



Research Study: Energy Development and the Transportation System

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FELSBURG HOLT & ULLEVIG

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RESEARCH STUDY:
ENERGY DEVELOPMENT
AND THE
TRANSPORTATION SYSTEM

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EXECUTIVE SUMMARY

Purpose and Goals

Energy Production and Potential

Colorado has substantial resources of both conventional and renewable energy. In 2007, Colorado produced 2,335 trillion British thermal units (Btu) of energy, making it the tenth highest energy producing state, accounting for approximately 3.3 percent of the nation's total energy production. The potential for further energy development in Colorado is considerable; ten of the nation's 100 largest natural gas fields and three of its 100 largest oil fields are found in Colorado. Oil shale deposits in Colorado hold an estimated one trillion barrels of oil – almost as much oil as the world's proven oil reserves. The state's sunny climate offers solar power potential, and windy conditions along the Front Range and the eastern plains offer wind power potential. Agriculture is an important component of Colorado's economy, resulting in great potential for biofuel production. Recent initiatives to establish Colorado's "New Energy Economy" are expected to substantially increase Colorado's production and use of renewable energy. Current and future activity leads to energy being a large contributor to our state's economy.

Energy Production in Colorado

Colorado ranks 10th in the nation in total energy production, 11th in crude oil production, 6th in natural gas production, 9th in coal production, and 6th in wind power capacity.

Source: U.S. Energy Information Administration and American Wind Energy Association

Use of the Transportation System

Energy development and production necessitates use of the transportation system, and the level at which that activity uses Colorado's state highway system varies dramatically depending upon the energy source. During the oil and gas energy boom that occurred in Colorado during the first eight years of the 21st century, many state highways experienced substantial increases in traffic and specifically in truck traffic. The state highways that have been identified as key energy development corridors for the oil and gas industry experienced an approximate 35 percent increase in truck traffic over the ten year period between 1997 and 2007. These increases have led to congestion at some locations and degradation of pavement conditions on facilities that were not designed to weather the wear and tear associated with heavy vehicles. Anecdotes about the impacts of energy development on the state's roads became widespread; however, very little research has been done to correlate energy development with transportation activity.

Planning for the Future

During the recent energy boom, oil prices peaked at approximately $145 per barrel. Currently, oil prices are in the range of $70 per barrel (December 2009), and Colorado is no longer experiencing the oil and gas boom of a few years ago. Although oil and gas development has reached a relative plateau, renewable energy development in Colorado is becoming increasingly prevalent, making this an opportune time for the Colorado Department of Transportation (CDOT) to plan for future energy development. CDOT initiated this study to gain a better understanding of how development and production of various energy sources affect the state's transportation system.

Energy Sources Addressed in Research Study:

Non-Renewable Energy
- Crude oil
- Natural gas
- Coal bed methane
- Oil Shale
- Uranium
- Coal

Renewable Energy
- Wind
- Solar
- Biofuels

Primary Goals of Research Study

- Provide an industry overview for each energy source and a general understanding of the development trends and potential in Colorado.
- Correlate the phases of energy development, production, and reclamation to transportation activity, as appropriate for each energy source.
- Develop a planning level tool that can be used to assess the transportation activity associated with future energy development scenarios and that provides a means of comparing the relative impacts to various state highway corridors.
- Provide a relative comparison of transportation activity between various energy sources.
- Provide recommendations on areas in which CDOT should focus efforts related to planning for future energy development.

Research Study Process

Project Oversight

The study process was guided by a Project Management Team, comprised of key staff from the CDOT Division of Transportation Development (DTD) and the consulting team. A CDOT Working Group also played a critical role in the study process. The Working Group consisted of CDOT staff from a variety of departments and from the three engineering regions that are most heavily impacted by energy development.

Literature Review and Key Person Interviews

The study began with a literature review to ascertain what level of information is readily available linking energy development with transportation demands. The literature review focused primarily on Colorado impact studies and data, but also drew information from other neighboring states with similar energy sources and extraction techniques and where methodologies for quantifying energy–related transportation demands have been established.

The literature review and key person interviews provided data to enable the project team to estimate the numbers and types of vehicles generated by the various energy development phases for each energy source.

To supplement the literature review, a series of interviews with knowledgeable representatives from the various energy industries, associated energy professional organizations, state regulatory agencies and local communities were conducted to gather additional information on industry operations, current and projected production levels, and the degree to which each energy sector uses Colorado state highways.

Travel Estimation Model Development

One of the primary goals of the research study was to develop a planning level tool to help CDOT and others estimate transportation activity associated with future energy development scenarios. The project team developed three travel estimation models using Microsoft Excel through a peer review process with the Project Management Team and the CDOT Working Group. The purpose for developing three models was that the level of information available and the complexity of transportation demand for the different energy sources vary widely. Rather than tying the models to specific energy development projection levels, the models serve as a tool to evaluate the transportation demands associated with given input values (i.e., energy development scenarios). This approach ensures the long-term utility and flexibility of the model as the energy industry evolves in Colorado.

Overview of Energy Sources

The nine energy sources that are the subject of this research study have diverse development and production requirements and create demands on the transportation system that can vary by magnitudes from one energy source to another. The following sections provide a general overview of each energy source along with a description of the type and relative magnitude of the transportation activity associated with each.

Oil & Gas

In 2008 there were over 38,000 active oil and gas wells in Colorado, which are widely distributed around the state. There are active wells located in two-thirds of Colorado counties, with the highest levels of activity occurring in the Piceance and Denver/Julesburg basins. The Colorado Energy Research Institute defines economic study areas associated with the different oil and gas basins in Colorado, as shown on the map on the following page. The map also shows the 39 key energy development corridors associated with oil and gas on the state highway system.

85 percent of Colorado's active oil and gas wells are located in the following six counties:

- Weld
- Garfield
- Yuma
- La Plata
- Las Animas
- Rio Blanco

Source: Colorado Oil and Gas Conservation Commission

Crude oil and natural gas have similar development and extraction processes. Potential productive wells undergo a site evaluation which may include seismic tests, exploratory well drilling or core sample testing to confirm the quality of the oil or gas reserves. After an acceptable site has been selected, construction can begin. Transportation demands during construction are substantial due to a short timeframe (generally 30 to 60 days) and a high volume of heavyweight truckloads. The number of truckloads of equipment and supplies can vary substantially from one well to the next depending upon the depth of the well and the configuration of the oil or gas deposit. The construction phase represents the highest intensity of travel demand at an oil or gas well. Well drilling equipment and materials must be delivered, along with well structures, pumps, and well casings. Additionally, significant amounts of fresh water are brought to the site and waste materials are taken from the site during construction.

Oil and Gas Trip Generation Rates (average trips per well)

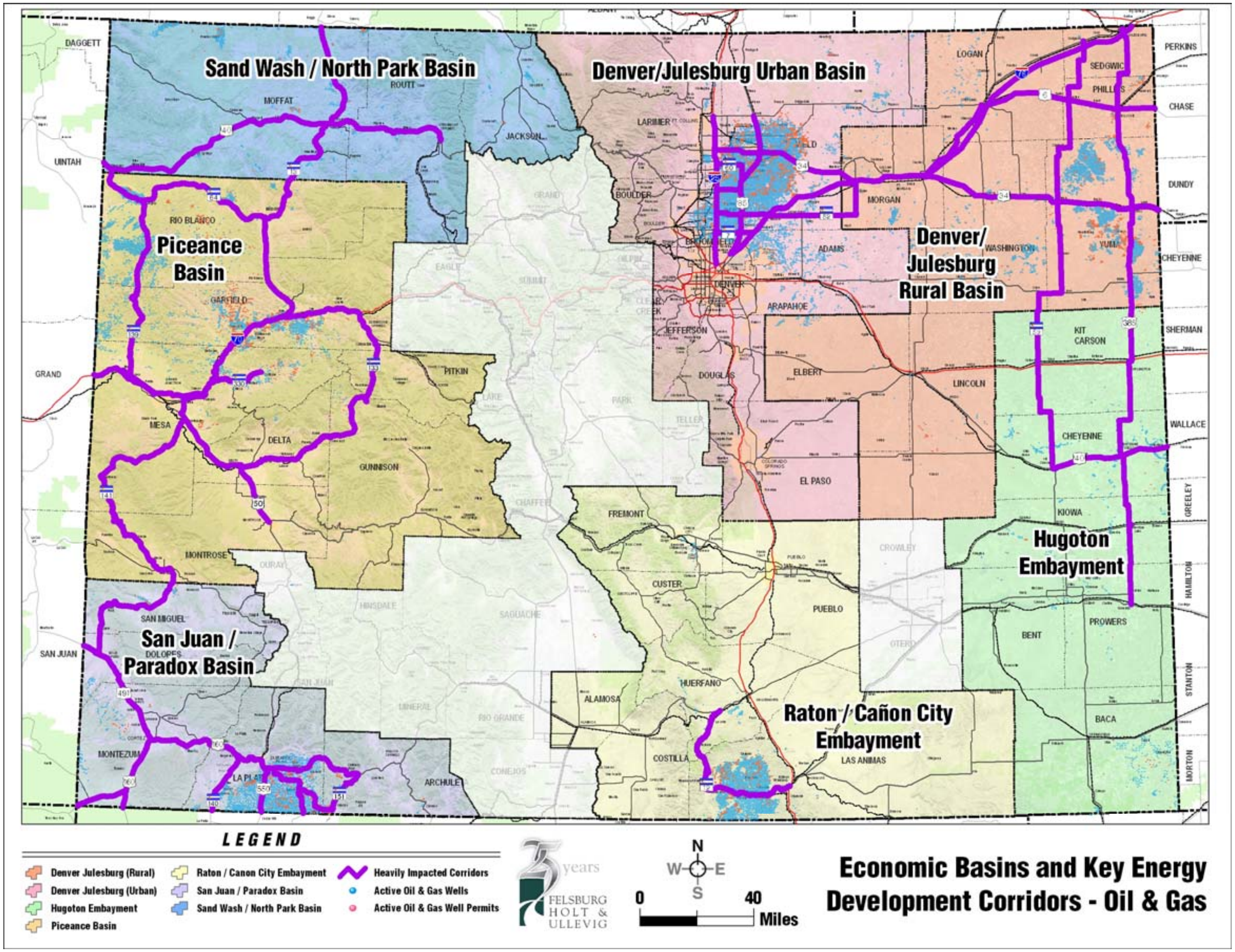
Phase	Crude Oil	Natural Gas	Coal Bed Methane
Development[1,2]	1,710	1,721	684
Production (Annual)	974	111	742
Reclamation[2]	250	73	146

[1] Development phase includes all activities prior to production (site preparation, drilling and completion)

[2] Development and reclamation trips represent single occurrences.

An operational well can produce oil or gas for about 10 to 30 years depending on the size of the resource deposit. During the production phase, trips to and from a well site are related to routine well maintenance, periodic well stimulation and removal of produced water. After extraction is complete, a well is retired and the site is reclaimed. Reclamation activities typically involve deconstruction, re-grading, removal of debris and contaminated soils, and plugging of the well.

Natural gas wells generally send product to market via surface and underground pipelines. Crude oil wells often require tanker trucks to deliver crude oil from the well to refineries.


Sand Wash / North Park Basin
Denver/Julesburg Urban Basin
Piceance Basin
Denver/ Julesburg Rural Basin
Hugoton Embayment
San Juan / Paradox Basin
Raton / Cañon City Embayment
LEGEND
Denver Julesburg (Rural)
Denver Julesburg (Urban)
Hugoton Embayment
Piceance Basin
Raton / Canon City Embayment
San Juan / Paradox Basin
Sand Wash / North Park Basin
Heavily Impacted Corridors
Active Oil & Gas Wells
Active Oil & Gas Well Permits
25 years
FELSBURG HOLT & ULLEVIG
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Economic Basins and Key Energy Development Corridors - Oil & Gas

Coal bed methane (CBM) is a form of natural gas extracted from underground deposits of coal. It is extracted using similar techniques to a conventional oil or gas well, but the depths of CBM wells are much shallower, resulting in less travel demand during the construction phase. CBM wells create large quantities of produced water; at the initial production stage, CBM wells produce mostly water. Trip generation rates during the production phase are higher than conventional natural gas rates because of the extensive water removal requirements.

Colorado produces more than one-fourth of all coal bed methane in the country; coal bed methane accounts for about half of Colorado's natural gas production.

Source: U.S. Energy Information Administration

Oil shale refers to any rock that contains solid bituminous materials that release as petroleum when heated. Oil shale can be extracted and processed to generate oil similar to oil pumped from conventional oil wells; however, the extraction and processing is more complex than conventional oil recovery and currently is significantly more expensive. The extraction process involves mining the oil shale and then heating it to a high temperature; the resultant liquid must then be separated and collected. An alternative, experimental process involves heating the oil shale while it is still underground, and then pumping the liquid to the surface.

The largest deposits of oil shale in the world are found in the United States in the Green River Formation, which covers portions of Colorado, Utah, and Wyoming. Although the oil shale deposits in Colorado (primarily in the Piceance Basin) are tremendous, the potential for commercial scale oil shale production is highly uncertain at this time, as are the transportation demands.

Uranium

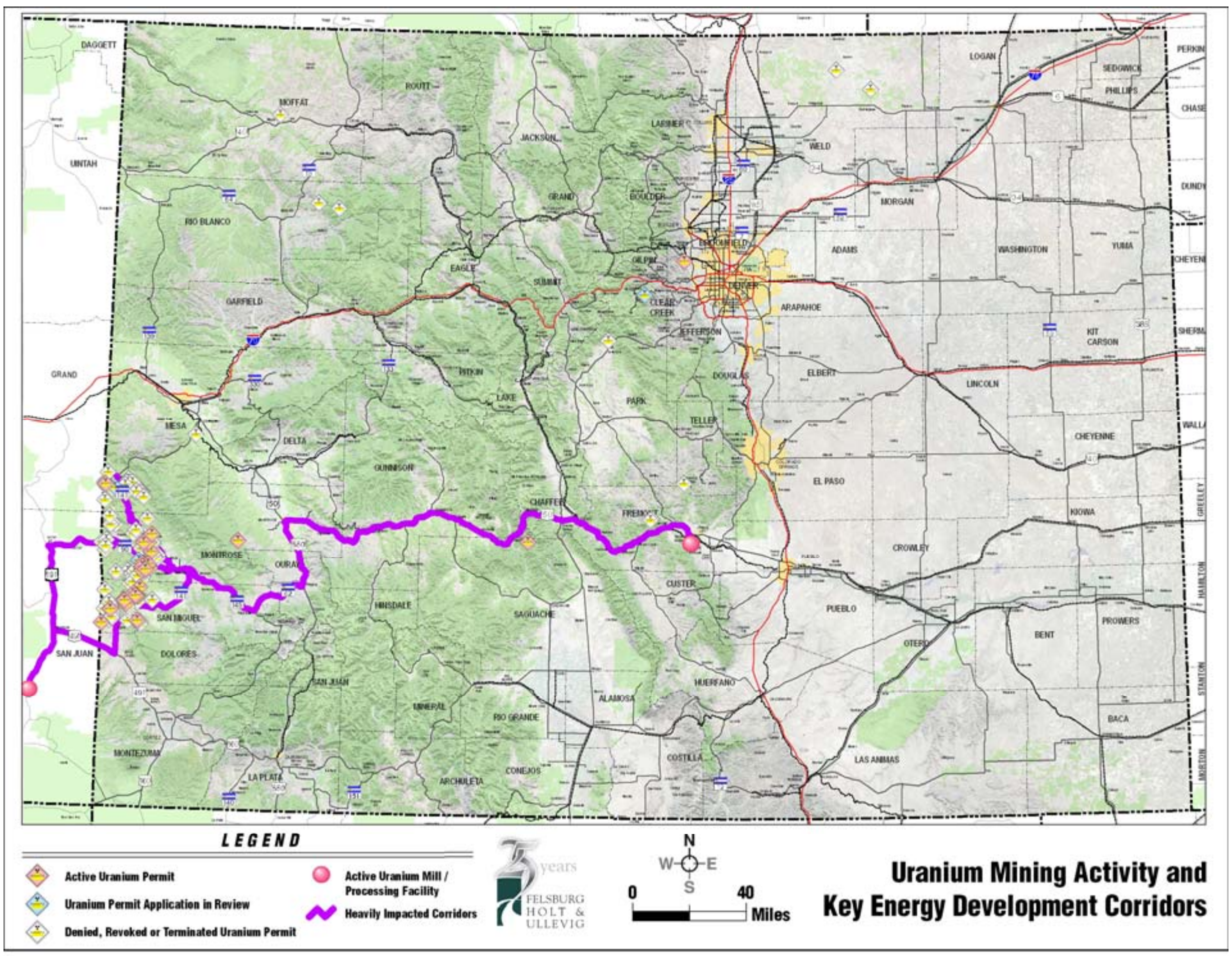
Uranium ore can be extracted using both open pit and underground mining methods. Given the proximity of uranium ore to the surface, open pit mining is the preferable extraction method in Colorado. Presently, all three operating uranium mines in Colorado are in the Uravan mineral belt which is located in the far western portion of the state in Montrose and San Miguel Counties.

Quarry material containing uranium ore must be transported to a processing facility; this transport represents the primary demand of uranium mining on the state highway system. The uranium is transported in trucks that carry 25 tons of ore. A typical uranium mining operation might mine 200 to 300 tons of uranium ore per day, which equates to 16 to 24 heavy vehicle trips per day to and from the mine.

Uranium Trip Generation Rate per Thousand Tons of Uranium Ore

Type	Trips
Haul Trips	**80**
Employee Trips (Annual)	**280**

There are only two uranium processing facilities in the region: the Canon City Mill near Canon City, Colorado and the White Mesa Uranium Mill near Blanding, Utah (as shown on the map below), although the Canon City Mill is not currently being used. Seven state highway corridors in Colorado have been identified as key energy development corridors for uranium. These corridors, as shown on the map below, are the routes which are used to travel between the Uravan mineral belt and the two processing facilities.



Source: Colorado Division of Reclamation, Mining, and Safety

Coal

Coal is one of the United States' most abundant and recoverable energy sources. The coal found in Colorado is generally low in sulfur and ash and is among the highest quality, cleanest coals found anywhere in the world, which makes it very desirable because it results in lower emissions when burned. Coal deposits are scattered throughout Colorado, primarily on the Western Slope and along the Front Range. The number of producing coal mines varies depending upon economic conditions; during the period between January and August of 2009, there were ten producing coal mines in Colorado.

Approximately three-quarters of rail freight originating in Colorado in 2005 was coal, and nearly 50 percent of the rail freight volume coming into Colorado was coal.

Source: 2035 Statewide Plan Freight Technical Report

In the United States, coal is predominantly transported by rail; the weight of coal and the length of travel make rail the most economical means of transporting coal. In Colorado, railroad spurs provide direct connections between producing coal mines and a mainline railroad. Therefore, the direct demands of coal mining on the state highway system are minimal, especially in comparison to the demands of the oil and gas industry. The primary impact of coal transport on the state highway system occurs at railroad/highway crossings. Where grade separated crossings are not provided, coal trains, which typically include 120 to 130 rail cars, create delays for the state highway system and also present safety concerns.

Wind

Wind power is the conversion of wind to a useable form of energy, typically electricity, using wind turbines. Wind energy production is attractive when a site has consistent winds with a mostly flat and open terrain. In eastern Colorado, all of these qualities are present. As of 2008, there were 820 wind turbines operating in Colorado throughout 11 operational wind farms, with a total wind power capacity of 1,068 megawatts (MW). The megawatt capacity of a wind turbine is the maximum potential energy produced with one hour of optimum wind speed.

In 2007, Colorado installed 776 MW of new wind power capacity, the second highest of any state that year.

Source: American Wind Energy Association

Wind Power Trip Generation Rates

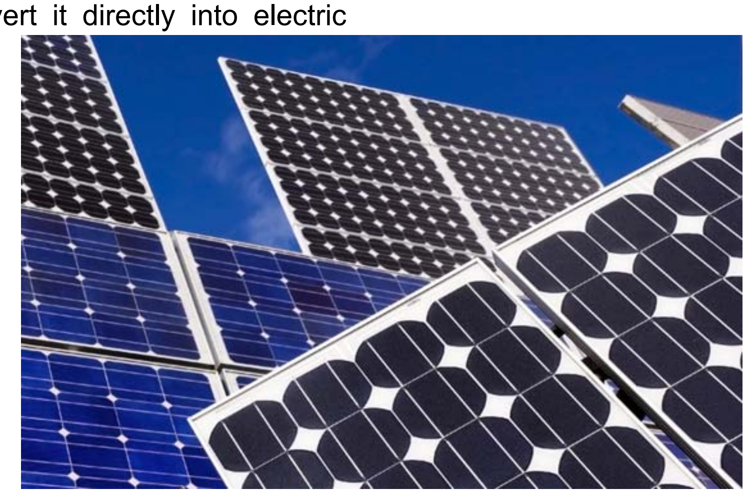
Phase	Trips per Turbine	Trips per MW[1]
Construction	126	79
Operations (Annual)	8	5

[1] Trips per MW calculated based on average wind turbine capacity of 1.6 MW

Transporting the massive structures needed for a wind turbine is challenging. A single turbine can require up to eight truck hauls. Although the turbine blades are relatively light (seven to eight tons each), they require permits for travel on the state highway system because they are so long (130 feet). Sometimes transporting wind turbines can necessitate the temporary removal of signal poles and mast arms at intersections. In addition to transporting the pieces of the wind turbines to the site, large cranes are required to erect the turbines, along with trips associated with building access roads, constructing concrete foundations, and delivering water for dust control. Once a wind farm is operational, it is typically staffed by on-site workers during normal business hours for routine maintenance. Infrequently, they need to bring in a crane to fix a problem. In some cases, the wind turbines are also monitored remotely.

Solar

There are two main types of solar energy, Photovoltaic (PV) and Concentrated Solar Power (CSP). CSP directs sunlight into a focused beam to create thermal energy for electric generation. PV cells capture solar radiation and convert it directly into electric current. This research study focuses on PV solar energy as development of this type has been more prevalent in Colorado. Solar energy production is attractive for areas with ample, direct sunlight. The entire state is suitable for utility-scale solar energy production, especially the southern third of the state. As of 2009, there were 16 megawatts (MW) of solar power capacity in Colorado across six utility-scale PV solar generation facilities, primarily located along the Front Range. PV solar panel capacity is



reported as the electric generation per hour of peak sun exposure. One MW of PV solar capacity typically requires ten acres of solar panels.

The primary equipment needed to build a PV solar facility, mounting materials and solar panels, can be delivered to a development site using semi-truck containers, flat bed trucks and light passenger trucks. Additionally, concrete is delivered to the site for pouring foundations that mount the panels. In addition to delivery of materials, construction equipment necessary for grading, dozing, excavating, trenching, and hoisting are delivered to the site. After a solar power array has been constructed, the operation requires periodic trips for general maintenance or for repairs caused by adverse weather conditions.

Solar Power Trip Generation Rates

Phase	Trips per MW[1]
Construction	202
Operations (Annual)	50

[1] One MW of capacity typically requires approximately ten acres of solar panels.

Biofuels

Biofuels, such as biodiesel and ethanol, are processed from organic matter and are designed to replace diesel and gasoline. Often, organic material is not grown for exclusive use at biofuel facilities; instead, the waste from organic production is used. Unlike other renewable energy sources, which are used for utility-scale electricity generation, the end use for biofuels is typically for personal or commercial auto transportation. American AgriDiesel

Colorado produces an estimated 125 million gallons of ethanol each year (about two percent of U.S. total production) and approximately 10 million gallons of biodiesel.

Sources: U.S. Energy Information Administration and American AgriDiesel

Biofuel plants exist throughout Colorado using corn, algae, soy, recycled vegetable oil, and woody biomass (small pellets of wood). Unlike most other energy sources, biofuels can be created wherever a developer chooses. The selected site is most likely near a developed transportation network to reduce transport costs. In Colorado, biofuel plants are generally very small scale at the present time and are located in areas on the Front Range and eastern plains.

Transporting materials to construct a biomass processing facility are similar to constructing other industrial manufacturing facilities. The largest transportation demands associated with biofuel are not during the construction phase as with other renewable power, but throughout the production phase as organic material is continually delivered to the processing plant for energy generation and processed fuels are exported for fossil fuel blending. These trips to and from the plants can be accomplished by semi-trucks.

Biofuel Trip Generation Rates

	Trips per Million Gallons of Ethanol or Biofuel
Input-Related	**793**
Output-Related	**442**
Total	**1,235**

Travel Estimation Models

The main impetus for this research study was the desire to better understand the level of travel demands placed on the state highway system by energy development in Colorado. The travel estimation models serve as a tool to relate future energy development scenarios to levels of travel demand on a statewide, economic basin, or corridor basis.

Travel Estimation Models

Oil & Gas Model
- Crude Oil
- Natural Gas
- Coal Bed Methane

Uranium Model

Renewable Energy Model
- Wind
- Solar
- Biofuels

Using information gathered through the literature review and the key person interviews, the three travel estimation models were developed. The trip generation rates provided in the tables in the previous section serve as the foundation for estimating future travel demands for each energy source. These models are not intended to evaluate impacts associated with a particular energy development site. Rather, they are intended to be used to gain an understanding of the relative magnitude of the transportation demands associated with the various energy development sectors in Colorado and to compare the relative demands of energy development on key energy corridors.

The oil and gas model is the most complex of the three models. The outputs of the model include trip generation and vehicle classification estimates for crude oil, natural gas, and coal bed methane, as well as an allocation of travel demand to corridors throughout the state that have been identified as key energy development corridors. Oil shale is not included as part of the model because the industry has not matured to commercial scale production; therefore, insufficient data are currently available.

The uranium model is similar to the oil and gas model in that it includes both a trip generation/vehicle classification component and a corridor allocation component. However, it is less complex because the mining operations in Colorado are localized, the origins and destinations are known, and the activity on the transportation system is less dispersed than in the oil and gas industry. Coal, the other subject energy source that is mined, is not included as a part of the model because coal is predominantly transported by rail.

The third model is for renewable energy, including wind, solar, and biofuels. This model is considerably more simplistic than the oil and gas or uranium models; it provides trip generation and vehicle classification information, but does not go to the extent of allocating travel demands to specific corridors. These industries are in their formative stages and Colorado has not seen heavy renewable energy development to date. In addition, it is difficult to predict the exact location of future renewable energy development as several environmental and market factors need to align to ensure efficient and economically viable resource production.

Findings and Recommendations

Comparison of Annual Trip Generation

Trip generation rates contained in the previous section are difficult to compare from one energy source to another since energy source development and production are measured in different units (i.e., a well, a wind turbine, tons of uranium, etc.). The table shown to the right provides estimates of the total number of trips that were generated in 2007 and 2008 by each of the energy sources in Colorado. These estimates are based on information gathered from various sources on the level of production and development that occurred in 2007 and 2008, and on the trip generation rates that have been documented in the research study. These estimates provide a clear comparison of the relative demand between the various energy sources. The annual trips in Colorado generated by the oil and gas industry dwarf the travel demands of the other energy sources. Based on these estimates, the oil and gas trips account for 98.7 percent of total energy trips.

Estimated Annual Trip Generation

Energy Source	2007	2008	Average
Oil & Gas[1]	15,900,000	17,900,000	16,900,000
Uranium	26,000	26,000	26,000
Wind	63,000	5,400	34,200
Solar	200	2,700	1,450
Biofuels	167,000	167,000	167,000
Total	16,156,200	18,101,100	17,128,650

[1] Includes crude oil, natural gas and coalbed methane

Study Recommendations

The trip generation rates and the travel estimation models that have been developed as a part of this research study are intended to be used by CDOT, as well as Metropolitan Planning Organizations, Transportation Planning Regions, municipalities and counties in Colorado, to proactively plan for future energy development and establish ways to address the demands on the transportation system. The following list of recommendations is intended to provide CDOT direction on areas in which to focus to most efficiently plan for future energy development in Colorado.

Policy Recommendations

- Since the oil and gas travel demands account for the vast majority of the energy demands to the state highway system, CDOT should focus its planning efforts on oil and gas development.

- The project team experienced some hesitation from the energy sector (particularly from the oil and gas industry) in sharing information for this research study. CDOT should continue to build and improve relationships with the energy development industry and pursue opportunities for partnership with the energy sector.

- Build partnerships with resource and regulatory agencies to ensure that CDOT's interests (i.e., demands to the transportation system) are considered and adequately addressed in any environmental studies pertaining to the energy industry and that CDOT is alerted of any potential issues.

- With respect to future wind power development, CDOT should take a statewide perspective in identifying the best routes for transporting the oversized loads that comprise the wind turbines. For routing through specific municipalities or counties, CDOT should defer to the local governments' knowledge of the best routes order to minimize delays and the need for temporary removal of signal equipment.

- To continue improving safety at highway/rail crossings, maintain relationships with the Public Utilities Commission (PUC) and the railroads to improve the safety at existing at-grade railroad crossings and to provide grade separated crossings, particularly along railroad lines that are heavy used by the coal industry.

Model & Corridor Improvement Recommendations

- A baseline comparison of travel demands by corridor is provided in the research study document. This comparison can be used both as a measure for prioritizing corridors in the long range regional and statewide transportation plans and as a basis with which to compare future conditions.

- The travel estimation models should be used to estimate the level of energy-related activity on key corridors in the state. CDOT staff should update the models in advance of the regional and statewide transportation planning processes so that up to date corridor travel estimations can be incorporated into the planning process.

- Efforts to validate the travel estimation models in the future based on actual traffic and energy development data will help to ensure the long term utility of the models.

- The research study identifies potential corridor improvements for each of the key energy development corridors in the state. Potential improvements include improving infrastructure (such as surface treatment, bridge repair or replacement); enhancing safety (such as geometric modifications, guardrail, widened shoulders); or improving mobility (such as major widening, auxiliary lanes, passing or climbing lanes).This information should be used as a basis for conducting more detailed corridor studies, and should be incorporated into the next iteration of the long range regional and statewide transportation plans.

I. INTRODUCTION

A. Study Background and Purpose

Colorado has become a destination for energy development in a wide range of energy sectors – coal bed methane, natural gas, oil, oil shale, uranium, coal, wind power, solar power and biofuels. With this activity comes great economic growth benefits, but it is also accompanied by demands on the transportation network. These demands are both direct (transportation demands due to installation, operation and maintenance of production facilities) and indirect (associated growth in population and employment and their related transportation needs).

The primary goal of this study is to understand the relationship between energy development and production and the demands it places on the state's transportation network. Both renewable and nonrenewable energy sources are widely available and are being developed in Colorado. This study considers the transportation demands associated with the following energy sources:

Non-Renewable Energy
- Crude oil
- Natural gas
- Coal bed methane
- Oil Shale
- Uranium
- Coal

Renewable Energy
- Solar
- Wind
- Biofuels

Transportation demands associated with each energy source can vary widely based on the truck trips required during construction, production and reclamation stages of resource development. Heavy and sometimes over-sized vehicles are required to haul equipment to the site, materials and construction equipment are transported to build access roads and prepare the site for energy development, and in some cases the produced energy is transported by truck. In addition, the employees needed to develop a site and perform on-going operations and maintenance tasks have an impact on the transportation system.

For each energy source, this research study provides an overview of the energy development process and a description of the relative demand each energy source has on Colorado's state highway system. Spreadsheet-based travel estimation models have been created to serve as a planning tool in approximating the relative demands of the different energy sources in the various regions of Colorado and on state highways that are key energy development corridors. These models are not intended to evaluate impacts associated with a particular energy development site; rather they are intended to be used to gain an understanding of the relative magnitude of the transportation demands associated with the various energy development sectors in Colorado.

B. Study Process

The study process was guided by a Project Management Team, comprised of key staff from the CDOT Division of Transportation Development and the consulting team. The Project Management Team met regularly throughout the process to discuss the outcome of the various tasks and to collaborate on how to best proceed in this unique study.

The CDOT Working Group also played a critical role in the study process. The Working Group consisted of CDOT staff from a variety of departments and from the three engineering regions that are most heavily impacted by energy development. The Working Group met at three key times during the study process to provide input and direction to the project team. The group met initially to discuss the findings of the initial research efforts and to discuss the methodology for the study. The second meeting involved a detailed presentation of the travel estimation model, and the Working Group was asked to provide comments on the assumptions included in the model. The final meeting involved a presentation of the draft report and the final models. The Working Group included representatives from the following entities within CDOT:

- Statewide Planning Unit
- MPO and Rural Planning Liaison Unit
- Pavement Management Program
- Commercial Vehicle Permits Office
- Mobility Analysis Unit
- Region 3 Planning and Environmental
- Region 4 Planning and Environmental
- Region 5 Planning and Environmental

The study began with a literature review to ascertain what level of information is readily available linking energy development with transportation demands. The literature review focused primarily on Colorado impact studies and data, but also drew information from other neighboring states with similar energy sources and extraction techniques and where methodologies for quantifying energy–related transportation demands have been established.

The next task was to conduct a series of interviews with knowledgeable representatives from the energy industry, associated energy professional organizations, state regulatory agencies and local communities to gather additional information on industry operations, current and projected production levels, and the degree to which each energy sector uses Colorado state highways.

The original scope of work for this study included obtaining energy development forecasts, which were to be used as input to estimate future demands on the state's transportation system using a model developed by the project team. Through key person interviews, it became clear that, given the uncertainties in the economy, projections of future energy development, particularly in the oil and gas industry, are not available. For this reason, the Project Management Team opted to change course and, rather than tying the model to specific energy development projection levels, develop a model to serve as a tool to evaluate the transportation demands associated with given input values that might be developed at some point in time. This approach ensures the long-term utility and flexibility of the model as the energy industry evolves in Colorado.

The Project Management Team also decided that, rather than developing one single model that could be applied to all resources, a series of three models would be a more user-friendly approach. The three models that were developed are as follows:

- Oil and Gas Model (includes crude oil, natural gas, and coal bed methane)
- Uranium Model
- Renewable Energy Model (includes wind, solar, and biofuels)

The models were developed through a peer review process with both the Project Management Team and the CDOT Working Group; both groups provided feedback on the structure of the models and the assumptions used in the models. Potential users of the models include CDOT staff from various departments and regions, Metropolitan Planning Organizations (MPOs), Transportation Planning Regions (TPRs), counties and municipalities within Colorado.

The remainder of this document is divided into separate chapters for each sector of energy: oil and gas, uranium, coal, wind, solar, and biofuels. Within each chapter, an overview of the industry is provided, followed by a discussion of the energy development within Colorado and a description of the transportation activity associated with that particular energy sector. The final section in each chapter provides a discussion of the transportation demands associated with development of the subject resource. The level of detail varies widely for this final section of each chapter.

The chapter on oil and gas provides the most detailed discussion and analysis of the associated transportation demands because 1) the industry is well established and the patterns of travel are much better understood, and 2) the transportation demands of the oil and gas industry in Colorado dwarf those of the other energy sectors. The oil and gas model is the most complex of the three models, and provides a trip generation/vehicle classification component and a corridor allocation component. Potential improvement types to offset the demands of oil and gas development are provided for the key energy development corridors.

It should be noted that the oil and gas model focuses on commercial development of crude oil, natural gas and coal bed methane resources. Commercial oil shale development is not included in the model because the industry has not matured to commercial scale production. While vast oil shale reserves exist in Garfield and Rio Blanco Counties in western Colorado, only small-scale research, development and demonstration projects are currently active. Oil shale development is discussed in more detail in Chapter II.

Because uranium is currently only mined in two counties in Colorado and the quarry material is transported to only two processing facilities in the region, the model developed for uranium is much more simplistic than the oil and gas model. The uranium model includes a trip generation component and a corridor allocation component. The chapter on uranium provides potential improvement types to offset the demands of uranium mining on those corridors that are currently impacted.

The chapters pertaining to solar, wind, and biofuels provide less detail relating to the transportation demands because these industries are in their formative stages and Colorado has not seen heavy renewable energy development to date. In addition, it is difficult to predict the exact location of future renewable energy development as several environmental and market factors need to align to ensure efficient and economically viable resource production. The renewable energy model includes trip generation and vehicle classification, but does not go to the level of allocating the demands to corridors.

Finally, the chapter on coal includes a very general overview of the transportation demands because coal is predominately transported by rail. The impact of coal extraction on the state highway system is limited. Consistent with the scope of work for this study, a model for coal has not been developed.

II. OIL AND GAS

A. *Industry Overview*

In 2008 there were over 38,000 active oil and gas wells in Colorado, which are widely distributed around the state. There are active wells located in two-thirds of Colorado counties – the highest concentrations of wells are located in Weld, Garfield, Yuma, La Plata, Las Animas, and Rio Blanco Counties. The wells in these six counties account for 85 percent of the state's active oil and gas wells. The potential for further energy development in Colorado is considerable; ten of the nation's 100 largest natural gas fields and three of its 100 largest oil fields are found in Colorado. Oil shale deposits in Colorado hold an estimated one trillion barrels of oil – almost as much oil as the world's proven oil reserves.

Literature Review

The project team conducted a literature review in order to gain an understanding of the work that has previously been completed and published relating oil and gas development to transportation activity. The primary purpose of the literature review was to guide in the development of a methodology to correlate energy development with activity on the state's transportation system. The literature review focused on previously completed studies on energy development in the western United States (references are provided in **Appendix B**). Studies ranged from Environmental Impact Statements (EIS) to economic impact studies to Environmental Assessments (EA).

The literature review yielded results on two distinct subjects: 1) transportation activities associated with oil and gas development and 2) levels of direct and indirect employment associated with energy development. From the literature review, it became apparent that transportation demands vary from one well to the next; a consensus has not been established on a single methodology. In addition, the scope of transportation demand estimates varies. Some studies only look at trips directly involved in the construction of a well, while others look at trips transporting construction materials from other states. **Appendix C** provides a summary of each relevant document that was reviewed.

The literature review provides the foundation for establishing a linkage between energy development activity and its associated transportation and employment requirements. The literature review allowed the study team to determine the average number of trips required to drill and complete an oil, gas or CBM well and the annual amount of trips required to operate and maintain a producing well. The tables presented in the next section show data extracted from documents in the literature review that serve as trip multipliers in the travel estimation model.

Key Person Interviews

Knowledgeable representatives from the oil and gas industry, professional trade organizations, local governments, and regulatory agencies have been interviewed to gather additional information on industry operations, current and projected production levels, and the degree to which each energy sector uses Colorado state highways. **Appendix D** provides a listing of each person interviewed and their affiliation and area(s) of expertise, along with documentation of each key person interview.

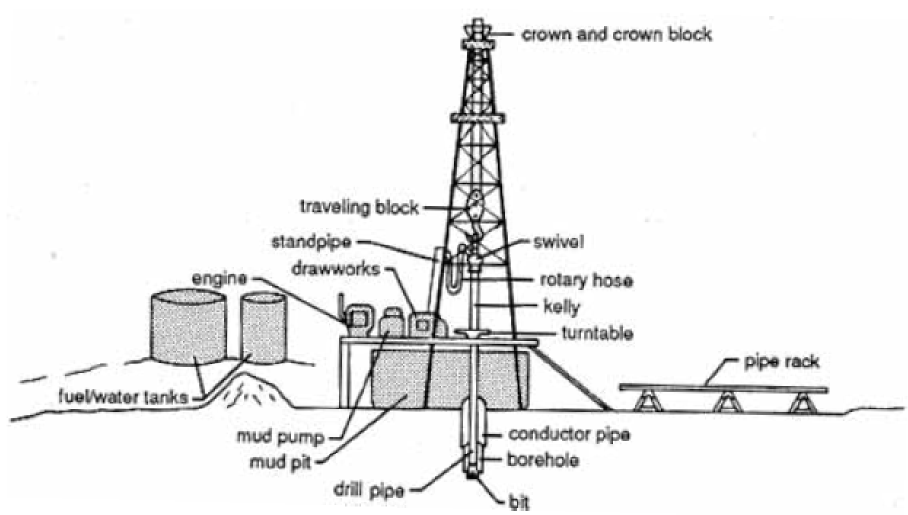
The key person interviews were intended to serve as a sounding board for reactions to what was learned in the literature review. In essence, the project team wanted to have a "reality check" on the trip generation information obtained in the various literature review documents. The project team was easily able to obtain access to government, trade industry and academic representatives, who generally confirmed the trip generation data found in the literature review. The interviewees also confirmed the notion that each well is unique and that the model should contain broad averages of trip generation information. For proprietary reasons, acquiring input from industry representatives proved to be more challenging; information contained in the model is largely sourced from the literature review.

Crude Oil and Natural Gas Extraction Process

Potential productive oil and gas wells undergo a site evaluation process to select a location with an economically attractive quantity of energy. The siting process may include seismic tests, exploratory well drilling or core sample testing to confirm quantity of oil or gas reserves. Once site selection activities have concluded and an acceptable site is chosen, development can begin.

Transportation activity during development, which includes site preparation, drilling, and completion, consists of delivering all well drilling rig equipment and materials, which are often the largest and heaviest loads associated with well development and energy production. Flat bed and trailer semi-trucks typically transport materials (well structures, pumps, well casings). In addition to drilling rig and well materials, large amounts of fresh water are brought to and waste materials are taken from the site throughout construction. During the development phase, transportation demands are substantial due to a short timeframe (generally 30 to 60 days) and a high volume of heavyweight truckloads. **Figure 1** is a diagram of a drilling rig for a typical oil or gas well.

Figure 1. Oil and Gas Drilling Rig Diagram



Source: Oil & Gas Accountability Project, *Oil and Gas at Your Door*

Following the development phase, the production phase begins. An operational well can produce oil or gas for about 10 to 30 years depending on the size of the resource deposit. During the production phase, transportation demands are more predictable and consistent than during the development phase.

Generally, natural gas wells send product to market via surface and subsurface pipelines, which keep transportation demands low. Water is produced as a byproduct along with natural gas and is stored on site and transported from the well periodically to evaporative pits. Evaporative pits are generally located near concentrations of natural gas, or at centralized waste processing facilities. Fracturing techniques are used periodically during the production phase to increase the flow rate of natural gas; these techniques necessitate heavy trucks to be brought to the well site. There are additional trips associated with routine well maintenance that occur at regular intervals throughout the life cycle of a producing natural gas well.

During the production phase, oil wells require tanker trucks to deliver crude oil from the well to refineries. In Colorado there is one oil refinery located in Commerce City, although oil produced in Colorado may be transported to Wyoming for refinement. Depending on productivity of the well multiple trips per day may be needed to deliver the extracted crude oil to refineries. Trips associated with fracturing techniques to stimulate oil production and routine maintenance are also generated by producing oil wells.

Once extraction is complete and no additional oil or gas can be produced, the well enters the third and final phase of development, reclamation. Reclamation activities typically include the deconstruction and removal of equipment, re-grading of used lands, removal of debris and trash, removal of contaminated soils, plugging the well with cement plugs, and re-vegetation. The Colorado Oil and Gas Conservation Commission (COGCC) maintains a series of reclamation regulations for the State of Colorado outlining all measures mandatory in oil and gas well reclamation.

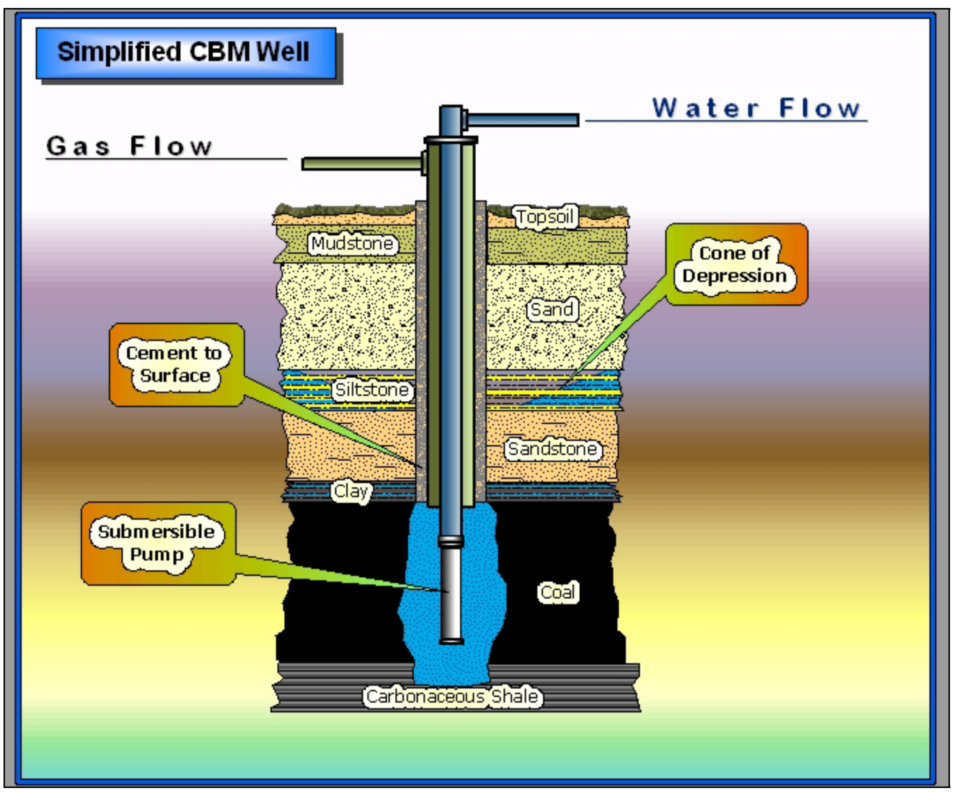
Coal Bed Methane Extraction Process

In underground deposits of coal, coal bed methane (CBM) is often present as a byproduct of the coal formation process. CBM is extracted by building a well using similar techniques to a conventional oil or gas well however, the depths of CBM wells are much shallower than traditional oil and gas wells.

The construction stage of development consists of delivering all the heavy, oversized rig equipment and materials. Flat bed and trailer semi-trucks typically transport materials (well structures, pumps, well casings). During construction, the transportation demands are substantial due to a short construction timeframe and a high volume of heavyweight truckloads.

As the production phase begins, CBM wells commonly use hydraulic fracturing and cavitation (practiced less often). Both techniques use pressure changes generated by pumping water and air into the well with the intention of stimulating gas flow. CBM wells are fractured and/or cavitated periodically throughout their life cycle. The operational well generally produces coal bed methane for about 20 to 30 years. A diagram of a CBM well is provided on **Figure 2**.

Figure 2. Coal Bed Methane Well Diagram



Source: Kenai Peninsula Borough, Oil and Gas Issues, http://www.cookinletoilandgas.org/kpb/issues.htm

Generally, CBM wells send product to a processing facility via surface and subsurface pipelines, which keep transportation demands low. During production, transportation demands are predictable and consistent. Maintenance personnel will visit each well once per day, to ensure proper functioning of the equipment and to haul water byproduct from the well. Trips during production for CBM are more frequent than natural gas and roughly the same as oil production because of the abundance of water byproduct.

Once production is complete and no additional CBM can be extracted, the well enters the third and final phase of development, reclamation. Similar to oil and gas, CBM reclamation activities typically include the deconstruction and removal of equipment, removal of debris and trash, removal of contaminated soils, and re-vegetation.

Oil Shale Extraction Process

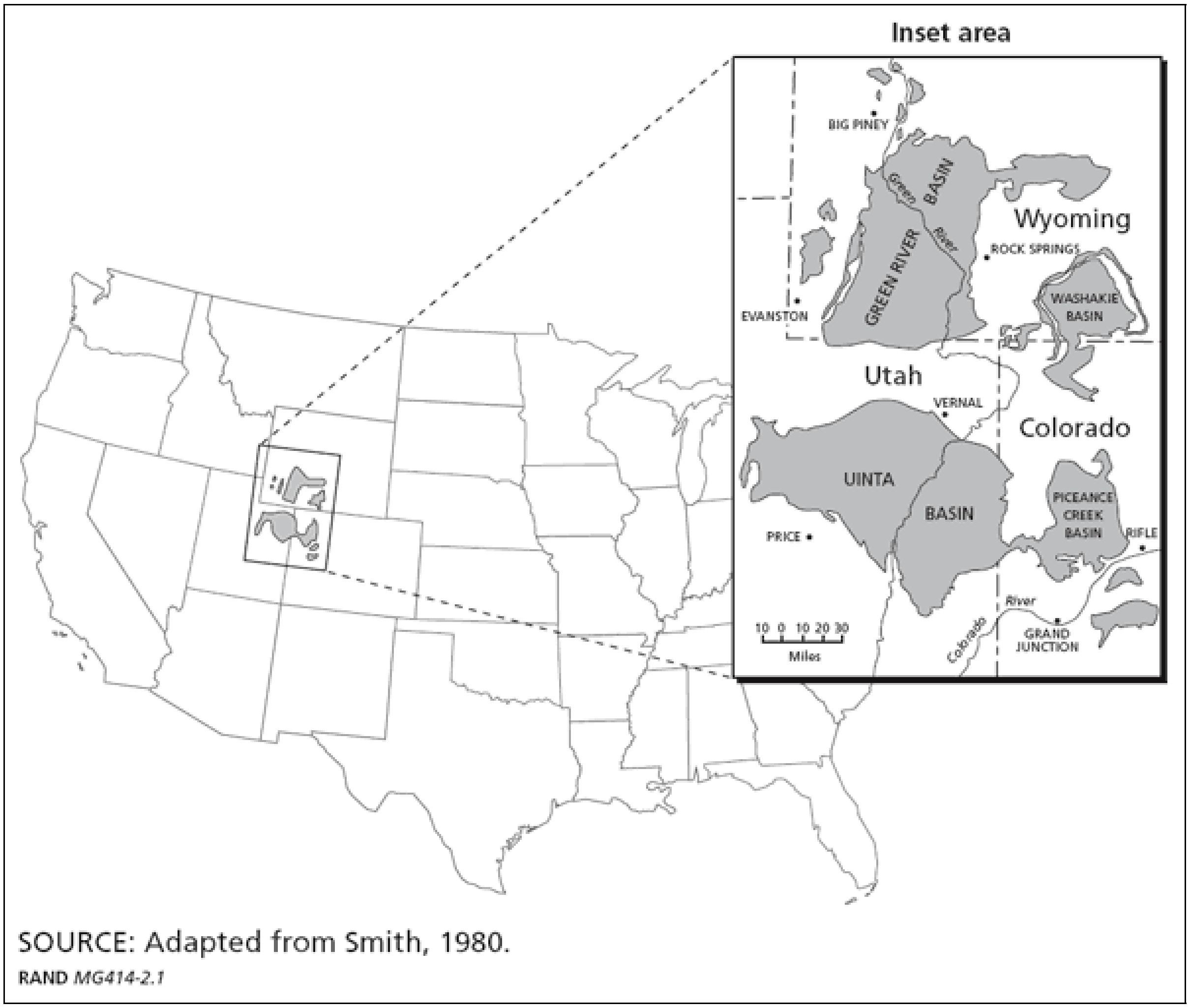
The term oil shale refers to any rock that contains solid bituminous materials that release as petroleum when heated. Oil shale was formed millions of years ago by deposition of silt and organic debris on lake beds and sea bottoms. Over long periods of time, heat and pressure transformed the materials into oil shale in a process similar to the process that forms oil; however, the heat and pressure were not as great. Oil shale generally contains enough oil that it will burn without any additional processing.

Oil shale can be extracted and processed to generate oil similar to oil pumped from conventional oil wells; however, the extraction and processing is more complex than conventional oil recovery and currently is significantly more expensive. The oil substances in oil shale are solid and cannot be pumped directly out of the ground. The oil shale must first be mined and then heated to a high temperature (a process called retorting); the resultant liquid must then be separated and collected. An alternative, but currently experimental, process referred to as in situ retorting involves heating the oil shale while it is still underground, and then pumping the resulting liquid to the surface.

The largest deposits of oil shale in the world are found in the United States in the Green River Formation, which covers portions of Colorado, Utah, and Wyoming. Estimates of the oil resource in place within the Green River Formation range from 1.2 to 1.8 trillion barrels. Not all resources in place are recoverable; however, even a moderate estimate of 800 billion barrels of recoverable oil from oil shale in the Green River Formation is three times greater than the proven oil reserves of Saudi Arabia. **Figure 3** shows the location of oil shale resources in the Green River Formation. (Oil Shale & Tar Sands Programmatic EIS Information Center, http://ostseis.anl.gov/guide/oilshale/index.cfm).

More than 70 percent of the total oil shale acreage in the Green River Formation, including the most attractive commercial oil shale deposits, is under federally owned and managed lands. Thus, the federal government directly controls access to the most commercially attractive portions of the oil shale resource base.

Figure 3. Green River Formation Oil Shale



Source: RAND Corporation, adapted from Smith, J. W., *"Oil Shale Resources of the United States,"* Mineral and Energy Resources, Vol. 23, No. 6, Colorado School of Mines, 1980.

In December 2007, the Bureau of Land Management (BLM) issued its Draft Programmatic EIS (PEIS) for resource management plan amendments to allow for leasing lands for commercial oil shale and tar sands development in Colorado, Utah and Wyoming. The PEIS concluded that the BLM did not have, at this time:

> *"adequate information on the (1) magnitude of commercial development and pace of that development, (2) potential locations of commercial leases, (3) technologies that will be employed, (4) size or production level of individual commercial projects, and (5) development time lines for individual projects to support decisions about lease issuance."*

The BLM has since issued five research, development and demonstration (RD&D) leases on lands in Rio Blanco County to Shell Frontier Oil and Gas (three separate leases), Chevron Shale Oil Company and EGL Resources Inc. (BLM Oil Shale PEIS, pages 1-9 and 1-10). All three companies are using these leases to further investigate in situ processes for extracting and recovering oil shale. Information from the BLM's PEIS indicates that the RD&D programs will have a fairly modest effect on local economic and transportation conditions, as these projects are small-scale models of potential commercial processes.

The prospects for development of a commercial oil shale industry in Colorado during the foreseeable future may depend on at least three critical factors:

- Growth or decline in world oil production and reserves from conventional sources and existing unconventional resources;
- Changes in world oil demand, including both growth in demand in developing economies and potential reductions in demand in developed economies due to higher prices; and
- Whether or not the current RD&D projects can identify ways to overcome significant technical, economic and environmental challenges.

Commercial scale oil shale development will undoubtedly add traffic to the state highway system that already must accommodate conventional oil and gas related traffic. The major source of information on the transportation demands of commercial oil shale production, the BLM's Oil Shale and Tar Sands PEIS, states that the "amount of heavy vehicles associated with oil shale is not large compared with the amount of light vehicles transporting employees; however, they would add to the congestion and may require special consideration when designing or upgrading access roads and highways." The PEIS does not specifically estimate transportation activity associated with oil shale production, processing or facility construction.

The PEIS mentions that oil shale facilities would undergo a temporary but massive construction phase, but after facilities are constructed transportation demands would mainly be caused by employees commuting to work at the facilities. In all development alternatives considered in the PEIS, oil shale would be processed on site and transported via pipeline for further processing at regional oil refineries.

The potential for commercial scale oil shale production in Colorado is highly uncertain at the time of publication of this report. The commodity price of crude oil has fallen from historical highs in recent years, further clouding the future of commercial oil shale production in Colorado. The only document published to date that studies impacts of commercial oil shale development is the BLM PEIS, which offers only vague descriptions of transportation demands associated with the in situ technologies currently being tested in the Piceance Basin. As a result of the dearth of available data, the project team elected not to create a model for oil shale transportation demands. It is recommended that CDOT become involved in the review of any future EISs associated with oil shale and that a model be developed once more is learned about the experimental technologies currently being tested as they potentially mature from the RD&D phase.

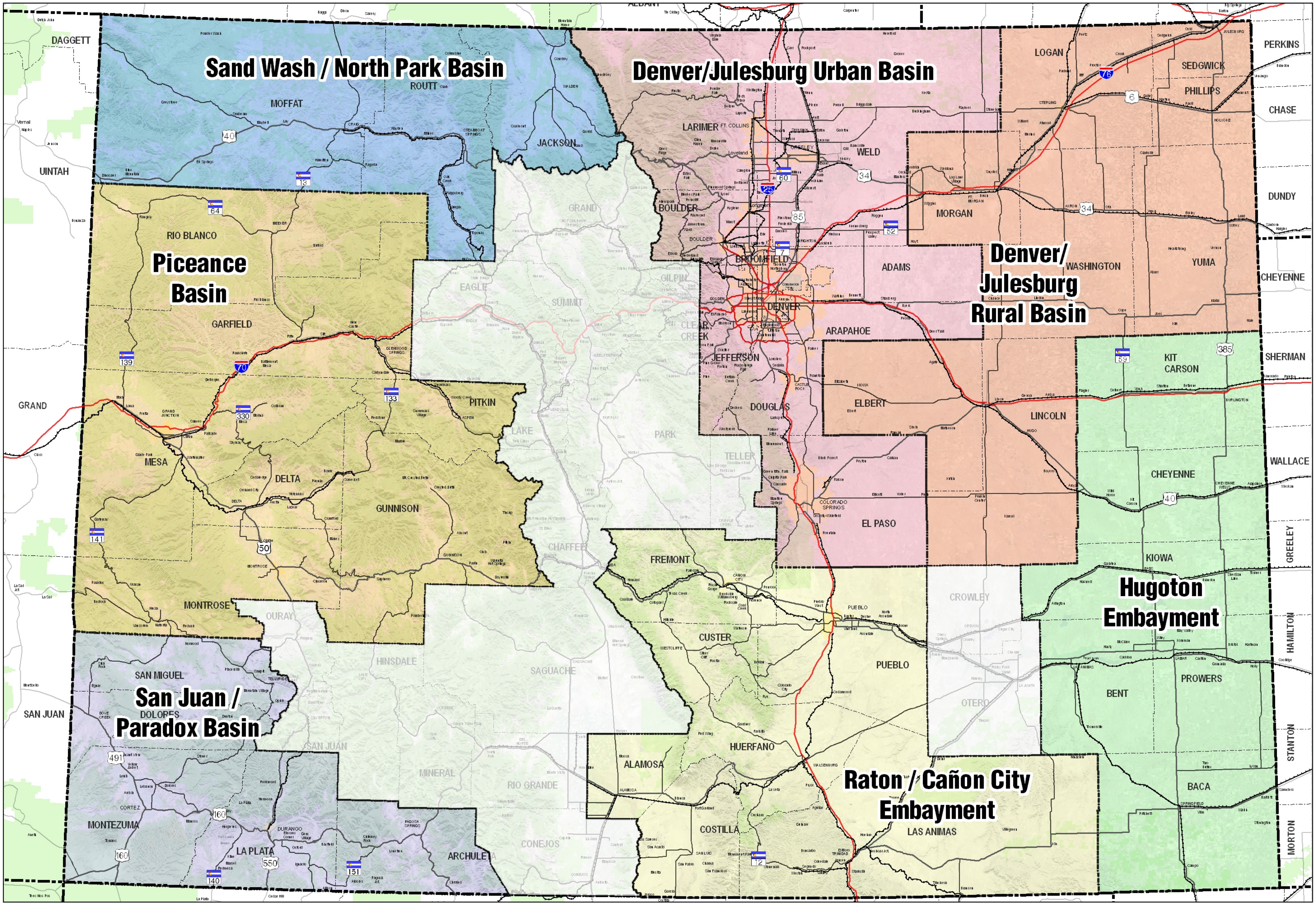
B. Resource Development in Colorado

The Colorado Energy Research Institute defines economic study areas associated with the different oil and gas basins in Colorado in their 2007 *Oil and Gas Economic Impact Analysis*. These seven economic basins, as depicted on **Figure 4**, have been used as the basis for dividing the state into manageable geographic regions in assessing the transportation demands of oil and gas development. All active wells in Colorado exist within these seven basins.

The Piceance and Denver/Julesburg basins contain most of the oil and gas activity in Colorado. The Piceance basin covers Garfield, Rio Blanco, Mesa and Moffat counties. Oil and gas activity in the Denver/Julesburg basin primarily occurs in Weld, Adams, Arapahoe, Boulder and Yuma counties, although there is activity in some other nearby counties. CBM is generally found in Colorado in the Denver/Julesburg Basin (central), Raton Basin (south central), San Juan Basin (southwest) and the Piceance Basin (west). Oil, gas and CBM activity in the aforementioned regions account for over 95 percent of all statewide activity. Oil shale deposits are primarily located in the Piceance Basin.

In addition to oil, gas, CBM and oil shale, there are deposits of carbon dioxide that are being developed in Montezuma County for use in oil field stimulation. The gas is extracted using a similar process to conventional oil and gas development and is transported by pipeline from southwestern Colorado through New Mexico to west Texas. There are currently fewer than 100 wells in operation in Montezuma County (Source: Colorado Oil and Gas Conservation Commission). Carbon dioxide extraction represents less than one percent of statewide energy development activity and is not included in the travel estimation model due to its relative size.

Oil and gas wells in Colorado have grown substantially in recent years. Over the past five years, there were over 12,000 wells constructed in Colorado, increasing the number of active wells in Colorado to move than 38,000 in 2008 (Source: Colorado Oil and Gas Conservation Commission). **Figure 5** shows the currently active oil and gas wells, along with the locations where drilling permits were obtained in 2008. As shown in **Table 1**, the Denver/Julesburg Urban Basin and the Piceance Basin have both the greatest number of active wells and the highest number of 2008 permits. More specifically, the greatest numbers of permits were added in Weld and Garfield Counties. Of the active wells in Colorado, approximately 60 percent of the wells are natural gas wells, 25 percent are crude oil wells, 12 percent are coal bed methane wells, less than one percent are carbon dioxide wells, and the type of well is unknown for the remaining 2.5 percent of the wells (Source: Colorado Oil and Gas Conservation Commission).



LEGEND

- Denver Julesburg (Rural)
- Denver Julesburg (Urban)
- Hugoton Embayment
- Piceance Basin
- Raton / Canon City Embayment
- San Juan / Paradox Basin
- Sand Wash / North Park Basin

25 years FELSBURG HOLT & ULLEVIG

N W E S

0 40 Miles

Figure 4

Economic Basins

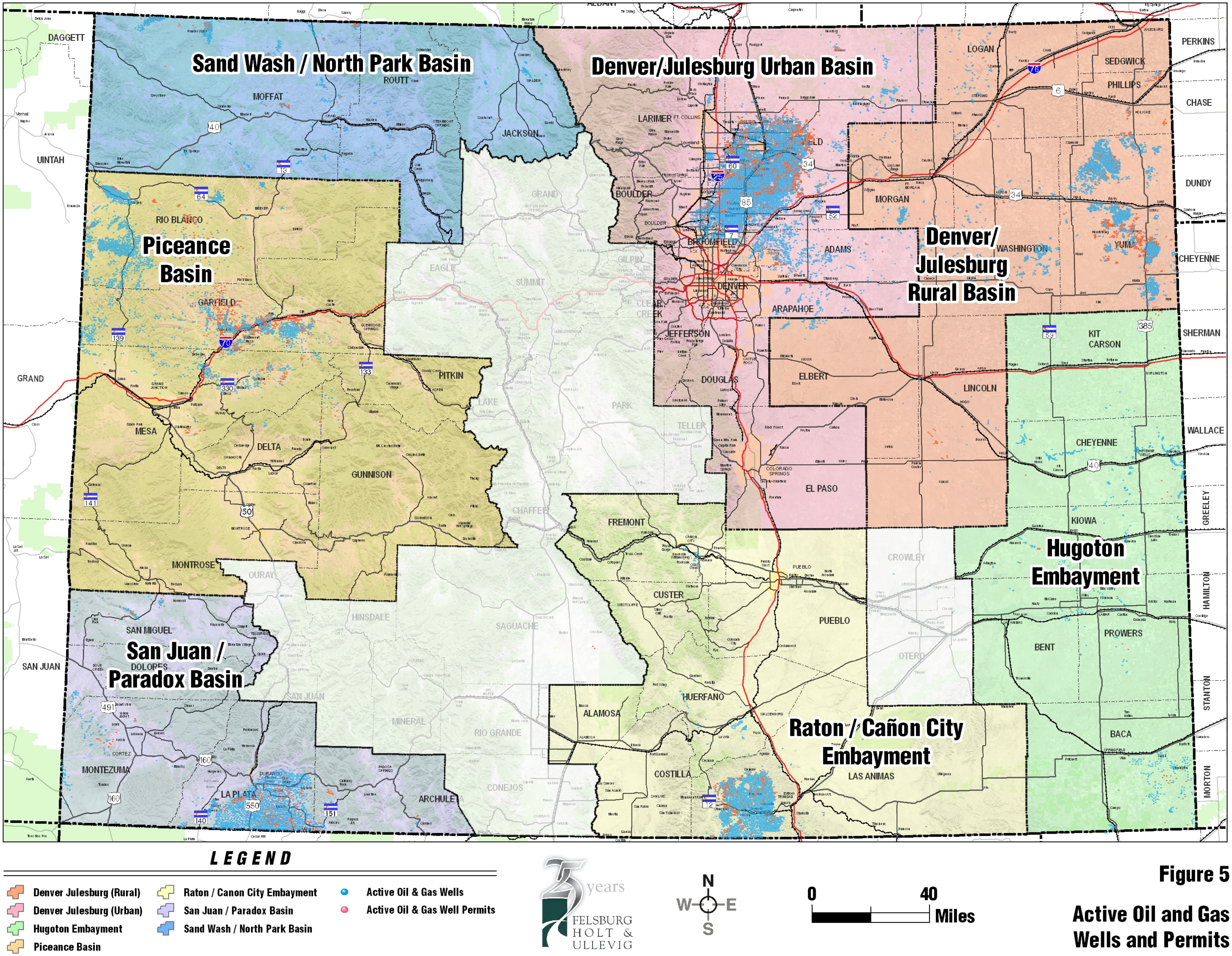


Figure 5

Active Oil and Gas Wells and Permits

Table 1. 2008 Active Oil and Gas Wells and Permits by Basin

Basin	Active Wells		2008 Permits	
	Number	Percent of Statewide Total	Number	Percent of Statewide Total
Denver/Julesburg Urban Basin	14,482	37.9%	1,595	25.7%
Denver/Julesburg Rural Basin	4,105	10.8%	548	8.8%
Piceance Basin	12,027	31.5%	3,281	52.9%
Sand Wash/North Park Basin	706	1.8%	77	1.2%
Raton/Canon City Embayment	2,848	7.5%	290	4.7%
San Juan/Paradox Basin	3,261	8.5%	354	5.7%
Hugoton Embayment	753	2.0%	60	1.0%
Total	**38,182**	**100%**	**6,205**	**100%**

Source: Colorado Oil and Gas Conservation Commission

C. Transportation Demands of Resource Development

A travel estimation model has been developed to help estimate the relative order of magnitude of the transportation activity associated with crude oil, natural gas, and coal bed methane development. The model is a planning tool that can be used by CDOT or others to gain an understanding of the relative demands that might be experienced in various regions of the state and on various state highway corridors based on a future energy development scenario. The information contained in the following sections has been used in developing the model; a detailed user's guide is included in **Appendix F**.

Trip Generation

The oil and gas travel estimation model uses trip generation rates per well to estimate the amount of transportation activity associated with the three phases of oil, gas and CBM development described in the industry overview. Each stage varies in intensity of associated transportation demands.

During the development phase, which typically occurs over a 30-60 day period, heavy equipment is transported to the well site to build access roads, construct a well pad and transport a drilling rig. The trip generation figures in **Tables 2 through 4** present development phase transportation demands as a one-time occurrence. For the purpose of the model, it is assumed that each well that commences development in a given year will complete development during that same year.

Production phase trip volumes provided in **Tables 2 through 4** are presented on an annual basis. These trips are associated with routine well monitoring and maintenance and periodic trips associated with well stimulation and removal of produced water. As mentioned in the industry overview, a typical well has an expected lifespan of 10-30 years depending on the resource type and mineral deposit size.

After a well exhausts the underground resource supply, it enters the reclamation process. Trips associated with reclamation include deconstruction of the physical well assembly and access roads and restoration of the site with native vegetation. None of the documents in the literature review provided trip information on site reclamation. As a result, trip figures for access road and well pad construction are used as a proxy for reclamation trip generation. Similar to the development phase, trips associated with the reclamation phase are one-time occurrences that, for the purpose of the model, are assumed to begin and end in the same year.

Tables 2, 3 and 4 show the trip generation rates by resource type and development phase used in the travel estimation model. The trip generation rates for crude oil and CBM are limited to one source; five data sources are listed for natural gas along with the average trip generation rates. The trip generation rates include the direct trips associated with resource development, production and reclamation including employee trips. All figures are expressed in terms of trips (i.e., one round trip equals two trips).

Table 2. Crude Oil Trip Generation Rates

Phase	Average Trips per Well (Bear Canon EA)
Development[1]	1,710
Production (annual)	974
Reclamation[2]	250

1 Development phase includes site preparation, drilling and completion and typically occurs over a 30-60 day period.
2 No data available for reclamation activities; assumed to be the same as site preparation and likely occurs over a one-week period.

Table 3. Natural Gas Trip Generation Rates

Phase	Trips per Well from Various Sources					Average Trips per Well
	UDOT	Jonah Infill EIS	Moxa Arch EIS	Roan Plateau EIS	ExxonMobil Piceance Basin	
Development[1]	2,100	1,700	886	2,075	1,846	**1,721**
Production (annual)	182	100	4	157	-	**111**
Reclamation[2]	120	40	42	88	-	**73**

1 Development phase includes site preparation, drilling and completion and typically occurs over a 30-60 day period.
2 No data available for reclamation activities; assumed to be the same as site preparation and likely occurs over a one-week period.

Table 4. Coal Bed Methane Trip Generation Rates

Phase	Average Trips per Well (San Juan EIS)
Development[1]	684
Production (annual)	742
Reclamation[2]	146

1 Development phase includes site preparation, drilling and completion and typically occurs over a 30-60 day period.
2 No data available for reclamation activities; assumed to be the same as site preparation and likely occurs over a one-week period.

The trip generation rates in the preceding tables vary by resource type. In the development phase, there are more trips required to drill for natural gas and oil because the mineral deposits are generally deeper underground than CBM. As a result there needs to be more well casings delivered to the well pad, more employee trips, and more water and waste transport during the longer drilling period.

There are also differences during the production phase. In general, CBM production frees deposits of water that are frequently present in the underground formation. The water byproduct, called "produced water" is collected in large on-site storage tanks that must be emptied often. Although there is also produced water that accompanies natural gas, it is significantly more abundant in CBM formations.

During oil production, tanker trucks visit well pads to transport crude oil to refineries. In Colorado, CBM and natural gas are often transported via pipeline to central collection and processing facilities before moving out of the region via pipeline to market. Natural gas storage facilities are generally located along the I-70 corridor in Mesa County, and in the eastern plains (three storage facilities are located in Morgan County, one in Arapahoe County, one in Jefferson County, and one in Baca County). There are three natural gas processing plants in Colorado, all of which are located in Weld County.

In general, natural gas and oil have more intensive trip generation during the development phase than CBM. During the production phase, oil and CBM require more trips than natural gas on an annual basis. The EIS documents allude to daily trips to each oil and CBM well during the production phase for oil or water hauling, respectively.

Vehicle Classification

Several of the documents reviewed during the literature search provide information on the type of vehicles used during the various phases of oil and gas development and production. The data varied substantially from one source to another. In order to provide an estimate of the type of vehicles accessing the wells, an average of the vehicle classification distribution from the various sources was calculated, and the results are shown on **Table 5**. For the purpose of this study, heavy trucks are defined as those with five or more axles. The light vehicles/pick ups are defined as any two-axle vehicles including passenger cars. Medium trucks are any trucks that fall in between those two categories.

Table 5. Estimated Vehicle Classification by Phase (Oil and Gas)

Vehicle Classification[1]	Phase		
	Development[2]	Production	Reclamation[3]
Heavy Trucks	25%	5%	25%
Medium Trucks	50%	15%	50%
Light Vehicles/Pick Ups	25%	80%	25%
Total	**100%**	**100%**	**100%**

[1] Sources: La Plata County Oil and Gas Impact Report, UDOT, Jonah Infill EIS, and Roan Plateau RMPA and EIS
[2] Development phase includes site preparation, drilling and completion
[3] No data available for reclamation activities; assumed to be the same as site preparation

During the site preparation, drilling and well completion, approximately 75 percent of the total trips to and from the wells are trucks. The heavy vehicles transport gravel, bull dozers, well casing, piping material, drilling rigs and frac units. Medium trucks transport water, sand, mud, and fuel. Vehicle classification information is not provided for the reclamation phase in any of the documents; the distribution of vehicle types has been assumed to be the same as the development phase.

The production phase has a much higher component of light vehicles; this includes general well maintenance. The medium trucks during the production phase include water trucks to remove water that has been contaminated with hydrocarbons and must be trucked to an approved disposal site. Heavy vehicles during the production phase can include workover rigs and oil tankers.

Employment

The oil and gas travel estimation model estimates the direct and indirect employment associated with oil, gas and CBM development in the seven economic basins shown on **Figure 4**. The project team used sources identified in the literature review for data on the employment requirements for the industry. Direct employment is defined as workers who are employed directly by the oil, gas and CBM industry. Indirect employment is defined as general workers in support industry sectors that include oil and gas raw material supply, retail, hospitality, personal services and other sectors of the economy that grow along with a region's general population growth. The energy development industry is considered a base industry that attracts investment and workers to a region. Indirect employment growth is dependent on growth of base industries.

Direct Employment

In reviewing the available data in the literature review, employment was divided into two classes in most data sources: well development and resource production. This worker classification fit well with the trip classification methodology and allowed employment impacts to be calculated at different rates for development and production phases.

The sources in the literature review varied somewhat and had different definitions of employment. Ultimately, the project team opted to use one source to derive the employment impacts, the Colorado Energy Research Institute's (CERI) Oil and Gas Economic Impact Analysis, because it provides a statewide accounting of well development, well production and associated employment activity. An average direct employment rate of 2.85 employees per well during the well development phase has been calculated using 2005 data contained in the CERI report. The employment component of the oil and gas travel estimation model uses this statewide direct employment per well drilled figure (2.85 employees per well drilled) to calculate direct well development employment.

The other component of industry employment is well production and maintenance employment, which is calculated using the same source and methodology as described above. An average direct employment rate of 0.077 employees per well during the production phase has been calculated and utilized in the oil and gas travel estimation model.

Indirect Employment

Indirect employment is typically calculated using multipliers, which are applied to direct employment, as indirect employment is dependent on the amount of direct employment. The project team used multipliers obtained from the Colorado Energy Research Institute's Oil and Gas Economic Impact Analysis, which provides indirect employment multipliers by economic basin. In general, urban basins have higher indirect employment multipliers because urban areas have more complete economies, which provide a wider array of support industries. In rural basins the indirect employment impacts leak out of the basin to other more urban areas. **Table 6** shows the indirect employment multipliers used in the travel estimation model.

Table 6. Indirect Employment Multipliers

Basin	Indirect Employment Multiplier
Denver/Julesburg Urban Basin	2.00
Denver/Julesburg Rural Basin	1.35
Piceance Basin	1.64
Sand Wash/North Park Basin	1.64[1]
Raton/Canon City	1.40
San Juan/Paradox	2.40
Hugoton	1.35[1]

Source: Colorado Energy Research Institute, Oil & Gas Economic Impact Analysis, 2007.
[1] Estimated by project team using nearby basin multipliers.

The source document detailed indirect employment multipliers for most economic basins. The project team used proxy multipliers for the Sand Wash/North Park and Hugoton Basins. For the Hugoton Basin, the same multiplier as the nearby Denver/Julesburg Rural Basin was used. The Piceance Basin multiplier is used as a proxy multiplier for the Sand Wash/North Park Basin. The basins were chosen because they are close geographically and show similar urbanization patterns and economic characteristics.

Key Energy Development Corridors

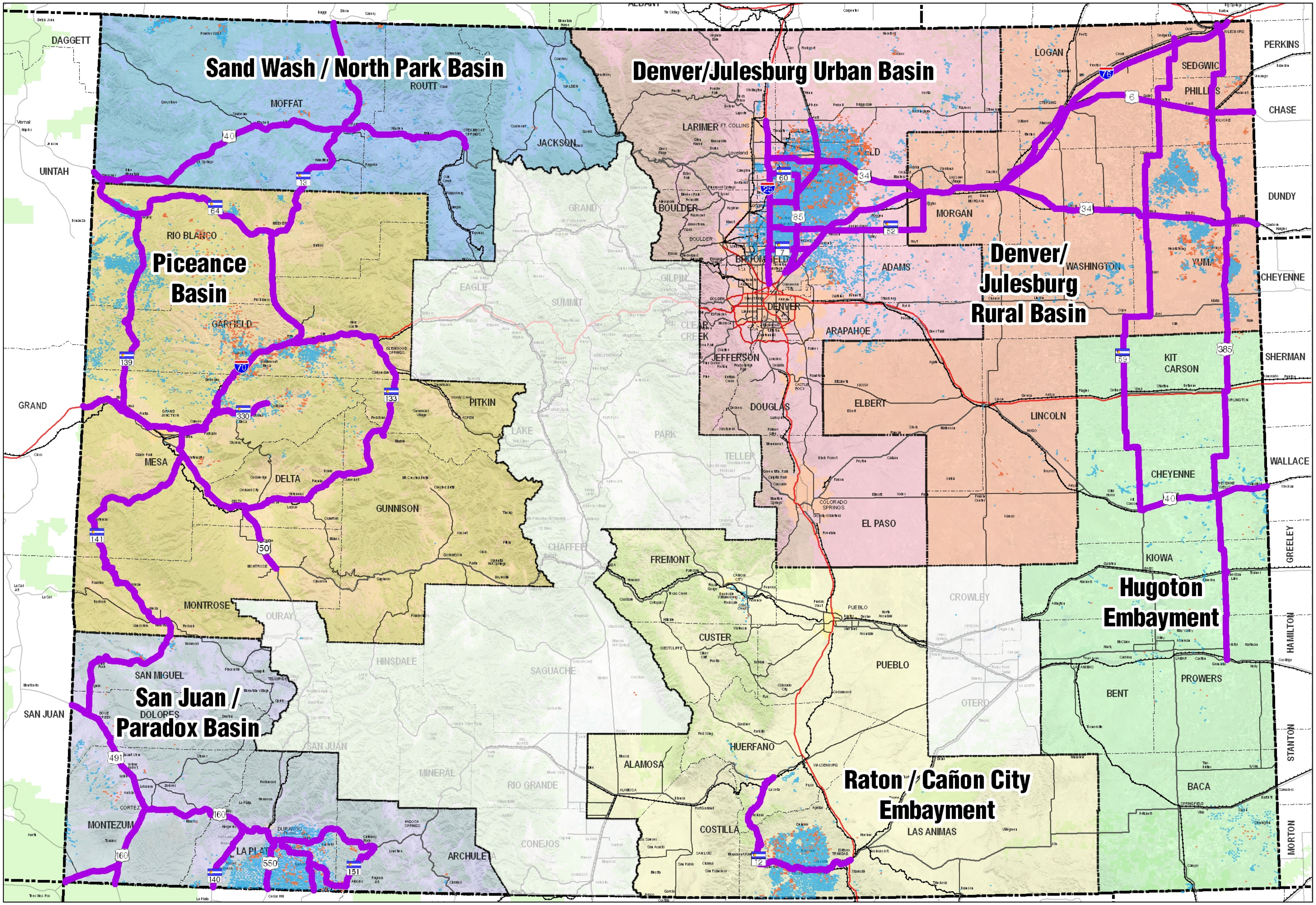
The 2035 Statewide Plan identifies corridors throughout the state that are "heavily impacted by energy development." These corridors were identified by the Metropolitan Planning Organizations (MPOs) and Transportation Planning Regions (TPRs); the process for selecting such corridors varied from one region to the next. The corridors identified in the Statewide Plan were used as a starting point and were refined, with input from the Working Group, to eliminate gaps and illogical breakpoints. A screening was also done to verify that the key energy development corridors do indeed have an above average percentage of truck traffic and/or a considerable number of wells in close proximity. A few corridors were removed because they did not meet these criteria. Other corridors have been added because they were specifically identified in one or more of the various studies reviewed during the literature search. The resulting key energy development corridors associated with the oil and gas industry are shown on **Figure 6**. The corridors have been segmented at the economic basin boundaries, for a total of 39 key energy development corridors for the oil and gas industry.

Model Development

The oil and gas travel estimation model is a Microsoft Excel spreadsheet model that uses oil and gas development input values and estimates the relative demand on select state highway corridors. Rather than tying the model to specific energy development projections, the model serves as a planning tool to evaluate the transportation demands associated with given input values. The model has been created to allow for testing future scenarios, and can be easily updated to reflect the characteristics of specific energy development projects.

The diagram shown on **Figure 7** provides a graphic outline of the model inputs, factors, and outputs. The model is divided into two discrete modules: a trip generation module, and a corridor allocation module. The purpose of the trip generation module is to estimate the number of annual trips in each of the seven economic basins in the state (refer to **Figure 4**) based on a set of input values including the energy source, the level of development, the location (basin), and the timing of development. The trip generation module also outputs the mix of vehicles for each development phase. The energy development phases include: development (site preparation, drilling and completion), production (operation and maintenance), and reclamation (well retirement).

The model uses employment and trip generation figures based on today's prevailing drilling and production technology. There are many reasons to believe that technological gains will continue, most notably advances in directional drilling and more efficient drilling rigs have lessened the transportation demands associated with oil, gas and CBM development. It is important to note that the model is based on a snapshot of the relationships between energy activity and associated employment and transportation demand as they exist today. It is possible, and perhaps likely, that these relationships will change in the future. The model has been developed in a way that the trip generation rates could easily be adjusted to reflect changes in drilling and production technology.



LEGEND

- Denver Julesburg (Rural)
- Denver Julesburg (Urban)
- Hugoton Embayment
- Piceance Basin
- Raton / Canon City Embayment
- San Juan / Paradox Basin
- Sand Wash / North Park Basin
- Heavily Impacted Corridors
- Active Oil & Gas Wells
- Active Oil & Gas Well Permits

25 years FELSBURG HOLT & ULLEVIG

Figure 6

Key Energy Development Corridors - Oil & Gas

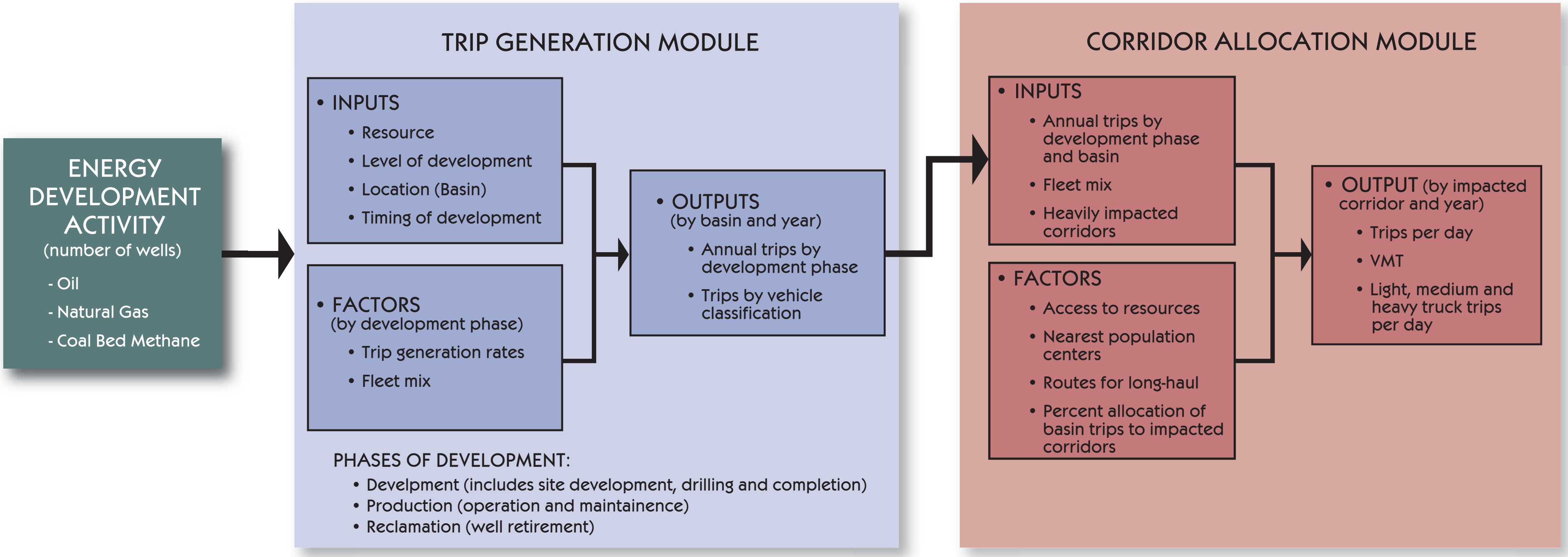


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Figure 7
Oil and Gas Model Diagram

Trip Generation and Vehicle Classification

The trip generation module allows the user to input current producing wells and expected future well development. The user also inputs a well retirement rate, which represents the annual rate at which wells are retired from production and are plugged and reclaimed. Different trip generation rates are applied to the wells in each phase of their life cycle; the model can estimate well development and production over long periods of time. The trip generation module also estimates the employment directly and indirectly associated with oil, gas and CBM development.

The trip generation module calculates annual trips associated with well development, production and reclamation and presents results by economic basin. Within each economic basin, annual trips are presented by life cycle phase and by type of vehicle (heavy trucks, medium trucks, and light vehicles).

Corridor Allocation

The second module of the model, the corridor allocation module, uses the outputs from the trip generation/vehicle classification module and assigns the energy development trip estimates to the state highways in Colorado that have been identified as key energy development corridors (refer to **Figure 6**). The allocation to the key energy development corridors is based on access to energy sources, the location of the nearest population centers (cities and towns from which employee and short-haul trips will likely originate), the availability of alternate routes and likely routes for long-haul trips. The final outputs from the model are provided for each of the key energy development corridors and include annual trips, annual vehicle miles of travel (VMT), the distribution of light vehicles, medium and heavy truck trips, truck percentage, and annual truck VMT. A flow chart describing the process utilized to estimate the demands by corridor is shown on **Figure 8**.

Each of the seven basins has been subdivided into sub-basins for the purpose of allocating the demands to the corridors. A sub-basin is an area defined as a group of wells/well permits that are likely to have common travel patterns. **Appendix E** includes a map of each basin showing the sub-basins, the active oil and gas wells, and the 2008 oil and gas permits. A key assumption in the corridor allocation module is that future oil and gas development will follow a similar development pattern as that represented by the 2008 permits. If a future development pattern, or a scenario to be tested, does not follow current patterns, the model has been built to be easily modified. Scaled symbols representing the relative size of the population bases within each basin are also shown on the maps in **Appendix E**. The size of the population centers was used to develop a quasi gravity model for each sub-basin. That is, short-haul trips to a sub-basin are more likely to originate from population centers that are closer and with higher relative populations (and therefore have more resources; both material and employees).

Other trips, particularly during the development phase, are long-haul trips in which materials such as piping infrastructure, drill stems, well heads, well casing and pumpjacks are brought into Colorado from out of state. In some cases, long-haul trips from one basin impact one or more corridor in other basins. This effect has been accounted for in the model for long-haul trips on I-70 on the Western Slope, I-76 in northeastern Colorado, as well as for long-haul trips destined to I-80 in Wyoming.

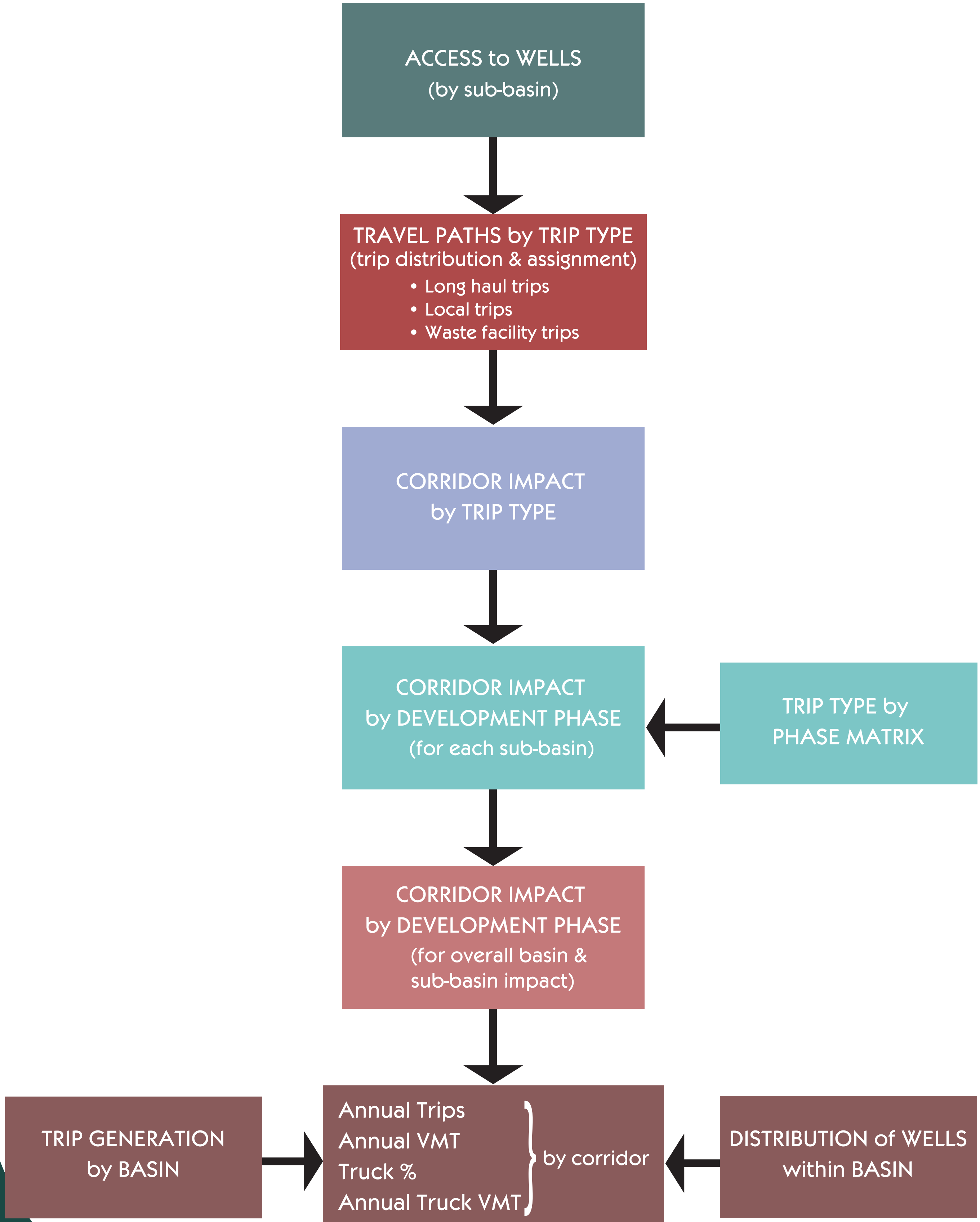


Figure 8
Corridor Allocation Flow Chart
Oil and Gas Model

FELSBURG HOLT & ULLEVIG

The model includes a matrix of trip type by phase that is used to assign trips to either the local area (for short-haul trips) or to the interstate system for long-haul trips. **Table 7** shows the trip type matrix that has been included in the model. Although no specific information about the trip types was revealed during the literature review, the estimates shown in the table were inferred from the various documents and from interviews with oil and gas industry representatives.

Table 7. Estimated Trip Types by Development Phase

Trip Type	Development[1]	Production	Reclamation
Long-haul Trips[2]	25%	5%	5%
Local Trips[3]	60%	90%	95%
Waste Management Facility Trips	15%	5%	0%
Total	**100%**	**100%**	**100%**

1 Development phase includes site preparation, drilling and completion.
2 Long-haul trips are generally more than 100 miles; usually out of state.
3 Local trips are to/from nearby population centers, generally within 50 miles.

In addition to local and long-haul trips, **Table 7** also provides estimates of waste management facility trips. These trips originate from the well and are associated with the removal of waste material including produced water and hydrocarbon-rich soils from the well site. In some cases, waste management facilities are located in close proximity to well sites, and trips to and from these facilities may have no impact to the state highway system. In other cases, waste trips can be longer in length; some waste water is trucked from wells in Colorado to evaporative ponds in Cisco, Utah.

For each sub-basin, travel paths have been established for long-haul, local, and waste management trips. By applying the trip type by phase information to the travel paths, the model calculates the demand per unit of energy development. The model then applies the trip generation and vehicle classification output, along with the distribution of wells to the sub-basins within a particular basin (assuming development patterns consistent with 2008 permits), resulting in annual total traffic and truck traffic demands to the key energy development corridors.

It should be noted that the results of the oil and gas travel estimation model are at a corridor-level and do not address specific segments of a particular corridor. For example, if the model were to estimate that 10,000 trips are expected to occur on a particular corridor over the course of one year, those 10,000 trips could occur anywhere along the corridor. The number of trips should not be compared to the capacity of the corridor. The reason for keeping the model at this general level is that providing more specificity about the direction of trips would introduce an additional level of assumptions into the model, and the project team felt that a corridor-level result was appropriate for the statewide nature of this project. While the results do not provide specific information about the impacts to a segment of state highway, they will allow CDOT to compare the demands of oil and gas development on one key energy development corridor against those of another corridor. In order to calculate vehicle miles of travel (VMT), it has been estimated that, on average, the energy-related trips travel half the length of a given corridor. If desired, this value can be adjusted within the model.

A detailed model user's guide is included in **Appendix F**.

Base Year Demands on Key Corridors

In order to calibrate the oil and gas model, the base year (2007) results have been compared to existing traffic data on the 39 key energy development corridors associated with the oil and gas industry. Average annual daily traffic (AADT) volumes and truck percentages have been extracted from CDOT's database for each segment that comprise the 39 corridors. As shown in **Table 8**, a single "weighted" value has been calculated based on the length of each segment within the corridor in order to provide composite values of AADT, vehicle miles of travel (VMT), truck percentage, truck AADT, and truck VMT.

The columns in **Table 8** that begin with "Energy" represent values that have been extracted from the oil and gas model with base year input values. The base year input includes all producing wells in 2007 and an estimate of the wells drilled in 2007 based on COGCC data, which reports the number of drilling rigs running in Colorado during each week. To convert these data to number of wells drilled, it was assumed that it takes three weeks to drill an average well.

The Energy output (daily VMT for total traffic and truck traffic) in **Table 8** can be compared to the CDOT traffic count data. The last columns for both total traffic and truck traffic calculate the proportion of the traffic on the corridor that is estimated to be energy-related. These values serve as a means of calibrating the model. In a few cases, the initial output values from the model (particularly for truck traffic) were higher than VMT values calculated from CDOT's database. In these cases, the model was calibrated to provide output results less than (and a reasonable percentage of) the total traffic or total truck traffic on the corridor. The oil and gas model results for base year can be used as a means of comparing the relative demand of energy development on the various corridors throughout the state based on energy development activity in 2007.

The daily vehicle miles of travel and the truck daily vehicle miles of travel associated with energy development have been totaled for each basin. These values provide a means of comparing the oil and gas-related transportation activity on the key energy corridors from one basin to another.

Table 8. Base Year Oil and Gas Model Results

Corridor	Description	Length (Miles)	Total Traffic				Truck Traffic				
			Weighted AADT	Daily VMT	Energy DVMT	Energy Percent of Total VMT	Weighted Percent Trucks	Weighted Truck AADT	Daily Truck VMT	Energy Truck DVMT	Energy Percent of Total Truck DVMT
Denver/Julesburg Urban Basin											
SH 7	I-25 to US 85	13.3	14,734	195,844	429	0.2%	5.7%	835	11,104	88	0.8%
I-25	US 36 to SH 14	52.4	79,464	4,161,053	11,159	0.3%	12.2%	9,718	508,897	2,328	0.5%
US 34	I-25 to I-76 (extends into D-J Rural)	53.4	14,240	760,174	80,332	10.6%	12.8%	1,826	97,454	16,567	17.0%
SH 52	I-25 to Weld/Morgan CL	47.7	4,516	215,517	15,652	7.3%	18.0%	813	38,793	3,217	8.3%
SH 60	I-25 to US 85	14.0	6,535	91,477	2,494	2.7%	6.2%	406	5,690	508	8.9%
SH 66	I-25 to US 85 (Platteville)	8.6	8,095	70,014	818	1.2%	10.5%	848	7,337	167	2.3%
I-76	US 85 to Weld/Morgan CL	51.4	15,820	812,847	26,348	3.2%	20.0%	3,167	162,732	5,460	3.4%
US 85	I-76 to SH 14 (Ault)	52.8	19,110	1,008,263	99,120	9.8%	10.2%	1,949	102,843	20,430	19.9%
Basin Total					**236,352**					**48,765**	
Denver/Julesburg Rural Basin											
US 6	I-76 (Sterling) to state line	95.6	1,961	187,460	8,254	4.4%	16.8%	329	31,437	1,675	5.3%
US 34	I-76 (Fort Morgan) to state line	85.7	2,914	249,607	31,556	12.6%	21.1%	614	52,592	6,436	12.2%
SH 52	Weld/Morgan CL to I-76 (Wiggins)	13.7	597	8,174	0	0.0%	14.5%	86	1,182	0	0.0%
SH 59	Kit Carson/Yuma CL to I-76 (Sedgwick) inc. US 36 (Cope to Joes)	116.8	555	64,836	8,898	13.7%	20.8%	115	13,460	1,817	13.5%
I-76	Weld/Morgan CL to state line	120.1	9,433	1,133,054	38,574	3.4%	23.6%	2,225	267,287	8,498	3.2%

Corridor	Description	Length (Miles)	Total Traffic				Truck Traffic				
			Weighted AADT	Daily VMT	Energy DVMT	Energy Percent of Total VMT	Weighted Percent Trucks	Weighted Truck AADT	Daily Truck VMT	Energy Truck DVMT	Energy Percent of Total Truck DVMT
US 385	Kit Carson/Yuma CL to I-76 (Julesburg)	111.8	1,028	114,948	37,234	32.4%	23.1%	238	26,599	7,582	28.5%
Basin Total					**124,516**					**26,008**	
Piceance Basin											
US 6	I-70 Frontage Road through Rifle, Silt, Parachute (6D,L,M)	31.2	3,629	113,221	38,616	34.1%	10.0%	363	11,333	9,960	87.9%
SH 13	I-70 to Rio Blanco/Moffat CL	64.2	3,012	193,244	15,064	7.8%	18.1%	545	34,977	3,901	11.2%
US 50	SH 141 (Whitewater) to US 550 (Montrose)	53.4	12,562	670,484	1,789	0.3%	8.2%	1,026	54,779	461	0.8%
SH 64	US 40 (Dinosaur) to SH 13 (Meeker)	73.7	1,598	117,773	22,124	18.8%	19.5%	312	22,977	5,575	24.3%
SH 65	SH 330 (Mesa) to I-70	10.2	2,398	24,503	3,082	12.6%	9.9%	237	2,418	795	32.9%
I-70	State line to SH 82 (Glenwood Springs)	116.4	19,024	2,214,013	215,718	9.7%	15.2%	2,884	335,644	56,082	16.7%
SH 82	I-70 (Glenwood Springs) to SH 133 (Carbondale)	11.7	25,010	292,592	49	0.0%	4.0%	1,003	11,733	15	0.1%
SH 92	US 50 (Delta) to SH 133 (Hotchkiss)	20.7	7,289	151,050	50	0.0%	5.6%	409	8,474	12	0.1%
SH 133	SH 92 (Hotchkiss) to SH 82 (Carbondale)	68.8	2,703	186,023	950	0.5%	6.0%	162	11,143	245	2.2%
SH 139	I-70 (Loma) to SH 64 (Rangely)	72.1	1,118	80,569	888	1.1%	21.5%	240	17,282	227	1.3%
SH 141	San Miguel/Montrose CL to I-70 (Clifton)	115.1	1,155	132,973	5,286	4.0%	17.5%	202	23,257	1,295	5.6%
SH 330	SH 65 (Mesa) to Colbran	11.4	1,900	21,651	3,281	15.2%	8.8%	167	1,903	846	44.4%
Basin Total					**306,987**					**79,414**	

Corridor	Description	Length (Miles)	Total Traffic				Truck Traffic				
			Weighted AADT	Daily VMT	Energy DVMT	Energy Percent of Total VMT	Weighted Percent Trucks	Weighted Truck AADT	Daily Truck VMT	Energy Truck DVMT	Energy Percent of Total Truck DVMT
Sand Wash/North Park Basin											
SH 13	Rio Blanco/Moffat CL to State line	82.6	1,753	144,752	15,363	10.6%	16.1%	282	23,320	3,311	14.2%
US 40	State line to SH 131 (Steamboat Springs)	136.5	3,627	495,158	33,718	6.8%	15.9%	577	78,730	6,760	8.6%
Basin Total					**49,081**					**10,071**	
Raton/Canon City Embayment											
SH 12	US 160 to I-25 (Trinidad)	70.4	1,642	115,574	55,057	47.6%	10.0%	165	11,580	11,045	95.4%
Basin Total					**55,057**					**11,045**	
San Juan/Paradox Basin											
SH 140	State line to US 160 (Hesperus)	23.4	2,074	48,604	1,257	2.6%	12.3%	256	5,998	257	4.3%
SH 141	US 491 to San Miguel/Montrose CL	55.7	541	30,139	9,113	30.2%	27.7%	150	8,351	1,864	22.3%
SH 151	SH 172 (Ignacio) to US 160 (Chimney Rock)	34.0	1,443	49,004	9,388	19.2%	13.3%	192	6,518	1,920	29.5%
US 160	State line to SH 151 (Chimney Rock)	127.0	7,909	1,004,206	199,315	19.8%	9.5%	749	95,098	40,859	43.0%
SH 172	State line to US 160 (Durango)	24.5	5,138	125,876	26,179	20.8%	12.7%	653	15,999	5,356	33.5%
US 491	US 160 (Cortez) to state line	43.2	4,451	192,421	12,508	6.5%	19.7%	875	37,811	2,553	6.8%
US 550	State line to US 160 (Durango)	16.6	6,791	112,466	7,997	7.1%	9.4%	639	10,583	1,636	15.5%
Basin Total					**265,757**					**54,445**	

Corridor	Description	Length (Miles)	Total Traffic				Truck Traffic				
			Weighted AADT	Daily VMT	Energy DVMT	Energy Percent of Total VMT	Weighted Percent Trucks	Weighted Truck AADT	Daily Truck VMT	Energy Truck DVMT	Energy Percent of Total Truck DVMT
Hugoton Embayment											
US 40	SH 59 (Kit Carson) to state line	41.7	842	35,133	1,876	5.3%	36.6%	308	12,845	375	2.9%
SH 59	US 40 (Kit Carson) to Kit Carson/Yuma CL	60.2	372	22,391	2,107	9.4%	36.7%	137	8,220	421	5.1%
US 385	US 40 (Cheyenne Wells) to Kit Carson/Yuma CL	118.2	806	95,277	20,531	21.5%	28.6%	230	27,240	4,106	15.1%
Basin Total					**24,514**					**4,902**	

The model suggests that, based on current conditions, the Denver/Julesburg Urban basin experiences the highest level of oil and gas related transportation demands. Over seven million annual oil and gas trips are estimated within the Denver/Julesburg Urban basin. In comparison, the model estimates approximately 2.4 million annual trips in the Piceance basin. A major difference between these two basins, however, is that the Denver/Julesburg Urban basin includes a substantial county road system that generally follows the mile-grid pattern. The existence of the county roads offsets the demands of the oil and gas industry on the state highway system. In contrast, in the Piceance basin, the oil and gas industry must rely heavily on the state highway system since the county road network is limited in the mountainous terrain of the Piceance basin.

The corridor results for the base year, as shown in **Table 8**, suggest that the corridors with the highest level of travel demand from the oil and gas industry include:

- US 34 Corridor in the Denver/Julesburg Urban basin
- US 85 Corridor in the Denver/Julesburg Urban basin
- US 6 Corridor (I-70 Frontage Road) in the Piceance basin
- I-70 Corridor in the Piceance basin
- US 160 Corridor in the San Juan/Paradox basin

Potential Corridor Improvements

Various types of improvements may be needed on each of the 39 key energy development corridors for the oil and gas industry to offset these demands. Since the scope of this study is statewide rather than corridor- or project-specific, general categories of improvement needs have been identified for each corridor. The 2035 Regional Transportation Plans (RTPs) for the applicable Metropolitan Planning Organizations (MPOs) and Transportation Planning Regions (TPRs) were used as references in understanding the current conditions of each corridor. An assessment of the current conditions, in combination with the strategies listed for the applicable corridor vision(s) in the RTPs was used to identify potential improvements to address energy development traffic demands, heavy truck utilization in particular. Potential improvements include improving infrastructure (such as surface treatment, bridge repair or replacement); enhancing safety (such as geometric modifications, guardrail, widened shoulders); or improving mobility (such as major widening, auxiliary lanes, passing or climbing lanes). Bridges with a sufficiency rating of less than 80 and are either Structurally Deficient or Functionally Obsolete are eligible for funding. Specifically, bridges with ratings between 51 and 80 are eligible for rehabilitation and those rated below 50 are eligible for replacement.

The following section provides a description of each corridor, including the economic basin and the MPO/TPR(s) in which it is located, an assessment of the current conditions, and a list of potential improvements. The main investment category associated with the improvement is listed in parentheses. If available through previous efforts such as EISs, specific recommendations for mitigation improvements have also been included. The purpose of this information is to provide a guide in selecting and prioritizing project needs in key energy development corridors. The potential corridors are listed in the same order that they are presented in **Table 8**.

SH 7 from I-25 to US 85

Basin: Denver/Julesburg Urban Basin

MPO/TPR(s): DRCOG

Existing Corridor Assessment based on 2035 RTPs:

- Congestion is currently experienced on the western end of the corridor
- Fair surface condition
- One structurally deficient bridge and one functionally obsolete bridge with sufficiency rating less than 80
- Paved shoulders wider than four feet

Potential improvements to address energy development traffic demands:

- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Repair or replace eligible bridges (System Quality)

I-25 from US 36 to SH 14

Basin: Denver/Julesburg Urban Basin

MPO/TPR(s): DRCOG, North Front Range

Existing Corridor Assessment based on 2035 RTPs:

- Congestion is currently experienced south of SH 52
- Approximately one-third of corridor has poor surface condition
- Many structurally deficient and functionally obsolete bridges with sufficiency rating less than 80
- Paved shoulders wider than four feet

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Repair or replace eligible bridges (System Quality)
- Construct interchange improvements at deficient interchanges that are heavily used by truck and other energy development traffic (Mobility)
- Construct additional general purpose lanes (one in each direction) from SH 66 to SH 14 and construct tolled express lanes (one in each direction) from US 36 to SH 14 (Mobility)

US 34 from I-25 to I-76

Basin: Denver/Julesburg Urban Basin

MPO/TPR(s): Upper Front Range, North Front Range

Existing Corridor Assessment based on 2035 RTPs:

- Some congestion is currently experienced through Greeley
- Approximately half of corridor has poor surface condition
- No deficient bridges
- Majority of corridor has paved shoulders wider than four feet

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Construct interchange improvements at deficient interchanges that are heavily used by truck and other energy development traffic (Mobility)

SH 52 from I-25 to Wiggins

Basin: Denver/Julesburg Urban Basin

MPO/TPR(s): Upper Front Range (a section is now in DRCOG)

Existing Corridor Assessment based on 2035 RTPs:

- Congestion is currently experienced between I-25 and Dacono/Frederick
- Approximately half of corridor has poor surface condition
- One structurally deficient bridge and one functionally obsolete bridge with sufficiency rating less than 80
- Approximately half of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Repair or replace eligible bridges (System Quality)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)

SH 60 from I-25 to US 85

Basin: Denver/Julesburg Urban Basin

MPO/TPR(s): North Front Range

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Approximately half of corridor has poor surface condition
- No deficient bridges
- Approximately one-quarter of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)

SH 66 from I-25 to US 85 (Platteville)

Basin: Denver/Julesburg Urban Basin

MPO/TPR(s): Upper Front Range (now in DRCOG)

Existing Corridor Assessment based on 2035 RTPs:

- Congestion is currently experienced between I-25 and Weld CR 13
- Approximately half of corridor has poor surface condition
- One functionally obsolete bridge with sufficiency rating less than 80
- Approximately half of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Repair or replace eligible bridge (System Quality)

I-76 from US 85 to Weld/Morgan County Line

Basin: Denver/Julesburg Urban Basin

MPO/TPR(s): Upper Front Range/DRCOG

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Good or fair surface condition
- Two functionally obsolete bridges with sufficiency rating less than 80
- Paved shoulders wider than four feet

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Repair or replace eligible bridges (System Quality)
- Construct interchange improvements at deficient interchanges that are heavily used by truck and other energy development traffic (Mobility)

US 85 from I-76 to Ault

Basin: Denver/Julesburg Urban Basin

MPO/TPR(s): DRCOG, Upper Front Range, North Front Range

Existing Corridor Assessment based on 2035 RTPs:

- Congestion is experienced through Brighton/Fort Lupton
- Approximately half of corridor has poor surface condition
- Five structurally deficient bridges and nine functionally obsolete bridges with sufficiency rating less than 80
- Paved shoulders wider than four feet

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Repair or replace eligible bridges (System Quality)
- Construct interchange improvements at deficient interchanges that are heavily used by truck and other energy development traffic (Mobility)

US 6 from Brush to Nebraska

Basin: Denver/Julesburg Rural Basin

MPO/TPR(s): Eastern/Upper Front Range

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Approximately one-quarter of corridor has poor surface condition
- One structurally deficient bridge with sufficiency rate less than 80
- Approximately one-quarter of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Repair or replace eligible bridge (System Quality)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Reconstruct sections of the roadway (System Quality)

US 34 from Brush to Nebraska

Basin: Denver/Julesburg Rural Basin

MPO/TPR(s): Eastern/Upper Front Range

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Mostly good or fair surface condition, some stretches of poor surface condition
- Three structurally deficient bridges and one functionally obsolete bridge with sufficiency rating less than 80
- Approximately half of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Repair or replace eligible bridges (System Quality)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)

SH 52 from Weld/Morgan Couty Line to Wiggins

Basin: Denver/Julesburg Rural Basin

MPO/TPR(s): Upper Front Range

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Approximately two-third of corridor has poor surface condition
- No deficient bridges
- Approximately two-thirds of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)

SH 59 from Kit Carson/Yuma County Line to Sedgwick

Basin: Denver/Julesburg Rural Basin

MPO/TPR(s): Eastern

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Mostly good or fair surface condition, some stretches of poor surface condition
- One structurally deficient bridge with sufficiency rating less than 80
- Most of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Guardrails at select locations to improve safety of corridor (Safety)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Repair or replace eligible bridge (System Quality)

I-76 from Weld/Morgan County Line to Nebraska

Basin: Denver/Julesburg Rural Basin

MPO/TPR(s): Eastern/Upper Front Range

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Approximately half of corridor has poor surface condition
- Five functionally obsolete bridges with sufficiency rating less than 80
- Paved shoulders wider than four feet

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Repair or replace eligible bridges (System Quality)
- Construct interchange improvements at deficient interchanges that are heavily used by truck and other energy development traffic (Mobility)
- Reconstruct sections of the roadway (System Quality)

US 385 from Kit Carson/Yuma County Line to Julesburg

Basin: Denver/Julesburg Rural Basin

MPO/TPR(s): Eastern

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Mostly good or fair surface condition, some stretches of poor surface condition
- One structurally deficient bridge with sufficiency rating less than 80
- Entire corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Repair or replace eligible bridge (System Quality)

US 6, I-70 Frontage Road through Rifle, Silt and Parachute

Basin: Piceance Basin

MPO/TPR(s): Intermountain

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Portions of the corridor have poor surface condition
- Two structurally deficient or functionally obsolete bridges with sufficiency rating less than 80
- Portions of the corridor have shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Repair or replace eligible bridges (System Quality)

SH 13 from I-70 (Rifle) to Rio Blanco/Moffat CL

Basin: Piceance Basin

MPO/TPR(s): Northwest and Intermountain

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Mostly good or fair surface condition, short stretch of poor surface condition
- No deficient bridges
- Approximately two-thirds of the corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Reconstruct roadway from Rifle to Garfield/Rio Blanco county line (System Quality)
- Passing lanes and/or pullouts on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)

US 50 from Montrose to Grand Junction (SH 141)

Basin: Piceance Basin

MPO/TPR(s): Gunnison Valley/Grand Valley

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints, future (2035) congestion expected through Montrose
- Mostly good or fair surface condition, some stretches of poor surface condition
- No deficient bridges
- Paved shoulders wider than four feet on majority of corridor

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Construct intersection improvements at deficient intersections that are heavily used by truck and other energy development traffic (Mobility)

SH 64 from US 40 (Dinosaur) to SH 13 (Meeker)

Basin: Piceance Basin

MPO/TPR(s): Northwest

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Approximately half of corridor in poor surface condition
- No deficient bridges
- Nearly entire corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)

SH 65 from I-70 to Mesa

Basin: Piceance Basin

MPO/TPR(s): Grand Valley

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Poor surface condition
- No deficient bridges
- Paved shoulders wider than four feet on majority of corridor

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)

I-70 from Utah to Glenwood Springs

Basin: Piceance Basin

MPO/TPR(s): Grand Valley/Intermountain

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Mostly good or fair surface condition, some stretches of poor surface condition
- Six structurally deficient or functionally obsolete bridges with sufficiency rating less than 80
- Paved shoulders wider than four feet on majority of corridor

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Construct interchange improvements at deficient interchanges that are heavily used by truck and other energy development traffic (Mobility)
- Reconstruction of sub-standard segments (System Quality)
- Repair or replace eligible bridges (System Quality)

SH 82 from Carbondale to Glenwood Springs

Basin: Piceance Basin

MPO/TPR(s): Intermountain

Existing Corridor Assessment based on 2035 RTPs:

- The section of SH 82 through Glenwood Springs currently experiences congestion, and the entire corridor is expected to experience congestion by 2035
- Fair surface condition
- One functionally obsolete bridge with sufficiency rating less than 80
- Paved shoulders wider than four feet on majority of corridor

Potential improvements to address energy development traffic demands:

- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Passing lanes and/or pullouts on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Repair or replace eligibile bridge (System Quality)

SH 92 from Delta to Hotchkiss

Basin: Piceance Basin

MPO/TPR(s): Gunnison Valley

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Good surface condition
- No deficient bridges
- Approximately two-thirds of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Passing lanes and/or pullouts on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)

SH 133 from Hotchkiss to Carbondale

Basin: Piceance Basin

MPO/TPR(s): Gunnison Valley/Intermountain

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Approximately one-quarter of corridor in poor surface condition
- No deficient bridges
- Approximately two-thirds of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)

SH 139 from Loma to Rangely

Basin: Piceance Basin

MPO/TPR(s): Grand Valley/Intermountain/Northwest

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Approximately half of corridor in poor surface condition
- No deficient bridges
- Approximately half of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Passing lanes and/or pullouts on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)

SH 141 from San Miguel/Montrose CL to Grand Junction

Basin: Piceance Basin

MPO/TPR(s): Gunnison Valley/Grand Valley

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Mostly good or fair surface condition, some stretches of poor surface condition
- No deficient bridges
- Entire corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Guardrails at select locations to improve safety of corridor (Safety)
- Improve geometrics in spot locations to improve safety of corridor (Safety)

SH 330 from Mesa to Collbran

Basin: Piceance Basin

MPO/TPR(s): Grand Valley

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Good surface condition
- Two functionally obsolete bridges with sufficiency rating less than 80
- Entire corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Passing lanes and/or pullouts on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Repair or replace eligible bridges (System Quality)

SH 13 from Rio Blanco/Moffat CL to Wyoming

Basin: Sand Wash/North Park Basin

MPO/TPR(s): Northwest

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Approximately one-quarter of the corridor has poor surface condition
- No deficient bridges
- Approximately half of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Passing lanes on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)

US 40 from Utah to Steamboat Springs

Basin: Sand Wash/North Park Basin

MPO/MPO/TPR(s): Northwest

Existing Corridor Assessment based on 2035 RTPs:

- Only capacity constraints are in the Steamboat Springs area
- Mostly good or fair surface condition, some stretches of poor surface condition
- No deficient bridges
- Paved shoulders wider than four feet on majority of corridor

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Passing lanes on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Guardrails at select locations to improve safety of corridor (Safety)

SH 12 from La Veta to Trinidad

Basin: Raton/Canon City Embayment

MPO/TPR(s): South Central

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Approximately half of corridor has poor surface condition
- Two structurally deficient bridges with sufficiency rating less than 80
- Most of the corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Passing lanes and/or pullouts on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Repair or replace eligible bridges (System Quality)
- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)

SH 140 from New Mexico to Hesperus

Basin: San Juan/Paradox Basin

MPO/TPR(s): Southwest

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Good surface condition
- Two functionally obsolete bridges with sufficiency rating less than 80
- Entire corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Passing lanes on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)

- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Repair or replace eligible bridges (System Quality)

SH 141 from Dove Creek to San Miguel/Montrose CL

Basin: San Juan/Paradox Basin

MPO/TPR(s): Southwest/Gunnison Valley

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Poor surface condition
- No strucurally deficient bridges
- Most of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Reconstruction on sections of corridor with remaining service life of 0 years
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Guardrails at select locations to improve safety of corridor (Safety)
- Improve geometrics in spot locations to improve safety of corridor (Safety)

SH 151 from Ignacio to Chimney Rock

Basin: San Juan/Paradox Basin

MPO/TPR(s): Southwest

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Approximately two-thirds of corridor has poor surface condition
- No deficient bridges
- Approximately three-quarters of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)

- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Improve geometrics in spot locations to improve safety of corridor (Safety)

US 160 from New Mexico to Chimney Rock

Basin: San Juan/Paradox Basin

MPO/TPR(s): Southwest

Existing Corridor Assessment based on 2035 RTPs:

- Congestion is currently experienced between Durango and Bayfield
- Mostly good or fair surface condition, some stretches of poor surface condition
- Five functionally obsolete bridges with sufficiency rating less than 80
- Paved shoulders wider than four feet on majority of corridor

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Repair or replace eligible bridges (System Quality)
- Improve geometrics in spot locations to improve safety of corridor (Safety)

SH 172 from New Mexico to Durango

Basin: San Juan/Paradox Basin

MPO/TPR(s): Southwest

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Poor surface condition
- No deficient bridges
- Approximately half of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)

US 491 from Utah to Cortez

Basin: San Juan/Paradox Basin

MPO/TPR(s): Southwest

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Approximately one-quarter of the corridor has poor surface condition
- No deficient bridges
- Paved shoulders wider than four feet on majority of corridor

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Passing lanes on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)

US 550 from New Mexico to Durango

Basin: San Juan/Paradox Basin

MPO/TPR(s): Southwest

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Good surface condition
- No deficient bridges
- Most of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Passing lanes on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)

US 40 from Kit Carson to Kansas

Basin: Hugoton Embayment

MPO/TPR(s): Eastern

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Good surface condition
- One structurally deficient bridge with sufficiency rating less than 80
- Entire corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Repair or replace eligible bridge (System Quality)
- Guardrails at select locations to improve safety of corridor (Safety)

SH 59 from Kit Carson to Kit Carson/Yuma County Line

Basin: Hugoton Embayment

MPO/TPR(s): Eastern

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Mostly good or fair surface condition, some stretches of poor surface condition
- One structurally deficient bridge with sufficiency rating less than 80
- Entire corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Guardrails at select locations to improve safety of corridor (Safety)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)
- Repair or replace eligible bridge (System Quality)

US 385 from Granada to Kit Carson/Yuma County Line

Basin: Hugoton Embayment

MPO/TPR(s): Southeast/Eastern

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Mostly good or fair surface condition, some stretches of poor surface condition
- No deficient bridges
- Entire corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Improve geometrics in spot locations to improve safety of corridor (Safety)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)

A summary of the potential improvements identified for the 39 corridors is provided in **Table 9**. The two most commonly sited potential improvement types for the corridors are surface treatments/overlays and geometric improvements. All three investment categories (safety, mobility, and system quality) are well represented in the list of potential improvements.

Table 9. Summary of Potential Corridor Improvements (Oil and Gas Corridors)

Corridor	Description	Surface Treatments	Passing Lanes	Auxiliary Lanes	Paved Shoulders	Improve Geometrics	Reconstruction	Guardrail	Repair or Replace Bridge	Interchange Improvements	Intersection Improvements	Major Widening
Denver/Julesburg Urban Basin												
SH 7	I-25 to US 85			●					●			
I-25	US 36 to SH 14	●				●			●	●		●
US 34	I-25 to I-76 (extends into D-J Rural)	●				●				●		
SH 52	I-25 to Weld/Morgan CL	●		●	●	●			●			
SH 60	I-25 to US 85	●			●	●						
SH 66	I-25 to US 85 (Platteville)	●		●	●	●			●			
I-76	US 85 to Weld/Morgan CL					●			●	●		
US 85	I-76 to SH 14 (Ault)	●				●			●	●		
Denver/Julesburg Rural Basin												
US 6	I-76 (Sterling) to state line			●		●	●		●			
US 34	I-76 (Fort Morgan) to state line	●		●	●	●			●			
SH 52	Weld/Morgan CL to I-76 (Wiggins)	●		●	●	●						
SH 59	Kit Carson/Yuma CL to I-76 (Sedgwick) inc. US 36 (Cope to Joes)			●	●	●		●	●			
I-76	Weld/Morgan CL to state line					●	●		●	●		
US 385	Kit Carson/Yuma CL to I-76 (Julesburg)	●			●	●			●			

Corridor	Description	Surface Treatments	Passing Lanes	Auxiliary Lanes	Paved Shoulders	Improve Geometrics	Reconstruction	Guardrail	Repair or Replace Bridge	Interchange Improvements	Intersection Improvements	Major Widening
Piceance Basin												
US 6	I-70 Frontage Road through Rifle, Silt, Parachute (6D,L,M)	●		●	●				●			
SH 13	I-70 to Rio Blanco/Moffat CL		●	●	●	●	●					
US 50	SH 141 (Whitewater) to US 550 (Montrose)	●									●	
SH 64	US 40 (Dinosaur) to SH 13 (Meeker)	●		●	●	●						
SH 65	SH 330 (Mesa) to I-70	●				●						
I-70	State line to SH 82 (Glenwood Springs)	●					●		●	●		
SH 82	I-70 (Glenwood Springs) to SH 133 (Carbondale)		●	●					●			
SH 92	US 50 (Delta) to SH 133 (Hotchkiss)		●	●	●	●						
SH 133	SH 92 (Hotchkiss) to SH 82 (Carbondale)	●		●	●							
SH 139	I-70 (Loma) to SH 64 (Rangely)	●	●	●	●	●						
SH 141	San Miguel/Montrose CL to I-70 (Clifton)	●			●	●		●				
SH 330	SH 65 (Mesa) to Colbran		●		●	●			●			
Sand Wash/North Park Basin												
SH 13	Rio Blanco/Moffat CL to State line	●	●	●	●	●						
US 40	State line to SH 131 (Steamboat Springs)	●	●	●				●				

Corridor	Description	Surface Treatments	Passing Lanes	Auxiliary Lanes	Paved Shoulders	Improve Geometrics	Reconstruction	Guardrail	Repair or Replace Bridge	Interchange Improvements	Intersection Improvements	Major Widening
Raton/Canon City Embayment												
SH 12	US 160 to I-25 (Trinidad)	●	●	●	●	●			●			
San Juan/Paradox Basin												
SH 140	State line to US 160 (Hesperus)		●	●	●	●			●			
SH 141	US 491 to San Miguel/Montrose CL	●			●	●	●	●				
SH 151	SH 172 (Ignacio) to US 160 (Chimney Rock)	●		●	●	●						
US 160	State line to SH 151 (Chimney Rock)	●		●		●			●			
SH 172	State line to US 160 (Durango)	●		●	●	●						
US 491	US 160 (Cortez) to state line	●	●	●								
US 550	State line to US 160 (Durango)		●		●							
Hugoton Embayment												
US 40	SH 59 (Kit Carson) to state line			●	●			●	●			
SH 59	US 40 (Kit Carson) to Kit Carson/Yuma CL			●	●	●		●	●			
US 385	US 40 (Cheyenne Wells) to Kit Carson/Yuma CL	●		●	●	●						

Planning Level Cost Estimates

For planning purposes, general unit cost estimates have been developed for the types of improvements that have been identified to address energy development demands on the key energy development corridors. As CDOT explores the potential improvements to the corridors, the unit costs for the improvements can be used as a tool to develop planning level cost estimates for overall corridor improvement scenarios.

Planning level cost estimates have been developed for three terrain types: plains, rolling, and mountainous. The estimates shown in **Table 10** have been calculated based on Bid Tabulation Archives for years 2000 through 2009, which are available on CDOT's website. These construction project cost data represent the actual construction costs; other items such as design, utilities, right of way, environmental clearances, and construction management are not included in the planning level cost estimates. Project construction costs were multiplied by U.S. Bureau of Labor and Statistics' inflation factors to bring the total costs to year 2009 dollars. The unit costs shown on the summary table are averages of at least three construction projects with similar project descriptions. In a few cases, there were insufficient data available for a particular terrain type, and the cost estimates are based on an estimated portion of another terrain type. Such exceptions are noted in the table. The project-specific construction costs used to develop the planning level cost estimates are provided in **Appendix G**.

Table 10. Planning Level Improvement Costs

Type of Improvement	Unit	Terrain		
		Plains	Rolling	Mountainous
Surface treatment/overlays	per lane-mile	$80,000	$100,000	$110,000
Passing lane	per mile	$1,500,000[1]	$1,800,000	$13,600,000
Auxiliary lanes	per lane	$620,000	$710,000	$900,000
Paved shoulders	per lane-mile	$380,000[1]	$440,000	$490,000
Improve geometrics	per mile	$660,000[1]	$770,000	$890,000
Reconstruction	per lane-mile	$770,000	$860,000	$1,280,000
Guardrail	per mile	$180,000	$220,000	$360,000
Repair bridge	each	$880,000	$980,000	$1,470,000
Replace bridge	each	$2,100,000	$2,400,000	$2,500,000
Interchange improvements	per interchange	$21,800,000	$21,500,000	$26,700,000
Intersection improvements	per intersection	$1,500,000	$1,700,000	$2,300,000

1 Insufficient data; cost for Plains estimated based on average ratio of cost for Plains to Rolling terrain of 0.86 for other improvement types.

III. URANIUM

A. Industry Overview

Uranium is extracted using both open pit and underground mining methods. Given the proximity of uranium ore to the surface, open pit mining is the preferable extraction method in Colorado.

Before a uranium mine is established, a site evaluation process occurs where exploratory holes are drilled to test a mineral deposit. Typically, rotary drill rigs would be used to drill exploratory holes to as deep as 700 feet. Where the target deposit is shallow (less than 200 ft), smaller drill rigs such as track- or truck-mounted wagon drills might be used. Exploratory holes are drilled as the last step in a due diligence process and generally occur infrequently and only when an operator is almost certain an economically viable project exists.

Once a mine site is identified, an operator will establish an open pit mine. Open pit mining generally involves the use of heavy earth moving equipment that remains on site at the mine. Uranium ore and waste rock produced at the mine is hauled using large trucks that hold about 25 tons of material per truck.

Literature Review

The literature review for uranium focused on previously completed studies on uranium development in the western United States (references are provided in **Appendix B**). Studies included an Environmental Assessment (EA) completed in 2008 for the Sunday Mines in San Miguel County, a Programmatic Environmental Assessment (PEA) completed in 2007 which addresses the uranium leasing program in the Uravan mineral belt, and publications by state regulatory agencies.

The literature review yielded results on two distinct subjects: 1) transportation demands of uranium development and 2) employment impacts of energy development. From the literature review, it was noted that uranium development is generally uniform and mine operations generally use similar equipment in mining and hauling uranium ore for processing. **Appendix C** provides a summary of each relevant document that was reviewed.

The literature review provides the foundation for establishing a linkage between uranium development activity and its associated transportation and employment requirements. The literature review allowed the study team to determine the truck size and haul capacity associated with uranium operations. The information contained in the travel estimation model is obtained from documents in the literature that specifically pertain to uranium development in the Uravan mineral belt in western Colorado.

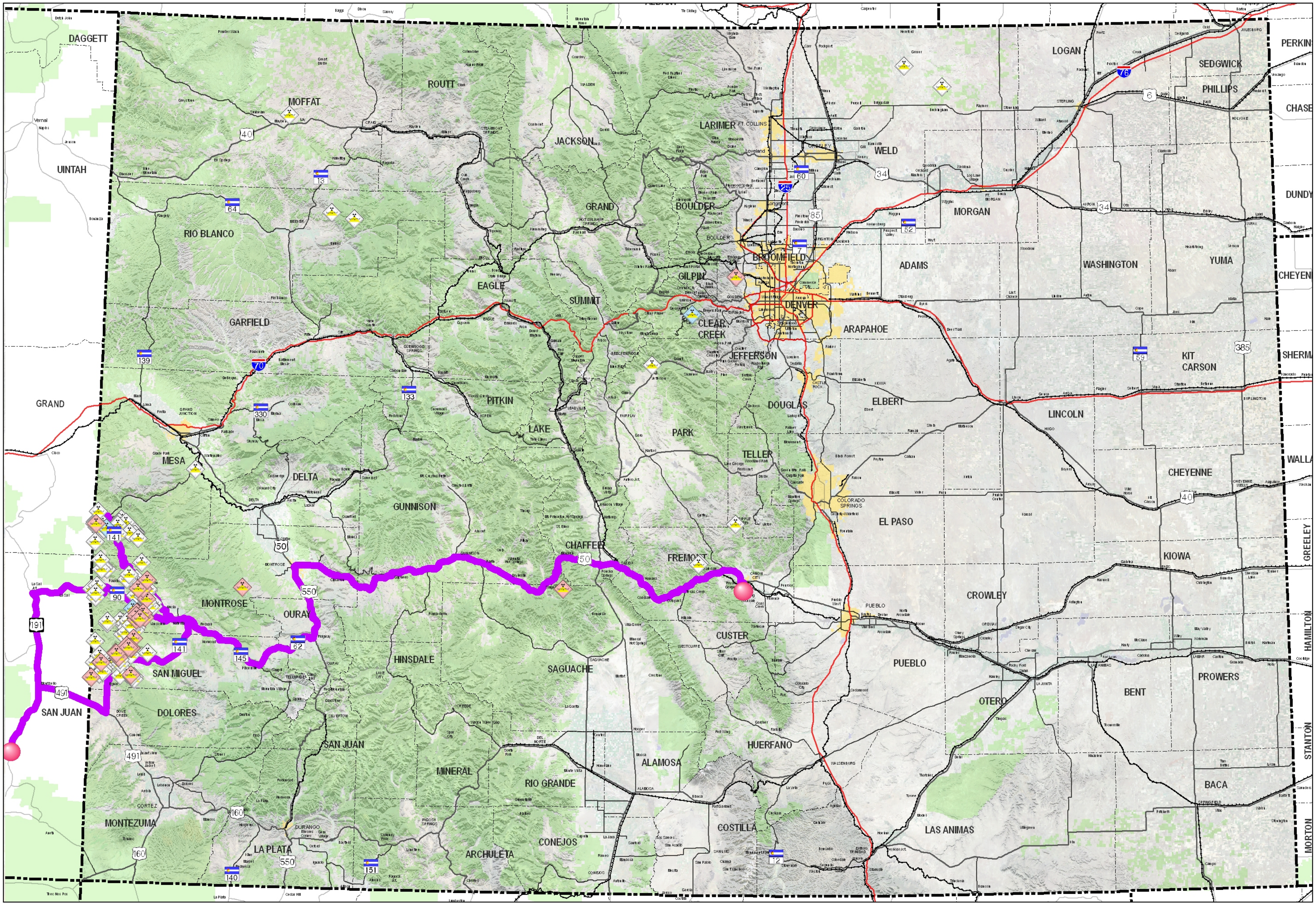
B. Resource Development in Colorado

At present, all uranium mining in Colorado occurs in the Uravan mineral belt region. The Uravan mineral belt bends across the western part of the state and has been home to more than 1,000 uranium mines. The majority of uranium mining occurs in Montrose and San Miguel Counties. Most of the uranium extraction occurs on public land and is operated under a leasing program by the Bureau of Land Management (BLM).

Transporting the quarry material containing uranium ore to a processing facility is economically challenging. There are only two processing facilities in the region: the Canon City Mill near Canon City, Colorado and the White Mesa Uranium Mill near Blanding, Utah. In 2005, four uranium mines in Montrose County were transporting their quarry material 300 miles to Canon City for processing and as a result had to shut down due to the high costs of transportation. As of July 2009, there are three uranium mines in San Miguel County that are in ore production. Each of these mines transport the quarry material to the processing facility near Blanding, Utah. Another 22 uranium mines have active mining permits but are not producing ore. Active mining permits, along with those that are in the application process and those that have been terminated or revoked are shown on **Figure 9**.

Energy Fuels Corporation gained final BLM approvals in September of 2008 for the Whirlwind Mine in Mesa County. However, on November 20, 2008 the company announced capital preservation measures which included putting the mine into maintenance status. Energy Fuels Corporation is also exploring the potential construction of a new uranium processing mill in Montrose County. The potential mill has not received any approvals as of the publication of this report. (State of Colorado, Division of Reclamation, Mining and Safety, Uranium Mining in Colorado, 2009)

As of July 2007, the Powertech Uranium Corporation has proposed a 5,000-acre uranium development operation in Weld County near the community of Nunn. To date, Powertech has not received any local, state or federal approvals to begin operations. If this mining operation were to go forward, Powertech officials have indicated that uranium extracted form the Nunn site would be transported to a yet-to-be-constructed processing facility in Wyoming for refinement.



LEGEND

- Active Uranium Permit
- Uranium Permit Application in Review
- Denied, Revoked or Terminated Uranium Permit
- Active Uranium Mill / Processing Facility
- Heavily Impacted Corridors

25 years
FELSBURG HOLT & ULLEVIG

N W E S

0 40 Miles

Figure 9

Uranium Mining Activity and Key Energy Development Corridors

Source: Colorado Division of Reclamation, Mining, and Safety

C. Transportation Demands of Resource Development

Trip Generation and Vehicle Classification

Literature review documents indicate that uranium ore is transported to processing mills in heavy trucks that can carry 25 tons. Based on this relationship, the project team calculated a trip multiplier of 80 trips per thousand tons of uranium mined (two trips per 25 tons), as shown in **Table 11**. All direct trips associated with uranium development are considered heavy truck trips, while the employee trips (described in more detail in the following section) are assumed to be light vehicles (passenger cars or pick ups).

Table 11. Uranium Trip Generation Rates and Vehicle Classification

	Trips per Thousand Tons	Vehicle Classification
Haul Trips	80	100% Heavy Trucks
Employee Trips (Annual)	280	100% Light Vehicles

Source: Uranium Leasing Program Final Programmatic EA

A typical uranium mining operation might mine 200 to 300 tons of uranium ore per day. This equates to 16 to 24 heavy vehicle trips per day to and from the mine.

Employment

The project team used sources identified in the literature review for data on the employment requirements for the uranium mining industry. Direct employment is defined as workers who are employed directly by the uranium industry. Indirect employment is defined as general workers in support industry sectors that include uranium mining raw materials supply, retail, hospitality, personal services and other sectors of the economy that grow along with a region's general population growth. The uranium development industry is considered a base industry that attracts investment and workers to a region. Indirect employment growth is dependent on growth of base industries.

Direct employment is calculated based on the relationship between measures of uranium production and the associated required workforce. The preferred alternative in the Uranium Leasing Program Final Programmatic EIS for the Uravan mineral belt in western Colorado described a scenario where about 1,020,000 tons of ore would be mined annually, employing 570 workers. This relationship equates to about 0.56 direct workers per annual thousand tons of mined uranium ore.

For each direct employee associated with uranium development, an annual trip generation factor of 500 (two trips per day assuming a five day work week with no mining activity on holidays) is applied as a proxy for daily trips to and from the mine site.

Indirect employment is calculated in the same manner as with oil, gas and CBM development. Indirect employment multipliers are applied to direct employment to calculate indirect employment. The same multipliers used in the oil and gas model are applied in the uranium model as there are similar economic relationships across all forms of mineral mining, whether oil and gas, coal, uranium or other mineral. The indirect employment multipliers are shown in **Table 6.** Active uranium mines are located in the Piceance Basin and the San Juan/Paradox Basin, where the indirect employment multipliers are 1.64 and 2.40 times the direct employment, respectively.

Key Energy Development Corridors

The key energy development corridors associated with uranium mining have been identified through two recently published documents; the Sunday Mines EA and the Uranium Leasing Program Final Programmatic EA. Since all uranium mining activity occurs in the Uravan mineral belt, and there are only two processing facilities in the region, the routes that are used by the uranium mining industry are limited. As shown on **Figure 9**, there are two primary routes that are used to haul uranium ore between the Uravan mineral belt and the White Mesa Mill near Blanding, Utah. The state highways included in these two routes are: SH 141, SH 90, and US 491. The total distance for this haul route varies between 70 and 170 mile, depending on the point of origin. Currently the operating uranium mines in Colorado utilize this mill, which is considerably closer than the mill in Canon City.

Depending on mill-feed requirements, mine operators have the option to transport ore to the Canon City Mill when mill feed and economic conditions warrant. The primary route that would be used to transport uranium ore from the Uravan mineral belt to the Canon City Mill would include SH 141, SH 90, SH 145, SH 62, US 550 and US 50. The total distance for this haul route is approximately 300 miles. Although this route is not currently being used to haul uranium, there is potential for its use at any time given the right economic conditions.

Model Development

The uranium model is similar to the oil and gas model in that it includes both a trip generation/vehicle classification component as well as a corridor allocation component. However, it is simpler because the mining operations in Colorado are localized, the origins and destinations are known, and the activity on the transportation system is less dispersed than in the oil and gas industry. The purpose of the uranium model is to provide a tool to test future uranium production and haul route scenarios to gain an understanding of the relative demands on key state highways.

The uranium model uses trip generation rates per ton of mined uranium ore to estimate the level of transportation activity. The trip generation/vehicle classification component utilizes the seven economic basins shown on **Figure 4** for geographic input values. Although all current uranium mining operations occur in the Uravan mineral belt, this allows flexibility in the model to compare the relative demands in other areas of the state if mining operations were to be initiated.

The uranium model estimates the direct and indirect employment associated with uranium development in the seven economic basins shown on **Figure 4**. The ratio described previously is used in the model to project direct employment associated with uranium model. The employment related trips are calculated annually in the model and added to direct trip generation figures described above. For vehicle classification purposes, all employee-related trips are assumed to be light trucks or passenger cars. Indirect employment is also estimated in the model.

The corridor allocation component of the uranium model focuses on the transport of uranium ore from the Uravan mineral belt to the two existing processing facilities near Blanding, Utah and Canon City, Colorado. Employment trips are expected to utilize only the state highways in the immediate vicinity of the existing mines. The main input values for the uranium model include the location, level of production, and mill destination. This allows the user to compare the relative demands to the affected state highways if the uranium ore is transported to the Canon City Mill versus the White Mesa Mill in Utah. A model user's guide is included in **Appendix F**.

Base Year Demands on Key Corridors

The Division of Reclamation, Mining & Safety provides an annual report on uranium mining in Colorado. The 2009 report states that there are currently three producing mines (the Sunday Mines) which are owned by Denison Mines (USA) Corp. The Sunday Mines EA, which was completed in 2007 states that current production from the active mines is 5,000 to 6,000 tons per month. Annual uranium production of 72,000 tons has been used for the purpose of testing the uranium travel estimation model. For this base year scenario it is assumed that all uranium ore is transported to the White Mesa Mill near Blanding, Utah. Half of the haul trips are assumed to use the northern route (via SH 90) and the other half of the haul trips are assumed to use the southern route (via SH 141 and US 491). The base year example also estimates the impact of the estimated 40 direct employees associated with the currently active mines.

Average annual daily traffic (AADT) volumes and truck percentages have been extracted from CDOT's database for each segment that comprise the seven corridors impacted by uranium development. As shown in **Table 12**, a single "weighted" value has been calculated based on the length of each segment within the corridor in order to provide composite values of AADT, vehicle miles of travel (VMT), truck percentage, truck AADT, and truck VMT.

The columns in **Table 12** that begin with "Uranium" represent values that have been extracted from the uranium model with base year input values.

The Uranium output (daily VMT for total traffic and truck traffic) in **Table 12** can be compared to the CDOT traffic count data. The last columns for both total traffic and truck traffic calculate the proportion of the traffic on the corridor that is estimated to be energy-related. These values serve as a means of calibrating the model. The uranium model results can be used as a means of comparing the relative demand of energy development on the various corridors with different production scenarios and mill destinations.

The total vehicle miles of travel and truck vehicle miles of travel related to uranium mining on the key uranium corridors is summarized at the bottom of the table.

Table 12. Base Year Uranium Model Results

Corridor	Description	Length (Miles)	Total Traffic				Truck Traffic				
			Weighted AADT	Daily VMT	Uranium DVMT	Uranium Percent of Total VMT	Weighted Percent Trucks	Weighted Truck AADT	Daily Truck VMT	Uranium Truck DVMT	Uranium Percent of Total Truck DVMT
US 50	US 550 (Montrose) to Canon City	186.4	3,689	687,636	0	0%	15.0%	552	102,953	0	0%
SH 62	SH 145 to US 550 (Ridgway)	23.4	3,828	89,635	0	0%	6.7%	255	5,968	0	0%
SH 90	Utah State Line to SH 141 (Naturita)	33.9	405	13,707	1,763	12.9%	17.0%	69	2,337	407	17.4%
SH 141	US 491(Dove Creek) to Gateway	64.4	631	40,643	2,705	6.7%	24.3%	153	9,865	773	7.8%
SH 145	SH 62 to SH 90 (Naturita)	32.6	1,627	53,018	0	0%	10.5%	171	5,576	0	0%
US 491	SH 141 (Dove Creek) to Utah State Line	8.2	2,518	20,520	98	0.5%	23.7%	596	4,859	98	2.0%
US 550	SH 62 (Ridgway) to US 50 (Montrose)	25.9	9,316	240,991	0	0%	7.3%	680	17,595	0	0%
Key Uranium Corridors Total					**4,566**					**1,278**	

The current uranium mining operations in the Uravan mineral belt affect only three state highway corridors in Colorado, since the mines transport the quarry material to the White Mesa Mill in Utah. Although the transportation demands of uranium mining appear small in comparison to the total traffic on these facilities, the historic uranium production in the 1970s and 1980s was more than double the current production; if uranium mining increases, the demand on the identified state highways could more than double.

Corridor Improvement Needs

Various types of improvements may be needed on each of the corridors that are impacted by uranium mining to offset these demands. Since only three of the seven uranium corridors are currently being utilized to transport uranium ore, general categories of improvement needs have been identified for only those three corridors (SH 90, SH 141 and US 491). The 2035 Regional Transportation Plans (RTPs) for the applicable Metropolitan Planning Organizations (MPO) or Transportation Planning Regions (TPRs) were used as references in understanding the current conditions of each corridor. An assessment of the current conditions, in combination with the strategies listed for the applicable corridor vision(s) in the RTPs was used to identify potential improvements to address energy development traffic demands; heavy truck utilization in particular. Potential improvements include improving infrastructure (such as surface treatment, bridge repair or replacement); enhancing safety (such as geometric modifications, guardrail, widened shoulders); or improving mobility (such as major widening, auxiliary lanes, passing or climbing lanes).

The following section provides a description of each corridor, including the MPO/TPR(s) in which it is located, an assessment of the current conditions, and a list of potential improvements. The main investment category associated with the improvement is listed in parentheses. If available through previous efforts such as EISs, specific recommendations for mitigation improvements have also been included. The purpose of this information is to provide a guide in selecting and prioritizing project needs in key energy development corridors associated with uranium transport.

SH 90 from Utah to Naturita

MPO/TPR(s): Gunnison Valley

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Poor surface condition
- No deficient bridges
- Entire corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)

- Reconstruction of sections of corridor with remaining service life of 0 years (System Quality)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Guardrails at select locations to improve safety of corridor (Safety)
- Improve geometrics in spot locations to improve safety of corridor (Safety)

SH 141 from Dove Creek to Gateway

MPO/TPR(s): Gunnison Valley/Grand Valley/Southwest

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Mostly good or fair surface condition, some stretches of poor surface condition
- No deficient bridges
- Entire corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Surface treatment/overlays on sections of corridor with poor surface condition (System Quality)
- Reconstruction of sections of corridor with remaining service life of 0 years (System Quality)
- Add/improve shoulders on sections of corridor with sub-standard shoulders (Safety)
- Guardrails at select locations to improve safety of corridor (Safety)
- Improve geometrics in spot locations to improve safety of corridor (Safety)

US 491 from Dove Creek to Utah State Line

MPO/TPR(s): Southwest

Existing Corridor Assessment based on 2035 RTPs:

- No capacity constraints
- Poor surface condition
- No deficient bridges
- Most of corridor has shoulder deficiencies (no shoulders, unpaved shoulders or paved shoulders less than four feet wide)

Potential improvements to address energy development traffic demands:

- Passing lanes and/or pullouts on sections with steep grades to accommodate passing of slow-moving trucks (Mobility)
- Auxiliary lanes at intersections, particularly those that are heavily used by truck and other energy development traffic (Mobility)

A summary of the potential improvements identified for the three corridors that are currently being affected by uranium mining is provided in **Table 13**. The SH 90 and SH 141 improvements are primarily focused on improving the system quality and safety of the corridors; the US 491 improvements focus on improving mobility along the corridor. The planning level unit cost estimates presented in **Table 10** can be used as a tool to develop planning level cost estimates for overall corridor improvement scenarios.

Table 13. Summary of Potential Corridor Improvements (Uranium Corridors)

Corridor	Description	Surface Treatments	Reconstruction	Passing Lanes	Auxiliary Lanes	Paved Shoulders	Improve Geometrics	Guardrail
SH 90	Utah State Line to SH 141 (Naturita)	●	●			●	●	●
SH 141	US 491(Dove Creek) to Gateway	●	●			●	●	●
US 491	SH 141 (Dove Creek) to Utah State Line			●	●			

IV. COAL

A. Industry Overview

Coal is one of the United States' most abundant and recoverable energy resources. The Energy Information Administration (EIA) estimates that 275 billion tons of recoverable coal exist in the United States, an amount greater than any other nation in the world. At the current rate of consumption, that figure could meet domestic demands for more than 250 years. The primary use for coal in this country is to generate electricity. In Colorado, coal is used to generate approximately 80 percent of the electricity consumed (source: Bureau of Land Management).

Coal mining processes are classified as either surface or underground operations. The most economical method of coal extraction from coal seams depends on the depth and the quality of the seams as well as the geologic and environmental factors in the area. When coal seams are near the surface, open cast mining (also referred to as strip mining) methods are usually used. Most coal seams are too deep for surface mining and require underground mining. Two-thirds of Colorado's coal production comes from underground mining operations.

B. Resource Development in Colorado

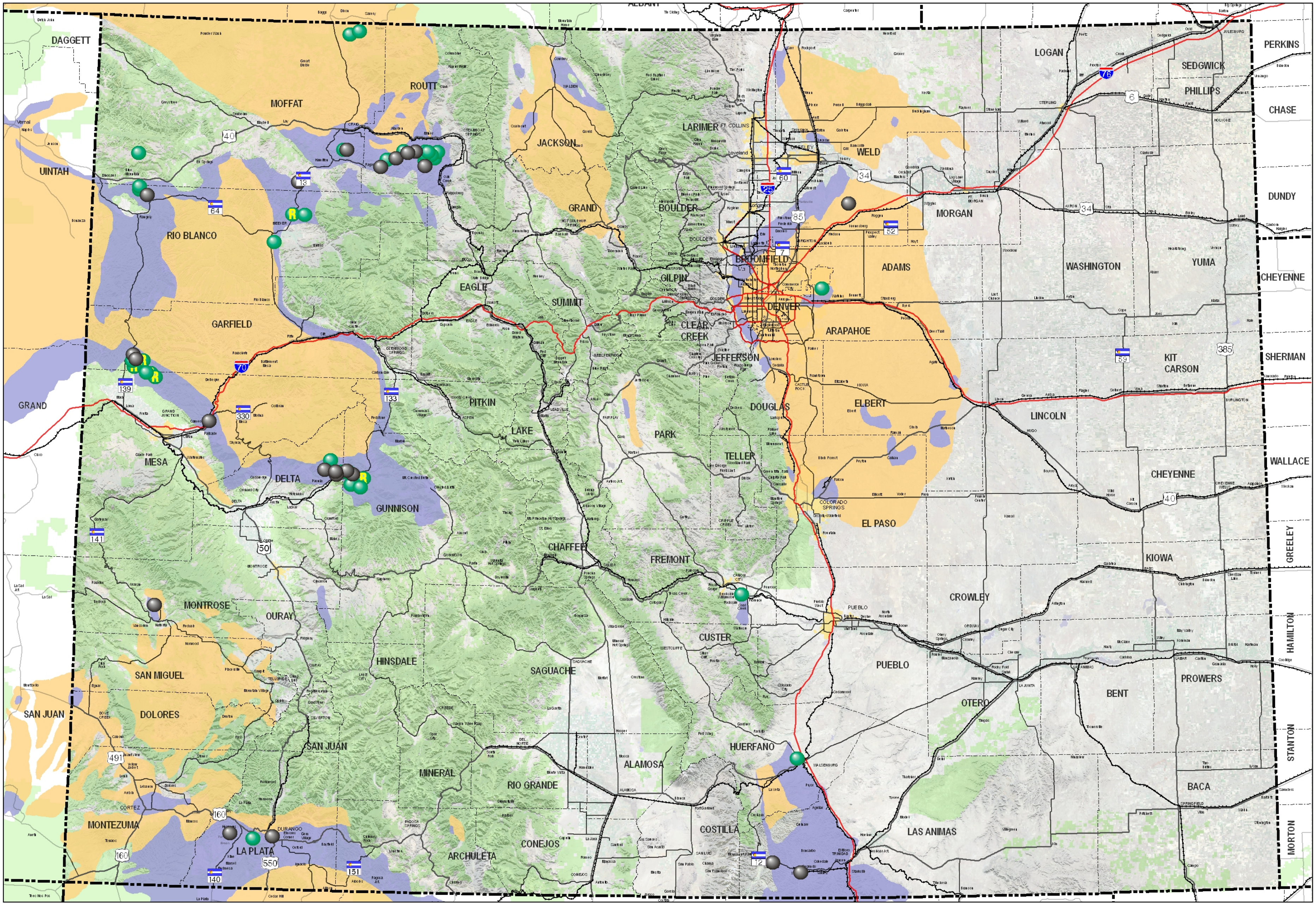
In 2008, Colorado ranked ninth in the nation in annual coal production. Colorado coal is generally low in sulfur and ash and is among the highest quality, cleanest coals found anywhere in the world, which makes it very desirable because it results in lower emissions when burned.

Coal deposits are scattered throughout Colorado, primarily on the Western Slope and along the Front Range, as shown on **Figure 10**. Only a fraction of the coal deposits have been identified as having the potential for mining activity. Many of the coal deposits are either too deep to be mined economically with current technology or they have high gas content making them too dangerous to mine. Ninety percent of coal deposits occur on public lands in Colorado. There are currently 22 active coal mine permits in Colorado, 29 active coal exploration permits, and 6 permit applications in review. At any given time, the number of producing coal mines varies depending upon the economic conditions; during the period between January and August of 2009, there were ten producing coal mines in Colorado.

C. Generalized Transportation Demands

According to data provided by the Bureau of Land Management, approximately 62 percent of Colorado coal is transported to other states, three percent is exported to foreign markets, and the remaining 35 percent stays in Colorado for power generation. Of the coal that is transported to other states, the highest percentages go to Kentucky, Tennessee, and Texas.

In the United States, coal is predominately transported by rail; the weight and the length of travel make rail the most economical means of transporting coal. In Colorado, railroad spurs provide direct connections between producing coal mines and a mainline railroad. Therefore; the impact of coal mining on the state highway system is minimal, especially in comparison to the demands of the oil and gas industry.



LEGEND

- Active Coal Mine Permit
- Active Coal Exploration Permit
- Permit Application In Review
- Known Potentially Minable Coal Deposits
- Other Known Coal Deposits

25 years FELSBURG HOLT & ULLEVIG

N W E S

0 40 Miles

Figure 10

Coal Mining & Exploration

Source: Colorado Division of Reclamation, Mining, and Safety

There are two primary travel patterns for coal transport through Colorado. In general, coal mined from the Western Slope is transported to the east by the Union Pacific railroad through Colorado to the eastern United States. In addition to the coal mined in Colorado, there is a significant amount of coal that is transported through Colorado. The Powder River Basin is a region in southeast Montana and northeast Wyoming about 120 miles wide and 200 miles long that is the single largest source of coal mined in the US and one of the largest deposits in the world. Much of the coal from the Powder River Basin is transported by the Burlington Northern Santa Fe railroad from Wyoming through Colorado's Front Range to destinations outside of Colorado.

As documented in the 2035 Statewide Plan Freight Technical Report, approximately three-quarters of rail freight (by volume) originating in Colorado in 2005 was coal. Similarly, nearly 50 percent of the rail freight volume coming into Colorado was related to the movement of coal.

The primary impact of coal transport on the state highway system occurs at railroad and highway crossings. Where grade separated crossings are not provided, coal trains, which typically include 120 to 130 rail cars, create delays for the state highway system and also present safety concerns.

V. WIND

A. Industry Overview

Wind power is the conversion of wind energy to a useable form of energy, typically electricity, using wind turbines. Wind turbines can be more than 260 feet high equipped with 3-130 foot long turbine blades. The turbine blades spin a rotor and drive components (called a nacelle) that transform wind into energy. Turbines installed across the U.S. in 2007 averaged 1.6 megawatts (MW) in generation capacity. The MW capacity of a wind turbine is the maximum potential energy produced with one hour of optimum wind speed. Given that wind speeds change frequently depending on the temperature of the earth and elevation of the turbine, the output from a turbine can vary dramatically. Typically, realized generation is 30% to 40% of full capacity.

In 2007, wind energy generation capacity in the United States was five times larger than in 2001. This rise in generation capacity necessitates increased manufacturing. Several wind companies such as GE, Vestas, and Siemens have established wind turbine manufacturing facilities in the United States; Vestas' manufacturing plants are located in Colorado.

Transportation demands during construction of a wind farm are extensive due to the heavy, oversized equipment and materials needed to erect the turbines (blades, towers and nacelles). Once the turbines are established, the energy production phase creates little, if any, traffic demands. Typically, four-wheel-drive trucks are used for periodic maintenance. Wind turbines remain active as long as they are maintained and connected to the electric grid.

Literature Review

The literature review associated with wind energy focused on previously completed studies pertaining to wind energy development in the United States (references are provided in **Appendix B**). Wind specific studies included a Programmatic Environmental Impact Statement (PEIS) on Wind Energy Development and scholarly articles examining the installation, cost, performance, and shipment related issues facing the wind industry. From the literature review, it became apparent that transportation demands are consistent from one wind farm to the next regardless of manufacturer or location; the two primary variable inputs are the quantity of wind turbines installed and opportunity to use railroad for site delivery. **Appendix C** provides a summary of each relevant document that was reviewed.

In 2005, the Bureau of Land Management (BLM) published the final Programmatic Environmental Impact Statement (PEIS) on Wind Energy Development. This document includes "an assessment of the positive and negative environmental, social, and economic impacts; discussion of relevant mitigation measures to address these impacts; and identification of appropriate, programmatic policies and best management practices (BMPs) to be included in the proposed Wind Energy Development Program." Essentially, this document serves as a road map for potential wind developers.

Key Person Interviews

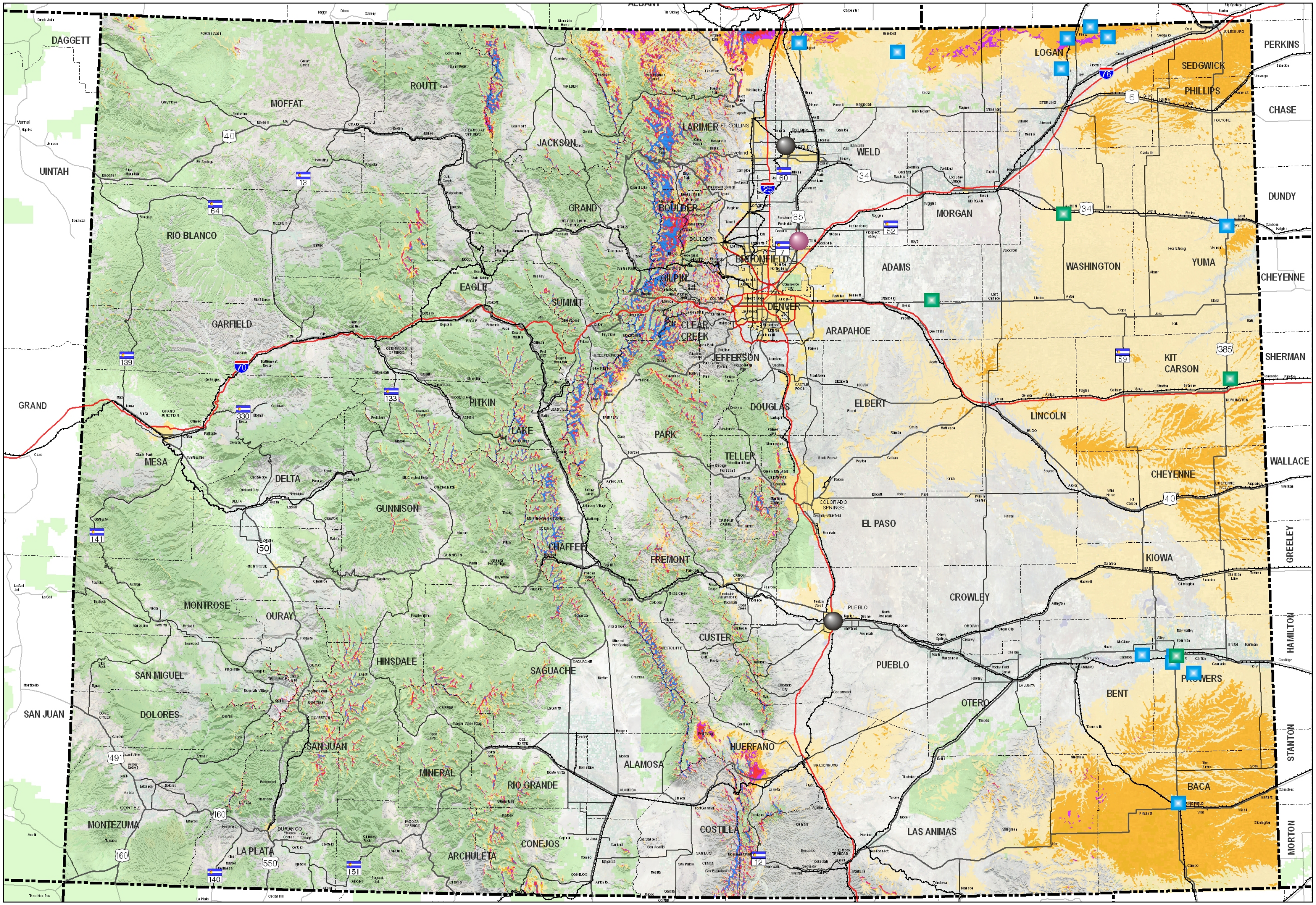
The project team also conducted interviews with trade group and industry representatives as part of the data collection process. The interviews affirmed information learned in the literature review and generally provided the project team with information on the number of trips required to build, operate and maintain wind farms.

B. Resource Development in Colorado

Wind energy production is attractive when a site has consistent winds with a mostly flat and open terrain. In eastern Colorado, all of these qualities are present. As of 2008, there were 820 wind turbines operating in Colorado throughout 11 operational wind farms. **Figure 11** displays all wind projects existing in Colorado as of 2008 as well as projects slated for completion through 2010. Active and planned wind farms in Colorado are listed in **Table 14**; the table also provides information about each plant's capacity, manufacturer and opening date. As shown, wind farms in Colorado are located primarily in the eastern plains.

In total, Colorado currently has 1,068 MW of wind power capacity. One MW of wind energy can typically power up to 300 homes over the course of a year; therefore, assuming a 30% generation rate, Colorado's wind farms could power over 96,000 homes per year.

Figure 11 also depicts the annual average wind resource potential throughout Colorado, at 50 meters above ground level. These data were developed by the National Renewable Energy Laboratory (NREL) with 200 meter resolution and are not suitable for micro-siting potential. The map shows that highest potential for wind power is along the foothills; however, this map does not consider the environmental or economic implications of wind farm construction. Much of eastern Colorado has good or fair wind power potential; future wind power plants will likely be located in eastern Colorado, consistent with existing locations.



LEGEND

- Superb Wind Power Potential
- Outstanding Wind Power Potential
- Excellent Wind Power Potential
- Good Wind Power Potential
- Fair Wind Power Potential
- Existing Wind Energy Generation Facility
- Proposed Wind Energy Generation Facility
- Existing Vestas Manufacturing Facility
- Planned Vestas Manufacturing Facility

75 years FELSBURG HOLT & ULLEVIG

N W E S

0 40 Miles

Figure 11

Active Wind Power Plants and Wind Power Potential

Source: National Renewable Energy Laboratory

Table 14. Active and Planned Wind Farms

Project Area and County	Date Online	Capacity (MW)	Manufacturer (Number of Turbines)
Ponnequin BU (Phase I) – Weld County	1999	5.1	NEG Micon (7)
Ponnequin PSCo (Phase II) – Weld County	1999	16.5	NEG Micon (15)
Ponnequin (Phase III) – Weld County	2001	9.9	Vestas (15)
Ridgecrest/Peetz Table Wind Farm – Logan County	2001	29.7	NEG Micon (33)
Colorado Green – Prowers County	2003	162.0	GE Wind 1500 (108)
Baca County (Springfield)	2004	1.5	GE Wind (5)
Prowers County	2004	6.0	GE Wind (4)
Colorado Pork Demonstration Turbine – Prowers County	2005	0.1	Vestas E-15 (1)
Spring Canon – Logan County	2006	60.0	GE Energy (40)
Twin Buttes – Bent County	2007	75.0	GE Energy (50)
Peetz Table Wind Energy Center (Phase I) – Logan Co.	2007	264.0	GE Energy (176)
Peetz Table Wind Energy Center (Phase II) – Logan Co.	2007	136.5	GE Energy (91)
Cedar Creek (Phase I) – Weld County	2007	79.5	GE Energy (53)
Cedar Creek (Phase II) – Weld County	2007	221.0	Mitsubishi (221)
Wray School District – Yuma County	2008	0.9	AWE (1)
Total Wind Energy Capacity in Colorado in 2008		**1,068**	

In addition to housing 11 wind farms, by the end of 2010, Colorado will also be the home of three plants that manufacture components of wind turbines. The Denmark-based company, Vestas, currently operates a blade-manufacturing plant in Windsor. Within the next year, Vestas will open a wind tower manufacturing plant in Pueblo and a third plant in Brighton producing blades and nacelles. The company expects to employ 2,500 people in Colorado by the end of 2010.

Combined, Vestas' three facilities will produce all major parts needed to develop turbines for use at a wind farm. These facilities comprise the epicenter of Vestas' U.S. manufacturing and distribution. **Table 15** displays the expected number of components each facility will produce in one year.

Table 15. Vestas Plant Production

Component Type (Location)	Production Output per Year
Turbine Blades (Windsor, CO)	1800
Nacelle Assembly (Brighton, CO)	1400
Tower Structure (Pueblo, CO)	900

C. Transportation Demands of Resource Development

Transporting the massive structures needed for a wind farm is challenging. Standard over-the-road trailer dimensions as well as a gross vehicle weight (GVW) put a constraint on the size of turbines installed unless special hauling permits or envoys are obtained. Once raw materials have arrived at the site of a future wind farm, large cranes are required to erect each turbine. "Crane requirements are quite stringent because of the large, heavy nacelle [the structure on the wind turbine that houses all of the drive components] in combination with the height of the lift and the required boom extension." (Source: US Department of Energy) Installation cranes are expected to lift as much as 75 tons.

In 2008, the American wind industry installed some 8,500 MW, which equated to over 5,000 turbines. According to the American Wind Energy Association (AWEA), a single turbine can require up to eight truck hauls (one nacelle, one hub, three blades, and three tower sections). The turbine blades are relatively light weight (seven to eight tons each), but they require permits for travel on the state highway system because they are so long. The heaviest pieces of the wind turbines are the tower base (the three components of the tower can range in weight from 40 to 60 tons) and the nacelle (approximately 75 tons). Additional transportation trips are necessary for road grading, laying foundations, and construction equipment.

Trip Generation and Vehicle Classification

Table 16 displays the transportation requirements in the development of a wind farm according to the BLM's Wind Energy Development PEIS. The trip figures shown in **Table 16** include trips associated with building access roads, constructing concrete foundations, delivering water for dust control and the delivery and construction of the wind turbines. One wind turbine requires approximately one week to construct, plus an additional week to wire the electronics. The operations-related trips are shown on an annual basis and show the trips associated with routine maintenance and periodic repair. Once a wind farm is operational, it is typically staffed by on-site workers during normal business

hours for routine maintenance. Infrequently, they need to bring in a crane to fix a problem. The wind turbines are also monitored remotely. There is no precedent for decommissioning of a wind farm in the United States.

An average wind turbine capacity of 1.6 megawatts was used to convert from turbines to megawatts; a megawatt capacity is the commonly used unit in describing the output of renewable energy sources and is used as the input unit for the renewable energy model.

Table 16. Wind Power Trip Generation Rates

Phase	Activity	Trips per Turbine	Trips per MW[1]
Construction	Road Grading	30	
	Foundations	34	
	Water	40	
	Turbine Delivery	20	
	Crane Delivery	2	
	Construction Total	126	79
Operations (Annual)		8	5

Source: BLM Wind Energy Development PEIS
1 Trips per megawatt calculated based on average wind turbine capacity of 1.6 megawatts.

Based on the BLM PEIS, each phase of development requires different truck types to complete the respective phases. **Table 17** displays the estimated percentage of truck types utilized during each phase of development.

Table 17. Wind Power Truck Types

Phase (Activity)	Light Vehicles	Flat Bed Equipment	Cement/Water Delivery Trucks	Oversized Trucks
Construction (Road Grading)	10%	70%	20%	0%
Construction (Foundations)	10%	30%	60%	0%
Construction (Water)	0%	0%	100%	0%
Construction (Turbine Delivery)	5%	0%	0%	95%
Construction (Crane Delivery)	0%	30%	0%	70%
Operations	90%	10%	0%	0%

Source: Adapted from BLM Wind Energy Development PEIS

Model Development

The renewable energy model includes a component for wind energy. The model is considerably more simplistic than the oil and gas model; it provides trip generation and vehicle classification information, but does not go to the extent of allocating the demands to specific corridors. A user's guide for the renewable energy model is provided in **Appendix F**.

VI. SOLAR

A. *Industry Overview*

There are two main types of solar energy, Photovoltaic (PV) and Concentrated Solar Power (CSP). CSP directs sunlight into a focused beam to create thermal energy for electric generation. Methods for concentrating sunlight include troughs, towers, and concave dishes. Once generated, this thermal energy has a variety of uses: powering steam turbines, storing molten salt, and filling elevated hydro pumps that allow water to fall through turbines when the sun is not shining.

This study focuses on PV solar energy as development of this type has been more prevalent in Colorado. PV cells capture solar radiation and convert it directly into electric current. Commonly, PV cells are made with crystalline silicone. In the first stage of development, construction materials (PV panels) and equipment (hoists and panel mounts) are transported to the site using semi-trucks. Depending on the size of the solar array, there can be hundreds of truckloads needed to deliver materials.

PV solar panel capacity is reported in the electric generation per hour of peak sun exposure. PV solar generation facilities typically provide 1 MW of capacity per 10 acres of solar panels (approximately 330 panels per acre). Therefore, assuming there is an average of six hours of peak sun every day, 10 acres (1 MW) of PV solar panels can realistically power 200 homes over the course of a year. Solar facility sizes in the US range from a few panels across a rooftop to a 15 MW (150 acre) facility outside of Nellis Air Force Base in Nevada.

Literature Review

The literature review of solar energy focused on previously completed studies pertaining to solar energy development in the United States (references are provided in **Appendix B**), as well as key person interviews with local solar industry workers. Solar specific studies included a BLM Draft Plan of Development for a large solar facility in Nevada and scholarly articles examining the installation, cost, performance, and shipment related issues facing the solar industry. The literature review yielded results on two distinct subjects: 1) transportation demands of solar energy development and 2) type of solar energy development. From the literature review, it became apparent that transportation demands are consistent from one solar facility to the next regardless of manufacturer or location; the primary variable input is the quantity of solar panels installed. **Appendix C** provides a summary of each relevant document that was reviewed.

Key Person Interviews

The project team also conducted interviews with trade group and industry representatives as part of the data collection process. The interviews affirmed information learned in the literature review and generally provided the project team with information on the number of trips required to build, operate and maintain solar farms.

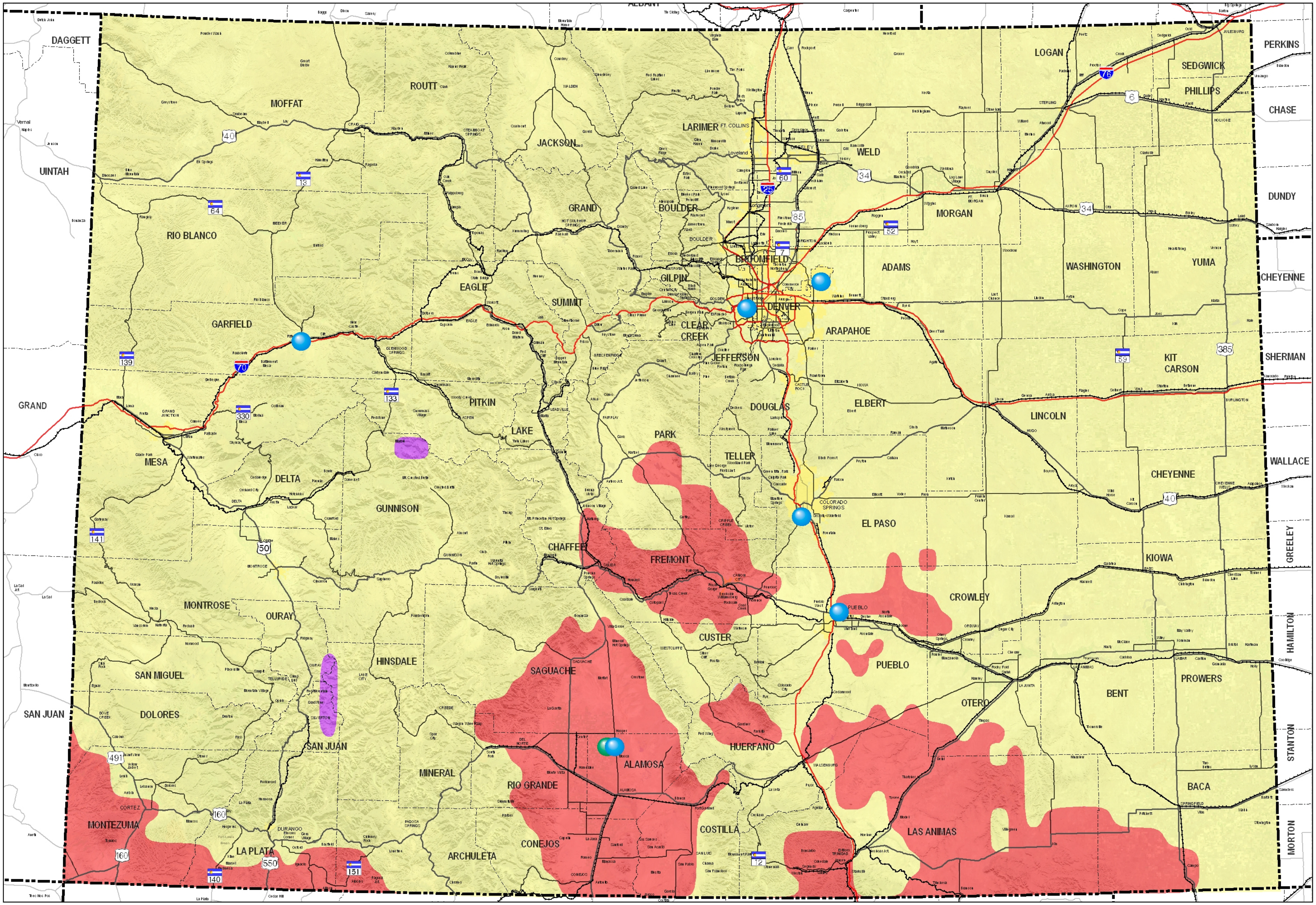
B. Resource Development in Colorado

Solar energy production is attractive for areas with ample, direct sunlight. The southern third of Colorado is most suitable for utility-scale solar energy production. As of 2008, there were no CSP energy generation facilities in Colorado, but NREL is currently testing the production capabilities of CSP in Colorado for future development. PV panels, however, are more prevalent throughout Colorado.

REC Solar and Standard Renewable Energy manufacture and install PV cells for residential and commercial properties in Colorado. Key person interviews with staff members at these organizations indicate that PV solar power is installed in a similar manner regardless of project size. PV panels are delivered to the development site, installed, and produce electricity. Once the PV panels are established, the energy production phase creates little, if any, traffic demands. PV generation facilities remain active as long as they are maintained and connected to the electric grid.

As of 2009, there were 16 MW of PV solar power capacity in Colorado across six utility-scale PV solar generation facilities. **Table 18** provides an overview of each active and planned solar power array facility including the location, generation potential, power purchaser, and manufacturer of the solar panels. **Figure 12** shows the location of the sun power arrays geographically. As shown, solar power arrays in Colorado are primarily located along the Front Range. In total, the solar power arrays have a capacity to generate approximately 32 MW of power. Assuming an average of six hours of direct sunlight per day, the arrays could provide electricity for the equivalent of 6,400 houses over the course of a year.

Figure 12 also shows the solar power potential in Colorado. Most of the state has very good solar power potential, and southern portions of the state have excellent solar power potential. These data were derived from average and annual daily total solar resources by the National Renewable Energy Laboratory (NREL). This information does not evaluate environmental or economic considerations in placing solar arrays.



LEGEND

- Excellent Solar Power Potential
- Very Good Solar Power Potential
- Good Solar Power Potential
- Existing Solar Power Arrays
- Proposed Solar Power Arrays

25 years FELSBURG HOLT & ULLEVIG

N W E S

0 40 Miles

Figure 12

Active Solar Power Arrays and Solar Power Potential

Source: National Renewable Energy Laboratory

Table 18. Active and Planned Solar Power Arrays

Project Area and County	Date Online	Capacity (MW)	Power Purchaser	Panel Manufacturer
Denver Federal Center – Denver County	2007	1.0	US Government	Sun Edison
CSU-Pueblo Solar – Pueblo County	2008	1.0	Black Hills Energy	BP
Denver International Airport Solar Array – Denver County	2008	2.0	DIA	World Water & Solar Technologies Group
Fort Carson Solar Array – El Paso County	2008	2.0	US Army	US Army
Sun Edison San Suis Valley Plant – Alamosa County	2008	8.2	Xcel	Sun Edison
Rifle Energy Innovation Center – Garfield County	2009	1.7	City of Rifle	Sun Edison
Greater Sandhill – Alamosa County	2010	16.0	Xcel	Sun Edison
Total Wind Energy Capacity in Colorado		**31.9**		

Source: Interwest Energy Alliance

C. Transportation Demands of Resource Development

The primary equipment needed to build a PV solar facility, mounting materials and solar panels, can be delivered to a development site using semi-truck containers, flat bed trucks and light passenger trucks. Additionally, concrete is delivered to the site for pouring foundations that mount the panels. Upon delivery of materials, construction equipment necessary for grading, dozing, excavating, trenching, and hoisting are delivered to the site. PV panels are hoisted using truck-mounted cranes as opposed to the large, high-weight cranes needed for constructing wind turbines.

Trip Generation and Vehicle Classification

In 2009, the BLM published a Draft Plan of Development for the Silver State North Photovoltaic Project. The project will have a generation capacity of 140MW spanning across some 3,200 acres in the Ivanpah Valley in Nevada. During peak construction, an estimated 53 truck trips per day will be required to supply concrete, construction materials, equipment and project components such as PV panels and mounting materials to the site. An approximate workforce of 285 people is required during peak construction. (Source: Silver State North Photovoltaic

Project Draft Plan of Development). Essentially, this document served as a model for solar development transportation impacts.

Table 19 displays the transportation requirements in the development of a solar facility according to the BLM's Draft Plan of Development. The construction trips include vehicle-trips associated with building access roads, constructing concrete foundations, delivering water for dust control and the delivery and construction of the PV solar panels.

The operations-related trips are shown on an annual basis and show the trips associated with routine maintenance and periodic repair. The 50 operations trips are derived from an average 232 trips for scheduled and unscheduled maintenance events per year over five years at the 4.6 MW Springerville PV array near Tucson, Arizona. On average, there are about 50 annual trips per megawatt. These trips are for general maintenance and also for repairs caused by adverse weather conditions. Solar facilities are generally monitored by remote telemetry, and sight visits are relatively infrequent. There is no precedent for decommission of a solar farm in the United States.

Table 19. Solar Power Trip Generation Rates

Phase	Trips per MW
Construction[1]	202[2]
Operations (Annual)[3]	50

1 Source: Adapted from Silver State North Photovoltaic Project Draft Plan of Development
2 Construction trips represent a single occurrence
3 Source: Five Years of Operating Experience at a Large, Utility-scale Photovoltaic Generating Plant

Based on the BLM Draft Plan of Development, each phase of development requires different truck types to complete the respective phases. **Table 20** displays the estimated percentage of truck types utilized during each phase of development.

Table 20. Solar Power Truck Types

Phase (Activity)	Light Vehicles	Flat Bed Equipment	Cement/Water Delivery Trucks	Semi-Trucks
Construction (Road Grading)	10%	80%	10%	0%
Construction (Foundations)	10%	20%	70%	0%
Construction (Water)	0%	0%	100%	0%
Construction (Panel Delivery)	5%	5%	0%	90%
Construction (Mounting Materials)	0%	30%	0%	70%
Operations	90%	10%	0%	0%
Decommission	10%	30%	30%	30%

Source: NextLight Renewable Power

Model Development

The renewable energy model includes a component for solar energy. The model is considerably more simplistic than the oil and gas model; it provides trip generation and vehicle classification information, but does not go to the extent of allocating the demands to specific corridors. A user's guide for the renewable energy model is provided in **Appendix F**.

VII. BIOFUELS

A. Industry Overview

Biofuels, such as biodiesel and ethanol, are processed from organic matter and are designed to replace diesel and gasoline. Biofuel facilities require constant attention, operation and maintenance. Often, organic material is not grown for exclusive use at biofuel facilities; the waste from organic production is used most often (e.g., leaves and stems from corn, dead trees, etc.). Dissimilar to other renewable energy sources, which are used for utility-scale electricity generation, the end use for biofuels is typically for personal or commercial auto transportation. Biofuels are used to reduce emissions for cars, trucks and, recently, jets.

Ethanol is the most commonly produced biofuel in the United States. In addition to fuel use, the bi-products of ethanol production, such as distiller's grain is sold as cow feed because of its high protein content. The second most commonly produced biofuel is biodiesel. Research is being conducted on the feasibility and cost of utilizing fast-growing algae to produce biodiesel instead of the more traditional inputs for biodiesel (soy and vegetable oil). Another type of biofuel, woody biomass (wood pellets) can be co-fired with fossil fuels to reduce emissions at existing power plants.

Biofuels, based on the inputs, end use, and growing method, produce a varying degree of transportation demands. For example, algae grown on site and turned into biodiesel are only transported to a blending facility. Conversely, traditional ethanol and biodiesel have organic inputs transported to the production facility as well as fuel outputs being transported to a blending facility. Lastly, biomass, such as wood pellets is only transported to the power plant to be burned onsite alongside fossil fuels.

Literature Review

The literature review of biofuel focused on previously completed studies pertaining to biofuel and biomass energy development in the United States (references are provided in **Appendix B**), as well as key person interviews with local biofuel industry workers. Bio-energy specific studies included a U.S. Department of Agriculture overview of transportation issues facing the United State's biofuel industry and scholarly articles examining the cost, performance, and shipment related issues facing the biofuel. The literature review yielded results on two distinct subjects: 1) transportation demands of biofuel energy development and 2) type of biofuel energy development. From the literature review, it became apparent that transportation demands vary considerably from one biofuel to the next; the primary variable inputs are the type of biofuel input, crop yield, and location of agriculture. **Appendix C** provides a summary of each relevant document that was reviewed.

Key Person Interviews

The project team also conducted interviews with trade group and industry representatives as part of the data collection process. The interviews affirmed information learned in the literature review and generally provided the project team with information the transportation activity associated with biofuel development.

B. Resource Development in Colorado

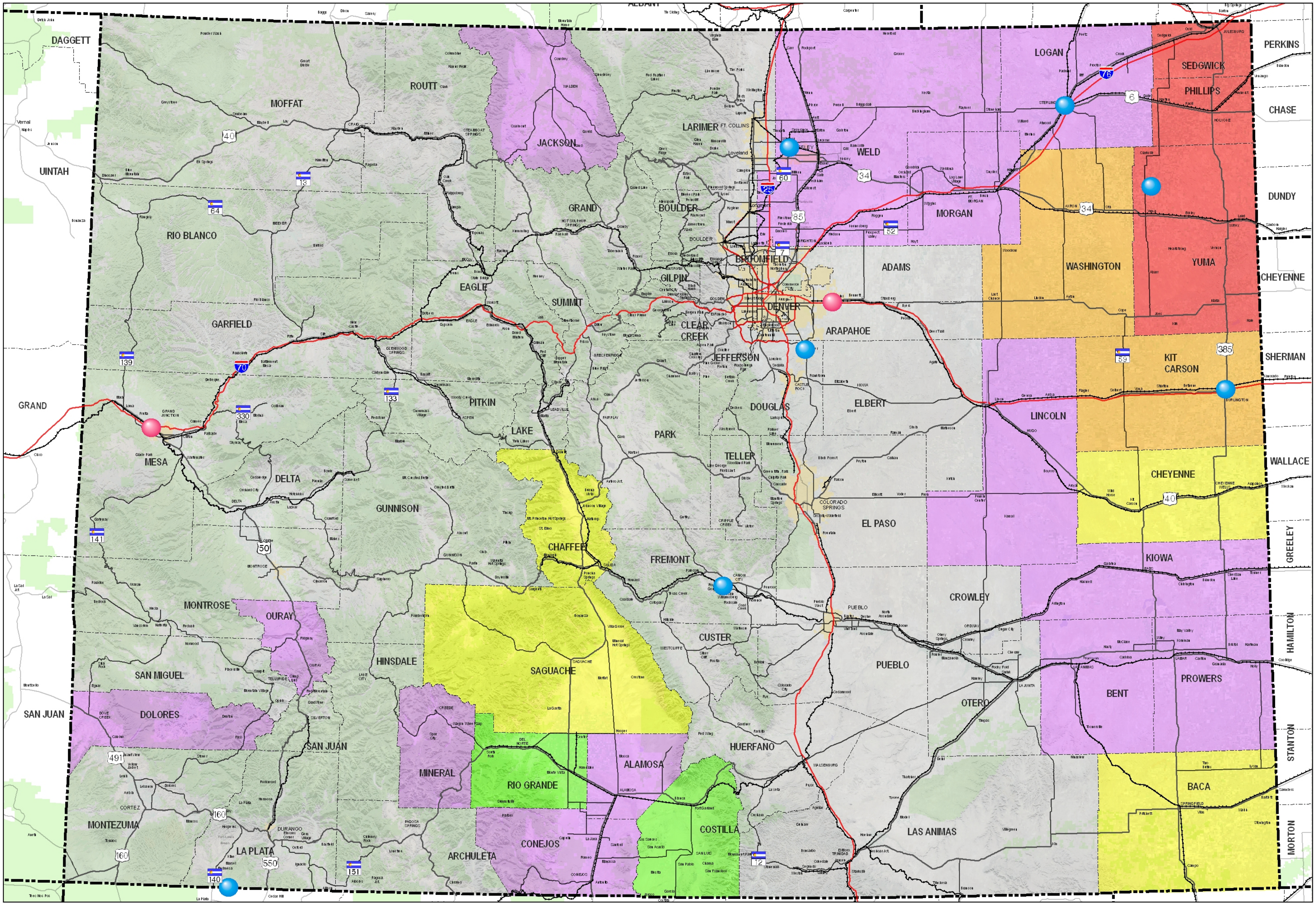
Biofuel plants exist throughout Colorado using corn, algae, soy, recycled vegetable oil, and woody biomass (small pellets of wood used for co-firing with coal). Unlike most other energy sources, biofuels can be created wherever the developer chooses. The selected site is most likely near a developed transportation network to reduce transport costs. Biofuel facilities resemble small industrial operations. In Colorado, they are generally very small scale at the present time and are located in areas on the Front Range and eastern plains.

There are currently three facilities in Colorado that manufacture ethanol. Once these facilities produce ethanol, it must be shipped to a blending facility and mixed with fossil fuel. In addition to ethanol facilities, there are two biodiesel production facilities. The remainder of facilities that create or use biofuel are less traditional as they use algae grown on site inside warm pools and wood pellets that are co-fired with coal for emission reductions. As of 2009, there were seven biofuel processing plants in Colorado. **Table 21** displays all facilities that use biofuels for energy generation. The biofuel processing plants are shown geographically on **Figure 13**.

Table 21. Biofuel Processing Plants

Production Company (Location)	Year Online	Energy Produced (input)
Rocky Mountain Biodiesel (Parker)	2009	Biodiesel (recycled vegetable oil)
Solix Coyote Gulch Facility (Durango)	2009	Biodiesel and Biojet Fuel (algae grown on site)
Sterling Ethanol LLC (Sterling)	2005	Ethanol (corn)
Yuma Ethanol LLC (Yuma)	2007	Ethanol (corn)
Front Range Energy LLC (Windsor)	2006	Ethanol (corn)
Aquila W.N. Clark[1] (Canon City)	2008	Electricity (woody biomass)
American AgriDiesel (Burlington)	2006	Biodiesel (soy, sunflower, canola)
Bye Energy[2] (Watkins)	TBD	Biojet Fuel (agricultural residue)
Suncor/Lignol[2] (Grand Junction)	TBD	Ethanol (woody biomass)

[1] The Aquila W.N. Clark facility is a coal-fired power plant that uses wood pellets to offset some of the emissions produced by the plant.
[2] These projects have site selected and business plans, but are not built.



LEGEND

- 25 - 50 Tonnes/Year/Person
- 15 - 25 Tonnes/Year/Person
- 10 - 15 Tonnes/Year/Person
- 5 - 10 Tonnes/Year/Person
- 1 - 5 Tonnes/Year/Person
- Less than 1 Tonnes/Year/Person
- Existing Biomass or Biofuel Facility
- Proposed Biomass or Biofuel Facility

75 years FELSBURG HOLT & ULLEVIG

N W E S

0 40 Miles

Figure 13

Available Biomass Resources

Source: National Renewable Energy Laboratory

Figure 13 also depicts the estimated technical biomass resources available by county, using information developed by the National Renewable Energy Laboratory (NREL) in their 2005 report titled, *A Geographic Perspective on the Current Biomass Resource Availability in the United States*. The biomass resource potential is based on the availability of biomass feedstock within each county. The following feedstock categories have been considered in NREL's report: crop residues, methane emissions from manure management, methane emissions from landfills and wastewater treatment facilities, forest residues, primary and secondary mill residues, urban wood wastes, and dedicated energy crops. The data shown on **Figure 13** have been normalized by 2000 Census population by county in order to demonstrate the biomass resources available per person.

Additional plans to increase Colorado's biofuel production capacity include the construction of an $88 million cellulosic ethanol plant. This plant will have the capability to make ethanol out of the dead trees left behind by the pine beetle throughout the mountains. The transportation implications of this production facility could be large from shipping the trees from the mountains to the Front Range.

C. Transportation Demands of Resource Development

In 2007, the United States produced nearly 6 billion gallons of ethanol while among the three operational ethanol plants in Colorado, an estimated 125 million gallons of ethanol (about two percent of U.S. production) are produced each year (source: U.S. Energy Information Administration). American AgriDiesel, which produces biodiesel, produces a much smaller quantity of fuel, just 10 million gallons per year.

Sterling and Yuma Ethanol LLC estimates that they generate 110 truckloads of activity per day, including delivery of organic material for inputs, the delivery of ethanol to market and the delivery of distiller's grain byproduct to feedlot operations.

Companies planning to produce and sell biofuel within the state are more likely to create greater traffic loads. In Colorado, Bye Energy plans to produce Jet-A fuel for use at Front Range Airport. The organic input to the bio-jet fuel is agricultural residue (waste products from corn including the stems and leaves). A likely supply of agricultural residue for the production plant will come from the farms in northeast Colorado. This waste residue is treated differently by every farm; it can be stored in a silo, turned into feed for cows, ground up as fertilizer for future crops, discarded, or sold to biofuel processing facilities. Bye Energy is still in the project development phases; therefore, the quantity of agricultural residue necessary for jet fuel production is unknown. Corn farms in northeast Colorado will most likely experience no significant increases in traffic load associated with Bye Energy's activities.

Companies planning to simply sell biofuel, such as Blue Sun Biodiesel, have little or no transportation demands associated with its renewable energy developments in Colorado. According to NREL, there are currently 21 biodiesel stations located throughout Colorado indicating that trucks delivering Blue Sun biodiesel around the state would likely travel similar routes as those traveled by regular diesel trucks. Information gathered during key-person interviews indicates that the biofuel market in Colorado will not have a major impact on transportation corridors.

Trip Generation and Vehicle Classification

Transporting materials to construct a biomass processing facility are similar to constructing other industrial manufacturing facilities. In some cases little construction is necessary as previous processing plants for fossil fuels can be retrofitted as bio-fuel processing plants. There are no large, expansive, or remote facilities required for biofuel production, as with wind or solar farms. The numerous methods employed to turn biomass into biofuel can create varying levels of transportation demand. At this time there is no environmental impact statement available for biofuel generation facilities. The estimated trips associated with a biofuel generation facility may be best evaluated on a case specific basis.

Throughout development phases, the largest transportation demands associated with biofuel are not during the construction phase as with other renewable power, but throughout the production phase as organic material is continually delivered to the processing plant for energy generation and processed fuels are exported for fossil fuel blending.

According to the National Commission on Energy Policy's Task Force on Biofuels Infrastructure, one semi truck can haul about 7,865 gallons of ethanol or biodiesel or about 910 bushels of corn. As stated on the previous page, annual ethanol and biodiesel production in Colorado averages about 135 million gallons. This equates to about 34,300 truck trips per year for output related trips. There would also be an estimated 25,400 output-related truck trips to haul distiller's grain byproduct from the ethanol plants in Colorado. The American Coalition on Ethanol estimates that for every gallon of ethanol produced, there are six pounds of distiller's grain byproduct produced. For-input related trips, the project team obtained data from the US Department of Agriculture, which stated a relationship of 2.77 gallons of ethanol per bushel of organic matter. As such, the current Colorado production of 135 million gallons of ethanol and biofuels requires about 48.7 million bushels of organic matter or about 107,100 truck trips per year. Based on these relationships, the trip generation rates for biofuel production are shown in **Table 22**.

Table 22. Biofuel Trip Generation Rates and Vehicle Classification

	Unit	Trips	Vehicle Classification
Input-Related Trips	Million Gallons of ethanol or biofuel	793	100% Heavy Trucks
Output-Related Trips	Million Gallons of ethanol or biofuel	422	100% Heavy Trucks
Total		**1,235**	

Sources: National Commission on Energy Policy's Task Force on Biofuels Infrastructure, American Coalition on Ethanol

Model Development

The renewable energy model includes a component for biofuels. The model is considerably more simplistic than the oil and gas model; it provides trip generation and vehicle classification information, but does not go to the extent of allocating the demands to specific corridors. For this reason, the project team has deemed it inappropriate to include a corridor allocation model for biofuels. A user's guide for the renewable energy model is provided in **Appendix F**.

VIII. FINDINGS AND RECOMMENDATIONS

Trip generation rates contained in the previous chapters are difficult to compare from one energy source to another since energy source development and production are measured in different units (i.e., a well, a wind turbine, tons of uranium, etc.). **Table 23** provides estimates of the total number of trips that were generated in 2007 and 2008 by each of the energy sources in Colorado. These estimates are based on information gathered from various sources on the level of production and development that occurred in 2007 and 2008, and on the trip generation rates that have been documented in the previous chapters. These estimates provide a clear comparison of the relative demand between the various energy sources. The annual trips in Colorado generated by the oil and gas industry dwarf the travel demands of the other energy sources. Based on these estimates, the oil and gas trips account for 98.7 percent of total energy trips.

Table 23. Estimated Annual Trip Generation

Energy Source	2007	2008	Average
Oil & Gas[1,2]	15,900,000	17,900,000	16,900,000
Uranium[3]	26,000	26,000	26,000
Wind[4]	63,000	5,400	34,200
Solar[5]	200	2,700	1,450
Biofuels[6]	167,000	167,000	167,000
Total	**16,156,200**	**18,101,100**	**17,128,650**

[1] Includes crude oil, natural gas and coal bed methane
[2] Basis for calculation: 33,800 active oil and gas wells in 2007 (1,935 of which were drilled that year), 38,200 active oil and gas wells in 2008 (2,160 of which were drilled that year), producing wells: 64% natural gas, 24% crude oil, 12% CBM), Source: Colorado Oil and Gas Conservation Commission
[3] Basis for calculation: Estimated 72,000 tons of uranium produced per year, Source: Sunday Mines EA
[4] Basis for calculation: New wind capacity added in 2007 = 776 MW, operating wind capacity in 2007 = 290.8 MW, new wind capacity added in 2008 = 0.9 MW, operating wind capacity in 2008 = 1066.8 MW
[5] Basis for calculation: New solar capacity added in 2007 = 1.0 MW, no operating solar capacity in 2007, new solar capacity added in 2008 = 13.2 MW, operating solar capacity in 2008 = 1.0 MW
[6] Basis for calculation: Estimated 125 million gallons of ethanol and 10 million gallons of biodiesel produced per year, Sources: US Department of Energy, Alternative Fuels and Advanced Vehicles Data Center and the State of Colorado Governor's Energy Office

The trip generation rates and the travel estimation models that have been developed as a part of this research study are intended to be used by CDOT, as well as Metropolitan Planning Organizations, Transportation Planning Regions, municipalities and counties in Colorado, to proactively plan for future energy development and establish ways to address the demands to the transportation system. The following list of recommendations is intended to provide CDOT direction on areas in which to focus to most efficiently plan for future energy development in Colorado.

Policy Recommendations

- Since the oil and gas travel demands account for the vast majority of the energy demands to the state highway system, CDOT should focus its planning efforts on oil and gas development.

- The project team experienced some hesitation from the energy sector (particularly from the oil and gas industry) in sharing information for this research study. CDOT should continue to build and improve relationships with the energy development industry and pursue opportunities for partnership with the energy sector.

- Build partnerships with resource and regulatory agencies to ensure that CDOT's interests (i.e., demands to the transportation system) are considered and adequately addressed in any environmental studies pertaining to the energy industry and that CDOT is alerted of any potential issues.

- With respect to future wind power development, CDOT should take a statewide perspective in identifying the best routes for transporting the oversized loads that comprise the wind turbines. For routing through specific municipalities or counties, CDOT should defer to the local governments' knowledge of the best routes order to minimize delays and the need for temporary removal of signal equipment.

- To continue improving safety at highway/rail crossings, maintain relationships with the Public Utilities Commission (PUC) and the railroads to improve the safety at existing at-grade railroad crossings and to provide grade separated crossings, particularly along railroad lines that are heavy used by the coal industry.

Model & Corridor Improvement Recommendations

- A baseline comparison of travel demands by corridor is provided in the research study document. This comparison can be used both as a measure for prioritizing corridors in the long range regional and statewide transportation plans and as a basis with which to compare future conditions.

- The travel estimation models should be used to estimate the level of energy-related activity on key corridors in the state. CDOT staff should update the models in advance of the regional and statewide transportation planning processes so that up to date corridor travel estimations can be incorporated into the planning process.

- Efforts to validate the travel estimation models in the future based on actual traffic and energy development data will help to ensure the long term utility of the models.

- The research study identifies potential corridor improvements for each of the key energy development corridors in the state. Potential improvements include improving infrastructure (such as surface treatment, bridge repair or replacement); enhancing safety (such as geometric modifications, guardrail, widened shoulders); or improving mobility (such as major widening, auxiliary lanes, passing or climbing lanes).This information should be used as a basis for conducting more detailed corridor studies, and should be incorporated into the next iteration of the long range regional and statewide transportation plans.

75 years

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