I-70 Clear Creek Corridor

SEDIMENT CONTROL ACTION PLAN

PREPARED FOR:

COLORADO DOT
DEPARTMENT OF TRANSPORTATION

Matrix DESIGN GROUP

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EXECUTIVE SUMMARY

The formation of this ***Sediment Control Action Plan*** (**SCAP**) for the reach of Interstate 70 (**I-70**) tributary to Clear Creek is a collaborative partnership between the Colorado Department of Transportation (**CDOT**) and the local mountain communities and entities in the Clear Creek watershed. This SCAP document was developed as a tool for CDOT and other agencies to better manage roadway traction sand and other highway-related sediment sources that can adversely impact the Clear Creek waterway. The SCAP study area is entirely within Clear Creek County and covers a 33-mile segment of I-70 from the east portal of the Eisenhower-Johnson Memorial Tunnel (MP 215) to the eastern side of Floyd Hill at Beaver Brook (MP 248). Georgetown Lake (MP 229) is a significant water body within this reach and divides the study area between upper and lower Clear Creek.

This SCAP document, consisting of a **Technical Report** and **Mapbook**, provides the justification, technical basis and approach for controlling sedimentation within the I-70 roadway corridor along Clear Creek. This report describes existing conditions, environmental considerations and requirements, BMP design tools, CDOT's maintenance program, an estimate of costs, and an implementation approach plan. This SCAP developed a "Menu" of applicable BMPs, and suggests how these may be implemented throughout the corridor. This document should be considered a *Master Plan*; details of specific BMP design and construction are beyond the scope of this SCAP but would be developed in a later phase during *Preliminary Design*.

Sediment loading in *upper* Clear Creek is two to three times higher than might be expected from base load conditions, and sediment loading in *lower* Clear Creek is three to five times higher than would be expected from base load conditions. This SCAP document is a voluntary effort by CDOT to address the sediment related water quality issues in Clear Creek. It is not intended to comply with regulations governing Municipal Separate Storm Sewer Systems (**MS4s**) communities as designated by the Environmental Protection Agency (**EPA**). Regulated MS4 areas are determined by population and their boundaries do not extend beyond Jefferson County into this mountain corridor within Clear Creek County. Clear Creek is not designated as impaired for sediment, and no Total Maximum Daily Load (**TMDL**) standards for sediment have been developed for Clear Creek in this mountainous reach. Therefore, there are no current mandates or quantifiable standards requiring CDOT to improve the water quality of Clear Creek by reducing the sediment loading.

There are, however, metal standards in place and nutrient standards proposed for Clear Creek. Reductions in sediment loading afforded by implementation of this SCAP will result in a reduction in trace metal and nutrient loading in Clear Creek.

Although CDOT has developed SCAPs for other **I-70** mountain corridor areas, such as along Straight Creek and Black Gore Creek, this is the first document of its kind for the Clear Creek corridor. This effort was born out of meetings with the ***Stream and Wetland Ecological Enhancement Program*** (**SWEEP**) Committee, an advisory committee consisting of fishery biologists, hydrologists and other watershed and water quality-related technical experts, community representatives and other potentially affected parties. The shared objective of all SWEEP Committee members is to improve stream and wetland conditions in the I-70 Mountain Corridor. This document develops a plan that can be expanded and revised in the future to help manage the sediment loading to Clear Creek. The SWEEP Memorandum of Understanding

(**MOU**), dated January 4, 2011, and this SCAP have set the foundation for sediment control in the Clear Creek I-70 corridor.

I-70 along the Clear Creek corridor was built in the 1960s, predating the National Environmental Policy Act (**NEPA**), with minimal drainage erosion control and certainly prior to concerns about managing the application of traction sand. I-70 drainage infrastructure consists of inlets and cross culverts that convey stormwater runoff and snowmelt from the hillside above, the inside travel lane and the median. The outside lane generally drains freely away from the roadway, down the fill slope into Clear Creek. The application of traction sand onto the highway is a visible and obvious concern to the adjacent Clear Creek waterway, particularly in narrow corridors where the interstate is in close proximity to the waterway. However, the term, *Sediment Control,* is collectively used to refer to *all* sources of sediment, including hillside erosion, cut and fill embankment erosion, and channel bank erosion.

BEST MANAGEMENT PRACTICES (BMPs)

The I-70 Clear Creek corridor can be conveniently separated into upper and lower Clear Creek with Georgetown Lake as the dividing line. The primary source of sediment in upper Clear Creek is I-70 traction sand and slope erosion. The primary source of sediment in lower Clear Creek is I-70 slope erosion, stream bank erosion, and offsite erosion of tributary drainages impacted by historic mining and local access roads. Traction sand, slope erosion, and stream bank erosion are sources of sediment directly related to the operation and maintenance of I-70.

The primary focus of this SCAP is sediment control and maintenance of related Best-Management Practices (**BMPs**) that are designed to capture the sediment before reaching Clear Creek. It is well documented that total phosphorus and total metals associated with sediment can also be controlled with adequate BMPs. Dissolved salts related to I-70 cannot be easily mitigated by conventional sediment control BMPs. However, retention of salt-laden runoff in control structures will also reduce direct salt loading to Clear Creek.

A list of recommended BMPs has been developed for the I-70 Clear Creek corridor and included in this report. To the extent possible, sediment should be managed and captured within the road right-of-way. Sediment control at the source is the most effective and sustainable method of protecting all segments of Clear Creek.

The primary sediment control strategies in this plan include:

- Minimize the application of traction sand through improved technologies
- Capture and remove sediment within the roadway right of way to the extent practical
- Capture/contain sediment and eroded material deposits in easily maintained areas
- Bypass clean tributary water to prevent contamination by highway runoff
- Minimize the volume of water requiring treatment
- Increase the number and size of sediment capture areas, especially in critical areas (high elevation and steep roadway sections)
- Provide controlled snow/sand storage areas, where possible
- Improve the highway storm drainage network and outfall areas to reduce erosion

- Reduce salt loading from snowmelt runoff
- Reduce cut slope and fill slope erosion
- Reduce rill erosion in shoulder areas
- Maximize vegetation cover as necessary to stabilize soil and prevent slope erosion
- Develop preventative maintenance programs (Sediment Maintenance Program)
- Increase funding for BMP maintenance

At the time this SCAP was written, there were only 13 BMPs that existed within the I-70 roadway corridor. Only a few were constructed for the purpose of intercepting traction sand. The eastbound Twin Tunnels project from Idaho Springs to Floyd Hill is the first CDOT project to implement the SCAP recommended BMPs and added to this list.

CDOT maintenance forces have been taking a more proactive approach in removing excess traction sand from the highway shoulders each year. Since it will take time and money to construct additional BMPs, there has been more reliance on maintenance to capture used traction sand on the highway. Current efforts to capture traction sand are mostly non-structural and include the following:

- Increased use of deicing salt agents rather than sand
- Better equipment and training to improve application to reduce over-sanding
- Roadway sweeping after snow events
- Shoulder cleaning and excavation annually to remove accumulated sand and sediment
- Cleaning of culverts and inlets

Based on past research and experience in high elevation snowfall traction sanding areas in Colorado, the following primary sediment control measures are proposed for the Clear Creek I-70 corridor:

- Sedimentation basins and traps (ponding areas) to capture sediment
- Paving of shoulder areas to reduce rill erosion and provide a surface for cleaning
- Rundowns to control erosion from concentrated stormwater runoff
- Valley pan drains to store snow and sediment, and control and route highway runoff
- Knee walls to prevent cut slope erosion
- Curb and gutter to contain sediment on the paved surface and reduce migration of sediment directly onto fill slopes
- Controlled snow storage/sand deposition areas
- Revegetation program
- Maintenance BMPs
- Sediment Maintenance Program

The SCAP is based on existing conditions of the I-70 drainage infrastructure. As the interstate is reconstructed, the drainage infrastructure will likely be replaced and upgraded to reduce or eliminate erosion and to provide for capture of sediment. The associated ***SCAP Mapbook*** provides recommendations for BMPs primarily within the interstate right-of-way for capital improvement projects to control sediment. The basis for this SCAP is control of highway traction sand and slope erosion, and therefore, the capital improvements are focused on highway-related sediment control. Erosion control of mine tailings, stream bank stability and general hillside erosion have been noted as sediment sources, but are not the focus of the SCAP document recommendations.

The accompanying ***SCAP Mapbook,*** in 11x17 format, was prepared to document existing conditions and identify the type and location of recommended BMPs for the entire corridor. The following tabulation describes the total number of nine different types of BMPs recommended along the corridor.

BMP	Quantity	Unit
Sediment Basin (small)	146	Each
Sediment Basin (large)	37	Each
Inlet Trap	191	Each
Bench Trap	14,537	Linear Feet
Clean Water Diversion	247	Linear Feet
Inlet	7	Each
Curb & Gutter	94,433	Linear Feet
Pipe Rundowns	57	Each
Valley Pan Drain	18,772	Linear Feet

The total cost to design and construct the recommended BMP infrastructure tabulated above is $21 million in 2012 dollars. The annual cost to maintain all of these BMPs once fully constructed is estimated to be $607,000 in 2012 dollars. In addition, $650,000 in new equipment will be necessary to adequately maintain these recommended BMPs. This new equipment can be shared throughout CDOT Region 1 and is not necessarily associated solely with the 33-mile reach of this SCAP.

PRIORITY AREAS

Although the amount of roadway traction sand applied each year is weather dependent, it is generally greatest at higher elevations associated with higher snowpack and colder temperatures. Slope erosion is most prevalent on steep gradient reaches of I-70 and where vehicle traction is most critical. The following criteria were used to establish priority areas for sediment control along the Clear Creek I-70 corridor:

- Areas with no structural BMPs currently in place
- Areas in close proximity to I-70, providing good access for installation and maintenance of structural BMPs with minimal disturbance to adjacent lands
- Elevation zone and high traction sand usage areas
- Areas with direct sediment transport to streams with little or no storage (tributaries)
- Drainage problem areas including cut slope and fill slope erosion

BMPs are needed throughout the Clear Creek corridor to reduce sediment loading; however, some reaches are a higher priority. The three reaches within the 33-mile study area of I-70 that received the most traction sand annually are listed below and noted with the associated mileposts (**MP**):

- East of Eisenhower–Johnson Memorial Tunnel (**EJMT**) (MP 215 – MP 219)
- Georgetown Hill (MP 225 – MP 228)
- Floyd Hill (MP 244 – MP 248)

These three areas represent 11 miles or 33% of the entire 33 mile study corridor, yet are estimated to produce over 50% of the highway-derived sedimentation in the I-70 Clear Creek corridor. This is primarily due to a combination of slope erosion in high gradient areas and more unconsolidated material (traction sand) resulting in high sediment transport rates. The three priority areas are described in greater detail below:

Eisenhower Tunnel MP 215-219

The first two miles (215-217) are highest in elevation and have very heavy traction sand use. Deep deposits of sediment are visible along the roadway in fill slopes and ditch lines. Full implementation of the SCAP on I-70 from in this area would provide significant water quality improvements to Clear Creek, and therefore is recommended to be a priority. Most of the BMPs recommended within this reach are large sedimentation basins along the roadway and at the toe of slopes.

Georgetown Hill MP 225-228

I-70 at Georgetown Hill has a steep gradient of greater than 6 percent consisting of a massive cut and fill slope. Rockfall mitigation is a major ongoing activity conducted by CDOT on Georgetown Hill. Mass wasting and erosion of the cut slope, as well as gully erosion on the fill slope caused by inadequate drainage control outfalls, supply sediment to Clear Creek in large quantities. A majority of the BMPs proposed in the SCAP for this area are sediment basins at the toe of the fill slope, or along the pavement of the cut slope ditch line. The basins are accessible for construction and maintenance from existing access roads for the Georgetown Loop railroad below the fill slope.

Floyd Hill MP 244-248

I-70 at Floyd Hill has steep gradients of greater than 5 percent on both west and east sides of the hill. The west side consists of massive fill slopes. Erosion repair and slope stabilization are ongoing activities conducted by CDOT on Floyd Hill. Sediment is deposited on the frontage road and at the toe of the fill slope, and is transported to Johnson Gulch and Clear Creek in large quantities. Full implementation of the SCAP is recommended for this high priority area of Floyd Hill. Nearly all of the BMPs proposed in the SCAP for this area are sediment basins near the toe of the fill slope and in ditch lines. The basins are accessible for construction and maintenance from the existing frontage road and I-70.

Another priority is capturing sediment from historic mining areas. Although not directly an I-70 issue, cooperation with CDOT to develop BMPs within the right-of-way will greatly benefit water quality in Clear Creek.

Mining District MP 234-241

Historic mine waste residuals are considered high priority material to collect and remove from CDOT right-of-way (**ROW**) before entering receiving streams. The SCAP recommends sediment control BMPs in mine waste and tributary areas to protect CDOT infrastructure and operations, while improving Clear Creek water quality.

OPERATIONS AND MAINTENANCE

Once permanent structural BMPs are installed, it is important to inventory the number and type of BMPs and document the amount of sediment captured each year. With each new BMP constructed it is important to develop an Operations and Maintenance Plan. The plan should address when maintenance is needed and what maintenance is required.

The plan should also include a disposal plan for the sediment. Used traction sand is considered solid waste and can be disposed of in landfills, but transportation costs can be high. Traction sand studies indicate that up to 50 percent of the sand can be re-used, but it must be washed and sorted to meet CDOT specifications for traction sand. On the western slope, used traction sand has been utilized for the construction of sound berms in urban areas along I-70. In narrow stream corridors such as Clear Creek, there is very limited space to dump excess rock and sediment. Fill areas need to avoid riparian zone and floodplain areas of the creek. Most of the available disposal sites have already been filled to capacity over the past 50 years in the I-70 Clear Creek Canyon area. A study should be conducted to determine the long-term feasibility, locations, and cost of highway-related sediment disposal for the Clear Creek corridor.

IMPLEMENTATION PLAN

Implementation of water quality BMPs is hampered by:

- Lack of funding
- Lack of complete highway re-construction projects that could implement BMPs
- Lack of space and safe access
- Limited land area within the CDOT Right-of-Way
- A voluntary program – there are no current state or federal regulatory requirements for permanent sediment control and maintenance

Many uncertainties exist regarding the timing of SCAP implementation in the Clear Creek corridor. Although the SCAP is designed for full build-out of the preferred alternative in the Programmatic Environmental Impact Statement (**PEIS**), it is unknown when funding will be available to reconstruct I-70. CDOT has committed to implementing the SCAP for each reconstruction project that is identified and funded; however, full implementation of the SCAP may take 20 years or longer. Therefore, a significant timing gap may exist for implementation of the SCAP recommended BMPs within the corridor.

Interim levels of SCAP implementation and costs must be considered to make progress towards sediment load reductions in Clear Creek in both the short and long term. Three SCAP implementation scenarios have been identified that include:

1. Maintenance Program,
2. Currently Identified Capital Improvement Projects and Maintenance, and
3. Full SCAP Implementation and Maintenance.

The challenge of BMP implementation for linear corridors has led to regional solutions by trading "water quality credits" within a watershed. For example, due to constraints such as land ownership and lack of space, BMP facilities are constructed where they treat water quality regionally so that the overall benefit to the stream system is equal to or greater than treating only the development project area.

There is need to pursue the low hanging fruit – sediment control projects that will have the greatest immediate benefits. Given the limited resources and available funding, preference should be given to priority projects. As noted, the high priority BMP areas are not within the currently funded CDOT project areas. CDOT should seek to build BMP projects where they will capture the most sediment and are most effective. CDOT is exploring options to construct BMPs outside of CDOT project areas. These pursuits may require partnerships with other entities.

PARTNERSHIPS

One solution for CDOT to reduce the amount of traction sand and salt applied to the interstate each year is simply closing the roadway during snow storms. This is certainly not practical due to the high usage and shows how everyone is a partner in the control of sediment.

The Upper Clear Creek Watershed Association (**UCCWA**) could provide the overall watershed policy leadership. With membership including representatives from all the major water providers in the upper Clear Creek watershed, it is UCCWA's primary focus to protect and enhance water quality within the watershed. Stakeholders should meet periodically to discuss the status of individual efforts and look for opportunities to partner and leverage each other's efforts to make projects larger, more complete and address "Gap Areas".

CDOT will be spending money on sediment control BMPs on future capital improvement projects on the I-70 Mountain Corridor. CDOT's expenditures should be used as a match to garner additional grant funds and partner funds. Because of the overall sediment control vision for the Clear Creek drainage, having the Clear Creek SCAP in place as a master plan vision for the entire corridor allows the opportunity to leverage existing project funds in different areas of the corridor.

1.0 INTRODUCTION AND PURPOSE

1.1 Background

The Colorado Department of Transportation (**CDOT**) Region 1 identified the need to control sedimentation along the Interstate Highway 70 (**I-70**) mountain corridor through the Rocky Mountains. Excessive sediment is produced from the erosion of existing highway road cut and fill areas and from traction sand applied to the roadway during the winter. This material, collectively referred to as sediment, is transported from the highway rights-of-way by surface water runoff and is deposited into streams, lakes, and wetlands. Excessive sediment loading can impair water quality, degrade fish habitat, and inundate wetland vegetation.

Surface water resources in the Clear Creek I-70 corridor from Beaver Brook to the Eisenhower-Johnson Memorial Tunnel (**EJMT**) have been identified through CDOT studies as being impacted by roadway-derived sediment. To-date, Clear Creek has not been formally identified as being impaired for sediment. CDOT has voluntarily undertaken efforts to reduce erosion and sedimentation from the highway in many areas. However, until this study, no comprehensive evaluation has been conducted in the Clear Creek corridor to quantify the extent of highway related sediment impacts or to develop control strategies.

Several sediment control structures already exist in the Clear Creek I-70 corridor. Permanent BMPs have been implemented in a few areas, including:

- Installation of sediment detention structures near the east portal of the EJMT and Georgetown Lake
- Installation of sediment detention structures and in selected mine-impacted tributaries near Dumont and Idaho Springs
- Sweeping and roadside collection and disposal of excess sediment
- Slope stabilization through riprap placement and revegetation of selected cut and fill slopes to reduce erosion rates in the Floyd Hill area

These activities are ongoing and their effectiveness in reducing sedimentation of Clear Creek has not yet been determined.

1.2 Study Area

The Clear Creek SCAP study area is entirely within Clear Creek County and covers a thirty-three mile segment of I-70 from the east portal of the Eisenhower-Johnson Memorial Tunnel (MP 215) to the east base of Floyd Hill at Beaver Brook (MP 248), see Figure 1-1. Clear Creek is the receiving waterway along the entire study area. Georgetown Lake (MP 229) is a significant water body on-line within the central reach of Clear Creek. I-70 follows the stream valley from the headwaters of Clear Creek near the Continental Divide downstream to Floyd Hill, with the creek flowing adjacent to I-70 throughout this length (29 miles). The Floyd Hill portion of I-70 is also tributary to Clear Creek from Johnson Gulch to Beaver Brook.

This highway segment is characterized as a steep mountain environment with hill slopes at the angle of repose and near vertical rock outcrops in steep canyon areas. I-70 was constructed primarily on the north side of Clear Creek by cut and fill methods in most areas, with fill material placed on the north bank of Clear Creek. The Clear Creek valley becomes more constricted into a narrow canyon and was channelized by I-70 fill material in many areas from

Dumont downstream to Floyd Hill. The cut and fill slopes have largely stabilized over the past 50 years, although slope erosion remains a problem in certain areas. Annual application of highway traction sand and deicer salts is required to maintain safe mobility during winter.

Figure 1-1 Study Area Map – EJM Tunnel to Beaver Brook – 33 miles

For purposes of this SCAP, the Clear Creek corridor has been segmented into upper and lower Clear Creek with Georgetown Lake being the dividing point. Georgetown Lake is the only major impoundment on Clear Creek in the study area and traps all sediment originating from upstream sources. Areas upstream of Georgetown Lake include Georgetown Hill and I-70 above 9,000 feet elevation where annual snowfall is much greater and more winter maintenance material (sand and salt) is required to maintain safe mobility. The highway gradient in upper Clear Creek is also greater in most areas, resulting in higher erosion rates. Sedimentation rates related to I-70 are documented to be greater in upper Clear Creek (CDOT 2011b).

Figure 1-2 Close up view of the inlet to Georgetown Lake. Note the sediment deposition.

The Georgetown Lake inlet collects mobilized sediment from the upper watershed. Although Georgetown Lake protects the downstream waterway, it does not benefit the upper watershed. Dredging of sediment from the Clear Creek channel at Georgetown Lake is not sustainable and would not protect the sensitive and diverse nature of the upstream impacted waterway from further impairment. Studies have shown that Clear Creek water quality is markedly improved immediately downstream of Georgetown Lake. Lower Clear Creek downstream of the reservoir includes areas of I-70 below 9,000 feet elevation that receive lower snowfall and require generally less winter maintenance material. This area also falls within the Colorado Mineral Belt where land disturbance from historical mining activity is prevalent, particularly in the Dumont-Idaho Springs area. Studies have shown that sedimentation of Clear Creek is dominated by other sources in lower Clear Creek relative to sediment from I-70. The major exception is Floyd Hill, with steep highway gradients on both the west and east approaches resulting in high slope erosion rates.

Clear Creek supplies water to approximately 350,000 people in the watershed, supports numerous industries, and supports a viable brown trout population within the corridor. Fish population estimates and habitat assessments have been conducted by the Colorado Parks and Wildlife and others to assess potential impacts to the aquatic environment.

1.3 Sweep Program and Related I-70 Programs

The Colorado Department of Transportation convened the Stream and Wetland Ecological Enhancement Program (**SWEEP**) Committee, an advisory committee consisting of fishery biologists, hydrologists and other watershed and water quality-related technical experts, community representatives and other potentially affected parties. The shared objective of all SWEEP Committee members is to improve stream and wetland conditions in the I-70 Mountain Corridor.

All parties, including CDOT to the SWEEP Memorandum of Understanding (**MOU)** have committed to a framework for cooperation that will:

1. Create a system for management and mitigation over the life of the projects.
2. Follow the CSS Decision Process in developing mitigation procedures based on SWEEP recommendations.
3. Outline a process for collaboration and defining specific strategies for avoidance and mitigation.
4. Determine appropriate people and data resources to develop strategies. Expand Tier 1 recommendations to avoid, minimize and compensate for impacts during Tier 2.
5. Identify issues to be considered.
6. Use diversity of data resources and stakeholders to recognize corridor issues related to streams and wetlands. Allow for dynamic nature of diverse experiences and ideas.
7. Address cumulative impacts.
8. Collect data on past corridor activities and future growth projections to predict potential impacts on water quality.
9. Prioritize and specify aquatic, riparian and amphibian resources.

10. Assemble Corridor studies and information on species with special designation to identify those species and habitats that should be priority while establishing mitigation recommendations.
11. Define the process for developing mitigation for Tier 2 documents (site-specific, project-level National Environmental Policy Act (NEPA) documents).
12. Determine SWEEP Committee involvement in Tier 2 and how mitigation recommendations will be incorporated into project development.
13. Identify parties and how they work together.
14. Agree to work together effectively and outline expectations, including general and specific roles and responsibilities.
15. Pool resources, when resources are available.
16. Maintain collaboration as an efficient way to use individual expertise, gather agency/group information and concentrate the focus while allowing room for innovative solutions.
17. Identify realistic opportunities for specific issues and sustainability.
18. Promote the development of mitigation recommendations specific to a watershed, community, or project with future needs and resources in mind.
19. Compare past activities and apply lessons learned to recommendations for future mitigation strategies.
20. Develop standards, quality control and assurance and processes for future studies.
21. Expand existing standards to fit future Tier 2 needs and support activities that meet or exceed these standards.

The SWEEP Committee identified and recommended appropriate mitigation strategies including design, implementation and monitoring for anticipated environmental impacts likely to occur as a result of redevelopment of the I-70 Mountain Corridor. These recommended mitigation strategies were presented in the SWEEP “Implementation Matrix” that became part of a Memorandum of Understanding (**MOU**), on January 4, 2011 among the SWEEP Committee members. Committee members and parties to the MOU include:

- Colorado Department of Transportation (CDOT);
- Federal Highway Administration (FHWA);
- U.S. Fish and Wildlife Service (USFWS);
- Rocky Mountain Region;
- USDA Forest Service (USFS);
- Arapahoe-Roosevelt and White River National Forests;
- USDOI Bureau of Land Management (BLM);
- Colorado Division of Wildlife (CDOW), now known as Colorado Parks and Wildlife(CPW);
- Clear Creek County;
- Clear Creek Watershed Foundation;
- Upper Clear Creek Watershed Association (UCCWA); and

- Colorado Trout Unlimited.

The SWEEP MOU, including the "Implementation Matrix" can be viewed on-line at i70mtncorridorcss.com. The "Implementation Matrix" provides guidance for developing recommendations at each life cycle phase of projects on the I-70 Mountain Corridor. The Matrix outlines inputs, considerations and outcomes for each life cycle phase of a project that are consistent with the phases used by the I-70 Mountain Corridor Context Sensitive Solutions (CSS) decision-making process.

There are five I-70 Mountain Corridor CSS project life cycle phases including:

1. I-70 Mountain Corridor Planning
2. Project Development
3. Project Design
4. Project Construction
5. I-70 Mountain Corridor Operations, Maintenance and Monitoring

The SWEEP "Implementation Matrix" addresses three major areas of concern: water quality, natural habitat and information. Sediment management is a major factor in protecting water quality within the watersheds of the I-70 Mountain Corridor. The corridor experiences severe weather during the winter months; therefore, CDOT and local agencies use significant amounts of traction sand and deicer salts to keep the roadway open and safe. CDOT previously developed two Sediment Control Action Plans (**SCAP**) on the West Slope to identify solutions to sedimentation, but not all watersheds have been studied.

The SWEEP "Implementation Matrix" identifies the need to develop SCAP's in areas where they are needed, such as the Clear Creek Watershed. SWEEP also supports updating existing SCAP's to reflect completed projects and water quality features, modifications and lessons learned.

All SCAP's, both the existing and newly created, must be coordinated with the wildlife linkage zones to minimize linkage interference as identified by the "A Landscape Level Inventory of Valued Ecosystem Components" Committee (**ALIVE**). This Committee's goal is to increase the permeability of the I-70 Mountain Corridor to terrestrial and aquatic species in order to provide and maintain long-term protection and restoration of wildlife linkage areas, improve habitat connectivity and preserve essential ecosystem components.

The Clear Creek SCAP is the first SCAP to be created or updated since the SWEEP MOU was signed in 2011. Therefore, this document serves as the most current template or model for sediment management within the I-70 Mountain Corridor.

1.4 PROJECT PURPOSE

Excessive sediment loading has been occurring in Clear Creek, especially in the areas where Clear Creek is directly adjacent to a roadway. Sources of sedimentation associated with I-70 include both cut and fill slope erosion and winter maintenance practices when the roads are sanded for traction to maintain safety to the traveling public.

This project purpose includes:

1. An assessment of water quality in Clear Creek and its impact on stream and riparian health, including an evaluation of sediment and magnesium chloride used for winter highway traction,
2. A quantification of the applied traction sand as a source of sediment,
3. Identification of conceptual methods for controlling or reducing sediment from natural erosion and roadway maintenance activities,
4. Development of conceptual designs for sediment control measures, i.e. Best Management Practices (BMPs),
5. Project mapping to identify locations for BMP installation,
6. Development of cost estimates for construction and maintenance of BMPs, and
7. Stakeholder coordination.

1.5 Stakeholder Coordination and Context Sensitive Solutions

This project applied the Contact Sensitive Solutions (CSS) approach developed for the I-70 Mountain Corridor. The project followed CSS principles regarding stakeholder involvement and the 6-step decision making process. CSS was implemented as directed in the *I-70 Mountain Corridor Guidance* document for coordination with the various stakeholders.

Stakeholder meetings were held for this project on the following dates for this project

- October 18, 2010 – Kickoff meeting
- November 15, 2010 – Coordination meeting
- November 29, 2011 – Progress meeting
- February 24, 2012 – Progress meeting

This study acknowledges the participation and contribution from the following individuals:

Name	Organization
Scott McDaniel	CDOT Headquarters
Jim Bemelen	CDOT Region 1
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Alison Michael	U.S. Fish & Wildlife Service
Gary Frey	Trout Unlimited
Mike Crouse	Clear Creek Consultants
Kevin Shanks	THK Associates
Allan Brown	Atkins
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1.6 Project Approach

An inventory of past sediment control activities and projects on Clear Creek was undertaken to identify permanent BMPs installed, maintenance operations to remove sediment, and other measures taken to address water quality impacts from highway-related activities. Work involved the collection and compilation of existing information, data, and mapping concerning the status of the highway drainage system, streams, and near-by water bodies or wetlands. Work included summarizing the current and past conditions of the affected streams and water bodies.

A detailed field reconnaissance of the Clear Creek I-70 corridor from the EJMT to the Beaver Brook interchange was conducted during the fall of 2010 and spring of 2011. The purpose of the reconnaissance was to:

- Make an initial assessment the effectiveness of existing sediment/erosion control measures, to the extent feasible
- Assess sediment deposition and erosion conditions
- Identify surface water resources that have been impacted, and potential source areas to the extent feasible
- Develop and refine conceptual permanent BMPs using field information
- Provide a preliminary hydrologic assessment of drainage conditions related to I-70 (review mapping and identify culvert outfall conditions)
- Identify and prioritize problem areas
- Make an initial assessment of the feasibility of implementation for cleanup measures and installation of permanent BMPs
- Conduct a limited geotechnical/soils and revegetation review with regard to slope stability and erosion control
- Photo-location documentation and mapping of existing conditions and relevant features

A GPS inventory of culverts, drainage features, problem areas and preliminary recommendations was completed for the Clear Creek corridor. Using existing information and additional site-specific observations collected during the reconnaissance, work maps were developed that depicted existing sediment control features and areas of significant sediment loading.

The field work and assessment culminated in a written analysis and recommendations for further cleanup and maintenance strategies. A listing of potential strategies was developed that included both non-structural operations and maintenance and capital improvements for BMPs that would be effective in sediment control. Permanent BMPs evaluated included traditional sediment control structures (detention basins) or slope stabilization activities, as well as innovative improvements used in other states. The evaluation included an overview of the institutional and regulatory environment, as well consideration of the community at large by acknowledging specific community concerns such as water supply/treatment intake areas.

An integrated watershed approach to sediment control is recommended to provide effective water quality protection. Recommendations included the implementation of multiple BMPs in priority areas with the object of reducing sediment loading to receiving waters. Drainage alternatives considered included re-routing clean water inflows to prevent contamination, or methods to capture sediment. Other options considered included reducing the size of contributing drainage areas by installing additional culvert drains to reduce the volume and erosive energy of the water. The hydraulic review was integrated with sediment control objectives to develop a menu of effective BMPs. With each potential capital improvement, the level of environmental analysis or permitting required was estimated to gain an understanding of the feasibility of the implemented activity.

This project Identified capital improvement projects and their estimate costs for construction and installation. The estimated costs for maintenance activities associated with sediment control (e.g., sediment removal and disposal, reclamation and revegetation, etc.) were also evaluated.

An implementation plan will be developed for this SCAP that further outlines feasibility and cost for various sediment control scenarios. This will include the development of a priority list of areas and control strategies.

1.7 PREVIOUS STUDIES

Two other streams of particular concern within the I-70 corridor have already been identified as being impaired by sedimentation from I-70. These include Straight Creek and Black Gore Creek. Straight Creek is a perennial mountain stream that parallels I-70 on the west side of the EJMT. I-70 was constructed along the length of Black Gore Creek, a perennial mountain stream on the west side of Vail Pass. Both of these stream systems have been impaired by excessive sedimentation from I-70 and are undergoing Total Maximum Daily Load (**TMDL**) monitoring and analysis under the Federal Clean Water Act. CDOT is undertaking efforts to reduce sediment loading in these watersheds and several Best Management Practices (**BMPs**) aimed at controlling sediment have been implemented. Stakeholder groups have been formed to discuss water quality concerns and to develop sediment control strategies. A significant amount of progress has been made towards remediating problem areas in Straight Creek and in Black Gore Creek.

Ongoing water quality studies related to historic mining activities have been undertaken by Federal and State agencies in the Clear Creek Watershed for more than 25 years. The Clear Creek/Central City Superfund Site was listed on the National Priorities List in 1983 by the U.S. Environmental Protection Agency to address pollution from abandoned mines. I-70 intersects the Idaho Springs and Silver Plume Mining Districts, which are included in the designated Superfund Site area.

1.8 Regulatory Framework and Stream Water Quality Regulations

Under the federal Clean Water Act of 1977 (**CWA**), as amended by the Water Quality Act of 1987, the Environmental Protection Agency (**EPA**) established a framework for protecting and improving the nation's water quality. The broad purpose of the CWA is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters". Its emphasis is to declare unlawful the unregulated discharge of pollutants into all waters of the United States. The CWA makes the States and EPA jointly responsible for identifying and regulating both point and non-point sources of pollution. Point sources are controlled by a permit-based system (water quality standards), while nonpoint sources are approached with a technology-based management strategy (treatment processes and best management practices).

Each state is required to develop and adopt water quality standards that enumerate the designated uses of each water body as well as specific criteria necessary to protect or achieve those designated uses. State water quality programs are required to integrate three components into water quality management planning:

(1) a designation of uses for all state waters
(2) numeric or narrative criteria to meet those uses, and
(3) an anti-degradation policy for waters that meet or exceed criteria for existing uses.

The Colorado Department of Public Health and Environment (**CDPHE**), Water Quality Control Commission, C.R.S. 1973, 25-8-101, as amended, promulgates regulations specifying classifications and numeric water quality standards for Colorado by river basin. The Clear Creek I-70 mountain corridor is in the South Platte River Basin, as defined by CDPHE. Water quality is regulated for the South Platte River Basin under Regulation No. 38 (CDPHE 2011). Each river basin is divided into regions related to watershed divisions. The I-70 mountain corridor east of the Continental Divide is in Region 3 and includes Mount Vernon Creek and Clear Creek. Water bodies are further divided into stream segments according to waste load allocations.

Surface waters of the state are classified according to the uses for which they are presently suitable or intended to become suitable. At a minimum, for all state surface waters existing classified uses and the level of water quality necessary to protect such uses must be maintained and protected. No further water quality degradation is allowable which would interfere with or become injurious to these uses. The classified uses shall be deemed protected if the narrative and numerical standards are not exceeded (CDPHE, 2011). The designated use classifications for study area stream segments are listed in Table 1-1. Numeric water quality standards apply for protection of these designated uses. Regulatory stream segments are shown in Figure 2-3.

Table 1-1 Clear Creek Stream Use Classifications

Stream Segment Description	Water Supply	Aquatic Life Cold 1	Recreation 1	Recreation 2	Agriculture
Clear Creek above Silver Plume (Seg.1)	X	X		X	X
Clear Creek Silver Plume to Argo T. (Seg.2a,b,c)[2]	X	X	X		X
Clear Creek Argo Tunnel to Golden (Seg.11)[1,2]	X	X	X		X

[1]Designated as Use Protected
[2]Listed on 303(d) for TMDL analysis for metals

Clear Creek Segment 11 is designated as use-protected. The Colorado Water Quality Control Commission has determined these are waters that do not warrant the special protection provided by the outstanding waters designation or the anti-degradation review process. Waters are designated by the Commission use-protected if any of the criteria below are met, except that the Commission may determine that those waters with exceptional recreational or ecological significance should be undesignated, and deserving of the protection afforded by the anti-degradation review provisions:

- The use classifications of the waters include aquatic life cold.
- The existing Clear Creek water quality is worse than that specified for the protection of aquatic life class 1, recreation class 1 and (for nitrate) domestic water supply uses for the following parameters per the EPA tables of guidelines:
    1. Dissolved oxygen, pH, fecal coliform or E. coli
    2. Chronic un-ionized ammonia, nitrate
    3. Chronic cadmium, chronic copper, chronic lead, chronic manganese, chronic selenium, chronic silver, and chronic zinc.
- The water body is subject to significant existing point source discharges and the quality currently is maintained better than standards only because the treatment achieved by the existing dischargers exceeds requirements of federal and state law and might not be maintained at that level in the future.

Several Clear Creek segments adjacent to I-70 have been identified as water quality impaired for metals related to historic mining. Clear Creek Segment 2a is listed as impaired for cadmium and zinc in the Silver Plume/Georgetown area. Segment 2c is impaired for copper in the Dumont/Idaho Springs area. Segment 11 is listed as impaired for cadmium downstream of Idaho Springs (CDPHE 2011).

Stream segments identified as impaired are those in which one or more classification or standard has not, or may not be, fully achieved. As necessary for the protection of the water resource, TMDLs are established to set the maximum amount of pollutant that may be allowed while still complying with water quality standards. TMDLs are implemented and regulated through the issuance of permits for point sources (such as wastewater treatment plants) and the use of BMPs for nonpoint sources such as highway runoff.

The results from water quality monitoring conducted in Clear Creek by CDOT from 2000 to 2009 are summarized in Table 1-2. The numeric stream standards currently in effect are also shown for comparison.

Table 1-2 Clear Creek Storm Event/Snowmelt Mean Concentrations (mg/L)
I-70 Mountain Corridor – 2000 to 2009

Stream Segment	Number of Samples	Suspended Solids	Phosphorus Total	Chloride	Sodium Diss.	Magnesium Diss.	Hardness as CaCO3	Cadmium Diss.	Copper Diss.	Manganese Diss.	Zinc Diss.
Standard*			***0.11***	***230***				***0.0003***	***0.008***	***0.050***	***0.094***
Clear Creek CC-1 (Seg.1)	124-131	200	0.27	48.8	19.3	5.5	63	0.0009	0.004	0.031	0.010
Standard*			***0.11***	***230***				***0.0015***	***0.008***	***0.050***	***0.353***
Clear Creek CC-2** (Seg.2a)	28-38	10	0.03	11.2	6.2	5.1	58	0.0008	0.003	0.008	0.080
Standard*			***0.11***	***230***				***0.0014***	***0.017***	***0.050***	***0.229***
Clear Creek CC-3** (Seg.11)	25-32	221	0.33	9.2	12.2	4.7	65	NA	0.006	0.221	0.120
Clear Creek CC-4** (Seg.11)	33-52	264	0.44	9.3	12.6	4.5	61	0.0011	0.006	0.154	0.097
I-70 Highway Runoff	65-72	953	0.87	137	71	16.1		NA	0.012	0.50	0.16

*Standards effective June 30, 2011 (standard for total phosphorus is proposed)
Trace metal standards based on average 61 mg/L hardness for Clear Creek; acute standards except chronic cadmium
**Data from 2000-2005 – no event samples collected after 2005; ambient cadmium data taken from UCCWA database

2.0 EXISTING CONDITIONS OF THE CLEAR CREEK I-70 CORRIDOR

2.1 Climate and Hydrology

Interstate 70 traverses the Clear Creek watershed through the SCAP study corridor extending from east to west at approximately 39.5 degrees north latitude. The climate is temperate, with warm summers generally extending from May to September and cold winters from October to April. The corridor is classified as a high mountain continental semi-arid climate strongly influenced by elevation and aspect.

Elevations range from approximately 7,200 ft-MSL at the west base of Floyd Hill to 11,200 ft-MSL at Eisenhower Tunnel. Altitude has the effect of changing temperature at a rate of 3.6 degrees Fahrenheit (^{o}F) for each 1,000-ft change in elevation. At this rate a temperature of 38 ^{o}F in Idaho Springs would correspond to a temperature of 23 ^{o}F at the Eisenhower Tunnel. This temperature gradient is a major factor with respect to the operation and maintenance of I-70 within the corridor during the winter months, when ice and snow accumulation is prevalent.

The seasonal temperature and precipitation distribution for the town of Idaho Springs is shown in Figure 2-1 (Colorado Climate Center 2012 http://ccc.atmos.colostate.edu/cgi-bin/monthlydata.pl). This data shows the temporal trend in mean temperature with below freezing conditions in winter (November to March) and maximum temperatures in July each year. The average annual temperature in the study area is 43 ^{o}F at Idaho Springs.

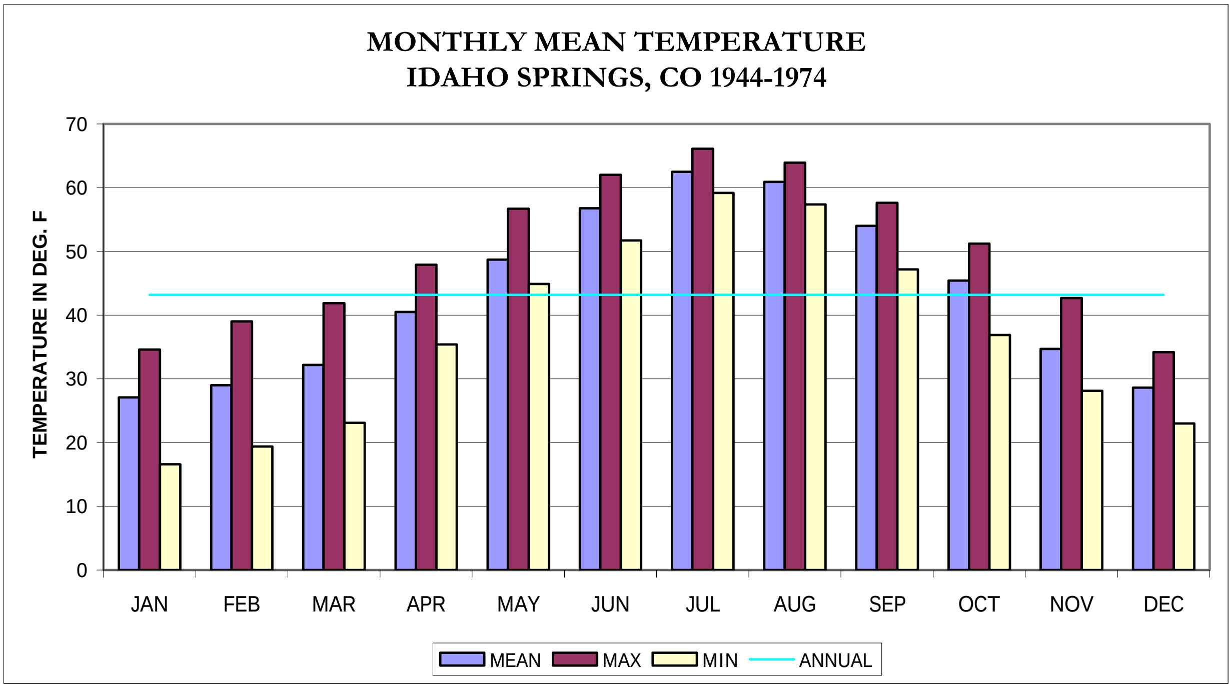
The elevation and season determine the form and temporal distribution of precipitation. Precipitation is dominated by rainfall during the summer months and snowfall during winter. Snow can remain on the north-facing slopes (where shaded) through the winter, while snow is removed from the highway to maintain safe mobility.

Precipitation amounts are moderate at lower elevations (7,000-9,000 ft-MSL) during winter and spring, with higher precipitation during the summer monsoon period (July-August), and a dry period in fall and early winter. Lower temperatures in winter result in most of the precipitation occurring as snowfall. Significant snow accumulation typically occurs through the winter months at elevations above 9,000 ft-MSL in the study corridor.

The seasonal precipitation pattern determines highway runoff and streamflow conditions in the study corridor. Other factors that can influence the natural hydrology include trans-mountain water diversions, storage reservoirs, and increases in impervious surfaces resulting from urban, commercial, industrial, and highway development.

The 2009 to 2011 mean daily streamflow hydrograph for Clear Creek at Kermitts (Station CC-4) is shown in Figure 2-2. The average mean daily flows for the period of record 1995-2005 are also plotted for historical comparison. This stream gage is operated by Clear Creek Consultants on behalf of the Upper Clear Creek Watershed Association (UCCWA), representing the Clear Creek I-70 corridor (267 square-miles). This gage location incorporates Clear Creek flows at the downstream end of the SCAP study area that have the greatest potential to be affected by I-70.

Snow that accumulates over the winter at elevations greater than approximately 9,000-ft melts in the spring, generating peak flows in Clear Creek. Streamflow generally recedes over the summer and fall, with increases resulting from rainfall-runoff events. Minimum flows occur in winter.



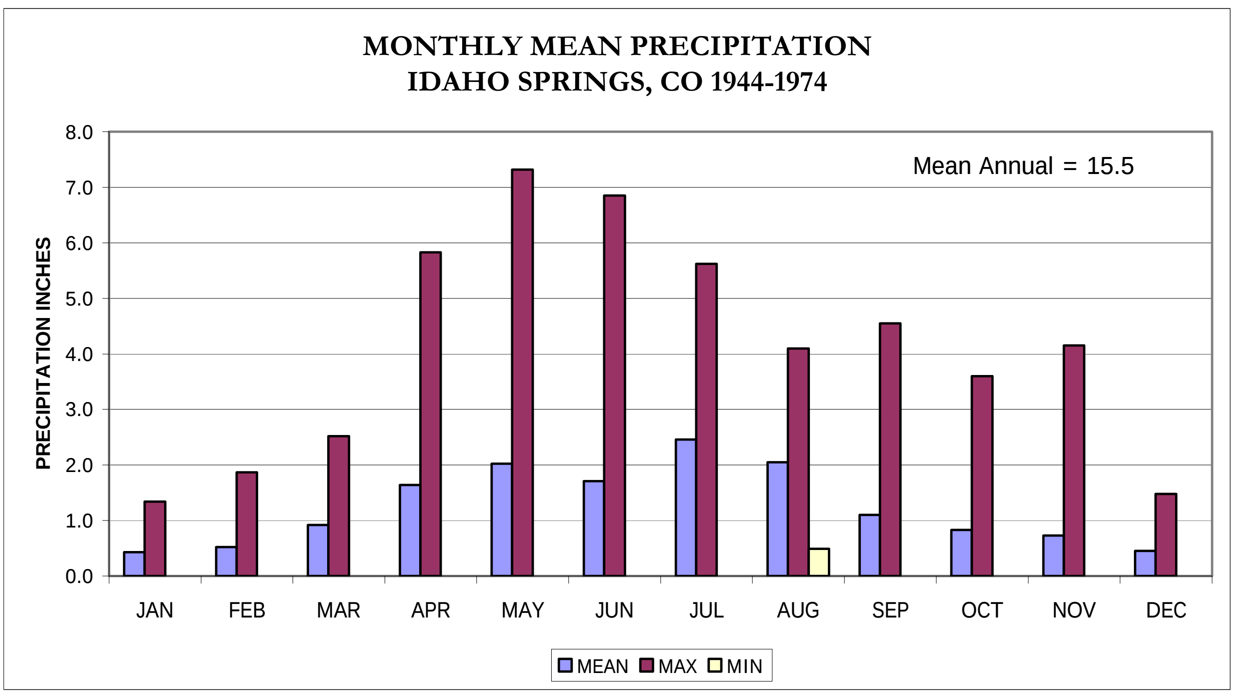


Figure 2-1 Monthly Mean Temperature and Precipitation – Idaho Springs, CO

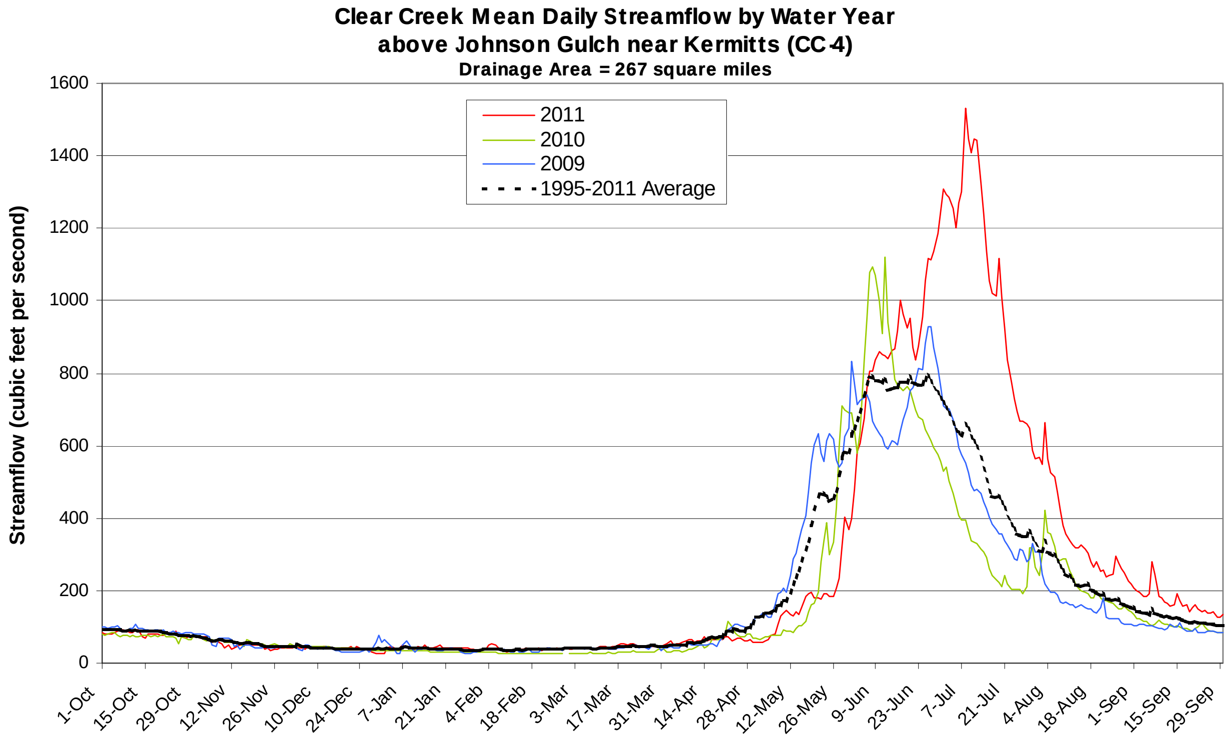


Figure 2-2 Clear Creek Mean Daily Discharge by Water Year

2.2 CDOT Water Quality Monitoring Data

The I-70 mountain corridor *Storm Water/Snowmelt Water Quality Monitoring Program* started in September 2000 and was continued through 2011 for selected streams along the interstate highway. The monitoring program is conducted under the direction of the CDOT. An I-70 Mountain Corridor Programmatic Environmental Impact Statement (**PEIS**) has also been completed to assess alternatives to improve mobility on I-70 between Golden and Glenwood Springs, Colorado, a distance of approximately 150 miles (CDOT 2011a). Four reports entitled "Data Evaluation Report, Interstate 70 Mountain Corridor Storm Event/Snowmelt Water Quality Monitoring" have been issued covering the period 2000-2011. The reader can refer to previous reports for detailed evaluation of data results (CDOT 2011b).

The monitoring program is an on-going long-term study of the effects of I-70 on receiving stream water quality in the mountain corridor. The objective of the monitoring program is to provide information on potential water quality effects of suspended sediment, phosphorus, trace metals, and dissolved salts (sodium and magnesium chloride) on streams within the study corridor. These are contaminants of concern that may originate from the road surface and highway rights-of-way of I-70. Stream water quality is affected by maintenance practices and material (sand and salt) that is constantly changing to meet the demands of the traveling public. On-going stream monitoring is needed to assess these changing conditions.

The 2001 to 2011 study period covers a broad range of annual flow conditions in Clear Creek, with relatively drier low flow years in 2002 and 2004 and higher than normal peak snowmelt years in 2006, 2007, and 2011. The frequency of storm runoff events varied considerably from year to year over the study period representing a wide range in runoff conditions at each Clear Creek monitoring station. Water quality variance associated with these flow conditions is represented in the CDOT data. Water quality monitoring results provide the basis for conducting SCAPs to address water quality impacts related to the operation and maintenance of I-70. Table 2-1 below presents the CDOT water quality monitoring locations on Clear Creek and Figure 2-3 on the next page displays the CDOT monitoring locations on a map, along with locations monitored by others in the watershed.

Table 2-1 Clear Creek CDOT Water Quality Monitoring Locations

Station ID	Location	Elevation (FT-MSL)	Latitude N Longitude W	Purpose
CC-1	Clear Creek below Herman Gulch	10,180	39 42' 01.00" 105 50' 56.00"	East Tunnel Approach water quality
CC-2	Clear Creek above West Fork	8,275	39 45' 09.00" 105 39' 41.50"	Riparian Zone – intermediate elev. conductivity/temperature only
CC-3	Clear Creek at Twin Tunnels	7,330	39 44' 41.00" 105 28' 19.90"	Hidden Valley Segment paired conductivity/temperature only
CC-4	Clear Creek at Kermitts	7,220	39 44' 46.27" 105 26' 9.19"	Hidden Valley Segment paired conductivity/temperature only
CC-231	I-70 Culvert at Empire Junction Milepost 231.5	8,225	39 45' 29.67" 105 39' 21.25"	I-70 highway water quality test section

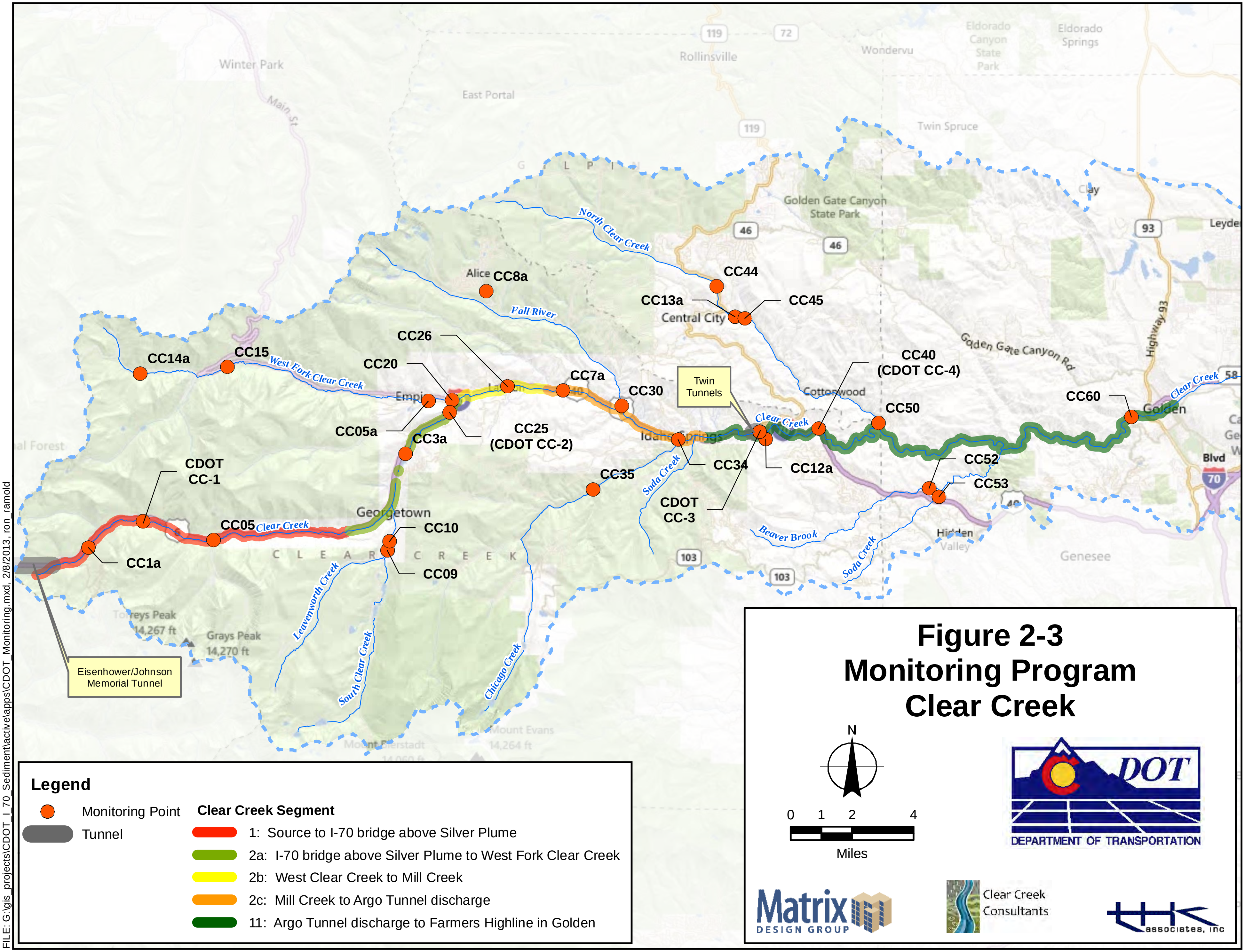


Figure 2-3 Monitoring Program Clear Creek

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2.3 Encroachment into the Natural Floodplain

Channel erosion is a major source of sediment and associated pollutants such as phosphorus, metals and other naturally occurring constituents. The EPA in 2003 released a publication called "*Protecting Water Quality from Urban Runoff*" that details a multiple step process to minimize impacts to receiving waterways. This EPA document suggests that the approach should be to "(first) seek out priority pollutant reduction opportunities, then protect natural areas that help control runoff, and finally begin ecological restoration and retrofit activities to clean up degraded water bodies." The four steps described in the EPA document include:

1. Employ Runoff Reduction Practices,
2. Implement BMPs that Provide a Water Quality Capture Volume with Slow Release,
3. **Stabilize Drainageways**, and
4. Implement Site Specific and Other Source Control BMPs.

This Clear Creek channel bank adjacent to I-70 is not stable and is actively eroding, especially during periods of high flow.

Channel bank erosion on this barren bank along I-70 is clearly evident in this reach of Clear Creek upstream of Idaho Springs.

Figure 2-4 Channel Bank Erosion Photographs

The local Urban Drainage & Flood Control District emphasizes the need for and importance of stream stabilization for a multitude of reasons, including: improving aquatic habitat, restoring hydrology and vegetation, and eliminating erosive banks that contribute sediment. A presentation at the 2011 Urban Drainage Seminar noted that the volume of sediment loading to a stream system from stream bank erosion can be much greater than the volume captured from urban runoff by BMPs. They noted that channel erosion is a major source of sediment and associated pollutants such as phosphorus, metals and other naturally occurring constituents.

The Clear Creek corridor has undergone many transformations over the last 150 years. Mining, roadways and development have clearly encroached upon the natural floodplain. During the mining era, the Clear Creek channel valley floor was covered with piles of mine tailings. When I-70 was constructed, the creek was pushed over to one side, and much of the roadway was built over the historic channel bed and floodplain.

Encroachment into the natural floodplain disrupts its natural equilibrium achieved over geologic time. There is a common need to armor the banks with rock on an altered stream corridor to protect the banks from erosion. Drop structures were installed in the stream channel in some areas along I-70 to reduce down-cutting of the channel where the stream gradient was altered (straightened) from natural conditions. Some areas of the roadway embankment have been lined with rock, boulders, retaining walls, and manmade materials out of necessity to stabilize it from scour. However, the opposite bank may be left unprotected, especially if there are no building structures impacted by the bank erosion. Bank erosion is visible from the highway.

Some portion of the sediment in Clear Creek originates from erosion of the channel bed and banks themselves. Tackling the sedimentation issue in Clear Creek means channel stabilization along I-70 as well as controlling sources from the roadway and cut/fill slopes.

Figure 2-5 Stabilized section of Clear Creek

Figure 2-5 shows a stabilized section of Clear Creek for river recreation and trout habitat. This stabilized reach of incised channel anchored the channel bed and banks, but did not try to re-establish the natural overbank floodplains.

Stabilizing the river channel to prevent erosion will reduced the sediment loading. A few reaches of the Clear Creek channel have been stabilized in the past, especially for boating recreation and trout habitat. The banks have been stabilized with large boulders, sometimes grouted in-place. The channel bed is stabilized by constructing grade control structures and drop structures to form chutes and pools. These efforts have limited the erosion of the channel in the stabilized areas and therefore, limited the sediment supply to the stream system.

Figure 2-6 Aerial Image of Clear Creek by Twin Tunnels

Figure 2-6 displays an aerial image west of the Twin Tunnels showing a manipulated river corridor. The stream follows an unnatural alignment. Clear Creek has been channelized in this area to facilitate the roadway construction and development. Realigned channels require armament and grade control to stabilize them against channel erosion since they will not achieve a geomorphic equilibrium.

2.4 Effects of I-70

Interstate 70 follows Clear Creek through the SCAP study corridor (see Figure 1-1). The relative proximity of I-70 to the stream is listed in Table 2-2. The percentage of total stream length adjacent to I-70 is an important factor to consider when assessing the potential water quality affects associated with highway runoff. Highway culverts that discharge directly into streams have a greater potential for in-stream water quality effects. Where I-70 is several hundred feet distant from receiving streams, contaminants in runoff may be deposited or sequestered before entering the stream.

Table 2-2 Physical Proximity of I-70 to Clear Creek

Study Area	Milepost	Percent of Total Stream Length Adjacent to I-70	Percent of I-70 Stream Length Channelized[1]
Clear Cr. Lower	233-244	100	82
Clear Cr. Middle	228-233	100	48
Clear Cr. Upper	216-228	90	42

[1]Includes US40 and/or US6 where they parallel I-70
Source: CDOT 2011a

Snowmelt runoff event samples were collected from selected I-70 shoulder and median areas to characterize highway source water quality (CDOT 2011b). Additional highway source characterization was conducted by sampling ice and snow in winter maintenance depositional areas. Rainfall-runoff samples were also collected from two highway drainage locations that represent the paved surface of I-70 including the shoulder and median.

Both diurnal snowmelt and rainfall-runoff samples were collected from receiving streams associated with I-70. The stream snowmelt samples represent early snowmelt runoff from I-70 in areas of the corridor with snow deposition, typically above 9,000-ft in elevation. Streamflow is low at the onset of snowmelt (February-April) and there is minimal dilution available, resulting in higher dissolved salts concentrations. Diurnal snowmelt and runoff from the highway can cause high dissolved salts during this period.

Rainstorm activity during the summer can cause relatively high energy rainfall-induced runoff and erosion/transport of material from I-70. This results in mobilization of both dissolved and particulate material from the roadway, as well as erosion of unconsolidated traction sand and soil. Receiving stream water quality can change dramatically under these conditions.

2.4.1 I-70 Snowmelt-Runoff

The highway can contribute surface runoff directly to receiving streams during snowmelt or rainfall runoff conditions. Snow is removed from the travel lanes and traction sand or deicers are applied to maintain winter mobility. A mixture of snow, traction sand, and salt accumulates along the highway shoulders over the winter at elevations above 9,000-ft, depending on slope and aspect. This snow begins melting through late winter and early spring, mobilizing dissolved and particulate contaminants entrained in the snow.

During late winter and early spring snowmelt rates are typically low because of cooler temperatures. Snowmelt saturates the highway shoulder and median soil, while flowing through shallow groundwater pathways and surface water drainages to receiving streams.

Contaminants move downslope and downstream at a slower rate during this period because snowmelt runoff rates are relatively low. Flow in receiving streams also remains low during this period (near winter minimum flow conditions). As such, there is little available dilution from clean snowmelt with data results showing higher concentrations of dissolved salts in receiving streams.

Sediment transport from the highway is relatively low during the early snowmelt period because the energy is typically not great enough to transport large quantities of sediment downstream though the system. Instead, material is deposited at the bottom of slopes and in the stream channel where gradients (and velocity) are too low for further transport. Data results show that higher stream sediment transport rates occur during the "first flush" of snowmelt flows in the spring (May) and during summer rainstorms. Under these conditions the energy (velocity) is high enough to transport material from highway sources and stream deposits downstream through the system.

2.4.2 I-70 Rainfall-Runoff

The depth and duration of rainfall (intensity) is the determining factor for stormwater runoff in the I-70 corridor during the summer (July through September). Continuous recording rainfall intensity gauges are utilized at stream monitoring locations to measure rainfall intensity. Rainfall-runoff volume is influenced by infiltration losses determined by factors such as antecedent soil moisture conditions, vegetation cover, soil type, and impervious surfaces associated with roadways and urban development.

Each stream monitoring station is located near I-70 to measure the effects of highway runoff. The paved surface of I-70 travel lanes and shoulders ranges in width from about 80 to 100 feet in most locations of the corridor. The paved surface is nearly impervious, resulting in minimal infiltration losses and high runoff rates during intense rainfall events. The same holds true for urbanized areas within the corridor where roads and buildings result in low infiltration capacity and high runoff rates.

2.4.3 I-70 Runoff Water Quality Results

The results of the highway runoff water quality testing are summarized in Table 2-3 and shown at the end of this chapter in Figure 2-8 through Figure 2-22. The following text describes the results of the water quality analysis.

Suspended Sediment and Phosphorus

Total suspended sediment (**TSS**) concentrations ranged from 11 to 2,460 mg/L for rainfall events and 13 to 6,700 mg/L for snowmelt events, indicating highly variable sediment transport rates (Figure 2-8). The event mean TSS concentrations were 387 and 1,182 mg/L, respectively with a high coefficient of variation.

Highway runoff Station CC-231 is at an intermediate elevation of the SCAP study corridor, with no slope erosion and moderate traction sand usage. This station is representative of highway runoff in the lower Clear Creek corridor, with no influence from mining or heavy traction sand use. TSS concentrations at CC-231 were lower than other areas of the study corridor with greater slope erosion/traction sand usage or areas disturbed by mining (CDOT 2011b).

Suspended solids concentrations in I-70 runoff are related to particulate material that accumulates along the highway such as traction sand, but also slope erosion which is mobilized during snowmelt/stormwater runoff conditions. Results show a wide range in TSS concentration that is dependent upon site-specific conditions. Sediment transport from I-70 is dependent upon transport (flow) conditions and the availability of sediment, with generally higher concentrations during larger runoff events and in high gradient traction sand usage areas.

The high suspended solids concentrations in I-70 runoff correlated with elevated total phosphorus concentrations. Total phosphorus (**TP**) is regulated in surface waters with a proposed stream standard of 0.11 mg/L.

Total phosphorus concentrations ranged from 0.14 to 2.1 mg/L, with a mean concentration of 0.55 mg/L and coefficient of variation of 1.0 in rainstorm event samples. In snowmelt samples, TP concentrations ranged from 0.02 to 8.0 mg/L, with a mean concentration of 0.77 mg/L and coefficient of variation of 2.1. Total phosphorus concentrations were greater than 1 mg/L in 21 of the 68 highway runoff samples collected (Figure 2-8).

Dissolved phosphorus concentrations were less than 0.4 mg/L in all highway runoff samples, with an average concentration of 0.06 mg/L. These results also show a strong correlation between solids and total phosphorus, but low dissolved phosphorus concentrations.

The paired suspended solids and total phosphorus sample results for I-70 highway runoff sample data is shown in Figure 2-9. These data show a positive correlation between suspended solids and total phosphorus, indicating phosphorus is associated with particulate sediment. The correlation coefficient was 0.87 for the 65 sample data pairs used.

These results suggest that, because the phosphorus is primarily in particulate form associated with sediment, implementation of standard sediment control best management practices (BMPs) would be effective in reducing total phosphorus transport from I-70 to receiving streams.

<u>Dissolved Salts</u>
Chloride concentrations were higher in I-70 snowmelt than rainfall samples at most locations (Figure 2-10). The secondary drinking water standard for chloride is 250 mg/L, while the chronic aquatic life criterion is 230 mg/L. Higher chloride concentrations were measured in snowmelt runoff associated with sand/salt used on I-70 during winter.

Sand containing 20 percent sodium-chloride based rock salt or ice-slicer is applied to I-70 as a treatment to maintain mobility during winter. The stream channel snow/ice sample results confirm that salt accumulates in the snow and ice along the shoulders of I-70 (CDOT 2004). The higher sodium-chloride concentrations in I-70 runoff were likely associated with the road sand/salt mixture that accumulates along the highway shoulders and median and is transported in runoff. Background stream sodium-chloride concentrations were low compared to highway runoff (CDOT 2011b).

Although liquid magnesium chloride deicer is used in several areas of the study corridor, sample results show that highway runoff chemistry was dominated by sodium chloride (Figure 2-10). Sodium was the dominant cation in I-70 runoff samples, indicating that the higher dissolved salts in runoff was caused by sodium chloride rather than magnesium chloride.

Trace Metals

Dissolved metal concentrations were typically low in I-70 runoff samples (Table 2-3). The exception is the highway rock cut west of Idaho Springs, which exhibited higher dissolved metal concentrations in runoff samples (CDOT 2011b). These concentrations are likely associated with runoff from the mineralized rock cut. Empire Junction also exhibited slightly higher dissolved manganese and zinc concentrations in highway runoff samples compared to other locations sampled along the I-70 corridor, although this station is not associated with highly mineralized geology.

Table 2-3 I-70 Highway Water Quality Results Summary 2001-2009 (mg/L)

	Flow (gpm)	Suspended Solids	Phosphorus Total	Chloride	Sodium Dissolved	Magnesium Dissolved	Copper Dissolved	Manganese Dissolved	Zinc Dissolved
Snowmelt Runoff									
Range	2-200	13-6,700	0.02-8.0	48-720	19-420	4.2-130	0.003-0.015	0.01-0.78	0.02-0.29
Mean	59	1,182	0.77	281	121	28.6	0.006	0.12	0.04
Coeff-Variation	1.1	1.6	2.1	0.8	0.8	0.9	0.5	1.5	1.6
Rainfall Runoff									
Range	18-664	11-2,460	0.14-2.1	4-36	2.5-29.8	2.3-7.1	0.005-0.020	0.003-0.54	0.04–0.53
Mean	166	387	0.55	20	12.0	4.8	0.011	0.057	0.129
Coeff-Variation	1.1	1.5	1.0	0.5	0.6	0.3	0.5	2.0	0.85

2.4.4 I-70 Runoff Water Quality Comparison to National Highway Data

Available data for urban stormwater and highway runoff water quality show similar pollutant constituents and concentrations (FHWA, 1996). Exceptions to this are the elevated levels of heavy metals in highway runoff due to vehicle use, wear, and emissions. According to the Transportation Research Board, the heavy metals copper and zinc are two of the most prevalent priority pollutants in highway runoff. A significant amount of nutrients and organic priority pollutants may also be present in the highway environment.

The major sources of pollutants on highways are vehicles, dustfall, and accidental spills of oil and fuel. Highway maintenance practices such a sanding and deicing or the use of herbicides on highway right-of-ways also act as sources of pollutants. The major influences on pollutant constituents and concentrations were found to be traffic characteristics, dry deposition (dustfall), precipitation, and site-specific conditions such as highway maintenance and land use practices (FHWA, 1996). Since vehicles are both direct and indirect sources of pollutants on highways, studies by FHWA have attempted to correlate traffic volume (average daily traffic - ADT) with pollutant accumulation. A summary of average constituent concentrations in highway runoff is provided in Table 2-4.

In the I-70 mountain corridor, sediment (bedload and suspended load) associated with traction sand creates an exceptionally higher pollutant loading condition. Particulates and solid materials in highway runoff are considered important pollutants because of their ability to sequester and transport other pollutant constituents such as phosphorus, organics, and trace metals. Exposure to runoff water can releases these pollutants into the aquatic system where they can impair aquatic habitat and compromise receiving stream water quality.

FHWA data show that paved roadways with Average Daily Traffic (ADT) > 30,000 vehicles produce runoff with two to five times greater constituent concentrations than highways with ADT < 30,000 vehicles. CDOT data shows the ADT for I-70 at the Eisenhower Tunnel exceeds 30,000 vehicles (the urban threshold). However, the FHWA study also noted that individual highway sites within each category were shown to have different pollutant concentrations and correlated poorly with traffic density.

Another measure of pollutant transport is vehicles during a storm (VDS). Vehicles acquire solid materials on the undercarriage from normal wear (e.g. brake lining dust) to be deposited on the road during rain events. Separate studies suggest that VDS may be a better predictor of pollutant concentrations, and showed a strong correlation between VDS values and lead, zinc, COD, and TKN (FHWA, 1996).

Average values reported by FHWA show a large range in concentrations, which is typical of highly variable highway runoff conditions. Source composition, antecedent moisture conditions, transport pathways, and storm event characteristics all contribute to this variance. Average concentration data reported by FHWA, however, generally fall within this range.

Monitoring results from I-70 within the mountain corridor also indicate a large variation in runoff constituent concentrations (see Table 2-4). For the constituents listed, the sample coefficient of variation was less than 1 for copper and chloride, but exceeded 1 for TSS, TP, manganese, and zinc. These results suggest highly variable highway runoff concentrations that can have an effect on receiving waters.

Comparisons of I-70 highway runoff sampling results with those reported for urban highways in Table 2-4 shows that I-70 on average produced greater suspended solids and total phosphorus concentrations. The availability of these constituents for transport in runoff is the likely result of highway application of over 500 tons of road sand/salt mixture per mile of I-70 during each winter season (CDOT 2011b). Although not measured in the FHWA studies, sodium and chloride concentrations were also elevated above background levels in I-70 runoff.

I-70 at a mineralized highway rock cut in the Idaho Springs mining district shows generally lower chloride concentrations when compared to I-70 highway runoff at other locations, but trace metal concentrations were higher. These data illustrate that runoff metal concentrations can be greater in mineralized areas intercepted by I-70 when compared to national study results. Average copper and zinc concentrations in I-70 runoff at other locations fall within the lower range of those reported by FHWA (see Table 2-4). It is important to note that the I-70 metal results represent the dissolved fraction while previous studies used the total fraction.

Table 2-4 Highway Runoff Average Constituent Concentrations (mg/L)

Constituent	Urban Average ADT > 30,000 (FHWA, 1996)	Rural Average ADT < 30,000 (FHWA, 1996)	I-70 Mean Values (CDOT)	National Range (FHWA)	I-70 Range (CDOT)
Suspended Solids	142	41	953	45 – 798	13 – 6,700
Total Phosphorus	0.40	0.16	0.87	0.11 – 1.0	0.02 – 8.0
Total Copper	0.054	0.022	0.012*	0.022 – 7.03	0.003–0.020*
Total Lead	0.40	0.08	NM	0.073 – 1.78	Not measured
Total Zinc	0.329	0.080	0.16*	0.056 – 0.93	0.005 – 0.53*

*Dissolved form of metal
FHWA, 1996 – Evaluation and Management of Highway Runoff Water Quality, Pub. No. FHWA-PD-96-032
Taken from CDOT I-70 Storm Event/Snowmelt Water Quality Data 2000-2008

2.5 Clear Creek Sediment Loading Conditions

A summary of snowmelt/storm event mean concentration data for Clear Creek is presented in Table 1-2. Results are compared to applicable Colorado stream water quality standards shown at the top of the table. CDOT data indicate that during the 2000-2009 monitoring period, lower Clear Creek had some of the highest mean suspended solids concentrations (264 mg/L) and event mean total phosphorus concentrations (0.44 mg/L). The uppermost Clear Creek station also had high concentrations relative to other stream reaches. Total phosphorus corresponded to high suspended solids indicating particulate phosphorus; dissolved phosphorus concentrations were relatively low in all stream samples.

Upper Clear Creek Station CC-1 is located approximately four miles downstream from the Eisenhower Tunnel below the Herman Gulch I-70 interchange (MP 219). This station represents runoff from the east portal area of the Eisenhower Tunnel, I-70, Loveland Ski Area facilities, US Highway 6 on the east side of Loveland Pass, and associated tributaries.

Station CC-1 had the greatest frequency of rain-induced turbidity events of the high elevation corridor stations, ranging from 5 in 2009 to 12 in 2007 with an average of nine events per year (CDOT 2011b). The TSS concentrations at Station CC-1 were often higher following intense summer rainstorms when compared to snowmelt flows. These results suggest that the source of sediment loading during intense summer rainfall events may be related to slope erosion of I-70 sand rather than re-entrained channel deposits. Observations indicate the source of sediment may be both unconsolidated traction sand deposited along I-70 and US-6 and erosion of dirt parking lots at Loveland Ski Area.

Mean concentrations of suspended solids and total phosphorus were higher than background at Station CC-1, and were typically higher than downstream Clear Creek stations during spring. The highest sodium-chloride concentrations sampled in Clear Creek were measured at CC-1. Trace metal concentrations were typically low or less than detection limits in upper Clear Creek storm event/snowmelt samples. Mean concentrations were less than established water quality standards.

2.5.1 Upper Clear Creek Suspended Sediment and Phosphorus

Under ambient conditions suspended solids (TSS) concentrations in upper Clear Creek Station CC-1 were typically low (<5 mg/L), but were elevated during storm event/snowmelt conditions. TSS sample results are plotted in Figure 2-11 for the 2001 to 2009 period. TSS concentrations ranged from less than 5 mg/L during non-event conditions to over 200 mg/L during event conditions. There was a large range of TSS from <5 to 7,730 mg/L with a mean concentration of 200 mg/L and a relatively high coefficient of variation of 3.8 (see Table 1-2). These results show that sediment transport rates in upper Clear Creek are dynamic, changing on an hourly or daily basis depending on sediment mobilization processes.

A continuous recording turbidity probe was installed at CC-1, with results for 2010 shown with the flow hydrograph at the bottom of Figure 2-12. Turbidity at CC-1 varied considerably in response to sediment transport events. Normally, turbidity in Clear Creek is low at less than 5 NTU. Sediment transport events typically increase the turbidity over 50 NTU during both first-flush snowmelt flow conditions in April-May and following intense summer rainstorm events.

A first-flush sediment transport phenomenon is typically measured, whereby sediment deposited in the stream channel and slope erosion of traction sand is mobilized during the onset of higher snowmelt flows in April-May. Turbidity and sediment transport is dependent upon sediment availability and timing of higher flow velocities during this period (see Figure 2-12). Data shows that turbidity and sediment concentrations increase briefly during these first flush events, followed by a decrease during peak snowmelt runoff and flow recessions at CC-1.

Once sediment is eroded and transported each spring, turbidity decreases to low (ambient) levels until intense rainstorms generate runoff and erode sediment deposited on slopes along I-70. In 2007 the highest turbidity at CC-1 was measured as a result of rainstorm-runoff events, although this varies from year to year according to rainfall patterns. In these instances, turbidity increases typically coincide with flow increases at CC-1.

The measured sample turbidity and TSS concentration results for CC-1 are plotted in Figure 2-13 with a best-fit regression line. These parameters show a strong positive correlation (r^2=0.93) for the 92 data pairs collected from 2001 to 2009. Utilizing the resulting regression equation, TSS concentrations were estimated based on the continuous recorded (15-minute) in-stream turbidity. For measured turbidity less than 5 NTU the TSS concentration was assumed to be 2.5 mg/L (½-detection limit of 5 mg/L).

The 15-minute TSS concentrations and loads for 2010-2011 are plotted in Figure 2-14 and Figure 2-15. Maximum seasonal concentrations at CC-1 ranged from about 200 mg/L in 2006 and 2009 to over 1,000 mg/L in 2007.

In addition to suspended sediment, bedload sediment is an important component of the mass transport in high-gradient mountain streams (CDOT 2009). The relationship between bedload and suspended sediment load was evaluated based on analysis of 57 paired sample sets. These data were collected at several CDOT stream monitoring sites from 2001 to 2009 including Clear Creek, Hoop Creek, Straight Creek, and Black Gore Creek.

Upper Clear Creek sediment loads were calculated each year as the total mass passing the CC-1 gage during the 15-minute recording interval. This is the combined result of both suspended and bedload. Runoff event loading results for 2010 and 2011 are plotted at the bottom of

Figure 2-14 and Figure 2-15. The event sediment loads were typically less than 3 tons, except in 2007 and 2010 which had summer events that ranged from 5 to 7 tons. The spring snowmelt period produced the majority of load in 2006, 2008, and 2009, while summer events produce the majority in 2007. The total seasonal load at Station CC-1 ranged from 579 tons in 2007 to 1,319 tons in 2011.

The suspended sediment load includes sediment entrained in the water column that, in the absence of large storage impoundments (e.g. Georgetown Lake), is transported through the system. This is generally finer-grained material derived from erosion of traction sand and hill slope soils. Suspended load is available for uptake by aquatic organisms and water supply intakes.

A portion of the suspended load is considered base load that occurs in natural undisturbed watersheds. This component was calculated by assuming a constant suspended sediment concentration of 5 mg/L through the season. This is considered a conservative assumption because the ambient sediment concentrations are less than 5 mg/L and are often less than 2 mg/L (CDOT 2011b). The suspended load results for 2006-2011 are shown in Table 2-5 along with the seasonal precipitation and flow volume.

Table 2-5 upper Clear Creek below Hermann Gulch (CC-1)
Suspended Sediment Loading Summary 2006-2011

Year	Sediment Load (tons)	Base Load (tons)	Precipitation (Jul-Sep inches)	Flow Volume (acre-feet)
2006	280	125	7.97	18,311
2007	160	70	7.45	10,252
2008	310	126	9.72	18,482
2009	249	111	3.24	16,351
2010	361	93	7.04	13,723
2011	331	128	8.66	18,862

These results indicate that sediment loading in upper Clear Creek is two to three times higher than would be expected (Figure 2-16). As sediment control BMPs are implemented as part of the Clear Creek SCAP these loads are expected to decrease and eventually approach base load levels.

While there is currently no total suspended solids standard for Clear Creek, a median, annual total phosphorus standard of 0.11 mg/L has been proposed (CDPHE, 2011). The purpose of the standard is to protect water quality in downstream water supply reservoirs filled by Clear Creek.

Total phosphorus (TP) concentrations were closely associated with TSS concentrations at upper Clear Creek Station CC-1 as shown in Figure 2-17. These data indicate that when TSS concentrations increase as a result of snowmelt or rainfall runoff in upper Clear Creek, TP concentrations also increase. Dissolved phosphorus concentrations were 0.02 mg/L or less in runoff samples from CC-1, indicating the phosphorus was in particulate form associated with the sediment.

The TP and TSS sample concentration data pairs collected from 2001 to 2009 are plotted for Station CC-1 in Figure 2-17. TP increases with TSS with maximum TP concentrations corresponding with maximum TSS concentrations. The regression results show a strong positive correlation (r^2=0.88) between TSS and TP.

The event mean TP load in pounds per day (lbs/day) is plotted along with the event mean discharge for the 2001 to 2009 sample data at the bottom of Figure 2-11. These data show that event mean TP loads were typically less than 25 lbs/d, but increased over 100 lbs/d during many events. The maximum event mean TP load ranged from 891 to 2,955 lbs/d during storm events.

Suspended sediment and total phosphorus results show that phosphorus loading is controlled by sediment transport rather than streamflow (see Figure 2-11). High streamflow periods did not necessarily result in higher sediment transport and phosphorus loading. Instead, the highest phosphorus loads were measured during periods of high sediment discharge at upper Clear Creek Station CC-1.

2.5.2 Lower Clear Creek Suspended Sediment and Phosphorus

Lower Clear Creek water quality is influenced by many factors including point source mine drainage and wastewater return flows as well as non-point source runoff from unconsolidated mine waste, steep mountain roads, urban and industrial areas, and I-70 (CDOT 2008). Clear Creek sediment loading data has been collected downstream of these influences at Station CC-4 near Kermitts (MP 244).

A summary of the loading results for 2009-2011 at CC-4 is provided in Table 2-6. These results indicate that sediment loading in lower Clear Creek is three to five times higher than would be expected from base load conditions. The sediment load in lower Clear Creek (CC-4) was about one order of magnitude greater than upper Clear Creek (CC-1).

Table 2-6 Lower Clear Creek at Kermitts (CC-4)
Suspended Sediment Loading Summary 2009-2011

Year	Sediment Load (tons)	Base Load (tons)	Precipitation (Jul-Sep inches)	Flow Volume (acre-feet)
2009	2,081	747	3.51	109,776
2010	2,683	672	3.77	98,764
2011	5,377	1081	7.34	158,885

The influence that I-70 has on lower Clear Creek water quality was assessed with CDOT monitoring locations chosen to isolate 2-mile segments of I-70 by using a paired station approach to focus on specific areas of I-70. For example, Station CC-2 represents the two-mile segment below Georgetown Lake adjacent to I-70. Paired stations CC-3 and CC-4 represent water quality upstream and downstream of the two-mile Hidden Valley segment of I-70. There are only minor tributary sources that influence water quality in these two stream reaches and little or no historic mining influence.

Although sample results indicate only minor changes in TSS/TP in the Twin Tunnels/Hidden Valley segment of I-70, concentrations can change rapidly during runoff. Synoptic storm event samples were collected at both CC-3 and CC-4 to isolate the Twin Tunnels/Hidden Valley segment of I-70 (CDOT 2008). The CDOT suspended solids (TSS) and total phosphorus (TP) results show that concentrations were similar at CC-3 and CC-4 during most events, with minor increases and decreases that could be attributable to sample variance. Mean concentrations of TSS and TP were slightly greater at CC-4 when compared to CC-3 (see Table 1-2). The sample concentration covariance was relatively high at both stations (CV=2.3).

Total phosphorus concentrations are positively correlated with suspended solids in Clear Creek (CCC, 2011). Storm event sample results from 52 data pairs for lower Clear Creek show a strong positive correlation (r^2=0.95) between TSS and TP (Figure 2-18). The highest TP concentrations (2.5 to 5.2 mg/L) were associated with the highest TSS concentrations (1,300 to 2,500 mg/L), while lower TSS concentrations resulted in lower TP. Dissolved phosphorus concentrations in storm event samples were typically two orders of magnitude lower, ranging from <0.01 to 0.07 mg/L with a mean of 0.02 mg/L in lower Clear Creek runoff samples.

The available CDOT storm water sample data for Clear Creek Stations CC-3 and CC-4 were compared to the 1994-2005 average ambient data collected at CC-4 by the Upper Clear Creek Watershed Association (UCCWA). Results show that TSS concentrations in Clear Creek were greater during storm water runoff conditions (mean=264 mg/L) when compared to ambient conditions (mean=2 mg/L). Likewise, data also show that TP concentrations at CC-4 during stormwater runoff conditions (mean=0.44 mg/L) were greater than ambient conditions (mean=0.02 mg/L) measured by UCCWA. The total (particulate) phosphorus and metal load in Clear Creek is dependent on the TSS concentration rather than streamflow (CCC 2012).

The generalized sediment loading condition in Clear Creek is illustrated in Figure 2-7. This map shows the areas of higher sedimentation based on CDOT data and other studies. CDOT data indicates highway-related sediment loading between Bakerville and EJMT caused by higher traction sand use and slope erosion. Both Georgetown Hill and Floyd Hill have high sedimentation rates from slope erosion. Georgetown Lake captures sediment from upstream sources.

The area from Dumont to Idaho Springs has significant tributary sediment loading caused by erosion of historic mine waste and steep unpaved access roads. Water quality studies have shown major erosion and sedimentation from Trial Creek, Virginia Canyon, and smaller tributaries disturbed by historic mining activities and roads (CCC 2012). A significant portion of the sediment loading in Trail Creek was caused by erosion from unpaved roads (CCC 2007-2011).

Figure 2-7
Generalized Illustration of Sedimentation in Clear Creek

2.6 Clear Creek Salt Loading Conditions

Sodium-chloride and magnesium-chloride salt based deicers are applied to I-70 during winter to maintain safe travel conditions. These salts are transported in runoff from the highway in dissolved form, entering and increasing the electrical conductivity of receiving streams.

Instantaneous measurements of stream conductivity in upper Clear Creek at Station CC-1 indicated a specific conductance reading of 595 uS (CDOT 2002c). The nearby background stream Herman Gulch had a specific conductance of 115 uS. Clear Creek above the confluence with Herman Gulch had a specific conductance of 671 uS. These data suggested that dissolved salt concentrations in upper Clear Creek were elevated above background levels. Therefore, a continuous recording conductivity/temperature probe was installed to measure conductivity trends at Station CC-1. The conductivity/temperature probe and data logger at Station CC-1 is operated year-round to monitor dissolved salts conditions in upper Clear Creek over the winter period when sodium and magnesium chloride are applied to I-70.

The 2010 flow and conductivity data for Station CC-1 is plotted in Figure 2-12. These data show a large variation in water quality each year at Station CC-1. Maximum conductivity is measured in winter and early spring. Snowmelt in May resulted in a rapid decrease in conductivity caused by dilution, with maximum snowmelt dilution flows in June each year. Conductivity increased throughout the summer and fall as streamflow receded.

The maximum daily conductivity measured at CC-1 from November 2001 to October 2011 is shown in Figure 2-19. These data indicate a large seasonal change in stream conductivity each year ranging from less than 100 uS during peak snowmelt dilution flows (June-July) to maximums over 800 uS during late winter/early spring low-flow conditions (March-April). The date of recorded maximum each year is shown on the plot, ranging from February 14 in 2003 to April 25 in 2007. Occasional increases were also measured as a result of rainfall-runoff events during summer. These results suggest that a source of dissolved salts enters upper Clear Creek during winter and early spring causing substantial increases in specific conductance.

Both magnesium-chloride and sodium-chloride are used as winter deicers on I-70. Sampling results from CC-1 are presented in Figure 2-20 which shows that sodium-chloride concentrations were on average 15-percent greater than magnesium-chloride. This indicates that rock salt was the primary source of dissolved salts in upper Clear Creek.

Chloride concentrations are regulated in Clear Creek by a secondary drinking water quality standard of 250 mg/L. The chronic aquatic life chloride criterion is 230 mg/L, while the acute criterion is 830 mg/L (US EPA 1988).

The highest mean chloride concentration was measured in upper Clear Creek (48.8 mg/L) with a range of 4.1 to 210 mg/L, more than 5 times greater than lower Clear Creek (see Table 1-2). Tributary background chloride levels were less than 2 mg/L (CDOT 2011b). The elevated chloride levels are related to road salts that are mobilized in I-70 runoff and transported into the streams. Trace metal concentrations during storm event/snowmelt conditions were low in upper Clear Creek; elevated trace metal concentrations in lower Clear Creek are primarily attributable to historic mining (UCCWA 2011).

The paired chloride and conductivity data from all CC-1 snowmelt/storm event runoff samples (2001-2009) was plotted in Figure 2-21 to assess the relationship between stream specific conductance and chloride concentrations. The results of this regression analysis indicate a strong positive correlation (r^2=0.96) between specific conductance and chloride concentrations at upper Clear Creek Station CC-1.

Using the regression equation, a specific conductance of 800 uS results in a chloride concentration of 233 mg/L; the chronic aquatic life standard is 230 mg/L. At maximums of 1,200 uS measured in 2003, 2004, and 2008, the chloride concentration was 413 mg/L which was below the acute aquatic life criteria of 830 mg/L. These results indicate that conductivity values less than 800 uS should result in chloride concentrations below the water quality standard of 230 mg/L.

A time series plot was developed to evaluate chloride trends at CC-1 from 2001 to 2009 in Figure 2-22 (CDOT 2011b). These trend analyses uses winter data greater than 40 mg/L, and shows a linear tend line with 95% confidence interval. Results indicate a slight increasing trend in chloride concentrations for the period of record at upper Clear Creek Station CC-1.

In summary, upper Clear Creek Station CC-1 exhibits concentrations of TSS, TP, and dissolved salts that were higher than background levels. Sources of sediment and dissolved salts include highway traction sand/salt accumulations along I-70 and US-6, and potential erosion of dirt parking lots at Loveland Ski area. These data suggest that implementation of standard sediment control best management practices (BMPs) as source control measures would be an effective method of reducing total suspended sediment and phosphorus transport in Clear Creek.

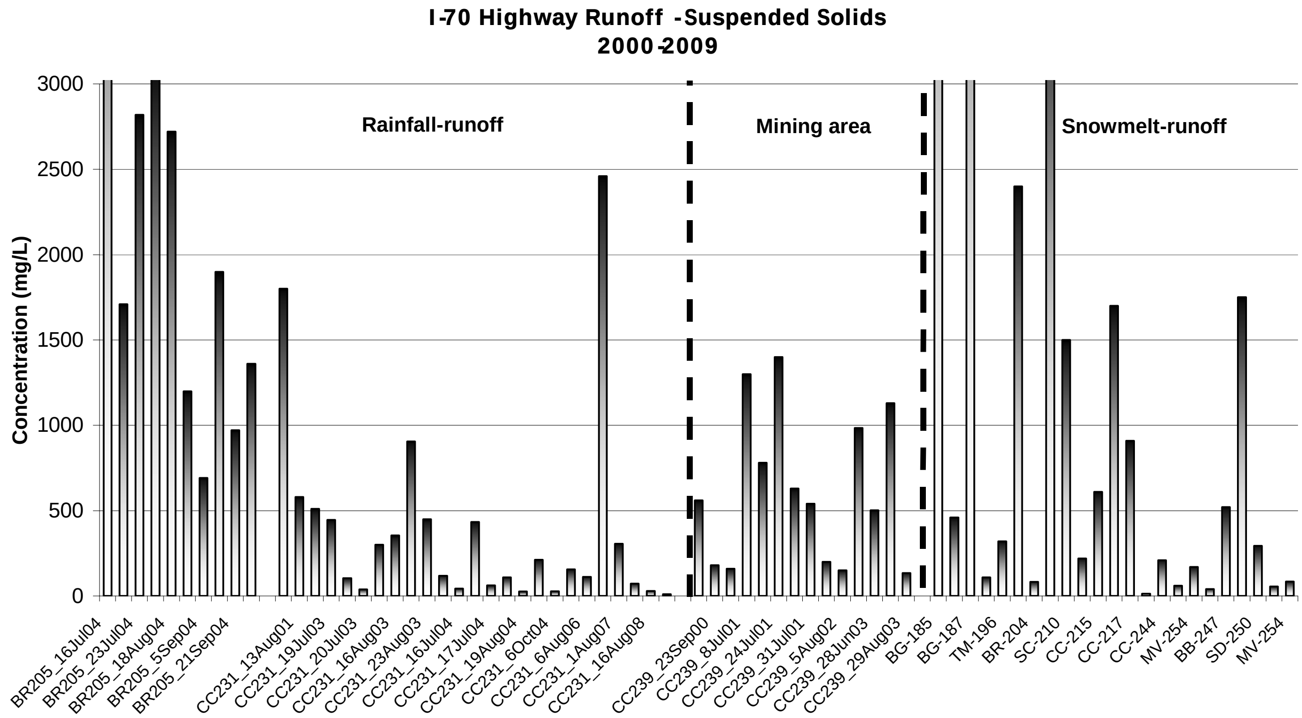
2.7 Clear Creek I-70 Reconnaissance Inventory and Mapping

Field investigations for the Clear Creek I-70 SCAP were conducted from September 2010 to August 2011 by Clear Creek Consultants. All drainage features, both naturally-occurring and I-70 as-built, along with associated sedimentation patterns were observed and documented between Eisenhower-Johnson Memorial Tunnel (MP 215.2) and the east side of Floyd Hill (MP 247.7) along Interstate 70 in Clear Creek County. Additionally, the areas both above and below the highway right-of-way (ROW) were assessed for sedimentation potential and dynamics. This inventory and map location of drainage and sedimentation features was accompanied by on-site designation of best management practices (BMPs) for mitigation of observed affects.

Field inspection, inventory, and location of drainage features were accomplished by a two-man team walking the 32.5 mile length of the study area. This inventory for both westbound and eastbound directions of I-70 included the cut slope (uphill) and fill slope (downhill) sides of this interval of I-70. The inventory includes areas where I-70 runoff and sedimentation directly influences other roadways such as US-6 adjacent to I-70 in the Loveland area and the US-40 frontage road on Floyd Hill.

Photo documentation and exact location of individual features were achieved through the use of a GPS-enabled Sony DSC-HX5 digital camera. The geo-referenced photography collected in the field was augmented by extensive written notation. Geo-referenced photographs were subsequently downloaded and plotted in Google Earth and captioned utilizing the field notes and spatial referencing afforded by Google Earth.

The I-70 drainage and sediment control BMP features identified during the reconnaissance were migrated into a GIS Mapbook with 73 sheets each covering approximately 0.5 miles. A legend was produced describing the major features for the SCAP.



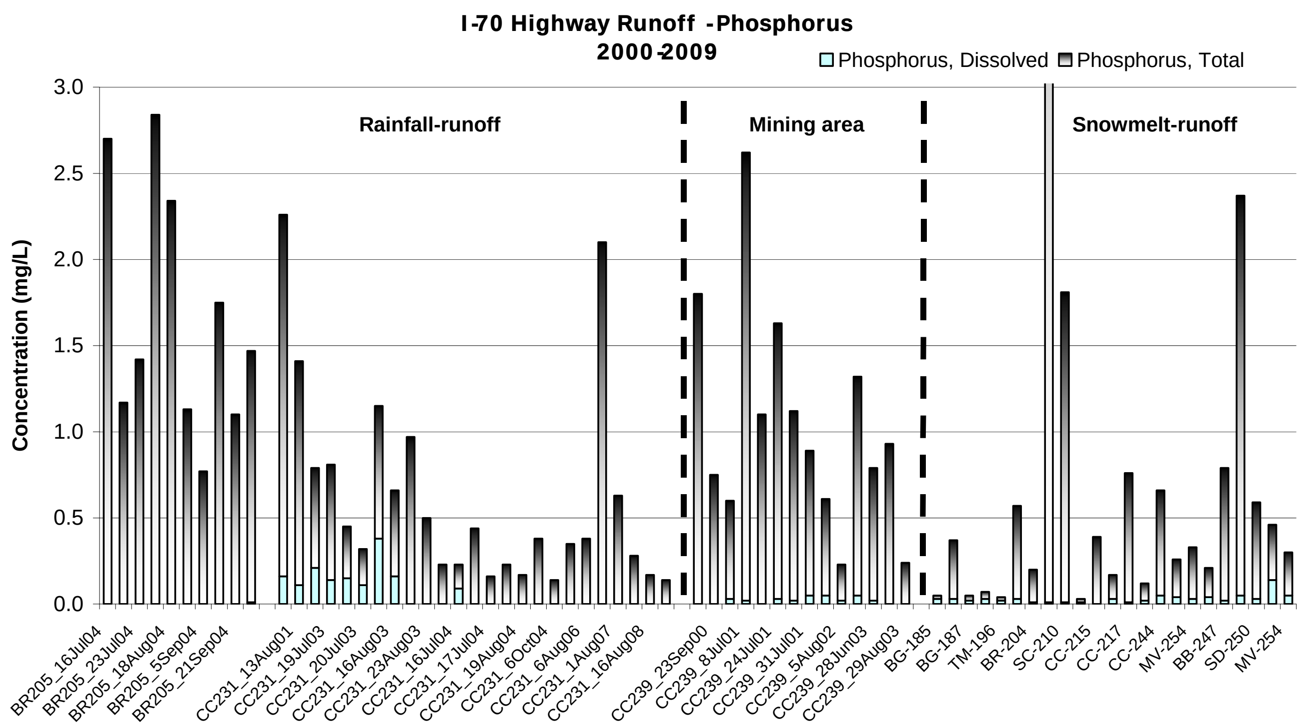


Figure 2-8 Suspended Solid and Phosphorus Concentrations – By Highway Segment

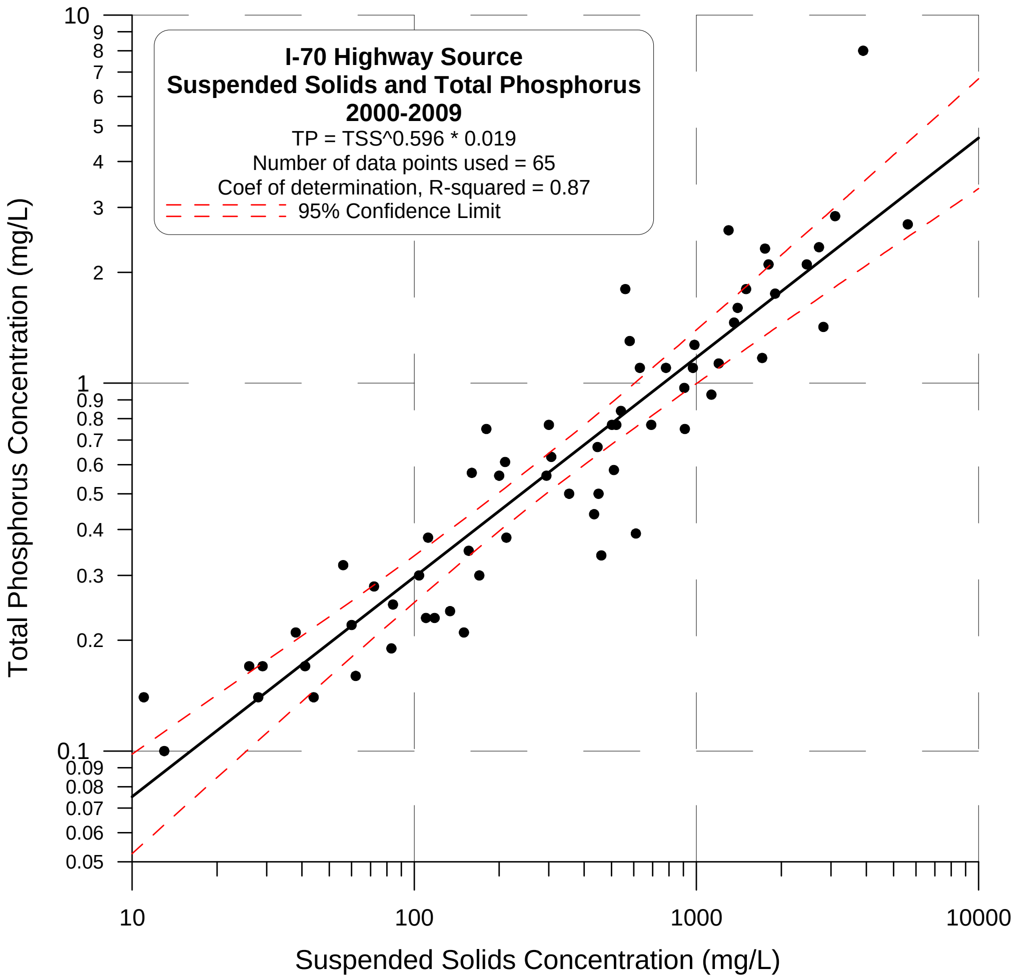
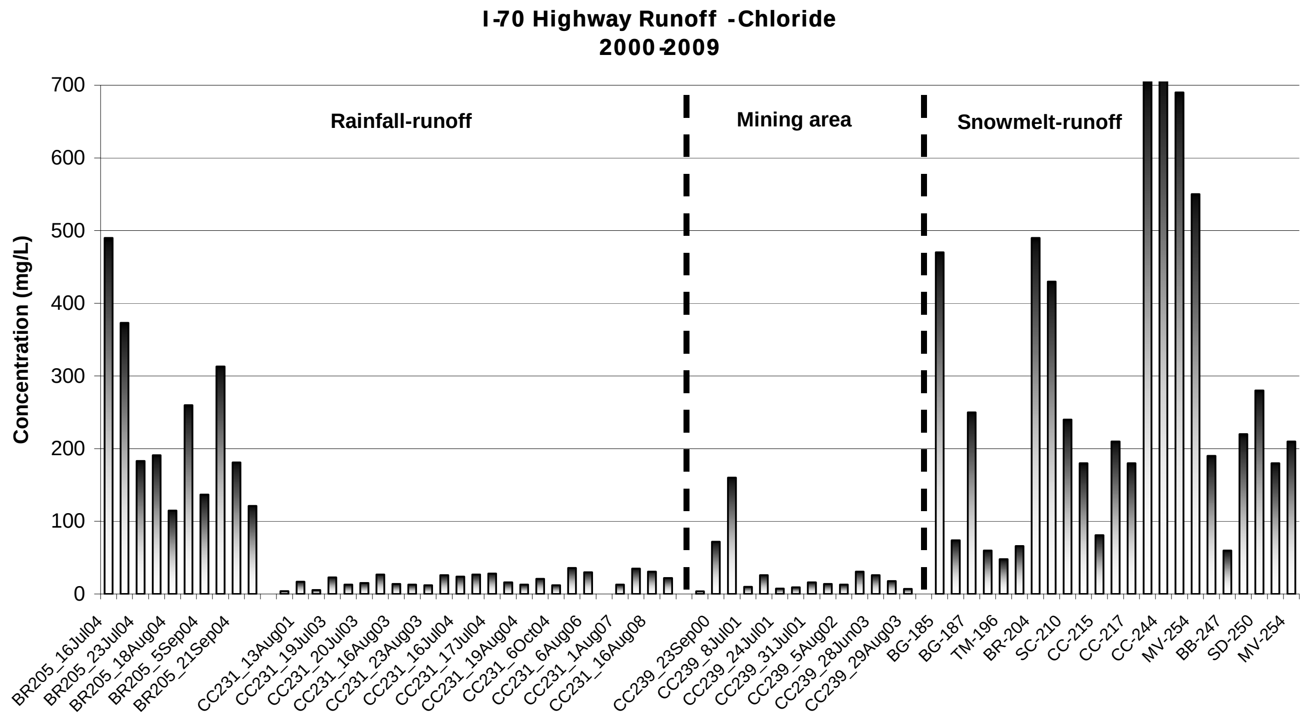


Figure 2-9 Highway Runoff – Suspended Solid vs. Total Phosphorus Concentration



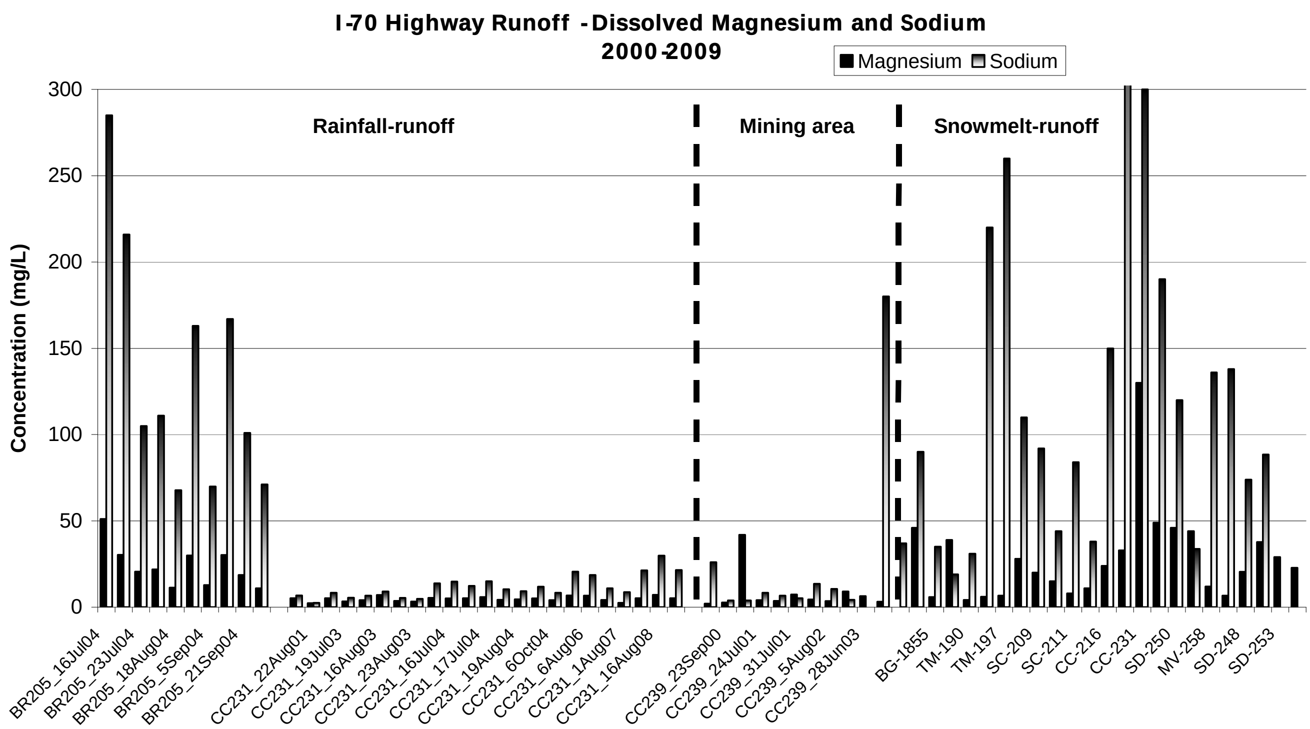
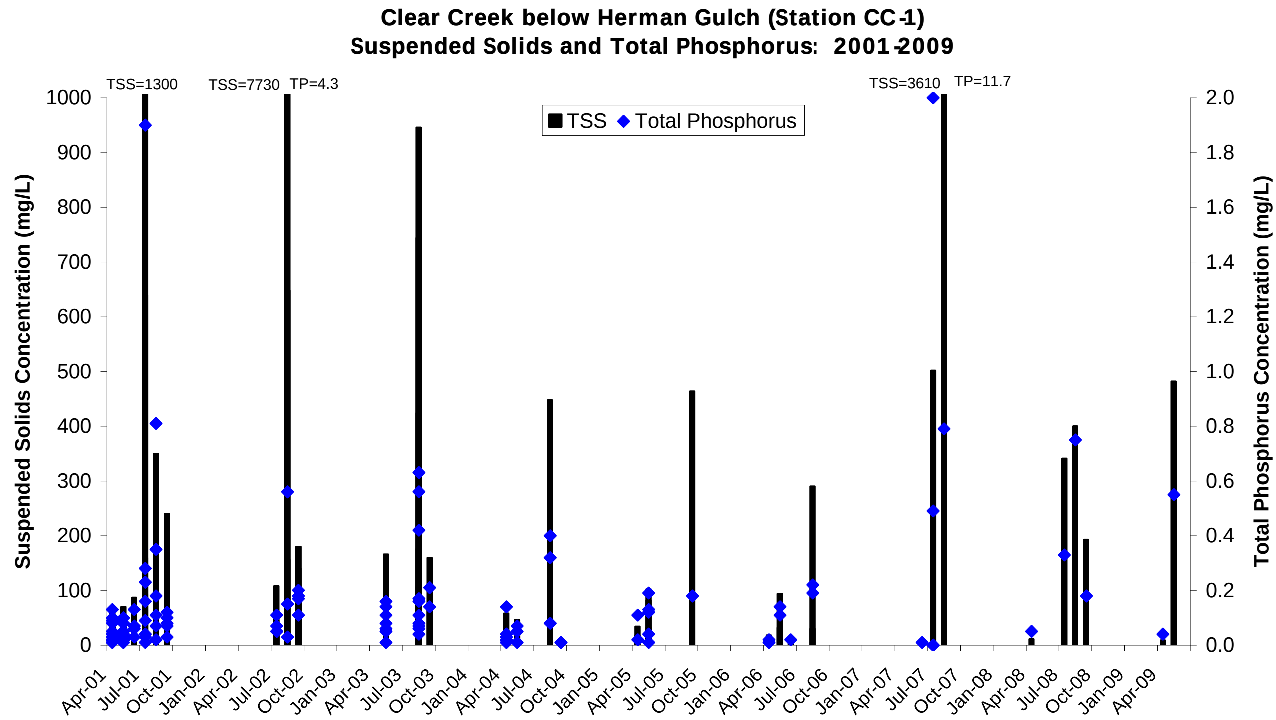


Figure 2-10 Chloride and Dissolved Magnesium and Sodium – By Highway Segment



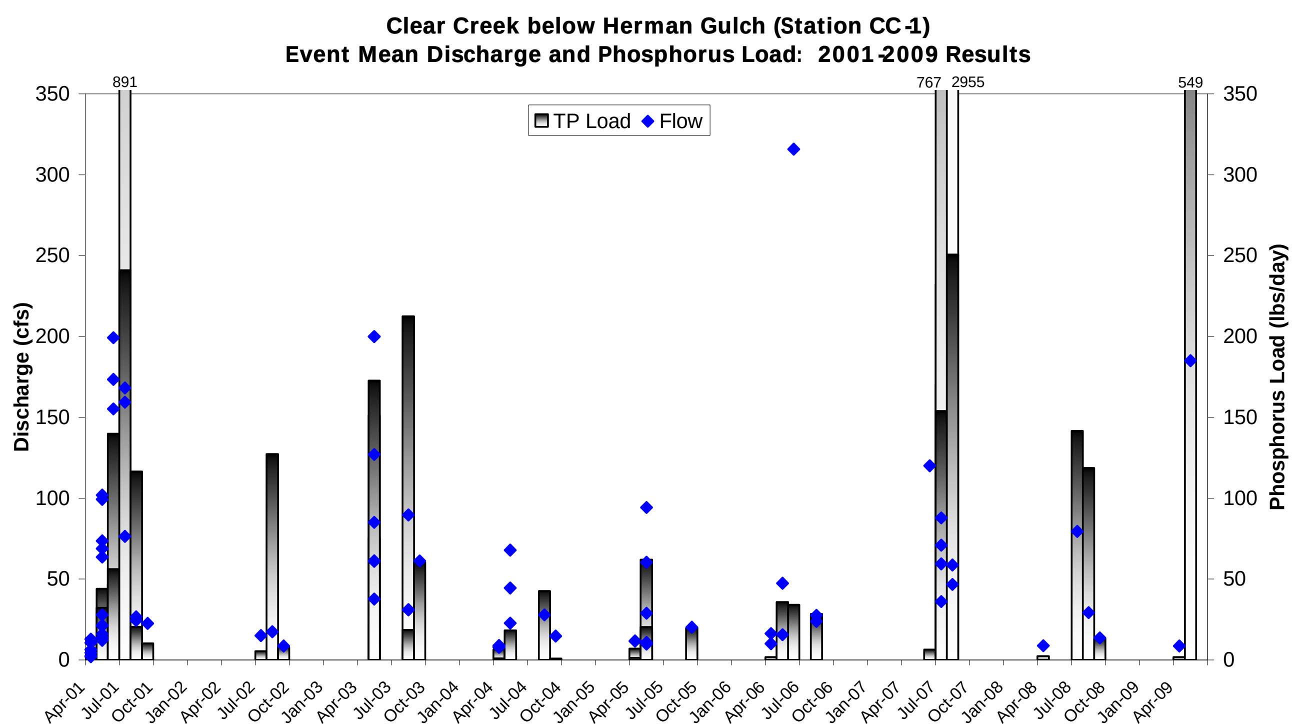
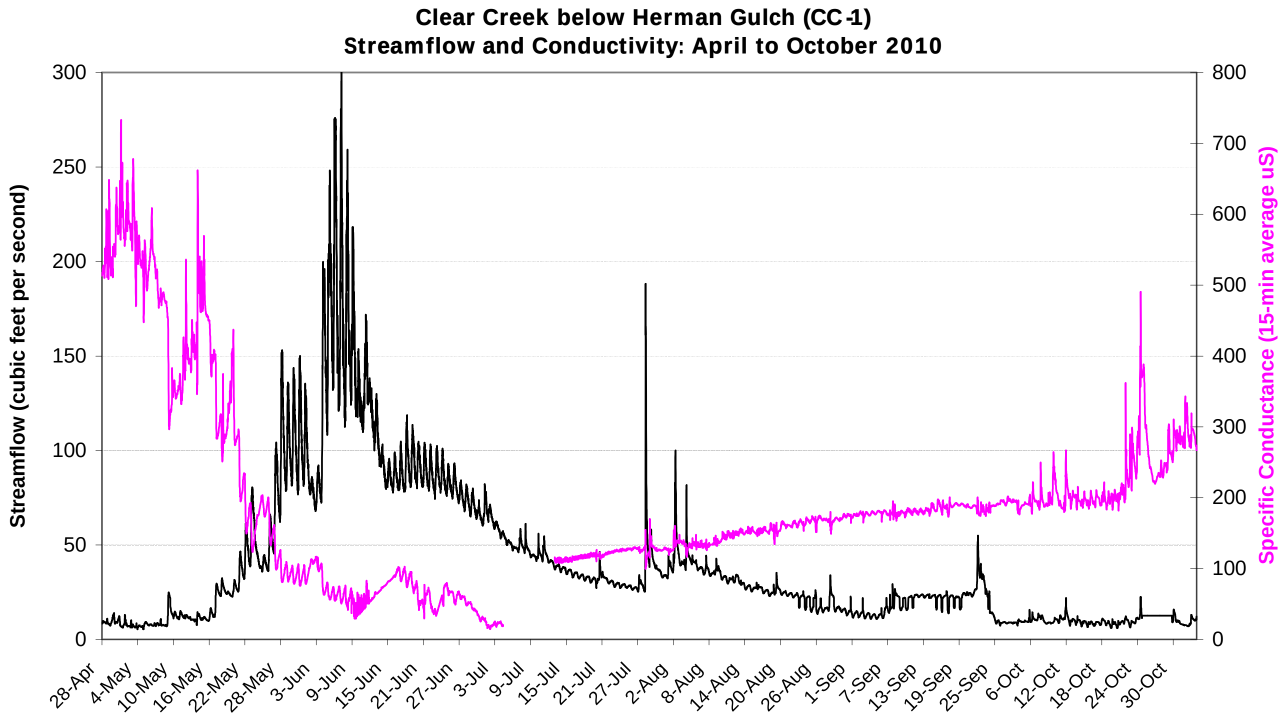


Figure 2-11 Suspended Solids and Total Phosphorus



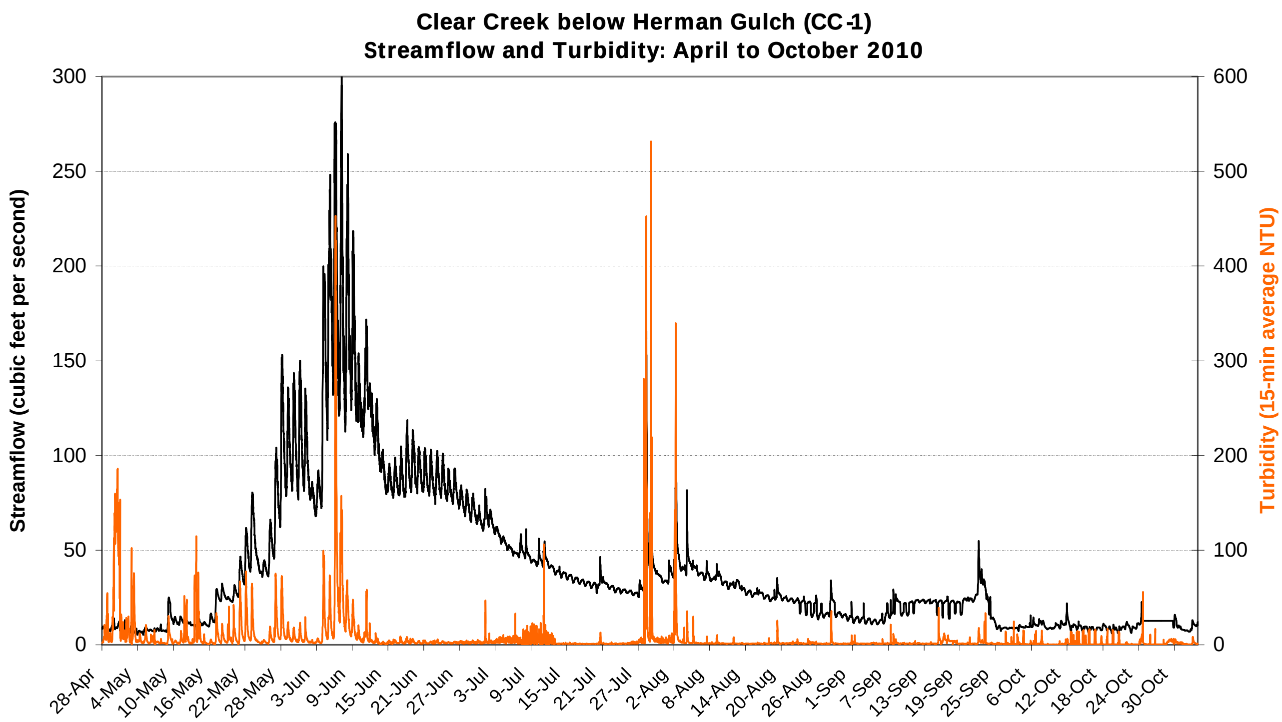


Figure 2-12 Streamflow, Conductivity, and Turbidity

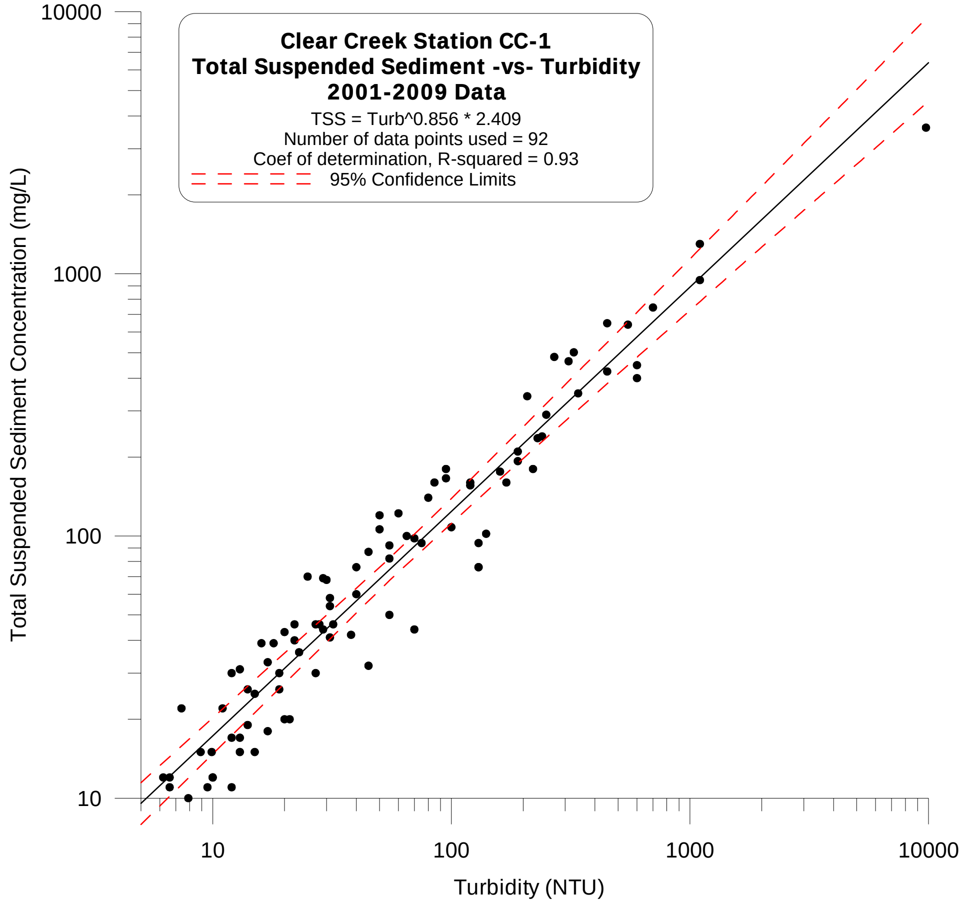


Figure 2-13 Suspended Sediment vs. Turbidity

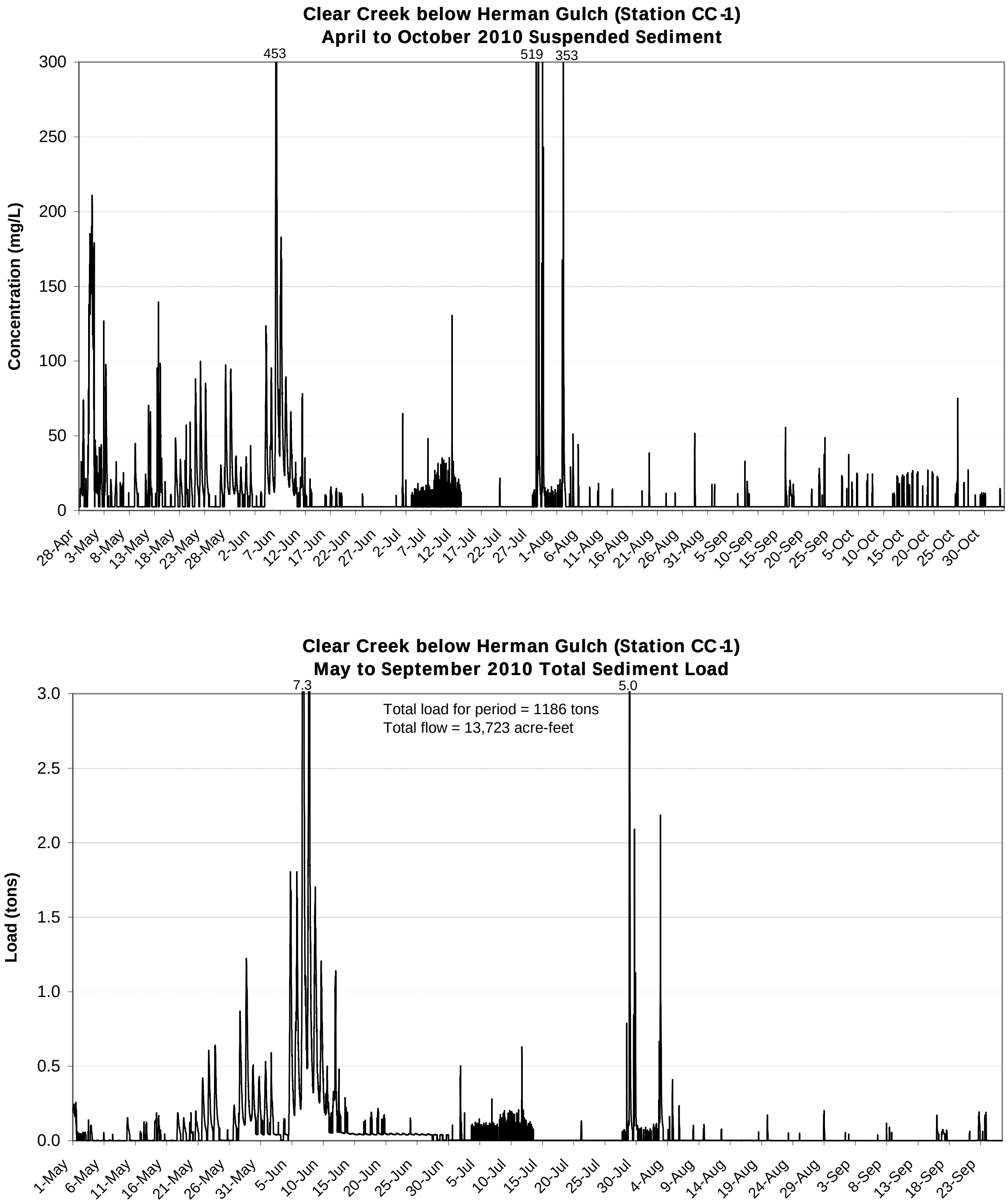
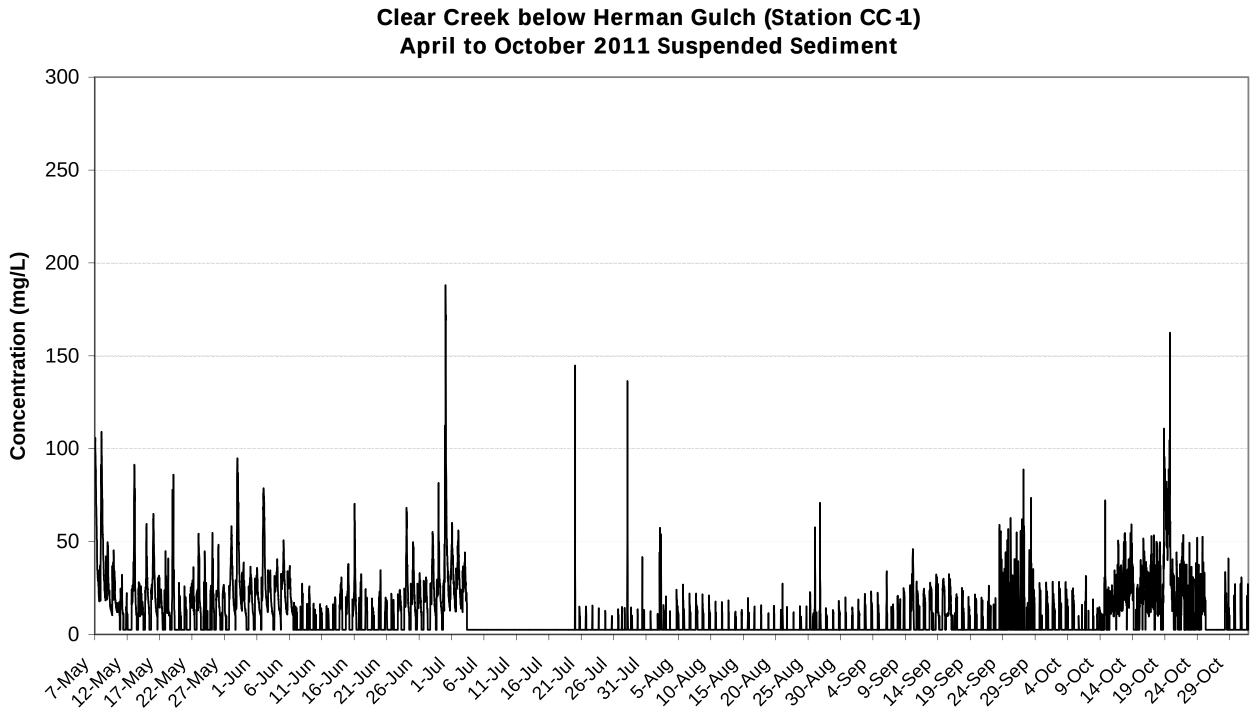


Figure 2-14 Suspended Sediment and Total Sediment Load - 2010



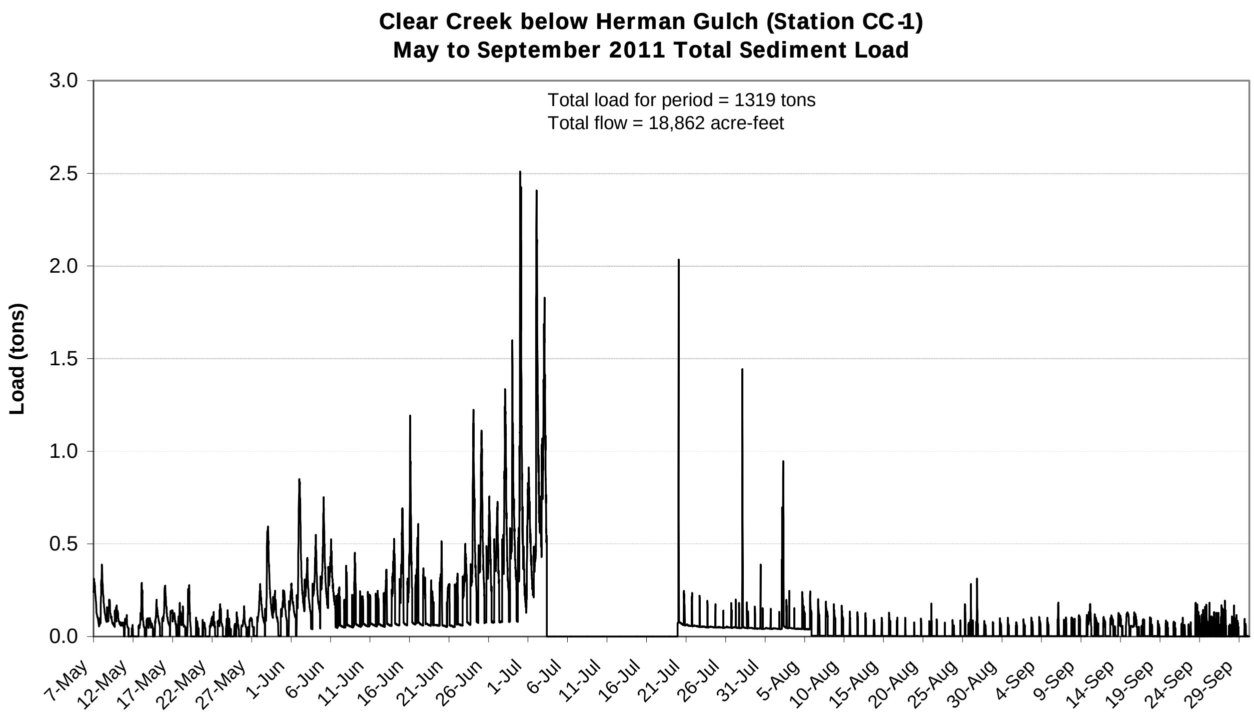


Figure 2-15 Suspended Sediment and Total Sediment Load - 2011

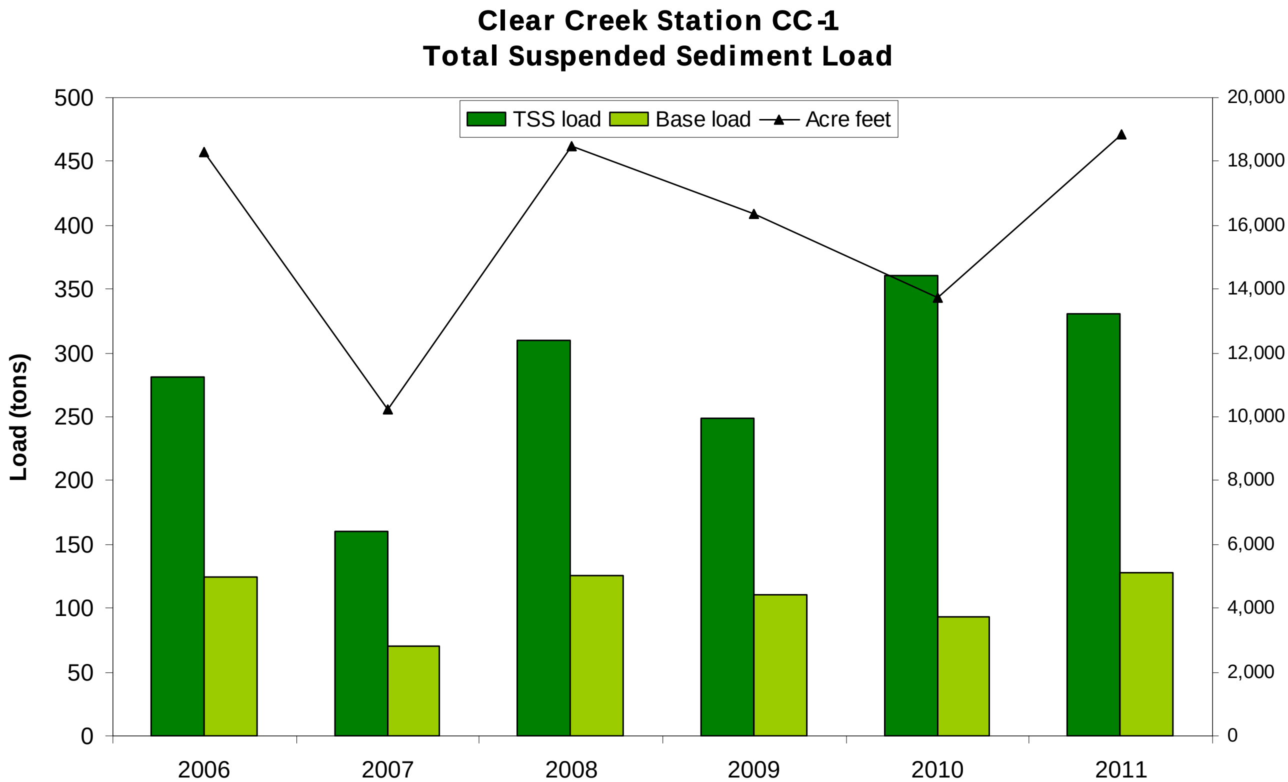


Figure 2-16 Clear Creek Total Suspended Sediment Load by Year

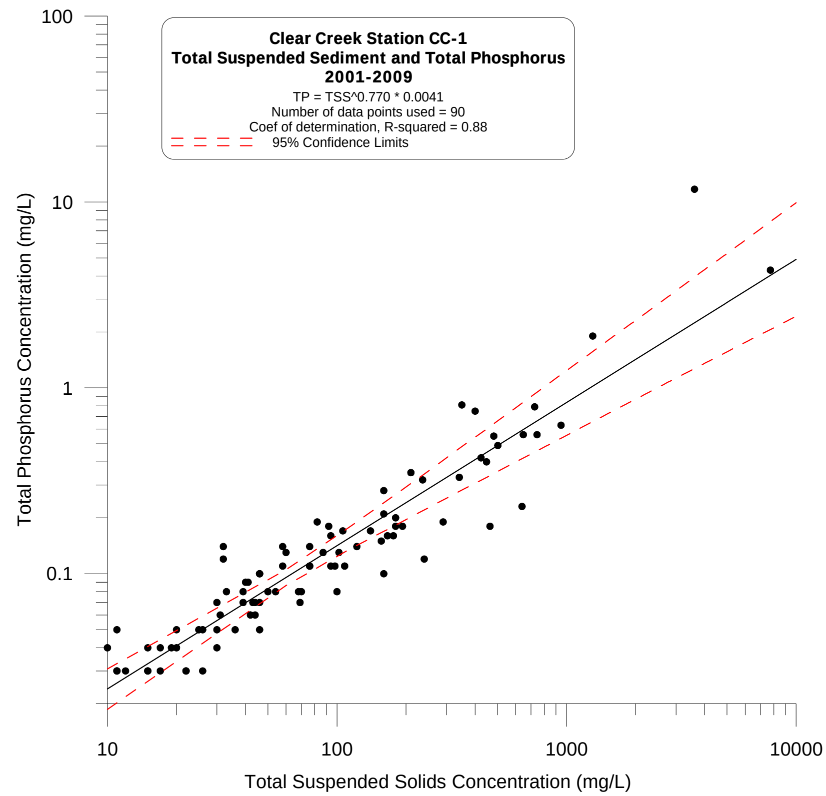


Figure 2-17 Clear Creek - Total Suspended Sediment vs. Total Phosphorus

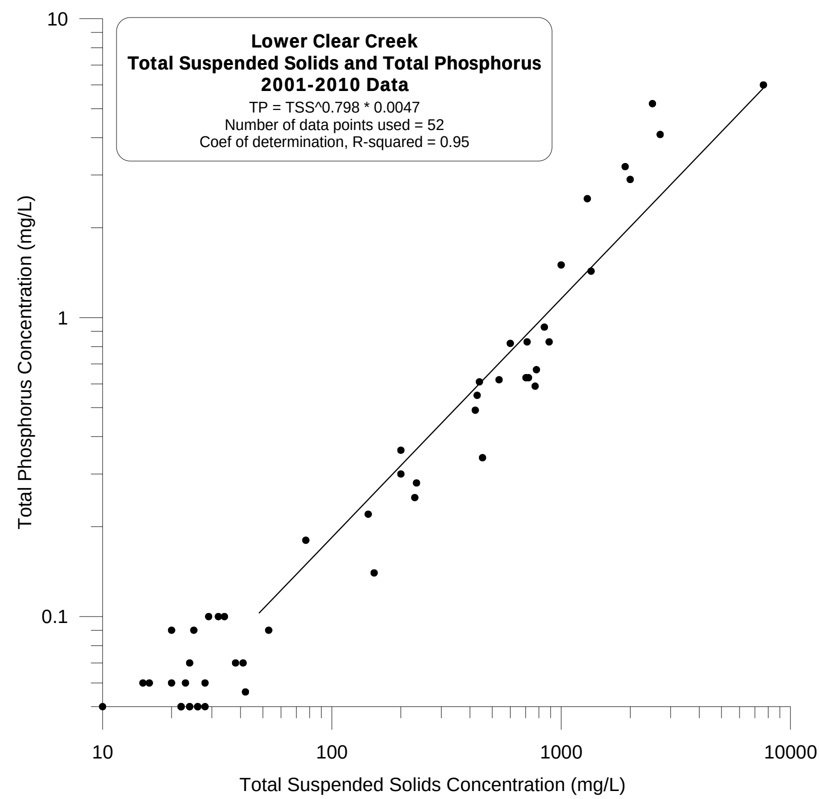


Figure 2-18 Lower Clear Creek - Total Suspended Sediment vs. Total Phosphorus

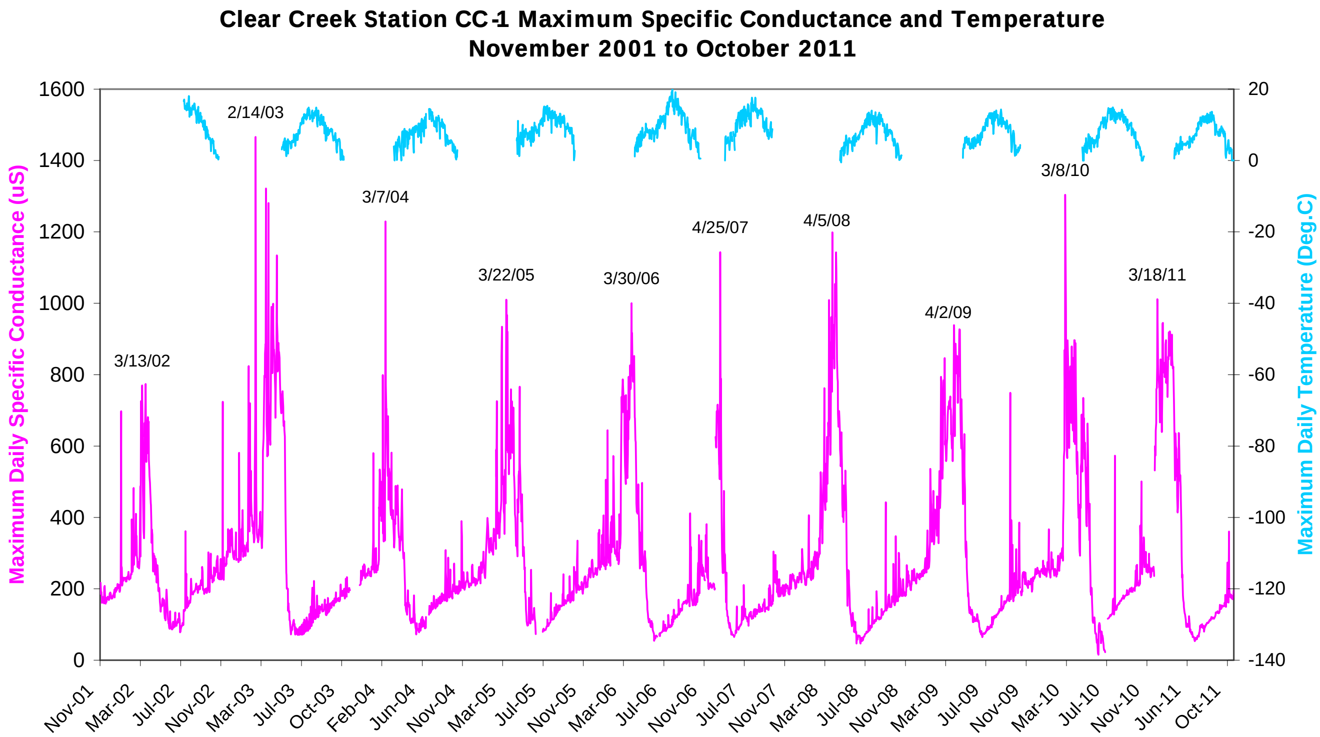


Figure 2-19 Specific Conductance and Temperature

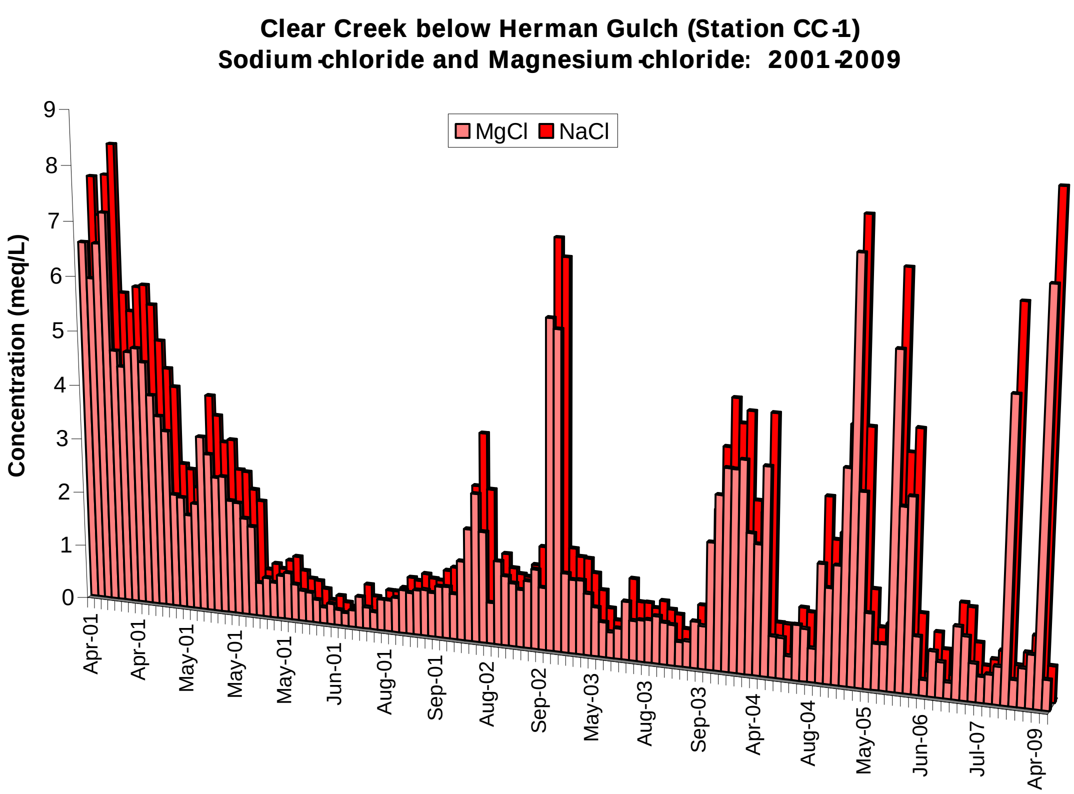


Figure 2-20 Sodium-Chloride and Magnesium-Chloride

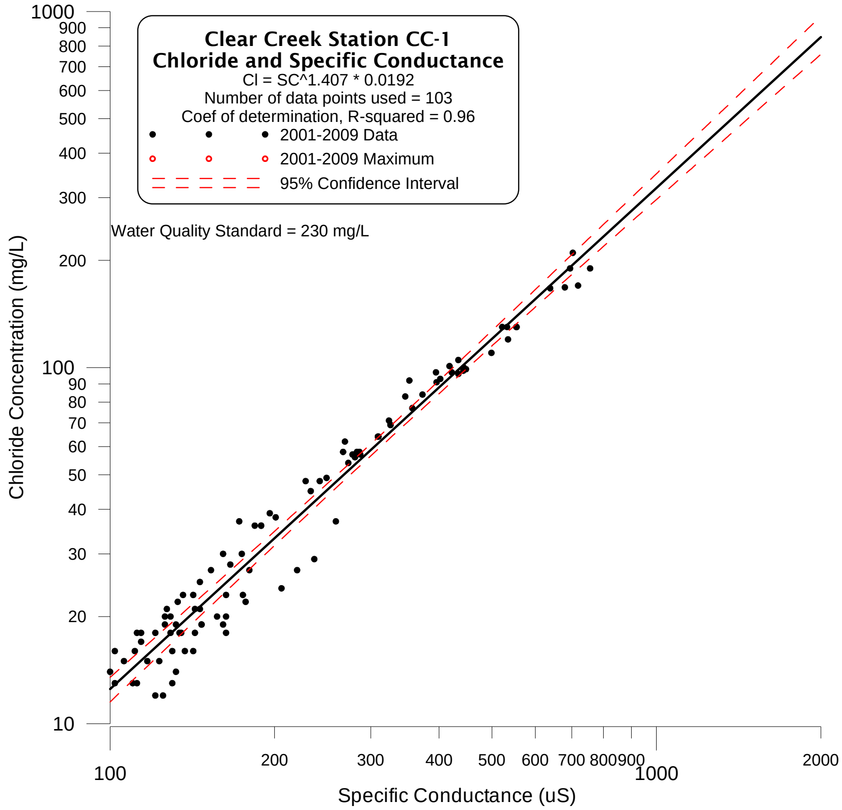


Figure 2-21 Chloride Concentration vs. Specific Conductance

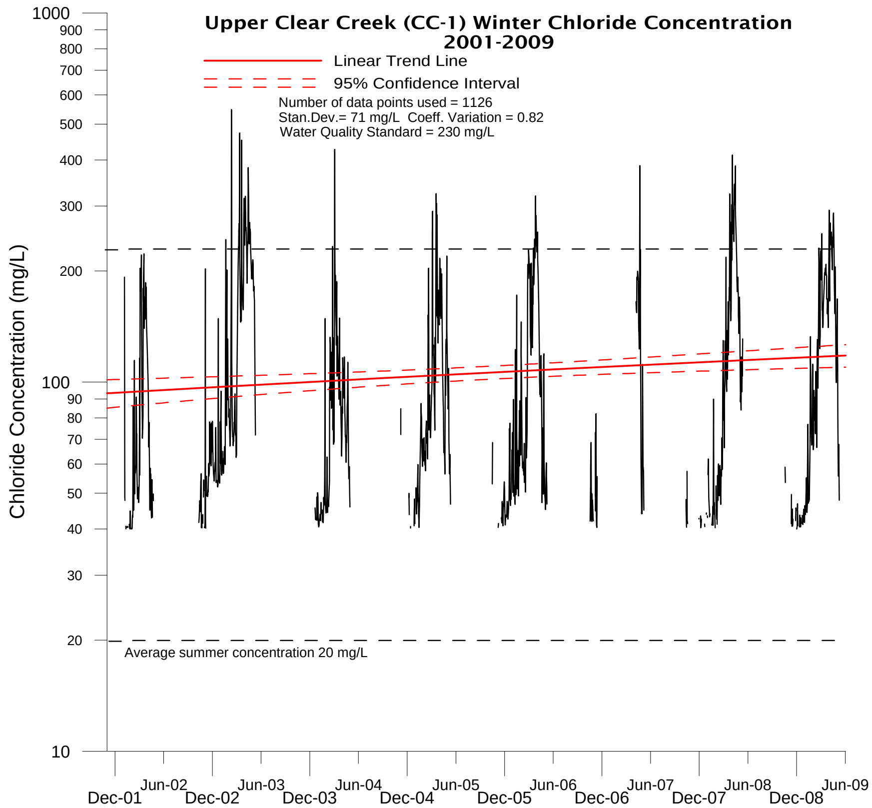


Figure 2-22 Upper Clear Creek – Winter Chloride Concentration

3.0 ENVIRONMENTAL CONSIDERATIONS AND REQUIREMENTS

3.1 Water Quality

The I-70 SWEEP program identifies primary issues related to water quality in the I-70 corridor and are summarized as follows:

- Sediment control and maintenance of BMPs
- Event impacts related to storms or other water quality upset conditions
- Water quality impaired stream segments listed for TMDL analysis
- Accident-related spills of hazardous materials
- Mineralized rock and mine workings
- Mine waste rock and tailings material

These water quality issues need to be considered for ongoing operation and maintenance of I-70 as well as for any new I-70 construction projects. This SCAP addresses these issues for existing I-70 conditions. For new projects the NEPA process is initiated to address project-specific impacts and mitigation as required under SWEEP.

The primary focus of this SCAP is sediment control and maintenance of related BMPs. It is well documented that total phosphorus and total metals associated with sediment can also be controlled with adequate BMPs. Dissolved salts related to I-70 cannot be easily mitigated by conventional sediment control BMPs. However, retention of salt-laden runoff in control structures will reduce direct salt loading peaks to Clear Creek.

3.2 Aquatic Biota

The Colorado Parks and Wildlife (CPW formerly Division of Wildlife) and the Colorado Hazardous Material and Waste Management Division of CDPHE undertook a cooperative long-term monitoring program of the aquatic resources in the Clear Creek Drainage, Clear Creek County, Colorado that was initiated in 1995. The objective of this monitoring program is to provide data that can be used to assess the success of various Superfund restoration projects in the drainage and to indicate where further efforts may be needed. Results of the 1995-2007 sampling program were summarized by CPW in 2008 as follows (Colorado DOW 2007).

> *"This summary indicates that metal contamination continues to negatively impact the aquatic community of Clear Creek. However, the naturally reproducing population of brown trout in the system has increased in abundance from Dumont, Colorado downstream to Golden, Colorado from the middle 1990's to the middle 2000's. This increase in the Clear Creek brown trout populations was due in part to decreased levels of copper and zinc in the stream. Additional removal of metals, especially copper, is needed to further increase the number of trout present in Clear Creek.*
>
> *Decreased copper loadings to Clear Creek would be beneficial in the stream reach upstream and downstream of Idaho Springs, Colorado. Other human related activities that negatively influence the Clear Creek aquatic ecosystem include such diverse activities as winter roadway sanding operations, discharges from domestic wastewater treatment facilities, nonpoint discharges of contaminants and episodic fish kills induced*

by human activities. The annual flow regime was also shown to influence trout populations. High spring flows result in a lower survival rate of brown trout that hatch that spring.

Clear Creek, like all streams, is a complex ecosystem. A wide range of human activities that negatively influence the stream biota confounds any study of the Clear Creek aquatic ecosystem. These sources include; mining activities from the 1860's to present, roadways and roadway construction, urban non-point storm runoff, effluents from domestic wastewater treatment plant, accidental spills from vehicles using the various roadways, etc.

Results of a 12-year fish monitoring program (1995-2006) indicated that metal contamination remained high enough to reduce the diversity and abundance of aquatic life in most portions of mainstem Clear Creek from the confluence of Spring Creek downstream to Golden, Colorado. However, the brown trout population has increased significantly in this same reach from fall 2000 through the fall of 2006. Copper was identified as the contaminant accounting for the most variability in brown trout throughout Clear Creek from just downstream of Lake Georgetown downstream to Golden, Colorado. Winter base flows and zinc were the two other variables that significantly accounted for some variability in brown trout numbers in the stream."

The CPW summary divided aquatic biota in Clear Creek into five distinct segments of which one covers the upper Clear Creek portion of this SCAP and two in the lower Clear Creek portion. Georgetown Lake was a separate segment. The assessment of aquatic biota found in these three areas is summarized below.

"The upper Clear Creek fish assemblage was composed of stocked Snake River cutthroat, rainbow trout, hybrids between the two species and a recently discovered relict population of pure greenback cutthroat trout in this portion of the drainage basin. Routine fish monitoring data were available from only the lower elevation portion of this stream reach. The physical habitat of this stream reach differed from Clear Creek downstream of Lake Georgetown because stream gradients are steeper and streambeds narrower than downstream segments.

Georgetown Lake supports cutthroat, rainbow, brook and brown trout. The CPW fish-stocking program probably maintains the populations of some species in Lake Georgetown while other trout species survive through successful natural reproduction. Low numbers of rainbow trout have periodically died in the reservoir in during late summer in some years. The dead fish were believed to be fish that had been stocked a few weeks earlier by the DOW. Exact cause of the deaths is unknown.

The lower Clear Creek numbers of trout and aquatic macro invertebrates varied in an inverse relation to zinc from 1995 to 2006 at the site downstream of Lake Georgetown. Brown trout numbers varied in inverse relationship to both zinc concentrations and the magnitude of spring snowmelt flows. Reductions in brown trout numbers were observed in the stream reach from downstream of the West Fork to Idaho Springs compared to brown trout population estimates upstream. The lower brown trout population estimates *were due to elevated metal concentrations in the water throughout the 12-year study period. The cause(s) of these reductions in brown trout numbers was related at least in part to an interaction of copper and zinc in this stream reach. The decrease in metal concentrations in the last six years or so of the study resulted in increased brown trout population estimates throughout lower Clear Creek compared to previous years.*

The aquatic macro invertebrate community of Clear Creek from just downstream of the Idaho Springs (Site 6) to Golden had the lowest diversity and abundance compared to other portions of the stream. Brown trout numbers remained depressed compared to upstream of Idaho Springs, but numbers appeared to double since 2001. Sedimentation as well as metal contamination may be responsible for the lower numbers and kinds of aquatic life in this stream reach."

The CPW identified additional studies that are needed to further assess the impact of human induced actions on the Clear Creek aquatic community. These studies need to determine the following:

1. The effect of sand and gravel applied to roadways during the winter months on abundance and diversity of the Clear Creek aquatic community.

2. The sources and loading of copper to Clear Creek from the confluence of the West Fork downstream of the discharge from the Argo Tunnel.

3. The effect of domestic wastewater treatment plant effluents on the Clear Creek aquatic community, specifically copper loading rates from the treatment plants.

4. The composition and loading of nonpoint sources to Clear Creek.

3.3 Wildlife

CDOT convened the ALIVE Committee, a technical advisory committee consisting of biologists from public entities with responsibilities pertaining to the I-70 Mountain Corridor (I-70 Corridor) Tier I Programmatic Environmental Impact Statement (PEIS) and Tier II (site-specific, project-level) National Environmental Policy Act (NEPA) documents. The ALIVE Committee ("A Landscape Level Inventory of Valued Ecosystem Components") has developed a landscape-based ecosystem approach for consideration of wildlife needs and conservation measures, and has identified measures to improve existing aquatic and terrestrial ecosystem connectivity across the I-70 Corridor between Denver and Glenwood Springs.

Using best available information, the ALIVE Committee identified 13 high-priority locations where evidence suggests that the highway's barrier effect impedes important wildlife migration or movement routes or zones of dispersal. These locations are referred to as linkage interference zones (LIZs). Three of the LIZs are located within the Clear Creek SCAP study corridor and are shown on the Mapbook sheets. The main features of these LIZ are described below.

Zone 10 – Herman Gulch/Bakerville (MP 216.7-220.8)

- Few median barriers are located through this zone, although guardrails are located through most of its length.
- Considered important lynx habitat. Arapaho-Roosevelt National Forest has designated the area a lynx linkage zone. Herman Gulch lynx linkage area is located within this zone, designated as a connection between suitable lynx habitats to the north and south of I-70. If quality habitat north of I-70 were combined with that south of the highway, a more viable lynx range would be possible, especially if connectivity across the Corridor improved.
- USFS and CDOW indicated that evidence existed that two female lynx were using the area as home range. A lynx was killed on I-70 by a vehicle in the area of Herman Gulch in 2000. Another female (pregnant with 2 fetuses) was killed near eastbound MP 217 on 5/19/2005.
- Boreal toad breeding area.

Zone 11 – East of Empire on US40 (MP 232)

- Steep slopes used by bighorn sheep on both sides of US 40. This zone was delineated specifically to address issues with bighorn sheep, which approach the edge of the highway to lick salt and are sometimes hit by vehicles at the edge of the I-70 and US 40 interchange.
- CDOW stated that bighorn sheep would not use an underpass or enclosed structure to cross a roadway.
- Mule deer winter concentration north; mule deer highway conflict area. Mountain lion conflict area.

Zone 12 – Fall River (MP 237.2 to 238.2)

- Two concrete box culverts, one 4 feet in height at Georgia Gulch, the other 10 feet in height at Fall River, currently exist in this linkage interference zone. An underpass is located at the intersection of US 40 and I-70. Solid median barriers are located through the length of the linkage interference zone and a guardrail is located on the south side of I-70 through most of the zone.
- The Fall River area provides a significant break in the surrounding topography and functions as a movement corridor for mule deer, elk, bighorn sheep, mountain goat, black bear, and mountain lion.
- CDOW noted that carnivores are frequently hit in this area, and there are concerns about elk populations becoming habituated and inhabiting the area year-round. Bighorn sheep, elk, bear, and mountain lion frequent the area and are hit occasionally.

This SCAP specifically did not include any new structural features that would impede wildlife movement within wildlife LIZ 10, 11, or 12. There are no known boreal toad breeding sites in

LIZ 10 at locations where water quality BMPs are proposed. The highway drainage system in this area will be improved and additional sediment basins installed to reduce water quality impacts to wetland areas downstream of the highway.

CDOT has developed “Project-Special Specifications” for management of boreal toads and leopard frogs found on their projects (CDOT 2012a). These specifications are based on standards and guidelines provided for the Straight Creek Watershed by the U.S. Forest Service (USFS) and Colorado Parks and Wildlife (CPW) biologists.

3.4 Drinking Water Supply and Source Water Protection

The Clear Creek Watershed is located due west of Denver, Colorado, spanning 575 square miles from Clear Creek’s headwaters near the Continental Divide (14,000 feet in elevation) to its confluence with the South Platte River in the northern metropolitan Denver area (5,000 feet in elevation). The watershed includes five counties, several towns and cities, and a considerable rural/mountain population. Water quality in the watershed has been negatively impacted by historic mining, transportation, and increasing population and associated urban development.

Clear Creek supplies water to approximately 350,000 people in the watershed, supports numerous industries, including those focused on recreation and agriculture, and provides habitat for some of the best fisheries close to an urban setting in Colorado. Standley Lake is located on the Big Dry Creek drainage in Jefferson County, Colorado and is the largest reservoir which is filled with Clear Creek water. Constructed in 1911, Standley Lake originally stored water for agricultural irrigation. In 1963 the City of Westminster rehabilitated the reservoir, adding an additional 12,000 acre-feet of storage for municipal use, bringing the total capacity of the reservoir its current 42,000 acre-feet. In 1979, the cities of Thornton and Northglenn also began using the reservoir for water storage (CLMRA 2013, Westminster 2013).

The majority of the water stored in Standley Lake is diverted from Clear Creek. Water is conveyed to Standley Lake via several large canals including the Croke Canal, the Farmers High Line Canal and the Church Ditch. Standley Lake holds one of the more senior water storage rights on Clear Creek. Accordingly, it generally diverts and stores the majority of the Clear Creek flow during the months of November through March. A significant amount of water is diverted into the reservoir during the summer months as well.

Clear Creek adjacent to the EJMT supplies water for snowmaking at Loveland Ski Area, while water for domestic use is supplied by Zip Creek which also bisects I-70. The Town of Silver Plume operates its domestic water supply diversion on Clear Creek adjacent to I-70. The City of Black Hawk operates a domestic water supply diversion in Clear Creek adjacent to I-70 at Hidden Valley. These water supply diversion points are shown on the Mapbook sheets. The City of Golden and Molson-Coors, both downstream of the study corridor, also rely on Clear Creek for their water supply.

3.4.1 Upper Clear Creek and Standley Lake Source Water Protection Plan

A Source Water Protection Plan (SWP) was developed for upper Clear Creek Watershed and Standley Lake in 2010 by the Cities of Westminster, Northglenn, and Thornton (SWP 2010). The stakeholders in the upper Clear Creek Watershed and Standley Lake Cities recognize the potential financial, public health, and water supply risks related to contamination of one or more of the community's water sources. The Clear Creek I-70 SCAP study area falls within the source water protection area.

The primary reason for developing and implementing source water protection measures is to provide an additional level of protection for the drinking water supply. Extensive changes in drinking water regulations have occurred over the past 20 years. These changes make compliance with the requirements of the Safe Drinking Water Act (SDWA) and the Clean Water Act (CWA) much more difficult. Protection of source water quality is becoming increasingly critical in order to protect public health, avoid increased treatment costs, prevent aesthetic water quality problems such as taste and odor events, and to meet new regulatory standards.

Both discrete and dispersed contaminant sources were identified and prioritized in the SWP. A public health-based approach was chosen to categorize contaminants identified in the Standley/Clear Creek SWP area. While this approach was driven mostly by the Cities' concerns with secondary drinking water contaminants, the presence of "nutrient-related contaminants" can also prompt concerns about the possibility of acute and chronic health effects.

The SWP identifies and recommends 11 BMPs for the study area, one of which is the installation and implementation of runoff sediment controls. One requirement of the CDPHE source water protection grant was to develop and implement a Best Management Practice (BMP) that will improve nutrient management in the watershed. The SWP steering committee decided that enhancing the ability to provide early warning for water quality events in Clear Creek will be a productive and feasible BMP project for this purpose.

3.4.2 SWP Early Warning Water Quality BMP

For over a decade, the existing Emergency Notification System (ENS) (formerly referred to as "Call-down System") has been critical to protecting the water supply for hundreds of thousands of people. The area affected by the ENS includes the Clear Creek Watershed from its headwaters downstream to the City of Golden. Maintained by the Clear Creek County Office of Emergency Management (OEM) and launched by the Clear Creek County Dispatch Center, the ENS notifies downstream water users of potential contaminants that have entered the stream. Participating entities are notified promptly of possible contamination threats and can refer to a time of travel study to calculate how long it will take for the contaminant to reach their headgate or raw water intake.

An early warning system for downstream users of Clear Creek is critical to protect water supplies (CCC 2010). Presently, the ENS greatly improves the chances that downstream entities are able to respond quickly and appropriately to possible contamination threats. The purpose of the BMP is to document the procedures, describe the ENS, and identify opportunities to improve the early warning system for spills and other water quality events that can occur in Clear Creek. The ENS protocols are documented and other stream monitoring procedures are assessed to evaluate response to events that may increase loadings of nutrients or other pollutants to Clear Creek and Standley Lake.

The ENS may be activated as a result of vehicle accidents, hazardous waste spills, fuel spills, mudslides, avalanche, or flood events that can threaten life or property. Accidental discharges from wastewater treatment facilities or mines, and intense storm runoff events are not currently part of the ENS (CCC 2010). Hazardous waste spills affecting waterways in the Clear Creek Watershed are most likely to occur as a result of vehicle accidents on Federal or State roadways (CCC 2010).

CDOT patrols are often some of the first to arrive at an accident scene. CDOT becomes involved if there is any road damage or traffic control at the accident scene and takes a lead role in ensuring the CDOT right-of-way (ROW) is restored. For spills that occur on the ROW, a Special Use Permit and Access Permit is required for any cleanup activities on property owned by CDOT (Red Campbell personal communication, 16-February-2010). Once an access permit is granted, the cleanup contractor must request a “No Further Action” determination from CDOT that also requires a closure report from the responsible party for spills in excess of 100 gallons on the ROW.

CDOT developed a document entitled “Procedures for Hazardous Material Spills that occur on State and Federal Highways within Colorado as a Result of a Highway Transportation Incident”. This document was developed to explain to motor carriers and others, their responsibilities regarding spills of petroleum fuel and other hazardous materials due to transportation incidents on State or Federal highways. The CDOT procedures document is a compilation of state rules, statues, procedures, state and local contacts, and other information intended to help explain the requirements on reporting, permitting, remediating, and receiving “No Further Action” determinations for incidents involving spills within the CDOT ROW. Reporting and cleanup is required by the responsible party if the amount of petroleum fuel spilled exceeds 25 gallons or if spilled materials have impacted or threaten to impact waters of the state.

CDOT authority to require remediation of hazardous spills only applies to spills within the highway ROW (Andy Flurkey personal communication, 16-February-2010). CDOT does not have regulatory authority to enforce cleanup standards. If the spill leaves the ROW and flows onto private or public land or into waterways CDPHE has jurisdiction, however there is currently no documented procedure or required enforcement action for cleanup and remediation (SWP 2010).

The BMP developed for the SWP recommended the following:

- Enhancements to the Clear Creek ENS system
- Post spill clean-up and documentation
- Inclusion of accidental wastewater discharges, mine drainage events, and storm events
- Real-time in-stream event monitoring
- Ambient sampling for priority pollutants
- Spill containment BMPS along highways

4.0 CDOT MAINTENANCE PROGRAM

Roadway and tunnel maintenance personnel are responsible for maintaining the operational capability of the I-70 highway system. The purpose of highway maintenance is to preserve and keep all roads, roadsides, structures, and miscellaneous facilities in as close to their original or improved condition as possible. The maintenance employee's primary duty is to keep all highways that are open to traffic in a safe and usable condition, as available resources allow. In Colorado, snow and ice control is the highest priority of all the maintenance activities in order to protect the safety of the traveling public. The operational capability of a highway system can be greatly diminished by such things as roadway surface deterioration, snow and ice, poor lighting, and inadequate lane demarcation.

Within CDOT, the state is divided into six engineering regions and nine maintenance sections. Each engineering region has project development (pre-construction and construction) responsibilities and maintenance sections. Engineering Region 1 encompasses 12 counties from the Kansas State Line to the summit of Vail Pass on I-70, excluding the Denver metropolitan area and Vail Pass west (Figure 4-2). The jurisdictional boundary between Engineering Regions 1 and 3 is at the top of Vail Pass.

Maintenance Sections 5 (Clear Creek) and 9 (Eisenhower Tunnel) are included within Region 1. Maintenance Section 5 includes Clear Creek County and extends westward to Vail. The Eisenhower-Johnson Memorial Tunnel (EJMT) and associated parking areas are maintained by Maintenance Section 9.

The Maintenance Sections are further divided into Foreman Areas and each Foreman Area is divided into Patrols. The Paul East Foreman Area maintains all of the state highways within Clear Creek County including I-70. The Paul East Foreman Area is divided into work groups called patrols. These patrols perform maintenance on specific roadway sections in the Paul Area. This SCAP includes two patrols: Patrol 41 extending from the Eisenhower Tunnel to Idaho Springs; and Patrol 45 extending from Idaho Springs to Beaver Brook.

The Paul East Area has 24 full-time maintenance workers (**FTE**) and 9 part-time workers (**PPTs**). These people are accountable for all the maintenance on 784 lane miles of state highways consisting of high mountainous terrain. This SCAP covers only a small portion of I-70 within the total Paul Area.

Public pressure is being placed on the CDOT maintenance to meet customer needs with increased traffic volumes, limitations on resources, and greater expectations. Not only does the Paul Area contain some of the most heavily traveled portions of the interstate system within the state, these personnel maintain the roadway network that service some of the most popular ski areas in the state during the winter months.

The routine maintenance of the I-70 corridor has focused primarily on maintaining the roadway surface. When I-70 was first constructed, the higher level of maintenance work needed to meet the growing needs was not anticipated. Public expectations for maintaining I-70 to a certain level have increased significantly since the completion of I-70. The scenarios presented in this

SCAP would require significant additional resources for roadway maintenance in order to provide the same level of service to the traveling public.

4.1 Maintenance Activities and Funding Mechanism

Maintenance personnel are responsible for a number of tasks and activities. These activities are divided into Major Program Areas (**MPAs**) and are funded according to established targets. CDOT uses a system of budgeting for maintenance based on Maintenance Levels of Service (**MLOS**) and MPAs. The Transportation Commission has established targets for the level of service for each MPA. The target rating drives the funding for the activities in each MPA. The rating ranges from "A+" being the top of the scale to "F-"being the bottom. For example, if an MPA is targeted at an A level of service it will receive more funding than if it is targeted at a C level of service. Interstate 70 is typically rated at a B level of service and would receive more funding if targeted at an A level of service.

Maintenance equipment, building maintenance, and sand shed allocations are managed separately. Routine maintenance activities under the current MLOS program will continue to be accomplished with existing personnel. The Maintenance MPAs are further defined below:

- Snow & Ice Control: snow removal, traction application (sanding & deicers), ice control, snow fence maintenance & repair, avalanche control, chain station operations, snow removal (special equipment), etc.

- Roadway surface: patching, seal coating, blading, restoring shoulders, crack sealing, etc.

- Traffic Services: maintenance and installation of signs and guardrail, and pavement striping, etc.

- Roadside Facilities: maintenance of drainage structures, maintenance of ditches, slope repair, litter & trash clean-up, mowing, sweeping, sound barrier maintenance, etc.

- Roadside Appearance: vegetation control, bridge/structure maintenance & repair, maintenance of deck expansion devices, etc.

- Tunnel Maintenance: tunnel operations, tunnel snow removal & sanding, auto extrication & fire fighting, tunnel washing, maintenance & mechanical operations, electrical & electronic warning systems, etc.

In order to track the management of maintenance expenditures the **SAP** (Maintenance Management System (MMS) prior to 2007) is used statewide by each CDOT Region. The SAP is a computer program designed to track materials, equipment, and labor expended on highway maintenance activities. This system provides information regarding the efficiency and effectiveness of resources, and is used to plan for activities and associated future costs. With this system, field personnel report their maintenance activities and inventories, which are then entered into a computer database.

Although sand cleanup can fall into many MPAs, such as Traffic Services for guardrail work or Roadway Surface for ditch cleaning, the majority of the environmental cleanup work falls under the Roadside Facilities MPA. Roadside Facilities typically includes mowing, fence repair, litter and debris control, sweeping, drainage structure maintenance, rock runs, slope repair, and streambed maintenance. These are considered routine maintenance activities.

Maintaining BMPs, collecting and hauling material, and data collection and reporting are all part of the environmental requirements, but these are not considered routine maintenance activities. Implementation of this SCAP as a part of "routine" operations within the context of the activities performed by maintenance personnel would require an entirely new focus and prioritization of maintenance operations under MLOS. In order to accomplish this, the extra work must be fully integrated into the maintenance program.

The clean-up of sand and sediment from the highway corridor is conducted through ditch cleaning, cleaning beneath guard rail, sweeping, and other related activities as work designated under Roadside Facilities. In Region 1, maintenance must budget for these activities among 12 counties. Since the beginning of the MLOS program in FY 2000, the MLOS for Roadside Facilities has been set at Level B. This has determined funding levels for this program area, including sand clean-up and other "environmental-related work" such as erosion and drainage control, constructing boreal toad habitat, maintaining sediment ponds, collecting and reporting data, and other similar activities.

The MLOS system was implemented largely to improve accountability and is tied to the annual budgeting process. Maintenance funds are limited since they are made up entirely of state funds and must cover a wide variety of activities within a given maintenance area. Winter operations to maintain the safety of the traveling public and the roadway surface remain two of the highest maintenance priorities where large portions of the funds are allocated. Maintenance staffing, equipment needs, and annual maintenance priorities are established by CDOT management, the Transportation Commission and state law, and are all tied closely to the MLOS system.

The relatively new environmental-related maintenance activities, such as additional sand cleanup beyond the routine work and implementing and maintaining source controls, were not funded or accounted for prior to FY 2007. However, there is no new source of funding nor have changes been made in the MLOS to provide additional resources for addressing these environmental components. The demand placed on existing maintenance forces to meet the full responsibility of the maintenance activities alone is worth noting. For maintenance personnel, it is an additional burden on their already taxed resources to address these relatively new environmental concerns, which is additional labor intensive work that can require specialty equipment and is expensive.

CDOT is receiving considerable pressure to increase the level of sediment control and cleanup, particularly in the I-70 mountain corridor, but in others as well. Within the Paul East Area alone, maintenance is required to address sediment related and water quality related problems that exist on Berthoud Pass from Empire to Winter Park, along the Clear Creek corridor of I-70, through the Dillon Valley, as well as the Black Gore Creek and Straight Creek I-70 corridors. With the sediment TMDLs on Straight Creek and Black Gore Creek, new requirements are expected of maintenance forces to accomplish work that is beyond the routine work established in the MLOS. A more extensive maintenance program is needed if the demands of the public are to be met to address the highway-related water quality issues.

The majority of the roadway surface treatments such as paving and seal coating are done in July and August when temperatures for these activities are optimum. Shoulder and ditch cleaning, and rock removal are performed primarily during May, June and September. Snow begins falling in September and roadside work becomes very sporadic in October. Additionally, maintenance must repair safety devices, perform structure work, slope repair, vegetation management, and many other required activities within the short summer months.

In FY 2000, the Transportation Commission began to fund an additional $200,000 for contracts to maintain and clean sediment basins, and an additional $100,000 per year for new sediment control projects to be matched with Federal grants. These funds are split between both the Black Gore Creek and Straight Creek I-70 corridors. Although these additional funds have certainly helped, they have been inadequate to fully address the problems on an annual basis. Escalating costs since FY 2000 have diminished their spending power. The options for maintenance are large increases in overtime, adding FTE's, or contracting out more maintenance related work such as paving or sand clean-up.

Many maintenance activities such as laying asphalt, sand cleanup under guardrails, or dredging sediment ponds are very labor intensive. For example, when a maintenance patrol lays asphalt it requires nearly the entire allotment of people in that foreman's area. These workers are therefore not available for dredging sediment ponds, although both activities must be accomplished during the summer months. The approach over the last several years has been to leave one patrol intact to do extra environmental clean-up work, while all the other patrols perform the paving. This is accomplished using the gang maintenance approach as much as possible between areas. For example, one year the Straight Creek patrol is left intact to clean sand, and the next year may work on Black Gore Creek. Berthoud Pass generally has some people working on environmental clean-up work as well. This restricts the efforts of the Clear Creek, Loveland Pass, and Highway 9 crews to conduct their routine maintenance activities and to accomplish extra environmental work on their highway segments.

The maintenance patrols make an effort to sweep after snow events whenever possible during winter, spring and summer operations. Due to lack of specialized equipment, adverse weather conditions, and extreme temperature fluctuations during late winter and spring, it is often not possible to sweep after every storm event. The area only has one broom that is used to sweep Straight Creek, Vail, Silverthorne, Frisco, and Dillon. Since snow and ice control is the highest priority for maintenance crews, they must respond quickly. When snowstorms are predicted, the affected patrols are preparing for adverse weather conditions by making sure all snow removal equipment is in good working order, important safety matters are addressed, and existing snow is pushed back to ensure adequate room for additional accumulations.

With the current allotment of funds in the maintenance budget for this work, maintenance forces can continue to maintain the shoulders, ditches, drainage structures, and eroded areas to the extent possible, but are typically unable to undertake more activities. At the current time if roadway resurfacing has been identified as a high priority for the Paul Area within a given season, this type of work must be done during the summer and utilizes all of the available resources.

In order to accomplish what is being requested of maintenance forces during the summer months to clean-up sediment material, maintain BMPs, and other environmental-related activities along the I-70 mountain corridor, the maintenance program will require a new approach and philosophy regarding maintenance priorities and responsibilities. To be effective, sediment control needs to become a high priority under the MLOS program during the summer months, as snow and ice control is during the winter months. Responsibilities within the current MPAs would need to be expanded to include resources for accomplishing these additional activities.

4.2 Winter Maintenance Material Use and Data Trends

The winter maintenance material usage data for the Clear Creek SCAP area of I-70 is compiled by CDOT in SAP according to maintenance patrol. Upper Clear Creek falls within Patrol 41 which extends 25 miles from MP 216 (EJMT) to MP 241 (east Idaho Springs). This 25-mile segment of I-70 includes the EJMT/Loveland area and Georgetown Hill, which requires substantially more winter maintenance material than lower Clear Creek due to the steep grades and higher elevations. The upper Clear Creek portion of this SCAP covers 12 miles or approximately one-half of Patrol 41. CDOT maintenance estimates that about two-thirds of the annual maintenance material in Patrol 41 is used in upper Clear Creek segment. Therefore, material application rates are much greater in upper Clear Creek.

Lower Clear Creek includes about 13 miles in Patrol 41 and 9 miles in Patrol 45. Patrol 45 extends from MP 241 (east Idaho Springs) to MP 250 (Beaver Brook). Floyd Hill is included in this patrol, which also requires more winter maintenance due to the steep grades and higher elevations.

The winter maintenance materials used on I-70 include both traction sand/salt mixtures (solids) and chloride-based liquid deicers (liquids). The application amounts for these materials were obtained from CDOT SAP Hyperion Report for FY 2001 to 2012. CDOT's Fiscal Year (FY) extends from July 1 to June 30, including the entire winter period each year. For example, FY 2012 spans July 1, 2011 to June 30, 2012.

The winter maintenance material application rates for Patrols 41 and 45 for 2001 through 2012 in tons per mile (not lane miles) is shown in tabular form in Table 4-1. The solids material application rates are also shown graphically along with liquid deicers in Figure 4-1 for the last 12 years. The amount of sand and salt used can vary considerably from year to year according to weather conditions (snowfall and icing). Solids use in Patrol 41 has remained relatively consistent since 2002, while the use of liquid deicer shows an increasing trend. Solids use in Patrol 45 shows a decreasing trend in recent years, while liquid deicer use has remained relatively constant.

Patrol 41 data was adjusted to account for higher application rates in upper Clear Creek as mentioned above. The _adjusted average application rate_ for upper Clear Creek was 222 tons/mile-year, and Patrol 45 was also 222 tons/mile-year. _Maximums_ were 377 and 362 tons/mile-year, respectively.

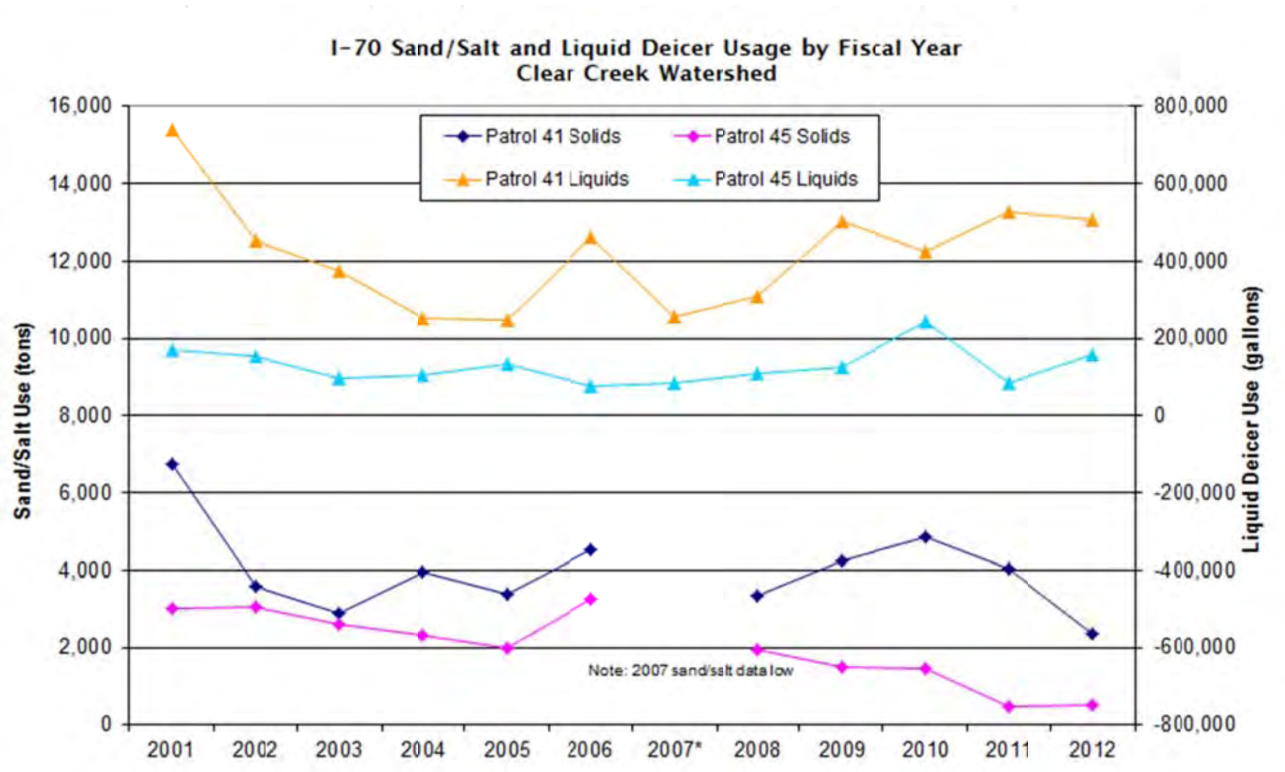
The solids material application rate is one factor used to determine sediment BMP capture volumes; however sediment from I-70 slope erosion and other sources must also be considered. It is important to recognize that weather conditions and application rates are not linear in the SCAP study corridor and reported data does not reflect site-specific conditions; application rates are greater at high elevations and in steep gradient areas of I-70.

Table 4-1 I-70 Clear Creek Winter Maintenance Materials Usage Data

I-70 Clear Creek Winter Maintenance Materials Usage Data - FY 2001 to 2012

Winter	FY	Length (miles)	Solid Deicer/Ice Slicer (tons)	Sand-Slicer Mix (tons)	Total Solids Sand & Salt *** (tons)	Rate (tons/mile)	MgCl Deicer (gal)	Caliper 1000 Deicer (gal)	Total Liquid Deicer (gallons)	Rate (gal/mile)
Patrol 41 - MP 216-241 Eisenhower Tunnel to Idaho Springs										
2000-2001	2001	25			6,756	270	368,125	371,375	739,500	29,580
2001-2002	2002	25	1,164	2,399	3,563	143	210,547	241,040	451,587	18,063
2002-2003	2003	25	238	2,644	2,882	115	138,947	235,392	374,339	14,974
2003-2004	2004	25	546	3,406	3,952	158	86,582	164,523	251,105	10,044
2004-2005	2005	25	477	2,902	3,382	135	62,076	185,568	247,644	9,906
2005-2006	2006	25	220	4,290	4,510	180		459,007	459,007	18,360
2006-2007	2007*	25	477	326			45,842	210,157	255,999	10,240
2007-2008	2008	25	1	3,339	3,342	134	299,948	7,700	307,648	12,306
2008-2009	2009	25			4,223	169			501,437	20,057
2009-2010	2010	25			4,836	193			424,247	16,970
2010-2011	2011	25			4,036	161			527,445	21,098
2011-2012	2012	25		2,348	2,348	94			506,722	20,269
2001-2012	**Average***				**3,985**	**159**			**420,557**	**16,822**
2001-2012	**Maximum**				**6,756**	**270**			**739,500**	**29,580**
2008-2012	**5-yr Average**				**3,757**	**150**			**453,500**	**18,140**
Upper Clear Creek		**Average****				**222**				
		Maximum				**377**				
Patrol 45 - MP 241-250 Idaho Springs to Beaver Brook										
2000-2001	2001	9			3,022	336	62,200	106,900	169,100	18,789
2001-2002	2002	9	548	2,516	3,064	340	62,000	90,000	152,000	16,889
2002-2003	2003	9	507	2,084	2,591	288	42,300	52,700	95,000	10,556
2003-2004	2004	9	204	2,094	2,298	255	62,100	42,500	104,600	11,622
2004-2005	2005	9	156	1,807	1,963	218	99,600	32,408	132,008	14,668
2005-2006	2006	9	61	3,194	3,255	362	45,300	27,800	73,100	8,122
2006-2007	2007*	9	236	324			68,407	13,574	81,981	9,109
2007-2008	2008	9		1,937	1,937	215	109,212		109,212	12,135
2008-2009	2009	9		1,490	1,490	166	124,957		124,957	13,884
2009-2010	2010	9		1,438	1,438	160	243,152		243,152	27,017
2010-2011	2011	9		340	465	52	82,122		82,122	9,125
2011-2012	2012	9		499	499	55			157,659	17,518
2001-2012	**Average***				**2,002**	**222**			**127,074**	**14,119**
2001-2012	**Maximum**				**3,255**	**362**			**243,152**	**27,017**
2008-2012	**5-yr Average**				**1,166**	**130**			**143,420**	**15,936**

Sources: CDOT Region 1 Maintenance Hyperion Reports MMS 2000-2007; SAP 2007-2011; 6-Aug-12 update from CDOT maintenance
*Year 2007 solid volumes not used; possible under-reporting caused by transition from MMS to SAP
**It is assumed that 2/3 of the winter materials in Patrol 41 is used in the 12-miles directly below the EJ Tunnel. This is termed "Upper Clear Creek".
***Total solids includes sand and solid salt deicers



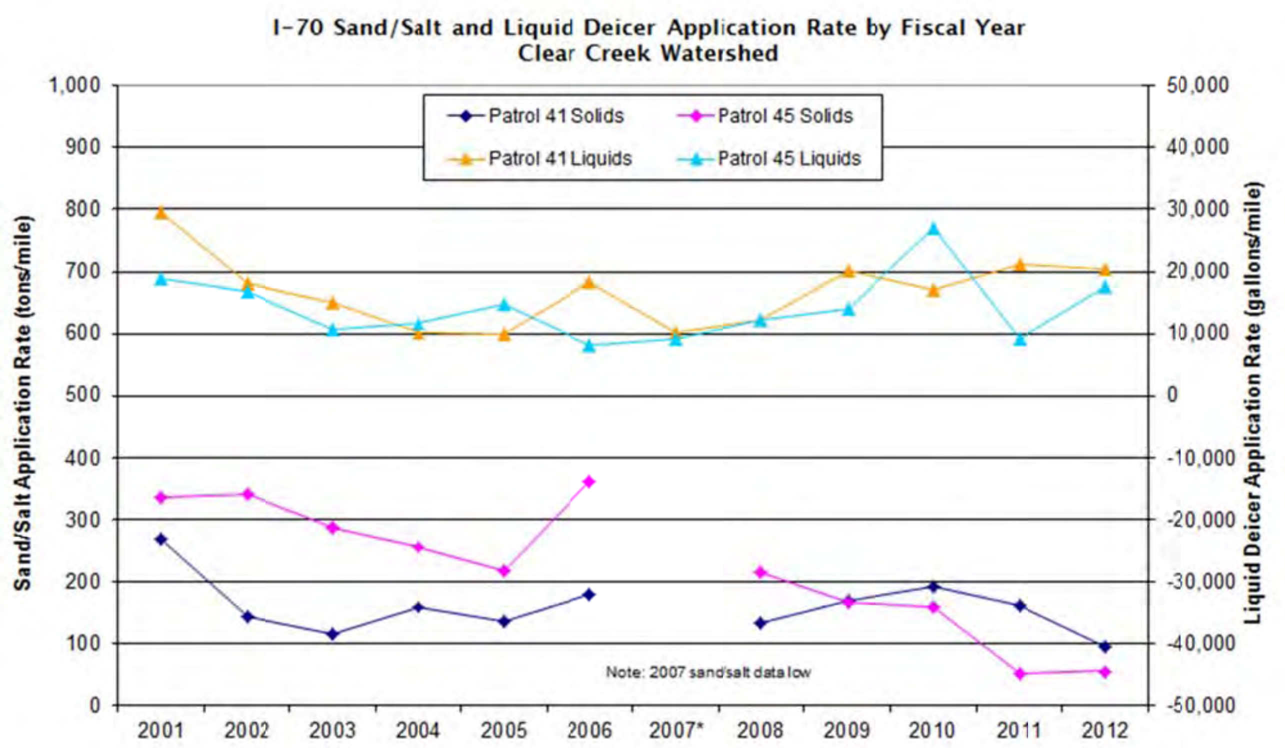


Figure 4-1 I-70 Sand/ Salt and Liquid Deicer Use

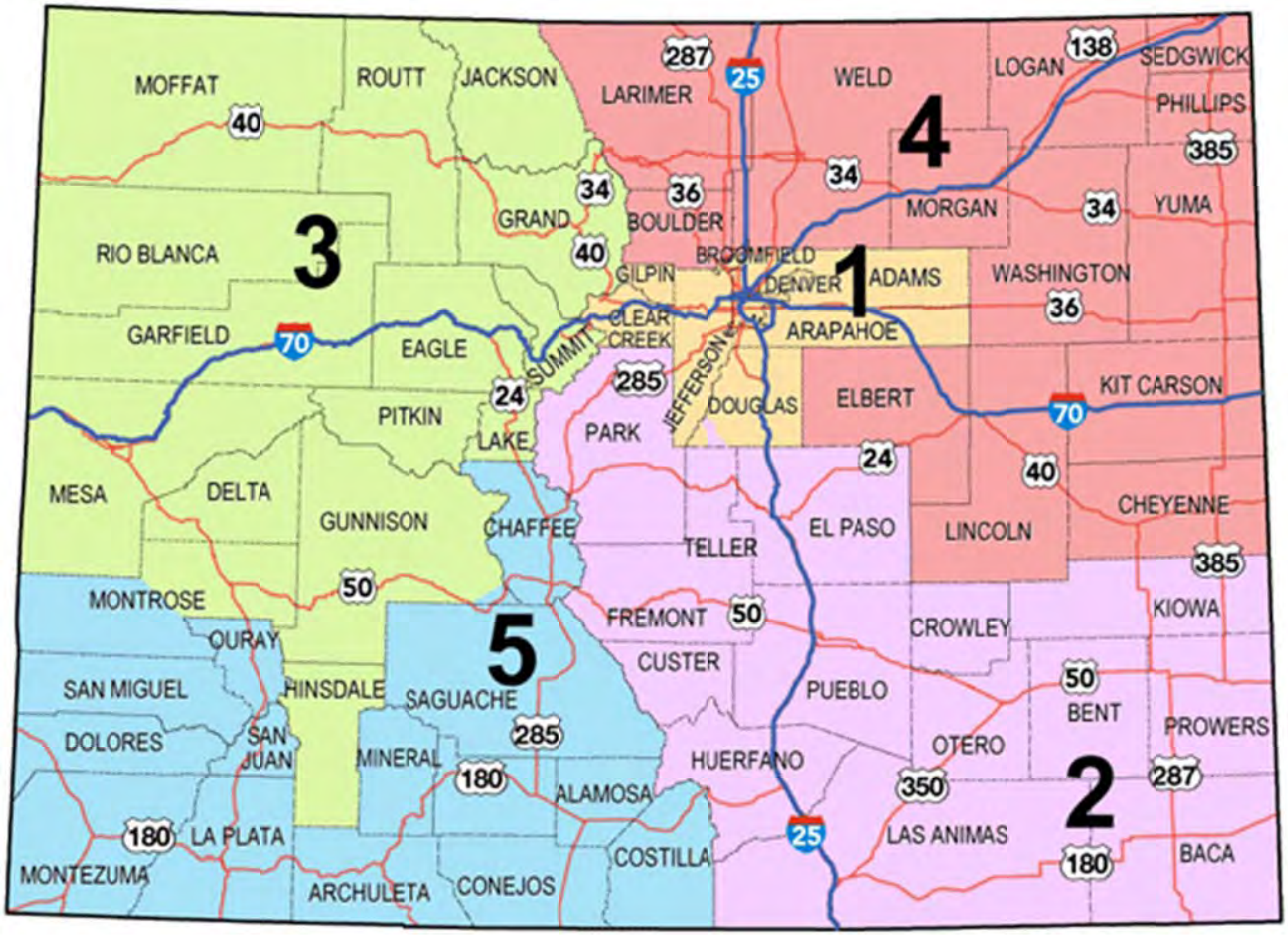


Figure 4-2 CDOT Engineering Regions

5.0 BMP DESIGN ANALYSIS FOR SEDIMENT CONTROL

This section provides information on sediment source identification, volume estimates, control strategies, preliminary hydraulic and drainage analysis, a menu of BMP design, proposed structural and nonstructural BMPs, and proposed maintenance program requirements for the Clear Creek I-70 corridor. The BMPs proposed in this SCAP were developed based on previous CDOT experience and research in implementing BMPs at high altitudes, both successes and failures. Research on efforts undertaken by CalTrans on Interstate 80 along Donner Pass through the Sierra-Nevada Mountains to address highway sediment-related water quality issues is also considered.

It is important to note that this is a planning level document only. Further site-specific analysis, design, and cost estimates will be required prior to implementation of specific sediment control measures.

Several proactive projects have been undertaken by CDOT in the past with installation of sediment collection basins near MP 216, 219, and 238. Georgetown Hill also receives considerable ongoing funding and work to mitigate rockfall hazard.

5.1 Literature Review

The following is a synthesis of reviewed literature and conversations with CDOT and Caltrans. A large portion of the information summarized here comes from a more exhaustive report on winter traction materials management prepared by the Western Transportation Institute at Montana State University (Shi 2004) for the Montana Department of Transportation.

5.1.1 Environmental Effects - Sand vs. Deicer

The environmental effects of highway traction sands and deicers have long been a concern. The majority of deicers are chloride-based and are soluble in water; as a result they are transported quickly with water and are quite difficult to remove in solute form. On the other hand, traction sands can be removed relatively easily with sedimentation or filtration and tend to accumulate near roadways and in the beds of receiving streams. While the toxicity of chlorides in the natural environment is concerning, the majority of the research on this subject finds that highway sanding generally has a more damaging immediate effect on aquatic and riparian ecosystems (Michigan DOT 2003, Buckler and Granato 1999, Lewis 1999, Shi 2004, Public Sector Consultants, Inc. 1993, Molles 1980).

Excessive highway sands and roadway embankment erosion can clog streams, bury habitat, and asphyxiate fish eggs and benthic macro invertebrates (CDPHE 2005). Excessive sediment with particle sizes less than 2mm blocks the movement of oxygen into stream substrates and harms the reproduction of aquatic species which lay eggs in these streambeds (Shi 2004). Reiser and White (1988) found that when 10 – 20 percent (by weight) of a stream's substrate is composed of sediment sizes less than 0.85 mm, salmon egg health was significantly compromised. It was also found that loss of invertebrate numbers around Santa Fe, New Mexico was more likely due to sedimentation from traction sanding than the effects of chemical deicers (Molles 1980). Molles suggested that that these traction sands likewise would be harmful to spawning trout.

Deicers on the other hand, are often diluted before they leave a roadway and receive subsequent dilution once they reach a waterway. This is not to say that they have no effect on the environment or infrastructure. Acute chloride concentrations are toxic and will lead to the direct mortality of aquatic life (Corsi 2010), while chronic exposure to road salts causes countless harmful effects including: impaired development of plants and algae, plant browning, decreased amphibian reproduction, reduced diversity of aquatic organisms (Kelly at al. 2010, Mullaney 2009), and encouraged stratification of lakes (denser salt water accumulates at the bottom - Kelly 2008). Deicers may also build up in streams with low flows, in wetland areas (Michigan DOT study), in the soil, and in groundwater (Kelly 2008). The long term chronic effects of environmental salt build up are concerning and are not entirely understood (Kelly 2008).

Two non-environmental issues which are also concerning are the contamination of subsurface drinking water supplies and the corrosion of vehicles and infrastructure caused by road salts.

Studies reporting the measured impacts and concentrations of chloride in streams have presented conflicting results. For a reference point on chloride concentration, the EPA chloride limit is 860 mg/L for acute (one hour average) and 230 mg/L for chronic concentrations (four day average) (US EPA 1988). The Montana DOT performed water testing in three streams during 2003-2004 and their results showed average winter chloride concentration less than 15 mg/L, with a peak measurement of 36 mg/L (Shi 2004). A CDOT study in 1997-1998, found that magnesium chloride use had limited detrimental impact twenty yards away from the highway (Lewis 1999). However other CDOT studies, in the I-70 mountain corridor, have shown that in-stream chloride concentrations can exceed water quality standards from roadway salt (CDOT 2011b). Additionally, a 2010 USGS study which analyzed 168 monitoring locations in 17 major metropolitan areas, found that the US EPA water quality criteria for chloride was exceeded acutely 25% and chronically 55% of the time - from November to April (Corsi 2010). Last, it is worth noting that the EPA is currently re-evaluating these chloride standards.

These conflicting findings suggest that the impacts of chloride-based deicers may be watershed specific, based upon the specific hydrology, loading rates, and species present in the basin. However, unless acutely high levels of chloride are present, the impacts of heavy highway sanding are believed to be more damaging on aquatic ecosystems than deicers (Shi 2004).

5.1.2 Chemical Deicers

Chemical deicers, both solid and liquid, have been used on highways since 1938. Many types are available today and can be categorized in to three groups of chemicals:

1. ***Chloride based***: sodium chloride, calcium chloride, and magnesium chloride;
2. ***Acetate based***: calcium magnesium acetate and potassium acetate; and
3. ***Bio-based***. Made from agricultural byproducts.

Deicers depress the freezing point by introducing particles which disrupt the crystallization process of water and separate water molecules from latching on to each other (Richardson 2012).

Sodium Chloride, Calcium Chloride and Magnesium Chloride

Sodium chloride (**NaCl**), commonly known as salt, is the most common and lowest cost deicer in use. It can be applied in solid form (rock salt) for de-icing or liquid form (salt brine) for anti-icing (Shi 2004). It is effective down to 10˚F and can be mixed with road sands (Transportation Research Board 1991). Salt is readily available in large quantities and less expensive than other forms of deicers.

Calcium chloride (**$CaCl_2$**) and magnesium chloride (**$MgCl_2$**) work at much lower temperatures than salt, however they are more expensive and more difficult to handle. Magnesium chloride is effective down to -22˚F and calcium chloride is effective to -50˚F. Magnesium chloride is less expensive and less corrosive than calcium chloride (Ketchum et al. 1996, Shi 2004).

Calcium Magnesium Acetate and Potassium Acetate

Calcium magnesium acetate (**CMA**) and potassium acetate (**KA**) are less corrosive and less toxic than chloride salts, however CMA is only effective to 23˚F and requires twice as much (by weight) as salt. KA performs down to -15˚F, but is more expensive. KA is used often at airports and occasionally in automated anti-icing sprayers on bridges. Both of these products will also contribute to Biological-Oxygen-Demand (BOD) loading (Kelly at al. 2010, Wegner and Yaggi 2001, Shi 2004).

Bio-Based Deicers

Bio-based deicers are created from agricultural byproducts and wastes, particularly sugar beet juice, corn, and molasses (Better Roads 2001). These products are non-corrosive, biodegradable and are often mixed with other deicers to reduce corrosiveness and lower the freeze point of the other deicer. Bio-based deicers may be more expensive than conventional deicers and there are some concerns with BOD, nitrogen, nitrates and phosphorus loading due to the organic nature of these products. Common bio-based or bio-blended deicer names are: IceBan, Caliber, and Dow Armor (Shi 2004).

5.1.3 Stream Impacts Based on Studies of I-70 Streams

Two other streams along the I-70 mountain corridor have been extensively studied to determine the impacts of Interstate-70 on receiving mountain streams. SCAPs for Black Gore Creek and Straight Creek were both published in 2002. Black Gore Creek flows northwest along I-70 from Vail Pass until it joins with Gore Creek to the east of Vail. Straight Creek flows west from the Eisenhower-Johnson Memorial Tunnel along I-70 to its confluence with the Blue River in Silverthorne.

Straight Creek was listed on Colorado's 303(d) list of impaired waters due to sediment loading from I-70 in 1998 and Black Gore Creek was added in 2002 (CDPHE 2012a). Straight Creek received a TMDL assessment for sediment loading in 2000 (CDPHE 2000).

The Black Gore Creek 303(d) listing requires the development of a TMDL with the goal of attaining the State's Narrative Standard for sediment (**Standard**) – however, to-date, a TMDL has not been finalized for Black Gore Creek. The State's narrative Standard states that "surface waters shall be free from substances attributable to human-caused point source or nonpoint source discharge in amounts, concentration, or combinations which can settle to form bottom deposits detrimental to the beneficial uses. Depositions are stream bottom buildup of materials that include but are not limited to anaerobic sludges, mine slurry or tailings, silt, or mud". The Standard applies to sediment impacts on aquatic life.

Black Gore Creek SCAP

The Black Gore Creek SCAP found that highway sanding and embankment erosion were damaging and destroying aquatic and riparian habitat. Even though Black Gore Creek can carry substantial sediment loads naturally (especially during spring runoff and summer rainstorms), sediment was accumulating in riparian and wetland areas. Sand deltas had also formed where highway runoff enters the creek. The SCAP identified six factors contributing to erosion and stream sedimentation:

1) On-site soil loss from landslide areas;
2) Inadequate drainage control system;
3) Unstable cut and fill slopes;
4) Failure to establish and maintain adequate vegetation on disturbed areas;
5) Lack of adequate sediment control structures; and
6) Ongoing traction sand loading from winter maintenance operations (CDOT 2002).

It emphasized the need for ***Source Controls*** to capture highway traction sands and recommended the use of snow storage areas and parallel snow storage to capture sediments from plowed snow before snowmelt is allowed to carry them downstream. It also recommended paving shoulders and routing runoff to treatment facilities - which may work in combination with parallel snow storage. The report advocates slope repair and revegetation efforts, as they have been very successful in reducing sediment loading from other highway slopes on I-70 (CDOT 2002a).

Straight Creek TMDL Monitoring Results

In 1998, Straight Creek was listed on Colorado's 303(d) list of impaired waters due to loss of habitat and aquatic life resulting from excessive sedimentation from the I-70 corridor (CDPHE 1998). Most of the debris jams and beaver ponds in Straight Creek were filled with sediment, and fish populations had been reduced due to the filling of pools and burial of natural stream substrate. I-70 traction sands and highway embankment erosion were found to be the predominate sources of sediment in the Straight Creek watershed. An estimated 46% of applied highway sand was determined to make its way to the stream (RCE, 1993).

The 2000 TMDL assessment for Straight Creek identified four water quality targets and laid out three sediment control practices to be implemented by CDOT as follows (CDPHE 2000):

1) Revegetation of at least 70% of cut and fill slopes to 70% of potential ground cover.
2) Cleaning and maintenance of twelve sediment control basins and sediment control structures on the I-70 roadway.
3) Removal of at least 25% of the traction sand applied yearly to the I-70 roadway between the Blue River and the west portal of the Eisenhower Tunnel.

In 2007, a TMDL Monitoring Results report found that channel morphology conditions were improving in Straight Creek and that some Colorado standards had been partially attained (Laurie, 2007). However, the targets set forth in the TMDL had not been attained (habitat, biological and stable channel targets). The report further listed several possible reasons as to why targets had not been met including:

- Maintenance of the sediment ponds is inconsistent. In some years the ponds are cleaned while in other years they become entirely filled.
- Several BMP failures occurred between 2003 and 2006 including: a culvert failure, a sediment basin mistakenly drained and sediment flushed downstream, and an overtopping failure of a basin.
- The existing sediment basins did not capture a large enough percentage of the annual sand applied to I-70.
- The irregular nature of sediment supply from the highway and from sand stored behind obstructions in the stream channel. It may take many years for the prior sediment stored in the channel to flush through the system and for the stream substrate to recover.
- A longer period of record may be necessary before a trend becomes significant.
- The sediment targets given in the TMDL may be inappropriate and unattainable in Straight Creek. The report stated that a review of the TMDL targets should be conducted.

CDOT considerably disagreed with this report and the TMDL targets; they took issue on the basis that the goals are impractical and inappropriate - for example requiring 5 age-classes of fish at every sampling location is unrealistic (Huyck 2007). Furthermore, CDPHE now considers these TMDL targets to be unattainable in Straight Creek (CDPHE 2012b).

The findings of this report demonstrate two important things: first the challenges of BMP implementation and maintenance along mountain highways; and second the importance to develop realistic water quality goals.

5.1.4 Sediment Control BMPs:

Stormwater Best Management Practices (**BMPs**) are often divided into two categories: *structural* and *non-structural* BMPs. In both literature and practice there are various opinions regarding the difference between structural and non-structural BMPs. In this report, non-structural BMPs are defined as institutional measures and structural BMPs defined as constructed measures.

5.1.5 Structural BMPs

Structural BMPs can be further divided into three categories: Preventative, Collection, and Treatment BMPs.

Preventative BMPs

A. **Snow Fence** – Snow fences reduce wind velocity and encourage snow to deposit near the snow fence. They can reduce the amount of snow drifting across a highway in unprotected or problematic areas. It has been shown that snow fences can increase road temperature by 10˚F compared to adjacent unprotected roadway (Tabler 2004). The Wyoming DOT saved over a third of its snow removal cost in the 1970's by employing snow fences over a 45-mile stretch of I-80 (Tabler 1991). Living snow fences, or tree-belts, can be very effective protecting a highway from snow drifts and are more aesthetically pleasing than constructed snow fences. However they take time to establish and cannot be adjusted or moved once they are in place (Shi 2004). Snow fences are less critical to the I-70 corridor than open plains areas where drifting snow is more of a concern than falling snow because of the problem of the mix of dry pavement and icy areas.

Collection BMPs

The conveyance of highway snowmelt and runoff to treatment BMPs can be difficult, especially in mountain environments. Most BMP literature and design manuals assume that runoff has already reached treatment BMPs; however these BMPs are only effective when pollutant laden runoff is actually directed into them. Therefore, it is especially important to implement and integrate collection type BMPs into highway drainage design (Shi 2004).

A. **Road Side Ditches and Swales –** Roadside ditches and swales are the most common means of transporting highway runoff to a BMP or outfall. Swales may be grass-lined or paved in steep areas. Grass-lined swales may also function as a treatment BMP. CDOT uses paved valley-pan drains in steep areas on Straight Creek (CDOT 2002b). Caltrans has paved swales on Donner Pass, but is having difficulties sweeping them because the ditch design is not compatible with their sweepers and is wearing out their equipment (Caltrans 2012). Roadside swales also double as parallel snow storage areas.

B. **Curb and Gutter** – Curb and gutter is important for trapping sediment on the highway rather than letting it runoff down the hillside in an uncontrolled manner. Sediment can be cleaned from the street using sweepers. Curb and gutter is effective in areas where space is too limited for the installation of sedimentation detention areas. Curbs create safety issues along high speed roadways and will need to be used in conjunction with guardrails (AASHTO 2011). Curb and gutter concentrates flows which can create highly erosive areas where it is discharged off of the paved areas. The use of curb and gutter requires regularly spaced inlets and rundowns to convey this concentrated flow to the receiving waterway without eroding the slope.

C. **Clean Water Diversions –** Clean water diversions are a common construction BMP and will also work very well as a permanent BMP. Clean water diversions separate upland drainage (tributary and groundwater seepage) flows before combining with contaminated highway runoff. This is accomplished by piping upland flows under and past the highway. Clean water diversions reduce the volume of highway runoff requiring treatment (CDOT 2002, Shi 2004).

D. **Snow Storage –** Snow storage areas allow plowed snow to melt in a contained area where the snowmelt can drain to a treatment BMP. Areas such as swales and ditches can function as parallel snow storage where the plows can easily push snow into them. In some locations, such as chain up areas, it may be helpful to have central locations to pile snow. It is important that these areas are configured with inlets and drain systems to convey contaminated snowmelt and highway runoff to a treatment BMP. CDOT has successfully implemented a system like this on Berthoud Pass (US Highway 40).

However, storage systems for high speed highways, such as I-70, need to prevent snowmelt from returning to and icing the highway.

Treatment BMPs

Treatment BMPs are structural systems which trap and treat runoff through sedimentation, straining, filtration, infiltration, adsorption, or biological mechanisms (UDFCD 2010a). These BMPs address both the rate (velocity) and quality of runoff.

Runoff pollutants can be divided into two categories: suspended and dissolved. Sand and deicers are the two primary pollutants of concern in highway runoff. Sand particles are suspended constituents, and deicer salts are mostly dissolved pollutants. The removal of suspended solids, particularly sand, can be effectively accomplished through settling. Settling is less efficient at removing finer silt and clay particles, but few of these are found in traction sand or in eroded geologic material along the I-70 Clear Creek corridor. Few structural BMPs can remove dissolved pollutants effectively (Shi 2004). Deicers are difficult to remove from runoff; however, detention can lower salt peaks and infiltration can reduce direct discharge into waterways. That said, this chapter will be devoted to BMPs which remove and control sediment from reaching the waterways.

A. **Detention/ Sedimentation Basins –** Detention based BMPs include: dry detention basins, extended detention basins, wet basins, and retention basins. Dry basins remove pollutants primarily by settling, whereas wet basins and retention basins add biological processes to help treat nutrients and dissolved constituents (UDFCD 2010). Detention basins are very effective at removing suspended solids, and sediment removal efficiency can be increased with the addition of berms and baffles to lengthen flow paths and prevent short-circuiting. A hard surface forebay will help with regular maintenance and energy dissipaters will prevent accumulated sediments from being re-suspended during heavy rains. Maintenance for dry basins can be simple with regular mowing, debris removal, and cleaning of the forebay (UDFCD 2010). Outlets should be inspected for clogging and sediment removal twice every year (MOLWAP 2004, Shammaa and Zhu 2001).

   Dry detention basins perform very well in cold climates and can remain effective during winter months. The effects of freezing should be considered in the outlet structure design with open channel weirs preferred rather than pipes. Dry basins can also be used as snow storage. Wet basins, which contain a permanent pool, will freeze during winter months unless a drain is provided. Permanent pool storage areas may require water rights to address evaporative losses and their use is limited in arid climates. Wet basins may also increase water temperature in receiving streams and provide habitat for mosquito breeding. Both wet and dry detention basins require large amounts of space (UDFCD 2010a, Shi 2004).

B. **Loading Dock Sediment Trap –** The loading dock style sediment trap is a sedimentation basin that resembles a loading dock and functions similar to a forebay. This type of sediment trap functions for removal of large volumes of coarse sediment. A layer of filter fabric or a rock gabion composes the back wall (or side wall) which detains, filters, and releases the highway runoff. This system captures coarse sediment but does not hold the runoff for a long period of time to allow settling of fine particles.

Advantages of the loading dock are that it has a large storage volume for large sediment deposits, is above ground but can be installed below grade, and can be easily cleaned out with heavy equipment such as a front-end loader. It does require more space than an inlet sediment trap, but can still fit in the shoulder area. This is Caltrans preferred type of sediment trap for durability and ease of maintenance (Caltrans 2010b). CDOT also uses loading-dock traps on Berthoud Pass. Issues with them have been lack of drainage/ clogged outlet and designed too narrow for the loader buckets (Caltrans 2012, CDOT 2012b). Caltrans is working on new designs for the rock gabion/ filter fabric outlet including: replaceable filter fabric with rock gabion and filter fabric only designs.

C. **Inlet Sediment Traps and "Sand Cans" –** Inlet sediment traps consist of a standard inlet with the outlet pipe raised up towards the top of the structure, creating a sump in the bottom. Caltrans has used *sand cans* (a.k.a., double-barrel modified CMP traction sand traps) which are CMP culvert sections buried vertically with a grate on top and an elevated outlet pipe. They have been shown to be effective for small volume sediment capture and as pre-treatment for other BMPs. These have the advantage of being low cost, easy to install, and require little space. Caltrans likes them as they are easy to inspect and clean out with a vacuum truck (Caltrans 2012). However, they do not have large storage volumes and may require more frequent maintenance unless used in lower sediment loading areas. For example, CDOT has used Modified-D inlet traps on Vail Pass; however, high sedimentation rates have resulted in limited effectiveness. They are also susceptible to wash-out from high flows (Caltrans 2010a,c, Shi 2004). An inlet can also be modified to create a small sediment basin or forebay immediately upstream of the inlet by elevating the inlet grate above the ground surface creating a storage volume in front of the inlet.

D. **Underground Vaults –** Underground vaults function similar to sedimentation basins except that they are underground. Usually they are multi-chambered and may also include a sand filter and a chamber to remove oils. These BMPs are very efficient at removing suspended solids and can fit in limited space areas where other BMPs cannot. Issues with these have been placement and confined space entry for maintenance. Some locations adjacent or under the highway may require traffic control and lane closures for maintenance, confined space certifications for maintenance crews, freezing issues, flow capacity issues, and scouring out during high flows (Caltrans 2012, Shi 2004). Caltrans also noted that vaults used to capture traction sands have had plugging problems with sand filters and clogging weep drains in the vaults. Underground systems are often discouraged because their ability to function is not readily visible. Underground vaults require frequent inspection and maintenance for proper operation. Despite shortcomings of underground vaults, Caltrans has quality details for these BMPs and has had successes using these systems where space is limited.

E. **Infiltration Based Retention Areas –** Infiltration based BMPs include: infiltration trenches, infiltration basins, and porous pavements. These BMPs function primarily by infiltrating runoff into the soil which reduces the volume of runoff and filters suspended solids. These systems do not function well in areas of rock or clay soil. Infiltration based BMPs are very good at removing suspended solids, but will easily clog with high sediment loading (UDFCD 2010a) and are therefore not good choices for capturing traction sands as the primary treatment mechanism (Shi 2004). Detention basins that incorporate infiltration and filtration as a secondary treatment mechanism may be very successful.

F. **Filter Based –** Sand filters may be located above ground or underground in a vault. They function by passing runoff water through a sand bed which filters solids and discharges the water through an underdrain. They are very good at removing suspended solids, but will clog when treating high sediment loads and will require pre-treatment and frequent maintenance to be used for treating winter highway runoff (Caltrans 2012, UDFCD 2010, Shi 2004). Above ground sand filters can be planted with vegetation that is tolerant to inundation.

G. **Bioretention –** Bioretention (a.k.a. rain gardens/ porous landscape detention) are engineered depressions that filter and infiltrate runoff through an organic soil mixture in which selected vegetation has been planted. They may need to be underdrained depending on soil conditions. Nutrients and other dissolved constituents can be treated by these facilities (UDFCD 2010a). These systems are most common in urban areas to manage runoff from rooftops. Like all infiltration based BMPs, they cannot handle high sediment loads without pre-treatment and therefore are not good choices for capturing traction sands. Bioretention BMPs may consume water. Their use could require water rights and/or an augmentation plan under strict adherence to Colorado Water Law.

H. **Filter Strips and Vegetated Swales –** Vegetated swales are shallow slow-flowing waterways lined with grass or other vegetation. Filter strips or grass buffers are densely vegetated linear strips of grass that accept sheet flow perpendicular to their length and are often incorporated with a grassed swale. Swales and filter strips reduce water velocities which promotes deposition of suspended solids. Treatment mechanisms are infiltration, straining, and sedimentation (UDFCD 2010a). These BMPs can remove a moderate amount of suspended solids and may function very well as pre-treatment for another BMP. Check dams or online detention can be fitted into the swales to increase the removal of suspended solids.

Grassed swales and filter strips are relatively inexpensive, do not need much alteration to adapt to cold climates, and can function as permeable snow storage during winter months. Maintenance generally consists of mowing and debris removal, however accumulated sediments will need to be removed over time (UDFCD 2010a). The main challenge in their application is establishment of vegetation and assurance of sheet flow into the filter strips (FWHA 1997).

Filter strips and vegetated swales may also have additional costs and implementation hurdles under Colorado water law, but to a lesser extent than bioretention and wetland BMPs.

CDOT has implemented a similar concept to filter strips called bench traps, which are graded benches down slope from the highway. The advantage of these is that they can be installed in areas downslope where the grade flattens out. These however cannot handle concentrated flows (CDOT 2012b).

I. **Constructed Wetlands –** Constructed wetlands are large shallow retention basins designed for the growth of wetland plants with the purpose of treating stormwater by sedimentation, filtration, and biological uptake (UDFCD 2010). This BMP can remove a high level of suspended solids and effectively treat dissolved pollutants. Like retention basins, constructed wetlands may require a water right to impound water and they require more land area than most BMPs because they are designed to spread water over a large shallow area. Their functionality in cold climates is not well understood or documented.

   Similar to bioretention, constructed wetland BMPs may consume additional water which could have water rights implications under Colorado water law.

J. **Erosion Control –** The erosion of cut and fill slopes adjacent to highway and along highway drainage channels is quite common. Many of these erosion problems can simply be avoided by good drainage design practices (Johnson et al. 2003). Narrow "V" shaped ditches tend to erode rapidly. The use of wide-rounded or trapezoidal drainage channels will reduce erosion potential (CDOT 2011c). Ditches with slopes lower than 5% can be lined with vegetation alone, while slopes above 5% will likely need blanket, mat, or geotextile lining (Minnesota DOT 2003). Establishing a dense heavy root mass of permanent vegetation is critical to their performance. Highly erosive drainage channels may require rock or concrete lining on steep slopes where other measures have failed. Rock, concrete, or culvert pipe drainage rundowns can prevent fill slope erosion in specific locations. Pipe rundowns have been used extensively by CDOT on steep fill slopes along Straight Creek.

Common Problems with Structural BMPs

Common problems reported with structural BMPs implemented to capture traction sands are:

- Lack of energy dissipation at the inlets to structures.
- Scouring out and re-suspension of accumulated sediments. Causes may include lack of maintenance and improper design (Caltrans 2012, Shi 2004).
- Facilities not designed for easy maintenance or accommodating to maintenance equipment (Caltrans 2012, CDOT 2012b).
- Facilities that stay wet and do not drain properly - outlets and weep drains often clog (Caltrans 2012).
- Undersized BMPs that do not hold an adequate volume of traction sands based upon the maintenance schedule, or BMPs that require excessive maintenance.
- BMPs lacking pretreatment to capture easily removed particles.
- Lack of maintenance. Regular and proper maintenance is critical to upholding the effectiveness of structural BMPs. Many structural BMPs fail for lack of proper maintenance. Maintenance should be performed on BMPs at least twice a year, in late spring and early fall (UDFCD 2010a).
- BMPs which infiltrate or store water may require water rights and raise difficulties under Colorado Water Law and with Interstate Water Compacts (i.e., the South Platte River Compact between the States of Colorado and Nebraska).

- While treatment BMPs are intended to reduce pollutant constituents, they are also capable of increasing constituent concentrations in certain cases if not maintained.

Cold Climate

Little technical research or guidance for structural BMPs in cold climates has been performed or published. Most BMP manuals and standards have been developed for use in urban areas with moderate climates. Design of BMPs for use in cold montane and subalpine climates need to consider lower and prolonged winter temperatures and much shorter growing seasons. The Montana DOT report on Winter Traction Materials Management (Shi 2004) describes at length cold climate modification for detention facilities.

5.1.6 Non-Structural BMPs

Non-structural BMPs are institutional measures which prevent or reduce the use of highway sanding and deicing materials. Effective implementation of non-structural BMPs often will lead to reduced costs of winter road maintenance and lessen the need or dependence on treatment BMPs (Shi 2004).

A. **Training -** The biggest challenge with non-structural BMPs is implementation; training is the key to successful implementation. Getting crews to buy into new ideas is the first step. Conducting yearly training classes, particularly in the fall, may be beneficial to both new and veteran employees. This also provides opportunity for feedback from crews and refinement of operation practices. Non-structural BMPs and new technologies are continually developing and will require continual training to test and successfully implement future ideas.

B. **Environmental Staff –** Several state DOTs have incorporated environmental staff into their departments to support and train crews in implementing sediment and erosion control practices. Particularly in New York and Virginia, environmental staff spent about 50% of their time in the field working with maintenance and construction crews. They also work to develop more effective and pragmatic practices (Rentch 2004).

C. **Street Sweeping –** Street sweeping removes sediments from roadways that have accumulated in the shoulders, curbs, and drainage pans before they are washed downstream by the next large storm. Highway sweeping on the Colorado mountain highways should take place immediately after spring snowmelt has finished (May), when sediment build-up is at its highest, and before heavy monsoon rains occur (CDOT 2007). Advancements in sweeping technologies include vacuum-assisted, regenerative air, and high speed sweepers. It has been reported that tandem sweeping (mechanical sweeping followed by vacuum-assisted sweeping) can significantly improve particulate removal efficiency (Sutherland 1995, Shi 2004).

D. **Vacuum Truck –** CDOT invested in a high performance vacuum truck in 2005 to clean sediment traps and culverts along high elevation highways in Colorado. This machine has proven to be versatile and effective in removing sediment from difficult access areas.

E. **Anti-Icing and Deicing –** Conventional deicing practice is to apply granular sand and salt deicers to a roadway after snow has fallen and ice has formed; deicer granules penetrate through ice and break the bond between ice and roadway, then the ice is plowed off. Over the last 15 years, a proactive method called anti-icing has developed which seeks to prevent ice from bonding to pavement. By applying liquid deicers before snowfall, snow and ice are prevented from bonding to the roadway which increases the effectiveness of plowing. Since anti-icing is a pre-emptive measure, it typically requires less deicing material than conventional deicing practices (Williams 2001). This strategy reduces the amount of deicers, traction sands, and plowing needed while saving money and improving roadway level-of-service (Boselly 2001, USEPA 1999). The effectiveness of anti-icing practices however, hinge on accurate and specific weather forecasts. Deicing, on the other hand, does not require accurate weather forecasts and is appropriate for lower service priority roadways or situations where anti-icing is ineffective (Ketchum et al. 1996).

The Montana DOT compared conventional snow removal practices and anti-icing practices between 1997 and 2000. The division utilizing anti-icing practices achieved 37% cost savings per lane-mile and maintained a higher level of service (Goodwin 2003).

F. **Road Weather Information Systems (RWIS) –** A road weather information system (RWIS) is a network of weather stations, forecasting services, and roadway data that provides real-time information about road conditions and site-specific forecasts. This information is extremely useful for DOT winter maintenance managers to plan snow fighting operations, particularly when to deploy anti-icing operations.

A GIS based decision support system (DSS) with real time information from weather stations, road cameras, weather forecasting services, and "pavement pucks" in the road provide useful weather data to maintenance staff. Pavement "pucks" are imbedded in the roadway and provide pavement temperatures and if the road surface is wet or icy.

The Federal Highway Administration has developed a Maintenance Decision Support System (MDSS) to help winter maintenance managers collect and process information from different sources and proactively respond to changing weather conditions. http://www.rap.ucar.edu/projects/rdwx_mdss/

G. **Automated Anti-Icing Sprayers –** An option which combines anti-icing and RWIS technology is to install automated anti-icing sprayers at critical locations that are more prone to icing, such as bridges. These systems can be operated remotely or with automatic control systems. Many states and municipalities have used these. The Ministry of Transportation, Ontario has a good case study (including lessons-learned) on their website of automated anti-icing sprayers installed on a highway interchange: http://www.mto.gov.on.ca/english/engineering/anti_ice/anti_ice.shtml

H. **Smart Overlays -** Research at Michigan Technological University has led to the development of a polymer pavement overlay that absorbs anti-icing chemicals for a length of time. The deicer chemicals do not easily wash off from the overlay but are still effective at preventing ice from bonding with the pavement. There have been proprietary installs at 21 sites in 13 states. Including tests performed by the Minnesota DOT and at Chicago O'Hare International Airport.

The Minnesota DOT tests evaluated installs at four bridge locations and found that the product performed very well initially with accident reductions at all sites. However they noted that the service life of the overlay was estimated to be 3.5 to 5 years and that more long term testing is needed (Evans 2010).

A report regarding the test section at Chicago O'Hare International Airport states that "the anti-icing coating does not offer a significant advantage or benefit over the adjacent pavements that were not treated with this coating" (Carroll and Dempsey 2007). However it seems that the report dismissed the fact that anti-icing methods still require plowing. The report states that a portion of the test overlay delaminated in an area of high use.

More cost information and durability studies are needed before the efficacy of smart overlays can be determined or suggested as a practice.

I. **Improved Sanding Practices –** Improved sanding practices can prevent inadvertent excessive sanding and reduce the amount of sand and salt immediately lost during application. The first step is to calibrate sand and deicer spreaders; this can be done for any piece of equipment regardless of its technological age. The tendency is to use less material in calibrated spreaders (Kelly at al. 2010). State-of-the art application regulators are being used in the snowplow trucks, and they may pay for themselves in a number of years. Reducing the speed of sanding trucks increases the amount of sand and salt that stays on the road – for example, at 30-miles-per-hour roughly 30% of the applied material bounces off of the roadway (Stormwater 2012). There are also spreaders that can discharge material backwards at the same speed as the trucks forward speed, resulting in zero velocity (Transportation Association of Canada 2003). However one report suggests that the vortices behind a truck traveling at higher speeds will disperse the sand and salt, which defeats the purpose of the zero velocity spreaders (Nantung 2001). Pre-wet sand and salt to help the granular materials stick to the roadway. Only loading the amount of material needed for the route helps to reduce excessive sanding since drivers tend to use what they load which is often more than what is needed (Kelly at al. 2010).

J. **Snowplow Technologies –** Advancements in technology have provided many new tools that can be added to snowplows to increase the effectiveness and management of their operations. Infrared pavement temperature sensors help drivers match application rates and deicer types with road temperatures. Global Position Systems (GPS) and Automated Vehicle Location (AVL) technology can provide real-time information on operations and material application. There have also been advances in collision avoidance equipment combining GPS, radar sensors, magnetic sensors, and onboard geospatial databases which can give the driver information and warnings on head-up displays.

5.1.7 Summary of Literature Review

The ecological impacts of traction sands and deicers are both concerning. Chloride based deicers pose acute and chronic toxicity concerns, however, literature indicates that highway sanding generally has a more damaging effect on the receiving aquatic and riparian ecosystems. There are conflicting findings on the effects of chloride-based deicers which suggests that the impacts of deicers is likely watershed specific, based upon the specific hydrology, loading rates, proximity to receiving waters, and aquatic species present in the receiving stream.

For roadways with high levels-of-service (LOS), such as I-70, implementing anti-icing practices is appropriate and will lead to significant reductions in both deicer and traction sand use. Anti-icing is a proactive strategy where liquid deicers are applied just before snowfall and prevents the bond between ice and roadway from forming. This considerably increases the effectiveness of plowing, reduces the need for further deicing and traction sanding. The keys to proper anti-icing implementation include accurate weather forecasting, road-weather information systems (RWIS), GIS-based decision support systems (DSS), and properly trained staff. Automated anti-icing sprayers may be installed at critical locations, such as bridges, and can be operated remotely or with an automated control system.

For roadways with lower LOS, or when anti-icing did not work, deicing practices are appropriate. Deicing practices require significantly more deicer application but do not require accurate weather forecasting and RWIS.

Snowplow technology is rapidly evolving and both ecological benefits and cost savings can be reaped through training and proper implementation of improved sanding and deicing practices. This includes calibration of spreaders, application regulators, reverse throw spreaders, pre-wetting sand/ salt mixture, applying at slower speeds, road temperature sensors, on-board GPS and computer systems, and training. The biggest challenge with non-structural BMPs is implementation; training is the key to successful implementation.

Even with successful anti-icing implementation, it is likely that traction sands will still need to be applied some portion of the time. Deicers are difficult to separate from runoff. The structural BMP selection will focus on systems which remove suspended solids. Good choices for BMPs that can handle the high sediment loading and function in mountain environments are those which are:

- Visible on the surface facilities,
- Function primarily by sedimentation, and
- Are easy to access and maintain.

This includes detention and sedimentation basins, loading dock sediment traps, inlet traps, swales, filter strips, and bench traps.

Conversely, BMPs which function primarily by infiltration or filtration will have significant clogging problems and will require high maintenance to continue functioning. For these reasons, BMPs such as infiltration trenches, porous pavements, sand filters, and bio-retention are not good choices for capturing traction sands. Underground vaults and oil separators should be considered a last resort due to issues associated with underground inspection, maintenance, cost, and safety. Routine inspection and proper maintenance are keys to structural BMP success; this point is well demonstrated by BMP mistakes and failures that have occurred along I-70 on the west side of Vail Pass and in the Straight Creek watershed.

Treatment BMPs are only effective when pollutant laden runoff is directed into them. This can be difficult in mountain highway situations and is why implementing collection system BMPs with drainage design is especially important. Roadside ditches or swales are the most common and economical conveyance method, however there are many places where swales will not fit and curb and gutter systems will be required. Implementation and maintenance of swales and curb and gutter will also reduce roadside erosion which is a major sediment source. Lastly, a successful sweeping program will be necessary where curb and gutter and paved shoulders have been used. This will greatly help to remove sediment from the drainage system before it even leaves the roadway.

5.2 Source versus Depositional Areas

Sources of sediment along I-70 in Clear Creek include traction sand, hill slope erosion, rockfall and mass wasting of cut slopes in steep canyon areas, unconsolidated mine waste rock, and sediment transport in ephemeral tributary flow. Traction sand and slope erosion are the primary sources in upper Clear Creek while other sources predominate in lower Clear Creek. These sources can contribute to sediment loads in surface runoff from I-70 and in Clear Creek.
Sediment from highway runoff is deposited on the shoulders and at drainage culvert outfalls which are often some distance away from the roadway. Shoulder deposits that are accessible can sometimes be removed by sweeping or shouldering with a road grader. Large deposits of traction sand have accumulated behind guardrail in some areas. This material is available for transport to receiving waters during runoff events.

Deposits at culvert outfalls are generally not removed and have developed into large accumulations in some areas and are also present along the roadway shoulders in upper Clear Creek. Mineral sediments carried in I-70 runoff continue to bury organic soils in wetlands. Other highway outfalls discharge directly onto fill slopes that form the creek bank, particularly in lower Clear Creek where I-70 is immediately adjacent to the waterway.

The primary strategy of this SCAP is to capture highway sediment near the source before it has an opportunity to leave the highway template (approximately 30' each side of I-70). To reduce the potential for off-site transport and deposition, the sediment must be controlled in this area. Observations indicate that most of the initial deposition of sand occurs near the template and at drainage outfalls (e.g. the snowplow cast on shoulders is on average about 10 feet). Sediment is lost into the stream or the riparian zone if it is not collected near the highway. It is therefore essential to gain control of sediment at the source before it is transported beyond the highway template.

5.3 Sediment Source Estimates

All sediment sources associated with I-70 need to be considered when determining the type and size of sediment control BMPs. CDOT data shows *average* traction sand/salt application rate ranging from 159 to 222 tons/mile-year and *maximum* rates ranging from 270 to 377 tons/mile-year in the study corridor. Higher applications are used in upper Clear Creek than lower Clear Creek.

Planning for design based on the average sand application rate will not provide adequate capture volume in many years and would increase maintenance requirements. There is also considerable uncertainty regarding the type of winter maintenance material that will be used and the maintenance level of service required for I-70 in the future. Therefore, the sediment capture design criteria for this SCAP must assume a high loading scenario for annual sediment control needs. A design base sediment loading rate of **500 tons/mile/year** will be used for this SCAP. This is minimum design figure for the Clear Creek corridor. In many years, the amount of traction sand use and sediment loading will be less than this estimate, and therefore, the frequency of cleaning the sediment collection structures may be less.

In addition to traction sand, sediment is generated from erosion of cut and fill slopes and shoulder drainage, particularly in steep gradient areas of the roadway. Considerations for sediment capture volume estimates must also consider variable annual winter weather conditions and sand application rates, storm runoff frequency, the type of sediment (traction sand or mine waste), and frequency of structure maintenance and required cleanout.

As part of the I-70 reconnaissance survey, the amount of traction sand accumulated behind the guardrail was quantified. The locations and estimated volumes are listed in Table 5-1. This material is available for transport to receiving streams and wetland areas. The total volume estimate is 1,150 cubic yards.

Table 5-1 Dimensions & Estimated Volumes of Sand Deposits Behind Guardrails

Mapbook Sheet	MM	Length feet	Width feet	Thickness feet	Volume Cu-yds	Comments
7	218.10	200	6	2	89	behind guardrail
10	219.54-219.62	300	15	0.5	83	chain-up area
11	219.71	200	6	1	44	behind guardrail
12	220.40	200	6	1	44	behind guardrail
12	220.55	200	6	1	44	behind guardrail
13	220.90	200	6	2	89	behind guardrail
15	221.50	200	6	2	89	behind guardrail
15	221.58	200	6	2	89	behind guardrail
15	221.69	200	6	2	89	behind guardrail
16	221.87	300	6	2	133	behind guardrail
16	221.98	300	6	2	133	behind guardrail
16	222.19	200	6	1	44	behind guardrail
19	223.52-223.63	300	6	1	67	behind guardrail - limited room
20	223.83	100	6	1	22	behind guardrail - limited room
65	244.40	200	6	2	89	waste rock dump
				Total	1150	

The locations of mine waste piles that are within approximately 500 feet of I-70 were documented during the reconnaissance survey. The volume of these piles was visually estimated as listed in Table 5-2. This is mine waste rock residual or mill tailings that is either on CDOT ROW or can be deposited onto ROW and through I-70 drainage culverts during runoff events. This sediment is typically laced with heavy metals and can be acidic. It is considered high priority material to collect and remove from CDOT ROW before entering receiving waters.

Table 5-2 Mine Waste Piles Adjacent to I-70 Estimated Volumes

Mapbook Sheet	MM	Volume Cu-yds	Comments
21	224.34	5,000	W. of Silver Plume mine dump north side
34	230.35	1,000	E. of Georgetown small mine dump
35	230.47	1,000	E. of Georgetown small mine dump
36	230.95	1,000	W. of Empire on-ramp mill tailings
41	232.17	1,000	Mill tailings in frontage road fill
46	235.54	10,000	Mine drainage
48	236.63	2,000	Mine dump north side
50	237.70	1,000	Mill tailings Fall R. exit
52	238.45	1,000	Mine dump
52	238.55	10,000	Hukill Gulch mine drainage
58	241.00	1,000	Idaho Spgs mill tailings
58	241.25	1,000	Idaho Spgs mill tailings
	Total	35,000	

An estimated 35,000 cubic yards of mine waste could be transported onto CDOT ROW in the study corridor (excluding W. Brown Gulch which may be at least 75,000 cy). While most of the material is not on CDOT ROW and may not need to be removed, it remains an important factor to consider in the design and implementation of water quality BMPs for I-70. Sediment from mine waste material needs to be considered in addition to traction sand and slope erosion sources.

Figure 5-1 Mine Tailings along Clear Creek near the Stanley Mine (6/13/12).

Figure 5-1 shows mine tailings along the bank of Clear Creek near the Stanley Mine, which is adjacent to I-70 and just upstream of Idaho Springs. These loose tailings, like many other piles, are a potential source of sediment and metals into Clear Creek.

5.3.1 Adjustment for Steep Gradient Areas

The uncertainties regarding the volume of sediment generated from slope erosion is the primary reason that sediment collection structures need to be sized with excess storage capacity in steep roadway sections. Field surveys indicate that sedimentation rates are higher in areas where the roadway gradient and shoulder slopes are greater than 5 percent, including both Georgetown Hill and Floyd Hill. Detailed reconnaissance in these areas shows significantly higher erosion rates. This can be highly variable due to the many factors contributing to sediment transport and the source of sediment (highway fill versus mine waste). In addition to higher traction sand use in steep areas, sediment from erosion of cut and fill slopes is estimated to contribute to the sediment loading. The recommended sediment capture volumes in this SCAP are **1,000 tons/mile/year for Floyd Hill and 1,500 tons/mile/year for Georgetown Hill**.

5.3.2 Adjustment for High Elevation Areas above 10,000 feet

Winter maintenance material application rates are non-linear in the Clear Creek I-70 corridor due to significantly more snowfall and colder temperatures at higher elevations, as well as steep roadway gradients in certain areas. Patrol 41 extends from 7,500 to 11,500 feet elevation over the 25-mile length. The material application rate reported for the entire patrol does not accurately represent elevations above 10,000 feet. Reconnaissance in these high elevation areas shows significantly greater deposits of traction sand than lower elevation areas of Clear Creek.

In Straight Creek for example (west side of EJMT), the traction sanding rate used in that SCAP was 5,000 tons/mile/year for the uppermost 2.5 miles near the EJMT (CDOT 2002b). Therefore, it is appropriate to assume higher application rates in the uppermost 2.5 miles of Clear Creek than lower elevation areas. For planning purposes the sediment loading rate (including sand deposits and slope erosion) is estimated to be **2,000 tons/mile/year for high elevations** which includes the 2.5 miles from the EJMT area down to the Herman Gulch interchange (MP 215.5 to 218). Table 5-3 below presents estimated maximum sediment loading rates by highway segment.

Table 5-3 Estimated Maximum Sediment Loading Rates by Highway Study Segment

Highway Segment	Est. Max. Loading Rate	
	Tons/ Mile	*CY/ Mile*
EJM Tunnel – Herman Gulch	2000	1347
Herman Gulch – Silver Plume	1000	674
Georgetown Hill	1500	1011
Georgetown – Idaho Sp.	500	337
Idaho Sp. – Kermitts Junction	500	337
Floyd Hill – Beaver Brook	1000	674

5.4 Sediment Control Strategy

Sedimentation caused by traction sand usage was not anticipated to be a significant or important concern at the time of I-70 construction. The primary method of controlling sediment has been through revegetation to prevent slope erosion. This SCAP proposes permanent sediment control measures along I-70, as well as a more intensive maintenance programs to manage sediment transport.

Several sediment control measures are considered in this study including both structural and non-structural controls. Structural sediment controls include features that are placed in the drainage pathway to dissipate hydraulic energy and settle mobilized sediment. This includes hydraulic control of highway runoff to reduce erosion of cut and fill slopes. Non-structural sediment controls include revegetation to prevent soil erosion and maintenance BMPs such as sweeping and shouldering. A proactive maintenance program involving BMPs such as utilization of controlled snow storage areas, and scheduled sand cleanup activities including sweeping and removal is integrated into this plan.

The primary sediment control strategies in this plan include:

- Minimize the application of traction sand through improved technologies
- Capture and remove sediment within the roadway right of way to the extent practical
- Capture and contain traction sand and eroded sediment in easily maintained areas
- Bypass clean tributary water to prevent contamination by highway runoff
- Minimize the volume of water requiring treatment
- Increase the number and size of sediment capture areas, especially in critical areas (high elevation and steep roadway sections)
- Provide controlled snow/sand storage areas
- Improve the highway storm drainage network and outfall areas
- Reduce peak salt loading from snowmelt runoff
- Reduce cut slope and fill slope erosion
- Reduce rill erosion in shoulder areas
- Maximize vegetation cover as necessary to prevent slope erosion
- Develop preventative maintenance programs (Sediment Maintenance Program)
- Increase funding in order to increase frequency of BMP maintenance

Highway drainage design plays a major role in the sediment control strategy. Several areas exist along I-70 where the original drainage design is inadequate, or the drainage system has been altered by sedimentation to the extent that it no longer functions properly. This can and has resulted in massive rill and gully erosion where runoff is concentrated on the highway shoulders and discharges on steep slopes.

There are several locations in the Clear Creek I-70 corridor where large gullies have formed in the I-70 fill slope, particularly on Georgetown Hill and Floyd Hill, as a result of improper drainage disposal. Rill formation is common in shoulder areas where highway runoff sheet flow is concentrated in unconsolidated sediments. In some areas, culverts are plugged with sediment and no longer function, resulting in concentration of large flow volumes that exceed downstream drainage system capacity.

By incorporating drainage design considerations, this SCAP also serves to resolve many of the highway drainage problems currently experienced in the Clear Creek I-70 corridor. Runoff water must be managed in a controlled manner through adequate drainage design. Designs that dissipate hydraulic energy also help to control sediment transport.

Paving of the shoulder areas, installation of “valley pan” drains, and concrete curbs placed to control highway runoff have all proven to be effective methods of controlling erosion along I-70 (CDOT 2002b). A 1990 study by the U.S. Forest Service on Straight Creek concluded that revegetation, coupled with construction of a collection ditch (valley gutter) had stopped the majority of erosion on test fill slopes (CDOT 2002b).

Vegetation has the ability to bind soil particles, provide organic enrichment, and maintain soil moisture. Adequate vegetation cover is widely recognized as a key element in stabilizing soil and preventing erosion. Most of the areas disturbed by I-70 construction have been successfully revegetated. However, vegetation in many areas remains under stress due to annual smothering by highway traction sand. An annual revegetation program for the hill slope areas along I-70 is proposed in an effort to improve and maintain adequate vegetation cover to prevent soil loss.

A preventative maintenance program is proposed to control annual sediment transport by collection and removal of accumulated sand and colluvial material. A cleanup and disposal plan will be required as part of the maintenance program. These aspects should be integrated into a Sediment Maintenance Plan as described in Section 6.

Based on past research and experience in high elevation snowfall traction sanding areas in Colorado, the following primary sediment control measures are proposed for the Clear Creek I-70 corridor:

- Basins and traps to capture sediment
- Paving shoulder areas to reduce rill erosion and provide a durable surface for cleaning
- Valley pan drains to store snow and sediment, and control and route highway runoff
- Knee walls to prevent cut slope erosion
- Curb and gutter to reduce migration of sediment onto fill slopes
- Controlled snow storage/sand deposition areas
- Revegetation program
- Maintenance BMPs
- Sediment Maintenance Program

5.5 Hydraulic/Drainage Analysis

The hydrology of the Clear Creek watershed is dominated by the annual cycle of snowmelt runoff. The winter snowpack effectively stores water for release to streams during spring and summer when daily temperatures increase. This phenomenon drives the hydrology of Clear Creek, including both surface and groundwater flows that cross I-70 within the corridor. Another factor that influences the natural hydrology is the increased impervious surfaces resulting from I-70 pavement and parking/chain station area development.

Many drainage problems were identified as part of the site reconnaissance. The overall drainage design for I-70 was simple, but functional when constructed. However, the drainage system has been altered from sand deposition along the shoulders of I-70. In addition, drainage criteria and drainage regulations have evolved since the original construction.

Drainage improvements are needed to reduce transport of deposited material and to provide adequate runoff conveyance. Present-day drainage and erosion problems occur primarily in locations of:

1. Sheet flow down unprotected slopes,
2. Unpaved shoulder and unvegetated cut slope areas,
3. Terminus of Type 4 (Jersey) barriers or guardrail curbs where runoff is concentrated along the roadway with no inlet drains or rundowns,
4. Areas where the inlet drains are plugged with sediment,
5. Areas where culvert cross drains daylight on fill slopes with no erosion protection or energy dissipation,
6. Culvert outfalls where no energy dissipation is provided, and
7. Median areas where flow is concentrated for long distances.

Some of the greatest problematic drainage areas are near Eisenhower Tunnel between MP 215 to MP 218. This area was identified as having some of the largest sediment loads to Clear Creek during the field reconnaissance and in-stream water quality monitoring data confirms this observation. The application of traction sand is significantly higher at these upper elevations.

I-70 bisects several tributary streams that flow perpendicular to the highway. Several ephemeral tributaries and groundwater springs that flow during the spring and early summer are also intercepted. The highway was designed to allow passage of these tributary flows through culvert cross drains. The culvert inlets and cross drains for perennial tributaries were generally in good condition. Each of the major perennial tributary flows were identified and mapped for this study.

A primary objective of this plan is to separate the clean tributary flows from highway runoff flows to the extent practical in order to:

1. Keep clean tributary water from becoming contaminated with highway runoff and sediment,
2. Reduce the volume of water requiring treatment, and
3. Maintain sediment basins as dry as possible between runoff events to improve trap efficiency and facilitate cleaning.

All of the largest existing clean tributary culverts will remain at their present locations and no major hydraulic modifications are proposed as part of this plan. The only alteration proposed is to extend the existing culvert inlets upstream as needed to collect the tributary flow before it reaches the shoulder of I-70. The goal is to isolate clean water from highway runoff, thereby reducing the amount of water than needs to be treated. Energy dissipation and outfall protection is also needed on some of the tributary cross drains.

Highway runoff will be routed in a separate channel past clean tributary inlets and into sediment control structures before release to Clear Creek. Treated runoff water will then be conveyed through existing culvert cross drains wherever possible. Culvert rundowns with energy dissipation will be installed where necessary to eliminate hill slope erosion and stabilize fill slopes.

5.5.1 Assumptions

Since highway runoff will be re-routed past clean tributary inlets into sediment basins or traps before being released through cross drains, the hydraulic (flow) length between cross drains could increase in certain areas. Therefore, it was necessary to re-evaluate the hydrologic design for I-70 drainage structures to determine conveyance needs based on CDOT hydrologic design criteria. A "worst case" scenario was evaluated assuming a maximum hydraulic length between cross drains to assess potential "fatal flaws" in the sediment control design in terms of hydraulic conveyance. The following assumptions were used in the hydraulic analysis.

1) No off-site areas contributing to highway runoff flows were evaluated. The only drainage areas considered were from the roadway and paved shoulders. Major off-site flows are clean water tributaries conveyed through existing cross culverts under I-70 and via slope drains to the valley floor. Runoff from minor tributary areas from the hillside will be managed with cross culverts.

2) The maximum longitudinal grade is 7% along the roadway and 2% roadway cross slope. This would create a worst case for velocity in the V-ditches and gutter pans. A channel slope of 1% was also evaluated to determine maximum carrying capacity.

3) The contributing drainage area is the traveling roadway and paved shoulder. The contributing area used for I-70 east of the Eisenhower Tunnel (Clear Creek) was three 12-ft traveling lanes in the east and west direction, with an 8-foot paved shoulder and 24-foot gravel shoulder. This accounts for expansion of I-70 from four to six lanes in the future.

4) Conveyance structures include paved V-ditches along the cut slopes and concrete valley pans along the fill section. Cross slopes were modeled for 8:1 to 12:1 (horizontal to vertical). Sides of the V-ditches and bottoms of trapezoidal pans must be 8-feet or greater to allow sweepers to clean and maintain them.

5) Cross drain structure inlets are CDOT Type C and D for the paved V-ditches and vane grates in the concrete valley pans. In addition to the vane grates, slotted drains may be

used to increase hydraulic efficiency. These inlets are shown in CDOT's Standard Plans-M&S Standards.

6) There are instances where V-ditch flows will be bypassed over major tributary cross culverts. These tributary culverts will be extended back into the slope for a short distance and similar cross culvert inlets will be used.

The design criteria used in the hydrologic analysis included the following:

1) The 2-year and 5-year rainfall frequency depth were used in the preliminary design since the structures proposed for erosion and sediment control are integrated with the existing I-70 storm drain system. As per CDOT Drainage Manual, the 2 to 5 year rainfall frequency is typically used for storm drainage design.

2) Rainfall intensity was determined from NOAA Atlas 2 "Precipitation Frequency Atlas of the Western United States-Volume III-Colorado.

3) Minimum freeboard requirements were evaluated to determine the degree of safety necessary to prevent overtopping of the conveyance structures. The freeboard will vary depending on location.

4) The Rational Method was used to estimate peak flows. All drainage areas met the criteria of less than 160 acres for use of this method. From Urban Drainage Flood Control District's "Urban Storm Drainage Criteria Manual", the 100% imperviousness runoff coefficients are 0.95 for both the 2-year and 5-year storm for all NRCS hydrologic soil groups. The same runoff coefficient was reported in the "Sand Recovery for Highway Drainage Designs" (Guo, 1999).

5) The time of concentration method used as outlined in the CDOT Drainage Manual, Chapter 7 - Hydrology.

5.5.2 Analysis

Hydraulic lengths ranging from 0.1 to 0.7 and 1.0 mile were evaluated to estimate peak highway runoff flow rates that could be generated between I-70 culvert inlets. These estimates represent one travel direction, either eastbound or westbound.

The I-70 highway is a linear drainage basin which crosses the isopluvial precipitation map over an approximate 32.5 mile long corridor. The study limit starts at a point approximately at 105˚54'12" W, 39˚40'45" N and ends at a point approximately at 105˚24'22" W, 39˚43'14" N. For this planning stage, the isopluvial with the highest precipitation crossed by the study corridor were read from the Figure 20, Figure 21, Figure 26 and Figure 27 of the NOAA Atlas 2 Volume III. Figure 5-2 to Figure 5-5 show the project corridor on isopluvial maps. The 1-hour precipitation depths for 2-year and 5-year frequency were calculated using Equation for Region 1 listed in Table 11 of the NOAA Atlas 2 Volume III. Figure 5-5 shows the project site locates in Region 1. The precipitation depths for rainfall duration less than 1-hour were calculated using adjustment factors from Table 12 of the NOAA Atlas 2 Volume III. Table 5-4 through Table 5-7 show the results of precipitation depths for corresponding rainfall durations.

To utilize the Rational Method for a peak discharge calculation, the time of concentration (Tc) is an important parameter. Tc is calculated by considering the total amount of time for the raindrop to travel from the most upper basin boundary to the first design point. Tc is the summation of the time of the overland flow plus the time of the channel flow throughout the drainage basin. The initial flow path length of 300 feet maximum for urban areas was used for the paved highway drainage basin. A series of Tc's were computed for the corresponding hydraulic lengths, and then the corresponding rainfall intensities were derived by interpolation using Table 5-5 and Table 5-6. The estimated peak flows for the hydraulic lengths are listed in Table 5-7.

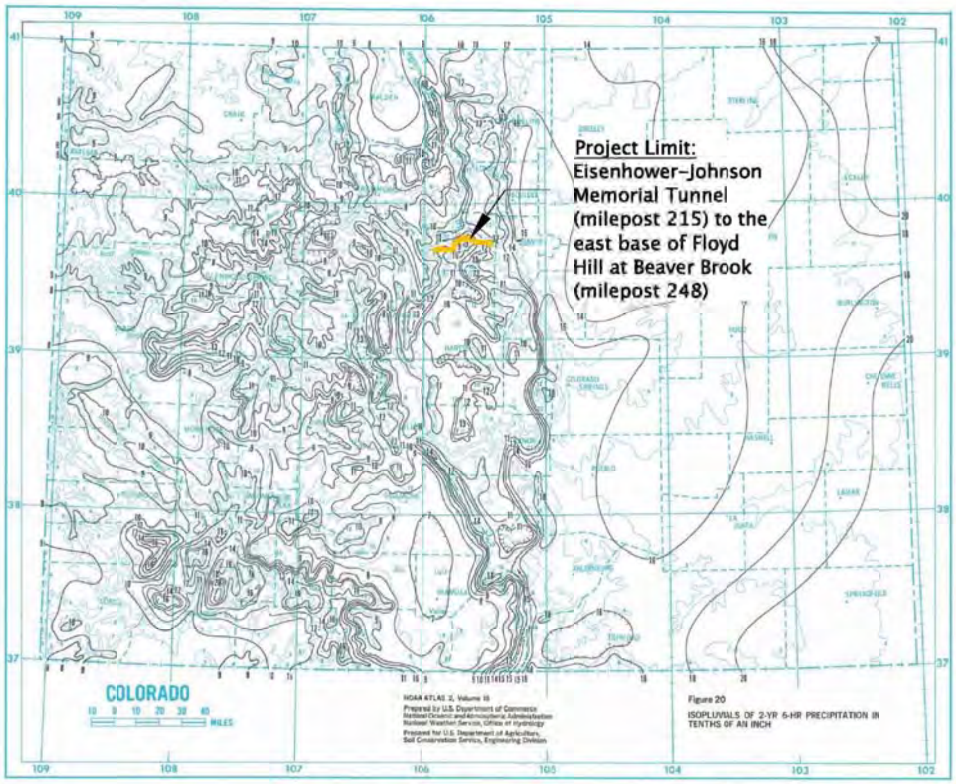


Figure 5-2 2-year 6-hour Isopluvial Map

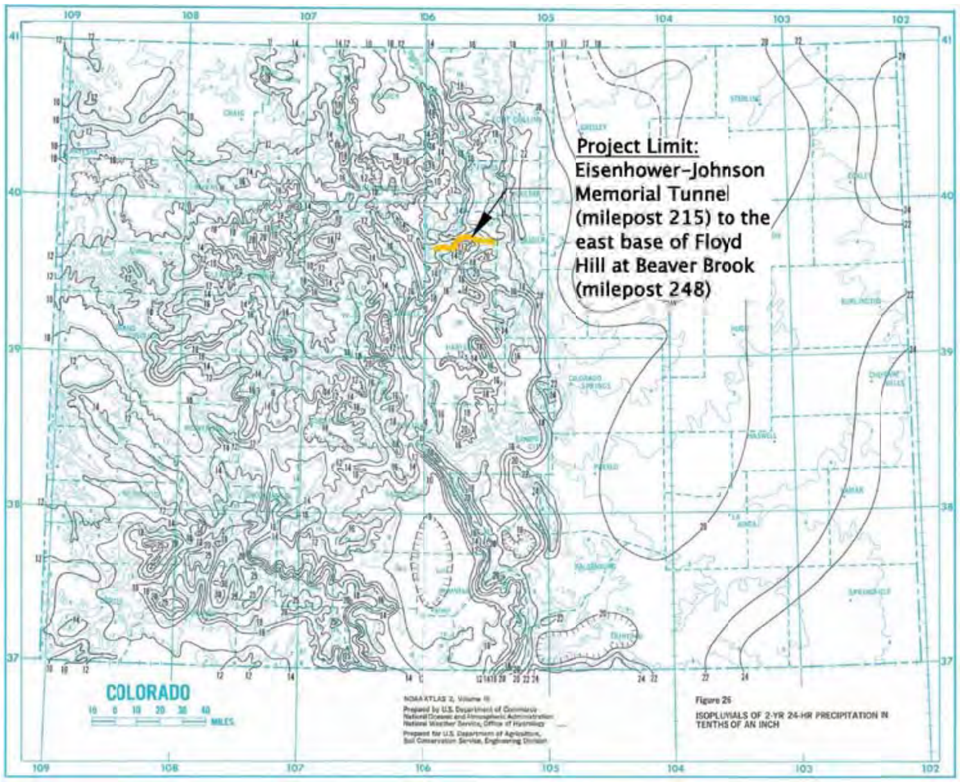


Figure 5-3 2-year 24-hour Isopluvial Map

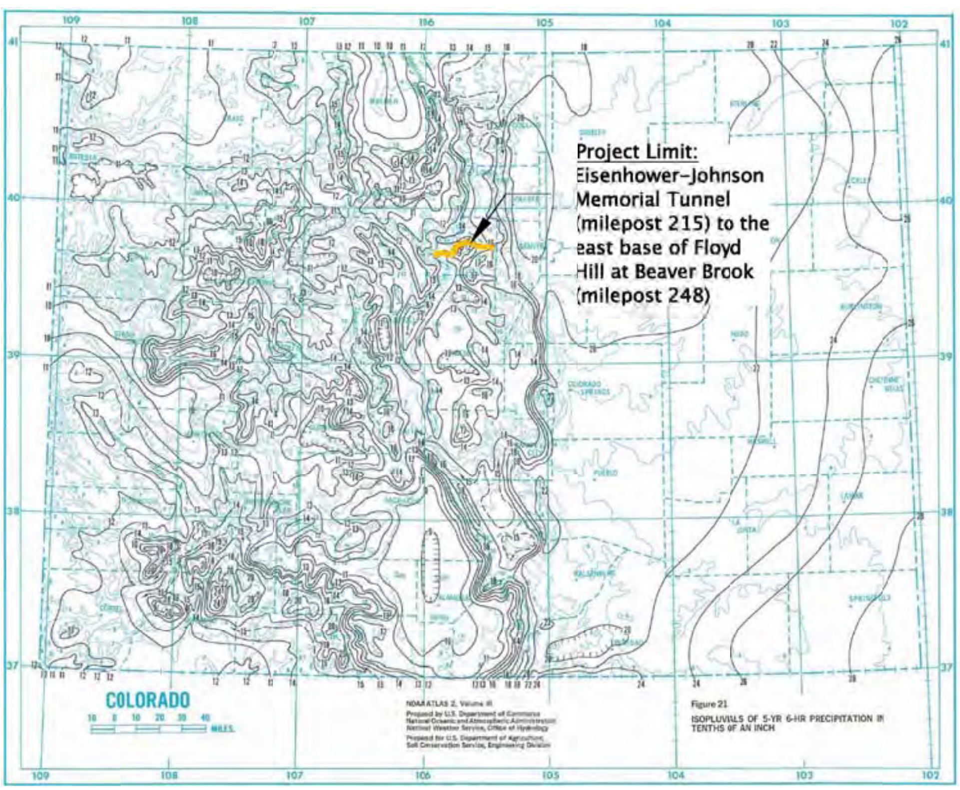


Figure 5-4 5-year 6-hour Isopluvial Map

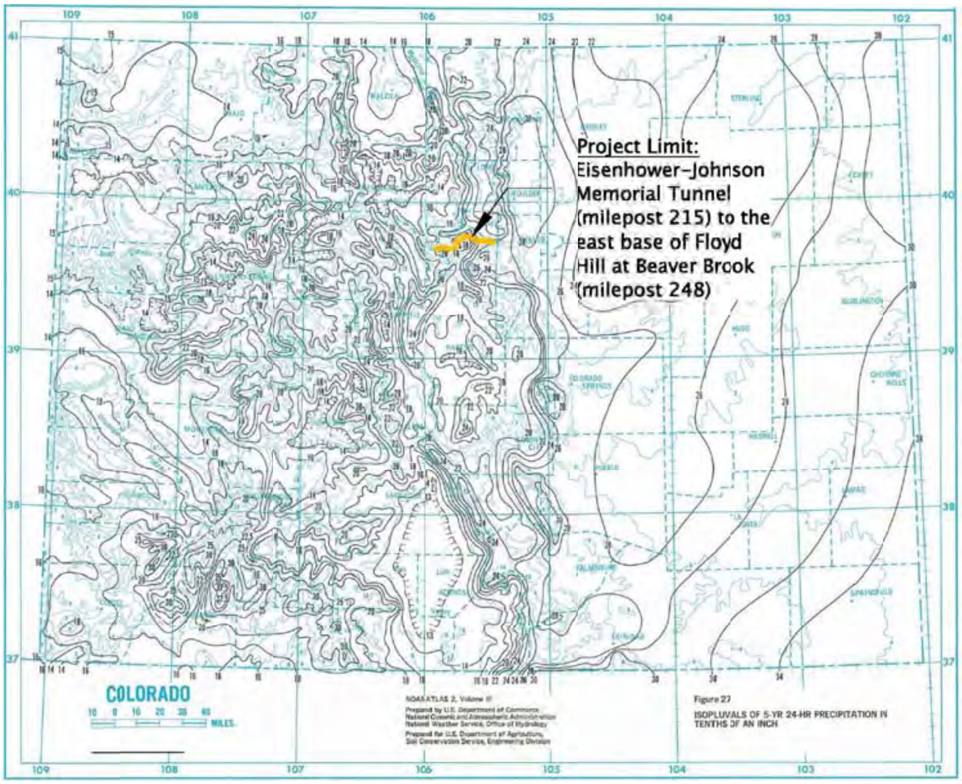


Figure 5-5 5-year 24-hour Isopluvial Map

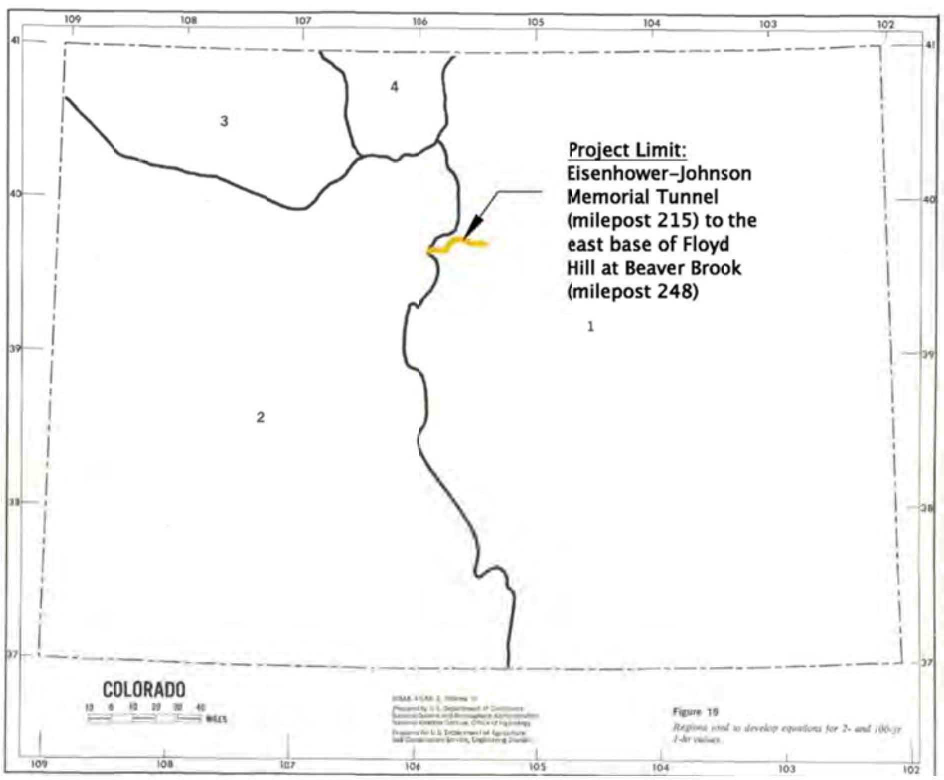


Figure 5-6 Regions used to develop equations for 2- and 100yr 1-hr values

Table 5-4 Estimate 1-hour Precipitation with Statistical Parameters Taken as the Highest Values from Figures 5.1 through 5.4

Frequency \ Duration (min)	1-hour* (inch)	6-hour** (inch)	24-hour** (inch)
2-year	0.72	1.1	1.7
5-year	0.97	1.6	2.4

*Precipitation depth calculated using Equation for Region One.
**Precipitation depth read from Isopluvial Map

Table 5-5 Estimate 2-year Precipitation Intensity

Duration (minutes)	5	10	15	30	60
Ratio to 1-hour	0.29	0.45	0.57	0.79	1.00
Precipitation (inch)	0.21	0.33	0.41	0.57	0.72
Intensity (inch/hour)	2.51	1.95	1.65	1.14	0.72

Table 5-6 Estimate 5-year Precipitation Intensity

Duration (minutes)	5	10	15	30	60
Ratio to 1-hour	0.29	0.45	0.57	0.79	1.00
Precipitation (inch)	0.28	0.44	0.56	0.77	0.97
Intensity (inch/hour)	3.39	2.63	2.22	1.54	0.97

Table 5-7 Estimate I-70 Culvert Design Peak Flow (cfs) using the Rational Method

Distance (miles)	Tc (minutes)	Minimum Tc (minutes)	Maximum Tc (minutes)	Tc used (minutes)	2-year (cfs)	5-year (cfs)
0.1	3.1	5	12.9	5.0	1.9	2.5
0.2	4.1	5	15.9	5.0	3.7	5.0
0.3	4.9	5	18.8	5.0	5.6	7.5
0.4	5.6	5	21.7	5.6	7.2	**9.7**
0.5	6.3	5	24.7	6.3	8.7	11.7
0.6	7.0	5	27.6	7.0	10.1	13.6
0.7	7.6	5	30.5	7.6	11.5	15.4
1.0	9.4	5	39.3	9.4	15.2	20.5

Hydrologic Parameter		
Runoff Coefficient	0.95	
Average Slope	7	%
Maximum flow path	300	Feet
Each side bound width	66	Feet
2-year 1-hour rainfall depth	0.72	inch
5-year 1-hour rainfall depth	0.97	inch

Several variables associated with design flows for the different conveyance structures were evaluated. Assuming a more conservative design 5-year storm with the spacing of inlets at 0.4 miles, the peak discharge is 9.7 cfs per east or westbound travel direction. Side slopes of the conveyance structures were varied from 8:1 to 12:1 (horizontal to vertical). The resulting estimates for water depth, velocity and top width are shown in Table 5-8.

Table 5-8 I-70 Hydraulic Conveyance Structure Estimates

Cross Slope (h:v)	Longitudinal Slope (ft/ft)	Peak Flow (cfs)	Flow Depth (ft)		Flow Velocity (ft/s)		Flow Top-Width (ft)	
			Asphalt V-ditch	Concrete Valley Pan	Asphalt V-ditch	Concrete Valley Pan	Asphalt V-ditch	Concrete Valley Pan
12:1	0.07	9.7	0.34	0.32	7.1	7.8	8.1	7.8
10:1	0.07	9.7	0.36	0.35	7.4	8.1	7.3	6.9
8:1	0.07	9.7	0.40	0.38	7.8	8.6	6.3	6.0
10:1	0.01	9.7	0.52	0.50	3.6	3.9	10.4	10.0

5.5.3 Results

Most of the cross culverts draining I-70 are 24-inches in diameter or larger. The full-flow capacity for a 24-inch CMP is about 22 cfs at 1% slope. Assuming half the flow from each side of the roadway, the allowable flow that can be generated between inlets is 11 cfs. The 9.7 cfs per direction computed in Table 5-6 for culverts with an average 0.4 mile spacing.

This exercise was completed to determine that the maximum allowable distance between sediment collection and cross drain structure inlets is approximately 0.4 miles in the Clear Creek I-70 corridor. Highway runoff water would not be conveyed any farther than this distance before being collected at sediment control structure inlets for discharge via cross culverts and rundowns. The hydraulic design assumptions and variables used in this analysis are considered to be conservative but appropriate for planning purposes.

5.6 Menu of Structural BMP Control Measures

Based on the literature review, conversations with CDOT and Caltrans, and engineering experience a menu of structural BMP control measures has been developed. Because deicers are difficult to remove from runoff, the structural BMP menu focuses on those which remove suspended solids, will function in mountain environments, and will be easy to maintain. Routine inspection and proper maintenance are vital to structural BMP success.

Menu of Structural BMP Control Measures

Collection System BMPs:

- Road Side Swale
- Curb & Gutter or Concrete Pan
- Snow Storage Areas and Parallel Snow Storage
- Drainage Rundowns
- Slope Stabilization and Revegetation
- Clean Water Diversion (Highway Bypass)
- Snow Fence

Treatment System BMPs:

- Detention/ Sediment Basins
- Loading Dock Sediment Trap
- Inlet Sediment Traps and Sand Cans
- Bench Trap
- Roadside Swales and Filter Strips
- Underground Vault (only if necessary)
- Oil Separators (only if necessary)

The following pages outline the best uses, advantages, and disadvantages of each BMP. More detailed information and discussion of these BMPs including BMPs which are not recommended can be found in the literature review.

5.6.1 Collection System and Snow Storage BMPs

A. Road Side Swale

Best Use: Conveying stormwater and snow melt to treatment and outfall facilities.

Advantages	Disadvantages
• Ditches and natural swales already exist in many areas • Grass lined swales promote infiltration in the collection system • Grass lined swales also offer treatment • Captures and redirects runoff to treatment facility • Also functions as parallel snow storage • Low Cost	• Requires space adjacent to highway

Other:

- Needs to be designed for highway safety.
- Sides of the V-ditches and bottoms of trapezoidal pans must be 8-feet or greater to allow sweepers to clean and maintain them.

Figure 5-7 Roadside Swale

B. Curb & Gutter or Concrete Valley Pan

Best Use: Conveying stormwater and snow melt to treatment and outfall facilities in areas of limited space.

Advantages	Disadvantages
• Does not require extra ROW – fits in narrow areas • Captures and redirects runoff to treatment facility • Prevents ditch and embankment erosion	• Curb and gutter creates safety problems on high-speed roads. May need to be integrated with a guard rail. • Expensive to install over large lengths of highway • Will require periodic to frequent sweeping • Snow and sediment which is plowed over the guardrail is not captured

Other:

- Curb and pan design needs to consider broom sweepers ability to effectively remove sediment
- Only needed in priority areas where I-70 is near Clear Creek

Figure 5-8 Highway Curb & Gutter (Mt. Vernon Canyon)

Valley Pan west of Eisenhower Tunnel

Figure 5-9 Highway Curb & Gutter – Note the Guardrails

C. Snow Storage Areas and Parallel Snow Storage

Best Use: Storing plowed snow adjacent or near to highway.

Advantages	Disadvantages
• Allows plowed snow with traction sand to melt in a contained area which drains to a treatment facility • Snow storage areas can be easily swept and cleaned • May double as treatment facility • May impede wildlife from entering roadway and being killed	• Requires space – this will be difficult in some narrow areas of I-70 • May be expensive to install • Plowing or moving snow into these areas will be more difficult than conventional plowing. • Snowmelt from parallel storage areas may freeze on highway – this will need to be addressed in site-specific design • May impede wildlife from crossing the roadway

Other:

- Will need to be swept and/or cleaned out each year.

Figure 5-10 Sediment accumulation in snow storage are on Berthoud Pass (Source: CDOT)

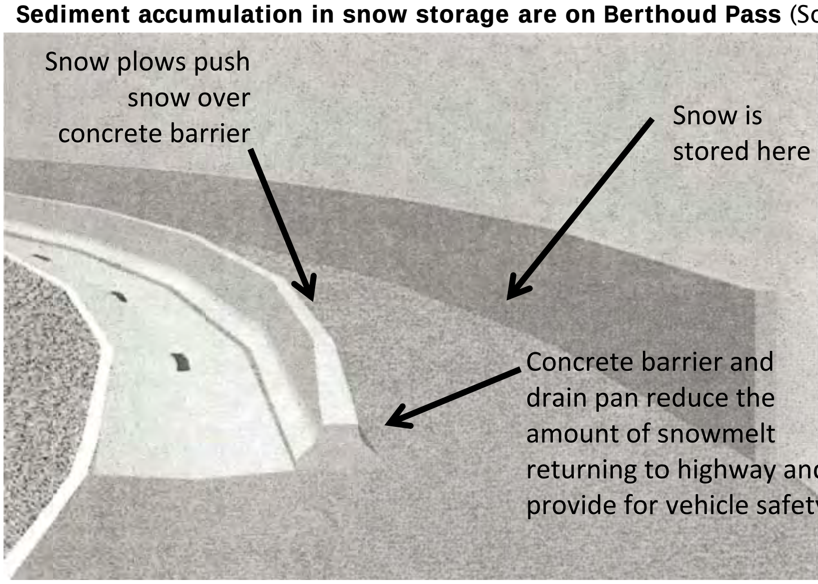


Figure 5-11 Parallel Snow Storage Concept (Source: CDOT Straight Creek SCAP, 2002)

D. Drainage Rundowns and Slope Drains

Best Use: A permanent BMP that conveys concentrated flows from top to bottom of an embankment. Stabilizes slope and eliminates embankment erosion. These may be constructed as a grouted boulder structure or a buried culvert pipe system. Excellent for long slopes.

Advantages
• Reduces erosion on highway embankments • Protects upstream improvements from undermining • Allows revegetation of slope and reduces aesthetic impacts
Disadvantages
• Expensive to construct • Difficult to install on steep slopes

Figure 5-12 Buried Culvert Rundown with Riprap Outfall (Source: Clear Creek Consultants)

E. Slope Stabilization and Revegetation

Best Use: Stabilizing slope and eliminating embankment erosion at locations of slope instability. Vegetative methods may be used on less-steep slopes. Structural methods may be needed on steeper and highly unstable or rocky slopes.

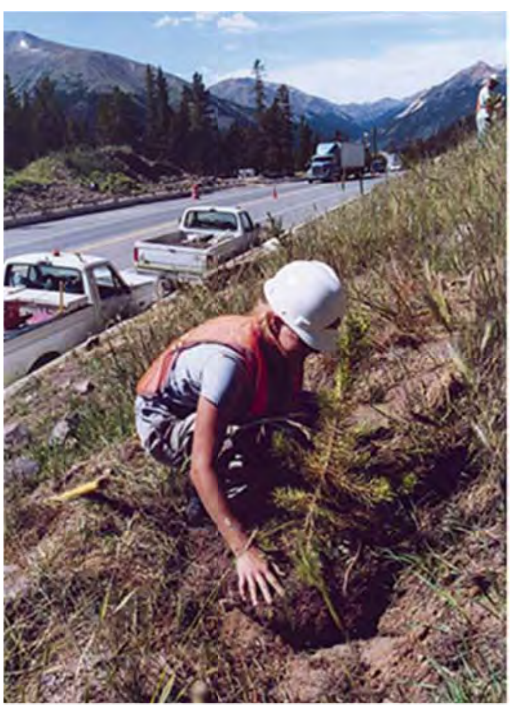


Figure 5-13 Slope Revegetation
(Source: CDOT)

Advantages
• Reduces erosion on highway embankments • Natural vegetation is aesthetically pleasing
Disadvantages
• Short growing season in high altitude areas • Difficult to establish vegetation on steeper or rocky slopes, and arid south-facing slopes • Structural stabilization methods may be expensive • Not effective in areas of high traction sand deposition

F. Clean Water Diversion (Highway Bypass)

Best Use: Bypass clean water from upper watershed around highway.

Advantages	Disadvantages
• Keeps clean water from upper watershed from being contaminated by highway pollutants • Reduces the volume of water through treatment facilities • Can be used for groundwater seeps and to reduce water in road subgrade • Important as a source water protection measure for water supply	• Need space to install bypass systems • May be expensive to install

Other:

- Tributary diversion culverts need to be extended far enough upstream to capture clean water before mixing with highway runoff.
- Highway runoff should be captured and treated before flowing into clean tributaries.
- Structures should be designed and installed in a manner that does not create fish migration barriers. In many cases, this may simply mean extending an existing culvert further upstream to make room for BMPs to treat highway drainage.

Figure 5-14 Clean Water Diversion at Loveland Ski Area Zip Creek Water Supply

G. Snow Fence

Best Use: Reducing drifting snow.

Advantages
• Reduces drifting snow and the need for successive plowing in problematic areas • May increase winter road temperature
Disadvantages
• Constructed snow fences have poor aesthetics

Figure 5-15 Snow Fence

Other:

- 'Living snow fences,' or tree-belts, can be very effective protecting a highway from snow drifts and are more aesthetically pleasing than constructed snow fences. However, they do take time to establish and cannot be moved once installed.

5.6.2 Treatment BMPs

A. <u>Detention/ Sediment Basins</u>

Best Use: Removing large amounts of sediment from runoff in locations with available space for treatment facility.

Advantages	Disadvantages
• Large storage volume • Promotes infiltration if soft bottom is used • Does not have to be directly adjacent to highway; can be located away from traffic • Treats large volume of water • Low cost if earthen embankment and rock spillway are used	• May require large amount of space outside of the clear zone • May be expensive to construct depending on material and design • Rubber-tired loaders and backhoes have trouble cleaning soft bottom basins. • Ponds that do not drain properly may result in water rights issues.

Other:

- Design needs to consider maintenance access and maximum reach of excavator.
- Construction of a maintenance access road may be necessary
- Designed to drain within 20-48 hours to avoid water rights issues.
- Maintenance: Clean once and inspect twice annually.

Figure 5-16 Sediment Basins

B. Loading Dock Sediment Trap

Best Use: Removing large amounts of sediment from runoff in areas with medium amount available space for facility.

Advantages	Disadvantages
• Large storage volume • Easy to maintain – may be cleaned with loader • Above ground • Can be located in shoulder below grade or adjacent to highway with concrete barriers or guardrail separating traffic	• Difficult to maintain if they do not drain properly • Expensive to construct (typically concrete)

Other:

- May require access road
- Concrete wall at end is helpful for loader to scoop against
- Caltrans puts replaceable filter fabric over the upstream side of the rock gabion.
- Needs to be wider than 12-feet to accommodate loader bucket for maintenance.
- Maintenance: Annually clean and replace filter fabric (if used). Inspect twice annually.

Figure 5-17 Berthoud Pass Loading Dock Sediment Traps (Source: CDOT)

Figure 5-18 Downstream end of Caltrans Loading Dock Sediment Traps
Note: Concrete bollard backstop and rock gabion (Source: Caltrans)

C. Inlet Sediment Traps and Sand Cans

Best Use: Removing smaller amounts of sediment from runoff in areas with lower sediment loading or limited space for treatment facilities.

Advantages	Disadvantages
• Fits in small space • Works well with curb and gutter • Easy to clean and inspect • Can be cleaned with vacuum truck • Simple to construct • Some designs may be driven over • Suitable for lower sediment loads • Can be designed with open bottom to allow infiltration of water in coarse or rocky soils	• Small storage volume • May require many in series to achieve necessary storage volume or may require more frequent maintenance • Plugging of weep drains can be problematic • Requires vacuum truck to clean. • Some designs prone to washout and re-suspension of sediments in higher flows

Other:

- Two types: CDOT Modified Type D, and Sand Cans (Caltrans Type).
- Pullout area for maintenance trucks is helpful – otherwise traffic control and lane closures may be necessary for maintenance.
- There are many similar proprietary devices available which will have higher removal efficiencies and are less prone to scour and re-suspension.
- Maintenance: Inspect twice annually and clean annually. More if necessary.

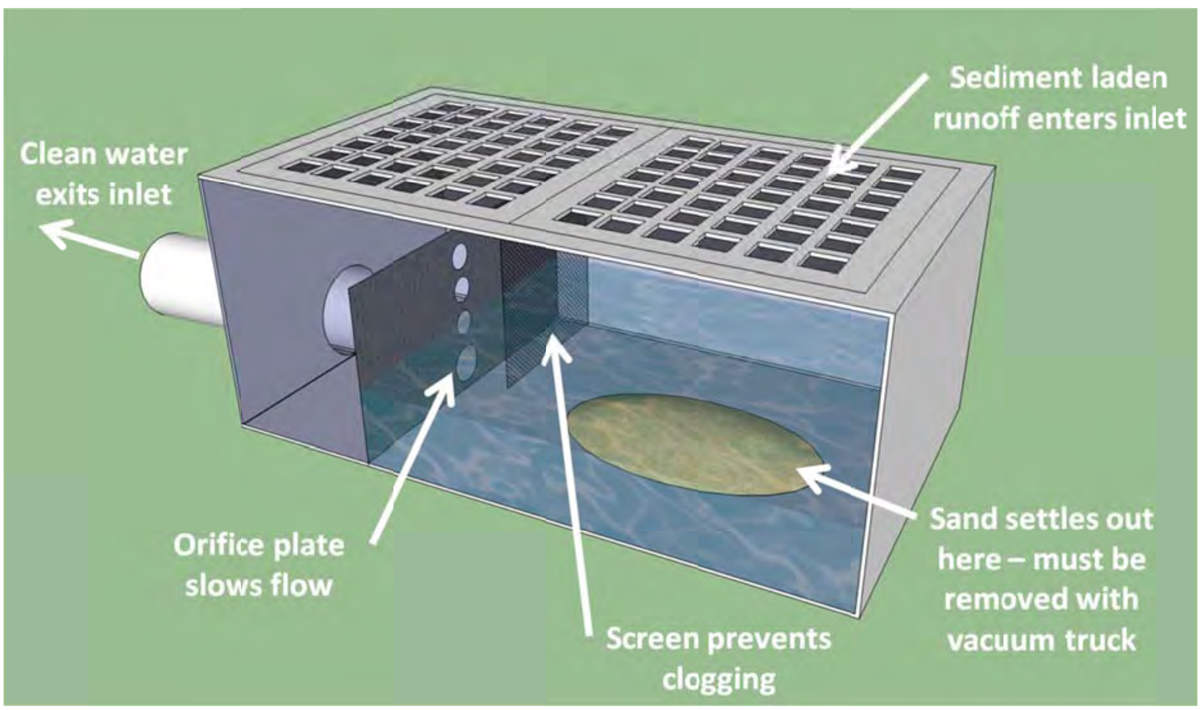


Figure 5-19 CDOT Modified Type D Water Quality Inlet

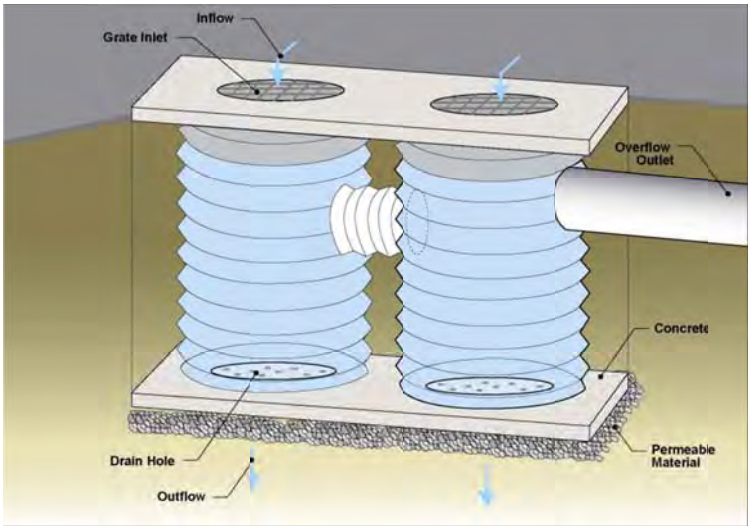


Figure 5-20 Caltrans Sand Can Sediment Tramp (Double Barrel Modified CMP)
(Source: Caltrans)

D. Bench Trap

Best Use: Capturing sediment from plow cast and overland flow along hillside.

Advantages	Disadvantages
• Easy to construct and maintain with conventional equipment • Does not have to be directly adjacent to highway; can be located away from traffic. • Does not need collection system • Captures overland flow • Low Cost	• Needs space between highway and waterway • Cannot handle concentrated flows

Other:

- Basically a ditch graded into the hill-slope between the highway and receiving waterway.
- Maintenance: Yearly inspection and can be maintained by excavation and re-grading when excessive sediment accumulates.

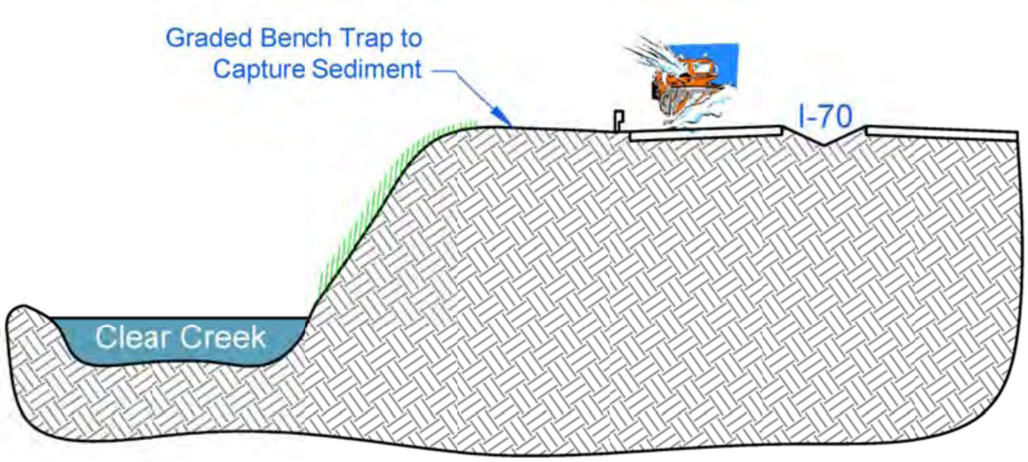


Figure 5-21 Bench Trap Concept

E. Underground Vault

Best Use: Capturing large amounts of sediment where no other treatment facility can fit.

Advantages	Disadvantages
• Moderate storage volume • Good for limited space areas – fits where above ground BMPs cannot • Can go almost anywhere (e.g. under highway or shoulder) • Retrofit on existing cross drains	• Effectiveness is not visible • Difficult to maintain • Difficult to inspect • Vacuum truck required to clean • Workers may need to enter vaults to finish cleaning. Confined space certifications. • Plugging of weep drains is problematic. Inlet chambers tend to stay wet. • Can be prone to washout and re-suspension of sediments in higher flows

Other:

- Needs to have enough hydraulic capacity to pass high flows
- Pullout area for maintenance trucks needed – otherwise traffic control and lane closures to maintain.
- Should be considered the last choice for a treatment BMP.
- Maintenance: Will need to be inspected and cleaned twice yearly, possibly more frequently.

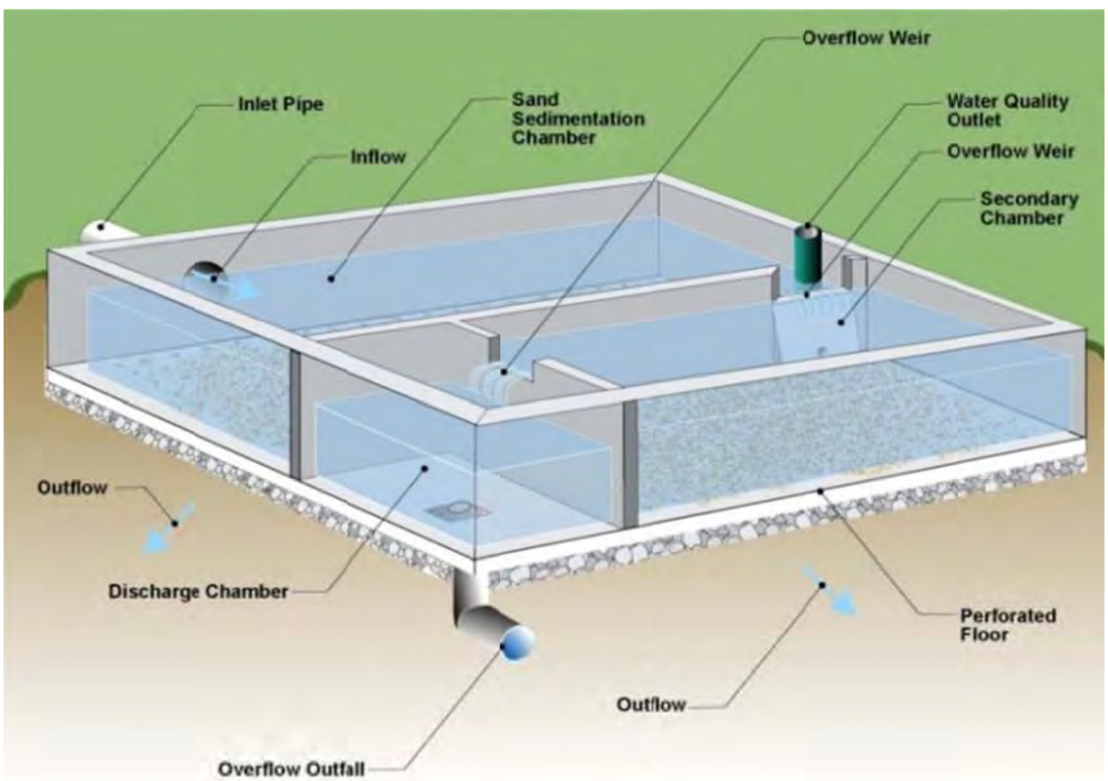


Figure 5-22 Caltrans Vault Sediment Trap (Source: Caltrans)

F. Roadside Swales and Filter Strips

Best Use: Capturing sediment in conveyance system adjacent to highway.

Advantages	Disadvantages
• Swales function as conveyance and treatment • Can double as snow storage • Low Cost • Infrequent maintenance (3-5 years)	• Sediment loading from I-70 may overload filter strips and swales ability to treat. • Will need re-grading after excessive sediment accumulates. • Requires space adjacent to highway. • Vegetation establishment is may be very difficult in high altitudes and narrow canyons.

Other:

- General maintenance is mowing and trash removal. Inspect yearly. Can be maintained by excavation and re-grading when excessive sediments accumulate.
- May need to be replanted after sediment removal/ maintenance grading occurs.

Figure 5-23 Roadside Swale

G. Oil Separators

Best Use: Removing oil from stormwater.

Advantages	Disadvantages
• Fits where above ground BMPs cannot • Removes oil from stormwater	• Must remain wet • Will need to be maintained frequently • May incur high material disposal costs • Difficult to inspect • Will not function when frozen • Prone to washout and re-mobilization of sediments and oils in higher flows

Other:

- Needs to have enough hydraulic capacity to pass high flows
- Can be used in combination with sedimentation vault or independently.
- Pullout area for maintenance trucks needed – otherwise traffic control and lane closures to maintain.
- Should be considered a last choice for treatment BMP.
- Maintenance: Will need to be inspected and cleaned twice yearly, possibly more frequently.

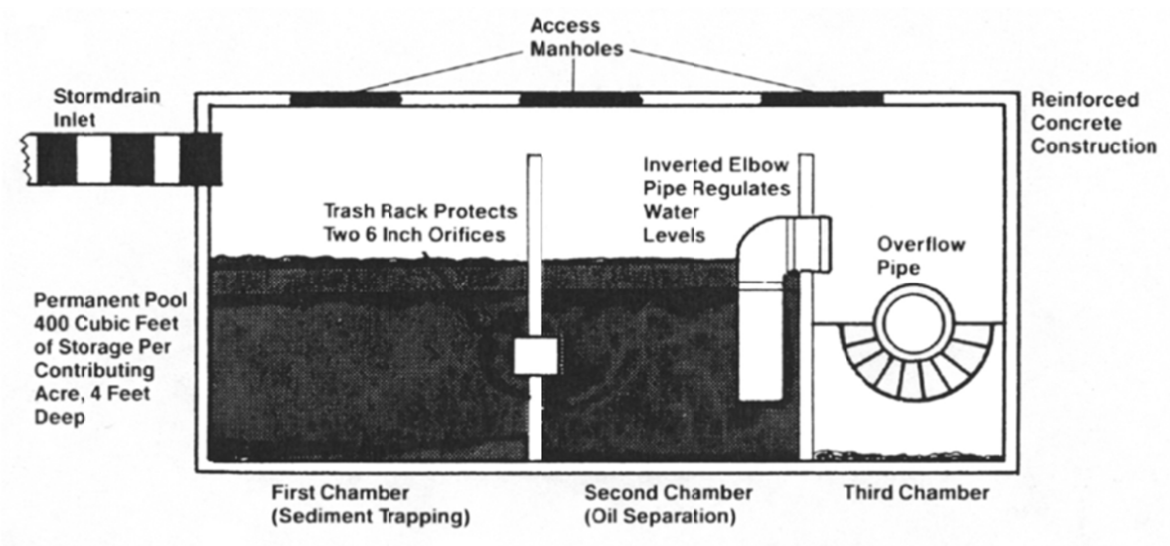


Figure 5-24 Oil and Grit Separator
(Source: Schueler, Tom 1987 *Controlling Urban Runoff)*

BMP Menu

ROADSIDE SWALE

RS

A grass lined ditch that both conveys runoff and provides some treatment. Treatment processes are sedimentation, straining, and infiltration. Requires 10-15 feet adjacent to the roadway. Most economical conveyance method.

SNOW STORAGE AREA

S

Allows plowed snow to melt in a contained area where the snowmelt can drain to a treatment BMP. Areas such as swales and ditches can function as parallel snow storage where plows can easily push snow into them. The snow storage area may also double as a treatment facility, such as a sedimentation basin.

CURB & GUTTER CONCRETE FAN

Collection system BMP. Curb and gutter is used to capture and redirect runoff to treatment and outfall facilities in areas where space is too limited for swales. Prevents embankment erosion. Expensive to install over large lengths of highway. Curbs create safety issues along high speed roadways and will need to be used in conjunction with guardrails.

DRAINAGE RUNDOWN

RD

A permanent BMP that conveys concentrated flows from top to bottom of an embankment. Prevents erosion and protects upstream improvements from undermining. Rundowns may be expensive and difficult to install on steep slopes.

FILTER STRIP

FS

Filter strips or grass buffers are densely vegetated linear strips of grass that accept sheet flow perpendicular to their length and are often incorporated with a grassed swale. Swales and filter strips reduce water velocities which promotes deposition of suspended solids. Cannot handle concentrated flows.

SLOPE STABILIZATION AND REVEGETATION

SS

Reduces embankment erosion at locations of slope instability. Not for concentrated flows. Vegetative methods may be used on less-steep slopes. Structural methods may needed on steeper and highly unstable or rocky slopes.

Vegetative methods are relatively inexpensive and structural methods will be more expensive. Both are very effective at reducing erosion when implemented properly.

BENCH TRAP

BT

A bench trap is a flat filter strip graded into the hill-slope between the highway and stream. Does not need to be directly adjacent to highway. Does not need a storm water collection system. Cannot handle concentrated flows. Treatment processes are sedimentation and straining.

CLEAN WATER DIVERSION

CWD

Diverts upland drainage flows before they combine with contaminated highway runoff. This is accomplished by piping upland flows under and past the highway. Diversion intake needs to extend upstream far enough to capture clean water before it mixes with highway runoff. This reduces the volume of highway runoff requiring treatment. Disadvantages are that space is required upslope and may be expensive to install.

SEDIMENT BASIN

B

A constructed basin, formed by an embankment of compacted soil, with a controlled release outlet structure. It detains sediment-laden runoff for enough time to settle out most of the sediment. Requires sufficiently large amount of space outside of the clear-zone and supporting topography. Can treat a large contributing area and can store a large amount of sediment. Hard surface forebay suggested for easy maintenance. Requires access road

UNDERGROUND VAULT

UV

Underground vaults function similar to sedimentation basins except that they are underground. Usually are multi-chambered and may also include a sand filter and/ or a chamber to remove oils. They are very efficient at removing suspended solids and can fit in limited space areas where no other BMP will fit. The contributing area may be small or medium. Issues with these are: extremely difficult to maintain, confined space certifications, freezing issues, flow capacity issues, and scouring out during high flows. Expensive to install and maintain.

Should be considered the last choice for a treatment BMP.

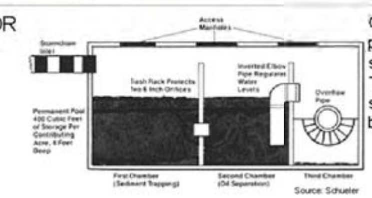
LOADING DOCK TRAP

LDT

A small sedimentation basin which resembles a loading dock and functions similar to a forebay. A layer of (replaceable) filter fabric and/or a rock gabion composes the back wall (or side wall) which detains, filters, and releases the highway runoff. Advantages are: large storage volume, above ground, and can be easily cleaned out with a front-end loader. It can fit in the shoulder area, but requires design for vehicle safety. May also be installed in small and dry drainage channels downstream from the highway. Treats medium sized contributing areas. Requires access road.

SAND/ OIL SEPARATOR

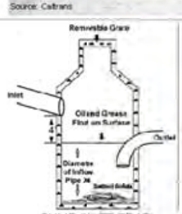
OS

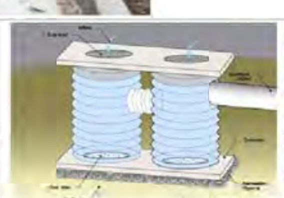


Oil Separators are a vault with an inverted outlet pipe which creates a permanent pool where oil and floatable debris will accumulate. Oil separators should only be used with grease and oil are the primary constituents of concern. These require frequent maintenance and are prone to freezing issues. Use should be limited to small treatment areas and sediment pre-treatment should be provided. Expensive to install and maintain.

INLET SEDIMENT TRAP

IB


SUMP INLET TRAP



SAND CAN TRAP


RAISED GRATE INLET

Three types: Sump Inlet, Sand Can, and Raised Grate Inlet.

1. Sump Inlet Traps consist of a standard inlet with the outlet pipe raised from the bottom of the structure creating a sump.
2. Sand Can Traps are CMP culvert sections buried vertically with a grate on top and an elevated outlet pipe.
3. Raised Grate Inlet Traps are a small sediment basin or forebay immediately upstream of an inlet created by elevating the inlet grate above the ground.

These have small storage volumes, require frequent maintenance, and are susceptible to wash-out from high flows. But they are effective in removing sediment from runoff with small contributing areas and in places with limited space for treatment facilities. They are low cost, easy to install, and require little space. A pullout area for maintenance trucks is helpful.

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SCALE HORIZ: N/A VERT: N/A
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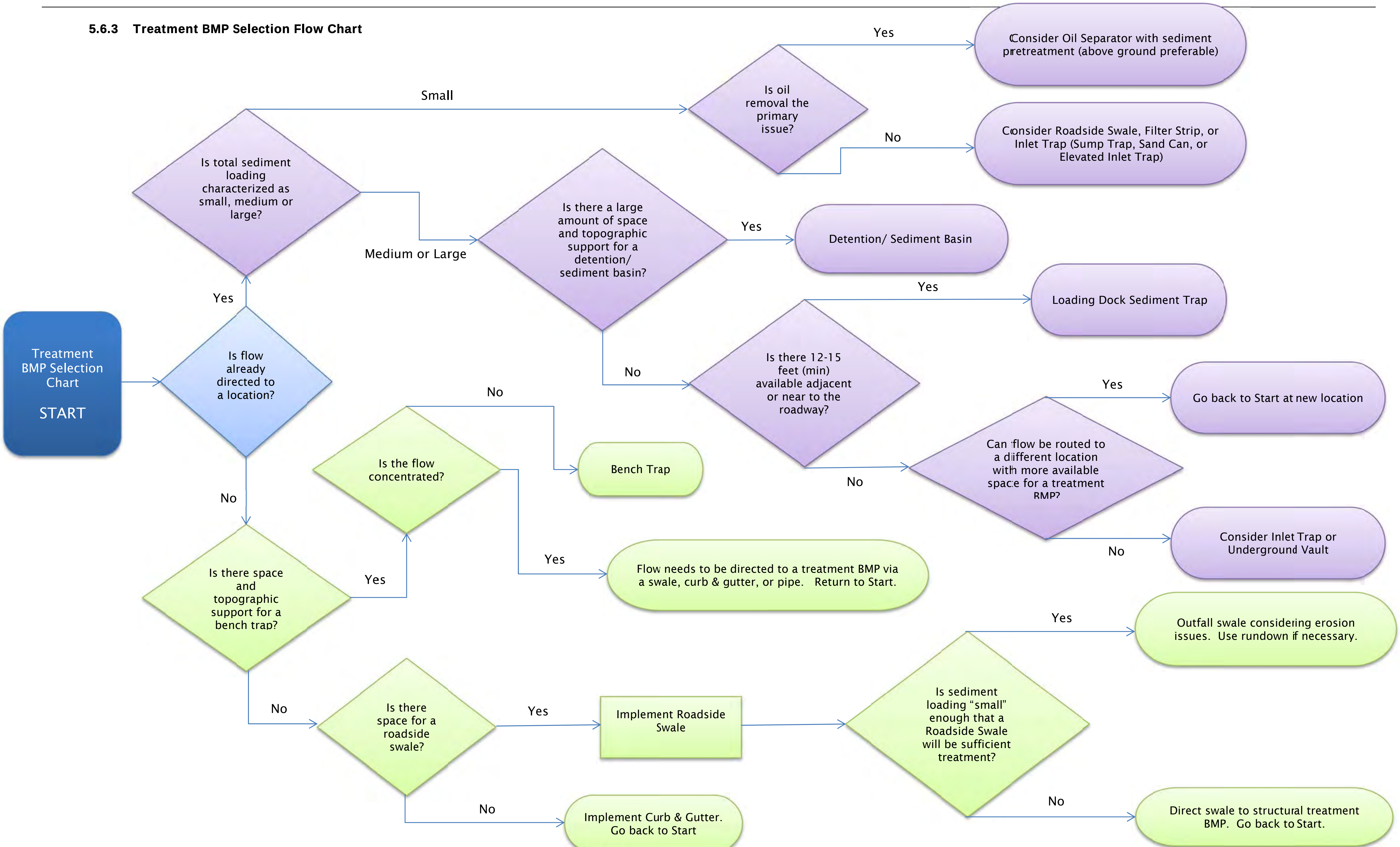
DRAWING No. BMP

Matrix DESIGN GROUP

COLORADO DEPARTMENT OF TRANSPORTATION
I-70 / CLEAR CREEK - SEDIMENT ACTION CONTROL PLAN
STRUCTURAL BMP TOOLBOX

5.6.3 Treatment BMP Selection Flow Chart



5.7 Menu of Non-Structural BMP Control Measures

Non-structural BMPs are institutional measures which prevent or reduce the use of highway sanding and deicing materials. Effective implementation of non-structural BMPs often will lead to reduced costs of winter road maintenance and lessen the need or dependence on treatment BMPs.

Menu of Non-Structural BMP Control Measures

- Staff Training
- Street Sweeping
- Anti-icing
- Road-Weather Information System (RWIS)
- Improved Sanding Practices
- Advanced Snow Plow Technology

The following pages outline components of each recommended non-structural BMP. More detailed information and discussion of these BMPs can be found in the literature review.

A. Staff Training

The biggest challenge with non-structural BMPs is implementation; training and increased resources are keys to successful implementation. Annual training classes should be held in the fall (before the winter season) and have the following goals:

- Help crews understand and accept new ideas
- Explanation of the impacts of sands and salts
- Training and review of anti-icing, deicing, and improved sanding practices
- Training with new technologies and application rates
- Provide opportunity for feedback from crews and refinement of operation practices
- Testing and successfully implementing future ideas

Several DOTs have successfully incorporated environmental staff into maintenance departments to support and train crews in implementing sediment and erosion control practices. They are also helpful in developing more effective and practical methods.

B. Street Sweeping

A successful sweeping program will significantly reduce sediment loading on downstream BMPs and the receiving streams by removing roadway sediment before it enters the drainage system. A successful sweeping program may include the following:

- Staff properly trained to operate broom sweepers
- Sweep when possible during the winter season and as soon as possible after spring snow melt has finished
- A routine sweeping schedule considers variable annual snow conditions
- Consider purchase of newer, more efficient sweepers
- Sweepers need to be compatible with curb and gutter and paved swale sections
- Some places may have deeper sediment deposits and need to be cleaned with a skid loader before sweeping

C. Anti-icing Practices

Anti-icing is a proactive strategy where liquid deicers are applied just before snowfall and prevents the bond between ice and roadway from forming. This considerably increases the effectiveness of plowing, reduces the need for further deicing, and will reduce the need for traction sanding. The keys to proper anti-icing implementation include:

- Accurate weather forecasting
- Road-weather information systems (RWIS)
- GIS-based decision support systems (DSS)
- Properly trained staff
- Snowplow trucks equiped with calibrated applicators and decing equipment

In addition, automated anti-icing sprayers may be installed at critical locations, such as bridges, and can be operated remotely or with an automated control system.

D. Road-Weather Information System (RWIS)

A road weather information system (RWIS) is a network of weather stations, forecasting services, and roadway data that provides real-time information about road conditions, pavement temperatures and site-specific forecasts. This data may be collected and analyzed in a GIS-based decision support system and is an integral part deciding when to deploy anti-icing operations.

E. Improved Sanding Practices

Improved sanding practices can prevent inadvertent excessive sanding and reduce the amount of sand and salt immediately lost during application. Improved sanding practices include:

- Calibration of spreaders
- Application regulators
- Reverse throw spreaders
- Pre-wetting sand/ salt mixture
- Applying sand and deicer at slower speeds
- Only load the amount of material needed

F. Advanced Snowplow Technology

Advancements in technology have provided many new tools that can be added to snowplows to help drivers match application rates and deicer types with road temperatures. These include:

- Infrared pavement temperature sensor
- Friction sensor
- Freeze point sensor
- Global Positioning System (GPS) and Automated Vehicle Location (AVL) technology provide real-time information on operations and material application rates.
- Onboard computer system with geospatial databases which can give the driver information and warnings on head-up displays.

5.8 BMP Summary and Costs

The field work completed for this study identified opportunities for additional BMPs along the I-70 corridor. These recommended BMPs are shown on the accompanying Mapbook. The intent of this program is to recommend capture opportunities for traction sand and other sources of sediment within the Clear Creek corridor. The number and extent of BMPs are not dependent upon any numeric goal or regulatory criteria. However, the volume capture of all the BMPs identified was compared to the estimated sediment loading rates for various study segments (see Table 5-3) to show that the proposed water quality BMPs could contain on average at least 80% of the sediment load.

The total number and type of BMPs recommended over the 33-mile corridor as shown in the accompanying Mapbook are summarized below in Table 5-9 along with their estimated construction cost. Unit construction costs were estimated for each item based on previous SCAPs, CDOT cost data, engineering judgment, and conversations with CDOT managers. If all of the BMPs are implemented, the total cost of the BMP infrastructure in 2012 dollars is $14 million. Engineering and contingency would add an estimated $7 million for a total of $21 million. At this time, there is no requirement or schedule to implement these recommended BMPs. However, the proposed improvements are shown to assist CDOT for budgeting purposes with a proactive approach to improved waterway stewardship of Clear Creek. The suggested BMPs can be used as a reference and guidance for future planning of the I-70 Clear Creek corridor.

Table 5-9 Construction Cost Estimate

BMP	Quantity	Unit	Unit Construction Cost	Total Item Cost
Sediment Basin (small)	146	ea	$25,000	$3,650,000
Sediment Basin (large)	37	ea	$35,000	$1,295,000
Inlet Trap	191	ea	$20,000	$3,820,000
Bench Trap	14,537	LF	$0	$0
Clean Water Diversion	247	LF	146	$36,062
Inlet	7	ea	$5,000	$35,000
Curb & Gutter	94,433	LF	$40	$3,777,320
Pipe Rundowns	57	ea	$6,400	$364,800
Valley Pan Drain	18,772	LF	$72	$1,351,584
SUBTOTAL CONSTRUCTION COSTS				$14,329,766
Engineering & Contingency				
Traffic Control	5%			$716,488
Contingency	20%			$2,865,953
Prelim Engineering	5%			$716,488
Construction Engineering	17.5%			$2,507,709
	47.5%			
TOTAL				**$21,136,405**

The location and amount of BMPs proposed in the accompanying SCAP Mapbook can capture a total of approximately 84% of the highway sand and road side erosion along this corridor. This is based on the sediment loading rates presented in Section 5.3. Percent capture rates vary by highway segment, which is dependent upon road gradient and elevation. Sediment loading and capture data are displayed by highway segment in Table 5-10. A detailed breakdown of these numbers can be found in Appendix A.

Table 5-10 Percent Capture of Highway Sediment Load – By Segment

Highway Segment	Sediment Capture (CY)				Sediment Loading (CY)	Percent Capture
	Basins & Traps[1]	Shoulder Sweeping[2]	Total Capture	Design Goal[3]		
EJ Tunnel – Herman Gulch *(MM 215.2 – 218.4)*	3780	210	3990	3449	4311	93%
Herman Gulch – Silver Plume *(MM 218.4 – 225.7)*	3394	490	3884	3937	4921	79%
Georgetown Hill *(MM 225.7 – 228.0)*	1720	150	1870	1861	2326	80%
Georgetown – Idaho Spr. *(MM 228.0 – 241.5)*	2650	900	3550	3640	4550	78%
Idaho Spr. - Kermitts Junct. *(MM 241.5 – 244.3)*	690	180	870	755	944	92%
Floyd Hill – Beaver Brook *(MM 244.3 – 247.7)*	1787	220	2007	1834	2292	88%
				Total Percent Capture		**84%**

[1] Basins and Traps include: above ground sediment basins, below ground inlet traps, and bench traps

[2] Shoulder Sweeping is estimated as 20% of base sediment loading (500 tons/mile)

[3] Design Goal is 80% of sediment loading.

6.0 BMP MAINTENANCE PROGRAM

6.1 Materials Management

Management to reduce the amount of sand and salt applied to I-70 is the most cost effective way to reduce water quality impacts from I-70. Materials management techniques that maintenance can implement include many of the non-structural BMPs described in Section 5 as summarized below:

- Maintenance Training and Environmental Support Staff
- Anti-Icing and Deicing
- Road Weather Information Systems (RWIS)
- Automated Anti-Icing Sprayers
- Improved Sanding Practices
- Snowplow Technologies

Implementation of these measures will reduce material usage and ultimate off-site water quality impacts. Although some of these technologies require initial capital expenditure, cost recovery would be realized through reduced long-term material, BMP maintenance, and disposal costs.

6.2 Maintenance Plan

The purpose of a Maintenance Plan is to establish standard maintenance practices for managing snow, sediment, and salt/sand materials along the I-70 mountain corridor to reduce off-site transport of contaminants. The objective is to control highway-induced sedimentation and runoff as near to the highway source as possible while utilizing maintenance practices that achieve this objective. The plan should be a working document to provide flexibility as new maintenance practices and procedures are implemented. As a working document, it is anticipated that revisions will be made as maintenance forces determine the best methods of managing snow and ice with the combined objective of sediment control.

Maintenance BMPs are those practices that must be integrated with the structural controls to achieve successful sediment control. For example, the snow storage areas should be properly utilized to avoid unnecessary off-site deposition of snow/sand. Sediment collection basins must be cleaned regularly to maintain effectiveness. Both winter and summer maintenance activities are necessary to adequately maintain the effectiveness of the drainage, erosion, and sediment control system in an effort to reduce off-site sedimentation. Maintenance BMPs taken from the CDOT's "Berthoud Pass East BMP Maintenance Plan" are provided below as an example:

- Reduction of the plow speed adjacent to the fill slope to 25 mph or less to prevent excessive snow/sand throw distance;
- Avoid plowing snow over the fill slopes;
- Utilize existing snow storage areas to the extent possible;
- Maintain drainage system, including culverts, inlets, and rundowns;
- Avoid broadcasting snow over the top of knee walls (Type 7 barrier);

- When the snow storage zones build up and require removal, notify appropriate personnel and follow the appropriate maintenance procedures;
- Conduct sweeping and removal operations on regular basis (develop schedule);
- Clean out sediment basins on regular basis (develop schedule);
- Remove sand/sediment material to permanent disposal areas;
- Identify and report areas where revegetation is needed;
- Keep track of the volume of sand/salt material applied and collected; and
- Report any difficulties encountered to allow for timely actions to be taken.

A maintenance plan can be developed and effectively implemented with or without structural controls in place. CDOT already implements routine sediment removal operations each year in the Clear Creek I-70 corridor with few structural controls in place. This includes sweeping, culvert cleaning, shouldering, and rock removal. If timed properly, routine maintenance can be very effective in reducing sediment transport.

As more structural BMPs are installed as part of I-70 reconstruction, the maintenance plan can be expanded to include new BMP features and methods as conditions warrant.

6.2.1 Structural BMP Maintenance

The following outlines key components of a BMP maintenance plan that may apply to the I-70 mountain corridor (adapted from *UDFCD vol. 3*):

1. A simple drawing of the BMP site, showing locations of all key components such as forebays, inlets, outlets, low flow channels or other components that require inspection or maintenance. The drawing should be kept in a location that is easy to access by maintenance managers and should be in the possession of inspection or maintenance crews when they inspect or perform maintenance of a BMP. Any changes to the facility over time should be noted on the drawing.
2. A brief description of the <u>inspection</u> procedures and frequencies.
3. A brief description of the <u>maintenance</u> procedures, requirements and expected frequency of actions. Include instruction on how to access each component of the BMP and with what equipment.
4. An inspection form or checklist for each BMP facility. A log of inspection forms should be kept to demonstrate that routine inspections and maintenance are occurring.
5. Other items as appropriate for specific conditions.

<u>Paved Swales, Shoulders, and Curbs</u>

General maintenance of paved swales, paved shoulders, and curbs consists of sediment removal by sweeping or other methods.

- Inspection - Inspect twice annually for sediment accumulation.

- Sediment Removal - Remove sediment twice annually or as needed based on inspections. Sweeping should take place as soon as possible after spring snowmelt has finished (May) and before summer monsoon rain storms begin (July). Inspection and sweeping in fall (October), before snowfall accumulates is also recommended.

Drainage Rundowns, Slope Drains, and Culverts

Drainage rundowns, slope drains, and culverts require inspection and maintenance as-needed, but if installed correctly should not accumulate sediment.

- Inspection - Inspect and clean the drainage systems every one to two years for clogging, sediment and debris accumulation, and structural integrity. Be sure to inspect downstream outlet for erosion and development of head-cuts in the downstream channel. These should be repaired as soon as possible to prevent further erosion and damage to drainage structures.
- Sediment Removal - Remove sediment and debris as necessary to ensure proper functionality of drainage structure. If sediment removal becomes routine at a given structure, upstream sediment capture BMPs may be necessary (such as a loading dock trap or sediment basin).

Filter Strips and Vegetated Swales

General maintenance of filter strips and vegetated swales consists of maintaining the grass cover and repair of rill or gully development.

- Inspection - Inspect vegetation annually for uniform cover and traffic impacts. Check for sediment accumulation and rill and gully development. For filter strips, check for evidence of concentrated flows and repair if necessary.
- Debris and Litter Removal - Remove litter and debris to prevent rill and gully development from preferential flow paths around accumulated debris, enhance aesthetics, and prevent floatables from being washed offsite. This should be done as needed based on inspection, but no less than two times per year.
- Sediment Removal - Remove sediment as needed based on inspection. Frequency depends on site-specific conditions.
    - For Filter Strips: Using a shovel or small loader, remove sediment at the interface between the impervious area and buffer.
    - For Swales: Remove accumulated sediment near culverts and in channels to maintain flow capacity.

  Spot replace grass areas as necessary. Reseed damaged areas to maintain healthy vegetative cover. This should be conducted as needed based on inspection. Over time, a portion of the swale or filter strip may need to be rehabilitated due to sediment deposition. Periodic sediment removal will reduce the frequency of revegetation required.

Bench Traps:

Routine maintenance of bench traps is not necessary, sediment removal activities will be needed every 5 to 10-years.

- Inspection – Inspect once annually for sediment, trash, and debris accumulation. Check for evidence of concentrated flows and repair if necessary.
- Debris and Litter Removal - Remove litter and debris annually.
- Sediment Removal – Sediment removal operations will be needed once bench trap has reached storage capacity. This will consist of excavation, disposal, re-grading, and revegetation of bench trap. These activities are expected once every 5 to 10-years.

Sediment Detention Basins and Loading Dock Traps:

Sediment basin and loading dock sediment traps require routine maintenance on an annual basis to ensure optimal functionality and prevent captured sediments from being re-suspended and transported downstream and into Clear Creek.

- Inspection - Inspect at least twice annually, observing the amount of sediment accumulated and checking for debris and clogging at the outlet structure.
- Debris and Litter Removal - Remove debris and litter from the detention area as required to prevent clogging of the outlet.
- Mosquito Control - Avoidance of standing water conditions should be the primary focus of mosquito control and may be accomplished through proper inspection and timely maintenance. However when treatment is necessary, it should be targeted toward mosquito larvae since mosquitoes are more difficult to control when they are adults. The use of larvicidal briquettes or "dunks" may be appropriate. These are typically effective for about one month. These inspections and treatment can be performed by a mosquito control service.
- Sediment Removal - Sediment basins are designed to require one annual cleaning. However, wet years with high applications of traction sand may increase the frequency of cleaning. Excessive sediment accumulation found by inspections may also warrant more frequent maintenance as well. BMPs should be maintained before accumulated sediment is in danger of being re-suspended with heavy stormwater runoff. Generally this is when accumulated sediment occupies 20-50% of the design volume or when sediment accumulation results in poor drainage or ponded water. Sediment removal from above ground detention ponds and loading docks can usually be accomplished with a loader or excavator. Sediment removal from small concrete structures may require a vacuum truck. Ensure that sediment is disposed of properly and not placed where it can be mobilized into the waterways.
- Erosion and Structural Repairs - Repair inlets, outlets, trickle channels, and all other structural components required for the basin to operate as intended. Repair and vegetate eroded areas as needed following inspection.

Inlet Sediment Traps:

Maintenance of inlet sediment traps requires cleaning of accumulated sediment to keep the inlet functioning. If these are not maintained, the inlets clog and become ineffective.

- Inspection - Inspect and clean the outlet screens, trash racks and orifice plates frequently to remove clogged debris. These tiny openings can clog easily. Inspect the vault structure at least annually. Look for excessive sediment accumulation and upstream debris that could cause bypass of the inlet. Specifically look for standing water in the inlet sediment traps indicating a clogged weep drain, screen, or orifice plate.
- Sediment and Debris Removal - Vacuum traps annually and more frequently as needed, based on inspections.
- Traffic Control – Inspections and sediment removal may require traffic control depending on the location of the BMP.

Underground BMPs:

Maintenance requirements of below-grade BMPs can vary greatly depending on the type of BMP. Frequent inspections (approximately every three months) are recommended during the first two years in order to determine the appropriate interval of maintenance for a given BMP. Traffic control may be necessary to inspect and clean underground BMPs adjacent to the highway.

- Inspection - Inspect and clean the outlet screens, trash racks and orifice plates frequently to remove clogged debris. These tiny openings can clog easily. Inspect underground BMPs at least quarterly for the first two years of operation and then twice a year for the life of the BMP, if a reduced inspection schedule is warranted based on the initial two years. Specifically look for debris that could cause bypass of the BMP. Strong odors may indicate that the facility is not draining properly. Inspection should be performed by a person who is familiar with the operation and configuration of the BMP.
- Sediment and Debris Removal - Vacuum units annually and more frequently as warranted based on inspections.
- Traffic Control – Inspections and sediment removal may require traffic control depending on the location of the BMP.

6.3 Operations and Maintenance Cost

Operations and maintenance costs are a large portion of the life cycle cost for any structural BMP. These costs will be especially significant for BMPs which receive high sediment loads, such as those in the I-70 mountain corridor. These BMPs will require frequent and thorough maintenance to maintain proper functionality.

Maintenance costs were estimated for the BMP specified in the SCAP Map Book. These include sediment basins, inlet sediment traps, and bench traps. The following data and figures present these estimates.

6.3.1 Operations and Maintenance Assumptions

The following assumptions were made to establish an annual cost for the BMP Maintenance Program.

- Sediment removal costs will be based on **80% of maximum traction sanding rates** and are presented below in Table 6-1. See Table 4-1 for yearly traction sanding data.

Table 6-1 O&M Traction Sanding Rates

Patrol	Maximum Traction Sanding Rate[1] *(Tons/mile-year)*	O&M Traction Sand Rate (80%) *(Tons/mile-year)*
Patrol 41 (EJMT to Idaho SP. - 26 miles)	270	216
Patrol 45 (Idaho Sp. to Beaver Brook - 7 mi.)	362	290

[1]Based on 2001-2012 CDOT data.

- Sediment removal unit cost is estimated as $95 per cubic yard (CY) as reported by CDOT Maintenance and Environmental personnel (Delong 2012, Huyck 2012). This includes traffic control, stormwater management plan (**SWMP**), sediment removal, equipment usage, and hauling.
    - o This is an average cost for the I-70 corridor assuming the material can be disposed at a CDOT site within 10-miles. Hauling to an off-site disposal facility will add additional transportation costs and dump fees.
    - o This average cost also includes sweeping and vacuuming costs which are generally higher than the average, but these costs are offset by sediment basin excavation which can be completed at a lower cost.
- An annual BMP maintenance training program can be provided for maintenance crews.
- The sediment disposal program identifies, permits, and maintains disposal sites for the recovered sediment.
- Specialized maintenance is required for the vacuum truck and sweeper equipment. The vacuum truck maintenance and repairs are estimated as $75,000/year and the sweepers as $38,000/year each. This results in $150,000/year to maintain 1 vacuum truck and 2 sweepers (Martinez, 2012). However it is assumed that these pieces of equipment will be used one-third of the time in the Clear Creek/ I-70 corridor, and the equipment maintenance costs related to this SCAP are estimated as $50,000/year.
- Additional traffic control needs are anticipated and estimated as 200-hours at $108/ hour (UDFCD 2010b).
- The current CDOT Clear Creek stream monitoring program should be continued in order to assess the effectiveness of implemented structural controls and the materials management program. The monitoring program is not a maintenance activity, but is an annual cost.

6.3.2 Annual Operations and Maintenance Cost

Based on the above assumptions, Table 6-2 presents the estimated annual operations and maintenance costs for the BMP Maintenance Program. When all of the BMPs have been constructed along the I-70 Clear Creek corridor, the annual cost to maintain these BMPs is estimated to be $607,000 using 2012 dollar costs. For partial implementation of the recommended BMPs, the annual maintenance budget should be prorated accordingly.

Table 6-2 Annual BMP Maintenance Program Costs

Annual Costs	Total Item Cost
Sediment Removal Program[1]	
Patrol 41 (EJMT to Idaho SP. - 26 miles)	$356,000
Patrol 45 (Idaho Sp. to Beaver Brook - 7 mi.)	$129,000
Sediment Removal Subtotal =	***$485,000***
BMP Maintenance Program	
Training Program	$10,000
Sediment Disposal Program	$25,000
Equipment Maintenance[2]	$50,000
Traffic Control (Additional)	$22,000
Maintenance Program Subtotal =	***$107,000***
Stream Monitoring Program	$15,000
Annual Cost TOTAL =	**$607,000**

[1]Based on current costs with 10-mile haul; longer hauls in the future will increase costs. These costs are based on full build-out of BMPs including: 191 Inlet Traps, 183 Sediment Basins, and 2.8 miles of Bench Traps. These costs assume 1.5 tons/ CY sediment density.

[2]This cost is estimated for maintaining 1 vacuum truck and 2 sweepers. Total estimated maintenance cost for these equipment is $150,000/year, they are assumed to be used roughly 1/3 of the time in the SCAP area. Standard equipment, such as loaders and backhoes are maintained separately.

6.4 Equipment

Meetings were held with CDOT maintenance personnel for this SCAP to gain an understanding of their issues and needs for sediment control. A recurring issue was the need for more equipment to clean up sand and sediment from the roadway. CDOT typically uses a multitude of equipment including excavators, front loaders, graders, and sweepers (brooms) to pick up sediment. This equipment fleet is shared among patrols and is used for other purposes in addition to sediment cleanup.

A high performance vacuum truck, designed to be effective at high elevations, was purchased by CDOT Region 1 in 2004. There has been very high demand for use of the vacuum truck throughout the region to clean culverts and sediment basins. A second vacuum truck is recommended for cleaning additional sediment basins and traps as they are constructed along I-70.

The sweepers typically in use by CDOT are not efficient at picking up sand and sediment; a better sweeper which is designed to collect sand is needed. In view of the high demand for suitable sand and sediment cleanup equipment, it is recommended that each patrol maintain a fleet of essential equipment. This is particularly important when considering the need to have equipment available for sand cleanup at specific times of the year for effective sediment control.

One high performance vacuum-truck and two high performance sweepers are recommended to be purchased to improve sediment collection within the I-70 Clear Creek corridor. The estimated costs of this addition equipment are shown as a one-time equipment purchase for the life of the equipment. This equipment can be shared throughout CDOT Region 1 and is not a sole cost for this 33-mile reach of I-70.

Table 6-3 Capital Equipment Costs for O&M

Item	Total Cost
Vacuum Truck Purchase (1 qty)	$450,000
Sweeper Purchases (2 qty)	$200,000
Capital Cost TOTAL =	**$650,000.00**

6.5 Disposal of Materials

Properly functioning treatment BMPs and a comprehensive maintenance program, create a new issue, such as how to dispose of recovered tractions sands. The disposal of these recovered traction sands is a major problem for CDOT. Over this study length of highway alone, an average of over 6,800 tons of sand is applied annually. In addition, highway shoulder and embankment erosion contribute significantly to the annual sediment load. The potential exists for these sands to be contaminated with hydrocarbons, oil and grease, trace metals, and deicing salts. The cost of disposing these recovered sands is high and likely to increase as space becomes more limited (CDOT2010). It is currently classified as a solid waste (CCC, 2008).

In 2008 and 2010, CDOT conducted studies for the reuse options of recovered traction sands (CCC 2008, CDOT2010) and have the following findings:

- Approximately 50-percent of recovered sands could be re-used as traction sands based on grain size. The minimum acceptable grain size is 0.85 mm;
- Metal concentrations in sediment samples are low and fall well below regulatory limits. The majority of metal found in used traction sands is likely from the source sand material rather than from highway sources;
- Phosphorus and nitrogen concentrations were low;
- Salinity in recovered sands was low. These sands are suitable to be used as a growing medium;
- Oil and grease was found in large enough quantities to merit a “solid-waste” classification for recovered traction sands, but not enough for “hazardous-waste” classification. These sands cannot be considered “clean fill.”

- Used traction sands meet the RCRA requirements for land disposal, but also may be reused in a controlled and CDPHE-approved manner.
- Re-use options include:
    - Traction sand,
    - Class 7 aggregate base course,
    - Pipe bedding,
    - Addition to asphalt mix,
    - Addition to concrete used in islands and medians,
    - Sound berms or barriers in approved areas
    - Structural backfill, and
    - Alternative cap material in a landfill.

Reuse options will require sieving to remove fines and trash. CDPHE stated in a phone conversation that non-landfill options for disposal are also possible:

> "*As long as CDOT is moving the sand to a controlled site (e.g. not to be gardened or dug for utilities), piles the material, and plants native species on it, the sand generally can be handled in this fashion. (Plants may actually use the hydrocarbons for nutrients.)*" (CCC 2008).

Non-landfill disposal in such a manner will need to be done under CDPHE guidance and there are additional testing and requirements not listed here. Traction sand reuse pilot projects should be considered to determine the feasibility, practicality, and other potential issues.

7.0 BMP SUMMARY RECOMMENDATIONS

The amount of roadway traction sand applied each year is weather dependent, but is generally greatest at higher elevations associated with higher snowpack and colder temperatures, and on steep gradient reaches of I-70 where vehicle traction is most critical. The following criteria were used to establish priority areas for sediment control along the Clear Creek I-70 corridor:

- Areas with no structural BMPs currently in place
- Areas in close proximity to I-70, providing good access for installation and maintenance of structural BMPs with minimal disturbance to adjacent lands
- Elevation zone and high traction sand usage areas
- Areas with direct sediment transport to streams with little or no storage (tributaries)
- Drainage problem areas including cut slope and fill slope erosion

The three reaches within the 33-mile study area of I-70 that received the most traction sand annually are listed below and noted with the associated mileposts (MP):

- East of Eisenhower–Johnson Memorial Tunnel (EJMT) (MP 215 – MP 218)
- Georgetown Hill (MP 225 – MP 228)
- Floyd Hill (MP 244 – MP 248)

The recommended BMPs for the entire corridor are shown in the accompanying Mapbook. The following tabulation describes the number of nine different types of BMPs recommended along the corridor.

Table 7-1 Summary of Recommended BMPs in Mapbook

BMP	Quantity	Unit
Sediment Basin (small)	146	EA
Sediment Basin (large)	37	EA
Inlet Trap	191	EA
Bench Trap	14,537	LF
Clean Water Diversion	247	LF
Inlet	7	EA
Curb & Gutter	94,433	LF
Pipe Rundowns	57	EA
Valley Pan Drain	18,772	LF

The total cost to design and construct the recommended BMP infrastructure tabulated above is $21 million in 2012 dollars. The annual cost to maintain all of these BMPs once fully constructed is estimated to be $607,000 in 2012 dollars. In addition, $650,000 in new equipment will be needed to adequately maintain these recommended BMPs. This new equipment can be shared throughout CDOT Region 1 and is not necessarily associated solely with the 33-mile reach of this SCAP.

8.0 CLEAR CREEK SCAP IMPLEMENTATION PLAN

8.1 Introduction and Purpose

8.1.1 SCAP Summary

The previous chapters of this SCAP document provide the justification, technical basis and approach for controlling sedimentation along I-70 within the Clear Creek corridor. This report describes existing conditions, environmental considerations and requirements, BMP design tools, and CDOT's maintenance program. This SCAP developed a menu of applicable BMPs and suggests how these may be implemented throughout the corridor.

The SCAP is based on existing conditions of the I-70 drainage infrastructure. I-70 is now more than 40 years old in the Clear Creek corridor and was not constructed to current drainage and erosion control standards. As the interstate is reconstructed, the drainage infrastructure will be replaced and upgraded to reduce or eliminate erosion and to provide for capture of sediment. The associated SCAP Mapbook provides recommendations for BMPs primarily within the interstate right-of-way for capital improvement projects to control sediment. The basis for this SCAP is control of highway traction sand and slope erosion, and therefore, the capital improvements are focused on highway-related sediment control. Erosion control of mine tailings, stream bank stability and general hillside erosion have been noted as sediment sources, but are not the focus of the SCAP document recommendations.

The corridor can be conveniently separated into upper and lower Clear Creek with Georgetown Lake as the dividing line. The primary source of sediment in upper Clear Creek is I-70 traction sand and slope erosion. The primary source of sediment in lower Clear Creek is I-70 slope erosion, stream bank erosion, and offsite erosion of tributary drainages impacted by historic mining and local access roads. These source loading areas are illustrated in Figure 2-7, page 34. Traction sand, slope erosion, and stream bank erosion are sources of sediment directly related to the operation and maintenance of I-70.

8.1.2 Relationship between Sediment, Nutrients and Metals

Sediment is described, for purposes of this SCAP, as inorganic mineral-derived geologic material generated from human induced erosion. The CDPHE Water Quality Control Commission has adopted "narrative standards" which apply to sediments that may form deposits detrimental to the attainment of aquatic life uses (CDPHE, 2005). CDPHE guidance is intended to apply only to the assessment of impacts to aquatic life uses in stream and river environments. These include higher gradient, cobble bed, coarse-grained, mountainous stream and wadeable river environments such as Clear Creek.

Excessive deposition of fine sediment on the bottom substrate of streams and rivers is an important cause of impacts to aquatic life (CDPHE, 2005). These impacts result from the loss of critical habitat for fish, aquatic invertebrates, and algae. For streams with aquatic life of fish concerns, measurement of particles between 0.25-inch (6.35-mm) and 3-inch (78-mm) are commonly used to describe spawning gravel quality and the emergence success of trout species. Clear Creek is a cold-water fishery supporting several species of trout. Various State and Federal agencies in Colorado have conducted studies that indicate fine sediment (less than 0.25-inch) are the particle size threshold considered detrimental to cold water fish species.

Studies conducted by CDOT and others indicate that sediment particle sizes less than 0.25-inch are readily transported by the high flow velocities commonly found in I-70 mountain corridor streams like Clear Creek (CDOT, 2009). Sediment is suspended in the water column and transported downstream potentially causing problems with trout spawning, water treatment, clogging intake structures, and reducing reservoir storage capacity.

Water quality sample analysis results from CDOT, UCCWA, and others indicate nutrient and trace metal concentrations are greater in high sediment waters. Constituent concentrations are also inversely proportional to particle size, with finer material showing higher metal concentrations.

There are metal standards in place and nutrient standards proposed for Clear Creek. Reductions in sediment loading afforded by implementation of this SCAP will result in a reduction in trace metal and nutrient loading in Clear Creek. These load reductions can be measured through monitoring of water quality conditions as described in Section 8.6.

8.1.3 Existing BMP Facilities

Georgetown Lake is acting as the most significant existing BMP in the Upper Clear Creek watershed. Clear Creek downstream from Georgetown Lake has better water quality and trout fishery than reaches upstream or further downstream. The on-line facility is trapping sediment that is mobilized in the headwaters of Clear Creek. However, the goal is to keep sediment from reaching *Waters of the U.S.* and therefore, the Lake should not be relied upon as a long-term water quality BMP. Sediment should be captured before entering Clear Creek.

Thirteen highway-related sediment control BMPs currently exist within the I-70 roadway corridor, however, only a few are constructed for the purpose of intercepting traction sand. Most of these existing BMPs are dedicated to managing sediment and debris from the hillside above flowing onto the interstate. There are a few informal sedimentation basins along I-70 near the Eisenhower Johnson Memorial Tunnel (EJMT) to capture roadway traction sand. These basins are small, have no formal access, and have simple perforated pipe outlet structures. The following **Table 8-1** lists the existing BMP facilities progressing from the EJMT to Floyd Hill:

Table 8-1: Existing BMPs

Mile Marker	Sediment Pond Type	Location	Comment
215.5	Snowmaking Pond	South of I-70 at the toe of the slope	Existing pond intercepts traction sand
216.0	Earthen pond	North of I-70	Perforated standpipe outlet. Captures large volumes of traction sand
216.1	Earthen pond	North of I-70	Perforated standpipe outlet. Captures large volumes of traction sand
216.1	Rock check dams	South of I-70 at the toe of the slope along Loveland Pass	Informal rock check structures to trap sand
216.3	Earthen pond	North of I-70 at the WB on ramp from Loveland Pass	Short perforated standpipe outlet.
218.9	Earthen pond	South of I-70 at the toe of the slope	Informal sump. Poor access. Improvement needed
219.0	Earthen pond	South of I-70 at the toe of the slope	Informal sump. Poor access. Improvement needed
219.3	Earthen pond, concrete outlet	North of I-70 at Watrous Gulch	New facilities primarily to capture sediment load from hillside above
219.5	Earthen pond, concrete outlet	North of I-70 on small tributary	New facilities primarily to capture sediment load from hillside above
228.4	Concrete basin 20x20	South of I-70 at Georgetown Lake	Minor use for traction sand
229.5	Concrete ramp basin	North of I-70 east of Georgetown Lake	Captures sediment load from hillside above
235.5	Earthen pond, concrete box outlet	North of I-70 on small tributary	Captures sediment load from hillside above and mine tailings
238.6	Earthen pond, concrete box outlet	North of I-70 on Hukill Gulch	Captures sediment load from hillside above and mine tailings

The eastbound Twin Tunnels widening project from Idaho Springs to Floyd Hill is the first CDOT project to implement BMPs recommended by the SCAP. This project, when complete, will add permanent BMPs to the existing facilities list.

Current efforts to reduce or capture traction sand are mostly non-structural and include the following:

- Increased use of deicing salt agents rather than sand
- Better equipment and training to improve application to reduce over-sanding
- Roadway sweeping after snow events
- Shoulder cleaning to remove accumulated sand and sediment
- Cleaning of culverts and inlets

CDOT has been active in the Clear Creek watershed in the past with monitoring programs to characterize water quality in Clear Creek. In an effort to improve water quality, CDOT is actively working to reduce traction sand, erosion and sediment loading to Clear Creek.

Other contributors to improved water quality (by reducing mobilization of mine-related sediment) are the Clear Creek Watershed Foundation (CCWF), Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE).

Local rafting companies, Trout Unlimited and Clear Creek County have installed channel stabilization and habitat improvement measures. These measures can reduce stream velocities and associated erosion which can contribute a significant amount of sediment material being mobilized in the waterway.

8.2 High Priority Areas

8.2.1 Highway Sediment and Nutrient Loading Areas

BMPs are needed throughout the Clear Creek corridor to reduce sediment loading; however, some reaches are higher priority. The highest I-70 highway-related sediment and nutrient loading areas along Clear Creek are shown in Figure 2-7, page 34. These include:

1) High traction sand use/slope erosion areas from EJMT to Herman Gulch (MP 215-219),
2) Georgetown Hill (MP 225-228), and
3) Floyd Hill (MP 244-248).

These three areas represent 11 miles or 33% of the entire 33 mile study corridor, yet are estimated to produce over 50% of the highway-derived sedimentation in the I-70 Clear Creek corridor. This is primarily due to a combination of high gradients and more unconsolidated material (traction sand) resulting in high sediment transport rates. Uncontrolled highway runoff also causes high slope erosion rates and sedimentation in these areas.

Implementation of BMPs in high priority areas is recommended, and the number and location of BMPs will depend upon balancing other needs (such as wildlife concerns) and funding. Clear Creek water quality and downstream water users will benefit the most from this approach.

These areas are described below and also in the context of the PEIS preferred alternative and currently identified CDOT capital improvement projects.

EJMT to Herman Gulch (MP 215-219)

This highway segment has the highest elevation and precipitation (snowfall) in the corridor, and subsequently has the highest traction sand usage and deposition. It is also represents the headwaters of Clear Creek and a viable cutthroat trout fishery. Boreal toad habitat is known to exist in wetland drainage features along I-70 in this area. The highway is in close proximity to Clear Creek in several areas, while in others wetlands exist in close proximity to I-70 that can be inadvertently buried by traction sand.

The first two miles (215-217) have very heavy traction sand use with deep deposits along the fill slopes and ditch lines. This includes the EJMT and Loveland interchange areas. The PEIS preferred alternative includes six lanes and the Advanced Guideway System (**AGS**) in this area to improve the existing four lanes. A CDOT capital improvement project in this area involves a new semi tractor-trailer chain station constructed on the eastbound shoulder near MP 217.

Full implementation of the SCAP on I-70 from EJMT to Herman Gulch would provide significant water quality improvements to Clear Creek, and therefore is recommended to be a priority. Nearly all of the BMPs proposed in the SCAP for this area are sediment basins at the toe of the fill slopes and in the ditch lines. The basins are accessible for construction and maintenance from the Loveland Ski Area or from U.S. Highway 6 below the fill slope. Most of these BMP locations will not be disturbed during reconstruction of I-70, and therefore, warrant installation when funding can be made available.

Georgetown Hill MP 225-228

I-70 at Georgetown Hill has a steep gradient of greater than 6 percent consisting of a massive cut and fill slope. Rockfall mitigation is a major ongoing activity conducted by CDOT on Georgetown Hill. Mass wasting and erosion of the cut slope, as well as gully erosion on the fill slope caused by inadequate drainage control outfalls, are common features. Sediment is deposited on the bike path and in areas at the toe of the fill slope, and is transported to Clear Creek in large quantities.

The PEIS preferred alternative includes six lanes and AGS in this area to improve capacity of the existing four lanes. No capital improvement projects have been identified by CDOT in the Georgetown Hill area. Full implementation of the SCAP is recommended in this high priority area.

A majority of the BMPs proposed in the SCAP for this area are sediment basins at the toe of the fill slope, or along the pavement of the cut slope ditch line. The basins are accessible for construction and maintenance from existing access roads for the Georgetown Loop railroad below the fill slope. These BMP areas will not be disturbed during reconstruction of I-70 and therefore warrant installation when funding can be made available.

Floyd Hill MP 244-288

I-70 at Floyd Hill has steep gradients of greater than 5 percent on both west and east sides of the hill. The west side consists of massive fill slopes. Erosion of cut slope areas and ditch lines, as well as gully erosion on the fill slope from inadequate drainage outfalls that discharge to erodible slopes are common features. Erosion repair and slope stabilization are ongoing activities conducted by CDOT on Floyd Hill. Sediment is deposited on the frontage road and at the toe of the fill slope, and is transported to Johnson Gulch and Clear Creek in large quantities.

The highway is already three lanes in the eastbound direction. The westbound direction is only two lanes, except for the east side of Floyd Hill where it is three lanes. The PEIS preferred alternative includes the addition of a third westbound lane west of the summit for a total of six lanes and AGS. However, no CDOT capital improvement projects have been identified in this area at this time.

Full implementation of the SCAP is recommended for this high priority area of Floyd Hill. Nearly all of the BMPs proposed in the SCAP for this area are sediment basins near the toe of the fill slope and in ditch lines. The basins are accessible for construction and maintenance from the existing frontage road and I-70.

8.2.2 Non-highway Nutrient and Metals Loading Areas

Several ares along I-70 receive heavy sediment loading unrelated to the operation and maintenance of I-70, as depicted in Figure 2-7, page 34. This sedimentation is generated from surface water runoff in tributary streams disturbed by historic mining activity and associated access roads. As such, this sediment generally has high metal concentrations. These tributaries cross I-70 before entering Clear Creek, and are common throughout the mining district from Silver Plume to Idaho Springs.

Although sedimentation from these areas is not caused by the operation and maintenance of I-70, material is deposited on CDOT ROW and in cross drain culverts beneath I-70. During storm events, runoff and debris from tributary runoff has covered I-70, causing closure of the roadway. Hence, CDOT operations are impacted by this sedimentation, and ongoing maintenance and mitigation is required by CDOT in these areas.

Table 5-2 in the SCAP lists mine waste piles that are within approximately 500 feet of I-70. This is mine waste residual or mill tailings that is either on CDOT ROW or can be deposited onto ROW and through I-70 drainage culverts during runoff events. This mine waste is considered high priority material to collect and remove from CDOT ROW before entering receiving streams.

The SCAP recommends sediment control BMPs in mine waste and tributary areas to protect CDOT infrastructure and operations, while improving Clear Creek water quality. The areas considered to be highest priority are listed in the following **Table 8-2** and shown in the SCAP Mapbook.

Table 8-2: Mine Waste Piles

High Priority Mine Waste Piles and Tributary Runoff BMPs Adjacent to I-70		
Mapbook Sheet	**MM**	**Comments**
22	224.7 - 224.9	Brown Gulch area large mine dump
41	233.20	Mine talings north side
46	235.54	Mine tributary drainage
47	236.20	Spring Gulch tributary mine drainage
48	236.63	Mine dump north side CDOT-ROW
50	237.70	Mill tailings Hoosao Gulch CDOT-ROW
51	237.95	Oro Gulch tributary mine drainage
51	238.05	Georgia Gulch tributary mine drainage
52	238.45	Mine dump north side CDOT-ROW
52	238.55	Hukill Gulch tributary mine drainage
53	238.95	Big 5 mine drainage CDOT ROW
53	239.00	Mine tailings north side CDOT ROW
55	239.55	Mine tailings south side CDOT ROW
58	241.00	Idaho Spgs mill tailings CDOT-ROW
58	241.25	Idaho Spgs mill tailings CDOT-ROW
59	241.65	Mine tailings south side CDOT ROW

The BMPs proposed in the SCAP for these mine waste areas and tributaries are sediment basins in the channel or in ditch lines. The basins are accessible for construction and maintenance from existing frontage roads or I-70. These BMPs will not be disturbed during reconstruction of I-70 and therefore warrant installation as funding is made available.

8.2.3 Other Areas

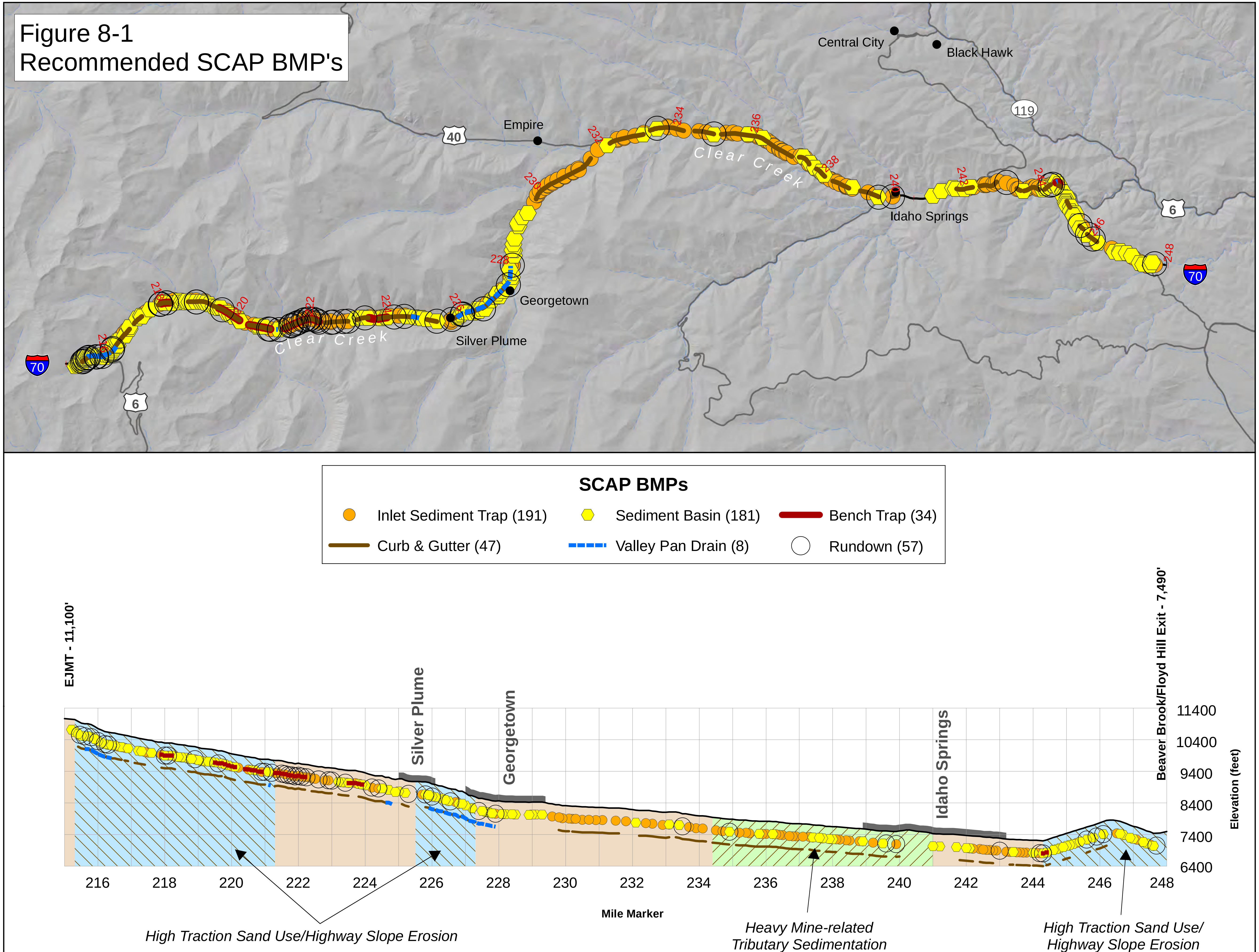
Sediment loading to Clear Creek in other areas of the corridor is lower for reasons previously discussed. Recommended sediment control BMPs in these areas typically consist of drainage inlet sediment traps. These structures will be installed as part of the necessary reconstruction of the I-70 drainage system.

Capital improvement projects currently identified by CDOT that fall within these areas include the eastbound shoulder lane widening between Empire Junction and Idaho Springs and the eastbound Twin Tunnels widening. These two specific project areas are not within any high-priority SCAP areas. However, any construction of the recommended SCAP BMPs will improve water quality.

8.3 Gap Analysis

The following **Figure 8-1**: Recommended BMP graphic depicts in plan view and also in profile view the SCAP recommended BMPs along the 33-mile corridor. The legend describes the number of each type of BMP proposed. The purpose of this graphic is to illustrate how the BMPs are scattered along the entire corridor.

Figure 8-1
Recommended SCAP BMP's



Recommended BMPs will begin to be implemented within the reach of CDOT roadway projects. However, CDOT has not identified projects covering the entire corridor. There are ***gaps*** between what is recommended and what can be constructed by CDOT in their currently identified projects. This SCAP cannot be fully implemented within a reasonable time period without additional support from other stakeholders. Sedimentation is not purely a CDOT problem to fix, but rather a watershed issue that will require support from many stakeholders.

The recommended BMPs are anticipated to cost over $21 million in 2012 dollars. CDOT has identified five current and upcoming projects which can be used as the contracting mechanism to build some or all of the recommended BMPs within the construction reach. These CDOT projects are known by the following names:

- Twin Tunnels eastbound widening Idaho Springs to Floyd Hill
- Peak Period Shoulder Lane eastbound Empire Junction to Idaho Springs
- Twin Tunnels westbound Floyd Hill to Idaho Springs
- Auxiliary Lane eastbound at Loveland Pass
- Auxiliary Lane westbound at Loveland Pass

The Peak Period Shoulder Lane is considered a "temporary" stop-gap measure, so that project will not include as many BMPs as a permanent lane addition would entail. The Auxiliary Lane is also temporary and being designed by CDOT Traffic Operations, which has only enough funding for the lane itself and will not be able to include any additional features such as water quality.

The recommended BMPs within each project reach is identified in Table 8-3 below. As noted above, it is unlikely that these projects will be able to construct all of the BMPs identified for various reasons. Even if the five projects were to construct all of the recommended BMPs, there would still be a gap of over half of the total SCAP recommended BMPs that does not currently have a project identified with which to build them.

Table 8-3: Gap Analysis

BMP Type	Total Number of Units	Units	Upcoming CDOT Project					No Project Identified
			Eastbound Auxiliary Lane	Westbound Auxiliary Lane	Peak Period Shoulder Lane Widening	Twin Tunnels Widening - Eastbound	Twin Tunnels Widening - Westbound	
Sediment Basin (small)	146	ea.	24	24	5	20	11	**62**
Sediment Basin (large)	37	ea.	5	9	0	0	0	**23**
Inlet Sediment Trap	191	ea.	4	20	32	13	16	**106**
Bench Trap	14,537	lf.	1,076	0	0	0	630	**12,831**
Clean Water Diversion	247	lf.	0	247	0	0	0	**0**
Inlet	7	ea.	4	0	0	0	3	**0**
Curb & Gutter	94,433	lf.	10,376	0	30,747	8,342	3,637	**41,331**
Pipe Rundown	57	ea.	11	2	4	3	3	**34**
Valley Pan Drain	18,772	lf.	2,603	3,190	0	0	341	**12,638**

The gap in BMP facilities, after CDOT's five projects are complete, is illustrated graphically in the following **Figure 8-2** to show the recommended BMPs remaining to be constructed, even if the projects constructed all of the recommended BMPs.

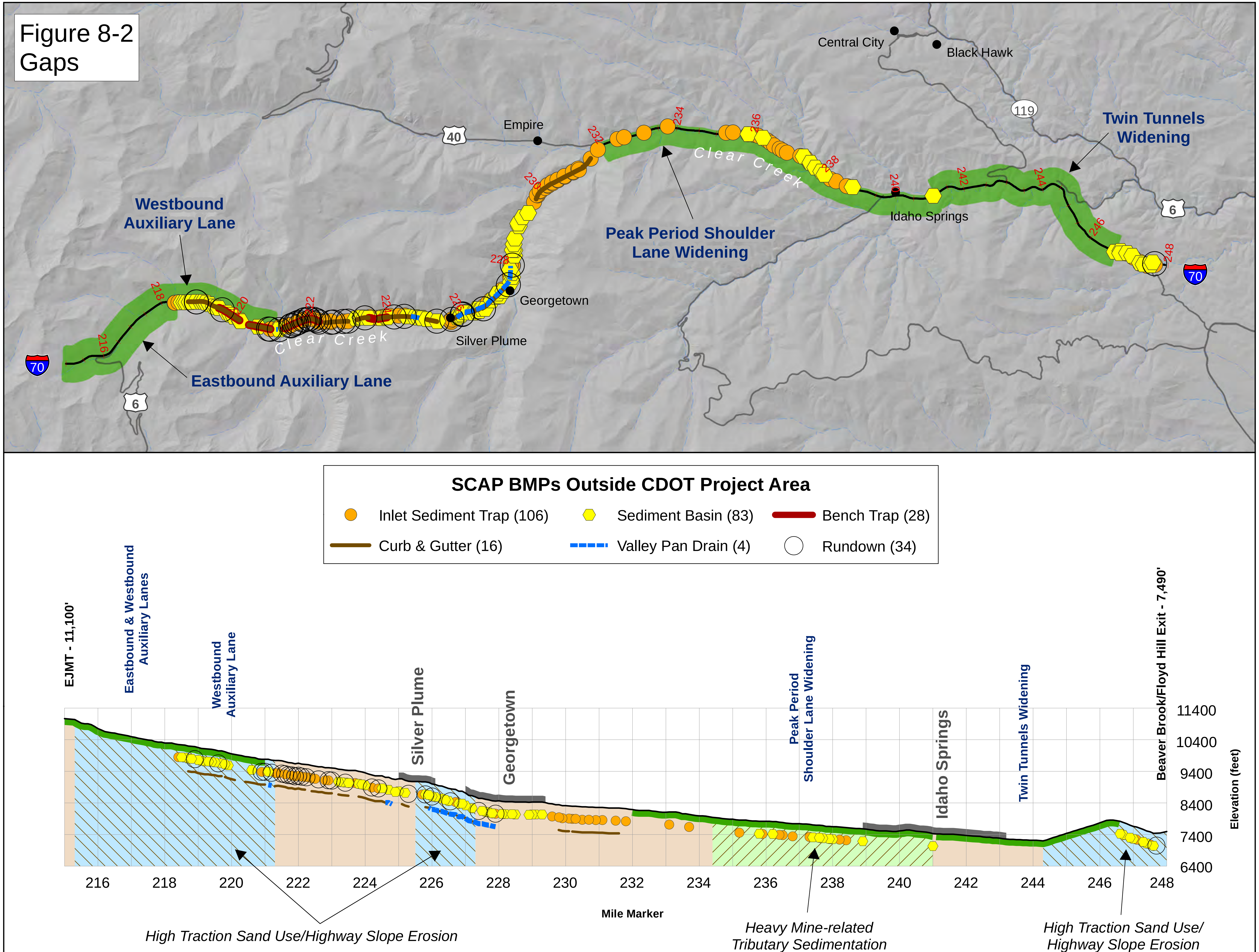


Figure 8-2
Gaps
Central City
Black Hawk
Empire
40
119
Twin Tunnels Widening
Westbound Auxiliary Lane
Peak Period Shoulder Lane Widening
Idaho Springs
Georgetown
Silver Plume
Clear Creek
Eastbound Auxiliary Lane
6
70
SCAP BMPs Outside CDOT Project Area
Inlet Sediment Trap (106)
Sediment Basin (83)
Bench Trap (28)
Curb & Gutter (16)
Valley Pan Drain (4)
Rundown (34)
EJMT - 11,100'
Eastbound & Westbound Auxiliary Lanes
Westbound Auxiliary Lane
Silver Plume
Georgetown
Peak Period Shoulder Lane Widening
Idaho Springs
Twin Tunnels Widening
Beaver Brook/Floyd Hill Exit - 7,490'
11400
10400
9400
8400
7400
6400
Elevation (feet)
216
218
220
222
224
226
228
230
232
234
236
238
240
242
244
246
248
Mile Marker
High Traction Sand Use/Highway Slope Erosion
Heavy Mine-related Tributary Sedimentation
High Traction Sand Use/ Highway Slope Erosion

8.3.1 Currently Identified CDOT Capital Improvement Projects

Of the five CDOT projects discussed above, there are only two that have funds currently identified by CDOT, which include:

- Eastbound-only Twin Tunnels widening MP 241.5 to 244.5
- Eastbound-only peak period shoulder lane widening MP 232.5 to 241.5

Water quality BMPs identified in the SCAP are recommended to be implemented for the eastbound lanes as part of these two projects. The Peak Period Shoulder Lane is considered "temporary," so it will not include as many BMPs as a permanent lane addition would entail. The Twin Tunnels project built most, but not all, of the BMPs that were recommended in the SCAP. Westbound lanes will not be changed and no SCAP BMPs will be implemented at this time for these projects. Hence, only a portion of the SCAP will be implemented in these project areas leaving a gap for future implementation.

8.3.2 PEIS Preferred Alternative

The maximum program of the preferred alternative for I-70 identified in the PEIS includes 6 lanes and an Advanced Guideway System throughout the Clear Creek corridor. The SCAP has been designed to accommodate full build-out of the preferred alternative. Therefore, no SCAP implementation gaps will exist upon full implementation of the PEIS preferred alternative.

While the currently identified two roadway capital improvement projects will be constructed within the next five years, completion of the preferred alternative and full implementation of the SCAP may take 20 years or longer. Therefore, a significant timing gap may exist for implementation of the SCAP recommended BMPs within the corridor. CDOT will need to consider interim measures such as a robust maintenance program to begin mitigation of water quality impacts in the near term.

8.3.3 Indirect Water Quality Impacts beyond CDOT ROW

Clear Creek faces serious challenges for future water quality improvement. As development in the corridor continues to progress, water quality will be further degraded unless permanent mitigation measures are put into place. Existing mine-disturbed areas and access roads outside of the CDOT ROW continue to impact water quality. In some areas these impacts are greater than highway impacts. CDOT may consider opportunities to trade BMPs in low highway impact areas with more effective BMPs outside the ROW. Difficulties of this option for CDOT include less control of maintenance outside of the ROW. However, other stakeholders could take the lead on these type of projects.

8.3.4 Trading Opportunities

There is need to pursue the *low hanging fruit* – sediment control projects that will have the greatest immediate benefits. Given the limited resources and available funding, preference should be given to priority projects. As noted, the high priority BMP areas are not within the currently funded CDOT project areas. CDOT should seek to build BMP projects where they will capture the most sediment and are most effective. CDOT is exploring options to construct BMPs outside of CDOT project areas. These pursuits may require partnerships with other entities.

Implementing water quality BMPs for linear corridors (i.e., roadway and rail) are particularly challenging. CDPHE and EPA are aware of this for compliance within MS4 communities such as Denver (the I-70 mountain corridor in Clear Creek County is outside of the MS4 boundary). BMPs are much easier to implement for site development projects where stormwater runoff from the entire project can be captured by one or more facilities. A linear corridor requires many BMPs along the route.

The challenge of BMP implementation for linear corridors has led to negotiations with regulatory agencies to trade water quality credits within a watershed. For example, due to constraints such as land ownership and lack of space, BMP facilities are constructed where they treat water quality regionally so that the overall benefit to the stream system is equal to or greater than treating only the development project area. Pioneering water quality trading opportunities would allow CDOT to focus BMP construction in areas where they would be most effective at controlling sediment, rather than trying to treat 100% of the corridor area.

8.4 Partnerships

8.4.1 The Need for Partnerships

Clear Creek water quality is a concern for many stakeholders. This is not just a CDOT-only problem to fix. CDOT is working to implement BMPs with their roadway projects, but as discussed, these projects do not cover the entire corridor. Additional work is needed in the watershed to improve water quality.

Implementation of water quality BMPs is hampered by:

- Lack of funding
- Lack of highway re-construction projects that could implement BMPs
- Lack of space and safe access
- Limited land area within the CDOT Right-of-Way
- The fact that this is a voluntary program – there are no current regulatory requirements for permanent sediment control and maintenance

The SWEEP Memorandum of Understanding and this SCAP have set the foundation for sediment control in the Clear Creek I-70 corridor. There is a movement with stakeholders toward solutions to improve the water quality in Clear Creek. BMPs have been identified which will help reduce sediment loading. However, full implementation will require partnerships. CDOT alone cannot tackle the sediment issue in Clear Creek. It will require contribution from all stakeholders to implement BMPs.

One solution for CDOT to reduce the amount of traction sand and salt applied to the interstate each year is simply closing the roadway during snow storms. However, this is certainly not acceptable or practical, but it illustrates how everyone is a partner in the control of sediment. CDOT's job is to keep the roadway open to the extent possible while maintaining the safety of the traveling public. Everyone using the interstate is therefore a stakeholder in the responsibility of controlling contaminants from the roadway. In particular, organizations such as the ski areas and the trucking industry are partners in the need to apply the traction sand and salt, and therefore in the need to clean it up afterward.

8.4.2 Potential Partners

The list of active existing stakeholders that are all potential partners, include the following from the SWEEP participant list:

- Federal Highway Administration
- USDA Forest Service (Arapaho and Roosevelt National Forests)
- U.S. Environmental Protection Agency
- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- Colorado Department of Transportation
- Colorado Parks & Wildlife
- Colorado Department of Public Health and Environment
- Clear Creek County
- Upper Clear Creek Watershed Association
- Trout Unlimited
- Clear Creek Watershed Foundation

8.4.3 Structure for Partnering

The I-70 Clear Creek Sediment Control Action Plan (SCAP) was born out of meetings with the Stream and Wetland Ecological Enhancement Program (SWEEP) Committee, an advisory committee consisting of fishery biologists, hydrologists and other watershed and water quality related technical experts, community representatives and other potentially affected parties. The SWEEP Committee was the beginning of a larger partnership to improve stream and wetland conditions in the I-70 Mountain Corridor.

This partnership, developed from the SWEEP Committee, agreed to an on-going framework for cooperation among the committee members as a part of SWEEP Memorandum of Understanding (MOU). The SWEEP MOU framework identified 21 different principles of cooperation. They included the following implementation principles:

- Create a system for management…
- Outline a process for collaboration…
- Determine appropriate people and data resources to develop strategies…
- Identify parties and how they work together.
- Pool resources when resources are available.
- Identify realistic opportunities for specific issues and sustainability.

As part of developing the Clear Creek SCAP, CDOT re-engaged SWEEP Committee members in a series of meetings to better define a specific collaborative process. CDOT felt that defining a specific collaborative process was critical in order to ensure future sediment control strategies are implemented to the fullest extent possible. Part of maximizing sediment control includes working in all areas along the I-70 Mountain Corridor that impact Clear Creek water quality. This includes locations where CDOT has does not have any planned improvements and in areas where sedimentation is caused by activity other than CDOT's management of I-70. Section 8.3 Gap Analysis of this Implementation Plan elaborates on these additional areas of sediment control concern.

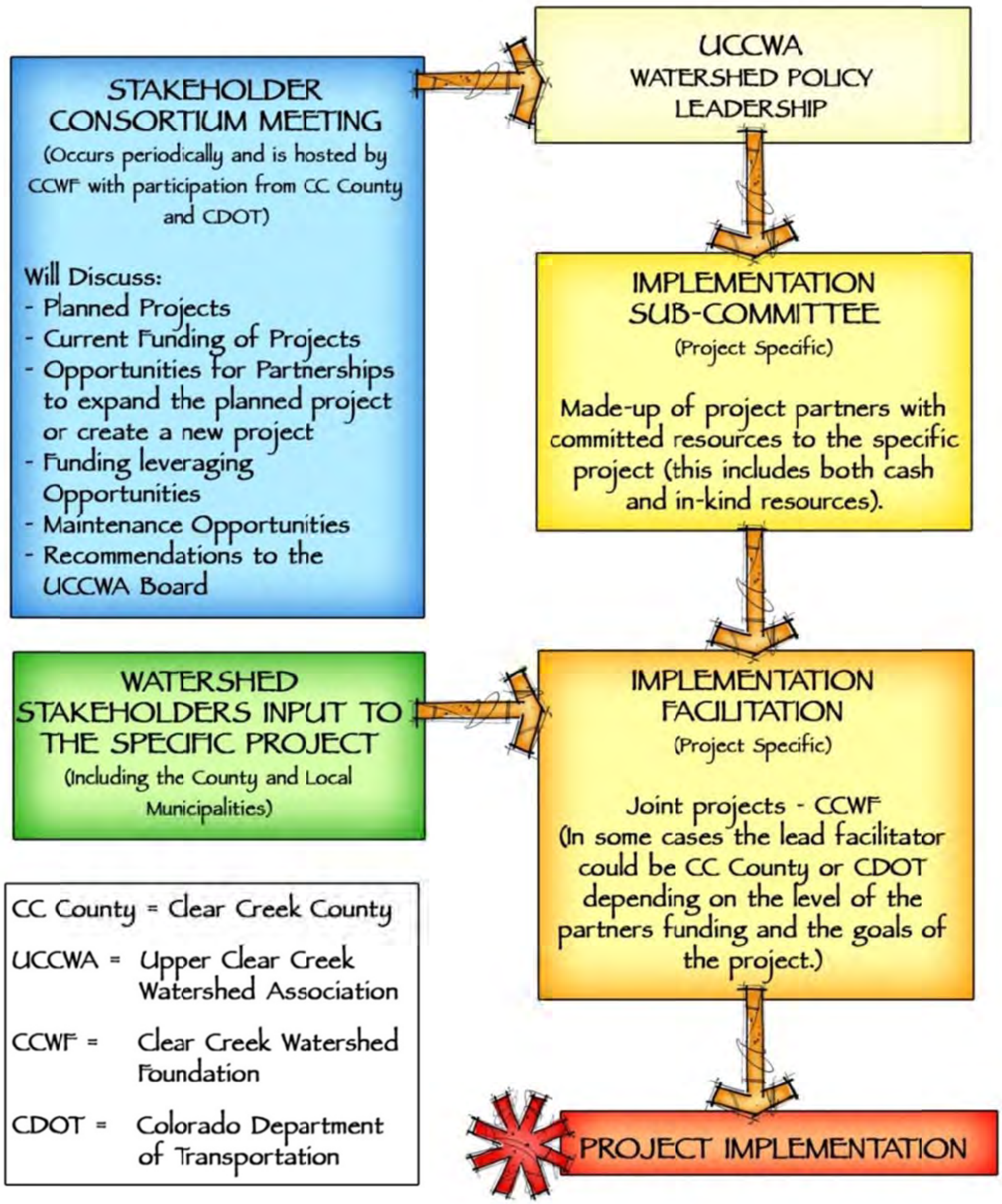
The goals behind developing a more specific collaborative process include the need for an on-going forum on strategy development and information sharing. Stakeholders should meet periodically to discuss the status of individual efforts and look for opportunities to partner and leverage each other's efforts to make projects larger, more complete and address "Gap Areas".

For example, CDOT will be spending money on sediment control BMPs on all future capital improvement projects on the I-70 Mountain Corridor. CDOT's expenditures should be used as a match to garner additional grant funds and partner funds. Because of the overall sediment control vision for the Clear Creek drainage, having the Clear Creek SCAP in place as a master plan vision for the entire corridor allows the opportunity to leverage existing project funds in different areas of the corridor.

The following chart describes how a structure for partnering with the Clear Creek Watershed Foundation (CCWF), as the lead facilitator, would help to administer and implement the SCAP and fill in the gaps (non-CDOT led projects) identified in Section 8.3.

SEDIMENT CONTROL IMPLEMENTATION

(Beyond what CDOT will Implement as a part of their Capitol Improvement Projects on I-70)



8.4.4 Role of the Upper Clear Creek Watershed Association (UCCWA)

UCCWA could provide the overall watershed policy leadership. With membership including representatives from all the major water providers in the upper Clear Creek watershed, it is UCCWA's primary focus to protect and enhance water quality within the watershed. UCCWA agreed to include an agenda discussion item every month at their regularly scheduled monthly meeting to discuss potential projects and the associated partnership. The intent is to review proposed project goals for conformance with overall watershed policy.

8.4.5 Role of the Clear Creek Watershed Fountain (CCWF)

CCWF would take the lead facilitation role at the stakeholder's consortium meetings and during the implementation phase for projects beyond what CDOT will implement as a part of their capital improvement projects on I-70. Project implementation budgets must include a line item to cover this cost of implementation facilitation. This is seen as a legitimate project cost by many grant agencies.

8.4.6 The Role of CDOT and Clear Creek County

In 2011, the I-70 Mountain Corridor PEIS identified environmental goals within the corridor. To meet these goals, CDOT initiated the formation of the SWEEP Committee to "identify and recommend appropriate mitigation strategies, including design, implementation and monitoring, for anticipated environmental impacts likely to occur as a result of redevelopment of the I-70 Mountain Corridor" (SWEEP MOU, 2011). Through the MOU, CDOT committed to providing technical support to the SWEEP and funding mechanisms to support mitigation strategies.

Both CDOT and Clear Creek County agreed to participate and support the effort to collaborate on sediment control projects. They are the two entities that will most likely be maintaining the sediment control BMPs that will be constructed. On every site specific project early in the process before the project design begins, the project maintenance responsibility must be accepted and agreed upon.

8.4.7 Examples of Project Partnering

In 2013, the Clear Creek Watershed Foundation (CCWF) applied for a Clean Water Act Section 319 grant through the Environmental Protection Agency (EPA) to reduce non-point source loading in streams. The grant funds were appropriated for the *Clear Creek Tributaries Sediment Control and Metal Removal Project* adjacent to segment COSPCL02 in Clear Creek County. This segment of Clear Creek is listed for cadmium on Colorado's Section 303(D) List of Impaired Waters. Impairments have been affected by runoff containing contaminated sediments from mine waste and mill tailings in tributary drainageways. This project proposes to build detention basins within CDOT's right-of-way to capture contaminated sediment prior to reaching Clear Creek to address water quality, a key SWEEP issue of concern. The *Clear Creek Tributaries Sediment Control and Metal Removal Project* is currently in the project development phase.

The proposed detention basins are outside of CDOT's MS4 permit area and do not manage highway runoff; however the contaminated sediments of concern drain onto CDOT's right-of-way. CDOT is planning highway improvement projects near the Clear Creek Tributaries Sediment Control and Metal Removal Project's area and will provide assistance with the detention basin project concurrently. Once the detention basins are complete, CDOT will operate and maintain the basins through periodic cleaning and disposal of contaminated sediment.

Project stakeholders currently consist of members representing the Clear Creek Watershed Foundation and CDOT. Funding for the detention basins will be from the Section 319 grant, with a 40% match from non-federal sources. In a letter of support for the grant application, CDOT offered to provide in-kind resources for design, access, right-of-way, traffic control, and construction mobilization for the project. Additionally, CDOT offered to help achieve the non-federal match for the grant.

This project and collaboration between CDOT and the CCWF aligns with the SWEEP MOU "Implementation Matrix" as shown on the following page.

8.5 Long Term Maintenance

8.5.1 Roles and Responsibilities

The entities available to conduct maintenance of BMPs in the Clear Creek corridor are likely CDOT and Clear Creek County. CDOT will maintain facilities within their right-of-way. Most projects identified in the SCAP will be CDOT maintained. BMP facilities outside the right-of-way could be maintained by Clear Creek County, CDOT, or any other stakeholders willing to accept the responsibility. The SCAP development team held a meeting with CDOT maintenance personnel responsible for the Clear Creek corridor to gain a better understanding of the current and future sediment control challenges they are facing.

8.5.2 Disposal of Material

The I-70 mountain corridor is constantly undergoing both natural and human-induced erosion and depositional processes, particularly in areas disturbed by roads. CDOT manages excessive amounts of cutslope rockfall, sediment erosion and deposition, and used traction sand along the roadway each year. This material must be managed and disposed of with very limited space for dump areas and is a serious maintenance issue.

Table 8-4: SWEEP MOU Implementation Matrix

Activities	Corridor Planning	Project Development	Project Design	Project Construction	Operations, Maintenance, Monitoring
Water Quality: Sediment Management					
Inputs	• Total Maximum Daily Loading (TMDLs) or other quantification of loading and characterization • Current operations • Existing conditions and anticipated broad impacts • Inventory of potentially impacted streams	• Existing water quality monitoring programs • Sediment Control Action Plans (SCAPs) • Site specific assessments	• Anticipated project impacts • Best management practices (BMPs) • Recommended mitigations • Existing water quality monitoring programs data • Water Quality Management Plan • SCAPs	• Storm Water Management Plan (SWMP) for the project • Water quality monitoring during construction	• Water quality monitoring programs • SCAPs • BMPs
Considerations	• What opportunities exist to minimize sediment loading?	• Does the existing SCAP provide strategies to avoid, minimize, or mitigate impact to meet the objective? • What are the costs and benefits of each strategy? • What revisions are needed for the SCAP?	• What are the appropriate site specific sediment controls? • What are the receiving waters in the project area? • How might any remaining impacts that exceed standards in the project reach be mitigated?	• What practices can be implemented to minimize or avoid construction related impacts?	• Are conditions and sediment levels consistent over time? • Do the current levels meet TMDLs
Outcomes	• Develop SCAPs for the I-70 Mountain Corridor	• Revise or endorse SCAP • Specific sediment management recommendations to meet the standards • Identify site specific mitigation strategies • Water Quality Management Plan	• Design sediment management strategies and structures • Plan for maintaining operations into the future • Water Quality Monitoring Plan	• Construct sediment management recommendations from the SCAP • Implement Best Management Practices (BMPs) • Maintenance and removal of temporary BMPs	• Maintenance of mitigation measures • Remove remaining temporary construction BMPs • Sediment basin maintenance • Meet the objective
Water Quality: Clean Water Act, Section 303(d) Listing of Stream Segments					
Inputs	• 303d listings	• 303d List impairments by segment • Gaining/losing segments	• Remediation strategies for specific segments • Sampling Analysis Protocol (SAP)	• Design requirements • Agency permit	• Listed stream segment inventory and remediation areas
Considerations	• What are the requirements for working in and/or near a listed segment?	• What is the baseline vs. event driven issues?	• What are project design options to lessen impacts to listed segments? • What are mitigation design options to remediate impaired segments?	• How can construction activities minimize impacts and control specific species of pollutants?	• How can maintenance activities avoid impacts?
Outcomes	• Recognition of impaired segments, isolated areas with increased concentration of pollutants, and associated requirements	• Remediation strategies for specific segments • Sampling Analysis Protocol (SAP) • Initiate site specific consultation with permitting agencies	• Non-point source mitigation design • Agency permit	• Remediate impaired areas consistent with agency BMPs and stipulations in agency-granted permits	• Monitoring and adaptive management to meet objective

Reference: SWEEP Implementation Matrix, SWEEP MOU, 2011

Used traction sand is considered solid waste and can be disposed of in landfills, but transportation costs can be high. Traction sand studies have indicated that up to 50 percent of the sand can be re-used, but it must be washed and sorted to meet CDOT specifications for re-use as traction sand. On the western slope, used traction sand has been utilized for the construction of sound berms in urban areas along I-70. In narrow stream corridors such as Clear Creek, there is very limited space to dump excess rock and sediment. Fill areas need to avoid riparian zone and floodplain areas of the creek. Most of the available disposal sites have already been filled to capacity over the past 50 years in the I-70 Clear Creek Canyon area.

In Clear Creek County, CDOT has been using a former mill tailings area in the Town of Empire to dump used traction sand and sediment from Berthoud Pass. However, according to CDOT maintenance, this area will reach capacity within two years, and no alternative disposal sites have been identified.

Based on this information it is concluded that a study should be conducted immediately to determine the long-term feasibility, locations, and cost of highway-related sediment disposal for the Clear Creek corridor. The sediment disposal study should result in a Sediment Disposal Plan that CDOT can carry forward now and into the future as part of SCAP implementation. Without a disposal plan, the SCAP cannot be effectively implemented.

8.5.3 CDOT Maintenance Plan

CDOT maintenance currently considers Georgetown Hill a high priority for cleaning of the drop inlet drains. Drainages in the Idaho Springs and Dumont area are also inspected and cleaned regularly using a vacuum truck. Roadways are intended to be swept following each snow/sanding event over the winter months, but limited resources often do not allow this. CDOT maintenance reports that existing equipment is at 171% of its life cycle. Since equipment is not being replaced and is aging, it frequently breaks down. In addition, some equipment originally assigned to the Clear Creek area for sediment control has been reassigned to other CDOT regions, resulting in equipment shortages.

Currently there are few BMPs to maintain in the Clear Creek corridor, although with the completion of the Twin Tunnels project and associated BMPs, there is a need to define the maintenance of those facilities. Although CDOT has installed sediment collection basins on Hukill Gulch and an off-site tributary near Dumont, there are currently no formal inspection programs or maintenance plans for those BMP facilities.

With each new BMP constructed it is important to develop an Operations and Maintenance Plan. The plan should address when maintenance is needed and what maintenance is required. The plan should also include a disposal plan for the sediment. Detailed costs for equipment, operation and maintenance of the BMPs, and sediment disposal need to be included. The operations and maintenance plan should be reviewed and updated as more BMPs are installed.

Currently, there are no formal inspections for any of the BMPs in Clear Creek. BMPs are cleaned out when they are significantly filled and CDOT Maintenance staff has the time and equipment to clean them.

8.6 Monitoring and Maintenance Tracking

8.6.1 BMP Inventory and Sediment Capture Volume Tracking

Once permanent structural BMPs are installed, it is important to inventory the number and type of BMPs and document the amount of sediment captured each year. For example, CDOT has numbered and provided signage for sediment control structures on Berthoud Pass, Straight Creek, and Vail Pass. This BMP identification facilitates tracking of capture and removal volumes, and any needed structure maintenance.

CDOT maintenance or others responsible for tracking and maintenance of BMPs need to document the location, date, and estimated sediment volume captured and removed each year. This information is vital for determining the effectiveness of permanent BMPs, maintenance conditions, and for reporting to regulatory authorities the amount of sediment captured and removed from the stream system. It is also often necessary as part of reporting for water quality grants, for estimating load reductions, and as vital data for CDOT to collect in order to receive recognition with local authorities for their efforts.

8.6.2 BMP Maintenance Manual

A BMP Maintenance Manual is recommended for each BMP that outlines BMP maintenance procedures and specifies information gathering and tracking requirements. As an example, a BMP Maintenance Manual was developed for US Highway 40 Berthoud Pass following reconstruction of the east side with new sediment control BMPs. The document was written as a manual for the CDOT maintenance patrol to follow each year. It outlines the background, purpose and need, types of BMPs, and maintenance procedures. It describes how to maintain the different types of installed BMPs, provides for contingency in excessive snowfall years, develops a maintenance schedule, and specifies documentation, tracking, monitoring, and reporting recommendations.

An I-70 BMP Maintenance Manual should have similar components to ensure any permanent BMPs installed are properly maintained and tracked. To ensure effectiveness, sediment control structures must be maintained, including regular inspections and periodic removal of sediment. The BMP structures are integrated with the drainage system and can cause drainage problems along the roadway if not properly maintained. The manual would be utilized by maintenance forces as a guide that will be updated as needed to reflect actual maintenance conditions and to accommodate new permanent BMPs when they are constructed.

A Maintenance Manual is considered a critical component for successful implementation of the SCAP. CDOT maintenance forces would be responsible implementing the Maintenance Manual. This plan is recommend to be developed immediately following completion of each of the two CDOT capital improvement projects (EB Twin Tunnels and EB Peak Period Shoulder Lane), at which time a sufficient number of BMPs will be in place that require maintenance.

An annual I-70 BMP maintenance report is recommended that would include a current inventory listing of permanent BMPs, maintenance inspections and activities, capture and removal volumes, disposal plans, any problems encountered, BMP repairs, SAP material usage data, cost accounting, and any recommendations for improvement.

CDOT currently uses a data collection and management system known as **SAP** to track the amount of traction sand, solid and liquid deicer salts applied to I-70 each year (see SCAP Section 4.0). This material usage data is vital for determining trends in material types and needs in the corridor. Annual traction sand and sediment cleanup volumes are also recorded in SAP for each I-70 patrol.

8.6.3 Stream Water Quality Improvement Monitoring

CDOT has conducted baseline stream water quality monitoring in Clear Creek to document conditions before I-70 reconstruction begins. Data is used for Tier II NEPA environmental impact studies and associated permitting required for new projects.

As the SCAP is implemented, stream monitoring could able to demonstrate load reductions and water quality improvements in Clear Creek. Monitoring information is recommended for non-point source funding grant applications and for BMP performance monitoring and reporting for grants. As stream conditions improve, monitoring results could be used to solicit support for needed funding of BMP maintenance and sediment disposal programs.

8.7 Funding Opportunities

8.7.1 Transportation Funding Mechanisms

CDOT generates funds for transportation projects through state and federal means. The Highway Users Tax Fund (HUTF) is the primary source of CDOT funding. Each year, gas tax revenues and motor vehicle registration fees are deposited into Colorado's HUTF. The real value of the gas tax revenues has decreased over the last 22 years. The fuel tax has not increased since 1991, and more efficient cars and inflation mean less money for more roads. CDOT struggles to maintain its funding, while federal funds have also been decreasing.

8.7.2 External Funding Opportunities

Funding opportunities external to CDOT may be viable. These external funding sources have varied submittal requirements. Other Clear Creek stakeholders may have to be the prime applicant. Often, CDOT can be a partner, even if they are not the prime applicant. For example, a number of grant programs require water providers to be the prime grant applicant. Since there are a number of communities that use Clear Creek as a water supply, these communities are all potential grant applicant partners. The following is a list of potential grant opportunities to be considered in the Clear Creek Watershed. They are organized by granting agency.

A. Colorado Water Conservation Board

1. Water Supply Reserve Account – Provides grants and loans to assist Colorado water users in addressing their critical water supply issues and interests. The funds help eligible entities complete water activities that may include competitive grants for technical assistance regarding permitting, feasibility studies and environmental

compliance, studies or analysis of structural, non-structural, consumptive and non-consumptive water needs, projects or activities and structural and non-structural water projects or activities. Contact Todd Doherty (303) 866-3441 ext. 3210 with questions. Applications must be received by July 15 for the September roundtable approval.

2. Watershed Restoration Program – This program provides grants throughout the state for watershed/stream restoration and flood mitigation projects. Grant money may be used for planning and engineering studies including implementation measures, to address technical needs for watershed restoration and flood mitigation projects. Special consideration is reserved for planning and project efforts that integrate multi-objectives in restoration and flood mitigation. CWCB costs shall not exceed 50% of the total cost of the project or study. Contact Chris Sturm at (303) 866-3441 ext. 3236 for more information. The program is typically announced in the early fall each year.

3. Non-Reimbursable Project Investment Program – Funding is available for projects or feasibility studies designed to address statewide, region wide or basin wide issues. River restoration, floodplain management projects affecting agriculture, recreation or other industries that economically impact significant areas of the state can be funded. Approximately 10% of the annual funds available will be set aside for feasibility studies and demonstration projects. Feasibility study and demonstration project investments will be limited to 50% of total study or project cost, up to a maximum of $110,000. Matching funds are encouraged. Contact Tim Feehan at (303) 866-3441 ext. 3211 for more information on the program. Applications are typically announced in the summer.

4. Rivers of Colorado Water Watch Network (River Watch) – This program is for water quality monitoring and assessment. There are no cost share matches; however, a contract must be signed for commitment. Contact Barb Horn at (303) 291-7412 with questions.

B. Colorado Department of Public Health and Environment (CDPHE)

1. Act 319 Clean Water Act – Colorado nonpoint source management area (NPS program) – This grant funds projects that address water quality impairments due to nonpoint source pollution, updates to watershed plans and provides educational and outreach activities that help maintain or restore water quality impacted by nonpoint source pollution. A non-federal, local match of no less than 40% of the total project funding is required. The match can be accrued as cash or in-kind services. Projects should have an educational component to increase nonpoint source pollution awareness within the watershed. Application material is available in September. Contact Lucia Machado (303) 692-3583 for more information.

C. U.S. Environmental Protection Agency (EPA)

1. Targeted Watershed Implementation Grant – The program provides funding to implement 3-5 year protection or restoration projects. Monies are used for implementation of on-the-ground restoration and protection activities designed to

achieve quick, measureable environmental results, based on a technically sound watershed plan. A 25% minimum non-federal match is required.

2. Water Quality Cooperative Agreements – This program is for research, investigations, experiments, training, environmental technology demonstrations, survey and studies related to the causes, effects, extent and prevention of pollution. The match requirement varies. For more information go to

http://www.epa.gov/owm/cwfinance/waterquality.htm.

3. Nonpoint Source Pollution – This program is to address water quality impacts from non-permitted, diffuse sources. Federal monies are provided to the states and the states then select and manage individual projects. A 40% minimum match is required. The requests for proposal usually come out in September. Contact EPA Region 8 Marcella Hutchingson (303) 312-6753 for more information.

D. U.S. Army Corps of Engineers

1. General Investigations – This program is designed to improve the riparian ecosystems degraded by channel instability, channel straightening, encroachment and invasive species. Funding is available as 65% Federal / 35% Non-Federal match.

2. Continuing Authorities Program Section 14 – This program provides funding for emergency stream bank erosion protection measures. The program is designed to prevent erosion damage to public facilities by the emergency construction or repair of stream bank protection works. Funding is available as 65% Federal / 35% Non-Federal match. The maximum Federal cost is $1,500,000.

3. Regional Priority Grant Program – A multi-program/funding opportunity request for proposals. Includes regional geographic initiative and total maximum daily load program opportunities related to water quality. Funding/cost share varies by program. This program is an annual competition that is usually posted in October. Proposals may be submitted under more than one grant program, but individual proposals must be submitted for each.

4. Community Action for a Renewed Environment (CARE) – A multi-media competitive grant program that offers an innovative way for a community to organize and take action to reduce toxic pollution in its local environment. A match is optional. Funding cannot be for projects that duplicate the Targeted Watershed Grant Program activities. More information is available at http://www.epa.gov/CARE/index.ht.

E. Natural Resource Conservation Service (NRCS)

1. Emergency Watershed Protection/EWP Program – This program helps to protect lives and property threatened by natural disasters such as floods, hurricanes, tornadoes and wildfires. Owners of public, private or tribal lands are eligible for assistance if their watershed area has been damaged by a natural disaster. The program is designed to help those property owners by implementing emergency measures to relieve imminent hazards to life and property created by a natural disaster. Technical and financial assistance is provided to remove debris from streams, to protect destabilized stream

banks, establish cover on critically eroding lands, and purchase floodplain easements. Contact Pueblo – Service Center – Rich Rhoades at (719) 543.8386, or the Colorado Springs – Service Center – Greg Langer, District Conservationist at (719) 632-9598 ext. 196.

The following is a source for loan funding:

A. U.S. Environmental Protection Agency (EPA)

1. Clean Water State Revolving Loan Program – This program provides loans for water pollution projects to the states. Go to the following web sites for more information: http://www.epa.gov/ogram information or

   http://www. epa.gov/owm/cwfinance/cwsrf/index.htm.

8.8 SCAP Implementation Scenarios

Many uncertainties exist regarding the timing of SCAP implementation in the Clear Creek corridor. Although the SCAP is designed for full build-out of the preferred alternative in the PEIS, it is unknown when funding will be available to reconstruct I-70. CDOT has committed to implementing the SCAP for each reconstruction project that is identified and funded. However, this is likely to take at least 20 years.

Therefore, interim levels of SCAP implementation and costs must be considered to make progress towards sediment load reductions in Clear Creek in both the short and long term. Three SCAP implementation scenarios have been identified that include

1) Robust Maintenance Program,
2) Currently Identified Capital Improvement Projects and Robust Maintenance, and
3) Full SCAP Implementation and Maintenance.

Each scenario is described on the following page:

8.8.1 Scenario One – Robust Maintenance Program

Presently, the standard Minimum Level of Service (MLOS) is being performed by CDOT maintenance forces in the Clear Creek corridor. There are currently few permanent sediment control BMPs in place in the Clear Creek I-70 corridor to maintain. As-needed shouldering, sweeping, guardrail cleaning, culvert cleaning, rockfall mitigation, and sediment removal are regular MLOS activities. Opportunities to begin a more robust maintenance program aimed at picking up more sediment each year before it reaches the creek, particularly in high priority areas, should be encouraged.

Using west Vail Pass as an example, funding is not available to implement the full SCAP in this corridor. Less than 25% permanent BMPs were installed and integrated with the drainage system as specified in that SCAP. Major capital improvement highway drainage projects have not been identified. Instead, CDOT maintenance forces have been taking a proactive approach to remove excess traction sand from the highway shoulders. If sand is removed early in the season before monsoon rains begin, maintenance can be very effective in reducing sediment loading to the stream system.

A similar approach in the Clear Creek corridor could reduce sediment loading impacts in the near term. The high priority areas identified in Section 8.2 should be the focus of a robust maintenance program that includes more frequent sweeping, early-summer shouldering, and removal of accumulated sediment deposits. Additional maintenance funding will be necessary and a Sediment Disposal Plan will need to be developed prior to implementation of Scenario One.

8.8.2 Scenario Two – Capital Improvement Project plus Robust Maintenance

Once the two currently identified and any future CDOT I-70 capital improvement projects are completed, new permanent BMPs will require maintenance in these areas. These maintenance activities will be combined with those identified in Scenario One. A Maintenance Manual will be developed and implemented as described in Section 8.6 for Scenario Two. Additional maintenance funding will be required and a Sediment Disposal Plan will need to be developed prior to implementation of Scenario Two.

8.8.3 Scenario Three – Full Capital Construction and Maintenance

This SCAP implementation scenario will require full build-out of the preferred PEIS roadway alternative. I-70 drainage infrastructure will be reconstructed, and the sediment control BMPs will be integrated with the drainage system. Scenario Three would include full SCAP implementation including a Maintenance Manual and Sediment Disposal Plan. Since the cost of drainage improvements will be part of the reconstruction project, the incremental additional cost to incorporate sediment control BMPs will be relatively small. However, Scenario Three may take many years to fully implement.

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APPENDIX A – BMP SEDIMENT VOLUME AND PERCENT CAPTURE TABULATION

Project: I-70 / Clear Creek SCAP
Client: CDOT
Calculation: BMP Sediment Volume and Percent Capture
Engineer: Matt Simpson

BMP Category	Size (CY)
Sediment Basin (small)	50
Sediment Basin (large)	100
Inlet Sediment Trap	10
Bench Trap (cy/mi)	150

Symbol	Zone	Max. Sediment Loading Rate: Rate (tons/ mi)	Volume (CY/mi)
T	Tunnel	2000	1347
GT	Georgetown Hill	1500	1011
FH	Bakerville/Floyd Hill	1000	674
LE	Low Elevation	500	337

Spec. Weight of Sand Applied	110	lbs/ CF	
Sweeping Recovery Rate	20%		
O&M Sed. Rate	250	*Tons/ Mile*	*169 CY/mile*

						Sediment Capture (Based on Maximum Loading Rate)												
						Number of BMPs						Sed. Capture Volume			Sed. Capture Design Goal ** (CY)	Sediment Loading (CY)	Percent Capture
Segment	Mile Marker West	Mile Marker East	Seg. Length	Sediment Loading Zone	Max. Sed. Loading Rate (CY/mi)	Sed. Basin (small)	Sed. Basin (large)	Tributary Basin (large)	Existing Sed. Basin (small)	Bench Trap (feet)	Inlet Sediment Trap	Basins & Traps (CY)	Sweeping*	Total Capture (CY)			
Tunnel	215.2	218.4	3.2	T	1347	46	10	0	6	1,076	15	3780	210	3990	3449	4311	93%
Herman Gulch - SP	218.4	225.7	7.3	FH	674	32	8	0	4	12,831	43	3394	490	3884	3937	4921	79%
Georgetown Hill	225.7	228	2.3	GT	1011	13	8	1	0	0	17	1720	150	1870	1861	2326	80%
GT - Idaho Sp	228	241.5	13.5	LE	337	16		10	2	0	75	2650	900	3550	3640	4550	78%
Twin Tunnels	241.5	244.3	2.8	LE	337	7		0	2	0	24	690	180	870	755	944	92%
Floyd Hill	244.3	247.7	3.4	FH	674	32		0	0	630	17	1787	220	2007	1834	2292	88%

Total Percent Capture **83.60%**

* Estimate Sweeping Recovery as 20% of low-elevation loading rate

APPENDIX B – MEETING MINUTES

Meeting Minutes

Project Leadership Team kick-off meeting

Clear Creek Sediment Control Action Plan (SCAP) and Clear Creek Mitigation Bank (CCMB)

October 18, 2010, 11:30-1:00

CDOT, Golden Corporate Circle, Fox Hollow Conference Room

Attendees: Bill Scheuerman (CDOT), Tyler Weldon (CDOT), Russel Cox (CDOT), Melinda Urban (FHAW), Monica Pavlik (FHWA), Robert Krehbiel (Matrix Design Group), Gary Frey (Trout Unlimited), Fred Lyssy (Upper Clear Creek Watershed Association), Ed Rapp (Clear Creek Watershed Foundation), Peter Kozinski (CDOT), Wendy Wallach (CDOT), Becky Pierce (CDOT), Scott McDaniel (CDOT), JoAnn Sorensen (Clear Creek County), Rich McEldowney (PBS&J)

Notes

Peter welcomed everyone, and group did introductions. Peter gave overview of the roles and responsibilities for a PLT and handed out the I-70 Mtn Corridor CSS pamphlet. He briefed group on the concepts and approach for the Corridor 3 prong approach:

1. Lead projects to completion
2. Champion the CSS process
3. Endorse and support projects and outcomes

Peter noted that technical issues for the SCAP and CCMB will be handled by the two contract lead project managers – Robert Krehbiel of Matrix and Rich McEldowney of PBS&J – and through the formation of technical issue teams.

Questions asked of group:
Do we have the appropriate people at the table at today's meeting?
-FHWA needs to decide if they should be involved, and if so, who from the agency. Bill encouraged their involvement in the PLT since many Clear Creek County projects are on the horizon.
-Invite someone from the Colorado Dept of Health and Environment (probably Steve Laudman) and Paul Winkle of the Colorado Division of Wildlife.

Action item – Russel will contact the CDPHE and Becky will contact Paul Winkle of the CDOW.

Do we have the resources to complete projects? This will be an ongoing question throughout the life of the PLT and Corridor projects.

Peter described the SCAP for Clear Creek. Project is on Clear Creek along I-70 from the Eisenhower Johnson Memorial Tunnel to I-70's junction with US 6. CDOT will address sediment control along the stretch with realistic measures. He mentioned some examples of unrealistic measures – new stream alignments and major geomorphologic studies

Becky briefed the group on the CCMB property location, a brief history of CDOT purchase of the property in 2001, and the CCMB contract. She touched on a few of the tasks from the contract.

Action item – Becky will send the Scope of Work for the CCMB to the PLT.

Scott – Prior to the next PLT meeting early action projects that could benefit water quality in the corridor should be identified. Project funding is not a sure thing, so that makes it challenging to combine efforts sometimes. If projects are identified early the team can be prepared with water quality mitigations so when funding becomes available those projects can move forward with mitigations attached.

Action item – Group will bring any early action projects and/or funding ideas to the next meeting.

Group discussed how $1 billion being appropriated.

Georgetown hill sediment pond – Russel asked if the request for the pond would be part of the SCAP. Peter said those concepts could be discussed in the SCAP but topic is more for a technical team. Ed brought up spill containment as an equally important mitigation measure as sediment control. Fred added that above Georgetown hill has more of a sediment problem than on the hill – notably in Silverplume. Ed commended CDOT's recent small project work collecting sediment. Peter told group to bring more ideas to the next meeting.

JoAnn – rafting groups, other recreation entities, and non-governmental agencies within Clear Creek County should be kept apprised of project actions. Stakeholders should receive meeting minutes. Included in this group is neighbors to the CCMB.

Action item – JoAnn will help Becky create contact list to receive information from the SCAP and CCMB.

SWEEP MOU – Peter – I-70 Mtn Corridor Draft EIS has been the main focus for CDOT lately. The last public hearing is Thursday, October 21st at CDOT HQ. The SWEEP MOU has not yet been signed because the FHWA legal staff has been working with the USFS legal staff to determine how the USFS could sign the MOU. The issue that arose since the last SWEEP meeting was the USFS couldn't sign the MOU if NGO's were involved, as per USFS policy. If the USFS can't sign it, the FHWA, CDOT, and USFS will have a separate MOU with exactly the same language as the main MOU. The goal is to have the signed MOU (or MOU's) in the ROD. The ALIVE committee is using the SWEEP matrix template.

Empire Junction – In the near future CDOT is completing a feasibility study of the interchange area improvements. Currently a contractor is being selected. Peter wants to see the PLT help/support the Empire Junction project. Ed raised concerns with CDOT creating a town at Empire Junction, for example by building a rail stop at the Junction. Ed doesn't want the character of the County to be ruined through land use changes at the Junction. Peter stated that CDOT is not in the land use/development business. Anything that happens as a result of an interchange improvement is at the direction of the land use authority. JoAnn added that the Clear Creek County master plan identifies the Junction as a mixed use development area. The group talked about the PLT for the Empire Junction project. Ed said the PLT should include the UCCWA and the CCWF. Peter admitted that formation of the initial PLT for the Empire Junction project missed the mark on inviting an environmental component to the table. The PLT has not met yet so there is still time to add to it. Scott added that the Clear Creek PLT can have influence on the Empire Junction work too.

Group briefly talked about the Context Statement but did not outline one.

Becky reminded the group that the PLT is 50% SCAP and 50% CCMB, to include not just water quality but wetland and stream resources and mitigation.

Ed warned the CCMB project team to avoid using “boreal toads” in conversation when talking about the future of the CCMB. He said that CDOT would be “waging war” by introducing boreal toads to the CCMB. Becky assured Ed that introduction of wildlife is not a component of the CCMB.

Peter added that the CSS process has 6 steps and should ensure that everyone is on the same page at the end of the process.

Gary asked if CDOT has a template/document for the procedure to develop a SCAP. Tyler worked on the Straight Creek and Black Gore Creek SCAPs so could offer insight.

Action item – Peter will send a link to the Black Gore and Straight Creek SCAPs.

Peter briefed group on the SCAP and CDOT’s contract with Matrix Design Group.

Becky briefed group on the CCMB contract with PBS&J. The contract has several tasks, and she went into a bit more detail about the contract creating three mitigation plans with one being chosen as the final to move forward. A banking instrument will be completed and finalized under the contract. Rich added that a task under the contract is to weigh costs and benefits to CDOT from different mitigation schemes. Ed brought up an overarching concern that CDOT needs to engage local stakeholders to create a more holistically-enhanced property. He mentioned getting credit for other enhancement activities, including on neighboring land with landowners involvement. Becky restated the intent of the property purchase – for habitat mitigation, not education.

Action item – Becky will invite an Army Corps person knowledgeable of mitigation banking to present an overview of banking o the PLT at the next meeting.

Gary asked how the PLT for CCMB works into SWEEP. Peter said through the CSS process all recommendations formed under the SWEEP committee will be considered at the CCMB.

Next meeting planned for November 15th, 1:00-3:00 in the Fox Hollow conference room at the CDOT Corporate Circle building (same location).

<u>Action items summarized</u>:
Russel – Invite someone from the CDPHE to join the PLT.
Becky – Invite Paul Winkle of the CDOW to join the PLT.
Becky – Send the Scope of Work for the CCMB to the PLT.
Group - Bring any early action projects and/or funding ideas to the next meeting.
JoAnn and Becky - Create contact list to receive information from the SCAP and CCMB.
Peter - Send the group a link for the Black Gore and Straight Creek SCAPs.
Becky - Invite an Army Corps person knowledgeable on mitigation banking to present an overview of banking o the PLT at the next meeting.

PROJECT LEADERSHIP TEAM MEETING MINUTES
Clear Creek Sediment Control Action Plan and Wetland Mitigation Bank
Monday November 15, 2010, 1:00 – 3:00 pm at CDOT Golden Office

Purpose: Meeting #2 to further introduce both projects to the stakeholders.
Guest presentation by Matt Montgomery, US Army Corps of Engineers

Exhibits:

a. Link to previous SCAP's – Black Gore Creek and Straight Creek
b. PBS&J Scope of Work for the Wetland Mitigation Bank
c. Aerial map of Wetland Bank area with approximate property limits
d. Corps of Engineers information on Wetland Banking – Timeline, Prospectus and Requirements

Attendees:

Peter Kozinski	CDOT	Peter.Kozinski@dot.state.co.us
Becky Pierce	CDOT	Rebecca.Pierce@dot.state.co.us
Scott McDaniel	CDOT	Scott.McDaniel@dot.state.co.us
Tyler Weldon	CDOT	Tyler.Weldon@dot.state.co.us
Robert Krehbiel	Matrix Design Group	robertk@matrixdesigngroup.com
Mike Crouse	Clear Creek Consultants	Mike.Crouse@clearcr.com
Rich McEldowney	PBS&J (via phone)	RMcEldowney@pbsj.com
Ed Rapp	Clear Creek Watershed	chris@clearcreekwater.org
JoAnn Sorensen	Clear Creek County	jsorensen@co.clear-creek.co.us
Gary Frey	Trout Unlimited	gbfrey@msn.com

1. Wetland Bank Projects Objectives

a. Two parcels were purchased by CDOT in 2001 as the first wetland bank in the watershed
    i. Southern property is 13.2 acres
    ii. Northern property is 18.9 acres
b. On the northern property, Clear Creek is heavily channelized and armored and lacks sinuosity
c. Clear Creek County has rezoned the properties as a Natural Resource for habitat enhancement
d. The intent is to complete wetland and stream restoration on northern property
e. The intent is to keep the southern property as is, except for weed control and maintenance
f. Private land exists between the two properties
g. CDOT intends to utilize all the available banking credits and will be the sole user

2. Follow up on Clear Creek Mitigation Bank questions

a. *Is this an existing contract with the PBS&J consulting firm?* Yes, it is a 2-year contract that began in September of this year.

b. *Are you planning to relocate a portion of this stream?* One of the 3 draft mitigation plans being developed by the consultant will include restoring the creek unless evidence precluding that option surfaces. To what extent the restoration option would include relocation will be determined at a later date. The draft and final mitigation plans will be reviewed in conjunction with the PLT.

c. *It appears that certain permits will be needed to do the work you're proposing.* The Army Corps will be involved as soon as the draft plans are completed and ready for review. The task that will likely require the most time is developing a banking prospectus and banking instrument, during which the Army Corps will be involved from the start. As for the permitting portion of the contract, depending on the proposed mitigation activities, the project may not require a section 404 permit. If a permit is required, such as a nationwide 27 for Aquatic Habitat Restoration, CDOT will obtain verification to use the permit following completion of the final mitigation plan. The Army Corps is already involved and will continue to be involved at all relevant steps.

d. *Task 1 calls for a Phase II Hazardous Waste Site Assessment. When was the Phase I study done?* The Phase I referred to in the contract is the review of federal and state environmental records completed for the PEIS. I've attached the documents from the 2004 draft for your information.

e. *Given the extent to which work has already been done on this proposal, what is the role of the PLT guiding this effort?* The goals of the PLT for the Clear Creek Mitigation Bank and SCAP are to help lead the projects to completion, champion CSS for this effort, and help enable decision-making. According to Ed, the SCAP is a "slam dunk," but he has concerns about the wetland bank. Ed would like there to be an opportunity to gather input from stakeholders to gain social and economic benefit, as well as environmental benefits. He sees opportunities such as a broader wetland bank for other users, visitor's center or regional trail. Once the preliminary investigations (topographic survey and hazardous materials investigation) are complete, the PLT will have the information to help in the next steps of building a successful mitigation bank for use in the corridor. CDOT will explore opportunities to create something bigger along the reach.

3. Presentation on wetland mitigation banking – U.S. Army Corps of Engineers

a. Create banking credits for future work by CDOT in the Clear Creek watershed
b. Approaches and typical associated credit ratios in parenthesis
   i. *Preservation* for wetlands under imminent threat (10:1)
   ii. *Establishment* or creation of wetlands (1:1)
   iii. *Restoration* of degraded wetlands (1:1)
   iv. *Rehabilitation* or enhancement of existing wetlands (4:1)
c. There is a public comment period before the Corps can accept the wetland bank
d. The Fish & Wildlife Service will have input on the wetland bank
e. The Corps does not regulate the number of users that can use the bank
f. Construction of the wetland bank area will likely be permitted under a Nationwide 27 permit
g. A Conservation Easement is needed on the property to protect it in perpetuity
h. Land uses are regulated on a Conservation Easement (i.e., no hunting, fishing or recreation)
i. Performance measures are used to release banking credits
   i. It is possible that only 10% of the credits are available initially upon construction
   ii. CDOT needs to anticipate when credits become available to match their needs

4. Next steps and meetings

a. Gary would like to have a site visit at the wetland mitigation bank site
b. No future meetings have been set yet
c. Paul Winkle from the Division of Wildlife will attend the next meeting

5. Action Items

a. JoAnn to reach out to adjacent landowners to the Wetland Bank and invite them to participate in these meetings
b. Peter and JoAnn to create a draft Context Statement
c. Becky to send out the link to the CDOT website for the Functional Assessment
d. Becky will invite the DOW to the next meeting

PLT MEETING MINUTES
I-70 Clear Creek
Sediment Control Action Plan (SCAP) and Clear Creek Mitigation Bank
Tuesday November 29, 2011, 9:00 am – 12:00 pm at CDOT Golden Office

Purpose: Re-engage the PLT as work on the Clear Creek SCAP and Mitigation Bank proceeds. Discuss goals of both projects, current statuses, relationship to the Twin Tunnel project and other projects, and schedules.

Attendees for the SCAP Portion:

Name	Organization	Email	Phone No.
Jim Bemelen	CDOT, Region 1	James.Bemelen@dot.state.co.us	303-365-7010
David Singer	CDOT	David.Singer@dot.state.co.us	303-512-5872
Becky Pierce	CDOT	Rebecca.Pierce@dot.state.co.us	303-512-4051
Holly Huyck	CDOT	Holly.Huyck@dot.state.co.us	720-497-6934
Russel Cox	CDOT	Russel.cox@dot.state.co.us	
Ty Anderson	CDOT	ty.anderson@dot.state.co.us	720-951-1439
Larry Dungan	CDOT	larry.dungan@dot.state.co.us	303-911-3223
Curtis Johnson	CDOT	curtis.johnson@dot.state.co.us	303-495-8617
Janet Gerak	CDOT Region 1 Environmental	Janet.Gerak@dot.state.co.us	303-877-5587
David Miller	CDOT Region 1 Maintenance	David.Miller@dot.state.co.us	303-512-5565
Mark Gocha	CDOT Region 1 Maintenance	Mark.Gocha@dot.state.co.us	303-512-5665
Ed Rapp	Clear Creek Watershed	info@clearcreekWater.org	303-567-2699
JoAnn Sorensen	Clear Creek County	jsorensen@co.clear-creek.co.us	303-679-2409
Chris Carroll	US Forest Service	christophercarroll@fs.fed.us	970-295-6637
Robert Krehbiel	Matrix Design Group	robertk@matrixdesigngroup.com	303-572-0200
Mike Crouse	Clear Creek Consultants	Mike.Crouse@clearcr.com	303-215-0040
Kevin Shanks	THK Associates	kshanks@thkassoc.com	303-770-7201
Allan Brown	Atkins	Allan.Brown@atkinsglobal.com	303-221-7275
Rich McEldowney	Atkins	rich.mceldowney@atkinsglobal.com	

<u>Clear Creek SCAP</u>

1. **Clear Creek SCAP Vision:** Create a Planning document that develops an approach to overall sediment control. It is intended to be a reference document for all future Tier 2 projects on I-70 between Floyd Hill and the Eisenhower Johnson Tunnel and include these elements:
    a. Existing Conditions (identify problem areas)
    b. History of the sediment issue
    c. Summarize Clear Creek water quality and chemistry
    d. Master Plan for the overall sediment control (not design)
    e. Regulatory criteria
    f. Toolbox of BMP's
    g. Cost vs. benefit to establish priorities
    h. Quantify maintenance costs and needs
    i. Establish a process and measures for applying criteria
    j. Guidance on using the SCAP

2. **Items to keep in mind when developing the SCAP**
    a. Chemical spill containment should be considered in BMP design
    b. Identify threatened and endangered species early – don't wait for final design
        i. Lynx crossings
        ii. Moonwort (primarily from Bakerville to EJT)
    c. Work restrictions – seasonal, spawning cycles, etc.

3. SCAP Work Plan

a. Process includes Data Gathering, Context Sensitive Solutions, Analysis and Recommendations
b. Preliminary schedule presented shows completion by August 2012
c. Next PLT meetings conceptually set for February, May and August 2012

4. SCAP Existing Conditions

a. Summary of Presentation on Stream Water Quality Monitoring
   1. Sediment and chloride is elevated seasonally, related to I-70 traction sand/salt runoff
   2. Streams are impacted in higher sand/salt use areas >9,000-ft
   3. Runoff trace metals are higher in mineralized geology
   4. Trace metal concentrations are low above the mining district
   5. Stream water quality characterization is significantly improved using continuous recording conductivity/turbidity probes
   6. Chloride was higher in upper Clear Creek (CC-1), related to I-70 traction sand/salt
   7. Total sediment and phosphorus was greater in lower Clear Creek (CC-40), related to the mining district
   8. There is not a close correlation between sediment load and flow volume
b. Summary of Questions Posed in the Water Quality Presentation
   1. Is the stream biota or habitat in upper Clear Creek affected by sediment deposition?
   2. What are the effects of chloride salts, if any, on aquatic biota?
   3. Are sensitive or protected aquatic species affected by the operation and maintenance of I-70 in these areas?
   4. Is it possible to mitigate these conditions with maintenance or structural water quality BMPs?
c. Presentation of Field Photo Log downloaded into Google Earth for entire corridor. Electronic file made available to the team by downloading onto Jim Bemelen’s computer for distribution
d. Ed Rapp commended the CDOT maintenance staff stating that they are doing a good job to protect water quality in Clear Creek. He stated, “I used to say that CDOT was the biggest polluter along Clear Creek, but I cannot say that anymore.”

5. SCAP Coordination with the Twin Tunnels Projects

a. Need drainage recommendations in January
b. Alan Brown needs input on how to manage drainage. Are we recommending valley gutters or place inlets on the shoulder?
c. Inlet protection
d. Sand-oil separators, particularly at CDOT’s Hidden Valley maintenance facility
e. Sediment Ponds
f. Controlling erosion in this section is just as important as capturing traction sand

6. Next Steps on the Clear Creek SCAP

a. Meeting with Maintenance Staff to understand sand & salt applications, and gather input on maintenance of existing structures

Clear Creek Mitigation Bank

Attendees for the Wetland Bank Portion:

Name	Organization	Email	Phone No.
Jim Bemelen	CDOT, Region 1	James.Bemelen@dot.state.co.us	303-365-7010
David Singer	CDOT	David.Singer@dot.state.co.us	303-512-5872
Becky Pierce	CDOT	Rebecca.Pierce@dot.state.co.us	303-512-4051
Holly Huyck	CDOT	Holly.Huyck@dot.state.co.us	720-497-6934
Janet Gerak	CDOT Region 1 Environmental	Janet.Gerak@dot.state.co.us	303-877-5587
Mark Gocha	CDOT Region 1 Maintenance	Mark.Gocha@dot.state.co.us	303-512-5665
Ed Rapp	Clear Creek Watershed	info@clearcreekWater.org	303-567-2699
JoAnn Sorensen	Clear Creek County	jsorensen@co.clear-creek.co.us	303-679-2409
Chris Carroll	US Forest Service	christophercarroll@fs.fed.us	970-295-6637
Robert Krehbiel	Matrix Design Group	robertk@matrixdesigngroup.com	303-572-0200
Kevin Shanks	THK Associates	kshanks@thkassoc.com	303-770-7201
Rich McEldowney	Atkins	rich.mceldowney@atkinsglobal.com	

Purpose: Develop the CDOT property along Clear Creek as a wetland mitigation bank to be used for CDOT projects within the Clear Creek Watershed from the Eisenhower Tunnel (headwaters) to the junction of US 6.

Hand Outs –Four 11x17 color maps

1. Southern Property with Greenway Bike Path
2. Alternative 1 – Existing channel with extensive regrading
3. Alternative 2 – Existing channel with minimal regrading
4. Alternative 3 – Realign channel

1. **Criteria used to select alternatives:**
   a. Create bank that offsets impacts for proposed improvements along I-70. Design parameters – improve functionality of stream, connect the stream with its floodplain, improve ecological functions such as water storage, and wildlife habitat.
   b. Develop wetland mitigation within the floodplain. Provide a functional and sustainable replacement for wetland impacts with minimal maintenance.
   c. Develop a plan that is sensitive to adjacent landowners
   d. Minimize excavation into mine tailings

2. **Describe three alternatives:**
   In addition to wetland credits there are also "Preservation credits" for keeping a site natural.

- **Alternative #1 –** Remove approximately 1000 feet of existing levee and filling the pond, creating an oxbow feature supported by groundwater. Reconnect the existing channel to the floodplain. Creates a variety of habitat sites. Requires less excavation, and provides higher credits. The overall project cost is less. Summary of wetland creation and work: 2.52 acres wetlands, 3.34 acres riparian buffer area, 9000 cy excavation, 3.19 acres total credits

- **Alternative #2 –** Remove the levee, but would not create a floodplain area. The pond would be filled. The oxbow feature would extend to the current Clear Creek channel. Otherwise, similar to Alternative #1, but fewer wetland credits. Summary of wetland creation and work: 1.62 acres wetlands, 2.74 acres riparian buffer area, 6900 cy excavation, 2.17 acres total credits

- **Alternative #3 -** Plug the existing channel, create a new channel through the floodplain. Riffles and pools with varying depth. Achieves channel sinuosity and channel credits in addition to wetland credits. Excavation is much higher than other alternatives. Greater buffer distance from the roadway for greater opportunity for pollutants removal. Pools ~5 feet deep outside of a meander. Create diverse aquatic habitat. Summary of wetland creation and work: 2.85 acres wetlands, 2.37 acres riparian buffer area, 16,300 cy excavation, 3.32 acres total credits

3. Comments from Ed Rapp and JoAnn Sorensen:

a. Alternative #3 is the worst case from a hydrology and hydraulics and fishery point of view to realign the channel due to difficulties of constructing with sand and cobbles. There are difficulties in re-creating a stream that has stabilized over time. Alternative #3 results in the most movement of existing channel which today is a good fishery of great value to the State of Colorado (to be confirmed). This channel was modified prior to the 1940's and has adjusted over time. Ed recommended against Alternative #3 by proposing not changing the existing channel.

b. The alternatives do not show how it will function with high and low flows. No piezometric water surfaces shown on the exhibits. This is a stream bank storage area. Like that it is shaping the channel, but getting few credits.

c. The land plan is not connected to upstream and downstream properties.

d. Very important to see piezometric surfaces for high-highs and low-lows. Data is only available for one time of year in the fall. There is spatial and temporal variability in the groundwater surfaces. He needs to see groundwater contours on the maps.

e. Agree that taking down the levee is a good idea, but it should be undulated. Only need to poke holes in the levee. Like more floodplain storage and filtering ability.

f. The plans lack a lot of detail at this stage. The PLT is very technically oriented, but information is not shown on the diagrams. Team is planning to share the information in the final plan. PLT would like to comment on some of the technical data. Becky responded that these exhibits are conceptual plans. The team has additional data, but did not show for clarity of the alternatives.

g. Share the technical data with the PLT. Reports have not been previously sent out to the PLT. The last data was shared a year ago at the 2010 PLT meeting.

h. Develop a table to compare the alternatives based on the list of expanded criteria heard today. Could add values to each alternative shown on the alternatives. Show how we got to these 3 alternatives. Summarize the pros and cons on a table for the PLT, to describe the differentiators. Develop the cost per credit. Rich McEldowney to put together the table with a review from Becky and David.

i. Discuss the greenway path, impacts upstream & downstream, and maintainability. No alternatives shown for the greenway trail. Becky pointed out what is depicted in the three Bank alternatives is the County's Alternative 2 in their Greenway Plan from 2005. The trail cannot be located in the wetlands per the Corps criteria for wetland banks. Drawing people into the wetlands could adversely impact the wetlands that are being used for credits. Becky has been managing the wetland site for 5 years, and has not been involved in the greenway planning. There is a need to consider other alternatives for the Greenway location. The County Open Space commission should be involved. The 2005 Greenway Plan does acknowledge the primary purpose of this parcel and states that wetland mitigation areas will be managed so as not to allow public access.

j. The County believes the Wetland Bank is not following the CSS process. No local context. Considerations should include multi-purposing for other considerations and opportunities to partner with other agencies. All alternatives neglect the local contexts for fulfilling other local needs. Other considerations include hiking, wildlife habitat, fishing, bird watching, education, ecological improvements to the community, etc. Stakeholders mentioned out-of-state examples of multi-purpose lands that include wetland creation, wildlife, educational and recreational features. More will have to be discovered from these examples before such models can be considered analogous for this small parcel.

4. **Comments from US Forest Service:**
    a. US Forest Service prefers Alternative #3 with the expectation that future maintenance of the wetlands will be lessened.

5. **Other Issues noted:**
    a. Property is extremely sandy and cobbly down to ~8 feet. High permeability and groundwater migration. Very porous. Transmissivity is 45 inches/hour.
    b. Tailing in the pits – Mill tailings or mine wastes? Identified tailings based up colors (orangish) higher conductivity. Ed said likely mine wastes rather than mill tailings. High in Manganese and Zinc. There was water in most of the pits that were dug in end of August, beginning of September. Soil sampling should be conducted to identify areas of mine tailings. Avoid Mine tailings within site.
    c. Ed said there are minor water rights issues related to storing more water. Taking out cottonwoods will offset some of the water usage. Water rights will be addressed and will be a project cost.
    d. CDOT has no idea of how much wetland credit is needed for the I-70 corridor. Are there options to create more wetlands? Cannot push further downstream due to property ownership. Area between the islands is already wetlands. Access has been limited.
    e. David explained that a larger, corridor wide joint planning effort is kicking off between CDOT and the Clear Creek County Greenway.
    f. Wetland water budget – Coordinate with SEO on water rights
    g. Consider erosion control and BMP measures necessary for the site

Wetland Bank Action Items –

1. Develop a table comparing the pros and cons of the alternatives
2. Meet with Clear Creek County Open Space regarding land use
3. Make technical reports available via FTP site
4. Add groundwater contours to the Wetland Bank alternatives

The Following Additional Action Items were requested by Ed Rapp –

5. Examine the fishery of Clear Creek in its present condition through the wetland bank site (work by Trout Unlimited and State Fishery)
6. Examine the maintainability of the three alternatives for the Clear Creek channel

PLT MEETING MINUTES
I-70 Clear Creek
Sediment Control Action Plan (SCAP)
Friday February 24, 2012, 9:00 am – 11:30 am at CDOT Golden Office

Attendees:

Name	Organization	Email
Jim Bemelen	CDOT Region 1	James.Bemelen@dot.state.co.us
David Singer	CDOT Region 1	David.Singer@dot.state.co.us
Holly Huyck	CDOT Region 1Environmental	Holly.Huyck@dot.state.co.us
Janet Gerak	CDOT Region 1 Environmental	Janet.Gerak@dot.state.co.us
Jeff Peterson	CDOT Environmental Programs	Jeff.peterson@dot.state.co.us
Jim Eussen	CDOT Region 1 Environmental	James.eussen@dot.state.co.us
Ed Rapp	Clear Creek Watershed	info@clearcreekWater.org
Gary Frey	Colorado Trout Unlimited	
JoAnn Sorensen	Clear Creek County	jsorensen@co.clear-creek.co.us
Carl Chambers	US Forest Service	c.chambers@fs.fed.us
Paul Winkle	Colorado Parks & Wildlife	Paul.winkle@state.co.us
Jim Lewis	Colorado Dept. Public Health & Env.	Jim.lewis@state.co.us
Robert Krehbiel	Matrix Design Group	robertk@matrixdesigngroup.com
Mike Crouse	Clear Creek Consultants	Mike.Crouse@clearcr.com
Kevin Shanks	THK Associates	kshanks@thkassoc.com

Purpose: Review work completed to date. Discuss the issues identified and the recommended solutions. Verify the contents of the Sediment Control Action Plan Document.

1. **Clear Creek SCAP Vision:** Create a planning document that develops an approach to overall sediment control. It is intended to be a reference document for all future Tier 2 projects along I-70 between Floyd Hill and the Eisenhower Johnson Memorial Tunnel. It will include these elements:
   a. Existing Conditions (identify problem areas)
   b. History of the sediment issue
   c. Summarize Clear Creek water quality and chemistry
   d. Master Plan for the overall sediment control (not design)
   e. Regulatory criteria
   f. Toolbox of BMP's
   g. Cost vs. benefit to establish priorities
   h. Quantify maintenance costs and needs
   i. Establish a process and measures for applying criteria
   j. Guidance on using the SCAP
   k. Environmentally sensitive areas – minimize disturbance to areas with T&E species
   l. Public Outreach (readily accessible format)

2. **SCAP Document**
   a. This document is a watershed approach
   b. Everyone benefits and should share in the partnership of water quality improvement
   c. Define resources and funding mechanisms to assist in water quality improvement
   d. Gather broad-based support for watershed protection. A discussion of suggestions to garner support included:
      i. Make it easy to carry the message
      ii. Tie into Water2012
      iii. Fishing tournaments
      iv. Fish and fisherman surveys

v. Schools studying the environment

e. This document could affect a “culture change” for regional watershed protection
f. Needs to be sustainable and focus on long-term users
g. Cannot be a blame game – the highway is just one of many impacts to the creek.
h. Don’t create scapegoats as a reason to not implement a SCAP, i.e., beetle kill.
i. Advocacy charge – show “here is what we are doing,” not “here is what we did”
j. Share information with local governments for consideration in local road maintenance practices
k. Should be a user friendly document that everyone can understand

3. Work Completed To-Date

a. SCAP CSS Process and Meetings (this is the 4th PLT meeting). Previous meetings:
   1) October 2010 – PLT Meeting #1. Project introduction and PLT formation
   2) November 2010 - PLT Meeting #2. Discuss scope of work and present previous SCAP’s on Straight Creek and Black Gore Creek
   3) November 2011 – PLT Meeting #3. Present vision statement, water quality conditions (PowerPoint), coordination with SWEEP and Twin Tunnels project, present mapping results for existing conditions
   4) December 2011 – Meeting with CDOT maintenance to discuss winter sand and salt application rates, existing BMP structures, maintenance concerns and challenges, equipment needs
b. Develop a SCAP work (action) plan and schedule
c. Water quality assessment summary
d. Field survey of Existing conditions inventory – loaded onto Google Earth
e. GIS based Mapbook of proposed BMP’s
f. Meetings with CDOT maintenance on traction sand applications

4. Presentation of Issues Identified

a. Highway drainage system built many years ago and the design did not anticipate the volume of traction sand it now experiences. Sand buries the adjacent slopes, particularly the fill slopes every year, making revegetation difficult. (On Straight Creek, the fill slopes are reseeded every 3-5 years in order to maintain vegetation.)
b. Sedimentation buries the riparian vegetation, which are vital to fisheries
c. Drainage from new bridges cannot drain directly to the creek under new criteria
d. Summary of Presentation on Stream Water Quality Monitoring
   1) Sediment and phosphorus loading are linked
   2) Sediment and chloride is elevated seasonally, related to I-70 traction sand/deicer salt runoff
   3) Streams are impacted in higher sand/salt use areas >9,000-ft
   4) Runoff trace metal concentrations are low above the mining district but are higher in mineralized geology
   5) Chloride was higher in upper Clear Creek (CC-1), related to I-70 traction sand/salt
   6) Total sediment and phosphorus was greater in lower Clear Creek (CC-40), related to the mining district and roadway runoff

5. Presentation of the Toolbox of Potential Solutions

a. Solutions must:
   1) Be easy to maintain
   2) Be compatible with high speed traffic (safe for traffic and for maintenance crews)
   3) Function in high mountain environment and climate
   4) Rely upon passive treatment systems
   5) Provide adequate storage volume to be maintained 1x per 1-3 years
   6) Fit in available space
   7) Be cost effective and cost beneficial
   8) Identify beneficiaries and potential partnerships

b. Collection System and Snow Storage Areas
   1) Road Side Ditch/ Swale - (where space allows) - minimizes channel erosion
   2) Curb &Gutter or Concrete Pan - (limited space) – requires drains and sweeping
   3) Snow Storage Areas and Parallel Snow Storage – cannot cause ice build-up on the highway
   4) Drainage Rundowns – (reduce slope erosion) – must be carefully installed with compressed riprap to avoid being undermined and failing
   5) Clean Water Diversions (bypass I-70) – important to not mix *clean* water with runoff from the highway

c. Treatment Systems
   1) Underground vaults – difficult to maintain and their function is not visible
   2) Loading dock style sediment trap – works well with large volumes of sediment
   3) Sedimentation ponds – surface systems are good because they are visible to understand how they are functioning and when maintenance is required
   4) Bench trap between the highway and river – access for maintenance is important
   5) Vegetated swales and filter strips – sediment loading can bury vegetation
   6) Spill containment vaults - should manage small spills of 150 gallons from the saddle tanks
   7) Oil-water-sand separators – for use in maintenance yards and chain stations. Expensive to build and maintain; use only where runoff regularly contains oil.

d. Non-Structural Measures
   1) Advanced Materials Management – apply only the amount of sand needed. Training is important for proper application rates. CDOT has purchased many new sanding trucks with automated controls helping with application rates
   2) Maintenance - Sediment removal and inspection important, must be completed annually at a minimum and inspected prior to winter season
   3) Highway Sweeping – beneficial to capture sediment along shoulders
   4) Stabilization and Re-Vegetation of Eroded Slopes – lots of opportunities to green up the corridor (including areas not immediately adjacent to roadway template). Revegetation is a good approach and volunteers can help rake and seed. Produce organic soil, compost and mulch locally. Ed Rapp can conduct a tour up Trail Creek to show the success of revegetation. They have been successful getting grasses to grow with a mixture of sugar beet residue, pine mulch and fertilizer.

6. Open Discussion

a. Beetle kill is a concern that could change stormwater runoff. The Forest Service indicated that beetle kill was not likely to increase sedimentation rates in runoff. Maintaining understory vegetation and mulch are the most important aspects to minimize hillside erosion.
b. CDOT is learning to apply liquid deicers (MgCl) which is relatively new approach in the last 10 years. It can have a wet appearance on the highway by pulling moisture from the air – particularly during high relative humidity from sudden temperature drops.
c. At some point, there should be "gap analysis" between what resources are available and what is needed. As part of outreach, identify and include all groups who benefit from high water quality in Clear Creek.

7. Action Items

a. Load Google Earth KMZ file on an FTP site for distribution to the PLT
b. Next meeting could be in May to discuss the draft document

PLT MEETING MINUTES
I-70 Clear Creek Corridor Sediment Control Action Plan (SCAP)
Wednesday, January 9, 2013, 10:00 am – 12:00 pm
CDOT Golden Office, Homestead Conference Room

Purpose: Present findings of the Draft Report and Mapbook. Receive review comments on the Draft SCAP documents. Discuss next steps for preparation of an Implementation Plan.

Attendees:

Name	Organization	Email	Phone No.
Jim Bemelen	CDOT, Region 1	James.Bemelen@dot.state.co.us	303-365-7010
David Singer	CDOT	David.Singer@dot.state.co.us	303-512-5872
Holly Huyck	CDOT	Holly.Huyck@dot.state.co.us	720-497-6934
Stephanie Gibson	Federal Highways Administration	Stephanie.gibson@dot.gov	720-963-3013
JoAnn Sorensen	Clear Creek County	jsorensen@co.clear-creek.co.us	303-679-2409
Gary Frey	Trout Unlimited	gbfrey@msn.com	
Paul Winkle	Colorado Parks & Wildlife	Paul.winkle@state.co.us	303-916-1043
Steve Laudeman	Colorado Dept of Public Health & Env	steve.laudeman@state.co.us	303-692-3381
David Holm	Clear Creek Watershed Foundation	jdavidholm@gmail.com	
Robert Krehbiel	Matrix Design Group	robertk@matrixdesigngroup.com	303-572-0200
Mike Crouse	Clear Creek Consultants	Mike.Crouse@clearcr.com	303-215-0040
Kevin Shanks	THK Associates	kshanks@thkassoc.com	303-770-7201

1. **Clear Creek SCAP Vision:** Create a planning document that develops an approach to overall sediment control. It is intended to be a reference document for all future Tier 2 projects on I-70 between Floyd Hill and the Eisenhower Johnson Tunnel. Sediment control is a voluntary program, but rather a commitment to the SWEEP program since the Clear Creek corridor is outside of the MS4 boundary and not designated as impaired for sediment.

2. **Presentation Overview Summarizing Findings (PowerPoint Presentation)**
   a. Draft Written Report Document
      i. Sediment loading in Clear Creek is higher than for a natural stream
      ii. Clear Creek has not been identified as impaired for sediment (only metals)
      iii. Georgetown Lake is currently capturing sediment, but the future goal is to capture sediment before it reaches the Clear Creek waterway
      iv. I-70 corridor is not within the MS4 boundary so clean up is voluntary
      v. Commitments by CDOT to the SWEEP committee to develop a SCAP
      vi. Sources of sediment in Clear Creek
         1. Natural erosion processes
         2. Roadway traction sand – primary concern of the SCAP
         3. Highway embankment cut / fill slope erosion – addressed in SCAP
         4. Mine tailings
         5. Channel instability and channel bank erosion
      vii. Recommended improvements
         1. Collection systems (swales, valley pans, curb & gutter, rundowns)
         2. Treatment systems (detention, sediment traps, vaults)
         3. Non-structural controls (sweeping, snow plow training, use of deicers)
   b. GIS Mapbook Master Plan showing existing features, drainage infrastructure and recommended highway-related BMPs

3. Open Discussion – Comments on the Draft SCAP

a. Written comments from JoAnn Sorensen and Paul Winkle (attached)
b. Discussion:
   i. Stream health is a watershed issue with many stakeholders
   ii. Importance of water quality monitoring and tracking BMPs
   iii. This SCAP is a living document. Appendices can be added later
   iv. CSS needs to address lessons learned in every document
   v. This study focuses on the highway impacts, but not mining impacts
   vi. CDOT cannot be responsible for all sediment in Clear Creek, it is a watershed issue. CDOT is just one of many stakeholders involved. This document needs to be useful to other stakeholders such as local governments
   vii. On-going time and expense for maintenance is one of the biggest complications for funding and implementation
   viii. It is better to develop a proactive approach to show action for improving water quality, rather than establishing impairment classification with the need for monitoring to demonstrate sediment control effectiveness
   ix. The SCAP should attempt to set the stage for prioritization and implementation in terms of water quality improvement

4. Implementation Plan

a. Pursue partnerships opportunities for funding and implementation
b. Develop initial strategies for implementation
c. Who is leading / facilitating moving this study forward?
d. What is the timing?
e. What money is available? Any grants?
f. Identify priorities in terms of water quality improvement - what to build first, or what areas from an ecological perspective need improving first
g. CDOT funds by project – limited CDOT future opportunities may include:
   i. Twin Tunnels (incorporated SCAP recommendations)
   ii. Peak period shoulder lane Idaho Springs to Empire Junction
   iii. Traffic and revenue study
   iv. Auxiliary lane Loveland Pass on-ramp extension
h. There is no separate funding source to improve Clear Creek water quality. For example, MAP-21 is the new approach to core formula program funding and the money is very competitive. The set-aside for Transportation Enhancements is eliminated.
i. The plan will establish criteria for priority areas
j. Implementation should include a phasing plan
k. Program costs should include a capital improvements plan and maintenance
l. Implementation will also include monitoring and tracking

5. Next Steps

a. Solicit any remaining comments
b. Finalize the SCAP Report
c. Develop an Implementation Plan

6. Action Items

a. Matrix to incorporate into the Mapbook the new survey of the I-70 Idaho Springs to Empire Junction reach
b. Kevin Shanks to meet off-line with David Holm, JoAnn Sorensen, and Jim Ford for final comments and to solicit input from those that could not attend
c. Consultant team to develop a Draft Implementation Plan for comment.
d. Conduct a follow-up PLT meeting on Implementation this spring

Responses to Comments
Draft I-70 Clear Creek Corridor Sediment Control Action Plan
Dated December 2012

General

1) The references to figure numbers should be matched with the proper figure.
2) Several reference citations are missing.

Comments from JoAnn Sorensen – Clear Creek County

1) Page 52, Section 3.4.2 - Verify the operational parameters of the ENS.

   Response: Section 3.4.2, page 52, paragraph 3 states "The ENS may be activated as a result of vehicle accidents, hazardous waste spills, fuel spills, mudslides, avalanche, or flood events that can threaten life or property."

2) Page 7 - Clear Creek County and Clear Creek Watershed Foundation should be listed separately.
   Response: Will revise.

3) Page 13 – Consider adding a map depicting stream segments.

   Response: The regulatory stream segment designations correspond closely with the upper and lower Clear Creek SCAP segments with the break point at Silver Plume for regulatory Segment 1 versus Georgetown Lake for the SCAP. Segment 11 is mostly outside the study area. We will add a general map showing these stream segment designations.

4) Page 15 and 19 – Consider adding a map depicting locations of CDOT stream monitoring stations.

   Response: We will add the CDOT monitoring stations to the map provided by CCWF for the Upper Clear Creek/Standley Lake Monitoring Program.

5) Page 51, Section 3.4 – Consider adding additional narrative regarding Standley Lake.
   Response: Will add narrative.

Comments from Paul Winkle – Colorado Parks and Wildlife

1) Page 25, Paragraph 3 – "Total phosphorus concentrations were greater than 1 mg/L during several highway runoff events (Figure 2-3)."
   The figure references should be Figure 2-6, and all future references adjusted accordingly. Additionally, it appears the figure shows about 21 runoff events greater than 1 mg/L, not just "several".

   Response: The figure references will be matched with the proper figure number. The text will be revised to state there were 21 sample results that show concentrations greater than 1 mg/L.

2) Page 28, Paragraph 2 – Add “associated tributaries” as another source of runoff, in addition to the already mentioned east portal, I-70, Loveland Ski Area, and US Highway 6.
Response: Will add to text.

3) Page 33, Paragraph 2 – “Sampling results indicate the dominant salt composition in upper Clear Creek is sodium chloride rather than magnesium chloride.”
Although this is true, magnesium chloride still comprises a substantial portion of the dissolved salts at Site CC-1 and should not be overlooked.

Response: The text will be revised to state that sodium chloride concentrations were on average 15 percent greater than magnesium chloride concentrations. The figure depicting this data will also be revised.

4) Page 47, Paragraph 4 – “Results of the 1995-2007 sampling program were summarized by CPW in 2008 as follows:”
What is the citation for this? It should be included.
Response: Will add citation.

5) Page 53, Paragraph 3 – “If the spill leaves the ROW and flows onto private of public land or into waterways, there is currently no documented procedure or authority that enforces cleanup or remediation of the contamination”.
Is this true? Wouldn’t CDPHE have jurisdiction?

Response: It is our understanding that CDPHE has jurisdiction for spills outside CDOT ROW, but that there is no procedure or required enforcement action for cleanup/remediation. We will confirm or clarify this with CDPHE.

6) Page 95 – “Clean Water Diversion (Highway Bypass)”
These structures should be installed so as not to create fish migration barriers. Fish may move into or out of the tributaries of Clear Creek to seek spawning habitat or seasonal refugia.

Response: The clean water diversion is a concept involving separation of natural hillside runoff from untreated highway drainage. Highway drainage will be routed into water quality BMPs installed along the shoulder before it enters existing tributary cross drains. In some cases it may be necessary to extend the existing tributary cross drain inlets upstream a distance ranging from 10 to 50 feet to make space for the BMP and to prevent untreated highway runoff from entering the tributary. These tributary culvert extensions will be similar to existing conditions, just a slightly longer culvert. We will add this clarification to the document.