CDOT
LANDSCAPE ARCHITECTURE MANUAL

2014, Revised 2020

CDOT LANDSCAPE ARCHITECTURE AND NATURAL RESOURCES MANUAL

Prepared for:
Colorado Department of Transportation (CDOT)

Prepared By:
DESIGNWORKSHOP

2014, revised December 2020

Acknowledgments:

This Landscape Architecture and Natural Resources Manual has been prepared under the guidance of the following CDOT Landscape Architects and CDOT environmental professionals: Michael Banovich, Belinda Arbogast, Susie Hagie, Nicolle Kord, Sarah Mitchell, Greg Fischer, Jen Klaetsch and Basil Ryer. In addition, Tom Boyce, Becky Pierce, Vanessa Henderson, Jill Schlaefer and Jeff Peterson were involved in the development and review of the manual.

TABLE OF CONTENTS

I | OVERVIEW

The intent of the Colorado Department of Transportation (CDOT) *Landscape Architecture and Natural Resources Manual* herein referred to as the (Manual) is to expand transportation design decisions beyond strictly functional and engineering criteria within a Context Sensitive Solutions approach. It seeks to incorporate broader design issues to complete transportation design. The Manual applies to the entire system of CDOT highways. It includes overarching objectives for highway design and is supported by detailed technical information on specific landscape, aesthetic, sustainable and environmental topics, as well as the design of manmade transportation elements. (Figure 1.a)

The Manual has been developed to provide designers of highway facilities including managers, engineers and landscape architects, a guide for the desired environmentally responsible and aesthetic outcomes of individual projects. It is intended for CDOT internal use, as well as for consultants, it gives direction for landscape and structural improvement design. The manual is a central resource to be used for design decisions associated with the areas of transportation right of way interface with adjacent communities, transportation facilities themselves and the aspects of design that are influenced by the settings around linear corridors. The manual serves as a starting point, and references other CDOT and external sources for further detailed information.

Figure 1.a: Interstate 70 has been located with aesthetic and environmental considerations.

Acronym List:

AASHTO: American Association of State Highway and Transportation Officials

ALIVE: A Landscape Level Inventory of Valued Ecosystem Components

ASCE: American Society of Civil Engineers

BA: Biological Assessment

BLM: Bureau of Land Management

BMP: Best Management Practice

BO: Biological Opinion

CBC: Concrete Box Culvert

CEQ: Council of Environmental Quality

CDOT: Colorado Department of Transportation

CDPHE: Colorado Department of Public Health and Environment

CDPS: Colorado Discharge Permit System

CFR: Code of Federal Regulations

CNHP: Colorado Natural Heritage Program

CM: Control Measure

CPW: Colorado Parks and Wildlife

CRS: Colorado Revised Statutes CSS: Context Sensitive Solutions

EPA: Environmental Protection Agency

EPB: Environmental Programs Branch

FEMA: Federal Emergency Management Agency

FHWA: Federal Highway Administration

FIR: Field Inspection Review

FOR: Final Office Review

IGA: Inter-Governmental Agreement

GIS: Geographical Information Systems

MS4: Municipal Separate Storm Sewer System

MUTCD: Manual of Uniform Traffic Control Devices

MOU: Memorandum of Understanding

NCHRP: National Cooperative Highway Research Program

NEPA: National Environmental Policy Act

NHPA: National Historic Preservation Act

NOAA: National Oceanic and Administration

NRCS: Natural Resources Conservation Service

NRHP: National Register of Historic Places

OHWM: Ordinary High Water Mark

PLS: Pure Live Seed

RAP: Recycled Asphalt Paving

SB 40: Colorado Senate Bill 40

Section 404: Clean Water Act

SCAPs: Sediment Control Action Plans

SWMP: Stormwater Management Plan

SWEEP: Stream and Wetland Ecological Enhancement Program

TERC: Transportation Environmental Resource Council

TRB: Transportation Research Board

USGS: United States Geological Society

VIA: Visual Resource Assessment

vms: Visual Modeling Simulation

1.1 Preface

Transportation facilities encompass a large area of land and therefore have a significant influence on both the natural and built environments. It is CDOT's responsibility to its customers and stakeholders that CDOT projects and operations:

- Reflect an expertise in landscape architecture, site design and aesthetics
- Mitigate the impacts of CDOT actions
- Enhance the user's experience and perception
- Encourage community involvement to help with representing stakeholders' interests and objectives

The Environmental Policy Agency (EPA) and Federal Highway Administration (FHWA) recognize that landscape elements must be taken into account in highway planning. These environmental components include aesthetics and visual considerations. Such resources are considered at various levels depending on the nature of the transportation project. The long-term goal is to consider transportation design in a broader, sustainable and contextual perspective (Figure 1.b).

Figure 1.b: This highway near Durango has been designed from a contextual perspective.

CDOT uses an enormous amount of environmental and landscape design information. New approaches to design, sustainability and contextual analysis have been incorporated into current CDOT project development practices and are included in this manual. Detailed information pertaining to environmental design, based on the experience of CDOT specialist working on complex environmental projects, has been included.

The manual guidelines provide the best available national information (such as: mitigation measures, assessment procedures, design details and criteria) supported by the CDOT landscape architect, environmental resource, and civil engineering disciplines that can be used by all CDOT regions to develop quality project plans and methods of work. The primary focus of the Manual is natural resources. The cultural resources department developed the CDOT Archaeology and History Analysis and Documentation Procedures Manual in 2010. The two manuals work in cooperation when dealing with CDOT landscape architecture issues. The information includes references to federal, state and local resource rules, regulations and policies that affect the landscape architecture and Environmental Design program. This information exists to ensure CDOT design, construction, maintenance and planning activities comply with the broad range

of state and federal regulations, executive orders, interagency agreements and CDOT policies mandating the protection and enhancement of the environment. To accomplish this, personnel trained and/or licensed in various disciplines are assigned to the Environmental Programs Branch (EPB) and regional environmental offices. Staff members establish CDOT policy for environmental issues, conduct scientific investigations, develop mitigation strategies (to avoid, minimize or mitigate environmental impacts), conduct training, prepare professional reports, provide aesthetic guidelines and conduct interagency negotiations that result in necessary approvals to complete CDOT activities. EPB is charged with ensuring that environmental issues are addressed uniformly in each of the department's five decentralized transportation regions.

CDOT landscape architects and other resource specialists are involved throughout the project development process to develop transportation corridors that are safe, functional appealing and ecologically sustainable. The goal is to integrate transportation facilities within their setting to create an environmentally responsible and visually pleasing travel experience for all who live, work, and travel in Colorado. The aesthetic guidelines in the Manual are based on long-standing principles of design such as line, texture, color, pattern and form which have been distilled and applied to highways and their settings (Figure 1.c).

Figure 1.c: This complex section of highway illustrates longstanding principles of design with consideration to harmonious line, pattern and form.

1.2 Use of the Manual

This document includes four major chapters:

- Chapter I. Overview, which addresses the intent and use of the manual;
- Chapter II. Natural Systems;
- Chapter III. Man made Structures; and
- Chapter IV. Community.

The Technical Appendix includes detailed information such as plan standards and specifications. The glossary provides definitions of terms and the bibliography provides sources, citations and website links to documents cited.

CDOT has a number of information portals with documentation from comprehensive and statewide plans to detailed specifications and construction bulletins. Typically, the documentation is provided on the CDOT website through the "LIBRARY" tab (www.coloradodot.info/library). The Manual provides a framework and reference for resources which are relevant to landscape architecture and environmental guidance.

At the beginning of each chapter of the Manual, relevant CDOT websites, plans, manuals and bulletins are referenced. Where there are existing resources, design guidance on specific topics is contained within the linked

documents, while in other instances, the guidance is provided within this manual. The information is relevant not only to new projects, but should be referenced for all project upgrades and maintenance. There are also keywords that have links to navigate within the document to provide flexibility and efficiency for the user. This document will be updated at the discretion of the CDOT Senior Landscape Architect.

1.3 Integration of Design, Environmental and Community Process

The Manual references the CDOT National Environmental Policy Act Manual (CDOT, 2013) and the CDOT Project Development Manual (CDOT, 2001). The purpose of the National Environmental Policy Act (NEPA) of 1969 is to declare a national policy that will: encourage productive and enjoyable harmony between man and his environment; promote efforts that will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; enrich the understanding of the ecological systems and natural resources important to the Nation; and establish a Council on Environmental Quality (CEQ). The act also declared that agencies assure for all Americans aesthetically pleasing surroundings for major Federal actions. Section 102, requires agencies to "utilize a systematic interdisciplinary approach which will ensure the integrated use of…Environmental Design Arts in the planning and decision making…". The coverage of highway aesthetics in Title 23 of the U.S. Code, Section 109(h) requires aesthetic values to be considered during project development. The CEQ regulations, Section 1508.8, effects, also state that aesthetic effects should be considered. In addition, an analysis of visual impacts is required by the Federal Highway Administration (FHWA) guidance in Technical Advisory T6640.8A, guidance on preparing and processing environmental and section 4(f) documents.

The CDOT NEPA Manual provides guidance for preparing and processing documents that comply with NEPA and other applicable state and federal environmental laws affecting transportation projects in Colorado. It provides references and links to related federal and state laws, executive orders, regulations, and policies. It also provides "best practice" examples for various compliance processes, defines mitigation commitments and objectives, permits, time frame and monitoring. The CDOT Product Development Manual defines when and how mitigations that are federally mandated should occur in the context of the project and what regulations will be implemented. Section 3 "Environmental" of the CDOT Product Development Manual is the most pertinent to the Manual.

In 2019 in collaboration with FHWA, CDOT developed the 2019 CDOT Visual Impact Assessment (VIA) Guidelines (CDOT, 2019) (Appendix 10) to establish a statewide standard for evaluating and documenting visual resources. CDOT recognizes the uniqueness and strong emotions that

visual resources can inspire in human viewers. Such special places often provide a sense of community to the inhabitants of an area and may attract tourism and drive its economy.

CDOT values the visual resources of Colorado and emphasizes the role of VIAs and visual resource mitigation in the NEPA decision process, project design, and project implementation. CDOT created guidance for VIAs that meets the expectations and standards of CDOT staff, communities and counties, and federal land management agencies. The 2019 VIA Guidelines establish a statewide standard that is meaningful to NEPA decision-making and that provides CDOT a better product, both a more useful VIA and a more context sensitive transportation improvement relative to Colorado's diverse regions, landscapes, and communities.

When a transportation project is initiated, the first step is to determine the level of environmental analysis required for the project. The NEPA process will highlight issues such as wetlands, floodplain, paleontology, cultural resources and, pertinent to this manual, the visual resources. It is important to identify these resources at the early stages of the process, creating the ability to implement the guidelines in this manual (for example, during the NEPA scoping process). In addition, the CDOT Highway Maintenance Levels of Service Manual should be referenced to provide the designers with end-user and level-of-service information to assist in the design process, particularly in terms of vegetation selection and landscape appearance.

The principal objective of NEPA is to avoid, minimize and mitigate any potential environment impacts. The information in this manual provides mitigation solutions and identifies when the landscape architect should be consulted to assist in developing these solutions. The guidelines in this manual are recommendations, unless they are specified as being required practices. The intent is to establish consistency throughout Colorado highway corridors.

1.3.1 Role and Responsibilities of the Landscape Architect

The landscape architect or environmental consultant may be a CDOT staff member or an outside consultant, and is responsible for integrating landscape architecture and environmental guidelines into a transportation project. The landscape architect needs to be involved in the project from the beginning and must be included on the project team that will be established using the Context Sensitive Solutions (CSS) multi-disciplinary team approach. Their role begins at the initiation of the project. It includes participating in community and stakeholder outreach and participation, NEPA project scoping, and consideration of aesthetic and environmental resources that will be affected by the project. As the project

progresses, the landscape architect continues to assist with establishing road alignments, road edge treatments, cultural resource protection, environmental stewardship and aesthetic quality. Early involvement will ensure that the final outcome of the project will meet the federally mandated mitigation standards to project impacts. In addition to the landscape architect facilitating a multi-disciplinary team approach within CDOT; it is important to collaborate with all the other involved agencies throughout the project.

The planning and design process has three phases in which the landscape architect plays a key role: scoping, project development and project design.

The scoping process is about understanding the setting of the project and the potential issues that may arise that will need to be addressed and resolved. As issues are identified, they should be documented in a Compliance Matrix that will be referenced and used throughout the project. The matrix outlines commitments from project scoping to final design. All potential impacts should be documented in the compliance matrix format. There may be one matrix that includes all the impacts of a small project, or a matrix may be created for each impact resulting from a large project. Table 1 is an example of a compliance matrix for one impact resulting from a project or activity:

Table 1. Compliance Matrix Example

PHASE I - SCOPING		
Project Activity Causing Impact	Description of the specific operation/ maintenance or construction activity that causes the impact (e.g. ground disturbance between April 15 and Oct 15).	New highway elements and change to visual characteristics – visual contrast between construction elements and the landscape
Location of Resource	The location of the resource that to which the activity is of concern (e.g. known or potential nesting locations at a specific mile marker) For a Statewide Plan, identify the geographic extent of concern (statewide, riparian areas, county, and MS4 areas).	Views of underpass structures from the bikeway – moderate to strong visual scale and contrast between the new element form and the land
Potential Impact of Activity	Description of the potential effect of the activity to the resource	Construction during nesting period may disturb active nests
CDOT Policies and Requirements	Describe any CDOT policies or requirements that are applicable to the resource and the potential impact.	I-70 Aesthetic guidelines

Associated Laws and Regulations	Identify the state, federal and other laws and regulations that are applicable to the resource and the potential impact.	National Environmental Policy Act of 1969, 43 U.S. Code 4321 et. Seq
Associated Permits	Identify any permits that are required in relation to the activity and potential impact to the resource.	Section 6 (f) permit
Associated Agencies	Identify agency stakeholders associated with the resource and the impact.	Colorado State Forest Service
PHASE II – PROJECT DEVELOPMENT		
General Potential for Impact to be Significant	General determination as to the potential overall significance of the impact to the resource (High, Medium, Low).	• The visual compatibility of the project will be high if visual character is similar (that is, weak degree of contrast) • Degree of contrast is very strong if all of the dominant elements of the visual landscape (form, line, color, texture) are affected
Data Sources and Evaluation Requirements	Description of the typical data sources and evaluation processes used to determine the extent of the impact resulting from the activity.	• Visual impact assessment
Mitigation Plan	A description of measures that would mitigate the impact (e.g. conduct bird surveys to identify active nests; if active nests are found, provide a construction buffer; if no active nests are found, discourage nesting by removing trees or monitor area daily to remove nests before they are completed and occupied).	• All construction material staging areas will be fenced and screened
PHASE III – PROJECT FINAL DESIGN		
Construction Drawings, Specifications and Notes	Specifications (Standard and/or special), plans and notes necessary to ensure the mitigation is implemented correctly.	Specification 214.04 – successful landscape establishment period – will be followed

Phase I – Scoping

In Phase I, the landscape architect takes the lead in preparing a contextual analysis to help the planning and engineering team develop a comprehensive understanding of the project area and influences. The analysis will identify major influences on the transportation project, including land-use, environmental conditions, visual aspects and socio-economic issues. This information is critical in developing a strategic approach to the project and will provide the background for scoping of potential issues related to project implementation. The scoping process

identifies potential stakeholders and possible issues. The 2019 CDOT VIA Guidelines (Appendix 10) provide more information on the scoping analysis for visual resources.

The landscape architect's role includes:

- Establishing the area of influence of the project that will be defined as the project setting or context
- Identifying key stakeholders and general community members who should have input in the process (Figure 1.d)
- Developing an inventory of existing resources and associated opportunities and constraints

Examples of deliverables include: context map defining study area boundaries; aerial photographs that illustrate existing conditions; land use maps; mapping of environmental features such as steep slopes, water bodies and vegetation types; recreational facilities and opportunities; general map of important visual features; land ownership information and documentation of other influences.

The results of the Contextual Analysis will inform the outcome of the project and will be referenced throughout the project design process.

Figure 1.d: Stakeholders play an important role in the process.

Phase II – Project Development

Project Development, is the stage at which the design team develops the project to the 30 percent level. During this phase, the project design will be taken to a sufficient level of detail to convey information about the project to the community and to determine levels of impacts on resources. General design products include illustrative materials, (e.g. 3-D model and photographic simulations), as well as specific mapping of areas of disturbance.

During this time, the landscape architect will prepare more detailed documentation on the affected resources for use in planning and design of the project. In addition, the landscape architect will be a member of the design team and will attend design sessions to create the Project Development visual analysis.

If visual resources may be impacted, a Visual Analysis Technical Memorandum is used by project planners in preparing the required NEPA documentation and should be referenced by the project design team. The 2019 CDOT VIA Guidelines (Appendix 10) provide templates for preparing the required NEPA documentation.

The visual analysis includes identification of existing view sheds, views both to and from the roadway, and potential impacts from the proposed project. It is important to consult with the land owner on whose property the project will occur since certain agencies have their own impact mitigation standards. For example, the U.S. Forest Service (USFS, 1995) and Bureau of Land Management (BLM, 1984; 1986 have manuals that describe their approaches to visual analysis and management plans that determine acceptable limits of change for visual resources. In addition, cities and counties may have community values expressed in planning documents.

The completed visual analysis will provide guidance with regard to aesthetic concerns. The information will be used by project designers to further develop and refine roadway, landscape and urban design development.

The landscape architect's role in Phase II includes the following:

- Utilize the NEPA analysis process to help develop environmental objectives in coordination with environmental specialists
- Prepare detailed contextual analyses for impacted resources
- Prepare the Visual Impact Analysis (if required)
- Design guidelines to mitigate impacts on resources and aesthetics
- Serve as the liaison between the designers/engineers and the environmental specialists
- Coordinate the site selection process to identify suitable areas for environmental mitigation. For example, a site may be required to create a new wetland to offset the impacts to existing wetlands. Develop site selection criteria, gather and analyze data and lead the mitigation design process
- Provide site specific analysis for integrated weed management, stormwater management, threatened and endangered species, wetland protection, stream restoration and other requirements of Senate Bill 40 (CDOT, 2003)

Phase III - Final Project Design

Phase III - Final Project Design is the stage at which the design team develops the project to a 90percent level and completes detailed documentation for construction and for impact mitigation. The landscape architect participates in developing construction drawings and specifications for environmental resources. Resources that may require protection and/or mitigation include: wetlands, riparian habitat, stormwater detention areas, or streams. In addition, the landscape architect is responsible for new landscape installations to remediate areas that have been disturbed by construction. These include planting and irrigation plans and specifications.

During Phase III, the landscape architect performs the following tasks:

- Develop the final design, plan and specifications for mitigation solutions in coordination with the environmental specialists.
- Develop an approach to providing interpretation of sensitive environments and successful mitigation. This may include plans to display sensitive environments or an interpretive signage program (Figure 1.e),
- Participate with the design team on aesthetic design for natural and manmade features; including retaining walls, site grading, color selection and planting.
- Prepare landscape and irrigation plans and specifications.
- Continue liaison role between engineers/designers and environmental specialists.
- Prepare stormwater management plans.
- Prepare wetland, riparian, threatened and endangered species, stream restoration and prairie restoration plans.
- Develop a noxious weed management plan.
- Develop project special provisions.
- Check that at the completion of the construction documentation, sufficient information is included to ensure that NEPA commitments have been met.

Figure 1.e: This overlook was placed carefully in order to minimize the impact on the environment. Interpretive signage is also provided.

1.3.2 Context Sensitive Solutions

Federal Highway Administration defines Context Sensitive Solutions (CSS)

as a collaborative, interdisciplinary approach that involves all stakeholders in developing a transportation facility that compliments its physical setting and preserves scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility for entire roadways or specific situations.

The following are pertinent resources:

CDOT Context Sensitive Solutions
CDOT NEPA Manual, Chapter 3
I-70 Mountain Corridor Context Sensitive Solutions
FHWA and Context Sensitive Solutions
CDOT 2019 Visual Impact Assessment Guidelines

CSS provides for flexibility in the design process in order to respond to the contextual elements and the outcomes of the community involvement process. It allows a customized approach to aesthetic features and the physical setting.

A well-developed community outreach plan is essential to the success of any project. Previously, public participation was mandated through the NEPA process requiring public scoping to determine issues of public concern to be addressed in the project process. The CSS process includes a broader spectrum of involvement. The intent is to integrate outcomes from the public involvement process into the design process. Examples of public involvement techniques for CDOT are listed on its CSS website (CDOT, 2012).

1.4 Transportation Planning Framework

The Manual focuses on the highway corridor element of transportation systems, and its related components. The CDOT roadway system is a significant component of the overall statewide transportation plan that provides a long-range vision of how the future multi-modal transportation system will serve the people and businesses of each region.

2035 Statewide Transportation Plan
2035 Regional Transportation Plans
2035 Denver Metro Transportation Plan
2035 Grand Valley Transportation Plan
2035 North Front Range Transportation Plan
2035 Pueblo Area Transportation Plan
2035 Pikes Peak Regional Transportation Plan

2 | DESIGN ZONES

CDOT's approach to transportation design requires that there be a direct relationship between the proposed design and the place it will be located – the site context. Defining design zones is critical to creating a relationship between transportation and landscape, while maintaining a consistent approach to design throughout the state. Five design zones for Colorado have been defined based on the natural characteristics of the areas including elevation, landform, vegetation, physiography, and historic settlement patterns. The boundaries of the design zones are established where there is a noticeable change in the surrounding landform and land cover. The influences within the zones include transportation design decisions. The highway design should respond to significant and definable changes that influence the landscape-providing a context for entire corridors rather than defining it by construction phases or funding increments.

The following links provide additional geographic information

Natural Resources Conservation Service (NRCS) WEBSoil Survey

Web Soil Survey provides soil data and information produced by the Cooperative Soil Survey. It is operated by the United States Department of Agriculture Natural Resources Conservation Service (NRCS) and provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95 percent of the nation's counties and anticipates having 100 percent in the near future. The site is updated and maintained online as the single authoritative source of soil survey information.

United States Census Bureau

Data is organized by census tracts and block numbers and also include political boundaries and general geographic areas.

United States Geological Survey (USGS)

The USGS provides a variety of cartographic, geographic, earth science, remotely sensed data, and other services in support of federal, state and *public interests.*

Federal Emergency Management Administration (FEMA)

FEMA produces maps portraying flood zones, areas that experience 100 and 50 year floods.

United States Geological Survey Streamstats

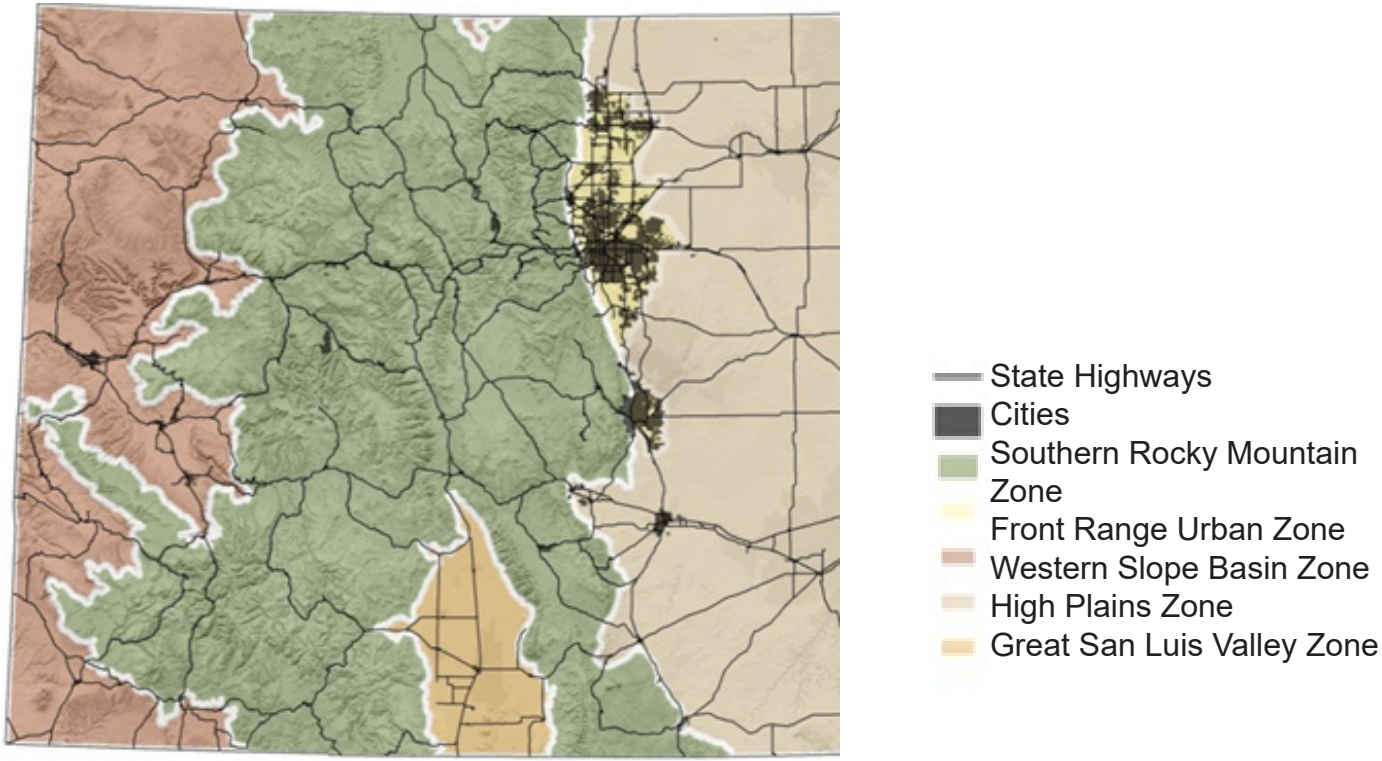
StreamStats is a web-based geographic information system (GIS) that provides users access to an assortment of analytical tools useful for water-resources planning and management, and engineering design applications, such as

the design of bridges. StreamStats allows users to easily obtain stream flow statistics, drainage-basin characteristics, and other information for user-selected streams sites.

National Oceanic & Atmospheric Administration (NOAA) Boulder, CO Climate and Weather Data

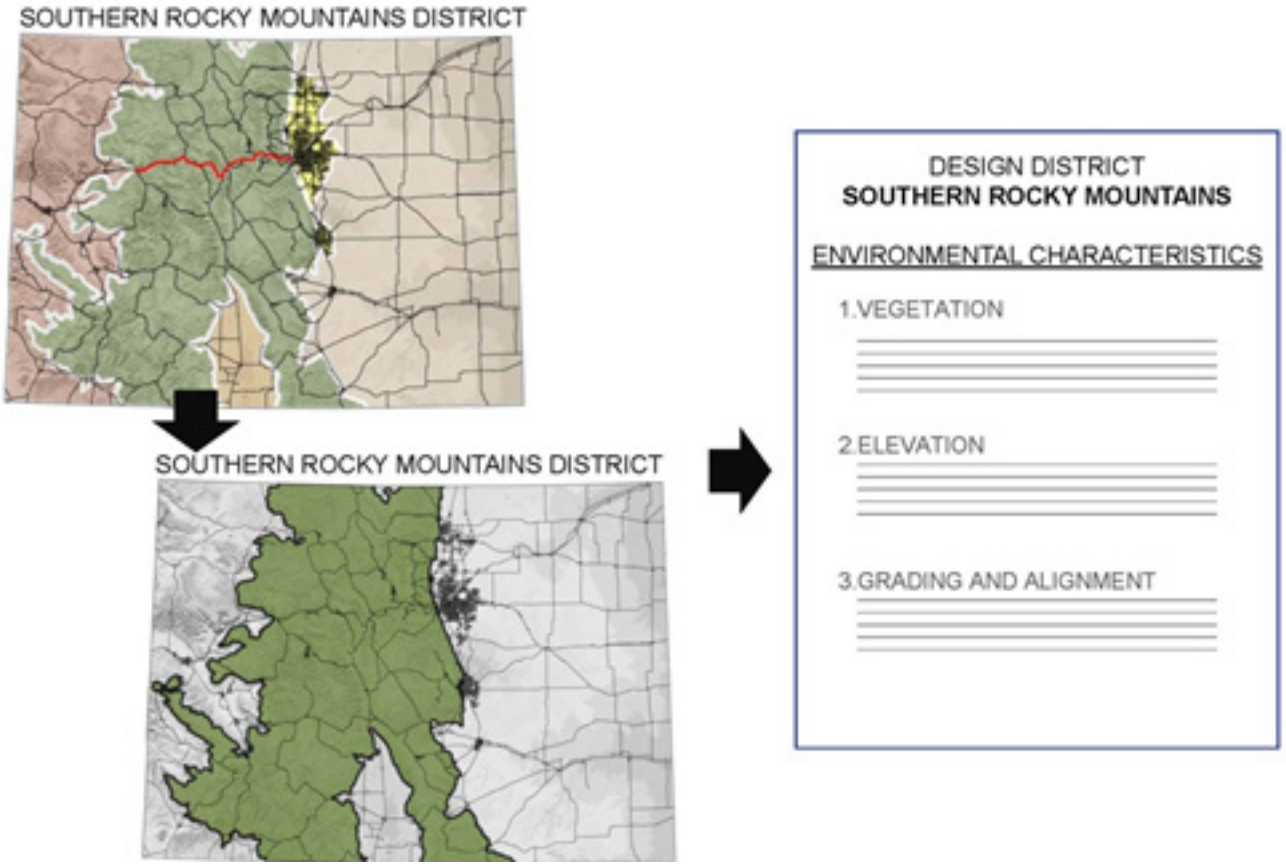
CDOT Detour Drainage Structure Design Procedure

Specific site features, to further reinforce context may include natural boundaries, political/administrative boundaries, physical/ infrastructure boundaries, sensitive areas and resources (e.g. historic sites, special wildlife habitats), facilities resources that protect public health (e.g. Superfund sites) and other places (e.g. military bases or Indian reservations).



Map of CDOT Design Zones

2.1 How Design Zones are Used



Southern Rocky Mountains District

The goal of the Manual is to establish guidelines to create a consistent and unified roadway system throughout Colorado. Within the broad framework, there are certain aspects of landform and land cover in the state that are dramatically different. In order to address special circumstances where these noticeable differences occur, five design zones have been selected.

By understanding the characteristics of each zone, CDOT can design unified corridors with consistency and a recognizable sense of place in each zone. For example, the road alignment should respond to the dominant land form of a zone while the plant palette should be derived from plant species native to the zone and micro-climatic conditions. Details, such as colors and textures, applied to transportation facilities could be reflective of the cultural and landscape context. The diagram below illustrates how the design zone maps can be used to quickly disseminate the different design zones.

Figure 1.f: The area near Grand Junction is typical of the Western Slope and Basin Zone.

Figure 1.g: The view across Colorado National Monument illustrates the character of the Western Slope and Basin Zone.

2.2 Environmental Characteristics of the Five Design Zones

The United States Environmental Protection Agency Ecoregions (EPA, 2012) and the United States Geological Survey National Land Cover Data set (USGS, 1992) were used to define the CDOT Design Zones. The ecoregions denote areas within which ecosystems are generally similar in terms of geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The land cover data provides various levels of detail of classifications for developed lands, hydrology, vegetation coverage and types and agricultural lands.

2.2.1 Western Slope and Basin Zone

The elevations in this zone are between 4,000 – 5,000 feet. The zone sits between the lower elevations of the Mojave and Sonoran high deserts (southwestward), and the rapid elevation gains of the Rock Mountains (eastward). Several rivers cross the zone, including the Colorado, Yampa, Gunnison, and San Miguel, as well as ephemeral and intermittent streams.

This zone is characterized by sagebrush shrublands interspersed with unusual rock formations (Figures 1.f and 1.g). The shrub/scrub is found within the lower elevations and flatter areas while evergreen and mixed forests are found on the higher elevations. Historically, agriculture, ranching, and some timber harvesting are common in this zone. There has been intensive energy exploration in the region as well as an increase in recreational activities. The Bureau of Land Management has significant ownership of lands in this zone. The larger cities and towns include Grand Junction, Delta, Montrose, Rifle, Orchard City and Cortez.

2.2.2 Southern Rocky Mountains Zone

Moving eastward, there is a rapid elevation gain of nearly 9,800 feet in the Southern Rocky Mountain Zone. This zone has over 50 mountains exceeding 14,000 feet and 300 peaks over 13,000 feet. Other notable topographic features include hogbacks, mesas, rocky outcrops (where the high mountains meet the plains on the eastern front), and rugged canyons and mesas (where the mountains meet the high desert country to the west).

Several rivers begin in and cross this zone, including the North Platte, Cache la Poudre, Arkansas, Rio Grande, and the Colorado. These are fed by medium and high-gradient perennial streams. Rainfall and snowpack provide water for lower elevations. This zone is dominated by forest of both deciduous and evergreen varieties, including spruce, fir, pine and aspen. The northern portion and higher elevations contain a large amount of grasslands, and the highest elevations are classified as barren land with less than 15percent vegetation cover. The lowest elevations are generally grass or shrub covered, while low to middle elevations are covered by a variety of vegetation types, including juniper, oak, Ponderosa pine, Douglas

Figure 1.h: Vail Pass is an example of the Southern Rocky Mountain Zone.

Figure 1.i: The Eagle area is an example of the Southern Rocky Mountain Zone.

fir, and Quaking aspen.

Forestry, gold, copper and silver mining, tourism and recreation, ranching and livestock grazing, and rural residential areas are in this zone. Extensive land areas are in public ownership (including: BLM, USFS, NPS), such as national forests, national parks and national monuments. Larger towns include Steamboat Springs, Estes Park, Kremmling, Glenwood Springs, Breckenridge, Leadville, Aspen, Gunnison, Telluride and Pagosa Springs. (Figures 1.h and 1.i).

2.2.2.1 Interstate-70 Corridor

The I-70 Mountain Corridor is within the Southern Rocky Mountains Zone and has been the subject of specific studies (Figures 1.j and 1.k). There are four design segments that make up the I-70 Mountain Corridor:

Crest of the Rockies

Rising to over 10,000 feet in elevation, the Crest of the Rockies design segment provides access to ski resorts and recreational opportunities through towns such as Silverthorne, Frisco, Copper Mountain, Vail, Avon and Edwards. The Crest of the Rockies offers dramatic views of peaks and valleys, steep topography, alpine vegetation, rocky hillsides and waterways.

Western Slope Canyons and Valleys

Characterized by rocky hillsides, canyons and montane landscape, the Western Slope Canyons and Valleys design segment is a clear transition from the alpine landscape of the Crest of the Rockies, this design segment connects the towns of Wolcott, Eagle, Dotsero and Glenwood Springs; provides scenic views of native vegetation, rocky hillsides and Colorado River; and provides direct access to recreational destinations.

Mountain Mineral Belt

Rich in mining history, the Mountain Mineral Belt design segment rises from the foothills. Dotted with historic towns including Idaho Springs and Georgetown, the Mountain Mineral Belt offers scenic views, lush forests, rocky hillsides, waterways, access to local and regional destinations and recreational opportunities.

Front Range Foothills

The Front Range Foothills design segment begins the ascent to the Rocky Mountains from the eastern plains and the Denver metropolitan area.

Figure 1.j: Glenwood Canyon illustrates the character of Western Slope Canyons and Valleys.

Figure 1.k: Georgetown is a small community in the Mountain Mineral Belt.

2.2.3 Great San Luis Valley Zone

The San Luis Valley is surrounded by the Southern Rocky Mountains Zone. This valley is part of the Rio Grande Rift that extends from central Colorado southward through New Mexico and West Texas into northern Mexico. Water is scarce; most streams are ephemeral and intermittent. The Rio Grande River runs through the valley and there are areas of irrigated agricultural lands. This zone is dominated by pasture and hay (for livestock grazing and production), as well as shrub mixes.

The Great Sand Dunes National Park and Preserve protects both the Great Sand Dunes and the archaeological sites discovered in the area. The sand dunes are directly to the west of the Sangre de Cristo Mountains and can reach 750 feet high. In comparison to the Southern Rocky Mountains and Western Slope and Basin zones, the Great San Luis Valley has less public lands, but does include BLM, FWS, NPS and state-owned lands (Figure 1.l).

The Ute Indians, prior to 1886, lived in the valley. In 1849, shortly after the Mexican War, the Ute established a peace treaty with the United States of America. Shortly thereafter, settlers from New Mexico established several small settlements in what is now Colorado. In 1868, the Utes were moved to the Southern Ute Indian Reservation in southwestern Colorado. Today, several smaller towns are located in the valley, including Saguache, Moffat, Center, Hooper, Del Norte, Monte Vista, Alamosa, Blanca, LaJara, Sanford, Manassa, Antonito and San Luis.

Figure 1.l: The Great Sand Dunes in the San Luis Valley Zone.
credit: Robin Stevens

2.2.4 Front Range Urban Zone

This zone contains the most populated areas in the state according to the 2010 U.S. Census population per square mile data. In comparison to the other Colorado zones, the Front Range Urban Zone has few public lands. This zone is highly developed, ranging from low to high density. This area is defined by the urban and suburban land use of the Denver and Colorado Springs metro areas, as well as the fast growing communities to the north and east of Denver. Several rivers flow across this zone, including the Cache la Poudre and Arkansas, with headwaters in the Southern Rockies Zone. (Figures 1.m and 1.n)

Figure 1.m: Denver's Riverside Park area illustrates the character of the Front Range Urban Zone.

Figure 1.n: Interstate 25 shows the level of infrastructure required for highway projects in the Front Range Urban Zone.

2.2.5 High Plains Zone

This zone includes eastern Colorado, which is flat topographically when compared to the other zones (Figures 1.o and 1.p). A few perennial rivers cross the region. These rivers originate in the Southern Rockies (e.g. the Arkansas River). This zone is dominated by cultivated crops and grassland/herbaceous plants. Cultivated crop lands are used for the production of annual crops and perennial woody crops such as orchards and vineyards. The native vegetation was short and midgrass prairie vegetation; however much of it is now greatly altered.

The larger cities and towns in this zone include: Pueblo, Lamar, Canon City, Coal Creek, Florence, Sterling, Fort Morgan, and Wellington. Cropland and grazing land are the principal land uses in the northern portion while the southern portion is more semiarid rangeland, with ranching and livestock grazing the dominant land uses. Urban development is increasing closer to the Front Range Urban Zone. In comparison to the other Colorado zones, the High Plains Zone has fewer public lands, most of which are state owned

Figure 1.o: The High Plains Zone is characterized by grasslands.

Figure 1.p: The High Plains Zone is flat and open.

Regulatory compliance is essential in project clearance and environmental protection at CDOT. Non-compliance with resource regulations results in project delays and potential damages. CDOT's transportation planning policies are guided by Federal and State rules and regulations. This section provides a broad overview and summary of applicable laws, acts and regulations. This section includes applicable federal and state regulations as described in the CDOT Project Development Manual (2001). The CDOT NEPA Manual (2013) should be referenced throughout the design process. The CDOT Environmental Stewardship Guide (2005) includes a description of roles and responsibilities of CDOT staff relative to implementing environmental policies and regulations.

CDOT Project Development Manual (2001, 2013)

CDOT Environmental Stewardship Guide – Appendix B: Summary of Federal Environmental Legislation and Regulations

CDOT NEPA Manual

CDOT Highway Maintenance Levels of Service Manual

CDOT Drainage Design Manual, Chapter 3 Policy

CDOT 2019 Visual Impact Assessment Guidelines

3.1 Federal Regulations

Federal law is codified by titles in the United States Code (USC, contains statutes only) and the United States Code Annotated (additional information including historical amendments and a popular name table are in the General Index). For the most up to date information, refer to the U.S. Government Printing Office, United States Code, at http://www.gpo.gov

Applicable Laws and Acts

- FHWA
- National Environmental Policy Act of 1969
- Transportation Equity Act for the 21st Century
- Resource Conservation and Recovery Act
- Comprehensive Environmental Response, Compensation, and Liability Act

- U.S. Department of Transportation Hazardous Materials Transportation Act
- U.S. Department of Transportation Act
- Land and Water Conservation Fund Act
- State Register Act of 1975
- National Historic Preservation Act of 1966
- Archaeological Resources Protection Act of 1979
- Native American Graves Protection and Repatriation Act
- Farmland Protection Policy Act
- Federal Clean Water Act, including 401, 402 and 404 permits
- Federal Water Pollution Control Act Amendments
- Endangered Species Act of 1973
- Wild and Scenic Rivers Act
- Noise Pollution and Abatement Act of 1970
- Transportation Equity Act for the 21st Century
- Federal Executive Order 13112, Invasive Species
- Surface Transportation and Uniform Relocation Assistance Act of 1987: Section 130
- Operation Wildflower
- Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA)
- Federal Aid Highway Program Manual 6-2-5., Subsection 1-Landscape and Roadside development.
- TEA-21, Transportation Efficiency Act for the 21st Century
- Migratory Bird Act

Code of Federal Regulations (CFR): The Code of Federal Regulations (CFR) annual edition is the codification of the general and permanent rules and regulations published in the Federal Register by the departments and agencies of the Federal Government. It is divided into 50 titles that represent broad areas

subject to Federal regulation. The electronic code of federal regulations at http://ecfr.gov.cgi-bin/ECFR?page=browse . Title 23 is highways and Part 771 is Environmental Impact and related procedures.

- Title 7 - Agriculture
    - Part 658, Agriculture – Farmland Protection Policy Act
- Title 23 – Highways
    - Part 752, Right of Way and Environment – Landscape and Roadside Development
    - Part 771, Environmental Impact and Related Procedures
    - Part 772, Procedures for Abatement of Highway Noise and Construction Noise
    - Part 777, Mitigation of Environmental Impacts to Privately Owned Wetlands
    - Part 450C, Planning and Research and Parts 810A, 810B, 810C, 810D – Public Transportation
    - Part 650A-B, Bridges, Structures and Hydraulics
- Title 26 – Internal Revenue
    - Part 800, Advisory Council on Historic Preservation
- Title 29 - Labor
    - Part 1910, Occupational Safety and Health Standards
- Title 33 – Navigation and Navigable Waters
    - Parts 320-384, U.S. Army Corps of Engineers – General Regulatory Policies
- Title 36 – Parks, Forests, and Public Property
    - Part 60, Department of the Interior, National Register of Historic Places
    - Part 800, Parks, Forests, and Public Property, Protection of Historic and Cultural Properties
- Title 40 – Protection of Environment

- Parts 100-399, Environmental Protection Agency
- Part 122, The National Pollutant Discharge Elimination System
- Parts 1500-1508, Council on Environmental Quality

- Title 50 – Wildlife and Fisheries
  - Part 402, Interagency Cooperation

U.S. Code (USC):

- Title 7 - Agriculture
  - 7 USC (4201-4209)
- Title 16 - Conservation
  - 16 USC 1531-1543
  - 16 USC 470aa-470II
  - 16 USC 4601-4608, Section 6(f) Requirements
  - 16 USC 106, 470-470t
- Title 23 - Highways
  - Transportation Equity Act for the 21st Century (Public Law 105-178)
  - USC 109 Standards - economic, social and environmental guidelines.
  - USC 109(j), Highway Project Consistency with State Implementation Plans
  - USC 109(l), Noise Standards for Highway Traffic
  - USC 138 Preservation of Parklands
  - USC 217 Bicycle transportation and pedestrian walkways
  - USC 319, Landscaping and Scenic Enhancement
  - USC 128, Federal-aid Highway Act Requirements for Public Hearings
  - USC 109(g) Erosion Control

    - USC 144, Historic Bridge
- Title 25 – Indians
    - Native American Graves Protection and Repatriation Act (Public Law 101-601)
- Title 33 – Navigation and Navigable Waters
    - 33 USC 1251-1376
- Title 42 - The Public Health and Welfare
    - USC 4321, National Environmental Policy Act
    - USC 6901
    - USC 7501 et seq Clean Air Act
- Title 49 - Transportation
    - 49 USC Section 303 4(f) Requirements

3.2 State of Colorado Regulations

State legislation is codified in state statutory volume titled Colorado Revised Statutes (C.R.S.). A C.R.S. reference contains these members which identify the title, article and section. Title 42, Vehicles and Traffic, and Title 43, Transportation, relate to CDOT. A guide to finding Colorado state statutes is available at http://www.vccs.edu/~library/find/colostatutes.html

Applicable Acts

- Weed Free Forage Crop Certification Act
- Colorado Register of Historic Places Act
- Colorado Historical, Prehistorical, and Archaeological Resources Act
- Colorado Senate Bill 40 of 1969, Wildlife Certification
- Colorado Water Quality Control Act
- Colorado Noxious Weed Act
- Colorado Executive Order D 00699, Development and Implementation of Noxious Weed Management Programs

Code of Colorado Regulations

- 600-605 Department of Transportation

Colorado Revised Statutes (CRS)

- Title 24 Art. 80.1, Register of Historic Places
- Title 35 Art. 5, Pest Control Districts (35-5-101 through 35-5-110)
- Title 24 Art. 80-401, Title to Historical, Prehistorical and Archaeological Resources
- Title 25 Art. 8, Water Quality Control (8-101 through 8-105)

II | NATURAL SYSTEMS

The protection and enhancement of natural systems affected by the transportation system is a focus of this manual (Figures 2.a and 2.b). The following resources include pertinent information that contributes towards meeting this goal.

CDOT Project Development Manual (2001, 2013)

CDOT Standard Specifications for Road and Bridge Construction, Section 200 – 240

These standard specifications are to be used on contract work awarded by the Colorado Department of Transportation (CDOT). They may be supplemented or modified to suit specific contracts. Chapter 200 contains specifications for landscape related work including soils, transplanting, and planting.

CDOT M (Miscellaneous) – Standard Plans

CDOT Environmental Stewardship Guide

The guide documents CDOT's environmental ethic "CDOT will support and enhance efforts to protect the environment and quality of life for all of Colorado's citizens in the pursuit of providing the best transportation systems and services possible." It describes the process by which social, economic, environmental, and engineering considerations are integrated in all aspects of transportation decision-making; including policy development, systems and project development; and the design, construction, maintenance and operations of the system. This guide has been developed to assist internal and external users who want an overview of the transportation decision-making process and a better understanding of the environmental considerations contained in that process. "CDOT will support and enhance efforts to protect the environment and quality of life for all of Colorado's citizens in the pursuit of providing the best transportation systems and services possible."

CDOT National Environmental Policy Act (NEPA) Manual

The purpose of this manual is to provide guidance on preparing and processing documents that comply with NEPA and other applicable state and federal environmental laws affecting transportation projects in Colorado. This manual provides references and links to related federal and state laws, executive orders, regulations, and policies. It also provides "best practice" examples for various compliance processes where appropriate.

Figure 2.a: The American Avocet lives in freshwater marshes and shallow lakes.

Figure 2.b: The Ferruginous Hawk lives in arid and semi-arid areas.

FHWA Strategic Transportation, Environmental and Planning Process for Urbanizing Places (STEP UP)

The intent of STEP UP is to address and avoid the potential environmental impacts early within the transportation planning process and to help ensure that projects selected for funding are able to proceed more quickly through the environmental review process.

Transportation Environmental Resource Council

CDOT and FHWA recognize that local, state and federal agencies should have a forum in which to discuss state transportation decisions and plan for environmental stewardship. The TERC was formed in 2002 to provide such a forum and strong working relationships. The Sustainability Subcommittee was formed in September 2010. They have developed tools and recommendations for sustainable practices that are located on their website.

I-70 ALIVE Memorandum of Understanding

This Memorandum of Understanding recognizes that the I-70 transportation system provides important benefits to Colorado citizens, local communities, and economic interests on a statewide level, but also acknowledges that this corridor fragments or isolates existing habitats, interferes with free movement of animals within their habitat, and reduces remaining quality wildlife habitat. Therefore this MOU reflects a desire to improve conditions for wildlife in the I70 corridor and established the ALIVE (A Landscape Level Inventory of Valued Ecosystem Components) committee, which develops measures to improve existing aquatic and terrestrial ecosystem connectivity between Denver and Glenwood Springs.

CDOT Project Development Manual

This manual outlines environmental procedures necessary for project clearance.

Stream and Wetland Ecological Enhancement Program (SWEEP) Memorandum of Understanding

This MOU (CDOT, 2011) recognizes that the existing I-70 Mountain Corridor and the proposed future improvements pass though several watersheds that support numerous aquatic resources, which impact the water quality and viability of ecology in these watersheds. The benefits derived from a transportation system may come at a cost to other resources, including water quality and aquatic resources, unless appropriate actions are taken to consider these resources during each step of CDOT's I-70 Mountain Corridor CSS Decision Making Process.

U.S. Department of Transportation, Federal Highway Administration (FHWA) INVEST Sustainable Highways Self-Eval Tool

FHWA's INVEST identifies characteristics of sustainable highways and provides information and techniques to help agencies and organizations integrate sustainability best practices into highway and other roadway projects. The tool is intended to provide a method for practitioners to evaluate their transportation projects and to encourage progress in the sustainability arena. It is not required and it is not intended to encourage comparisons across transportation agencies and projects. The tool is being developed with ongoing input from state and local transportation agency officials, staff and professional organizations such as American Association of State Highway and Transportation Officials (AASHTO) and American Society of Civil Engineers (ASCE). FHWA plans to continue to update this tool as the transportation sustainability field advances.

The term “environment” includes the natural environment, the built environment, and the cultural and social aspects of our communities; these things all affect our quality of life. In conjunction with our environment, the concept of sustainability considers three primary principles: Social, Environmental, and Economic. This interconnectivity should be considered on all CDOT projects with regards to the impact on the present and the future. These thoughts are captured in the CDOT Environmental Stewardship Guide. It states: (Figure 2.c).

> “Environmental Stewardship is more than just managing environmental clearances and ensuring regulatory compliance for transportation projects. Environmental Stewardship means that CDOT employees are environmentally conscientious and ensure that the statewide transportation system is constructed and maintained in an environmentally responsible, sustainable and compliant manner. CDOT considers environmental factors to be an important part of every plan and decision in the same way that engineering, economic, and other factors are considered. CDOT’s environmental ethic establishes a moral foundation of environmental responsibility that helps guide policy and systems planning decisions. As the planning and decision-making process becomes more project oriented, this environmental ethic is incorporated into environmentally responsible engineering, construction and maintenance practices” (CDOT, 2005).

Figure 2.c: A raised boardwalk allows access while minimizing impacts on this created wetlands.

1.1 Ecological Sustainability & Stewardship

In ecology, sustainability describes how biological systems remain diverse and productive over time. Landscape stewardship means making informed decisions about when and where to preserve, plant, remove or change the management of vegetation to achieve an optimal balance between transportation needs, ecology and context. These decisions are related to soil management, grading, drainage, and erosion control. CDOT has a significant investment in the landscape design and management of roadsides. The following are some measurable benefits of landscape stewardship:

- Pollutant removal
- Carbon sequestration
- Stormwater management and erosion control (Figure 2.d)
- Contained or reduced maintenance costs
- Increased natural systems resilience, health and stability

Figure 2.d: This pond serves to detain stormwater and create habitat.

- Improved viewshed
- Better integration of facilities into their surroundings, enhancement of local economies and better public relations

1.2 Unregulated Impacts

Highway operations affect environmental resources at the federal, state, and local levels. Unregulated impacts can include the consumption of non-renewable resources (oil, petroleum, natural gas, gravel, metal ores) and renewable resources (water, timber, wind, solar) which may be limited in availability now or in the future. Generally, such impacts cannot be entirely avoided or quantified. It is recognized that these impacts should be minimized to the extent practicable. Sustainable practices incorporated into the project planning, construction, and maintenance can minimize resource impacts.

CDOT encourages the identification and utilization of opportunities and methods to reduce the impact of projects on social, economic, and environmental resources. The development of sustainable processes and an increase in sustainable material useage can be achieved by supporting innovative programs and providing flexibility in project planning, construction and maintenance. This includes renewable and non-renewable resource conservation, waste minimization, reduction of virgin materials, efficient use of water and energy, and air pollution prevention.

1.3 Alternative Materials

CDOT encourages the identification and incorporation of proven alternative materials that are long lasting, require less maintenance and meet the primary obligation for providing a safe and efficient transportation system. CDOT is developing procedures for “green” products and materials which are reused, recycled, minimally processed and packaged, locally-available and produced using sustainable methods. Use of sustainable materials must be cost competitive. However, cost considerations include life cycle analysis for materials and practices which may cost more up-front but will perform more cost-effectively over time. Cost considerations also include social and community benefits and the value of helping communities preserve local resources.

CDOT must comply with Senate Bill 40 (SB 40), the Endangered Species Act, the Migratory Bird Treaty Act and NEPA in order to protect wildlife (2.e). CDOT should consider a comprehensive approach similar to the Landscape Level Inventory of Valued Ecosystem Components (ALIVE) approach for the I-70 Mountain Corridor (CDOT, 2008). The following are relevant documents and links:

CDOT SB 40 Wildlife Certification Guidelines

Senate Bill 40 (33-5-101-107, CRS 1973 as amended) requires any agency of the state to obtain wildlife certification from the Colorado Parks and Wildlife (CPW) when the agency plans construction in "...any stream or its bank or tributaries..." Although Senate Bill 40 (SB 40) emphasizes the protection of fishing waters, it does acknowledge the need to protect and preserve all fish and wildlife resources associated with streams in Colorado.

CDOT Wildlife Guidelines & Permit Applications

This website provides a location for all related wildlife documentation for CDOT including the lists, handbooks, memos and policies.

U.S. Fish and Wildlife Service (USFWS) Threatened and Endangered Species List

A list is provided of species considered to be "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, per the Endangered Species Act of 1973. The act defines an endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range."

Colorado Parks and Wildlife (CPW) Threatened and Endangered Species List

The Colorado Wildlife Commission is directed by statute to consider and establish at least once every five years, a list of wildlife species native to Colorado which are considered to be endangered or threatened. This directive establishes definitions, criteria and a procedure for making recommendations to the commission for listing and delisting species as endangered or threatened.

USFWS & National Marine Fisheries Endangered Species Consultation Handbook

The USFWS and the National Marine Fisheries Service handbook provides internal guidance and establishes national policy for conducting consultation and conferences pursuant to Section 7 of the Endangered Species Act of 1973, as amended. The purpose of the handbook is to promote efficiency and nationwide consistency within and between all Federal agencies.

Figure 2.e: Mule deer habitat is common in many parts of Colorado.

CDOT Wildlife Guidelines: Prairie Dog Guidelines & Policy Memos (in Technical Section)

CDOT Wildlife Guidelines: Migratory Bird Specifications Section 240 (in Technical Section)

CDOT NEPA Manual

FHWA Linking Colorado's Landscapes

Linking Colorado's Landscapes was conceived to focus conservation efforts on areas of the landscape that provide important connectivity functions for native wildlife. The study identifies and prioritizes broad linkage zones that facilitate movement of diverse wildlife species. The study analyzes factors such as the presence of local partners; stretches of roadway with frequent animal-vehicle collisions; planned transportation projects projected by CDOT through 2030; and the distribution of linkages across the state and their complementary contributions to landscape connectivity. It provides transportation planners, community leaders and conservationists with a statewide vision for protecting and restoring habitat connectivity, which is vital for maintaining healthy populations of native species.

CDOT Project Development Manual, Section 2.12 Division of Wildlife, 2.13 Threatened and Endangered Species

This manual provides a quick, easy-to-use overview of situations or dilemmas that might be encountered in the course of developing a project. It is intended to assist new engineers, designers and consultants by identifying and describing the activities related to project development from conception to award, and establishing a uniform application of processes and procedures for use department-wide.

CDOT Drainage Design Manual, Chapter 15 Surface Water Landscape

The CDOT Drainage Design Manual was developed to provide guidance and to establish criteria for engineers performing hydrologic and hydraulic analysis and design (including aquatic species). This manual is intended for use by CDOT hydraulics and roadway design engineers, consultants and local entities involved in CDOT administered projects.

2.1 Wildlife Corridors and Crossings

The provision for wildlife corridors and crossings allows for the natural movement of fish and wildlife while reducing the potential for animal – vehicle collisions. Wildlife crossings will provide appropriate clearances, sight lines, lighting (or lack thereof), cover and buffering that will create usability for animals. Wildlife protection fences should blend with the environment and utilize the same design throughout the corridor.

Design guidance includes:

- Consult the CDOT accident data.
- Use open-span bridges to improve visibility for wildlife.
- Underpasses for wildlife should incorporate naturally occurring materials that exist in adjacent areas on the ground surface. Reconstruct the ground plane in a natural configuration using rocks, soil, plants, etc. to create a natural-appearing corridor. Avoid cement bottom structures. Design crossing as large as possible.
- Apply design criteria and strategies for transportation structures to wildlife crossing structures. Coordinate roadway and bridge design with naturally occurring landform and associated wildlife movement patterns (Figure 2.f).
- Use wooden pressure-treated posts with non-galvanized rectangular wire in the construction of wildlife fencing.
- Wildlife fencing and crossings should be designed in accordance with the “Wildlife Crossing Structure Handbook, FHWA publication number: FHWA-CFL/TD-11-003, March 2011 (Figure 2.g).
- Anchor the ends of fencing into landforms, rock faces, or structures rather than simply terminating posts and wire.
- Install escape ramps in conjunction with wildlife fencing to minimize the trapping of wildlife on the ROW
- Visually buffer wildlife fencing by integrating fencing into existing landforms and away from the road edge where possible.
- Consideration should be given to fish movement. Provide baffles in concrete box culverts to allow for rest areas for aquatic species.
- Consider using wildlife friendly fencing when typical ROW fences are required.
- Consider installing dry benches in culvert for terrestrial wildlife movement.
- Consider installing smooth dirt shelves under bridges with rip rap to allow for wildlife movement.
- Minimize the use of retaining walls, rip rap, cement barriers, new guardrail, lighting in rural areas, cut slopes and very steep fill slopes.

Figure 2.f: This raised roadway crossing over a natural drainage provides a wildlife movement corridor.

Figure 2.g: An example of wildlife fencing and controlled access.

Examples of wildlife crossings include:

- Berthoud Pass – CDOT has provided three differently designed animal underpasses. The largest and most effective is a 12’ high x 24’ wide steel arch which is used heavily by deer. The smallest one is only 4’ x 5’ and designed for smaller animals, including lynx. To date only bear, mountain lion and small mammals are known to use this crossing. The medium size underpass is 8’ x 10’ and has a skylight. Because it has a slight bend with no view to the other side, it is not used except by a few small mammals. Newer underpasses are designed straight, so the animal can see through to the other side. US 550 near Ridgeway – In addition to the tunnel underpass, crews installed special fencing and escape ramps to keep animals off the highway. The underpass is tall enough for large animals to use comfortably, and there is plenty of sight distance.

- I-70, in selected locations, between Glenwood Springs and Denver – The highway is raised high enough to provide light and space for naturally occurring vegetation to be preserved or re-established below the highway. This creates excellent opportunities for wildlife movement corridors (Figure 2.h).

Figure 2.h: This bridge is raised high enough for naturally occurring vegetation to be preserved.

2.2 Habitat Restoration

When a transportation construction project or maintenance activity may affect sensitive species and/or critical habitat, it is necessary to determine habitat restoration needs to comply with Threatened and Endangered Species Acts and all other wildlife regulations. Several steps in the construction process are critical to successful habitat protection and enhancement as follows:

- Identify and mark the limits of existing habitat to be restored or mitigated.

- Review the schedule for work allowed adjacent to habitat. Sometimes there are critical periods within which work may not occur due to the needs of the sensitive species.

- Prepare a Construction Work Access Plan to minimize impacts on the habitat.

- Provide interpretation or display of sensitive environments – to educate the public and the contractors as to the needs of the species or habitat to be protected. (Figures 2.i).

Figure 2.i: This riparian area adjacent to the Colorado River has been protected and restored adjacent to the trail.

Landscape habitat reconstruction is typically required to provide mitigation of impacts. A work program should be developed by a team of consultants, including a biologist, landscape architect and engineer. The construction of habitat includes the following tasks:

- Grading and Survey
- Planting
- Protection
- Maintenance and Monitoring

Landscape habitats that may require reconstruction include, but is not limited to, wetlands, Preble's meadow jumping mouse habitat, beaver habitat, and fish crossings. Many of the sensitive habitats are related to water: ponds, streams, wetlands or riparian areas (Figure 2.j). See the Technical Appendix for specific details on restoration techniques for these areas.

2.2.1 Preble's meadow jumping mouse

The Preble's meadow jumping mouse is listed as threatened under the Endangered Species Act. Consequently, before development occurs in any Preble's habitat, CDOT needs to work with the U.S. Fish and Wildlife Service to ensure their actions do not bring harm to the mouse, or jeopardize its continued existence through degradation of essential habitat.

CDOT's goal is to plan transportation projects and maintenance activities in ways that protect the Preble's meadow jumping mouse and its habitat. Preble's meadow jumping mice live in riparian or streamside areas with adjacent undisturbed uplands in the foothills of the Southern Rocky Mountain Front Range.

There are several methods of mitigating construction impacts to the mouse:

- Improve the riparian habitat along the creek, allowing existing populations of the Preble's mouse to persist in the area.
- Construct check dams to slow down the flow of the stream water and catch sediment behind the dams. This allows groundwater levels to be restored and riparian vegetation and habitat conditions to improve. Once a rainstorm fills the channel behind the check dams, the vegetation begins to bloom.
- Another protection technique is the establishment of a large length of conservation bank to provide opportunities for mitigation to offset highway construction impacts to the mouse.

The result of implementing these techniques is that the overall health

Figure 2.j: This riparian area adjacent to the Colorado River has been protected and restored adjacent to the trail.

Figure 2.k: This wetlands was constructed as mitigation for transportation impacts to natural wetlands.

of the riparian area is improved and habitat for a range of creatures is enhanced (Figure 2.k).

2.2.2 Compliance Oversight - Link to Regulations

See the Wildlife Protection Guidelines, Specifications and Permit Applications from the CDOT Wildlife Link (CDOT, 2009) in Chapter V. Technical Appendix.

2.3 Site Protection and Preservation

2.3.1 Establishing Limits of Clearing

- Minimize the area to be disturbed by construction to preserve natural character and habitat to the maximum extent.
- Minimize linear effect of vegetation clearing. Staggered clearing lines provide a more natural appearance. Naturalize the clearing lines.

2.3.2 Protection Fencing

CDOT Construction Manual, Section 607 Fences

The CDOT Construction Manual defines the criteria and procedures to be used by Project Engineers and Project Inspectors in the administration of construction contracts.

The CDOT Construction Manual addresses identifying and staking natural resources that need to be protected (CDOT, 2002). Fencing around sensitive resources provides additional protection, unless fencing precludes wildlife from accessing a resource (Figure 2.l).

2.3.3 Managing Construction Impacts

Construction management plans must include methods of minimizing construction impacts on natural resources, including wildlife habitat. Specific measures should include sedimentation and erosion control, protection from hazardous material spills and minimizing opportunities for human and wildlife conflicts.

- Overall, the area of disturbance should be limited to the minimum practical area to avoid unnecessary destruction of habitat. The area should be contained within protection fencing where possible.
- Erosion control includes minimizing cut and fill slopes and maintaining slopes at maximum 2.5H:1V for vegetation.

Figure 2.l: Erosion control techniques prevent runoff and resulting impacts to water quality.

- Temporary stabilization measures should be observed during construction, including sediment control BMPs and temporary seeding.
- Material reuse is recommended to limit the amount of materials that would need to be transported to the landfill.
- Do not allow stockpiling or disposal of pollutants used during construction in or near any watercourse.
- Construction workers should be provided information on appropriate food disposal practices to avoid encouraging rodents, birds and even bears to visit the site in search of food.
- A noxious weed management plan should be developed and followed.

2.3.4 Wildlife management during plant establishment

Wildlife management is often necessary during the period of plant establishment, since young plants may provide easy food sources for certain animals.

- Animal protection fence is recommended around newly installed trees when beaver are present.

3 | EARTHWORK

The following resources include pertinent information related to earthwork in relation to roadway design and construction:

CDOT Roadway Design Guide

CDOT Construction Manual, Section 200 Earthwork

CDOT Drainage Design Manual

Erosion Control and Stormwater Quality Guide (CDOT, 2002)

The guide addresses the degradation of water quality and minimization of erosion associated with highway operations, and the prevention or minimization of degradation through the implementation of planning, proper construction, and proper installation of Best Management Practices (BMPs).

CDOT Water Quality Program

This CDOT website contains links and overviews of stormwater programs, maintenance, planning, design and construction.

New Development and Redevelopment Stormwater Management Program (CDOT, 2004)

CDOT ensures that permanent BMPs are installed at appropriate construction sites to reduce the discharge of pollutants into stormwater after construction is complete. This program also provides for maintenance of the BMPs.

CDOT NEPA Manual

Reference and comply with 23 CFR Part 650B, Bridges, Structures and Hydraulics – Erosion and Sediment Control on Highway Construction Projects.

Reference and comply with 23 USC 109g, Erosion Control

Reference and comply with 40 CFR Part 122, Clean Water Act

Reference and comply with 33 USC 1251-1376, Clean Water Act

CDOT Standard Specifications for Road and Bridge Construction

This document outlines bidding requirements, contract execution, scope, legal procedures and construction details.

3.1 Site Grading and Slopes

3.1.1 Grading

Earthwork (grading) is potentially the biggest impact from a project. It clears the landform of vegetation and alters the topography. Some impacts may be temporary but revegetation takes time to reestablish.

- All site grading and restoration of existing disturbance should utilize landforms that are similar to the naturally occurring patterns and diversity found throughout the corridor (Figure 2.m).
- Earthen embankments should mimic the patterns of pre-construction conditions.
- Grading should avoid scarring on steep slopes and the negative visual effects that result.
- Where the top of a slope meets existing grade, slope rounding is required. For slopes steeper than 2H:1V, the rounding needs to occur over a distance of 10 feet on each slope. For less than 2H:1V, the rounding needs to occur over a distance of 20 feet on each slope (Figure 2.n).

Figure 2.m: An example of site grading to match naturally occurring landforms.

3.1.2 Maximum Slope Steepness and Embankment Shaping

- Limit slopes to 2H:1V maximum and physical disturbance from the edge of pavement to the farthest edge of cut or fill. Slope angle design is driven by soils, avoidance and minimization, available ROW, equipment access and stabilization. Slope steepness should be addressed with the landscape architect, engineer and geotech to determine the best alternative of treatments and angles for the project setting. If steeper than 3:1 must be used, consideration should be given to the use of a roadside barrier
- Side slopes should also be based on consideration of equipment access for installation and stabilization. Normally slopes should be limited to 3:1 to make it easier for motorized equipment to be used in maintenance. In developed areas, sufficient space may not be available to permit the use of desirable slopes. Back slopes steeper than 3:1 should be evaluated with regard to soil stability and traffic safety.
- Slopes steeper than 2:1 make revegetation more difficult and

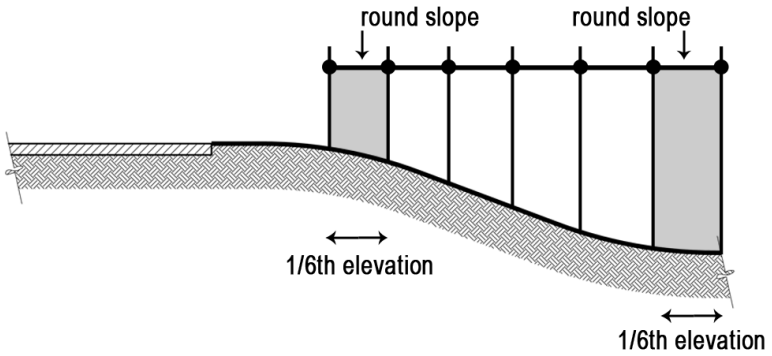


Figure 2.n: This diagram explains the concept of slope rounding.

chances of erosion increase.

- If slopes steeper than 3:1 must be used, consideration should be given to the use of a roadside barrier.
- When clearing vegetation is necessary, the roadway design may remove more vegetation than is strictly required for grading in order to create a natural and irregular edge, allow a naturalized rounding of the slope, and frame scenic views.
- Round the top and bottom of the slope to provide a stable area for revegetation and transition the embankment back into natural grade. When viewed in elevation, this rounded transition should occur over the last 1/6th of the slope top and toe (Figure 2.o).
- Forest rounding is recommended, similar to slope rounding, so that a gentle edge is created to the forest rather than an abrupt line.

Southern Rocky Mountains Zone: Limit slopes to 2.5H:1V maximum and physical disturbance to less than 40 vertical feet from the edge of pavement to the farthest edge of cut or fill. Restoration is more critical in higher alpine areas as growing seasons are short and the temperatures are more extreme. Since it may be difficult to regrade disturbed areas to meet existing grade in a reasonable distance, walls may be required to make the appropriate connections and recommended grades (Figure 2.p).

Figure 2.o: These slopes have been rounded to provide a stable area for revegetation.

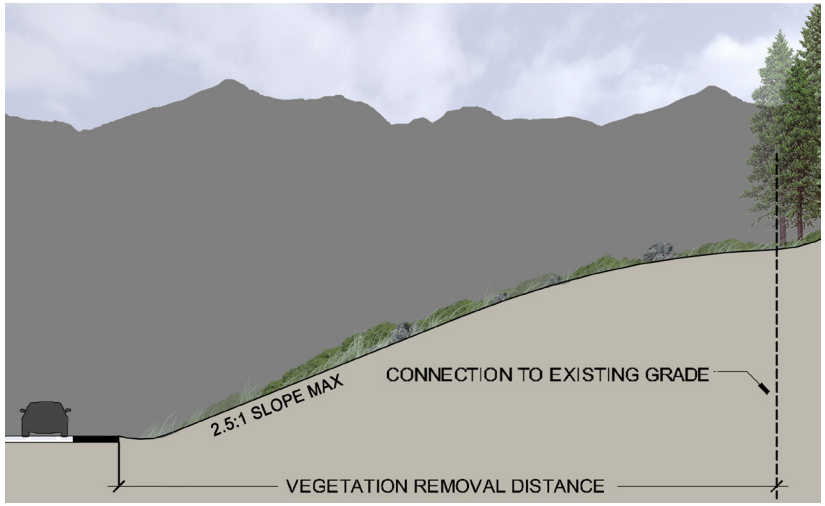


Figure 2.p: This diagram illustrates recommended grading for the Southern Rocky Mountains Zone.

3.1.3 Slope Ratio and Treatment

CDOT Construction Manual, Section 203 Excavation and Embankment

- Use a warped or variable slope technique in areas where the terrain is rolling and road work requires frequent shifts between cuts and fills.
- Soften transitions by laying back the slopes more at the ends of the cuts and fills than in the middle.
- Vary the slope of the embankment through the length of a large cut or fill area. A consistent slope should not be used for a longitudinal length greater than 300’.
- 3:1 or flatter slopes are safe for restoration equipment access drill seeder, soil amendment implements and mulch crimper. Drill seeding greatly improves seeding establish success.

- Replicate the diversity of natural slope conditions in new earthwork design and construction.

3.2 Rock Cuts and Rock Fall Protection

3.2.1 Rock Cuts

- New rock cuts will be naturalized with custom shaping and coloration applied to reduce the contrast between new cuts and existing rock faces (Figure 2.q).

- Use scatter blasting techniques and random rock drilling at varying depths to cause rock to break in natural patterns and expose natural rock fractures. Match new cuts with the characteristics and patterns found in the natural condition prior to construction.

- The geologic properties of rock within each design zone should serve as the basis for strategies to contain rock fall in order to maintain these natural forms. The design team should include a multidisciplinary group of geotechnical engineers, civil engineers, and landscape architects whose role is to maintain the inherent character of the natural bedding planes, fractures, joints and overall stability of rock.

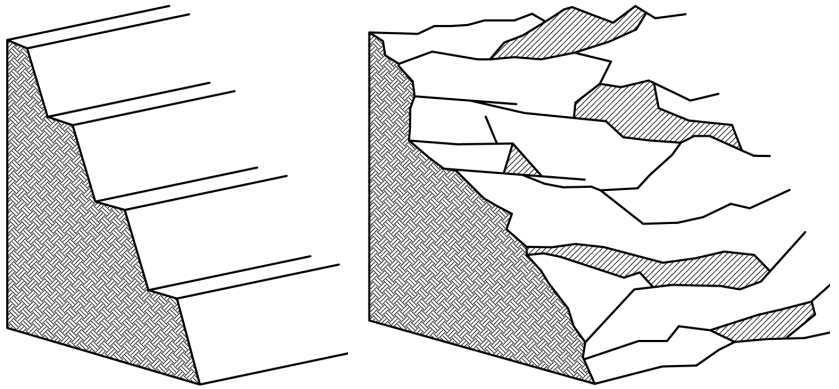
- Based on careful geological, site and cost analyses, rock cuts should strive to minimize the need for rock fall protection.

- Employ custom naturalized cuts and staggered benches (when approved) and avoid the use of straight vertical cuts and benches that have a sheer, unnatural appearance (Figure 2.r).

- Allow natural rock outcrops along the roadway to be left in earthwork rather than covered up or removed. When a rock cut is necessary, place bench-boulders within the slope to be visually compatible with existing rock outcrops

- Utilize tieback and other anchoring strategies to preserve and stabilize rock formations rather than the installation of rock fall protection devices (Figure 2.s).

- Where feasible, sculpt new rock cuts to include soil pockets within rock ledges. The soil pockets will present opportunities for revegetation that reflect the natural patterns found in pre-development conditions.



Figures 2.q: The diagram on the left illustrates regular rock face benching and the diagram on the right illustrates the recommended rock face cutting technique.

Figure 2.r: Naturalized cuts and benches, as in this example, are encouraged.

3.2.2. Rock Staining

- Design new rock cut slopes to blend with existing rock formations. Use rock staining, soil-coloring treatments, and/or accelerated weathering treatments to match new rock cuts with existing rock. See CDOT Specification 203 - rock staining (CDOT, 2011).

3.2.3 Rock fall protection methods

- Evaluate moving the road away from the rock face to avoid rock fall.
- For rock fall protection, use naturally sculpted benches and ledges across the face of rock instead of artificial looking benched features. When required, the use of natural contours supplemented with retention devices (such as protection fencing or mesh screens) can be used to minimize the extent of benching.
- Consider low reflectivity and color matching materials for rock safety structures. Rock safety structures that include earth-tone colors will match the patterns of surrounding rock.
- When mesh rock fall draping is required, it should follow the existing natural contours of the rock face. The end of the mesh material should terminate in a hidden condition to reduce visual clutter on the rock face (Figure 2.t).
- Minimize the “mouth” at the top of mesh rock fall draping to lessen the possibility of bird entrapment.

Figure 2.s: Soil nail techniques are used for stabilizing rock faces.

Figure 2.t: Mesh rock fall draping follows the contours of the rock face.

3.3 Disturbance Mitigation

3.3.1 Topsoil Conservation and Native Soils

Salvaging, storing and redistributing topsoil in all disturbed areas is a required practice. The native topsoil contains a natural seed bank, moisture-retaining capacity, and nutrients to support plant growth. When these resources are managed properly, successful revegetation and long-term restoration can be achieved. Restoring disturbed areas eliminates the appearance of artificial construction, creating an authentic representation of the site’s natural conditions.

The following resources provide detailed information:

CDOT Construction Manual, Section 201 Clearing and Grubbing

CDOT Construction Manual, Section 207 Topsoil

CDOT 2011 Standard Specifications for Road and Bridge Construction, Division 207 Topsoil

CDOT Migratory Bird Specifications (in Technical Section)

The following are recommended actions:

- Analyze the location and amount of native topsoil prior to construction.
- Ensure native topsoil is collected and stored for reuse to maintain the seed source and soil bacteria. Carefully remove, stockpile and store the native topsoil of new construction projects to be used as final bedding material to improve revegetation success.
- Ensure native soil stockpiles are protected from wind and water erosion. Use techniques such as weed free straw mulch, tackifier or erosion blankets to stabilize temporary stockpiles. Avoid storage next to streams or other water bodies.

3.3.2 Grading and Drainage

- The final portion of embankment grading is intended to create a naturalized effect and promote plant growth. It includes perpendicular track walking with earthwork equipment to create small depressions and pockets to capture water.
- Landscape retaining walls are defined as being completely set within the existing landscape – not associated with the roadway structure or surface and are generally small in size. Landscape retaining walls should utilize materials found in the natural surroundings – including boulders, rock, or talus. The design of these landscape-associated walls is in contrast to the aesthetic of walls directly related to transportation facilities.

3.3.3 Surface Stabilization

- Use large-scale rip-rap and talus (including boulders) in conjunction with native grass, wildflower, shrub, and tree species for restoration on steep slopes (Figure 2.u).
- Grind and chip existing shrubs and other plants grubbed in the area of disturbance and mix with topsoil and/or use as mulch to increase organic matter and regenerative capacity.

3.4 Erosion Control

The CDOT Erosion Control and Stormwater Quality Guide identifies that erosion control is desirable not only for environmental reasons but also for highway safety purposes. The following resources provide more information:

CDOT Construction Manual, Section 208 Erosion Control

CDOT Construction Manual: Section 216 Soil Retention Covering

Erosion Control and Stormwater Quality Guide (CDOT, 2002)

Erosion Control and Stormwater Quality Field Guide (CDOT, 2011)

CDOT 2011 Standard Specifications for Road and Bridge Construction, Division 208 Erosion Control

CDOT Project Development Manual, Section 3.17 Water Quality

Figure 2.u: A combination of river rock rip rap and reseeding protected by erosion control blankets are used in the streamsides. These are examples of heights steps, transitions and ends. The top left angular, irregular pattern should be avoided.

Uncontrolled erosion during highway construction, and subsequent sedimentation, causes adverse impacts on streams, damage to drainage structures and public (or private) lands and public criticism. Stabilized slopes are desired because they are visually pleasing; they protect against erosion, and yield a smooth roadside surface, which can assist errant vehicles in regaining control. Progressive design and construction techniques, including the use of BMPs, will prevent soil erosion and negative results (CDOT, 2002).

CDOT has written policies and procedures for the control of erosion, abatement of water pollution, and prevention of damage by sediment deposits. Erosion control measures are installations used to inhibit dislodging of soil particles by water or wind. Sediment control measures are installations used to remove settled sediments from surface runoff.

Erosion and sedimentation control solutions are briefly outlined below:

- Shield soil from rainfall and runoff - mulches, blankets, and nettings are available, as are chemical soil binders (Figure 2.v).
- Minimize soil exposure time between earthwork and slope revegetation.
- Control runoff water - keep natural or clear water runoff separate from construction or project runoff.
- Trap sediment using silt fences, erosion bales, erosion logs or sediment basins.
- Revegetate slopes with permanent or temporary seed mixes throughout construction (Figure 2.w).
- The landscape architect and other Stormwater Management Plan (SWMP)

preparers provide the resident engineer with a SWMP for incorporation into the Final Office Review Plans. For projects prepared by consultants or local agencies, the CDOT landscape architect reviews the plans.

The erosion and sediment control measures and procedures required for construction are:

- Utilize stabilized channels and surfaces to minimize soil loss.
- Show erosion control measures in the plans, specifications and estimate.
- Establish permanent erosion control practices at the earliest practicable time.
- Coordinate temporary erosion control measures with permanent measures to ensure an economical, effective and continuous control throughout construction.
- Monitor, maintain or revise erosion and sediment practices to adapt to actual construction of the project.

The *CDOT Erosion Control and Stormwater Quality Guide*, Chapter 5, includes the following approved BMPs (CDOT, 2002):

Erosion Control (EC) BMPs

- Seeding EC 1
- Mulching EC 2
- Mulch Tackifier EC 3
- Soil Binder EC 4
- Erosion Control Blankets EC 5
- Turf Reinforcement Mats EC 6
- Embankment Protector EC 7
- Berm/Diversion EC 8
- Check Dams EC 9
- Outlet Protection EC 10
- Temporary Drainage Swale EC 11
- Grading Techniques EC 12

Sediment Control (SC) BMPs

Figure 2.v: A variety of techniques are used in this urban setting. They include chain link fencing for site protection, straw erosion control matting and black silt fencing to trap sediments.

Figure 2.w: A variety of techniques are used in this urban setting. They include chain link fencing for site protection, straw erosion control matting and black silt fencing to trap sediments.

- Erosion Bale SC 1
- Erosion Logs SC 2
- Silt Fence SC 3
- Storm Drain Inlet Protection SC 4
- Sediment Trap SC 5
- Sediment Basin SC 6
- Dewatering Structure SC 7
- Stabilized Construction Entrance SC 8,
- Brush Barrier SC 9,
- Gravel Barrier SC 10
- Silt Barrier SC 11

4 | HYDROLOGY

Hydrologic features such as rivers, streams, intermittent drainages, ponds and wetlands may be affected by transportation facility construction or management. The following documents contain pertinent information on BMPs for stormwater, stream, and wetland protection and mitigation.

CDOT Drainage Design Manual, (Most Pertinent Chapters, 3, 5, 6, 15, 16, 17, and 19 Appendix II)

CDOT Erosion Control and Stormwater Quality Guide

CDOT Water Quality Program

CDOT New Development and Redevelopment Stormwater Management Program

Urban Drainage and Flood Control District: Drainage Criteria Manual (V.2) Revegetation

This manual provides information on methods, and plant materials needed for revegetation of drainage facilities within the Urban Drainage and Flood Control District.

CDOT NEPA Manual

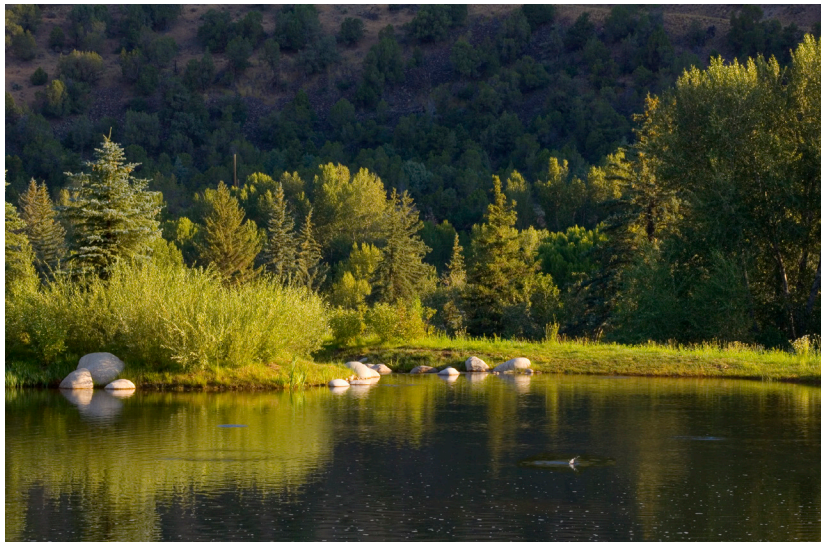


Figure 2.x: This pond illustrates principles of good design with well placed boulders and a variety of native plant types, creating diverse habitat.

Hydrologic features that may be affected by any transportation facility construction should be restored to reflect the surrounding environment. Channels, ponds, drainages and riparian environments hold high ecological and scenic value and require visual design consideration as part of their implementation (Figure 2.x).

By implementing Low Impact Development (LID) principles and practices, water can be managed in a way that reduces the impact of built areas and promotes the natural movement of water within an ecosystem or watershed. Applied on a broad scale, LID can maintain or restore a watershed's hydrologic and ecological functions. LID has been characterized as a sustainable stormwater practice by the Water Environment Research Foundation and others.

In accordance with the CDOT Drainage Design Manual, CDOT is a developer of transportation facilities that have the potential to stimulate secondary activity along the transportation corridor (CDOT, 2004). Secondary activity is a local planning function that must address overall stormwater management needs in conjunction with other utilities (e.g. water, wastewater, and power). The transportation corridor often traverses several watersheds; therefore, coordinated planning among concerned parties should take place. A stormwater management and drainage plan should consider the total scope of development. CDOT coordination with responsible local agencies is essential to ensure that proposed facilities are compatible with the long-term needs of the

area. The CDOT Drainage Design Manual addresses engineering design criteria and methods for hydrology.

4.1 Hydrologic Features and Water Quality

CDOT Drainage Manual
CDOT Water Quality websites

The CDOT Drainage Design Manual, Chapter 19, Appendix II, addresses the Colorado Discharge Permit System (CDPS) stormwater discharge permit issued to the Colorado Department of Transportation (CDOT) that requires CDOT to implement a program to reduce the discharge of pollutants from areas of new highway development and significant redevelopment after construction is complete. The BMP fact sheets provide the planner and designer with basic application guidelines and design criteria to be able to perform preliminary selection and design of permanent BMPs. The fact sheets include information on other resources that provide the detailed design procedures and are updated periodically. The detailed design procedures are evolving, and the designer is encouraged to research the latest available information to implement the Water Quality Control Measures.

- Analyze the entire stream course necessary to understand the overall hydraulic and geomorphologic conditions as a foundation for the design of stream enhancements, including landform, planting, edge conditions and drop structures.
- Treat stream edges with a variety of rock, plant materials and landform appropriate to the functional aspects of individual drainages and stream courses.
- Design stream and hydrologic enhancements with a sinuous and meandering aesthetic to blend with existing drainage and landscape patterns (Figure 2.y).
- Pursue aesthetic and functional restoration of natural channels where they have been previously damaged or modified by roadway improvements.
- Allow sedimentation ponds and features to perform water quality functions prior to draining into natural hydrologic systems.
- Utilize natural rock, riparian planting and stream channel improvements to preserve and/or enhance the visual quality of features including streams, ponds and waterfalls (Figure 2.z).
- Attempt to use bio-engineering methods and to enhance mitigation.

Figure 2.y: The natural sinuous pattern of the stream is echoed in the surrounding landscape. The bridged highway minimizes disturbance to this ecosystem.

Figure 2.z: The use of natural elements enhances the visual quality of this constructed stream.

- Vary the size of rock treatments. Meander naturalized treatments so that they feather into the landscape as natural appearing streams.
- Treat various sizes of drainages in a manner appropriate to their hydrologic function and importance. Bridge perennial streams and significant drainages to minimize disturbance to hydrologic features.
- Where possible, creeks should not be straightened or channelized in order to accommodate roadway improvements. Roadways should accommodate natural stream sinuosity courses and natural appearance.
- Shape wetlands, pond edges, and shorelines with naturalized forms to appear as if they were existing features. Avoid straight edges or rectangular shapes.
- Utilize naturally placed rock and aggregate at culvert outlets to provide a natural appearance and reduce flow energy.
- Detention basins should be revegetated or covered with appropriate ground treatment in order to avoid the visual appearance of an engineered landscape.
- Design drop structures and other stream improvements with natural materials rather than use concrete structures.

4.2 Wetlands Mitigation and Restoration

CDOT Project Development Manual, Section 3.18 Wetlands
Department of the Army, Corps of Engineers, 33 CFR Parts 325 and 332

Prior to commencing any mitigation planning, the designer should discuss the mitigation site with the following: Regional Environmental personnel, CDOT landscape architect and the person responsible for the wetland delineation. This coordination should determine if the wetland mitigation site is a creation, restoration or enhancement site, the size of mitigation area(s) and type of mitigation required. In order to determine the type of mitigation required, the hydrology of the site should be determined including the source, quality and quantity (Figure 2.za).

- The designer should ensure sufficient water availability to sustain the desired size of the wetland. When expanding a wetland, the designer should ensure sufficient water to avoid the loss of the existing wetland.
- If the water table at the mitigation site has many fluctuations, it may not be desirable to reestablish a wetland.

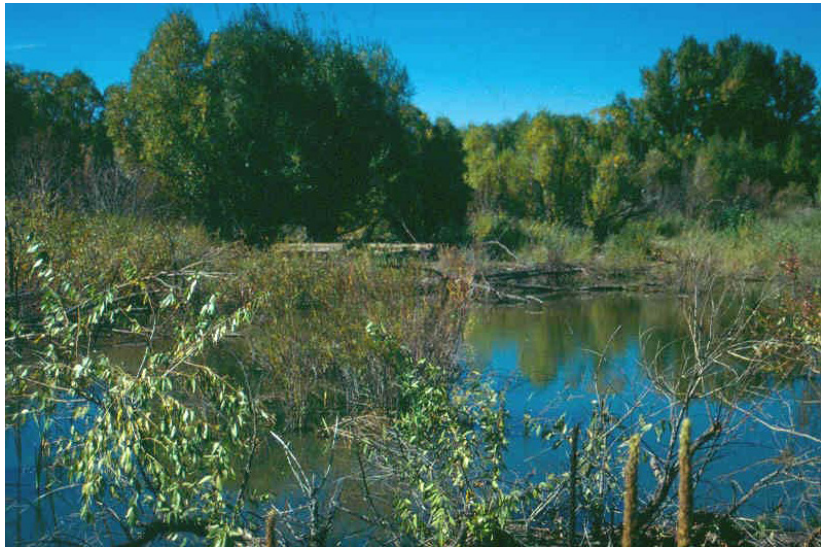


Figure 2.za: Documenting the existing wetland conditions will provide direction for mitigation if the highway construction causes impacts.

- Stormwater run-off only, is not a reliable source for water in a wetland mitigation site and should be avoided. Priority should be placed on creating a self-sustaining wetland.

- If roadway run-off will be used to supply the wetland, sediment and erosion control strategies should be used prior to the water entering the wetland.

It is also important to determine the type of mitigation needed for the soil composition (sands, clays or silts), topsoil availability and potential contamination. This will affect the strategy for grading. Elevation variations should be created at the bottom of the mitigation site of +/- 6 inches, for species diversity.

During the plan preparation the wetland designer should be in contact with team members for additional information, if needed. Team members include region environmental, CDOT landscape architect, CDOT biologist, hydraulic engineers, design and construction engineers. For wetland design done outside of CDOT, the CDOT Landscape Architect must review the plans prior to the FOR for accuracy and content.

A site visit should include CDOT region environmental specialist, a CDOT wetland biologist and landscape architect, a hydrologist, and project engineers. The site visit should assess the existing vegetation, identify species for revegetation and determine the presence of noxious weeds. Sources that should be considered for revegetation include cuttings from nearby willow sources or plugs from adjacent wetland sources. Choose native plants that are adapted to the water levels, soils and climate elevations of the site (Figure 2.zb). However, if the roadway is located in an urban area, other tree species more appropriate for urban conditions should be considered. The site visit should also determine if there are trees, shrubs or existing wetlands that need to be protected during construction. Finally, the site visit should assess if there are any signs of wildlife or grazing cattle that will require permanent fencing.

Figure 2.zb: Constructed wetlands mitigation site using native plants.

4.3 Riparian and Stream Restoration SB 40 Criteria

The practices discussed below are intended to be in conformance with guidelines specified in the following CDOT documents.

CDOT Drainage Design Manual, (Most Pertinent Chapters, 3, 5, 6, 15, 16, 17, and 19 Appendix II)

CDOT Erosion Control and Stormwater Quality Guide

CDOT Standard Specifications for Road and Bridge Construction

Municipal Separate Storm Sewer System (MS4) Permit (CDOT, 2006)

Discharges from the storm sewer systems of larger municipalities, and from

the CDOT highway drainage system that lies within those municipalities, are subject to MS4 Permits issued by the Colorado Department Public Health and Environment Water Quality Control Division. All discharges to the CDOT highway drainage system or within the right-of-way (ROW) must comply with the applicable provisions of the Colorado Water Quality Control Act and the Colorado Discharge Permit Regulations Permit # COS-000005.

CDPHE. Colorado Discharge Permit System, Municipal Stormwater Discharge Permit, Summary of Rationale, Colorado Department of Transportation, Permit Number # COS-000005.

CDOT SB 40 GUIDELINES

Sections II and III provide guidance for determining when SB 40 wildlife certification is necessary and when application should be made. They list general conditions, or best management practices, that apply to all jurisdictional SB 40 transportation projects, whether those projects require formal or programmatic certification. These general conditions are designed to minimize or avoid potential negative impacts from CDOT projects in the vicinity of aquatic systems and riparian areas.

4.3.1. Erosion Control Relative to Stream Restoration

Efforts to control erosion and to avoid impacts to aquatic resources and riparian areas, including wetlands, should be commensurate with the size of the project, site conditions, the quality of the natural resource and the potential for off-site damage. Stream profile, substrate and habitat values shall be restored to a condition similar to or better than pre-project conditions.

- Temporary fills, such as coffer dams and temporary road crossings, using imported material shall utilize clean, chemically-free fill to avoid increasing suspended solids or pollution. Fill material shall not be obtained from the live water area in the stream unless approved by Colorado Parks and Wildlife (CPW).
- Discharge of water directly into the stream from coffer dams or new channel construction shall be in accordance with applicable Clean Water Act Section 401, 402, and 404 regulations and permits. In some instances, such water must be treated prior to discharge.
- All reasonable measures shall be taken to avoid excess application and introduction of chemicals into aquatic

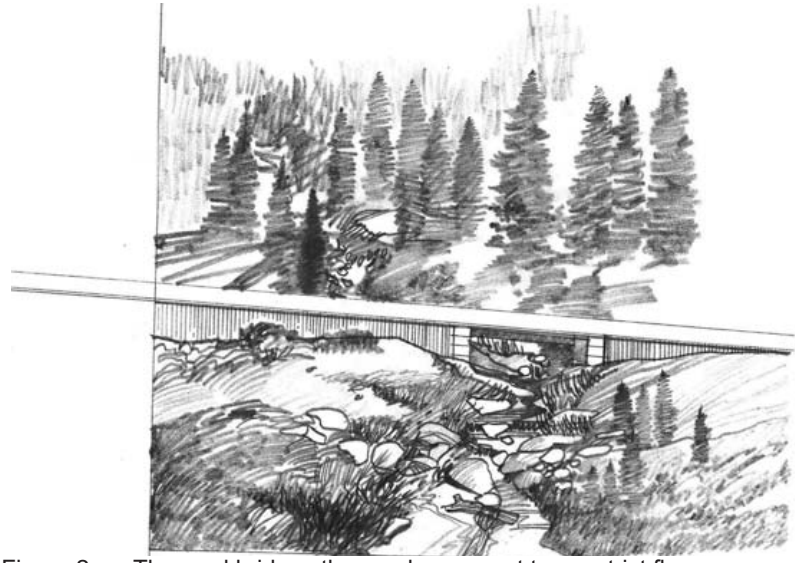


Figure 2.zc: The road bridges the creek so as not to constrict flow or degrade habitat.

ecosystems and adjacent riparian areas, including wetlands.

- Erosion control is required on all projects. Erosion control is particularly important around aquatic ecosystems and riparian areas, including wetlands, because of their sensitivity to sediments and pollution in roadway runoff. Temporary and permanent erosion and sediment control measures shall be installed at the earliest practicable time consistent with permit requirements and good construction practices. Such measures shall be properly monitored and maintained throughout the operation of the project per permit requirements.

- Riprap above the ordinary high water mark shall be covered with topsoil and revegetated as specified by the CDOT landscape architect (CDOT Specification 506). Areas under bridges do not need topsoil treatment; however, an artful approach may remove slope paving and lessen the slope. Rock rip-rap may be used as a surface beneath bridges. The area beneath the bridge may require a walking bench for wildlife.

- Where appropriate, streamside areas at the ordinary high water mark should be revegetated with brush layer cuttings of native riparian shrub species. Consult with the CDOT landscape architect for an appropriate treatment (Figure 2.zc). The strip that is most successful for brush layer cutting establishment is several yards wide and approximately two feet from the ordinary high water line. Details for brush cutting installation are provided in Division 214.04 of the CDOT Specifications for Road and Bridge Construction (CDOT, 2011).

- Bioengineering solutions, such as native riparian shrub plantings, for stream stabilization projects and for improving stream and riparian habitat values are recommended. Ensure that appropriate growing conditions exist for these techniques.

- Bioengineering techniques are required for all bank protection activities in important spawning areas that exceed 50 linear feet.

- During project design and construction, consideration should be given to ways to improve in stream habitat and riparian areas. Appropriate in stream structures shall be used to dissipate water velocity, reduce erosion, and improve fish habitat. The Colorado Parks and Wildlife (CPW) shall be

Figure 2.zd: Willow shrubs provide a well-stabilized river bank.

consulted regarding the means and methods being considered to improve in stream habitat and riparian areas.

- Stream crossing structures shall not degrade the stream or fish habitat or block fish movement, including constricting stream flows that increase water velocities, nor shall such structures unnecessarily widen streams and thereby decrease water velocities and increase sediment deposition (Figure 2.zd).
- Highway runoff shall be diverted away from the stream channel and associated wetlands to avoid siltation and other pollution problems. Such runoff shall be treated with the most appropriate temporary and permanent BMPs.
- To mitigate unavoidable impacts to wetlands and riparian areas, restoration and creation of such areas should be conducted as close as possible to the impact site. Evaluate what is best for the aquatic resource as a whole.
- Completion of the required mitigation should occur as quickly as possible. Delays in the replacement of wetlands may result in increased mitigation requirements.
- Water diversions shall be minimized. If necessary, clean water diversion techniques shall be used to divert water around or to pipe water through the active construction site to minimize water quality contamination, siltation, and sedimentation.
- Unless otherwise stipulated, temporary or permanent culverts shall be embedded and backfilled 12 inches into the channel substrate.

4.3.2 Bank Stabilization

CDOT Drainage Design Manual, Chapter 17 Bank Protection
CDOT Drainage Design Manual Chapter 16 Erosion and Sediment Control

- Riprap materials used below ordinary high water shall be durable angular rock free of organic material, pollution, and erodible material such as dirt and gravel. Rounded river cobble or stone is not acceptable as riprap (Figure 2.ze).
- In streams with less than 20 feet average width at the ordinary high water mark (OHWM), no more than ¼ cubic yard of material per linear foot may be placed below the plane of the OHWM. This requirement is based on Section 404 regional

Figure 2.ze: Rock riprap is integrated into a vegetated slope.

conditions for Colorado. Placement of materials in excess of these limits requires notification to the U.S. Army Corps of Engineers district office.

- Use of gabions is discouraged except where no other practicable solution exists to address the problem. If gabions are used in bank stabilization, the gabion shall be clean, durable rock material free of organic matter, sand, dirt, and gravel. River cobble is an acceptable material for filler provided it is large enough to stay within the mesh (Figure 2.zf).

- The use of broken concrete as slope stabilization is prohibited because concrete is a potential pollutant.

Figure 2.zf: Well constructed rock gabions.

4.3.3 Protection and Revegetation

Preserve wide, undisturbed natural riparian areas along streams (Figure 2.zg). These buffers help protect water quality by filtering pollutants, sediment and nutrient from runoff and aid in flood control, stream bank stabilization and stream temperature control.

- Protect and retain existing riparian vegetation whenever possible. Consider enhancing the existing buffer area by planting site-appropriate, native plants. Make the natural riparian area an integral part of the site design (Figure 2.zh).

- Clearly mark the riparian area to be protected on landscape plans. Generally, when landscaping in a riparian area, do not clear existing vegetation, disturb soil by grading or stripping, or fill in these areas. Exceptions may include removal of dead/diseased vegetation, stream restoration and stabilization activities or installation of stormwater BMPs.

- Plan site drainage so the existing hydrology of the riparian buffer area is maintained.

- Restore natural vegetation in riparian areas whenever possible when it has been disturbed by development.

- Check regulations for buffer setback requirements, typically ranging from 25 feet to more than 100 feet. Features such as erodible soils, unstable stream bank conditions, steep slopes, presence of a wildlife migration corridor, poor vegetative cover, or property usage involving hazardous materials, may warrant large setbacks. Permits may be required to disturb land within

Figure 2.zg: The riparian valley adjacent to the stream is preserved since the highway is located upslope.

the setback requirement.

- Clearly specify landscape maintenance practices that are acceptable within buffer zones. For example, the use, storage and application of pesticides are generally not appropriate for these areas. Landscape maintenance equipment should not be used in these areas.
- Manage the riparian buffer canopy to maintain maximum vigor of the overstory and understory.
- During the planning and construction of a project, measures shall be taken to avoid disturbance to existing vegetation. The length of time disturbed areas are left exposed shall be minimized, as should the extent of disturbed areas.
- All disturbed areas above the ordinary high water mark shall be revegetated with appropriate native plant species to provide bank stabilization, erosion control, and habitat replacement. These activities shall be conducted according to specifications approved by the CDOT Landscape Architect.
- Temporary seeding shall be done where necessary and the spread of weeds should be strictly controlled. Only certified weed-free hay and straw shall be used.
- Avoid unnecessary destruction of trees and shrubs in the vicinity of streams and in riparian areas. Trees removed should be considered for use on-site in a manner that improves riparian habitat for bank stabilization purposes. All trees removed during construction, shall be replaced with a goal of 1:1 based on a stem count of all trees with diameter at breast height of 2 inches or greater.
- All shrubs removed during construction, shall be replaced based on their pre-construction area coverage, measured in square feet.
- All replacement trees and shrubs shall be native species. Additional considerations should include the existence of appropriate growing conditions, consistency with existing natural conditions, what is best for the natural resource, and input from the CDOT landscape architect and staff biologist. Given these site considerations, it may be appropriate to replace trees with shrubs under certain circumstances.

Figure 2.zh: A restored pond, wetland, and riparian environment is an integral part of the I-70 site design.

- Where lack of sufficient right of way space limits full replacement on site, the remaining stock should be placed in areas that serve similar stream functions.

4.3.4 Channel Re-Alignment

- Stream profiles, substrate and aquatic habitat values shall be restored equal to or better than pre-construction conditions. Maintain the existing stream length, terraces at flood stage elevations and width and establish a low-flow channel in the realigned stream channel.

- Existing or comparable stream bottom material shall be used in the re-aligned stream channel. However, such material shall not be obtained from the live water area in the stream unless approved by Colorado Parks and Wildlife (CPW).

- A vegetated buffer area shall be maintained between the stream and the highway.

- During project design and construction, consideration should be given to ways to improve in-stream habitat and riparian areas in the vicinity of such projects. Where necessary, appropriate structures and/or bioengineering techniques shall be used to dissipate water velocity, reduce erosion, and improve fish habitat. Preference should be given to native materials. CPW shall be consulted regarding the means and methods used to improve in-stream habitat and riparian areas.

4.4 Stormwater Management

CDOT Erosion Control and Stormwater Quality Guide

CDOT Drainage Design Manual, Chapter 15 Surface Water Landscape, and 16 Erosion and Sediment Control

CDOT Project Development Manual, Section 3.15 SWMP

CDOT Roadway Design Guide 2005, Chapter 3, 3.6.1 Drainage and Erosion Control, Chapter 4, 4.7 Drainage Channels and Sideslopes, Chapters 5-9 address grading and drainage for various roadway types

The CDOT Roadway Design Guide was developed by CDOT engineers and is based on the American Association of State Highway and Transportation Officials' *A Policy on Geometric Design of Highways and Streets*, commonly known as the AASHTO Green Book, and on established Colorado Department of Transportation (CDOT) policies and practices.

Urban Drainage and Flood Control District: Urban Storm Drainage Criteria

Figure 2.zi: Riprap lined drainage swales provide stormwater treatment in an urban area.

Manual (V.2) Revegetation

This manual provides information on methods and plant materials needed for revegetation of drainage facilities within the Urban Drainage and Flood Control District, including natural channels, grass-lined channels, detention ponds, retention ponds, constructed wetlands/wetland channels, and stream bank stabilization and grade control structures.

Establishment of a robust cover of native vegetation or cover approved in urban areas is critical to the proper functioning of drainage structures such as grass-lined channels, detention basins, retention ponds and wetlands (Figure 2.zi). Vegetation serves multiple purposes, including stabilization of structures to prevent excessive erosion and removal of pollutants in stormwater. The semi-arid nature of the climate, prevalence of introduced weeds, and variety of soil types encountered in the District virtually mandate prompt implementation of a revegetation plan to achieve revegetation success. The erosion control BMPs listed previously are also effective for stormwater management.

5 | VEGETATION PROTECTION AND REMOVAL

The following are resources related to vegetation protection and removal (Figure 2.zj):

CDOT Drainage Design Manual

CDOT Construction Manual, Section 216 Soil Retention Covering

CDOT Construction Manual, Section 214 Planting

Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado

The manual describes conservation practices for the Green Industry in Colorado. As a whole, GreenCO is dedicated to the conservation and preservation of all Colorado's precious resources. Since 1996, the Green Industries of Colorado (GreenCO) has been working with a diverse set of industry experts and partners to develop a water conservation and water quality protection program. In May 2002, the first release of the BMP manual was developed and distributed to the green industry through the support of GreenCO, Wright Water Engineers, Inc., Colorado Water Conservation Board, and Headwaters Consulting, LLC. Coincidently, following the initial release of the manual, the Green Industry was hit-hard by drought restrictions during 2002 and 2003. The drought has been a wake-up call for Green Industry professionals and communities alike; emphasizing that water conservation must become a way of life.

CDOT Drainage Design Manual (V.2), Revegetation

This chapter provides information on methods and plant materials needed for revegetation of drainage facilities within the Mile High Flood District (MHFD). Establishment of a robust cover of vegetation is critical to the proper functioning of drainage structures such as grass-lined channels, detention basins, retention ponds, and wetlands.

(Legislation established the Urban Drainage and Flood Control District for the purpose of assisting local governments in the Denver metropolitan area with multi-jurisdictional drainage and flood control problems. The District boundaries have changed since the original legislation, and it now covers an area of 1608 square miles and includes Denver, parts of the six surrounding counties, and all or parts of 33 incorporated cities and towns.)

Figure 2.zj: Mature trees are a valuable resource to be considered for protection in highway site design.

5.1 Clearing and Grubbing

CDOT 2011 Standard Specifications for Road and Bridge Construction, Division 201

Clearing and grubbing is to occur only within the designated area of disturbance. Topsoil that is removed should be stockpiled on site.

5.2 Tree Protection

Preserve existing healthy trees. Established plants have often developed a root system that is adapted to lower water conditions. Preserving healthy trees means following industry standards to protect canopies, trunk and critical root zones during construction and modifications. Typically, the critical root zone is defined as the drip line of the plant, but it may be more extensive, depending on tree species and size. Areas within the critical root zone are no-work areas, including no storage of equipment or stockpiling of soils or materials, with the exception of foot traffic or work designed to improve the health of the tree.

- Preserve islands of significant existing trees, by techniques such as dividing the highway, use of structure to avoid grading and supporting the embankment with stabilization techniques such as gunite (Figure 2.zk and Figure 2.zl).
- Where practical, provide fencing around the trees at closest at the tree's drip line, to protect the trees from construction impacts.
- The contractor shall have all root and branch pruning completed by a licensed and certified tree arborist. All work shall be in accordance with American National Standard Institute.
- Tree roots two inches or greater in diameter shall not be removed, unless they interfere with the work. Extensive root pruning may require tree replacement as directed by the engineer. Roots below the excavation depth for the work shall not be pruned.
- Small trees that can easily be moved should be considered for relocation and transplanting elsewhere on the site.
- Vertical mulching/aeration may be recommended for trees located close to construction activity.
- Mitigation of the impacts of removing trees is recommended to assist with efforts to minimize climate change. For example, one suggested mitigation is to replace trees that have a 2-inch or greater caliper, on a one for one basis. Trees with a greater than 12-inch caliper may be replaced on a two to one basis.
- Trees that are to be preserved should be identified clearly on site. If any of the "trees to be preserved" are taken down during construction without authorization from the landscape architect, the contract documents may allow for penalties to be enforced.

Figure 2.zk: These mature trees have been preserved using a median in the urban Denver area.

Figure 2.zl: This separated highway provides protection of existing trees.

5.3 Transplanting

CDOT Construction Manual, Section 215 Transplanting

CDOT Standard Specifications for Road and Bridge Construction, Section 214 and 215

Existing native plants should be salvaged prior to construction if they can be reused in the project in a timely manner, which means to plant without holding material in a collection mode for longer than 48 hours. By reducing the amount of plant material removed the designer:

- Reduces erosion.
- Reduces maintenance - existing native grass, shrubs and trees require less mowing, herbicides and water.
- Reduces number of plants required to be planted on a job.
- Increases visual aesthetics of the roadway.

Select plants that are to be transplanted based on size, location, soils, plant value and potential survival rate. Salvaged plants can provide mature specimens that would otherwise take years to establish. Where existing native plants cannot be reused, chip salvaged plants and incorporate them into the topsoil. Use the following transplanting guidelines:

- Transplant in the season when plants are in a dormant condition.
- Transplant plugs in early spring when plants are emerging. Plugs must be a minimum of four inches in diameter and six to eight inches deep, with the root mat intact. Plugs are to be replanted immediately.
- Consult the CDOT Specifications, section 215 for minimum rootballs for collected plants.
- Transplant on-site or contractor to source (obtain) brush layer cuttings (e.g. willow) within 1000 feet of elevation of the location and of the same species.
- Use tree spades to transplant trees and transport trees in a pod trailer. Transplanting is to be completed in one day.
- During the construction phase of a project, vegetation can be protected by placing plastic temporary fencing around the drip line of a tree (at a minimum) or around the edges of wetlands or shrub masses.

- A specification can be placed in the contract document to require the contractor to replace or repay for any damages accrued to vegetation (that is intended to be preserved) during construction activities.

The following are resources related to vegetation protection and removal (Figure 2.zm):

CDOT Drainage Design Manual

CDOT Erosion Control and Stormwater Quality Guide

AASHTO Guide for Transportation Landscape and Environmental Design

This 1991 book supersedes the 1970 Guide for Highway Landscape and Environmental Design, and has been expanded to include all modes of transportation and interaction of landscape considerations with transportation improvements. It is a basic reference to help practitioners improve landscape and environmental design.

CDOT Right of Way Manual, Chapter 7

The purpose of the manual is to provide guidance in all phases of acquiring, managing and disposing of real property. It is based on federal and state statutes, rules, policies, and procedures related to real estate, condemnation, and relocation.

Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado

CDOT Drainage Design Manual, Revegetation

CDOT Highway Maintenance Level of Service

CDOT Standard Specifications 212, 213,214, 215 and 217

Figure 2.zm: The rabbitbrush and sagebrush filled meadows and hillsides vegetated with scrub oak, serviceberry, and juniper are characteristic of the Colorado mountain landscape.

Throughout the landscape design process, the CDOT landscape architect collaborates with professionals in other disciplines. Discussions with region environmental, traffic, design and construction engineers and maintenance personnel aid in resolving design problems and providing consensus solutions that are acceptable to all. All consultant design projects should be reviewed by the CDOT landscape architect to ensure landscape being provided will thrive in the areas it is being placed, safety and regulatory standards are being met, and plans are accurate with proper pay items and specifications.

Communication should begin at the time of project scoping or when a problem is identified to ensure a cost effective, safe and informed solution. The communication should continue through the Field Inspection Review (FIR), Final Office Review (FOR), construction, and maintenance portions of a project to ensure design intent has been accomplished.

A landscape planting program (native seeding at a minimum) will be included with every CDOT project associated with a soil disturbance. The program will include a plan

for landscape type, maintenance, and funding and be completed in partnership with agencies and communities. Where appropriate, trees, shrubs, grasses and herbaceous plants will be incorporated into new projects. Restoring the visual conditions with new landscape is essential to the restoration of a natural appearance to the land after construction (Figure 2.zn). At the beginning of the planting design process, CDOT Landscape Architects should consult the CDOT Levels of Maintenance to understand the future site conditions of the area to be planted.

6.1 Landscape Design

Plan and design landscapes comprehensively to conserve water and protect water quality. Consider view, slope, exposure to natural (e.g. wind, sun) and man-made (e.g., pedestrian traffic) elements, soils, availability of natural precipitation and supplemental irrigation and drainage when designing the overall landscape. Base designs on sound landscaping practices. Implement Xeriscape principles (see section 6.1.7, Xeriscape). The CDOT Landscape Architect should be consulted to specify appropriate plants and seed mixes.

6.1.1 Planting on Slopes

- On steep slopes, select plant species that produce dense, fibrous roots to help prevent soil erosion (Figure 2.zo). Maintenance safety issues should also be considered in selecting plants for these areas. For example, mowing may not be safe on steep slopes; therefore, alternatives to manicured turf should be explored.

- A temporary nurse crop of grasses (oats) may be required to provide immediate soil stabilization on steep slopes. Consult with CDOT Landscape Architect for information to avoid planting overly aggressive species that may compete with permanent ground cover.

- Provide for a combination of understory and overstory plantings to improve long-term establishment.

- Use soil retention covering, or spray on mulch blankets on slopes of 2.5:1 or greater to minimize erosion and provide more stable soils for plant establishment. Treatments may vary with design zones. Consult a CDOT Landscape Architect for slope treatments.

Figure 2.zn: An example of successful revegetation in the mountains using grasses and wildflowers.

Figure 2.zo: Successful restoration planting uses native plants to mimic the patterns of the natural landscape.

6.1.2 Plant Selection

CDOT Policy Directive 503.0 Landscaping with Native Plant Material

Plant selection can make the difference between success and failure in transportation revegetation efforts. The roadway corridor is open to strong winds, and susceptible to many chemicals used on the roadways and adjacent land. Soils are often poor because of the roadway construction activity. Native plant materials are suited to the local environment and climate and their use is required by CDOT on highway corridors (Figure 2.zp). When choosing plant material, the following guidelines should be followed:

- Match plants to the environmental conditions; shady or sunny, adequate or inadequate drainage, temperature, soil or air quality, wind and salts.
- Use existing transplanted material when available. Direct transfer of material is encouraged.
- Native plant material should be the first choice. Consult with a landscape architect when nonnatives are considered in urban settings.
- Xeriscape plant material should be used.
- Use plants which do well with little or no maintenance. Plants that are known to have pest or disease problems should not be used.
- Species that are known to survive highway conditions must be used (Figure 2.zq). A small percentage of material that has not been successfully established on highway projects may be used when approved by the landscape architect.
- Review desired visual quality with consideration to each plants seasonal characteristic.
- When irrigation is required, plants (turf, herbaceous and woody ornamentals) should be selected that have the greatest chance for survival if the water becomes unavailable.
- Use plants that are reasonably priced and easily available.
- Nursery stock shall be sourced from an elevation within 1,000 feet of the project.

Figure 2.zp: Slope revegetation with native wildflowers including blue flax, gaillardia, coneflowers, and yarrow.

Figure 2.zq: In the highway environment, hardy grasses and shrubs are required. Boulders add interest to the planting.

6.1.3 Native Seeding

CDOT Policy Directive 503.0 Landscaping with Native Plant Material

- It is the policy of the Department to use native or dryland adaptable plant material on future Department landscaping projects. The Department policy also encourages other state and local agencies, and the landscape industry in general, to use native and dryland adaptable plant materials in their landscape projects. Landscape designs, specific seed mixtures and type of plantings must be approved by the landscape architects, environmental, planning, maintenance, right-of-way and traffic sections. They must follow the seven Xeriscape Principles of Planting and must be low water/native type plant material (see section 6.1.7, Xeriscape).

- The Seeding Plan must use native species; both warm season and cool season grasses, both bunch and sod forming grasses, native wildflowers, shrubs (if approved by Maintenance) and a nurse crop, e.g. oats (Figure 2.zr, Figure 2.zs and Figure 2.zt). The plan must identify the method of seeding and mulching, address the soil conditioning/organic fertilizer and include appropriate erosion control techniques when required.

- Pure live seed (PLS) is based on seed species/pound and desired seeds/sq. ft. (ideal seed/ft. is 100). Nurse crops weight should not exceed 5 lbs. /acre

- Soil preparation, soil conditioning or topsoil, seeding (native), and mulching will be required for the disturbed area within the right of way limits which are not surfaced. Seeding application will be drilling due to high failure rates with hydro mulching and/or hydro seeding.

- See Section 212 of the CDOT Construction Manual for further detail on seeding (CDOT, 2002).

In general, a native mix shall contain a mixture of warm and cool season grasses, bunch and sod forming grasses, at least one wildflower and one nurse crop. Pounds/acre is based on planting 90-125 seeds/sq. foot based on drill seeding equipment as the planting method. Seeds are selected for adapting to climate and soil conditions in the area.

The following is a sample Seeding Plan with types of seeds and planting rates that shall be used:

Figure 2.zr: Penstemon provide good cover on this disturbed slope. They are hardy and attractive native plants with low water requirements.

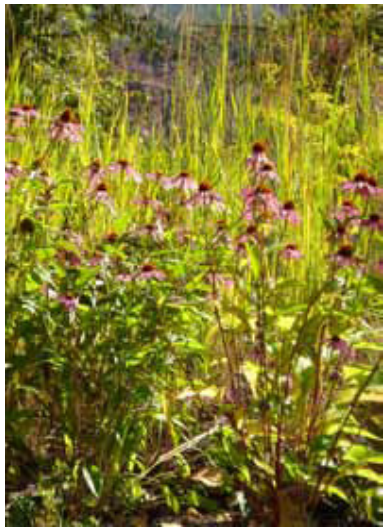


Figure 2.zs: Purple coneflowers provide good late summer color.

Figure 2.zt: Mules ears are abundant in Colorado in the early summer.

COMMON NAME	BOTANICAL NAME	POUNDS PLS/ACRE
Blue grama (warm season)	Bouteloua gracilis Hachita	2
Western wheatgrass (cool season sod former)	*Pascopyrum smithii* Arriba	6
Sideoats grama (warm season sandy soils)	Bouteloua curtipendula Vaughn	3
Little bluestem (warm season sandy soils and bunch grass)	*Schizachyrium scoparium* Pastura	3
Switchgrass (Bunch grass for ditches)	*Panicum virgatum* Pathfinder	4
Slender wheatgrass	*Elymus trachycaulus* Pryor	4
Junegrass	*Koeleria macrantha*	0.2
Prairie coneflower	*Ratibida columnifera*	0.3
Purple prairie clover	*Ratibida columnaris*	0.5
Gaillardia	*Gaillardia aristata*	1
Oats (Nurse crop)	*Avena sativa*	3
TOTAL		26

6.1.4 Turf Grass

Specifications for installation of turf grass are provided in existing CDOT documents as follows:

CDOT Construction Manual, Section 212 Seeding, Fertilizer, Soil Conditioner and Sodding

CDOT 2011 Standard Specifications for Road and Bridge Construction, Division 212

Use of turf grass is to be limited to high-use areas in urban and developed areas. It is effective as a border or edge treatment to naturalized wildflower plantings (Figure 2.zu)

6.1.5 Wildflowers

Wildflowers are effective for revegetation of road edges in natural settings.

CDOT Project Development Manual 2001, Section 2.25 Wildflowers

Federal Highway Administration, Department of Transportation. 23 CFR 752.11 (b). Right-of-Way and Environment - Landscape and Roadside Development. Require that wildflower seed, seedlings or both, shall be provided on all federal-aid projects

Figure 2.zu: Limited turf grass areas are appropriate in the urban landscape.

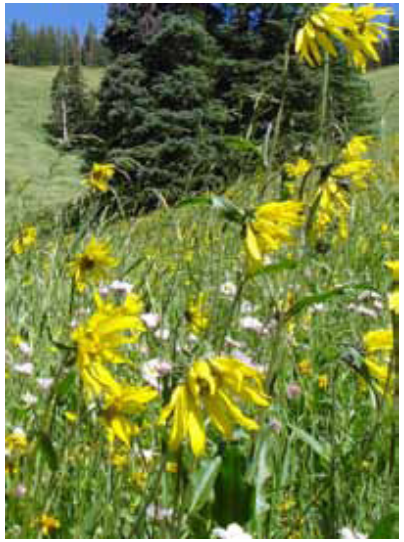


Figure 2.zv: Native wildflowers in a natural setting.

Figure 2.zw: A wildflower seed mix generally includes annuals for color in the first year.

Incorporate the Federal Highway Administration (FHWA) Operation Wildflower Program in revegetation efforts. Consult the CDOT Landscape Architect for specific seed mixes for each site (Figure 2.zv and Figure 2.zw).

6.1.6 Mulching

Specifications for mulching are provided in existing CDOT documents as follows:

CDOT Construction Manual, Section 213 Mulching

CDOT 2011 Standard Specifications for Road and Bridge Construction, Division 213

6.1.7 Xeriscape

Xeriscaping refers to landscaping and gardening in ways that reduce or eliminate the need for supplemental water from irrigation. Most of CDOT's projects are non-irrigated and require designs adapted for site conditions. Xeriscaping is promoted in regions that have limited water supplies, and is gaining acceptance in other areas as climate patterns shift. Implement the seven basic landscape principles of Xeriscape: planning and design, soil improvement, hydro zoning of plants (select low water plants and group plants of similar water needs together), creating practical turf areas, efficient irrigation, mulching (allows moisture to percolate into the soil, reducing runoff; suppresses weeds) and appropriate maintenance.

- Plan and design landscaping comprehensively. Begin with a site inventory and analysis that identify existing conditions such as drainage, exposures, soil types, views and existing plants. Develop a list of activities and their support facilities to be included in the design. Diagram possible locations for the activities while allowing for planned traffic patterns and access or screening. Identify areas where planting will achieve program goals (e.g. creating a strong colorful visual affect or providing shade). Based on an understanding of the micro-climate conditions, select appropriate plants and plant groupings (Figure 2.zx).

- Evaluate soil and improve if necessary. Improve soil before planting and installing the irrigation system. Soil improvement

Figure 2.zx: An example of planting for color and program goals in an urban setting.

Figure 2.zy: Low water use grasses are effective in highway landscape.

promotes better absorption of water, improved water holding capacity and drainage of the soils. It also allows for better oxygen transfer within the root zone.

- Group plants according to their water needs (“hydrozoning”). Use plants with lower water requirements such as native species adapted to Colorado’s climate.

- In the Front Range Urban Design Zone, include turf areas where they provide defined functions. Choose the appropriate grass for the desired use. Select alternative low water use grasses where possible. These may include buffalo grass, blue grama and wheat grass Figure 2.zy).

- Water efficiently with a properly designed irrigation system. Irrigate according to the condition of the plants, not on a fixed schedule. Well-planned sprinkler systems save water when properly installed and operated. Turf areas should be watered separately. Apply only as much water as the soil can absorb to avoid runoff. Use low volume drip emitters or a system accepted by local maintenance forces for efficiently watering trees and shrubs. To promote deep rooting, water infrequently, but deeply.

- Use organic mulches to reduce surface evaporation of water and weeds. Mulches cover and reduce temperature extremes in the soil, minimize evaporation, reduce weed growth and slow erosion. Organic mulches are typically bark chips, wood grindings or pole peelings. Inorganic mulches include rock and various gravel products. Place mulch three to four inches deep directly on the soil or on breathable fabric.

- Practice appropriate landscape maintenance. Proper pruning, weeding, mowing and fertilization, plus attention to the irrigation system, are needed to maximize water savings. Regular maintenance preserves the intended beauty of the landscape and saves water and maintenance costs. Water according to plant needs and current soil moisture conditions, not on a rigid schedule.

6.1.8 Monitoring and Maintenance

- Monitor revegetation during construction to ensure the specified materials and installation methods have been used. Include plant establishment periods and landscape maintenance periods (24 months) on landscape projects. Monitor and maintain areas of revegetation and weed

control for up to five years to ensure successful native plant establishment.

- Develop a program to control noxious weeds and invasive plant species. In areas requiring revegetation, quickly establishing native species is the most effective method of controlling invasive weeds. Use biotic or organic forms of control, such as temporary mulches, to prevent invasive species from establishing.
- Utilize a central control for irrigation systems and consider the use of reclaimed water, including fully treated effluent and water harvesting techniques, as a supplement to irrigation.
- Provide temporary watering for containerized native plants for a period of approximately 2 years.

6.2 Replication of Existing Landscape Patterns

The goal for transportation design and alignment is to achieve a seamless connection with the natural surroundings. Replicating existing landscape patterns will ensure meeting this goal.

6.2.1 Overall Site Considerations

- Evaluate sites for elevation, moisture conditions/climate, solar orientation, and soil conditions to determine landscape planting patterns.
- Plant selections should be reviewed for drought tolerance, salt and alkali tolerance, seedling vigor, fire retardant characteristics, growth habit, suitable soil groups, and seeding rates. Use native plants already found in this design zone. Natural patterns and distribution of plants is predominate landscape design principle (Figure 2.zz). Ensure that the selected plant palette compliments the site-specific existing vegetation. Restored plant communities should have variations in plant height, size, and width.
- Minimize the linear effect of vegetation clearing.
- Create a continuous habitat pattern by extending plantings across the full extent of medians and roadway edges.
- Mimic surrounding conditions of plant density, size and spacing, species composition (including understory, over story), and plant community structure including moisture and

Figure 2.zz: An example of natural patterns and distribution of plants.

drainage conditions.

- Blend existing rock and natural materials from the site with the landscape. Save and reuse native rock, stumps, and other natural materials in conditions such as boulder fields, talus slopes, or ground cover that emulates the existing landscape. Reuse of existing materials should be considered part of the site design.

6.2.2 Plant Placement

CDOT Standard Specifications for Road and Bridge Construction, Section 214 Planting

CDOT M-214-1 Planting Details and Specifications

CDOT M (Miscellaneous) – Standard Plans

This website contains links to standard construction specifications in PDF form.

Planting design concepts are a result of the landscape architects training in elements such as color, form, line and texture (Figure 2.zza). The placements of plantings on the highway right of way serve to:

- Protect against erosion.
- Minimize water use through the use of native drought tolerant species, mulches, and the use of irrigation systems designed for low precipitation systems.
- Promote stormwater reduction runoff practices via interception and root infiltration.
- Screen undesirable views from the highway and screen highway from adjacent land owners.
- Guide traffic.
- Avoid root or foliage contact from deicers.
- Minimize maintenance requirements.
- Provide shade at scenic overlooks or at rest areas.
- Frame and emphasize a view.
- Screen highlight glare.

Figure 2.zza: The natural landscape provides an excellent example of color, line, form, and texture.

- Mitigate impacts to surrounding communities.
- Reduce driver monotony.
- Provide wildlife habitat.
- Salvage, protect or reuse existing vegetation, when possible.
- Mitigate for wetland/riparian impacts.

Plant placement should be pleasing and coordinated with the total highway environment, with safety being the most important consideration. The planting design should correspond to adjacent land forms, grading, drainage and locations of any fencing or sound walls. General planting guidelines follow:

- Consider speed of travel. Landscape detail is not perceived well along 55 mph and greater corridors.
- Coordinate plantings and lighting so that the safety and security of users are not compromised by shadows and dark areas.
- Carefully choose and locate plants to minimize potential hiding places for vandals.
- Planting design should respond to what motorists can actually see from their vantage point; i.e., do not plant where it is obscured by walls, barriers and guardrail.
- Do not place plants that may attract large mammals (e.g. deer or elk) adjacent to the roadway.

Design Context:

- Avoid straight lines of trees or rectangular masses. Design for natural or informal placement of plants, with exceptions for urban areas.
- Plant masses should relate to the size of planting area and speed of traffic. Reserve small groups and more detailed plantings for rest areas, ramps or community side of noise walls.
- Utilize several different species to eliminate a monoculture environment.

- Overlap masses of different size plant material.
- Graduate the heights of plant material as the design moves away from the roadway.
- Large masses of trees or shrubs shall be punctuated with appropriate accent plants or flowers.
- Avoid equal or monotonous spacing of plant material. Vary the number of plants in adjoining groups. Vary the distances between accent plants.
- Refer to the zone's natural plant palette and recommended hardiness zones as a starting point to develop a full revegetation plant list tailored to the specific location of the project. Hardiness zones are defined in U.S. Department of Agriculture publications. Elevation and ecosystem information can be found in the Design Zones section.
- Select plants that are well adapted to the climate, topographic and geologic conditions of the site. Native plants and plants with documented lower water requirements should be given priority in landscape design.
- Where possible, retain significant native vegetation that is already adapted to the site.
- Incorporate trees into the landscape to provide shade, reduce stormwater runoff, stabilize soil and protect against wind (2.zzb and 2.zzc).
- Landscape bare areas to reduce soil erosion. Landscaping practices can reduce stormwater runoff rates and volumes, sediment loads and pollutants.
- In the Front Range Urban Zone, turf grass can be particularly effective in erosion-prone areas and can be used in buffer strips and grassy swales to filter out sediment. Consider installing grassy buffer in areas adjacent to or contiguous to, open waterways or known recharge areas, to provide extra filtering of runoff.

Maintenance:

- For ease of maintenance, plant groups should be placed in a mulch bed. When plants are not contained in a mulch bed, trees should be spaced at least 24.6 m (15 feet) apart to allow

Figure 2.zzb: Incorporating trees in the urban landscape provides many benefits, including shade and reduction in stormwater runoff.

Figure 2.zzc: Trees also provide aesthetic benefits, such as this display of color.

mowers to maneuver between them.

- Do not completely encircle lights, signs or other roadway structures with vegetation to ensure these elements are accessible to Maintenance;
- Plant beds adjacent to mowing area should have a free flowing outline to favor mowing practices.
- Group plants with like water needs together. Plants located within the drip line for large trees and shrubs should have similar water requirements as the trees and shrubs.
- Consider using ground covers with lower water requirements for slopes and hard-to-mow locations.
- When designing plant placement on slopes, place lower-water demand plants at the tops of slopes and higher-demand plants at the bottom (Figure 2.zzd).
- In the Front Range Urban Zone, when selecting turf grass, consider the use, visual and design goals of the site, estimated water use and maintenance budget. In areas where irrigation is not planned, a mix of mainly native bunch and sod-forming grasses can be used. Avoid using turf in areas less than 10 feet wide and on slopes steeper than 4:1.
- Use weed barrier fabrics and organic or inorganic (e.g., gravel, rock) materials to reduce weeds while still allowing water and air to penetrate the soil. Do not use black plastic.

6.2.2.1 Plants and Salt

Injury due to de-icing practices is common where landscape plants are growing adjacent to transportation corridors salted for ice. Salt spray and salt runoff into the soil caused by snow plowing are the primary causes of problems. When salt is present in the soils, symptoms may not show up for several years. To decrease the effects of salts on plants, consider the following when designing:

- Injury occurs within 30’ to 50’ of the road.
- Avoid planting where water from the roadway collects or drains.
- The sides of the plants facing the road have most of the damage.

Figure 2.zzd: Plants placed aesthetically on a revegetated slope and to assist with sound buffering.

- Downwind plants have more damage.
- Injury decreases with distance from the road.

6.3 Urban Planting Patterns

In the Front Range Urban Design Zone and other urban areas, the design approach to planting may allow for more formal design responses and more ornamental planting patterns. However, the overall goal is still to create a naturalized, consistent appearance and to focus use on xeric and native plants (Figure 2.zze).

- Include turf areas where they provide defined functions. Choose the appropriate grass for the desired use. Select alternative low water use grasses where possible. These may include tall fescue, buffalo grass, blue grama and wheat grass (Figure 2.zzf).
- In Main Street locations, the use of street trees for shading, visual interest and human scale, is encouraged.
- Planting should be considered in large massings in order to be appropriate to the scale of the roadways and to achieve a consistent appearance.

Figure 2.zze: Xeric plants used in a median in an urban landscape.

6.4 Clear Zones and Sight Distances

Clear zones are calculated based on sight distances and these are CDOT requirements for creating safe roadway intersections.

- Determine site triangles - these areas must be kept free of visual obstructions that may impair a driver's detection of oncoming traffic.
- Calculate the clear zone - minimum set back distances for plants must be determined.
- Avoid blocking views or vistas, interfering with drainage, or encroaching on sight distances.
- Evergreen tree placement should not cause shading/icing on CDOT roadways.
- Trees are allowed within the clear zone if they are behind existing guardrail (but may put up guardrail to place trees closer to road).
- Landscaping shall not inhibit the driver's sight distance (Figure 2.zzg). Tree and other planting must observe the CDOT required safety sight lines, as defined in the CDOT Roadway Design Guide, Chapter 3.

Figure 2.zzf: Turf grass provides a border to this median planting in an urban setting.

6.5 Irrigation and Drainage

- Design the site for efficient irrigation, including both state-of-the-practice irrigation technologies and management practices. Landscape plans should also include specific irrigation plans.
- Incorporate the concept of water-wise irrigation zones to develop planting lists for landscape components. For example, identify zones of high, moderate and low water usage and then identify water requirements and appropriate plants for each zone.
- Design landscapes to harvest water to avoid losing runoff. This results in the greatest possible use of natural precipitation by landscape plants, while minimizing runoff into stormwater drainage systems. In non-irrigated areas favor planting locations near or in swales, seeps and moist areas.
- Grade landscaped areas to maximize infiltration, while minimizing runoff and ponding.
- Include decorative berms, grassy swales, and buffer zones to direct water flow to cultivated areas at locations where sediment movement into surface water or drainage ways has been observed. Be careful not to create steep, hard-to-manage slopes when designing berms.
- To the extent possible, design the site to blend with existing topography, following existing contours to preserve the overall natural major drainage patterns. This should not be confused with localized site grading at the micro-drainage level, which can provide water quality and water conservation benefits.
- Consider installing terraced gardens on slopes to allow heavy rains to soak in, rather than to runoff and cause erosion.
- Ensure more successful plant establishment by using temporary and permanent drip irrigation where possible (and when approved by Maintenance and Operations).
- Avoid manual truck watering of seed beds unless a three month watering period can be maintained. Consult CDOT landscape architect for seed bed establishment schedule.

Figure 2.zzg: Low landscaping with grasses and wildflowers preserves drivers' sight distances.

6.5.1 Irrigation Requirements in the ROW

Irrigation in the ROW should be considered as follows:

- Water taps, meters and backflow devices shall not be on the

CDOT right of way.

- The Local Agency shall provide water for irrigation purposes in the CDOT right of way for planting, at no cost to the state.
- No irrigation overspray on the roadways.
- Power sources for the irrigation clocks, and the clocks themselves, shall be off the CDOT right of way. Mainline shall have a shut-off valve at the CDOT right of way line, on the highway side. Any irrigation line under an on/off ramp shall have a shut-off valve on the upstream side of the ramp. All shut-off valve locations shall be clearly and visibly marked for CDOT.
- Mainlines shall be as far away from edge of pavement as possible and irrigate from the middle of the right of way to the edge of pavement (not from edge of pavement to the middle of right of way).

6.6 Soil for Planting

CDOT Standard Specifications for Road and Bridge Construction, Section 201 Clearing and Grubbing

CDOT Standard Specifications for Road and Bridge Construction, Section 207 Topsoil

CDOT Standard Specifications for Road and Bridge Construction, Section 212

- At a minimum always amend soils with organic fertilizer, humate and or compost in areas below 7500 feet in elevation. In urban landscapes, obtain at least one soil nutrient analysis prior to completing a project design. Amend soil with compost and organic fertilizers as required for the plant material
- Provide appropriate specifications to ensure soils are properly prepared and amended during landscape installation. Loosening of the plant bed and incorporation of amendments is vital to plant establishment (CDOT Standard Specifications Section 212).

6.6.1 Topsoil Preservation and Reuse

Green Industry Best Management Practices (BMPs) for the Conservation and Protection of Water Resources in Colorado

CDOT Standard Specifications for Road and Bridge Construction, Division 207

Topsoil preservation and reuse involves the preservation of a scarce and irreplaceable natural resource. Topsoil is valuable for the establishment and maintenance of protective vegetation and ornamental landscaping. Topsoil is the uppermost, usually darker colored, horizon of a natural soil, possessing the most favorable characteristics for plant growth, including a good supply of organic matter, nutrients, biological activity, and good structure which promotes the infiltration and circulation of water and air and the development of healthy root systems in plants.

- At a minimum, topsoil preservation and reuse involves the removal, stockpiling, and respreading of the surface with four inches of natural soil (Figure 2.zzh).
- Salvaged topsoil should be stockpiled in an area where it is protected from off-site surface drainage, wind and water erosion, and weed invasion. The stockpile should be located and protected so that unavoidable erosion does not pose a threat to off-site property or water quality.
- Man-altered landscapes (i.e., fills, cuts, dumps, etc.) may possess surface soils that are inferior and the soils need to be evaluated for physical and chemical properties that influence plant growth.
- Colorado subsoils, with their accumulations of clay, low permeability, high pH and concentrations of salts, tend to be hostile to plant growth and even if amended with fertilizers and conditioners, cannot be easily transformed into good plant growth media.
- Topsoil preservation and reuse has important implications for the conservation of water supplies, as well as for protecting water quality.
- Importing topsoil requires testing for pH, organic matter and salinity and should be allowed when all other options of amending embankment and topsoil salvage are not possible.
- In mountain zones or public lands (USFS or BLM) importing topsoil is prohibited due to the potential spread of noxious weeds and disease.

Figure 2.zzh: Topsoil is stockpiled on site and watered to minimize dust.

6.6.2 Soil Amendments and Fertilizers

CDOT Standard Specifications for Road and Bridge Construction, Section 212 and 213

- Apply a prescribed soil treatment (e.g. plowing, disking, harrowing, furrowing, mulches of certified weed free hay or straw, tackifiers) to ensure successful re-establishment. Soil surfaces should be roughened before planting to create favorable seed sites, particularly for grass and forb seeds (Figure 2.zzi).

- Compost is a recommended soil amendment. Compost must be tested in accordance to Specification 212 and incorporated into soil.

- Humates and organic fertilizer should be used on all projects involving native seeding

- When amendment incorporation is not possible (2.5H:1V or steeper slopes) surface organic materials can be applied followed by mulching.

Figure 2.zzi: Hydro-mulching is a technique to seed large areas of land.

6.7 Noxious Weeds

The following are resources related to noxious weeds:

Colorado Weed Management Association Noxious Weed List

This website describes what noxious weeds are their impacts, management applications and provides a list of noxious weeds in Colorado.

U.S Department of Agriculture Plants Database

Colorado Department of Agriculture Noxious Weed Site

CDOT Project Development Manual, Section 3.11 Noxious Weeds

On projects involving SB 40 certification, consideration shall be given to eradication of state-designated noxious weeds in riparian environments. In some circumstances, it may be possible to use such efforts as a mitigation option in areas where replacement of habitat is limited. In order to avoid the spread of invasive aquatic species including, but not limited to, Eurasian watermilfoil, zebra mussel, quagga mussel, and New Zealand mudsnail, the following BMPs shall be practiced. This guidance is also intended to fulfill requirements set forth under General Condition 11, Invasive Aquatic Species for Nationwide Permits under Section 404 of the Clean Water Act.

- The NEPA analysis should reference potential noxious weed preventative control measures that will be incorporated into the scope, design and

construction process. The method of control can have an adverse effect on the sensitive environments containing the noxious weeds. The analysis should address potential impacts of the chemical, biological and/or mechanical control methods on the surrounding ecosystem.

- The use of native grasses and forbs will be used on all CDOT rights of way for revegetative purposes. Transplanting and purchasing of native plant material (trees and shrubs) from nurseries is encouraged whenever feasible.
- The environmental documents must address that materials used for the project must be inspected and regulated by the Weed Free Forage Act, Title 35, Article 27.5,CRS.
- When salvaging topsoil from on-site construction locations, the potential for the spreading of noxious weeds shall be considered. Importing topsoil onto the project site shall not be allowed.
- Equipment should remain on designated roadways and stay out of weed-infested areas until they are treated. All equipment shall be cleaned of all soil and vegetative plant parts prior to arriving on the project site.

6.8 Roadside Vegetation Maintenance

Roadside vegetation maintenance is thoroughly addressed in the CDOT Highway Maintenance Level of Service Manual (Figure 5.8.a and Figure 5.8.b):

CDOT Highway Maintenance Level of Service Manual

III | MANMADE SYSTEMS

1 | INTRODUCTION

In this chapter, Manmade Systems, the principles of aesthetics and environmental sustainability pertain, particularly in road alignment decisions and in the selection of materials for use on the roadway, structures and roadsides (Figure 3.a).

CDOT Roadway Design Guide

The Roadway Design Guide was developed by CDOT engineers and is based on the 2004 edition of the American Association of State Highway and Transportation Officials' A Policy on Geometric Design of Highways and Streets (PGDHS), commonly known as the AASHTO Green Book, and on established Colorado Department of Transportation (CDOT) policies and practices.

CDOT Right of Way Manual

The purpose of the manual is to provide guidance in all phases of acquiring, managing and disposing of real property. It is based on federal and state statutes, rules, policies, and procedures related to the real estate, condemnation, and relocation.

Greenroads Manual

Greenroads is a voluntary third party rating system for road projects. The Greenroads Manual, authored by the University of Washington and CH2MHill, contains project requirements and voluntary credits to create roadways that go above and beyond current standards for environmental compliance, roadway design and construction practice. Greenroads projects demonstrate a level of excellence in sustainability beyond the average roadway project and communicate substantial achievement to project stakeholders.

NEPA Manual

The Visual Resources/Aesthetics section outlines requirements to develop aesthetic guidelines and a master design guide for each corridor study.

CDOT 2019 Visual Impact Assessment Guidelines

The CDOT VIA Guidelines provide detailed guidance on evaluating and documenting visual resources.

Figure 3.a: This aesthetically pleasing highway solution is a result of careful road alignment and selection of appropriate materials.

1.1 Elements

The elements of manmade systems and considered in aesthetic issues as a whole, might include the following:

- Roadway lanes and alignment
- Freeway and local roads alignment
    - Intersection alignment
    - Interchange
    - Right-of way
- Bridges
- Roundabouts
- Embankment slope
- Abutments
- Superstructure
- Girder type
- Piers
- Parapet wall and railings
- Wingwalls
- Retaining walls
- Noise barrier – sound attenuation walls
- Guard rails and barriers (including bridge, median, guard, bicycle, fencing, and splashguards)
- Medians
- Pedestrian/Bicycle facilities
- Lighting and illumination
- Signage

Figure 3.b: This highway near Boulder is an example of simplicity and elegant consistency.

1.2 Approach to Aesthetics

Aesthetic guidance is important to transportation design, since projects that will be implemented across the entire region have the potential to create elegant consistency (Figure 3.b). It is anticipated that CDOT professionals will collaborate on the design of new and upgraded roadways. While engineering personnel will lead decisions on roadway speeds and safety, CDOT Landscape Architects serve an important role in providing aesthetic guidance to particular aspects of the roadway and roadside design. It is critical that the entire design team works together from the initiation of the project through conclusion, so all aspects of roadway design, including sustainability, public involvement and aesthetics are integrated. Over-arching principles for aesthetic design of roadway systems include:

- Consider the whole environment.
- Create consistency throughout the state and within roadway corridors.
- Elegant aesthetics is a result of well thought out and integrated engineering and consistent application of design principles to create a single project.
- Create the roadway secondary to its environment.
- Create the roadway character in response to the overall landscape, or design zone, of a place. Avoid random changes in road segments or changing responses based on specific local conditions or piecemeal project construction.
- Consider important viewsheds that include (a) the view from the road user's perspective and (b) the view of the road from the resident or adjacent community's perspective.

Landscape architects play an important role in preparing visual assessments to evaluate views, impacts of new development and visual impact mitigation measures. The visual impact assessment methodology is summarized in the Community chapter and in Appendix 10 under 2019 CDOT Visual Impact Assessment Guidelines, and described in detail on the CDOT Environmental Visual Resources website. There is a variety of simulation software available for use (e.g. video, rendering, and visual modeling simulation (vms) software).

The following sections describe the application of aesthetic guidance to particular aspects of roadway design.

Visually pleasing transportation infrastructure is carefully located and set harmoniously in the environment (Figure 3.c). The following documents provide guidance on how to achieve harmonious settings:

CDOT Roadway Design Guide

CDOT Right of Way Manual

AASHTO Policy on Geometric Design of Highways and Streets

FHWA Flexibility in Highway Design

This Guide explains how to design highways, incorporating community values that are safe, efficient, effective mechanisms for the movement of people and goods. It is written for highway engineers and project managers who want to learn more about the flexibility available to them when designing roads and illustrates successful approaches used in other highway projects. It can also be used by citizens who want to gain a better understanding of the highway design process.

Community Culture and the Environment: A Guide to Understanding a Sense of Place (EPA, 2002

O, Say, Can You See: A Visual Awareness Tool Kit for Communities

Visual Impact Assessment for Highway Projects (FHWA, 1989)

Visual Values for the Highway User—An Engineer's Workbook (Hornbeck & Gerland, 1976)

Bridge Aesthetics Around the World

Attention to existing landform and topography, water features and vegetation will provide guidance for siting the transportation facility or improvements. The desired result is a transportation facility that minimizes alteration to land, avoids creating slopes that appear artificially constructed and blends in with the surrounding environment (3.d). Techniques for both retro-fitted and new construction include contoured grading, elevating structures, retaining embankments, adapting design to topographic conditions, and respecting the historic limits of disturbance (Figure 3.e).

2.1 Roadway Lanes and Alignment

CDOT Roadway Design Guide; Chapter 3

CDOT Roadway Design Guide; Chapter 5-9 includes Local Collectors, Rural & Urban, Freeway, and Intersections

Figure 3.c: This transportation infrastructure is carefully located and set harmoniously in the environment.

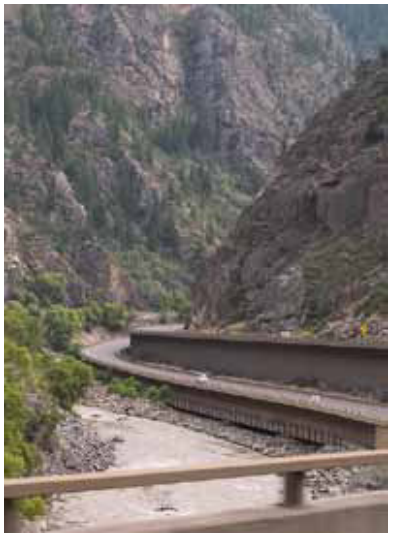


Figure 3.d: This interstate highway was located with careful consideration of the landform and topography of Glenwood Canyon.

Figure 3.e: The elevated structure of Highway 82 minimizes impacts to the steep rocky topographic conditions.

The CDOT Roadway Design Guide identifies major considerations for horizontal alignment. Determination of the alignment is based on a holistic process that addresses many elements (Figure 3.f). The considerations are grouped below to identify those which fall within the purview of the landscape architect.

- Topography
- Existing highway and cultural development
- Likely future developments
- Environmental
- Geological features
- Drainage
- Construction costs

CDOT engineers consider all of the elements above, as well as the considerations below:

- Type of facility
- Design speed
- Profile grade
- Subsurface conditions
- Location of the highway terminals
- Right of way
- Safety

The Roadway Design Guide states that all of the above considerations should be balanced to produce an alignment that is appropriate for the location and functional classification of the highway. To a large extent, topography controls both curve radius and design speed. From a visual perspective, using minimal road widths will allow the highway to fit into the landscape with fewer modifications to the natural environment and will reduce the visual impact of the manmade structures. Balancing aesthetic considerations with engineering criteria for safety, results in a recommendation for reducing the design speed for roadways on constrained topographic or urban conditions.

Other important engineering considerations include coordination between

Figure 3.f: The horizontal alignment of the interstate highway near Eagle is based on a variety of landscape considerations.

horizontal and vertical alignments and the provision of adequate sight distances. For example, horizontal curvature and profile grade should be made as flat as possible at highway intersections.

On divided highways, variation in the width of medians and the use of separate profiles and horizontal alignment should be considered to derive the design and operational advantages of one-way roadways. The use of medians or separate profiles also provides opportunities to reduce the impact of the highway in the landscape (Figure 3.g).

The Roadway Design Guide recommends that geological features that may affect design, such as potential slide areas and subsurface water, should be investigated by the Materials and Geotechnical Branch. These features, and others such as rock faces, should be considered from an aesthetic viewpoint. They may be scenic features, such as rivers, to be preserved (Figure 3.h). The designer should consider the visual or scarring impact of disturbance on the feature.

In locations where the roadway also functions as a main street or an important access into a community, it is necessary to engage the community in the decision making for the roadway. Integrate non-motorized (pedestrian and bicycle) safety and use of the roadway and its environs.

Figure 3.g: This divided highway utilizes narrower lane widths and vegetated medians to respond to the landscape context.

Figure 3.h: This elevated highway is a sensitive response to preserving the river and riparian environment.

2.1.1 Freeway Alignment

- Rural freeways should have smooth flowing horizontal and vertical alignments. Proper combinations of flat curvature, shorter tangents, gentle grades, variable median widths, and separate roadway elevation enhance the safety and aesthetic aspect of freeways. Changing median widths on tangent alignments should be avoided where practical to avoid a distorted appearance.

- Rural freeways can usually be constructed near ground level with smooth and relatively flat profiles. The profile of a rural freeway is controlled more by drainage and earthwork considerations and less by the need for frequent grade separations and interchanges.

Southern Rocky Mountains Zone

a. For a mountainous interstate application, use medians of between 80 feet to 100 feet to adapt to topographical conditions and provide a buffer between lanes.

b. For a mountainous interstate application, provide a vertical elevation separation between lanes of at least six feet to adapt the

roadway to the existing mountainous and topographic conditions. The vertical separation will also eliminate the need for high barriers and devices that shield on-coming headlights.

c. Separate eastbound or westbound lanes by a preferred distance of 80 to 1,500 feet - a minimum median width that allows a clear zone without guardrail or barriers.

d. Look to Vail Pass as a design precedent for substantial and variable median widths, successful landscape revegetation, and the integration of recreation and habitat within the median and right of way.

e. In mountainous areas or areas subject to icing, consideration should be given to locating the road so a southern exposure will be obtained wherever possible.

2.1.2 Intersection Alignment

- Horizontal and vertical alignment and cross-sectional features affect driver and/or vehicle behavior at and on the approach to the intersection, and therefore are important design considerations. The horizontal and vertical alignment of the intersecting roads should permit users to readily discern and perform the maneuvers necessary to pass through the intersections safely and with a minimum of interference by other users.

- As a rule, alignment and grade are subject to greater restriction at or near intersecting roads than on the open road. Their combination at or near the intersection must produce traffic lanes that are clearly visible to the operators at all times and plainly understandable for any desired direction of travel, free from unexpected hazards, and consistent with the portions of the highway just traveled.

- Both individual vehicle operations and the nature of vehicle conflicts are affected by the angle of intersection. Roads intersecting at acute angles require extensive turning roadway areas and tend to restrict visibility, particularly for drivers of trucks.

- Geometric counter measures, although expensive, are generally the best solution in designing skewed-angle intersections.

- Special care should be taken in designing intersections near

horizontal curves. The driving task of tracking the curve takes up much of the driver's focus, leaving less attention for conflict resolution.

2.1.3 Local Roads and Streets Alignment

- Alignment in residential areas should fit closely with the existing topography to minimize the need for cuts or fills. The alignment should not reduce safety but may serve a special purpose if desired by the local planning officials. Street alignment in commercial and industrial areas should be commensurate with the topography but should be as direct as possible. The avoidance or minimizing of involvement with adjacent property associated with hazardous waste or petroleum product contamination may influence the choice of alignment, cross section, and right of way width.

- Street curves should be designed with a minimum radius of 100 feet. Where curves are super elevated, lower values may apply, but the radius should never be less than 75 feet for a 20 mph design speed.

2.2 Interchanges

CDOT Roadway Design Guide; Chapter 10 Grade Separations and Interchanges

An interchange is a system of interconnecting roadways in conjunction with one or more grade separations that provide for the movement of traffic between two or more roadways or highways on different levels.

The type of grade separation and interchange, along with its design, is influenced by many factors such as highway classification, character and composition of traffic, design speed, and degree of access control. These controls plus signing requirements, economics, terrain, environment, and right of way are of great importance in designing facilities with adequate capacity to safely accommodate traffic demands. Interchange types are characterized by the basic shapes of ramps, namely, diamond, loop, directional, "urban" and cloverleaf interchanges. These interchange examples can further be classified as either local street interchanges or freeway-to-freeway interchanges. The following are guidelines for aesthetic interchange design:

- Efficiently use land, reduce visual prominence, and integrate with the landscape context and existing land uses (Figure 1.2.a).

- In sites that are constrained, for example as a result of topographical or

urban conditions, compact designs should be used. Utilize a compact interchange design to avoid consuming more land than necessary. Utilize vertical walls to facilitate this style of design.

- In locations adjacent to existing communities, provide contextual solutions. Consider the urban design implications associated with interchanges including connections to the local road network, pedestrian circulation, and adjacent land uses.
- Ensure smooth and seamless access into the community.
- Provide substantial landscaping in open areas to create a transition from the transportation corridor to the community environment.

2.3 Roundabouts

National Highway Research Program Roundabouts: An Informational Guide

The guide provides planning, operational analysis, safety, geometric design, application of traffic control devices, illumination, landscaping, construction and maintenance considerations.

In recent years, roundabouts have become tools for moving traffic across intersections while maintaining traffic flow. Roundabouts are frequently located at the entrances to communities. The large center island of the roundabout provides an opportunity to landscape and can provide a sense of community identity. The edge of the island may be a concrete curb or a deeper concrete edging. A stamped pink concrete is used in many Colorado locations. It is important to consolidate signs at the roundabout and use a consistent highway theme when selecting colors and plant species (Figure 3.i).

Figure 3.i: A roundabout at an entry to Eagle/Vail provides opportunities to enhance a sense of community identity using planting design.

2.4 Right of Way

CDOT Right of Way Manual

The purpose of the CDOT Right of Way Manual is to provide guidance in all phases of acquiring, managing and disposing of real property. It is based on federal and state statutes, rules, policies, and procedures related to real estate, condemnation, and relocation.

In 1982, the preparation of ROW Plans, deeds and condemnation exhibits was decentralized to the CDOT regional offices. At that time, staff ROW retained the responsibility of securing approvals, reviewing projects, preparing commission resolutions, the application for state and Federal land rights, and the federal oversight of the ROW process. ROW plans are prepared by both internal CDOT personnel and external consultants with contract management and

review being handled by the Regional offices. ROW Plan authorization has been delegated by FHWA via the Stewardship Agreement to the Central Office Project Development Branch, ROW Services. The region ROW unit takes responsibility for a thorough review of consultant ROW plans for format and compliance with the CDOT ROW manual. For more information on process, timeline and content requirements for right of way Plans, refer to the CDOT ROW Manual (2010).

The designer needs to consider enough right of way to accommodate the preferred transportation design. The designer should work with ROW services to determine the amount and appropriate ROW to acquire early in the design process. The landscape architect should be involved from scoping until the final field inspection review. The early stages of a project are critical, as all the elements and required widths need to be determined so that the width of the ROW can be calculated. These elements include landscape character, soil types, grading requirements and wetlands mitigation.

ROW Permits should be coordinated with access and special use permits. The process described above will apply. The owners' plans need to be approved by CDOT Landscape Architects as part of the access and special use permits process.

CDOT Standard Specifications for Road and Bridge Construction

Urban Design for Region 6, 2003 (as of 2013, Region 1 and Region 6 merged to become a new Region 1)

CDOT Highway Design Manual

CDOT Bridge Design Manual, Section 2

AASHTO Bridge Aesthetics Sourcebook 2010.

CDOT Bridge Design Manual, Section 1.1.4 CDOT Staff Bridge Worksheets

AASHTO Guide for Development of New Bicycle Facilities

FHWA-RD-75-114 Safety and Locational Criteria for Bicycle Facilities (Smith, 1976)

Americans with Disabilities Act Accessibility Guidelines, Architectural and Transportation Barriers Board, 1991

Federal Register, Proposed Rules, December 21, 1992.

This chapter provides guidance for bridges, retaining walls, sound walls, guard rails and barriers. Consistent design treatment of these facilities will promote visual continuity throughout Colorado. Consistency of structures may be achieved through the thoughtful use of line, mass, form, materials, color, light, shadow, texture and patterns (Figure 3.j). The relationship of facilities to the natural grade and the way in which planting is used on roadsides and medians will also provide visual continuity. These landscape elements are addressed in Chapter II: Natural Systems.

Within design zones, there are opportunities for differentiation based on the manmade and natural settings. One of the goals of providing visual continuity is to link existing and new transportation facility structures. It is important to look at existing design practices and built structures and extrapolate from desirable projects. Interstate 70 at Glenwood Canyon is considered to be a successful example of a highway built in a mountain environment.

The design should provide similar proportions, material and finish for all structural components. In areas of retrofit construction, refer to the existing character of structures and facilities across the design zone to achieve a consistent design aesthetic, rather than a series of disconnected and random structures. New construction should be of the same design family as successful existing facilities, enabling individual projects to become part of the larger context of facilities.

Figure 3.j: This elegant single span bridge fits harmoniously in the canyon environment.

3.1 Bridges

CDOT Bridge Design Manual

The Bridge Manual provides the policy and procedures currently in effect for the design of bridges and other highway structures on the state highway system and on federally funded off-system projects. The current AASHTO Standard Specifications for Highway Bridges is the basic document guiding the design of highway structures. The CDOT Bridge Design Manual supplements the AASHTO specifications by providing additional direction. This manual also provides standards for pedestrian and bicycle bridges and for retaining walls.

AASHTO Standard Specifications for Highway Bridges, 2002

CDOT Roadway Design Guide; Chapter 15 Bridge

CDOT Project Development Manual, Section 3.08 Historic Properties Clearances

CALTRANS Bridge Design Practices, Section 7 Bridge Design Aesthetics

Colorado Bridge Enterprise (CBE), CBE Funding for Structure Aesthetics March 26, 2012

The Transportation Research Boards' Bridge Aesthetics Around the World (TRB, 1991) includes papers on aesthetic evaluation of bridges developing guidelines for aesthetic design

Bridge aesthetics depend upon the thoughtful combination of the structural components. The aesthetic design choice needs to consider maintenance practices and balance additional costs with the improved appearance of the bridge (Figure 3.k). Integrating aesthetic guidelines at the beginning of the bridge design process will allow for the most economical solution. The objective is to integrate all facets of the design - environmental, structural, functional and visual – into an elegantly engineered solution in which all the conditions of design are simultaneously resolved and the structure looks like it belongs in its environment.

Figure 3.k: This bridge illustrates thoughtful consideration of the design components.

Figure 3.l: This is an example of compatible proportions and consistent treatment of structural components and finishes.

3.1.1 Overall Design Aesthetic

- Bridges should be of compatible proportions, using materials and finishes that share like design of structural components (Figure 3.l).
- Simple and elegant bridge design is more appropriate than complex shapes and geometries. The elegant design provides an aesthetic contrast to the complexity of the surrounding landscape.
- The bridge's horizontal profile and span should be highlighted.

The appropriateness of the structural system is the most important factor in bridge aesthetics.

- Bridge components given aesthetic considerations: span, embankment, abutment, superstructure, girder, pier, parapet wall and railing, and bridge rail and wall transitions.

3.1.2 Span Layout

Multiple factors are involved in determining the span layout, including the span to depth relationship, river and wetlands crossings and the road layout. All these factors must be balanced; and environmental, economic and aesthetic factors should be integrated in the span layout design.

- Consider how the span frames the view (Figure 3.m).
- A single span represents the ultimate bridge provided it is thin enough.
- Two spans cause a split compositions effect in a natural setting but appear to belong to a freeway environment.
- A multiple number of odd spans are more visually appealing than a multiple number of even spans.

3.1.3 Embankment Slope

The treatment selected for slope utilization can be one of the most important because of the visible mass of typical bridge slopes.

- Slope paving is not recommended for embankment slopes unless the slope is too steep to revegetate or it is a shady area under the bridge.
- Use vertical abutment design where feasible to limit slope paving and provide space for revegetation (Figure 3.o).
- Create minimum embankment slope laybacks of 3:1 (H:V) to provide for successful revegetation. This minimum slope will provide stability, cause less erosion, and provide space for planting. The soil types and stability as well as safe equipment access should be considered in establishing the minimum slope.
- Stabilize the landscape slope with revegetation or rock mulch, or a combination.
- Use weed barrier beneath the surface of slope pavement and

Figure 3.m: An example of a single span bridge framing the view to the mountains.

Figure 3.n: Two spans cause a split composition but appear appropriate due to the highway configuration and the median.

Figure 3.o: Use vertical abutment design to limit slope paving and provide space for planting.

other surfaces as well.

- The elevation of the slope pavement and top of type 4 barrier should match.
- Revegetate embankment slopes with low water use native plant grasses, wildflowers and shrubs, considering ease of long term maintenance and minimal supplementary irrigation.
- Plant trees on the bridge embankment slope to anchor the ends of the bridge and connect the span to the embankment (where irrigation, maintenance and surrounding environment permit).

Front Range Urban Zone

The landscape architect should be consulted to finalize the design choices described below.

- Slope paving should wrap the slope to minimize erosion and make mowing easier and safer.
- When using concrete slope paving, consider what may be the best finish. A simple finish may include brushed concrete and two by two foot square patterns created with expansion joint liners.
- Other concrete finishes, particularly for special conditions, may include exposed aggregate, color or a stamped pattern. The brushed finish is recommended for general applications.
- The recommended size for rock mulch is three to six inches.

3.1.4 Abutments

- An abutment should provide a visual anchor to the bridge (Figure 3.p).
- Abutment treatment should be the same on all sides of the bridge.
- The abutment should be expressed as a vertical element.
- Utilize closed end abutment designs which have a minimum vertical height of six feet (eight feet in mountainous environments).
- In retrofit projects, precast panels may be applied as a façade

Figure 3.p: The abutment provides a visual anchor to the bridge.

to existing bridges or wing walls to provide visual consistency.

- Wing walls that are set back from the deck enhance shadows and make the structure appear lighter.
- Apparent bridge length (slenderness) is increased by using the shortest wing wall length (Ritner, 1985)
- Provide minimal apparent size in abutments (Figure 3.q). Rather than using a static vertical face, create a sloping face that continues the lines of the deck downward into the ground.
- Consider how signage interacts with abutments, for example the relationship of the sign with the joints.

3.1.5 Superstructure

- A strong shadow line should underscore the bridge's horizontal profile, creating a lighter, more elegant appearance (Figure 3.r).
- Incorporate thoughtful and deliberate shadow patterns on super structures and abutments.
- Neither the deck nor the girder line should dominate the composition.
- The overhang of the bridge deck should be equal to 2/3 the height of the girder to produce the desired shadow on the super structure. The overhang needs to be weighed against girder spacing (Figure 2.1.f).
- Painting a shadow line may help achieve the desired effect in retrofit projects.
- Consider the underside of the superstructure (e.g. the joint of a box beam with the abutment).

3.1.6 Girder Type

- When girders may be visible, girder types that lend themselves to the curvature of a roadway are preferred. Consistent use of girder types is recommended.
- Steel Box Girder spans generally range from 150 to 250 feet. The box section is visually pleasing because of the well-defined super structure lines and an absence of exterior stiffeners and bracing. It allows longer spans with a relatively

Figure 3.q: The heights of the abutments are reduced and combined with a sloping face.

Figure 3.r: A strong shadow line creates a lighter, more elegant appearance.

shallow depth. Curved and flared alignments are more challenging.

- A Steel “T” Girder is a common and economical bridge type that offers numerous advantages in design as well as fabrication and construction. The piers are normally wide at the top. A framed-in cap is recommended for a more slender pier. The unpainted steel achieves a deep brown color through the weathering process.

- A Pre-Stressed Concrete “G” Girder is an economical structure for span lengths up to 135 feet; however, since it usually requires a massive cap and beams, it is not aesthetically pleasing.

- A Precast Concrete Box Girder is commonly used for shorter spans but may not be aesthetically pleasing due to its straight lines; the need for large pier caps or multiple columns or piers is recommended. It may be made more attractive by adding transitional elements between the main elements.

- A Cast-In Place Concrete Box Girder is commonly used for interchanges and grade separation structures. It has well defined lines, is attractive and economical for spans from 80 to 150 feet, and with post tensioning, it can span much further. It requires extensive framework and forming.

- Arched Structures are atypical of CDOT standards, but can look attractive in urban settings (e.g. Speer Boulevard).

3.1.7 Pier Design

Pier design or column proportions affect the aesthetics of bridges. Disproportionately sized piers or piers with projecting cap ends can appear out of balance with the rest of the structure.

- Octagonal columns appear the slimmest as they have the greatest number of surfaces.

- All piers within a single interchange or segment of highway should be of the same style.

- Use an integral pier cap to preserve the horizontal quality of the bridge and/or incorporate the pier cap with overall design considerations.

- Construct piers of proportionate size to the overall structure.

Figure 3.s: The visual prominence of the pier is reduced by using simplified surface treatment.

A general guideline for pier width is for it to be approximately one-third of the superstructure's girder and parapet height. In circumstances of an open rail, pier width should be approximately three-fifths the superstructure height. Piers less than 30 inches wide are not generally recommended. Reduce the visual prominence of piers by using simplified and consistent surface treatments (Figure 3.s).

- Avoid locating piers in a stream or river for environmental reasons and avoid locations where scour could occur.

- Using a clear span without a center pier is recommended for special view locations.

3.1.8 Parapet Wall and Railing

- Solid concrete parapet walls cause the overall superstructure to appear thick and heavy in proportion to span and abutment height.

- To avoid heavy proportions, use attached metal rails or a 24" high concrete wall with attached metal rail rather than solid concrete barrier for bridge rails (Figure 2.1.h).

Specific options include utilizing a 42" high double steel tube railing attached to the bridge parapet or a 32" high single steel tube railing attached to the bridge parapet. Rails should meet the TL-4 testing requirements. Epoxy-coated reinforcing steel is used in the concrete. See FHWA NCHRP Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Features (Ross and others, 1993).

3.1.9 Bridge, Rail and Wall Transitions

- Use a consistent material for approach rail and bridge rails. Ensure the point of attachment between the two does not sacrifice the appearance of continuity.

- Create a distinct rail termination by extending the parapet beyond the bridge and abutment by a minimum of six feet (Figure 3.t).

- Where retaining walls are attached to bridges as wing walls, use the same material for the walls as for the bridge. Do not use multiple materials or finishes.

3.1.10 Coordination of Signage with Bridge Aesthetics

- Signage should complement the overall bridge design and not detract from the aesthetic expression.

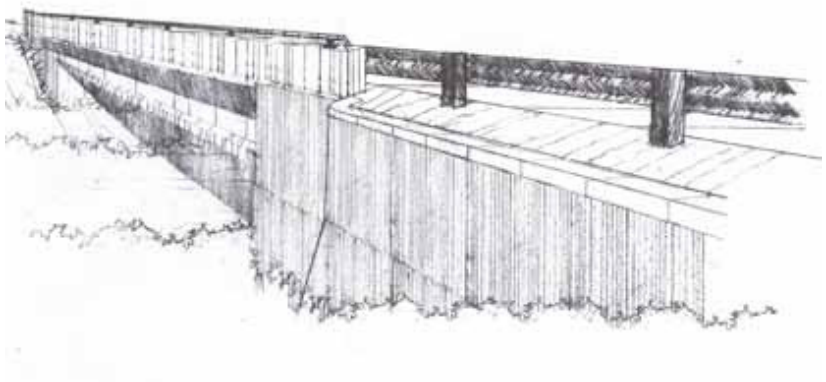


Figure 3.t: The parapet extends beyond the bridge to create a distinct rail termination.

- Sign and support structures should be integrated into the design to reflect the uniqueness of the corridor.
- Where possible, place signs and support structures so they do not block or visually interfere with bridge aesthetics. Paint support structures where possible to coordinate with bridge aesthetics.
- Align sign elements in an organized manner so that sizes and proportions appear balanced. Consistent or proportional sign panel sizes should be coordinated to strengthen visual ties between adjacent signs and their relationship to the mounting structures.
- Panel size should not dominate the bridge.
- Consolidate signage to create a unified appearance.
- To preserve bridge aesthetics, signage should not be attached to the bridge. However, if signage is necessary, in lieu of adding sign supports, signage requirements should be considered with the design of the bridge.

3.1.11 Pedestrian Bridges

CDOT Project Development Manual, Section 5.04 Pedestrian Overpasses and Underpasses

- Pedestrian bridges are located over highways to serve as overpasses that either connect trail systems or connect commercial or residential areas of use. Bridge Design Manual, Section 2.3 Pedestrian and Bicycle Facilities)
- Pedestrian bridges are smaller scaled and may be more decorative in character than highway bridges (Figure 3.u).

Figure 3.u: Pedestrian bridges may be smaller scaled and more decorative than highway bridges.

3.1.12 Color and Texture

- Utilize a concrete wall face with a simple vertical or horizontal texture pattern on bridge abutments or piers. Avoid using multiple colors or textures on piers.
- Treat the color of bridges and other structures in a manner consistent with the design zone's color palette. Elaborate and jarring color schemes are inappropriate. (See Section 4.1.1 Criteria for Color Selection.)
- Select one primary color and one accent color (15% or less) from the color palette.

- There are differences in appearances of bridges based on the amount of funding and input from local communities. People often like to create a community identity for highway structures that are within their communities. CDOT Landscape Architects should work closely with the communities to ensure that the overriding CDOT design standards are referenced and included.

- The goal is to create a balance between community identity and corridor consistency through color and texture (Figure 3.v).

3.2 Retaining Walls

Urban Design for Region 6 (CDOT, 2003)

CDOT Bridge Design Manual

CDOT Project Development Manual, Section 5.08 Retaining Walls

Retaining walls may be constructed of poured in place concrete, precast concrete or mechanically stabilized earth (MSE) systems. Treatment for MSE walls is different than treatment for poured in place concrete or concrete panel walls. Shotcrete walls are also used in areas where slopes are required to be cut. Shotcrete wall technology minimizes the impact on vegetation above the cut. Typically, the final finished wall is constructed in front of the shotcrete wall.

When walls are placed within communities, it is important to ensure that the neighborhood is satisfied with, and proud of, the result. Therefore, involving the neighborhood in the wall selection process through community meetings and opportunities for input is key.

3.2.1 Design Aesthetic

- Construct of a single material with a visually simple texture that renders a shadow pattern on the surfaces (Figure 3.w).

- Avoid multiple materials, decorative pictorial patterns, shapes, and styles of retaining walls. These create visual confusion.

- Where possible, provide space for landscape screening treatments in front of retaining walls that are visible from the roadway or adjacent communities (Figure 3.x).

- Incorporate wall materials that have a consistent texture, color and pattern. (See Color Selection, Section 4.4.1)

- Employ simple vertical textures and patterns on walls to create shadows and interest.

Figure 3.v: There is a balance between community identity and corridor consistency through the use of consistent color and texture.

3.w: The fluted formwork of this concrete wall creates a visually simple texture that renders a shadow pattern on the surfaces.

Figure 3.x: Space is provided between the walls for landscape screening treatments.

- Use grading strategies to minimize the height of retaining walls along the corridor.
- Utilize landscape platforms and turn the ends of walls to meet with the grades of hills and slopes to ensure that retaining walls are integrated with adjoining slopes (Figure 3.y).
- Design walls with a single material, style and method rather than a mix of materials-even if the wall height varies.
- Design walls to include an appropriate cap with an overhang to create shadows and interest.
- Consider integrating steps in the wall when the slope of the landscape allows. Steps should be simple, infrequent and suitable for the landscape scale.
- In the Western Slope, Basin and Southern Rocky Mountains Zones install roadway retaining walls greater than 12 feet in height below the elevation of the roadway.
- In the Front Range Urban Zone, walls may have an artistic panel design. The panel design should be simple and created in a way that allows variety in the wall pattern through panel placement in different orientations (Figure 3.z).

Figure 3.y: The retaining walls are curved to become well integrated with the adjoining slope.

Figure 3.z: This twig pattern in concrete is simple and allows variety through placement in different orientations.

3.2.2 Design Details

- Design details should be simple and continuous throughout all components of the roadway system.
- Simple vertical textured patterns are recommended on concrete walls. They can be achieved through the use of form liners when pouring the concrete.
- Providing simple caps on walls is recommended for creating a strong shadow effect and for defining the top of the wall. The cap should be of a consistent height and width.
- There are several methods to expose aggregate including acid etching, chemical retardant and sand blasting that may be applied in urban areas. Treatments should be applied consistently throughout all components of the roadway system. The treatments may also be used to create simple patterns in the vertical surfaces of the concrete
- While vertical form liners are recommended to create simple

patterns on the walls, other form liners may be used to create patterns of texture, light, and shadow in urban environments. The patterns should have a consistent impression.

3.3 Sound Attenuation and Walls

The CDOT District's noise specialist in the Environmental Program Branch should be consulted to identify whether a noise analysis is required to determine the need for noise barriers. (See **Chapter 4: Technical**, for the process and submittals for noise barrier design in the Front Range Urban Design zone.) The following are useful links:

CDOT Roadway Design Guide; Chapter 18 Noise (2013b)

This chapter is intended to help designers identify issues related to highway traffic noise, understand the applicable federal and state regulations and guidelines, analyze traffic noise for specific projects, and select and implement noise mitigation measures.

The Code of Federal Regulations (23 CFR 772)

The regulations that govern highway traffic noise for Federal-aid projects are contained in Part 772 of Title 23 of the Code of Federal Regulations (23 CFR 772) (1). Regulation 23 CFR 772 mandates the noise impact and abatement procedures that must be followed in the evaluation and mitigation of highway traffic noise in Federal-aid highway projects.

CDOT Noise Analysis and Abatement Guidelines (CDOT, 2013)

This chapter describes the federally approved analytical methods, procedures and abatement measures that must be followed for the evaluation of impacts and mitigation of highway traffic noise in Colorado and on federal-nexus highway projects.

CDOT Project Development Manual, Section 5.09 Noise Walls

When warranted, noise mitigation is to be considered as an integral component of the total project development process and incorporated as such (Figure 3.za). This applies to new highways, alterations of existing highways, and retrofit projects. There are several methods of mitigating noise impacts, including:

- Traffic management measures
- Roadway design alternatives
- Acquisition of Right of Way

Figure 3.za: Noise mitigation is an integral component of project development and both sides of a sound wall should be considered.

- Noise insulation or other extraordinary abatement measures
- Noise barriers

Construction of noise barriers is the most common noise mitigation method when noise levels exceed 65 decibels (dB). Essentially, a noise barrier is a solid structure that is constructed for the purpose of reducing noise levels. Normally, noise barriers are effective for receivers within 300 feet of the noise source if they are high enough to block the view of the roadway and are long enough to prevent sound from bending around the ends. A noise reduction of 5dB is fairly simple to achieve, but a 7dB reduction is required. Reductions of 15 or more decibels are difficult to almost impossible to achieve.

Walls are a common means for reducing noise levels. Noise barrier walls are mostly constructed out of concrete, masonry block, or brick. However, absorptive and light weight specialty wall materials have met approved CDOT and industry standards for acoustic density and in some cases absorptive coefficient. These wall materials are included in the CDOT Materials Pre-Approved Environmental Product List (link). Walls are preferred in many areas because they can be constructed within a limited amount of space. Berms are another method of reducing noise. Berms can be planted so that they are more natural in appearance, but berms require more space than walls to be effective. Berms should be considered in areas where sufficient right of way is available to install them and preserve the visual and environmental qualities of the corridor.

The CDOT Roadway Design Guide, Chapter 18, Section 18.5, provides information on criteria for safety and engineering design, visual analysis and aesthetic guidance for sound walls (CDOT, 2013b).

3.3.1 Aesthetic Design for Sound Walls

- Per CDOT guidance (CDOT, 2013d), the noise barrier should not exceed a height of 20 feet above the traveled way, nor should it be shorter than 8 feet. To prevent noise from flanking around the barrier ends, the barrier should extend past the end receiver at least four times the perpendicular distance from the receiver to the barrier. If this is not possible, the barrier can be bent back towards the receiver (wrapping the barrier). Also, combining the barrier with natural terrain features and existing structures may help in this case. The EPB or qualified Region noise specialist will recommend final barrier dimensions and placement.

Visual design principles are presented, however these principles are applied in

only a limited, general way to the design of the wall itself. The focus is on using planting to screen the wall, but in many instances when a wall is needed, there is limited space available for planting. Where possible, walls should incorporate landscape features and earth forms to soften the visual impact. Native vegetation will require temporary irrigation during the establishment period.

The main aesthetic issues pertaining to sound wall design are grouped into the following three categories: the wall's relationship to the barrier rail, the design of the aesthetic treatment, and height transitions. Wall treatments offer opportunities for design expression and corridor beautification from both the motorist's view and neighboring developments.

3.3.1.1 Sound Attenuation Landscape Aesthetic Considerations

- Alternatives to sound walls should be considered in the search for sound mitigation solutions.
- No free standing sound attenuation should be used. Where it is required, sound attenuation should incorporate landscape features and earth forms to the extent feasible.
- Initially address sound attenuation by considering vertical and horizontal alignment. The intent is to eliminate the need for sound attenuation through the appropriate design of the transportation facility.
- Utilize landform and berming strategies or integrated landform and wall systems for noise protection rather than stand-alone sound walls.
- Integrate sound walls into the right of way with landscape planting as a transition between sound walls and the roadway. The use of grading and earthwork in the landscape area will allow for reductions in the height of the exposed sound walls (Figure 3.zb).
- Incorporate landscape screening on both sides of the sound wall.
- Utilize variable grade options on both sides of sound walls to optimize the net height of the exposed wall to 12 feet wherever possible, while still meeting overall dimension requirements as prescribed by EPB or qualified Region noise specialist.
- The geometric alignment of sound walls should include variations created by earthwork, landscape or offset faces when viewed from the transportation facility.

Figure 3.zb: The use of grading allows for reduction in height of the wall and also for landscape planting.

3.3.1.2 Concrete Barriers and Sound Walls

- Avoid placing sound walls on top of concrete barriers where feasible. Sound walls should be consistent structures using a consistent material. As an alternative design, install sound walls separate and parallel to barriers, leaving at least 8 feet in between.

- Where a wall is constructed on a barrier rail, the focus should be on minimizing the visual disruption between the two systems and allowing the barrier rail to visually anchor and support the wall. Where this is not achieved, the wall looks awkward and mismatched in relation to the rail.

- Where sound walls are combined with concrete barriers, coordinate the color finish of concrete barriers with sound walls (Figure 2.3.b). Coordinating the colors of sound walls and concrete barriers is the simplest way to create consistency between structures.

3.3.1.3 Wall Surfaces

Aesthetic wall surface treatments can range from being too repetitive and boring to being visually distracting. Patterns positioned too low make the wall look out of scale. Monotonous patterns lead to driver fatigue and disengagement with the corridor. Visually demanding patterns can divert the motorist's attention and create safety issues.

- Surface texture is an important beneficial noise absorptive treatment and graffiti deterrent. Deep texturing or rusticated texture is encouraged for any wall panel design. Smooth surface design reflects noise more efficiently and is discouraged for noise attenuating wall roadway facades.

- Increase the complexity of panel designs with pattern applications that can be rotated and used in multiple arrangements. Use one or two panel designs that can be repeated yet rotated to increase pattern variation.

- Establish a family of panel designs. Increase the number of panels used in order to expand the range of patterns, while establishing unity.

- Avoid bright colors or busy patterns that are visually distracting. Motifs or pictorial representations are not to be used on sound walls, except in the Front Range Urban Zone (Figure 3.zc).

Figure 3.zc: This is a simple wall that avoids busy patterns and has a simple motif.

- Design structures to comply with the themes and treatment levels identified in the design zones. The highway experience should be characterized by consistent and elegantly designed structures that reflect the heritage, cultural and environmental qualities of the unique area through which the highway passes.

- Position aesthetic treatments according to overall wall proportions. Pattern designs should seamlessly transition between walls of varying heights.

- Projects that must address graffiti require designs with detailed color and patterning to be placed 8 feet or higher on the wall to discourage graffiti.

- Utilize aesthetic surface treatments on both sides of sound walls in areas of high visibility. Providing aesthetics on both sides of a wall shows mutual respect and care for the community.

- For post and panel walls, utilize a surface pattern and color scheme that minimizes the focus on where segments stop and start. This can be achieved through vertical patterning on the panels and color patterns that do not highlight the horizontal/ vertical discontinuity (Figure 3.zd).

Figure 3.zd: Vertical patterning is useful as it conceals vertical joints.

3.3.1.4 Sound Walls on Bridges

- Bridge design should consider the relationship of walls on and adjacent to the bridge. The goal is to create a continuous and consistent wall from the ground, extending on and over the bridge.

3.3.1.5 Height Steps, Transitions and Ends (Figures 3.ze and 3.zf)

- Incorporate a 90 degree stepped or sinuous horizon line at the top of walls. Elevation changes should be 6” to 24” in height. Utilize a maximum 2 feet stepped transition. Horizontal transition distance varies either in relationship to the vertical distance or in relationship to topographic conditions. In circumstances requiring quick vertical changes, such as sound abatement needs, the preferred option is for the horizontal measurement to be equal or in proportion to the vertical change (for example, 1V:1H or 1V:3H). In areas where topography changes necessitate the need for height transitions, the distance between transition points should be regularly spaced or visually correlate with topography changes.

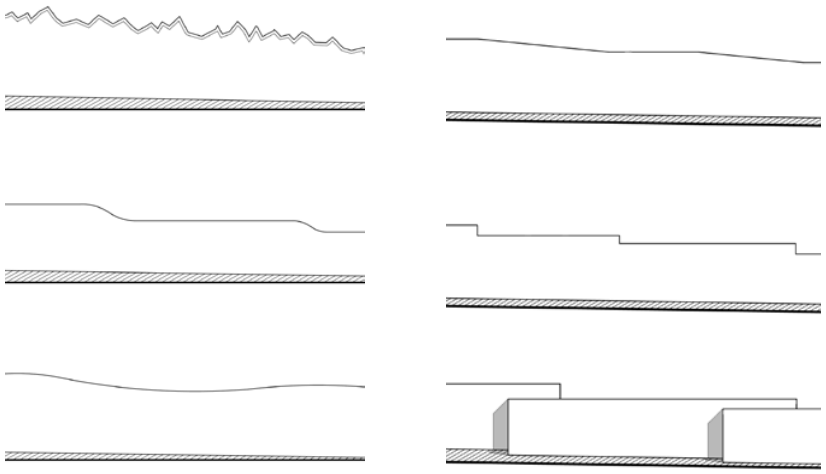


Figure 3.ze and 3.zf: These are examples of heights steps, transitions, and ends. The top left angular, irregular pattern should be avoided.

- Utilize curved and tapered wall transitions that do not exceed 3 feet wall height changes. Curved transitions appear more naturalized and subtle, allowing for a maximum of a 3 feet height transition. Tapered transitions should not exceed 3 feet over a period of 20 to 30 feet. Step downs at the end of the walls reduced visual impact. Curved tops may have greater flexibility but should have a few long radii versus several short radii.

- Use overall design consistency on wall end points to transition from the top of the wall to the ground plane.

See diagram on following pages:

Front Range Urban Zone & Noise Barrier Locations

Noise barriers should be sited by the noise analytics with preference/priority given to CDOT ROW. To minimize maintenance behind walls that can be built 2-5 feet from the ROW line (the space required to avoid construction easement), a geotextile weed barrier (pay item 420) should always be laid between the completed barrier and the homeowner's fences (or ROW line, where there is no private fence). The weed barrier should be covered by a 3 foot inch thickness of Class 2 aggregate base course.

In many areas, where the roadway elevation is five for more feet above the homes (e.g. all overpasses), the barrier must be located along the edge of the shoulder instead of the ROW line because too much traffic noise would pass over the top of the ROW barrier. This location often requires additional fill or a stronger retaining wall design to withstand wind loads. These walls are generally protected by a Type 4 guardrail for safety and maintenance reasons.

Where shoulder barrier segments end and barriers along the ROW line begin, it is generally necessary to overlap the segments by a length of 3-4 times the distance between the two barriers. The distance can be reduced by slanting the last 30-40'of barrier lengths toward each other. A minimum of 15 feet should be allowed between all barrier segments for maintenance vehicles.

Height Considerations

It is CDOT's policy to build noise barriers that are predicted to reduce 20-year future highway noise levels at all homes to at least 67 decibels (dB), or at least five dB below future noise levels without a barrier, whichever is greater. However, exceptions to this policy have been made in cases where 12 foot barriers along the edge of the widened shoulder (or edge of fill placed for the ultimate, full build roadways) are predicted to achieve noise levels within two dB of the FHWA's 67 dB noise abatement criterion for homes. Per FHPM 7-7-3,

any such exceptions along interstates (or discretionary funded projects) must be approved by FHWA. An informal public meeting to present the proposed heights and resultant dB levels may be advisable (soon after the FIR) to allow time for design modifications that may be necessary to avoid negative neighborhood responses during or soon after construction.

Barriers less than eight feet or more than 16 feet in height will generally not be considered because they are not acoustically sufficient (the past public response) or cost effective, respectively. Barriers along shoulders will generally not exceed 12 feet in height to avoid safety problems of roadway icing. Barriers extending east-west should have heights that do not cast winter shadows further than two feet onto the driving surface for more than two weeks per year.

The end treatments of all noise barriers should have a one-foot-in-ten taper in height down to eight feet (unless the taper reduces the degree of noise reduction at a nearby home).

Prior to any public commitment, it is generally CDOT's policy to analyze the cost-effectiveness of the proposed noise mitigation. Barrier design costing less than $3,000 per dB reduction per home, averaged over the entire project, is considered cost-effective.

Noise barrier construction for any land uses other than residential will be considered on a case-by-case basis. Most businesses prefer to have their signs and advertisements visible to highway motorists. Because noise barriers must be continuous and sufficiently long to be effective, several adjacent businesses would have to unanimously request a barrier before one would be built for them. FHWA's noise abatement criterion for all non-residential land uses is 72 dB. Barrier design:

1. Use standardized panels (of non-wood materials).

2. Provide a greater variety of aesthetic treatments in standard designs.

3. End post should be attached to the barrier foundation instead of being an integral part of the barrier.

4. Where ROW width allows, self-supporting (no foundation, only soil anchors or weighted geotextile) walls should be designed.

5. Reduce caisson depths based on the latest AASHTO wind load criteria and an improved soil failure method (to be investigated by Bridge Staff).

6. The aluminum post-and-panel system that has been used extensively on bridges should be eliminated as a future alternative.

7. Colors should be neutral or natural in appearance.

Figure 3.zg: This simple barrier design with rusted metal rails and wood posts blends well in its setting.

3.4 Guard Rails and Barriers

CDOT Cable Barrier Guide, 2009

The Cable Barrier Guide provides specifications and installation guidance for high-tension cable barriers.

CDOT Project Development Manual, Section 2.09 Roadside Barrier Design and Review, 2013

CDOT Construction Manual, Section 606 Guardrail

AASHTO Roadside Design Guide, 2011

A guardrail and/or barrier is a longitudinal barrier used to shield motorists from natural or manmade hazards located along either side of a roadway, and may occasionally be used to protect bystanders, pedestrians and cyclists from vehicular traffic. Where guardrail and concrete barrier rail systems are warranted, they are installed to prevent errant vehicles from leaving the traveled way and moving into fixed objects, steep slide slopes, and opposing traffic. Different types of designs exist to address specific conditions.

CDOT desires to install guardrail only when it is not economically feasible to eliminate a hazard, make the feature traversable, or terrain conditions are such that an adequate roadside recovery area cannot be provided for the given design speed. The designer should work with the resident engineer through the design sequence for the placement of guardrails, as described in the CDOT Project Development Manual, Section 2.09 (CDOT, 2013).

Figure 3.zh: Utilize continuous concrete barriers.

Figure 3.zi: Barriers with vertical fluted treatments enhance light and shadow effects.

3.4.1 Design Aesthetic

- Protection from edge obstacles is more desirable with a recovery zone than with guardrail or barriers.
- Where guardrails are required, consistent use of the guardrails described below is recommended (Figure 3.zg).
- The use of cable rail/barrier is discouraged because of the long-term maintenance cost and unattractive aesthetics as a result of multi-strands, misalignment and snow conditions. It has been used primarily in the median of divided highways to prevent crossover crashes. It has been installed on outside shoulders to shield steep slopes and protect from fixed hazards within the clear zone.
- Incorporate landform and planting directly with concrete barrier walls.

3.4.2 Materials

- Use continuous concrete barriers rather than segmented movable barriers (Figure 3.zh).
- The materials used for guardrails will be steel 'W' Rail with a 'rusted rail' finish and wooden posts. Use self-weathering Type 3 Guardrail Wbeam with wooden posts for guardrails. Eliminate the use of galvanized Wbeam (Figure 2.4.c).
- There are various treatments for type 4 barriers including plain, fluted and stippled. Barriers combined with retaining walls create interesting edge treatments.

3.4.3 Color

- Color selection must be approved by the landscape architect.
- Colored concrete barriers using the selected colors from the design zone color palette should be used in order to blend the roadway into the surrounding environment.
- Provide edge delineation through applied markings and reflectors rather than painting bright contrasting colors on concrete barriers.
- Rails that have vertical fluted treatment provide opportunities to enhance light and shadow by using light and dark colors (Figure 3.zi).
- Glare should be minimized. The backs of signs should be painted.
- Additional paint and materials should be ordered and stored for maintenance and consistency purposes.
- In the Front Range Urban Zone, a contrast in colors between the rail and the bridge provides a distinct character. In urban areas, the use of a bright color on the rail can create a sense of identity and character. Color choice should be consistent with the surrounding area and should be part of an overall theme for the roadway segment.

3.5 Lighting and Illumination

CDOT Lighting Design Guide (CDOT, 2006)

The CDOT Lighting Design Guide is based on the Illuminating Engineering Society of North America (IESNA) Lighting Handbook and the American Association of State Highway and Transportation Officials (AASHTO) 2005

Figure 3.zj: A simple pole configuration.

Figure 3.zk: A durable powder coated finish should match the design zone's color

Roadway Lighting Design Guide. It represents the current recommended practice for roadway lighting and includes criteria for typical applications found in the state of Colorado.

CDOT Roadway Design Guide; Chapter 3, 3.7 Lighting

CDOT Construction Manual, Section 613 Lighting

CDOT Bridge Design Manual

CDOT Standard Specifications for Road and Bridge Construction

CDOT Project Development Manual, Section 4.08 Lighting Plan

Lighting should satisfy safety and functional needs, and will avoid excessive light levels and high mast lighting applications. In consideration of adjoining neighborhoods and the protection of the dark night sky, light spillage and encroachment will be avoided.

- Lighting for pedestrian bridges shall be provided on poles independent of the bridge structure where possible.
- Select an elegant and simple pole configuration (Figure 3.zj)).
- Use a durable, powder-coated color finish for light poles and fixtures to match the design zone's color palette (Figure 3.zk).
- Focus attention on luminance versus illumination (i.e., brightness of pavement versus brightness of light) when establishing light levels to be provided.
- Use lighting fixtures that minimize light pollution and glare, provide even light dispersion, and fully conceal the light source. Use fixtures with full cutoff luminaires.
- Avoid high mast lighting and metal halide light sources.
- Design lighting in accordance with the policies and programs of the International Dark Sky Association to minimize light pollution.
- Prepare a lighting study as part of the design process that addresses lighting from multiple perspectives including, but not limited to, minimum transportation lighting requirements, impacts on wildlife and recreation, and pedestrian perspectives.
- Use intelligent lighting systems for roadside facilities that are only functional during specific situations. For example, recent lighting upgrades at chain stations only activate when the chain law is in effect.
- Consider reflective lane striping.

- Highly reflective finishes should be avoided.
- Coordinate with the region utility engineer and the local utility company.
- Minimize light pollution in conformance with 24-82-902 Colorado Revised Statutes (CRS).
- Utilize lighting to enhance safety.
- Bridge-mounted highway lighting shall be avoided wherever possible. The designer shall investigate the possibility of mounting the lighting on an extended pier cap. If bridge-mounted lighting cannot be avoided, it shall be located as close to a pier as is practical.
- Bridges crossing all public ways will have underneath lighting.
- For pole light foundations, if screw-in foundations will be used, ensure that the required Soil Test Reports have been received from the contractor and found acceptable.

3.6 Signage

CDOT Outdoor Advertising Manual (CDOT, 2011)

This manual provides “effective control” of outdoor advertising devices visible from the main traveled way and within the control area adjacent to the Interstate, Federal Aid Primary, National Highway System and State Secondary Highways within the State of Colorado. It provides a clear understanding of the procedures involved for the erection and ongoing maintenance of outdoor advertising devices.

Manual on Uniform Traffic Control Devices (MUTCD), Part 2 Signs (FHWA, 2009)

This manual defines the standards used by road managers nationwide to install and maintain traffic control devices on all public streets, highways, bikeways, and private roads open to public traffic. The MUTCD is published by the Federal Highway Administration (FHWA). This Manual shows many typical standard signs and object markers approved for use on streets, highways, bikeways, and pedestrian crossings.

Figure 3.zl: This LED sign is constructed of high quality durable material.

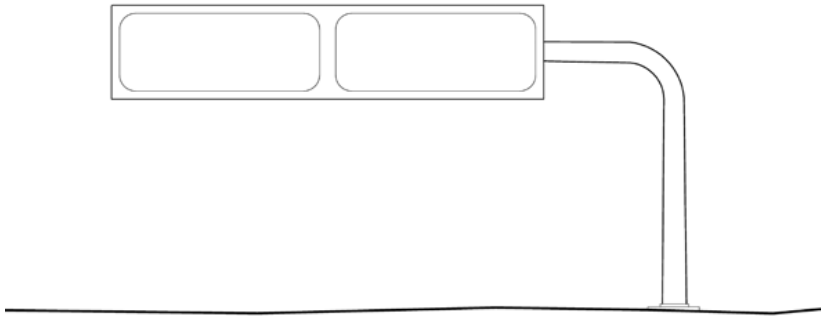


Figure 3.zm: Single arm monotube systems are recommended.

A clear and intuitive visual scene, free of clutter caused by signs of various types, sizes, materials, and purposes should be the dominant experience perceived by the traveler so the beauty of the surrounding landscape can be enjoyed. Signage should be kept to a minimum. Sign supports should be constructed with a simple elegant design. Commercial billboard advertisements and signage affect the visual integrity of the landscape and are not appropriate

for the corridor.

- Design signage to meet all applicable Colorado Department of Transportation (CDOT) and Manual on Uniform Traffic Control Devices (MUTCD) standards.
- Prepare a conceptual signing plan to ensure signage can be located and implemented correctly within the context of the improvement at approximately the 15% design stage.
- Apply a consistent color and material to signage support structures that matches this zone's color palette.
- Construct signs of a high quality and durable material (Figure 3.zl).
- For interstate highways, use single-arm monotube systems for signage support rather than complex steel trusses to reduce visual clutter (Figure 3.zm).
- Limit signage on the roadway to identify road services, communities, and cultural, recreational or historical points of interest.
- Integrate signage into bridge structures. Eliminate a tacked-on appearance by considering placement as an early component of design, see also Section 3.1 Bridges.
- Complete the roadway signing plan as a part of FIR plans so that signs can be considered as an integrated part of the final structures and roadway design. This will avoid placing signs as an after-thought and protect sight lines to focal points along the corridor.

3.7 Utilities

CDOT Roadway Design Guide, Section 3.8 Utilities

Utilities, such as power and gas distribution lines can create poor visual quality in a corridor. When, considering alternatives for utility alignments, visual degradation can be avoided by burying overhead lines, relocating them, and reducing crossing of the highway. These scenic improvement opportunities are to be comprehensively considered with corridor projects.

- Consider placing utility lines underground to minimize conflict with high-value views to improve scenic and visual appearance.
- Realign utility corridors to avoid a direct or unobscured view from the corridor.

- Add landscape plantings and landforms to screen and block views from the transportation corridor toward existing utility corridors.
- Avoid straight-line cut patterns in forests or dense vegetation. Varying cuts will create a feathered or irregular pattern, providing a more natural appearance.
- Apply the appropriate color from the zone's color palette.
- Coordinate with the region utilities engineer early and throughout the design process.
- Plot existing utilities in plan, profile, and cross sections to identify potential conflicts with design elements.
- An Inter-Governmental Agreement (IGA) may be necessary.

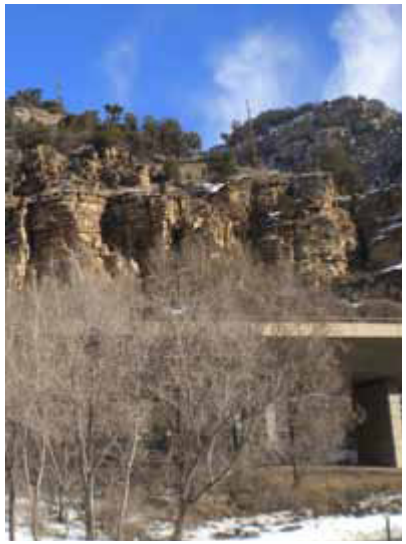


Figure 3.zn: The transportation element is harmonious with its setting due to consistent use of a natural color.

Figure 3.zo: Good color selection and use of texture allow this wall to blend into its setting.

Figure 3.zp: The color selection for this wall is based on the natural tones of the cliffs.

4.1 Color Selection and Consistency

Urban Design for Region 6 (CDOT, 2003)
I-70 Corridor Aesthetic Design Guidelines

The CDOT Landscape Architect shall lead the color selection process. Generally, color selection shall be from the recommended color palettes included in this document. The CDOT Landscape Architect must be consulted for color selection of all elements of the transportation facility and must stamp the final approved colors. Again, the overarching goal is to achieve consistency and provide for the transportation element to be harmonious with its setting (Figure 3.zn). Different elements of the highway need to be color coordinated, not addressed individually.

4.1.1 Criteria for Color Selection

- The landscape architect should be involved in decisions relating to color selection.
- Generally, only two colors should be used in highway applications. Occasionally a third color may be added for accents.
- Color selected for transportation features, including light standards, sign supports, and other vertical construction will blend into the surrounding natural and manmade environment (Figures 3.zo and 3.zp).
- Apply each zone's color palette to transportation structures and associated facilities within the design zone; including sound walls, retaining walls, lighting, signage, bridges, etc. The colors selected for each zone complement the unique features found there and provide consistency across entire corridors.
- Accent colors should be used to highlight structural aspects and/or details of highway structures, such as the beam of a bridge or a bridge railing. Ensure accent color application logically responds to and reinforces structural features or change in materials (Figure 3.zq).
- Coordinate with communities and agencies outside of CDOT to determine color palette exceptions.

Figure 3.zq: the accent color reinforces the change in materials and structural features.

Figure 3.zs: Color selection is included for detailed corridor plans.

- Additional paint and materials should be ordered and stored for maintenance and consistency purposes.

4.1.2 Color Use

- Accent colors for the design zone are tones currently found in this zone and should represent no more than 5 to 10% of the painted structure.
- Apply the base color to the dominant sections of the structure. Utilize accent colors to highlight smaller details that are attached to the overall roadway structure.
- Vertical metal features such as light poles, sign poles, and highway edge facilities should be colored with the finished selected color palettes (Figure 3.zr).

Figure 3.zt: Selected colors for Crest of the Rockies segment.

4.1.3 Color Palettes

- Colors should be selected from the Federal Standard 595 Color Server. A color palette has been selected for use throughout the state. When detailed corridor plans are completed, color selection must be included (Figure 3.zs).
- Colors currently being used or approved along Colorado highways include:

Interstate-70 Mountain Corridor

- Western Slope Canyons and Valleys Segment:
    - Federal Standard 595B Color 30372: Application: All road structures
    - Federal Standard 595B Color 30227: Application: Accents
    - Federal Standard 595B Color 20059: Application: All vertical features
- Front Range Foothills Segment:
    - Federal Standard 595B Color 30372: Application: All Road Structures
    - Federal Standard 595B Color 20227: Application: Accents
    - Federal Standard 595B Color 20059:

Application: All Vertical Features

- Crest of the Rockies Segment (3.zt):
    - Federal Standard 59B5 Color 30372:
      Application: All road structures
    - Federal Standard 595B Color 30233:
      Application: Accents
    - Federal Standard 595B Color 20059:
      Application: All vertical features
- Mountain Mineral Belt Segment:
    - Federal Standard 595B Color 30372:
      Application: All road structures
    - Federal Standard 595B Color16329:
      Application: Accents
    - Federal Standard 595B Color 20059:
      Application: All vertical features

Region 1

Region 1 currently has a variety of recommended colors. Future color modifications for highway corridors in Region 1 should be selected from the colors identified below (Spruce Green, Flesh and Red Accent are not encouraged for further new use):

- E-470
    - Light Grey 26440
    - Dark Grey 26132
    - Red Accent 11140
- I-76: SH 51 to Bromley
    - Light Grey 26440
    - Spruce Green 24159
- I-25: 58th Ave to US 36
    - Light Brown 30117

        - Medium Beige 30450
    - I-25: 6th Ave to I-70
        - Light Grey 26440
        - Medium Grey 26251
    - SH 270: I-25 to I-76
        - Light Brown 30117
        - Medium Beige 30450
    - C-470: I-70 to Yosemite
        - Flesh 31667
        - Medium Brown 30219
    - Hampden: Santa Fe to Eldridge
    - I-225: Smith Road to Yosemite
        - Light Beige 33531
        - Dark Brown 30108
    - I-225: I-25 to I-70
        - Light Beige 33531
        - Dark Brown 30108
    - SH 285: Santa Fe to C-470
        - Light Beige 33531
        - Dark Brown 30108

4.1.4 Paint and Finishes

2011 Construction Specifications Book, Section 708 Paints

- Anti-graffiti surfaces should be provided.
- Paint Matches, additional paint and materials should be

ordered and stored for maintenance and consistency purposes.

4.2 Sustainability and Recycled Materials

FHWA INVEST Sustainable Highways Self-Evaluation Tool

FHWA's INVEST identifies characteristics of sustainable highways and provides information and techniques to help agencies and organizations integrate sustainability best practices into highway and other roadway projects. The tool is intended to provide a method for practitioners to evaluate their transportation projects and to encourage progress in the sustainability arena. It is not required and it is not intended to encourage comparisons across transportation agencies and projects. The tool is being developed with ongoing input from state and local transportation agency officials, staff and professional organizations such as AASHTO and ASCE. FHWA plans to continue to update this tool as the transportation sustainability field advances.

Materials Recycling and Reuse–Finding Opportunities in Colorado Highways (Stevens, 2007). Prepared for CDOT Research Branch in cooperation with EPA

The Colorado Department of Transportation (CDOT) secured a Resource Conservation Grant provided by the U.S. EPA to determine a strategy to improve recycling on highway projects and reduce waste in landfills. The project focused primarily on five high-tonnage materials: asphalt, concrete, metal, wood, and tires. These materials can be reused, recycled, and replaced on highway projects in cost-effective ways. Recommendations are provided.

Most of the information on recycling on the CDOT website pertains to research or recommendations from recent Environmental Impact Statement's.

The research document, Materials Recycling and Reuse includes identifying multiple reuse opportunities for materials on highway construction and maintenance projects that could provide many opportunities for CDOT to dramatically increase their recycling rate. Up to 100percent of asphalt, concrete and metal could be recycled with minor changes to the design process, specifications, and/or construction methods, and with little to no adverse changes in performance expectations, overall cost, and structural longevity. Several changes could be made to significantly reduce waste on highway projects based on the research conducted.

Pertinent recommendations include:

- Asphalt: Increase the percent of recycled asphalt paving (RAP) allowed in

highway asphalt pavement projects from 25% to 30%. Also, increase the amount of hot in-place and cold in-place pavement recycling.

- Wood: Replace treated and painted wood products with more durable and recycle-friendly products such as steel and recycled materials.
- Metal: Replace raw materials with highly recyclable metal products containing steel, iron, lead, copper and aluminum.
- Recycled Tires: Utilize scrap tires for pavement additives, crack sealant, walls, mulch, sidewalks, permeable and lightweight fill, and many other applications where tires perform equally or better than other materials.
- Plants and organics should be recycled or reused on site as mulch, soil amendment, and erosion control. For example, use mulch for weed control and water conservation when mulch is made from tree bark and clean wood chips from construction wood waste.
- Specify the use of Certified Compost in accordance with CDOT specifications.
- Modify construction specifications and improve tracking to both increase and measure efforts.
- Present findings to engineers and CDOT designers responsible for materials selection in project design.

Implementation recommendations:

- Educate, inform, and motivate engineers and contractors about opportunities for recyclable materials to replace conventional materials on highway projects. Specify the use of Certified Compost in accordance with CDOT specifications.
- Remove the recycling barriers inherent to current highway design plans by including more information, design notes, and requirements or incentives to recycle in the special conditions.
- Revise construction specification language to provide clear direction to contractors, encouraging them to reuse and recycle. Areas of focus include materials removal, erosion control and possibly an overall “greening” specification.
- Improve tracking of reused and recycled material, starting with a baseline to compare future efforts. By using the CDOT Cost Data Book, project specifications and pay item numbers would be developed for reuse and recycled materials. These items would be accounted for in the design and

construction of a project using the same bid item process currently in use. Progress could then be tracked over time to identify improvements and further analyze methods to increase recycling.

- Share research and recommendations from this project with CDOT staff, corporations, other government agencies, and the environmental community through an outreach program.

Overall, in order to reduce construction waste and reduce the impact to the environment, recycled materials should be specified on new projects and salvaged during demolition.

4.2.1 Recommended Changes to Specifications

Changes are recommended to the specifications to increase the use of recycled materials on CDOT construction projects:

4.2.1.1. Section 208 – Erosion Control Specifications

- Mandate recycled concrete as aggregate for stabilized construction entrances in CDOT Region 1 and allow for it in other regions in Specification 208.02 (l).
- The engineer will have to designate, in the plans or in a project, special provisions, the specific salvable materials within the project limits, list acceptable reuse of these items, and/or list authorized recycling facilities for the materials listed.
- Work with manufacturers and vendors to determine cost effective material alternatives that support reuse and recycling.

4.2.1.2 Section 216 – Soil Retention Covering Specifications

- Rolled erosion control products are classified into the following two main categories:
  - Soil Retention Blanket)SRB)
  - Turf Reinforced Mats (TRM)
    - Specification 216.02 (a).

4.2.1.3 Section 506 – Riprap Specifications

- Include size restrictions as necessary.
- The engineer will have to designate, in the plans or in a project, special provisions, the specific salvable materials within the project limits, list acceptable reuse of these items and/or list authorized recycling facilities for the materials listed.

Figure 3.zu: Transportation art may be incorporated directly into the highway design like the patterns in this retaining wall.

Figure 3.zv: This fish artwork is harmoniously integrated with the architectural design of the wall.

4.2.2 Greenroads

The Greenroads program is one of many programs that encourage and document the greening of highway systems, (http://www.greenroads.us). Greenroads is a voluntary third party rating system for road projects. It seeks to recognize and reward roadway projects that exceed public expectations for environmental, economic and social performance. CDOT has several similar programs underway.

4.3 Transportation Art

Guidelines for Integrating Artwork into CDOT Transportation Facilities (2009)

This technical memorandum covers integration of artist treatments, artwork placed on highway or other structures, and freestanding artwork within the right of way (ROW) of Colorado state highways. It emphasizes the importance of designs sensitive to nearby communities, the surrounding environment and the safety of the traveling public. It considers integration of art forms and artwork an important tool to help create a successful roadway environment. There is a description of the application process, requirements for artwork, and minimum standards for region traffic engineers to use in review and approval.

The CDOT process requires specialists to review multiple documents. This section highlights the most pertinent guidelines for aesthetic consideration, but the designer needs to refer to the appropriate source for engineering standards, procedures, legal requirements, maintenance and updates to the source document.

Transportation art is usually provided by entities other than CDOT, unless it is incorporated directly into the roadway design (Figure 3.zu). CDOT's Art in the Public Right of Way Guidelines sets minimum standards for transportation art and identifies what cannot be used based on criteria of highway safety and functionality.

All artwork shall meet the following requirements:

- Artwork must be located completely within the CDOT ROW. Maintenance shall be the responsibility of the sponsor throughout the lifecycle of the artwork. All construction and maintenance activities shall be completed without access or egress from the traveled way on any Colorado State highway section where the posted speed is greater than 45 miles per hour, unless otherwise approved by the region traffic engineer. Artwork that would require access or egress from the interstate mainline section for construction or maintenance activities will not be approved.

Figure 3.zw: this artwork reflects local values and traditional cultures.

- Artwork for highway structures, such as bridges or retaining walls, shall be harmoniously integrated with the architectural design of these structures (Figure 3.zv). In general, artwork which meets the aesthetic requirements of the highway or its components and is integrally designed with them shall be approved. Artwork that is attached or hung from structures in a manner which detracts from the visual quality or functionality of any highway feature, will not be approved.

- The content of all artwork must be socially acceptable. The artwork's appearance and visual relationships with the surrounding environment shall also be considered. Artwork which conflicts with local values or is determined to not be in the public interest will not be approved (Figure 3.zw).

- Artwork shall exhibit lasting qualities that are not trendy or subject to change within a short period of time.

- As part of the application packet, the applicant shall demonstrate that the proposed artwork will not compromise motorist safety, road and roadside functions or highway design standards. No public artwork features shall be located within the clear zone. In addition, the proposed artwork location shall conform to the Americans with Disabilities Act (ADA) design criteria, if applicable. The following design features will not be approved:

    - Artwork that is going to be a public nuisance
    - Bold or vibrant colors, especially colors that can be mistaken for signal lights
    - Animation and moving parts
    - Water features
    - Lighting or reflective elements
    - Flashing disks that simulate lighting
    - Company logos or symbols
    - Living logos
    - Flags and banners
    - Text messages, except on local government or CDOT signs
    - Artwork that requires electricity

Figure 3.zy: This mural evokes clear meaning and purpose.

- Artwork shall not simulate a traffic control device. Artwork having a predominant red or orange background or any other Manual on Uniform Traffic Control Devices (MUTCD) color will not be approved.

- Artwork shall not be commercial signing or advertising of any kind. Signs associated with a business, including non-profit organizations, business complexes or regional shopping centers or event will not be approved.

- Non-traffic related signs that may be permitted along highways include Municipal Entrance Identification Signs within the ROW, Community Identification Signs off the ROW and Community Recognition Signs. Such signs shall be reviewed by the appropriate Regional Outdoor Advertising Inspector for conformance with the applicable rules.

- Artwork shall be permanent and maintainable (Figure 3.zx). It shall have technical plans with a PE stamp signed by a licensed professional engineer registered in the State of Colorado approving structural stability and the ability to withstand the necessary wind loads. Artwork shall also be designed using long lasting materials and construction techniques which require minimal care and resist vandalism.

- Artwork placed on highway structures shall not be detrimental to the longevity of the structure. Neither shall it unduly inhibit maintenance of the structure by restricting access to inspect, paint, or perform other maintenance operations. Artwork placed on highway structures shall have technical plans with a PE stamp signed by a licensed professional engineer registered in the State of Colorado, to assure the integrity of the structure is not comprised by the addition of the artwork.

- Artwork damaged by vehicular accidents, vandalism, acts of nature or necessitated by maintenance operations or construction projects will be required to be repaired or removed by the local governing agency within 30 days of written notification. If the artwork is not repaired or removed as required, it will be removed by CDOT or its agents without commitment for restoration or replacement. When artwork removal is required, its sponsor shall be responsible for all of the costs involved. All graffiti shall be removed within two business days of written notice at no cost to CDOT.

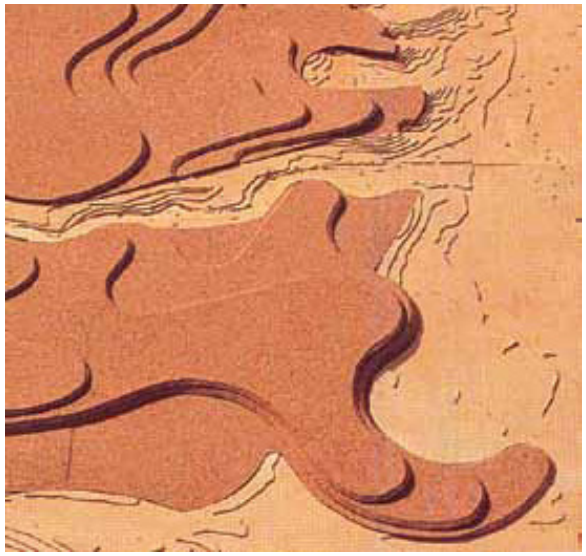


Figure 3.zz: This artwork illustrates contouring of the lands in the Southern Rocky Mountain Zone.

4.3.1 Meaningful Art

- Create regionally appropriate, meaningful art. For the roadway user, an artscape enhances the travel experience and the impression of place. Transportation art should be authentic and should evoke clear meaning and purpose that relates to

the surrounding place, the unique culture and environment of the area, and the travel experience (Figure 3.zy).

- Consider ways in which art can be integrated into the essential highway components (e.g. using patterns on concrete retaining or wing walls).
- Patterns imprinted on a highway structure should be designed with an artistic composition of objects, imprints, or patterns. While complementing other highway structures in form and color, patterns should offer a level of complexity and interest that responds to the unique experience of the place and roadway travel.
- Artwork should be of a scale appropriate to highway travel speed.
- Consider artwork that expresses the element of light, involving both sunlight and artificial light.
- Avoid monotony in the duplication of repetitive literal pictorial applications, such as profiled mountains rendered in concrete texture.

Figure 3.zza: Artwork should engage communities and be part of a comprehensive art program.

4.3.2 Craftsmanship and Quality

- Elements of highway art should not be obvious and should be authentic. Avoid the use of ready-made, randomly placed, stand-alone objects or imprints that depict little meaning. Rather, transportation art should have an excellence of craftsmanship, quality, truthfulness and originality.
- Use evocative artistic expressions that complement highway structures and the surrounding landscape and engage observers. Rather than imprints of obvious subject matter, select more complex artistic expressions that encourage viewers to “fill in the blanks” and in so doing evoke a higher level of meaning.

4.3.3 Art as Part of a Larger Context

- Consider each art piece as part of a larger whole. The simplest of elements can have a powerful effect. When planning transportation art, the entire length of each design zone should be considered.
- The placement and design of art should consider views to the surrounding landscape.

- Ensure transportation art supports the design zone themes (Figure 3.zz). The choice of appropriate subject matter and media is essential to obtaining the desired expression of each design zone.

4.3.4 Engage Local Agencies and Organizations in the Planning Process

- Consider transportation art at the onset of project development. Engage community members, artists, landscape architects, and Architects early in the design and development stages of highway projects to ensure an integrated and comprehensive art program (Figure 3.zza).

- Develop relationships with local communities and organizations to partner in efforts to establish and fund transportation art.

Figure 4.a: Georgetown is a community along I-70.

IV | COMMUNITY

This chapter of the Manual addresses contextual issues related to highway design, that is, the community environment of the highway. The following are pertinent resources:

Environmental Stewardship Guide

Context Sensitive Solutions CSS Vision for CDOT

The purpose of this policy memo is to explain CSS to CDOT.

The Colorado Department of Transportation states: "…early application of CSS principles in the transportation planning process may save money and reduce project delays, resulting in significant benefits to transportation agencies. Beyond its value as a public-involvement strategy to foster improved community participation, CSS considerations in transportation planning can help identify community needs and potential problems (and solutions) ahead of the project development/ NEPA stage. "Context Sensitive Solutions involves a collaborative, interdisciplinary approach in which citizens are part of the design team. Generally, CSS seeks transportation solutions that improve mobility and safety while complementing and enhancing community objectives. Context Sensitive Solutions are most successfully reached through joint efforts involving all stakeholders.

Community environment is identified as the physical land uses surrounding the highway, as well as the opinions of the people in the community (4.a). In 1969, NEPA introduced the concept of public involvement to evaluate environmental impacts of highway design. In the early 1990's, Context Sensitive Solutions (CSS) extended the importance of public involvement in decisions relating to highways and their environs. CSS is not just an aesthetic treatment; rather CSS involves developing a transportation solution to fit into its context. The purpose of the CSS approach is to identify and address both transportation and project area needs during project development. Transportation needs include the inter-relationship of highways with other modes of transportation including transit systems, railroads, and biking and pedestrian circulation.

Also, CSS allows CDOT to vary the standards of the *CDOT Standard Specifications for Road and Bridge Construction* (Green Book).

Figure 4.b: Transportation alignments should consider and provide for adjacent communities as in this example.

A thoughtful transition between transportation alignments and adjacent community oriented land uses will buffer noise and visual impacts and help preserve the quality of life for residents living and working next to the roadway (Figure 4.b). Alignment, landscape, earthwork, and structural solutions should include an evaluation of the potential interface with adjacent communities. Designs that facilitate pedestrian and multi-modal connections across the transportation route strengthen mobility within the community and encourage successful land use patterns and circulation. The design can further enhance the functionality of adjacent communities by appropriately identifying gateways, regional highway connections, and recreational or cultural activities. These primary interchanges and locations should be highlighted to visually communicate their importance to the traveler. The following are pertinent resources:

CDOT Project Development Manual 2001, Section 2.02 Public Involvement

Federal-aid Highway Act Requirements for Public Hearings, 23 UCS 128, section 128.

I-70 Mountain Corridor Context Sensitive Solutions — I-70 CSS

2035 Statewide Transportation Plan

The 2035 Statewide Transportation Plan, Moving Colorado: Vision for the Future, prepared in accordance with state and federal law, represents a comprehensive effort to develop a transportation vision for all of Colorado. To plan for the future, the Colorado Department of Transportation has worked with residents, the business community and elected officials across the state to define Colorado's transportation vision. The comprehensive vision updates the 2030 Statewide Transportation Plan, including the 350 multimodal transportation corridors throughout the state. The vision provides a framework to prioritize roadway, transit and aviation projects that support Colorado's transportation needs.

CDOT NEPA Manual, Chapter 7

Each project should have a public involvement strategy but a formal public involvement plan is mandatory for all Environmental Impact Statement (EIS) processes and recommended for other projects where there are complex issues. Depending on the type of NEPA document being prepared, there are specific legal requirements for public involvement that must be met. The requirements and process are described in this document.

CDOT Context Sensitive Solutions

FHWA defines Context Sensitive Solutions (CSS) as a collaborative, interdisciplinary approach that involves all stakeholders in developing a

Figure 4.c: This planted berm is a good buffer from the highway.

Figure 4.d: In downtown Denver, land uses influence design standards for highways.

transportation facility that complements its physical setting and preserves scenic, aesthetic, historic and environmental resources while maintaining safety and mobility. (Context Sensitive Design, on the other hand, applies to a transportation project's engineering design features, and may include design features that help the project fit harmoniously into the community (e.g. form liners for bridge piers, colored crosswalks, or cubing detail). A summary of the process and its benefits is reproduced at this link.

CDOT Policy Memo 26, Context Sensitive Solutions

FHWA Flexibility in Highway Design (FHWA)

This publication identifies and explains the opportunities, flexibilities, and constraints facing designers and design teams responsible for the development of transportation facilities.

The design of the roadway will consider a buffer and transition area between transportation facilities and community oriented land uses (Figure 4.c). In order to avoid potential visual and scenic impacts, buffer highway noise, and preserve community character and patterns, the landscape planting, earthwork, structural solutions and location of the transportation facilities need to be fully examined. Road and trail connections within communities and multi-modal travel corridor opportunities should be considered. Reinforcement of alternative methods of travel such as pedestrian and biking paths should be incorporated and coordinated with community and recreational planning efforts.

Land use is an important determinant of the function of an area's roads. As land use changes because of development, especially at the urban fringe, road functions also change. It is not uncommon for roads that once served as rural local access routes to farmland, and now serve suburban residential subdivisions and commercial land uses, to be reclassified as urban collectors or arterials, depending on the intensity of development and the type of traffic generated by the development (Figure 4.d). Design standards and guidelines must change to meet actual or impending change in traffic character and road function.

Actions taken by a local jurisdiction to control or direct the form and location of growth or to preserve the current physical and scenic characteristics of a highway corridor should also reflect the need for a reexamination of existing functional classification. For example, the construction of a new controlled-access bypass route might allow for a downward reclassification of what had been the existing arterial route through a community to a collector-level facility.

One solution to the issue of changing land use is to directly relate the functional classification of the highway system to the "level of development" or, in other words, the design criteria that should be applied. The State of Washington is one jurisdiction that

Figure 4.e: When highways become Main Streets, the character changes to be more pedestrian friendly.

Figure 4.f: Communities are engaged in corridor design.

has done this. This process allows for improvements to even minor arterial-type routes to be designed using 3R standards (resurfacing, restoring, rehabilitating), as opposed to applying traditional design criteria for new-location highway facilities that fall within this functional classification.

1.1 Consideration of Adjacent Communities

There are several general conditions of state highway/community land use relationships that require different design responses, from interstate exit ramp treatment to highways as Main Streets (Figure 4.e). For example, a state highway might bypass a community with only an exit road that accesses the community, or it may pass through a community, but not provide access to community land uses. Where a state highway passes through a community and land uses are directly adjacent to and accessed off the highway, it may serve as the Main Street. There are also circumstances where a state highway passes through a community and impacts to adjacent residential areas need to be buffered.

The guidelines below provide direction for these different conditions:

- Consider alignment alternatives that improve community interface.
- Consider design speeds appropriate to the level of development adjacent to the alignment. For example, where there is dense development, road speeds should be slow.
- Engage the adjacent community in a discussion about appropriate interfaces.
- Design the corridor in partnership with communities, agencies, and future project planners to create a buffer and transition from the transportation corridor to community-oriented land uses. (Figure 4.f) Landscape, earthwork, and structural solutions may be used to create the appropriate transition based on the adjacent land uses and character.
- Minimize impacts and consider the potential negative effects of roadway design on residential and commercial areas.
- Where walls are required for road construction or noise mitigation, see Chapter 3: Manmade, for further guidance.

1.2 Linkages and Connections

In many locations, state highways pass through areas where there is potential to separate communities and negatively impact the communities' function and connectivity. Safe and visually pleasing connections from one side of the highway to the other are essential for a healthy community. Connections may

Figure 4.g: Use of appropriately scaled materials enhance the pedestrian environment of this underpass.

Figure 4.h: Good lighting enhances this well placed pedestrian underpass that connects existing pedestrian circulation networks.

serve vehicular, transit, bicycle or pedestrian users.

- Create open pedestrian underpasses to allow for maximum natural lighting, which enhances a feeling of safety and comfort. The use of landscape and appropriate materials will contribute to the comfortable pedestrian environment (Figure 4.g).
- Plan and integrate transit connections and access into the corridor design to enhance the community interface with future transit systems.
- Consider the relationship of communities to the location of rest areas, recreation portals, chain-up stations, etc. The location and design of these facilities will follow standard federal requirements and will also consider potential community impacts and benefits such as resident access to recreation, traveler use of community services and amenities, tourist accommodations, etc.
- Locate safe pedestrian crossings in conjunction with existing or planned pedestrian circulation networks (Figure 4.h). Pedestrian networks should provide access to community parks, recreation trails, attractions, and businesses as well as connections between city districts.

1.3 Main Streets

The American Planning Association *Policy Guide on Surface Transportation* (2010) proposes a new unified vision for transportation policy that will support the integration of planning for transportation with land use, health, economic development, environmental and other important planning areas. This includes the goal of creating safe, healthy, accessible communities for everyone with special focus on the experience of the pedestrian.

Colorado Sustainable Main Streets Initiative 2010

This program brought state, federal, local, nonprofit, foundation and private sector resources to make progress on downtown main street revitalization in four pilot communities.

CDOT Region 1 Urban Design Guidelines

Policy Guide on Surface Transportation (American Planning Association, 2010)

Colorado Department of Local Affairs Main Street Program

There are several nationwide initiatives to make highways that pass through communities, into streets that are walkable and livable. The 2010 Colorado Main Streets Initiative was a pilot program that modified the federal sustainability principles for Colorado. Caltrans, the California state agency

Figure 4.i: Use of different paving materials, pedestrian crossing markings and traffic lights promote traffic calming.

Figure 4.j: Raised planters and striped crossings are visual cues to a more pedestrian environment.

responsible for highway, bridge and rail transportation planning, construction and maintenance, has a document called Making State Highways that Happen to be Main Streets More Walkable and Livable addressing methods of traffic calming, pedestrian and bicycle use and safety and creating a more human scale to the highways. CDOT is incorporating this approach on a project specific basis, on the I-70 corridor and in several projects in the Front Range urban zones. The Context Sensitive Solutions approach provides guidance on involving communities to assist with this objective.

1.3.1 Promote Traffic Calming on Main Streets (Figure 4.i)

- Reduce traffic speed to provide for narrower road widths and safer and friendlier pedestrian environments.
- Provide visual cues that let drivers know they are entering an area of increased non-motorized activity. Cues might include: sidewalks, raised medians, dragons teeth, signalized pedestrian crossings, landscaping, ornamental lighting, street furniture or transportation art (Figure 4.j).
- Consider the use of roundabouts that reduce vehicle travel speeds and provide opportunities for landscaping treatment.
- Provide a raised landscaped median island to reduce the scale of the street and promote a more pedestrian friendly environment. In snowy climates, consider methods of snow removal around the median.
- The preferred sidewalk width in a downtown environment is ten feet. Maximize the width of sidewalks. Ensure sidewalks and curb ramp designs meet ADA accessibility requirements.
- Bring the sidewalk into the street. Use bulb outs and textured paving in areas of pedestrian crossings.
- Provide curbside parking in angled or parallel parking arrangements.

1.3.2 Provide Furnishings and Landscaping on Main Streets

- Use purpose suited lighting that identifies the pedestrian zone for pedestrian safety.
- Include street furnishings that provide useful functions and make downtowns more interesting for people (Figure 4.k).
- Provide street landscaping which makes downtowns more livable and beautiful (Figure 4.l). Landscaping can also

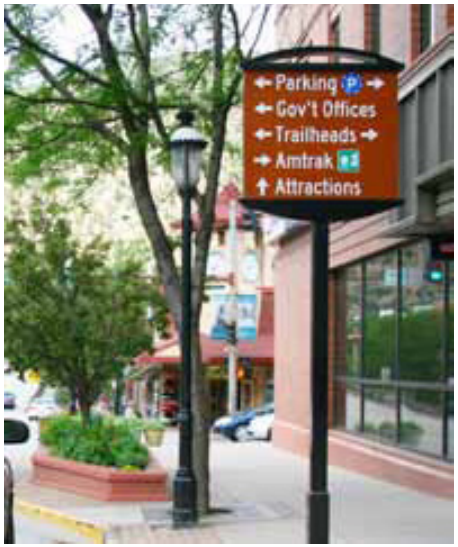


Figure 4.k: Attractive signage provides a useful function and makes the downtown environment more interesting.

Figure 4.l: Street tree planting and raised planters make downtowns more livable and beautiful.

promote environmental stewardship by preventing the heat island effect and exchanging carbon dioxide for oxygen. Pay careful attention to selection of appropriate species of plants for the design zone.

- Use medians to serve other land stewardship functions - managing water quality, storing snow, preserving vegetation, and restoring the disturbed landscape.
- Incorporate variable widths of medians and include plants and landscape materials characteristic of the various landscape types found in the applicable design zone.
- Establish community identity along the Main Street by using banners, consistent sign design (that meets MUTCD standards) or transportation art.
- Avoid vertical walls and splash block.
- Incorporate solutions for stormwater retention, e.g. rain gardens.

Figure 4.m: This signage is well integrated into the environment and draws attention to natural resources.

Figure 4.n: Visitors are exposed to a variety of activities through mult-use facilities, trails, and signage.

Many existing landscape features, whether manmade or natural, should be protected through a process of identification, enhancement, restoration or preservation, avoidance or incorporation into the design of the highway improvement. Several of the previously mentioned laws and regulations mandate this. Below are links to recreational and cultural resource websites:

2035 Statewide Transportation Plan and 2035 Regional Transportation Plans (CDOT 2008)

Cultural Resources Procedures Manual by CDOT (CDOT)

Section 106 of the National Historic Preservation Act (NHPA) sets forth the process that Federal agencies must follow when planning undertakings that have the potential to affect historic properties. FHWA has authorized CDOT to conduct cultural resource surveys, recommend determinations of eligibility and effects, and consult directly with the State Historic Preservation Officer (SHPO) on its behalf. This document explains the process for complying with the Federal laws.

Protection of natural and cultural elements can be accomplished by avoidance, grade changes, retaining walls and/or providing buffer strips. Alignments and profiles may be adjusted to allow these features to enhance the traveler's experience. These elements may provide scenic beauty, erosion control, wildlife habitat, vegetative diversity, and screening or reduction of air, noise and visual pollutants.

The design of corridor facilities should encourage access to the wealth of recreational and cultural resources that exist throughout the corridor. Clear and intuitive signage, parking areas, trailheads, and interpretive elements will draw attention to these resources and accommodate both travelers and local residents alike (Figure 4.m). Corridor design should be utilized to explore opportunities to combine functions into multi-use facilities which encourage efficient use of space and expose visitors to a variety of activities (Figure 4.n).

2.1 Designation of and Access to Resources

National Historic Preservation Act of 1966 (NHPA), As Amended (2006)

This Act establishes preservation as a national policy and directs the Federal government to provide leadership in preserving, restoring and maintaining the historic and cultural environment of the United States.

Historic and archaeological resources that are required to be considered

by CDOT are those that are listed or have been officially determined to be eligible for listing on the National Register of Historic Places (NRHP). To be considered important, historic and archaeological resources must possess sufficient integrity of location, design, setting, materials, workmanship, feeling and association, and meet one or more of the NRHP evaluation criteria. Section 106 of the National Historic Preservation Act (NHPA) directs federal agencies to consider the effects of proposed federally sponsored or assisted undertakings on historic properties.

Historic and archaeological resources are tangible remains of past human activity and include archaeological artifacts, features, and sites, as well as historical buildings, structures, districts and features.They are generally over 50 years old.

Other historic or cultural areas of significance may be identified and included as part of highway rest area facilities.

- Designate rest area facilities, scenic areas, and viewpoints as shared-use to accommodate both recreational users and travelers (Figure 4.o). Design these facilities in a deliberate manner to minimize potential conflicts between recreational users and travelers, and provide interpretive signage, restrooms, and parking for cars and trailers.

- Utilize signage to indicate points of historical or cultural importance, recreation, natural history, or landmarks for travelers to note along the corridor (Figure 4.p).

2.2 Road Service Areas and Adjunct Facilities

CDOT Project Development Manual, Section 8.04 Safety Rest Areas

Road service areas and adjunct facilities along the corridor will be designed in conjunction with the roadway as a complete design effort. Facilities can be designed to integrate with their surrounding context by utilizing colors, materials, architectural elements, and plant communities that are reflected in the adjacent landscape. Rest areas, viewpoints, and pull-offs have the opportunity to serve as multi-functional spaces that provide traveler services in addition to acting as launch points for recreational and/or cultural activities. Roadside facilities that are directly related to safety, such as chain stations, should remain dedicated to those specific functions. Visually screening maintenance and equipment areas will limit visual clutter and ensure a consistent relationship between the roadway, traveler and surrounding environment.

Figure 4.o: A rest facility designed as a multi-use facility for recreationalists and travelers.

Figure 4.p: Overlooks and signage identify landmarks.

2.2.1 Road Services Areas (Safety Rest Areas)

The CDOT Project Development Manual describes safety rest areas as follows:

- Safety rest areas with parking facilities separated from the roadway are provided as a place for the motorist to stop and rest for short periods of time. At CDOT, the resident engineer is responsible for scoping and design of the safety rest area.
- Safety rest areas are off-roadway areas that provide drinking water, toilets, tables and benches, telephones, information facilities, and other facilities for travelers. The rest area may be located at a scenic location and include historic or scenic information (Figure 4.q).
- Safety rest areas will provide full consideration and accommodation for the disabled. They should have controlled entrance and exit connections with proper signage, restroom facilities, parking areas, adequate lighting, adequate water sources, and proper sewage disposal (Figure 4.r).
- The objective is to give weight to the appropriateness of the site rather than exact adherence to constant distance or driving time between sites. Planners should consider distance to the nearest safety rest areas to provide an opportunity for the motorist to stop at reasonable intervals.
- A team of design, construction, maintenance, landscaping, and right of way personnel should select the best feasible site to optimize factors such as safety, materials, utility, drainage, economy, and scenic value. These factors may be determined by examination of aerial photos and by ground reconnaissance.
- FHWA regulations should be consulted regarding oversight that may apply to safety rest area development.

There are excellent examples of sensitively designed rest areas in the Glenwood Canyon segment of the I-70 Corridor with rest areas designed as follows:

- Design road service areas to consider and preserve major site resources and features such as topography, views and vistas, unique vegetation, geological features, wetlands, and other qualities native to the site and its surroundings.

Figure 4.q: This rest stop is located in a scenic area and provides historic information.

Figure 4.r: This rest area has necessary facilities and accommodates all users.

- Utilize local materials, plantings, and landscape features to blend seamlessly with the surrounding landscape.
- Locate truck parking in a manner so as not to disrupt views and other features (Figure 2.2.c).
- Site road service areas in relation to activities located adjacent to the highway.
- Coordinate with appropriate agencies to provide informational signage for shared-use activities.
- Incorporate park-and-ride lots, activity access, and transit stops to encourage public transportation, particularly in areas of heavy tourist traffic.
- Sustainable architecture, or green building design, is highly suitable to many highway rest areas and other such facilities where water, energy, and landscape resources are difficult to secure and maintain.

2.3 Pedestrian and Bicycle Facilities

There is a growing trend towards enhancing manuals that are commonly used by highway designers covering roadway geometrics, roadside safety, and bridges to incorporate design information that integrates safe and convenient facilities for bicyclists and pedestrians (including people with disabilities)into all new highway construction and reconstruction projects(Figure 4.s).

The CDOT Bike and Pedestrian Policy Directive promotes transportation mode choices by enhancing safety and mobility for bicyclists and pedestrians on or along the state highway system (CDOT, 2009). It defines the policies related to education and enforcement, planning, programming, design, construction, operation and maintenance of bicycle and pedestrian facilities and their usage. It requires the accommodation of bicyclists and pedestrians in all transportation facilities as a matter of routine (Figure 4.t).

AASHTO Guide for the Development of Bicycle Facilities

CDOT Bike and Pedestrian Policy Directive, 1999

Colorado Statewide Bicycle and Pedestrian Plan 2012

The intent of this project is to produce a document that provides planning level direction and guidance for a unified approach to improving bicycling and walking in Colorado. This project will identify the vision, goals, objectives and strategies for bicycle and pedestrian accommodation in Colorado. It will develop criteria and a process for determining how the state will best spend its

Figure 4.s: This road crossing is designed to accommodate bicyclists and wheelchairs with the on-grade median crossing.

Figure 4.t: This separated bicycle path is attractively buffered from the highway.

limited resources, identify how the Bike/Ped Plan (BPP) will align with regional (MPO and TPR-Transportation Planning Region) bicycle and pedestrian plans and how it will be integrated into the Statewide Transportation Plan. Performance measures will be incorporated for evaluating the progress towards goals/objectives and improvements to bicycle and pedestrian facilities.

Colorado Guide for the Development of Local and Regional Bicycle and Pedestrian Plans (CDOT, 2012)

This guide includes the principles which provide the foundation for institutionalizing bicycling and walking into Colorado's transportation system, considerations for the planning and engineering for these facilities as well as program planning.

Colorado Department of Highways Staff Bridge Design Policy Memo No. 2-2

This specification provides width, clearance, grades and railing standards for pedestrian bridges

CDOT Roadway Design Guide; Chapter 4, 4.16 Pedestrian Facilities, 4.17 Bicycle Facilities, Chapter 14 Bicycle and Pedestrian Facilities

CDOT Construction Manual; Section 608 Sidewalks and Bikeways

CDOT Project Development Manual, Section 2.10 Bicycle and Pedestrian Facilities

CDOT Policy Directive 902.0, Shoulder Policy

2.3.1 Non-motorized Transportation System

Non-motorized transportation systems (NTS) include bicycle and pedestrian systems. Consideration should be given to the interface of motorized and non-motorized systems, e.g. multi-modal transit centers (Figure 4.u).

- Engage federal, state and local agencies as well as local user groups and organizations in the planning, design, and implementation of non-motorized transportation facilities. Ensure proper planning conveniently accommodates NTS while minimizing adverse safety and environmental impacts. Consult the statewide bicycle and pedestrian plans prepared by CDOT.

- NTS systems can be accommodated and should be encouraged within some areas of the highway right of way. Where right of way topography, site conditions, and land use warrant, separate bicycle paths may be built. Where possible, ensure that direct connections are made to existing and future

Figure 4.u: Attractive landscaping helps to integrate this bus stop with the highway and separated sidewalk.

trail systems and multi-use pathways.

- For an interstate application, incorporate a landscaped buffer of at least 30 feet between the roadway shoulder and any adjacent trails or bike paths to minimize conflicts in locations where recreational trails parallel the roadway.

2.3.2 On-street Facilities

Bicyclists can be found on almost every type of roadway, from rural interstates to local streets, and the majority of these roads have no special facilities designated for bicycling. These facilities are a critical part of the bicycling infrastructure and need to be maintained and operated so that bicyclists can use them safely and comfortably. Drainage grates, railroad tracks, potholes, utility covers, gravel, wet leaves, pavement joints and many other surface irregularities have a profound impact on bicyclists and can cause falls and serious injury. Often, many roads have no need for special on-street bike facilities as long as an acceptable amount of space is provided for bicyclists and the pavement has an acceptable level of maintenance.

Adding or improving paved shoulders often can be the best way to accommodate bicyclists and they have the additional attraction of providing a variety of benefits to motorists and other road users. Dimensions are as follows:

- Less than four feet: any additional width of paved shoulder is better than none at all, but below four feet, a shoulder should not be designated or marked as a bicycle facility.
- Four feet-minimum width to accommodate bicycle travel. This measurement should be the useable width and should not include the gutter pan or any area treated with rumble strips.
- Five feet or more-minimum width recommended from the face of a guardrail, curb or other barrier.

Widths should be increased if there are higher levels of bicycle usage, motor vehicle speeds are above 50 mph, or there is a higher percentage of truck and bus traffic. Further guidance on the appropriate width of shoulders to accommodate bicyclists on roadways in these situations can be found in *Accommodating Bicycle & Pedestrian Travel: A Recommended Approach* (FHWA, 2012).

Figure 4.v: Shared roadways and bike routes are identified with standard symbols marked on the road. Credit: Carl Sundstorm

Figure 4.w: An attractive separated two way bike path.

2.3.2.2 Wide Outside Lanes

In urban areas, paved shoulders are not normally provided on major roads. A wider outside (or curbside) lane allows a motorist to safely pass a cyclist while remaining in the same lane and this can be a significant benefit and improvement for cyclists, especially more experienced riders. A wider outside lane also helps trucks, buses and vehicles turning onto the major road from a driveway or wide street. Dimensions are as follows:

- 14 feet-recommended width for wide outside lane must be useable and measurement should be from the edge line or joint of the gutter pan to the lane line.
- 15 feet-preferred where extra space required for maneuvering (e.g. on steep grades) or to keep clear of on-street parking or other obstacles.
- Continuous stretches of lane wider than 15 feet-may encourage the undesirable operation of two motor vehicles trying to squeeze into one lane. Where this much width is available, consideration should be given to striping bike lanes or shoulders.

Figure 4.x: A shared use path that is separated from the roadway, adjacent to a landscaped storm water system.

2.3.2.3 Signed Shared Roadways

The AASHTO *Guide for the Development of Bicycle Facilities* describes signed shared roadways (bike routes) as “those that have been identified by signing as preferred bike route”, however poorly planned signage can cause safety issues. The guide recommends considering a number of factors before signing a route (AASHTO, 2012) (Figure 4.v):

- the route provides through and direct travel
- the route connects discontinuous segments of shared use paths or bike lanes
- bicyclists are given greater priority on the signed route than on the alternate route
- street parking has been removed or limited to provide more width
- a smooth surface has been provided
- regular street sweeping and maintenance is assured
- wider curb lanes are provided compared to parallel roads

- shoulders are at least four feet wide
- shared roadway signing should not end at a barrier such as a major intersection or narrow bridge

2.3.2.4 Bike Lanes

The Pedestrian and Bicycle Information Center (PBIC) provide the following information about bike lanes. Bike lanes are defined as “a portion of the roadway which has been designated by striping, signing and/or pavement marking for the preferential or exclusive use by bicyclists” (PBIC, 2012). Bicycle lanes make the movements of both motorists and bicyclists more predictable and, as with other bicycle facilities; there are advantages to all road users in striping them on the roadway. In general, bicycle lanes should be (Figure 4.w):

- One-way, carrying bicyclists in the same direction as the adjacent vehicular travel lane.
- On the right side of the roadway.
- Located between the parking lane (if there is one) and the travel lane.
- Bicycle lane width:
- Four feet: minimum width of bike lane on roadways with no curb and gutter.
- Five feet: minimum width of bike lane when adjacent to parking, from the face of the curb or guardrail.
- 11 feet: total width for shared bike lane and parking area with no curb face.
- 12 feet: shared bike lane and parking area with a curb face.
- Bicycle lane stripe width:
- Six inch: solid white line separating bike lane from motor vehicle lane (possibly increased to eight inches (200mm) where emphasis is needed).
- Four-inch: optional solid white line separating the bike lane from parking spaces.

2.3.4 Shared Use Paths

Shared use paths are for bicyclists and pedestrians and are separated

from the roadway. Shared use paths are an addition, and complimentary, to the roadway network although they may be connected to the roadway at crossing points and intersections. Many guidelines for Shared Use Paths are located in the AASHTO guides and the FHWA Manual on Uniform Traffic Control Devices (FHWA, 2009) (4.x).

2.3.5 Additional Guidance for Bicycle and Pedestrian Facilities

The following information provides guidance to CDOT personnel regarding bicycle and pedestrian facilities.

2.3.5.1 Width and Clearance

- The minimum clear width for a pedestrian bridge shall be eight feet. For an attached sidewalk on a vehicle bridge, the clear walkway shall be four feet minimum, but in no case shall it be narrower than the approaching sidewalk. Additional width may be required in an urban area or for a shared pedestrian-bikeway facility.
- The minimum vertical clearance from under a pedestrian bridge is typically specified as 17’-6”. A lowered height of 16 feet is recommended, provided all vehicles can safely travel beneath.
- The minimum vertical clearance from the walkway surface to an overhead obstruction is typically specified as 8’-6”, measured at one foot from the face of curb, parapet or rail. An increased height of 9’-6” is recommended to improve the pedestrian experience.

2.3.5.2 Ramps

- Pedestrian overpass structures, if practical, may be improved with both ramps and stairways, but under no condition should a structure be built with stairs only.
- Maximum grades on pedestrian bridges and approach ramps shall be 8.33percent.
- Landings shall be provided to accommodate a maximum rise between landings of 30 inches. The maximum spacing of landings will be 30 feet for an 8.33percent grade or 40 feet for a 6.25percent grade.
- Landings are not required when the grade is less than 5 percent.

Figure 4.y: Bicycle railings should be integrated into the overall railing design.

Figure 4.z: Light fixtures should be integrated into the bridge design.

2.3.5.3 Bicycle Railings

- Bicycle railings shall be used on bridges specifically designed to carry bicycle traffic, and on bridges where specific protection of bicyclists is deemed necessary. The minimum height of railing used to protect a bicyclist is 54 inches, measured from the top of the surface on which the bicycle rides to the rail. Smooth rub rails shall be attached to the barriers at a handlebar height of 42 inches (Figure 4.y).

- Chain-link fences may be used in lieu of bicycle railing. However, smooth rub rails shall be attached to the fence posts at a handlebar height of 42 inches.

2.3.5.4 Landings and Surfaces

- Landings shall be level, full width of the bridge, and a minimum of 5 feet in length (Figure 2.3.g).

- Landings shall be provided whenever the direction of the ramp changes.

- The deck shall have a non-skid surface; e.g. transverse fiber broom finish for concrete.

2.3.5.5 Lighting

- Lighting for pedestrian bridges shall be provided on poles independent of the bridge structure where possible (Figure 4.z).

2.3.5.6 Pedestrian Railings

- Pedestrian railing shall be designed in accordance with AASHTO Specifications.

- Handrails shall be provided for all stairs and for ramps with grades greater than 5percent. The rail height shall be 32 inches as measured from the tread at the face of the riser for stairs and from the ramp surface for ramps (Figure 4.za).

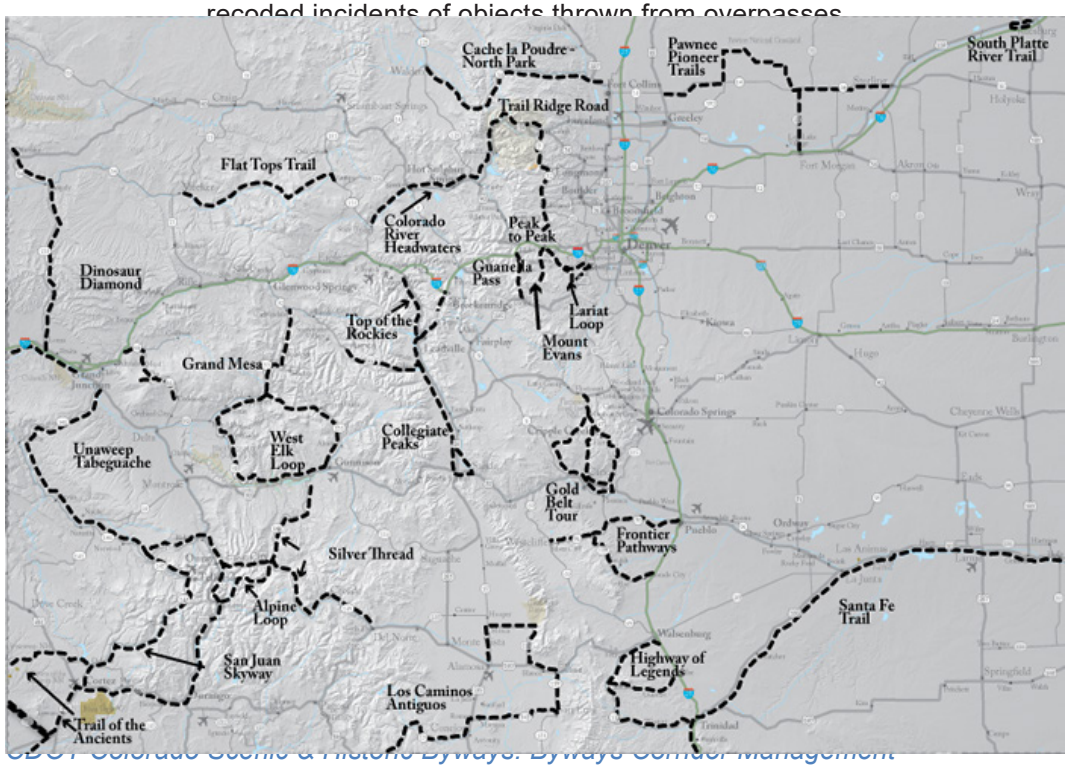
2.3.5.7 Chain Link Fence

- A chain-link fence or other approved screening must be provided on portions of pedestrian bridges or walkways over traffic. The screening must have a minimum height of 8feet-6inches above the walkway.

- In general, vertical fences shall be used. However, where

Figure 4.za: Pedestrian railings can be more decorative in character.

warranted due to pedestrian volume, or where there are recoded incidents of objects thrown from overpasses.



2.4

CDOT Colorado Scenic & Historic Byways: Byways Corridor Management Plans

Within the Scenic and Historic Byways Program, each Byway has a management plan which provides a vision, goals and objectives for the corridor as well as outlines the issues, constraints and the management actions necessary to reach objectives and resolve problems.

Figure 4.zb: The Colorado Scenic Byway symbol.

2.4.1 Scenic Byways

The Colorado Scenic and Historic Byways program is a statewide partnership intended to provide recreational, educational and economic benefits to Coloradans and visitors. This system of outstanding touring routes in Colorado affords the traveler interpretation and identification of key points of interest and services while providing for the protection of significant resources (Figures 4.zb and 4.zc) Scenic and Historic Byways are nominated by local partnership groups and designated by the Colorado Scenic and Historic Byways Commission for their exceptional scenic, historic, cultural, recreational and natural features. There are Corridor Management Plans associated with each byway.

Figure 4.zc: A scenic byway in Colorado. Credit: Sally Pearce, CDOT

Figure 4.zd: This highway is designed with consideration of the visual effects in the landscape.

2.4.2 Blue Star Memorial Highways

The Blue Star Memorial Highways are a tribute to the armed forces of the United States of America. The National Garden Clubs, Inc. is the parent organization for Blue Star Memorial Highways. The idea dates back to 1944 when the New Jersey State Council of Garden Clubs beautified a 5½-mile stretch of U.S. 22 from Mountainside to North Plainfield to honor the military. Approximately 8,000 dogwood trees were planted as a living memorial to the men and women in the Armed Forces from New Jersey.

Colorado's first dedicated highways were U.S 40, U.S. 24, U.S. 85, and U.S. 87. The first marker was dedicated at the Utah border at Dinosaur, Colorado in 1947. Others followed at the borders near Cheyenne, Wyoming, Cheyenne Wells, Colorado, and at Raton Pass. All of these established Blue Star Memorial Highways remain in place. There are approximately 20 Blue Star Memorial Highway Markers in Colorado.

2.5 Visual Aesthetics

Public opinion on the visual importance of roadway facilities makes it essential to assess visual impacts during the transportation development process. Community acceptance of a project may be influenced by its visual effects (Figure 4.zd). Highway planners can help resolve controversies with public groups by assessing visual impacts and the effectiveness of proposed mitigation measures.

Many federal laws and regulations deal with visual considerations in the highway environment. The Historic Preservation Act of 1966 directs federal agencies to account for the effects of proposed projects on historic resources. The National Environmental Policy Act of 1969 (NEPA), Section 101-b-2, states that it is the responsibility of the federal government to "use all practicable means" to "assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings."

The following is an outline of a visual assessment methodology to use in evaluation of the visual impact of a highway on the environment around it and the impact of the highway on viewers in other well used public locations.

2.5.1 Visual Impact Assessment Methodology

Adapted from the NY DOT Visual Impact Assessment for Highway Projects:

- Determine the need for a Visual Impact Assessment (VIA). VIAs might be required in major reconstruction projects where there is a substantial visual change proposed in the highway corridor, or where new or out-of-kind replacement buildings, bridges or other structures are proposed, or where there is significant vegetative cutting along State highways.
- Consult with a CDOT Landscape Architect regarding any project-specific methodology and subtasks before starting the work.
- Identify the viewshed to define the physical limits of the affected visual environment and locate the areas of heavy public use.
- Identify viewer groups, viewpoints and key viewing locations.
- Prepare high quality representative photographs from the viewing locations and prepare images of the future scenarios.
- Assess the visual impacts, including changes to significant

Figure 4.ze: This grading for storm water detention uses rounded and naturalized slopes, in addition to the naturalized channel with riprap.

visual resources and probable viewer response to these changes.

- Propose measures to avoid, minimize, or mitigate negative visual impacts and to enhance positive impacts.

- Document this study in a Visual Impact Assessment report, to be presented as a technical appendix. This report shall include color copies of the simulations.

2.5.2 Reducing Visual Impacts

When the potential visual impacts are of concern to the community, identify visual impact mitigation techniques that might help. Several of the visual mitigation techniques have been described in related sections of the Manual. The measures are summarized below:

2.5.2.1 Landforms

When landforms are disturbed by roadways, several measures can be taken during grading operations to reduce the visual impacts and to aid in the revegetative process (Figure 4.ze).

- Slope Rounding: breaks the sharp unnatural edges formed by the junction of a cut or fill slope with the naturally rounded land form. Where rounding occurs above the slope, additional right of way may be needed and more vegetation disturbed, but rounding decreases the time required for re-vegetation on a slope.

- Lay Back Draws: where natural draws are encountered, the cut slope can be laid back to match the existing grade.

- Warping Slopes: a slope treatment that varies the slope ratios to blend with the surrounding land forms. Through this technique false draw, ridges, and rolling slopes can be created.

- Slope diversity can be added with the use of large boulders or rock outcroppings found during excavation. These rocks can be placed in random clusters or individually during grading operations to provide a more natural appearing highway slope. Clusters and individual rocks should be of different sizes and spacing. Contact the CDOT Landscape Architect for boulder placement.

2.5.3 Selective Thinning

Selective thinning is an on-site design process that can be used for scenic enhancement along with clearing a zone for roadside safety. The CDOT Landscape Architect will mark the trees for removal. Thinning breaks up straight lines of trees left by roadway clearing and grubbing operations. An irregular free flowing clear line provides the traveler with enclosures and openings which add to the driving experience and can provide for wildflower meadows.

Selective thinning for safety increases the off-road vehicle recovery space, vehicle site distance, reduces vehicle/animal collisions, and provides snow storage space.

When selectively thinning the following trees should be considered for removal:

- Trees left in an altered state due to change of grade, hydrology, etc.
- Trees that are hazardous, diseased, dying or dead.
- Trees of undesirable species.
- Trees subject to wind throw.
- Trees intolerant of ice-melting chemicals.
- Trees subject to sun scald.
- Trees obstructing desirable views.

Successful thinning leaves a stand of healthy trees with various ages.

Along with thinning, feathering the edges of a cut adds to the clear line. Feathering involves reduction of the vegetative density along with a gradation from tall vegetation to low vegetation at the clearing edge. Contact the CDOT Landscape Architect for an AutoCAD detail sheet to be added to the set of plans.

V | TECHNICAL APPENDICES

The Technical Appendix includes additional resources and information that are too detailed for the body of this manual, but are important to landscape aesthetics and environment for CDOT's Landscape Architects.

CDOT Construction Manual

CDOT CADD Manual

The CDOT Computer Aided Design and Drafting (CADD) Manual addresses issues such as: software, tools, techniques, standards, and procedures, which will aid the user in the efficient production of CDOT plan sets and facilitate the exchange of information between CDOT Regions, specialty groups and consultants working on CDOT projects.

2011 Construction Specifications Book (Section 100 – Section 700)

CDOT Maintenance Levels of Service Manual

This manual provides guidance on maintenance levels of service (LOS) implemented by CDOT as part of its maintenance performance budgeting and maintenance program management. Maintenance program areas include: Planning and Training; Roadway Surfacing; Roadside Structures; Roadside Appearance; Traffic Services; Structure Maintenance; Snow and Ice Control; Material, Equipment and Buildings; and Tunnel Activities.

CDOT M (Miscellaneous) – Standard Plans

The CDOT M (Miscellaneous) – Standard Plans website contains links to standard construction specifications in PDF form.

APPENDIX 1 | CDOT WILDLIFE GUIDELINES AND PERMIT APPLICATIONS (FROM CDOT WILDLIFE LINK)

Colorado County List 2012

Threatened, endangered, candidate and proposed species by County

Bird Spec CDOT Biologist

Bird protection specification when using a CDOT biologist for biological work. Describes construction procedures in relation to protecting habitat and activities of migratory birds.

Bird Spec Contractor Biologist

Bird protection specification when using a contractor biologist for biological work. Describes construction procedures in relation to protecting habitat and activities of migratory birds.

Bird Spec Structure Work

Bird protection specification to use when working on concrete box culverts (CBC), bridges, and other structures.

Prairie Dog Statement

CDOT's position on eradicating prairie dogs on CDOT right of way

SB 40 Guidelines

Senate Bill 40 (33-5-101-107, CRS 1973 as amended) requires any agency of the state to obtain wildlife certification from the Colorado Division of Wildlife (DOW) when the agency plans construction in "...any stream or its bank or tributaries...". Although Senate Bill 40 (SB 40) emphasizes the protection of fishing waters, it does acknowledge the need to protect and preserve all fish and wildlife resources associated with streams in Colorado. The purpose of these guidelines is to clarify when SB 40 certification is required and to describe the procedures to be followed by the Colorado Department of Transportation (CDOT) in securing this certification.

Short Grass Prairie B.O.

This is the U.S. Fish and Wildlife Service's (Service) programmatic biological opinion on impacts to federally-listed endangered and threatened species associated with Federal Highway Administration (FHWA) funding of the Colorado Department of Transportation's (CDOT) routine maintenance and upgrade activities on existing transportation corridors of eastern Colorado over the next 20 years. The project focuses on the Colorado portion of the central short grass prairie ecoregion as defined by Bailey

et al. (1994), and modified by The Nature Conservancy (TNC) to include all segments of Interstate 25 (I-25) within Colorado. This biological opinion is based on the project proposal as described in the May 2003, report prepared principally by the Colorado Natural Heritage Program (CNHP) entitled “Programmatic Biological Assessment, Conference Report, and Conservation Strategy for Impacts from Transportation Improvement Projects on Select Sensitive Species on Colorado’s Central Short Grass Prairie”

Biological Assessment Contents

Suggested Process and Contents for Biological Evaluations and Biological Assessments prepared by U.S. Fish and Wildlife Service. The BE or BA should present a clear line of reasoning that explains the proposed project and how you determined the effects of the project on each threatened or endangered species in the project area.

Prairie Dog Memo

Prairie Dog relocation guidelines

Prairie Dog Policy

CDOT’s black-tailed prairie dog policy

USFWS Section 7 Consultation Handbook

A Joint U.S. Fish and Wildlife Service and National Marine Fisheries Service handbook. Procedures for Conducting Consultation and Conference Activities under Section 7 of the Endangered Species Act

SB 40 Application

Form for Application for SB 40 Wildlife Certification

Federal Recovery Permits

Describes the types of U.S. Fish and Wildlife Endangered Species Program Permits and how to apply. Click on “permit application,” then click on “Form 3-200-55.”

Wildlife Collection Permits

State of Colorado Division of Wildlife collection permits

Application of the Migratory Bird Treaty Act to Highway Projects

The purpose of the MBTA is to protect listed birds, eggs and nests. Generally it does not apply to the habitat that might be used by the listed birds. However, to the extent that there are birds, nests and eggs in the CDOT project area that might be harmed and, given that the MBTA has both criminal and civil aspects to it, FHWA needs to be careful in its actions and environmental analysis.

APPENDIX 2 | EROSION CONTROL AND RECYCLING SPECIFICATION CHANGE

Recommended Changes to Specifications

The following are suggested changes to specification sections noted below:

6.2.2 Suggested Changes to Section 208 – Erosion Control Specifications

- Based on discussions with Mike Banovich of the CDOT Environmental Programs Branch, the following revisions are recommended to be included to Section 208 – Erosion Control Specifications to increase the use of recycled materials on CDOT construction projects:

- Add crushed recycled concrete as a construction material for check dams and outlet protection in Specification 208.02 (f) and (g), respectively. Include size restrictions as necessary.

- Mandate recycled concrete as aggregate for stabilized construction entrances in CDOT Region 1 and allow for it in other regions in Specification 208.02 (l). If this revision is incorporated into the CDOT Standard Specifications or a standard special provision, the engineer will have to designate, in the plans or in a project special provision, the specific salvable materials within the project limits, list acceptable reuse of these items and/or list authorized recycling facilities for the materials listed.

6.2.3 Suggested Changes to Section 216 – Soil Retention Covering Specifications

Further discussions with Mike Banovich of the CDOT Environmental Programs Branch yielded the following recommended revisions to be included to Section 216 – Soil Retention Covering Specifications to increase the use of recycled materials on CDOT construction projects:

- Add shredded soda bottles and other three-dimensional recycled polyester fibers as a construction material for soil retention blankets in Specification 216.02 (a).

- See Appendix Q for a draft version of the potential revision to this specification as drafted by CDOT.

6.2.4 Suggested Changes to Section 506 –Riprap Specifications

Based on discussions with Mike Banovich of the CDOT Environmental Programs Branch, the following revisions are recommended to be included to Section 506 – Riprap Specifications to increase the use of recycled materials on CDOT construction projects:

- Add crushed recycled concrete as a construction material for riprap in Specification 506.02.
- Include size restrictions as necessary.
- If this revision is incorporated into the CDOT Standard Specifications or a standard special provision, the engineer will have to designate, in the plans or in a project special provision, the specific salvable materials within the project limits, list acceptable reuse of these items and/or list authorized recycling facilities for the materials listed.

APPENDIX 3 | FENCE DESIGN – REVISION TO SECTION 607

Revision of Section 607 Fence (Metal) (Sound Barrier) (60 Inch)

Section 607 of the Standard Specifications is hereby revised for this project as follows:

Subsection 607.01 shall include the following:

- This work shall consist of furnishing and installing metal sound barrier in accordance with these specifications and in reasonably close conformity with the dimensions and details shown on the plans or established.

Subsection 607.02 shall include the following:

The metal sound barrier panels, hereafter referred to as panels, shall conform to the following:

- When tested in accordance with test procedure ASTM E 90-75, the panels shall show A-weighted transmission loss of 22 DBA, based on a generalized spectrum of diesel truck noise from NCHRP 78. This acoustical test shall be performed by a recognized acoustical consultant and the contractor will submit copies of the test results to the Department prior to bidding.

- Each panel shall be of a laminate construction of aluminum sheets, aluminum frame and paper honeycomb core.

- The aluminum sheets shall be fabricated in one piece from .063 inch aluminum porcelain enameling sheet of Alclad alloy 6061-H-11 with an alloy 1100 cladding of approximately 5 percent on both sides.

- The aluminum sheets shall be treated, in accordance with the current Porcelain Enameling Institute specifications, to produce maximum adherence of the porcelain enamel. Adherence of the porcelain enamel coating shall be checked by an accelerated spall test in accordance with the current PEI specifications.

- The exterior faces of the aluminum sheets shall be porcelain enameled a minimum of .002 inch in thickness. The porcelain enamel shall be applied in two coats by automatic spray equipment that conforms to current Porcelain Enamel Institute specifications. The porcelain enamel shall have a gloss reading of 50 to 70 units at a 45 degree angle when measured on the photovolt meter. Reference test ASTM designation C 346-76. Color variation to be within, plus or minus, 2 N.B.S. units. The color shall be Federal Standard 515a, Number 3011.

- Each panel section shall have a perimeter frame made of aluminum alloy

6063-T6 or 6063-T52. This frame shall be assembled by heliarc welding or self-tapping hex head stainless steel screws. A sealant will be required at corners to prevent moisture penetration.

- Core material shall be phenolic impregnated 80 pound craft paper honeycomb. Core material shall meet specification MIL-STD-810C for fungus resistance. The cell size of the honeycomb shall be 1/2 inch and shall be impregnated 18 percent by weight minimum. The thickness of the core material shall conform to the dimensions indicated on the plans.

- The honeycomb laminate construction shall have a minimum tensile strength of 50 psi. Reference ASTM test method C 297-61 and ASTM C 481-61.

- The laminating adhesive shall be of the thermo-setting type and shall produce a permanent oil and water resistant bond. Bonding of the panels shall be performed in a heated flat plated press capable of exerting 10 psi over the entire panel area at one time. Interior faces of the sheets shall be cleaned prior to laminating.

- The contractor shall furnish to the Department certification of prior testing of the adhesive laminate according to test method ASTM E 72-80 and ASTM C 273-61. Test shall be performed by an independent testing laboratory.

- All laminated panels shall have exterior faces of such flatness that when measured at temperatures of 70° to 80° F, the maximum wave slope shall not exceed one percent. Wave slope shall be computed in the following manner: Measure the distance between high points (DIM. A). Place a straight edge across these points and measure depth of slope (DIM. B). Divide one-half of A into B to determine percent of wave slope.

- On the perimeter of the finished panel, a 1/8 inch tolerance from flush between the frame and sheets will be allowed and all edges shall be straight within 1/8 inch from a straight plane.

The sound and alignment tube shall be solely manufactured from either neoprene or EPDM. This elastomer shall be 60 durometer hardness, verifiable in accordance with ASTM D 2240-81. When tested in accordance with ASTM D 1171-68 for ozone cracking, the elastomer shall have minimum ratings of 2 and 80 percent for exposure and quality retention, respectively. The ozone chamber exposure method A shall be used for test condition.

All structural tubes and the attached tabs shall be painted in accordance with Section 509. All blemishes, discontinuities, bare edges, or other imperfections shall be repainted before the installation of the panels. The color shall be the

same as the panels.

The anchorage assembly for the structural tube shall be galvanized.

Subsection 607.03 shall include the following:

- The contractor shall furnish shop drawings for the panels, structural steel, and sound and alignment tube elastomer bid under this item as specified in subsection 105.02.
- Mill and shop inspection of structural steel shall be in accordance with subsection 509.17.
- Mill and shop inspection of the panels shall also follow the requirements of subsection 509.17, but may be waived and complete inspection made when fabricated panels are delivered to the work site.
- Subsection 607.04 shall include the following:
- Metal sound barrier will be measured by the linear foot. Measurement will be along the base of the metal sound barrier from outside to outside of end structural tubes for each continuous run of sound barrier.
- Subsection 607.05 shall include the following:
- The accepted quantity of metal sound barrier will be paid for at the contract unit price.
- Payment will be made under:

Pay Item	Pay Unit
Fence (Metal) (Sound Barrier) (60 Inch)	Linear Foot

Payment will be full compensation for all work necessary to complete the item including furnishing and installing all structural tubes, panels, anchorage assemblies, sound and alignment tube, angles, and other miscellaneous hardware required.

APPENDIX 4 | GREENROADS MANUAL SCORESHEET

GREENROADS RATING SYSTEM

LIST OF CREDITS (v1.5)

No.	Title	Pts.	Description
Project Requirements (PR) – Mandatory for all projects			
PR-1	Environmental Review Process	Req	Complete a comprehensive environmental review
PR-2	Lifecycle Cost Analysis (LCCA)	Req	Perform LCCA for pavement section
PR-3	Lifecycle Inventory (LCI)	Req	Perform LCI of pavement section
PR-4	Quality Control Plan	Req	Have a formal contractor quality control plan
PR-5	Noise Mitigation Plan	Req	Have a construction noise mitigation plan
PR-6	Waste Management Plan	Req	Have a plan to divert C&D waste from landfill
PR-7	Pollution Prevention Plan	Req	Have a TESC/SWPPP
PR-8	Low Impact Development (LID)	Req	Complete a LID feasibility study
PR-9	Pavement Management System	Req	Have a pavement management system
PR-10	Site Maintenance Plan	Req	Have a roadside maintenance plan
PR-11	Educational Outreach	Req	Publicize sustainability information for project
Environment & Water (EW) – Up to 21 Points			
EW-1	Environmental Management System	2	ISO 14001 certification for general contractor
EW-2	Runff Flow Control	1-3	Reduce runoff quantity
EW-3	Runoff Quality	1-3	Treat stormwater to a higher level of quality
EW-4	Stormwater Cost Analysis	1	Conduct an LCCA for stormwater elements
EW-5	Site Vegetation	1-3	Use native low/no water vegetation
EW-6	Habitat Restoration	3	Restore habitat beyond what is required
EW-7	Ecological Connectivity	1-3	Connect habitat across roadways
EW-8	Light Pollution	3	Discourage light pollution
Access & Equity (AE) – Up to 30 Points			
AE-1	Safety Audit	1-2	Perform roadway safety audit
AE-2	Intelligent Transportation Systems (ITS)	2-5	Implement ITS solutions
AE-3	Context Sensitive Solutions	5	Plan for context sensitive solutions
AE-4	Traffic Emissions Reduction	5	Reduce emissions with quantifiable methods
AE-5	Pedestrian Access	1-2	Provide/improve pedestrian accessibility
AE-6	Bicycle Access	1-2	Provide/improve bicycle accessibility
AE-7	Transit Access	1-5	Provide/improve transit accessibility
AE-8	Scenic Views	1-2	Provide views of scenery or vistas
AE-9	Cultural Outreach	1-2	Promote art/culture/community values
Construction Activities (CA) – Up to 14 Points			
CA-1	Quality Management System	2	ISO 9001 certification for general contractor
CA-2	Environmental Training	1	Provide environmental training
CA-3	Site Recycling Plan	1	Have a plan to divert waste from landfill
CA-4	Fossil Fuel Reduction	1-2	Use alternative fuels in construction equipment
CA-5	Equipment Emissions Reduction	1-2	Meet EPA Tier 4 standards for non-road equip.
CA-6	Paving Emissions Reduction	1	Use pavers that meet NIOSH requirements
CA-7	Water Tracking	2	Develop data on water use in construction
CA-8	Contractor Warranty	3	Warranty on the constructed pavement
Materials & Resources (MR) – Up to 23 Points			
MR-1	Life Cycle Assessment (LCA)	2	Conduct a detailed LCA of the entire project
MR-2	Pavement Reuse	1-5	Reuse existing pavement sections
MR-3	Earthwork Balance	1	Use native soil rather than import fill
MR-4	Recycled Materials	1-5	Use recycled materials for new pavement
MR-5	Regional Materials	1-5	Use regional materials to reduce transportation
MR-6	Energy Efficiency	1-5	Improve energy efficiency of operational systems
Pavement Technologies (PT) – Up to 20 Points			
PT-1	Long-Life Pavement	5	Design pavements for long-life
PT-2	Permeable Pavement	3	Use permeable pavement as a LID technique
PT-3	Warm Mix Asphalt (WMA)	3	Use WMA in place of HMA
PT-4	Cool Pavement	5	Contribute less to urban heat island effect (UHI)
PT-5	Quiet Pavement	2-3	Use a quiet pavement to reduce noise
PT-6	Pavement Performance Tracking	1	Relate construction to performance data
Custom Credits (CC) – Available for all projects based on context and innovation, subject to approval			
CC-1	Custom Credit 1	1-5	Design a new voluntary credit
CC-2	Custom Credit 2	1-5	Design a new voluntary credit
	Greenroads Total Points:	**118**	

APPENDIX 5 | LANDSCAPE PLAN DEVELOPMENT

When landscaping is incorporated into a project, a landscape plan must be incorporated in the construction documents. The plan should be developed in consultation with the CDOT Landscape Architect to go over conceptual and final design intent. For a successful product in the field, the document must be as accurate as possible with all necessary pay items and specifications associated with it.

The landscape plan is based upon the goals and objectives set forth in discussions with the Region and other involved personnel. The environmental manager, CDOT landscape architect, engineers, consultant and other people as deemed necessary, should tour the site of the project to become familiar with the project location and to discuss various landscape options.

A. Site Inventory

A site inventory should be performed to document existing conditions that affect the planting design. Items to be considered include the following:

1. Existing vegetation - if present:
    a. Identify plant communities that are native to the area and note individual plants or plant groups that should be preserved.
    b. Are there any plants that can be transplanted?
    c. Note existing grasses and forbs, if reseeding with a native seed mix
    d. Are there any noxious or nuisance weeds on site that will have to be addressed?
2. Existing/potential view sheds. Note aesthetically pleasing views so they be preserved or enhanced.
3. Existing terrain
4. Drainages and ditches
5. Slope and slope aspects
6. Soil types
7. Adjacent land uses
8. Access
9. Right of way limits
10. Existing fences
11. Adjacent structures. Note items such as buildings, outdoor advertising signs locations, and lighting
12. Utility locations. Underground and over head

13. Areas appropriate for planting
14. Areas appropriate for native seeding
15. Areas of erosion
16. Unpleasant views
17. Structures, such as Noise walls, guard rails, underpasses

B. Final Landscape Plan

The final landscape plans and specifications should be included in the FOR (final office review) document.

Base Map Scale: 1”=100’ or greater (1”=50’)

1. Label
    a. North arrow
    b. Scale
    c. Stationing of adjacent roadway
    d. Highway, road or street names
    e. Any other pertinent information
    f. Legend showing plant symbols and common names on each sheet
    g. Match lines
18. If planting is occurring on a corridor project, where multiple sheets are required, include a site location map on each sheet.
19. Show, if applicable:
    a. Utilities lines
    b. Right of way lines
    c. Toe of slope
    d. Drainage structures or culverts, riprap locations
    e. Existing vegetation and wetlands
    f. Limits of disturbance
    g. Any other pertinent information
20. Grading plan, when applicable, should include:
    a. Labeled existing and proposed contours
    b. Any high points or low points
21. Identify proposed areas for planting. Each sheet that includes planting:

a. Label plant material and include a legend showing the plant symbols and common names

C. LANDSCAPE TABULATION SHEET

The landscape tabulation sheet should include the following items:

1. Plant material tabulation:
    a. Common and Scientific names
    b. Size of material
    c. Unit
    d. Quantities
    e. Plant spacing
    f. Any additional comments on the condition of plants (i.e. Clump form)

If the project is a corridor project with multiple sheets, the tabulation should be broken down to the amount of material used on each sheet (for plants, mulch, edging, etc.) and then totaled for the project.

2. Notes. These may include, but are not limited to:
    a. Any pre-construction meetings that should take place prior to construction commencing to discuss design intent.
    b. Time of year work is to be accomplished.
    c. Topsoil. Location of source, depth it should be obtained to, depth it should be placed. If topsoil is not to be used, soil amendments should be added to the soils. Contact the CDOT Landscape Architect for more information.
    d. Responsible party for staking tree, shrub, and perennial plants, locations prior to planting (typically the CDOT landscape architect or contractor can do this with CDOT Landscape Architect approval).
    e. Soil amendments for planting pit. Fertilizer should not be included in wetland areas.
    f. Who is supervising or approving grades, etc. (typically the CDOT landscape architect).
    g. Survey hours to ensure final grades are accurate.
    h. Wildlife control or cattle control.
    i. Herbicide treatment for noxious or nuisance weeds.
    j. Erosion control - if in addition to the stormwater management sheet.
    k. Slope stabilization techniques - if in addition to the stormwater management sheet
3. Details included on plans may include:

a. Clarifying cross-section of landscape design intent
b. Beaver control fence
c. Tree or shrub planting details if different technique from the CDOT M-214-1 Planting Standards
d. Hardscape details - wall, pavement, etc.
e. Amenity details - lighting, trash receptacles, etc.

4. Provisions for protecting existing vegetation not to be disturbed during construction. This may include: placing orange plastic fence to prevent encroachment from construction traffic.

5. Pay items and quantities for all items. Pay items and descriptions must match the CDOT Cost Item Book. Quantities, may include, but not limited to:
    a. Unclassified excavation - when grading is included in the landscape plan.
    b. Dozing hours for fine grading
    c. Topsoil
    d. Silt fence, or other erosion control features not addressed on the Stormwater Management Plan Sheet
    e. Plant material - trees, shrubs, perennial plants, etc.
    f. Wood chip mulch. If large mulch beds are being placed on the project, mulch should be paid for separately. Otherwise, mulch can be included in the price of the plant material.
    g. Rock mulch
    h. Metal edging
    i. Landscape Maintenance. Landscape maintenance should be paid for when additional maintenance is needed on a project above what is typically covered in the landscape establishment period. See Section 214 Planting, of the CDOT Standard Specifications Book.
    j. Landscape Incentive. An incentive may be considered in non-irrigated situations. This should be discussed with the project manager, region environmental and CDOT landscape architect prior to adding the pay item to the project.
    k. Watering. Paying for water may be considered when planting in non-irrigated situations, not located adjacent to wetlands or other water sources.
    l. Transplant tree or shrub
    m. Weed barrier fabric - can be paid for separately or included in the price of the work. Weed barrier fabric should be paid for as Geotextile (weed barrier), or a special provision is required.
    n. Herbicide - when noxious weeds are present on the site, herbicide should be considered
    o. Plastic fence - to protect existing vegetation
    p. Applicable irrigation pay items

q. Force account items for irrigation and landscape repair that may be required if existing landscape in the area is going to be damaged by construction.

D. PLAN DEVELOPMENT AND REVIEW

During the plan preparation the landscape architect should be in contact with team members for additional information, if needed. Team members include region environmental, CDOT landscape architect, design and construction engineers.

Specifications must be developed for all pay items not covered in the CDOT Standard Specifications book. For information on Special provisions that are available for additional landscape items or what may be required, contact the CDOT landscape architect.

E. FINAL OFFICE REVIEW

Plans and specifications should be included in the FOR set of plans for review. Any revisions that occur from this meeting must be done prior to the Advertisement date.

F. CONSTRUCTION

When specified on the plans a pre-construction meeting should occur on site prior to landscape construction commencing. This meeting should include the engineer, contractor, CDOT landscape architect, and if necessary, region environmental. The meeting is to discuss the landscape intent, clarify who should be contacted if problems arise during construction, and let the engineer know whom they should be contacting for review and overseeing of the landscape construction project. Typically the person aiding in construction is the CDOT landscape architect.

- A SEEDING PLAN must use native species; both warm season and cool season grasses, both bunch and sod forming grasses, native wildflowers, shrubs(if approved by maintenance) and a nurse crop. The seeding plan must identify the method of seeding and mulching, address the soil conditioning/organic fertilizer and include soil retention blanket when in design.

- Pure Live Seed is based on seed species/pound and desired seeds/ square foot (ideal seed/ft is 100). Nurse crops weight should not exceed 5 pounds/square foot.

- Soil preparation, soil conditioning or topsoil, seeding (native), and spray-on mulch blanket will be required for an estimated xxx acres of disturbed area within the right of way limits which are not surfaced. The following types and rates:

Biological nutrient organic based fertilizer (lbs./acre)*	Humate (lbs./acre)	Compost (cyds./ acre) (1/2 inch depth)
600	200	65

*Biological nutrient shall not exceed 8-8-8 (Nitrogen-Phosphorus-Potassium/N-P-K). Humate based material and compost shall be in accordance to Section 212. Refer to Project Special- Topsoil for additional topsoil amendments. Placing compost when required to amend embankment in accordance to special provision 207 and 212, and as soil conditioner may be combined as a single application.

- BLANKET APPLICATION: On slopes and ditches requiring a blanket, the blanket shall be placed in lieu of mulch and mulch tackifier. See SWMP for blanket locations.

- SEEDING APPLICATION: Drill seed 0.25 inch to 0.5 inch into the soil. In small areas not accessible to a drill, hand broadcast at double the rate and rake 0.25 inch to 0.5 inch into the soil.

- MULCHING APPLICATION: Apply 1.5 tons of certified weed free native hay per acre mechanically crimped into the soil in combination with an organic mulch tackifier.

- SPECIAL REQUIREMENTS: Due to high failure rates, hydromulching and/or hydroseeding will not be allowed

- Soil conditioning and fertilizer requirements:

Soil conditioner paid for as Item 212- Soil Conditioning (Acre)

APPENDIX 7 | NOISE BARRIER DESIGN PROCESS AND SUBMITTALS

When drafting a Form 463 or a scope of work for consultant services, the CDOT design project manager should contact the District's noise specialist in the Environmental Unit to ask if a noise analysis is required to determine a need for barriers. Under Federal Highway Program Manual 7-7-3, noise analyses are required for most lane addition and bridge widening projects. If one is required, the noise specialist will determine whether it will be done by the District or the consultant (if there is one). Regardless of who will do the analysis, the following design information will be needed:

Required Design Data:

1. Topographic mapping at any standard scale (50, 100 or 200:1) with:
    a. Proposed roadway alignments (with stationing) superimposed on the existing system;
    b. The number of through lanes, and any auxiliary lanes over .4 miles in length (each direction);
    c. One or two-foot contours and building footprints;
    d. Identification of residences and businesses within the footprints, noting any that will be displaced by the project.
2. Existing and proposed roadway profiles.
3. Existing and proposed typical section.
4. Highest peak hour or DHV traffic data for all roadways:
    a. Existing volumes;
    b. Year 2010 project volumes;
    c. Vehicle mix (percentage of autos, single unit trucks, and combination trucks) of existing volumes (available form CORIS), and project 2010 mixes (if the consultant has developed any).

<u>During Conceptual Design and FIR</u>: If sufficient design information is available, the preliminary noise analysis should be completed by the time the FIR is held (for those projects without EIS's or EA/FONSI's). If the analysis is completed by a consultant, the District's noise specialist should be allowed two weeks to review the data file, topo grid, and approve the OPTIMA results. He/she should meet with the consultant's noise analyst to discuss assumptions in the data, and follow up analysis may be required before noise related design work begins.

For projects that have EIS's or EA/FONSI's: The scope of work for the consultant should include a review of all environmental commitments made in those documents to avoid late review discoveries that would require redesign to accommodate noise barriers (see the discussion under Height Considerations).

During Final Design: Subsequent refinement of the barrier placement, such as the relocation of short barrier segments to save construction costs or to avoid new-found utilities, is almost necessary before the project is advertised for bids. The designer should always contact the District's noise specialist when such refinements are needed so that the acoustic sufficiency of the design change can be evaluated. Copies of the sheets from the FOR plan that show the noise barrier location, heights, and details should be sent the specialist for review.

Noise Barrier Design Approval after FOR: Copies of the sheets from the final bid plans that show the noise barrier location, heights, and details should be sent to the State noise specialist and to the design project manager after the final bid plans have been reviewed for conformity with the noise analysis, shortly before the advertisement for construction bids. The District noise specialist will obtain FHWA approval of noise mitigation that is required for interstate projects.

APPENDIX 8 | RIPARIAN AND STREAM RESTORATION SB 40

GENERAL CONDITIONS

Sections II and III provide guidance for determining when SB 40 wildlife certification is necessary and when application should be made. This section lists general conditions, or best management practices, that apply to all jurisdictional SB 40 transportation projects whether those projects require formal or programmatic certification. These general conditions are designed to minimize or avoid potential negative impacts from CDOT projects in the vicinity of aquatic systems and riparian areas. Efforts to control erosion and to avoid impacts to aquatic resources and riparian areas, including wetlands, should be commensurate with the size of the project, site conditions, the quality of the natural resource, and the potential for off-site damage. The practices discussed below are intended to be in conformance with guidelines specified in the following CDOT documents: *Erosion Control and Stormwater Quality Guide*; *Standard Specifications for Road and Bridge Construction*; Municipal Separate Storm Sewer System (MS-4) permit; and CDOT *Drainage Design Manual*.

A. Temporary fills, such as coffer dams and temporary road crossings, using imported material shall utilize clean, chemically-free fill to avoid increasing suspended solids or pollution. Fill material shall not be obtained from the live water area in the stream unless approved by Division of Parks and Wildlife.

B. Discharge of water directly into the stream from coffer dams or new channel construction shall be in accordance with applicable Clean Water Act Section 401, 402, and 404 regulations and permits. In some instances, such water must be treated prior to discharge.

C. All reasonable measures shall be taken to avoid excess application and introduction of chemicals into aquatic ecosystems and adjacent riparian areas, including wetlands. The use of chemicals such as soil stabilizers, dust palliatives, herbicides, sterilants, growth inhibitors, fertilizers, deicing salts, etc., during construction and maintenance operations shall be in accordance with the manufacturer's recommended application rates, frequency, and instructions. These chemicals shall not be used, stored, or stockpiled within 50 horizontal feet of the ordinary high water mark of any state waters, including wetlands, except when otherwise specified in the project contract.

D. Construction staging areas, including construction and waste material, fill material, equipment, fuel, etc., shall be located outside of the area adjacent to streams, including wetlands and riparian areas. At a minimum, such staging areas and materials shall not be located within 50 horizontal feet of the ordinary high water mark of any watercourse. Equipment refueling and servicing shall occur only within approved designated areas.

E. All equipment shall be free of noxious weed seed and reproductive vegetative plant parts prior to use of that equipment in aquatic ecosystems and riparian areas, including wetlands. Such equipment shall be maintained in good working order to avoid

unnecessary discharge of harmful materials used in the operation of that equipment, including petroleum products, radiator fluid, hydraulic fluid, etc.

F. No wet concrete from placement of forms, washing of trucks or equipment, or concrete saw water shall be allowed in aquatic ecosystems and riparian areas, including wetlands. Concrete washout activities may occur only within approved, designated areas per CDOT specifications.

G. Erosion control is required on all projects. Project construction activities that result in land disturbance of equal to or greater than one acre require a stormwater Construction permit. Erosion control is particularly important around aquatic ecosystems and riparian areas, including wetlands, because of their sensitivity to sediments and pollution in roadway runoff. Temporary and permanent erosion and sediment control measures shall be installed at the earliest practicable time consistent with permit requirements and good construction practices. Such measures shall be properly monitored and maintained throughout the operation of the project per permit requirements.

H. All practicable efforts shall be expended to avoid and minimize instream work. Where practical, equipment shall be operated from banks or shoulders above riparian and wetland areas. In those instances where instream work is required, such work shall be performed during low- or no-flow periods, and the use of heavy equipment in streambeds, especially in live or flowing water, shall be minimized. The equipment used shall be of such a type that will produce minimal environmental damage, including damage to the stream bottom. Except for authorized in stream work, fording streams will be allowed only as authorized by the U.S. Army Corps of Engineers 404 Permit.

I. Under current CDOT policies and the General Conditions of the 404 permit, in stream work is limited to specific periods in order to avoid disruption of fish migration and spawning seasons. Under certain circumstances, in stream work during such periods may be allowed. Special construction techniques are required during such situations and shall be pursued in consultation with Division of Parks and Wildlife staff. The timing of such activities shall be based on the species, elevation, and location of the project after consultation with Division of Parks and Wildlife staff.

J. During the planning and construction of a project, all practicable measures shall be taken to avoid disturbance to existing vegetation. The length of time that disturbed areas are left exposed shall be as short as practicable and the extent of such disturbed areas shall be as small as practicable. Limitations on the duration and extent of disturbed areas lessen the potential for erosion and runoff of sediments into adjacent areas. Sensitive areas shall be fenced as necessary. Particular attention shall be paid to protecting aquatic ecosystems, riparian areas, wetlands, and habitats for threatened and endangered species from such impacts and unnecessary disturbance. Once earthwork has begun on a section, it shall be pursued until complete. Final stabilization shall begin within 48 hours after topsoil placement, soil conditioning, or combination thereof starts and shall be pursued to completion. Disturbed areas where work is

temporarily halted shall be temporarily stabilized immediately after the activity ceases for the day. Disturbed surfaces outside the pavement limits slope shall be left in a surface roughened or vertically tracked condition at the end of each shift.

K. All disturbed areas above the ordinary high water mark shall be revegetated with appropriate native plant species to provide bank stabilization, erosion control, and habitat replacement. These activities shall be conducted according to specifications approved by the CDOT landscape architect. Temporary seeding shall be done where necessary and all practicable efforts shall be expended to control the spread of weeds. Only certified weed-free hay and straw shall be used.

L. All practicable effort shall be expended to avoid unnecessary destruction of trees and shrubs in the vicinity of streams and in riparian areas. Trees removed should be considered for use on-site in a manner that improves riparian and in stream habitat and for bank stabilization purposes. Trees removed during construction, whether native or non-native, shall be replaced with a goal of one-to-one replacement based on a stem count of all trees with diameter at breast height of 2 inches or greater. Tree replacements shall be considered successful as per CDOT Specification 214 which requires a 12-month Landscape Establishment period beginning at the spring planting season and beginning immediately.

If the Notice of Substantial Landscape Completion is issued at any other time the landscape establishment period begins at the start of the next spring planting season. Additional trees may need to be planted to replace any unsuccessful plantings and subject to the same criteria until a 1:1 ratio has been successfully achieved. Shrubs removed during construction, whether native or non-native shall be replaced based on their pre-construction areal coverage. Shrub replacements shall be considered successful as per CDOT specification 214 and subject to the same criteria as the trees. In all cases, all such trees and shrubs shall be replaced with native species.

Where lack of sufficient right of way space limits full replacement on site, consideration should be given to placement of the remaining stock in other areas that serve similar stream functions. Additional considerations should include the existence of appropriate growing conditions, consistency with existing natural conditions, what is best for the natural resource, and input from the CDOT landscape architect and staff biologist. Given these site considerations, it may be appropriate to replace trees with shrubs under certain circumstances.

M. All practicable efforts shall be expended to avoid and minimize impacts to streams, riparian areas, and wetlands. Because of their importance to wildlife and the environment, all practicable efforts shall be made to replace on site all wetlands and riparian areas impacted by the project.

N. Riprap above the ordinary high water mark shall be covered with topsoil and revegetated as specified by the CDOT landscape architect. Areas under bridges do not need topsoil treatment. Where appropriate, streamside areas at the ordinary high

water mark should be revegetated with brush layer cuttings of native riparian shrub species.

O. Preference shall be given to bioengineering solutions for stream stabilization projects and for improving stream and riparian habitat values. Use of such techniques, however, should be mindful that appropriate growing conditions exist. Bioengineering techniques, such as native riparian shrub plantings, are required for all bank protection activities that exceed 50 linear feet in important spawning areas.

P. During project design and construction, consideration should be given to ways to improve in stream habitat and riparian areas in the vicinity of such projects. Where necessary, appropriate in stream structures shall be used to dissipate water velocity, reduce erosion, and improve fish habitat. DPW shall be consulted regarding the means and methods being considered to improve in stream habitat and riparian areas.

Q. Stream crossing structures shall not degrade the stream or fish habitat or block fish movement, including constricting stream flows that increase water velocities, nor shall such structures unnecessarily widen streams and thereby decrease water velocities and increase sediment deposition.

R. Highway runoff shall be diverted away from the stream channel and associated wetlands to avoid siltation and other pollution problems. Such runoff shall be treated with the most appropriate temporary and permanent best management practices.

S. When temporary crossing or work areas occur in wetlands and riparian areas, it may be possible to prepare the area such that construction impacts are limited and temporary. This is especially true of willow thickets. In such cases, the area is cut down to ground level, geotextile fabric is laid down and a layer of certified weed-free hay or straw is laid on top. Thereafter, a layer of soil at least two feet thick is applied on which construction equipment can move. After construction is complete, the layer of dirt is removed until the layer of hay or straw is encountered. This layer signifies that the geotextile fabric layer is near and more careful excavation is necessary. Last, the layer of geotextile fabric is removed. Such areas should recover within one or two growing seasons. Note: this technique may not be appropriate for extremely wet areas or on soils with a high percentage of organic matter. All materials shall be removed from site once work is completed.

T. In terms of mitigating unavoidable impacts to wetlands and riparian areas, restoration and creation of such areas should be conducted as close as practicable to the impact site in order to preserve the local functions and values of such areas. Consideration of the various mitigation options available should involve evaluation of what is best for the aquatic resource as a whole. Completion of the required mitigation should also occur as quickly as possible. Substantial delays in the replacement of wetlands may result in increased mitigation requirements.

U. On projects involving SB 40 certification, consideration shall be given to

eradication of state-designated noxious weeds in riparian environments. Under some circumstances, it may be possible to use such efforts as a mitigation option in areas where replacement of habitat is limited.

V. Invasive Aquatic Nuisance Species. In order to avoid the spread of invasive aquatic species including but not limited to Eurasian water milfoil, zebra mussel, quagga mussel, and New Zealand mud snail, the following BMPs shall be practiced. This guidance is also intended to fulfill requirements set forth under General Condition 11 (Invasive Aquatic Species) for Nationwide Permits under Section 404 of the Clean Water act.

If heavy equipment is used that was previously working in another stream, river, lake, pond, or wetland one of the following procedures is necessary to prevent the spread of Aquatic Nuisance Species and other pathogens:

> Remove all mud and debris from equipment (tracks, turrets, buckets, drags, teeth, etc.) and spray/soak equipment with a solution of Sparquat 256 (5 ounces Sparquat per gallon of water). Treated equipment should be kept moist for a least 10 minutes, managing rinsate as a solid waste in accordance with local, county, state, or federal regulations,
>
> OR
>
> Remove all mud and debris from equipment (tracks, turrets, buckets, drags, teeth, etc.) and spray/soak equipment with water hotter than 140 degrees F for at least 10 minutes.

SPECIAL CONDITIONS

This section lists special conditions that apply specifically to the four primary project activities in and adjacent to streams – structural crossings, bank stabilization, stream encroachment, and channel re-alignment. These special conditions are to be used in conjunction with the general conditions in Section V. Like the general conditions, these special conditions apply to all jurisdictional SB 40 transportation projects whether those projects require formal or programmatic certification.

A. <u>Structural Crossings</u>

1. As practicable, stream profile, substrate and habitat values shall be restored to a condition similar to or better than pre-project conditions. During project design and construction, consideration should be given to ways to improve in-stream habitat and riparian areas in the vicinity of such projects. Where necessary, appropriate in-stream structures shall be used to dissipate water velocity, reduce erosion, and improve fish habitat. DPW shall be consulted regarding the means and methods used to improve in-stream habitat and riparian areas.

2. Water diversions shall be minimized. Only use clean water diversion techniques

when necessary to divert water around or to pipe water through the active construction site to minimize water quality contamination, siltation, and sedimentation.

3. Unless otherwise stipulated, temporary or permanent culverts shall be embedded and backfilled 12 inches into the channel substrate.

B. Bank Stabilization

1. Where practicable, preference shall be given to bioengineering techniques for bank stabilization and similar activities. Bioengineering techniques, such as native riparian shrub planting, are required for all bank protection activities that exceed 50 linear feet in important spawning areas.

2. Riprap materials used below ordinary high water shall be durable angular rock free of organic material, pollution, and erodible material such as dirt and gravel. Rounded river cobble or stone is not acceptable as riprap.

3. In streams with less than 20 feet average width at the ordinary high water mark (OHWM), no more than ¼ cubic yard of material per linear foot may be placed below the plane of the OHWM. This requirement is based on Section 404 regional conditions for Colorado. Placement of materials in excess of these limits requires notification to the U.S. Army Corps district office.

4. Use of gabions is discouraged except where no other practicable solution exists to address the problem. If gabions are used in bank stabilization, the gabion shall be clean, durable rock material free of organic matter, sand, dirt, and gravel. River cobble is an acceptable material for filler provided it is large enough to stay within the mesh.

C. Channel Re-Alignment

1. Stream profiles, substrate and aquatic habitat values shall be restored equal to or better than pre-construction conditions as practicable. All practicable efforts shall be expended to maintain the existing stream length and width and to establish a low-flow channel in the realigned stream channel.

2. Existing or comparable stream bottom material shall be used in the re-aligned stream channel. However, such material shall not be obtained from the live water area in the stream unless approved by DPW.

3. When practicable, a reasonable vegetated buffer area shall be maintained between the stream and the highway.

During project design and construction, consideration should be given to ways to improve in stream habitat and riparian areas in the vicinity of such projects. Where necessary, appropriate in stream structures shall be used to dissipate water velocity, reduce erosion, and improve fish habitat. DPW shall be consulted regarding the means and methods used to improve in stream habitat and riparian areas.

D. General Procedures under Special Conditions

The following are general procedures to be used during the four primary construction activities discussed above:

1. Water shall be diverted around or piped through the active construction site to minimize water quality contamination, siltation, and sedimentation. These are commonly referred to as clean water diversions. Design and use of such diversions shall be mindful of fish movement requirements.

2. Where possible, all work shall be done from above, not in the stream.

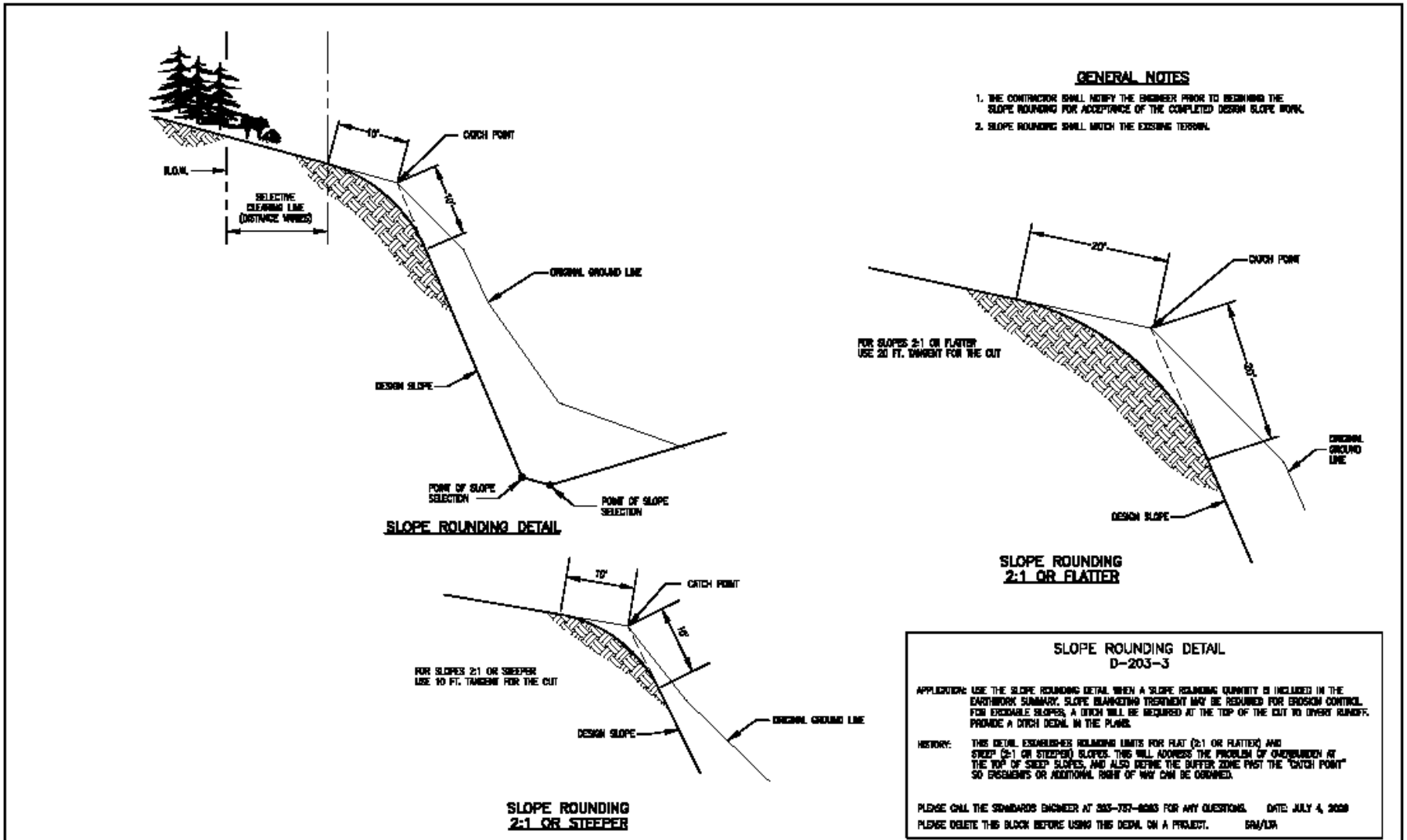
3. In clearing trees and shrubs to facilitate work in riparian areas and associated wetlands, plants shall be trimmed above the ground without removing the root mass.

4. All temporary fill shall be removed to an upland site upon completion of wetland or in stream construction activities unless otherwise agreed upon by CDOT, the U.S. Army Corps, and DPW. Such fill material shall be stabilized and revegetated at its upland site.

5. When temporary crossing or work areas occur in wetlands and riparian areas, the techniques used shall follow those discussed for temporary work areas in General Condition(s).

6. All practicable efforts shall be expended to avoid channelization of streams. In situations where channelization is unavoidable, consideration shall be given to installation of in stream energy-dissipating and grade control structures.

9 I SLOPE ROUNDING DETAIL



APPENDIX 10 | VISUAL AESTHETICS AND VISUAL IMPACT ANALYSIS

Introduction:

The *Visual Impact Assessment for Highway Projects* manual (FHWA, 1990) was used to develop a methodology for describing existing conditions and assessing visual impacts. The methodology included field documentation of the existing visual character; an inventory of land use; referencing existing community plans; and identification of important view sheds and areas of high scenic integrity for motorists, residents, and corridor users from field reconnaissance and public input. Visual resources are not limited to elements or features that are of outstanding visual quality, but include all features regardless of their quality. Viewer sensitivity or local values can add visual significance to landscape features and areas that could otherwise appear unexceptional.

Public concerns expressed through the public involvement process regarding visual character include:

- Definition of terminology
- Identification of important views from various points within the study area.
- Identification of how important or sensitive views/view sheds were determined.
- Description of alternative screening related to visual quality issues.
- How cumulative projects affect the overall visual character of the study area.
- Description of landscape characteristics; and reference to previous doc.

Visual Aesthetics and Visual Impact Analysis Introduction:

Americans have repeatedly shown in surveys that driving on scenic roads is one of their favorite activities. Public opinion on the visual importance of roadway facilities makes it essential to assess visual impacts during the transportation development process. Community acceptance of a project may be influenced by the visual effects of the project. Highway planners can help resolve controversies with public groups by assessing visual impacts and the effectiveness of proposed mitigation measures.

Many Federal laws and regulations deal with visual considerations in the highway environment. The Historic Preservation Act of 1966 directs federal agencies to account for the effects of proposed projects in historic resources. The National Environmental Policy Act of 1969 (NEPA) states that it is the responsibility of the federal governments to “use all practicable means” to “assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings.”

The following is an outline of a visual assessment methodology to use in evaluation of the visual impact of a highway on the environment around it and the impact of the highway on viewers in other public locations.

Visual Impact Assessment Methodology, adapted from: https://www.dot.ny.gov/divisions/engineering/environmental-analysis/repository/I.pdf

Introduction

- Determine the need for a Visual Impact Assessment (VIA). VIAs might be required in major reconstruction projects where there is a substantial visual change proposed in the highway corridor, or where new or out-of-kind replacement buildings, bridges or other structures are proposed, or where there is significant vegetative cutting along State highways.
- Prepare a Visual Impact Assessment (VIA) of significant visual resources. The VIA shall be prepared by or under the direct guidance of a Registered Landscape Architect experienced in VIA preparation.
- In addition to the general methodology and subtasks, consult with the LA regarding any project-specific methodology and subtasks before starting the work.

Viewers, Viewsheds and Views

- Prepare appropriate viewshed mapping for existing conditions each design alternative to define the physical limits of the affected visual environment.
- Delineate the relevant viewsheds on a 7.5 minute topographic map: Foreground (0 to 0.5 mile), middleground (0.5 to 3.5 miles) and background (3.5 to 5 miles).
- Indicate the location of all public use areas on this map.
- Identify each viewer group within the project area and determine the viewer exposure and viewer sensitivity of each group.
- Identify the key views and the range of significant visual resources for each viewer group. Conduct necessary in-field analysis. Key views shall include the views of the project that best represent the visual environment for each design alternative.

Visual Simulations

- Prepare high quality representative photographs from each identified viewing location (i.e., photo station) keyed to the maps and showing both existing and proposed/simulated views. At least two, 8-1/2 inch x 11 inch photographs using 55mm and 85mm camera lenses should be provided from each photo station. Also provide GPS coordinates for each station. A third photograph using a 120mm or greater camera lens is recommended for each photo station to aid in the development of simulations. Photographs should be labeled or indexed to a table describing the location the photograph was taken from and the size (mm) of the camera lens used.

- Determine what constitutes sufficient detail for producing quality simulations, e. g., pavement delineation, guide rail, traffic control devices (overhead signs, signals, etc.), structure type (truss vs. contemporary), sidewalks, side roads, and any enhancements. Based on this information produce the visual simulations and review initial drafts before they are finalized.

Visual Impacts

- Assess the visual impacts of each design alternative, including changes to significant visual resources and probable viewer response to these changes.

- Separate representative line of sight profiles of actual visibility from each viewing location/photo station depicting the proposed structure, existing topography and heights of intervening vegetation may be required.

Mitigation

- The VIA shall include measures to avoid, minimize, or mitigate negative visual impacts and to enhance positive impacts. Descriptions and costs of these measures shall be in sufficient detail for incorporation into the preliminary design and for use in evaluating relative advantages and disadvantages among the alternatives.

- Document this study in a Visual Impact Assessment report, to be presented as a technical appendix. This report shall include color copies of the simulations.

Reducing Visual Impacts: Several of the visual mitigation techniques have been described in related sections of the Manual. The measures are summarized below:

Landforms: When landforms are disturbed by roadways, several measures can be taken during grading operations to reduce the visual impacts and to aid in the revegetative process.

Slope Rounding: Slope rounding breaks the sharp unnatural edges formed by the junction of a cut or fill slope with the naturally rounded land form. Where rounding occurs above the slope, additional right of way may be needed and more vegetation disturbed, but rounding decreases the time required for revegetation on a slope. Visual scars heal faster as well.

Lay Back Draws: Where natural draws are encountered, the cut slope can be laid back to match the existing grade.

Warping Slopes: Warping slopes is a slope treatment to vary the slope ratios to blend with the surrounding land forms. Through this technique false draw, ridges, and rolling slopes can be created.

Large Boulders: Slope diversity can be added by the use of large boulders or rock outcroppings found during excavation. These rocks can be placed in random clusters or individually during grading operations to provide a more natural appearing highway slope. Clusters and individual rocks should be of different sizes and spacing. Contact the CDOT landscape architect for boulder placing.

Selective Thinning: Selective thinning is an on-site design process that can be used for scenic enhancement along with clearing a zone for roadside safety. The CDOT landscape architect will mark the trees for removal. Thinning breaks up straight lines of trees left by roadway clearing and grubbing operations. An irregular free flowing clear line provides the traveler with enclosures and openings which add to the driving experience and can provide for wildflower meadows.

Selective thinning for safety increases the off-road vehicle recovery space, vehicle site distance, reduces vehicle/animal collisions, and provides snow storage space.

When selectively thinning the following trees should be considered for removal:

- Trees left in an altered state due to change of grade, hydrology, etc.
- Trees that are hazardous, dying, diseased or dead
- Trees of undesirable species
- Those subject to windthrow
- Trees intolerant of ice-melting chemicals
- Those trees subject to sun scaled

- Trees obstructing desirable views.

Successful thinning leaves a stand of healthy trees with various ages.

Along with thinning, feathering the edges of a cut adds to the clear line. Feathering involves reduction of the vegetative density along with a gradation from tall vegetation to low vegetation at the clearing edge. Contact the CDOT landscape architect for an AutoCAD detail sheet to be added to the set of plans.

APPENDIX 11 | WETLAND MITIGATION AND RESTORATION

Prior to commencing any work on the project the designer should discuss the mitigation site with regional environmental personnel, CDOT landscape architect and the person responsible for doing the wetland delineation and associated finding. Items that need to be assessed are:

- Is the wetland mitigation site a creation, restoration or enhancement site?
- Size of mitigation area(s).
- Type of mitigation required.
- Site visit. Depending on the project, a team of people may be required for the site visit including, but not limited to, region environmental, CDOT biologist and landscape architect, hydrologist, design and construction engineers. During the site visit the following may be assessed:
    - Existing vegetation in the area:
        - Identify upland plant species for revegetation of upland slopes following construction.
        - Is there a willow source nearby for cuttings?
        - Are there adjacent wetlands not being impacted, where plugs of wetland plant material may be obtained?
        - Are there trees, shrubs or existing wetlands that need to be protected during construction? Riparian vegetation should not be cut down to create wetlands.
        - Are there any visible utilities on the selected site?
    - Hydrology.
        - Is the water at the proposed site from groundwater or surface flow? What is the water source?
        - What is the quality and quantity of the water?
        - Will there be seasonal fluctuations in the water source?
    - Are there any signs of nuisance wildlife (i.e. beaver, deer) or grazing cattle that will require permanent fencing?
    - Are noxious weeds present on the site or adjacent to it that will require herbicide treatment?
    - Soils:

        - Is wetland or regular topsoil available on site? Wetland topsoil containing cattails should not be stockpiled for future use in the mitigation site.
        - What is the soil composition? (sands, clays or silts) Is bedrock present?
        - How permeable and/or erodible are the soils.
        - Is there any chance that the soils may be contaminated?
    - Where is the right of way line located? Will additional right of way be necessary? Is an easement possible?
    - If applicable, has staking for new toes been done? How do they affect the site location?
    - Ground water-monitoring wells:
        - If wells have not been placed on site, should wells be placed on site to monitor ground water? Wells should be placed on a grid pattern across the potential site, with reference wells placed in adjacent wetlands, if possible. The number of wells depends on the size and the complexity of the site. Wells should be monitored weekly during the growing season to observe fluctuations in the ground water.
    - Earthwork. How much earthwork will be required? Can material be wasted within wetland project limits or on the project site?
    - Are hazardous materials present in the ground water or in the form of debris?
    - Is construction feasible? What are the limitations, if any?
    - What will the access to the site be? If necessary, can it be controlled?
    - Will there be any water rights issues?
- Review well data if available:
    - Data collected from mid-April through August is the most important, with emphasis on May-July.
    - Review the data from all the wells to determine the depth of the

ground water table. The year that the data was taken needs to be taken into consideration to determine if it was an average, dry or wet year for precipitation. If the water is too deep, costs to excavate could be prohibitive.

- Look for large fluctuations in the water table. Sites that have a lot of fluctuations in the water table may not be as desirable.

- Any problems that the designers foresee with the water table that may reduce the success of reestablishing a wetland should be reported immediately to the Region Environmental representative, as a new site may have to be located.

- Review surface water availability:

    - Will there be sufficient water to sustain the desired size of the wetland being designed? If expanding an existing wetland, it is essential to know how much water will be required to support the wetland. If there is insufficient water, expansion could result in a failed wetland creation site as well as loss of the existing wetland.

    - Will roadway sediment flow into the site? Roadway run-off can be used to supplement water supply, if a sediment basin is designed into the plan.

    - Will the site be subject to flooding? Will sediment deposition be a factor? Could the stream leave the channel and divert through the mitigation site?

    - Stormwater run-off *only*, is not a reliable source for water in a wetland mitigation site and should be avoided.

- If necessary, is there an existing survey for the site? If the mitigation site is located off-site, survey information may not be available; however, if grading is going to be required, a survey must be acquired. A survey should include:

    - Existing contours at 1 foot or 0.2 meter intervals.

    - Utility locations.

    - Fence locations.

    - Ground water-monitoring wells.

    - Vegetation lines surveyed. Where trees are within the site,

surveying each tree is helpful when grading the site.

If these items are not on an existing survey, a new survey may be required to ensure accurate plans.

- Determine if any permanent structures will have to be installed in order to control or back up the water on site. Sites with little or no future maintenance are preferred.
- After reviewing the data, ask yourself, will the mitigation site be successful in this location? If you have concerns, contact the Region Environmental person immediately.

Plan Development: When designing the mitigation areas remember that a self-sustaining wetland is priority.

- Grade the wetland after reviewing all available well data.
- Create elevation variations at the bottom of the mitigation site of +/- 6 inches, for species diversity.
- Choose plants, native to the area, that are adapted to the water levels, soils, and climate elevations of the site.

  For wetlands adjacent to streams consider:

  - Fluctuations in the stream due to the seasonal flows and storm events.
  - Erodibility of stream banks.
  - The dynamic natures of streams and rivers.

Final Wetland Mitigation Plan: The final wetland mitigation plan and specifications should be included in the FOR document.

Base Map: Scale: 1”=100’ or greater (1”=50’)

- Label
  - North arrow
  - Scale
  - Stationing of adjacent roadway
  - Highway, road or street names

    - Any other pertinent information
- Show, if applicable:
    - Utilities lines
    - Right of way lines
    - Toe of slope
    - Drainage structures or culverts, riprap locations
    - Existing well locations
    - Existing vegetation and wetlands
    - Limits of disturbance
    - Any other pertinent information
- Grading plan should include:
    - Labeled existing and proposed contours
    - Any high points or low points
- Identify mitigation area with a hatch symbol. Side slopes of a mitigation site are not considered part of the mitigation area. These areas should not be included in the total or shown as mitigation.
- Identify proposed areas for planting.
- Notes, may include, but not limited to:
    - Size of the mitigation area
    - Any pre-construction meetings that should take place prior to construction commencing to discuss design intent
    - Time of year work is to be accomplished
    - Plant types. Include:
        - Common and Scientific names
        - Size of material
        - Soil amendments for planting pit. Fertilizer should not be included in wetland areas.

    - Quantities

- Water requirements for wetland plants, i.e. saturated soils, 1-2” water, etc.
- Wetland topsoil, location of source, depth it should be excavated to, depth of placement
- Responsible party for staking tree, shrub, perennial plants, brush layer cuttings locations prior to planting (typically the CDOT landscape architect or contractor can do this with CDOT landscape architect approval)
- Who is supervising or approving grades, etc. (typically the CDOT landscape architect)
- Survey hours to ensure final grades are accurate
- Wildlife control or cattle control
- Herbicide treatment for noxious weeds
- Erosion control
- Slope stabilization techniques
- Seeding and mulching of upland slopes that are disturbed during construction. The upland seed mix may be the same as shown on the stormwater management plan sheet. Wetland and upland mixes should include:
    - Common and Scientific names
    - Variety of species, if applicable
    - Lbs. pure live seed (pls) per acre (kgs pls/hectare)
    - Seeding application
    - Mulching application

Details included on plans may include:

- Clarifying cross-section of wetland design intent
- Beaver control fence
- Wattles

- Tree or shrub planting details if different technique from the CDOT M-214-1 Planting standard
- Hydraulic structures required for mitigation: check structures, head gates, etc.

Provisions for temporary impacts to wetlands. This may include:

- Returning grades at culverts to the elevations of surrounding existing wetlands
- Placing a geotextile and straw barrier underneath detours or access areas to protect existing wetlands
- Stockpiling existing wetland topsoil. After construction work is accomplished in the area, return the wetland topsoil at the same location and elevation prior to the disturbance.

Provisions for protecting existing wetlands not to be disturbed during construction. This may include:

- Placing orange plastic fence to prevent encroachment from construction traffic
- Placing silt fence to prevent sediment or fill from entering wetlands
- Discussing with roadway engineers the possibility of steepening slopes adjacent to wetlands to avoid impacts.

Provide pay items and quantities for all items. Pay items and descriptions must match the CDOT Item Book. Pay items/quantities, may include, but are not limited to:

- Unclassified excavation
- Dozing hours for fine grading
- Topsoil
- Silt fence
- Seeding (native)
- Seeding (wetland)
- Mulching
- Mulch tackifier

- Plant material: brush layer cuttings, shrubs, trees, perennial plants, wetland plugs, etc.
- Herbicide
- Plastic fence

Fertilizer is not required on seeded slopes adjacent to the wetland mitigation sites, and should not be included when planting trees, shrubs, or wetland plants.

Plan Development and Review: During the plan preparation the wetland designer should be in contact with team members for additional information, if needed. Team members include region environmental, CDOT landscape architect, CDOT biologist, hydraulic hngineers, design and construction engineers. For wetland design done outside of CDOT, the CDOT landscape architect must review the plans prior to the FOR accuracy and content.

Specifications must be developed for all pay items not covered in the CDOT Standard Specification book. For information on Special provisions that are available for additional wetland items or what may be required, contact the CDOT landscape architect.

Final Office Review: Plans and specifications should be included in the FOR set of plans for review. Any revisions that occur from this meeting must be completed prior to the Advertisement date.

Construction: When specified on the plans a pre-construction meeting should occur on site prior to commencement of wetland mitigation construction. This meeting should include the engineer, contractor, CDOT landscape architect, and region environmental. The meeting is to discuss the wetland intent, to clarify who should be contacted if problems arise during construction, and to let the engineer know whom they should be contacting for review and overseeing of the wetland construction project. Typically the person aiding in construction is the CDOT landscape architect. The regional environmental person should be contacted for final review of the project and when any problems occur on site.

Compliance Objectives (SB 40 and 404 permit requirements) – Regulations

Planting in Wetlands – CDOT details

- Wetland Planting
- Wetland Vegetation
- Use of Native Plants for Wetlands

- Wetland Plant Patterns
- Plant Selection for Wetlands
- Wetland Plant Types
- Wetland Seed Mixes
- Wetland Plant Mortality Rates
- Wetland Plant Densities
- Source of Wetland Plants
- Wetland Planting Season
- Handling & Storage of Wetland Plants
- Rate of Planting for Wetlands
- Wetland Planting Techniques
- Water Level Management During Plant Establishment for Wetlands
- Facilitate Communication Between CDOT engineering and contractor

Monitoring

- Animal Protection
- Temporary Protection of Wetlands

APPENDIX 12 | WETLAND MITIGATION NOTES

SAMPLE WETLAND MITIGATION NOTES:

Preconstruction Meeting:

Prior to wetland construction commencing a preconstruction meeting shall occur on site between the engineer, contractor, CDOT landscape architect, and CDOT wetland biologist. At this meeting the following will be discussed:

[Select all that apply]

Permits

Access areas

Protection of existing vegetation and wetlands. Flag areas to be protected with fence (plastic).

Locations of wetland topsoil to be used at mitigation site. Areas shall be flagged for: [select one] immediate removal and stockpile, protection with fence (plastic) until scheduled for use.

Wetland mitigation intent

Planting

Sediment and erosion control in accordance with the Stormwater Management Plan (SWMP).

Wetland Protection:

[Select all that apply]

Prior to construction commencing the contractor shall place fence (plastic), as directed by flagging:

a. to protect existing vegetation (trees, shrubs, wetlands) not to be disturbed. No disturbance of soil or stockpiling of material shall occur within areas protected by fence.

b. to protect existing wetlands until wetland topsoil is scheduled for use.

c. to delineate access areas to limit construction traffic.

When disturbance is occurring near or adjacent to wetlands and there is a potential for sediment entering the wetland, BMPs shall be placed in accordance with the SWMP.

It is estimated that xxx lineal feet of item fence (plastic) will be required.

Wetland Construction:

[Select all that apply]

Existing topsoil at mitigation site shall be stripped to a depth of xxx inches and stockpiled in an upland location for reuse on newly created slopes adjacent to the mitigation area. Stockpiles shall be protected as directed by the SWMP. It is estimated that xxx cubic yards of stockpile topsoil will be generated.

[Wetlands with stockpile wetland topsoil]

Existing wetland topsoil from permanently disturbed wetlands shall be stockpiled for placement in the mitigation site. Stockpiled wetland topsoil shall not be stored for more than 3 months prior to being placed in the mitigation sites. Wetland topsoil shall not be stockpiled over the summer months. Wetland topsoil shall be placed to a depth of xxx inches. It is estimated that xxx cubic yards of stockpiled wetland topsoil will be required for placement onto the mitigation area.

Grades shown for the mitigation area are conceptual. Final contours shall be generated by xxx after well data is obtained from the xxx growing season.

Wetland grading shall be accomplished between dd/mm/year and dd/mm/year. Grading shall be accomplished only during non-growing season.

It is estimated that xxx cubic yards of Unclassified Excavation (CIP) shall be generated on site. Contours shown are final after placement of wetland topsoil.

Prior to final grading and placing of wetland topsoil, the engineer will arrange for the CDOT landscape architect to be on site to approve grades and shaping of the wetlands. The contractor shall verify elevations by surveying the wetland mitigation site prior to this meeting.

Wetland topsoil from stockpile shall be placed in the mitigation site to a depth of xxx inches. It is estimated that xxx cubic yards of wetland topsoil will be required.

Final contouring shall be accomplished by Dozing (Landscaping) hours (xxx to xxx hp range) capable of operating in saturated soils.

The mitigation site shall be left in a roughened condition. The engineer will arrange for the CDOT landscape architect to direct and approve final contouring of the site.

It is estimated that xxx square feet of wetlands will be created.

[Projects with direct transfer of wetland topsoil]

Wetland topsoil shall be excavated to a depth of xxx inches. It is estimated that xxx cubic yards of wetland topsoil shall be directly transferred to the mitigation area.

[Need to add notes for projects without wetland topsoil]

[Projects with soil placed over riprap]

Place clean embankment or topsoil from top of riprap to ordinary high water mark (2 yr. storm event) or designated contour over riprap to fill voids in rock. It is estimated that 30 cubic yards material/1000 sf of surface will be required to partially fill voids in rock.

[Need to add detail of fill over riprap]

Revegetation/Planting

[Select all that apply]

Immediately upon completion of grading, stockpiled topsoil shall be placed on disturbed upland slopes to a depth of xxx inches. Slopes shall be seeded with a native mix as directed by the SWMP.

Fertilizer will not be used in the wetland mitigation site and surrounding upland slopes.

Prior to planting the engineer will arrange for the CDOT landscape architect or CDOT wetland biologist to approve plant material.

Prior to planting nursery stock wetland material (214 Perennial (2.25 Inch Pot)) the engineer will arrange for the CDOT landscape architect to stake planting locations. Plants shall be placed in moist areas in the spring after the danger of frost and prior to May xxx. It is estimated that xxx perennial plants will be required on the project.

Wetland transplant plugs shall be placed in the mitigation area as directed by the CDOT wetland biologist or CDOT landscape architect. The engineer shall contact the CDOT wetland biologist or CDOT landscape architect to flag areas for wetland plug collection. Collection areas are xxx. Species to be used on site are: [list common and scientific names of plants]. Wetland transplant plugs shall be placed prior to xxx. It is estimated that xxx transplant plugs will be required on the project.

Water requirement for plant material:

[Add table of plant species showing water requirements such as saturated, saturated to 3”, up to 6” of water]

Brush layer cuttings shall be placed in the spring while dormant, prior to xxx. The engineer will arrange for the CDOT wetland biologist or CDOT landscape architect to stake locations for willow planting. It is estimated that xxx brush layer cuttings will be required on the project.

Prior to planting trees and shrubs the engineer will arrange for the CDOT landscape architect to stake planting locations. Shrubs and trees shall be planted as directed by the Standard Plans. Soil conditioning shall be used in the planting pits in accordance with subsection 214.03. Wood chip mulch shall be placed around the planting pits to a depth of 6 inches. Trees and shrubs shall be planted in the spring prior to xxx. Soil conditioning and wood chip mulch shall be included in the cost of the work.

Immediately after planting (same day) each tree shall have beaver protection installed. See detail.

Willow wattles shall be placed in the spring while dormant, prior to xxx. The engineer will arrange for the CDOT wetland biologist or CDOT landscape architect to stake locations for wattle placement. It is estimated that xxx wattles will be required on the project. See detail and Project Special Provision 214.

On site trees shall be salvaged to be used in wetland mitigation sites. The engineer will arrange for the CDOT landscape architect to flag trees to be used. Work shall be in accordance to Project Special Provision 213. It is estimated that xxx landscape logs shall be used.

Notes to Designer:

Notes are to be included on wetland template sheets. Include only those necessary for the project, delete all others. Notes to designer are in red. Attach required specifications or those referenced in notes as needed. Carry quantities to the wetland tabulation sheet, and then to summary of approximate quantities sheets.

GLOSSARY OF TERMS AND ACRONYMS

The following are definitions for many of the terms commonly used in this Manual. The sources for the definitions are cited at the end.

Aesthetics: A set of principles concerned with the nature and appreciation of beauty.

Categorical Exclusion (CatX): A NEPA document prepared for certain actions that are known through past experience to have no significant environmental impact and therefore “excluded” from future NEPA processing.

Best Management Practices (BMPs): Schedule of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States.

Bicycles/Pedestrian Lanes: Shared use lanes connecting residential, retail, office and open lands for alternative transportation usage.

CADD: Acronym for “Computer Aided (i.e., Assisted) Design and Drafting,” a digital design process in which landscape architects use computers to help produce precise drawings and details for the construction of a project.

Clear Zone: The total roadside border area, starting at the edge of the traveled way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. The desired minimum width is dependent upon traffic volumes and speeds and on the roadside geometry. It is an unobstructed, relatively flat area beyond the edge of the traveled way that allows a driver to stop safely or regain control of a vehicle that leaves the traveled way.

Consultant: A professional who provides professional or expert advice in a particular area or specialized field. A consultant is engaged to fulfill a brief in terms of helping to find a solution to specific issues.

Conservation: The protection, improvement and use of natural resources according to principles that will assure the highest economic or social benefits for people and the environment now and in the future.

Context Sensitive Solutions (CSS): A collaborative, interdisciplinary approach that involves all stakeholders in providing a transportation facility that fits its setting. It is an approach that leads to preserving and enhancing scenic, aesthetic, historic, community, and environmental resources, while improving or maintaining safety, mobility, and infrastructure conditions.

– Results of Joint AASHTO / FHWA Context Sensitive Solutions Strategic Planning Process, Summary Report, March 2007

Design: The creative illustration, planning and specification of space for the greatest possible amount of harmony, utility, value and beauty.

Easement: The legal grant of right-of-use to an area of designated private property.

Ecology: A branch of biology dealing with the relationship between living things and their environment.

Environment (Built Environment): The human-made surroundings that provide the setting for human activity, ranging in scale from buildings and parks or green space to neighborhoods and cities that often include their supporting infrastructure such as water supply, or energy networks. The built environment is a material, spatial and cultural product of human labor that combines physical elements and energy in forms for living, working and playing. It encompasses places and spaces created or modified by people including buildings, parks and transportation systems.

Environment (Natural Environment): The natural environment encompasses all living and non-living things occurring naturally on Earth or some region thereof. It is an environment that encompasses the interaction of all living species. The concept of the natural environment can be distinguished by components: 1. Complete ecological units that function as natural systems without massive human intervention, including all vegetation, microorganisms, soil, rocks, atmosphere, and natural phenomena that occur within their boundaries. 2. Universal natural resources and physical phenomena that lack clear-cut boundaries, such as air, water and climate, as well as energy, radiation, electric charge, and magnetism, not originating from human activity. A geographical area is regarded as a natural environment.

Environmental Assessment (EA): An EA is a concise document summarizing technical analysis to support the discussion of alternatives and their associated impacts. If there are no significant impacts, a Finding of No Significant Impact (FONSI) is prepared. The FONSI completes the NEPA process. If there is not a FONSI than further analysis would be required, e.g. an Environmental Impact Statement (see below).

Environmental Impact: The change to an area's natural resources, including animal and plant life, resulting from use by man. Some projects may require conducting of an "environmental impact study" before development can proceed.

Environmental Impact Statement (EIS): Is a full disclosure document that details the process through which a transportation project was developed, includes consideration of a range of reasonable alternatives, analyzes the potential impacts resulting from the alternatives, and demonstrates compliance with other applicable environmental laws and executive orders. The EIS process in completed in the following ordered steps: Notice of Intent (NOI), draft EIS, final EIS, and record of decision (ROD).

Environmental Stewardship: Refers to responsible use and protection of the natural environment through conservation and sustainable practices. Aldo Leopold (1887–1948) championed environmental stewardship based on a land ethic "dealing with man's relation to land and to the animals and plants which grow upon it".

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

Finding of No Significant Impact (FONSI): A FONSI is the decision document which completes the EA process.

Grade: The slope of land. Grading is the mechanical process of moving earth, changing the degree of rise or descent of the land in order to establish good drainage and otherwise suit the intent of a landscape design.

Highway Corridor: The long narrow passageway or linear tract of land containing and immediately surrounding a highway. The visual limits of a corridor are generally defined by the perception of the users of the highway.

Hydrology: Hydrology is the study of the movement, distribution and quality of water on Earth including the hydrological cycle, water resources and environmental watershed sustainability.

Land Use: A term which relates to both the physical characteristics of the land surface and the human activities associated with the land surface.

Landscape*:* An expanse of natural scenery seen by the eye (Webster 1960)

Landscape Architect: A professional who designs, plans, and manages outdoor spaces ranging from entire ecosystems to residential sites and whose media include natural and built elements; also referred to as a designer, planner, consultant. Not to be confused with landscapers, landscape contractors or nurserymen.

Landscape Architecture: The science and art of design, planning, management and stewardship of the land. Landscape architecture involves natural and built elements, cultural and scientific knowledge, and concern for resource conservation to the end that the resulting environment serves a useful and enjoyable purpose. Successful landscape architecture maximizes use of the land, adds value to a project and minimizes costs, all with minimum disruption to nature.

National Environmental Policy Act (NEPA): A national policy set for the protection of the natural environment and human health and welfare by promoting efforts to prevent or eliminate damage to the environment. From a transportation perspective, NEPA requires that alternatives be evaluated and decisions be made in the public's best interest based on a balanced consideration of the need for safe and efficient transportation.

National Historic Preservation Act of 1966: Legislation intended to preserve archeological and historical sites in the United States.

Natural Resources: The elements of supply inherent to an area that can be used to satisfy human needs, including air, soil, water, native vegetation, minerals and wildlife.

Mitigate: The act of lessening, offsetting, or compensating an impact.

Preservation: Preservation is an endeavor that seeks to preserve, conserve and protect buildings, objects, landscape or other artifacts of historical significance or assigned value.

Protection: The practice of protecting the natural environment on individual, organizational or governmental levels, for the benefit of the natural environment and humans.

Restoration: The practice of renewing and restoring degraded, damaged, or destroyed ecosystems and habitats in the environment by active human intervention and action. The Society of Ecological Restoration defines ecological restoration as an “intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability.”

Riparian: The interface between land and a river or stream. Riparian is also the proper nomenclature for one of the fifteen terrestrial biomes of the earth. Plant habitats and communities along the river margins and banks are called riparian vegetation, characterized by hydrophilic plants.

Rural: A geographic area located outside the cities and towns.

Reclamation: Any attempt to restore to beneficial use land that has lost its fertility and stability; most often applies to mining reclamation, such as the restoration of strip mines and quarries.

Record of Decision: The ROD is the final step in the EIS process. The ROD selects a preferred alternative, presents the basis for the decision, discusses alternatives considered, specifies the “environmentally preferable alternative,” and provides information on the measures to avoid, minimize and mitigate for environmental impacts.

Scenic Easement: A legal means of protecting beautiful views and associated aesthetic quality along a site by restricting change in existing features without government approval.

Sight Distance: The distance along a roadway throughout which an object of specified height is continuously visible to the driver.

State Historic Preservation Officer (SHPO): State Historic Preservation Officers play a critical role carrying out many responsibilities in historic preservation.

Stewardship: An ethic that embodies responsible planning and management of resources. The concept of stewardship has been applied in diverse realms, including with respect to environment, economics, health, property, information, and religion, and is linked to the concept of sustainability.

Stormwater: Water that originates during precipitation events. It may also be used to apply to water that originates with snowmelt that enters the stormwater system. Stormwater that does not soak into the ground becomes surface runoff, which either flows directly into surface waterways or is channeled into storm sewers, which eventually discharge to surface waters.

Sustainability: In a general sense is the capacity to support, maintain or endure. Since the 1980s human sustainability has been related to the integration of environmental, economic, and social dimensions towards global stewardship and responsible management of resources. In ecology, sustainability describes how biological systems remain diverse, robust and productive over time, a necessary precondition for the well-being of humans and other organisms.

Topography: The lay of the land, particularly its slope and drainage patterns; the science of drawing maps and charts or otherwise representing the surface features of a region or site, including its natural and man-made features.

Urban Area: An area characterized by higher population density and vast human features in comparison to areas surrounding it. Urban areas may be cities or towns.

View: Something, especially a broad landscape or panorama that is looked toward or kept in sight; the act of looking towards an object or a scene.

Viewshed: An area of land, water or other environmental element that is visible to the human eye from a fixed vantage point.

Visual Analysis: A method for assessing, documenting and increasing the understanding of the landscape elements that creates scenic views.

Wetland: A land area that is saturated with water, either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem. Primarily, the factor that distinguishes wetlands from other land forms or water bodies is the characteristic vegetation that is adapted to its unique soil conditions: Wetlands consist primarily of hydric soil, which supports aquatic plants

Xeriscaping: Refers to landscaping and gardening in ways that reduce or eliminate the need for supplemental water from irrigation.

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