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Final Report

ASSESSMENT OF COLORADO DEPARTMENT OF TRANSPORTATION REST AREAS FOR SUSTAINABILITY IMPROVEMENTS AND HIGHWAY CORRIDORS AND FACILITIES FOR ALTERNATIVE ENERGY SOURCE USE

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16. Abstract
The research project focused on two sustainability based elements associated with the Colorado Department of Transportation (CDOT) Maintenance operations, namely rest areas and right-of-way (ROW) utilization. For the first element, a sustainability assessment was performed on selected rest areas in the areas of sustainable design and operations. Assessment criteria and scoring criteria developed by the Colorado State University-Pueblo Team focused on the following areas: existing site conditions, materials recycling and reuse, existing environment, air quality, water quality/usage, energy, and public/motorist/trucking outreach and services. Rest area carbon footprints were calculated and carbon reduction strategies developed primarily for long term idling trucks. Cost-effective sustainable recommendations were provided that focused on efficient use and consumption of natural resources. A second element of the study evaluated the potential use of CDOT ROW for alternative energy applications, including solar, wind, biomass, geothermal, and hydropower sources. Total potential for energy production was calculated for CDOT Regions.

Implementation:
Cost-effective strategies were developed and identified to CDOT Highway Maintenance Managers to reduce rest area operational costs while conserving finite natural resources. Initial cost analysis indicates that reduced operational costs can be realized by implementing water conservation practices (waterless urinals, water harvesting, irrigation, energy conservation and alternative energy practices, and re-use and recycling of solid waste and landscaping transition toward xeriscape practices).

Project steps for the second element of the study, evaluation of CDOT ROW for alternative energy applications, included researching and preparing GIS-based mapping of alternative energy resources in Colorado; overlaying ROW mapping to identify areas of low, moderate or high potential for alternative energy production within ROW; and applying criteria to estimate the net energy produced under technology, safety and site constraints. The total potential for energy production was calculated for CDOT Regions and the State, and suitable areas of ROW for alternative energy production were identified. Legal and policy influences on the ability of CDOT to use produced energy for its own purposes and/or for sale to outside users were also evaluated.

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EXECUTIVE SUMMARY

The functional and amenity expectations of rest areas by the public have substantially grown over the past decade. Meeting these expectations and increased safety concerns have resulted in the addition of features such as high intensity lighting, air conditioning, paving, and grassy areas. Maintaining and operating these features comes at increased environmental and economic costs. The **first (rest area) purpose** of the study is to assess sustainable rest area design and operations from a representative sample of rest areas in Colorado. In addition, recent federal energy policies have placed increased emphasis on strategies by federal agencies to reduce greenhouse gas (GHG) emissions. The State of Colorado has also adopted GHG reduction policies, including the Governor's 2007 Climate Action Plan which calls for a 20 percent reduction in GHG emissions from 2005 levels by 2020 and an 80 percent reduction by 2050. The Colorado Department of Transportation (CDOT) maintains 9,144 linear miles of roadway right-of-way (ROW) and numerous other properties including rest areas, maintenance yards, remnant parcels and offices complexes. However, there is little data on the amount and locations of the ROW that is potentially suitable for alternative energy production. Lacking such data, CDOT cannot plan effectively to achieve federal GHG reduction goals or the Colorado Governor's Energy Initiative. The **second (right-of-way) purpose** of this study is to address that gap in information about ROW for alternative energy production purposes.

Regarding the rest area purpose of this study, Colorado State University - Pueblo (CSU-Pueblo) was selected by CDOT to perform the sustainability analysis at six rest areas that were selected as representative of CDOT rest areas designs and operations:

- Sterling Rest Area (Visitor Center in Region 4),
- Poudre Rest Area (Visitor Center in Region 4),
- Vail Pass Rest Area (Recreational Rest Area in Region 1),
- Hanging Lake Rest Area (Recreational Rest Area in Region 3),
- El Moro Rest Area (Basic Services in Region 2), and
- Sleeping Ute Mountain Rest Area (Basic Services in Region 5).

Onsite evaluations were performed by the CSU-Pueblo Team in the months of July and August, 2010. The Project Rest Areas were evaluated using a sustainability evaluation checklist that focused upon the following areas:

- Site Conditions – current year round operating conditions and activities of the Project rest areas
- Materials, Recycling and Reuse – solid waste management practices at the Project rest areas
- Environment – existing environmental conditions and harmony with wildlife habitat
- Air Quality – identifies activities that could affect air quality at the Project rest areas such as chemicals used/stored, overnight truck parking, etc.
- Water Quality/Usage – identifies the measures taken to protect water quality and identifies rest area water usage such as for irrigation and restroom services
- Energy – energy usage, management practices and costs at the Project rest areas
- Public/Motorist/Trucking Outreach and Services – identifies the community involvement and impacts by the operation and use of the rest area

Using the sustainability scoring method developed for this project, the Vail Pass Rest Area was identified as the most sustainable rest area based upon existing practices.

Unique to rest area research studies is the development of rest area carbon footprints. The rest area carbon footprint provides a unique way of reviewing and assessing overall energy consumption and resulting emissions. The method used by the CSU-Pueblo Team was consistent with the Greenhouse Gas Protocol (GHGP) established by the World Resource Institute. This project will provide CDOT environmental personnel, who are responsible for greenhouse gas management information on the amount of direct and indirect loading that occurs for specific rest areas and an overall cumulative estimate on greenhouse gas annual loading.

The rest areas have a lot of potential for using alternative energy to power facility operations and reduce the overall carbon footprint. Many rest areas are located in identified priority areas for solar energy (direct and passive) and wind. Geothermal energy, using local groundwater as a heat pump, can potentially reduce energy consumption. Wind energy has the potential of providing energy to rest areas especially in the plains regions. The use of alternative energy at rest areas could reduce greenhouse gas emissions and could save CDOT financial resources in the long term.

This study will provide CDOT with rest area-specific observations and recommendations for sustainable rest area designs, and operation and maintenance. These recommendations are provided to help improve the overall environment, conserve finite resources, enhance the visitor experience, and reduce rest area operational costs.

Regarding the right-of-way purpose of this study, as noted, recent federal energy policies have placed increased emphasis on strategies by federal agencies to reduce GHG emissions. Executive Order 13514 (EO 13514) was issued on October 5, 2010 by President Obama with a goal to "establish an integrated strategy towards sustainability in the Federal Government and to make reduction of greenhouse gas emissions a priority for Federal agencies." EO 13514 sets requirements related to energy efficiency and GHG management that change the way Federal agencies do business with federal and state partners. Compliance with EO 13514 provides a strong motivation for agencies including state DOTs to adopt sustainability measures.

The State of Colorado has also adopted GHG reduction policies, including the Governor's 2007 Climate Action Plan which calls for a 20 percent reduction in GHG emissions from 2005 levels by 2020 and an 80 percent reduction by 2050. The corresponding Colorado Governor's Energy Initiative of 2007 (Executive Orders D011 07 and D012 07) calls for state agencies to reduce their overall energy use by 20 percent and to reduce state vehicle petroleum consumption by 25 percent in volume by 2012.

CDOT maintains 9,144 linear miles of roadway right-of-way (ROW) and numerous other properties including rest areas, maintenance yards, remnant parcels and offices complexes. Colorado's unique characteristics – more than 300 days of sunshine per year; productive wind areas; locations of geothermal activity; areas with grasses, timber and crops; and mountainous areas with fast-moving streams – are conducive to alternative energy production from solar, wind, geothermal, biomass and hydropower systems. However, there is little data on the amount and locations of the ROW that are potentially suitable for alternative energy production. Lacking such data, CDOT cannot plan effectively to achieve federal GHG reduction goals or the Colorado Governor's Energy Initiative. The purpose of this study is to address that gap in information about ROW for alternative energy production purposes.

The basis for selecting the types of alternative energy to be evaluated in this study was a 2009 report by the Colorado Governor's Task Force on Renewable Resource Generation *"Connecting Colorado's Renewable Resources to the Markets"* which mapped and evaluated Colorado's solar, wind, and hydroelectric power, as well as geothermal and biomass resources. Geographic information system (GIS) data layers for each resource were obtained from the report and the study team traced the data back to the original source(s). The study team also used the report's energy production categories (wind power classes, range of solar power levels, etc.) to maintain consistency between the reports. Where necessary, area calculations were converted from square meters to acres.

Maps were prepared for the entire State of Colorado to show the location and distribution of the resources. For wind and solar resources, mapping was also prepared for each of the six CDOT Regions to provide more detail on ROW locations and resource distribution. These mapping steps produced an estimate of the theoretical maximum amount of energy from each energy type for CDOT. The ROW maps were then overlain with GIS data layers of each alternative energy resource type (solar, wind, geothermal, biomass, and hydropower) to calculate the total energy potential within usable CDOT ROW, generally in gigawatt-hours per year (GWh/year).

Criteria were applied to ROW acreage to identify areas accepted for development under existing constraints. A 50-foot buffer along the edge of pavement was assumed to provide the clear zone for safety purposes. It was assumed that solar resources could be located beyond the 50-foot clear zone buffer, while wind turbines would require a minimum 250-foot buffer (50-foot clear zone plus an additional 200 feet to protect the roadway in the unlikely event of a blade drop). Because biomass can be harvested without the need for barriers or setbacks, biomass acreage did not include a 50 foot safety zone from edge of pavement as was assumed for solar and wind energy. No alternative energy resources would be allowed within the median area per current CDOT policy.

Right-of-way findings

Solar – Based on the rates of solar insolation (amount of energy received from sunlight per acre per day) in various areas within Colorado, combined with the ROW acreage in each insolation level, Colorado ROW receives almost 554,700 giga-watt hours per year (GWh/year) of direct solar insolation. If 100 percent of this energy was converted to electricity it would meet ten percent of Colorado's total electricity demand based on year 2007 consumption rates (SWEnergy, 2010). However, only approximately ten percent of direct solar insolation is translated into electricity by current technology, resulting in approximately 55,500 GWh/year that could be produced from CDOT ROW. This net energy production would meet approximately 1.0 percent of Colorado's total 2007 electricity demand.

Wind – Although Colorado does have reliably windy areas, relatively little usable CDOT ROW is located in those areas. If all usable ROW was devoted to wind energy generation, approximately 380 GWh/year could be generated statewide (much less than solar). This amount of energy would meet approximately 0.0001 percent of Colorado's total electricity demand based on 2007 consumption rates.

Biomass – Most of the state is capable of producing some amount of biomass from wood, some grasses, manure and crops including corn. Statewide, an estimated 4,974 tons could be produced annually on CDOT ROW. This amount of biomass could generate approximately 4.9 GWh/year, meeting approximately 0.000001 percent of Colorado's total electricity demand based on 2007 consumption rates.

Geothermal – Research indicates that geothermal resources within Colorado are concentrated in the south central portion of the state. Statewide, approximately 8,530 acres of ROW are located in geothermal areas. However, little site-specific data exists on the locations of reliable geothermal resources. Unless CDOT evaluates specific ROW sites in high-potential areas, the true potential of ROW for geothermal uses will be largely unknown.

Hydropower – There are currently about 62 operating hydropower facilities in Colorado producing about five percent of Colorado's electric energy annually (NREL, 2005). It is unlikely that existing CDOT roadway ROW contains any existing hydropower facilities and this study did not attempt to quantify usable acres of ROW for hydropower production. Rather, the study identified about twelve of the 91 potential hydropower sites that may be located within 1/2 mile of a CDOT roadway. Such sites could provide electricity through a short transmission line to CDOT facilities such as rest areas and maintenance buildings, or for roadway lighting and signals.

Transmission – Although Colorado has thousands of miles of transmission lines, there are large portions of the state with sparse coverage. Yet, these mostly rural areas can have significant potential for renewable energy production such as wind, solar and biomass. Without access to transmission lines, production of such energy may be cost prohibitive.

Several new major transmission lines through Colorado are proposed. The High Plains Express is a 500 kilovolt (kV) system that is proposed to traverse eastern Colorado from north to south, crossing large areas undeveloped rural areas. The Eastern Plains Transmission Project would include about 1,000 miles of new high-voltage lines in eastern Colorado and western Kansas. These and other new transmission lines would fill gaps in transmission service and allow connection to a much larger grid from new alternative energy projects on CDOT ROW in rural eastern and central locations.

Implementation Statement

Regarding the rest area purpose of this study, although the CDOT rest areas are well-maintained and provide basic services to the traveling public, most rest areas inefficiently consume natural resources, financial resources, and can have an environmental impact. The following is a summary of the recommendations:

- Truck idling restrictions could be instituted in rest areas to reduce greenhouse gas emissions and noise. This action could reduce the consumption of fossil fuels.

- Water conservation studies for irrigation and restroom services could be performed in order to save in rest area operating costs. Waterless urinals could be considered in many rest areas.
- Most rest areas irrigate landscapes dominated by high water demand, non-native plants that use routine fertilizer and herbicide applications. Landscaping changes could be taken to transition to native plant, drought tolerant species.
- Recycling efforts at rest areas could be implemented to reduce the amount of solid waste being managed at the rest area and ultimately being transported to a landfill.
- Energy conservation measures should be considered at rest areas for restroom and parking area lighting, hot water heating, wastewater treatment, and restroom heating.
- Stormwater best management practices could be instituted in sensitive environmental areas to prevent pollutants from entering adjacent stream systems.
- Rest area operational data could be made more available to CDOT Maintenance Management to monitor and manage water, electrical and waste management costs

The recommendations of this study should be evaluated and carried forward by CDOT Maintenance Management, and the CDOT Sustainability Council. CDOT Maintenance Superintendents and their staffs should discuss these recommendations in efforts to save operating costs and reduce natural resource consumption. The results of this study can be carried forward by CDOT in the following ways:

- CDOT Maintenance personnel could start obtaining and reviewing water and electrical consumption data for rest areas. This will identify specific rest area functions that may not be operating correctly and need to be modified or replaced.
- CDOT Maintenance Management could develop site-specific or regional rest area sustainability plans in efforts to conserve energy, water, and financial resources and reduce environmental impacts. Initially standard operating procedures could be reviewed and modified that will not require large capital cost expenditures.
- The CDOT Sustainability Council can help facilitate the implementation of sustainable recommendations by coordinating with Maintenance Management and funding additional projects.

- The CDOT Maintenance Academy could identify key recommendations and present them during training sessions.

Regarding the right-of-way purpose of this study, DOT currently has some authority to produce alternative energy within ROW, but it is limited by state policy that does not recognize alternative energy sources as ‘utilities’ and does not set guidelines for managing energy production in ROW areas. While this study estimates potential energy production, more detailed data would be needed to assist with decisions on changing CDOT policies. Recommendations include:

- Review other states’ policies with regard to alternative energy development, such as Oregon, Minnesota, Texas and California, to glean information on design standards, innovative partnerships, and funding mechanisms.
- Using the statewide and regional maps, prepare more detailed maps and checklists for each CDOT Region to confirm the best sites based on additional criteria such as slope, aspect, tree coverage, vegetation types, etc.
- Revise the CDOT *Utility Accommodation Policy* to recognize alternative energy as a form of ‘utility’ and to include design requirements such as set-backs, minimum site densities, height limits, etc. for alternative energy production. Also, revisit the prohibition on the use of medians for longitudinal utilities.
- Build partnerships with private utilities, banks, and private energy developers to act as future partners for claiming state or federal tax credits, thereby reducing net costs to CDOT.
- Work with the Colorado Public Utility Commission (PUC) and other state agencies to promote best practices and standards for transmission line siting and interconnections to existing lines adjacent to CDOT ROW.
- Consider one or more ‘pilot programs’ to situate alternative energy on CDOT buildings or sites such as rest areas, or to allow harvesting of biomass by private operators, and monitor the produced energy, net reduction in carbon footprint and cost-effectiveness to CDOT. Involve the public by encouraging public viewing of the pilot program sites and where possible include live monitoring data on the CDOT website.

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LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AC	Alternating Current
CDOT	Colorado Department of Transportation
CFR	Code of Federal Regulations
CREB	Clean Renewable Energy Bond
CRS	Colorado Revised Statutes
CSP	Concentrated Solar Power
CSU-P	Colorado State University-Pueblo
DC	Direct Current
DEA	David Evans and Associates, Inc.
DOE	U.S. Department of Energy
DNI	Direct Normal Insolation
°F	Fahrenheit
FHWA	Federal Highway Administration
GDA	Renewable Resource Generation Development Areas
GHG	Greenhouse gas
GIS	Geographic Information System
GW	Gigawatt
GWh	Gigawatt-hour
HB	House Bill
INEEL	Idaho National Engineering and Environmental Laboratory
I-25	Interstate 25
I-70	Interstate 70
kW	Kilowatt
kWh	Kilowatt-hour
m	Meter
MW	Megawatt
MWh	Megawatt-hour
NREL	National Renewable Energy Laboratory
PV	Photovoltaic

RES	Renewable Energy Standard
ROW	Right-of-Way
SH	State Highway
Tri-State	Tri-State Generation and Transmission
UAP	Utility Accommodation Plan
US	United States
USC	United States Code
W	Watt
WAPA	Western Area Power Administration

CHAPTER 1. INTRODUCTION (REST AREAS)

Sustainability has been broadly defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland Commission, United Nations, 1987). Within a transportation system context, a sustainable transportation system can be defined as achieving improvements in the natural, built, and social environments while meeting the system's functional transportation requirements. The essence of these definitions is the efficient consumption and use of finite resources.

CDOT has adopted a strong proactive environmental ethics statement for the development and operation of transportation systems: *"CDOT will support and enhance efforts to protect the environment and quality of life for all Colorado's Citizens in the pursuit of providing the best transportation systems and services possible."* CDOT has made the commitment to go beyond environmental compliance and strive for environmental excellence. CDOT designs, constructs, maintains, and operates the statewide transportation system in a manner which helps preserve and sustain Colorado's historic and scenic heritage and fits harmoniously into communities and the natural environment (CDOT, 2005).

The Assessment of CDOT Rest Areas for Sustainability Improvements and Highway Corridors and Facilities for Alternative Energy Source Use Project (the Project) complements the sustainability principles and environmental ethics statement by enhancing the local environment within and near the CDOT rest areas and right-of-way (ROW), meeting the needs and presenting a positive Colorado image to the traveling public and using cost-effective actions that conserve natural resources and make efficient use of CDOT financial resources.

Colorado State University at Pueblo (CSU-Pueblo) was selected by the CDOT Division of Transportation Development's (DTD) Applied Research and Innovation Branch to perform a study of selected CDOT rest areas. The essence of the study is to conduct energy and conservation audits of selected CDOT rest areas with regard to current resource consumption, energy costs, emissions and types of waste treatment. Findings from these assessments will be used to identify cost-effective methods for CDOT to consider to retrofit or improve the facilities that may reduce CDOT operating costs.

Rest Area History

Rest areas are to be provided on Interstate highways as a safety measure. Safety rest areas are off-road spaces with provisions for emergency stopping and resting by motorists for short periods. They have freeway type entrances and exit connections, parking areas, benches and tables and may have toilets and water supply where proper maintenance and supervision are assured. They may be designed for short-time picnic use in addition to parking of vehicles for short periods.

~ A Policy on Safety Rest Areas for the National System of Interstate and Defense Highways, 1958

The Federal-Aid Highway Act of 1952 authorized the first funding specifically for the nation's Interstate Highway System construction, at an initial cost of $50 million with subsequent funding in 1954, which authorized an additional $325 million. Under the leadership of President Eisenhower, the question of how to fund the entire Interstate Highway System was resolved with enactment of the Federal-Aid Highway Act of 1956. It served as a catalyst for the Interstate Highway System's development and, ultimately, its completion. Title I of the 1956 Act increased the Interstate Highway System's proposed total length of 41,000 miles. It also called for nationwide standards for design of the Interstate Highway System, authorized an accelerated program to establish a new method for apportioning funds among the States and changed the name to the National System of Interstate and Defense Highways, and set the Federal Government's share of project cost at 90 percent (FHWA, 2010).

Safety rest areas (rest areas) were constructed as part of the Interstate Highway System, and were modeled after roadside parks. Rest areas were initially intended to provide minimal comfort amenities for the traveling public; generally consisting of toilet facilities, drinking water, picnic grounds and information dispersal. In 1958, a Policy on Safety Rest Areas was developed by the American Association of State Highway Officials to standardize the design and construction of rest areas. As a result of uniform design and function requirements, design aesthetics moved toward the tradition of roadside architecture. This roadside architecture came to dominate American highways and rest area sites emerged as unique and colorful expressions of regional flavor and modern architectural design. Rest areas functioned to create a context of place within the Interstate Highway System, achieved through the implementation of unique design elements and the use of regionally signifying characteristics. By the mid 1960s, rest areas lined Interstates to provide travelers a respite from the hectic and potentially monotonous nature of high-speed Interstate travel (Organization Road Development, 2010).

Rest Area Function and Operations

The safety function of rest areas over the past several years has remained the same since the creation of the Interstate Highway System; however, there have been dramatic changes in design and operation of rest areas to accommodate the expectations of modern travelers. Where rest areas use to provide the connection of people to a local region, commercial truck stops now provide the major service to travelers for food, petroleum fuels and area connection. Originally rest areas were designed around a central architectural theme, which was created around the restroom building and then reflected in the other structures in the rest area, most commonly picnic and information shelters. Rest areas were to be functionally and aesthetically satisfying settings that provided a relaxing atmosphere.

CDOT currently owns and operates 32 rest areas throughout Colorado (Appendix A). These facilities are visited by thousands of travelers every year, offering temporary parking for cars, recreational vehicles (RVs), and semi-trailer trucks. For many first-time visitors to Colorado, highways and their rest areas create a strong first impression of the State. CDOT is concerned about the increasing costs of maintaining rest area services and operations at high standards, in light of tight maintenance budgets.

Meeting increasing service demands has resulted in increased maintenance and operational costs (Rest Area History, 2010). Rest area design and function has been upgraded and modified within the past 10 years to provide the motoring public with new amenities such as air conditioning, flush toilets/urinals, security lighting, vending machines, pet walks, lighted truck parking, sewage disposal, and visitor information centers. It has also resulted in increased impervious surfaces, more storm water runoff, higher potential for pollutant discharges into local water resources, more non-native grassed areas, and higher irrigation and lighting intensity.

The CDOT Maintenance Department budget has not grown fast enough to be able to effectively finance the operation and maintenance of all state rest areas in Colorado. As a result of these limited financial resources, rest area closures have occurred in Colorado, such as the well-used Larkspur Rest Area on Interstate 25. Rest area closures are being implemented by state DOTs nationwide. The New York DOT is expected to closed “several dozen” rest areas at a savings of $2 million per year (Time Herald Record, 2010). Due to budget cuts, Minnesota is proposing the short- and/or long-term closure of 44 of the 75 rest areas at a cost savings of over $4 million per year (AllBusiness, 2010). The Arizona DOT announced that it is temporarily closing 13 of 18 state-owned rest stops as part of a plan to shore up a projected $100 million shortfall in highway user funds (Pederson, 2009).

There is a need to evaluate rest areas in terms of sustainable design, and operations and maintenance in the State of Colorado that identifies means of reducing costs associated with rest are maintenance and operation while also reducing the environmental impacts of the rest areas. A sustainability based assessment uses a new approach and context that incorporates cost economics, environmental, and social elements into rest area operations. There has been an increased awareness of climate change and efficient resource consumption by the State of Colorado as a result of Governor Ritter’s Executive Orders D0011 07, D0012 07 and D2010 006 that require state agency achievement by 2010/2011 (Ritter, 2007) for the following actions:

- 20% reduction in energy consumption – energy management plans are required that address water and energy conservation
- 25% reduction in petroleum consumption – a vehicle replacement plan must be implemented to transition to low consumption or alternative fuel vehicles
- 10% reduction in water consumption – water and energy consumption must be tracked and managed using EnergyCAP software
- Zero goal for solid waste generation – a recycling plan must be developed and implemented; waste diversion from landfills of 75 percent by 2020
- Energy-efficient building – new buildings must be certified by United States Green Building Council LEED as a Silver Rating
- Increase purchasing and use of environmentally friendly products – green products should be purchased according to the State of Colorado Preferable Purchase Policy

- Reduce greenhouse gas emissions by 20 percent below 2005 – greenhouse gas emissions will be reported annually to the Green Government Council

There have been significant environmental changes in the past five years that add to the complexity of managing rest area operations. There is an increased awareness of managing carbon/greenhouse gas emissions from highway operations and rest areas. State agencies are being required to start managing greenhouse gas emissions as part of the State of Colorado Climate Action Plan (2007) developed by Governor Ritter (Ritter, 2007). Water is a valuable resource in Colorado that needs to be conserved especially in light of climate change projections. Domestic waste and treatment costs continue to increase due to more stringent environmental regulations. Rest areas have been aging and many are not efficient in terms of resource consumption, operational costs, and services. The cost of solid waste management and landfilling is continuing to increase for rest areas. These issues require a new way to review and evaluate rest area operations that reflect good management practices, directives, environmental regulations, and costs.

CHAPTER 2. REST AREA PROJECT GOALS AND OBJECTIVES

As part of the Project, CDOT directed the development of a Sustainable Rest Areas Task to address the economic, environmental, and social (traveling public) impacts of rest area operations. Onsite evaluations of six selected rest areas were performed by the CSU-Pueblo team using a sustainability based assessment of rest area design and operation and maintenance. The purpose of this task is to conduct energy and conservation audits of CDOT rest areas with regard to current resource consumption, energy costs, emissions, and types of waste treatment. The findings from the assessments are used to identify recommendations for cost-effective methods to retrofit or improvement options for the facilities that may reduce CDOT operating costs. The goals for this rest area sustainability evaluation study are to provide recommendations that CDOT can consider to:

- Reduce life cycle cost for energy, materials and CDOT manpower,
- Conceptualize sustainable and renewable actions and features for rest areas,
- Improve the visitor experience in Colorado,
- Reduce long-term rest area operation and maintenance costs and avoid a large manpower-resource commitment by CDOT Maintenance,
- Develop sustainable retrofit or improvement recommendations,
- Evaluate the resulting environmental footprint achieved by reducing emissions, conserving natural resources, and protecting the local environmental conditions,
- Evaluate the carbon footprint of the Project rest areas and identify reduction strategies for rest areas to potentially reach carbon neutrality, and
- Estimate the carbon footprint for all CDOT rest areas combined.

Based upon these Project goals, the following Project Objectives were established:

- Develop a method that will obtain, organize, and evaluate site-specific rest area information
- Coordinate and interact with CDOT rest area representatives to obtain operational information and understand rest area operating procedures
- Establish a rest area based carbon footprint method that follows scientifically accepted calculation protocols and is accepted by CDOT prior to use

- Develop and implement a sustainability scoring methodology that provides a metric of the existing sustainable actions being performed at the Project rest areas
- Evaluate database information that will provide sustainable actions in the categories of Site Conditions, Materials, Recycling and Reuse, Environment, Air Quality, Water Quality/Usage, Energy, and Public/Motorist/Trucking Outreach
- Provide information to CDOT Maintenance Management in an effort to save operational costs, while maintaining and improving rest area functionality

CHAPTER 3. REST AREA RESEARCH METHOD

The CSU-Pueblo Team recognized that there were several critical actions and issues that needed to be addressed in order to achieve the Project's goals and objectives. A stepwise evaluation method was developed to address the following critical project issues necessary to evaluate sustainable rest area design and operation and maintenance activities:

- Coordinating with the CDOT Point Contact and developing working relationships with CDOT Maintenance professionals,
- Understanding CDOT maintenance, environmental, and engineering structure and operations,
- Understanding and meeting the expectations of the Study Panel members,
- Obtaining critical CDOT rest area operations and visitation information,
- Studying and assessing a representative population of CDOT rest areas,
- Complementing work and studies initiated by CDOT such as the CDOT Energy Performance Contract study,
- Gaining access to CDOT ROW for assessment studies, and
- Identifying funding mechanisms to design and implement recommended actions within CDOT statewide via public-private partnerships.

The following method was developed and implemented by the CSU-Pueblo Team in coordination with CDOT in order to achieve the goals and objectives and critical elements of the Project:

- Selection of Project rest areas,
- Perform a literature search on sustainable rest area studies,
- Develop and complete Sustainable Rest Area Field Evaluation Checklists,
- Coordinate with CDOT representatives,
- Conduct onsite evaluations of Project rest areas,
- Develop and complete the Sustainable Rest Area Evaluation Database,
- Develop and apply the Sustainable Rest Area Scoring Criteria, and
- Calculate Project rest area carbon footprints.

Rest Area Selection

CDOT currently owns and operates 32 rest areas throughout Colorado (see Appendix A). These facilities are visited by thousands of travelers per year, offering temporary parking for cars, recreational vehicles (RVs), and semi-trailer trucks. There are four types (Tiers) of CDOT rest areas that were identified by the CSU-Pueblo Team based upon rest area services and function:

> Tier I rest areas contain or are adjacent to visitor centers. These rest areas are larger in size, receive the most motorist visitation, and provide numerous amenities such as air conditioning, RV waste disposal, visitor information, and large truck parking areas. Tier I rest areas are located along the Interstate Highway Systems in Colorado (Interstates 25, 70 and 76). There are five Tier I rest areas within Colorado.

> Tier II rest areas are located in recreational areas and are more destination-oriented than other rest area types. These types of rest areas provide services to motorists, tourists, bicyclists, and hikers. There are usually a large number of car parking spaces and the rest areas are located near bicycling and other recreational areas. There are limited or no areas available for long-term freight truck parking (greater than 8 hours). These areas are generally smaller in size and operational complexity than Tier I rest areas. There are five Tier II rest areas located mostly along Interstate 70 throughout Colorado.

> Tier III rest areas provide basic services to the traveling public and trucking industry. They are limited in the type of public services and center mostly upon restroom facilities and picnic tables. Pet walking and limited vending machines are usually found in these rest areas with some long-term semi-trailer truck parking and idling. There are 17 Tier III rest areas located along the Interstate Highways and the State of Colorado Highways in western Colorado.

> Tier IV rest areas are simple pull-out locations associated with temporary truck parking or scenic overlooks. No restroom facilities are provided at this type of rest area. There are five Tier IV rest areas throughout Colorado located along Interstate Highways and the State of Colorado Highways.

The purpose of the Project is to assess rest area design and operations for a representative sample of rest areas in Colorado. Six rest areas were selected as representative of Tier I, II and III rest areas. Two rest areas for each of the Tiers were selected to comprise a group of rest areas that collectively met the following criteria:

- Rest area classified as either Tier I, II or III rest areas,
- At least one rest area resides within every CDOT Region (except CDOT Region 6), and
- At least one rest area resides within each type of eco-region (desert, mountains, canyon, and plains).

Using these selection criteria, the following rest areas (Project rest areas) were selected for the study:

- Sterling Rest Area
  Tier I – Visitor Center/Region 4; plains eco-region
- Poudre Rest Area
  Tier I – Adjacent to Visitor Center (newest)/Region 4; plains eco-region
- Vail Pass Rest Area
  Tier II – Recreational Rest Area/Region 1; mountain eco-region
- Hanging Lake Rest Area
  Tier II – Recreational Rest Area/Region 3; canyon eco-region
- El Moro Rest Area
  Tier III – Basic Services/Region 2; high plains eco-region
- Sleeping Ute Mountain Rest Area
  Tier III – Basic Services/Region 5; desert eco-region

The selection of these Project rest areas was coordinated with the CDOT Study Panel.

Literature Search on Sustainable Rest Area Studies

A literature search was performed by the CSU-Pueblo Team on research or studies performed on rest areas throughout the United States and Europe. Sustainable actions found to be easiest and most life cycle cost-effective were searched by referencing web sites and the CSU-Pueblo Team attempted to contacting several state DOTs (Michigan, Minnesota, Florida, North Carolina, Illinois, Wisconsin, Washington, Oregon, Texas, Virginia), Transportation Research Board

(TRB), and the American Association of State Highway and Transportation Officials (AASHTO). Web searches on European sustainable rest areas were performed with limited success. Overall there was very limited information obtained from this literature review, since this type of sustainable rest areas assessment has not been performed or information published by DOTs. The following summarizes the information collected from responding DOTs during the literature review:

- North Carolina DOT – One LEED certified rest area has been build and has a web site where electrical consumption can be monitored. Most retrofits involve the use of solar heated water. The DOT reduced water usage from irrigation and restroom areas. Material recycling is occurring at rest areas. North Carolina came up with a list of sustainable actions that was reviewed and some elements adopted into the assessment checklist by the CSU-Pueblo Team. Truck electrification was thought not effective unless there is a regulatory incentive.
- Michigan DOT – Looking for alternative wind generation especially for rest areas with air conditioning. The DOT is reducing the amount of solid waste by material recycling and ononsite compositing of lawn waste material. Michigan is looking into truck idling related to noise and emissions.
- Florida DOT – Eliminated hot water in restroom areas to reduce energy costs. The DOT has been recycling rest area waste materials for years with the help of local communities. They have eliminated lawn irrigation to save money and reduce water consumption. Stormwater best management practices for all rest areas are a Florida DOT policy requirement.
- Utah DOT – looking into alternative energy sources such as wind, solar and hydro-power.
- Wisconsin DOT – recycling solid waste materials from rest areas for years.
- New York DOT – not focused on sustainable rest area operations and has been concentrating more on sustainable design.
- Minnesota DOT – pilot program that utilizing geothermal and wind turbine systems at Camden State Park.
- Pennsylvania DOT – opened the first truck stop electrification facility to comply with state truck idling regulations.

The information acquired from this task was used to develop the Sustainable Rest Area Field Evaluation Checklist (Appendix B) and Sustainable Rest Area Scoring Criteria that was developed in coordination with CDOT (Appendix C).

As part of this information gathering activity, the CSU-Pueblo Team coordinated with Johnson Controls, Inc. (Johnson Controls) who is the main contractor for the CDOT Energy Performance Contract. Johnson Controls was in the process of performing energy audits on all CDOT Maintenance facilities that include rest areas. The overall goal of these energy evaluations is to save CDOT financial resources by using energy conservation measures, evaluating the use of cost-effective alternative energy, and developing creative financing for energy payments to utilities. The CSU-Pueblo Team was also concerned about energy consumption as it relates to potential financial savings and the reduction in the overall rest areas' carbon footprint. Johnson Controls was in the process of identifying a rest area (potentially the El Moro Rest Area) that would be a net zero energy consumption facility. Two meetings were held between the parties to avoid duplication of effort, and share data, observations, and recommendations.

Sustainable Rest Area Field Evaluation Checklist Development

The Sustainable Rest Area Field Evaluation Checklist was developed to assist the CSU-Pueblo Team in assessing the Project rest areas. The development of the sustainability criteria mainly referenced the Leadership in Energy and Environmental Design (LEED) Checklist categories and criteria. A list of evaluation parameters was developed within the following broad categories:

- Site Conditions – This category establishes the baseline conditions by detailing the current year round operating conditions and activities of the Project rest areas
- Materials, Recycling, and Reuse – This category is related to the conservation of natural resources by using material reuse and recycling. Material recycling and reuse reduces that amount of solid waste that is transported and ultimately landfilled.
- Environment – This category evaluates how well the rest area is in harmony with overall local environment such as wildlife habitat and mobility.
- Air Quality – This category identifies activities that could affect air quality at the Project rest areas such as toxic chemicals used/stored, overnight truck parking, etc. Rest area

actions that impact air quality are the emission of greenhouse gases and the exposure of chemicals to rest area workers and visitors.

- Water Quality/Usage – This category identifies the measures taken to protect local water quality and identifies rest area water usage such as for irrigation and restroom services. Water is a very finite resource within Colorado and water conservation is very important and cost-effective.
- Energy – This category relates to energy usage, management practices, and costs at the Project rest areas. Rest area energy is expensive and is generated by finite fossil fuel resources that add to the greenhouse gas loading in the State of Colorado.
- Public/Motorist/Trucking Outreach and Services – This category represents how well the local community is being involved with the operation of the rest area (regional information, free coffee) and the level of services provided to the traveling public (maps, weather forecasts).

The development of the field evaluation criteria was influenced by the State of Colorado Environmentally Preferable Purchasing Policy developed in July 2010 (State of Colorado, 2010), the LEED scoring criteria and the sustainable vision elements expressed by Governor Ritter within Executive Orders D0011 07 and D0012 07 (Ritter, 2007) and D 2010-006 (Ritter, 2010). The Sustainable Rest Area Field Evaluation Checklist contains 124 site evaluation elements that were coordinated with the CDOT Study Panel prior to Project rest area use by the CSU-Pueblo Team (see Appendix B).

Coordination with CDOT Representatives

The CSU-Pueblo Team gave a presentation to the CDOT Study Panel at the initiation of the Project. The CDOT Study Panel was formed by the CDOT Environmental Research Manager to provide feedback and direction to the CSU-Pueblo Team throughout the Project. The overall Project approach was outlined to the CDOT Study Panel. At this meeting the CSU-Pueblo Team provided CDOT with a list of initial data needs for the appointed CDOT rest area representatives to help facilitate the onsite meetings with the CDOT rest area contacts and the CSU-Pueblo Team. This list included the following requested information for each Project rest area:

- Any energy-related studies performed by Johnson Controls or other contractors on these and/or other rest areas
- Electrical power consumption (parking lot lighting, structure lighting, heat, water pump, air conditioning, treatment system)
- Natural gas consumption (heating)
- Water consumption (restrooms, landscaping/irrigation)
- Water sources (public or well; well capacity)
- Treatment system design and maintenance costs
- Landscaping activities and costs (manpower, fuel consumption, vegetation, herbicide use)
- Snow maintenance (manpower costs, deicer usage)
- Site visitation records
- Rest area age, acreage, and site visitation records
- Solid waste and recycling information
- Stormwater management and costs
- Mowing frequency and manpower cost
- Truck visitation data

The following CDOT rest area representatives were appointed as point contacts for the CSU-Pueblo Team:

- Vail Pass Rest Area (Vail Pass-Region 1) – April Thomas/Mike DeLong
- El Moro Rest Area (Trinidad-Region 2) – Robert Trujillo/Jeff VanMatre
- Hanging Lake Rest Area (Glenwood Canyon-Region 3) – Dave Schultz/Mike Goolsby
- Poudre Rest Area (Fort Collins- Region 4) – Tom Lujan/Ed Stieber
- Sterling Rest Area (Sterling- Region 4) – Victor Romero/Ed Stieber
- Sleeping Ute Mountain Rest Area (Cortez-Region 5) – Edward Olguin/Kyle Lester

Onsite Rest Area Visits and Evaluations

Three rest areas were assigned to each of the two graduate students. These graduate students were responsible for conducting onsite reviews, obtaining operational and maintenance data and performing data analysis.

The Project rest areas were visited by the CSU-Pueblo Team during the months of July and August, 2010. The initial portion of the site visit involved talking with and interviewing the CDOT rest area representatives and other maintenance representative(s) directly responsible for the operation and maintenance of the rest area to review the physical characteristics of the rest area and the restroom structure. The site visit was attended by the rest area representative when possible. The CSU-Pueblo Team left the area when the Rest Area Field Evaluation Checklist was completed. Follow up communication and requests for additional information occurred between the team members and the CDOT representatives.

Development of the Sustainable Rest Area Evaluation Database

The collected field data was placed into an Excel spreadsheet-database. The rest area information was organized to allow the field and site-specific operations information to be viewed and evaluated across all the Project rest areas. The development of the database allowed for the direct comparison of information among and between Project rest areas. The database also allowed for the identification of suspect data and rest area operations that are not sustainable. Appendix C contains the Sustainable Rest Area Database. The database spreadsheet can provide CDOT with a useful baseline assessment tool to help manage the Project rest areas and other CDOT rest areas statewide.

Sustainable Rest Area Scoring Criteria

A Sustainability Rest Area Scoring approach was developed by the CSU-Pueblo Team to achieve the comparison metric and to evaluate the current baseline sustainability status of the Project rest areas' design and operation and maintenance (Appendix D). The development of the Sustainability Rest Area Scoring Criteria referenced the LEED approach and contains similar information contained in the Rest Area Field Evaluation Checklist. The LEED approach assigns a score to specific sustainable criteria; criteria were given points ranging from 1-3 points

(USGBC, 2007). If the sustainable criteria were achieved for a given rest area, then all the maximum points were awarded.

The LEED approach that was a reference for this Sustainable Rest Area Scoring was specifically for new construction and not for rest areas. The sustainability scoring approach and criteria was developed by the CSU-Pueblo Team based upon the definition of sustainability, the project goals and objectives, and their knowledge of sustainable design and operations. The development of the criteria was influenced by the State of Colorado Environmentally Preferable Purchasing Policy developed in July 2010 (State of Colorado, 2010), the LEED scoring criteria and the sustainable vision elements expressed by Governor Ritter within Executive Orders D0011-07/ D0012-07 and D2010-006 (Ritter, 2007, Ritter 2010). Based upon the literature search performed by the CSU-Pueblo Team, no existing sustainable rest area checklist exists or has been disseminated by other DOTs. The Sustainable Rest Area Scoring criteria used for this project are unique and represent a new way to assess the design and operations of rest areas.

The 61 sustainable scoring criteria elements were grouped into the following categories with the maximum number of points per category. These categories are similar to those contained in the Sustainable Rest Area Field Evaluation Checklist:

- Materials and Reuse/Recycling (13 points)
- Environment/Site Conditions (25 points)
- Air Quality (13 points)
- Water Quality/Usage (21 points)
- Energy (30 points)
- Public/Motorist/Trucking Outreach (11 points)
- Innovation Score (4 points)
- Maximum Score (117 points)

The Sustainable Rest Area Scoring Criteria spreadsheet with criteria rationale was coordinated with the CDOT Study Panel. Appendix D provides the Sustainability Rest Area Scoring Sheet which includes the summary results of all Project rest area scores.

Calculation of Project Rest Areas' Carbon Footprints

The calculation of the Project rest areas' carbon footprints is a unique evaluation approach to determine rest area impact upon the environment by estimating greenhouse gas emissions. The rest area carbon footprint provides a way of reviewing and assessing overall energy consumption and resulting emissions. The carbon footprint provides the baseline to which carbon reduction options can be identified and measured against in an attempt to achieve carbon neutrality for each rest area.

The method used by the CSU-Pueblo Team is consistent with the Greenhouse Gas Protocol (GHGP) established by the World Resource Institute (WRI, 2004). The GHGP approach is a well-established and accepted method for carbon footprint calculations. The carbon footprint calculations follow the method used by EPA; multiplying the volume or amount of fuel combusted by an emission factor. The Technical Memorandum (August 27, 2010) that outlines in detail the method and carbon footprinting calculations was coordinated with the CDOT Study Panel (Appendix E). The overall carbon footprint estimates for all CDOT rest areas are shown in the Sustainable Rest Area Database Spreadsheet (Appendix C) and discussed in Chapter 4.

The GHGP approach identifies three Scope Emission types to identify and estimate direct and indirect emission sources. These Scope Emissions (Scope 1, Scope 2 and Scope 3) are used to provide consistency in accounting for and mitigating greenhouse gas emissions (IPCC, 2007). The following summarizes the GHGP scopes as they relate to the Project rest areas:

> **Scope 1 – Direct GHG Emissions**: these type of emissions come from combustion sources that are owned by the entity (CDOT) that are directly related to the operations of the rest area such as propane and natural gas for heating, and gasoline/diesel fuel for the transportation of materials, equipment, mowing, and personnel transportation to and from work.
>
> **Scope 2 – Electrical Indirect GHG Emissions:** accounts for GHG emissions from the generation of purchased electricity consumed by the company (CDOT). The actual emissions occur at the power facility where the electricity is generated. This type of

indirect emission will be used for rest area heating/cooling and lighting and is expected to be the largest type of emission for rest areas.

Scope 3 – Other Indirect GHG Emissions: these types of emissions are a consequence of activities of the company (CDOT), but occur from sources not owned or controlled by the company (CDOT). The main rest area source for this type of indirect emission is from truck idling.

The equations used to calculate the carbon footprint use emission factors kilogram (kg/gallon) for carbon dioxide ($CO_{2)}$, nitrous oxide/oxides of nitrogen (N_2O), and methane ($CH_{4)}$ that are referenced from the United States Environmental Protection Agency (EPA, 2005). These emission factors are multiplied by the amount of fossil fuel consumed by the Project rest areas and then multiplied by the respective Global Warming Potential (GWP). GWP is defined as the amount of impact or the degree of harm a particular gas has on the atmosphere (Jakubski, 2008). When the GWP is multiplied by the amount emitted, it is converted to an equivalent amount of CO_2 and that is called "Equivalent CO_2" or CO_2e.

The estimated, cumulative carbon footprint for all CDOT rest areas was estimated by taking an average of the carbon footprint values calculated for each rest area tier type (Tiers I-III). That value was multiplied by the total number of corresponding tier type rest areas managed by CDOT. The total carbon footprint for all CDOT rest areas was then determined by the summation of all rest area tiers type carbon footprints. This value provides CDOT a gross estimation of the total carbon equivalent loading from all rest areas. This provides a baseline for CDOT's efforts to manage greenhouse gas emissions. This greenhouse gas management is consistent with the Colorado Climate Action Plan expectations of reducing greenhouse gas emissions by 20% by 2020 (Ritter, 2007b).

CHAPTER 4. REST AREA RESULTS AND DISCUSSION

Onsite assessments were performed by the CSU-Pueblo Team during the months of July and August 2010. CDOT rest area representatives and maintenance managers met the CSU-Pueblo Team at the rest areas to provide written and verbal operational information for each rest area. The Sustainable Rest Area Field Evaluation Checklist was sent out to the CDOT rest area contacts prior to the meeting and was the center of the discussions and assessment activities during the rest area visits. The information provided by the CDOT contacts was recorded and inserted into the Sustainable Rest Area Database. The following tier level Project rest areas were visited by the CSU-Pueblo Team:

- Tier I – Sterling Rest Area (August 25, 2010)
- Tier I – Poudre Rest Area (August 19, 2010)
- Tier II – Vail Pass Rest Area (July 15, 2010)
- Tier II – Hanging Lake Rest Area (July 16, 2010)
- Tier III – El Moro Rest Area (August 6, 2010)
- Tier III – Sleeping Ute Mountain Rest Area (July 9, 2010)

The following sections provide the detailed assessment information for each rest area:

- Rest Area Setting
- CDOT Rest Area Operations
- Rest Area Carbon Footprint
- Rest Area Sustainability Scoring
- Rest Area Observations/Recommendations

4.1 Sterling Rest Area

Rest Area Setting

The Sterling Rest Area is located 1 mile west of Interstate 76 at mile marker 125. The rest area is located within the city limits of Sterling (elevation 4,040 feet) in Logan County. The rest area is adjacent to the Sterling Municipal Building and is 0.2 miles from the CDOT Sterling Maintenance Facility. The Sterling Rest Area is characterized as a Tier I rest area that represents the more complex, visitor center type rest area. A visitor center operated and maintained by

CDOT is contained within the main restroom building. The visitor center, supported by volunteers, provides travelers with road maps and regional and state tourism information. The rest area comprised of seven acres is located in a semi-arid, grassland-plains eco-region based upon the type of native vegetation and precipitation. The rest area is visited by approximately 384,000 people every year. The rest area was constructed in 2000 and is open 24 hours a day for seven days a week, all year. The rest area accommodates large amounts of freight trucks due to a large parking area for commercial vehicles and available restroom services. The Sterling Rest Area is located at the critical location where Interstate 76 is routinely shut down due to winter storms and provides important services to cars and trucks during these storm events. The rest area is managed by CDOT Region 4. Figure 1 shows a site plan of the Sterling Rest Area.

Sterling Rest Area Operations

The Sterling Rest Area was evaluated by the CSU-Pueblo Team on August 25, 2010 with informational support provided by the CDOT Maintenance representatives. The following summarizes the Sterling Rest Area operations:

- The rest area contains a 3,900 square foot structure, which contains the restrooms and the visitor center (see Figures 2 and 3).
- The visitor center area is air conditioned and the main restroom and lobby areas are naturally cooled. The rest area has picnic tables, vending machines, recycling bins, and a fenced dog walking area.
- The Sterling Rest Area uses the City of Sterling for domestic water and wastewater treatment.
- A recreational vehicle waste disposal system is located near the truck parking area and the waste is treated off site.
- Limited natural vegetation is allowed to grow on rest area property except for random small patches near the truck parking location.
- The rest area has approximately three acres of buffalo grass.
- The rest area is heavily used by travelers and especially by trucks.
- The stormwater best management practices include vegetated basins, which are very protective of water quality (see Figure 4).

- The design of the rest area fits well into the context of Colorado and the local area (see Figure 5).

Figure 1. Sterling Rest Area Site Plan

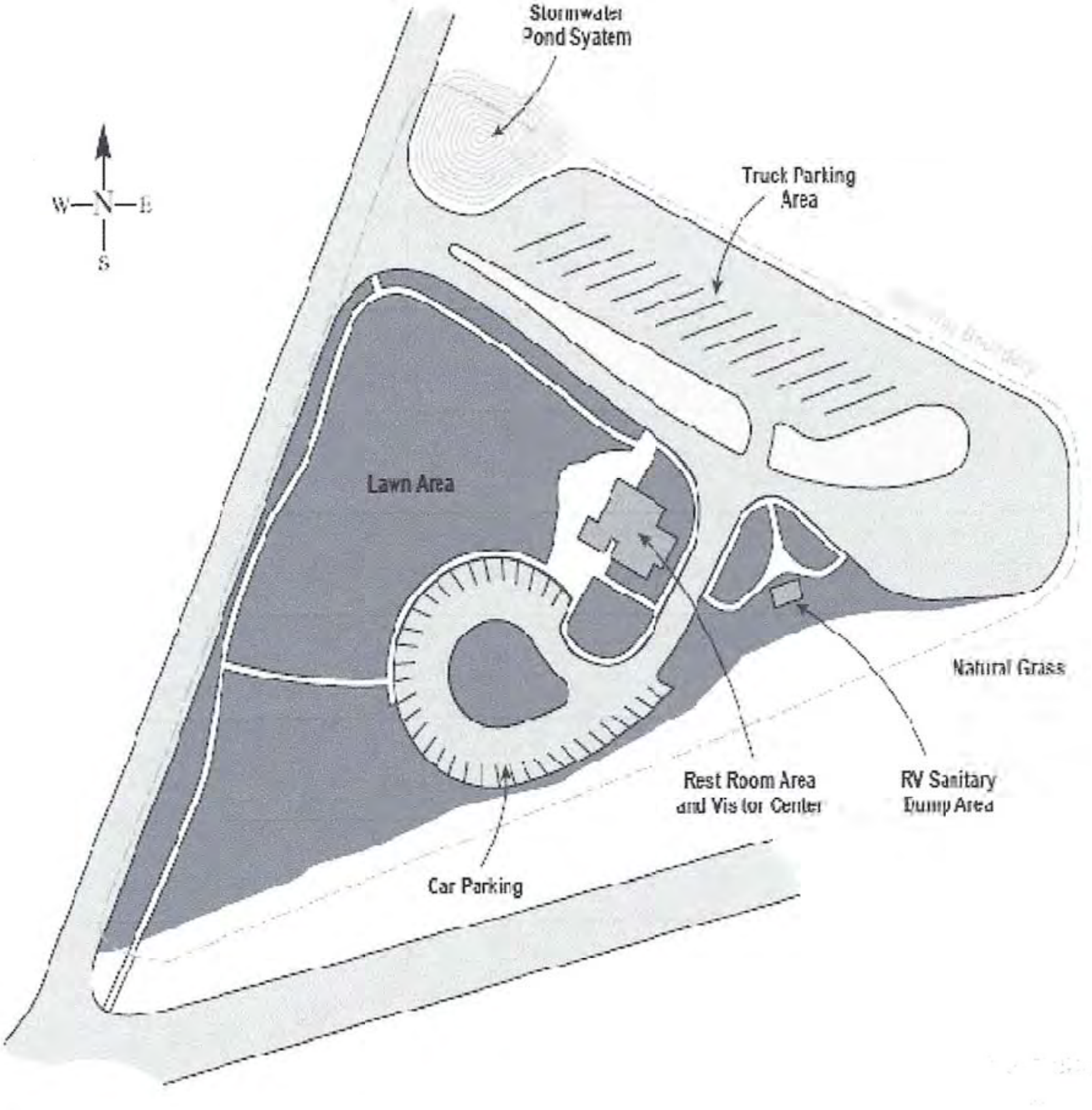


Figure 2. Sterling Restroom and Visitor Center Entrance

Figure 3. Sterling Rest Area Visitor Center Entrance

Figure 4. Sterling Rest Area Stormwater Basin

Figure 5. Sterling Rest Area Center Piece Sculpture

- There are 47 parking spaces for cars and 24 parking spaces for semi-trailer trucks. It was estimated that approximately 18 semi-trailer trucks park and idle for greater than eight hours per day.
- The rest area is maintained by two full-time maintenance employees and is cleaned four times a day.
- Electricity and natural gas are the only sources of energy in the rest area.

Sterling Rest Area Carbon Footprint

Scope 1 greenhouse gas emissions from the Sterling Rest Area include emissions produced by gasoline and natural gas consumption. Gasoline is used by CDOT Maintenance vehicles to transport materials and equipment to and from the maintenance facility (located less than a mile away) and by the operation of onsite maintenance equipment such as mowers, weed eaters, snow blowers, and snow removers. The total average gasoline consumption for the Sterling Rest Area is low in compared to the other Project rest areas because of the closeness of the rest area to the CDOT Maintenance facility. Consumption of gasoline in 2009 was about 92 gallons (personal conversation, 2010). The rest area uses natural gas for water and building heating. The annual average consumption of natural gas is 7,949 therms (Excel Energy, 2010). Since meters measure volume and not energy content, a therm factor is used by gas companies to convert the volume of gas used to its heat equivalent, and thus calculate the actual energy use (one therm equals 100,000 British Thermal Units (BTUs) or about 97 cubic feet of natural gas). The annual Scope 1 carbon footprint of the Sterling Rest Area is 44 metric tons CO_2e /year.

Scope 2 greenhouse gas emissions are produced by electric consumption at the rest area. The Sterling Rest Area uses electricity mainly for the building and the parking lot lighting. The average annual consumption for the Sterling Rest Area is 126,530 kilo-watt-hours (kWh/year) (Excel Energy, 2010). The annual scope 2 carbon footprint for the Sterling Rest Area is 108.6 metric tons CO_2e/year.

Scope 3 greenhouse gas emissions are a result of the overnight idling of large freight trucks (greater than eight hours). As a worst case emission scenario, the Sterling Rest Area has on average 18 idling trucks per night. The overnight idling results in a scope 3 average annual carbon footprint of 2,853.6 metric tons CO_2e/year.

The total estimated carbon footprint for the Sterling Rest Area is 3,006 metric tons CO_2e/year.

Sterling Rest Area Sustainability Scoring

The overall Sterling rest area sustainability score was 30 out of 117 points. The following summarizes the sustainability scores (see Sterling Sustainable Scoring in Appendix D for details). The following summarizes some of the sustainability actions and total scoring:

- Materials and Reuse Score – only rest area among the Project rest areas that recycles aluminum and plastic bottles (no glass). The rest area obtains landscaping mulch from the local prison generated by tree cutting and trimming. (6 of 13 points)
- Environment/Site Condition Score – uses drip irrigation for non-native landscaping and irrigates lawn at night (5 of 25 points)
- Air Quality Score – smoking prohibited in rest rooms (2 of 13 points)
- Water Quality/Usage Score – contains excellent stormwater best management practices in the form of a vegetated swale-detention pond (7 of 21 points)
- Energy Score – only rest area that uses an electric vehicle for onsite maintenance activities (6 of 31 points)
- Public/Motorist/Trucking Outreach – area exhibits context sensitive design of community and high community involvement (4 of 11 points)
- Innovation Score – (0 of 4 points)

Sterling Rest Area Observations and Recommendations

The Sterling Rest Area contains a large area of grass buffalo grass (*Bouteloua dactyloides*) and small patches of native grasses. Although the buffalo grass is less water intensive than non-native bluegrass, it does require only occasional irrigation. Vegetation covers about 50% of the rest area with 3 acres of buffalo grass and approximately 83 trees. CDOT could consider minimizing the buffalo grass area in favor of native grass that requires less irrigation and chemical treatment in combination with improved irrigation practices to conserve water. This action will also reduce the mowing frequency and the amount of herbicides and fertilizer needed to maintain the grass. The cost savings as a result of lower water usage, labor for mowing, gas and herbicides consumption can be significant.

The Sterling Rest Area has the highest carbon footprint of all the Project Areas with 3006 metric tons CO_2e/yr. The biggest contributor to air pollution and the carbon footprint is overnight truck idling with an average of 18 idling trucks per night emitting approximately 2,853 metric tons of CO_2e/yr. Greenhouse gas emissions could be reduced at the rest area by instituting idling restrictions or providing alternative energy sources to trucks such as truck electrification, which would need to be evaluated in another research study.

The Sterling Rest Area has the highest water consumption of all the Project rest areas. Municipal water is the only water supply for the rest area with an average annual purchasing cost of $14,814 and an average annual consumption of 10,326,400 gallons. The restroom facilities use water-saving faucets and use low flush urinals and toilets. It is assumed that the majority of the water usage is from spray lawn irrigation. Daytime irrigation was noted during the onsite evaluation which is not an efficient irrigation technique in the summer. A water conservation study could be performed in an effort to determine the exact use and volume of water at the rest area. As previously mentioned, the landscaping of the rest area could be changed to use more native plants and rock landscaping to reduce water demand. The water conservation study could save CDOT significant financial resources in domestic water purchase and waste treatment costs.

The Sterling Rest Area uses two sources of energy: 1) electric energy for lighting the restroom/visitor center building, the parking lot areas, and the visitor center air conditioning, and 2) natural gas for hot water and building heating. The average annual electrical consumption of the rest area is 126,530 kWh (Excel, 2010) with an average annual cost of $9,201. Lights in the rest area are on all night year round. No energy saving lighting or motion detectors were noted during the assessment. Energy conservation methods could be considered to reduce energy consumption in the rest area such as using motion sensors to initiate lighting in the restroom areas. The amount of air conditioning usage may be reduced by using natural ventilation coupled with vegetative shade and by making sure the visitor center door is closed to avoid cooling the larger restroom and lobby areas.

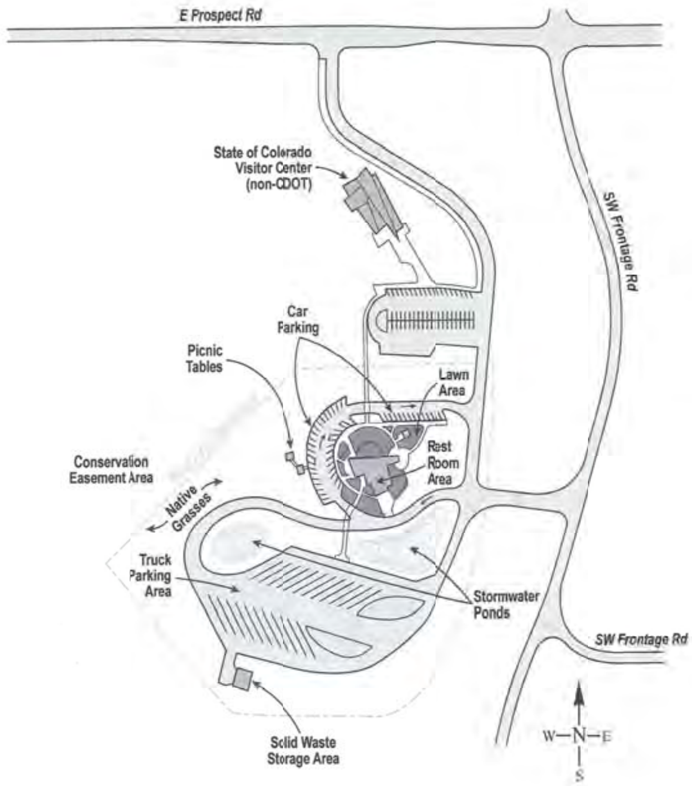
The overall appearance of the Sterling Rest Area is very good. A fenced dog run area is provided for the rest area visitors and local community information is available for the public though information signage and bulletin boards. The local community is involved in helping with some of the rest area's activities especially the operation of the visitor center. Onsite volunteers were seen during the rest area evaluation. The design of the rest area reflects the local area context; a local artist designed the sculpture at main rest area. The rest area could a consider security camera system like other rest areas to enhance visitors' security. The cooperation between CDOT and the local state prison for materials recycling and reuse is excellent and should continue in the future.

4.2 Poudre Rest Area

Rest Area Setting

The Poudre Rest Area is located southwest of the Prospect Road and Interstate 25 interchange at mile marker 268, on the southeast portion of Fort Collins (elevation 5,003 feet) in Larimer County. The rest area is characterized as a Tier I rest area that represents the more complex visitor center type rest area. The rest area is located in a semi-arid grassland-plains eco-region based upon the type of native vegetation and precipitation. The rest area is open year round, 24 hours a day, seven days a week with a yearly visitation of approximately 122,000 people. The Poudre Rest Area is adjacent and separate from a State of Colorado Visitor Center (not directly operated by CDOT) that helps generate visitor visits to the rest area. The rest area is located next to a sensitive wildlife corridor that is located less than one mile away from the Poudre River. The rest area receives large amounts of semi-trailer trucks year round due to a large parking area and restroom services. Unique to the Poudre Rest Area is a kiosk located inside the restroom building that allows motorists and trucking professionals to check current road conditions and access many CDOT weather cameras throughout Colorado. The Poudre Rest Area is operated and maintained by CDOT Region 4. Figure 6 shows a site plan of the Poudre Rest Area.

Figure 6. Poudre Rest Area Site Plan



CDOT Rest Area Operations

The Poudre Rest Area was evaluated by the CSU-Pueblo Team on August 19, 2010 with informational support provided by the CDOT Maintenance representatives. The following summarizes the Sterling Rest Area Operations:

- This rest area is comprised of 16 acres and is the largest among the Project rest areas.
- It contains a 2,500 square foot restroom building, picnic tables, vending machines, and separate parking for commercial and private vehicles (see Figure 7).
- The rest area is along a portion of Interstate 25 that is traveled by approximately 7,000 trucks a day and there are 23 parking spaces for semi-trailer trucks at the rest area.

- There are approximately 15 trucks a day using the rest area for a period of greater than 8 hours (see Figure 8).
- The rest area is serviced by one CDOT Maintenance employee who maintains the landscaping, buildings and overall operations.
- The Poudre Rest Area is the only Project rest area where CDOT contracts with a custodial contractor to clean the restroom building three times per day. The contactor provides and uses their own type of cleaning chemicals.
- The area uses traction sand and magnesium chloride during storms and sweeps the area twice a year.
- The CDOT Maintenance building in Loveland, Colorado serves as the base location for the rest area maintenance crew and is located 12 miles south of the Poudre Rest Area.

Poudre Rest Area Carbon Footprint

Scope 1 greenhouse gas emissions from the rest area involve the use of CDOT vehicles that transport equipment, operate equipment, and shuttle personnel to and from the CDOT Loveland Maintenance Facility and the operation of equipment necessary to maintain the rest area. The total approximate amount of gasoline used at the Poudre Rest Area is 33 gallons/year and the amount of diesel used is 750 gallons/year. The average natural gas consumption at the rest area is 1,350 therms annually.

These emissions generate an annual scope 1 carbon footprint of 15 metric tons CO_2e /year.

Scope 2 greenhouse gas emissions are from the generation of purchased electricity consumed by CDOT. This type of indirect emission is a result of rest area heating, air ventilation, and lighting. The average annual electrical consumption for the Poudre Rest Area is 144,000 kWhr/year (City of Fort Collins, 2010); this electrical consumption results in a Scope 2 footprint of 123.6 metric tons of CO_2e/year.

Scope 3 greenhouse gas emissions are a consequence of activities that occur from sources not owned or controlled by CDOT. The main rest area source for this type of indirect emission is

Figure 7. Poudre Rest Area Main Entrance

Figure 8. Poudre Rest Area Truck Parking Area

from truck idling. Based upon CDOT information it was estimated that 15 trucks idle at the rest area for 8 hours or greater per night. As a worst case scenario, the fuel consumed from long-term idling is responsible for a scope 3 footprint of 2,377 metric tons CO_2e /year (94% of the total carbon footprint).

The total estimated carbon footprint for the Poudre Rest Area is 2,517 metric tons CO_2e /year, the second highest footprint among the Project rest areas.

Poudre Rest Area Sustainability Scoring

The overall Poudre Rest Area sustainability score was 33 out of 117 points. Among the Tier I rest areas, the Poudre Rest Area achieved the higher sustainability score with 33 points versus 30 points for Sterling. The following summarizes some of the sustainability actions and total scoring (see Poudre Rest Area Scoring Sheet in Appendix D for details):

- Materials and Reuse Score – uses recycle asphalt for pavement repairs (3 of 13 points)
- Environmental/Site Conditions Score – open fencing and uncut native vegetation around the perimeter of the rest area. This vegetation management approach provides consistent habitat and mobility for the various types of wildlife in the area and along the corridor (9 of 25 points)
- Air Quality Score – no smoking signs posted in restrooms (2 of 13 points)
- Water Quality/Usage Score – excellent stormwater best management practices by having two vegetated retention ponds (see Figure 9) (5 of 21 points)
- Energy Score – lighting cut off fixtures used to reduce stray light and use of energy conservation measures (double-pane windows, caulking) and use of natural lighting (Figure 10) (7 of 30 points)
- Public/Motorist/Trucking Outreach Score – a computer-based kiosk that provides rest area users valuable road condition information, especially during winter storm conditions (7 of 11 points)
- Innovation Score – (0 of 4)

Poudre Rest Area Observations and Recommendations

There is no recycling available at the rest area. With the high amount of commercial and public vehicles using the rest area, recycling containers could be provided to reduce the amount of solid waste that eventually is placed in a landfill. Potential recycle materials (glass, aluminum cans, and plastics bottles) can either be taken to the town of Fort Collins Recycling Center or picked up and removed by Waste Management. Waste Management is already contracted to remove solid waste from the adjacent State of Colorado Visitor Center and offers the option of collecting recycle materials. This recycling option could reduce the total amount of solid waste produced and reduce landfilling costs.

The maintenance staff mows approximately nine acres of vegetation at least once per week (both native and non-native) and bags the grass clippings as solid waste. This increases the amount of solid waste that is taken to the Ault Landfill by Waste Management. If the grass clippings were mulched or composted onsite there would be a decrease in the solid waste produced, saving landfilling costs. Also, mulched grass is beneficial to lawns because it conserves moisture, lessens the need for pesticides, and saves money (Beck, 2004). The other option is not to mow the buffalo grass, which would significantly reduce overall lawn maintenance.

To reduce the amount of greenhouse gases emitted from idling trucks, idling restriction signs could be placed in the commercial vehicle parking lot. If there were restrictions on the length of idling times or if an electrical hookup was provided (truck electrification), significant reduction in the amount of greenhouse gas emissions could be realized.

The amount of water used for toilet flushing at the Poudre Rest Area was the highest of all of the Project rest areas. The toilets use 2.5 gallons per flush. Relative to the other Project rest areas, this appears to be an excessive amount of water that increases the amount of domestic water usage and wastewater sent to the Fort Collins treatment facility, thus increasing operational costs. The cost for domestic water is $2.27 per 100 gallons. Also, the urinals use 0.5 gallon per flush. If the urinals were changed to waterless, there could be zero domestic water usage and treatment cost associated with them. These changes could decrease overall operations costs

Figure 9. Poudre Rest Area Vegetated Retention Stormwater Management Pond

Figure 10. Poudre Rest Area Natural Lighting in the Main Restroom Entrance Lobby

because CDOT pays for both the incoming water and treatment of the outgoing wastewater. In addition, stormwater management fees imposed by the City of Fort Collins are significant and are based upon the volume of domestic water purchased (approximately $585 per month).

The rest area has approximately two acres of landscaping that receive fertilizers, herbicides, irrigation, and mowing. The area is irrigated three times per week during the summer. The overall consumption of purchased water for the rest area is 1.2 million gallons ($2,460/year) second only to the Sterling Rest Area for purchased water. It is assumed that the majority of the water consumption is from lawn irrigation practices. Alternative landscaping in the form of native vegetation use and xeriscape practices could be incorporated.

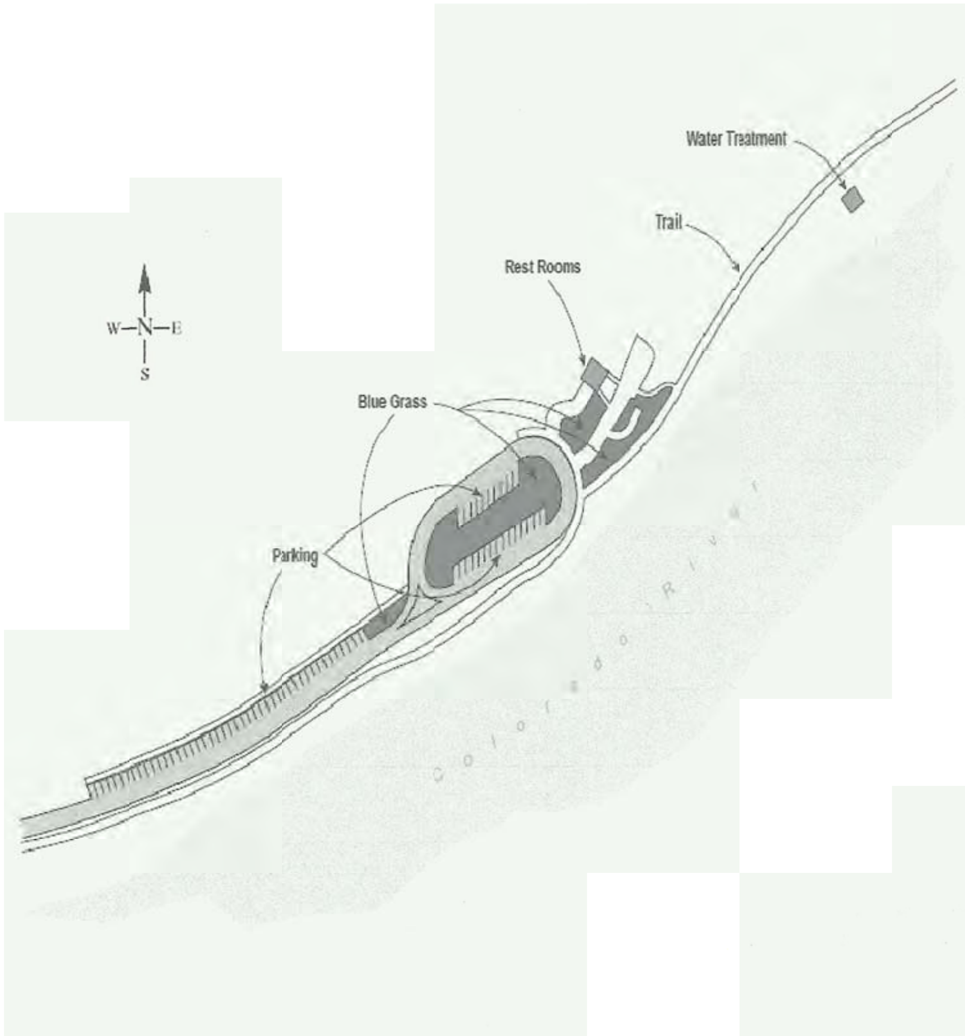
Alternative energy generation has potential at the Poudre Rest Area. The existing energy sources include both electric (heated floor, air conditioning, lights, and irrigation pumps) and natural gas (heating). The heated floor may not be a necessary feature for the rest area and its elimination could reduce electric energy use. The Poudre Rest Area has sufficient space to contain photovoltaic cell panels on existing roof surfaces and on the ground. This rest area has a large amount of unused land, especially to the west of the rest area building that could be used for the photovoltaic panels. The design and implementation of photovoltaic cells could have a dramatic impact on the rest area’s carbon footprint and reduction in electrical consumption cost. Photovoltaic cells could also demonstrate CDOT’s commitment to alternative energy and reduction in greenhouse gas emissions.

4.3 Hanging Lake Rest Area

Rest Area Setting

The Hanging Lake Rest Area is located on Interstate 70 at mile marker 124. It can be accessed only from the eastbound lane on Interstate 70 past the Grizzly Creek Rest Area, and is located on the south side of Interstate 70. The rest area is in Garfield County and located in Glenwood Canyon adjacent to the Colorado River (elevation 6,155 feet). The rest area is located in a canyon eco-zone area. The Hanging Lake Rest Area, built in 1993, is a Tier II rest area that provides parking and services for visitors interested in recreational activities. Annually, the rest area is visited by more than 73,000 motorists, tourists, hikers, and bicyclists primarily to access the Hanging Lake Trail. The rest area was closed to the public at the time of the site evaluation (from May 1, 2010 to September 6, 2010) due to United States Forest Service (USFS) construction on the popular Hanging Lake Trail. The rest area maintains a bike path to the east and west of the area and a small outdoor chemical toilet to the east. The rest area is normally open year round 24 hours a day seven days a week. The Hanging Lake Rest Area is comprised of four acres and is operated and maintained by one CDOT Maintenance representative. The restroom building is 2,296 square feet and the design reflects the local context of the area. The rest area is managed by CDOT Region 3. The actual rest area property is owned by the USFS and leased to CDOT. Any CDOT rest area improvements or changes that alter the area aesthetics must be approved by the USFS (USDA, 2010). Figure 11 shows the site plan for the Hanging Lake Rest Area.

Figure 11. Hanging Lake Rest Area Site Map



CDOT Rest Area Operations

The Hanging Lake Rest Area was evaluated by the CSU-Pueblo Team on July 16, 2010 with informational support provided by the CDOT Maintenance representatives. The following summarizes the Hanging Lake Rest Area Operations:

- The rest area contains the restroom building, picnic tables, vending machines, and two water wells which supply all the rest area water needs (see Figure 12).
- The total area of the rest area is 4 acres where one acre of bluegrass vegetation is used for dog walking and picnic areas.

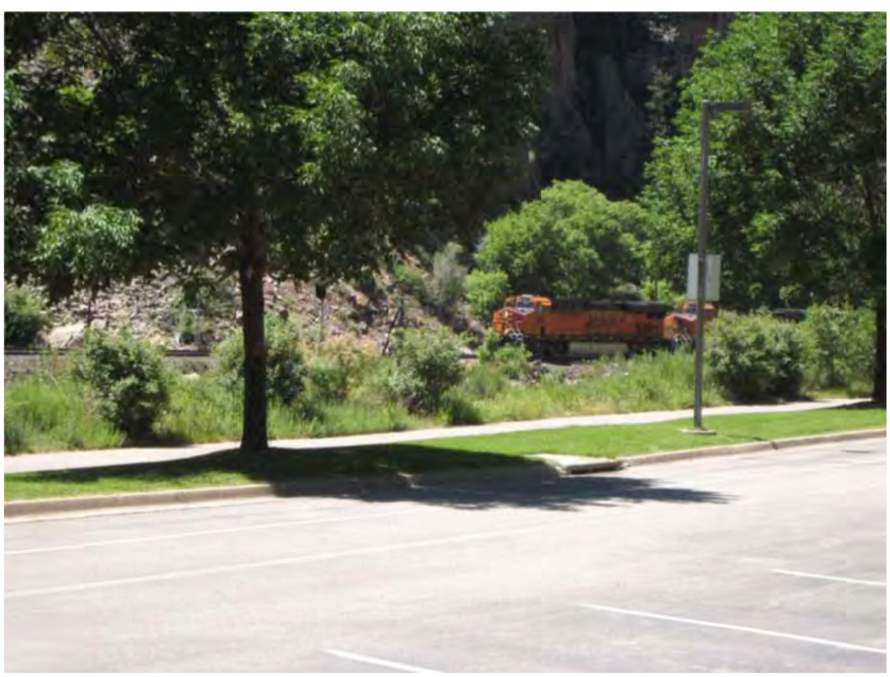
- Native grasses and vegetation are allowed to grow along the perimeter of the rest area which covers approximately three acres. Native grass provides a buffer between the rest area and sensitive environmental areas, such as wetlands and riparian vegetation along the Colorado River.
- There is an onsite wastewater treatment system that is permitted by the Colorado Department of Public Health and Environment to discharge directly into the Colorado River (see Figure 13). The Packed Bed Recirculation Treatment system that uses ozone treatment wastewater is managed for CDOT by an outside contractor (Alpine Environmental Consultant-Glenwood Springs).
- Domestic and irrigation water is supplied by an onsite well.
- There are 72 parking spaces mostly used by hikers and tourists using the Hanging Lake Trail. There is no large truck parking at the rest area due to the configuration of the rest area ingress and egress from Interstate 70.
- There are no stormwater best management practices and stormwater discharges; only a natural vegetated depression adjacent to the Colorado River (see Figure 14).
- The rest area is maintained by one worker whose base of operations is the CDOT Maintenance Facility in Glenwood Springs, which is nine miles from the rest area.
- Native vegetation is used as a buffer zone between the Colorado River and the rest area (see Figure 15).

Figure 12. Hanging Lake Rest Area Main Entrance and Walkway near Colorado River

Figure 13. Hanging Lake Rest Area Wastewater Treatment System

Figure 14. Hanging Lake Rest Area Unprotected Stormwater and Vegetated Ditch

Figure 15. Hanging Lake Rest Area Mixture of Native and Non-Native Vegetation



Hanging Lake Rest Area Carbon Footprint

Scope 1 greenhouse gas emissions from the Hanging Lake Rest Area include maintenance vehicles that transport materials, solid waste, and equipment to and from the CDOT Glenwood Spring Maintenance Facility. Emission sources also include onsite maintenance equipment such as mowers, weed eaters, snow blowers, and snow removal equipment. The total average gasoline consumption for the Hanging Lake Rest Area is 1,154 gallons/year which produces an annual scope 1 carbon footprint of 10.3 metric tons CO_2e/year.

Scope 2 greenhouse gas emissions are produced by electric consumption of the rest area. Hanging Lake Rest Area uses electricity for heating, lighting, water pumps and wastewater treatment. The average annual consumption for the Hanging Lake Rest Area is 154,818 kWh/year (Excel Energy, 2010). The total scope 2 carbon footprint for the Hanging Lake Rest Area is 132.9 metric tons CO_2e/year.

Scope 3 greenhouse gas emissions are a result of overnight idling trucks. This does not apply to the Hanging Lake Rest Area since it does not receive any semi-trailer truck visitations.

The total estimated carbon footprint for the Hanging Lake Rest Area is 143.2 metric tons CO_2e/year.

Hanging Lake Rest Area Sustainability Scoring Overview

The overall Hanging Lake Rest Area sustainability score was 31 out of 118 points. The following summarizes the existing sustainability actions and total rest area scores for all of the evaluation criteria (see Hanging Lake Scoring Sheet in Appendix C for details).

- Materials and Reuse Score – signage to promote no littering or trash dumping at rest area (1 of 13 points)
- Environment/Site Condition Score – native vegetation provides an excellent buffer zone between the rest area operations and the Colorado River that provides protection to the Colorado River and the local wildlife (10 of 25 points)
- Air Quality Score – one of the first CDOT rest areas to adopt the use of “green” cleaning chemicals (2 of 13 points)

- Water Quality/Usage Score – water-saving faucets are used in the restroom areas (3 of 21 points)
- Energy Score – uses natural ventilation for cooling in lieu of air conditioning (10 of 31 points)
- Public/Motorist/Trucking Information – rest area uses security cameras for public security and context sensitive design that fits the canyon area (5 of 11 points)
- Innovation Score – (0 of 4 points)

Hanging Lake Rest Area Observations and Recommendations

The Hanging Lake Rest Area does not have a recycling program for paper, aluminum, glass, and plastic materials. The staff did not seem to have an interest in such a program due to safety issues (encountering syringe needles, or meth-lab residues) and enticing wildlife to look for food in the recycling receptacles. CDOT could consider providing visitors with bins for recyclable items such as plastic, glass, aluminum, and paper since recycling has become an accepted practice and is expected by the traveling public. Recycled materials can be transported to Glenwood Springs for processing. Recycling can reduce the amount of waste being transported and landfilled and would reduce operating costs. Animal-proof recycle bins can be used in the Hanging Lake Rest Area due to the active local wildlife. Recycle containers can also be designed to accommodate specific bottle types to reduce the potential for the disposal of unwanted waste. A waste compactor could also be considered to reduce waste volume and number of trips to the disposal area.

The Hanging Lake Rest Area has the second highest water consumption of all the Project rest areas, with the majority of water used to irrigate non-native grass (a total average of 135,600 gallons/per month). The annual consumption for the rest area for the year 2009 was 1.6 million gallons which may have been influenced by an irrigation system line break. CDOT Maintenance representatives could monitor water usage records in order to identify unusually high water consumption and signal an operational problem.

The three urinals in the men's restroom area automatically flush 1.6 gallons every 10 minutes. This is the only automated flushing system among the Project rest areas. This automatic flushing was taking place even when the rest area was closed for 3 months (estimated discharge of 60,963 gallons), in order to maintain the optimization of the wastewater treatment system. CDOT Maintenance could consider a third-party evaluation of the water conservation practice performed at the rest area. The amount of water used for urinal flushing and toilet flushing (1.6 gallons per flush) may be excessive and generates approximately 243,885 gallons of discharge per year. The wastewater treatment system could be evaluated to determine if less wastewater flow could reduce treatment costs. While cost reduction is important, the efficient use of a finite resource such as water is also an important environmental stewardship practice.

There are very limited alternative energy options at Hanging Lake due to the canyon topography. Electric energy is the only source of power for the Hanging Lake Rest Area. It is used for lighting, heating, water pumping, and wastewater treatment. The average total electrical consumption for the Hanging Lake Rest Area is 154,818 kWh/year, which is the second most annual consumption among the Project rest areas. The main constraint for using solar power is the limited amount of sunlight due to the steep and narrow Glenwood Canyon. Cost-effective, innovative energy alternatives such as geothermal energy could be considered to reduce the electrical heating demand of the rest area, due to the presence of high yielding groundwater wells onsite.

The restroom building does not have motion detectors to initiate nighttime lighting in order to conserve energy. There are two levels of outdoor lighting systems at the rest area; lower lamp lighting for pedestrian walking and higher lighting poles for vehicle parking. There seems to be a redundancy in lighting the overall rest area near the restroom building and picnic areas. The lighting system should be evaluated to ensure there is electrical and lighting efficiency without compromising public safety. It is unclear how many people use the rest area facilities at night.

4.4 Vail Pass Rest Area

Rest Area Setting

The Vail Pass Rest Area is located on Interstate 70 at mile marker 190 on top of Vail Pass (elevation 10,666 feet). The rest area is in Eagle County and located on the southern side of Interstate 70 adjacent to Shine Pass Road. The rest area is above tree line and is characterized as a sub-alpine zone by Engelmann spruce, bristle cone pine, lodge pole pine and aspen (Pesman, 1967). The occurrence of Ten Mile Creek, beaver dams, wetlands, and fragile riparian vegetation makes this a very sensitive environment adjacent to the rest area. The rest area is characterized as a Tier II rest area that represents a recreational type rest area. The rest area was constructed in 1980 and is open year round 24 hours a day with a yearly visitation of approximately 680,000 people (Thomas, 2010); by far the most visited of the Project rest areas. It is a unique rest area since it receives large amounts of tourist and recreational traffic in both the summer and winter; bicyclists and tourists in the summer and skiers and snowmobilers in the winter. Based upon conversations with CDOT representatives, the rest area is undersized relative to the number of rest area visitors. The Vail Pass Rest Area is operated and maintained by CDOT Region 1. The rest area property is owned by the USFS and leased to CDOT. Any CDOT rest area improvements or changes that affect the area aesthetics must be approved by the USFS (USDA, 2010). Figure 16 shows a site map of the Vail Pass Rest Area.

Vail Pass Rest Area Operations

The Vail Pass Rest Area was evaluated by the CSU-Pueblo Team on July 15, 2010 with informational support provided by the CDOT Maintenance representatives. The following summarizes the Vail Pass Rest Area Operations:

- The Vail Pass Rest Area is comprised of 2.6 acres and contains a restroom building, picnic tables, vending machines, and a wastewater treatment system that discharges into the headwaters of Ten Mile Creek (see Figures 17 and 18).
- The rest area is adjacent to the Vail Pass-Ten Mile Creek Bicycle Trail that is a popular tourist and local bicycling trail.
- There are 73 spaces for car and RV parking. Very few large freight trucks use the rest area due to the tight access road configuration and the presence of a truck parking area near the CDOT Maintenance Patrol Shed on Interstate 70 near mile marker 189.

- The rest area is serviced by two CDOT Maintenance employees
- The Eisenhower-Johnson Memorial Tunnels (13 miles east of the Vail Pass Rest Area) serves as the base location for the maintenance crew.

Figure 16. Vail Pass Rest Area Site Map

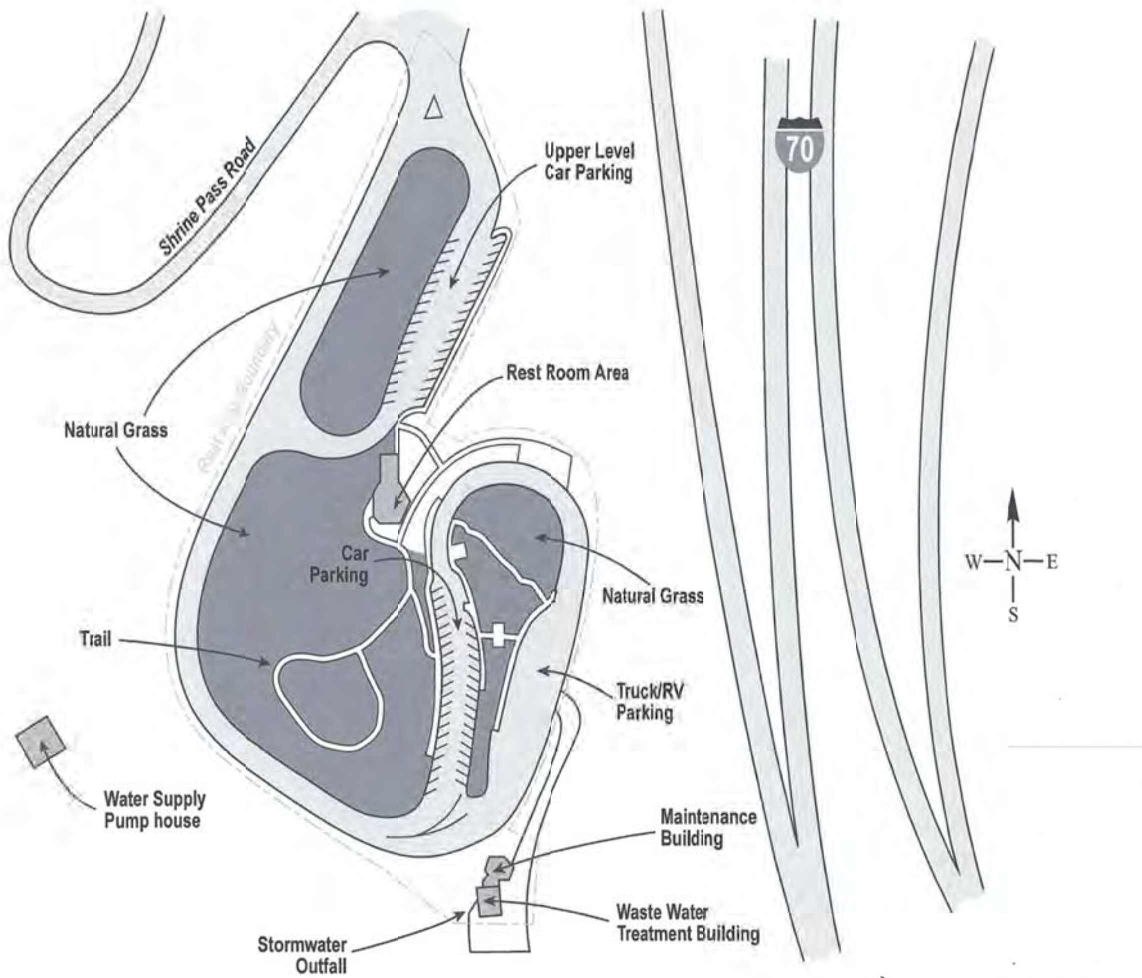


Figure 17. Vail Pass Rest Area Parking Area (looking east)

Figure 18. Vail Pass Rest Area Restroom Structure

- The rest area crew cleans the restroom area twice per day. The restroom structure is partially buried as it was built within a sloped-hill area; this design moderates the inside temperature from being too hot in the summer and too cold in the winter (see Figure 19).
- The rest area has an onsite waste treatment system that uses a sequencing batch reactor prior to wastewater discharge into Ten Mile Creek. The rest area has a National Pollutant Discharge Elimination System (NPDES) Permit from the Colorado Department of Public Health and Environment for wastewater discharge.
- The domestic water usage comes directly from Ten Mile Creek via a pump house located down gradient from a beaver pond (see Figure 20).

Vail Pass Rest Area Carbon Footprint

Scope 1 greenhouse gas emissions from the rest area involve the use of CDOT vehicles that transport equipment, operate equipment, solid waste, and personnel to and from the Eisenhower-Johnson Memorial Tunnels and the operation of equipment necessary to operate and maintain the rest area. The total amount of gasoline used at the Vail Pass Rest Area is 1,204 gallons that generates an annual scope 1 carbon footprint of 10.7 metric tons CO_2e/year.

Scope 2 greenhouse gas emissions are from the generation of purchased electricity consumed. This type of indirect emission is a result of rest area heating, air ventilation, lighting and waste treatment. The average annual electrical consumption for the Vail Pass Rest Area is 268,290 kWhr/year (Excel Energy, 2010); this results in a Scope 2 footprint of 230.3 metric tons CO_2e/year.

Scope 3 greenhouse gas emissions are a consequence of activities that occur from sources not owned or controlled by the CDOT. The main rest area source for this type of indirect emission is from truck idling. The Vail Pass Rest Area has approximately four freight trucks idling for greater that 8 hours per night; therefore, the scope 3 emissions are 645.3 metric tons CO_2e/year (73% of the total rest area carbon footprint).

The total estimated carbon footprint for the Vail Pass Rest Area is 886 metric tons CO_2 e /year.

Figure 19. Vail Pass Rest Area Native Grass and Context Sensitive Design

Figure 20. Water Pump From Vail Pass Ten Mile Creek

Vail Pass Rest Area Sustainability Scoring Overview

The overall Vail Pass Rest Area sustainability score was 37 out of 117 points which was the highest score among all the Project rest areas. The following summarizes some of the current sustainability actions and the total sustainability scoring (see Vail Pass Rest Area Scoring Sheet in Appendix C for details):

- Materials and Reuse Score – signage to promote no dumping or littering at the rest area (1 of 14 points)
- Environmental/Site Conditions Score – good vegetative buffer that separates the rest area services from Ten Mile Creek and associated wetlands. The area is dominated by native vegetation without using lawn irrigation and no herbicide and fertilizer applications. There is no rest area fencing that would interfere with wildlife movement (14 of 25 points)
- Air Quality Score – no smoking signs in restroom areas (2 of 15 points)
- Water Quality/Usage Score – no lawn or plant irrigation, water conservation studies performed, bio-solids recycled as compost (5 of 21 points)
- Energy Score – natural ventilation used instead of air conditioning, natural lighting via sky lighting, solar powered emergency phone (6 of 30 points)
- Public/Motorist/Trucking Outreach Score – context design of the restroom structure, security cameras used on site, (5 of 11 points)
- Innovation Score – the only rest area to receive innovation points for its restroom area design. The structure is built within a hill and is partially buried, which moderates the temperatures in the summer and winter thus saving heating energy costs (4 of 4 points)

Vail Pass Rest Area Observations and Recommendations

The volume of solid waste generated and handled at the rest area is 1,820 cubic yards per year (35 cubic yards per week on average) at an annual cost of $17,200 (Thomas, 2010). The volume of waste generation is by far the highest among all the Project rest areas. There are recycling options available at the rest area at the Town of Vail Recycling Center. To reduce the volume of solid waste, the traveling public can be provided with the opportunity to recycle their aluminum cans, plastic bottles, and glass containers at the rest area. Much of the solid waste at the rest area is from bottled water or carbonated beverage containers sold at the rest area. Recycle containers can be designed to accommodate specific bottle types to reduce the potential for the disposal of unwanted waste. The recycled material could be transported to the Town of Vail or Frisco recycling centers on a routine basis. In addition, the use of a solar waste compactor could also be considered to reduce waste volume and number of trips to the CDOT Maintenance area for disposal that is 13 miles from the Vail Pass Rest Area (see Appendix G).

The Vail Pass Rest Area is dominated by natural vegetation and does not use irrigation practices. It was noticed that extensive grass eating/mowing practices are used to trim or mow the native grass species in areas near restroom entrance area. It was estimated that 15 hours a week is spent on native grass control, which seems excessive. This type of grass control may be needed in areas near pet walks and picnic table locations; however, reduced weed eating/mowing of native grasses will allow for improved plant density by encouraging seed dispersal near the restroom area and improve the overall native aesthetics.

The Vail Pass Rest Area uses standard retail type cleaning chemicals (Pine-Sol and Windex) that are not compliant with the State of Colorado Environmentally Preferable Purchasing Policy (2009). The policy specifies the use of cleaning chemicals that are environmentally compatible without toxic chemicals or high VOCs that contribute to greenhouse gas emissions and those chemicals that are biodegradable without phosphorous. Coordination between the rest areas and with procurement office staff could be done to obtain a list of environmentally preferable cleaning materials that are effective.

CDOT has an existing stormwater management program for construction and post-construction projects and maintenance facilities. There is no regulatory requirement for the placement of best management practices in rest areas, although they do have large amounts of impervious surfaces and potentially contain pollutants (sediments, metals and oil and grease). CDOT could develop best management practices to prevent stormwater and its associated pollutants from entering the headwaters of Ten Mile Creek by:

- Ensuring exposed areas are vegetated/mulched,
- Ensuring stormwater inlet protection is in place and maintained,
- Sweeping traction sand and other sediment material frequently,

- Evaluating and modifying the existing vegetated depression area (near treatment building) to accommodate the stormwater from the parking area as a final BMP before stormwater discharge,
- Ensuring there is a final BMP for the all stormwater discharge outlets, and
- Evaluating snow storm storage management to ensure traction sand/snow is contained to prevent discharge into the headwaters of Ten Mile Creek.

The volume of water used for urinal and toilet flushing is 1.6 gallons per flush. These volumes are high in comparison to other Project rest areas. It is recommended that a water conservation study be performed at the rest area to reduce water consumption and to make sure that the waste treatment operations are in sync with incoming volumes and loading to potentially reduce waste treatment operating costs.

There are alternative energy generation options at Vail Pass. Electric energy is the only power source for the Vail Pass Rest Area and is used for rest area heating, lighting, water pumping, and wastewater treatment. The rest area has sufficient space to contain photovoltaic cell panels on existing roof surfaces and potentially as a ground array. There are several constraints in the establishment of photovoltaic cell panels such as snow accumulation, USFS aesthetic guidelines, and system maintenance. The design and implementation of photovoltaic cells could have an impact on the rest area's carbon footprint and reduction in electrical consumption cost. Photovoltaic cells could also demonstrate to rest area visitors CDOT's commitment to alternative energy.

There are several energy conservation actions that can be taken by the Vail Pass Rest Area to reduce electrical consumption, such as the use of motion detectors to initiate restroom lighting during nighttime hours. Motion detectors can be placed in strategic places to avoid vandalism and initiate lighting well ahead of entering the restroom for security. The intensity of the lighting can be changed inside the restroom area to accommodate the sky lighting that can add significant amount of lighting during the daytime. The use of an on-demand hot water heater, potentially in combination with a solar hot water heating system, could be an important energy reduction action.

4.5 El Moro Rest Area

Rest Area Setting

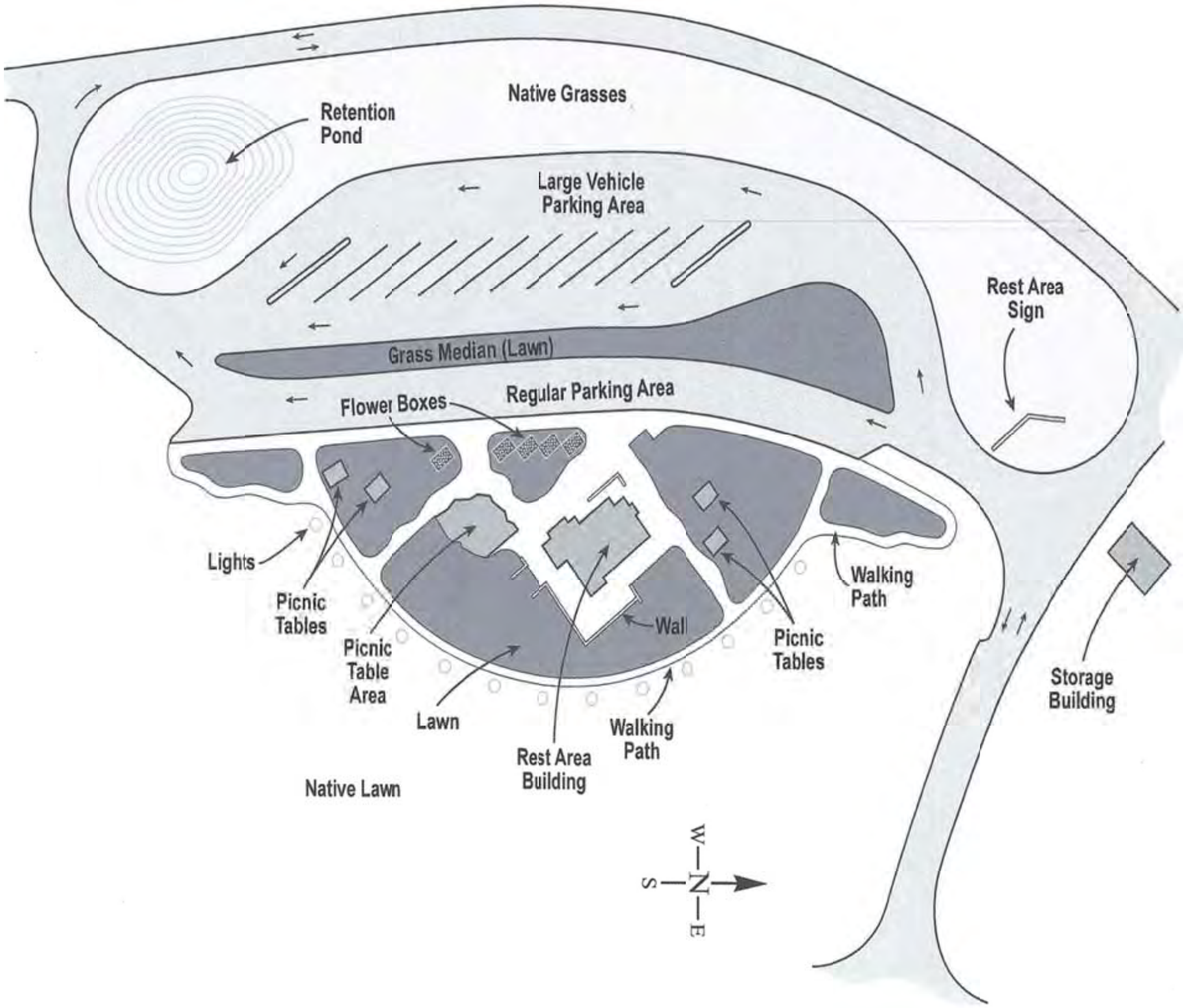
The El Moro Rest Area is located on Interstate 25 at mile marker 17 just north of Trinidad (approximate elevation of 6,025 feet). The rest area is located on the western side of Interstate 25 on County Road 71 in Las Animas County. The El Moro Rest Area is a Tier III rest area that provides only basic services to the traveling public. The rest area was built in 2000 and is open year round 24 hours a day, seven days a week with a yearly visitation of approximately 328,500 people. The rest area resides in a semi-arid, high plains eco-region where there is a broad mixture of wildlife such as deer, elk, raptors, snakes and coyotes. El Moro is an important rest area since it is the first rest area encountered when entering Colorado from New Mexico on Interstate 25 and provides the traveler a first impression of Colorado. The El Moro Rest Area is operated and maintained by CDOT Region 2. A site map of the rest area is provided in Figure 21.

El Moro Rest Area Operations

The El Moro Rest Area was evaluated by the CSU-Pueblo Team on August 6, 2010 with informational support provided by the CDOT Maintenance representatives. The following summarizes the El Moro Rest Area Operations:

- The El Moro Rest Area is comprised of 7.1 acres of which are five acres of bluegrass is mowed once per week.
- This rest area contains a restroom building (2,400 square feet), 11 picnic tables, vending machines, and a walking path (see Figure 22).
- There are 39 parking spaces for cars and small recreational vehicles.
- Large commercial trucks and large recreational vehicles have a total of 14 parking spaces to use. In the winter, all of these commercial parking spaces are used at night.
- The rest area is serviced by two CDOT Maintenance employees.

Figure 21. El Moro Rest Area Site Map



- The Aguilar Maintenance Facility (16 miles north of the El Moro Rest Area) serves as the base location for the maintenance crew.
- The rest area crew cleans the restroom area three times per day in the summer and two times per day in the winter.
- The restroom building has a design that fits the context of Colorado and the local area and has a unique large set of artistic graphics (glyphs) in aluminum, bronze, steel, glass, and slate (Boak, 2010). Water is purchased from the local municipality (City of Trinidad) for domestic drinking and irrigation. In addition the rest area wastewater is treated by the local municipality.

- Spray irrigation is used to irrigate the five areas of bluegrass and drip irrigation methods are used for native plant landscaping (see Figure 23).
- Stormwater is managed by a retention basin that is occupied by wetlands (see Figure 24).

El Moro Rest Area Carbon Footprint

Scope 1 greenhouse gas emissions from the rest area involve the use of CDOT vehicles that transport equipment, operate equipment, solid waste, and personnel to and from the Aguilar Maintenance Facility. The combustion of the fuel from equipment necessary to operate and maintain the rest area is also part of this emission type. In addition, the use and combustion of natural gas for heating is an important Scope 1 emission source. The total amount of gasoline used at the El Moro Rest Area is 65 gallons per year, the total amount of diesel used is 1,154 gallons, and the annual average consumption of natural gas is 5,307 therms. Collectively, these emissions generate an annual scope 1 carbon footprint of 59.3 metric tons CO_{2e}/year.

Scope 2 greenhouse gas emissions are from the generation of purchased electricity consumed by CDOT. This type of indirect emission is a result of rest area lighting and other maintenance electrical uses. The average annual electrical consumption for the El Moro Rest Area is 2,527 kWhr/year (Johnson Controls, 2010); this results in a scope 2 footprint of 2.2 metric tons CO_2e/year. The electrical consumption seems very low in comparison to other Project rest areas; Johnson Controls could verify this electrical consumption rate as part of their rest area evaluations.

Figure 22. El Moro Rest Area Entrance Area with Copper Siding and Roof

Source: www.bookart.com/PublicArt2.html

Figure 23. El Moro Rest Area Large Lawns of Bluegrass (looking north at rest area)

Figure 24. El Moro Rest Area Flower Box with Drip Watering System

Figure 25. El Moro Rest Area Stormwater Ponds with Wetland Vegetation

Scope 3 greenhouse gas emissions are consequences from activities that occur from sources not owned or controlled by CDOT. The main rest area source for this type of emission is from truck idling. The El Moro Rest Area has an average of 14 trucks idling per night for a duration of 8 hours or greater; therefore, the Scope 3 emissions are 2,219 metric tons CO_2e/year (97% of the total carbon footprint).

The total estimated carbon footprint for the El Moro Rest Area is 2,281 metric tons CO_2e/year.

El Moro Rest Area Sustainability Scoring Overview

The overall El Moro Rest Area sustainability score was 32 out of 117 points. The following summarizes some of the sustainability activities and total scoring (see El Moro Rest Area Scoring Sheet in Appendix C for details):

- Materials and Reuse Score – uses recycled asphalt material for surface repairs, rest area uses a mulching mower to reduce solid waste disposal (5 of 13 points)

- Environmental/Site Conditions Score – buffer zones to protect sensitive areas, drip irrigation used for native species plants (7 of 25 points)
- Air Quality Score – smoking prohibited in restroom areas (2 of 13 points)
- Water Quality/Usage Score – effective stormwater best management practices using wetlands (3 of 21 points)
- Energy Score – energy conservation methods used in the rest area include efficient lighting (compact fluorescent bulbs) and the use of natural ventilation in lieu of air conditioning (11 of 30 points)
- Public/Motorist/Trucking Outreach Score – context sensitive design with the local community and environment, local community information provided to visitors (4 of 11 points)
- Innovation Score – (0 of 4)

El Moro Rest Area Observations and Recommendations

No recycling options are available at the rest area. The large amount of commercial and public vehicles using the rest area offers the opportunity for recycling. The rest area has a total of 18 trash cans that collect a high quantity of waste from the traveling public. Recycling containers could be provided to reduce the three cubic yards per day of solid waste that eventually ends up in the Trinidad Landfill. The recycled material (glass, aluminum cans, and fibers) can be taken to the town of Trinidad for processing. In addition, trash compaction using a solar powered compactor will reduce trash volumes and frequency of trash pickups. Appendices F and G provide the cost savings that could be realized by CDOT using the solar compactor.

There are opportunities to improve the natural wildlife in and around the rest area. To improve the habitat for wildlife, the mowing of the native vegetation east of the walking path could be reduced. This may improve the plant density for wildlife habitat, consumption, and mobility while reducing the labor and fuel needed to mow the vegetation.

There are a relatively high number of truckers (average of 14 per day) that use this rest area over night and idle for eight hours or longer. To reduce the amount of greenhouse gases emitted from idling trucks, idling restriction signs could be placed in the commercial vehicle parking lot. If there were restrictions on the length of idling times or electrical hookup present, drivers could plug their trucks into an outlet (electrification) and the amount of greenhouse gases could be reduced. CDOT could consider the potential of instituting a pilot study at El Moro and other high truck idling areas using truck electrification to reduce truck idling and emissions.

The domestic water used for restrooms and irrigation is purchased from the City of Trinidad. Wastewater generated at the rest area is transferred and treated by the City of Trinidad. The total amount of water consumed is approximately 39,554 gallons per year. Since the lawn is irrigated seven days a week in the summer, it is assumed that most of the purchased water is used to irrigate the non-native grass lawn. Approximately five acres of bluegrass within the rest area are being irrigated. This size of lawn and type of non-native grass require a large amount of water to survive in the dry conditions found in the Trinidad area (Lockhart, 2004).

Based upon discussions with CDOT Maintenance representatives, there is a concern about the excessive amount of driving necessary to get to work. CDOT representatives who live in Trinidad drive to Aguilar to get a work truck, although there is a CDOT office in the closer Trinidad, and then drive 16 miles to the rest area. If employees could park the CDOT trucks at the CDOT Trinidad office, the amount of diesel used for all the driving back and forth could drastically decrease because Trinidad is only about two miles away from the rest area. This could decrease the rest area's fuel consumption and the carbon footprint.

4.6 Sleeping Ute Mountain Rest Area

Rest Area Setting

The Sleeping Ute Mountain Rest Area is located on US Highway 60 at mile marker 46.4 and is about six miles east of Cortez (elevation 6,200 feet). The rest area is in Montezuma County and located on the northern side of US Highway 60 directly north of Mesa Verde National Park. The rest area is representative of a Tier III rest area that provides basic services. The rest area was constructed in the 1970s and retrofitted in 1998. The 10.4 acre rest area is open year round 24 hours a day, seven day a week with annual average visitation of approximately 65,700 people. Unique to this rest area is a long walking path through the Juniper and Pinon Pine forest that is adjacent to Bureau of Land Management property. The Sleeping Ute Mountain Rest Area is operated and maintained by CDOT Region 5. A site map is provided in Figure 26.

CDOT Rest Area Operations

The Sleeping Ute Mountain Rest Area was evaluated by the CSU-Pueblo Team on July 9, 2010 with informational support provided by the CDOT Maintenance representatives. The following summarizes the Sleeping Ute Mountain Rest Area Operations:

- The rest area is dominated by native vegetation and occupied by approximately 820 Juniper and Pinon Pine trees (see Figure 27).
- The Sleeping Ute Mountain Rest Area contains a 1,245 square foot restroom building, picnic tables, vending machines, a walking path, and housing for the onsite CDOT employee (see Figures 28 and 29).
- The restroom building is surrounded by 900 square feet of bluegrass that is irrigated three to four times per week (see Figure 30).
- There is a total of 40 parking spaces, with 37 for car and RV parking and three for large freight trucks.
- The rest area is serviced by one CDOT Maintenance employee who lives onsite. Since there is a CDOT Maintenance representative who lives on location, there is little travel to and from Cortez or Durango to maintain the rest area.
- The CDOT Maintenance facility in Cortez (six miles east of the Sleeping Ute Mountain Rest Area) serves as the base location.
- The employee goes to the CDOT facility in Cortez only once a week for supplies. The onsite Maintenance employee cleans the restroom area daily.

Sleeping Ute Mountain Rest Area Carbon Footprint

Scope 1 greenhouse gas emissions from the rest area involve the use of CDOT vehicles that transport equipment and personnel to and from the Cortez Maintenance facility and the use of equipment necessary to operate and maintain the rest area and propane (1,806 gallons per year) (AmeriGas, 2010) for restroom heating. The annual fuel consumption used at the Sleeping Ute Mountain Rest Area is approximately 22 gallons of gasoline and 815 gallons of diesel that generates an annual scope 1 carbon footprint of 23 metric tons CO_2e/year.

Figure 26. Sleeping Ute Mountain Rest Area Site Map

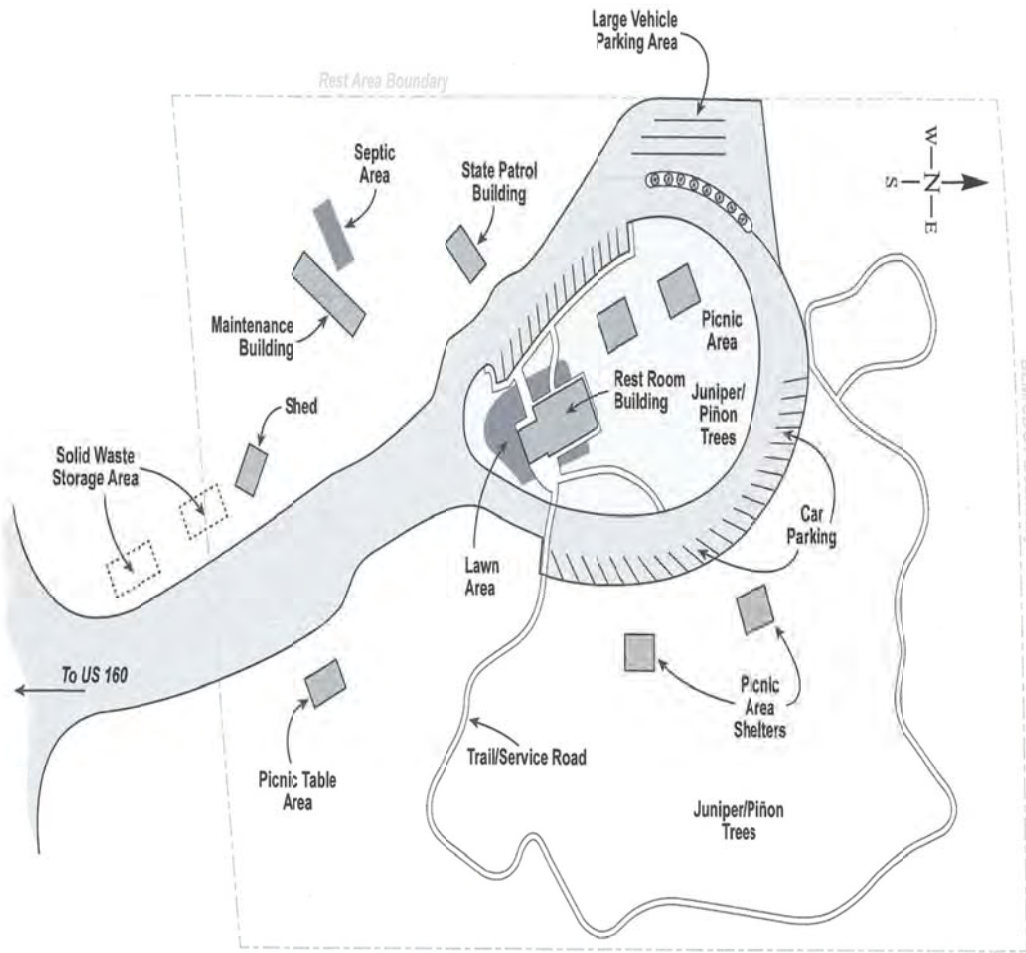


Figure 27. Sleeping Ute Mountain Rest Area Northern Portion of Rest Area with Hiking Trail Near BLM Property

Figure 28. Sleeping Ute Mountain Rest Area Restroom Structure

Figure 29. Sleeping Ute Mountain Rest Area Example of Picnic Shelters in Rest Area

Figure 30. Sleeping Ute Mountain Rest Area Lawn Area Surrounding Restroom Structure

Scope 2 greenhouse gas emissions are from the generation of purchased electricity consumed by CDOT. This type of indirect emission is a result of rest area heating, air ventilation, and lighting. The average annual electrical consumption for the Sleeping Ute Mountain Rest Area is 57,948 kWh/year (Empire Electric, 2010); this results in a scope 2 footprint of 50 metric tons CO_2e/year.

Scope 3 greenhouse gas emissions are a consequence of activities that occur from sources not owned or controlled by CDOT. The main rest area source for this type of indirect emission is from truck idling. Scope 3 greenhouse gas emissions are a result of overnight idling trucks. This does not apply to the Sleeping Ute Mountain Rest Area since it does not receive any semi-trailer truck visitations.

The total estimated carbon footprint for the Sleeping Ute Mountain Rest Area is 73 metric tons CO_2e/year, the lowest among all the Project rest areas.

Sleeping Ute Mountain Rest Area Sustainability Scoring Overview

Overall, the Sleeping Ute Mountain Rest Area sustainability score was 35 out of 117 points. The following summarizes the current sustainability actions and the rest area scoring (see Sleeping Ute Mountain Rest Area Scoring Sheet in Appendix C for details):

- Materials and Reuse Score – recycled/reused asphalt material was used to make pothole repairs on the main rest area entrance (5 of 13 points)
- Environmental/Site Conditions Score – wooden ranch rail fence that encloses the rest area from BLM land and a natural Juniper and Pinon Pine forest surrounds the restroom that provides shelter, food, and wildlife to migrate through the rest area. Less than 25% of the rest area is routinely mowed thus allowing native vegetation to grow (10 of 25 points)
- Air Quality Score – no smoking allowed in restroom areas (2 of 13 points)
- Water Quality/Usage Score – reduced volume of water used for urinal flushing, water-saving water faucets used in rest rooms (3 of 21 points)
- Energy Score – motion detectors used in restroom areas to conserve electricity, natural ventilation used in lieu of air conditioning and use of hand blowers instead of paper towels (9 of 30 points)

- Public/Motorist/Trucking Outreach Score – context sensitive design to local environment, local community information provided to visitors, security camera used (6 of 11 points)
- Innovation Score – (0 of 4 points)

Sleeping Ute Mountain Rest Area Observations and Recommendations

No recycling options are available to the public at the rest area. Recycling containers could be provided to reduce the amount of solid waste that is produced from this rest area. The recycled glass, aluminum, and paper can be taken to ECOtrez in Cortez. Recycling could reduce solid waste amounts and decrease the solid waste disposal cost by reducing the waste pickup frequency from 3 cubic yards per week to biweekly or monthly pickups. This recycling action could reduce the amount of solid waste that is currently being taken to a landfill near Cortez.

The amount of water used for toilet volume flushing at this rest area was the second highest of all the Project rest areas. The toilets use two gallons per flush. This may be an excessive amount of water that increases that amount of water being purchased from the Mancos Rural Water Company whose resulting wastewater is treated via an onsite septic system. Manually adjusting the amount of water used for toilet flushing could be performed. The use of waterless urinals could also be considered to significantly reduce the cost and amount of water used in the rest area.

The 900 square foot bluegrass lawn that surrounds the restroom area is irrigated three to four times per week. Water savings could be realized by replacing the lawn vegetation with native vegetation that is adapted to the high desert climate. This vegetation could be combined with other landscape features to form a xeriscape garden (Lockhart, 2004).

There are potential cost-effective alternative energy opportunities at Sleeping Ute Mountain Rest Area. The existing energy sources for the Sleeping Ute Mountain Rest Area include both electric and propane. The Sleeping Ute Mountain Rest Area has the space necessary to contain photovoltaic cell panels on the existing roof surfaces and on the ground. There may be constraints in the establishment of photovoltaic cell panels on the roof of the restroom building because of the limited surface area. However, this rest area has a large amount of unused land that could be used for the photovoltaic panels and arrays. The design and implementation of photovoltaic cells could have a dramatic impact on the rest area’s carbon footprint and reduction in electrical consumption cost. Photovoltaic cells could also demonstrate CDOT’s commitment to alternative energy. Photovoltaic cells could be very beneficial to this rest that consumes only 57, 948 kWh of electricity per year (lowest among the Project rest areas).

CHAPTER 5. REST AREA CONCLUSIONS AND RECOMMENDATIONS

Specific sustainable observations for each Project rest area are provided in Sections 4.1 through 4.6. These observations were based upon site visitations and assessments that are compiled in a Sustainable Rest Area Database (Appendix C). Existing rest area sustainable actions were rated according to a scoring system established by the CSU-Pueblo Team. There are sustainability based observations and recommendations that are common among all the Project rest areas and possibly rest areas statewide. This section identifies and summarizes the following major observations and conclusions identified for the Project rest areas:

- Rest Area Sustainability Scoring
- Summary of Rest Area Carbon footprints and Reduction Strategies
- Alternative Energy Use for CDOT Rest Areas Using CDOT ROW
- Coordination with Johnson Controls
- Common Project Rest Area Sustainable Observations and Recommendations
- Further Rest Area Sustainability Studies and Funding

5.1 Rest Area Sustainability Scoring

Rest Area Sustainability Scoring Criteria were developed as a tool to assess the level of sustainability practices currently being used at the Project rest areas and provide a metric for Project rest area comparison among scoring elements and categories. The scoring matrix is composed of 6 categories comprising a total of 61 scoring elements with 117 being the maximum number of points per rest area (Appendix D). The following summarizes the scoring comparison:

- Tier I rest area (visitor center type rest area) – Poudre Rest Area (33 points) higher than the Sterling Rest Area (30 points)
- Tier II rest area (recreational based rest area) – Vail Pass Rest Area (37 points) higher than Hanging Lake (31 points)
- Tier III rest area (basic rest area services) – Sleeping Ute Mountain Rest Area (35 points) higher than the El Moro Rest Area (32 points)
- Overall, the Vail Pass Rest Area obtained the most sustainability points among all the Project rest areas with a score of 37 points

- The scoring distribution was very close among the rest areas with a point spread from 30-37 and a mean of 33 points.

No one rest area scoring stood out from the other Project rest areas, which indicates consistent rest area management among all the Project rest areas. Each rest area had its own particular sustainability strengths and weaknesses for the scoring categories (see Table 1).

- Materials and Reuse/Recycling – the Sterling Rest Area scored the highest number of sustainability points (6) mostly because it is the only rest area with recycling activity
- Environment/Site Conditions – the Vail Pass Rest Area scored the highest number of sustainability points (12) mostly because of high native vegetation use, lack of fencing that would affect wildlife mobility sensitive area buffer zones, and no lawn irrigation activities
- Air Quality – all rest areas scored a consistent score of 2
- Water Quality/Usage – the Sterling Rest Area scored the highest number of sustainability points (7) due to the use of low volume restroom faucets, and the low flow urinal and toilet flush volumes; although, the Sterling Rest Area has the highest water consumption of all Project rest areas (not a scoring criteria)
- Energy – the El Moro Rest Area scored the highest number of sustainability points (11) because of the energy-efficient lighting use in the restroom areas
- Community Education and Outreach – the Sleeping Ute Mountain Rest Area scored the highest number of sustainability points (6) because of its use of security cameras
- Innovation Scoring – the Vail Pass Rest Area received 4 innovation points for the restroom sustainable design that was constructed with the slope of a hill

Table 1. Summary of Project Rest Area Sustainability Scoring

Sustainability Categories	Maximum Points	Sterling	Poudre	Hanging Lake	Vail Pass	El Moro	Sleeping Ute Mountain
Total Materials and Reuse Score	13	6	3	1	1	5	5
Total Environment/Site Conditions	25	5	9	10	12	7	10
Total Air Quality	13	2	2	2	2	2	2
Total Water Quality/Usage	21	7	5	2	2	3	3
Total Energy	30	6	7	10	6	11	9
Total Public/Motorist/Trucking Outreach	11	4	7	5	5	4	6
Innovation Score	4	0	0	0	4	0	0
Total Rest Area Scoring	**117**	**30**	**33**	**31**	**37**	**32**	**35**

There was some existing sustainable action and scoring consistency among most of the Project rest areas in the following areas:

- At least 50 feet of protection is given to sensitive areas (surface water/wetlands) via buffers, fencing, non-assessable areas or other means to reduce rest area impacts
- Irrigation occurs in the evening hours to reduce evaporation as opposed to mid-day irrigation
- Water-saving faucets used within restrooms for water conservation
- Most restroom areas use hot air hand dryers instead of paper towels to reduce solid waste volume
- Local community or other groups provide some local and educational information and support to most rest areas
- No charcoal grills at rest area picnic areas which reduces smoke emissions and fire risk
- Smoking is prohibited within restroom areas with signage to reduce exposure to secondhand smoke
- Context Sensitive Design was used for all rest areas that reflects local community, area culture or local environment
- Most rest areas have open type fencing that reduces habitat fragmentation and allows for wildlife movement

- Most rest areas conduct limited or no mowing practices around the rest area perimeter to allow nesting and maintain habitat conditions
- Dog run areas are available with collection bags or disposal requirement signage

5.2 Summary of Rest Area Carbon Footprints and Reduction Strategies

Carbon footprints were calculated for all the Project rest areas which incorporate scope 1 emissions (fossil fuel combustion onsite), scope 2 emissions (indirect emissions from electrical consumption) and scope 3 emissions (uncontrolled emissions such as idling). The following summarizes the carbon footprint results for the Project rest areas (see Table 2):

- The Tier I rest areas' (visitor centers) carbon footprints were 3,006 metric tons metric tons CO_2e/year for the Sterling Rest Area and 2,517 metric tons CO_2e/year for the Poudre Rest Area; truck idling emissions account for 94-95% of total carbon footprint emissions. The average carbon footprint for the Tier I rest areas was 2,762 metric tons CO_2e/year.
- The Tier II rest areas' (recreational areas) carbon footprints were 886 metric tons CO_2e/year for the Vail Pass Rest Area and 143 metric tons CO_2e/year for the Hanging Lake Rest Area. Higher electrical usage for heating, lighting and waste treatment operations resulted in a higher overall carbon footprint for the Vail Pass Rest Area. The average carbon footprint for the Tier II rest areas was 515 metric tons CO_2e/year.
- The Tier III rest areas' (basic services) carbon footprints were 2,281 metric tons CO_2e/year for the El Moro Rest Area and 73 metric tons CO_2e/year for the Sleeping Ute Mountain Rest Area; higher natural gas usage, and truck idling were the main reasons for the higher footprint value at the El Moro Rest Area. The average carbon footprint for the Tier III rest areas was 1,177 metric tons CO_2e/year.
- The Sterling Rest Area had the highest carbon footprint among all the Project rest areas with a carbon emission value of 3,006 metric tons CO_2e/year; whereas the Sleeping Ute Mountain Rest Area had the lowest carbon footprint value of 73 metric tons CO_2e /year.
- The metric tons CO_2e/year per restroom square foot are the highest at the Poudre Rest Area (1 metric ton/square foot) followed by the El Moro Rest Area (0.95 metric ton/square foot).

Table 2. Summary of Project Rest Area Carbon Footprints.

	Sterling	Poudre	Hanging Lake	Vail Pass	El Moro	Sleeping Ute Mtn.
Scope 1 Carbon Footprint (operations - metric tons CO_2e/year)	44.000	15.154	10.27	10.72	59.351	22.945
Scope 2 Carbon Footprint (electrical consumption - metric tons CO_2e/year)	108.615	123.61	132.897	230.303	2.169	49.74
Scope 3 Carbon Footprint (idling - metric tons CO_2e/year)	2853.6	2377.82	0	645.35	2219.3	0
Total Carbon Footprint (metric tons CO_2e/year)	3006	2517	143	886	2281	73
Tons/square foot restroom area	0.7708	1.0066	0.0624	0.1641	0.9503	0.0584
Tons/Acre	429.4593	157.2865	35.7918	124.8413	321.2423	6.9889
Scope 3 Emission - % of Total	95%	94%	0%	73%	97%	0%

- The metric tons of CO_2e/year per acre is the highest for the Sterling Rest Area (429 metric tons CO_2e/year metric tons/acre) followed by the El Moro Rest Area (321 metric tons CO_2e/year).
- It is possible that the Sleeping Ute Mountain Rest Area is the only Project rest area that is close to being carbon neutral. The total carbon footprint is 73 metric tons CO_2e/year and the total amount of trees for carbon sequestration within the 10.4 acre rest area is 820 Juniper and Pinon Pine trees (82 trees/acre).

Truck idling dominates the carbon footprint emissions for most of the Project rest areas followed by electrical consumption. The number of trucks parking and idling for 8 hours or more at the Project rest areas (El Moro, Vail Pass, Poudre and Sterling) range from 4-18 truck per night and emit greenhouse gases such as carbon dioxide, nitrous oxides, and methane. Truck idling also releases fine particulates, fumes, and generates noise at the rest areas. Electrical consumption is dominated by lighting and heating. Lighting is primarily used by the rest areas for restrooms, parking areas, and pedestrian walkways.

The carbon footprint values calculated for the Tier I, II and III rest areas provide initial emission information such that a gross estimate can be made for the combined total carbon footprint for all the rest areas managed by CDOT. The following average carbon footprint for each Tier rest area (Tier I-2,762 metric tons CO_2e /year, Tier II- 515 metric tons CO_2e /year and Tier III-1177 metric tons CO_2e /year) is multiplied by the number of rest areas within each Tier (Tier I-5 rest areas, Tier II-5 rest areas and Tier III-17 rest areas) to estimate the total combined carbon footprint for all CDOT rest areas.

- Tier I - 13,810 metric tons CO_2e/year
- Tier II - 2,575 metric tons CO_2e/year
- Tier III - 20,009 metric tons CO_2e/year
- Total estimated carbon footprint for all CDOT rest areas is 36,394 metric tons CO_2e/year

There is an increasing emphasis on a federal and state level for CDOT and other DOTs to reduce and manage carbon footprint emissions. There are numerous carbon footprint reduction strategies that can be instituted at CDOT rest areas. The acceptance and implementation of these strategies will require a shift in how CDOT views the purpose and operation of rest areas. It will require a shift in looking at the type of rest area services provided to the traveling public and trucking professionals and how economics, the environment, and the community/traveling public are integrated into the overall rest area operations. The following are options to reduce rest area carbon footprints:

- Limit long-term truck idling from CDOT rest areas unless in emergency situations such as harsh weather events and road closures
- Provide rest areas with truck electrification capabilities that could limit idling by using auxiliary power units
- Develop strategies to reduce the amount of fuel consumption used for mowing and to transport personnel, equipment, and materials to and from the main CDOT Maintenance facilities. These strategies may include increased storage and compaction of solid waste at the rest area to reduce the number of trips and reduce the frequency of mowing activities in the summer by reducing irrigation and fertilizer applications

- Develop strategies to reduce the amount of electricity used for lighting the restroom areas by using energy-efficient lighting bulbs, shutting off lights during day time hours, installing solar tubes or skylights, and using motion detectors that will turn on lights in restrooms during nighttime hours
- Perform energy audits on all rest areas to reduce natural gas, propane and electrical, consumption. Johnson Controls is currently performing energy audits on many CDOT Maintenance facilities and rest areas to identify specific actions to reduce rest area energy consumption
- Limit the use of air conditioning by using natural ventilation and tree shading
- Investigate the use of individually solar powered lights with daylight savers for walkway, parking, and safety lighting.
- Place vending machines inside the restroom area rather than outside where they are exposed to extreme outdoor summer temperatures and direct exposure to the sun
- Ensure onsite waste treatment systems are optimized to reduce electrical consumption from pumps
- Limit the use of hot water at rest areas. Supplying hot water may not be a necessary function of a rest area and it requires natural gas or electrical consumption. As an alternative, solar heated water systems and/or Energy Star Rated on-demand heating systems could provide hot water to the rest areas
- Investigate the feasibility and cost-effectives of using photovoltaic, wind, and geothermal (heat pump) technologies to provide onsite alternative energy production to the rest area. CDOT could work with the USFS on solar panel and wind turbine system aesthetic impacts for those rest areas located on USFS property
- Upgrade hot air hand dryers to Energy Star Rated hand dryers for restrooms
- Explore ways to reduce the amount of fossil fuel consumption by using biodiesel and electric power for rest area maintenance vehicles
- Plant trees and native grasses to sequester carbon from the atmosphere and provide rest area and visitor center building shade

5.3 Alternative Energy Use for CDOT Rest Areas Using CDOT ROW

Alternative energy generated within the CDOT Right-of-Way (ROW) can be a source of power for CDOT rest areas. The CSU-Pueblo Team has developed GIS-based mapping that identifies priority areas for solar, wind, biomass, geothermal, and hydropower power sources. Rest areas in these priority locations could consider performing feasibility studies to assess the installation of these alternative energy sources. Johnson Controls is contracted by CDOT to review energy consumption at all CDOT facilities including rest areas. Their analysis will help identify economically viable alternative energy options for rest areas. The Project rest areas that fall within the solar, wind, biomass, geothermal, and hydropower priority areas (see Figures 31-36) are:

- Sleeping Ute Mountain Rest Area – high solar, low wind, potential of geothermal, no hydropower, low biomass
- Hanging Lake Rest Area – low solar, low wind, geothermal potential, hydropower potential, no biomass
- Vail Pass Rest Areas – low solar, low wind, no geothermal, hydropower potential, no biomass
- Sterling Rest Area – moderate solar, good-moderate wind, no geothermal, no hydropower, high biomass
- Poudre Rest Area – moderate solar, low wind, no geothermal, no hydropower, high biomass
- El Moro Rest Area – high solar, marginal wind, no geothermal, no hydropower, low biomass

5.4 Coordination with Johnson Controls

The CSU-Pueblo Team and Johnson Controls Team worked together by sharing data and discussing rest area observations and recommendations. Although the two projects' goals, objectives and scopes are different, there was common interest in rest area operations, energy and water consumption. Two working sessions were conducted between the CSU-Pueblo Team and Johnson Controls Team to share energy data sources, observations and opinions on energy use and alternative energy potentials. From an energy conservation and cost perspective, the first action that could be performed at CDOT is to improve energy efficiency. The initial emphasis could be placed on efficient heating/cooling, lighting and winterizing. After energy conservation practices are in place, alternative energy options such as solar, wind and geothermal energies could be considered at the rest areas. The CSU-Pueblo Team recommends that the energy conservation analysis also consider the reduction of the carbon footprint by the implementation of alternative energy generation.

5.5 Common Project Rest Area Sustainable Observations and Recommendations

The following summarizes the sustainable actions as identified in this study, which could be considered for implementation by CDOT for the Project rest areas and other CDOT statewide rest areas. It is recognized that some of these sustainable action recommendations will require some initial capital costs and that some recommendations can only be accomplished as part of retrofitting or constructing a new rest area. Table 3 provides a summary of the main project recommendations based upon the sustainable observations made at all the Project rest areas.

Rest Area Operations Information

Operational information, such as electricity and water consumption, was difficult to obtain from CDOT. It was not possible to separate out specific rest area operations (waste treatment, parking lighting, heating, etc.) for electric consumption data; therefore it was hard to track specific electrical consumption for an operation over time. Water consumption data (restroom, irrigation) was also difficult to identify. Much of the CDOT electrical and water consumption data was based upon the amount paid by CDOT Accounts Payable and did not reflect actual consumption; therefore, data was obtained by the CSU-Pueblo Team from the actual service vendor or Johnson Controls. Most of the CDOT Maintenance Managers or rest area representatives do not regularly obtain or review resource consumption data. Water and electrical consumption data could be reviewed routinely to identify operational problems that are not readily observed by rest area personnel. Maintenance Mangers could be reviewing consumption information to identify problem areas and areas for improved conservation. Electrical and water data can also be monitored and logged routinely by rest area personnel.

Restroom Water Conservation

Water is a valuable finite resource, especially in Colorado. Water is used by the rest areas for restroom services and lawn irrigation. Some rest areas purchase water from municipalities while some rest areas have onsite domestic water sources. The amount of water used for toilet and urinal flushing varies among Project rest areas. Flushing systems varied between manual, motion initiated, and timed.

Table 3. Summary of Project Rest Areas Observations and Recommendations.

Observations	Recommendations	Rationale/Remarks/Benefits
Environmental Site Conditions		
Lawn irrigation occurs at most rest areas 3-7 times per week during the growing season using sprinkling systems. Large volumes of water are being used for lawn irrigation	• Lawn areas could be reduced in size and located just near picnic areas. • Consider using xeriscape landscaping with native grasses that require no or limited water for growth. • Evaluate opportunities for water harvesting of rainwater and snowmelt to augment drip and limited spray irrigation at rest areas that purchase water from municipalities.	• Water is a valuable and finite resource in all areas of Colorado. • Cost savings could be realized by CDOT by reduced water purchasing and landscape maintenance.
Non-native landscape grasses are being used that require intensive water irrigation, fertilizers and mowing maintenance	• Work with the CDOT Landscape representatives to identify native grasses that are drought tolerant • Identify vegetation that can grow and provide soil stability and aesthetics.	• Native vegetation usage will reduce water and mowing requirements thus saving financial resources. • Fertilizer /herbicide mixture will not be needed. • Native grasses provide vegetation habitat continuity.
Some rest areas have limited number of trees and there is available space to increase the number of tree plantings	• Work with the CDOT Landscape representatives to identify native trees that will survive environmental conditions at rest area. • Locate trees strategically to increase shade near restroom and picnic areas.	• New tree planting will increase carbon sequestration and help with CDOT greenhouse gas management. • Improved rest area cooling can be achieved by strategic planting locations to increase building shade. • Improve landscape aesthetic may be realized by rest area users. • Some additional costs will be needed to purchase plant,

Observations	Recommendations	Rationale/Remarks/Benefits
		establish and maintain the trees.
Rest areas maintain a good buffer zone (>50 feet) between sensitive environmental areas and rest area operations (people, pets, maintenance equipment)	• Continue to maintain buffer zone areas with native vegetation and avoid broadcasting herbicides. • Look for ways to enhance buffer zones and perimeter areas to support local wildlife	• Provides protection primarily to wetlands, riparian and surface water systems adjacent to or near rest areas
High frequency of mowing rest areas during the growing season (generally 1-2 times per week)	• Reduce the mowing frequency by reducing irrigation and fertilizer applications. • Change over to more native grasses and vegetation. • Native grass could be allowed to grow naturally without mowing that will allow for revegetation of exposed soil areas; this will add to the rest area aesthetic.	• Reduced mowing will result in reduced gas consumption thereby helping reduce the rest area carbon footprint. • Reduced labor costs could also be experienced at the rest area. • Signage could be used to educate the public on why the grass is not being mowed and is consistent with the sustainable nature of the rest area.
Chemical herbicides are used onsite and mixed with fertilizers and routinely applied or sprayed onto lawn areas to control weeds	• Eliminate or significantly reduce the routine use of the fertilizer/herbicide mixture placed on non-native (bluegrass) and native grasses • Prioritize mechanical weed control methods before using spot spraying chemical application. • Follow CDOT Noxious Weed Management Plan (CDOT, 1999). • Provided signage to public about the planned and recent use of herbicides	• Herbicides are comprised of toxic chemicals and are emitted into the environment by the manufacture and use of the product. • Eliminating or significantly reduce herbicide application can reduce operational costs • There are people who are very sensitive to any exposure to herbicides; reducing the use of these chemicals will reduce risk of exposure. • Warning signs of recent application will reduce exposure to the chemically sensitive public
Most rest areas do not have fencing that restricts wildlife movement and uses limited or no mowing around the rest area perimeter to allow nesting and maintaining habitat conditions	• Continue this approach and evaluate rest areas with chain link fencing to allow wildlife mobility without compromising public safety with animal collisions. • Use native vegetation to promote existing or improve wildlife habitat at the rest area	• Reduces wildlife fragmentation and will improve local wildlife habitat conditions
Absence of cleaning products and chemicals that are least toxic and environmentally biodegradable as possible	• Follow the State of Colorado Environmentally Preferable Purchasing Policy (2009) in purchasing the most environmentally friendly	• Reduce potential impacts on the environment by reducing the amount of persistent toxic chemicals within the rest area and into the overall

Observations	Recommendations	Rationale/Remarks/Benefits
	chemicals • Coordinate with other rest areas to determine what product(s) work best	environment • Consistent with former Governor Ritter's Executive Orders
Area sweeping done on periodic basis	• Sweep rest area parking areas on both a routine and as needed basis. • Conduct sweeping immediately after each snow storm event as a best management practice to collect traction sand and protect vegetation and local water resources.	• Reduces the amount of sediment going into the stormwater • Protects local and watershed surface water systems.
Materials Reuse and Recycling		
Rest areas do not routinely acquire reused or recycled materials for rest area repairs and operations (recycled asphalt or concrete) and minimal recycling of old material from the rest area maintenance or repairs (guardrails, metal posts)	• CDOT Maintenance could develop a program that prioritizes the use of reused/recycled materials for rest area repairs or retro-fit construction. • Maintenance facilities could stockpile materials that can be reused for rest area or road maintenance operations. • Paper products used at the rest area could have recycled material content.	• Use of reused or recycled materials reduces the demand for virgin materials. • Use of stockpiled materials for reuse will reduce virgin material harvesting and reduce product transportation costs.
Grass is being collected at some rest areas and being contained and disposed of as solid waste	• Eliminate the amount of grass being managed as solid waste • Eliminate grass being collected, transported and landfilled at rest areas • Use onsite composting or mulching mowers.	• Reduction in solid waste will save in rest area operational costs by reducing the volume of material, frequency pick-up and landfilling costs. • Reducing landfilling helps reduce the amount of land needed for waste management. • Reduced fuel consumption from waste transport will reduce greenhouse gas emissions of the rest area.
There is very limited material recycling offered to the traveling public at rest areas (glass, plastic, aluminum)	• CDOT could develop a recycling program that uses local recycling centers for material acceptance and processing. • Collected materials from rest areas can be stored and mixed with recycled material from the maintenance facilities. • Recycle containers could be obtained to accommodate specific container sizes.	• Recycling aluminum, glass and plastic from waste will reduce the demand for virgin material and reduce the amount of waste managed and landfilled. • It is suggested that recycling opportunities be present where there are vending machines that generate solid waste.

Observations	Recommendations	Rationale/Remarks/Benefits
	• Local community groups interested in recycling could be contacted for support; recycling profits from aluminum recycling could be an incentive. • Use signage to explain and promote public recycling efforts.	
Minimal solid waste minimization/ reduction practices observed at rest areas	• The use of a compactor may be cost-effective for rest areas generating high amounts of solid waste. The compactor would reduce the volume of waste stored onsite, reduce waste pick up frequencies and reduce the volume landfilled (see Appendices F and G). • Look at opportunities to recycle cardboard and paper board materials. • Some CDOT rest areas could consider the elimination of soda vending machines that generate solid waste. • Signage could be provided to educate the public about CDOT's efforts to reduce solid waste • Consider eliminating paper towels for hand washing	• Cost savings can be realized by using a trash compactor by reducing waste volumes for transporting/landfilling. • The elimination of vending machines and promotion of water consumption will reduce solid waste and electrical costs • Eliminating paper towels will help reduce the amount of solid waste generated and disposed of in a landfill
Lack of a CDOT Maintenance policy or practice to use new source materials that come from certified sustainable practices	• CDOT could develop a policy that wood materials used for rest area maintenance or retrofits could be certified as being from sustainable sources.	• Using certified wood materials promotes the use of sustainably based silviculture practices thus promoting sustainable land uses
Air Quality		
CDOT Rest Area personnel has limited knowledge of using low volatile organic chemicals (VOCs) incorporated in paints , equipment cleaning materials and adhesives	• CDOT could consider following the State of Colorado Environmentally Preferable Purchasing Policy (2009) that promotes the use of low VOC materials. • Rest area representatives could be educated on how to purchase low VOC paints and adhesives at local retail centers or through CDOT procurement.	• The use of low VOCs will reduce toxic emissions from the manufacture and use of paints, cleaning materials and adhesives. • Reduced employee and traveling public's expose to toxic materials • Consistent with former Governor Ritter's Executive Orders
No truck idling restrictions and at rest areas for large commercial trucks;	• Consider the elimination or significant reduction of long term truck parking and idling at CDOT rest areas unless in emergency situations such as harsh weather events and road	• Restricting truck idling is a management approach for CDOT to reduce greenhouse gas emissions that is consistent with the State of Colorado's Climate Change

Observations	Recommendations	Rationale/Remarks/Benefits
	closures. • Trucks could be directed to other locations that have facilities to support trucking professionals during extreme heat and cold conditions. • CDOT could perform a study to assess the installation of truck electrification units at selected areas and require their usage by trucks.	Action Plan. • Trucks using electrification and having auxiliary power units can eliminate idling while still using the trucks air conditioning/heating systems. • Truck idling emits fumes, fine particulates, generates noise and consumes diesel fuel
Some cleaning chemicals used in restrooms are not compliant to the State of Colorado Environmentally Preferable Purchasing Policy (2009) that promotes green, biodegradable, environmentally friendly chemicals	• CDOT rest area managers could select cleaning chemicals for CDOT staff and contractors who clean restrooms. • A list of effective green cleaning chemicals could be developed and shared among CDOT Regions. • Low phosphorous chemicals/detergents could be considered for use.	• Cleaning chemicals can contain toxic chemicals and do not readily biodegrade in the environment. • Green cleaning chemicals are low in VOCs and are less toxic to the environment. • Eliminating phosphorus from detergents reduces the risk of water quality problems
Water Quality/Usage		
There are some rest areas that have no stormwater/snowmelt BMPs to prevent pollutants from entering the storm conveyance system.	• Rest areas should institute stormwater BMPs such as inlet protection, vegetation of exposed soil areas and use sediment ponds to provide final stormwater collection and treatment. • Snow containing deicers and traction sand needs to be stockpile in an area to avoid runoff into stormwater conveyances and ultimately into surface water systems. • Innovative stormwater BMPs such as porous pavement or groundwater infiltration could be explored for rest areas being retrofitted.	• The development and use of stormwater BMPs is consistent with the vision of the CDOT Stormwater MS4 Program. • Pollution prevention is important especially in sensitive areas associated with surface water and wetland areas.
There appears to be an excess in water consumption associated with toilet and urinal flushing; Toilets generally range from 1-2 gallons per flush (gpf) and urinals range from 0.5-1.6 gpf	• Water conservation studies for restrooms could be considered at CDOT rest areas, especially those that purchase water from municipalities or have onsite waste treatment systems. • Evaluate and consider eliminating automatic-timed urinal flushing (Hanging Lake) • Evaluate the cost-effectiveness of waste treatment systems that	• Water conservation studies can isolate areas that can use less water and save money. • The less water purchased for toilet/urinal flushing relates to less water needing physical, chemical and biological treatment thus reducing operating expenses. • Water is a finite resource in

Observations	Recommendations	Rationale/Remarks/Benefits
	require automatic flush systems to maintain optimum treatment. • Consider waterless urinals to conserve water and reduce long term water costs (See Appendix F).	Colorado and should be conserved.
There appears to be an excessive use of irrigation water to maintain non-native vegetation. Lawn irrigation frequencies range from 3-7 days per week.	• CDOT could evaluate irrigation volumes used at rest areas • Lawn landscaping could be re-evaluated towards using native, low water demand plants. • Water consumption could be monitored to identify potential irrigation piping leaks. • Irrigation of lawns could be kept at a minimum or eliminated, especially for those rest areas that purchase water from municipalities. • Water harvesting of rain water and snow melt could be considered as a pilot study to evaluate potential area irrigation (See Appendices F and H)	• The Sterling Rest Area purchases domestic water at an annual cost of over $14,000 (over 10 million gallons per year). • Significant cost savings could be realized by reducing and in some areas eliminating lawn irrigation.
No Signage to conserve water in restroom areas	• Place signage in the restroom area to sensitize the public on the importance of water conservation in Colorado	• Good public relations and public outreach • Water is a finite resource in Colorado and should be conserved
Traction sand is used during the winter for parking lot maintenance and snow is plowed and piled/stockpiled onsite	• Consider using limited amount of traction sand to maintain parking lots in winter to reduce sediment loading into the nearby stream. • Stockpile snow at strategic locations to reduce potential of entering stream	• Traction sand and deicers will be kept from being introduced into nearby surface water systems.
Potential water storage area may exist for the collection and reuse of gray water or water harvesting	• Evaluate retrofit costs for gray water reuse for toilet/urinal flushing • Consider pilot study for water harvesting potential	• Water conservation measures would reduce amount of water purchased from municipalities or nearby stream/groundwater systems. • Water harvesting is estimated to be cost-effective at select rest areas (see Appendices F and H).
Energy		
Vending machines are located outside exposed to direct sunlight and extreme weather conditions	• Beverage vending machines could be located inside the rest area building to reduce weather extremes thus reducing consumption of electricity.	• Reducing or eliminating energy consumption from vending machines will help reduce operating costs • Reduction in solid waste

Observations	Recommendations	Rationale/Remarks/Benefits
	• Consider the elimination of soda vending machines for reduced electrical consumption, plastic bottle demand and solid waste generation	generation at the rest area • Promotes the reduction of plastic bottle production that emits greenhouse gases and fills up limited landfill areas.
Traditional fluorescent lighting and incandescent lighting bulbs area being used in some restroom areas	• Rest areas could evaluate the cost of using and potentially retrofitting existing lighting systems to provide more efficient and cost-effective lighting	• More efficient lighting using LED or compact fluorescent bulbs could save energy and operational costs • The Johnson Controls report could address this observation
No alternative energy sources are being used to power rest area operations	• CDOT could consider performing an alternative energy feasibility study to assess the use of alternative energy sources (solar, wind and geothermal). • Most rest areas have sufficient roof and land area to use solar panels. • Wind studies at specific rest area locations within alternative energy priority areas could be conducted. • Geothermal heat pumps that can easily be retrofitted into rest areas could be investigated by CDOT. • Hydro power from adjacent streams could be evaluated to power rest areas.	• Alternative energy at rest areas offers a significant opportunity to reduce the overall carbon footprint, which is important in managing CDOT greenhouse gas emissions. • Reduced long term operating costs could be realized in addition to positive public perception of a pro-active environmental philosophy. • The Johnson Controls Report could be addressing this observation within an economic perspective
Increased use of natural ventilation and cooling could be evaluated for rest areas using air conditioning	• Natural ventilation using the existing ventilation system, fans and strategic tree shading could be evaluated to augment or eliminate the use of air conditioning in rest areas.	• Air conditioning results in electrical consumption and operating costs for rest areas. • This action could help reduce the carbon footprint of the rest area.
Some restrooms use electrical lighting during daylight hours where lighting is already provided by skylights	• Rest room lighting could be reduced when sky lights offer sufficient lighting. • Light intensity monitoring could moderate restroom lighting	• Reduced lighting would reduce electrical consumption, operating costs and greenhouse gas emissions. • The Johnson Controls Report could address this energy conservation issue
Conventional hot water heaters are used at rest areas	• CDOT should consider eventual retrofitting of selected rest areas with solar hot water heating and/or on demand hot water heaters. • Hot water usage in some restrooms could be eliminated	• Use of passive solar energy could reduce energy consumption and reduce the overall carbon footprint. • Hot water is not necessary for hand washing and could be eliminated to reduce

Observations	Recommendations	Rationale/Remarks/Benefits
		energy consumption and cost.
Most electric hand dryers are not the most energy-efficient	• CDOT could eventually replace aging hand dryers with Energy Star Rated or equivalent hand dryers	• EPA Energy Star certified or equivalent hand dryers will potentially reduce energy consumption and costs and help reduce the carbon footprint
Rest area maintenance vehicles use conventional fossil fuels that contribute to the rest area carbon footprint	• Consider replacing aging or high fuel consumption vehicles used to maintain and operate the rest areas with vehicles that are more energy-efficient and use alternative fuels such as bio-diesel, natural gas or electricity. • Onsite maintenance vehicles for larger rest areas could be powered with electricity. • Consider having CDOT Maintenance develop a written plan and operating procedures to reduce fuel consumption	• Using alternative fuels for maintenance vehicles will help reduce fleet gasoline/fossil fuel consumption in compliance to Governor Ritter's Executive Orders. • Alternative fuels will reduce the carbon footprint of the CDOT rest areas
Some rest areas use a two tiered lighting system for car/truck parking and pedestrian walking.	• Rest area lighting could be evaluated to determine if two lighting systems are necessary to provide pedestrian security and vehicle parking safety	• It is possible that one lighting system could suffice for both parking and pedestrian security. • Electrical consumption and operating costs could be reduced. • The Johnson Controls Report could address this observation
Generally motion detectors are not used in restrooms to initiate lighting at night	• Motion detectors could be installed in restrooms so lighting can be shut off at night when no services are being provided in the restroom. • Motion detectors will initiate and maintain lighting in restrooms for a pre-determined time to ensure security. • Place motion detectors so they cannot be tampered with by vandals while providing public security.	• Motion detectors provide a way to efficiently use electricity and lighting systems in restrooms. • This action will reduce electrical consumption and operating costs. • The Johnson Controls Report could address this observation.
Public, Motorist, Trucking, Outreach and Participation		
No preferential parking for alternative fuel cars at rest areas	• CDOT should consider using a pilot study to provide hybrid or alternative energy fuel cars preferential parking near restroom facilities. • Signage could be provided to	• Preferential parking is mostly for public awareness of CDOT progressive policy to promote the use of alternative fuel and hybrid vehicles.

Observations	Recommendations	Rationale/Remarks/Benefits
	education and sensitize the public on hybrid and alternative fuel cars for preferential parking	• Positive public relations and awareness could result from this action.
No mechanism to provide immediate road conditions and weather conditions at most rest areas	• Computer based kiosks could be installed in strategic rest areas to provide the public important road and weather conditions. • Kiosk information could be expanded to promote local community and businesses	• Traveler information could prevent potential weather related emergencies or hardships to the traveling public and trucking professionals from bad winter storms and road closures. • Community information could provide information about lodging or restaurants during storm events
Security surveillance cameras do not generally exist at rest areas for public and rest area protection	• Consider adding security cameras at rest areas to protect the traveling public. Security camera signage may discourage vandalism • Security cameras could be located at strategic locations to avoid vandal destruction and record destructive activities	• Improved public security and rest area protection may be achieved. • Signage may influence destructive behavior
Limited CDOT public outreach to local communities for support in operation, maintenance or tourist services (coffee)	• CDOT Maintenance Managers and staff could contact local community groups to obtain interest in supporting and enhancing the services of the rest area • Evaluate involving local organizations to help support recycling efforts	• This action will provide good public relations for CDOT and possibly improve relationships with local communities. • Community support would help provide the traveling public with a great experience
No public-private partnerships exist for the operation and maintenance of rest areas	• CDOT could explore potential partnerships with private companies or local communities to help fund and/or operate portions of the rest area	• Public-private partnerships can provide CDOT financial relief in the operation and maintenance of rest areas. • Private interests may find it advantageous to use rest areas for advertising and public relations.
No information exists about the CDOT rest area environment, operations, and CDOT sustainable rest area actions	• Provide signage to the public to educate them on the sustainable operation of the rest area such as the design, skylights, natural vegetation, energy and water conservation	• Good public outreach will help modify behavior for recycling, water conservation and overall area use.

Automatic flushing generates high volumes of water for treatment and discharge (for example, the Hanging Lake Rest Area has an estimated annual discharge of 243,855 gallons per year).

Wastewater is treated at a municipality for a cost per gallon or is treated and discharged from onsite treatment systems. The amount of wastewater discharged is dependent upon the amount of domestic water used at the rest area. Cost savings could be achieved and less water used if rest areas performed restroom conservation studies and routinely monitored water usage. Waterless urinals are estimated to be cost-effective for the Sterling, El Moro, and Vail Pass rest areas (Appendix F). It is possible that CDOT could reduce operational costs by: 1) reduced domestic water purchasing, 2) reduced cost for municipal waste treatment, 3) reduced onsite consumption of waste treatment chemicals, and 4) reduced electrical usage from pumps. Rest areas that purchase water from municipalities could be prioritized for water conservation studies due to the high cost of water and wastewater treatment.

Lawn Irrigation and Landscaping

Some rest areas have large areas of open space that are occupied by non-native and native vegetation. Large amounts of water are used by most rest areas to irrigate high demand non-native vegetation such as bluegrass. Fertilizers are applied to most of these areas to promote an aesthetic green color that requires frequent mowing, labor, and lawn irrigation. There could be a transition away from high water demand, non-native vegetation and toward xeriscape landscaping using low water demand, drought tolerant plant species. The evapotranspiration rate (evaporation from soil plus transpiration from plant tissue) is twice as high for bluegrass as for buffalo grass (CSU, 2010). It requires six times the amount of water to maintain a bluegrass lawn than a buffalo grass lawn (CSU, 2010b). Drip irrigation could be used or expanded in rest areas and spray irrigation could be limited to conserve water. This transition could save CDOT financial resources by not having to purchase domestic water from municipalities, reducing electrical cost for irrigation pumping, limiting contractor costs who apply a fertilizer/herbicide mixture to lawns, and reducing labor and equipment costs from reduced mowing operations. This transition could also conserve local water resources. Water harvesting from roof runoff has been estimated to be cost-effective at the Poudre, El Moro and Sterling Rest Areas (Appendix F and H). It is recognized that water harvesting is constrained by water right laws. Based upon discussions with legislative representatives and Councils (Kurtis Morrison-Legislative Council-Colorado General Assembly and Jeff Lyng-Governor's Energy Office), it could be possible that a pilot study can be conducted by CDOT in cooperation with the State of Colorado Water

Conservation Board and State Legislature to evaluate the feasibility of this water collection and distribution system.

Solid Waste Management

Solid waste is generated at rest areas by site operation and maintenance activities and by the traveling public and trucking professionals. Rest area operations generate waste in the form of paper, cardboard, grass, cleaning materials, and miscellaneous trash. A significant amount of solid waste from the traveling public and trucking professionals is in the form of paper waste, trash, and beverage containers made of plastic, glass and aluminum. CDOT currently has no rest area program or directive to recycle solid waste from rest areas. It is recommended that CDOT institute a rest area recycling program to collect and transfer recyclables (metal, glass, aluminum, plastic, cardboard, office paper and paperboard) to local recycling centers. With the high amount of commercial and public vehicles using the rest area, recycling containers could be provided to reduce the amount of solid waste that eventually is placed in a landfill. Recycling could reduce the total amount of solid waste produced and reduce landfilling costs. Recycling containers that are designed to accommodate beverage containers can be used at rest areas. Signage can be posted to educate and gain support from the public in recycling efforts. Solid waste compaction units that are solar powered have been estimated to be cost-effective and could be considered for specific rest areas that generate large amounts of solid waste (see Appendix G).

Waste minimization procedures such as the elimination of grass in solid waste containers could be instituted at rest areas. Rest areas should consider using mulching mowers that would eliminate the need for grass collection and landfilling. It is recognized that there may be additional labor involved in the management of recyclables; however, it is an important sustainable action that can decrease operational costs by reducing the amount of solid waste contained, transported and landfilled.

Rest Area Energy Conservation

Rest areas consume electric, propane and natural gas energy for lighting, heating, air conditioning and waste treatment operations. Energy is also consumed by CDOT vehicles and equipment (diesel and gasoline) for the movement of equipment, personnel, mowing, and snowplowing. It is recommended that an energy conservation study be performed for CDOT rest areas to reduce operating costs, avoid inefficient use of energy, and reduce the overall carbon footprint. It was not within the scope of the CSU-Pueblo Team to perform energy audits at the Project rest areas and it is recognized that Johnson Controls is performing these site-specific energy audits. Energy conservation actions could be investigated and performed at rest areas such as motion detectors to initiate nighttime lighting, turning off lights during daytime hours, energy-efficient lighting systems, and use of alternative energy (solar, wind and geothermal). Hydroelectric power for rest areas immediately adjacent to stream systems could be considered for rest area power generation, similar to the effort being explored by the Utah Department of Transportation (UDOT, 2010). Limiting or eliminating the use of hot water use could be considered for selected rest areas to reduce energy; this is similar to the approach taken by the Florida Department of Transportation (FDOT, 2010).

Truck Idling Emissions

Truck idling emissions constitute the major source of greenhouse gas emissions at the Project rest areas (over 90% at Tier I rest areas). In addition to greenhouse gases, truck idling emits fine particulates and fumes and generates noise at the rest areas. A significant amount of diesel fuel is inefficiently used by truck idling. Truck idling provides trucking professionals with cab heating, air conditioning, and power for computers and appliances. Auxiliary power units can be purchased by trucking companies or by independent truckers to avoid the need for idling by plugging into provided electrical outlets (truck electrification). CDOT could develop truck idling restrictions to or significantly limit long-term idling within rest areas. CDOT could conduct feasibility studies to identify priority locations and operational procedures for truck electrification facilities.

Public-Private Partnerships

Public-private partnerships are a potential financial strategy that could be explored by CDOT. There are regulatory constraints imposed upon DOTs who want to use the Interstate ROW as a means to supplement their tight budgets. DOTs such as Arizona are looking to close down many rest areas due to state budget limitations and are looking for flexibility in managing rest areas.

Arizona Governor Jan Brewer and the Arizona Department of Transportation (ADOT) are trying to change federal laws that govern rest area commercialization, appealing to states nationwide to change the way rest areas operate without relying on budgets allocated for public safety services, (TruckingInfo.com reports, 2010). Arizona officials maintain that the existing federal policies penalize states with newer infrastructure by prohibiting privatization or partnerships to operate rest areas (NACS, 2010).

CDOT could explore partnerships with private businesses and/or local communities to share the expenses associated with rest area maintenance and operations. For example, ski companies or ski towns could financially support CDOT rest areas for recreational and local services advertising. CDOT could evaluate using public-private partnerships in rest area operations that could help finance rest area services, maintenance actions, improved amenities and support rest area security. The concept of using public-private partnerships for private truck stops adjacent to rest areas is discussed in the report entitled Truck Parking Issues at State Facilities in Colorado (FHU, 2007).

5.6 Further Rest Area Sustainability Studies and Funding

It is recommended that CDOT implement many of the opportunities identified by the CSU-Pueblo Team at the Project rest areas and other CDOT rest areas. It is also recommended that CDOT isolate one rest area that can be a showcase of a sustainable rest area. It is possible that a CDOT rest area could be retrofitted to accommodate this study's recommendations and achieve carbon neutrality. It is also possible that one of these Project rest areas can be a candidate rest area for retrofitting and improvement. The following are potential funding mechanisms that would support the implementation of this report's sustainable recommendations and towards the development of an innovative, retrofitted, carbon neutral rest area:

- **Colorado Governor's Office**

  Under the "Commercial & Public" tab at the Colorado Governor's Office webpage (www.rechargecolorado.com), there are lists of rebates and grants that public facilities can apply for to conserve energy. One of them is the energy performance contracting program. It assists Colorado state agencies to purchase new energy-efficient equipment and pay for them later through the energy money savings. This website also lists many other rebates that may be applicable.

- **Denver Regional Council of Governments (DRCOG)**

  The DRCOG website lists available grants at www.drcog.org. This list is located under "Regional Sustainability" and then under "Grant Opportunities". The list includes the grant name, application due date, description, and eligible entities. Also, the website states that if there are suggestions for additional grant opportunities to contact Jill Locantore at 303-480-6752.

- **United States Department of Energy (DOE)**

  Within the DOE, the Office of Science has a program known as the Office of Science Financial Assistance Program. All available government grants are posted at www.grants.gov.

- **United States Department of Transportation**

  There are grant programs available from the Federal Transit Administration (FTA). They can be found at www.fta.dot.gov/funding/grants_financing)263.html. These programs are FTA sponsored and have an overview page that describes the programs and other relevant information. The only program that may apply to the recommended sustainability work is the Flexible Funding for Highway and Transit.

- **United States Environmental Protection Agency (EPA)**

  The EPA posts synopses of competitive grants opportunities from www.grants.gov. on the EPA website (www.epa.gov/ogd/grants/funding_opportunities.htm). Also located on the EPA website is the Catalog of Federal Domestic Assistance (CFDA) for potential funding. The CFDA gives access to a database of all Federal programs available to state and local governments.

- **American Recovery and Reinvestment Act (ARRA)**

  Under ARRA, the Obama Administration has committed to investing $3.2 billion in energy efficiency and conservation projects in U.S. cities, counties, States, territories, and Native American tribes. The Energy Efficiency and Conservation Block Grant Program (EECBG), funded by ARRA, will provide formula grants for projects that reduce total energy use and fossil fuel emissions, and improve energy efficiency nationwide. A detailed breakdown of the EECBG funding by State, county, city and tribal government can be found at www.energy.gov/recovery.

- **Regional Air Quality Council (RAQC)**
  The mission of the RAQC is to develop and propose effective and cost-efficient air quality planning initiatives with input from government agencies, the private sector, stakeholder groups, and citizens for the Denver Area and North Front Range 8-hour Ozone Nonattainment Area. The RAQC provides up-to-date information on diesel-related issues and technologies; Clean Air Fleets also educates fleet operators through conference and workshops. Funding opportunities available through Clean Air Fleets for retrofit and alternative fuel projects can be found at www.cleanairfleets.org.
- **Energy for Sustainability -** The National Science Foundation requests proposals for Energy for Sustainability. This program supports fundamental research and education in energy production, conversion, and storage and is focused on energy sources that are environmentally friendly and renewable. Sources of sustainable energy include: Sunlight, Wind/Wave, Biomass, and Geothermal. Responses due 3/3/11. For more info, contact Gregory Rorrer at grorrer@nsf.gov or go to: http://www.grants.gov/search/search.do?mode=VIEW&oppId=58929. Refer to Sol# PD-11-7644. (Grants.gov 11/30/10)
- **Environmental Sustainability -** The National Science Foundation requests proposals for Environmental Sustainability. This program supports engineering research with the goal of promoting sustainable engineered systems that support human well-being and that are also compatible with sustaining natural systems. Research in Environmental Sustainability typically considers long time horizons and may incorporate contributions from the social sciences and ethics. Responses due 3/3/11. For more info, contact Bruce Hamilton at bhamilto@nsf.gov or go to: http://www.grants.gov/search/search.do?mode=VIEW&oppId=59009. Refer to Sol# PD 11-7643. (Grants.gov 12/3/10)

CHAPTER 6. INTRODUCTION (RIGHT-OF-WAY [ROW])

6.1 Background

Recent federal energy policies have placed increased emphasis on strategies by federal agencies to reduce greenhouse gas (GHG) emissions. Executive Order 13514 (EO 13514) was issued on October 5, 2010 by President Obama with a goal to "establish an integrated strategy towards sustainability in the Federal Government and to make reduction of greenhouse gas emissions a priority for Federal agencies." EO 13514 sets requirements related to energy efficiency and GHG management that affect FHWA policy regarding business with federal and state partners. Compliance with EO 13514 provides a motivation for agencies including state DOTs to adopt sustainability measures.

The State of Colorado has also introduced clean air policy through measures such the Governor's 2007 Climate Action Plan, which calls for a 20 percent reduction in greenhouse gas (GHG) emissions from 2005 levels by 2020 and an 80 percent reduction by 2050. The corresponding Colorado Governor's Energy Initiative of 2007 (Executive Orders D011 07 and D012 07) calls for state agencies to reduce their overall energy use by 20 percent and to reduce state vehicle petroleum consumption by 25 percent in volume by 2012.

In 2004, Colorado voters passed a Renewable Energy Standard (RES) requiring the state's largest utilities to supply at least 10 percent of the electricity from renewable sources by 2015. This mandate has now been raised to providing 30 percent renewable energy by 2020. As a result, there is increased emphasis on CDOT to develop strategies to reduce GHG emissions. One strategy may be to use existing ROW to produce energy, either through use of existing biomass, geothermal or hydropower resources, or to use the land area for energy 'capture' through solar or wind applications. However, there is little comprehensive data on the amount of ROW within Colorado that is potentially suitable for alternative energy production. The purpose of this study is to address that gap.

CDOT maintains 9,144 linear miles of roadway ROW, which includes roadway surfaces, medians, shoulders, clear zones and interchange areas. CDOT is also responsible for approximately 400 facilities and 40 other 'remnant' land parcels. Because of Colorado's unique characteristics – more than 300 days of sunshine per year; productive wind areas; locations of geothermal activity; vegetated areas with grasses, timber and crops; and mountainous areas with fast-moving streams, CDOT ROW may be well-suited to produce alternative energy from solar, wind, geothermal, biomass, and hydropower systems.

CDOT conducted this study to evaluate the ROW acreage in Colorado for its energy-producing capacity and to estimate the amount of electricity in kilowatt-hours (kWh) or biomass in tons for electricity that could be generated from available ROW. CDOT also wished to better understand the federal and state legal and policy framework relating to CDOT's ability to use produced energy internally and/or providing an external revenue source to fund CDOT operations. The benefits of the study to CDOT include providing a clearer picture of the quantity and quality of alternative energy resources under its management and the potential cost savings for illumination, signals, ramp metering, facilities and maintenance. Such knowledge will allow CDOT to expand its partnership with the Governor's Energy Office to meet both state and federal requirements for alternative energy generation, and to offer a potential funding source for CDOT operations.

The basis for selecting the types of alternative energy to be evaluated in this study was a 2009 report by the Colorado Governor's Task Force on Renewable Resource Generation *"Connecting Colorado's Renewable Resources to the Markets"* which mapped and evaluated Colorado's solar, wind, hydroelectric power, geothermal, biomass and ethanol and biodiesel fuels resources. The report identified 'Renewable Resource Generation Development Areas' (GDAs), which are defined as compact geographic areas capable of producing a minimum of 1000 megawatts (MW) of developable electric-generating capacity that could connect to an existing or new high voltage transmission line.

Although the report contained useful information on the locations and types of alternative energy within Colorado, it was not intended to serve the same purpose as this research effort and does not specifically address ROW as a contributor to alternative energy production. However, the geographic information system (GIS) data layers for each resource were obtained from the Governor's Task Force and the study team traced the data back to the original source(s) as described below. The study team also used the report's energy production categories and units (wind power classes, range of solar power levels, etc.) to maintain consistency between the reports. By comparing findings of both studies, the percentage of total statewide energy that could be produced within CDOT ROW can also be estimated.

6.2 Method

The study was conducted by CSU-Pueblo and involved preparing mapping of CDOT ROW and overlaying mapping of alternative energy information in order to identify the production capability for each resource in CDOT ROW. Maps were prepared for the entire State of Colorado to show the location and distribution of each resource. Mapping was also prepared for each of the six CDOT Regions for wind and solar to provide more detail on resources and ROW locations. The mapping and resource evaluation included several steps:

- Obtain GIS data layers and prepare mapping of existing CDOT ROW and facilities statewide and for each of the six CDOT Regions;
- Develop and apply criteria on the usability of CDOT ROW (to exclude areas where safety could be compromised by construction of structures, fencing, ingress-egress, for example);
- Prepare mapping overlays of alternative energy by type (solar, wind, geothermal, biomass and small hydropower) and usable CDOT ROW;
- Calculate the total energy potential within usable CDOT ROW (generally in gigawatt-hours per year [GWh/year]).

For Step 1, alternative energy GIS data were obtained from sources including the National Renewable Energy Laboratory (NREL), which also supplied much of the data for the Governor's Energy Report. Other sources included the Idaho National Engineering and Environmental Laboratory (INEEL), the Colorado Governor's Energy Office, Western Area Power Administration (WAPA), and utility companies including Xcel Energy and Black Hills Energy.

For Step 2, State Highway Geometrics linear GIS data was obtained from CDOT[1] and sorted into categories to indicate those areas that would safely and legally allow alternative energy production and transmission under current restrictions. The State of Colorado has adopted a nationwide recommended policy that does not allow utilities within the median area of freeways, except for some direct crossings (*A Policy on the Accommodation of Utilities within Freeway Right-of-Way*, AASHTO, 2005). Although medians could provide substantial acreage for the production of alternative energy, for purposes of this study medians were excluded from potential energy production calculations. However, this policy could be amended in the future, particularly for the harvesting of biomass for energy production. Therefore, the electronic ROW files included with this report include a data field that could be applied to total ROW in the future.

ROW types that were analyzed included:

a) ROW on either side of the roadway extending up to 50 feet from the edge of pavement. It was assumed that no alternative energy infrastructure or production would be allowed by the FHWA within this area, which includes the shoulders and clear zones[2] that are maintained for safety purposes.
b) ROW on either side of the roadway extending 50 to 200 feet from the edge of pavement. Those areas are typically outside of the clear zone and could more safely accommodate infrastructure and provide access to energy production sites.
c) ROW on either side of the roadway extending 200 feet or more from the edge of pavement. Such wide areas may provide sufficient setback from the roadway to allow construction of large structures and facilities such as wind towers with long turbine blades. Less buffering from the roadway (barriers, fencing, etc.) would also be required.
d) Additional ‘remnant’ parcels of land adjacent to the ROW that are managed by CDOT but do not contain buildings or other infrastructure. Approximately 260 acres in 42 parcels of one or more acres were identified from mapping obtained from CDOT

[1] GIS ROW data received from Gary Aucott, CDOT, August 2010.
[2] Clear zones are defined as 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 width is dependent upon the traffic volumes and speeds, and on the roadside geometry (AASHTO, 2005)

Regions. It was assumed that parcels of less than one acre could not safely or efficiently accommodate structures such as solar installations and the required ingress/egress.

e) CDOT facilities including rest areas, maintenance yards, and offices. CDOT is currently conducting a separate study by Johnson Controls to identify and characterize these facilities, and detailed information was not available at the time of this report. However, the six rest areas that were evaluated in the Rest Area Sustainability portion of this research project were mapped and are identified on the base maps (Sleeping Ute Mountain [Cortez]; El Moro [Trinidad]; Poudre [Fort Collins/Loveland]; Hanging Lake [Glenwood Springs]; Vail Pass [Vail]; and Sterling [Sterling]).

These steps produced an estimate of the theoretical maximum amount of energy from each energy type for all CDOT ROW except facilities (see e, above). Additional criteria were then applied to more realistically estimate energy production such as the degree of technology efficiency, the percentage of surface area that could be feasibly devoted to energy production, and inherent challenges in accurately estimating energy production. For example, tons of biomass per acre can vary widely depending on the type of vegetation and the growing conditions.

Findings of this analysis process are described below for each alternative energy resource type. Chapter 8 discusses the existing legal and policy issues surrounding the use of alternative energy.

CHAPTER 7. SOLAR ENERGY

Information from NREL on the solar radiation received in the United States (US) by one square meter of land per year (Direct Normal Insolation [DNI]) identifies ten categories within the United States (US). Each category reflects the average amount of solar insolation received per square meter in watt-hours (Wh) per day. The State of Colorado falls in the upper five of these categories. DNI categories for Colorado are shown in Table 4 and are expressed in units compatible with other solar data obtained from the Governor's Energy Study (gigawatt-hours/acre/year [GWh/acre/year]).

Table 4. Direct Normal Insolation Levels, Colorado

DNI Category (average GWh/acre/year)
8.08
8.66
9.12
9.63
10.38

Source: (National Renewable Energy Laboratory NREL)

Calculations of the potential solar energy produced by CDOT ROW included converting square meters to acres to correlate with the Governor's Energy Report. An average annual daily DNI per acre for each category was then calculated. The total acres of ROW for all six CDOT Regions were calculated for each category and multiplied by the annual DNI (GWh/Acre/year) to produce the theoretical maximum total DNI of the ROW in one year.

Table 5 indicates the total acres for each region based on the five DNI categories. Table 6 indicates acres of ROW and energy production by DNI category.

Table 5. Total Acres by CDOT Region, per DNI Category

DNI Category (Average GWh/year)	Acres of ROW					
	Region 1	**Region 2**	**Region 3**	**Region 4**	**Region 5**	**Region 6**	**State Total**
8.08	1,385	0	3,432	7,181	0	584	12,582
8.66	6,276	310	7,872	5,288	494	3,093	23,333
9.12	3,411	4,112	4,666	0	1,938	0	14,127
9.63	62	3,173	166	0	3,963	0	7,364
10.38	0	347	0	0	4,581	0	4,928
						Total	62,334

Table 6. Maximum Energy Production by Direct Normal Insolation (DNI) Category, in GWh/acre/year

DNI Category (average GWh/acre/year)	Acres	GWh/year
8.08	12,581	101,668
8.66	23,333	202,145
9.12	14,126	128,838
9.63	7,363	70,893
10.38	4,927	51,163
Total	62,330	554,707

Colorado receives fairly intense rates of solar insolation, with the highest rates in the far southern and southwestern locations from the San Luis valley west to Cortez within CDOT Regions 2 and 5 (NREL, 2009). Figure 31 indicates insolation levels for the entire state, and Figures 1-a through 1-f indicate the levels for each of the six CDOT Regions. The northern areas in CDOT Regions 3, 4, and 6 receive lesser amounts of solar insolation, but at considerably higher rates than the nationwide average.

Figure 31. Colorado Solar Resource Potential

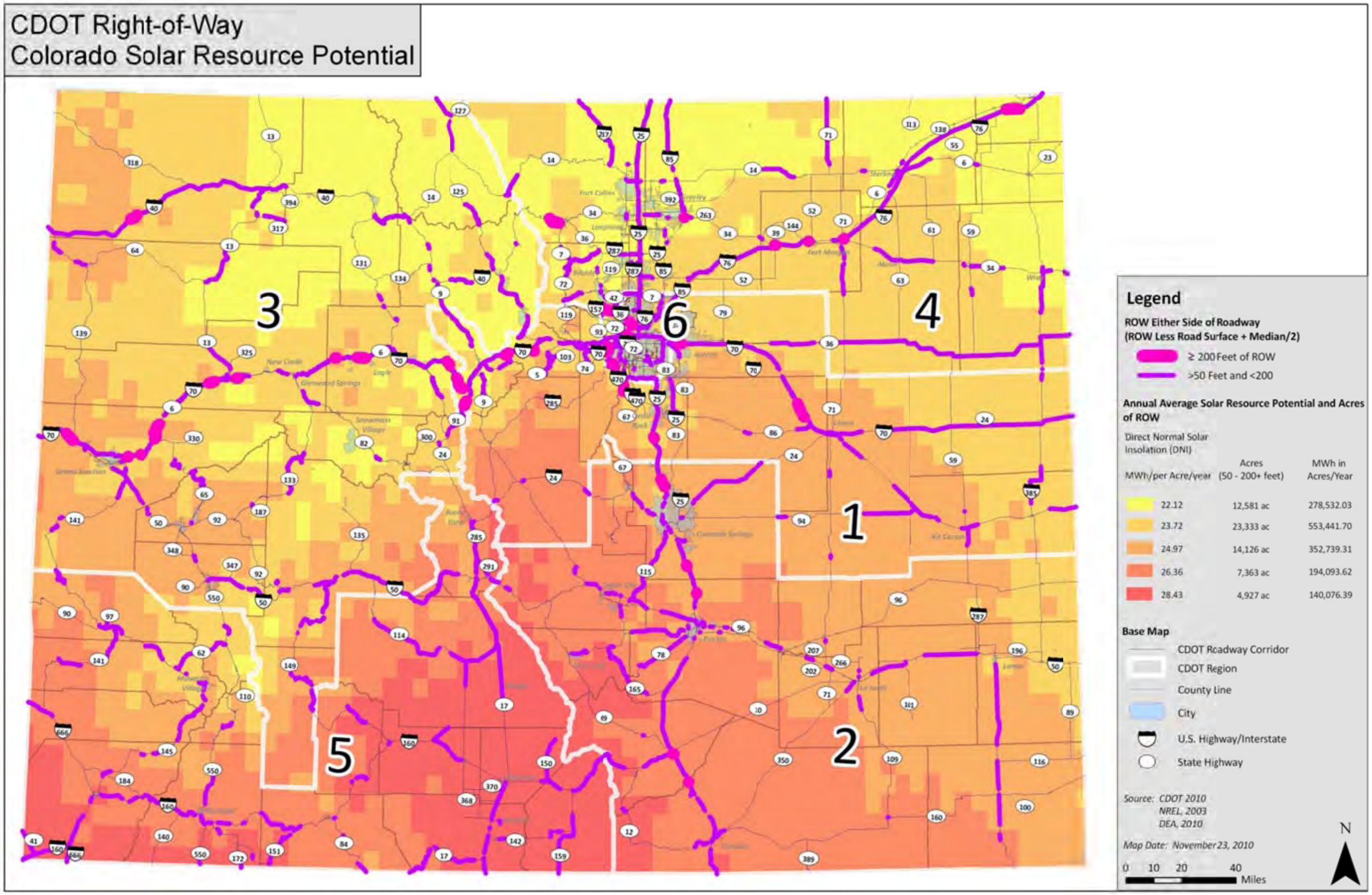


Figure 31-a. Colorado Solar Resource Potential Region 1

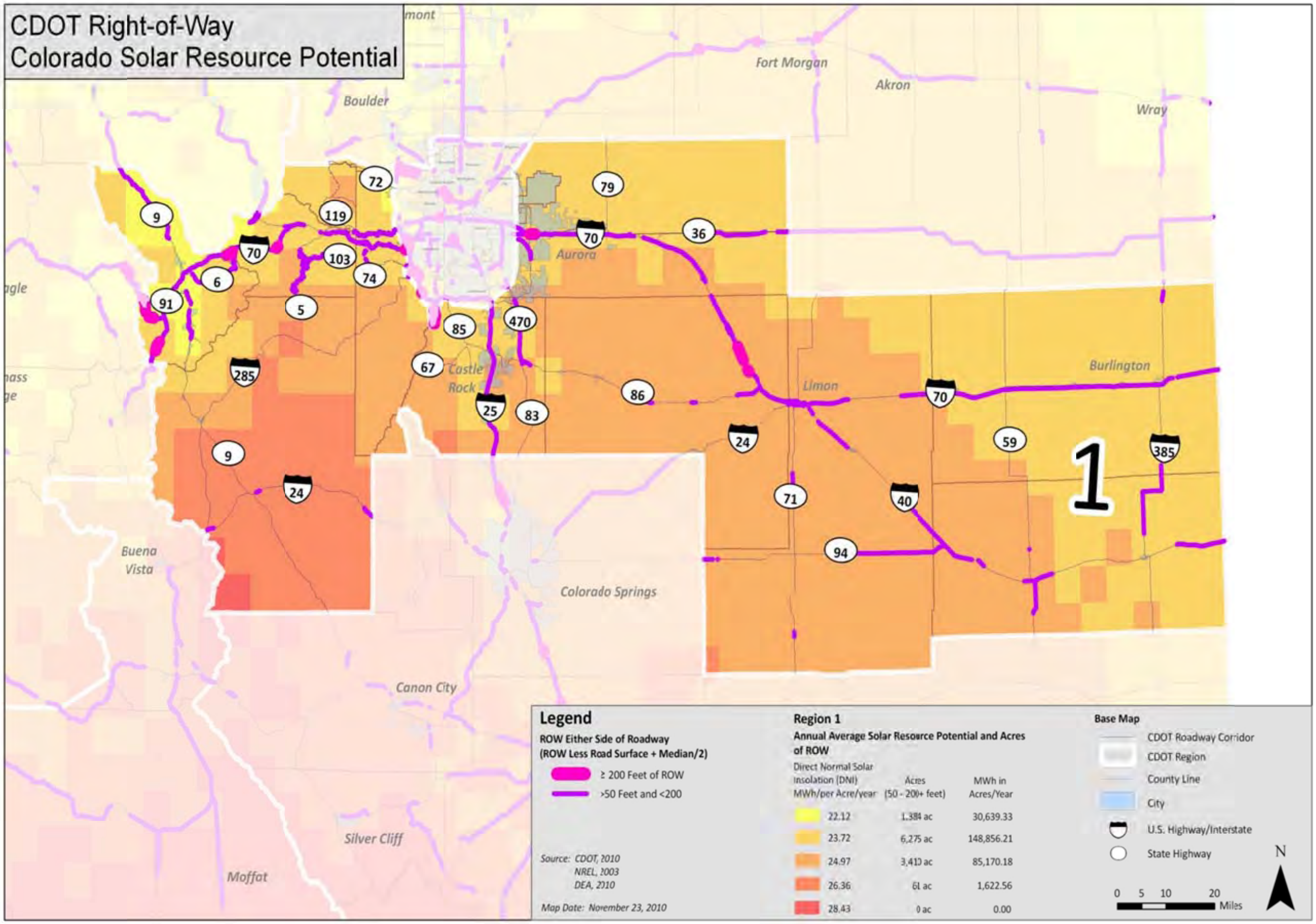


Figure 31-b. Colorado Solar Resource Potential Region 2

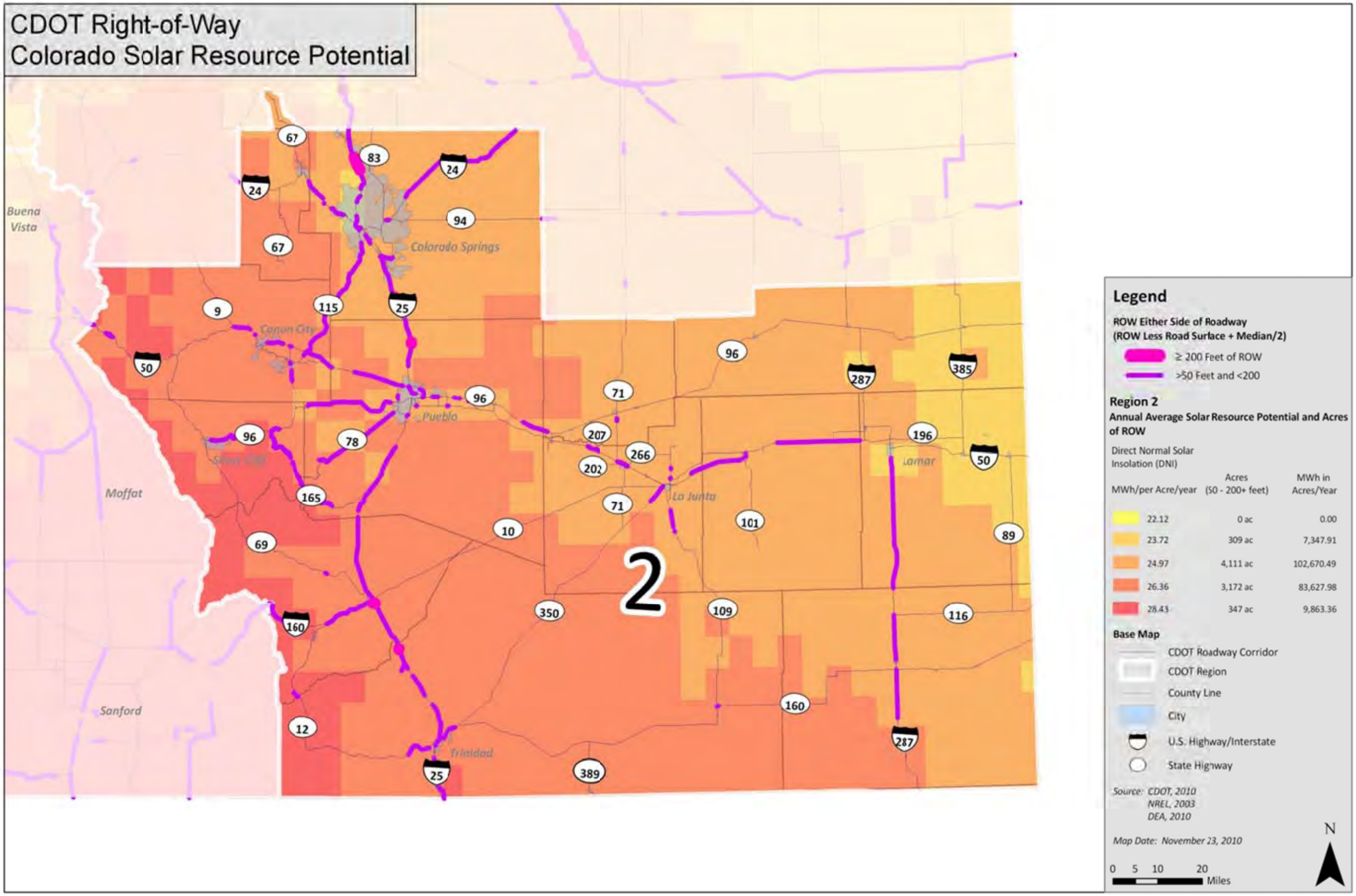


Figure 31-c. Colorado Solar Resource Potential Region 3

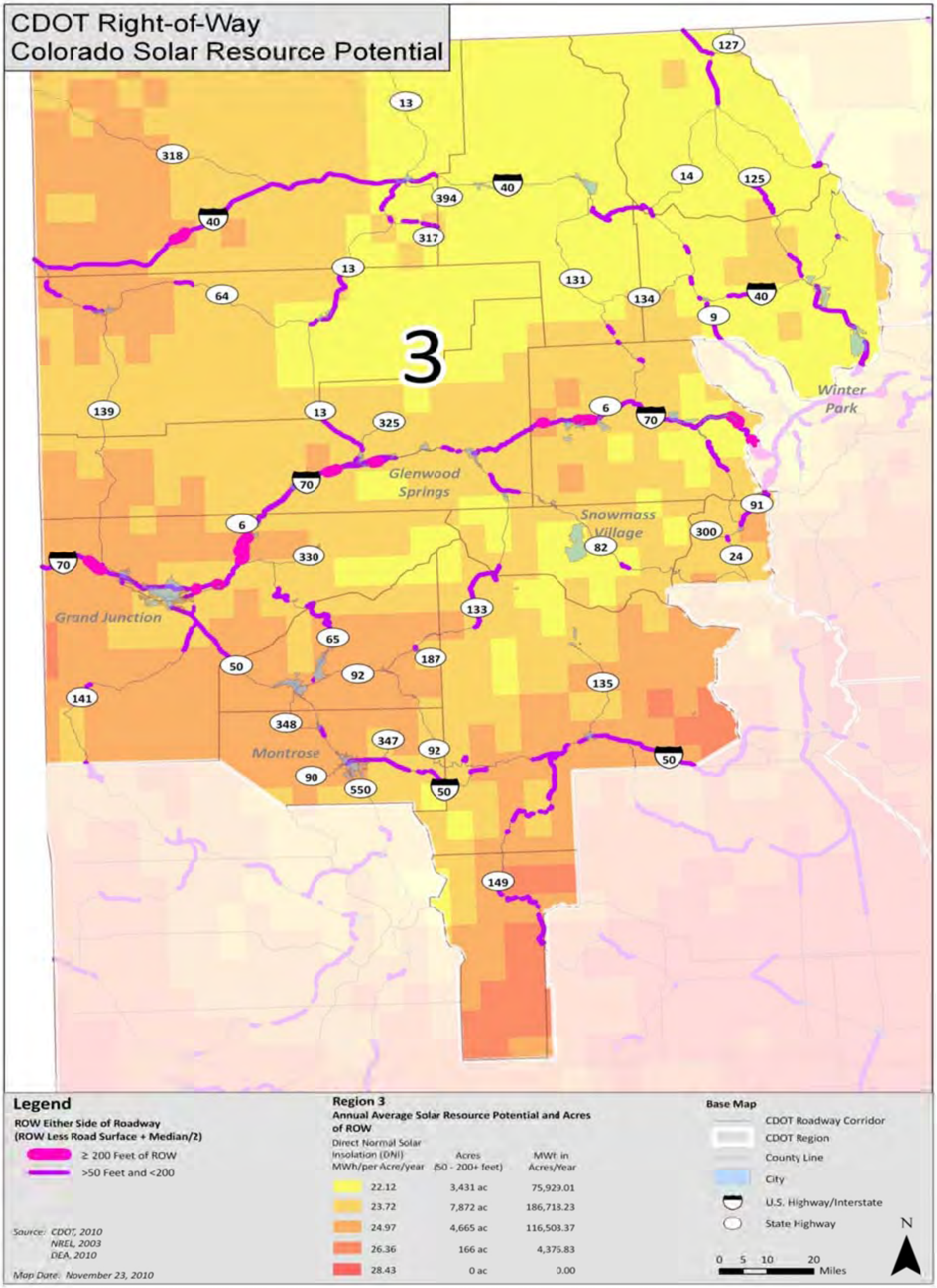


Figure 31-d. Colorado Solar Resource Potential Region 4

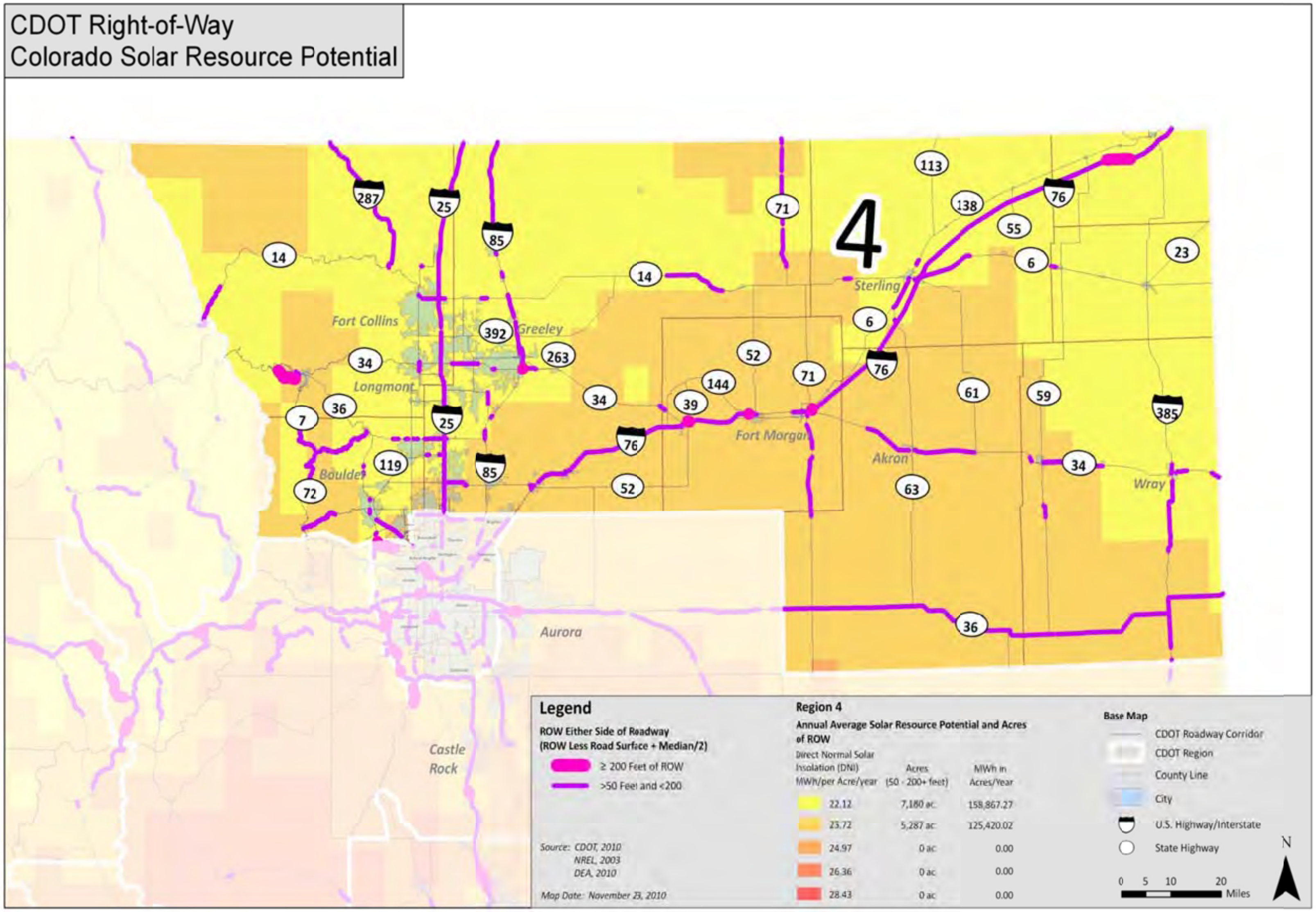


Figure 31-e. Colorado Solar Resource Potential Region 5

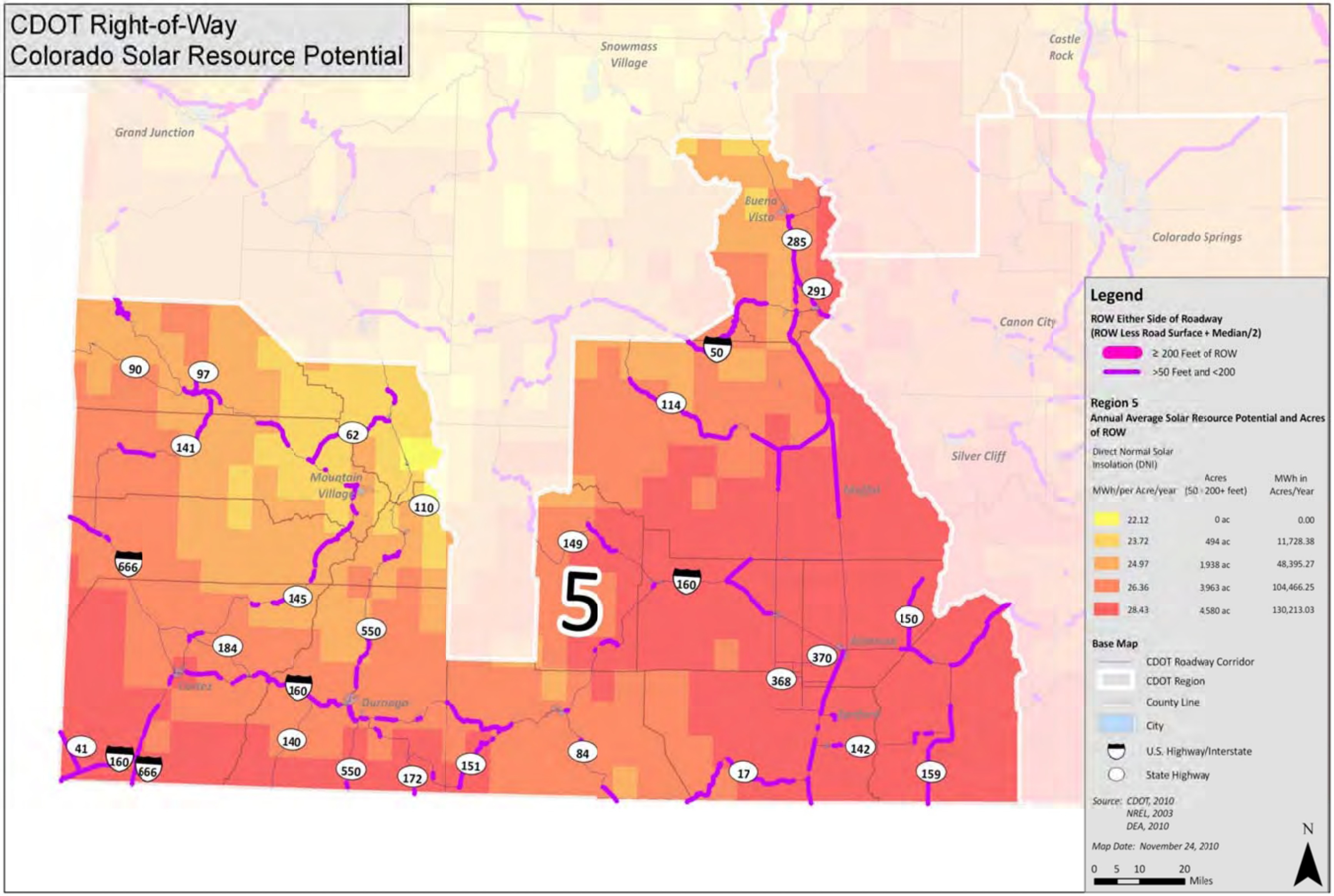
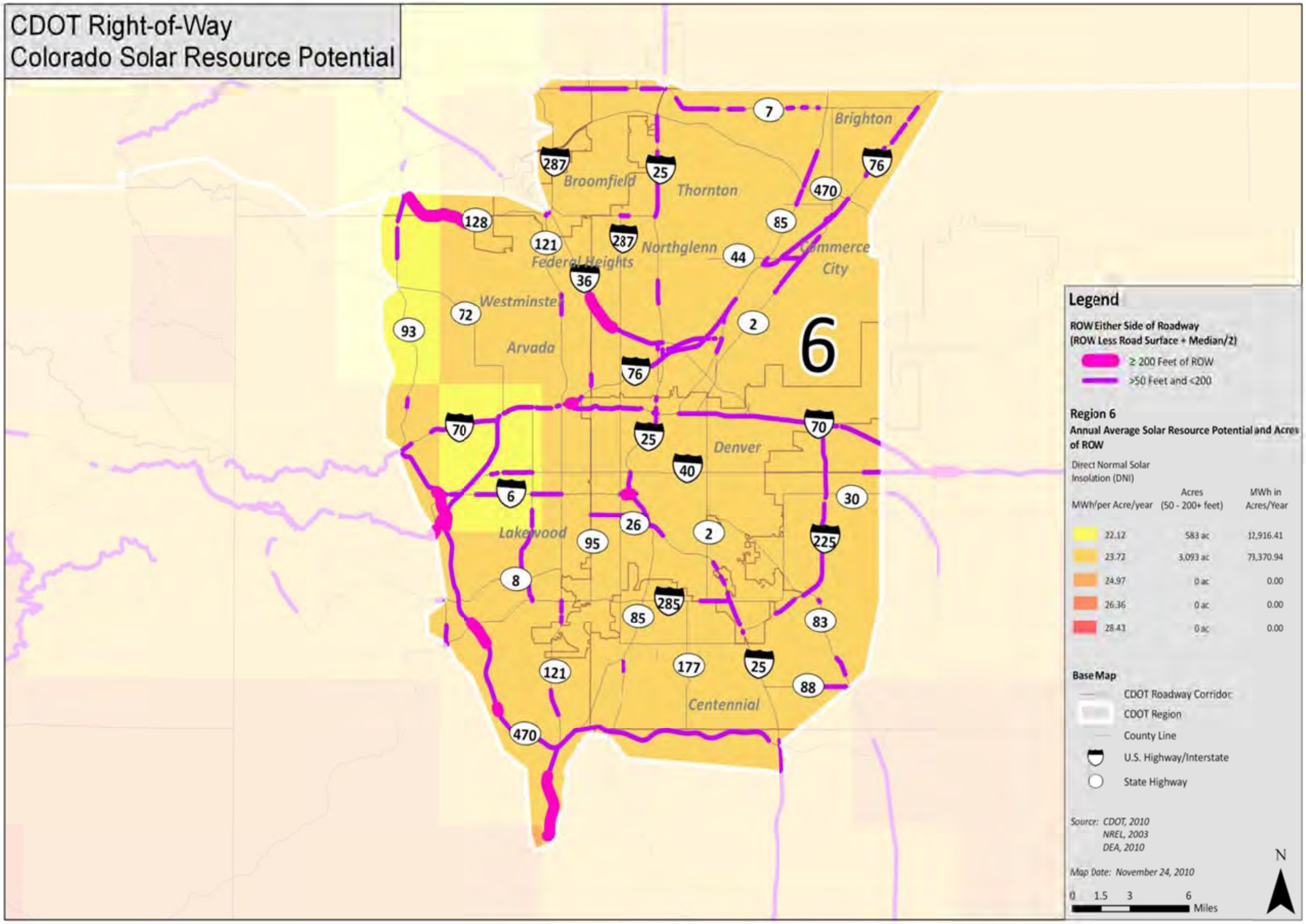


Figure 31-f. Colorado Solar Resource Potential Region 6



7.1 Solar Efficiency

Solar energy can be converted to electricity through various commercially available technologies including photovoltaics (PV) and concentrated solar power (CSP). For consistency with other published energy reports for Colorado (NREL and Western Governor's Association), PV production technology was assumed.

Both the efficiency of the PV panel (technology efficiency) and the site utilization efficiency (site efficiency) must be considered when calculating potential electricity from ROW. *Technology efficiency* reflects the energy produced when the panel is operating at full capacity. According to NREL, an average efficiency of current PV technology is approximately 20 percent (NREL, 2010). *Site efficiency* is determined by the spacing of PV panels and the amount of land devoted to ingress/egress, transmission facilities, maintenance areas, etc., and the degree to which the site may be impaired by obstacles such as trees and buildings.

The loss of efficiency of converting direct current (DC) output from PV panels to alternating current (AC) power suitable for input to the electrical grid is minimal at approximately five percent. As a result, the loss of power during DC to AC conversion was not considered in the technology efficiency analysis.

As an example of site efficiency, the CSU-Pueblo solar array is comprised of 4.3 acres and 6,800 solar panels with a surface area of 1.3 m^2 per panel, resulting in a total coverage area of 2.2 acres. Therefore, the resulting site efficiency for the CSU-Pueblo array is approximately 50 percent.

Figure 31-g. Portion of CSU-Pueblo Solar Array

When considered together, these factors represent the capacity factor[3] of a particular site and technology. The capacity factor was applied to ROW energy production calculations. An overall capacity factor of ten percent was calculated based on 50 percent (site) and 20 percent (technology) efficiency. Thus, only 10 percent of the total amount of solar energy received by ROW in Colorado is available for electricity production.

Comprehensive data on the total amount of electricity used by CDOT annually was not available, but records on recent electricity use for various locations in Region 2 were obtained and analyzed to compare existing usage to the potential energy generated by a PV facility. For example, the total electricity usage at an interchange complex in Walsenburg in 2009 was 38.6 MWh/year. This interchange includes approximately 18.6 acres of land, which is estimated to include 25 percent undeveloped land (4.65 acres) that is outside of the clear zone. A solar PV installation on this 4.65 acre site could generate 4.5 GWh/year based on a DNI of 9.63 GWh/year, 20 percent solar panel efficiency and assuming 50 percent land coverage by the solar panel array. The existing interchange lighting would require only 1.5 percent of the solar array power, and the remaining electrical supply would be available for other purposes.

In another example, records indicate that the CDOT Region 2 Colorado Springs office used 2.3 GWh of electricity in 2009. A section of Interstate 25 that meets the criteria for potential solar applications (ROW wider than 50 feet from edge of pavement) is located within one mile of the office. If this 10.8 acre site was fully developed with solar PV, approximately 9.8 GWh could be produced annually. This amount would meet 100 percent of the office's yearly electricity needs and provide a surplus.

As a current transportation example, the Oregon Department of Transportation (ODOT) recently installed a relatively small PV system (0.2 acres) within the ROW of the major interchange area at I-5/I-205 to generate electricity for the interchange's lighting needs (Oregon Department of Transportation, Solar Highway, 2009). This system generates approximately 130 MWh/year (at

[3] Capacity factor is the ratio of the actual output of a power producer such as a solar PV system over a period of time compared to output if it had operated at full capacity the entire time. Capacity factors vary greatly depending on the type of fuel. Solar energy, for example, is not produced during nighttime or cloudy conditions, and efficiency is decreased with factors such as the degree of slope and obstacles such as trees. Current technology is also not 100 percent efficiency in converting solar energy to electricity.

net levels, including site and technology efficiency), or about 30 percent of the large interchange's total annual electricity requirements (Figure 31-h).

Figure 31-h. Aerial view of ODOT 'Solar Highway' Site at I-5/I-205

Based on the DNI rates and the ROW acreage in each DNI level (approximately 62,300 total acres), Colorado ROW receives almost 554,700 GWh/year of solar energy. If 100 percent of this energy was converted to electricity it would meet ten percent of Colorado's total electricity demand based on year 2007 consumption rates (SWEnergy, 2010). Based on an overall efficiency rate of 10 percent, approximately 55,500 GWh/year could be produced, providing one percent of Colorado's electricity at demand levels in 2007.

Solar-generated electricity requires transmission lines to transport the electricity either to nearby CDOT facilities or to a larger regional energy grid. Except in highly urban areas, Colorado lacks a cohesive transmission grid that could transport electricity generated within rural ROW to outside markets. This issue is discussed in Chapter 12.

CHAPTER 8. WIND ENERGY

NREL research established seven categories for wind power density ranging from 0 watts per square meter (W/m2), described as 'poor', to 800 or greater W/m^2 described as 'superb.' Categories for wind resource in Colorado are shown in Table **7**. The total wind power potential in the ROW was calculated by converting meters to acres and multiplying the annual wind energy per acre (mWh/acre) in each category by the total number of acres in the ROW in that category. Table 8 indicates the total wind power generated in GWh per year.

Table 7. Colorado Wind Power Classes

Power Class	Resource Potential	Wind Power Density at 50m height, (W/m^2)
	Poor	0 - 199
	Marginal	200 - 299
	Fair	300 - 399
	Good	400 - 499
	Excellent	500 - 599
	Outstanding	600 - 800
	Superb	>800

Table 8. Wind Energy Production by Acres and Wind Power Class, in GWh/year

Power Class	Resource Potential	Wind Power Density (MWh/Acre/Year	Acres	GWh/Year
	Poor	183.3	2394	197.5
	Marginal	261.8	546	64.3
	Fair	366.5	449	74
	Good	471.2	197	41.7
	Excellent	575.9	10	2.7
	Outstanding	733	0	0
	Superb	837.7	0	0

Wind power production efficiency is also dependent on the site capacity and the turbine efficiency. Site capacity refers to the percentage of land that can be used for one wind turbine, considering adequate spacing between the wind towers. This percentage is based on the turbine blade length and the height of the tower. For example, a 50-meter (164-foot) tall Vestas V39 500 kW turbine has a blade length of 19.5 meters (64 feet) (NREL/SR-500-44280, December 2008). Based on a minimum 250 feet minimum setback distance (the required setback by the State of Minnesota DOT for wind turbines for safety purposes and to accommodate ingress/egress) and 64 feet to contain the sweep of the turbine blade, approximately 314 feet outside of the 50-foot clear zone is needed for one turbine. NREL data suggests a distance of 7-10 turbine diameters between each turbine. Accounting for a 314-foot setback distance, a minimum of nine acres per wind turbine would be required. For this report, a minimum of 10 acres was considered to be a realistic assumption for one wind turbine (0.1 turbine per acre).

Turbine efficiency refers to the percentage of time the turbine is producing at its maximum capacity. An efficiency rate of 45 percent is typical for a wind turbine (Aeolos 2010).

Areas of highest wind production in Colorado include the Eastern Pwesterlains from Sterling south to La Junta, including CDOT Regions 1, 2, and 4. Figure 32 indicates the wind power classes in Colorado, and Figures 32-a through 32-f show wind power classes for each of the six CDOT Regions. These areas are mostly rated as Wind Power Classes “Fair” to “Good” (NREL, 2009), with a few localized areas of “Excellent” classification north of Sterling and southeast of La Junta.   There are numerous other sites within Colorado that are also rated as “Excellent” and “Superb,” but these tend to be on mountain ridge areas and are not within CDOT ROW.

Accounting for efficiency factors relating to a minimum 250-foot safety setback, the need for adequate site spacing (density) and turbine efficiency levels, approximately 380 GWh/year could be produced on Colorado ROW. This is far less energy than could be produced by solar applications on ROW, but the availability of wind in some locations in Colorado, particularly in Regions 1, 2, and 4 could still provide good local sources of electrical power.

Figure 32. Colorado Wind Resource Potential

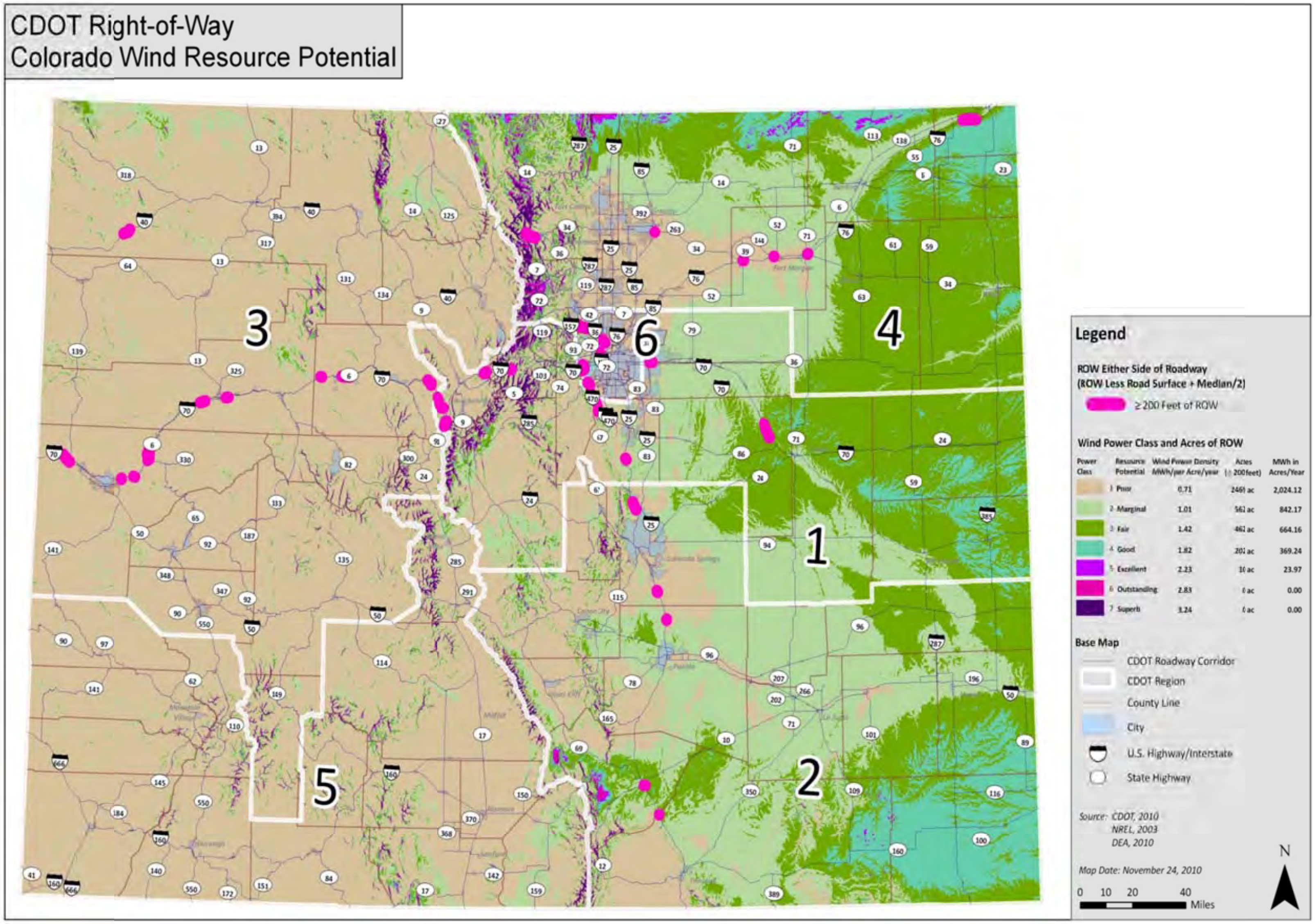


Figure 32-a. Colorado Wind Resource Potential Region 1

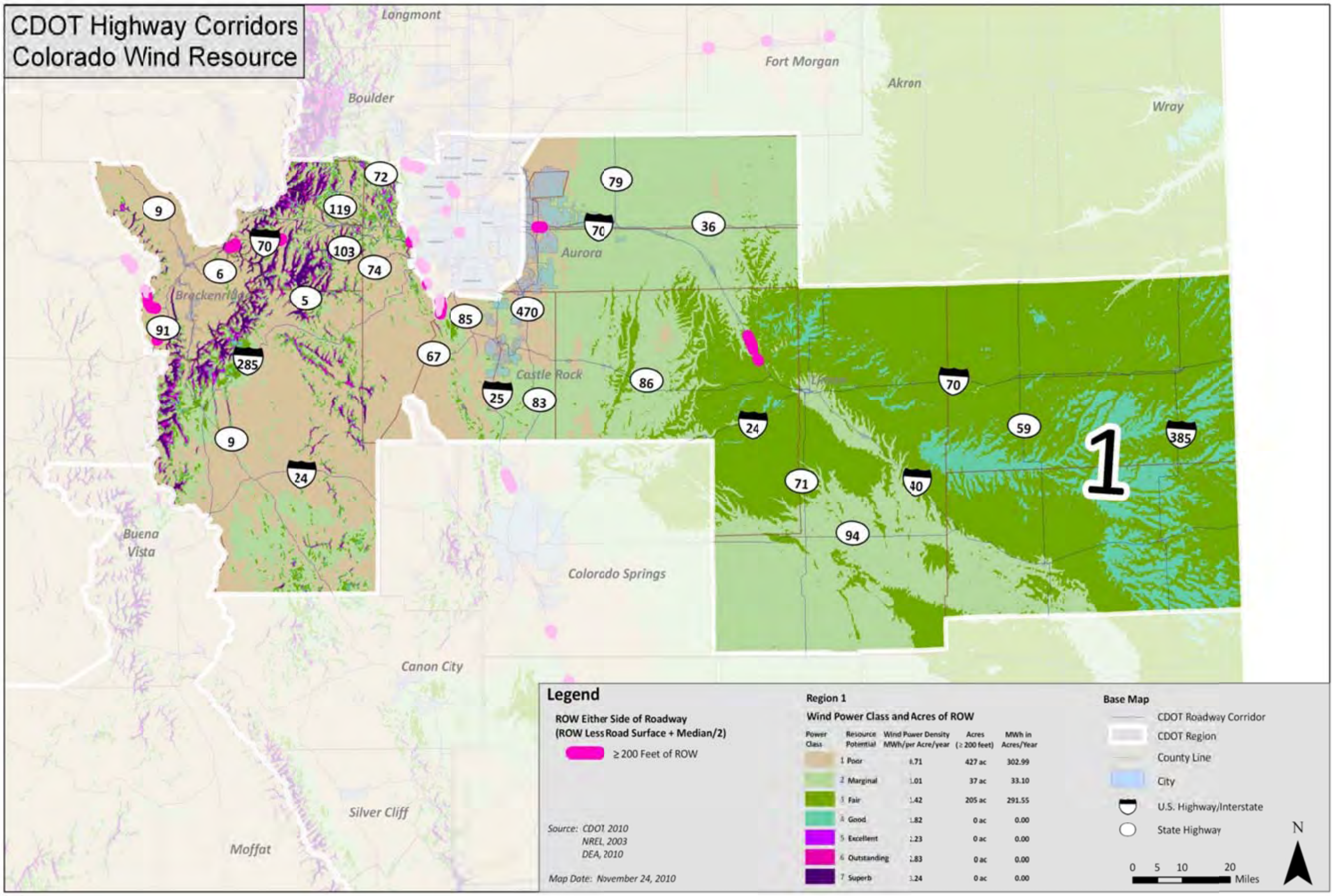


Figure 32-b. Colorado Wind Resource Potential Region 2

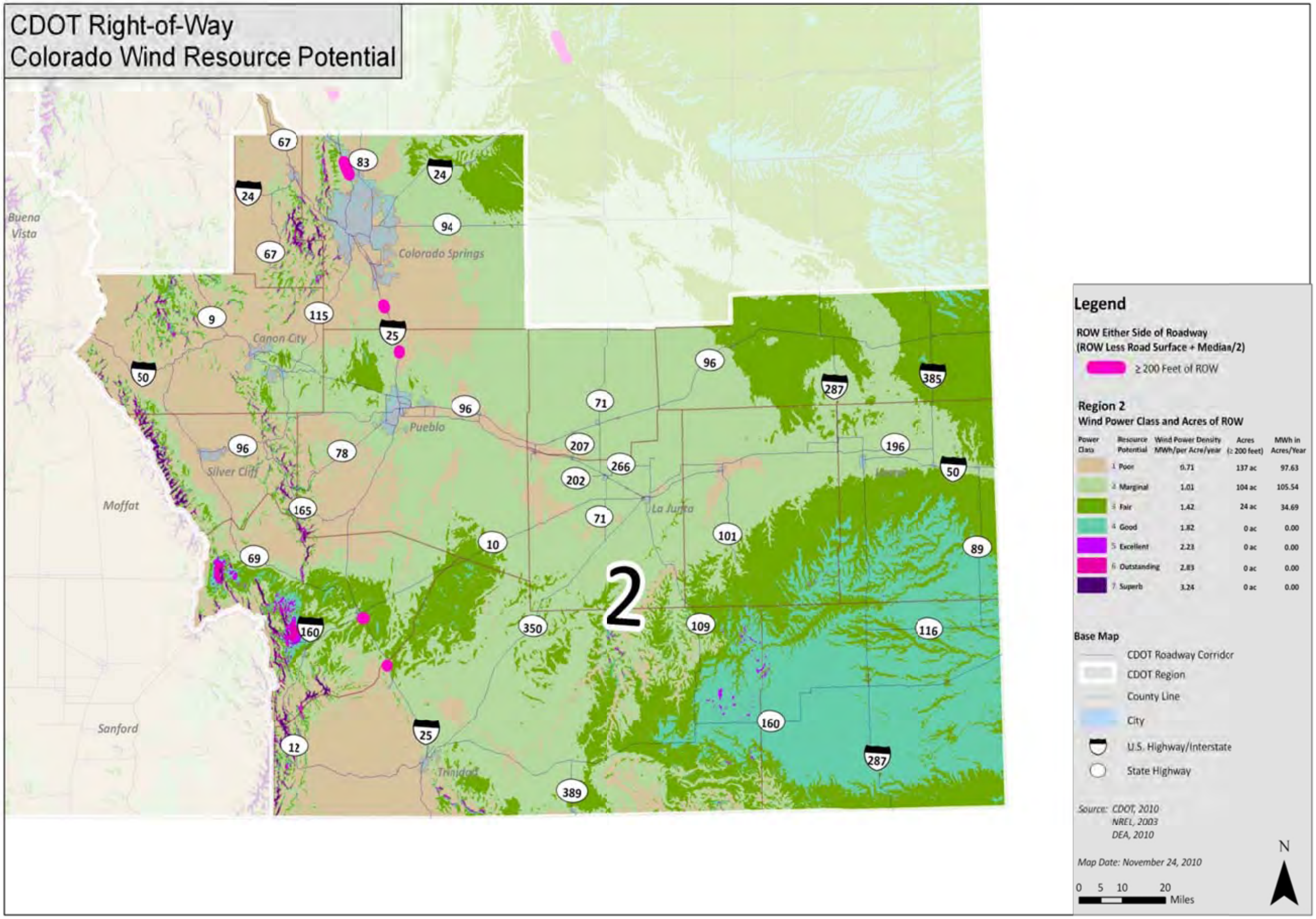


Figure 32-c. Colorado Wind Resource Potential Region 3

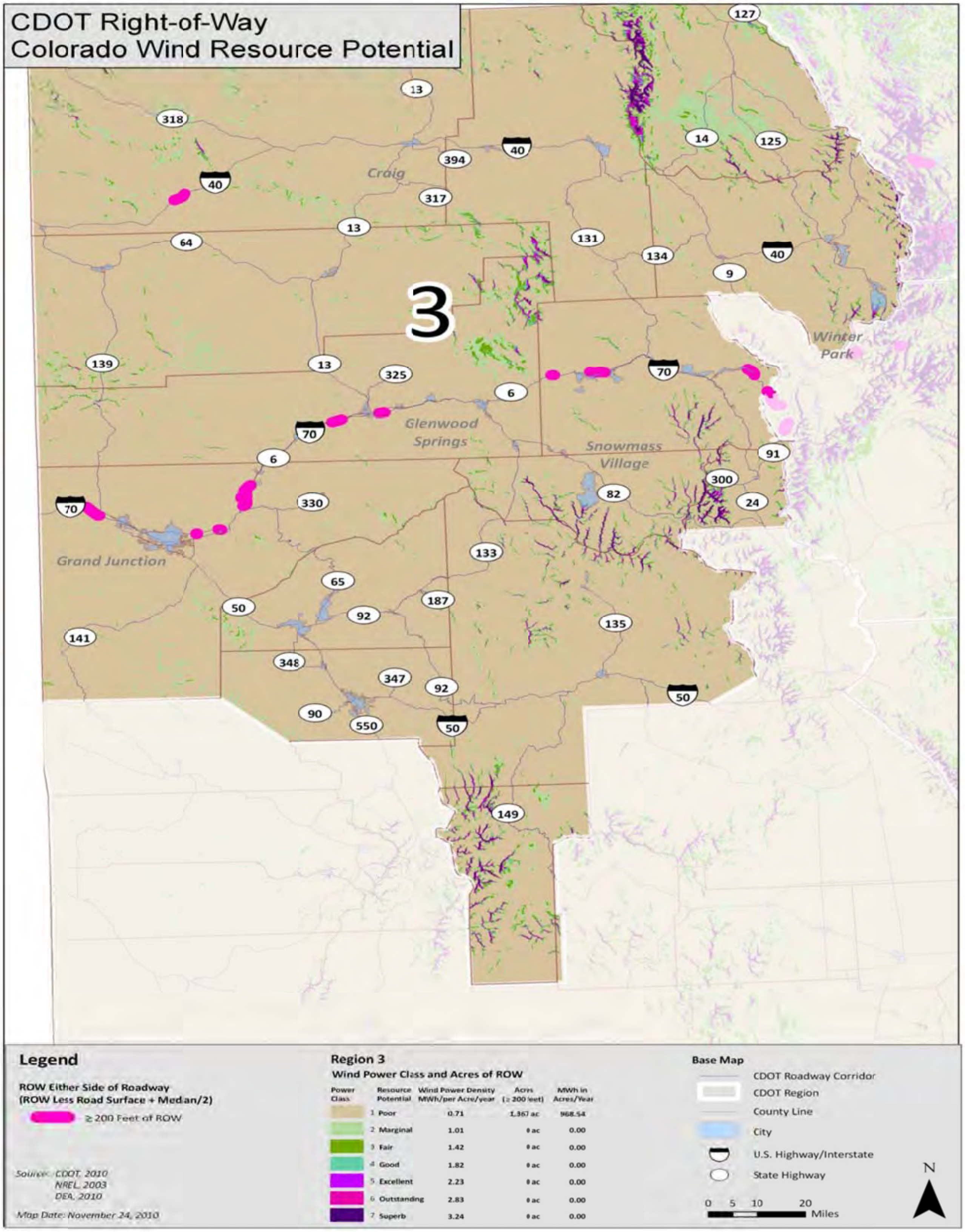


Figure 32-d. Colorado Wind Resource Potential Region 4

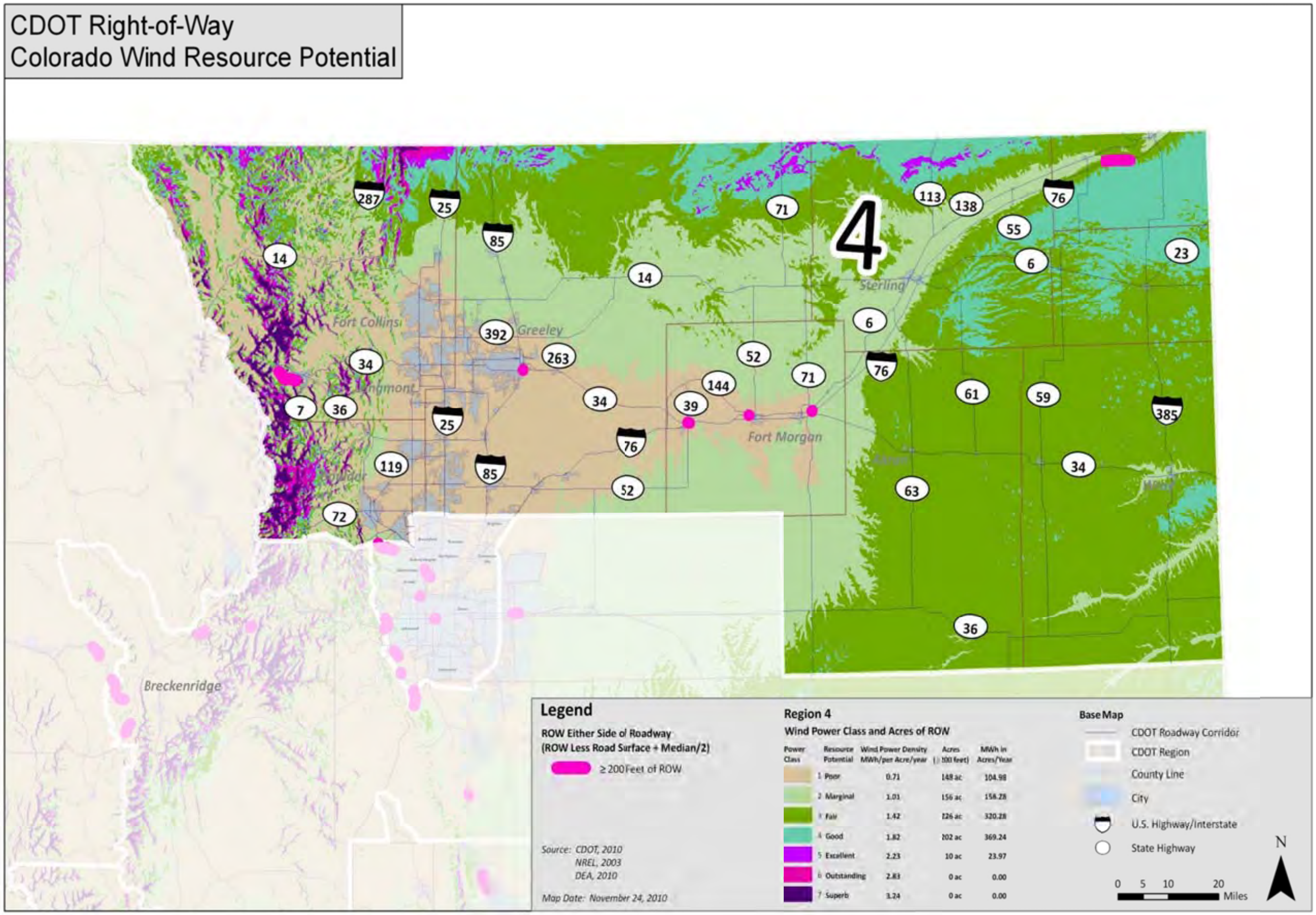


Figure 32-e. Colorado Wind Resource Potential Region 5

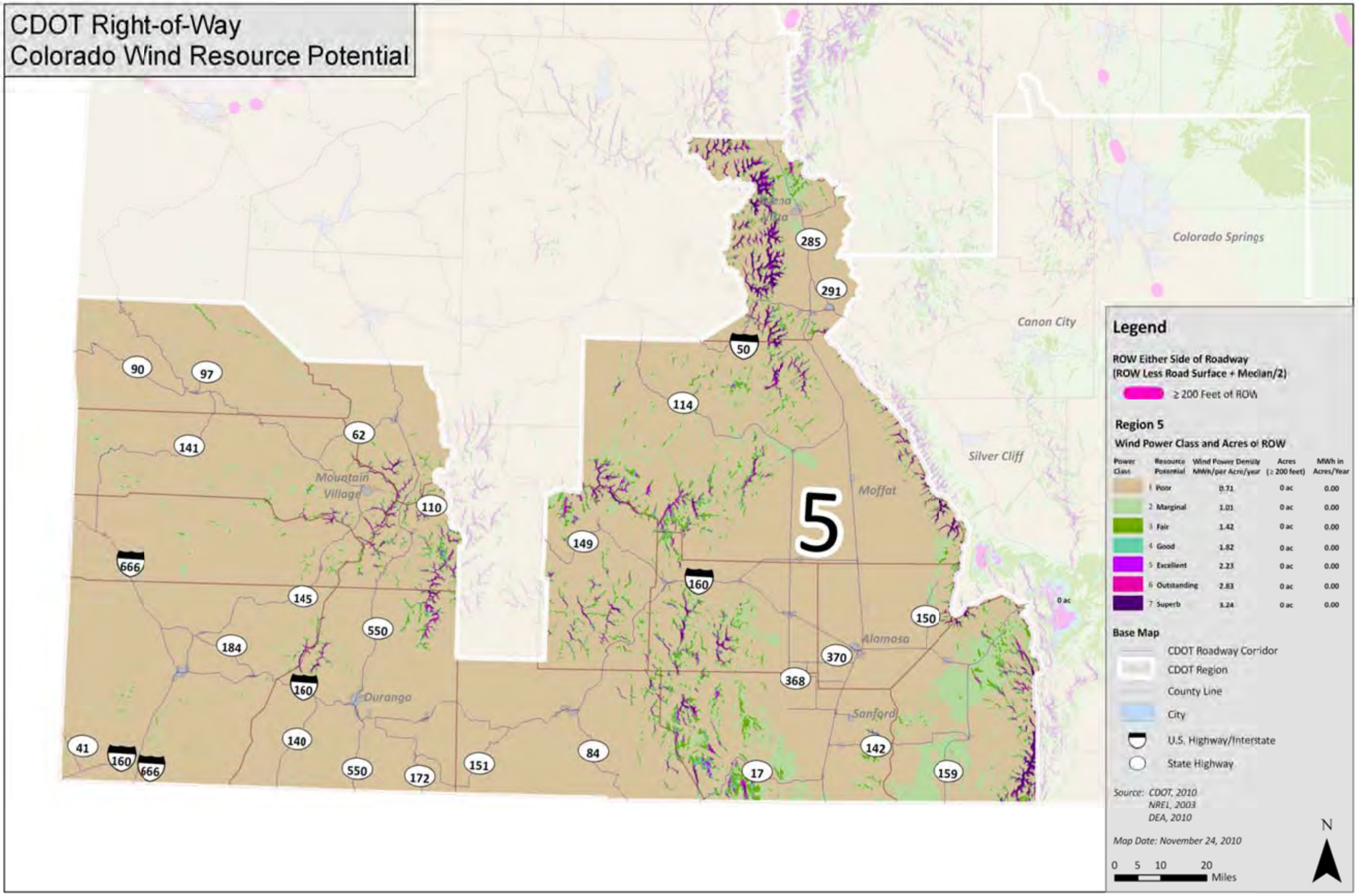
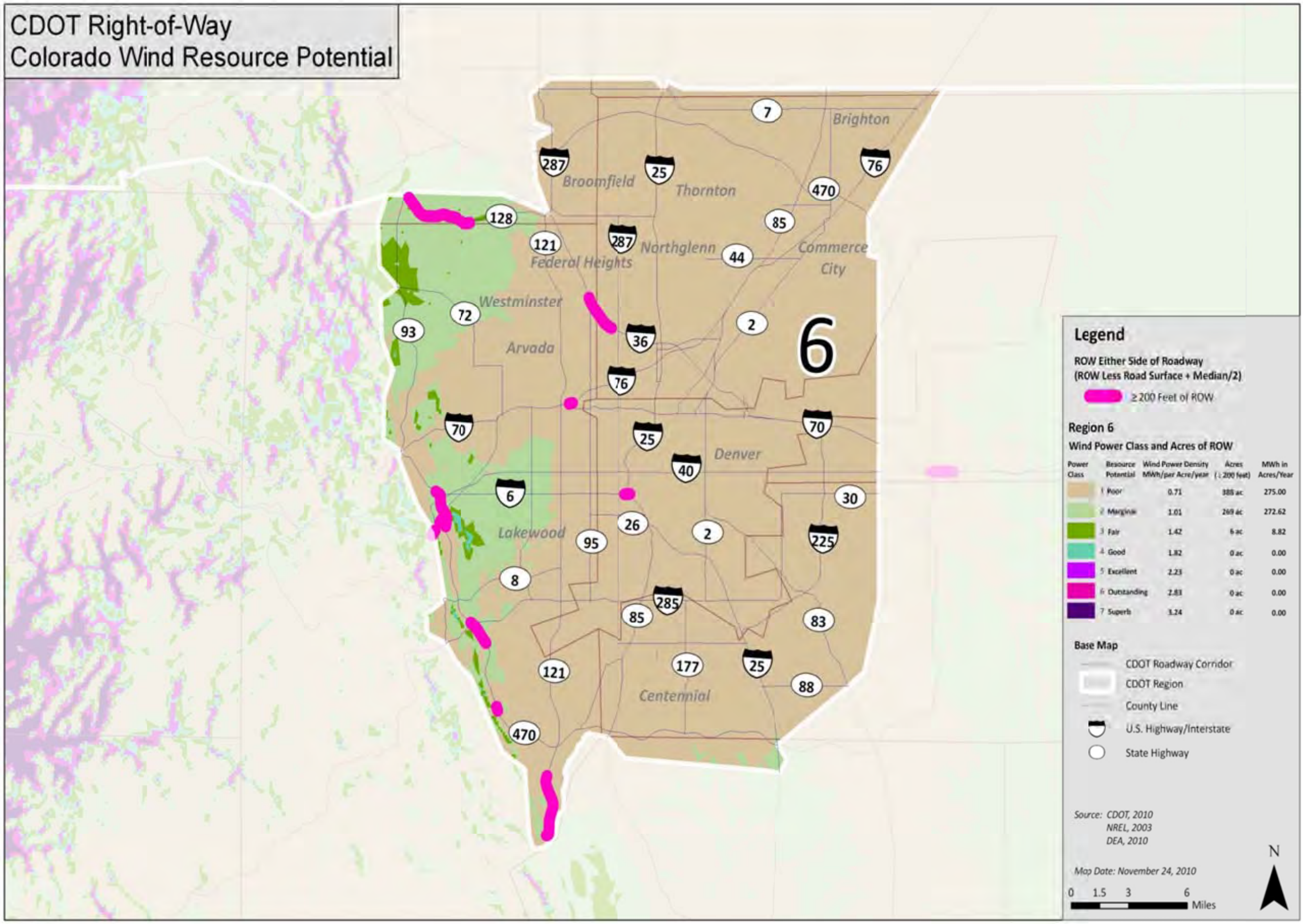


Figure 32-f. Colorado Wind Resource Potential Region 6



CHAPTER 9. BIOMASS

In the State of Colorado, biomass with potential as biofuel includes forest material, landfill, wastewater, manure, and some crops such as corn and soybeans. Biofuels are already produced in Colorado, and several ethanol and biodiesel refineries are located in the Front Range and Eastern Plains. Several landfill methane production facilities are also operating in Colorado as shown in Figure 33.

Five biomass production categories were established by NREL for the State of Colorado (Table 9). These categories range from very low production (an average of 0.0053 tons/acre/year) to a high production level (an average of 0.23 tons/acre/year). Each county in Colorado falls in only one of these five categories depending on how many tons could be produced based on land uses and vegetation types. Because biomass can be harvested without the need for barriers or setbacks to separate traveling vehicles from structures, usable ROW (excluding medians) was calculated from edge of pavement to the outside edge of the ROW. Therefore, biomass acreage did not include a 50 foot safety zone from edge of pavement as was assumed for solar and wind energy.

Biomass categories were converted to tons per acre per year to determine the tonnage that can be produced in CDOT ROW for that category. Table 9 indicates the number of tons that can be produced by each biomass category in CDOT ROW statewide.

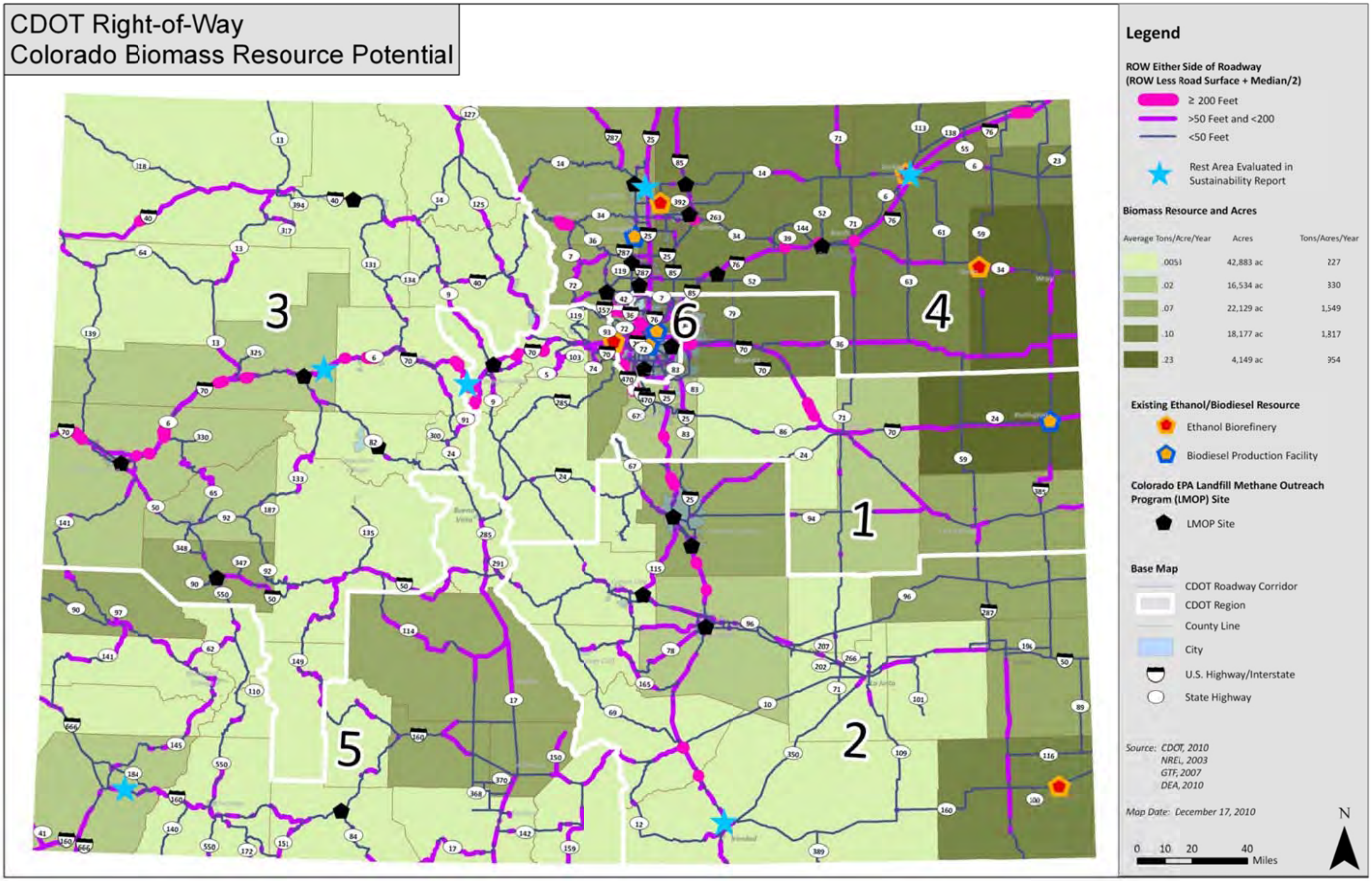
Table 9. Biomass Production, tons/year

Biomass Resource and Acres

Average Tons/Acre/Year	Acres	Tons/Year
.0053	42,883 ac	227
.02	16,534 ac	350
.07	22,129 ac	1,558
.10	18,177 ac	1,901
.23	4,149 ac	938

For the entire state an estimated 4,974 tons could be produced annually from ROW, providing approximately 5.0 GWh/year, or 0.000001 percent of Colorado's total electricity demand based on 2007 consumption rates.

Figure 33. Colorado Biomass Resource Potential



CHAPTER 10. GEOTHERMAL

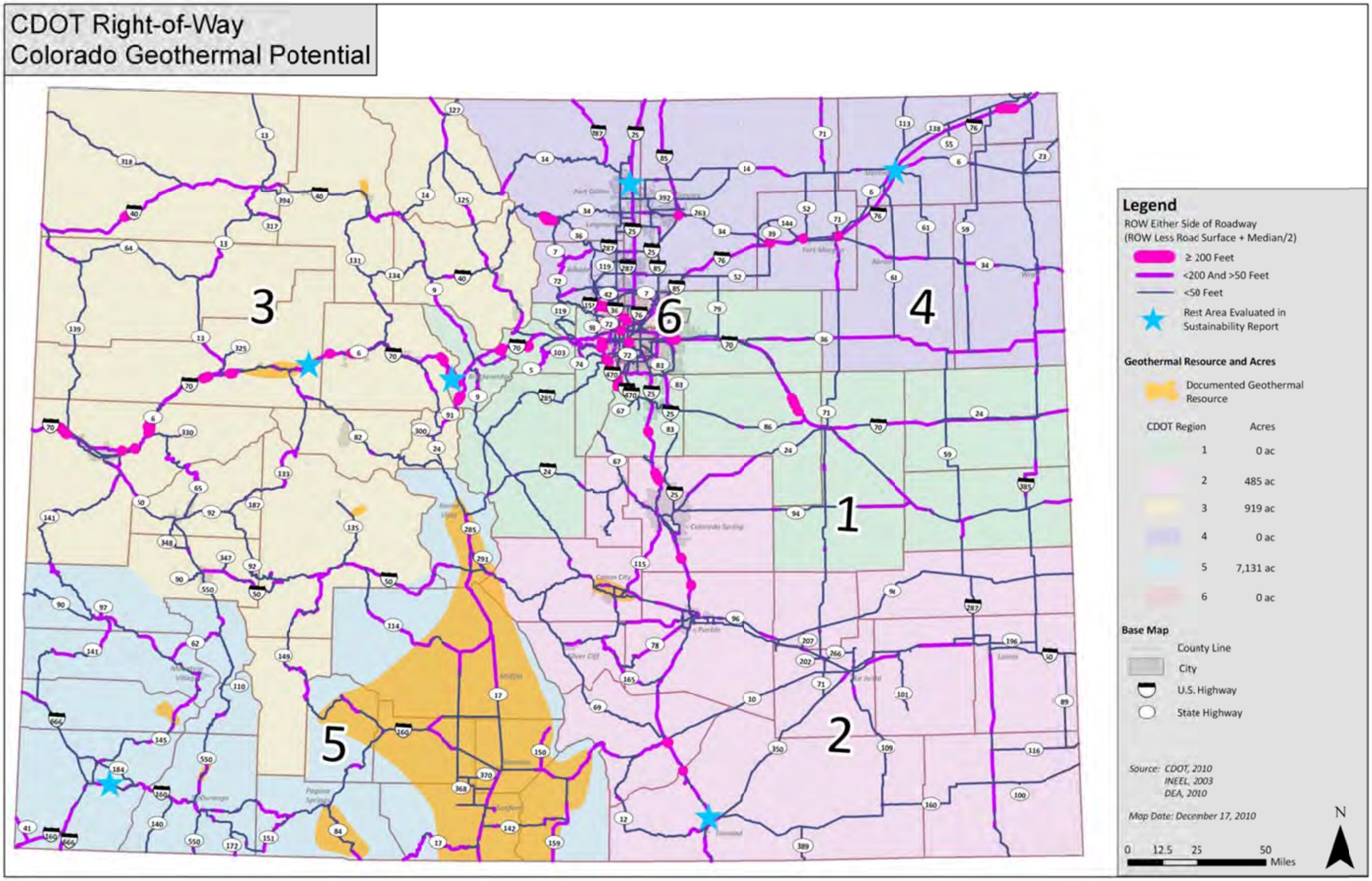
Colorado has numerous areas of known geothermal activity including well-known hot springs such as those in Idaho Springs, Glenwood Springs, Buena Vista, Pagosa Springs, and Steamboat Springs, and a total of 59 hot springs and 34 geothermal well sites statewide (*Colorado Geothermal Development Strategic Plan*, 2007, GeoPowering the West - Colorado State Working Group). These sites produce geothermal heat through geoexchange (heat pumps), direct use (pools, greenhouses, etc.), and electrical power generation. Electrical power production requires higher temperatures than geoexchange or direct uses, and until recently steam geothermal power plants have required water temperatures above 300 degrees Fahrenheit (°F). However, recent technologies are now using water at temperatures as low as 165 degrees °F. States producing commercial-scale geothermal and electrical power include California, Nevada, Utah, Hawaii, and Alaska. Colorado does not currently have any geothermal electricity generation.

Colorado does have characteristics that indicate geothermal resources with electrical power generation potential, including high heat flows in the mountains of central and western Colorado; activity in the Dotsero volcano about 4,000 years ago; recent fault activity and the extension of the Rio Grande rift zone through Colorado from the San Luis Valley north to central Colorado (*Colorado Geothermal Development Strategic Plan*, 2007). Also, Colorado's high altitude results in a lower boiling point for water that also lowers the 'flash point' for steam production that can be used to produce electricity (at 8,000 feet in elevation water boils at almost 15 degrees °F lower than at sea-level) (Snyder, undated).

Ongoing research into Colorado's geothermal resources is being conducted by the Colorado Geological Survey, the Massachusetts Institute of Technology, and others to better identify the potential for energy production. Recent maps indicate that resources within Colorado are concentrated in the south-central portion of the state from Buena Vista through Alamosa and to the state line, along Interstate 70 in and near Glenwood Springs, near Canon City and along State Highway (SH) 145 near Telluride (Figure 34). An overlay of this mapping with CDOT ROW areas wider than 50 feet on either side of the highway indicate that CDOT Regions 2, 3 and 5 have ROW within documented geothermal areas. Region 5 has the most acres of potential geothermal-producing ROW (7,131 acres). Regions 1, 4 and 6 do not have ROW located in known geothermal areas. Statewide, approximately 8,530 acres of ROW are located in geothermal areas.

Opportunities for CDOT to use geothermal resources may include heating and cooling of nearby CDOT facilities with heat pumps and the minor production of electricity through small-scale steam production to power facilities such as roadway lighting, rest areas, workshops, and offices. If transmission capacity is available, electrical power could be transported much further, but transmission lines outside of Colorado’s urban areas are generally quite disperse and may not be available. Until more reliable data are available, or unless CDOT evaluates specific ROW sites in high-potential areas, the true potential of ROW for geothermal uses will remain largely unknown.

Figure 34. Colorado Geothermal Potential

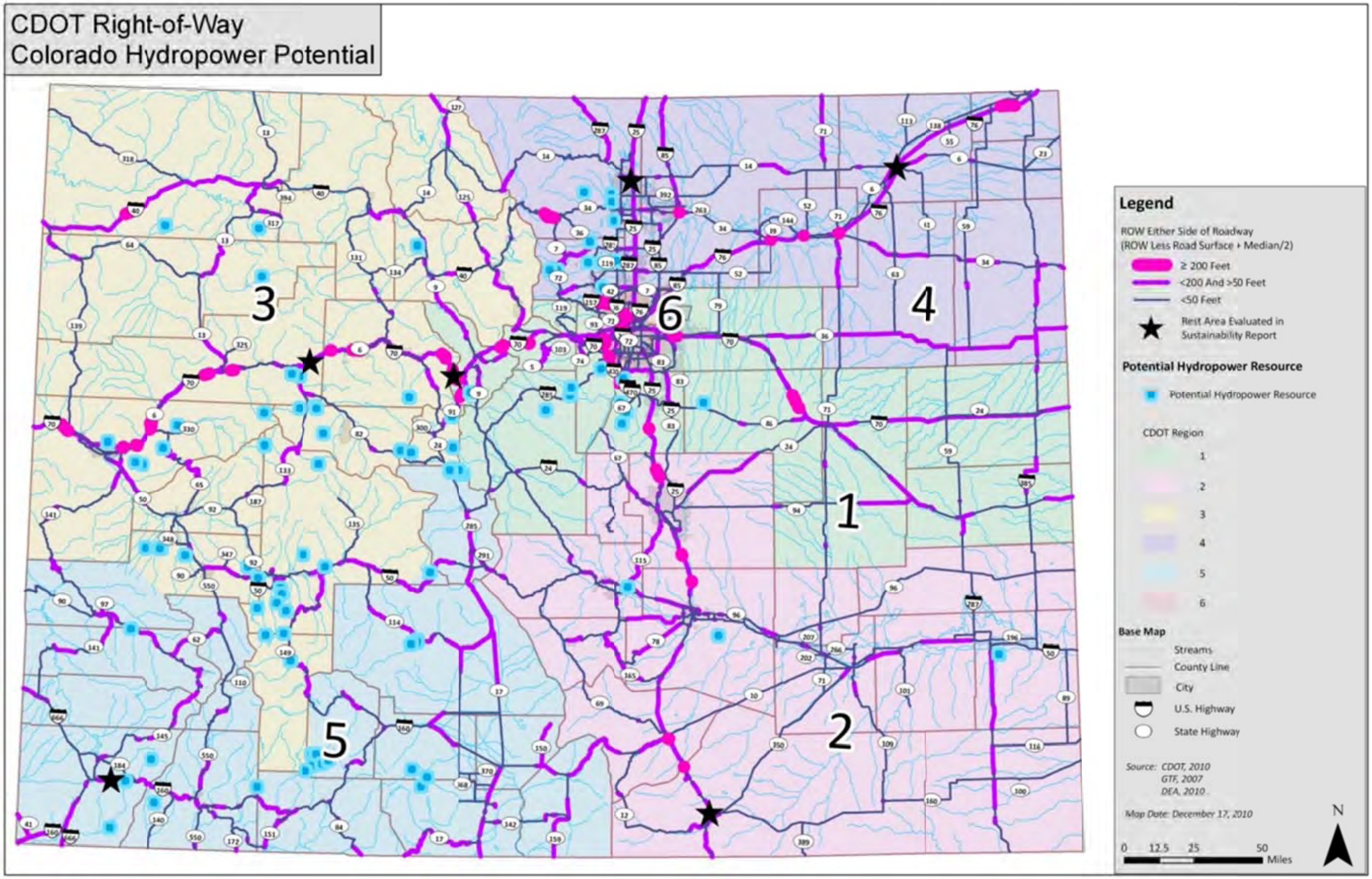


CHAPTER 11. HYDROPOWER

Hydropower has played a major role in electricity production in Colorado for over one hundred years due in large part to Colorado's rugged terrain, which provides numerous sites where energy from streams and rivers flowing from higher to lower elevations can be captured. There are currently about 62 operating hydropower facilities in Colorado, producing about five percent of Colorado's electric energy annually (NREL, 2005). Most hydropower plants are located in CDOT Regions 3, 4, 5, and 6. Many of these facilities could operate at higher capacities with the installation of efficiency improvements, and the U. S. Department of Energy (DOE) Idaho National Engineering and Environmental Laboratory (INEEL) has identified 91 additional sites in Colorado for potential new hydropower development. These sites are shown in Figure 35.

Detailed mapping of the locations of existing and potential new hydropower sites was not available, and it is unlikely that CDOT ROW contains any existing hydropower facilities. Therefore, this study did not attempt to quantify acres of ROW that would be suitable for hydropower development. Rather, as Figure 35 illustrates, this study mapping identifies about a dozen potential sites that appear to be located within 1/2 mile of a CDOT roadway. Such sites could provide electricity through a short transmission line to CDOT facilities such as rest areas and maintenance buildings, or for roadway lighting and signals.

Figure 35. Colorado Hydropower Potential



CHAPTER 12.   TRANSMISSION

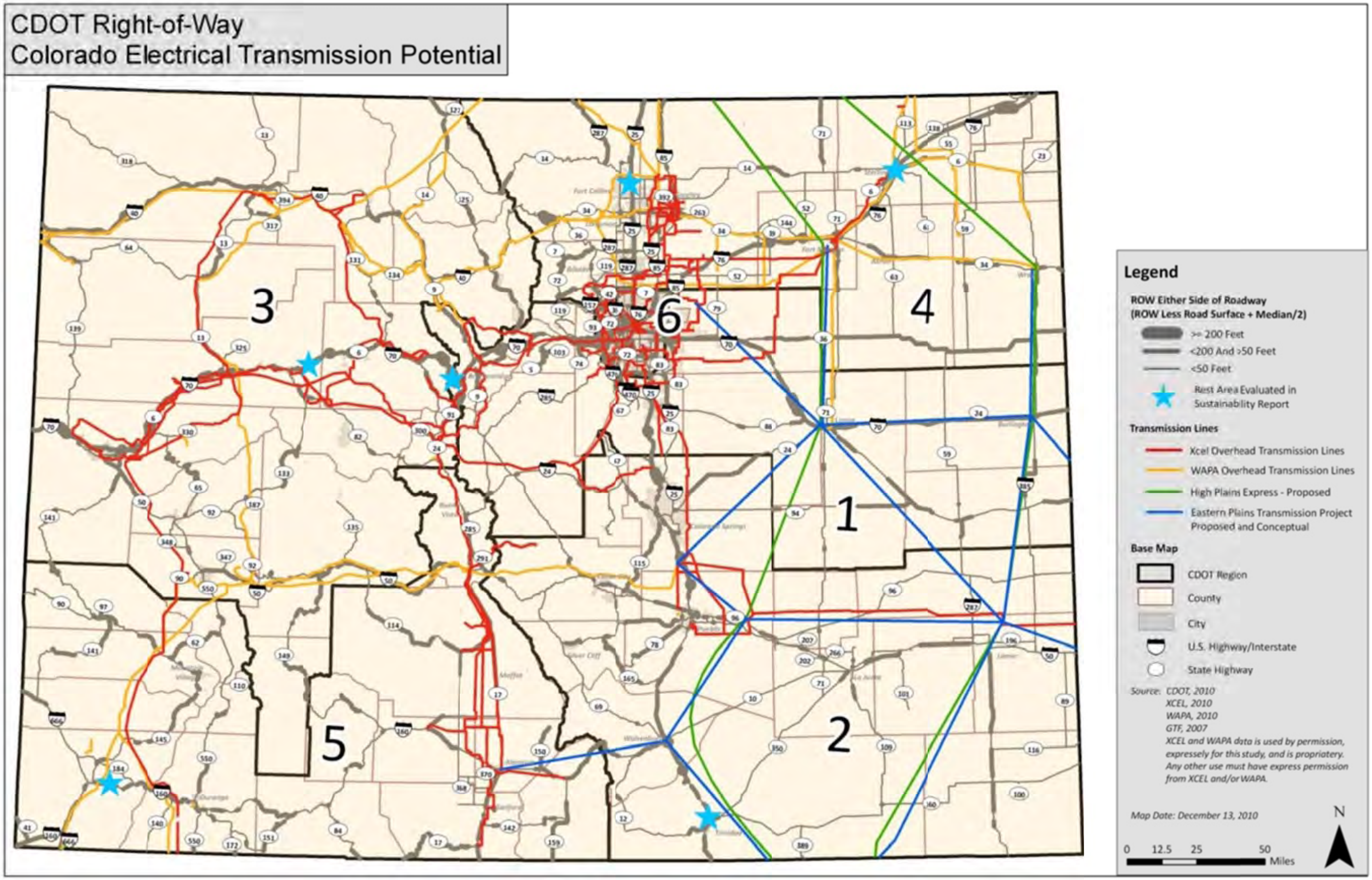
After electricity is generated it must travel on transmission lines to the end consumers, unless it is consumed onsite. Although Colorado has thousands of miles of transmission lines, there are large portions of the state with sparse coverage. Yet, these mostly rural areas can have significant potential for renewable energy production such as wind, solar and biomass. Without access to transmission lines, production of such energy may be infeasible or cost-prohibitive.

As shown in Figure 36, both Xcel Energy and the Western Area Power Administration (WAPA) maintain major transmission lines in Colorado. Tri-State Generation and Transmission (Tri-State) also has a substantial network of transmission lines, but mapping of those lines was not available and is not shown in Figure 36.

Also indicated in Figure 36 are the conceptual routes for two proposed major transmission lines. The High Plains Express is a 500 kV system that is proposed to traverse eastern Colorado from north to south, crossing large areas undeveloped rural areas. Project sponsors are Xcel, Tri-State, WAPA, Colorado Springs Utilities and utilities in New Mexico, Wyoming and Arizona. The Eastern Plains Transmission Project is sponsored by Tri-State, WAPA and the Public Service Company of Colorado, and would include about 1,000 miles of new high-voltage lines in eastern Colorado and western Kansas. The lines could be expanded west to Alamosa and south to New Mexico, tapping into new alternative energy projects in those locations.

The availability of existing and proposed transmission was not used to evaluate the potential for alternative energy because of the lack of complete data and the conceptual level of mapping detail obtained from Xcel and WAPA. It does appear, however, that substantial investments in new major transmission lines will take place over the next decade, and that the ability to connect alternative energy production sources on CDOT ROW to a much larger grid will improve in the future.

Figure 36. Colorado Electrical Transmission Potential



CHAPTER 13. LEGAL AND POLICY CONSIDERATIONS

Prior to 1988, the FHWA prohibited the installation of most new utilities within interstate ROW, and many states including Colorado adopted the same policy for state highways. In 1988, that policy was changed to allow each state to decide whether to permit new utilities within interstate ROW and to specify the conditions for approval. Each state is required to prepare a Utility Accommodation Policy (UAP) that describes the state's plan for allowing public and/or private utilities within ROW. The state's Utility Accommodation Policy must be approved by FHWA.

The 1988 FHWA policy also redefined public utilities as those 'in the public interest' and allows such utilities in interstate ROW if accommodated in a way that is safe for the traveling public. A Special Use Permit, or similar permit, must be issued by the state for public utilities. Private utilities can also be allowed within ROW, but must be permitted under an 'airspace lease' (23 Code of Federal Regulations (CFR) 710.405) that has different and more stringent requirements. For example, states must charge fair market prices for private utility leases with some exceptions for leases that 'provide an overall public benefit.' The net income from such leases may only be used for transportation purposes.

Emerging technologies for solar, wind and other alternative energy systems have caused FHWA and the states to reexamine existing definitions of 'utilities.' In 2005, AASHTO published the '*Policy on Accommodation of Utilities within ROW*' that proposes a uniform policy under which public and private utilities should be accommodated. FHWA policy now indicates that most technologies relating to alternative energy do meet the definition of a utility. In March 2009, the FHWA issued new guidance on utilization of interstate system ROW, and recommended that each state reevaluate its current Utility Accommodation Policy and make modifications or updates based on renewable energy considerations. FHWA has also adopted Interstate Standards (USC Title 23 Section 109) that must be adhered to for utility installations in the ROW to maintain safety. However, these standards do not prescribe details such as setbacks or minimum parcel sizes for utilities.

CDOT's most recent UAP was adopted in 2009. However, the definition of 'utility or utility facility' does not specifically describe alternative energy sources such as wind, solar, geothermal or biomass, nor does it provide guidelines or standards for permitting alternative energy in ROW such as setbacks or other safety buffers. A recommendation of this study is that CDOT revise the UAP to include design standards for alternative energy within ROW.

CHAPTER 14. POTENTIAL ENERGY PARTNERSHIPS

Although CDOT could appropriate its own funds for developing alternative energy resources on ROW, the availability of federal tax credits through public-private partnerships could help to minimize CDOT's capital and operating costs. In such partnerships, the private party (typically a private utility or bank) can use the current 30 percent federal tax credit and utility incentives (available from Xcel and several other utilities) to assist in financing projects. As a public agency, CDOT has no tax liability and cannot take advantage of such credits on its own. The history of the mandates and incentives for Colorado's Renewable Energy Standards (RES) that include the opportunity for utility tax incentives is contained in Appendix **A** to this report.

Recent federal energy legislation includes the Business Investment Tax Credit, which allows for a 30 percent tax credit for photovoltaic systems and some other renewable energy including fuel cells and small wind systems through the year 2016 (USC Title 26, Section 48(a)). Alternatively, rural electric cooperatives can now issue Clean Renewable Energy Bonds (CREBs) as a substitute for tax credits (cooperatives are considered public utilities and are not eligible for renewable energy tax credit incentives). Potentially, CDOT could partner with a rural electric cooperative that could issue bonds for the project at an attractive interest rate.

In the future, Colorado legislation may also be passed to allow CDOT to develop alternative energy on property owned or controlled by CDOT. A similar program was established for Colorado State Parks through House Bill (HB) 10-1349 (June 8, 2010), which created the *Reenergize Colorado* program with the goal of generating, or off-setting, all of the division of parks and outdoor recreation's electrical energy consumption by using renewable energy sources on land owned, leased, or controlled by the division, by the year 2020. This law raises the cap on the allowable amount of renewable energy generated onsite (which includes all contiguous property owned or leased by the customer) from no more than 120 percent of the user's average annual electricity consumption at that site. Unless a similar provision is included in any legislation pertaining to CDOT, an undeveloped site currently consuming no electrical energy (such as most of CDOT ROW) would not be allowed to produce energy.

CHAPTER 15. RIGHT-OF-WAY FINDINGS AND RECOMMENDATIONS

Although CDOT maintains thousands of acres of ROW throughout the state, virtually none are currently used for the production of alternative energy. Yet, demand for electricity is rising at a rate of 2.5 percent per year in Colorado (SWEnergy, 2010), and recent national and state mandates are calling for increased use of renewable energy sources in the place of nonrenewables such as coal and natural gas. Findings of this analysis are as follows.

15.1 Findings

Solar – Based on the rates of solar insolation in various areas within Colorado and the existing ROW acreage in each insolation level, Colorado ROW receives almost 554,700 giga-watt hours per year (GWh/year. If 100 percent of this energy was converted to electricity it would meet ten percent of Colorado's total electricity demand based on year 2007 consumption rates (SWEnergy, 2010). However, based on an estimated net efficiency rate of ten percent, approximately 55,500 GWh/year could be produced from CDOT ROW. This energy production would meet approximately one percent of Colorado's 2007 electricity demand.

Wind – Although Colorado does have windy areas, relatively little usable CDOT ROW is located in those locations. Wind energy is still limited by technology, and large turbines require wide spacing and safety set-backs from the highway for safe and efficient operation. Total potential wind energy generation is highest in CDOT Region 1, 2 and 4, and all usable ROW would generate approximately 380 GWh/year statewide. This small amount of energy would meet approximately 0.0001 percent of Colorado's total electricity demand based on 2007 consumption rates.

Biomass – Most of the state is capable of producing some amount of biomass from wood, certain grasses, landfill methane, manure and crops including corn. One ton of dry biomass can produce approximately 1 MWh of electricity, and for the entire state an estimated 4,974 tons could be produced annually on CDOT ROW, generating approximately 5.0 GWh/year. This amount of energy would meet approximately 0.000001 percent of Colorado's total electricity demand based on 2007 consumption rates.

Geothermal – Research indicates that geothermal resources within Colorado are concentrated in the south central portion of the state. CDOT Regions 2, 3, and 5 have ROW within documented geothermal areas, while Regions 1, 4, and 6 do not have ROW in known geothermal areas. Statewide, approximately 8,530 acres of ROW are located in geothermal areas.

Opportunities for CDOT to use geothermal resources may include heating and cooling with heat pumps and the production of steam power. However, until more reliable data are available, or unless CDOT evaluates specific ROW sites in high-potential areas, the true potential of ROW for geothermal uses will remain largely unknown.

Hydropower **--** There are currently about 62 operating hydropower facilities in Colorado producing about five percent of Colorado's electric energy annually (NREL, 2005). Most hydropower plants are located in CDOT Regions 3, 4, 5, and 6.

Although detailed mapping is not available, it is unlikely that CDOT ROW contains any existing hydropower facilities and this study did not attempt to quantify usable acres of ROW. Rather, about a dozen potential sites that may be located within 1/2 mile of a CDOT roadway were identified. Such sites could provide electricity through a short transmission line to CDOT facilities such as rest areas, maintenance buildings and for roadway lighting or signals.

Transmission – Although Colorado has thousands of miles of transmission lines, there are large portions of the state with sparse coverage. Yet, these mostly rural areas can have significant potential for renewable energy production such as wind, solar and biomass. Without access to transmission lines, production of such energy may be cost prohibitive.

Several new major transmission lines through Colorado are proposed. The High Plains Express is a 500 kV system that is proposed to traverse eastern Colorado from north to south, crossing large areas undeveloped rural areas. The Eastern Plains Transmission Project would include about 1,000 miles of new high-voltage lines in eastern Colorado and western Kansas. These and other new transmission lines would fill gaps in transmission service and allow connection to a much larger grid from new alternative energy projects on CDOT ROW in rural eastern and central locations.

15.2 Recommendations

CDOT currently has some authority to produce alternative energy within ROW, but it is limited by state policy that does not recognize alternative energy sources as ‘utilities’ and does not set guidelines for managing energy production in ROW areas. And, as a not-for-profit agency, CDOT may not be able to sell surplus energy to a private market. While this study does estimate and quantify potential energy production, more detailed data would be needed to assist with decisions on changing CDOT policies. Recommendations include:

- Review other states’ policies with regard to alternative energy development, such as Oregon, Minnesota, Texas and California, to glean information on design standards, innovative partnerships, and funding mechanisms.
- Using the statewide and regional maps, CDOT Regions should develop their own maps and checklists to confirm the best sites based on additional criteria such as slope, aspect, tree coverage, vegetation types, etc.
- Revise the CDOT Utility Accommodation Policy to recognize alternative energy production as a form of ‘utility’ and to include design requirements such as set-backs, minimum site densities, height limits, etc. for alternative energy production. Also, revisit the prohibition on the use of medians for longitudinal utilities, particularly on wide medians in rural areas.
- Continue to build partnerships with private entities such as private utilities, banks and private energy developers to act as future partners for claiming state or federal tax credits, thereby reducing net costs to CDOT.
- Work with the Colorado Public Utility Commission (PUC) and other state agencies to promote best practices and standards for transmission line siting and interconnections to existing lines adjacent to CDOT ROW.
- Consider one or more ‘pilot programs’ to situate alternative energy on CDOT buildings or sites such as rest areas and monitor the produced energy and net reduction in carbon

footprint. Involve the public by encouraging public viewing of the pilot program sites and include live monitoring data on the CDOT website.

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Appendix A Colorado Department of Transportation Rest Areas

Route	Milepost	Location	Restroom	Picnic Area	Handicap Access	Trailer Dump	Visitor Info	Trailhead Access	River Access	Point of Interest
US 40	101	Hayden (Seasonal)	✓	✓	✓					
US 50	388.69	Hadley (E of La Junta)	✓	✓	✓	✓				✓
US 50	467.39	Holly	✓	✓	✓	✓				✓
SH 139	55.9	Rangely (Maintained by Bureau of Land Mgmt.)	✓	✓	✓					
US 160	46.42	Cortez (6 mi East)	✓	✓	✓					
US 160	191.39	Shaw Creek	✓	✓	✓		✓			
US 287	55.20	Gobblers Knob (no running water)	✓							✓
US 287	383.5	Virginia Dale (Closed May-August)	✓	✓						✓
US 287	407.8	Hugo Rest area is closed 9/7/10 - 11/5/10 due to construction.	✓	✓						
SH 340	0.3	Fruita Welcome Center	✓	✓	✓	✓	✓			✓
I-25	17.72	El Morro	✓	✓	✓					✓
I-25	74.39	Cuerno Verde-Colorado City	✓	✓	✓		✓			✓
I-25	111.69	Pueblo (Southbound)	✓	✓	✓					
I-25	114.99	Pueblo (Northbound)	✓	✓	✓					
I-25	268	Poudre Rest Area (New)	✓	✓	✓		✓			✓
I-70	90	Rifle	✓	✓	✓	✓	✓			
I-70	114.92	West Glenwood Springs	✓	✓	✓					

http://www.coloradodot.info/travel/state-highway-rest-areas 10/30/2010

Appendix A continued

Route	Milepost	Location	Restroom	Picnic Area	Handicap Access	Trailer Dump	Visitor Info	Trailhead Access	River Access	Point of Interest
I-70	118.64	No Name, Glenwood Canyon	✓	✓	✓			✓	✓	✓
I-70	121.02	Grizzly Creek, Glenwood Canyon	✓	✓	✓			✓	✓	✓
I-70	125.13	Hanging Lake, Glenwood Canyon	✓	✓	✓			✓	✓	✓
I-70	128.5	Bair Ranch, Glenwood Canyon	✓	✓	✓			✓	✓	
I-70	160.00	Edwards	✓	✓	✓	✓				
I-70	190	Vail Pass Rest Area	✓	✓	✓			✓		
I-70	226.51	Georgetown Overlook Pull-Out								✓
I-70	254	Genessee Buffalo Herd Pull-Out								✓
I-70	306.85	Bennett	✓	✓	✓					
I-70	332.01	Deer Trail	✓	✓	✓					
I-70	383.3	Arriba	✓	✓	✓	✓				
I-70	437.6	Burlington	✓	✓	✓	✓	✓			✓
I-76	180.5	Julesburg	✓	✓	✓	✓	✓			✓
I-76	125	Sterling	✓	✓	✓	✓	✓	✓	✓	✓
I-76	66	Wiggins	✓	✓	✓					

Colorado **Rest Areas** & Welcome Centers. State Highway **Rest Areas.**
http://www.coloradodot.info/travel/state-highway-rest-areas

Appendix B Sustainable Rest Area Field Evaluation Checklist

	Date	
	Rest Area Name/Location/CDOT Region	
	Location	
	CDOT Region	
	Type of Rest Area (visitor, recreation, basic)	
	Location (Highway/mile marker)	
	CDOT Maintenance Representative(s)	
	CDOT Contact Phone Number/email	
	Evaluation Team Members	
√	**Rest Area Evaluation Information**	**Remarks/Observations**
	Site Conditions	
	Overall Rest Area (acres)	
	Rest Area Building (sq ft)	
	Distance from maintenance facility (miles)	
	Is a Rest Area Site Map available	
	Rest area construction/retrofit year	
	Operational hours	
	Rest Area Maintenance Visits by CDOT Frequency/Schedule	
	Site Visitation Data (cars and trucks)	
	Area located on USFS or other agency land	
	Onsite Compost Area for grass/other organic waste	
	Winter maintenance (operations/maintenance actions)	
	Winter maintenance materials (deicing/sand)	
	Winter maintenance equipment/type	
	Area sweeping schedule	
	Use of recycled asphalt for pavement repairs	
	Type of local wildlife	
	Pervious/Impervious Area	
	Parking lot area/spaces-cars and trucks	
	Vending machines (glass/plastic/metal)	
	Materials and Reuse/Recycling	
	Solid Waste (trash) Disposal and Storage Locations	
	Solid Waste Disposal/Removal Frequency and Volume	
	CDOT recycling of solid waste (metal, glass, plastic)	
	Local municipality have waste recycling program	
	Solid Waste Landfill location/distance	

	Recycled or reused materials used at rest area	
	Restroom cleaning frequency	
	Onsite waste separation recycling for motorists/truckers (metal, glass, plastic)	
	Roofing material (metal, shingle)	
	Hand paper towels or hot air blower	
	Environment	
	Mowing procedures (special mowing height, locations)	
	Mowing Area and Frequency	
	Noxious Weed Management	
	Fertilizer Applications	
	Depth to groundwater	
	Wildlife Structures or habitat improvements (bird houses, etc.)	
	Natural grass/vegetation and area	
	Bluegrass (non-natural) vegetation and area	
	Disturbed areas without vegetation	
	Proximity to sensitive areas (surface water/wetlands)	
	Biome type (montane, grassland, desert, etc.)	
	Open area for potential tree planting	
	Open area for solar potential	
	Estimated Percent vegetative cover	
	Number of trees at rest area	
	Open area for potential wind system	
	Air Quality	
	Low VOC and biodegradable-green chemicals used onsite	
	Low VOC paints used at rest area	
	Number/average of idling trucks at night	
	Chemicals used onsite; see MSDS sheets	
	Charcoal grills	
	Smoking not allowed in rest area	
	Cigarette butt disposal in rest area	
	Water Quality/Usage	
	Water Source (onsite or offsite)	
	If off site source is water treated	
	Well water tested for drinking? When?	
	Location and depth of well (if present)	
	Water used for irrigation (gallons)	
	Irrigation type (drip/spray)	
	Irrigation frequency	
	Gallons per flush settings	
	Water-saving faucets/toilets	
	Gallons per urinal flush	
	Waste treatment system type (lagoon/septic field/septic tanks)	
	Energy for waste treatment system (gravity/electrical pumps)	

	Motorist waste disposal system (RVs)	
	Motorist Waste Disposal maintenance frequency (solids pump out)	
	Bio-solids disposal frequency, location and distance	
	# water spigots for motorists use	
	# drinking fountains	
	# urinals/toilets/sinks-men	
	# toilets/sinks-women	
	Landscaping type (xeriscape, lawn, natural)	
	Stormwater best management practices	
	Water harvesting potential	
	Energy	
	Lighting system in parking lot (LED/sodium vapor)	
	Natural lighting/skylights in restroom structure	
	Natural gas/propane usage and cost	
	Electrical usage and cost	
	Heating system type (gas/electric/propane)	
	Gasoline consumption mowing (gallons per month)	
	Gasoline consumption for maintenance transportation to site for maintenance activities	
	Heat pump (groundwater) used for heating/cooling	
	Window type(s)-single or double pane	
	Total energy usage information obtained	
	Lighting system in restroom and building area (compact fluorescent, fluorescent, other)	
	Motion detectors in restrooms for lighting	
	Number of light poles	
	Air conditioning in restroom area	
	Passive or direct solar panels (electrical, hot water)	
	Natural ventilation and fans	
	Public/Motorist/Trucking	
	Local community involvement	
	Overall appearance of rest area	
	Pet waste management	
	Security Cameras	
	Dog run area and waste management signage/bags	
	No solid waste dumping signs	
	Colorado Promotional/Informational signage	
	Site Aesthetics to local context	
	Local community information	
	Emergency phone	
	Computer-kiosk Information to traveling public	
	General Notes	

Appendix C Sustainable Rest Area Database Spreadsheet

Rest Area Evaluation Information	Sleeping Ute Mtn. (Cortez)	El Moro	Poudre	Hanging Lake	Vail Pass	Sterling
Inspection Dates	7/9/2010	8/6/2010	8/19/2010	7/16/2010	7/15/2010	8/25/2020
Rest Area Type (basic, recreational, visitor center)	basic	basic (truck stop)	Visitor Center	Recreational	Recreational	Visitor Center
CSU-Team Owner	Kim Schott	Kim Schott	Kim Schott	Ayman Hama	Ayman Hama	Ayman Hama
Address	5910 Highway 160, Cortez, CO 81321	16051 CR 71, Trinidad, CO 81089	1751 SW Frontage Road Fort Collins, CO 80524	MP 126.13 Interstate I-70, Glenwood Springs, CO 81610	MP 189 Interstate 70/0157 Shrine Pass, Copper Mountain CO 890443	12510 CR 370, Sterling, CO 80751
Latitude/Longitude	37.29918286/-108.6183929	37.22594601/-104.4949687	40.56436726/-105.0055325	39.59001401/-107.1905994	39.5276337/-106.218068	40.62110284/-103.1807613
Site Conditions						
Level of Service Rating	C	C	C	C	C	C
Site map or plot obtained from CDOT	yes	yes	aerial	aerial	aerial	aerial
Overall Rest Area (acres)	10.4	7.1 (5 of 7.1 is mowed)	16	4	7.1	7
Rest Area Building (sq ft)	1245	2400	2500 building /900 shed	2296	5,400	3900
Distance from maintenance facility (miles)	0	16 (aquilar)	12	9	13	2
Rest Area Construction Year (year)	org. 1970 retrofit 1998	2000	2007	1993	1980	2000
Operational hours/full season	24/7-full season	24/7-full season	24/7-full season	7-3:30; 7 day a week-ful season	24/7-full season	24/7-full season
Pervious/Impervious Area (acres)	8.3/2,1	5.0/2.1	6.4/9.6	2.5/1.5	3.6/3.5	4.0/3.0
CDOT Maintenance Frequency (daily/weekly)	daily -1 full time	daily -1 full time	daily -1 full time	daily -1 full time	daily -1 full time	2 full time/8hrs
Site Visitation Data (cars/trucks)	15 cars/7-20trucks daily	140,000 vehicles total yearly	20cars/20-30trucks	No Trucks, Yes RV, Cars	234,600 commercial vehicles	No data
Site Visitation Data (people per year)	65,700	328,500	121,711	72,049	680,000	300,600
Compost Area for Grass/other organic waste (Yes/No)	no	no	no	no	no	no
# Parking lot area/spaces-cars	37	39	46	72	73	47
# Parkling lot area for trucks	3	14	23	None	7	24
Winter maintenance materials (sand) (Yes/No)	yes	no	yes	No	Yes	Yes
Winter maintenance materials (deicing chemicals) (Yes/No)	yes, 80-150lbs Calcium Chloride	yes	yes, sometimes	Calcium Chloride on side walks	yes	Rock Salt
Winter maintenance equipment/type	atv with blade and truck with blade	John Deere 4200 (with snowblower attachment)	mid-range plow b-box sander & JD tractor	Snow plow + Snow blower	Plows/Snowblows	Plow+blower
Area sweeping schedule (days per month)	as needed	4 use backpacker air blower	2 sweeps a year	2-3/day	24 hr/month	As Needed 3-4/yr
Materials and Reuse/Recycling						
Solid Waste Disposal Collection Frequency per Week	1 time per week by contractor pick up	2 times per day to CDOT to maintanance facility	1 time per week by contactor	7- daily to CDOT maintenance facility	7- daily to CDOT maintenance facility	one/week, Summer 2/week
Solid Waste Volumes to Landfill Location (yards per week)	3	3	5	4	35	4-5 Yards
Volume of material recycled from rest area (Yards per week)	0	0	0	0	0	2 estimated
On site recycling separation for motorists/truckers (Yes/No)	no	no	no	No	No	Yes
Local recycling operations available (Yes/No)	yes-Cortez (ECOtrez)	sometimes-Trinidad (only 4 times a year)	yes, Fort Collins	yes, Glenwood Springs	yes, Vail	Yes- Sterling Prison
Local Recyling Materials (glass, aluminum, plastic, etc)	glass, fibers, aluminum	glass, fibers, aluminum	glass, tin, aluminum, fibers, tin, plastics	glass, plastics, fibers, aluminum cans	glass, plastics, fibers, aluminum cans	Alum, Plastic, no glass- taken to state prison
Roofing material (metal, shingle)	sheetmetal	copper	rock asphalt	Metal	Metal	Metal
Wintertime energy conservation (windows, insulation, stripping)	doublepane windows	doublepane windows	doublepane windows	Double Pane	Triple and double windows	Double
Recycled/Reused materials used at rest area (Yes/No)	no	no	Yes	No	No	Yes
Hand paper towels or hot air blower	World Dryer (hot air blower)	hot air blower	energy efficient hot air blowers	Air blower	hot air	air and paper

Rest Area Evaluation Information	Sleeping Ute Mtn. (Cortez)	El Moro	Poudre	Hanging Lake	Vail Pass	Sterling
Rest room cleaning frequency (number per week)	(14-21); 2-3 times daily for 2-3 hours	14 times; 1.5 hrs each time	21 by contractor	7	14	28
Environment						
Mowing to promote wildlife and vegetation (Yes/No)	no	no	yes	yes	no	no
Proximity to sensitive areas (surface water/wetlands) >50 feet (Yes/No)	none present	none present	none present	yes-Colorado River	Yes-Ten Mile Creek	none present
Biome type (montane, grassland, desert, etc)	juniper/pinon forest -- high desert	pinon juniper forest	Grassland/plains	Montane-Canyon	Montane/Treeline	Grassland/plains
Mowing Frequency (times per week-growing season)	1	1	1	1	2/week weed eating Only	1 or 2
Grass native or tuff	blue grass <900 sq ft and natural	blue grass	blue grass and native buffalo grasses	blue grass	Native	Buffalo grass
Mulch Mowers used for lawn mowing (Yes/No)	yes	yes	no	yes	No mowing	no
Disturbed areas without vegetation (acres)	none present	none present	none present	none present	none present	none present
Herbicides/Pesticides Used On Site (Yes/No)	yes	yes	yes	yes	yes	yes
Fertilizer Applications (Yes/No)	yes	yes	Yes	Weed + Feed	No	Yes
Open area for potential tree planting/carbon offset (Yes/No)	no, only juniper and pinon grow	yes	yes	no	Yes but difficult at altitude	Yes
Colors/shading to reduce heat island effect (Yes/No)	no	no	no	No	No	No
Open area for solar potential (Yes/No)	yes	yes	yes	No	Yes	Yes
Wildlife Structures (bird houses, etc) (Yes/No)	yes, bird feeders	no	no	no	no	no
Percent area covered by vegetation (estimate percentage)	80% sparse vegetation native and non-native	70% lawns and native	40% native and lawn	70% lawns and native	70% lawns and native	50%/lawns
Landscaping (xeriscape/native/non-native/high water demanding)	dominant non-native and native	dominant non-native (lawn) & native	non-native dominant and native	both native and non-native	Native dominant	Non navtive domiant and native
Number of trees in rest area	820 juniper/pinon trees	119 total (Pinion Pine 107, Cottonwood 4, Dwarf Alberta Spruce 8	38 (Hacberry, Kentucky Coffetree, English oak, English Burroak, Patrnoc Ash, Shade Master Honeylocust, Skyline Ash Burr Oak, Chinkopin Oak)	50	0-above tree line	83
Acres of vegetation in rest area	8	5	9	3	3.6	1.5
Air Quality						
Low VOC paint and adhesives used on site	No	No	No	No	No	No
Green/Biodegradable chemicals used onsite	yes, "green"	no	no	Yes	No-Pinesol/Windex/Lysol	No
Chemicals are phosphorous free	yes	yes	yes	yes	yes	yes
Number/average of idling trucks at site visit >4 hours per day	none but some present during the night	14	15	NA	4	18
Smoking allowed in rest room area (Yes/No)	No	no	no	No	No	No
Water Quality/Usage						
Water Source (well/municipal /surface water)	Municipal	Municipal	Municipal	Well	Surface Water	Municipal
Number of wells	0	0	0	2	0	0
Existing stormwater best management practices	No	retention and detention ponds	retention areas	No	None	All water collected for irrigation
Irrigation type (drip/spray)	spray	spray=grass drip=trees & planters	drip (flower beds & trees) spray (grass)	spray	NA	drip & spray
Irrigation frequency (time/week)	3.5	starts @ 7pm/ 7 days a week	3; 2am-6am	3.5	None	3
Volume of water used for irrigation (gallons/month)	No Data	No Data	No Data	135,600 gal/month	no data	860,533
# water spygots for motorists use	0	0	0	0	1	2
# drinking fountains	2	2	2	2	1	1
# sinks-men	2	4	3	3	3	4
# urinals-men	2	3	3	3	3	7

Rest Area Evaluation Information	Sleeping Ute Mtn. (Cortez)	El Moro	Poudre	Hanging Lake	Vail Pass	Sterling
# toilets for men	2	5	5	3	3	4
# toilets-women	4	8	8	5	6	4
# sinks-women	2	4	3	3	6	4
Volume of water for urinal flushing (gallons)	0.5	1	0.5	1.6/10 min-auto flush	1.6	0.5
Volume of water for toilet flushing (gallons)	2	1.6	2.5	1.6	1.6	1
urinals water saving via motion sensors (Yes/No)	yes	no	yes	no-autoflush	No	Yes
water saving faucets (Yes/No)	yes	yes, have sensors	yes, motion activated	Yes	Yes	Yes
Waste treatment system type (lagoon/septic field/septic	On site spetic field	Municipal	Municipal	Pack Bed Recirculation Filter	Sequencing Batch Reactror	Municipal
Electrical energy used for waste treatment (Kwhrs/year)	NA	NA	NA	NA	268,290	NA
Total volume of water purchased (Annual average)	41682	39,554	1,200,000	NA	NA	10,326,400
Total water purchasing cost (Annual Average)	$1,244.64	$767.90	$2,460.00	NA	NA	$14,814.00
Total volume of water for water treatment (Annual Average)	n/a	No data	1726	19,000	No Data	No Data
Total water treatment costs (Annual Average)	n/a	$886.56	No Data	NA	NA	$510.00
Motorist RV septic waste disposal volume (Yes/No)	no	no	no	No	No	Yes and to municpal treatment
Solid septic disposal facility location (miles)	n/a	n/a	NA	9	26	NA
Maintenance frequency (bio-solids pump out)	No Data	NA	NA	Every fall	Every 3-4 months or as needed	NA
Energy						
Lighting system in parking lot (LED/sodium vapor)	sodium vapor	sodium/ mercury vapor	Sodium	Sodium Vapor	Soduim	Sodium
Lighting system in rest room area (compact fluorescent, fluorescent, other)	fluorescent--T8	fluorescent	fluorescent	both	Fluorecent	Fluorescent
Motion detectors to initiate lighting in rest rooms (Yes/No)	yes	no	no, lights on all the time	No	No	No
Natural lighting/skylights (Yes/No)	yes, large windows	yes (lobby and womens bathroom)	yes	Yes	Yes	Yes main lobby
Air conditioning (Yes/No)	no	no	yes	No	No	yes in visitor center and none in main rest room areas- doors open in visitor center
Heating system type (gas/electric/propane)	propane	gas	gas	Electric	Electric	Gas
Heat Pump System (yes/no)	No	No	No	No	No	No
Passive or direct solar panels (electrical, hot water)	none	no	no	No	No	No
Certified Energy Saving Hand dryers (Yes/No)	no	no	no	No	No	NO
Truck Electrification Available (yes/no)	No	No	No	No	No	No
Natural ventilation and fans (Yes/No)	yes	yes	No	yes	yes	yes
Total Propane gas usage per year (gallons)	1805.5	n/a	NA	NA	NA	NA
Total Propane gas cost per year	$3,540	n/a	NA	NA	NA	NA
Total Natural gas usage per year (therms)	n/a	5307	1350	NA	NA	7949
Total Natural Gas Cost per year-data from vendor	n/a	$4,454.00	$1,029.00	NA	NA	$6,570.00
Total Electrical usage per year-data from vendor (KWHr)	57948	2527	144000	154,818	268,290	126,530
Total Electrical cost per year	$5,400.00	$511.00	$15,480.00	$11,235.00	$19,158.00	$9,201.00
Total Gasoline consumption (mowing) per year	21.67 gal. gas	64.9 gal. gas	32.49 gal. gas and 32.49 gal. diesel	10 gal	107	30/yr
Total Gasoline consumption maintenance transportation per year	814.81 gal. diesel	1153.85 gal. diesel	750 gal. diesel	1144 gal	1054	50
Total Gasoline Consumption per year	21.67 gas / 814.81 gal. diesel	64.9 gal. gas and 1153.85 gal. diesel	32.49 gal. gas and 752.49 gal. diesel	1154	1204	92
Scope 1 Carbon Footprint (operations)- tons #-CO2 eq / year)	22.945	59.351	15.154	10.27	10.72	44.000
Scope 2 Carbon Footprint (electrical consumption) tons #-CO2 eq / year)	49.74	2.169	123.61	132.897	230.303	108.615
Scope 3 Carbon Footprint (idling) tons #-CO2 eq / year)	0	2219.3	2377.82	0	645.35	28536
Total Carbon Footprint (tons #-CO2 eq / year)	73	2281	2517	143	886	3006

Appendix C
Sustainable Rest Area Database Spreadsheet

Rest Area Evaluation Information	Sleeping Ute Mtn. (Cortez)	El Moro	Poudre	Hanging Lake	Vail Pass	Sterling
Public/Motorist/Trucking						
No dumping signs (Yes/No)	yes	no	on dumpster	No	Yes	Yes
Colorado Promotional/Informational signage (Yes/No)	yes	yes	yes	Yes	Yes	Yes
Overall appearance of rest area	very good	very good	very good	Very Good	Very Good	Very Good
Dog run area (Yes/No)	yes	yes	yes	Yes	Yes	Yes-fenced area
Pet waste management (Yes/No)	yes	no	yes	Yes	Yes	Yes
Local community information (Yes/No)	yes	yes	yes	Yes	Yes	Yes
Preferential parking for alternative fuel cars	no	no	no	No	No	No
Context Design to area-community (Yes/No)	yes	yes	yes	Yes	Yes	Yes
Computer Kiosk	No	No	No	No	No	Yes
Local Community Engagement support	No	No	Yes	No	No	Yes
Security Camera (Yes/No)	yes	No- not working	no	Yes	Yes	No
Emergency Phone and Number	none	no but pay phone	no--pay phone	No	yes	Yes
Total Sutainability Score (From Scoring Sheet)	35	32	33	31	37	30

Appendix D Sustainability Rest Area Scoring Sheet

	Total	Poudre	Sterling	Sleeping Ute	El Moro	Hanging Lake	Vail	**Rationale**
Rest Area Evaluation Information	**Potential Points**	**Evaluation Points**	**Evaluation Points**	**Evaluation Points**	**Evaluation Points**	**Evaluatio n Points**	**Evaluation Points**	
Materials and Reuse/Recycling								
Public solid waste recycling (glass, plastic, aluminum) available	3	0	3	0	0	0	0	Reduces material that would go to the land fill; reduces landfilling and transportation costs; reduces ghg emissions by reduced transportation; promotes use of recycled material instead of virgin materials; potential financial benefit towards collecting and recycling aluminum.
Rest area generated building waste is recycled/reused by CDOT Maintenance and used at other locations	2	0	0	0	0	0	0	Reduces material that would go to the land fill; reduces landfilling and transportation costs; reduces ghg emissions by reduced transportation; promotes use of recycled material instead of virgin materials
Reused or recycled pavement and/or construction materials used by CDOT Maintenance at rest areas (asphalt, guardrail, wood, metal sheeting, etc.)	2	2	2	2	2	0	0	Material needs for rest areas are first checked at the Maintenance area to identify if being stored. Reduces material that would go to the land fill; reduces landfilling and transportation costs; reduces ghg emissions by reduced transportation; promotes use of recycled material instead of virgin materials this is consistent with the State of Colorado Environmentally Preferable Purchasing Policy (2009)
Signage to promote no littering/trash dumping or solid waste disposal at rest area	1	1	1	1	1	1	1	Public awareness may reduce the amount of solid waste for CDOT to manage thus reducing landfilling and transportation costs

Rest area/CDOT Maintenance has a policy or practice to use new source materials that come from certified sustainable practices	2	0	0	0	0	0	0	Certified materials are grown and manufactured using sustainable practices that have less impact on the environment and normal commercially grown materials; this is consistent with the State of Colorado Environmentally Preferable Purchasing Policy (2009)
Rest area uses mulching mowers to reduce grass collection and landfilling	2	0	0	2	2	0	0	Reduces material that would go to the land fill; reduces landfilling and transportation costs; reduces ghg emissions by reduced transportation
Approaches taken to reduce heat island effect (roofing, pavement, use of trees)	1	0	0	0	0	0	0	Materials with high albeto will reflect light and prevent infrared wavelengths from being absorbed thus reducing localized heating. Use of vegetative shading, reflective paint or roofing materials will help reduce localize temperatures
Total Materials and Reuse Score	**13**	**3**	**6**	**5**	**5**	**1**	**1**	
Environment/Site Conditions								
Maintenance actions/designs supportive of local wildlife habitat, movement and migration	2	2	0	2	0	2	2	Maintenance operations such as mowing and landscaping can impact local wildlife; operations can be performed that aid in maintaining or improving local wildlife. Fencing can be wooden posts to allow for wildlife movement is not restricted by using barbed or cage wire.
Noise reduction practices within rest area or rest area designed or located to reduce highway noise to visitors	1	1	0	1	0	0	0	Noise from idling trucks or highway traffic can be disruptive and signage is encouraged. Rest areas could take advantage of trees to block highway noise.
At least 50 feet of protection given to sensitive areas (surface water/wetlands) via buffers, fencing, non-assessable areas or other means	3	3	0	0	3	3	3	Protection to sensitive areas reduces direct impacts from motorists using the rest area and from maintenance representatives. 50 feet is a normal distance to protect sensitive areas such as requirements established in the CDOT Erosion Control Plan and SWMP requirements

Less than 25% of total rest area is routinely mowed	2	0	0	2	0	0	2	Native grasses being allowed to grow without routine mowing helps establish and promote grass propagation and establishment especially in steep slope areas and reduces the gasoline and labor costs for mowing.
Majority of rest area's vegetated area is (> 75%) dominated by native grass, shrubs and trees	2	0	0	2	0	2	2	Native plants require less water and maintenance than non-native species which conserves a finite resource.
No irrigation or xeriscape landscaping used to minimize water irrigation	3	0	0	0	0	0	3	Xeriscaping eliminates the amount of water necessary for landscaping; use of drought tolerant plants such as buffalo grass and rock/stone material reduces water consumption.
Drip irrigation used for non-native landscape vegetation	2	2	2	0	2	0	0	Drip irrigation reduces the amount of evaporation as opposed to spray or sprinkling irrigation techniques
Irrigation occurs in the evening hours to reduce evaporation as opposed to mid-day irrigation	1	1	1	1	1	1	0	Reduced evaporation conserves water resources
Erosion control best management practices (BMPs) used on disturbed non-vegetated to promote vegetative growth and ground cover	1	0	0	0	1	0	0	Erosion control BMPs will reduce sediment loading offsite and protect receiving streams.
Chemicals that are applied to control weeds are least toxic and environmentally biodegradable if possible	2	0	0	0	0	0	0	Herbicides are toxic to the public and the overall environment. Mechanical methods are an alternative to chemical control methods. Herbicides are toxic to the public and the overall environment. Mechanical methods are an alternative to chemical control methods. This is consistent with the State of Colorado Environmentally Preferable Purchasing Policy (2009)

Noxious weeds are controlled through prevention and physical, mechanical and biological controls; if chemicals are used they applied by using spot spraying	2	0	2	2	0	0	0	Herbicides are toxic to the public and the overall environment. Mechanical methods are an alternative to chemical control methods; this is consistent with the State of Colorado Environmentally Preferable Purchasing Policy (2009)
No fertilizer applications to promote grass growth	2	0	0	0	0	0	2	Fertilizers promote vegetation growth that requires additional mowing and water usage. Fertilizers are manufactured from fossil fuels that contribute to greenhouse gas emissions. Fertilizers should only be used on areas trying to establish vegetation and not to make the lawn green.
All surfactants or detergents do not contain phosphates or other agents known to result in water quality degradation	2	0	0	0	0	2	0	Nutrients such as phosphates is a major pollutant that affects water quality nationwide. Phosphates can cause acceleration of algae growth and result in oxygen depletion in streams and lakes/reservoirs; this is consistent with the State of Colorado Environmentally Preferable Purchasing Policy (2009)
Total Environment/Site Conditions	**25**	**9**	**5**	**10**	**7**	**10**	**14**	
Air Quality								
Low Volatile Organic Carbon (VOC) materials are used for paints, adhesives and other chemicals used onsite	3	0	0	0	0	0	0	Green products should be used for cleaning and painting activities that do not release toxic chemicals into the air.; this is consistent with the State of Colorado Environmentally Preferable Purchasing Policy (2009)

Idling Restriction Signage at rest areas for trucks	2	0	0	0	0	0	0	Idling trucks emit unnecessary greenhouse gases into the atmosphere for long periods of time by trucking professionals. Idling trucks can discharge particulates in the air and can be noisy to the motoring public. Diesel engines must idle down after being worked at highway speeds.
No charcoal grills at rest area and/or alternatives to charcoals grills provided to public	1	1	1	1	1	1	1	Charcoal grills contribute to greenhouse gas emissions using charcoal and lighting fluids
Electrification provided for trucks	3	0	0	0	0	0	0	Electrification for trucks eliminate long idling times and reduce greenhouse gas emissions and noise
Smoking prohibited in restroom area with signage	1	1	1	1	1	1	1	Secondhand smoke is a health and odor problem that can be eliminate by signage and butt disposal
CDOT Maintenance plan or written operating procedures identifies rest area practices to minimize fuel consumption	3	0	0	0	0	0	0	Fuel conservation reduces the amount of greenhouse gas emissions by CDOT vehicles used to maintain rest area. Standard operating procedures or written guidance provides employees a basis for to develop and/or adhere to a fuel conservation plan. This approach is consistent with Governor Ritter's Executive Order to reduce fuel consumption by 20%.
Total Air Quality	**13**	**2**	**2**	**2**	**2**	**2**	**2**	
Water Quality/Usage								
Potable water from onsite well or surface water	1	0	0	0	0	1	1	Reduces electrical costs for pumping on distances and is cheaper to obtain for onsite use
Stormwater BMPs being implemented and maintained at rest area	2	2	2	0	2	0	0	Rest areas contain impervious surface that can transport trash and sediment to receiving streams. Sediment loading into surface water is the number one water pollution problem in Colorado and the US

Waterless urinals being used in men restroom	2	0	0	0	0	0	0	Waterless urinals can save significant amounts of water be consumed at rest areas
Reduced volume/flush toilets used in restroom areas (1 gallon or less)	2	0	2	0	0	0	0	Significant amounts of water can be saved by using low flush toilets
Reduced volume/flush urinals used in restroom areas (0.5 gallon or less)	2	2	2	2	0	0	0	Significant amounts of water can be saved by using low urinals toilets
Signage to conserve water in restroom areas	1	0	0	0	0	0	0	Public awareness important in helping conserve water at rest areas
Water conservation studies performed to reduce water consumption and treatment	2	0	0	0	0	1	1	Water conservation can reduce electrical costs for pumping and onsite treatment or cost associated with domestic water purchasing and treatment
Water-saving faucets at restroom area	1	1	1	1	1	1	1	Spring loaded, motion initiated/timed faucets can save significant amounts of water at rest areas
Solids from lagoon/septic system recycled as compost by municipality or contractor	2	0	0	0	0	0	2	Reuse/recycling of waste via a municipality that creates compost from sludge reduces landfilling costs and impacts
Innovative waste management technologies used at rest area to reduce water and energy consumption and water discharge.	3	0	0	0	0	0	0	Waste treatment costs are significant in terms of labor, chemicals and electricity. Closed loop treatment systems would generate gray water or methane based energy from wastewater treatment could reduce energy costs.
Impervious area minimized by using porous pavement in car traffic area	3	0	0	0	0	0	0	Porous pavement is an innovative BMP that promotes infiltration of stormwater into underlying soil.
Total Water Quality/Usage	**21**	**5**	**7**	**3**	**3**	**3**	**5**	
Energy								

Lighting system in parking lot area uses energy conservation techniques to reduce lighting and energy consumption	2	0	0	0	0	0	0	Energy conservation can save rest area operational costs and reduce the demand for electricity thus indirectly reduce greenhouse gas emissions
Energy-efficient lighting system (Compact Fluorescent Bulb or other) used in restroom areas	2	2	0	0	2	2	0	Energy conservation can save rest area operational costs and reduce the demand for electricity thus indirectly reduce greenhouse gas emissions
Lighting shut off in restrooms and parking areas during daylight hours as a result of natural lighting	1	1	0	0	1	0	0	Energy conservation can save rest area operational costs and reduce the demand for electricity thus indirectly reduce greenhouse gas emissions
Motion detectors used in restrooms to initiate lighting at night	2	0	0	2	0	0	0	Energy conservation can save rest area operational costs and reduce the demand for electricity thus indirectly reduce greenhouse gas emissions
Natural ventilation for cooling (vents, fans, open windows, etc.) is used in lieu of air conditioning to reduce energy consumption	2	0	0	2	2	2	2	Air conditioning requires a high amount of electrical energy in rest areas where people only benefit from it for a short amount of time. Natural ventilation and shading can reduce energy costs while reducing energy demand. Signage about this approach for public education and outreach will help increase understanding.
Heat pump or alternative approaches are used onsite for heating/cooling using ambient groundwater or below grade soil temperatures (semi-buried buildings)	3	0	0	0	0	0	0	Heat pumps using groundwater or buildings built within or earth covered can increase the baseline temperature conditions making it more energy-efficient to heat or cool.
Energy conservation methods area being used at the rest area to reduce heat loss (ex. windows are at least double paned and glazed, weather stripping, etc.)	3	3	0	3	3	3	0	Most rest areas open all year and winterizing them can save energy costs to CDOT
Lighting cut off fixtures used to control light pollution	1	1	1	0	1	1	1	Lighting is direct and focused downward that reduces light dispersion and maintain a dark skies environment
Solar powered emergency phones	1	0	0	0	0	0	1	Energy-efficient phone system for public safety

Solar based hot water system onsite	2	0	0	0	0	0	0	Cost-effective way to heat hot water at rest area for restrooms
EPA Energy Star certification or equivalent hand dryer blowers are used at rest area to reduce energy consumption	3	0	0	0	0	0	0	Certified energy-efficient hand driers are available to reduce energy cost for rest areas. Hand driers are a commonly used electrical device use by most visitors; this is consistent with the State of Colorado Environmentally Preferred Purchasing Policy
Solar or wind based alternative energy used onsite to power rest area	3	0	0	0	0	0	0	Alternative energy will reduce long term energy costs and promote positive environmental image of Colorado; consistent with Governor Ritter's vision for Colorado
Vehicles used to maintain the rest area use alternative fuels such as bio-diesel, natural gas or electricity	3	0	3	0	0	0	0	Use of alternative fuels reduce the use of greenhouse gas emissions from fossil fuels and is consistent with Governor Ritter Executive Order and the State of Colorado Environmentally Preferable Purchasing Policy (2009)
Rest area uses hand blowers instead of paper towels to reduce solid waste volume and promote energy efficiency	2	0	2	2	2	2	2	Energy-efficient hand dryers reduce energy costs and reduce the amount of paper needing to be managed and ultimately landfilled.
Beverage vending machines located inside rest area building	1	0	0	0	0	0	1	Keeping the vending machine inside will reduce the electrical consumption as oppose to keeping it outside exposed to the high summertime temperatures
Total Energy	**30**	**7**	**6**	**9**	**11**	**10**	**6**	
Public/Motorist/Trucking Outreach								Community and social impact and benefit is part of sustainability definition (environment, economic and society)

Colorado sustainability and/or environmental protection signage at rest area	1	0	0	0	0	0	0	Educating the public is important in rest area energy and resource conservation. Education will make the public more accepting of energy and cost savings approaches that could extend into their ways of life
Context Sensitive Design used for rest area that reflects local community or area culture	2	2	2	2	2	2	2	The rest area design and function is consistent with the local or regional area; promotes Colorado as a progressive state with unique resources
Dog run area available with collection bags/disposal method signage	1	1	1	1	1	1	1	Dog rest areas with proper management are important to the traveling public and helps maintenance representatives in dog material collection and management. Encourage public to pick up after their pet.
Preferential parking has been designated for alternative fuel cars	1	0	0	0	0	0	0	Innovative approach in supporting hybrid or alternative fuel cars; not at the expense of handicap parking
Local community or groups provide local and educational information and support to the rest area	1	1	1	1	1	0	0	Helps educate motoring public and help advertise local communities or businesses
Informational computer kiosks for truckers and motorists	2	2	0	0	0	0	0	Informational kiosks provide road conditions, weather and directions for traveling public and truckers; local businesses and resources is a plus to the public
Security cameras onsite to monitor for illegal activities and provide public safety	2	0	0	2	0	2	2	Security cameras are important in motorist safety and reduces the dumping of hazardous materials into dumpsters
Signage about proper cigarette smoking and butt disposal management to reduce potential for fire	1	1	0	0	0	0	0	Cigarette butts and one of the major trash items in a rest area; smoking should be in areas that will not be conducive to starting a fire.
Total Public/Motorist/Trucking	**11**	**7**	**4**	**6**	**4**	**5**	**5**	
Innovation Score	4	0	0	0	0	0	4	Additional scoring for innovative and progressive actions that are sustainable
Total Rest Area Scoring	**117**	**33**	**30**	**35**	**32**	**31**	**37**	

Appendix E Technical Memorandum (August 27, 2010); Rest Area Carbon Footprint Calculations

Technical Memorandum

Date: August 27, 2010

To: Vanessa Henderson
Jill Schlaefer

From: Ayman Hama
Art Hirsch

Subject: Rest Area Carbon Footprint Calculations

One of the several goals identified for the CDOT Alternative Energy and Sustainable Rest Area Project is to evaluate sustainable rest area designs and maintenance practices. The development and mitigation of the study areas' carbon footprint is the unique approach that will be taken by the Colorado State University-Pueblo Team (CSU-Pueblo Team). There has been very limited if any research performed on carbon footprinting of rest areas so there limited opportunity to compare actual or estimated carbon loadings from other State Department of Transportation rest areas.

The purpose of this technical memorandum is to provide the CDOT Project Oversight Committee the proposed method on how the carbon footprint will be calculated for the Project. The carbon footprint will address the associated carbon dioxide-equivalent emissions from direct and indirect sources associated with the operation and maintenance of the Project rest areas. The carbon footprint will also address indirect emissions from idling trucks that park at the rest areas for 8 hours.

General Carbon Footprint Overview

The major greenhouse gases identified for reduction in the Kyoto Protocol, to mitigate global climate change, are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and sulfur hexafluoride (SF6), and two classes of gases, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) (Jakubski, 2008). An international standard has been established to calculate the emission of these greenhouse gases known as the Greenhouse Gas Protocol (GHGP). This standard was initiated when two major organizations, the World Resource Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), recognized the need for an international standard to account for greenhouse gas emissions to meet rapidly evolving climate change policies. Working together with General Motors, British Petroleum, Monsanto and other industries, WRI introduced the Safe Climate, Sound Business Report that identified an action agenda which included a standardized measurement for GHG emissions. In 1998, an agreement was achieved between WRI and WBCSD, which led to launching a non-governmental organization business partnership to establish standardized methods to account for GHG emissions.

WRI and WBCSD were able to convince many environmental groups and major corporations such as the WWF, the Pew Center on Global Climate Change, the Energy Research Institute, and Shell to become involved and lead the multi-stakeholder standards development Process. In 2001, the first edition of the GHGP was published. Since then, the GHGP has built many tools to aid businesses in calculating their GHG emissions.

Carbon Footprint Calculation Method

The GHGP identifies three main Scope Emissions to identify and delineate direct and indirect emission sources. These Scope Emissions (Scope 1, Scope 2 and Scope 3) are used to provide consistency in accounting for and mitigating greenhouse gas emissions. The following summarizes the GHGP Scopes as they relate to CDOT rest areas (WRI, 2004):

> **Scope 1- Direct GHG Emissions**- these type of emissions come from combustion sources that are owned by the entity (CDOT) that are directly related to the operations of the rest area such as propane and natural gas for heating, and gasoline/diesel fuel for the transportation of materials, equipment, mowing and personnel transportation to and from work.
>
> **Scope 2- Electrical Indirect GHG Emissions-** accounts for GHG emissions from the generation of purchased electricity consumed by the company (CDOT). The actual emissions occur that the power facility where the electricity is generated. This type of indirect emission will be used for rest area heating/cooling and lighting and is expected to be the largest type of emission for rest areas.
>
> **Scope 3- Other Indirect GHG Emissions**- these types of emissions are a consequence of activities of the company (CDOT) but occurs from sources not owned or controlled by the company (CDOT). The main rest area source for this type of indirect emission is from truck idling.

The following sections discuss the equations that will be used to calculate the total carbon footprint for Scope 1, 2 and 3 emissions for the Project rest areas. Example calculations based upon draft rest area data are provided.

<u>Scope 1 Direct Emission Equation</u>

Equation 1 will be used for the direct emissions associated with the operation and maintenance of the rest areas. The equation basically uses emission factors (kg/gallon) for CO_2, N_2O, and CH_4 that are referenced from the United States Environmental Protection Agency (EPA, 2005). These emission factors are multiplied by the amount of fossil fuel consumed and by the respective Global Warming Potential (GWP) (Jakubski, 2008). GWP is defined as the amount of impact or the degree of harm a particular gas has on the atmosphere; more details are available in Chapter 2 of the IPCC’s Fourth Assessment Report (IPCC, 2007). When the GWP is multiplied by the amount emitted, it is converted to an equivalent amount of CO_2 and that is called "Equivalent CO_2" or CO_2e (See Figure 1).

Equation

$$Usage\ (Gal)\ \times CO_2\ Emission\ Factor\ \left(\frac{KgCO_2}{Gal}\right) \times \frac{1Metric\ Ton}{1000Kg} + \ Usage\ (Gal) \times N_2\ O\ Emission\ Factor\ \left(\frac{KgN_2\ O}{Gal}\right) \times \frac{1MetricTon}{1000Kg}\ \times 310\ GWP + \ Usage\ (Gal) \times CH_4\ Emission\ Factor\ \left(\frac{KgCH_4}{Gal}\right) \times \frac{1MetricTon}{1000Kg}\ \times 21\ GWP = CO_2\ e\ Metric\ Ton \qquad Eq\ (1)$$

Equation 1 is applicable to any type of fossil fuel, such as diesel fuel; however, emission factors will change whenever the type of fuel changes since emission factors are specific to the type of fuel being used in the carbon footprint calculations. The emission factors that will be used for rest area used diesel fuel; propane and natural gas are as follows (DOE, 2005):

- Diesel fuel (10.15 Kg CO_2 per gallon)
- Natural gas (53.06 Kg CO_2 /MMBtu or 5.306 Kg CO_2 /therm)
- Propane (63.10 Kg CO_2 /MMBtu or 5.75 Kg CO_2 /therm

Example Scope 1 Calculation (Vail Pass Rest Area)

The Vail Pass Rest Area is a high altitude rest area that is open all year and located on I-70. The largest consumption of fossils fuel is associated with the transportation of personnel, equipment and solid waste for disposal. The rest area is 13 miles one way (26 miles round trip) from the main CDOT Maintenance Facility located at the Eisenhower Tunnel. The annual total miles traveled by CDOT Maintenance crew for 365 days per year are 9,490 miles/yr. The total gasoline consumption by CDOT trucks based on an average of 9 miles/gal is 1,054 gallons/yr. By applying equation (1), the Scope 1 direct emission carbon footprint for the Vail Pass Rest Area is estimated to be 9.384 metric tons per year of CO_2 e. The following shows the Scope 1 direct emission calculation for carbon dioxide; methane and nitrous oxide (see Table 1 for emission factors):

Gasoline consumption per year= 1,054 gallons
Emission factor $-$ CO_2 $=$ 8.8 Kg /gallon
Emission factor $-$ N_2O = 0.000199 Kg/gallon
Emission factor $-$ CH_4 $=$ 0.00182 Kg/gallon
GWP $-$ CO_2 $= 1$
GWP $-$ N_2O $= 310$
GWP $-$ CH_4 $= 21$

$$1054\ (gallons\ gasoline) \times 8.8\ \left(\frac{KgCO_2}{Gal}\right) \times \frac{1MetricTon}{1000Kg} +\ 1054(gallons\ gasoline) \times (0.000199)\left(\frac{KgN_2\,O}{Gal}\right) \times \frac{1MetricTon}{1000Kg}\ \times 310\ GWP +\ 1054\ (gallons\ gasoline) \times (0.00182)\left(\frac{KgCH_4}{Gal}\right) \times \frac{1MetricTon}{1000Kg} \times 21\ GWP = \mathbf{9.384}\ \frac{\boldsymbol{Metric\,Ton}}{\boldsymbol{yr}} \boldsymbol{of\ CO_2}\ e$$

Scope 2- Electrical Indirect GHG Emission Equation

Equation 2 will be used to calculate the Scope 2 Electrical Indirect GHG Emissions for the Project rest areas. The equation involves the amount of electricity consumed in KWh. This electrical consumption information will be obtained directly from the electrical provider and will be based upon a 5 year average, whenever possible. Equation 2 is based upon the consumption of electricity (KWh) multiplied by the emission factor and GWP, similar to Equation 1. The emission factors used in Equation 2 are based upon eGRID data developed by EPA (EPA, 2008), and since the EPA data are given in pounds rather than kilograms, an extra conversion factor is included in Equation 2. These factors are regional based within the United States and are dependent upon varying methods for generating electricity (coal, natural gas, nuclear or renewable).

Equation

Usage (KWh) X CO_2 emission factor (lbs CO_2/KWh) / 2204.62 1bs/metric ton + Usage (KWh) X CH_4 emission factor (lbs CH_4/KWh) / 2204.62 1bs/metric ton X 21 GWP + Usage (KWh) X N_2O emission factor (lbs N_2O/KWh) / 2204.62 1bs/metric ton X 310 GWP = CO_2e Metric Ton

Eq.(2)

Example Scope 2 Calculation (Hanging Lake Rest Area)

Hanging Lake Rest Area is located on I-70 within Glenwood Canyon. The Hanging Lake Rest Area consumes electricity for rest area heating, lighting and wastewater treatment operations. Based upon the average five year annual electrical consumption of 154,816 KWh/yr (JCI, 2010) the carbon footprint emission is estimated to be 132.866 metric tons CO_2e/yr. Emission factors are taken from EPA eGRID presented in Table 2. The following is the calculation used for the Hanging Lake Scope 2 -Electrical Indirect GHG Emissions calculation:

Electrical consumption-154, 816 KWh
1 metric ton=2,204.63 pounds
$\mathrm{GWP} - \mathrm{CO_2}\ = 1$
$\mathrm{GWP} - \mathrm{N_2\,O} = 310$
$\mathrm{GWP} - \mathrm{CH_4}\ = 21$
Emission Factor-CO2=1.883 (lbs CO_2/KWh)
Emission Factor- CH4=0.00002288 (lbs CH_4/KWh)
Emission Factor-N2)=0.00002875 (lbs N_2O/KWh)

154,816 *(KWh) X 1.883 (lbs CO_2/KWh) / 2204.62 1bs/metric ton* + 154,816 *(KWh) X 0.00002288 (lbs CH_4/KWh) / 2204.62 1bs/metric ton X 21 GWP* + 154,816 *(KWh) X 0.00002875 (lbs N_2O/KWh) / 2204.62 1bs/metric ton X 310*
GWP = ***132.866 Metric ton/yr CO_2*** *e*

Scope 3- Other Indirect GHG Emissions

Trucks idling in rest areas represent a significant greenhouse gas emission source that is associated with the operation and service of the rest area. It is estimated that greater than 500,000 heavy duty trucks (>26,000 lbs) travel more than 500 miles as an average daily trip within the United States. Long haul truck drivers are required by the Department of Transportation to rest 8 hours after a maximum of 10 hours driving (EPA, 2002). During this time most long haul truckers continue to idle their engines. Assuming that these 500,000 truck idle for 8 hours a day for 300 days per year at fuel consumption rate of 0.8 gallons/hr, trucks can generate and emit over 10.9 million tons of CO2 per year (21.7 tons /year per truck) and 190,476 tons of NOX per year (0.38 tons per year per truck). Under this trucking scenario, heavy duty trucks would consume 960 million gallons of diesel fuel while idling (EPA, 2009).

The EPA was tasked by President Bush in 2001 to work closely with the U.S. Department of Transportation (DOT) to reduce truck idling. As part of that initiative the EPA initiated a study that quantified long duration idling emissions and fuel consumption. The tests were performed on nine class-8 trucks (model years ranging from 1980-2001). Based upon this study it was determined that on average an idling Class 8 truck would (EPA, 2002):

- Consume 0.82 gallons/hour of diesel fuel
- Emit 8.224 kg/hour of CO_2 (Emission factor = 10 Kg/gallon)
- Emit .144kg/hour of N_2O (Emission factor = 0.18 Kg/gallon)

Example Scope 3 Calculation (Vail Pass Rest Area)

As a hypothetical example, it is assumed that the average heavy duty truck consumes 0.82 gallons/hr of diesel fuel while idling and there is an average of three trucks that individually idle 8 hours/per day at the rest area; therefore, 6.6 gallons of diesel would be consumed per truck with an overall consumption value of 19.7 gallons of diesel fuel for three trucks per day. It is assumed that the 3 trucks idle for 8 hours for 365 days per year, in which 7,183 gallons of diesel is consumed annually from idling at the Vail Pass Rest Area. The following is an example calculation for the truck idling carbon footprint. Equation 1 is again used to estimate the Scope 3 Indirect GHG Emissions for Vail Pass rest area.

Diesel fuel consumption per year (idling) = 7,183 gallons
$\text{Emission factor} - CO_2 = 10.\text{Kg /gallon}$
$\text{Emission factor} - CH_4 = 0.000199\ \text{Kg/gallon}$
$\text{Emission factor} - N_2O = 0.18\ \text{Kg/gallon}$
$\text{GWP} - CO_2 = 1$

$\text{GWP} - \text{N}_2\,\text{O} = 310$
$\text{GWP} - \text{CH}_4\ = 21$

$$\left(7183\ (gal/year) \times 10\ \left(\frac{KgCO_2}{Gal}\right) \times \frac{1MetricTon}{1000Kg} +\ 7183(Gal/year) \times\ \ (0.18)\left(\frac{KgN_2\,O}{Gal}\right) \times \frac{1MetricTon}{1000Kg} \times 310\ GWP\right) = \mathbf{472.67\ metric}\ \frac{\mathbf{ton}}{\mathbf{year}}\ \mathbf{of}\text{CO2}\ \mathbf{e}$$

There is very little information available for a methane emission factor for diesel truck idling. One emission factor found in the literature showed a value 12 g/hr (EPA, 2002). Based upon the relatively small emission factor in comparison to CO_2 and NO_2, methane will be ignored due to its insignificant effect on final carbon footprint calculations.

Carbon Footprint Analysis

The development of a rest area's carbon footprint will provide a unique way of analyzing the Project rest areas' energy consumption. The Sustainable Rest Area Report will identify the greenhouse gas emissions from Scope 1, 2 and 3 emissions at all Project study rest area sites and will develop potential mitigation schemes and recommendations toward making the rest area carbon neutral. Potential mitigation techniques may include but not limited to changes in rest area operating procedures, reducing gas consumption, heating/energy conservation, vegetation/tree sequestration, truck electrification (auxiliary power units) and alternative energy photovoltaic cells.

Table 2: CH_4 and N_2O Emission Factors for Highway Vehicles[a]

Vehicle Type/Control Technology	Emission Factor (g/mile) N_2O	Emission Factor (g/mile) CH_4	Emission Factor (g/km) N_2O	Emission Factor (g/km) CH_4
Gasoline Passenger Cars				
Low Emission Vehicles	0.0150	0.0105	0.0093	0.0065
Tier 2	0.0036	0.0173	0.0022	0.0108
Tier 1	0.0429	0.0271	0.0267	0.0168
Tier 0	0.0647	0.0704	0.0402	0.0437
Oxidation Catalyst	0.0504	0.1355	0.0313	0.0842
Non-Catalyst	0.0197	0.1696	0.0122	0.1054
Uncontrolled	0.0197	0.1780	0.0122	0.1106
Gasoline Light-Duty Trucks				
Low Emission Vehicles	0.0157	0.0148	0.0098	0.0092
Tier 2	0.0066	0.0163	0.0041	0.0101
Tier 1	0.0871	0.0452	0.0541	0.0281
Tier 0	0.1056	0.0776	0.0656	0.0482
Oxidation Catalyst	0.0639	0.1516	0.0397	0.0942
Non-Catalyst	0.0218	0.1908	0.0135	0.1186
Uncontrolled	0.0220	0.2024	0.0137	0.1258
Gasoline Heavy-Duty Trucks				
Low Emission Vehicles	0.0320	0.0303	0.0199	0.0188
Tier 2	0.0134	0.0333	0.0083	0.0207
Tier 1	0.1750	0.0655	0.1087	0.0407
Tier 0	0.2135	0.2630	0.1327	0.1634
Oxidation Catalyst	0.1317	0.2356	0.0818	0.1464
Non-Catalyst	0.0473	0.4181	0.0294	0.2598
Uncontrolled	0.0497	0.4604	0.0309	0.2861
Diesel Passenger Cars				
Advanced	0.0010	0.0005	0.0006	0.0003
Moderate	0.0010	0.0005	0.0006	0.0003
Uncontrolled	0.0012	0.0006	0.0007	0.0004
Diesel Light Trucks				
Advanced	0.0015	0.0010	0.0009	0.0006
Moderate	0.0014	0.0009	0.0009	0.0006
Uncontrolled	0.0017	0.0011	0.0011	0.0007
Diesel Heavy-Duty Trucks				
Advanced	0.0048	0.0051	0.0030	0.0032
Moderate	0.0048	0.0051	0.0030	0.0032
Uncontrolled	0.0048	0.0051	0.0030	0.0032
Motorcycles				
Non-Catalyst Control	0.0069	0.0672	0.0043	0.0418
Uncontrolled	0.0087	0.0899	0.0054	0.0559

Table 1- CH_4 and N_2O Emission Factors for Highway Vehicles

Gases and Their Global Warming Potential	
CO_2*	1
CH_4*	21
N_2O*	310
HFC-23	11,700
HFC-32	650
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800
HFC-152a	140
HFC-236fa	6,300

Figure 1. Gases and their respective Global Warming Potentials

Taken from (Jakubski, 2008)

Table 2: Emission Factors for Different US Regions (EPA, 2008)

eGRID subregion acronym	eGRID subregion name	Annual output emission rates			Annual non-baseload output emission rates		
		Carbon dioxide (CO_2) (lb/MWh)	Methane (CH_4) (lb/GWh)	Nitrous oxide (N_2O) (lb/GWh)	Carbon dioxide (CO_2) (lb/MWh)	Methane (CH_4) (lb/GWh)	Nitrous oxide (N_2O) (lb/GWh)
AKGD	ASCC Alaska Grid	1,232.36	25.60	6.51	1,473.43	36.41	8.24
AKMS	ASCC Miscellaneous	498.86	20.75	4.08	1,457.11	60.47	11.87
AZNM	WECC Southwest	1,311.05	17.45	17.94	1,201.44	20.80	8.50
CAMX	WECC California	724.12	30.24	8.08	1,083.02	39.24	5.55
ERCT	ERCOT All	1,324.35	18.65	15.11	1,118.86	20.15	5.68
FRCC	FRCC All	1,318.57	45.92	16.94	1,353.72	48.16	12.95
HIMS	HICC Miscellaneous	1,514.92	314.68	46.88	1,674.15	338.44	51.42
HIOA	HICC Oahu	1,811.98	109.47	23.62	1,855.10	120.11	20.79
MROE	MRO East	1,834.72	27.59	30.36	1,828.63	28.82	25.20
MROW	MRO West	1,821.84	28.00	30.71	2,158.79	45.57	35.22
NEWE	NPCC New England	927.68	86.49	17.01	1,314.53	77.47	16.02
NWPP	WECC Northwest	902.24	19.13	14.90	1,333.64	49.28	18.73
NYCW	NPCC NYC/Westchester	815.45	36.02	5.46	1,525.05	56.80	9.08
NYLI	NPCC Long Island	1,536.80	115.41	18.09	1,509.85	60.32	10.78
NYUP	NPCC Upstate NY	720.80	24.82	11.19	1,514.11	45.30	18.41
RFCE	RFC East	1,139.07	30.27	18.71	1,790.50	41.61	24.36
RFCM	RFC Michigan	1,563.28	33.93	27.17	1,663.15	29.40	26.24
RFCW	RFC West	1,537.82	18.23	25.71	1,992.86	24.49	31.72
RMPA	WECC Rockies	1,883.08	22.88	28.75	1,617.71	22.42	20.14
SPNO	SPP North	1,960.94	23.82	32.09	2,169.74	31.18	31.99
SPSO	SPP South	1,658.14	24.98	22.61	1,379.05	24.40	12.04
SRMV	SERC Mississippi Valley	1,019.74	24.31	11.71	1,257.10	29.50	9.82
SRMW	SERC Midwest	1,830.51	21.15	30.50	2,101.16	25.66	32.92
SRSO	SERC South	1,489.54	26.27	25.47	1,697.22	35.20	26.41
SRTV	SERC Tennessee Valley	1,510.44	20.05	25.64	1,998.36	28.25	32.86
SRVC	SERC Virginia/Carolina	1,134.88	23.77	19.79	1,781.28	40.09	27.46

Figure 2. EPA eGrid (EPA, 2008)

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Appendix F Cost-Effective Sustainable Strategies

An initial Level 1 cost-effective analysis was performed on three sustainable actions: 1) water harvesting for irrigation water or gray water utilization, 2) waterless urinals for water conservation and 3) trash compactors to reduce solid waste volumes generated at rest areas. The following summarizes the initial results of the analysis.

Water Harvesting Analysis
Water harvesting is the collection of rain and snow melt from the restroom structure roof. This water would normally be discharged as stormwater through a culvert conveyance system into a receiving stream. There are water rights issues associated with collecting and using harvested water for consumption purposes such as irrigation or use as gray water for urinal or toilet flushing (see Appendix H). It is possible that a pilot study could be conducted by CDOT in cooperation with the State of Colorado Water Conservation Board and State Legislature to evaluate the feasibility and legality of this water collection and distribution system.

Three rest areas were selected for analysis for water harvesting; Poudre, Sterling and El Moro. These rest areas were selected because they purchase water from local municipalities and are relatively larger consumers of water than the other Project rest areas. The critical variables associated with this analysis are local annual precipitation (inches) and restroom roof area (square foot). The following summarizes the water collection calculations:

Rest Area	*Annual Precipitation (inches)	Roof Area (sq ft)	Water Collected (gallons)/year	Cost of domestic water/ gallon	Cost savings/year
Poudre	15.2	2500.00	23687	$0.0023	$53.77
El Moro	13.7	2400.00	20495	$0.0224	$459.40
Sterling	16.3	3900.00	39625	$0.0204	$806.37

*reference: http://countrystudies.us/united-states/weather/colorado/

This analysis does not address the initial capital costs associated with gutter conveyance, water containment, filters, pumps and plumbing.

El Moro and Sterling appear to be the potential candidates for water harvesting with an estimated annual savings of $459 and $806, respectively.

Urinal Discharge Analysis
The uses of waterless urinal are becoming more popular in areas with high domestic water costs or with aggressive water conservation practices. A common complaint by maintenance workers is that waterless urinals are not easy to maintain due to odors and frequent filter changes. Manufactures of waterless urinals have made filter design changes in recent years to reduce change out frequencies and odors. An initial Level 1 cost-effective analysis for the use of waterless urinals was performed on all six of the following Project rest areas. The following summarizes the analysis:

Rest Area	Visitation per year	# males using urinals/day	Gallons per flush	Total gallons per day from urinals	Total Gallons per year for urinals
Sterling	383,597	420	0.5	168	61,376
El Moro	328,500	360	1	288	105,120
Poudre	121,711	133	0.5	53	19,474
Hanging Lake	72,049	79	2.9	184	67,277
Vail Pass	680,000	745	1.6	954	348,160
Sleeping Ute Mtn.	65,700	72	0.5	29	10,512

Rest Area	Domestic water cost per 1000 gallons	Cost per gallon	Total Cost of urinal water/year	Number of urinals	Urinal/Installation Cost	ROI/years
Sterling	$20.35	$0.02035	$1,248.99	7	$3,500.00	2.8
El Moro	$22.41	$ 0.02241	$2,356.26	3	$1,500.00	0.6
Poudre	$2.27	$0.00227	$44.21	3	$1,500.00	33.9
Hanging Lake	*$1.00	$0.00100	$67.28	3	$1,500.00	22.3
Vail Pass	*$1.00	$0.00100	$348.16	3	$1,500.00	4.3
Sleeping Ute Mtn.	*$1.00	$0.00100	$10.51	2	$1,000.00	95.1

*Rough assumption estimate

The cost assessment assumes that the cost of the waterless urinal is $300 plus $200 for installation. The estimate does not factor in the cost of filters or the labor costs with filter change outs.

The initial analysis indicates that the Sterling, El Moro and Vail Pass rest areas are candidate areas for waterless urinals. The cost of onsite wastewater treatment savings is not factored into this assessment and would potentially make the Hanging Lake Rest Area a candidate area and provide Vail Pass Rest Area with a shorter return on investment.

Reference: ZeroFlush (personal conversation/http://www.zeroflush.com/, December 1, 2010)

Trash Compactor

Trash compaction is an effective way to reduce solid waste management costs by reducing volume that could reduce frequency of waste collection trips by a vendor or transport from the rest area to the maintenance facility for ultimate landfilling disposal. For the initial Level 1 cost-effectiveness analysis the BigBelly Solar Compactors were used as the model due to their solar energy capabilities and flexibility for installation. Appendix G provides the cost breakdown and return on investment calculations.

The El Moro Rest Area was selected as a model for this cost assessment. The assessment is based upon replacing 18 existing containers with 14 BigBelly 2-unit Kiosks. The existing containers are collected 14 times per week; with the BigBelly System, that frequency can be reduced to 3 times per week. This reduction could save CDOT approximately 286 staff/vehicle hours annual which amounts to approximately $15,730 per year in savings. The return on investment is 4.44 years with an approximate savings of $87,510 over the life of the equipment.

Reference: BigBelly Solar (personal conversation/http://bigbellysolar.com/, December 3, 2010)

Appendix G Solid Waste Compaction

BigBelly SOLAR

bright ideas for waste management

Prepared By:
Liam Reitz
November 11, 2010

COST SAVINGS ANALYSIS

Prepared For:
Colorado Department of Transportation

Company Contact:
Benjamin Schleich

Collection Route:
Rest Stop

Input customer data in yellow.

Current Collection System

Number of bins in target area		18	bins
Size of each bin		35	gallons
Number of collections each week		14	
Time needed to collect each bin		1.7	minutes
Total Labor Rate (including benefits)	$	30.00	

Total route time (including travel from garage)		0.5	hours
Vehicle cost/hour fully loaded (US Gov't FEMA)		$25.00	
# of people on collection route		1.0	
Labor rate including benefits	$	30.00	
Capacity available (per week)		8,820	gallons

BigBelly Collection System (Proposed Data)

Number of bins in target area		14	bins
Capacity of each BigBelly or Kiosk*		220	gallons
Number of collections each week		3	each
Time needed to collect each bin		1.7	minutes
Total Labor Rate (including benefits)	$	30.00	

Collection ratio (target 4-7 to 1):		4.7	to 1
Total route time (including travel from garage)		0.5	hours
Cost of each BigBelly unit	$	4,985	
Total cost for BigBelly Collection System	$	69,790	
Capacity available (per week)		9,240	gallons
Capacity safety margin		5%	extra capacity

** BB Capacity averages 160 gal, each recycling module adds 60 gallons*

Annual Cost of Current Collection System

Total hours per year on route		364	hours
x Labor Rate (fully loaded)	$	30	
Annual Labor Cost:	$	10,920	
Vehicle - hours per year		364	hours
x Vehicle Cost (per hour fully loaded)	$	25	FEMA rate
Annual Vehicle Cost:	$	9,100	
Annual Vehicle Fuel Usage @: 1.5		546	gallons**
Total Annual Cost:	$	**20,020**	

*** Fuel: Use 5.7 gal per hour in city, 4.7 for parks, 1.5 for pickup trucks*

Annual Cost of BigBelly Collection System

Total hours per year on route		78	hours
x Labor Rate (fully loaded)	$	30	
Annual Labor Cost:	$	2,340	
Vehicle - hours per year		78	hours
x Vehicle Cost (per hour fully loaded)	$	25	
Annual Vehicle Cost:	$	1,950	
Annual Vehicle Fuel Usage *(same truck type)*		117	gallons
Total Annual Cost:	$	**4,290**	
Annual Reduced Operating Costs:	$	**15,730**	
CO2 Emissions saved annually (Tons):		**5**	

Payback on BigBelly deployment

With 100% focus on cost reduction

Annual Reduced Operating Costs:	$	15,730	
Ten Year Cost Savings:	$	**87,510**	
Payback Term:		**4.44**	years
% reduction in operating cost:		**79%**	

With 100% focus on workforce productivity

Annual Reduced Operating Costs:	$	7,150	
Ten Year Cost Savings:	$	**1,710**	
Payback Term		**9.76**	years
% reduction in operating cost:		36%	
Net gain in productive hours (per week)		6	hours/wk
Net gain in productive hours (per year)		286	hours/year
Productivity gain over lifespan of machine		2,860	hours/lifetime
Dollar value of productivity gain (lifetime)		$85,800	10 year value

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Appendix H Colorado Rainwater Harvesting Legal Analysis

Statutory matters regarding precipitation harvesting pilot projects, including rainwater harvesting, include the following:

SB09-080 (signed by the governor April 22, 2009; effective June 2 and July 1, 2009) allows limited use of collection and use of precipitation for private landowners that are not served by municipal water, have a well or would be approved for a well, and limit the use to household water. This aspect of SB09-080 is codified in C.R.S. 37-90-105, which in part states that the state engineer can approve permits for allowing certain rooftop precipitation collection systems for buildings that are primarily residences and that are not served by a domestic water system serving more than 3 single-family dwellings, so long as the water is used for ordinary household use, fire protection, watering for domestic animals, poultry or livestock, or irrigation of not more than one acre of gardens and lawns. The option exists for those using or legally entitled to use a well, and the water can be used only for the same buildings, and subject to the same limitations, that exist or would exist in a legal well permit.

In addition, part of SB09-080 is codified in C.R.S. 37-60-115, which allows for certain pilot projects regarding precipitation harvesting. The goal of these pilot projects is to gain field-verified information about the feasibility of rainwater harvesting as a water conservation measure. 37-60-115 tasks the Colorado Water Conservation Board (CWCB), in consultation with the state engineer, with selecting the sponsors of up to ten new residential or mixed-use developments that will conduct individual pilot projects to collect precipitation from rooftops and impermeable surfaces, for nonpotable uses.
C.R.S. 37-60-115 emphasizes that the pilot projects will measure precipitation capture efficiencies, and compile and analyze data collected; and provide data to allow their sponsors to develop permanent augmentation plans.

The statute further states that until the pilot project sponsor applies to the water court for a permanent augmentation plan, the pilot project is required to replace an amount of water equal to the amount of precipitation captured and measured from rooftops and impermeable surfaces for nonpotable uses.

A recent CWCB document (at http://cwcb.state.co.us/legal/Documents/Guidelines/FINALRainwaterPilotCG.pdf, last examined December 17, 2010) provides criteria and guidelines for pilot project applications.

An application fee and annual review fee ($4000 and $7000 respectively) are required.

Appendix I Renewable Energy Standards (RES) Background

Numerous mandates and incentives for utilities to develop partnerships with energy customers are contained in Colorado statute, as follows.

Colorado's renewable portfolio standards were created by ballot initiative; Amendment 37 was passed with approximately 54% of the votes cast on the measure in November 2004, and was codified in Colorado Revised Statutes (C.R.S.) 40-2-124. It includes the following as part of the legislative intent:

> "...Colorado's renewable energy resources are currently underutilized. Therefore, ...it is in the best interests of the citizens of Colorado to develop and utilize renewable energy resources to the maximum practicable extent."

It set renewable energy standards that have since been altered and amended by HB 10-1001 (signed by the Governor March 22, 2010; effective August 11, 2010), HB 1418 (signed by the Governor June 10, 2010; effective August 11, 2010), and SB 10-177 (signed by the Governor June 9, 2010; effective August 11, 2010), with alterations and amendments also residing in C.R.S. 40-2-124.

In summary, Colorado's renewable portfolio standard requires retail utilities (excluding municipally-owned utilities serving 40,000 or fewer customers) to generate, or purchase, electricity from renewable sources meeting 12% of retail electricity sales in Colorado for 2011-2014, with "distributed generation" (partially defined below) comprising at least 1% of retail electricity in 2011 and 2012 and 1.25% in 2013 and 2014; 20% of retail electricity for 2015-2019; and 30% of retail electricity for 2020 and beyond (and increasing distributed generation).

At least half of the distributed generation must be retail distributed generation, meaning that it is from renewable energy located on the customer's site, interconnected on the customer's side of the meter, primarily for the customer's load, and supplying no more than 120% of the average annual consumption of the customer at that site, including contiguous property.

Renewable energy is solar, wind, geothermal, biomass (urban wood waste, brush, animal wastes, methane as a byproduct of wastewater residuals), hydropower, and fuel cells (so long as the hydrogen is derived from renewables). The statute gives a weight of 1.25 for power generated within Colorado, except for retail distributed generation; a weight of 2.0 is given for renewable energy interconnecting to transmission or distribution owned by a cooperative electrical association or municipally owned utility, up to a certain size and interconnection voltage; a weight of 1.5 is given for community-based projects (including those by a local government). Solar electric generation receives a weight of 3 through 2015, for cooperative electric associations and municipally owned utilities.

C.R.S. 40-2-124 codifies that contiguous property owned or lease by the customer is without regard to interruptions in contiguity by easements, public thoroughfares, transportation right-of-way, or utility right-of-way.

Qualifying retail utilities not meeting the standards above are allowed to acquire renewable energy credits. Also, a rebate program is set up, requiring retail customers a standard rebate offer of some amount per watt of installation of solar electric on customer's premises, up to 100kW installation. The standard rebate offer is $2/Watt in the statute, although the amount can be lowered if the Colorado Public Utilities Commission so determines. Excess electricity for any one month can be carried forward as credit for the following month, and the customer can be reimbursed for excess production at the average hourly incremental cost (unless the excess is requested to be carried forward as a month-to-month credit indefinitely).

The owner or operator of the solar electricity generation facility can sell the electricity to the consumer on whose property the generation facility lies, up to 120% of the average annual consumption of electricity (again, the notion of property includes contiguous property).

Utilities may establish offers to purchase renewable energy credits. The typical investor-owned utility incentives now (2010) are $2/Watt for the standard rebate offer. (For commercial systems, an additional renewable energy credit incentive of $80-$115 for each annual megawatt hour of production is typical. For residential systems, an additional incentive of $.45/Watt for the purchase of solar renewable energy credits, i.e. a total incentive of $2.45/Watt of solar installation, is now typical. It is important to note that the amount of these incentives can change; the purchase of renewable energy credits for residential users alone had been $2.50/Watt a few years ago.)

The Colorado Public Utilities Commission has issued rules, in 4 Code of Colorado Regulations (CCR) 723-3 (effective September 14, 2010), regarding rules regulating electric utilities. These rules explicitly state in part what C.R.S. 40-2-124 codifies; specifically, under the heading "Net metering", it states that all investor-owned qualified retail utilities will allow electrical consumption to be offset by renewable energy, provided in part that the system is sized to supply no more than 120% of the customer's average annual electricity consumption at that site (where, as noted above, the term 'site' includes all contiguous property owned or leased by the customer, without regard to interruptions in contiguity by easements, public thoroughfares, and transportation or utility rights of way).

The document includes details such as who provides the meter and how many meters are to be used (since there are different needs based on use of solar renewable energy).
HB 10-1349 (signed into law by the Governor June 8, 2010; effective June 8, 2010) also has some implications for what is possible regarding renewable energy for certain components of state government. It created the Reenergize Colorado program codified in C.R.S. 24-33-115, with the goal of generating, or off-setting, all of the division of parks and outdoor recreation's electrical energy consumption using renewable energy sources on land owned, leased, or controlled by the division, by the year 2020. A key exception in this law is that the renewable energy generating equipment on site is allowed to exceed the 120% threshold noted above; specifically, the utility has the right of first refusal in purchasing the excess power, and if it does purchase the power it can claim renewable energy credits.

A corporate tax benefit applying to businesses, i.e. the Business Investment Tax Credit, allows for a 30% tax credit for photovoltaic systems and some other renewable energy including fuel cells and small wind systems [and is outlined in the United States Code, Title 26, Section 48(a)]. This tax benefit, through December 2016, is different from the stimulus-funded federal grant program for businesses. Such a tax credit is crucial as a benefit for a private-sector partner in developing renewable energy opportunities.

Patent issues may arise, based in part on the experiences of the Oregon Department of Transportation. If activity is considered to infringe on a patent claim, licensing may be an option; however, questions of patent validity may also arise. Parties often consider filing a declaratory judgment (DJ) action. Standards for filing DJ actions in patent cases have been shifting in recent years, and the general trend is that a party may file a DJ action even if the patent holder is not threatening direct litigation. For instance, the US Supreme Court case *MedImmune v. Genentech* (2007) eliminated the prior reasonable apprehension of litigation requirement for filing a DJ action. Roughly, the newer standard is whether there is a substantial controversy and sufficient immediacy and reality to warrant the issuance of a declaratory judgment. Issued patents are presumed valid, and a patent holder must show infringement only by a preponderance of the evidence standard, while one contesting a patent must use the higher standard that there is clear and convincing evidence of invalidity. Nevertheless, a patent can be ruled invalid particularly if it is challenged on grounds not originally considered by the Patent Office. Grounds for invalidating a patent include a finding that the invention was not novel. This may include a finding that it was known or used by others in this country, or patented or described in a printed publication (which might include materials presented at a conference) in this or a foreign country, before the invention by the patent holder. So-called statutory bars to patentability include a finding that the invention to be patented was in public use or on sale in this country more than one year prior to the date of application in the US. Obviousness is another valid ground for invalidating a patent. Once again, the general trend is to find an increasing number of inventions to be obvious; the perspective used remains that of a person having ordinary skill in the art, at the time of the invention. Obviousness can be based on numerous prior references.

Various scenarios for taking advantage of the above tax credits and incentives from utilities include a private-sector partnership with an energy producer and utility, e.g. in the form of a solar power purchase agreement or solar lease. In a purchase power agreement scenario, CDOT would not own the electrical generation system, but rather would pay for electricity only, often at a fixed negotiated rate. Another entity would develop and maintain the system, and the utility could acquire renewable energy credits. (In a solar lease, the customer is paying for the equipment, and costs could presumably vary with time.)