacles;
- Roughness elements should be added to the existing ditches to help trap sediment;
- The large deposition zone on the east side of the road near mile marker 145.2 needs to be cleaned out;
- With existing machinery, the large pullout area located near mile marker 145.7 could be scraped to recover traction material

*Comprehensive Maintenance Plan*

Structural BMPs recommended for this priority problem area aggressively address the sedimentation issues observed on both sides of the road. They are detailed in Mapbook pages 42-45 and consist of the following:

- Grading and defining the pullout as a snow storage area;
- Cutting off the supply from the pullout area with a sediment basin;
- Excavating a well formed channel along the east side of road;
- Due to the length of the ditch and amount of sediment, a loading dock-style trap is recommended for the deposition area near mile marker 145.2;
- Establishing defined sediment storage areas on the west side of the road. Designing and installing paved parallel storage (similar to those present on Berthoud Pass) along here should be considered;
- Loading dock traps should also be considered for this area.

a.)

b.)

Figure 19. a.) Looking north (uphill) at large pulloff area on east side of the road, which is likely used for snow storage. This area acts as a source zone, supplying material down along the road through the obvious erosion runnels. b.) Looking south (downhill) at erosion runnel that flows to the large deposition zone depicted in Figure 20.

Figure 20. a.) Looking downslope, west, at section of bedrock that constrains the available space in which to implement BMPs. b.) Uphill, east, view of large deposition area located at the end of the bedrock section, depicted in (a). c.) Looking uphill, east at the channel forming along the south side of the road.

**Large Pulloff Area near Milepost 146**

*Description*

Just east of milepost 146 (Mapbook pages 46-48) there is a large pullout that is used for snow storage on the south side of the road. The pullout, approximately 1 acre in size, is full of traction sand and contains several large erosion runnels that transport material to the west, (Figure 21a and 21b). The western edge of the pull out abruptly drops into the adjacent valley, eventually transporting material away from the road corridor. The road shoulder at this location, and moving east, is steep and laden with traction material (Figure 21c).

On the north side of the highway there is a large, heavily eroded cut slope (Figure 22a). The slope is sparsely vegetated, supporting some small pines and grasses. The cut slope is located at a local topographical high point. A ditch has formed at the base of the cut slope which runs along the road to both the west and east, eventually spilling out into the adjacent valleys. The spill point at the western end has eroded a substantial channel into deposited traction sand (Figure 22b). There is not much shoulder space available in which to implement sediment control features.

The road grade to both the west and east is elevated above the valley and a significant amount of traction sand is deposited on the shoulders of both sides of the road (e.g., Figure 21c). The shoulder slopes are generally steep, containing significant erosion runnels.

*Solutions*

*Enhanced Maintenance Plan*

BMPs implemented as part of the Enhanced Maintenance Plan for this priority area include recovering traction sand and facilitating drainage beneath the cut slope on the north side of the road. More specifically, the recommended BMPs include:

- Limiting the extent to which stored snow is pushed away from the road;
- Scraping sand out of the pullout area;
- Cleaning out and adding basic roughness elements, such as riprap or erosion logs, to the drainage channel on the north side of the road, beneath the cut slope;
- Working with the USFS to discuss revegetation possibilities along the road grade;
- Mapping, cleaning and marking culverts along this stretch of US40;

*Comprehensive Maintenance Plan*

Solutions for this area potentially implemented as part of the Comprehensive Maintenance Plan involve containing the traction sand, channeling the runoff, and revegetating the road shoulder. The recommended BMPs include:

- Excavating and establishing drainage ditches along the north side of the road;
- Installing sediment basins at both ends of the installed drainage ditches;
- Establishing snow storage zones on the south side of the road, including treatment sediment basins;
- Implementing plowing methods that maximize the use of the storage areas;
- Implementing a revegetation program;
- Re-grading and treating the cut slope;

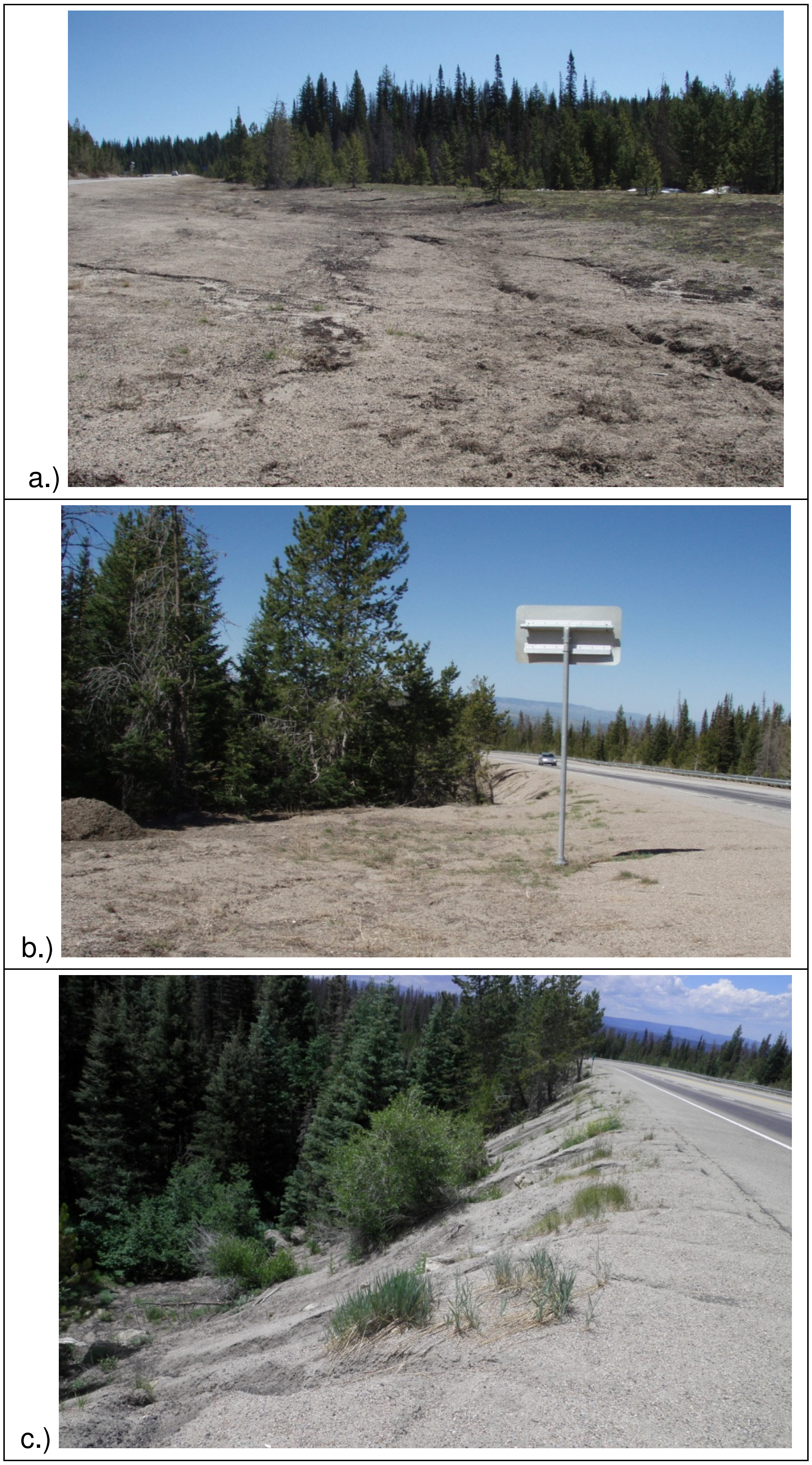



Figure 21. a.) Looking east across pullout area. b.) Looking at western edge of area. c) View from western side of pulloff area, looking at the accumulation of material on steep roadside edge.

a.)

b.)

Figure 22. a.) Photo showing cut slope on north side of the road. A natural channel has formed at the base, indicated by the presence of vegetation. b.) View of the western edge of the cut slope and the discharge outlet trending toward the lower left of the photo.

**CDOT Maintenance Shed**

*Description*

Issues associated with the CDOT maintenance shed are a significant concern of the USFS. As a result, members of both CDOT and the USFS have discussed the sedimentation issues and developed a rough plan for addressing the site.

Key challenges for the site include redirecting runoff from the slope to the east, cleaning out the pond, revegetating the area north of the shed and south of the pond (Figure 23a), and installing a permanent sediment basin. As the flow pathways are currently situated, runoff from the slope east of the shed combines with runoff from the site, and heads toward a large deposition area just south of the pond (Figure 23b). The sediment load of this runoff is augmented by traction material scattered and tracked across the driveway by the snowplow trucks. CDOT has also been storing plowed snow from the lot in this deposition area. On the north side of the shed is a large gravel and sand lot that has been supplying material to the stream flowing into the pond (Figure 23c). The USFS has indicated that they would like to reclaim this area with willows.

*Working Plan*

A working plan to address the issues associated with the CDOT maintenance shed has already been developed. Those sediment control and site reclamation features can be found on Mapbook pages 81 and 82. The general strategy is to prevent clean runoff from entering the site, while treating the runoff generated on the site before it makes it way off site. Clean runoff from the slope to the east will be prevented from entering the site through the construction of ditches along the east side of the property. The first ditch will be constructed along the dirt road that extends north of the site (Mapbook page 81). It will be used to capture runoff and direct it towards the area to be revegetated north of the shed – the intent is to use the runoff to help establish the willows. An additional ditch will be excavated to capture clean runoff from the slope to the east. The ditch will run from the northeast corner of the property, behind the housing and down along the road. A consideration for this ditch is not extending so far north as to cut off, or divert, subsurface flow from the creek floodplain. Also, if the access road is to be maintained, grading the road down into the ditch, creating a small crossing, should be considered. Runoff flowing down the access road tracks will then be captured by the ditch and directed toward the willow area.

Snow storage has been proposed for either the northeast corner of the property (Mapbook page 81) or near the trap that is to be constructed. At the last stakeholder meeting (held March 19th, 2012) the USFS expressed concerns about storing snow in the northeast location. Maintenance seemed to agree that the trap could be designed to accommodate storage from the site. An additional drainage ditch is proposed for behind the housing units, separating them from runoff generated on the adjacent hill slope (Mapbook page 82). This ditch should extend from just south of the proposed storage area behind the housing units, to the low spot where a culvert will need to be installed in order to convey runoff to the trap. This clean runoff can then either bypass the trap using a clean water diversion or be direct to the trap.

The area north of the shed is to be reclaimed as a wetland. This will require the removal of material and the construction of a barrier. The material will have to be amended with topsoil and fertilizer in order to support vegetation. The recommended seed mix for the berm is the native seeding mix (refer to section 4.3). For the wetland area, new fill will need to be brought in and graded, maintaining a hydraulic gradient through the wetlands to the creek. Brush layer (willow) cuttings should be installed at 2 to 4 foot centers throughout the area. The wetland seeding mix should be applied throughout. Additionally, it has been suggested to stagger the willow cuttings along the length of the pond and stream edge (email communication with Paula Durkin, CDOT Wetlands Specialist, on 1/10/13.

The area directly along the east side and south of the pond is also to be revegetated. There is existing berm that extends along the pond. This berm should have any existing structural issues fixed and also be revegetated with the native seeding mix. It will both prevent runoff and sediment from entering the pond, and direct flow south along the driveway to the location of the proposed loading dock trap.

As a result of the high volume of material leaving the paved area just below, or south of, the pond, a loading dock sediment trap has been proposed by CDOT engineers. Preliminary calculations suggest that the proposed sediment control structure be sized to capture 1/2 inch of runoff from an area estimated to be 500 feet long by 200 feet wide – a volume approximately equal to 150 cubic yards. AMEC generally agrees with this number as long as the proposed ditches are effective in preventing runoff from entering the site from the slope to the east. If the clean runoff from the adjacent slope is funneled to the trap, it will require additional capacity to account for the additional runoff. A two tier catchment system would then be placed near the location indicated on Mapbook page 82. The first basin would act as the main trap for the site. An additional trap would be added to the back to filter the water one last time before discharging to the stream and wetland area to the west (email exchange with Mark Eike on 11/16/12).


a.)


b.)


c.)

Figure 23. a.) View looking south across the pond. Note the deposition of material in the lower right foreground. b.) Looking west across the deposition area located just beyond the south edge of the pond. c.) Area to the north of the shed to be reclaimed with willows.

**Muddy Creek Culvert near Milepost 153**

*Description*

Just east of milepost 153 the US40 road grade is elevated as the highway crosses over Muddy Creek (Figure 24a). The creek passes through a major culvert, at least 6 feet in diameter (Figure 24b). Slopes above the culvert, extending east and west across the valley are laden with both scoria and traction sand, a result of plowing and snow throw over the edge of the road. Significant deposits of scoria can be seen next to the culvert in Figure 24b, evidence of the material's persistence. Muddy Creek also contains deposits of sand and scoria both near the culvert and for some distance along and down the stream. Additionally, several major erosion runnels have formed, extending from the road grade down slope towards the valley floor and creek. Some of these runnels have begun cutting into the pavement at the edge of the road, potentially becoming a major road hazard (e.g., Figure 24b). Grasses are trying to establish on the slopes, a task made difficult by a seasonal inundation of traction material. Solutions for this problem area generated much discussion at the March 19th stakeholder meeting. Since the adjacent valley and floodplain vegetation is acting as a natural filter, some stakeholders suggested leaving the area alone. Given the presence of material in Muddy Creek, leaving the site alone is not the recommended course of action.

*Solutions*

Sediment control measures for this section of road include stabilizing the slopes below the road grade, repairing the road surface, and installing pan drains and sand cans. They are illustrated on pages 88-90 of the Mapbook.

*Enhanced Maintenance Plan*

Non-structural BMPs to be implemented as part of the Enhanced Maintenance Plan include the following:

- Cleaning out culverts and additionally mapping and marking those not identified in the Mapbook;
- Scraping and cleaning traction material from the sides of the road grade;
- Installing rundowns to repair and armor the major erosion runnels observed along the grade;
- Developing a revegetation plan for the slopes adjacent to the road.

*Comprehensive Maintenance Plan*

The structural BMPs suggested for this priority area address the movement of traction material into Muddy Creek, a fish bearing stream. The general strategy is to intercept runoff with pan drains and subsequently direct flow to sand cans and sediment basins. An alternative option may be to use curb and gutter, however these features will need to be designed with either the existing or a replacement guardrail. In order to determine the best solution, survey grade terrain data should be collected in order to precisely determine flow paths and the placement of BMPs. One possible strategy, emphasizing the use of pan drains and sand cans, is detailed on Mapbook pages 88-90 and consists of the following:

- Using geo-textile tubes to set a barrier around the culvert inlet and outlet;
- Using pan drains to capture runoff and direct it toward the lower collection ditch via rundowns;
- Installing sand cans and sediment basins to treat the runoff before it leaves the site;
- Developing a plan to regularly inspect and clean the installed features;
- Implementing and supporting a revegetation plan for the slopes adjacent to the road.

a.)


b.)


c.)


Figure 24. a.) Photo taken on south side of highway, looking west at elevated road grade. b.) Muddy Creek culvert. Note the large erosion runnel cutting into, and extending from road surface. The dark material adjacent to the culvert is scoria. c.) Photo looking east from south side of the road at elevated road grade.

# 5.0 SUMMARY AND RECOMMENDATIONS

The Rabbit Ears SCSS presents conceptual recommendations and actions to give CDOT the tools necessary to implement a management strategy for the corridor as a whole. This approach will increase the effectiveness of measures implemented, whether they be training programs for maintenance staff, or structural features to control sediment. While CDOT is currently maintaining the corridor to the best of their ability given available resources, the reactive approach to sediment control and management is not sufficient to mitigate the associated problems.

Adjustments and improvements to the existing maintenance strategy can likely greatly assist CDOT in controlling sediment at its source and avoid exacerbating additional problems. The main components of the resulting enhanced maintenance plan include:

- Locating, mapping, marking, and cleaning all of the culverts on the Pass;
- Installing basic sediment trapping features;
- Cleaning out deposition zones;
- Developing a routine maintenance schedule that works with current schedules;
- Finding a disposal site for recovered traction sand that cannot be reused.

The general strategy of the sediment control features in this study is to facilitate the drainage of the road corridor, while reducing the flow of traction material offsite. Given funding limitations, it is likely that particular areas will be selected for treatment initially, with subsequent areas added as funds become available. In this case, it is recommended that the following approach be taken to prioritize the areas needing attention:

- Address the priority problems areas to the extent funding allows. Table 6 below provides a general ranking and summary of the problems and tasks associated with the Enhanced Maintenance Plan;
- Begin working on the west side, followed by the east side, and finally the top;
    - Implement the highest (or furthest upstream) feature, located in any particular flow path;
    - Work downstream, incrementally addressing issues until the entire flow path is completely contained.

There would be great value in revegetating many of the unconsolidated slopes located throughout the Pass. CDOT and the USFS should develop strategies to assess which roadside revegetation and cut slope treatment options are best suited to Rabbit Ears Pass. One option to minimize risk is to implement pilot studies that test solutions on smaller areas before extrapolating the best fit to other areas of the Pass. This approach minimizes risk, creating a high probability of success.

**Table 6 Summary and Ranking of Enhanced Maintenance Plan for Priority Project Areas**

| Problem Area | Ranking | Milepoints | Mapbook Pages | Problem Identification | Mitigation Proposal | Maintenance Tasks |
|---|---|---|---|---|---|---|
| Milepost 140 | 2 | 140.2 | 14-16 | Sediment Accumulation<br>Blocked drainage<br>Erosion<br>Offsite transport | Clean sediments, define and promote drainage, prevent offsite transport of material | Sweeping<br>Clean and Mark culverts<br>Install erosion logs or rip rap in ditch<br>Clean sand from deposits<br>Install sediment basins |
| Milepost 145 | 1 | 145.7-145.2 | 42-45 | Sediment Accumulation<br>Offsite transport<br>Erosion | Clean sediments, define snow storage area, prevent offsite transport of sediment, fix erosion issues | Sweeping<br>Clean and Mark culverts<br>Install erosion logs or rip rap in ditch<br>Clean sand from deposits<br>Install sediment basins<br>Scrape sediments from pullout area |
| Pulloff at MP 146 | 3 | 146.1 | 46-48 | Sediment Accumulation<br>Offsite transport<br>Erosion | Clean sediments from roadside deposits, define snow storage area, prevent offsite transport of material | Sweeping<br>Clean and Mark culverts<br>Clean sand from deposits<br>Install sediment basins<br>Scrape sediments from pullout area |
| CDOT Shed | 4 | 152 | 81-82 | Sediment Accumulation<br>Offsite transport | Clean sediments from areas adjacent to drive, Install and promote drainage, prevent offsite transport of sediment | Sweeping<br>Clean existing culverts, install proposed culvert<br>Clean sand from deposits |
| | | | | | | |
| Muddy Creek Culvert | 5 | 153.1-153.4 | 88-90 | Sediment Accumulation<br>Offsite transport<br>Erosion | Clean accumulated sediments from roadside, install rundowns to address erosion issues | Sweeping<br>Install drainage rundowns<br>Install sediment basin |

# 6.0 ACRONYMS

BMP: Best Management Practice

CDOT: Colorado Department of Transportation

CDPHE: Colorado Department of Public Health and Environment

CDPS: Colorado Discharge Permit System

DEM: Digital Elevation Model

DOT: Department of Transportation

FHWA: Federal Highway Administration

GIS: Geographic Information System

MDSS: Maintenance Decision Support System

NEPA: National Environmental Policy Act

PRISM: Parameter-elevation Regressions on Independent Slopes Model

RWIS: Road Weather Information System

SCP: Stormwater Construction Permit

SCSS: Sediment Control Scoping Study

SNOTEL: SNOpack TELemetry

SWMP: Stormwater Management Plan

TRPA: Tahoe Regional Planning Agency

UDFCD: Urban Drainage and Flood Control District

USFS: U. S. Forest Service

# 7.0 REFERENCES

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# APPENDIX A

# COST ESTIMATES

### *Ditch Cost Estimates*

In order to generate cost estimates for the ditches recommended in this project it was necessary to make certain assumptions about the drainages. Using the GIS, slopes, drainage areas, and length of ditch were used as analogs for ditch capacities. It was assumed that larger drainage areas, longer features, and steeper slopes would require larger capacity ditches. Conversely, smaller drainage areas, shallower slopes, and shorter features will generally suffice with lower capacity ditches. As snow is pushed from adjacent areas, snow storage zones will generally increase the amount of runoff associated with a particular drainage area and/or feature. However, it is assumed that snowmelt generally behaves as a quasi steady state process, providing a continuous supply of meltwater, rather than the larger pulses associated with thunder storm (i.e. rainfall) events. Thus, greater erosive energies are associated with rain storm events, not snowmelt events (CDOT, 2002c). Bearing in mind these considerations, ditches were classified into small, medium, and large classes.

Since ditch cost is calculated by volume, it was necessary to estimate cross-sectional areas associated with the ditch classes, a task significantly complicated by the general lack of shoulder space along the steeper west side of the Pass. In order to make initial estimates, ditch widths of three, four, and five feet, with a triangular profile and wall slopes of 3:1 were assumed. If the resulting areas are then buffered by 25%, the classes then range from 0.5-1 square feet for small, 1-1.7 square feet for medium, and 1.8-2.6 square feet for large. Recommended sizes are provided for each area of the Pass and symbolized in the Mapbook with different colors representing each size.

### *Sediment Basin Cost Estimates*

Determining the size of the sediment basins is complicated by several variables. In general, the size of these features is proportional to the drainage area that it treats, up to a maximum treatment area of 10 acres (CDOT, 2002a). However, in many instances, much of the drainage area is covered in pine forest. These forested drainages store, transpire and slowly release accumulated precipitation over longer periods of time, so a straightforward area calculation, as applied to construction sites, etc, is probably not applicable. Additionally, the volume of the sediment basins should consider the amount of material that it is intended to store. Sediment accumulates differently around the Pass, with larger amounts of material in deposition zones, either by transport (and subsequent deposition) or snow storage. Some basins may need to handle as artificially high load as a result of snow storage. A final consideration is, again, the lack of shoulder space available in which to safely construct sediment traps. In locations where 26 feet of clear zone space is not available and drainage is desired, jersey barrier or guardrail can be used to allow for the construction of sediment control features.

Bearing in mind these considerations, the size of each of the basins was estimated using drainage area and presence of accumulated material along the drain line. As with the drainage ditches, the sediment basins were classified in three classes - small, medium and large. Surface areas for each category were estimated using published numbers from the *Weir Length Table* in the *Erosion Control and Stormwater Quality Field Guide* (CDOT, 2011), reproduced and added to Table A1. Assuming a 2:1 length to width ratio, surface areas were calculated from the supplied weir lengths (bottom width of the trap). Length and width numbers can be adjusted to fit with site specific physical constraints. Those values were then adjusted up and down by 25% to estimate ranges, and those values used to define the size categories. Specific volumes can be more precisely calculated, considering the available road shoulder space, prior to the design efforts of any implemented projects. Cost estimates can then be refined accordingly.

**Table A1. Sediment basin ranges**

| Drainage Area (Acres) | Weir Length (Feet) | Calculated Surface Area ($ft^2$) | Adjusted Surface Area Range ($ft^2$) | Size Classification |
|---|---|---|---|---|
| 1 | 4 | 32 | 24 - 40 | Small |
| 2 | 6 | 72 | 54 - 90 | |
| 3 | 8 | 128 | 96 - 160 | Medium |
| 4 | 10 | 200 | 150 - 250 | Large |
| 5 | 12 | 288 | 216 - 360 | |

Drainage area and weir lengths reproduced from CDOT, 2011

***Unit Costs***

The unit cost tables below summarize costs for the various recommended non-structural and structural control measures, Tables A2 and A3, respectively. The 2011 CDOT Cost Data Book and Standard Specifications for Road and Bridge Construction were used to develop this information (average prices are presented).

Unit costs for revegetation measures, including use of seed and willow cuttings to revegetate wetland areas, are provided in Table A2. The USFS assisted in identifying items from the CDOT Cost Data Book that should be considered.

Because geo-textile tubes are not included in the Cost Data Book, a representative from Layfield Environmental Systems was consulted for pricing information (Quillen, personal communication). Similarly, access road and pavers are not in the Cost data Book; therefore, industry knowledge and experience was used to estimate these particular unit values shown in Table A3. Additionally, cost estimates for the slope stabilization and erosion control systems recommended for the cut slope areas were developed with assistance from representatives from Presto Geoweb. However, the estimates provided are general. Refinements can be made when other variables, such as slope, material composition, and dimensions, are known.

It should be noted that the estimates in Tables A2 and A3 are conceptual in nature and do not include all the necessary components for construction, e.g., use of heavy equipment, labor hours and annual maintenance. They are meant as a guide and to give an idea of order of magnitude costs for individual measures.

## Table A2. Unit Costs for Non-Structural Control Measures

| Item | | Detail from Cost Data Book | Unit | Unit Cost |
|---|---|---|---|---|
| 1 | Revegetation, Seeding (Native) | Seeding (Native) | acre | $619.00 |
| 2 | Revegetation, Seeding (Wetlands) | Seeding (Wetlands) | acre | $1,968.45 |
| 3 | Willow Cuttings | Willow Cuttings | each | $6.69 |
| 4 | Transplant Plug | Transplant Plug | each | $47.53 |
| 5 | Mulching | Mulching (Weed Free Straw) | acre | $893.54 |
| 6 | Mulch Tackifier | Mulch Tackifier | pound | $4.32 |
| 7 | Soil Conditioner | Soil Conditioning | acre | $2,180.97 |
| 8 | Soil Retention Blanket | Soil Retention Blanket (Biodegradable Straw/Coconut) | sq yard | $1.62 |

Source: 2011 CDOT Cost Data Book (CDOT, 2012) and 2011 CDOT Standard Specifications for Road and Bridge Construction

## Table A3. Unit Costs for Structural Control Measures

| Item | | Detail from Cost Data Book | Unit | Unit Cost |
|---|---|---|---|---|
| 1 | Access Road | N/A | mile | $200,000.00 |
| 2 | Barrier | Guardrail Type 7 (Precast) | lin foot | $65.46 |
| 3 | Berm | Embankment Material (Complete in Place) | lin foot | $6.76 |
| 4 | Curb | Curb, Type 4 (Section B) | lin foot | $35.00 |
| 5 | Cut slopes | N/A | | |
| 6 | Ditch - small | Unclassified Excavation (Complete in Place) | cubic yard | $6.38 |
| 7 | Ditch - medium | Unclassified Excavation | cubic yard | $6.55 |
| 8 | Ditch - large | Unclassified Excavation (Special) | cubic yard | $9.00 |
| 9 | Ditch - drain | N/A | N/A | N/A |
| 10 | Ditch - grade | Embankment Material (Complete in Place) | cubic yard | $6.76 |
| 11 | Ditch - armoring | Riprap (9 Inch) | cubic yard | $59.83 |
| 12 | Ditch - armoring (grade) | Riprap (6 Inch) | cubic yard | $157.52 |
| 13 | Ditch - rip rap | Riprap (6 Inch) | cubic yard | $157.52 |
| 14 | Geo-textile tube | N/A | | |
| 15 | Grade | Embankment Material (Complete in Place) | cubic yard | $6.76 |
| 16 | Pavers | N/A | sq foot | $8.00 |
| 17 | Sediment Trap | Sediment Trap | each | $1,521.31 |
| 18 | Sediment Basin - small | Sediment Basin | each | $3,066.56 |
| 19 | Sediment Basin - medium | Sediment Basin | each | $3,833.20 |
| 20 | Sediment Basin - large | Sediment Basin | each | $4,791.50 |

N/A: Items not found in CDOT Cost Data Book. Unit costs were generated based on contact with a vendor or industry knowledge

Source: 2011 CDOT Cost Data Book (CDOT, 2012),2011 CDOT Standard Specifications for Road and Bridge Construction, industry knowledge, Quillen (personal communication) and Kinnard/Wedin (personal communication)