SEDIMENT CONTROL ACTION PLAN
STRAIGHT CREEK I-70 CORRIDOR

Prepared by

Colorado Department of Transportation

IN COOPERATION WITH

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EXECUTIVE SUMMARY

This Sediment Control Action Plan (SCAP) provides an analysis of sediment control for the Straight Creek section of the Eisenhower Tunnel West corridor along Interstate Highway 70 (I-70) in Colorado. Due to erosion and winter traction sanding operations, sediment controls are needed to decrease water quality impacts to surface waters from I-70 operations. This area lies entirely within the White River National Forest in Summit County, west of the Denver Metropolitan area. Summit County has experienced significant growth over past twenty-five years creating more traffic demand on the I-70 corridor. In addition, the growth of interstate traffic, particularly truck traffic, in the mountains west of Denver is noteworthy. These factors have created their own set of travel conditions, demand patterns, and maintenance needs that differ significantly from other portions of the state because I-70 provides excellent winter access to and through these areas.

The Straight Creek I-70 corridor is a steep high elevation mountain corridor that receives significant snowfall during the winter months and is subject to extreme weather conditions. The I-70 mountain corridor in this area is sensitive to winter maintenance issues due to its unique characteristics such as high elevation snowfall, steep gradient mountain passes, areas susceptible to avalanches, its proximity to many of the state's most popular ski areas, as well as the amount of traffic that it carries.

Excessive sediment loading has been occurring over the thirty years of I-70 operation in the Straight Creek corridor. Sedimentation is caused by both cut and fill slope erosion and winter maintenance practices, when I-70 is sanded for traction to maintain safety for the traveling public. This material, collectively referred to as sediment, is transported into the natural environment from the I-70 right-of-way by surface water runoff, depositing into streams, lakes, and wetlands. Excessive sediment loading can impair water quality, increase nuisance nutrient concentrations, reduce fish habitat, and inundate wetland vegetation. This situation is largely due to inadequate source controls and drainage problems along I-70.

Sediment controls are referred to as Best Management Practices (BMP's) under the Clean Water Act. Implementation of sediment control BMP's can reduce the amount of sediment loading in receiving waters. Additional controls and drainage improvements are required to reduce the sediment loading from I-70. Therefore, the focus of this SCAP is related primarily to drainage improvements and sediment source controls along the Straight Creek I-70 corridor.

In November 2000, development of this SCAP was approved by the Transportation Commission to determine planning strategies for controlling sedimentation from I-70, including the identification of potential implementation scenarios and cost estimates for consideration. Extensive analysis was required to assess these needs, and this SCAP is the most comprehensive examination of I-70 of its type completed to date.

This SCAP is a planning document that includes relevant background information, an evaluation of I-70 sediment sources, sand volume estimates, hydraulic/drainage analysis, and maintenance practices to develop a source control strategy. Both structural and non-structural sediment control BMP's are proposed. To assist in the planning and decision making process, four implementation scenarios with cost estimates have been developed: (1) Existing Maintenance Program (baseline); (2) Enhanced Maintenance Program; (3) Capital Construction and Maintenance Program; and (4) Prioritized Capital Construction and Maintenance Program.

A great deal has been learned in the Straight Creek I-70 Corridor to help address the sedimentation over the past ten years, contributing to the proposed solutions put forth in this SCAP. The strategy adopted for this planning document is focused on source control. Investigative data, field studies, and observations indicate that presently, the majority of sediment transported to Straight Creek is accumulated traction sand that is applied to I-70 during winter maintenance operations. Annual applications currently average approximately 10,000 tons/year on Straight Creek (CDOT, 2001). About 25 percent of the residual traction sand is collected and disposed of annually; 10 percent by volume of traction sand can be collected in existing sediment basins, while an additional 15 percent of the sand is collected under routine maintenance operations (ditch cleaning). The remaining 75 percent either remains on the shoulders of I-70, or is transported in surface water runoff to receiving streams. The area included in this SCAP is the highway shoulder and median, extending to approximately 30-feet on either side of the edge of pavement. Any work beyond the highway corridor 30-foot zone will need to be addressed in a separate study.

In recent years, there has been an increased focus on environmental facets of routine CDOT maintenance practices. Operational BMP's for sediment control are relatively new to the CDOT maintenance program. A major portion of this SCAP is dedicated to maintenance practices and operations. Since the completion of I-70, the focus of maintenance operations has been on maintaining the highway surface. The higher level of maintenance work to meet the growing needs was not anticipated at the time of I-70 construction. Public expectations for maintaining I-70 to a certain level have increased accordingly.

The scenarios presented in this plan would require significant additional resources for I-70 maintenance to provide the same level of service to the traveling public and adequately address the sedimentation problem. This would indicate that additional resources, as well as changes in policies and priorities, are required to meet all the needs. It is clear that maintenance forces are under-staffed and under-funded at the current time to adequately clean-up traction sand and sediment material. It is estimated for Control Scenario 1 that approximately $40,000 to $80,000 is spent annually on the Straight Creek I-70 corridor, within existing budget allotments, to conduct maintenance activities related to traction sand and sediment removal, hauling, and disposal.

At this time, funding options for implementing Control Scenarios 2, 3 or 4 have not been identified. To adequately control sediment in the Straight Creek corridor utilizing non-structural methods including an enhanced maintenance program, it is estimated that approximately $200,000 to $400,000 is needed annually. In order to construct adequate source controls along the corridor, the estimated cost is $16 million. Full structural controls would require approximately $450,000 annually for routine maintenance. These estimates were based on experience with existing sediment and erosion controls in other areas of I-70, hydrologic analysis, and the Maintenance Management System (MMS).

New and innovative ideas are brought forth in this SCAP to identify and address current and future needs. The treatments being proposed will significantly intercept the flow of sediment material from I-70 into the natural environment of Straight Creek. Additional hydraulic analysis and design will be necessary prior to implementation of the scenarios presented. However, this plan lays the groundwork for retrofitting I-70 with the necessary measures needed. Although it is noted that Straight Creek will ever be a pristine stream, it is recognized that the stream system will recover once the constant inundation of sediment material is arrested, thereby allowing for water quality improvements over time.

1.0 INTRODUCTION AND PURPOSE

This Sediment Control Action Plan (SCAP) was undertaken by the Colorado Department of Transportation (CDOT) to develop a strategy for addressing sediment loading from Interstate 70 (I-70) in the Straight Creek corridor. The Straight Creek corridor is located within the White River National Forest in Summit County, Colorado, where I-70 follows Straight Creek for approximately eight miles from the Clear Creek/Summit County line (Eisenhower/Johnson Memorial Tunnel) to the Town of Silverthorne (Figure 1). CDOT operates I-70 under a U.S. Forest Service easement.

Development of the SCAP was approved by the Colorado Transportation Commission (TC) in November, 2000 to plan strategies for controlling sedimentation from I-70, including identification of potential implementation scenarios and cost estimates for TC consideration. The Straight Creek watershed is of particular interest because construction and operation of I-70 through this area created unique circumstances associated with high traffic volumes, steep slopes and highway grades, extreme winter weather conditions, winter maintenance operations (including traction sanding), and other characteristics that have contributed to accelerated sediment loading within an otherwise pristine mountain environment. The construction and operation of I-70 through the Straight Creek watershed has essentially formed a new landscape that has forever altered the natural environment.

I-70 is a major route through Colorado, serving both the eastern plains and the western slope and is the only east-west interstate highway route through Summit County. Traffic along I-70 through the mountains has been increasing at a rate of approximately 5% every year since it was completed in the 1970's. Recent traffic counts from I-70 at the Eisenhower/Johnson Memorial Tunnel show traffic volume greater than 30,000 vehicles per day. Numerous recreational areas, including some of the most popular ski resorts in the state, are located within or near Summit County. These areas have experienced significant residential, economic, and recreational growth over the past twenty-five years. This factor has created its own set of travel conditions, demand patterns, and maintenance needs that differ significantly from other portions of the state because I-70 provides excellent winter access to and through these mountain areas.

Although highway maintenance is a year-round activity, the I-70 mountain corridor is extremely sensitive to winter-related maintenance issues due to its unique characteristics such as high elevation snowfall, steep gradient mountain passes, areas susceptible to avalanches, its proximity to many of the state's most popular recreational areas, as well as the amount of car and truck traffic that it carries. In the I-70 mountain corridor, winter weather is an important factor where snow and ice on the highway regularly causes conditions that reduce speeds and can adversely impact capacity.

A comprehensive study of this magnitude has not been undertaken since the construction of I-70. This SCAP provides the first attempt to fully assess and identify potential measures that could be utilized to help control sedimentation from the highway, as well as an analysis of maintenance operations as they relate to sedimentation. In order to develop the SCAP, an extensive assessment and analysis of the Straight Creek I-70 corridor was required. This includes an analysis of relevant background information, evaluation of sediment sources, hydraulic/drainage analysis, sediment volume estimates, development of a sediment control strategy, and recommended potential structural and non-structural BMP's for sediment control. Four implementation scenarios with cost estimates were developed to assist with the planning and decision-making process as part of this SCAP: (1) Existing Maintenance Program (baseline); (2) Enhanced Maintenance Program; (3) Capital Construction & Maintenance Program; and (4) Prioritized Construction & Maintenance Program.

1.1 Implementation of the SCAP

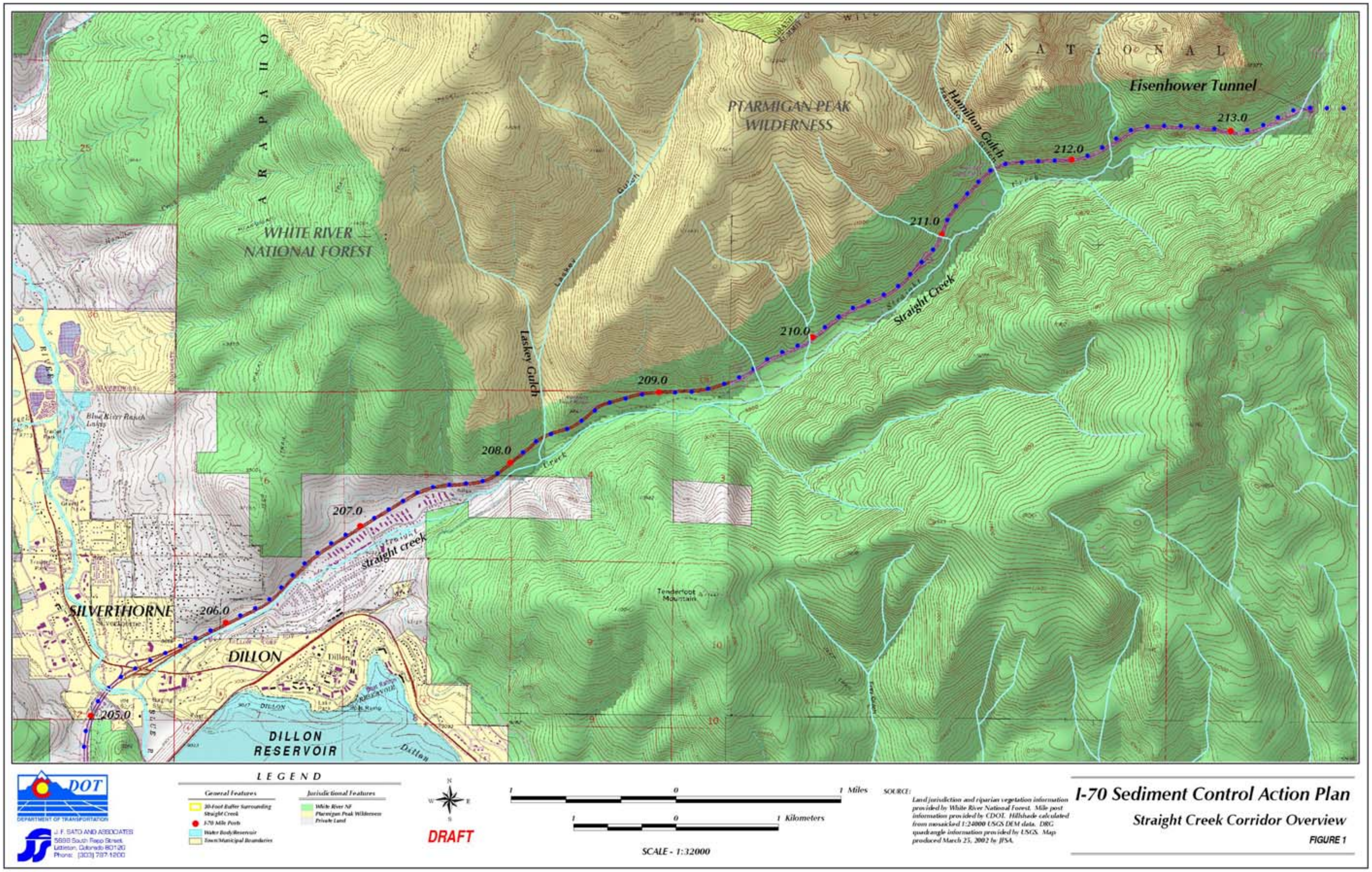
Because of the complexities and potential costs associated with implementing the various aspects of the SCAP, it must be emphasized that the SCAP is a planning document only. Further design and hydraulic analysis will be necessary prior to implementation. No funding sources for full or partial implementation of this SCAP have yet been identified. The rationale of the SCAP was to provide the analysis needed to develop concepts, methods, and potential costs for controlling sedimentation originating from I-70 in the Straight Creek corridor. Due to these factors, it is important to understand the scope of this document and its limitations. A Glossary of Terms has been included in the report that will aid in interpretation of the terminology used. A chronology for the Straight Creek I-70 corridor has been developed to assist with historical perspective.

Development of the SCAP was a voluntary effort on the part of CDOT and was not undertaken as part of any mandate or regulatory requirement. Actions taken by CDOT regarding unregulated nonpoint source issues are not incorporated into the Department's routine planning and project development process. Such actions are initiated on a case-by-case basis, as funding becomes available. No funding mechanism has yet been identified to implement this SCAP. It is anticipated that further clearances and coordination with the U.S. Forest Service and resource agencies will be required prior to implementation of the SCAP.

CDOT Region 1 has been proactive over the years with addressing nonpoint source highway-related water quality issues, and has collaborated with local stakeholders and other agencies through the State's Nonpoint Source program (NPS). The NPS program remains voluntary under the Clean Water Act (CWA). Much has already been accomplished in the Straight Creek and other highway corridors using this approach. Region 1 takes non-regulated nonpoint source issues very seriously and has an active water quality program dedicated solely to this issue. Within this program, the Region interacts with various agencies and entities to facilitate communication with local watershed groups and other interested parties to enhance and improve both the regulatory (those projects requiring NPDES permits) and the nonpoint source (non-regulatory) water quality and erosion control programs.

The Region 1 boundaries include the following watershed areas: Cherry Creek, Chatfield, Upper South Platte, Dillon, Republican River, Fraser River, Clear Creek, Upper Blue River, Bear Creek, Black Gore, and Straight Creek, among others. Therefore, the implementation of projects and funds for erosion control and water quality issues, particularly those that are unregulated, remain highly competitive among all the various stakeholders and local entities. The Region-wide program tries to take a balanced approach and works closely with the State's Nonpoint Source program to ensure that steps taken to address the highway related issues are in keeping with the appropriate goals and priorities as established within the State's overall program. Although the SCAP was completed specifically for the Straight Creek corridor, it could have application elsewhere as a tool for evaluating and assessing nonpoint source issues along other high elevation highway corridors.

Currently, a Programmatic Environmental Impact Statement (PEIS) is underway to address transportation issues in the I-70 mountain corridor. Should the SCAP be implemented prior to selected alternative(s) identified in the PEIS, sediment control BMP's would be incorporated as part of the new highway design. However, all of the non-structural controls and many of the structural controls proposed in this SCAP would not be affected by the reconstruction of I-70, although they need to be considered in such efforts.


WHITE RIVER NATIONAL FOREST
ARAPAHO
NATIONAL
PTARMIGAN PEAK WILDERNESS
Eisenhower Tunnel
Hamilton Gulch
Laskey Gulch
Straight Creek
Straight creek
Tenderfoot Mountain
SILVERTHORNE
DILLON
DILLON RESERVOIR
Blue River Ranch Lakes
205.0
206.0
207.0
208.0
209.0
210.0
211.0
212.0
213.0
LEGEND
General Features
30-Foot Buffer Surrounding Straight Creek
I-70 Mile Posts
Water Body/Reservoir
Town/Municipal Boundaries
Jurisdictional Features
White River NF
Ptarmigan Peak Wilderness
Private Land
DOT
DEPARTMENT OF TRANSPORTATION
J. F. SATO AND ASSOCIATES
5898 South Rapp Street
Littleton, Colorado 80120
Phone: (303) 797-1200
DRAFT
1 0 1 Miles
1 0 1 Kilometers
SCALE - 1:32000
SOURCE:
Land jurisdiction and riparian vegetation information provided by White River National Forest. Mile post information provided by CDOT. Hillshade calculated from mosaicked 1:24000 USGS DEM data. DRG quadrangle information provided by USGS. Map produced March 25, 2002 by JFSA.
I-70 Sediment Control Action Plan
Straight Creek Corridor Overview
FIGURE 1

2.0 STRAIGHT CREEK I-70 CORRIDOR

The Straight Creek basin is located within the Upper Colorado River Basin and lies in the subalpine vegetation region. The basin originates above timberline at an elevation of approximately 13,000 feet above sea level with the lowest elevation of the basin at 9,000 feet above sea level. Most of the I-70 corridor is heavily forested encompassing an area approximately 8 miles long and 2.5 miles wide and consists of rugged terrain (see figure 1).

During the 1960's, the Colorado Department of Highways (now the Colorado Department of Transportation) was granted approval to construct I-70, including the Straight Creek Tunnel through the Continental Divide (referred to as the Eisenhower/Johnson Memorial Tunnels). I-70 was constructed along a virgin alignment through the Straight Creek watershed that negated the need to reconstruct U.S. 6 over Loveland Pass.

In order to satisfy federal design standards at the time, I-70 and the connecting tunnel were constructed as a four-lane divided highway requiring that two separate tunnels be constructed, each containing two lanes of one-way traffic. The Eisenhower Tunnel (Tunnel) is the highest vehicular tunnel in the world, located at an elevation of 11,500 feet above sea level. The Straight Creek corridor of I-70 is an eight-mile corridor beginning at the west portals of the Tunnel and continuing down to the Town of Silverthorne where Straight Creek confluences with the Blue River. The corridor was constructed on grades up to 7%. Today, the Average Daily Traffic (ADT) on I-70 at the Tunnel exceeds 30,000 vehicles per day.

There was very little disturbance to the Straight Creek watershed prior to the construction of I-70. I-70 was constructed using cut and fill methods, resulting in a six-mile long cut on the south-facing slope of the Straight Creek Valley on grades up to 7 percent. Highway construction resulted in steep cut and fill slopes that are on average 40% steeper than the natural slopes, and many are near the angle of repose (RCE, et.al, 1993). Due to the high altitude and extreme weather conditions, unvegetated and highly erodable cut and fill slopes, and the use of traction sand/salt mixture during the winter months to maintain safety along I-70, accelerated sediment loading has occurred within the corridor.

The Straight Creek corridor was constructed to 1960 design standards, at which time NEPA regulations were not in place. An EIS was completed for the second bore of the Eisenhower Tunnel and it's approaches during the latter 1970's. This EIS did not address the potential for accelerated sedimentation because such impacts were not predicted at the time.

The Straight Creek Valley poses a number of difficulties with regard to the proper management of highly erodable cut and fill slopes, and sedimentation problems created when the slopes were constructed. In addition to those problems normally encountered when reestablishing vegetation at high altitudes, the slopes are extremely steep and unstable. Conditions such as seasonal moisture availability, short growing season, extreme temperatures, and strong winds make it difficult to sustain vegetation growth. The soils are low in nutrients, seasonally limited in moisture content, and low in organic matter. Glacial till material leftover from the ice age created unstable slopes in the Straight Creek Valley, which were disturbed when the I-70 road cut was created.

Major factors that are generally associated with the severe erosion, stream sedimentation, and damage to the aesthetic and natural values along the Straight Creek I-70 corridor include: 1) on-site soil loss from landslide areas; 2) inadequate highway 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) and ongoing traction sand loading from winter maintenance operations.

Over the past decade, CDOT has worked continuously in the Straight Creek basin to address the sediment and water quality issues. Since CDOT Region One has been funding highway related water quality issues, Straight Creek was determined as the highest priority. In 1991, the Straight Creek Clean-up Committee was formed with local stakeholders, as well as federal and state agencies, to work together to resolve the sedimentation issues. This effort has been beneficial and has provided a practical approach to identifying priorities, funding sources, educational opportunities, and other relevant approaches to solving these complex issues. Since 1991, numerous erosion control and sediment control projects have been implemented along the Straight Creek I-70 corridor. A chronology of activities associated with the development of I-70 in relation to sediment control in the Straight Creek corridor is provided at the end of this section.

2.1 WATERSHED DESCRIPTION

The headwaters of Straight Creek originate near the Tunnel at elevations of approximately 13,000 feet above sea level. Straight Creek flows from east to west along I-70 for approximately eight miles to the Town of Silverthorne at an elevation of 9,000 feet, where Straight Creek confluences with the Blue River (see Figure 1). The Straight Creek I-70 corridor as defined in this SCAP includes the upper seven miles of Straight Creek. I-70 is a six lane divided highway cut along the south-facing slope of the Straight Creek Valley. Prior to construction of I-70 there was no road in Straight Creek, and U.S. 6 over Loveland Pass was the primary highway used to access the Dillon Valley from the east.

The Straight Creek I-70 corridor is largely comprised of sub-alpine forest and bisects five ecosystems including Engelmann Spruce-Subalpine fir, lodgepole-aspen, shrub, wet meadow, and dry meadow. The drainage basin is underlain with erosion-resistant granitic rocks that are overlain by glacial and periglacial deposits that are relatively stable in their natural forms (RCE, et. al, 1993). The stream flows through a narrow valley with an average gradient of about 6%, while channel gradients range from about 3% to 10%. I-70 was constructed on the south-facing slope of Straight Creek for its entire length of eight miles from the headwaters to the mouth.

The mean annual precipitation (1961-90) at Loveland Basin is 32 inches, with the maximum snow water equivalent occurring in April at an average of 17 inches (NRCS, 2002). Loveland Basin is the nearest long-term high-elevation climatic data station, located on the east side of the Eisenhower Tunnel. These data show that over 50 percent of the annual precipitation is in the form of snow at higher elevations of

Straight Creek near the Tunnel. The average annual precipitation along the Straight Creek I-70 corridor ranges from approximately 16 inches at Silverthorne to 35 inches at west Eisenhower Tunnel, an increase of 120 percent over a distance of eight miles (CCC, 1980).

Elevation and season determine the type and temporal distribution of precipitation in the Straight Creek watershed. Precipitation is relatively evenly distributed throughout the year in Dillon, with slightly greater precipitation during the summer months (Figure 2). Precipitation at Vail, Colorado is shown for comparison purposes. Precipitation is greater during March and April at the higher elevations of the watershed (Loveland Basin). The mean annual precipitation in Dillon (9,000 ft-MSL) is 14 inches and at Loveland Basin (11,400 ft-MSL) it is 32 inches. Monthly mean temperatures for Dillon are shown in Figure 3, and precipitation is dominated by snowfall when temperatures are below freezing during winter (November through March). At the higher elevations, snowfall can occur any time of the year due to the lower temperatures. Snow accumulates in the Straight Creek watershed from November through April each year, especially above 9,500 ft-MSL. The seasonal distribution of precipitation plays a dominant role in the hydrology of Straight Creek.

Straight Creek has a drainage area of approximately 20 square miles. The hydrology of Straight Creek is dominated by the annual cycle of snowmelt runoff (Figure 4). Peak streamflow resulting from snowmelt occurs in May or June each year, followed by lower flows through the fall and winter months. Mean streamflow in Straight Creek ranges from less than 10 cubic feet per second (cfs) from late summer through early spring (August through April), to 70 cfs in June (USGS, 2001). Streamflow generally recedes during the summer months, with short-term fluctuations caused by rainfall-runoff events.

Straight Creek is a gaining stream, that is, streamflow increases from tributary inflows with distance downstream. Other factors that influence the natural hydrology include increased impervious surfaces resulting from I-70 and urban development in Dillon Valley. The narrow Straight Creek valley area occupied by I-70 contains limited quantities of ground water in the form of alluvial aquifers. Bedrock is shallow in most areas, which limits the depth of alluvium and associated ground water volume. However, ground water plays an important role in sustaining streamflow during dry periods.

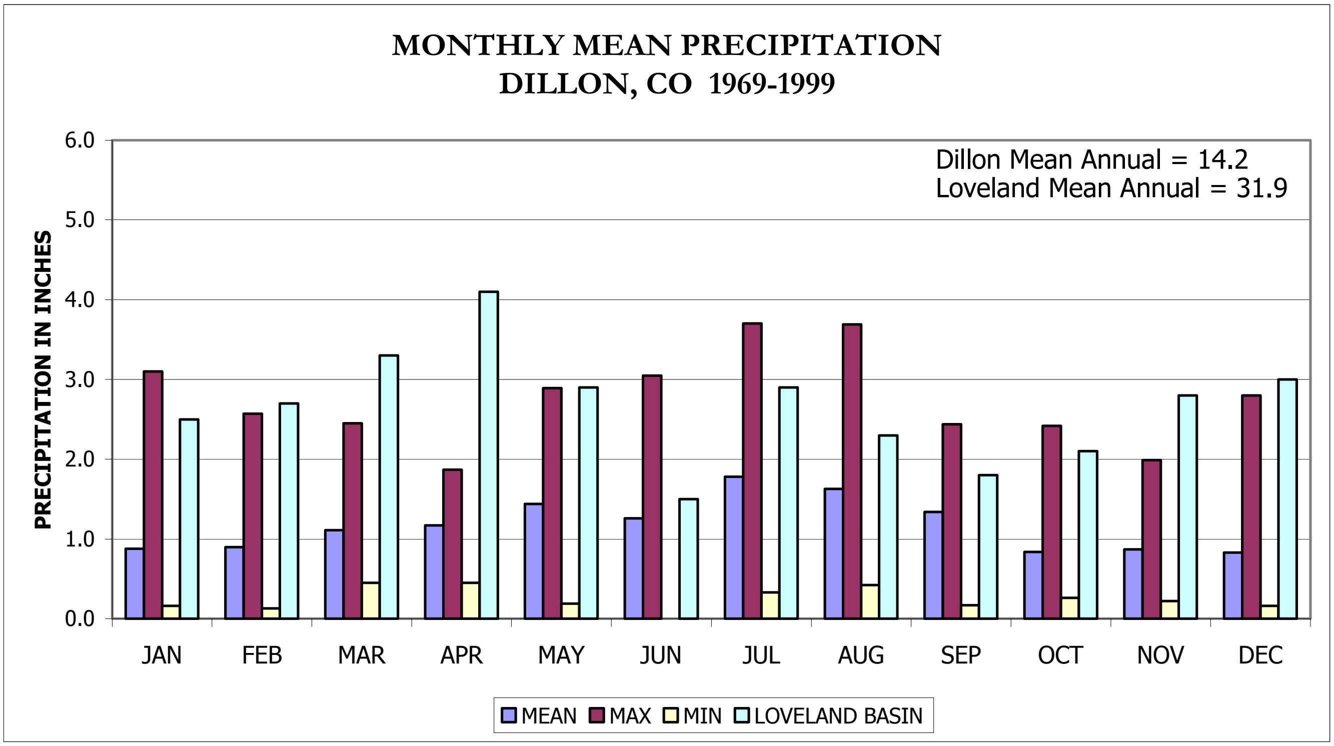
In many areas, I-70 cuts have intercepted and exposed shallow ground water that reports in the form of springs. Most ground water springs are ephemeral, flowing during the snowmelt period, but some are perennial (flowing year-round). These springs are visible along the I-70 road cuts in the Straight Creek watershed, particularly in spring and summer. Where ground water flows are intercepted they are routed to surface drainage features along I-70. Conversely, I-70 fill slopes have buried many former ground water springs and wetland areas (e.g., the Hamilton Box area). In this manner, the highway construction has altered the hydraulic route by which ground water enters Straight Creek in certain areas.

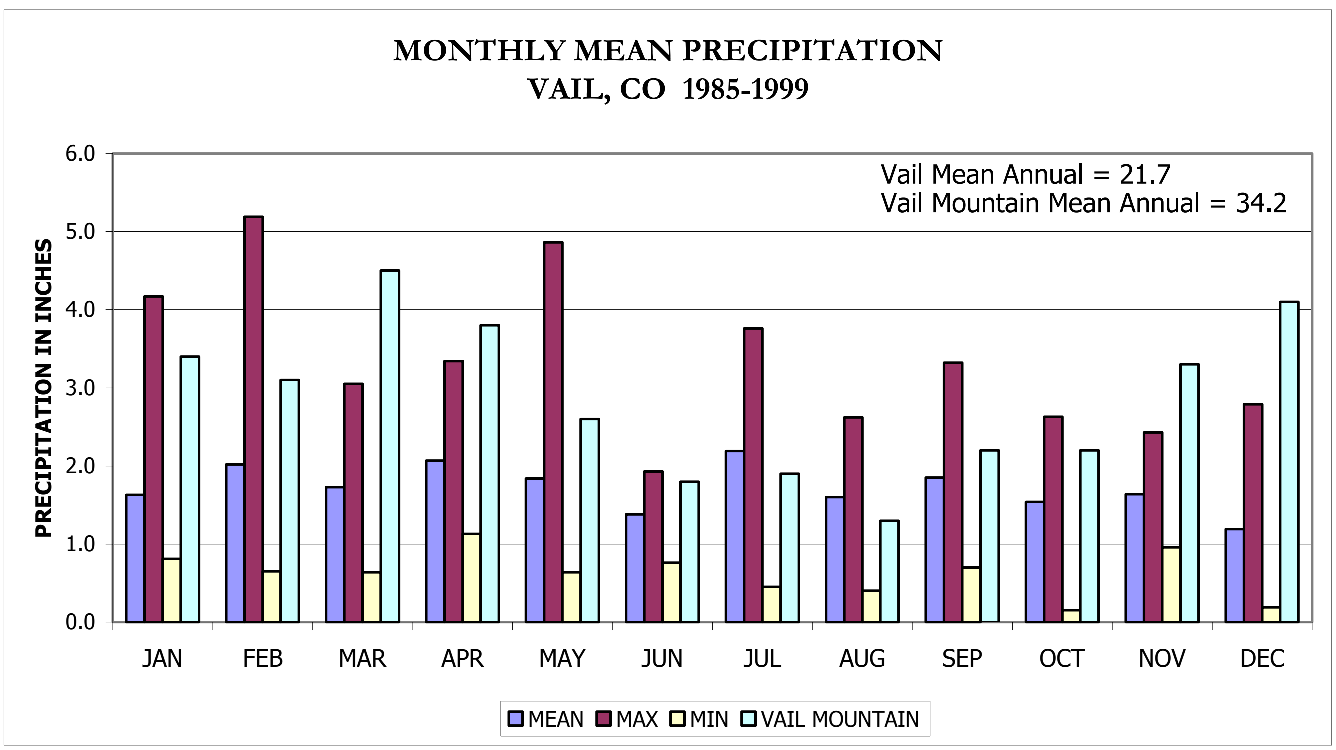
I-70 was constructed using cut and fill methods, resulting in a six-mile long cut on the south-facing slope of the Straight Creek valley. I-70 parallels the creek and its floodplain, but for the most part Straight Creek has not been significantly channelized by the construction of I-70. The creek is separated from I-70 fill material by a buffer of forested hillslopes and riparian wetlands in most areas. Several tributaries enter Straight Creek from the north and south through study area. The largest of these, Hamilton Gulch and Laskey Gulch, enter Straight Creek from the north and culvert pipes are used to convey tributary flows beneath I-70.

CDOT operates the west portals of the Tunnel at the headwaters of Straight Creek. This area includes maintenance and sand storage facilities and large pull-off areas used primarily by semi-trucks. The Tunnel area requires substantial resources to maintain during the winter season because of high snowfall accumulations. The Tunnel draws its domestic water supply from Straight Creek.

A water intake structure is operated on lower Straight Creek by the Town of Dillon for water supply purposes. This intake includes Laskey Gulch flows, where the lower portion of the Laskey Gulch channel was abandoned and flows were re-routed to the facility during the construction of I-70. The lowermost two miles of Straight Creek flow through the Dillon Valley subdivision before entering the Blue River at Silverthorne.

Straight Creek enters the Blue River near the Towns of Dillon and Silverthorne. The Blue River is designated by the Colorado Division of Wildlife (CDOW) as a Gold Medal Trout Stream from Dillon Reservoir dam (immediately upstream from Straight Creek) to its confluence with the Colorado River, approximately 35 miles downstream from Straight Creek.


MONTHLY MEAN PRECIPITATION
DILLON, CO 1969-1999
Dillon Mean Annual = 14.2
Loveland Mean Annual = 31.9
PRECIPITATION IN INCHES
6.0
5.0
4.0
3.0
2.0
1.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MEAN
MAX
MIN
LOVELAND BASIN


MONTHLY MEAN PRECIPITATION
VAIL, CO 1985-1999
Vail Mean Annual = 21.7
Vail Mountain Mean Annual = 34.2
PRECIPITATION IN INCHES
6.0
5.0
4.0
3.0
2.0
1.0
0.0
JAN
FEB
MAR
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MAY
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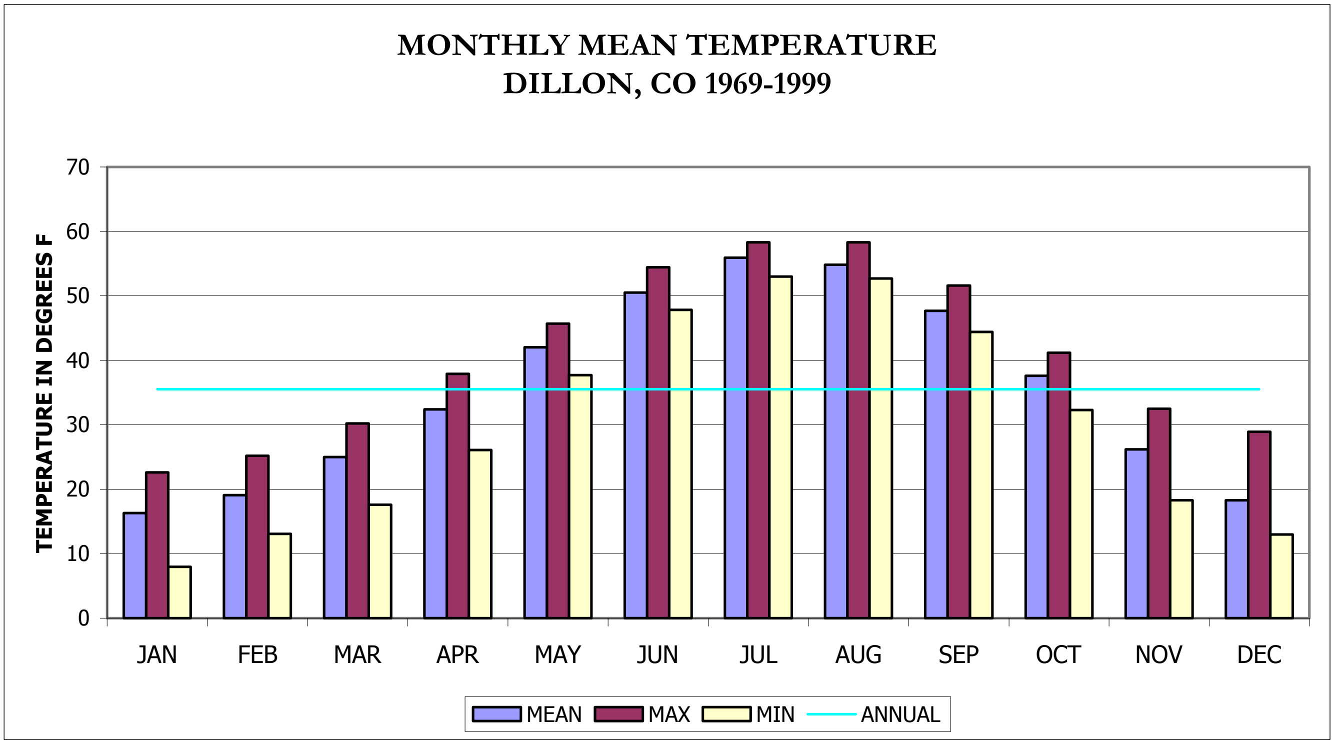
MEAN
MAX
MIN
VAIL MOUNTAIN

FIGURE 2


MONTHLY MEAN TEMPERATURE
DILLON, CO 1969-1999
TEMPERATURE IN DEGREES F
0
10
20
30
40
50
60
70
JAN
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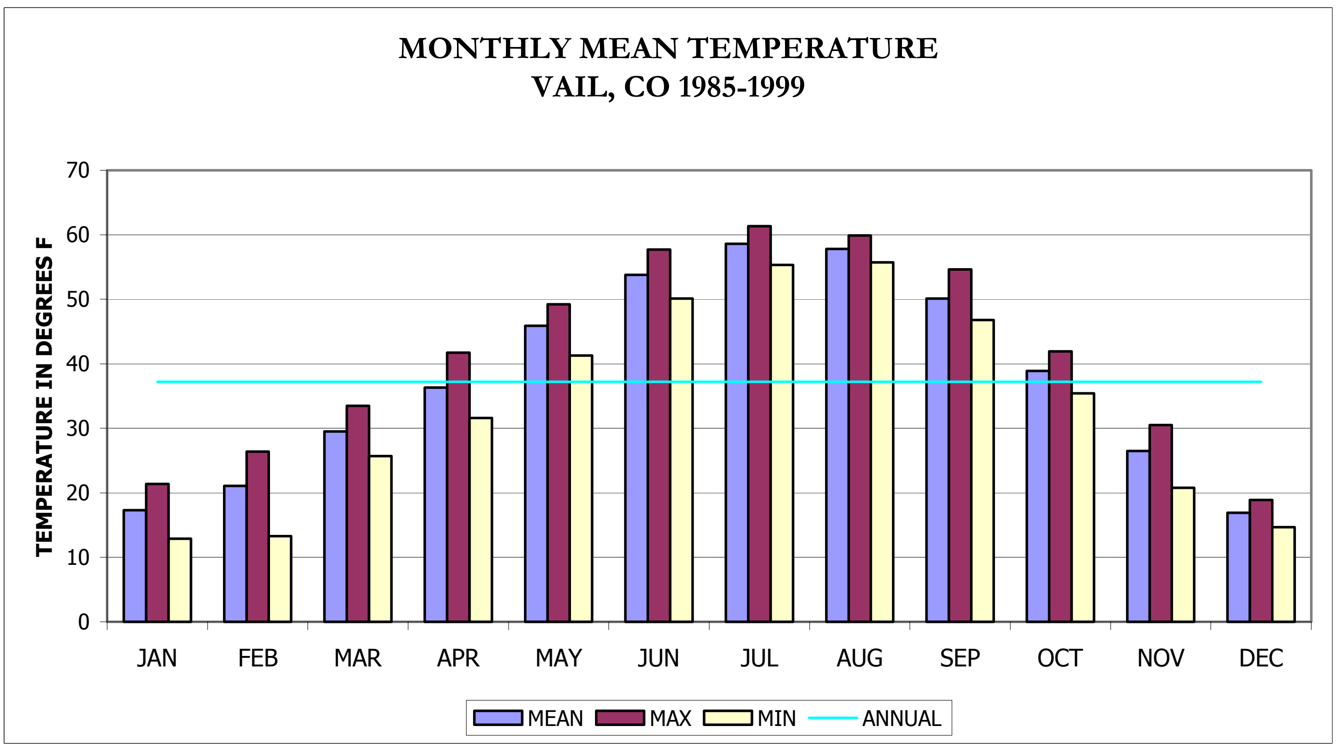
MONTHLY MEAN TEMPERATURE
VAIL, CO 1985-1999
TEMPERATURE IN DEGREES F
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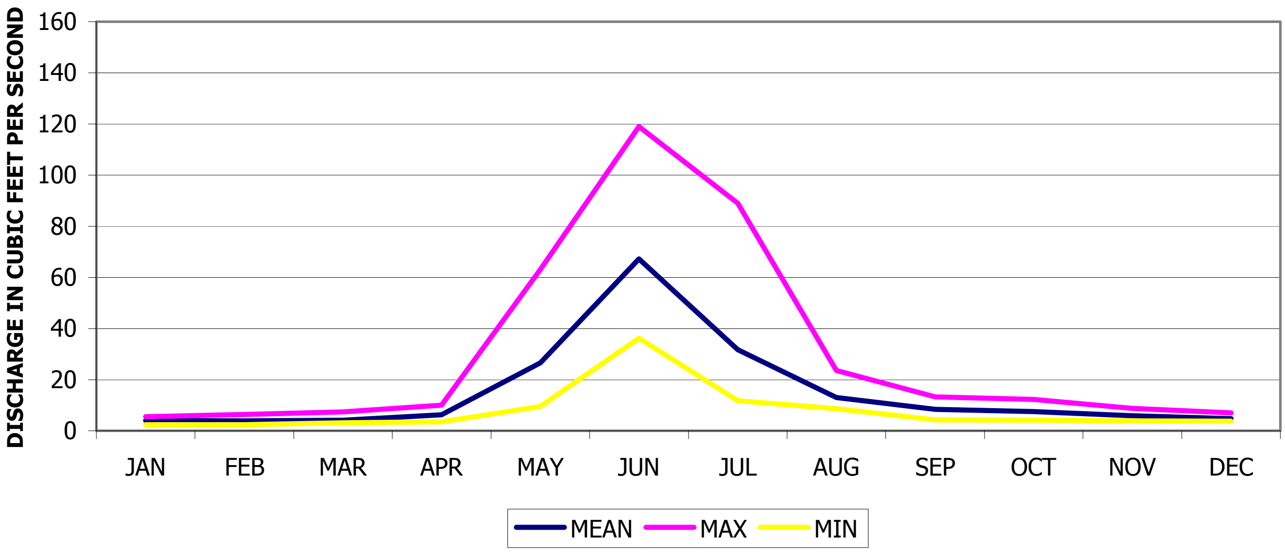
FIGURE 3

STRAIGHT CREEK MONTHLY MEAN DISCHARGE
Below Laskey Gulch Near Dillon, CO 1987-2000
Drainage Area = 18.3 sq-mi



BLACK GORE CREEK MONTHLY MEAN DISCHARGE
Above Timber Creek Near Vail, CO 1948-2000
Drainage Area = 12.6 sq-mi

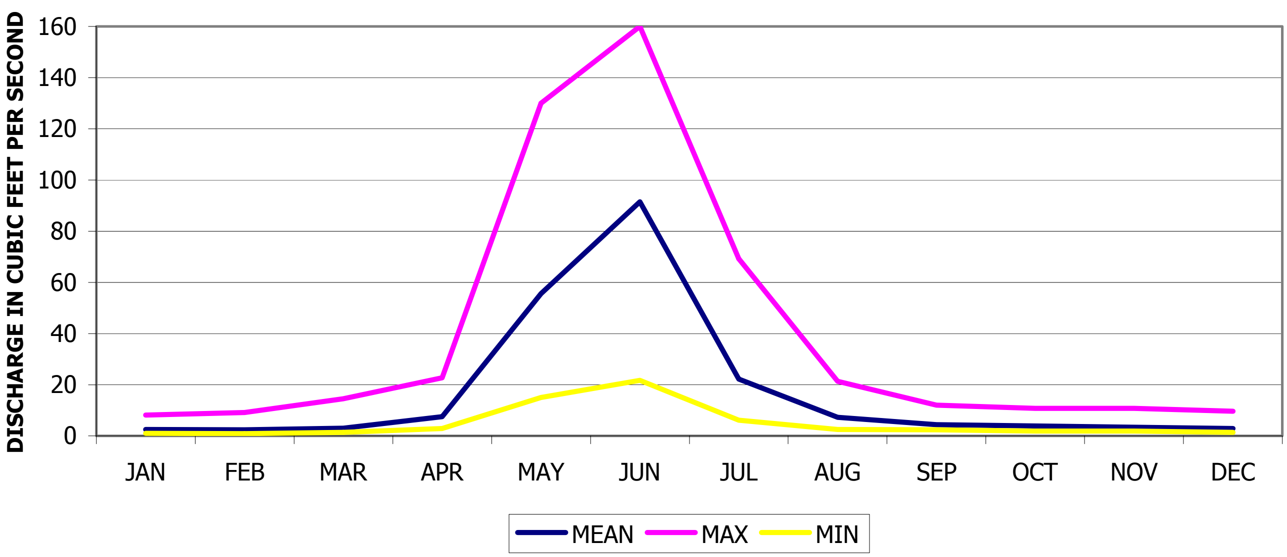


FIGURE 4

2.2 AFFECTS OF I-70

The Straight Creek section of the I-70 corridor carries a significant portion of both intrastate and interstate traffic. Summit County has experienced significant growth since the completion of I-70. Breckenridge and other ski areas in the vicinity are popular destination resorts. This portion of I-70 is also experiencing increasing commercial truck traffic. The chain law is invoked when needed to help control semi-trucks during adverse winter weather conditions.

Due to heavy interstate traffic during the winter, a salt/sand mixture is used, along with chemical deicers, to maintain safety and traffic flow on I-70. Over the years, local entities and the traveling public have increasingly demanded that this section of I-70 remain open at all costs, requiring extensive efforts by CDOT maintenance to accommodate this demand. These factors, along with erosion of cut and fill slopes, have led to a massive increase in sediment delivery to Straight Creek.

The Straight Creek corridor of I-70 was constructed in the early 1960's before the National Environmental Policy Act (NEPA) was enacted in 1969. Because the topography is very steep in this narrow mountain valley, the I-70 corridor was subjected to severe slope erosion problems that have plagued Straight Creek since construction. Revegetation efforts were not started until many years after construction, resulting in high slope erosion rates following construction of I-70 in the Straight Creek corridor. Today, the slope erosion has been reduced and stabilized through revegetation efforts, but annual traction sand inputs continue to plague Straight Creek.

The affects of I-70 on Straight Creek have been assessed to some degree both qualitatively and quantitatively. Highway construction resulted in steep cut and fill slopes that have experienced over twenty years of accelerated erosion. The annual application of the salt/sand mixture used on the highway during the winter months has varied from 6,000 to 14,000 tons per season (4,444 to 10,370 cu-yds) to provide adequate traction for the safety of the traveling public (Table 1). This table shows the total traction sand/salt tonnage used each fiscal year (July-June) for each winter season from 1990 to 2000. The area includes the entire eight-mile Straight Creek I-70 corridor from milepost 205 (Silverthorne) to 213 (Tunnel). The application rate in tons per mile is calculated as an average rate, even though the application rate is not linear through the corridor as discussed in Section 5. The 11-year average total application rate was approximately 10,000 tons (7,407 cu-yds) per year.

The sedimentation from I-70 has resulted in impairment to water quality and aquatic life uses in Straight Creek (CDPHE, 2000). However, the full extent of impacts from sedimentation on the natural environment has not yet been fully determined. Relatively fine-grained sediment from I-70 has been deposited in quantities of approximately 2,000 cu-yds per mile in the Straight Creek channel, whereas 6,800 to 15,300 cu-yds per mile are deposited in temporary storage sites on adjoining slopes and the valley floor (RCE, 1993).

Table 1
Winter Maintenance Materials Usage Data
Straight Creek I-70 Corridor

Winter	FY	Patrol (milepost)	Length (miles)	Sand/Salt Mixture (tons)	Rate (tons/mile)	Liquid Deicer MgCl (gal)	Rate (gal/mile)
1990-1991	1991	205-213	8	14,000	1,750		
1991-1992	1992	205-213	8	12,000	1,500		
1992-1993	1993	205-213	8	12,500	1,563		
1993-1994	1994	205-213	8	8,000	1,000		
1994-1995	1995	205-213	8	7,000	875		
1995-1996	1996	205-213	8	13,000	1,625		
1996-1997	1997	205-213	8	9,500	1,188		
1997-1998	1998	205-213	8	6,000	750		
1998-1999	1999	205-213	8	9,000	1,125		
1999-2000	2000	205-213	8	12,000	1,500	75,857	9,482
2000-2001	2001	205-213	8	10,500	1,313	147,982	18,498
1990-2001	**Average**		**8**	**10,318**	**1,290**		

Sources: Straight Creek TMDL, CDOT Maintenance

Due to the complexities of source and depositional areas within the Straight Creek I-70 corridor, three distinct impact "Zones" have been identified in this SCAP:

- Zone 1 - I-70 Immediate Travel Corridor
- Zone 2 - Adjoining Slopes and Valley Area
- Zone 3 - Receiving Water Body and Riparian Corridor

These impact zones are illustrated in Figure 5. The SCAP exclusively addresses Zone 1, the I-70 Immediate Travel Corridor. Zone 1 includes that area approximately 30 feet either side of the actual travel surfaces. This is the originating sand source area that is accessible and that CDOT maintenance forces typically maintain. Zone 2 includes the area of adjoining slopes or valleys extending from the outer edge of Zone 1 to the edge of the receiving water body or riparian corridor (Zone 3). Zone 3 includes the Straight Creek riparian zone.

The limitation to maintain a 30' width from the edge of pavement for Zone 1 is primarily based on access and maintenance needs. However, this is only an approximation used for planning purposes. The actual width of Zone 1 will vary throughout the I-70 corridor. This is particularly true in those locations where the bike path is situated near the roadway, and in other areas that are routinely maintained by CDOT maintenance forces. Therefore, the actual area within Zone 1 will vary and the 30' is an average distance that is used as a reference to help distinguish between the different areas within the corridor and for source control and cost estimating purposes.

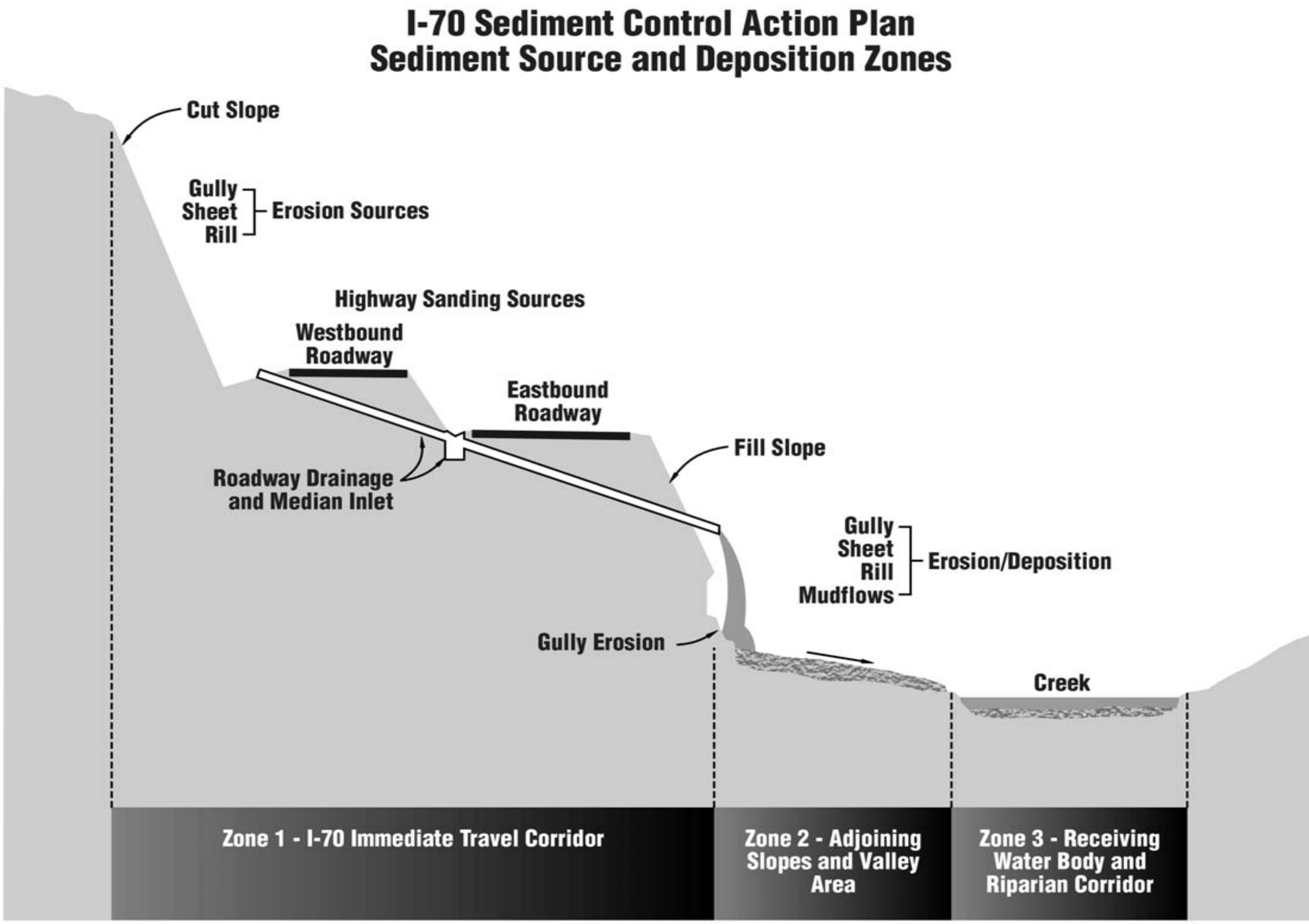

I-70 Sediment Control Action Plan
Sediment Source and Deposition Zones
Cut Slope
Gully
Sheet
Rill
Erosion Sources
Highway Sanding Sources
Westbound
Roadway
Eastbound
Roadway
Fill Slope
Roadway Drainage
and Median Inlet
Gully
Sheet
Rill
Mudflows
Erosion/Deposition
Gully Erosion
Creek
Zone 1 - I-70 Immediate Travel Corridor
Zone 2 - Adjoining Slopes and Valley Area
Zone 3 - Receiving Water Body and Riparian Corridor

FIGURE 5

CDOT recognizes the need for sediment controls at the source. Source controls are imperative to the eventual recovery of Straight Creek. It is important to arrest future deliveries of highway sand to the affected areas before undertaking any cleanup of historical sand accumulation in Zones 2 or 3. The analogy being: “first stop the bleeding”, or stabilize the situation at the source.

Straight Creek is tributary to the Blue River, creating concerns about the potential effects that sediment loading from the Straight Creek corridor may have on the Gold Medal trout fishery in the Blue River. The Blue River is very important to the economic vitality of the Dillon Valley. To date, little work has been done in the Blue River immediately downstream of Dillon Reservoir to assess sediment transport and stream channel stability to adequately determine the current condition of the stream and establish future goals. This should be done as part of an overall watershed planning process. It is believed that once sediment source controls are fully implemented along the Straight Creek I-70 corridor, future potential impacts to the Blue River from I-70 will be greatly reduced.

A comprehensive watershed analysis suggests a watershed approach to addressing the overall issue with regard to the entire Blue River watershed. A watershed approach to managing both point and nonpoint sources could be beneficial in implementing cost effective management strategies for protecting water resources, forest lands, and the environment. This type of plan would consider the watershed as a whole, incorporating all activities that may impact the uses and quality of the water resource including local initiatives and concerns regarding watershed management. A watershed analysis should focus on resource restoration. Resource restoration is a process that attempts to reduce or eliminate existing impacts on beneficial uses and is utilized to solve problems that are occurring due to past or present activities. In this case, it may be appropriate to determine a general endpoint as part of the restoration plan, e.g., reduced sediment loading and improved water quality and fish habitat. This focuses the planning and management on exploring how much improvement is feasible, with respect to the problems identified, rather than on achieving a precise defined level of water quality.

Straight Creek and its tributaries, like many similar mountain streams, can transport sediment load naturally during spring runoff and rainstorms. Further sampling and analysis of the sediment loading will be necessary in order to gain a better understanding of current and future stream conditions. The effects of I-70 in the Straight Creek I-70 corridor on the surrounding areas and stream systems will therefore require further study and analysis.

2.3 Literature Review

A literature review was conducted as part of the SCAP to identify and assess previous research, studies, and known information to determine the body of knowledge existing about the Straight Creek I-70 corridor, particularly with respect to remedial efforts identified or undertaken. Research on the Straight Creek corridor has been ongoing for a number of years to obtain a better idea of the impacts of sedimentation on the basin and to develop methods and treatment measures that can address the challenges associated with sedimentation impacts. These studies have provided some insight into the difficulty with assessing and addressing high elevation sedimentation impacts and necessary control measures.

In 1979, the Colorado Department of Highways commissioned a study to evaluate the fill slopes along Straight Creek. This final report entitled, *"Review of Colorado Department of Highways Study on Evaluation of Fill Slope Erosion Control Methods along the Straight Creek – I-70 Corridor",* by Daryl B. Simons of Colorado State University. The study attempted to determine effective methods of erosion control on the fill slopes using techniques such as the utilization of vegetation and flow control structures. This study provided background information on the Straight Creek watershed and identified erosion control measures that should be studied using test plots along the lower gradient fill slopes. The on-site test plots were implemented. In 1983, the Colorado Department of Highways developed a report to document the performance of the various features installed in the test sections.

In June, 1991 the Colorado Division of Wildlife completed its report, *Straight Creek, Summit County,* on the condition Straight Creek. The report summarizes the findings of a stream survey completed in November, 1989 to assess the impacts of nonpoint source pollution on the aquatic community of Straight Creek.

In 1992, an Environmental Assessment was completed for Straight Creek by the U.S. Forest Service. This resulted in a Finding of No Significant Impact (FONSI) in 1993. The results of the decision allowed for the construction of sediment ponds, access road completion, and other measures to help control the sedimentation from the slopes and the highway (USFS, 1993). The selected remedy (Alternative Three) and mitigation measures in the EA included:

- Construction of sediment basins
- Construction of new access road and reconstruction of existing roads
- Resource enhancement measures; and
- Providing recreational use along Straight Creek access road

The FONSI states that "This alternative will effectively resolve the current problems of increased sediment loading into Straight Creek, unregulated recreation use and resource damage to the existing road, and degraded water quality".

The Summit Water Quality Committee, in conjunction with the Straight Creek Clean-up Committee, commissioned an investigation with U.S. EPA funds in 1993 to quantify highway related sediment effects along the upper 5.7 miles of Straight Creek and to develop physically and biologically based metrics for monitoring the sedimentation (RCE, 1993). Although a final report was never completed due to a lack of sufficient funds, the preliminary investigations revealed in the draft report were:

1) Erosion of cut and fill slopes are primarily the result of ineffective surface runoff disposal
2) Approximately 2,000 cubic-yards per mile of relatively fine-grained sediment are stored within the pools in the stream channel and upstream of local base level controls

3) There are between 6,800 and 15,300 cubic-yards per mile of highway erosion and sanding-derived sediments in temporary storage sites on the valley floor
4) Current and past attempts to reduce highway related sediment delivery to Straight Creek will have little effect on Straight Creek Sediment loads as long as flows from the highway continue to traverse 20 years of accumulated valley floor sediments
5) In-stream metrics and criteria that could be used to monitor change include V* (% of pool volume filled with fine sediment), Ds (sediment sorting parameter), benthic macroinvertebrates (density, number of taxa, species diversity), and trout density and biomass.

In 1992, EPA provided a Section 319 Grant to undertake a demonstration project along the Straight Creek I-70 corridor to assess methods for capturing sediment at the source. This project was implemented along the cut slope of I-70 in which the ditch section was paved with asphalt and check dams were installed on the paved section. The check dams were created using a modified silt fence design. The results of this project indicated that the check dams were difficult to maintain and were not able to withstand the adverse weather conditions. However, the paving resulted in a very positive benefit since a paved shoulder allows for sweeping the ditch section of I-70. The other outcome of the project was the creation of the concrete weirs that were installed west of the Tunnel on the westbound lane. The findings of the Section 319 Project can be found in the final report for the project, *Straight Creek, Section 319 Grant Project Final Report*.

A plan was completed by CDOT in October 1993 concerning the maintenance of sediment ponds that were being designed and constructed for Straight Creek. This document, *Sediment Pond Maintenance-Straight Creek Erosion Control Project,* specified information to maintenance forces regarding pond sizes, locations, and inspection and clean-out frequency (CDOT, 1993).

In 1995, CDOT conducted an analysis on the efficiency of eleven sediment collection basins that had been constructed between the toe of fill and the stream channel. The report, *Efficiency of Sediment Basins* (CDOT, 1996), provides information about the amount of material captured by the basins and their efficiency in removing sediment from the highway runoff. The study resulted in the following conclusions:

1) It is estimated that 985 tons (730 cu-yds) of sand and sediment material are captured annually by the eleven sediment basins
2) The efficiency of the sediment basins was estimated based on sampling one pond during runoff events. The calculated TSS removal efficiency was determined to be 90.5%
3) It was determined that on an annual basis, a total of 1,088 tons (806 cu-yds) will enter the basins. Of this amount, 985 tons (730 cu-yds) will be intercepted and captured. An additional 103 tons will be conveyed through the basins to Straight Creek. In terms of pounds per acre of highway pavement, the estimated sediment capture rate was determined to be 88,300 lb/acre. Approximately 58,040 pounds per acre of sediment from the cut slopes would be captured annually by the basins
4) The maintenance clean-out cycles predicted during design were found to be reasonable, based on the survey information. However, clean-out cycles would have to be carefully monitored by maintenance

forces since some of the actual constructed volumes of the basins differ from the design volumes, the sand application rates vary from year to year and maintenance practices vary as well

5) An analysis of the size of the sediment in the basins was completed. For all rainfall simulation and snowmelt events, no material larger than 0.25 mm sieve left the basin
6) The total cost to construct the basins and the anticipated cost to construct the remainder of the access road was $864,980. Assuming a 25-year life for the basins, the unit cost to capture sediment material was estimated at $35/ton, excluding maintenance costs.

In June 2000, CDPHE completed a Total Maximum Daily Load (TMDL) analysis for Straight Creek (CDPHE, 2000). The TMDL report explains the rationale for the TMDL and discusses the long-term plan for Straight Creek. The plan includes surrogate measures, or water quality goal targets consisting of the following:

- Demonstrate an increase in the median particle size (D50) of sediment deposits in the stream to a target level of 60 mm
- Demonstrate a decrease in the average percentage of in-stream pool volume filled with fine sediment (V*) to a target level of 15%
- Make an assessment of changes in stream morphology using characteristics defined by Rosgen (1996) as a guide to qualitatively assess the morphological health of the stream
- Demonstrate the presence of five or more age classes of brook trout at all CDOW fish collection sites

The load allocations specific in the TMDL require implementation of the following BMP's:

- Revegetation of at least 70% of the cut and fill slopes to 70% potential cover
- Dredging and maintenance of the sediment basins, sediment control structures on the I-70 roadway
- Removal of at least 25 % of the traction sand material applied annually to I-70 between the Blue River and the Tunnel

In accordance with the TMDL, the Straight Creek Clean-up Committee is to meet on an annual basis to review progress made and data and information collected. A resolution regarding the TMDL was approved by the Transportation Commission in November 2000. At that time, the Commission also approved an extra $150,000 of maintenance funds to be used on the I-70 corridor for Straight Creek and Black Gore Creek.

In September 2000, CDOT began snowmelt/storm event water quality monitoring of the I-70 mountain corridor pursuant to a monitoring plan entitled I*nterstate 70 Mountain Corridor Runoff Event Baseline Water Quality Monitoring Plan* (CCC/JFSA, 2000). This program includes monitoring of Straight Creek near Silverthorne. A data summary report was prepared covering the 2000 monitoring efforts (CCC/JFSA, 2001). Water monitoring of the corridor continued in 2001 and a data evaluation report is being prepared. The monitoring program provides new data that did not exist prior to this SCAP.

2.4 STRAIGHT CREEK MONITORING

This section describes stream monitoring efforts undertaken for the Straight Creek watershed.

2.4.1 Past Stream Monitoring Efforts

Through the Straight Creek Clean-up Committee, efforts have been made to conduct stream sampling over the last ten years. The Forest Service provided personnel to conduct cross-sections and pebble counts to ascertain the biological condition of the stream. Other efforts have been made through qualitative methods, including photo documentation.

Monitoring of Straight Creek water quality has been conducted by the Denver Water Department who owns the water rights in Straight Creek. When the Straight Creek Clean-up Committee began, it was determined that both qualitative and quantitative methods should be used for documenting improvements over time in the basin. A USGS gaging station is located on Straight Creek near Silverthorne to monitor streamflow.

Ambient water quality monitoring was conducted by the Summit Water Quality Committee from 1985 to 1989 at the mouth of Straight Creek (SWQC, 1991). Results from this monitoring show mean concentrations of suspended solids ranging form 9 to 13 mg/l and total phosphorus ranging from 0.01 to 0.02 mg/l. These data indicate that suspended solids and phosphorus concentrations are typically low in Straight Creek under non-storm water runoff conditions.

In 1989, the Colorado Division of Wildlife (CDOW) assessed aquatic impacts in Straight Creek from sedimentation. Three sampling locations were chosen, with the uppermost sampling site (Station 1) located 4.7 miles upstream of the mouth of Straight Creek, Station 2 was located 2.9 miles upstream of the mouth of Straight Creek (just downstream of the confluence of Laskey Gulch), and Station 3 was located approximately 1 mile upstream of the Straight Creek confluence with the Blue River. Information regarding fish populations, macroinvertebrates, and physical habitat were collected at each station. Brook trout were the dominant fish species at all three sampling locations. The largest numbers of fish were collected at the lowermost station (Station 3). The fisheries data yielded the following information on trout numbers:

- Station 1 (9,880-ft elevation) – 9 brook, 1 cutthroat trout
- Station 2 (9,320-ft elevation) – 21 brook trout
- Station 3 (8,950-ft elevation) – 43 brook, 4 brown trout

A 1998 SWQC study concluded that urban development in the vicinity of Silverthorne causes mobilization of suspended solids, soluble phosphorous, and particulate phosphorous. Water samples were collected from Straight Creek above any urban development as well as at the mouth of Straight Creek. Suspended solids concentrations increased from urban development in 11 of 13 samples collected. The average total suspended solids increase through the urban area near the mouth of Straight Creek was 79 %

with a range of 8 to 375%. Total phosphorous concentrations increased from urban development in all 13 samples collected. The average total phosphorous increase through the urbanized area near the mouth of Straight Creek was 152%, with a range of 19 to 1,020%. The annual transport of total phosphorous increased by 52% within this area of Straight Creek (SWQC, 1999). Although I-70 is known to be a major nonpoint source of sediment above Dillon Valley, it is recognized that urban development in the valley also contributes to nonpoint source pollutant loading in Straight Creek.

In association with the TMDL in 1999, it was agreed that various stakeholders on the Straight Creek Clean-up Committee would undertake certain monitoring activities with regard to assessing stream health and further stream analysis was undertaken. During the fall of 1999, the CDOW again conducted a fish survey with the following results:

- Station 1 (9,880-ft elevation) – 3 brook trout
- Station 2 (9,600-ft) – 13 brook, 3 cutthroat trout
- Station 3 (8,950-ft) – 12 brook, 9 brown trout

This is provisional data from CDOW and no analysis or report is available. Routine fish sampling should continue on Straight Creek to monitor changes over time. A monitoring plan will need to be developed and as proposed in this SCAP.

2.4.2 CDOT I-70 Baseline Runoff Event Water Quality Monitoring

An I-70 runoff event baseline monitoring program was initiated by CDOT in conjunction with the I-70 PEIS in August 2000 (CCC/JFSA, 2000). The objective of the monitoring program is to develop baseline information to assess the effects of snowmelt and rainfall runoff associated with I-70 on receiving stream water quality. The monitoring program began on Straight Creek in September 2000 at the end of the runoff season, and was continued throughout the 2001 monitoring season from March to September. Results from the 2000 monitoring program are limited to one rainfall-runoff event and are provided in a data summary report (CCC/JFSA, 2001). A 2001 monitoring report is being prepared.

The monitoring season extends about seven months over the spring and summer along the I-70 corridor (March to September). Melting of the accumulated winter snowpack generates snowmelt runoff in spring, whereas monsoon moisture produces rainfall runoff in July and August each year. The I-70 storm water monitoring program utilized automated storm water sampling with following general components:

1) Assessment of I-70 runoff water quality affects to receiving streams using automated monitoring systems at selected locations throughout the I-70 mountain corridor
2) Highway culvert drainage automated monitoring stations representing rainfall-runoff from the paved surface, shoulder, and median of I-70; and
3) Snowmelt-event sampling representing runoff from the paved surface, shoulder, and median of I-70

As part of the CDOT I-70 baseline storm water event monitoring program, snowmelt and rainfall-runoff event water quality monitoring was conducted in Straight Creek in 2001. This monitoring station is located at the USGS gaging station near Silverthorne 1.8 miles upstream from the mouth (MP 207). Snowmelt samples were collected from the shoulder of I-70 (MP 209-211) in the Straight Creek corridor in April 2001. The constituents tested include suspended solids, magnesium, sodium, chloride, total and dissolved phosphorous, and the dissolved metals arsenic, copper, manganese, and zinc. Water quality results from the Straight Creek I-70 corridor runoff event/storm monitoring program are summarized in Table 2.

Table 2
Straight Creek above Silverthorne
Snowmelt/Storm Event Water Quality Data 2000-2001 (mg/l)

	Suspended Solids	Phosphorous Total	Chloride	Sodium Dissolved	Magnesium Dissolved	Copper Dissolved	Manganese Dissolved	Zinc Dissolved
Straight Creek Results								
No.Samples	46	43	46	38	37	35	35	35
Range	<5-860	<0.01-1.40	7.6-92	5-35	1.6-6.6	<0.002-0.002	<0.005-0.016	<0.005
Mean	116	0.09	35	17.6	3.9	<0.002	<0.005	<0.005
Std.Dev.	235	0.23	26	9.3	1.6	<0.002	<0.005	<0.005
I-70 Snowmelt Runoff MP 209-211								
No.Samples	3	3	3	3	3	3	3	3
Range	220-3,900	0.02-8.0	180-430	92-260	8.0-20	0.004	0.029-0.074	<0.005-0.006

The results of the stormwater monitoring program are preliminary since they reflect only one full monitoring season of data (2001). Additional data, obtained over several more years, are needed to more fully assess stormwater runoff quality along the Straight Creek I-70 corridor. However, the data obtained to date indicate a large variation in water quality constituent concentrations. For many of the constituents tested, the sample standard deviation was close to or greater than the mean, suggesting that the effects of I-70 runoff on Straight Creek water quality can be significant under certain conditions.

I-70 Runoff Water Quality Results (shoulders and median)

Preliminary 2001 results show that suspended solids concentrations in highway snowmelt runoff from the I-70 shoulders and median ranged from 220 to 3,900 mg/l, while total phosphorous ranged from 0.02 to 8.0 mg/l (see Table 2). There was a positive correlation between suspended sediment and total phosphorous, indicating that phosphorous is associated with particulate material. The higher concentrations were associated with road sand transported in runoff. Comparisons of the preliminary I-70 runoff sampling results with those reported for urban highways show that the Straight Creek I-70 corridor has greater than average suspended solids and total phosphorous concentrations (FHWA, 1996).

Highway snowmelt-runoff sample results indicate elevated chloride concentrations (430 mg/l) in I-70 runoff to Straight Creek. Sand containing 5% salt (NaCl) is applied to I-70 as a treatment to maintain mobility during winter. The higher sodium-chloride concentrations were likely associated with the road sand/salt mixture that accumulates along the shoulders and median of I-70 and is transported in runoff. Although liquid magnesium-chloride deicer is used in certain areas of the I-70 corridor, data show that highway runoff water chemistry in the Straight Creek corridor is dominated by sodium-chloride. The availability of these constituents for transport in runoff is the likely result of the average application of over 1,200 tons of sand/salt mixture per mile in the Straight Creek I-70 corridor during each winter season (see Table 1).

Straight Creek Water Quality Results

Preliminary 2000-2001 results indicate low or non-detectable dissolved trace metal concentrations in Straight Creek during snowmelt or rainfall runoff event conditions (see Table 2). No exceedences of water quality standards for trace metals were measured for the 35 samples collected in Straight Creek (see Table 2). Neither dissolved arsenic or zinc were detected in runoff samples. Low concentrations of dissolved copper and manganese were detected that could be related to natural geologic sources or I-70 runoff.

The 2001 streamflow hydrograph for Straight Creek is plotted in Figure 6, along with conductivity. These data show an inverse relationship between flow and conductivity. Conductivity is an indicator of dissolved solids including sodium-chloride. During early spring (April) when streamflow is low, conductivity values are high. Significant dilution takes place in May and June as flow volumes increase, resulting in lower conductivity. Conductivity increased slightly in July following peak flows but remained low to moderate through the summer. Rainfall events in July 2001 produced runoff with elevated suspended solids as discussed below.

Sodium and chloride concentrations in Straight Creek show the same temporal trend as conductivity, and storm water quality results indicate a positive correlation between conductivity and sodium-chloride concentrations. The maximum chloride concentration measured in Straight Creek during 2001 was 92 mg/l, which is lower than the drinking water standard of 250 mg/l. Ambient water quality data for chloride collected at the mouth of Straight Creek between 1985 and 1989 show mean concentrations ranging from 4 to 16 mg/l (SWQC, 1991). The maximum mean chloride concentration measured in the SWQC study (16 mg/l) was less than 50 percent of the average, and less than 20 percent of the maximum chloride concentration measured in Straight Creek storm water runoff samples in 2001. These data indicate that the majority of chloride associated with I-70 is transported during snowmelt and rainfall-runoff conditions.

An estimated 3,000 tons of traction sand is delivered to Straight Creek each year through the primary mechanisms of snowmelt and rainfall runoff, and highway maintenance/snow removal, resulting in elevated suspended solids concentrations under certain conditions. Suspended solids results from the 2000-2001 storm water/snowmelt event sample from Straight Creek show a mean concentration of 116 mg/l with a standard deviation of 235 mg/l. The large deviation indicates highly variable water quality conditions associated with runoff events, where results show suspended solids concentrations ranging from less than 5 to 860 mg/l in Straight Creek (see Figure 6). It should be noted that this monitoring station is downstream from a large wetlands complex that may serve as a sediment trap, and therefore suspended solids concentrations may be greater upstream.

2.4.1 Stream Monitoring Data Needs

The implementation of source controls in this corridor is not dependant on water quality or biological monitoring results. Source controls are necessary regardless of the condition of the stream. Once additional source controls are in place along the corridor, the stream condition should improve significantly. However, additional baseline information is required to adequately characterize the aquatic biological and water quality attributes of Straight Creek. Monitoring of suspended solids (TSS) for in-stream improvements before and after source controls are implemented is necessary to determine BMP effectiveness and to assess stream conditions and improvements over time. Other research needs may include stream physical and aquatic biological parameters. CDOT's continued participation in a stream monitoring program for Straight Creek to collect data related to sedimentation is useful and necessary. An overall stream monitoring program will be further developed as a separate plan with the basic components described below.

Baseline Stream Monitoring

A continuation of the current CDOT baseline runoff event water quality monitoring program is proposed as part of this SCAP to establish baseline sediment and salt loading conditions to Zone 3 of the Straight Creek I-70 corridor prior to implementation of the proposed BMP's. Baseline information is required to measure the future effects of sediment control BMP's. Additional baseline information is also necessary to adequately characterize the aquatic biological attributes of Straight Creek including fish populations, macroinvertebrates, and habitat conditions. These data can be used to assess the overall biological health of Straight Creek and to direct any future efforts toward improvements.

The baseline stream monitoring program would incorporate the existing baseline event water quality monitoring and the appropriate sediment deposition or habitat metrics and aquatic biological components identified in the TMDL to provide the following data and information about Straight Creek:

- Obtain baseline highway-related water quality data for the Straight Creek area
- Establish background sediment loading conditions for the Straight Creek watershed
- Evaluate the effects and trends of winter maintenance and chemical use (e.g. salt/sand and liquid deicers) on Straight Creek water quality
- Characterize the principal aquatic biological components and overall health of Straight Creek
- Identify data needs or deficiencies, including sediment deposition and biological components
- Provide a baseline for future I-70 construction or improvement alternatives
- Contribute to the efforts of the Straight Creek Cleanup Committee to monitor and evaluate stream conditions

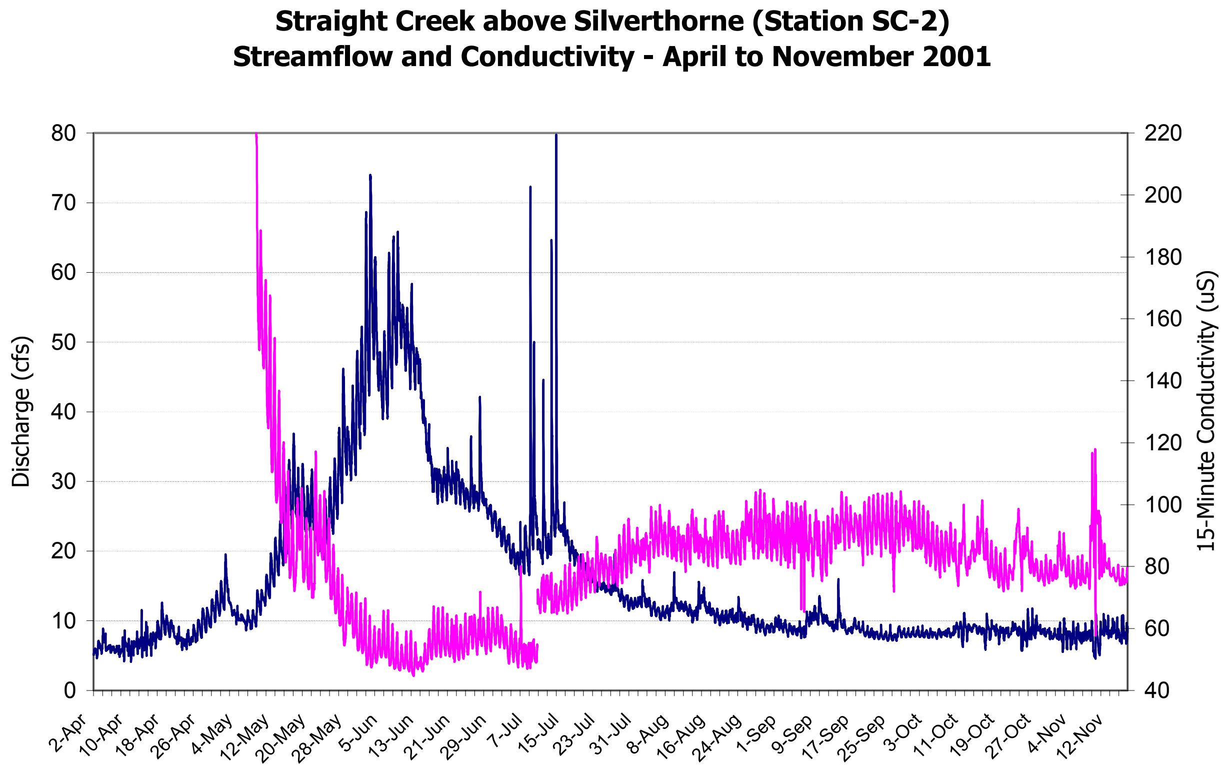
Long-Term Stream Monitoring of Sediment Control BMP Effectiveness

In order to assess BMP effectiveness, a long term stream monitoring program is needed. Because of the extensive deposits of sediment material in the Straight Creek corridor (Zones 2 and 3), it will take time to measure improvements in water quality. However, if source controls are fully implemented, the annual transport and deposition of sediment to Straight Creek will be largely eliminated. Once the annual sediment source is controlled, areas will begin to stabilize and improvements in the stream system can be effectively measured through a carefully executed monitoring program. The following information would be derived from the long-term stream monitoring program:

- Monitor and evaluate the effectiveness of BMP's and improving trends
- Evaluate the effects and trends of winter maintenance and materials use (e.g. salt/sand and liquid deicers) on Straight Creek water quality
- Provide the data necessary for strategy and management decisions regarding Straight Creek water quality and aquatic resource protection

In order to assess sediment control BMP effectiveness for example, a water quality monitoring program has been initiated on Hoop Creek near Berthoud Pass. CDOT has been conducting water quality monitoring in Hoop Creek associated with implementation of sediment control BMP's on U.S. Highway 40. Preliminary results suggest a decrease in suspended sediment load in this basin. Suspended sediment concentration data are also used to track changes in total phosphorous concentrations associated with the sediment. Dissolved solids related to the use of road salt are also monitored to assess the affects of winter highway maintenance practices.

The long-term stream monitoring program for Straight Creek would include both storm event water quality and biological monitoring components, and incorporate the appropriate monitoring requirements of the TMDL. These components should be integrated into a monitoring plan that specifies the objectives, scope of work, methodology, and reporting requirements. The parties responsible for conducting the various aspects of the monitoring program would be defined, and costs for implementing the program would need to be determined.


Straight Creek above Silverthorne (Station SC-2)
Streamflow and Conductivity - April to November 2001
Discharge (cfs)
15-Minute Conductivity (uS)
0
10
20
30
40
50
60
70
80
40
60
80
100
120
140
160
180
200
220
2-Apr
10-Apr
18-Apr
26-Apr
4-May
12-May
20-May
28-May
5-Jun
13-Jun
21-Jun
29-Jun
7-Jul
15-Jul
23-Jul
31-Jul
8-Aug
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27-Oct
4-Nov
12-Nov

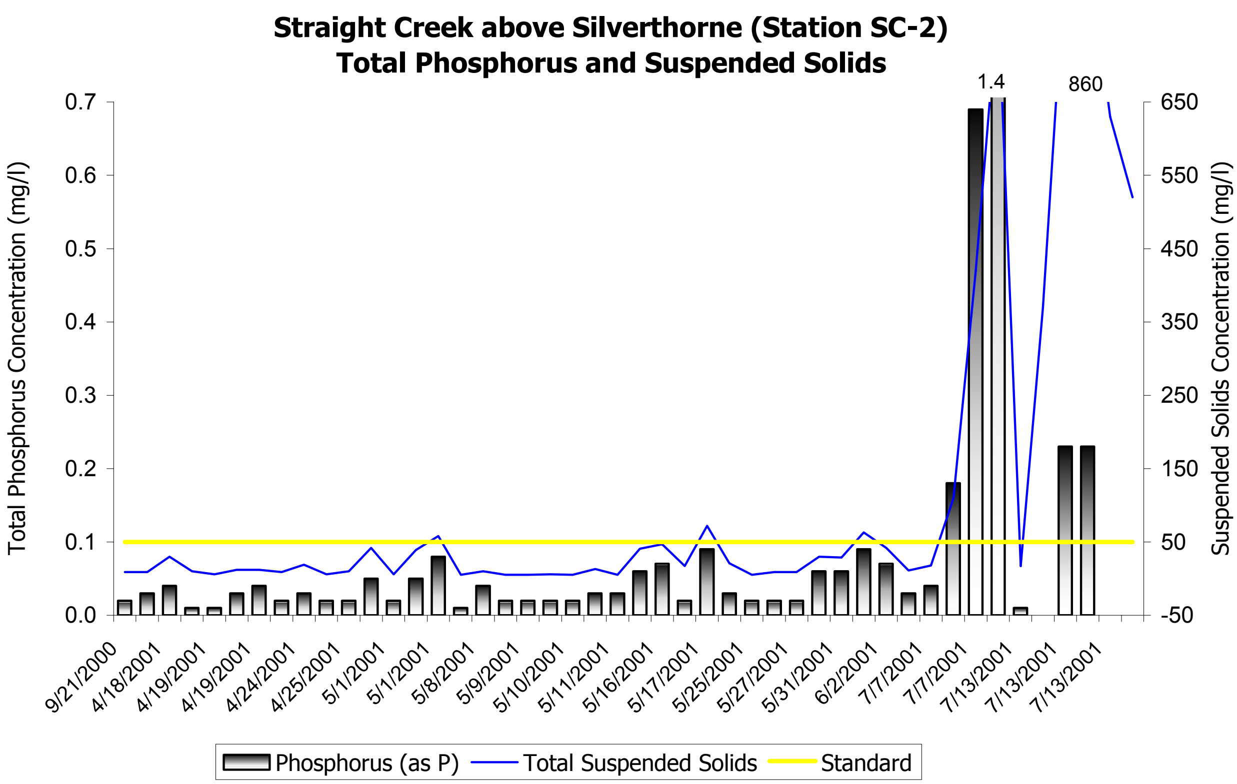
Straight Creek above Silverthorne (Station SC-2)
Total Phosphorus and Suspended Solids
Total Phosphorus Concentration (mg/l)
Suspended Solids Concentration (mg/l)
1.4
860
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
-50
50
150
250
350
450
550
650
9/21/2000
4/18/2001
4/19/2001
4/19/2001
4/24/2001
4/25/2001
5/1/2001
5/1/2001
5/8/2001
5/9/2001
5/10/2001
5/11/2001
5/16/2001
5/17/2001
5/25/2001
5/27/2001
5/31/2001
6/2/2001
7/7/2001
7/7/2001
7/13/2001
7/13/2001
7/13/2001
Phosphorus (as P)
Total Suspended Solids
Standard

FIGURE 6

2.5 RECONNAISSANCE AND MAPPING

A reconnaissance of the Straight Creek section of I-70 was conducted in 2001 as part of this SCAP to assess sedimentation conditions and to identify potential locations for sediment control structures and drainage improvements along I-70. Winter maintenance practices were also evaluated during several reconnaissance visits to the area in 2000-2001. The reconnaissance was integrated with the CDOT storm water monitoring program in which snowmelt and rainfall runoff conditions were monitored during 2000-2001.

Detailed field notes and photo documentation of conditions along I-70 were taken as part of the 2001 reconnaissance efforts. Inspection of the condition and ground-truthing of all existing sediment basins and appurtenances was conducted. The reconnaissance included the lower portion of Straight Creek below Hamilton Box where sediment control treatments have not yet been installed. Potential control measures were evaluated primarily based on past CDOT experience in Straight Creek and Berthoud Pass. Several interviews and site visits with CDOT maintenance personnel and engineers involved with previous sediment control projects on high elevation highways in Colorado were conducted. Involvement and participation in meetings and activities covering issues undertaken by the Straight Creek Cleanup Committee and CDOT also provided valuable information for the development of this SCAP. The following general observations were made during the reconnaissance visits and monitoring in the Straight Creek I-70 corridor:

- Cutslopes on the uphill side of I-70 are generally steeper than original slopes in order to construct a flat roadbed. This has resulted in accelerated slope erosion in some areas.
- Fillslopes below the road prism primarily consist of the materials removed from cutslopes, and are generally steeper than the original slopes.
- The eastbound and westbound lanes are often grade-separated to reduce cutslope and fillslope angles.
- Drainage is primarily to the outside shoulder in each direction, except on curves where the highway is super-elevated for high-speed traffic safety.
- Runoff from the cutslopes, median, and highway generally drains into ditches and through cross culverts to Straight Creek.
- New culvert rundowns have been installed at several locations above Hamilton Box, resulting in elimination of severe gully erosion on fillslopes
- Sediment basins have been installed at the toe of the fillslope at several locations above the Hamilton Box.
- Many of the existing sediment basins were full of traction sand with large dead storage areas, indicating the hydraulic loading capacity of the basins was exceeded.
- In areas of the I-70 corridor below the Hamilton Box, large active deposits of traction sand were encountered.

- In sections where a Type 4 (Jersey) barrier, guardrail, or curb and gutter is adjacent to the edge of pavement, runoff water concentrates and reports at the end of the feature, causing severe fillslope gully erosion.
- Excess snow/sand material is moved long distances (greater than 30 feet) from the edge of highway with heavy equipment to maintain ample storage capacity along I-70 in the upper portion of Straight Creek. This material is wasted in forested areas, meadows, and over fillslopes.
- Culvert inlets are plugged with excessive sediment in certain shoulder and median areas.
- Sheet flow from the paved surfaces of the highway generates rill erosion of the sand accumulated on the unpaved shoulders.
- The used road sand particle size and shape result in high mobility and transport on the generally steep gradients found in the Straight Creek I-70 corridor.

Based on the site reconnaissance, a narrative description of proposed sediment control measures has been developed according to milepost for both the westbound and eastbound directions of I-70. These results cover milepost 213.5 (Tunnel) to 206.5 (Silverthorne), beginning at the Eisenhower Tunnel and continuing in a westerly direction to Silverthorne. Descriptions of the proposed treatments are provided in Appendix A. Appendixes A-1 and A-2 provide photo documentation from the Tunnel to Silverthorne for the eastbound and westbound lanes of I-70, respectively.

Current drawings or maps for the Straight Creek valley floor are limited. The only recent drawings found were CADD-based for the I-70 template in the Straight Creek corridor. No maps or as-built drawings of the existing sediment basin locations are available. Fortunately, the CADD drawings for the I-70 template area are relatively accurate and these drawings were used to map the Straight Creek sediment control features discussed in this document. Several scales were evaluated to determine the optimum resolution and coverage for the SCAP, resulting in a set of 14, 1:200 scale maps that are provided in Appendix B.

The mileposts (MP) indicated on these maps are based on external references and do not necessarily reflect the same milepost markers found along the highway. The highway reference markers may have changed since construction, whereas the computer-generated points on the maps are accurate depictions of the relative distances. These maps show the cutslope treatments with a green line and fillslope treatments with an orange or purple line. Sediment basins are scaled and shown as rectangles and below-grade sediment traps are shown as green cross-hatched lines. Clean tributary flows are shown in blue with inlets as open squares. Culvert rundowns are shown in red with inlets as open squares.

Future land surveys will be required as specific projects are undertaken to construct permanent BMP's along the corridor.

STRAIGHT CREEK CHRONOLOGY
I-70 RELATED ACTIVITIES

1963 - First construction contracts awarded to provide access roads to construct the west portal of the Eisenhower Tunnel.

1968 - Construction began of the first bore of Eisenhower Tunnel. Laskey Gulch was rechannlized and diverted to the Town of Dillon water supply intake on Straight Creek. A sediment pond was constructed at Hamilton Gulch.

1972 - Earthwork on four major slides was conducted prior to paving I-70.

1973 - I-70 opened to traffic. Disturbed areas were seeded and trees were planted.

1974 - Environmental Impact Statement was completed for the second bore of the Eisenhower Tunnel.

1979 - Colorado State University Research Institute experimental study and evaluation of fill slope erosion control methods. Recommendations included use of soil retention blankets, a higher percentage of native/integrated plant species and hand-planted shrubs, installation of sediment collection devices to determine effectiveness of treatment with cleanout twice each year after snowmelt and before snowfall.

- CDOT initiates first fill slope erosion control project. The project utilized test sections incorporating paved shoulders with Type 4 (Jersey) barrier, valley pan gutter, timber erosion checks, and integrated drainage pipes and sediment collection facilities.
- Construction of two truck escape ramps and spill detention ponds for retaining oil or chemical spills.
- Second bore of Eisenhower Tunnel opened to traffic.

1985 - Second erosion control project consisting of channelizing drainage ditches and piping runoff to bottom of fill slopes. Sediment ponds may be constructed in the future, requiring an access road.

1990 - U.S. Forest Service study indicates that the revegetation experimental plots and other erosion control measures near the parking and turn around area had been relatively successful. However, fish habitat in Straight Creek had been eliminated between the Tunnel and Silverthorne. The fill slope between the Hamilton Box and Tunnel was severely eroding, and all of the sediment traps had filled and no attempt had been made to clean them out. The FS recommendation was for CDOT to take more aggressive action to clean up the excess sand and gravel between snow storms and in the spring, and sand should not be dumped over the side indiscriminately because of the adverse effects on the vegetation and the stream. An Environmental Assessment - Straight Creek Watershed Improvement was started.

1991 - Colorado Division of Wildlife stream survey report recommending completion of the revegetation program begun in 1979, construction of basins, culverts, sand traps, sediment ponds to collect sand, and curtailing the use of salt and sand. The use of machinery to remove sediment from Straight Creek would likely cause more damage, so explore the use of limited manual removal coupled with letting nature repair the damage.

- Straight Creek Cleanup Committee created to act as a sounding board of community issues related to the Straight Creek Watershed Improvement Project.

1992 - EPA provided a Section 319 Grant to undertake a demonstration project along the Straight Creek I-70 corridor to assess methods for capturing sediment at the source. This project was implemented along the cut slope of I-70 in which the ditch section was paved with asphalt and check dams were installed on the paved section.

1993 - U.S. Forest Service issues a Finding of No Significant Impact following an Environmental Assessment - Straight Creek Watershed Improvement Project. The FONSI selected Alternative Three with associated mitigation measures consisting of potential construction of 42 sediment ponds, 2.3 miles of new access road and 4.1 miles of reconstruction the existing access road, recreational resource enhancement providing public access along Straight Creek road.

- Special-Use Permit FS-2700-4 (7/93) issued by the U.S. Forest Service covering the potential construction of 42 sediment ponds and 6.4 miles of road within Straight Creek watershed. This permit specifies requirements for the construction season, maintenance, removal and planting of vegetation, and dam safety evaluations. The permit will expire at midnight on June 12, 2015.
- Straight Creek sedimentation investigation completed by Resource Consultants & Engineers, Inc. This study developed physically and biologically based metrics for monitoring the accelerated sedimentation of Straight Creek, and concluded that there will be no reduction in sediment yields in the short term as a result of the current erosion control measures implemented by CDOT.
- CDOT begins access road construction and installation of sediment ponds.

1994 - CDOT Enhancement Funds totaling $2,000,000 approved for Straight Creek Erosion Control Project in response to the EA requirements.

- CDOT completes installation of 13 sediment ponds as part of the Straight Creek Erosion Control Project. All of the ponds except one were constructed near the toe of the I-70 fill slope within the upper 2.5 miles of Straight Creek between Hamilton Box and the Eisenhower Tunnel. Concrete valley pan drains and culvert rundowns were installed on the I-70 template in the upper corridor to control drainage to the basins. Approximately 50 acres of fill slope were seeded and mulched.
- CDOT begins research study to determine efficiency of the sediment basins.

1996 - CDOT research report completed analyzing the efficiency of eleven sediment basins constructed as part of the Straight Creek Erosion Control Project. This research concluded that 985 tons (about 10 percent of the average annual traction sand usage) was captured annually by the eleven sediment basins, and sediment basin removal efficiency was 90.5 percent.

1998 - Straight Creek is identified as a water quality limited segment because of documented impairments to both habitat and aquatic life from sediment deposition, and is placed on the Colorado Water Quality Control Commission 303(d) list for sediment Total Maximum Daily Load development.

2000 - Colorado Water Quality Control Division issues Total Maximum Daily Load Assessment for Straight Creek. The TMDL specifies sediment control BMP requirements including 1) the revegetation of at least 70 percent of the I-70 cut and fill slopes to 70 percent potential cover, 2) cleaning and maintenance of the 12 sedimentation basins, holding pond above the Town of Dillon drinking water diversion structure, and sediment control structures on the highway, and 3) removal of at least 25 percent of the traction sand applied annually to the I-70 Straight Creek corridor.

2001 - The Straight Creek Erosion Control Project continued in 2000 and 2001 with 107 acres of seeding and mulching on cut and fill slopes, planting with 1,000 tree tublings, and highway cleaning of 5,530 cu-yds (7,466 tons) of sand and sediment for construction of sound berms and disposal areas at the base near Silverthorne. This project nearly completes the initial revegetation efforts for I-70 slopes in the Straight Creek corridor. Approximately 2,000 linear feet of asphalt ditch paving was also accomplished to reduce erosion and provide a surface for sweeping.

3.0 ENVIRONMENTAL CONSIDERATIONS AND REQUIREMENTS

This section provides a summary of relevant water quality regulations and environmental requirements.

3.1 WATER QUALITY REGULATIONS

Under the Federal Clean Water Act of 1977 (CWA), and the Colorado Water Quality Control Act (CWQCA), Colorado has instituted various programs to protect state surface waters. Water quality standards and classifications have been developed by the Colorado Water Quality Control Commission (WQCC) and are implemented by the Water Quality Control Division of the Colorado Department of Public Heath and Environment (CDPHE).

Pollutants that affect water resources are divided into point and nonpoint sources of pollution. Water resources may include public water supplies, fisheries, wetlands, recreational uses, wildlife, aquatic habitat, and other functions of the stream system. Pollutants from point and nonpoint sources can include nutrients, sediments, salts, pesticides, acid mine drainage, toxic waste, herbicides, fertilizers, petroleum and many other forms of pollutants. Point sources are direct discharges to a water body from a single source such as water treatment plants or industrial facilities. Nonpoint sources originate from diffuse sources of pollutions such as urbanization, agriculture, mining, roadways, and construction sites. Point sources are regulated under the CWA, whereas nonpoint sources remain largely unregulated.

In the Straight Creek I-70 corridor, it is recognized that the primary pollutant of concern is sediment that originates from I-70 cut and fill slopes and the sand/salt mixture applied during winter maintenance operations. Although there are natural background sediment sources, there are essentially no other major anthropogenic sources of sediment loading to Straight Creek other than I-70. To date, sediment loading above natural background levels has been occurring since operations began on I-70 without adequate source control, although various measures have been implemented in the Straight Creek basin on a voluntary basis by CDOT and the USFS under the state's nonpoint source program.

In Colorado, there are currently no numeric standards for sediment, but narrative standards do apply as follows (WQCC, 1999b): "state surface waters shall be free from substances attributable to human-caused point source or nonpoint source discharge in amounts, concentrations or combinations which: "can settle to form bottom deposits detrimental to the beneficial uses. Depositions are stream bottom buildup of materials which include but are not limited to anaerobic sludges, mine slurry or tailings, silt or mud" (Reg. No. 31, 31.1.1(1)(a)(I)). To help address this, the state has developed the "Provisional Implementation Guidance for Determining Sediment Deposition Impacts to Aquatic Life in Streams and Rivers (WQCC 1998a). This guidance requires that both habitat and aquatic life must be demonstrated to be impaired before a stream is considered impaired by sediment.

The WQCD has documented impairments to both habitat and aquatic life of Straight Creek related to sediment deposition. Due to the impairment of Straight Creek, it was placed on the State's list of impaired waters in 1998, under provisions of Section 303(d) of the CWA as unable to support designated stream uses. Under Section 303(d), the state is required to identify stream segments not meeting water quality standards and those streams are placed on the 303(d) list. Once listed, a Total Maximum Daily Load (TMDL) is developed for that stream segment. A TMDL is part of a plan to address water quality problems and identifies the action needed to restore and protect the water resource. An assessment of the ongoing cleanup efforts was conducted and additional goals were established for improving Straight Creek. In June 2000, a TMDL for sediment was approved by EPA and finalized for Straight Creek.

3.1.1 Best Management Practices (BMP's) for Nonpoint Source Control

Under the CWA, BMP's are measures used to address nonpoint sources of pollution. BMP's are essentially structural or nonstructural measures undertaken to help reduce or prevent the pollution of surface waters. In the case of highway construction and operation, BMP's include maintenance practices as well as measures for the control of erosion and sedimentation, and for the treatment of stormwater runoff. Structural BMP's are those that require construction of a specific measure, such as a sediment trap or detention basin. Nonstructural BMP's do not typically require construction; for example, revegetation and maintenance training programs.

BMP's are divided into temporary and permanent. Temporary BMP's are used to control erosion and runoff during construction activities. Permanent BMP's are implemented for use after construction activities are completed. This SCAP identifies additional permanent BMP's that can potentially be implemented along the Straight Creek I-70 corridor to control sediment transport. These include sediment basins and revegetation efforts, for example.

When used for sediment control, BMP's also have the added potential of capturing highway runoff. Quantification of highway runoff, or nonpoint source pollution loads, is not a routine activity within highway planning and design procedures at this time. Highway runoff is difficult to assess since it can contain various pollutants from a variety of sources. However, since runoff can contain residual chemicals left behind on the roadway, it is believed that some of this material can potentially be captured and properly disposed of along with the sediment material.

This SCAP develops an analysis and recommendation of BMP's that can be utilized to directly address sedimentation. Retrofitting BMP's along a highway corridor is expensive and challenging, particularly in the mountainous environment.

3.2 CDOT Environmental Process

Within the CDOT process of developing projects, environmental clearances are required to comply with the National Environmental Policy Act (NEPA) and are completed during the project design phase. These clearances may include hazardous waste, water quality, wetlands, Threatened & Endangered Species (T&E), history, archaeology, and others. Any construction work conducted by CDOT has to be approved by the Federal Highway Administration (FHWA). Appropriate permits are obtained prior to construction.

It is recognized that implementation of any portion of the SCAP would benefit the Straight Creek I-70 corridor. In developing this SCAP, certain environmental issues have been identified which will require additional coordination with the appropriate agencies include:

1) NEPA documentation
2) Wildlife and threatened & endangered species issue consultations
3) Aesthetic values
4) Wetland & riparian area identification
5) Remediation of valley and stream/water body corridors

3.3 NEPA DOCUMENTATION

Within the Straight Creek I-70 corridor the level of NEPA requirements will be determined in consultation with the Forest Service and FHWA prior to design and construction of BMP measures. There are specific NEPA requirements for "federal actions" and some of the likely treatment locations are outside the I-70 easement on National Forest Service land. NEPA will need to be satisfied prior to design and construction of some proposed BMP measures. Other BMP's, especially those within the immediate travel corridor, may not require NEPA evaluation. The level of documentation will not be known until the detailed scope of projects is clearly identified.

Environmental documentation is generally not required for routine maintenance work along I-70. Many of the proposed non-structural BMP's will fall into this category. CDOT and Forest Service officials are coordinating to make these determinations on a case-by-case basis.

In the Straight Creek watershed, an EA was completed in 1992 by the U.S. Forest Service, for the S*traight Creek Watershed Improvements Project,* to address sediment and erosion control treatments for I-70 within the Straight Creek corridor. A Decision Notice and Finding of No Significant Impact (FONSI) was completed in 1993 specifying a reclamation alternative and mitigation measures for sedimentation caused by I-70. The selected remedy (Alternative Three) and mitigation measures in the EA included the following:

- Construction of sediment basins
- Completion of an access road to construct and maintain the sediment ponds
- Resource enhancement measures; and
- Providing recreational use along the Straight Creek access road

The EA for Straight Creek stressed the need for the implementation of source control measures. The FONSI states that, "This alternative will effectively resolve the current problems of increased sediment loading into Straight Creek, unregulated recreation use and resource damage to the existing road and degraded water quality." It is not known at this time if the Straight Creek EA will need to be supplemented if the SCAP is implemented.

3.4 WILDLIFE AND THREATENED & ENDANGERED (T&E) SPECIES

Wildlife and T&E species issues have been identified, prompting initial discussions with the US Fish & Wildlife Service (USF&W) regarding the implementation of the SCAP and it's potential impacts on wildlife. The lynx is a known T&E species in the area of Straight Creek and at least one kill on I-70 has been recorded. The boreal toad may also be an issue within the I-70 corridor.

The level of environmental documentation that may be required for the protection of T&E species will be determined with the USF&W prior to implementation of BMP's. Further discussions with the USF&W, Colorado Division of Wildlife, and U.S. Forest Service pertaining to wildlife and T&E will be required prior to project implementation in the corridor.

3.5 AESTHETIC VALUES, WETLAND & RIPARIAN AREAS

Other environmental concerns, such as aesthetic values, must also be considered. The Straight Creek I-70 corridor is located in a scenic area where aesthetic values are important. The U.S. Forest Service and other interested parties will be consulted regarding this matter prior to implementation of projects. Additionally, clearances will be needed for any potential wetland impacts, tree removal, or disturbance of riparian or other natural areas. Permits, such as Section 404 and 402 permits, will be determined on a project-specific basis before construction activities commence. CDOT coordinates the permitting process with the appropriate regulatory agencies.

3.6 CDOT EXPERIENCE WITH THE STRAIGHT CREEK I-70 CORRIDOR

The strategy used on the Straight Creek I-70 corridor over the last ten years has been to gain control of the sediment loading to the extent possible with the limited funding. Any available funding has gone towards addressing the problem and not with additional studies or monitoring efforts. It is acknowledged that Straight Creek may never again be a pristine mountain stream; however, the stream will support a fishery. Improvements will occur when adequate structural controls, including slope repair and revegetation, are implemented to further address the sedimentation problem.

Within the Straight Creek Valley, only minimal attempts have been made to address the inundation of sediment material into the riparian and wetland areas. It has long been the strategy within this corridor to undertake restoration projects in the natural environment only where feasible and practicable. The philosophy being that over time, the riparian zone will repair itself as sediment deposition stabilizes and as the stream moves the remaining sediment through the system. It has been acknowledged by natural resource experts that more harm could be done to the riparian zone and stream by undertaking extensive clean-up efforts, and that the stream system will recover when adequate source controls are implemented.

Although this strategy takes a long period to achieve, it is thought to be the better alternative in the end to protect the natural environment.

In the Straight Creek corridor, any projects undertaken beyond Zone 1 have been coordinated with and approved by the Forest Service. Certain site-specific projects have been undertaken by the Forest Service and CDOT within the Straight Creek Valley to re-establish wetland areas and undertake wetland restoration projects.

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.
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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 7). Engineering Regions 1 and 3 boundaries meet at the Vail Pass summit.

Maintenance Sections 5 (Straight Creek) and 9 (Eisenhower Tunnel) are included within Region 1 (Figure 8). Maintenance Section 5 includes Summit County and extends westward to East Vail Interchange. The Eisenhower Tunnel 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 Foreman Area maintains all of the state highways within Summit County, and a significant portion of state highways in Clear Creek, Grand, and Eagle Counties, including I-70 from Idaho Springs to East Vail, Berthoud Pass (SH 40) from Empire Junction to Winter Park, SH 9 south of Breckenridge to the Grand County Line, and Loveland Pass (US 6).

4.1 PAUL FOREMAN AREA

The Paul Foreman Area is divided into work groups called patrols. These patrols perform maintenance on specific roadway sections in the Paul Area. This includes Patrol 43 from the west portal of the Eisenhower Tunnel to Officer's Gulch, including the Straight Creek portion of the I-70 corridor.

When fully staffed, the Paul Area has 38 full-time maintenance workers (FTE), 3 supervisors, 1 heavy equipment operator and 4 heavy equipment mechanics. In the winter months, 38 part-time workers (PPTs) are hired to assists for winter maintenance operations. 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.

4.2 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 rate 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. 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:

Traffic Services: installation, maintenance and installation of signs, maintenance and installation of guardrail, 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 Maintenance Management System (MMS) is used statewide by each CDOT Region. The MMS 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 BMP's, 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, guard rail cleaning, 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 FY2000, 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, are not funded or accounted for within the current system. 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 additional burden on their already taxed resources to address these relatively new environmental concerns, which is additional labor intensive work that requires specialty equipment and is expensive.

CDOT is receiving considerable pressure to increase the level of sediment control and cleanup, particularly in these two segments of the I-70 mountain corridor, but in others as well. Within the Paul 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 TMDL on Straight 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. The shoulder and ditch cleaning, and rock removal are performed primarily during May, June and September. The 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 $150,000 for maintenance to conduct sediment related clean-up activities. The funds were split between both the Black Gore Creek and Straight Creek I-70 corridors. Although this additional funding certainly has helped, it is inadequate to address the problem on an annual basis. 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 Black Gore Creek. Berthoud Pass is 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.

Due to the cap on FTE's in the Department, maintenance cannot hire additional front-line personnel to perform additional tasks. 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.

Staffing levels for front-line maintenance employees have basically remained the same since the number of allowable FTEs was reduced in the mid-1980's. Historically, the FTE count was augmented during the winter months with temporary help. However, these workers were not covered by state benefits and were paid hourly, making it difficult to retain adequate temporary help. By 1995, it became necessary for the Department to take extreme measures to hire maintenance workers to work during the winter months in the high country. In order to attract seasonal workers, temporary positions were converted to permanent part-time (PPT) positions and paid on adjusted high-cost pay. A PPT is ½ of an FTE and is fully covered by all state personnel rules applicable to full time employees.

This effort helped alleviate the immediate staffing shortages, but did not solve the problem during the winter months. By FY 2000, many maintenance positions remained vacant. At that time, some of the PPT positions were converted to FTE positions in order to find workers. Since maintenance has a cap on allowable FTE's, an exchange was made of two PPT positions for every one FTE. Now, instead of having two plow drivers to plow Vail Pass or Straight Creek on a cold snowy winter night, there is now only one. However, this FTE now works year round and is available during the summer months.

In order to accomplish what is being requested of maintenance forces during the summer months to clean-up sediment material, maintain BMP's, 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. Sediment control needs to become as high a 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.

FIGURE 7
CDOT TRANSPORTATION REGIONS

FIGURE 8
CDOT MAINTENANCE SECTIONS

5.0 BMP DESIGN ANALYSIS FOR SEDIMENT CONTROL

This section develops the basis for sediment source identification, volume estimates, control strategies, preliminary hydraulic and drainage analysis, proposed structural and nonstructural BMP design, and proposed maintenance program requirements for the Straight Creek I-70 corridor. The BMP's proposed in this SCAP were developed largely on previous CDOT experience and research in implementing BMP's at high altitudes. It is important to consider 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.

Between 1992 and 1993 a project was initiated by CDOT, using Federal Enhancement Funds, to construct sediment basins, reconstruct the access road in the Straight Creek Valley, install new culvert rundowns, and initiate revegetation efforts on the cut and fill slopes. At that time, eleven sediment basins were constructed at the toe of the I-70 fill slope. Ten of the basins were located in the upper portion of the Straight Creek corridor between the Tunnel and the Hamilton Box (2.5 miles). One basin was located in the lower portion of the Straight Creek corridor west of the Hamilton Box. Concrete valley pan drains and culvert rundowns were installed in the upper Straight Creek I-70 corridor to reduce erosion and to direct highway drainage to the basins. Approximately fifty acres of fill slopes were revegetated. A sediment pond maintenance plan was developed that specified pond sizes, locations and inspection and dredging frequencies.

Other projects have been undertaken since 1994, primarily to complete the revegetation of the fill slopes. Some experimental revegetation efforts were undertaken on the fill slopes to identify treatments that would be most effective. Stabilization of the cut slopes presented distinct challenges, but revegetation efforts have proven effective once specific treatment measures were identified and were found to be successful. The last project along the Straight Creek corridor was constructed during the 2000-2001 season in which 107 acres of seeding and mulching was completed on cut and fill slopes. The project included planting with 1,000 tree tublings, construction of approximately 2,000 linear feet of asphalt ditch paving, and cleaning of 5,530 cu yds (7,466 tons) of sediment material from the shoulders of I-70. This project virtually completed the initial revegetation efforts for the I-70 slopes. Another project is currently in the design phase.

As in the past, the primary strategy for the Straight Creek I-70 corridor is to control and capture sediment material as close to the source as possible to reduce the potential for off-site transport and deposition. In the SCAP, this area is defined as the I-70 Immediate Travel Corridor Zone 1 (30' from edge of pavement). The hydraulic distance to Straight Creek is only a few hundred feet down steep fillslopes in many areas, and sediment is lost to the riparian zone if not collected near the highway. Therefore, it is essential to gain control of sediment at the source before it has an opportunity to be transported further. The site reconnaissance indicated that areas beyond the I-70 Corridor Zone are inundated with new sediment annually. Deltas have formed at many locations where drainage from I-70 enters Straight Creek.

5.1 SOURCE VERSUS DEPOSITIONAL AREAS

Recent studies have indicated that I-70 traction sand is the primary source of sediment loading to Straight Creek. Approximately 10,000 tons of this material is applied to the highway surface each year. Most of this material is plowed off the highway with snow, depositing on the shoulders until surface water runoff becomes available to transport the sand. Thus, the mobilization of sand to receiving waters is dependent on the hydrology.

Data indicate that two primary hydrologic conditions mobilize sediment; snowmelt runoff and rainfall runoff. Snowmelt along I-70 in Straight Creek extends over a period of several weeks beginning in March and substantially ending in May. During this extended snowmelt period a significant amount of snowmelt infiltration can occur along the shoulders of I-70. This results in generally lower runoff volumes in early spring than might be experienced during summer rainfall-runoff events. Thus, the erosive energy (water velocity) available to mobilize sediment is generally lower during snowmelt periods than following intense rainstorm events. The data collected to date support this hypothesis, indicating the maximum sediment loads in Straight Creek occur following summer thunderstorm events.

The primary strategy of this Plan is to capture the highway sediment before it has an opportunity to leave Zone 1 (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. Data indicate that most of the initial deposition of sand occurs in Zone 1, e.g. the snowplow cast is on average about 10 feet. The hydraulic distance to Straight Creek is only a few hundred feet down steep fillslopes in many areas, and sediment is lost to 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.

Highway sediment is deposited on hillslopes, in forested and wetland areas, and along the banks of Straight Creek in several areas (RCE, 1993). Site reconnaissance in 2001 indicated that these areas continue to be inundated with new traction sand annually, even downstream of existing sediment basins. Sand deltas have formed at many locations where drainage from I-70 enters Straight Creek. Mineral sediments carried in I-70 runoff continue to bury organic soils in wetlands. These visual indicators of the impacts further illustrate the need for implementing source controls along the highway template to reduce sediment transport into the natural environment. Otherwise, areas downstream from the I-70 template will continue to be inundated with sediment.

5.2 SEDIMENT SOURCE ESTIMATES

An average of about 10,000 tons of traction sand is applied to I-70 between mileposts 205 (Silverthorne) and 213 (Tunnel) based on the past 11 years of record (1991-2001). Maximum application rates were reported at about 13,000 tons in winter 1995-1996 (see Table 1). Cut and fill slopes along I-70 and natural sources also contribute sediment to Straight Creek through erosion processes. However, successful slope revegetation efforts over the past decade, and recent studies indicate that these sources are negligible by comparison and that traction sand is the primary source of sediment in Straight Creek.

Sediment from I-70 is contributed to Straight Creek throughout its length to varying degrees. Sand application rates during most winter storms are non-linear over the 8-mile Straight Creek segment of I-70; rather sand is applied according to specific traction needs based on roadway snow and ice conditions. The higher elevation areas typically require more traction sand. Precipitation (snowfall) increases with elevation by approximately 120 percent from Silverthorne to the Tunnel, and hence traction sand usage also generally increases with elevation. For sediment control design purposes, a conservative approach was used to estimate the volume of traction sand used by factoring in these potential differences in sand application rates.

It is assumed that sand cleanup is only feasible after snow has melted (May), resulting in one full winter season of sand usage that would need to be captured. The sand application rate used as the design criteria in this study assumes the average annual total of 10,000 tons per year for lower Straight Creek (below Hamilton Box) and 12,500 tons per year for upper Straight Creek (Hamilton Box to Tunnel). These criteria incorporate the maximum annual sand application rates at higher elevations, and the average rate for lower elevations.

These design criteria assume a "worst case" scenario for annual sediment control needs, such as that experienced for the winter 1995-1996. Because sand usage during most years will be less than this estimate, the sediment collection structures specified in this plan may require less frequent cleaning. Further, the uncertainties regarding the volume of cut slope and other sediment produced annually demands that sediment collection structures be sized for adequate storage capacity.

5.3 SEDIMENT CONTROL STRATEGY

Several permanent sediment control BMP's have been implemented in the upper portion of the Straight Creek I-70 corridor (above Hamilton Box). Many of these BMP's are effective in controlling sedimentation. However, very few sediment control measured have been implemented in the lower six miles of the Straight Creek corridor. This Plan proposes additional permanent sediment control measures along the template of I-70 that will enhance the effectiveness of treatments already in place, and complete the controls needed for both the Tunnel area and the lower portion of Straight Creek.

Sediment control measures considered in this study include both structural and non-structural controls. Structural sediment controls include features that are placed in the drainage pathway to dissipate hydraulic energy and settle solid material. 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 other maintenance BMP's. A proactive maintenance program involving BMP's such as utilization of controlled snow storage areas, chain law enforcement, and scheduled sand cleanup activities including sweeping and removal are integrated into this SCAP.

The primary sediment control strategies in this SCAP include:

- Bypass clean tributary water to prevent contamination by highway runoff
- Minimize the volume of water requiring treatment
- Maximize sediment capture volumes
- Removal of sand stored within Zone 1
- Reduce the size and number of vehicle turnouts and/or implement erosion control BMP's
- Reduce cutslope and fillslope erosion
- Reduce rill erosion along shoulders
- Improve highway drainage network
- Maximize vegetation cover necessary to prevent erosion
- Provide controlled snow/sand storage areas
- Develop a preventative maintenance program (Sediment Maintenance Program)

Highway drainage design plays a major role in the sediment control strategy. Although the Straight Creek I-70 drainage system has been improved in several areas with valley pan drains and culvert rundowns, several areas exist that remain problematic with respect to sedimentation. In some areas, culverts are plugged with sediment and no longer function, resulting in the concentration of large flow volumes that exceed downstream drainage capacity.

The sediment loading exceeds the capacity of several of the existing sediment basins, as evidenced by large "dead storage" zones. There are several locations along I-70 in the lower Straight Creek study area where large gullies have formed, particularly in fillslope areas, as a result of improper drainage. Rill formation is common in shoulder areas where highway runoff sheet flow is concentrated in unconsolidated sediments. In some areas, springs contribute substantial flows that are routed through the existing sediment basins, keeping them full of water and reducing their effectiveness in trapping sediment during runoff events.

By incorporating drainage design considerations, this SCAP also serves to resolve many of the drainage problems currently experienced in the Straight Creek I-70 corridor. Because hydraulic energy must be dissipated to control sediment, runoff water must be managed in a controlled manner through adequate drainage design.

Paving of the shoulder areas, installation of "valley pan" drains, and concrete guardrail placed to control highway runoff have all proven to be effective methods of controlling erosion along I-70. An experimental erosion control project conducted on Straight Creek in 1979 by the Colorado State University Research Institute and the Federal Highway Administration found that Type 4 guardrail (Jersey barriers) and valley gutter drains at the top of the fillslope were treatments that worked well in controlling runoff and reducing erosion (FHWA, 1980). 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 fillslopes (CDOT, 1992).

Vegetation has the ability to bind soil particles, provide organic enrichment, and maintain soil moisture. Adequate vegetation cover is wisely 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 hillslope areas along I-70 is proposed as part of this SCAP 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 and to remove accumulated sand. A cleanup and disposal plan will be required as part of the maintenance program. These aspects will be integrated into a Sediment Maintenance Plan as described in Section 5.6.

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 Straight Creek I-70 corridor:

- Basins and traps to capture sediment
- Paving of shoulder areas to reduce rill erosion and provide a durable surface for cleaning
- Valley pan drains to control and route highway runoff
- Knee walls to prevent cut slope erosion
- Type 7 (Jersey barrier) concrete guardrail to reduce migration of sediment from fillslopes
- Controlled snow storage/sand deposition areas
- Revegetation program
- Maintenance BMP’s
- Sediment Maintenance Program

5.4 HYDRAULIC/DRAINAGE ANALYSIS

The hydrology of the Straight Creek watershed, described in Section 2.1, 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 Straight Creek, including both surface and ground water flows that intercept I-70 within the corridor. Another factor that influences the natural hydrology is the increased impervious surfaces resulting from I-70 pavement and parking area development.

Drainage problems were identified as part of the site reconnaissance. It is noted that overall, the drainage design for I-70 was probably adequate when constructed. However, the drainage system has been altered from sand deposition along the shoulders of I-70. Several of the existing sediment basins are continually saturated with clean tributary flows. Thus, drainage improvements are needed to reduce transport of deposited material and to provide adequate runoff conveyance. Present-day drainage and erosion problems occur primarily at 1) unpaved shoulder and unprotected cutslope areas, 2) the terminus of Type 4 (Jersey) barriers or guardrail curbs where runoff is concentrated along the roadway with no inlet drains, 3) areas where the inlet drains are plugged with sediment, 4) areas where culvert cross drains daylight on fillslopes with no erosion protection or energy dissipation, 5) at rundown outlets where no energy dissipation is provided, and 6) median areas where flow is concentrated for long distances.

One problematic drainage area is near milepost 209.0, where substantial I-70 runoff volume is concentrated and released, causing large gully formation through the forested areas to Straight Creek. This appears to be largely a drainage issue, although sedimentation from traction sand accompanies the runoff throughout lower Straight Creek. This area, as well as sources at mileposts 208.3 and 210.3, was identified as having some of the largest sediment loads to lower Straight Creek during the 2001 field reconnaissance.

The I-70 highway cut bisects several tributary streams that flow perpendicular to the highway. Several ephemeral tributaries and ground water springs that flow only 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 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.

Highway runoff will be routed in a concrete channel past clean tributary inlets and into sediment control structures before release to Straight Creek. Runoff water will be conveyed through existing culvert cross drains wherever possible. Culvert rundowns with energy dissipation will be installed where necessary to eliminate hillslope erosion and stabilize fillslopes.

5.4.1 Assumptions

Since highway runoff will be re-routed past clean culvert 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 area contributes to highway runoff flows. The only drainage area considered was that from the roadway and paved shoulders. The off-site flows are clean water tributaries conveyed through existing cross culverts under I-70 and via slope drains to the valley floor.

2) A maximum longitudinal grade of 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 slope of 1% was also evaluated to determine maximum carrying capacity.

3) Contributing area is the traveling roadway and paved shoulder. The contributing area used for I-70 west of the Eisenhower Tunnel (Straight Creek) was three 12-ft traveling lanes in the east and west direction, with an average 30-ft paved shoulder. Note: the actual lane width is 11 feet, but by using 12 feet an added level of conservatism was applied to the estimates.

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).

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:

- The 2-yr rainfall frequency depth was 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 yr rainfall frequency is typically used for storm drainage design.

- Rainfall intensity was determined from NOAA Atlas 2 "Precipitation Frequency Atlas of the Western United States-Volume III-Colorado. Rainfall amounts for Vail Pass were slightly higher than for Straight Creek.

- 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.

- 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. The runoff coefficient used was the 2-yr value for paved streets of 0.87 from Urban Drainage Flood Control District's "Urban Storm Drainage Criteria Manual". The time of concentration method used was that outlined in the CDOT Drainage Manual Chapter 7 - Hydrology.

5.4.2 Results

Hydraulic lengths ranging from 0.1 to 1.0 mile were evaluated to estimate peak highway runoff flow volumes that could be generated between I-70 culvert inlets. These estimates represent one lane direction, either eastbound or westbound (Table 3).

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 one percent slope. It was conservatively assumed that the total flow at the point where drainage from both the eastbound and westbound lanes combines in the 24-inch culvert drain should not exceed 10 cfs. Therefore, the maximum allowable distance between sediment collection and cross drain structure inlets is approximately 0.4 miles in the Straight 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.

Table 3
Straight I-70 Culvert Design Peak Flows (cfs)
Each Lane Direction

Distance (miles)	2-year	5-year
0.1	1.7	2.7
0.2	3.2	5.4
0.3	4.6	7.0
0.4	**5.7**	8.6
0.5	6.8	10.4
0.6	7.5	11.6
0.7	8.0	12.8
1.0	11.1	15.5

Several variables associated with design flows for the different conveyance structures were evaluated. The parameters that were fixed were slope at 0.07 ft/ft and a peak discharge of 5.7 cfs per lane 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 4.

Table 4
Straight 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	5.7	0.4	0.3	7.4	6.8	4.3	6.4
10:1	0.07	5.7	0.4	0.3	7.7	7.1	3.9	5.7
8:1	0.07	5.7	0.4	0.3	8.0	7.5	3.4	4.9
10:1	0.01	5.7	0.5	0.4	3.9	3.4	5.4	8.2

The hydraulic design assumptions and variables used in this analysis are considered to be conservative but appropriate for planning purposes. Results indicate that there should be no I-70 drainage issues that would present a problem for future design and construction of the proposed sediment control measures (CDOT, 2002).

5.5 PROPOSED STRUCTURAL CONTROL MEASURES

Several permanent sediment collection structure designs have been used by CDOT in an effort to capture highway sand in the Colorado Rocky Mountains. On Straight Creek, earthen sediment basins are used at the toe of the I-70 fillslope to capture sediment. Along I-70 near the west portal of the Eisenhower Tunnel, a series of concrete above-grade sediment traps are utilized to capture traction sand. On U.S. 40 Berthoud Pass east, below-grade concrete sediment traps have been installed in the highway template to capture road sand because the steep topography and grades do not allow sufficient space for conventional earthen sediment basins.

All of these sediment control features have in common a drainage network that routes sediment-laden water into collection structures that dissipate energy to settle solid material. Thus, runoff controls are an integral part of the structural sediment control design. Another important structural aspect is the combined need to reduce erosion of unprotected soil and to provide a durable surface from which cleanup activities can take place without causing damage to the vegetated slopes or highway template.

The I-70 roadway and shoulder vary considerably throughout the Straight Creek I-70 corridor, making a single sediment control design solution impractical. A safety "clear zone" of 30 feet from the edge of pavement is recommended wherever possible along I-70 due to the high-speed design of the highway. In many areas the clear zone is less than 30 feet because of the steep mountainous topography, and concrete Type 7 (Jersey) barriers or steel guardrails are required in narrow locations within the corridor. Since the sediment should be controlled as close to the highway source as possible, the type and location of sediment control structures must be carefully considered.

There are no sediment basins in areas of the Straight Creek I-70 corridor below the Hamilton Box (milepost 211), although structures were specified by the U.S. Forest Service in the EA. An access road exists from the Town of Dillon water supply diversion structure (milepost 208) to milepost 210.4. This SCAP specifies the construction of 10 new sediment basins in this area. This will require access road improvements for construction and cleaning of the basins. Costs have been estimated for access road improvements.

5.5.1 Runoff and Erosion Control Structures

Permanent non-erodable surfaces are proposed for the conveyance of I-70 runoff to sediment collection structures. Some of these features are in place along the I-70 Straight Creek corridor and have proven to be effective in reducing erosion. The objective of this analysis is to integrate drainage design features into a sediment control plan. Because full integration was never a primary goal for the sediment control actions taken to date on Straight Creek, this plan serves to enhance the controls already in place. As such, a complete remedy is specified using an integrated approach rather than attempting to retrofit existing control structures.

The highway shoulder in both cutslope and fillslope areas will be paved to a distance of approximately 15 feet from the edge of the highway. Concrete valley pan drains will be used to convey highway runoff to sediment collection structures. Drop inlet drains will be used below the outfall of sediment collection features to capture and route highway runoff water through existing cross drain culverts beneath I-70. Where necessary, rundown culverts will be installed at fillslope locations for runoff conveyance to Straight Creek. Energy dissipaters will be used at the outlet of culvert rundowns where necessary to prevent erosion or re-entrainment of sediment in existing basins.

Typical highway sections for two cutslope and two fillslope treatments are shown in Figures 9 and 10. The shoulder widths on I-70 are not uniform and the typical configurations shown will vary considerably in many areas. However, for planning purposes it is necessary to establish an average condition. A site-specific analysis will be required before final design and construction.

Cut Slope Treatments

Permanent structural treatments to control erosion and to convey runoff in cutslope areas of I-70 are:

- Pave shoulder to an average distance of approximately 15 feet from the edge of highway
- Cross culvert extensions for clean tributary flows
- Knee wall at toe of cutslope (approximately 18-inch high concrete)
- 6-inch perforated underdrain behind knee wall in high seepage areas
- Concrete valley pan drain (approximately 7 feet wide)
- 8-inch perforated underdrain beneath valley pan
- Sediment basins or below-grade sediment traps
- Inlets to existing cross culverts

The typical section for cut slopes assumes a total paved distance of approximately 15 feet from the edge of highway. The valley pan drain will occupy approximately 7 feet, while approximately 8 feet is utilized for snow/sand storage. The eight foot paved section is designed for easy access with a sweeping machine (broom) to collect accumulated sediment. The knee wall at the toe of the cut slope will prevent undercutting of the slope and provide a durable surface for cleaning.

In areas of high spring flows or ground water seepage, a perforated underdrain will be installed behind the knee wall to collect and convey clean water flows to the nearest clean water tributary inlet. The culvert inlets at clean water tributaries will be extended up the slope above the invert of the valley pan drain to separate clean tributary flows from highway runoff. The knee wall seep collection drains will be routed to clean tributary culvert inlets.

Concrete valley pan drains will be used to convey highway runoff to sediment collection structures. An underdrain will be installed beneath the valley pan to collect subsurface water in areas with high subsurface water. The subsurface water will be routed to clean tributary culvert inlets.

Three alternatives are considered for cutslope areas where the highway shoulder is greater than approximately 30 feet wide and the space is not used for drainage control and sediment collection structures. These include; 1) backfilling the unused area with used road sand and regrading/revegetation to extend the slope to the knee wall/valley pan drain, 2) installation of Type 7 barrier (34-inch tall) instead of the knee wall (18-inch tall) and utilizing the area for seasonal snow/sand storage, or 3) installation of a revegetated earth berm and utilizing the area for seasonal snow/sand storage.

Fill Slope Treatments

Permanent structural treatments to control erosion and to convey runoff in fillslope areas of I-70 are:

- Paved shoulder to an average distance of approximately 15 feet from the edge of highway
- Type 7 (Jersey) barrier at crest of fillslope (approximately 34-inch high concrete)
- Concrete valley pan drain (approximately 7 feet wide)
- Sediment basins or below-grade sediment traps
- Inlet to existing cross culverts
- Culvert rundown with energy dissipation

The typical section for fill slopes assumes a total paved distance of approximately 15 feet from the edge of highway. The valley pan drain will occupy approximately 7 feet, while approximately 8 feet is utilized for snow/sand storage. The eight foot paved section is designed for easy access with a sweeping machine (broom) to collect accumulated sediment. The Type 7 (Jersey) barrier will be installed on the crest of the fillslope to prevent migration of sand.

In fillslope areas where at least 8 feet of width is available behind existing concrete barriers, a snow/sand storage zone will be constructed by installing both a Type 7 (Jersey) barrier and a retaining wall as shown in Figure 11. This type of configuration will be effective in trapping sand and is feasible in many areas of the Straight Creek I-70 corridor where guardrail already exists.

Where snow storage is required, selected fillslope areas with greater than approximately 30 feet of shoulder width will be paved and utilized for seasonal snow/sand storage. Valley pan drains will be used to convey shoulder snowmelt and highway runoff to sediment collection structures. Highway runoff will be separated from clean tributary culverts wherever possible.

5.5.2 Sediment Collection Structure Preliminary Design

An analysis of the existing sediment basins constructed as part of the Straight Creek Erosion Control Project was conducted by CDOT in 1995 (CDOT, 1996). This analysis was conducted to determine the volume of sediment captured and the efficiency of the sediment basins in removing sediment from the highway runoff. Flow measurement and water sampling equipment was used at one basin to determine sediment loading rates and removal efficiency during storm events.

The estimated volume of road sand applied to I-70 between the Tunnel and Silverthorne in 1993-1994 was 3,953 cu-yds (5,337 tons) (CDOT, 2001). Seven basins were operational from October 1993 to October 1994, with 435 cu-yd (587 tons) of sediment collected for the period (CDOT, 1996). Assuming none of the sediment collected was from cut or fill slope erosion sources or re-transported from depositional areas, about 11 percent of the road sand applied was collected in the sediment basins.

The design volume of all eleven sediment basins combined was estimated at 1,489 cu-yds (2,010 tons). Not all basins are fully utilized due to differences in hydraulic and sediment loads. However, assuming a trap efficiency of 90.5% it was estimated that 730 cu-yds (985 tons) of road sand and sediment combined would be collected annually with the eleven basins (CDOT, 1996). Of this total, the study estimated that about 2/3 was road traction sand and 1/3 was from erosion of cut and fill slopes.

Between 1994 and 1998, the volume of sand applied to I-70 along Straight Creek ranged from 4,260 tons to 9,213 tons per year, with an average annual volume of 6,196 tons (CDOT, 2001). Using the estimates developed for the sediment pond efficiency study, an average of 660 tons of traction sand (985 x 0.67) would be collected in the sediment basins annually since 1994, or about 11 percent of the average annual sand applied during these years. An estimate of the average annual volume of sand applied along Straight Creek from 1991 to 1999 is 10,244 tons (CDPHE, 2000). Assuming the entire 985 tons collected annually by the sediment basins is road sand, about 10 percent of average annual sand applied would be captured with the existing basins.

The primary constraints that determined the type and location of sediment collection structures in the study area were physiography, accessibility, safety, hydrology, and sediment volume generated. The potential locations for sediment control structures were identified through the site reconnaissance described in Section 2.6. Evaluation of the existing sediment basins on upper Straight Creek suggest they are undersized for the volume of sediment load that is generated from I-70. Estimates indicate they are capable of collecting a maximum of only about 15 percent of the average sediment load (CDOT, 1996). While the existing sediment basins will continue to be used and are incorporated into this analysis, additional sediment collection structures are needed. It has been determined that it is not feasible to increase the size of the existing basins appreciably due to topographic constraints and potential wetland encroachment.

For optimum effectiveness and accessibility for maintenance, the goal of this plan is to control sediment as close to the source as possible. There are several locations in cutslope areas where the topography along I-70 west of the Eisenhower Tunnel offers suitable locations for conventional sediment basins. These areas are typically small depressions that are sufficiently outside the "clear zone" to allow installation of a series of small earthen dams for use as sediment detention basins. Sediment basins are the most commonly used off-site control (Barfield and Haan, 1983). In narrow shoulder sections along I-70 (less than 30 feet), a series of below-grade sediment traps are specified.

Sediment collection structures currently in use on Straight Creek were evaluated with respect to these constraints and their effectiveness in trapping sediment to determine if similar designs may be appropriate for use in the Straight Creek I-70 corridor. Alternative sediment collection structures evaluated included conventional earthen sediment basins, above-grade concrete traps, below-grade concrete traps, and snow storage areas. The following sand volume assumptions were used to establish the initial structure design requirements for the Straight Creek I-70 corridor.

1) A total sand application of 7,500 tons/year for the lower six miles of the corridor (MP 205-211); equivalent to 463 cubic-yards per mile or 46 cu-yds/tenth-mile for each lane direction.
2) A total sand application of 5,000 tons/year for the upper two miles of the corridor (MP 211-213); equivalent to 925 cubic-yards per mile or 92 cu-yds/tenth-mile for each lane direction.
3) The average storage volume for sediment basins installed at the toe of the I-70 fillslope on Straight Creek is 139 cu-yds (CDOT, 1996). Reasonable sizing for a small sediment basin is 20-ft x 40-ft (60 cu-yds); large sediment basin is 30-ft x 68-ft (150 cu-yds).
4) Below-grade traps specified at 8-ft x 50-ft with 4-ft depth flat bottom (59 cu-yds).
5) 80 percent trapping efficiency for a rectangular shaped basin.

The above assumptions were used to develop the estimates of spacing requirements for sediment collection structures along I-70. These assumptions result in a reasonably conservative approach to sediment collection in the Straight Creek I-70 corridor. During a "worst case" snowfall/sand usage year such as 1996, many of the sediment collection structures would be filled with sand in one season and would require cleanout. In an average year, many of the collection structures would only partially fill after one season and cleanout may only be required every two or three years. Therefore, a conservative initial design is appropriate to ensure efficient capture of sediment under a range of potential conditions.

The principal type of sediment collection structure proposed in this study can be generally categorized as a detention dry basin (FHWA, 1996). Detention dry basins are depressed basins or traps designed to remove particulate pollutants and to reduce maximum (peak) runoff flows. Nutrients, heavy metals, toxic materials, and oxygen-demanding substances associated with sediment particles are also removed. These sediment basins are designed to temporarily store a portion of the highway runoff following a snowmelt or storm water runoff event.

The largest constraint with respect to sediment collection structure design for the Straight Creek I-70 corridor is access and space. The nature of the topography and highway safety issues dictate the type and location of potential structures that can be used. Based on these considerations, two types of collection basins are proposed in this study, including below-grade sediment traps and sediment basins. Typical diagrams of these structures are provided in Figures 12 and 13.

The below-grade traps are rectangular shaped concrete vaults that are installed in series below or partially below grade. The dimension of each trap is 8 feet wide, 4 feet deep, and 30 to 50 feet long depending on slope gradient conditions. A perforated steel plate is used at the outlet end to allow accumulated water to seep out between runoff events. Highway runoff water enters the trap near the upstream end and passes through the length of the trap. Excess runoff spills over the steel end plate and into the next downstream trap or culvert inlet.

The sediment basins are rectangular-shaped earthen basins specified in series where space allows. Two sizes are proposed; a small basin 20 feet wide, 4 feet deep at the dam, and 40 feet long; and a large basin 30 feet wide, 4 feet deep at the dam, and 68 feet long. Sediment basins will be designed with a reinforced spillway structure to pass the design storm. If possible, the bottom of the basin will be constructed in natural soil to promote infiltration of water between runoff events. In some instances it may be necessary to line the bottom of the basin with asphalt or concrete to provide a durable surface for cleaning. For lined (impervious) basins, a trickle tube pipe will be installed through the face of the dam to promote drainage of water between runoff events.

5.5.3 Sediment Collection Efficiency

The water quality benefits of any sediment collection structure increases by extending the detention time. To maximize the detention time and trap efficiency the sediment collection structures are placed in series wherever possible. In this fashion, the sediment trap efficiency is optimized and finer particle sizes can be settled before the water is released to Straight Creek.

Utilizing the traction sand usage assumptions described earlier, the volume of sediment generated per tenth of a mile of highway was calculated for both the westbound and eastbound lane directions of I-70. The location, type, and number of sediment collection structures were determined according to space constraints and the sediment volume estimates. Collection structure treatments included large basins (150 cu-yd), small basins (60 cu-yds), and below-grade traps (59 cu-yds).

Using a trap efficiency of 80 percent, the ratio of theoretical sediment volume captured versus volume generated was computed. For purposes of this plan, this ratio can be considered a margin of safety. Values greater than 1 indicate the specified number and placement of collection structures should be adequate to theoretically collect all of the sediment generated. Results are provided in the structure estimates table in Appendix B.

In most areas a safety factor of 1 or greater was achieved, indicating that most of the applied sand would be collected if transported into the collection structures. In some areas, a combination of basins and below grade traps is used. It is believed that this analysis provides a conservative approach, and that the number of collection structures estimated may be the maximum required since not all of the sediment will be transported into the structures. However, as stated earlier it is impossible to accurately determine the volume of sediment that will enter the basins, so any added capacity will only result in less frequent clean out requirements.

Collection structures were designed to capture the maximum amount of sediment while passing the design storm. Since no effluent standard is applicable, the effluent concentration is not predicted. However, the trapping efficiency of the proposed collection structures was determined to provide a theoretical basis for estimating of the volume of sediment collected. The factors which control sediment transport through a collection structure are the:

- Physical characteristics of the sediment
- Hydraulic characteristics of the basin
- Inflow sedigraph
- Inflow hydrograph
- Basin geometry
- Chemistry of the water and sediment

Sediment basin shape has a strong influence on how effectively the volume is utilized in sedimentation. It is assumed in most analysis that some areas of the basin are bypassed and is therefore totally ineffective in the settling process (Barfield and Haan, 1983). This is referred to as dead storage. Some examples of sediment basins with dead storage volumes can be found on Straight Creek, where the basins had to be constructed perpendicular to steep slopes and hence the flow path through the basin is shortened. In order to minimize dead storage, the EPA recommends that the ratio of average length of flow path to effective width of the basin be greater than 2.0. Therefore, all sediment basins and traps proposed in this study are rectangular-shaped with length/width ratio of at least 2.0.

The settling velocities of sand sized and larger particles are determined by using the size of sieve openings and calculating the settling velocity. Studies of road sand particle size from I-70 on Straight Creek (CDOT, 1996) indicated that the diameter of 85 percent of all stockpiled road sand, used sand on shoulder, and cut slope soil was greater than fine sand size (0.25mm). Studies of road sand from I-70 on Black Gore Creek (Lorch, 1998) indicated that 90 percent of the particles were greater than medium sand size. Thus, for purposes of determining collection structure trap efficiency, 85 percent of all source material is assumed to have a diameter greater than fine sand size.

An analysis of the trapping efficiency for the rectangular basins proposed in this study was made using settling velocities assuming steady state inflow and outflow conditions. Discrete particle settling is assumed for the road sand. An average rectangular-shaped basin size of 10-ft x 50-ft x 4-ft depth was used in the analysis conservatively assuming a peak flow of 5 cfs. Assuming a specific gravity of 2.65, the fall velocity would range from 0.1 ft/s for a 0.25mm (fine sand) particle to 2 ft/s for a 8mm diameter particle (fine gravel). Based on the trajectory of particles through the settling basin, the critical settling velocity was calculated to be 0.01 ft/s, which is the velocity that will just allow the particle to settle to the bottom in its trajectory through the flow length of the basin.

This analysis indicates that 90 percent of all particles in the size range measured for I-70 sand on Straight Creek will be settled in a 50-ft long basin. In fact, particles as small as 0.08mm (very fine sand) would be captured at the critical settling velocity in a 50-ft long basin assuming a steady state flow of 5 cfs. The minimum basin size required to achieve settling of 0.08mm (very fine sand) and larger particles would be 8-ft x 30-ft x 2-ft depth at a peak flow rate of 5 cfs. Therefore, the sediment basins proposed in this study are designed to capture at least 90 percent of the stockpiled (road) sand, used shoulder sand, and cut slope soil particles with a 10-fold factor of safety.

The size distribution of inflowing sediment is the single most important factor determining the trap efficiency of a sediment basin. This analysis indicates that under steady state flow conditions over 90 percent of the sediment would be trapped. However, factors such as turbulence, non-steady flow conditions, and high flow velocity will reduce trap efficiency. Considering that all of these conditions are likely to be encountered on the steep gradients and highway runoff conditions found in the study area, the theoretical trap efficiency was conservatively reduced from 90 percent to 80 percent. CDOT (1996) estimated that, based on measured particle size distributions, about 78 percent of the source material should be intercepted and captured by the sediment basins on Straight Creek.

Based on the above analysis and assumptions, about 80 percent of the material that enters the proposed sediment collection structures will be captured. This does not include sand that bypasses the collection structures or is deposited in other locations along I-70. Some of this extraneous sediment will be removed by maintenance through maintenance BMP's, while a portion will be transported from the I-70 template and permanently lost to the environment. Because of the highly variable nature of topographic, sand usage, and runoff conditions along I-70, it is impossible to accurately quantify the total volume of sediment that will be removed. Therefore, for purposes of this study it is estimated that at least 50 to 80 percent of the traction sand applied annually to Straight Creek I-70 corridor could potentially be collected and removed if full structural controls and a rigorous maintenance program were in place.

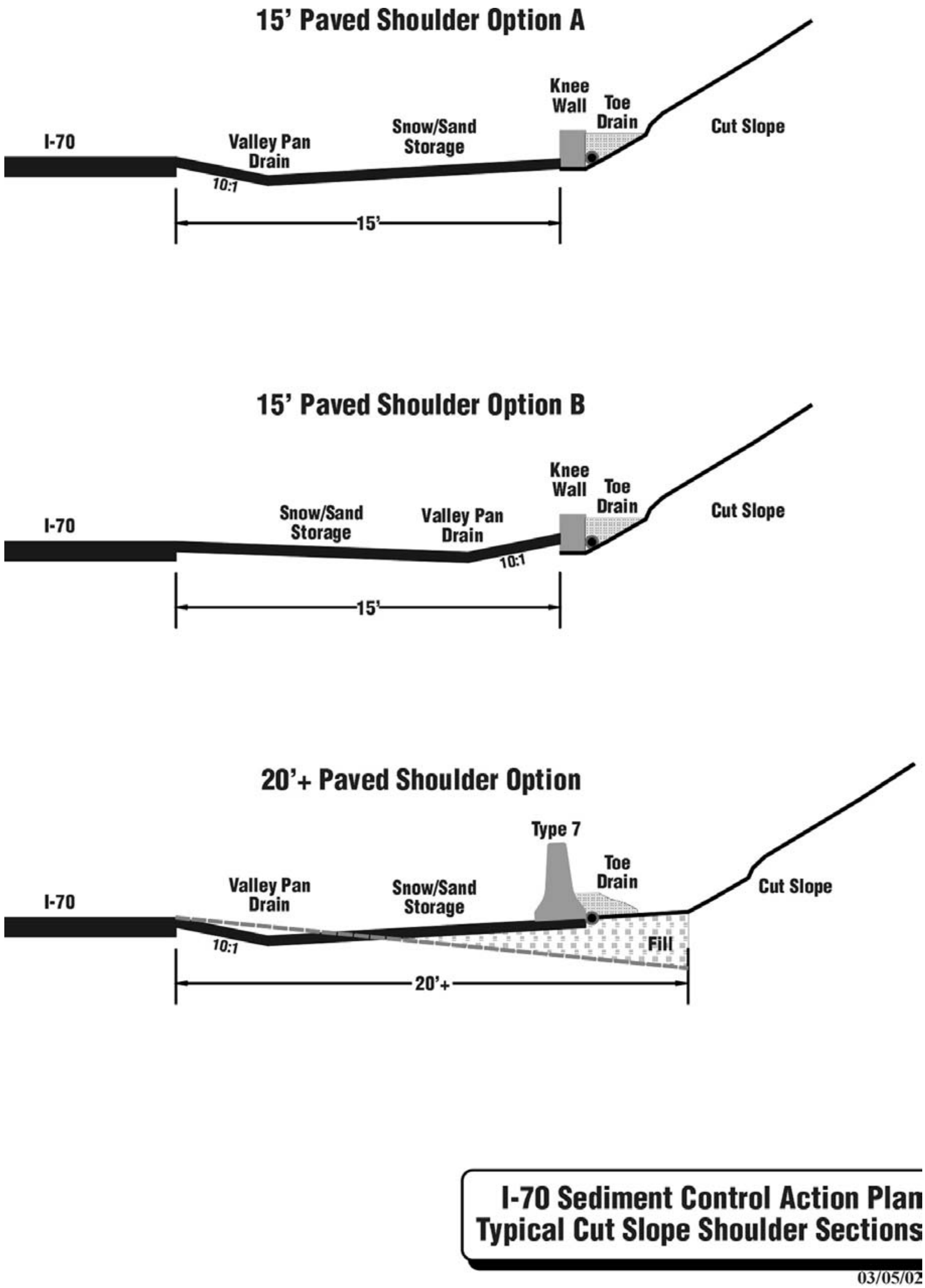

15' Paved Shoulder Option A
I-70
Valley Pan Drain
10:1
Snow/Sand Storage
Knee Wall
Toe Drain
Cut Slope
15'
15' Paved Shoulder Option B
I-70
Snow/Sand Storage
Valley Pan Drain
10:1
Knee Wall
Toe Drain
Cut Slope
15'
20'+ Paved Shoulder Option
I-70
Valley Pan Drain
10:1
Snow/Sand Storage
Type 7
Toe Drain
Cut Slope
Fill
20'+
I-70 Sediment Control Action Plan
Typical Cut Slope Shoulder Sections
03/05/02

FIGURE 9

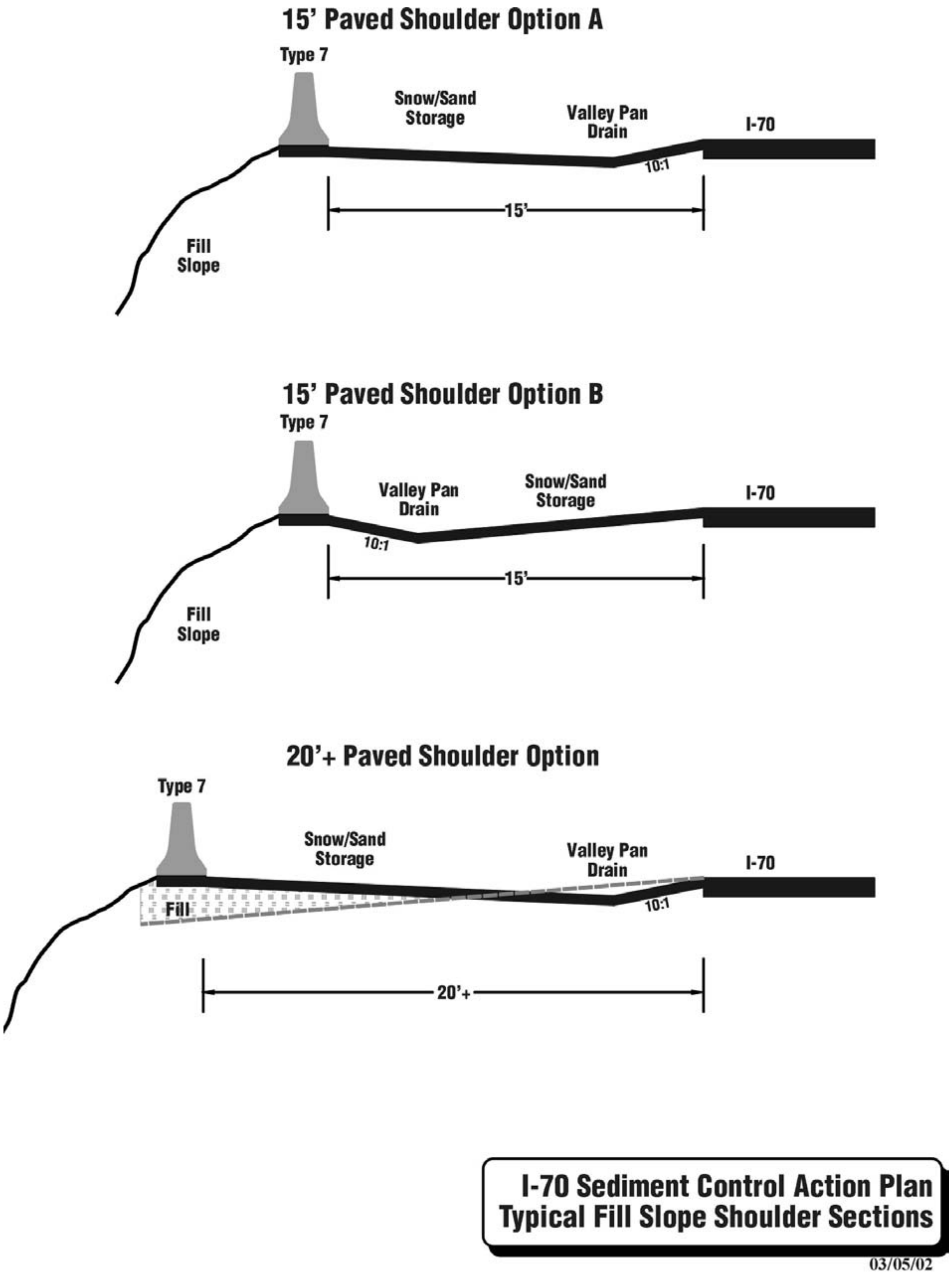
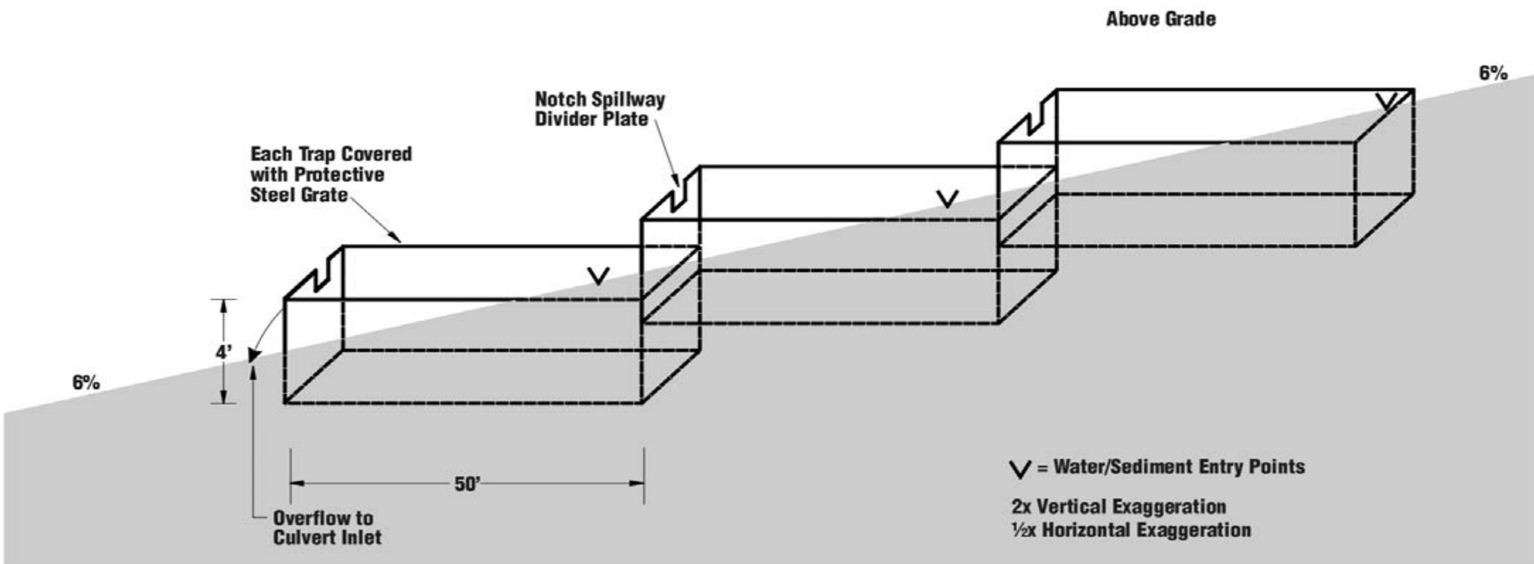

15' Paved Shoulder Option A
Type 7
Snow/Sand Storage
Valley Pan Drain
I-70
10:1
15'
Fill Slope
15' Paved Shoulder Option B
Type 7
Valley Pan Drain
Snow/Sand Storage
I-70
10:1
15'
Fill Slope
20'+ Paved Shoulder Option
Type 7
Snow/Sand Storage
Valley Pan Drain
I-70
Fill
10:1
20'+
I-70 Sediment Control Action Plan
Typical Fill Slope Shoulder Sections
03/05/02

FIGURE 10

FIGURE 11
PARALLEL SNOW STORAGE



I-70 Sediment Control Action Plan
Typical Below-Grade Sediment Traps
6% Shoulder Grade

03/05/02

FIGURE 12

FIGURE 13
TYPICAL SEDIMENT BASIN

5.6 PROPOSED NON-STRUCTURAL CONTROL MEASURES

Various non-structural control measures exist that can be utilized for highways. Some of these include maintenance BMP's, seeding & slope stabilization, roadside swales, drainageway protection, terracing slopes, porous pavement, implementation of the chain-law, training of construction and maintenance personnel, phasing project activities, proper material storage practices, and other measures. Revegetation and maintenance practices are the primary non-structural control measures discussed in this SCAP. However, this does not preclude the use of other measures that should be evaluated and utilized along the corridor.

5.6.1 Re-vegetation Program

Establishment of vegetation and stabilization of slopes to prevent soil loss were difficult challenges faced during the construction of I-70. Steep slopes, a short growing season, and highly erodable soils are encountered at the high elevations of the Straight Creek I-70 corridor. These factors continue to make high altitude revegetation efforts challenging. The history of these erosion control efforts is described in Section 2.

Most of the remaining unvegetated portions of cut and fill slopes along I-70 were revegetated as part of the Straight Creek Erosion Control Project between 2000 and 2001. There are about 20 acres remaining to be seeded in 2002.

The revegetation program for Straight Creek will require an ongoing monitoring and reseeding program to maintain vegetation cover. Vegetation along the highway continues to be buried annually with traction sand and is under considerable stress. Fillslope and cutslope areas also receive new sand annually and vegetation covers is less than optimal in many areas. Many of these areas will begin to stabilize after sediment control structures are in place and maintenance practices are modified under the SMP.

Areas disturbed by installation of any new sediment collection structures, as well as areas where sand is removed, will need to be revegetated. The criteria for vegetation cover establishment will be determined through negotiations between CDOT and the U.S. Forest Service. Experience from revegetation efforts on Straight Creek and Berthoud Pass will greatly assist CDOT and the Forest Service in selecting successful seed mixes and cover criteria for the Straight Creek I-70 corridor. A vegetation monitoring plan will be developed that includes the following components:

- Agreed upon seed mixes and soil amendments
- Vegetation cover criteria for different slope aspect and soil types
- Establishment of vegetation reference areas along the two I-70 study corridors
- Approximate transect monitoring locations
- Schedule for annual cover surveys
- Reporting requirements

This SCAP recommends that an annual revegetation monitoring program be undertaken by CDOT. This program would include an annual vegetation cover survey and a report to be developed that identifies problem areas, recommends solutions, and proposes any actions needed to improve vegetation cover. It is undetermined at this time if the annual revegetation program will be administered as a maintenance program or as part a construction program. A vegetation monitoring plan will be developed that includes the following components:

- Agreed upon seed mixes and soil amendments
- Vegetation cover criteria for different slope aspect and soil types
- Establishment of vegetation reference areas along the two I-70 study corridors
- Approximate transect monitoring locations
- Schedule for annual cover surveys
- Reporting requirements

5.6.2 Proposed Maintenance BMP's

Maintenance will play an integral role in sediment control on I-70 as part of this SCAP. Currently, there is no maintenance plan that specifically deals with the removal of excess highway sanding material (see Section 4). Excess highway sand is cleaned up according to the availability of labor resources and funding which is highly variable from year to year. In the year 2000, a new MMS acronym, SCL (sand clean-up), was added to the MMS system, allowing those maintenance activities directly related to sand clean up to be more closely monitored.

Sweeping is accomplished as time allows and after sand pick-up, work can be performed along the shoulders and median areas. The sand pick-up schedule at the higher elevations generally occurs between May and September when maintenance forces are able to clean ditches and guardrail. Due to the need for maintenance personnel during the winter months, and since the state fiscal year ends on June 30, vacations for maintenance personnel are taken before the end of June for those who must take their time, or throughout the rest of the summer months for all others. There are presently few maintenance crews fully staffed during May and June.

Sediment Maintenance Program

An important recommendation of this SCAP is the development of a Sediment Maintenance Program (SMP), as part of implementation. The SMP will specify procedures for sediment collection and, at a minimum, would specify critical periods in the schedule for inspection and maintenance requirements. Accumulated sediment would be removed and disposed of according to the SMP. Installation of permanent sediment collection structures will require a routine inspection and maintenance program for the cleanup and removal of accumulated sediment. This program will also require an annual inspection program to assess the integrity and condition of sediment control BMP's and other drainage treatments. The following components should be included in the SMP:

1) Sediment control BMP structure and drainage inspection schedule
2) Sediment removal and disposal plan
3) Implementation schedule and requirements for routine maintenance BMP's (e.g. annual sweeping schedule, guardrail and ditch cleaning, chain law enforcement, etc.)
4) Snow removal and disposal techniques
5) Location and utilization of controlled snow storage areas
6) Revegetation program
7) Maintenance training program
8) Documentation, data collection, and reporting requirements

As part of the SMP, a training module covering specific aspects of sediment control would need to be incorporated into the existing CDOT snow and ice training program. This training module would cover sediment control issues related to winter maintenance such as the use of controlled snow storage areas, snowplow cast zones, snow blowing, snow removal from bridges, and winter sweeping.

I-70 Immediate Travel Template Depositional Area Sand Cleanup (Zone 1)

There is uncertainty regarding the exact volume of sand deposited along the I-70 template in the Straight Creek corridor. The deepest deposits are found immediately behind guardrail that acts as sediment traps. In these areas, annual deposition rates are too great for vegetation to become well established. In other locations, the sand depths are highly variable and much of the material has either been integrated into the shoulder, removed, or washed away downslope. Vegetation has established to varying degrees in these areas. To prevent further disturbance to vegetation and subsequent erosion, areas with well established vegetation or areas beyond approximately 30 feet from the edge of I-70 will not be disturbed except where necessary to install sediment collection structures.

Several areas adjacent to I-70 along the Straight Creek corridor serve as effective sand traps. Sand material accumulates each year in the same areas (typically behind guardrails) and migrates slowly downslope. Runoff water is often not available to transport the sand in these areas and material can accumulate for many years. The sand volume accumulated within Zone 1 was estimated for this plan for both the eastbound and westbound shoulders of I-70 and behind guardrails. However, CDOT believes that the total amount of sand within Zone 1 of the Straight Creek I-70 is about 24,000 cu-yds.

Removal of sand material within Zone 1 is prerequisite to installation of the permanent sediment control measures proposed in Scenarios 3 and 4 in this plan. Many of these deposition zones are areas where sediment has accumulated from routine winter maintenance practices, indicating good potential for future sand traps. This plan proposes removal of the existing guardrail and accumulated sand, paving to the crest of the fillslope, and installation of new concrete barriers and valley pan drains. Thus, removal of the Zone 1 sand deposited immediately adjacent to I-70 is part of this SCAP.

In areas beyond 30 feet from the travel lane that are easily accessible, some sand deposits will also be removed. This includes areas that receive annual I-70 sand loads that are easily accessible with heavy equipment with minimal disturbance to the environment. Certain cutslope areas having large deposits of natural sediment that are easily accessible will also be cleaned of sand deposits and prepared for permanent BMP's.

Seasonal Cleanup Needs

The timing of sand cleanup is critically dependent on the season of the year because sediment transport is dependent on hydrology. Sediment is transported away from the highway template by surface water runoff in spring (snowmelt) and summer (rainstorms). If sand is readily available, these seasonal conditions will serve as the sediment transport mechanism. However, if sand is removed to the extent practical before transport can occur, sediment loading to receiving streams will be substantially reduced.

As stated in Section 5.5, it is estimated that at least 50 to 80 percent of the road sand applied annually could be captured and removed through the combined implementation of permanent sediment collection structures and maintenance sweeping and removal efforts. Using an average of 10,000 tons per year total application for the 8-mile corridor, average annual capture and removal would be approximately 5,000 to 8,000 tons annually.

Sediment transport by surface water runoff that occurs during snowmelt and rainfall periods determines the timing required for maintenance and removal of accumulated sediment in Zone 1. Although snowmelt can occur any time during the winter, temperatures are typically too low to generate large runoff volumes. Hence, sediment transport is generally low during winter. The period in which the majority of snowmelt occurs is from March through May each year, during which time enough meltwater volume is generated to provide higher flow velocities and sediment transport energy. It has been observed that the used traction sand along I-70 is typically rounded and has a tendency to be mobilized with relatively low flow velocity. This high mobility factor, combined with the relatively steep gradients along I-70 result in potentially large sediment transport rates during the spring snowmelt period.

Major sediment transport occurs as a result of summer rainstorm events. The summer monsoon rainfall period in the study area is from June through August each year. The highest sediment transport rates in Straight Creek have been measured as a result of July rainfall runoff events. The erosive energy of raindrop impact and potential flow volume is greater than that of snowmelt, resulting in greater potential for mobilization of sediment accumulated along I-70.

Sand is deposited annually along the highway shoulders, but large amounts are also entrained in snow stored along the highway each winter. Large volumes of snow/sand mixture accumulate along I-70 resulting from winter snow removal practices. When the snow melts in April and May it can mobilize the sand in runoff. If it were feasible to remove the snow/sand mixture late in the winter season when snow volumes were relatively low, for example in April, this would reduce the sediment transport to receiving streams. Some high elevation mountain towns utilize controlled snow storage areas that allow snow to melt with minimal transport of contaminants. However, it is unlikely that sufficient permanent storage areas could be secured for the large volume of snow/sand that is typically present along the I-70 corridor in April.

In some areas, the I-70 snow piles do not fully melt until May. Melting typically takes place first near the road surface and shoulders where solar heating is greatest, and on south-facing slopes. Accumulated traction sand is transported in snowmelt water from shoulder areas. However, the runoff water typically concentrates in rills and gullies, leaving large deposits of traction sand in shoulder areas (see photos in Appendix A). This plan proposes to pave these shoulder areas and route the runoff to valley pan drains and sediment collection structures. Observations of paved shoulder areas on Straight Creek indicate that large deposits of road sand can remain on the paved surface immediately following the snowmelt period.

To maximize the sediment control effectiveness, accumulated sand must be removed from the highway shoulders by sweeping or other methods immediately following snowmelt. This should be accomplished by May 15 each year. The timing for sweeping and removal is critical because rainfall can occur in May or June, and rainfall runoff is very effective at washing the accumulated sand off the paved shoulders. Early spring sweeping and removal on a rigorous schedule will result in less mobilization and will lower sediment transport volumes. At a minimum, the SMP to be developed will specify this critical period in the schedule for inspection and maintenance requirements.

There are two critical periods when inspections, maintenance, and sediment removal are required for sediment collection structures and depositional areas to ensure adequate volume is maintained to capture sediment. Inspection and removal from structures should take place following the two major sediment transport periods:

1) June - following snowmelt in late spring but before monsoon thunderstorms in July
2) September - following the summer monsoon rainfall period but before the onset of winter weather

Removal of sediment from structures in June will help ensure that collection structures and depositional areas are maintained with adequate capacity to capture sediment transported during the summer monsoon rainfall runoff period. Sediment removal in September will help ensure that collection structures and depositional areas are maintained with adequate capacity to capture sediment transported during the winter and early spring snowmelt runoff period.

Sand Disposal

One of the largest challenges faced by CDOT is securing long-term disposal sites for used traction sand and other sediment generated along the highway. Unfortunately, there is no market that has yet been identified for used traction sand. CDOT research has indicated that the angularity of the sand grains is lost once the sand is applied to the highway and pulverized by vehicle traffic, resulting in poor traction characteristics. Haul distances for this type of solid waste also must be kept to a minimum to control costs.

The functionality of used sand for purposes of disposal or reuse becomes problematic. The mixture used by CDOT on state highways, including the Interstate system, is purchased as a mixture of salt and sand from qualified sand and gravel companies, in accordance with specifications established by CDOT. Gravel companies bid on contracts let by each Region, generally on an annual basis. Due to various reasons, these companies do not want the used sand returned to them for disposal.

It is not practical for the used sand to be recycled since it has been pulverized after being on the road and therefore, no longer meets the required specification. Additionally, it would take a large amount of space and labor to sift through the material that would need to be collected for recycling. After being on the roadway surface, the material also becomes contaminated with impurities from litter, natural sediment, chemicals, petroleum hydrocarbons, and other types of pollutants that mix with the salt/sand mixture. Without adequate storage facilities, the only other alternative is to haul the material annually to disposal sites willing to take the material. This means of sand removal and disposal could potentially become cost prohibitive.

Practical alternatives for the disposal of used traction sand material are extremely limited. However, some communities adjacent to I-70 are realizing the advantages of sound berms to reduce highway noise. Currently, the disposal of some accumulated sediment material from the Straight Creek I-70 corridor is used for the construction of berms along I-70 in Silverthorne/Dillon and surrounding areas. Sound berms have been constructed using I-70 sand near Silverthorne/Dillon utilizing 22,950 cubic yards of road sand and sediment.

Preliminary research by CDOT into sand disposal options for the Straight Creek section of I-70 indicate that at least one new sand berm can be constructed near Frisco at an estimated capacity of 5,000 cubic yards. Potential exists for an additional 8,000 cubic yard disposal site in this area (CDOT, 2002). Estimates indicate that 3,704 cu-yds (5,000 tons) may be captured annually from the Straight Creek corridor for disposal. Clearly, substantial permanent disposal areas will be needed before this SCAP can be implemented. This will require an active approach in identifying sand disposal sites in advance, before significant volumes of traction sand can be removed from the highway and an effective sediment control program can be implemented.

As described in Section 5.5, the cross sections at certain locations along I-70 may require infilling of material near the toe of cutslopes or the crest of fillslopes to accommodate drainage design. Depending on the suitability of sand for use as a fill material, it may be possible to utilize these areas as permanent sand disposal sites. In this fashion, the sand removal BMP's specified in Control Scenario 2 may be integrated into certain fill requirement needs for Control Scenario 3 or 4. This option would be particularly useful for disposal of the sand accumulation in both study corridors.

Equipment

The equipment required to remove sediment from Zone 1 consist primarily of mechanical sweepers/brooms, front-end loaders, graders, and haul trucks. The sediment collection structures will likely require cleaning with a track hoe (excavator), or vacall truck. There are several advantages offered by a vacall truck including a reduction in manpower and the ability to remove sediment when it is saturated with water. CDOT equipment needs will depend on whether or not the equipment will be purchased or leased. The estimated equipment needs and costs are included in the various Scenarios presented in this SCAP.

Snow Removal and Storage

The current CDOT snow removal practice involves moving snow as far away from the highway template as possible in the high elevation areas of the I-70 corridor, including Straight Creek. Once snow is plowed to the shoulder with snow plow trucks during the initial snowstorm, it is later moved further off the shoulder using heavy equipment such as loaders or bulldozers. The maximum extent of plow cast is typically 10 to 20 feet, whereas snow is often moved beyond the plow cast zone during subsequent removal operations in certain areas. The main purpose of this practice is to allow sufficient space for new snow storage as the winter progresses. Further, CDOT has determined that after snow is moved once, it is more difficult to move the second time due to consolidation processes that occur in the snowpack.

As described in earlier sections of this plan, snowfall is generally proportional to elevation with the highest amounts above 9,500 feet. Locations above 9,500 feet on the west approach to the Eisenhower Tunnel require substantial snow storage areas to maintain a clear zone along I-70 during winter. Unfortunately, storage space is limited due to the steep nature of the topography. The snow removed from the highway includes a mixture of traction sand and salt. Therefore, large deposits of traction sand remain in snow storage areas following snowmelt.

Even without the advantage provided by structural controls, there are opportunities to reduce migration and transport of traction sand that result from snow storage practices. In some areas, traction sand deposits are 30 feet or more from the edge of the highway, well beyond the extent to which plow trucks can cast snow during initial removal operations. Wide shoulders beyond the clear zone are cleared in these areas during winter that are not utilized. Even though vegetation is smothered each year, sand deposits are diffuse and even structural controls would only be marginally effective and difficult to maintain in these areas.

Two situations are common in snow storage zones along I-70 including 1) snow is moved off the highway shoulder into forested areas to distances of 30 feet or more from the edge of pavement sometimes resulting in large expanses of excess snow storage capacity, and 2) snow is dumped over the crest of fillslopes even when large snow storage areas remain open. One reason for these procedures is to maintain substantial snow storage capacity at all times. Another is to provide adequate drainage to ensure melting snow does not reach the travel portion of the highway where it could re-freeze. However, if adequate capacity is available late in the winter (for example in April), and proper drainage controls are in place, there is probably no need to dump the snow over hillslopes because the storage capacity is not likely to be reached before winter's end and drainage onto the roadway would not occur.

In some areas it may be possible to limit the distance by which snow/sand is moved away from the highway shoulder. This would require structural controls in combination with a change in maintenance procedures and techniques involving designation of an initial limit to the distance snow could be moved off the shoulder. For example, a maximum distance of 30 feet from the edge of pavement could be designated as the limit for snow removal. If the snow pile became too large the drainage was affecting safety on I-70, maintenance forces could mobilize heavy equipment to reduce the height of the snow pile. Likewise, snow could remain on the highway template within 30 feet of the edge of pavement, and could be dumped over the hillslope only if maximum storage capacity was reached. Once the snow/sand is dumped over the hillslope it is impossible to recover the sand or to establish a permanent vegetation cover in the fillslope areas buried by sand each year.

Any of these changes in snow/sand storage practices would 1) reduce the extent of sand deposition and facilitate cleanup efforts, 2) reduce the migration and transport of sand into receiving streams, and 3) improve vegetation cover and the success of revegetation and slope stabilization efforts. Any changes in current maintenance practices would likely require both a training program and an active management strategy. Judgment would have to be applied on the ground regarding when and where to move snow if this were determined to be a feasible BMP for sediment control.

Finally, snow blowers are used occasionally to remove excess snow along the Straight Creek I-70 corridor. This maintenance practice results in dispersing the sand that is entrained in the snow over wide areas to distances of 100 feet or more from the highway. Snow blowing disperses the sand, possibly resulting in lower accumulation depths in certain areas. However, the sand eventually accumulates in forested areas far from the highway where removal is no longer feasible. Therefore, careful consideration should be given to these factors before this snow removal technique is used. Snow blowing criteria will be developed as part of the SMP.

Liquid Deicer Program

During the 1994-95 winter season, traction sand usage was reduced along the I-70 west corridor in an effort to decrease the amount of the salt/sand mixture applied. This action resulted in numerous road closures that season. In the spring of 1996, CDOT began the experimental use of liquid de-icers to reduce the quantity of salt/sand mixture used in the I-70 mountain corridor while still maintaining mobility and safety during the winter. Since that time, the use of liquid de-icers has been increasing since they have helped to keep I-70 open, while maintaining the safety of the traveling public. Traction sand is still required to accompany the chemicals used since a certain amount of traction is still required.

It has been demonstrated that there is a direct correlation between the amount of salt/sand mixture applied to the roadway and the severity of a given winter season. Therefore, the amount of material applied varies from year to year. Although, salt/sand usage along I-70 west has decreased overall, due primarily to better housekeeping and management practices over the years, the average (mean) has remained relatively constant, while the use of liquid deicers has increased dramatically.

Liquid deicers are becoming more commonplace at the higher elevations, when used in conjunction with traction sand material. At this time, the most common liquid deicer is Magnesium Chloride. When liquid deicers are applied to dry pavement prior to a snow event, it is called anti-icing. The intent is to create a barrier between the road surface and the snow and ice. This prevents ice from bonding to the asphalt and this material works to a certain surface temperature. When the road surface drops below that temperature, it is not longer effective. An advantage of anti-icing is that once the temperature begins to rise again, the snow and ice plow off the road easily because it has not bonded to the pavement. This notably reduces the time to dry pavement.

Deicing is a procedure where liquid deicers are applied to the road surface while a snow event is in progress. This is done in an effort to keep the road surface wet for a longer period. The liquid deicers reduce the freezing temperature of water to a certain point, when they lose their effectiveness. It is at this point that maintenance crews select one of two options: 1) switch to a different type of deicer with a lower freezing point, or 2) begin the application of traction sand.

Even with the increased usage of liquid deicers, some amount of traction on the roadway is still necessary due to snow-pack build-up, ice, and refreezing, especially with the steep grades that exist on Vail Pass and Straight Creek. Therefore, although there have been recent reductions in sand usage, this is very weather dependant and traction sand will continue to be used in the I-70 mountain corridor into the foreseeable future.

6.0 STRAIGHT CREEK SEDIMENT CONTROL SCENARIOS

The SCAP includes four scenarios for consideration by the Transportation Commission and CDOT management. These Scenarios include: (1) Existing Maintenance Program (baseline); (2) Enhanced Maintenance Program; (3) Capital Construction and Maintenance Program; and (4) Prioritized Capital Construction and Maintenance Program. Each Scenario includes BMP items and estimated costs that were developed for planning purposes only and therefore may not be all- inclusive. The costs do not, for example, include potential costs associated with environmental clearances or permitting since these cannot be accurately identified at this time but would have to be determined on a project-specific basis.

6.1 SEDIMENT CONTROL SCENARIO 1 - EXISTING MAINTENANCE PROGRAM (BASELINE)

Sediment Control Scenario 1 assumes a continuation of the existing CDOT maintenance program with no additional enhancements or funding for sand cleanup. This was deemed important to include in the SCAP since all other control scenarios will require significant maintenance resources and policy changes within the existing maintenance program in order to implement.

Control Scenario 1 assumes that the routine maintenance practices such as ditch cleaning (including limited sand and sediment removal, rockfall removal, etc.) will be accomplished within existing budgets using existing personnel. Shoulder, ditch cleaning, and rock removal are primarily performed during the months of May, June, and September. High priority activities such as paving and other roadway activities must also be accomplished during the summer months due to the short summer season. Additional work for environmental purposes such as sand removal, constructing boreal toad habitat, maintaining sediment ponds, collecting and reporting data, and other activities within the Paul Area can currently be accomplished only as resources and staffing and resources allow.

As part of Control Scenario 1, the load allocations specific in the TMDL will require implementation of the following BMP's:

- Revegetation of at least 70% of the cut and fill slopes to 70% potential cover
- Dredging and maintenance of the sediment basins and sediment control structures on the I-70 roadway
- Removal of at least 25 % of the traction sand material applied annually to I-70 between the Blue River and the Tunnel

Cost Summary

With the current allotment of funds in the maintenance budget for roadside appearance, the service provided will remain the same or possibly decrease. Maintenance forces will continue to maintain the shoulders, ditches, drainage structures, and eroded areas to the extent possible with existing maintenance forces and funding. The culverts along the corridor are aging and will require repairs and replacement that may also need to be funded out of the roadside appearance budget.

It is estimated that approximately $40,000 to $80,000 will continue to be spent annually on sediment removal activities in the Straight Creek I-70 corridor (excluding the extra $75,000 provided by the Transportation Commission in FY 01-03).

6.2 SEDIMENT CONTROL SCENARIO 2 – ENHANCED MAINTENANCE PROGRAM (NON-STRUCTURAL CONTROLS)

It is apparent from the analysis conducted for this SCAP that a more aggressive maintenance program is needed to better control the sediment at the source, to collect sediment material more frequently, and to establish and utilize long-term disposal areas. In order to more fully develop this program, Sediment Control Scenario 2 assumes an enhanced maintenance program, but with no new structural controls along I-70. Instead, Scenario 2 emphasizes the use of maintenance BMP's, cleanup requirements, revegetation, and other non-structural controls. Routine repair or replacement of existing drainage structures, such as culverts and inlets, is presumed as part of regularly funded maintenance activities.

Scenario 2 requires additional equipment, staffing, and funding to improve current maintenance operations beyond the "routine" operations, practices, and policies under MLOS. This scenario requires that maintenance increase the use of maintenance BMP's (i.e., sweeping, guardrail and ditch cleaning, annual sediment removal, revegetation, etc.), collecting and hauling material on a routine basis, developing and implementing a sediment maintenance program as a part of "routine" operations, and providing an improved MMS system for data collection and retrieval needs, among others.

Control Scenario 2 assumes that the maintenance BMP measures specified in Section 5.6 will be implemented to the extent possible but with no new structural controls. This scenario includes removal of the estimated 24,000 cu-yds of sand accumulated in Zone 1 of the Straight Creek I-70 corridor. The requirements of the TMDL for Straight Creek will also be included under Control Scenario 2.

Without structural drainage controls such as sediment basins, there are few practical means of sediment control during the March-April snowmelt period. However, maintenance BMP's such as removal and sweeping could play a major role in sediment control if a strict schedule is adhered to. For example, during most years snow/sand removal and sweeping activities could begin in April at the lower elevations of the Straight Creek I-70 corridor. These cleanup activities would begin at lower elevations proceeding to progressively higher elevations by May. This would assure that sand accumulated in shoulder and snow storage areas would be removed before May 15, after which time rainfall events would start to occur that mobilize the sand.

This sand removal maintenance BMP could result in effective sediment control because a large portion of the annual sand deposits that are normally mobilized during summer (June-July) rainfall-runoff events would be removed from the system by May 30. During summer rainfall-runoff events residual material is mobilized, some of which is transported into receiving streams while a portion is re-deposited along the highway template. Therefore, a secondary period when sediment removal and sweeping should take place is in the fall (September) following the summer rainfall season. This second annual cleanup will assure that the highway shoulders and drainage networks are free of sediment buildup before the next winter season begins, minimizing source areas.

It is anticipated that CDOT will need to utilize contractors for hand-work and seasonal work to conduct these annual cleanup activities. This can provide many benefits including:

- Elimination of internal schedule conflicts associated with CDOT winter maintenance forces
- Rapid response and timely cleanup
- Mobilization of sufficient labor resources and heavy equipment to complete the task quickly

A Sediment Maintenance Program (SMP) will be developed as part of Control Scenario 2 that specifies a schedule and scope of work for annual sediment cleanup activities, as described in Section 5.6.

CDOT records indicate that it has been possible to collect about 25 percent of the annual sand input in the Straight Creek I-70 corridor from ditch cleaning, drainage features, sweeping, and sediment basins. For an average (10,000 ton) application year, this translates to about 2,500 tons (1,852 cu-yds) of sand removal from in the Straight Creek I-70 corridor.

Based on the information obtained during the development of the SCAP, it is conservatively assumed that the utilization of non-structural maintenance BMP's under Control Scenario 2 would be capable of capturing and removing at least 25 percent of the average annual sand applied to Zone 1 of the Straight Creek I-70 corridor. Therefore, permanent disposal facilities would be required to accommodate these annual sediment volumes. This will require an ongoing effort by CDOT, local agencies, and communities to identify and secure more permanent sediment disposal sites for at least 20 years into the future.

The replacement and cleaning of highway drainage features such as culvert inlets, culverts, and installation of erosion protection measures at culvert inlets and outfalls are routine maintenance activities carried out by CDOT. These activities are included in Control Scenario 2 because of their importance in facilitating sediment control. Several culvert inlets are buried or plugged in the Straight I-70 corridor. These conditions cause runoff to concentrate in downstream areas, producing excessive flow velocities, erosive energy, and sediment transport.

The integrity of the existing drainage system is evaluated by CDOT maintenance as part of routine sediment control BMP's to identify problem areas and solutions. In some instances the existing inlets or culverts may be damaged and require replacement. Cost estimates for routine replacement of drainage structures are included. However, major structural control improvements such as culvert rundowns and sediment basins are not included as part of Control Scenario 2.

Several pieces of equipment are presently owned and utilized by CDOT to remove accumulated traction sand and roadcut sediments from the I-70 corridor. These generally include graders, front-end loaders, track loaders and/or bulldozers, mechanical sweepers, and tandem dump trucks. Since most of the shoulder areas of I-70 where excess traction sand accumulates are unpaved, the typical procedure is to grade the excess sediment into a windrow for removal by loaders and trucks. It is assumed under Control Scenario 2 that this will continue to be the primary method of sand cleanup.

The mechanical sweeper requires approximately eight feet of flat paved surface to operate effectively. There are several segments within the Straight Creek I-70 corridor where the shoulders have been paved and sweeping is effective. This practice will continue in paved shoulder areas under Control Scenario 2. There is no effective mechanical method for removing sand from beneath guardrails, so these areas are typically cleaned by hand. This procedure will probably need to continue until such time the guardrails can be replaced with improved structural controls.

This Plan recommends that an annual revegetation program be undertaken by CDOT. This program would include an annual vegetation cover survey and a report to be developed that identifies problem areas, recommends solutions, and proposes any actions needed to improve vegetation cover. It is undetermined at this time if the annual revegetation program will be administered as a maintenance program or as part of the construction program. However, it is incorporated as part of Control Scenario 2.

Sediment Control Scenario 2 consists of the following maintenance BMP items:

- Removal of 24,000 cu-yds of sand accumulated in Zone 1
- Development of a Sediment Maintenance Program with resource allocation and schedule
- Fulfillment of the Straight Creek TMDL requirements
- Maintenance training for improved snow removal and storage practices
- Annual sweeping of paved shoulders
- Annual inspection and removal of sediment deposited in existing basins
- Semi-annual ditch cleaning/removal of traction sand accumulated within 30 feet of the edge of pavement (May and September)
- Sediment disposal program
- Revegetation program
- Vegetation monitoring program
- Stream monitoring program
- Drainage system repairs
- Vacall truck and other necessary equipment
- Hiring of up to 6 additional CDOT FTE's (or equivalent contracting)

The estimated cost for Control Scenario 2 is summarized in the following table. This estimate indicates approximately $400,000 would be required annually to fully implement Control Scenario 2. Approximately $1,000,000 would be required for removal and disposal of the sediment accumulated in Zone 1, purchase equipment, and develop the SMP.

6.2.1 Control Scenario 2 - Lite

As an option for consideration, selected key components of Scenario 2 could be implemented in the short-term to reduce costs while still removing up to 25 percent of the annual sand input. This approach would incorporate any new structural BMP's as they come on line such as those being installed in 2002.

Scenario 2 Lite would include the following priority components for an estimated annual cost of $165,000.

- Development of a Sediment Maintenance Program with resource allocation and schedule ($10K)
- Maintenance training for improved snow removal and storage practices ($5K)
- Annual inspection and removal of sediment deposited in existing basins and Semi-annual ditch cleaning/removal and disposal of traction sand accumulated within 30 feet of the edge of pavement (May and September) ($65K)
- Sediment disposal program ($15K)
- Revegetation and monitoring program ($25K)
- Stream monitoring program ($25K)
- Drainage system repairs ($20K)

Control Scenario 2 Lite incorporates the priority components required to establish sediment maintenance BMP's as routine practice within the CDOT maintenance program. It is also important to establish a sediment maintenance program early in the process before structural controls are installed to improve effectiveness. This alternative also provides the essential funding needed for removal of annual sand inputs. Monitoring programs and a sediment disposal program would be formally started to assess trends and data needs. Given the limited funding potential at this time, Control Scenario 2 Lite provides a cost effective alternative for immediate implementation.

Control Scenario 2 Cost Summary
Straight Creek

BMP Item	Units (cu-yds)	Cost/Unit	Estimated Cost	Assumptions/Notes
Capital Expenditure				
Sediment Deposition Removal	24,000	$35	$840,000	Incremental removal of sediment stored on I-70 template - assumes 6,000 cu-yds/year for 4-years
Equipment Purchase			$225,000	One broom and vacuum truck - assumes equipment not leased, design life 20-years, 50/50 split with Black Gore
Sediment Maintenance Program Development			$15,000	SMP will be collaborative effort with CDOT maintenance and environment - assumes 50/50 split with Black Gore
Capital Total			**$1,080,000**	
Annual Costs				
Winter Maintenance Sediment Control Training			$5,000	Training at Maintenance Training Academy - assumes 50/50 split with Black Gore
Annual Basin Sand Removal and Ditch Cleaning	1,852	$35	$64,820	Pickup, hauling, dumping, (optional contracting), traffic control, seasonal work – 25% of average annual sand (2,500 tons/1.35 ton/cu-yd)
Sediment Disposal and Reclamation Program			$30,000	Includes stockpiling, forming, topsoil, reseeding, drainage controls, identification and permitting of disposal areas
Re-vegetation Program			$50,000	Annual re-seeding and soil amendment, cover surveys, and reporting, and completion of unvegetated areas
Stream Monitoring & Reporting			$25,000	Assumes stream monitoring of improvements at three stations, coordination for aquatic biology surveys, etc.
Temporary Drainage System BMP's			$35,000	Drop inlet protection and cleaning, culvert maintenance
Annual Equipment Lease			$72,000	Annual lease loader/haul truck/excavator assumes 6 units @ $2,000/month = $12,000/month split 50/50 Black Gore
Maintenance Environmental Specialist	1 FTE	$50,000	$50,000	Technical support at Jr. Foremen level to oversee and manage environmental activities and reporting
Maintenance Labor Needs	2.5 FTE	$30,000	$75,000	Labor at M-1 level for sediment maintenance program (optional contracting)
Annual Total			**$406,820**	

6.3 SEDIMENT CONTROL SCENARIO 3 – CAPITAL CONSTRUCTION AND MAINTENANCE PROGRAM

Control Scenario 3 integrates full structural sediment and erosion controls, non-structural controls, and an enhanced maintenance BMP program. It assumes that all structural control measures outlined in Section 5 would be implemented in the Straight Creek I-70 corridor, including:

- Basins and traps to capture sediment
- Paving of shoulder areas to reduce rill erosion and provide a durable surface for cleaning
- Valley pan drains to control and route highway runoff
- Knee walls to prevent cut slope erosion
- Type 7 concrete guardrail to reduce migration of sediment from fillslopes
- Controlled snow storage/sand deposition areas

The following maintenance BMP's outlined for Control Scenario 2 would also be included:

- Removal of 24,000 cu-yds of sand deposits in Zone 1
- Development of a Sediment Maintenance Program with resource allocation and schedule
- Fulfillment of the Straight Creek TMDL requirements
- Maintenance training for improved snow removal and storage practices
- Semi-annual sweeping and ditch cleaning/removal of traction sand accumulated within 30 feet of the edge of pavement (May and September)
- Annual inspection and removal of sediment deposited in sediment basins and traps
- Sediment disposal program
- Revegetation program
- Vegetation monitoring program
- Stream monitoring program
- Drainage system repairs
- Vacall truck and other necessary equipment

Detailed capital construction costs are provided in Appendix C and are summarized in the following table, along with the annual maintenance costs. The capital construction costs for the structural BMP's proposed for the Straight Creek I-70 corridor is approximately $16,000,000. The non-structural BMP's including maintenance would require approximately $400,000 annually. This cost estimate includes the following contingency components:

- Traffic control – 10%
- Incidentals – 20%
- Inflation – 10%
- Preliminary Engineering Design – 5%

- CE Construction Costs – 17.5%

For estimating purposes, it is assumed that sediment would be removed from the collection structures twice each year as outlined in Section 5.6. The frequency of cleaning will also be dependent on weather conditions, sand usage, basin collection efficiency, and the effectiveness of the maintenance BMP's. The SMP will specify maintenance procedures, including a collection structure inspection schedule, from which the results will ultimately be used to determine the frequency of cleaning.

Many of the existing sediment basins (and WesTraps) in the Straight Creek area are continually saturated with water from perennial flows, making it very difficult to remove accumulated sediment. Under these conditions, the material is the consistency of soup, making removal inefficient and loss of material during transport problematic. The structural drainage control design proposed for Control Scenario 3 will resolve this problem in most areas by routing clean perennial flows away from sediment basins to clean tributaries.

Control Scenario 3 proposes that a vacall truck be used to clean sediment basins and traps, as well as any future sediment basins. A vacall truck could provide the most efficient and cost effective method for removing sediment from collection basins because they can be accessed for cleaning remotely without entering the basin with heavy equipment. This would be particularly useful for the small basins associated with this SCAP. A labor cost savings may be realized with a vacall truck since only one or two operators are required. It is assumed that a vacall truck cannot be leased, but will have to be purchased. Equipment costs are included as part of Control Scenario 3.

The annual volume of sediment captured and removed will be approximately 50 to 80 percent of the sand applied, or an average total of 5,000 to 7,500 tons (3,704-5,556 cu-yds) for Zone 1 of the Straight Creek I-70 corridor. The sediment removal and disposal cost is estimated at $35 per cubic yard, regardless if the source is from sediment collection basins, snow storage areas, or sweeping.

Control Scenario 3 Cost Summary
Straight Creek

BMP Item	Units (cu-yds)	Cost/Unit	Estimated Cost	Assumptions/Notes
Capital Construction				
Full Build-Out of Structural BMP's			$15,279,000	Installation of all required structural sediment source controls and drainage improvements
Sediment Deposition Removal	24,000	$35	$840,000	One-time cost for removal of sand deposits down to design grade on I-70 template
Equipment Purchase			$225,000	One broom and vacuum truck - assumes equipment not leased, design life 20-years, 50/50 split with Black Gore
Sediment Maintenance Program Development			$15,000	SMP will be collaborative effort with CDOT maintenance and environment - assumes 50/50 split with Black Gore
Capital Total			**$16,359,000**	
Annual Costs				
Winter Maintenance Sediment Control Training			$5,000	Training at Maintenance Training Academy - assumes 50/50 split with Black Gore
Annual Sand Removal and Ditch Cleaning	3,704	$35	$129,640	Pickup, hauling, dumping, (optional contracting), traffic control, seasonal work – 50% - 80% of average annual sand (5,000-7,500 tons/1.35 ton/cu-yd
Sediment Disposal and Reclamation Program			$30,000	Includes stockpiling, forming, topsoil, reseeding, drainage controls, identification and permitting of disposal areas
Re-vegetation Program			$50,000	Annual re-seeding and soil amendment, cover surveys, and reporting, and completion of unvegetated areas
Stream Monitoring & Reporting			$25,000	Assumes stream monitoring of improvements at three stations, coordination for aquatic biology surveys, etc.
Sediment Collection/Drainage System BMP's			$37,500	Collection structure monitoring and maintenance, repairs, performance evaluations, assumes 0.25% of capital
Annual Equipment Lease			$36,000	Annual lease loader/haul truck/excavator assumes 3 units @ $2,000/month = $6,000/month split 50/50 Black Gore
Maintenance Environmental Specialist	1 FTE	$50,000	$50,000	Technical support at Jr. Foremen level to oversee and manage environmental activities and reporting
Maintenance Labor Needs	2.5 FTE	$30,000	$75,000	Labor at M-1 level for sediment maintenance program (optional contracting)
Annual Total			**$438,140**	

6.4 SEDIMENT CONTROL SCENARIO 4 – PRIORITIZED CONSTRUCTION AND MAINTENANCE PROGRAM

Control Scenario 4 presumes a phased approach to sediment control according to priority needs and the availability of funding. This control scenario integrates the components of Scenarios 2 and 3 into prioritized capital improvement and maintenance needs based on specific problem areas identified in the Straight Creek I-70 corridor.

This scenario assumes that the enhanced maintenance program (Scenario 2) will be implemented and capital construction will be phased-in over a period of 10 years according to priority areas identified in the SCAP. Using a 10 percent annual capital expenditure of the total estimate of approximately $15,000,000 in today's dollars, the total annual capital construction budget of $1,500,000 would be allocated. The capital cost estimates are the same as Control Scenario 3 (see Appendix C). The annualized costs are shown in the following table for Control Scenario 4.

As the structural source control measures are brought on line, the maintenance program would need to be adjusted accordingly. This would be outlined in the Sediment Maintenance Program (SMP). The components of the SMP are described in Section 5.6 and summarized with costs in Control Scenario 2. This information is integrated into Control Scenario 4 to provide an enhanced maintenance program that would be implemented in conjunction with prioritized capital construction.

Additional maintenance resources would be needed as the additional sediment collection structures are brought on-line and the SCAP is fully implemented. Sediment removal and disposal would also increase accordingly from at least 25 percent of the annual sand input initially, up to 80 percent of the annual sand input after all structural controls are installed. For estimating purposes the annual maintenance costs assume that full structural controls are in place.

Control Scenario 4 Cost Summary
Straight Creek

BMP Item	Units (cu-yds)	Cost/Unit	Estimated Cost	Assumptions/Notes
Capital Construction				
Phased Build-Out of Structural BMP's			$1,528,000	Assumes 10% of total build-out of all required structural sediment source controls and drainage improvements
Sediment Deposition Removal	24,000	$35	$840,000	One-time cost for removal of sand deposits down to design grade on I-70 template
Equipment Purchase			$225,000	One broom and vacuum truck - assumes equipment not leased, design life 20-years, 50/50 split with Straight Cr.
Sediment Maintenance Program Development			$15,000	SMP will be collaborative effort with CDOT maintenance and environment - assumes 50/50 split with Straight Cr.
Capital Total			**$2,608,000**	
Annual Costs				
Winter Maintenance Sediment Control Training			$5,000	Training at Maintenance Training Academy - assumes 50/50 split with Black Gore
Annual Sand Removal and Ditch Cleaning	3,704	$35	$129,640	Pickup, hauling, dumping, (optional contracting), traffic control, seasonal work - 50% - 80% of average annual sand (5,000-7,500 tons/1.35 ton/cu-yd
Sediment Disposal and Reclamation Program			$30,000	Includes stockpiling, forming, topsoil, reseeding, drainage controls, identification and permitting of disposal areas
Re-vegetation Program			$50,000	Annual re-seeding and soil amendment, cover surveys, and reporting, and completion of unvegetated areas
Stream Monitoring & Reporting			$25,000	Assumes stream monitoring of improvements at three stations, coordination for aquatic biology surveys, etc.
Sediment Collection/Drainage System BMP's			$37,500	Collection structure monitoring and maintenance, repairs, performance evaluations, assumes 0.25% of capital
Annual Equipment Lease			$36,000	Annual lease loader/haul truck/excavator assumes 3 units @ $2,000/month = $6,000/month split 50/50 Black Gore
Maintenance Environmental Specialist	1 FTE	$50,000	$50,000	Technical support at Jr. Foremen level to oversee and manage environmental activities and reporting
Maintenance Labor Needs	2.5 FTE	$30,000	$75,000	Labor at M-1 level for sediment maintenance program (optional contracting)
Annual Total			**$438,140**	

Areas along the Straight Creek I-70 corridor have been prioritized according the sediment loading conditions. Areas having the greatest sediment load and direct transport pathway to receiving waters are first in priority, followed by progressively lower impact zones. The Straight Creek Erosion Control Project focused on structural and non-structural BMP's in the upper 2.5 miles of the I-70 corridor (above Hamilton Box). As described in Section 2.0, the higher elevation zones typically receive the greatest snowfall and sanding volumes and these areas are generally the highest priority for sediment control.

There has been few control measures implemented in the lower 5.5 miles of the Straight Creek corridor. However, observations during water quality monitoring (including data) and reconnaissance in 2001 indicate significant sediment loading throughout the lower portion of Straight Creek. The following criteria were used to establish priority areas for sediment control in Zone 1 of the Straight Creek I-70 corridor.

- Areas with no structural BMP's currently in place
- Areas in close proximity to I-70, providing good access for installation and maintenance of structural BMP's 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 cutslope and fillslope erosion

Based on these criteria, the following table was developed listing areas in order from highest priority for treatment in Zone 1.

Prioritized Capital Construction
Straight Creek Area
Control Scenario 4

Priority Ranking	Milepost Length	Description
1	212.9-213.5 0.6-mi.	Tunnel area – high sand use and sediment transport, large impervious surfaces, snow storage issues, steep gradient, direct pathway to headwaters of Straight Cr., ongoing revegetation requirements
2	210.1-210.8 0.7-mi.	High sand usage and transport, no sediment controls, active deposition in wetland area and riparian areas, direct pathway to Straight Creek
3	209.5-210.1 0.6-mi.	High sand usage and transport, no sediment controls, active deposition in wetland area and riparian areas, direct pathway to Straight Creek
4	208.7-209.5 0.8-mi.	High sand usage and transport, no sediment controls, drainage problems, severe gully erosion, active deposition in wetland area and riparian areas
5	208.0-208.7 0.7-mi.	High sand usage and transport, no sediment controls, drainage problems, heavy sand deposition in forested areas, Town of Dillon water supply intake
6	212.3-212.9 0.6-mi.	High sand usage and transport, sediment basins overloaded, active deposition in wetland area and riparian areas, direct pathway to Tributaries & Straight Creek, ongoing revegetation requirements
7	211.5-212.3 0.7-mi.	High sand usage and transport, sediment basins overloaded, active deposition in wetland area and riparian areas, direct pathway to Tributaries & Straight Creek, ongoing revegetation requirements
8	210.8-211.5 0.7-mi.	Hamilton Box area - high sand usage and transport, no sediment basins in lower portion, active deposition in wetland area and riparian areas
9	207.4-208.0 0.6-mi.	Moderate sand usage and transport, no sediment controls, drainage problems, heavy sand deposition in forested areas
10	206.5-207.4 0.9-mi.	Moderate sand usage and transport, no sediment controls, sediment berms with drainage problems, residential area

7.0 SUMMARY AND RECOMMENDATIONS

This Sediment Control Action Plan sets forth the technical analysis and basis for future actions that address sediment control related to highway operation and maintenance in the Straight Creek I-70 corridor. This is considered a planning document only, but provides the guidance necessary for implementation of sediment controls. Additional design and hydraulic analysis will be necessary to fully implement this SCAP. A shift in CDOT policy and priorities, particularly with respect to maintenance operations, will be necessary before effective actions can be taken.

In the Straight Creek I-70 corridor, only partial implementation of permanent structural measures has been completed to control sediment loading caused by traction sanding. Slope erosion along this section of I-70, although problematic when I-70 was first constructed, has been significantly reduced in recent years. However, active erosion does continue to occur on slopes in the Straight Creek corridor, especially in the lower section where drainage BMP's have not been installed. The primary source of sediment in Straight Creek today is traction sand. It is estimated that approximately 24,000 cubic yards of used traction sand is in "temporary storage" adjacent to I-70 along the shoulders. A portion of this material continues to migrate from I-70 to the forest and ultimately Straight Creek. It is estimated that with structural controls, at least 50 to 80 percent of the annual traction sand applied could be removed with the proposed control measures in place along I-70. Ongoing monitoring of both structural and non-structural BMP's, vegetation, and water quality is needed.

Different sediment control scenarios for potential implementation were developed in order to provide a range in costs, including Scenarios (1) Existing Baseline Condition, (2) Enhanced Maintenance Program, (3) Capital Construction and Maintenance Program, and (4) Prioritized Capital Construction and Maintenance Program. These control scenarios take into consideration the existing conditions and requirements needed to address all matters related to CDOT operations in the corridor.

The SCAP provides information for CDOT management and decision-makers regarding the current condition and future needs along the corridor. The SCAP focuses on implementing corrective measures along the I-70 corridor to help address sediment loading at the source. Once the source in Zone 1 is under control, it is believed that recovery in the areas beyond the highway will occur over time. Impacts from I-70 sedimentation beyond the immediate highway corridor (Zones 2 and 3) are recognized. However, further consultation and coordination with the appropriate agencies, entities, stakeholders, and experts is needed prior to evaluating remedial efforts affecting the forest or stream riparian corridors.

Currently, no funding stream has been identified or policy modifications made to the existing system that would allow for partial or full implementation of this SCAP. Maintenance operations, in particular, will need to be reviewed and policy decisions made before this plan is implemented. It is not practicable or prudent to allocate resources for construction of sediment control structures without an adequately defined maintenance program (SMP) to maintain them on a routine basis. The ability within the current maintenance program to provide the necessary resources to conduct annual sediment clean-up of this corridor is limited. Maintenance personnel do what they can with available resources, but are currently taxed with conducting their routine duties. This SCAP identifies these deficiencies within the current system.

There is no doubt the cost of cleanup, implementing source control measures, providing for adequate maintenance, and other related costs along this corridor from over twenty years of operations will be significant. When the interstate system was designed and constructed, permanent source controls and the control of highway drainage and associated impacts were not known or considered. Therefore, the current roadway configuration will require retrofitting to include the necessary controls and ongoing maintenance to ensure effectiveness and efficiency.

A summary of recommendations from this SCAP is presented below. These have been identified for review and consideration through the examination and analysis of research, policies, field surveys, data, and other information obtained and developed for this SCAP. This list reflects the most imperative needs identified, but may not be entirely complete.

1) Pursue funding for capital construction of sediment control structures
2) Increase funding to this Maintenance MPA or create a new MPA to address sediment maintenance
3) Initiate specialized training programs for sediment maintenance
4) Implement policy changes in maintenance operations regarding priorities
5) Implement BMP monitoring and maintenance program
6) Implement annual revegetation program
7) Support an ongoing stream monitoring program related to sediment data collection
8) Restructure the MMS to include environmental data

7.1 RESEARCH CONCEPTS FOR CONSIDERATION

Although I-70 was never designed to control sediment loading to receiving streams from traction sand, the issues identified in this SCAP warrant additional research and considerations for both structural and non-structural sediment control methods for the I-70 mountain corridor. Conventional methods for maintaining mobility in high-elevation mountain environments include snow removal and traction sanding. These methods are costly in terms of labor and equipment resources, and pose many safety hazards and environmental consequences. Potential concepts that warrant research involving other options for maintaining mobility on I-70 during winter are provided below.

Future Highway Design Structural Sediment Controls

Future I-70 design in the mountain corridor should incorporate sediment control and collection structures within the highway template, particularly in high-elevation zones and sensitive aquatic environments. Sediment basins are proven to provide many water quality benefits by controlling particulate contaminant transport. Many of the structures proposed in this plan have proven constructability and maintainability, and would not be a significant cost factor if integrated into the highway design. Examples of this can be found on the U.S. Highway 40 Berthoud Pass East project where sediment control structures (below-grade traps) and snow storage areas were incorporated into highway design and reconstruction.

Automated Liquid De-icing Systems

Automated liquid de-icing systems are commonly used in new bridge construction in cold environments to reduce ice formation. I-70 in Glenwood Canyon has such a system that is effective under certain conditions. These systems can reduce or eliminate the need for traction sanding. There are many locations along the I-70 Straight Creek corridor where an automated de-icing system could be effective in reducing traction sand usage.

The dissolved solids in runoff associated with liquid deicers (commonly magnesium chloride) can affect water quality in receiving streams. However, if a system was designed to capture and recycle or dispose of the excess deicer runoff the environmental benefits over traction sand may be warranted. A pilot study and monitoring program should be considered to determine the feasibility of this technology for use in the Straight Creek I-70 corridor.

Solar Snow Storage Zones

A major issue with snow removal from I-70 in high elevation areas is snow disposal. Removed snow is typically stored in large piles along the shoulder of I-70, or is wasted over fill slopes. This snow contains traction sand and other particulate contaminants from the highway that have detrimental effects on vegetation, slope stability, and water quality. The excessive buildup of this material is a major operational, safety, and maintenance concern for CDOT and requires substantial labor and equipment resources to manage.

There are several snow storage zones utilized along the Straight Creek I-70 corridor that are on south-facing slopes with excellent solar exposure. A portion of the snow stored in these areas can melt and consolidate, but ambient temperatures are typically too low during winter to melt enough snow to prevent excessive accumulation of the material removed from the highway. However, if the ground surface in these areas could be maintained just above the freezing point during the daytime (i.e., >32 degrees F), it may be possible to melt enough snow to prevent excessive buildup. This would eliminate the need for large snow storage zones and wasting over fill slopes, and melt water would be released at a slow rate thereby minimizing sediment and particulate transport.

It may be feasible to construct a solar heating system that would melt snow at the crest of certain fill slopes that have south exposures with solar gain. This concept is similar to solar hot water systems in common use today for residential and commercial applications. Further research into the feasibility of such a system and a pilot study is warranted for use in selected snow storage areas along I-70.

Porous Pavement

Pavement reduces infiltration of water and promotes rapid runoff, potentially increasing the erosive energy of water. Porous pavement, grasspave, and other paving products are commercially available that allow infiltration of water while controlling soil erosion.

It is anticipated that various products and treatments can be evaluated on an experimental basis. For example, these treatments could be implemented in selected areas to control runoff and erosion from I-70 parking areas, pull-offs, maintenance yards, and other similar areas.

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GLOSSARY/TERMINOLOGY

CDOT Terminology:

Colorado Department of Transportation (CDOT): State of Colorado agency charged with management of the state transportation system; including the construction, operation and maintenance of the state's highways

Enhancement funds: federal TEA-21 funds granted to state's for certain types of environmental projects

Fiscal Year (FY): the 12-month period for which the use of state funds is planned; the Colorado state fiscal year is July 1 – June 30.

Milepost (MP): original point based on roadway when CDOT first installed mileposts; designated on the roadway by "milepost markers", now referred to as reference posts

Region: One of six engineering regions in the state that are responsible for construction, right-of-way acquisition, environmental clearances, design and maintenance of state highways within their designated areas

State Transportation Improvement Program (STIP): Statewide, six-year listing of transportation projects eligible for federal funding

TEA – 21: Current federal transportation legislation

Transportation Commission (TC): An 11-member citizen board appointed by the governor that provides guidance to the Colorado Department of Transportation

Transportation Planning Region (TPR): local planning entity responsible for determining transportation priorities within a given area of the state.

Agencies:

Colorado Department of Public Health & Environment (CDPHE): The state agency for public health and environmental programs

Colorado Division of Wildlife (CDOW): State agency responsible for wildlife management

Federal Highway Administration (FHWA): responsible agency for federal highway programs

U.S. Army Corps of Engineers (COE): federal agency that oversees waters of the U.S.

U.S. Forest Service (USFS): federal land agency responsible for management of forest lands in the U.S.

Water Quality Control Commission (WQCC): A 9-member citizen board appointed by the governor that develops state water quality control policy and regulates pollutant sources

Water Quality Control Division (WQCD): a division of the Colorado Department of Public Health and Environment (CDPHE) responsible for the implementation of water quality programs and regulations established by the WQCC and through state and federal law

CDOT Maintenance Terms:

Accomplishment Unit: the unit of measure used to describe the quantity of work performed for each activity, e.g., cubic yards, linear feet, plow miles, etc.

Acronym: a three-letter code used in the MMS system to allow for tracking of various types of activities

Activity Report: CDOT Form #909, “Green Sheet”, that records (maintenance) work accomplished in the field. Information from the Green Sheets is entered into the MMS System

Anti-icer: any anti-icing agent used to create a barrier between the roadway surface and snow & ice build-up; occurs before a snow event

De-icer: any anti-icing agent used to improve traction on the roadway surface; usually occurs during a snow event

Foreman’s Area: area maintained by more than one maintenance patrol

Haul: the average one-way distance from the material source or stockpile to the work site on the highway

Liquid de-icers: chemical de-icing and anti-icing agents produced in liquid form; e.g., magnesium chloride

Magnesium Chloride: brine from the Great Salt Lake used as a liquid de-icing and anti-icing agent

M-1: refers to job classification of Highway Maintenance Worker I

M-2: refers to job classification of Highway Maintenance Worker II (the senior worker on a patrol)

Maintenance Management System (MMS): a computerized maintenance program used to track expenditures and work activities

Major Program Area (MPA): maintenance program used by the Transportation Commission to allocate funding for maintenance of state highways

Patrol: the smallest maintenance organizational unit, headed by a senior worker (M-2)

Section: refers to a maintenance section, the largest highway maintenance organizational unit headed by a Maintenance Superintendent

Sediment Maintenance Plan (SMP): In the SCAP, a program to be developed to assist maintenance forces with sediment clean-up activities and routine maintenance of sediment control structures

Traction sand/salt mixture: mixture purchased annually to be used on state highways to provide traction for vehicles during the winter months

Environmental/Water Resource Terms:

Aesthetic quality: a concept pertaining primarily to desirable visual values and with judgments concerning beauty. In highway design, it related highway landscape and planting design to nature, natural objects and other amenities

Aquatic life: wildlife living, growing on, in, or adjacent to water

Augmented flow: the increased volume of water entering a channel from diversion of surface water, water from another steam or watershed, or from waters withdrawn or collected upstream and released after use.

Best Management Practices (BMP’s): schedules of activities, prohibitions of practices, maintenance procedures, and other management practices utilized to prevent or reduce the pollution of waters of the U.S. in accordance with the Clean Water Act

Channel: a natural stream that conveys water; a ditch or channel excavated for the flow of water

Clean Water Act (CWA): the federal law that directs national water quality policy. It is intended to address water pollution in the United States

Drainage: the removal of excess water or groundwater from land by means of surface or subsurface drains

Drainage basin: a geographical area or region defined by hydrologic boundaries

Ecosystem: living organisms and the nonliving environment interacting in a given area. The complex of a community and its environment functioning as an ecological unit in nature. Small part of a larger life system, but large enough to be comprehended and analyzed

Environmental Protection Agency (EPA): Federal regulatory agency responsible for national environmental programs

Erosion: the process whereby soil materials are detached and transported by water, wind, ice or gravity

Headwater: the source of a stream; the water upstream from a structure or point on a stream

Intermittent stream: a stream or potion of a stream that flows only in direct response to precipitation

National Environmental Policy Act (NEPA): Requires environmental documentation based on anticipated level of impact to the environment by federally funded projects

Nonpoint Source Pollution (NPS): pollution that enters a water body from diffuse sources, e.g., highways, agricultural areas, urban areas, mine sites, etc.

Nonstructural controls: controls that do not require construction and are used to prevent nonpoint source pollution from entering near-by receiving streams; e.g., training, maintenance practices, etc.

Perennial stream: a stream that maintains water in its channel throughout the year

Point Source: pollution originating from a specific point, e.g., a pipe

Runoff: that portion of precipitation that flows from a drainage area on the land surface, in open channels, or in a water conveyance system or stream

Section 319 of the Clean Water Act: Allows grants to be given to address nonpoint source pollution

Section 303(d) of the Clean Water Act: Requires that pollutants of concern be addressed in stream segments not meeting their beneficial uses

Sediment: solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its origin by air, water, snow, gravity, or ice, and has come to rest on the earth's surface either above or below sea level

Sheet flow: water, usually storm runoff, flowing in a thin layer over the ground surface

Shoulder: the portion of a roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses

Stormwater: roadway runoff, snowmelt runoff, surface runoff and drainage

Structural Controls: controls constructed on the ground to decrease or eliminate nonpoint source pollution from entering near-by receiving streams

Surface water: all water the surface of which is exposed to the atmosphere

Suspended Solids: solids either floating or suspended in water

Total Maximum Daily Load (TMDL): Total load of pollutant, both point or nonpoint allowed in a stream segment

Water Quality: a term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose or use e.g., drinking water, agricultural uses, recreational uses, etc.

Water Resources: the supply of groundwater and surface water in a given area; defined as those resources dependant on or resulting from specific stream systems or other water bodies; aquatic-dependant communities, recreation, wetlands, riparian areas, floodplains, stream hydrology, and other stream communities

Watershed: drained by a river system. Alternatively, the area from which water reaches a specific point on a river or tributary

Wetland: an ecosystem that depends on constant or recurrent shallow inundation or saturation at or near the surface of the substrate

Engineering/Hydraulic Terms:

Clear Zone: area along a highway corridor that is kept clear of obstructions; provides a recovery area for vehicles leaving the traveled way

Corridor: a strip of land between two termini within which traffic, topography, environment, and other characteristics are evaluated for transportation purposes

Culvert: a closed conduit, other than a bridge, which conveys water carried by a natural channel or water transversely under the roadway

Culvert rundowns: water conveyance culverts that continue down a slope

Cut: portion of land surface or areas from which earth has been removed or will be removed by excavation; adjacent embankments or fill areas

Cut-and-fill: process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas

Detention basins: depressed basins or traps designed to remove particulate pollutants and to reduce maximum (peak) runoff flows

Ditch: an open drain for carrying surplus surface or groundwater flow

Fillslope: highway embankment; opposite to the cut slope

Gaging station: where measurements of discharge are made on a stream channel

Grade: the slope of a road, channel; or natural ground

Gradient: change of elevation, velocity, pressure, or other characteristics per unit length; slope

Hydraulic: the motion of fluid media

Hydrology: the scientific study of water

Hydrologic studies: a step required prior to the hydraulic design of a highway drainage structure. Such studies are necessary for determining the rate of flow, runoff, or discharge that the drainage facility will be required to accommodate.

Infiltration rate: a soil characteristic determining or describing the rate at which water can enter the soil under specific conditions including the presence of an excess of water

Jersey barriers: short concrete walls used as traffic barriers along a highway, used as a BMP in this application

Knee wall: short barrier used along a cut slope to help prevent undercutting of the slope; used as a BMP

Non-structural controls: BMP's that do not typically require construction, e.g., seeding, training, maintenance practices, etc.

Outfall: the point, location, or structure where wastewater or drainage discharges from a drain to a receiving body of water

Overland flow: waters derived from rain or snow that diffuse themselves over the land surface

Peak discharge: the maximum instantaneous flow from a given runoff condition at a specific location

Porous Pavement: a pavement through which water can flow at significant rates

Riparian: pertaining to anything connected with or adjacent to the banks of a stream or other body of water

Sediment: fragmentary solid material that originates from weathering of rocks or other particulate sources and is transported by, suspended in, or deposited by water

Sediment traps: constructed above grade or below grade to collect sediment material for temporary storage

Sediment basins: depressions used to collect sediment material; used for sediment collection and temporary storage

Slope: Degree of deviation of a surface from the horizontal; measured as a numerical ratio, percent, or in degrees

Slope Stabilization: providing adequate measures, vegetative and/or structural, that will reduce movement or prevent erosion from occurring

Soil: the unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants

Structural controls: relating to something constructed; constructed BMP's used to control runoff or soil erosion

Superelevation: the raised portion of highway above the normal cross slope to prevent a vehicle from sliding outward, or counteracting all the centrifugal force of a vehicle traveling at an assumed speed

Suspended load: sediment that is supported by the upward components of turbulent currents in a stream and that stays in suspension for an appreciable length of time.

Toe of Slope: where the slope stops or levels out. The bottom of the slope

Type 4 Guardrail: 34-inch tall concrete barrier typically used for temporary construction purposes

Type 7 Guardrail: 34-inch tall concrete barrier

Westrap: type of check dam/weir structure constructed out of concrete

V-ditch: paved ditch along a roadway used to channelize runoff

Valley Pan Drain: drains installed along the ditch to drain runoff to a particular point

APPENDIX A

SEDIMENT CONTROL TREATMENTS

STRAIGHT CREEK

APPENDIX A-1

STRAIGHT CREEK

EASTBOUND PHOTOS – TUNNEL TO SILVERTHORNE

APPENDIX A-2

STRAIGHT CREEK

WESTBOUND PHOTOS – TUNNEL TO SILVERTHORNE

APPENDIX B

SEDIMENT CONTROL STRUCTURE ESTIMATES AND MAPS

STRAIGHT CREEK

APPENDIX C

I-70 SEDIMENT CONTROL ACTION PLAN

STRAIGHT CREEK COST ESTIMATE – 2002