Appendix A
Soil Types in the Figure Four Project Area

APPENDIX A - SOIL TYPES IN THE FIGURE FOUR PROJECT AREA

Rio Blanco County Soils

Barcus channery loamy sand (map unit 6). This deep excessively drained soil is located on alluvial fans and in narrow valleys at elevations between 5,800 and 6,800 feet amsl on slopes of 2 to 8 percent. The soil is calcareous throughout and consists of a surface layer of pale brown channery loamy sand about 6 inches thick, an underlying layer of light yellowish brown channery loamy sand about 10 inches thick, and stratified light yellowish brown and pale brown very channery sand and loamy sand to a depth of about 60 inches. The soil is characterized by rapid infiltration, slow runoff, and a low available water capacity. The water erosion hazard is moderate.

Castner channery loam (map unit 15). This shallow, well-drained soil is located on mountainsides, ridgetops, and uplands at elevations between 6,900 and 7,800 feet amsl on slopes of 5 to 50 percent. The soil consists of a surface layer of dark grayish-brown channery loam about 7 inches thick, an underlying layer of dark grayish-brown very channery loam about 4 inches thick, and grayish-brown calcareous very channery loam to depth of about 10 to 20 inches. The soil is characterized by moderate infiltration, medium to rapid runoff, and a very low available water capacity. The water erosion hazard is moderate to very high.

Forelle loam (map unit 33). This deep well-drained soil is located on terraces and uplands at elevations between 5,800 and 7,200 feet amsl on slopes of 3 to 8 percent. The soil consists of a surface layer of pale brown loam about 4 inches thick, an underlying layer of yellowish brown clay loam about 12 inches thick, and very pale brown loam to a depth of about 60 inches. The soil is characterized by moderate infiltration and runoff, and a high available water capacity. The water erosion hazard is moderate.

Glendive fine sandy loam (map unit 36). This deep well-drained soil is located along drainageways on alluvial valley floors at elevations between 5,800 and 7,200 feet amsl on slopes of 2 to 4 percent. The soil is calcareous throughout and consists of a surface layer of pale brown fine sandy loam about 6 inches thick and very pale brown, stratified fine sandy loam to a depth of about 60 inches. The soil is characterized by moderately rapid infiltration, slow runoff, and a moderate available water capacity. The water erosion hazard is slight and the soil is subject to rare periods of flooding.

Hagga loam (map unit 40). This deep poorly-drained soil is located on floodplains and alluvial valley floors at elevations between 5,800 and 7,200 feet amsl on slopes of 0 to 5 percent. The soil consists of a surface layer of light brownish gray loam about 5 inches thick and stratified silt clay loam to loamy fine sand to a depth of about 60 inches. The soil is characterized by moderately slow infiltration, slow runoff, and a high available water capacity. The water erosion hazard is slight and the soil is subject to brief periods of flooding in the spring and summer.

Havre loam (map unit 41). This deep well-drained soil is located on floodplains and alluvial low stream terraces at elevations between 5,800 and 7,200 feet amsl on slopes of 0 to 4 percent. The soil consists of a surface layer of light brownish gray loam about 21 inches thick and stratified light gray loam and silt clay loam to a depth of about 60 inches. The soil is characterized by moderate infiltration, moderate runoff, and a high available water capacity. The water erosion hazard is slight and the soil is subject to brief periods of flooding in the spring and summer.

Irigul channery loam (map unit 42). This shallow well-drained soil is located on ridges and mountainsides at elevations between 7,600 and 8,700 feet amsl on slopes of 5 to 50 percent. The soil consists of a surface layer of grayish brown channery loam about 5 inches thick and brown extremely channery loam about 7 inches thick. Hard sandstone is at a depth of 12 inches. The soil is characterized by moderate infiltration, moderate to rapid runoff, and a very low available water capacity. The water erosion hazard is very high.

Irigul-Parachute complex (map unit 43). This map unit is located on ridges and mountainsides at elevations between 7,600 and 8,500 feet amsl on slopes of 5 to 30 percent. The unit is 60 percent Irigul loam and 30 percent Parachute loam. The Irigul soil is shallow and well-drained, with a surface layer of grayish brown channery loam about 5 inches thick and brown extremely channery loam about 7 inches thick. Hard sandstone is at a depth of 12 inches. Permeability of the Irigul soil is moderate and available water capacity is very low. Runoff is medium to rapid and the water erosion hazard is slight to high. The Parachute soil is moderately deep and well-drained. The surface layer is grayish-brown loam 4 inches thick. The upper 20 inches of subsoil is grayish-brown loam and channery loam and the lower 8 inches is pale brown very channery loam. Sandstone is at a depth of 38 inches. Permeability of the Parachute soil is moderate and available water capacity is low. Runoff is medium and the water erosion hazard is moderate to very high.

Northwater loam (map unit 56). This deep well-drained soil is located on mountainsides at elevations between 7,700 and 8,400 feet amsl **and** on slopes of 5 to 50 percent. The surface is typically covered with a mat of partially decomposed leaves about 2 inches thick. The surface layer is grayish brown loam about 20 inches thick. The upper part of the subsoil consists of brown loam about 5 inches thick and the lower part is pale brown very channery loam about 6 inches thick. Fractured sandstone is at a depth of 47 inches. The soil is characterized by moderate infiltration, medium runoff, and a moderate available water capacity. The water erosion hazard is moderate to very high.

Parachute loam (map unit 58). This moderately deep, well-drained soil is located on ridges and mountainsides at elevations between 7,500 and 8,700 feet amsl on slopes of 25 to 75 percent. The surface layer is grayish-brown loam 4 inches thick. The upper 10 inches of subsoil is loam followed by 10 inches of channery loam and 8 inches of very channery loam. Fractured sandstone is at a depth of 38 inches. Permeability is moderate and available water capacity is low. Runoff is medium and the water erosion hazard is very high.

Parachute-Rhone loams (map unit 59). This map unit is located on mountainsides and upland ridges at elevations between 7,600 and 8,600 feet amsl on slopes of 5 to 30 percent. The unit is 55 percent Parachute loam and 35 percent Rhone loam. The Parachute soil is moderately deep and well-drained. The surface layer is grayish-brown loam 4 inches thick. The upper 10 inches of subsoil is loam followed by 10 inches of channery loam and 8 inches of very channery loam. Fractured sandstone is at a depth of 38 inches. Permeability of the Parachute soil is moderate and available water capacity is low. Runoff is medium and the water erosion hazard is moderate to high. The Rhone soil is deep and well-drained. The upper part of the surface layer is dark grayish brown loam about 8 inches thick, the next layer is 16 inches of dark grayish brown loam, and the lower part is grayish brown very channery loam about 16 inches thick. The substratum is brown very channery loam 10 inches thick. Fractured sandstone is at a depth of about 50 inches. Permeability of the Rhone soil is moderate and available water capacity is high. Runoff is medium and the water erosion hazard is moderate to high.

Piceance fine sandy loam (map unit 64). This moderately deep, well-drained soil is located on uplands and broad ridgetops at elevations between 6,300 and 7,500 feet amsl on slopes of 5 to 15 percent. The surface layer is brown fine sandy loam 4 inches thick. The upper 5 inches of subsoil is brown loam followed by 13 inches of light yellowish brown loam. The substratum is very pale brown channery loam about 8 inches thick. Hard sandstone is at a depth of 30 inches. Permeability is moderate and available water capacity is moderately low. Runoff is slow to medium and the water erosion hazard is moderate to high.

Redcreek-Rentsac complex (map unit 70). This map unit is located on mountainsides and ridges at elevations between 6,000 and 7,400 feet amsl on slopes of 5 to 30 percent. The unit is 60 percent Redcreek sandy loam and 30 percent Rentsac channery loam. The Redcreek soil is shallow and well-drained. The surface layer is brown sandy loam 4 inches thick. The next layer is calcareous sandy loam about 7 inches thick. The underlying material is very pale brown, calcareous channery loam about 5 inches thick. Hard sandstone is at a depth of 16 inches. Permeability of the Redcreek soil is moderate and available water capacity is very low. Runoff is medium and the water erosion hazard is moderate to high. The Rentsac soil is shallow and well-drained. The upper part of the surface layer is grayish brown channery loam about 5 inches thick, the next layer is 4 inches of brown very channery loam, and the underlying material is very pale brown extremely flaggy loam 7 inches thick. Hard sandstone is at a depth of about 16 inches. Permeability of the Rhone soil is moderate and available water capacity is very low. Runoff is medium and the water erosion hazard is moderate to high.

Rentsac channery loam (map unit 73). This shallow well-drained soil is located on ridges, foothills, and sideslopes at elevations between 6,000 and 7,600 feet amsl on slopes of 5 to 50 percent. The upper part of the surface layer is grayish brown channery loam about 5 inches thick, the next layer is 4 inches of brown very channery loam, and the underlying material is very pale brown extremely flaggy loam 7 inches thick. Hard sandstone is at a depth of about 16 inches. Permeability of the Rhone soil is moderate and available water capacity is very low. Runoff is rapid and the water erosion hazard is moderate to very high.

Rhone loam (map unit 76). This deep, well-drained soil is located on mountainsides, upland ridges, and sideslopes at elevations between 7,600 and 8,600 feet amsl on slopes of 30 to 75 percent. The upper part of the surface layer is dark grayish brown loam about 8 inches thick, the next layer is 16 inches of dark grayish brown loam, and the lower part is grayish brown very channery loam about 16 inches thick. The substratum is brown very channery loam 10 inches thick. Fractured sandstone is at a depth of about 50 inches. Permeability is moderate and available water capacity is high. Runoff is medium and the water erosion hazard is very high.

Silas loam (map unit 82). This deep, well-drained soil is located in the bottom of narrow mountain valleys at elevations between 7,300 and 8,500 feet amsl on slopes of 0 to 8 percent. The upper part of the surface layer is dark gray loam about 4 inches thick, and the lower part is dark gray loam about 20 inches thick. The underlying material is stratified, dark gray loam and dark gray sandy clay loam to a depth of 60 inches or more. Permeability is moderate and available water capacity is high. Runoff is medium and the water erosion hazard is slight to moderate.

Starman-Vandamore complex (map unit 87). This map unit is located on rolling ridges and windswept ridgetops at elevations between 7,500 and 8,900 feet amsl on slopes of 5 to 40 percent. The unit is 50 percent Starman channery loam and 40 percent Vandamore channery loam. The Starman soil is shallow and well-drained. The surface layer is grayish-brown channery loam 2 inches thick. The upper 6 inches of the underlying material is pale brown extremely channery loam, and the lower part is very pale brown extremely channery loam about 9 inches thick. Hard shale is at a depth of 17 inches. Permeability of the Starman soil is moderate and available water capacity is very low. Runoff is medium and the water erosion hazard is moderate to very high. The hazard of soil blowing is moderate to high. The Vandamore soil is moderately deep and well-drained. The surface layer is light grayish brown very channery loam about 4 inches thick, and the next layer is 4 inches of light brownish-gray very channery loam. The underlying material is very pale brown extremely channery loam 17 inches thick. Sandstone is at a depth of about 25 inches. Permeability of the Vandamore soil is moderate and available water capacity is very low. Runoff is medium and the water erosion hazard is moderate to very high. The hazard of soil blowing is moderate to high.

Torriorthents-Rock outcrop complex (map unit 91). This map unit is located on extremely rough and eroded areas on mountains, hills, ridges, and canyonsides at elevations between 5,100 and 7,500 feet amsl. The unit is 50 percent Torriorthents on slopes of 15 to 65 percent and 30 percent rock outcrop on slopes of 35 to 90 percent. Torriorthents are very shallow to moderately deep and well-drained to somewhat excessively drained. Torriorthents are calcareous throughout and highly variable with no single profile being typical. In some areas the surface layer is stony or flaggy. Permeability is moderate and available water capacity is very low. Runoff is very rapid and the water erosion hazard is very high. Rock outcrop consists of barren escarpments, ridge caps, and points of sandstone, shale, limestone, or siltstone.

Veatch channery loam (map unit 96). This moderately deep well-drained soil is located on mountainsides at elevations between 6,500 and 7,500 feet amsl on slopes of 12 to 50 percent. The surface layer is dark brown channery loam about 8 inches thick. The upper 5 inches of the subsoil is dark brown channery loam and the lower 5 inches is brown channery loam. The underlying material is very pale brown extremely channery light loam 14 inches thick. Sandstone is at a depth of about 32 inches. Permeability is moderate and available water capacity is moderate. Runoff is medium and the water erosion hazard is moderate to very high.

Yamac loam (map unit 104). This deep well-drained soil is located on rolling uplands, terraces, and fans at elevations between 5,800 and 7,100 feet amsl on slopes of 2 to 15 percent. The surface layer is brown loam about 4 inches thick. The upper 8 inches of the subsoil is brown loam and the lower 10 inches is highly calcareous loam. The upper 26 inches of the substratum is very pale brown loam and the lower part to a depth of 60 inches or more is pale brown loam. Permeability is moderate and available water capacity is moderate to high. Runoff is medium and the water erosion hazard is slight to moderate.

Garfield County Soils

Irigul-Starman channery loams (map unit 50). This map unit is located on mountain ridges and the crests and sides of hills at elevations between 7,800 and 8,400 feet amsl on slopes of 5 to 30 percent. The unit is 40 percent Irigul loam and 30 percent Starman soil. The Irigul soil is shallow and well-drained, with a surface layer of grayish brown channery loam about 6 inches thick and brown extremely channery loam about 7 inches thick. Hard sandstone is at a depth of 13 inches. Permeability of the Irigul soil is moderate and available water capacity is very low. Runoff is medium to rapid and the water erosion hazard is moderate to very severe. The Starman soil is shallow and well-drained. The surface layer is grayish-brown channery loam 2 inches thick. The upper 6 inches of the underlying material is pale brown extremely channery loam, and the lower part is very pale brown extremely channery loam about 5 inches thick. Hard shale is at a depth of 11 inches. Permeability of the Starman soil is moderate and available water capacity is very low. Runoff is medium to rapid and the water erosion hazard is moderate to very severe.

Northwater-Adel complex (map unit 52). This map unit is located on mountainsides and footslopes at elevations between 7,700 and 8,400 feet amsl on slopes of 5 to 50 percent. The unit is 50 percent Northwater soil and 40 percent Adel soil. The Northwater soil consists of a surface layer of grayish brown loam about 28 inches thick. The subsoil consists of yellowish-brown very channery loam about 20 inches thick. The substratum to a depth of 60 inches or more is yellowish-brown extremely channery loam. The soil is characterized by moderate infiltration, medium to rapid runoff, and a moderate available water capacity. The water erosion hazard is severe to very severe. The Adel soil is deep and well-drained. The surface layer is dark grayish brown clay loam about 20 inches thick. The subsoil is brown clay loam about 11 inches thick and the substratum to a depth of 60 inches or more is brown clay loam. Permeability is moderate and available water capacity is high. Runoff is medium and the water erosion hazard is severe to very severe.

Parachute-Irigul complex (map unit 55). This map unit is located on ridges and mountainsides at elevations between 7,600 and 8,800 feet amsl on slopes of 5 to 30 percent. The unit is 60 percent Parachute soil and 30 percent Irigul soil. The Parachute soil is moderately deep and well-drained. The surface layer is grayish-brown loam 10 inches thick. The subsoil is brown very channery loam about 15 inches thick. Fractured sandstone is at a depth of about 25 inches. Permeability of the Parachute soil is moderate and available water capacity is very low. Runoff is medium to rapid and the water erosion hazard is moderate to very severe. The Irigul soil is shallow and well-drained, with a surface layer of brown channery loam about 6 inches thick and brown very channery loam about 7 inches thick. Hard siltstone is at a depth of 13 inches. Permeability of the Irigul soil is moderate and available water capacity is very low. Runoff is medium to rapid and the water erosion hazard is moderate to very severe.

Parachute-Irigul-Rhone association (map unit 56). This map unit is located on ridges and mountainsides at elevations between 7,600 and 8,800 feet amsl on slopes of 25 to 50 percent. The unit is 35 percent Parachute soil, 30 percent Irigul soil, and 20 percent Rhone soil. The Parachute soil is on north- and west-facing sideslopes, the Irigul soil is on ridges and south- and east-facing sideslopes, and the Rhone soil is on toeslopes. The Parachute soil is moderately deep and well-drained. The surface layer is grayish-brown loam 10 inches thick. The subsoil is brown very channery loam about 15 inches thick. Fractured sandstone is at a depth of about 25 inches. Permeability of the Parachute soil is moderate and available water capacity is very low. Runoff is medium to rapid and the water erosion hazard is moderate to very severe. The Irigul soil is shallow and well-drained, with a surface layer of brown channery loam about 6 inches thick and brown very channery loam about 7 inches thick. Hard shale is at a depth of 13 inches. Permeability of the Irigul soil is moderate and available water capacity is very low. Runoff is medium to rapid and the water erosion hazard is moderate to very severe. The Rhone soil is deep and well-drained. The surface layer is very dark grayish-brown loam 10 inches thick. The subsoil is dark grayish brown very channery loam about 16 inches thick. Fractured sandstone is at a depth of about 55 inches. Permeability of the Rhone soil is moderate and available water capacity is moderate. Runoff is rapid and the water erosion hazard is very severe.

Parachute-Rhone loam (map unit 57). This map unit is located on ridge crests, mountainsides, upland slopes, and sideslopes at elevations between 7,600 and 8,800 feet amsl on slopes of 5 to 30 percent. The unit is 55 percent Parachute loam and 35 percent Rhone loam. The Parachute soil is on north- and west-facing sideslopes, the Irigul soil is on ridges and south- and east-facing sideslopes, and the Rhone soil is on toeslopes. The Parachute soil is moderately deep and well-drained. The surface layer is grayish-brown loam 10 inches thick. The subsoil is brown very channery loam about 15 inches thick. Fractured sandstone is at a depth of about 25 inches. Permeability of the Parachute soil is moderate and available water capacity is very low. Runoff is medium to rapid and the water erosion hazard is moderate to very severe. The Rhone soil is deep and well-drained. The surface layer is very dark grayish-brown loam 10 inches thick. The next layer is dark grayish brown channery loam about 29 inches thick. The subsoil is brown very channery loam about 16 inches thick. Fractured sandstone is at a depth of about 55 inches. Permeability of the Rhone soil is moderate and available water capacity is moderate. Runoff is medium to rapid and the water erosion hazard is moderate to very severe.

Silas loam (map unit 63). This deep, well-drained soil is located on alluvial valley floors at elevations between 7,800 and 8,400 feet amsl on slopes of 1 to 12 percent. The surface layer is dark grayish brown loam about 18 inches thick. The upper part of the underlying material is dark grayish brown clay loam about 27 inches thick, and the lower part is grayish brown clay loam to a depth of 60 inches or more. Permeability is moderate and available water capacity is high. Runoff is slow and the water erosion hazard is slight to very severe.

Torriorthents-warm-Rock outcrop complex (map unit 66). This map unit is located on steep, mainly south-facing slopes of mountains, hills, ridges, and canyonsides in extremely rough and eroded areas at elevations between 6,200 and 8,500 feet amsl. The unit is 50 percent Torriorthents and 40 percent rock outcrop. Torriorthents are very shallow to moderately deep and well-drained to somewhat excessively drained. Torriorthents are calcareous throughout and highly variable with no single profile being typical. In some areas the surface layer is stony or flaggy. Permeability is moderate and available water capacity is very low to moderate. Runoff is very rapid and the water erosion hazard is very severe. Rock outcrop consists of barren escarpments, ridge caps, and points of sandstone, shale, limestone, or siltstone.

Tosca channery loam (map unit 67). This deep, well-drained soil is located on mountain sideslopes at elevations between 6,200 and 8,500 feet amsl on slopes of 25 to 80 percent. The surface layer is dark grayish brown channery loam about 8 inches thick. The next layer is brown very channery loam about 7 inches thick. The upper part of the underlying material is brown very channery loam about 9 inches thick, and the lower part is very pale brown very channery loam to a depth of 60 inches or more. Permeability is moderate and available water capacity is low. Runoff is rapid and the water erosion hazard is very severe.

Wrayha-Rabbitex-Veatch complex (map unit 75). This map unit is located on canyon sideslopes at elevations between 5,800 and 7,600 feet amsl on slopes of 45 to 65 percent. The unit is 35 percent Wrayha soil, 20 percent Rabbitex soil, and 20 percent Veatch soil. The three soils are intermingled. The Wrayha soil is deep and well-drained. The surface layer is grayish-brown gravelly sandy loam about 4 inches thick. The upper part of the underlying material is pale olive clay loam about 24 inches thick. The next layer is reddish gray silty clay loam about 21 inches thick. The lower part of the underlying material to a depth of 60 inches or more is grayish brown silty clay loam. Permeability of the Wrayha soil is slow and available water capacity is moderate. Runoff is rapid and the water erosion hazard is very severe. The Rabbitex soil is deep and well-drained, with a surface layer of brown loam about 7 inches thick. The upper part of the subsoil is light gray loam about 8 inches thick and the lower portion is grayish brown silty clay loam to a depth of 60 inches or more. Permeability of the Rabbitex soil is moderate and available water capacity is high. Runoff is rapid and the water erosion hazard is very severe. The Veatch soil is moderately deep and well-drained. The surface layer is dark grayish-brown loam about 6 inches thick. The upper part of the subsoil is dark grayish brown loam about 5 inches thick and the lower part is pale brown very channery sandy loam about 21 inches thick. Sandstone is at a depth of about 32 inches. Permeability of the Veatch soil is moderate and available water capacity is low. Runoff is medium and the water erosion hazard is very severe.

Appendix B
CDOW Defines Big Game Range Categories

Appendix B. CDOW Defined Big Game Range Categories.

Range Category	**Description**
Overall Range	The area which encompasses all known seasonal activity areas within the observed range of a species population.
Winter Range	That part of the overall range of a species where 90% of the individuals are located during the average five winters out of ten from the first heavy snowfall to spring green-up, or during a site specific period of winter as defined for each DAU.
Severe Winter Range	That part of the range of species where 90% of the individuals are located when the annual snowpack is at its maximum and/or temperatures are at a minimum in the two worst winters out of ten.
Production Area	The part of the overall range of a species occupied by the females from May 15 to June 15 for calving
Resident Population Area	An area used year-round by a population. Individuals could be found in any part of the area at any time of the year; the area can not be divided into seasonal ranges.
Summer Range	The part of the range of a species where 90% of the individuals are located between spring green-up and the first heavy snowfall, or during a site specific period of summer as defined for each DAU. Summer range is not necessarily exclusive of winter range.

Colorado Division of Wildlife – Natural Diversity Information Source. 1999.
http://ndis1.nrel.colostate.edu/ndis/ftp_html_site/ftp.asp

Appendix C
Potential Raptor Species Occurring In or Near the Figure Four Project Area

Appendix C. Potential Raptor Species Occurring In or Near the Figure Four Project Area.

Common Name	**Scientific Name**
Red-tailed Hawk	*Buteo jamaicensis*
Cooper's Hawk	*Accipiter cooperii*
Sharp-shinned Hawk	*Accipiter striatus*
Northern Goshawk	*Accipiter gentilis*
American Kestrel	*Falco sparverius*
Prairie Falcon	*Falco mexicanus*
Peregrine Falcon	*Falco peregrinus*
Golden Eagle	*Aquila chrysaetos*
Bald Eagle	*Haliaeetus leucocephalus*
Northern Harrier	*Circus cyaneus*
Swainson's Hawk	*Buteo swainsoni*
Turkey Vulture	*Cathartes avia*
Flammulated Owl	*Otus flammeolus*
Great-horned Owl	*Bubo virginianus*
Northern Pygmy Owl	*Glaucidium gnoma*
Northern saw-whet Owl	*Aegolius acadicus*

Kingery, H.E. (ed.). 1998. Colorado Breeding Bird Atlas. Colorado Breeding Bird Atlas Partnership, Denver. 636pp.

Appendix D
Air Quality Impact Assessment Methodology

Appendix D

Air Quality Analysis
For the Figure Four Project

Table of contents

1.0 CLIMATE

The Figure Four Project Area is located in a high mountainous continental climate regime on the southern slopes of the Piceance Creek basin. The topography in the Project Area slopes downward south to north with a series of southwest to northeast trending ridges and valleys. Elevations in the Project Area range from 6,100 feet above mean sea level (msl) to 8,500 feet msl. The climate of the Project Area is classified as semi-arid continental characterized by low relative humidity and precipitation, abundant clear skies, high evaporation, and large daily temperature ranges.

Specifically, the temperature and precipitation in the Project Area can be represented by the Little Hills meteorological monitoring station approximately 25 miles northeast of the Project Area at an elevation of 6,140 feet msl. Data were collected from 1948 to 1991 (Western Regional Climate Center 2003). The annual temperature varies from a maximum mean monthly temperature of 86 ˚F in July to a mean monthly minimum temperature of 3 ˚F in January. The Project Area receives about 14 inches of precipitation annually and 86 inches of snow between October and May. Precipitation is fairly equally distributed from March through October (about an average of 1.3 inches per month), and tends to be less than an inch from November through February. Table 1 provides a summary of Project Area climate data.

The transportation and dilution of air pollutants are functions of wind velocity and atmospheric turbulence. The wind velocity dictates the direction in which pollutants are transported and the atmospheric turbulence (a function of temperature and wind speed) dictates the dilution rate for pollutants.

The meteorological data collected in 1984 at the Occidental Shale Tract Cb (BLM 1999) are considered to be representative of the Project Area. The wind data shown on Figure 1 shows that the wind blows from the southeast through the southwest approximately 67 percent of the time. Note that the data represent the direction from which the wind is blowing. For example, winds blowing from the south would transport pollutants to the north and vice versa. Therefore, on an average annual basis, pollutants would be transported northward approximately 67 percent of the time.

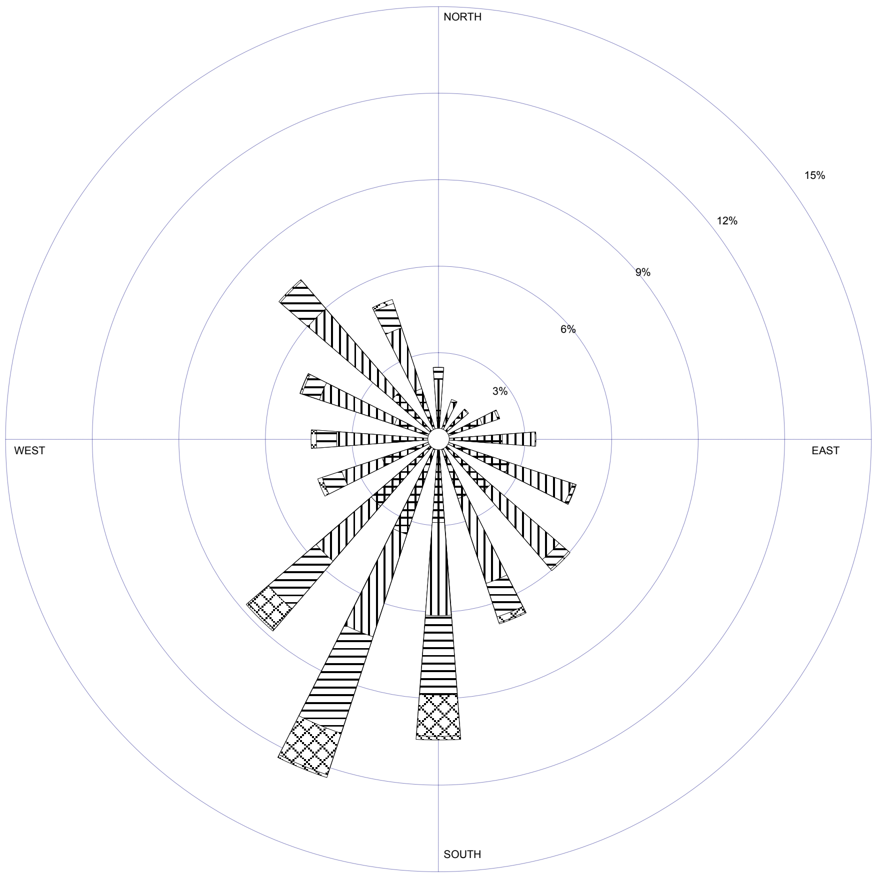
Table 1. Project Area Climate

Month	Temperature (°F)		Precipitation (Inches)			
	Mean Maximum	Mean Minimum	Mean	Maximum	Mean Snowfall	Maximum Snowfall
January	37	3	0.74	1.87	10.8	33.0
February	42	8	0.79	3.09	9.2	30.6
March	48	17	1.24	2.82	11.5	31.7
April	58	24	1.44	3.33	5.1	18.0
May	68	32	1.36	3.23	1.1	11.5
June	79	38	1.11	3.84	0.1	3.0
July	**86**	45	1.25	3.97	0.0	0.0
August	83	43	1.55	4.50	0.0	0.0
September	76	34	1.17	5.29	0.1	2.2
October	64	24	1.24	4.32	2.4	13.0
November	49	14	0.97	2.31	5.9	35.5
December	39	5	0.95	2.65	10.5	29.5
Annual	**61**	**24**	**13.82**	**20.37**	**86**	**208**

Source: Western Regional Climate Center 2003.

WIND ROSE PLOT

Figure 1. Tract Cb Windrose



Wind Speed (Knots)

- > 21
- 17 - 21
- 11 - 16
- 7 - 10
- 4 - 6
- 1 - 3

DISPLAY **Wind Speed**	UNIT **Knots**
AVG. WIND SPEED **4.78 Knots**	CALM WINDS **13.38%**
ORIENTATION **Direction (blowing from)**	PLOT YEAR-DATE-TIME **1984 Jan 1 - Dec 31 Midnight - 11 PM**

COMMENTS

WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com

2.0 PROJECT AREA AIR QUALITY AND REGULATORY SETTING

National Ambient Air Quality Standards (NAAQS) have been promulgated for the purpose of protecting human health and welfare with an adequate margin of safety. The State of Colorado has adopted the NAAQS with a modification for sulfur dioxide (SO_2). Criteria pollutants for which standards have been set include SO_2, nitrogen dioxide (NO_2), carbon monoxide (CO), particulate matter less than 10 or 2.5 microns in effective diameter (PM_{10} and $PM_{2.5}$), and ozone (O_3). Existing air quality in the region is acceptable based on State of Colorado standards for the protection of human health. Garfield and Rio Blanco Counties are designated as attainment areas, meaning that the concentration of criteria pollutants in the ambient air is less than the NAAQS (CAQCC 2003). Additionally, representative monitoring of air quality in the general area indicates that the existing air quality is well within acceptable standards. Table 2 provides a summary of representative air quality data for the Piceance Creek area.

Table 2. Existing Air Quality Summary for Piceance Creek Area

Pollutant	Averaging Period					Monitoring Station Location Description
	Annual	24-Hour	8-Hour	3-Hour	1-Hour	
	Ambient Air Average Concentration (μg/m^3)					
PM_{10}	24	54	NA	NA	NA	Rifle, Garfield County. (1998-2000 data collected by CDPHE) [a]
$PM_{2.5}$	7	19	NA	NA	NA	Grand Junction, Mesa County. (1999-2001 data collected by CPHE) [a]
NO_2	34	NA	NA	NA	NA	Provided by CDPHE [a]
CO	NA	NA	4,444	NA	8,000	Grand Junction, Mesa County. (Average of 1999-2001) [a]
SO_2	11	39	NA	110	NA	Provided by CDPHE [a]
Ozone			145		145	Provided by CDPHE[b]

NA: not applicable
μg/m^3: micrograms of pollutant per cubic meter of ambient air
[a] Background concentrations recommended by CDPHE for the Glenwood Springs RMP air quality analysis
b (Navy Chick) as composite averages of ozone monitoring locations in western Colorado and Eastern Utah

Under the Prevention of Significant Deterioration (PSD) provisions of the Clean Air Act (CAA) administered by the State of Colorado, incremental increases of specific pollutant concentrations are limited above a legally defined baseline level. Many national parks and wilderness areas are designated as PSD Class I. The PSD program protects air quality within Class I areas by allowing only slight incremental increases in pollutant concentrations. Areas of the state not designated as PSD Class I are classified as Class II. For Class II areas, greater incremental increases in ambient pollutant concentrations are allowed as a result of controlled growth. The area surrounding the Project is designated as PSD Class II. The Colorado Ambient Air Quality Standards, existing air quality, and PSD increments for Class I and II areas are presented in Table 3.

Table 3. Ambient Air Quality Standards and PSD Increment Values

Pollutant	Averaging Period(s)	Colorado Ambient Air Quality Standard ($\mu g/m^3$)	PSD Class II Increments [1] ($\mu g/m^3$)	PSD Class I Increments [1] ($\mu g/m^3$)
SO_2	Annual	15	20	2
	24-hour	100	91	5
	3-hour	700	512	25
NO_2	Annual	100	25	2.5
PM_{10}	Annual	50	30	4
	24-hour	150	17	8
CO	8-hour	10,000	None	None
	1-hour	40,000	None	None
Ozone	8-hour	157	None	None
	1-hour	235	None	None

Source: Colorado Air Pollution Control Division
$\mu g/m^3$: micrograms of pollutant per cubic meter of ambient air
[1]Increments expressed as allowable increases over an established baseline.

3.0 CLASS I AREAS

National Parks and certain USDA - Forest Service managed wilderness areas are designated as federally mandated Class I areas. Within these Class I areas, the allowable increases in air pollution is much smaller than for all other areas. Similarly, only small changes are permitted for Air Quality Related Values (AQRV) such as visibility and acid deposition in Class I areas. In addition, certain National Monuments in the region that are designated as Class II areas are also considered sensitive to visibility and AQRV impacts.

Visibility is best characterized by the parameters standard visual range (SVR), which represents the greatest distance at which an observer can just see a black object viewed against the horizon sky. Visibility related background data are collected as part of the Interagency Monitoring of Protected Visual Environments (IMPROVE 2004) program. IMPROVE data for 2001, the latest available, indicates that visibility is generally very good in northwestern and central Colorado.

Table 4 summarizes the visibility conditions measured at Class I areas. The location of Class I and Class II areas in the project region are shown on Figure 2. The 2001 data shows the SVR value that is equal to or higher 20 percent of the year (the 20% best), the annual mean SVR, and the SVR value that is equal to or lower 20 percent of the year (the 20% worst).

Table 4. Visibility Conditions Measured at Class I Areas

Sensitive Area	Federal Land Manager	PSD Designation	Distance [1] from Proposed Action (kilometers)	20% Best SVR (kilometers)	Mean SVR (kilometers)	20% Worst SVR (kilometers)
Black Canyon of the Gunnison National Park [b]	NPS	Class I	147	290	211	139
Eagle's Nest Wilderness Area [a]	FS	Class I	185	290	211	139
West Elk Wilderness Area [b]	FS	Class I	162	290	211	139
Flat Tops Wilderness Area [a]	FS	Class I	78	290	212	140
Maroon Bells-Snowmass Wilderness Area [a]	FS	Class I	148	291	212	140
Mt. Zirkel Wilderness Area [a]	FS	Class I	166	253	185	127
Arches National Park [c]	NPS	Class I	168	226	167	119
Colorado National Monument [c]	NPS	Class II	89	226	167	119
Ouray National Wildlife Refuge [c]	USFWS	Class II	122	226	167	119
Raggeds Wilderness Area [b]	[FS	Class II	134	290	211	139
Dinosaur National Monument [c]	NPS	Class II	110	226	167	119
Holy Cross Wilderness Area [b]	FS	Class II	163	290	211	139

[a] Measured IMPROVE data[b]
[b] No measurement available – estimated from Flat Tops data
[c] No measurement available – estimated from nearby Canyonlands NP IMPROVE data
[1] Distance from center of Figure Four Project Area to closest boundary of Class I area Source: IMPROVE 2004.

An additional concern is the potential of changing the Acid Neutralizing Capacity (ANC) of lakes within high elevation PSD Class I and other sensitive areas. Table 5 provides background ANC data for lakes identified by the USDA – Forest Service within PSD Class I and II area located in the project region

Table 5. Measured Acid Neutralizing Capacity of Sensitive Lakes Within Nearby PSD Class I and II Areas

Location	Sensitive Lake	Background ANC (µeq/l)	Watershed Area (acres)
Eagle's Nest WA	Booth	84.1	138
Flat Tops WA	Ned Wilson	38.0	124
Holy Cross WA	Blodget	36.9	127
Maroon Bells WA	Moon	51.5	397
Raggeds WA	Deep Creek #1	44.3	360
West Elk WA	S. Golden	111.0	112

µeq/l – microequivalents per liter
Source: USDA-Forest Service (2001)

4.0 PROPOSED ACTION

Project-related emissions have the potential to affect air quality on both a local and a regional scale. Emission inventories were developed and dispersion modeling was performed to assess the potential air quality impacts from the Proposed Action with respect to various significance criteria. The modeling assessment of the Figure Four Project consists of evaluating air quality impacts on sub-grid, near-field, and far-field scales. The Industrial Source Complex (ISC) dispersion model was used to evaluate the sub-grid and near-field impacts. The CALMET/CALPUFF dispersion model was used to evaluate far-field impacts.

The sub-grid analysis modeled air quality impacts from short-term activities such as well pad and road construction, well drilling, and well completion activities that would not only be geographically separated, but would not generally occur simultaneously. A construction scenario was developed for each short-term activity. The sub-grid modeling also assessed impacts from hazardous air pollutants (HAP) from the proposed compressor stations, the largest single type of permanent facility associated with the Proposed Action.

The mid-range analysis involved the impacts within the Project Area, and to a distance of 10 kilometers beyond the project boundary, that would occur from permanent facilities installed for the 30 year life of the project. This analysis included all well pad, compressor station, and vehicle-related emissions that would occur after the field would be fully developed.

The far-field analysis evaluated potential air quality impacts as well as air quality related values (visibility and acid deposition) at distant federal Class I and selected Class II areas. Modeling was performed to assess both construction and operational impacts.

In order to evaluate potential air quality impacts, scales of measurement, or significance criteria, must be defined. Potential impacts to air quality that would result from the implementation of this project were compared to the significance criteria listed below.

Colorado and National Air Quality Standards

Colorado and National Ambient Air Quality Standards (CAAQS and NAAQS) have been promulgated for the purpose of protecting human health and welfare with an adequate margin of safety. Pollutants for which standards have been determined include sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and particulate matter less than 10 microns in diameter (PM_{10}) and less than 2.5 microns in diameter ($PM_{2.5}$). The applicable ambient air quality standards are summarized in Table 4. It should be noted that the recently promulgated standards for $PM_{2.5}$ and ozone (8-hour) will be federally enforced by EPA until revised State Implementation Plans are approved.

Under the Prevention of Significant Deterioration (PSD) provisions of the Clean Air Act (CAA), incremental increases of specific pollutant concentrations are limited above a legally defined baseline level. Many national parks and wilderness areas are designated as PSD Class I. The PSD program protects air quality within Class I areas by allowing only slight incremental increases in pollutant concentrations. Areas of Colorado not designated as PSD Class I are classified as Class II. For Class II areas, greater incremental increases in ambient pollutant concentrations are allowed. The PSD increments for both Class I and II areas are also shown in Table 4.

Throughout this analysis, all comparisons with PSD increments are intended only to evaluate potential significance, and do not represent a regulatory PSD increment consumption analysis. PSD Increment consumption analyses are typically applied to large industrial sources during the permitting process, and are solely the responsibility of the State of Colorado and the Environmental Protection Agency.

Acute and Chronic HAP Exposure Thresholds

There are no applicable federal or State of Colorado ambient air quality standards for assessing potential HAP impacts to human health. Therefore, reference concentrations (RfC) for chronic inhalation exposure, and Reference Exposure Levels (REL) for acute inhalation exposures are applied as significance criteria. Table 6 provides the RfCs and RELs. RfCs represent an estimate of the continuous (i.e. annual average) inhalation exposure rate to the human population (including sensitive subgroups such as children and the elderly) without an appreciable risk of harmful effects. The REL is the acute (i.e. one-hour average) concentration at or below which no adverse health effects are expected. Both the RfC and REL guideline values are for non-cancer effects.

Table 6. HAP Reference Exposure Levels and Reference Concentrations

Hazardous Air Pollutant (HAP)	Reference Exposure Level [REL 1-hr Average] ($\mu g/m^3$)	Reference Concentration [1] [RfC Annual Average] ($\mu g/m^3$)
Benzene	1,300 [2]	30
Toluene	37,000 [2]	400
Ethylbenzene	350,000 [3]	1,000
Xylenes	22,000 [2]	430
n-Hexane	390,000 [3]	200
Formaldehyde	94 [2]	9.8

[1] EPA Air Toxics Database, Table 1 (EPA, 2002)
[2] EPA Air Toxics Database, Table 2 (EPA, 2002)
[3] Immediately Dangerous to Life or Health (IDLH)/10, EPA Air Toxics Database, Table 2 (EPA, 2002) since no available REL

Incremental Cancer Risk

Risk assessment methods can be applied to assess the incremental risk resulting from long term exposure to carcinogenic HAP emissions. The calculated risk for the most likely exposure (MLE) scenario can be compared to the significance criterion of one to one-hundred additional cancer cases per one million exposures (1 to 100 x 10^{-6}). Two carcinogenic HAPs typically associated with oil and gas operations (benzene and formaldehyde) were evaluated. The chronic (annual) inhalation cancer risk factors applied for the analyses are listed in Table 7.

Table 7. Carcinogenic Unit Risk Factors

Hazardous Air *Pollutant*	Carcinogenic Unit Risk Factor [Annual Inhalation Exposure] ($1/\mu g/m^3$)
Benzene	7.8 x 10^{-6}
Formaldehyde	5.5 x 10^{-9}

Source: EPA Air Toxics Database, Table 1 (EPA, 2002)

Acid Deposition

The USDA-Forest Service (Fox, et al 1989) has established a 3 kilogram per hectare per year (kg/ha/yr) total nitrogen deposition acceptable threshold for PSD Class I areas, below which no reductions in emissions would be necessary. In addition, potential changes in ANC at sensitive lakes located within several wilderness areas were evaluated and compared to a 10 percent change threshold (USDA-Forest Service 2000).

Visibility

Potential visibility degradation can be evaluated in terms of the change in deciview (Δdv) or a change in background extinction (B_{ext}). A 1.0 dv "Just Noticeable Change" is equivalent to a 10% change in B_{ext}. There are no applicable federal, state, tribal, or local visibility standards. However, predicted visibility impacts are compared to Levels of Acceptable Change (LAC) developed by Federal Land Managers (FLAG 2000). This threshold is based on the original development of the deciview scale (Pitchford and Malm 1994), and is supported by EPA's Final Regional Haze Regulation (64 FR 126, July 1, 1999) decision to use of 1.0 dv as the significance level when preparing periodic reasonable progress reports. Therefore, a "Just Noticeable Change" threshold of a 10% change in the reference background extinction or 1.0 Δdv is utilized.

4.1 IMPACT ASSESSMENT METHODOLOGY

Sub-Grid and Near-Field Analysis

The potential effects from the Proposed Action were determined using computer dispersion modeling. The U.S. Environmental Protection Agency (EPA) Industrial Source Complex, Version 3, (ISC3) model (EPA 1995) was used to assess the potential near-field (within 50 kilometers) air quality impacts of the Proposed Action and background sources. The most recent available version of ISC3 (02035) was used and input was configured in accordance with the Guideline on Air Quality Models, Revised (EPA 1995). The ISC3 model is a steady-state Gaussian plume model designed to predict ground-level pollutant concentrations from multiple and various sources associated with an industrial source complex.

To simulate the movement and dispersion of pollutants, the ISC3 uses hourly sequential meteorological data. A representative meteorological data set was available for the Figure Four area. Extensive meteorological data were collected during the 1970s and 1980s for environmental studies of various oil shale projects. The Cathedral Bluffs Oil Shale Project Tract C-b Site 023, located 3 miles to the east of the Figure Four area, was selected as being representative. The Colorado Department of Public Health and Environment, Air Pollution Control Division (CAPCD) previously approved the use of the Tract C-b data for the American Soda Nahcolite Mine PSD permit application in December 2002. One year of data (1984) taken at a 10-meter (m) tower were used for the impact analyses.

Far-Field Analysis

The potential effects at distant Class I and Class II areas were analyzed using the CALMET/CALPUFF modeling system. The Figure Four far-field analysis tiered directly to an ongoing BLM project. The BLM Vernal Field Office (under the management of Utah BLM) and Glenwood Springs Field Office (under the management of Colorado BLM) are preparing Resource Management Plans (RMP) and associated environmental impact statements (EIS) for the Vernal Field Office in northeastern Utah and the Glenwood Springs Field Office in northwestern Colorado. Because of the close timing of these two projects, the Utah and Colorado State BLM offices are working closely to prepare one combined analysis. The Figure Four project is within the modeling domain of the RMP analysis. Therefore, to ensure consistency with the ongoing RMP air quality analyses, the same modeling domain and meteorological data developed for the RMP analysis was used for the Figure Four far-field modeling. The data and methodologies are described in the draft Air Quality Assessment Report for the Vernal and Glenwood Springs Resource Management Plans (BLM 2003) and are incorporated by reference.

4.2 EMISSIONS

To assess potential air quality impacts, emission inventories were developed for the Proposed Action and the No Action alternative. Derivation of the emissions inventory used for the near-field modeling analysis is described in detail in Appendix C. Project emissions would consist of the criteria pollutants (nitrogen oxides [NO_x], carbon monoxide [CO], particulates [PM_{10} and $PM_{2.5}$], sulfur dioxide [SO_2], volatile organic compounds [VOC]), and hazardous air pollutants (HAP). These pollutants would be emitted from the following activities and sources:

- Well pad and road construction: equipment producing fugitive dust while moving and leveling earth;
- Drilling: vehicles generating fugitive dust on access roads, and drill rig engine exhaust;
- Completion: vehicles generating fugitive dust on access roads and flaring emissions;
- Vehicle and equipment exhaust emissions associated with all development phases;
- Well pad operation: three-phase separators, flashing and breathing emissions from condensate tanks; and
- Compressor stations: compressor engines and central glycol dehydration units.

Potential emissions for the construction of facilities and drilling and completion of wells are shown in Table 7. These emissions would continually annually for the 10-year development phase. The production-related emissions would increase each year as more wells would be completed and brought into production. Table 8 summarizes the project-related emissions at the full-field development.

Table 7. Figure Four Annual Construction/Drilling Emissions

Pollutant	Emissions Source (tons/year)			
	Construction [1]	Drilling [2]	Completion [2]	Total
NO_X	5.90	366.55	1.14	373.59
CO	1.49	94.31	5.86	101.66
VOC	0.26	11.68	0.86	12.80
SO_2	0.13	10.81	0.04	10.98
PM_{10}	20.44	301.95	152.70	475.09
$PM_{2.5}$	3.41	52.25	23.41	79.07
Benzene			0.00	0.00
Formaldehyde	0.10		0.00	0.10
Toluene			0.00	0.00
Hexane			0.01	0.01

[1] Emissions for construction of 55 well pads and access roads
[2] Emissions from drilling and completing 33 wells

Table 8. Figure Four Annual Production Emissions

Pollutant	Emission Source (tons/year) [1]						
	Separators	**Dehydrators**	**Condensate Tanks**	**Compressor Stations**	**Vehicle Tailpipe**	**Vehicle Fugitive Dust**	**Total**
NO_X	55.13			123.60	2.04		180.77
CO	11.45			123.60	9.26		144.31
VOC	0.35		2423.60	61.80	1.22		2486.97
SO_2	0.00			0.00	0.10		0.10
PM_{10}	4.14			2.72		74.70	81.56
$PM_{2.5}$	4.14			2.72		11.45	18.32
Benzene	0.001	7.81	11.63	0.22			19.67
Toluene	0.002	4.34					4.34
Ethylbenzene							0.00
Xylene		1.13					1.13
n-Hexane	0.98	0.51	33.93				35.42
Formaldehyde	0.04			12.36			12.40

[1] Table indicates emissions at full field development (327 wells). Emissions would incrementally increase during the first ten years at approximately 10% during each year of development.

4.3 SUB-GRID IMPACTS

Development Activities

The sub-grid analysis considered potential impacts to air quality that would occur near construction activities. The analysis considered short-term activities such as well pad and road construction, well drilling, and well completion activities that would not only be geographically separated, but would generally not occur simultaneously.

Based upon the proposed project schedule, a maximum of three well pads and associated access roads would be constructed simultaneously. Additionally, three drilling and completion operations could also be conducted simultaneously. Therefore, the average emissions in a 24-hour period were calculated and modeled on adjacent well pad locations to determine the maximum 24-hour PM_{10} impacts from each of these three development activities. The annual PM_{10} impact was evaluated by considering the total emissions that could occur at the three well pads for the duration of construction, drilling, and completion. This case considers a 10-day construction period, a 30-day drilling period, and a 10-day completion period. The PM_{10} generated from vehicles traveling to and from the site was scaled to the one mile of road near the pad. All of the PM_{10} emissions were then assumed to emanate from the well pad.

The emissions from each scenario are shown on Table 9 and the impacts are shown on Table 10. Figure 2 shows the maximum 24-hour concentrations associated with completion activities. The maximum concentration for completion would be 71 $\mu g/m^3$. The spatial distribution would be similar for drilling and construction, but the ambient air impacts would be less.

Table 9. Development-Related PM_{10} Emissions

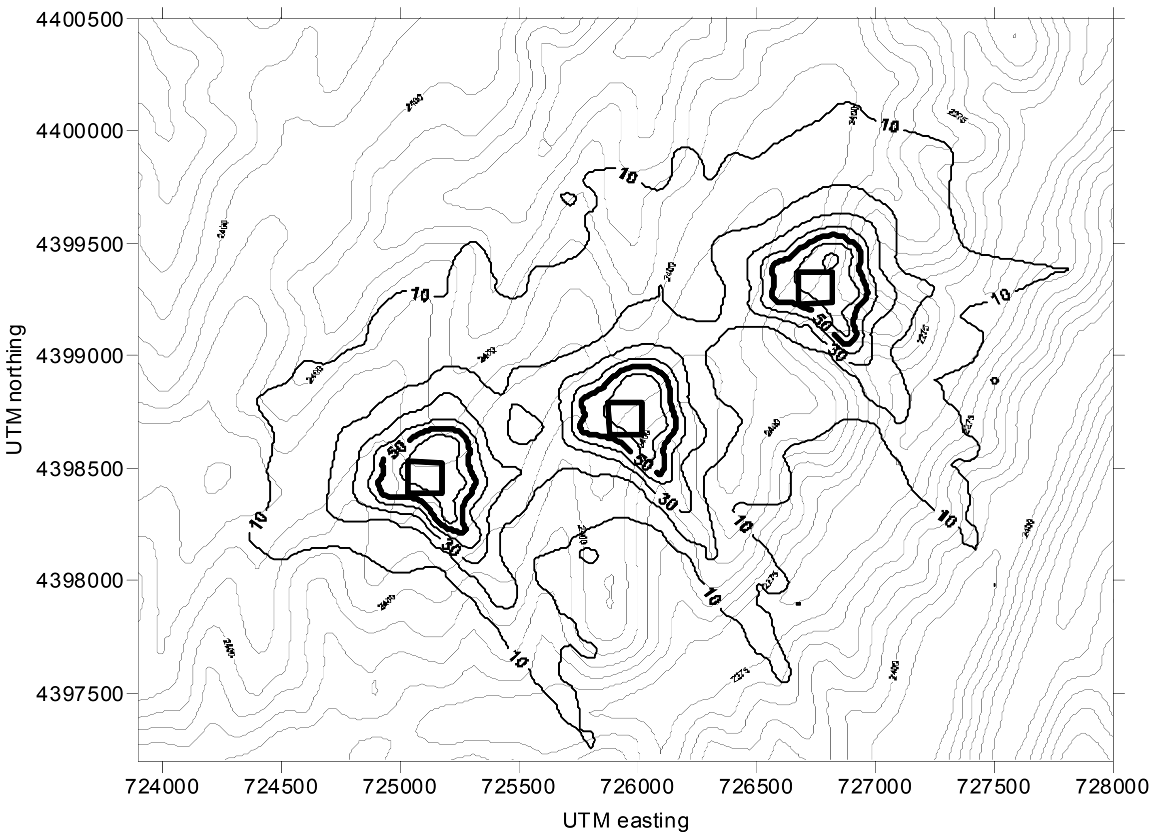
Activity	Duration (days)	Emissions (lb/day)	Emissions (lbs/yr)
Construction	10		
Earth Moving		12.92	129.22
Equipment Exhaust		1.17	11.73
Road Dust		3.04	30.41
Drilling	30		
Road Dust		24.67	740.00
Completion	10		
Road Dust		38.54	385.41

Table 10. Proposed Action PM_{10} Development Impacts

Averaging Time	Development Activity (3 wells)	Maximum Predicted Impact ($\mu g/m^3$)	Background Concentration ($\mu g/m^3$)	Background Plus Impact ($\mu g/m^3$)	CAAQS/ NAAQS Standard ($\mu g/m^3$)	Impact Percentage of CAAQS/ NAAQS
24-hour Average	Construction	8.2	54	60.2	150	40%
	Drilling	45.5	54	99.5	150	66%
	Completion	71.2	54	125.2	150	83%
Annual Average	Construction, Drilling, Completion	1.8	24	25.8	50	52%

Hazardous Air Pollutants

The dominant sources of HAP emissions would be the natural gas fueled compressor engines (formaldehyde), central dehydrator vents (benzene, toluene, ethylbenzene, xylenes, n-hexane), and condensate tanks (benzene and n-hexane). The compressor stations would be located in valleys with elevated terrain nearby. Therefore, the impacts of benzene and formaldehyde are within 25 percent of the short-term REL. Predicted maximum HAP concentrations are provided in Table 11. To assess potential acute health effects, maximum one-hour average concentrations are compared to the HAP-specific REL (reference exposure level). Potential chronic health effects are assessed by comparing the maximum predicted annual average concentrations to the HAP-specific RfC (reference concentration for continuous inhalation exposure). As shown in Table 11, maximum acute and chronic HAP concentrations are not predicted to exceed the RELs or RfCs. Therefore, adverse non-carcinogenic human health effects would not be expected under the Proposed Action.



Concentration Interval 10 micrograms per cubic meter

Elevation Interval 25 meters

Figure 2. 24-Hour PM10 Impacts Completing 3 Wells Simultaneously

Table 11. Non-Carcinogenic Acute RELs and RfCs

Hazardous Air Pollutant	Predicted Maximum 1-Hour Impact ($\mu g/m^3$)	REL ($\mu g/m^3$)	Impact Percentage of REL	Predicted Maximum Annual Impact ($\mu g/m^3$)	RfC [1] ($\mu g/m^3$)	Impact Percentage of RfC
Benzene	1205	1,300 [2]	92.6	16.9	30	19.3
Toluene	669	37,000 [2]	1.8	9.4	400	<1
Ethylbenzene	0.02	350,000 [3]	<0.1	<0.01	1,000	<1
Xylenes	174	22,000 [2]	0.8	2.5	430	<1
Formaldehyde	71	94 [2]	75.5	2.3	9.8	10.1
n-Hexane	18.9	390,000[3]	<0.1	0.21	200	0.1

[1] EPA Air Toxics Database, Table 1 (EPA, 2002)
[2] EPA Air Toxics Database, Table 2 (EPA, 2002)
[3] Immediately Dangerous to Life or Health (IDLH)/10, EPA Air Toxics Database, Table 2 (EPA, 2002) since no available REL

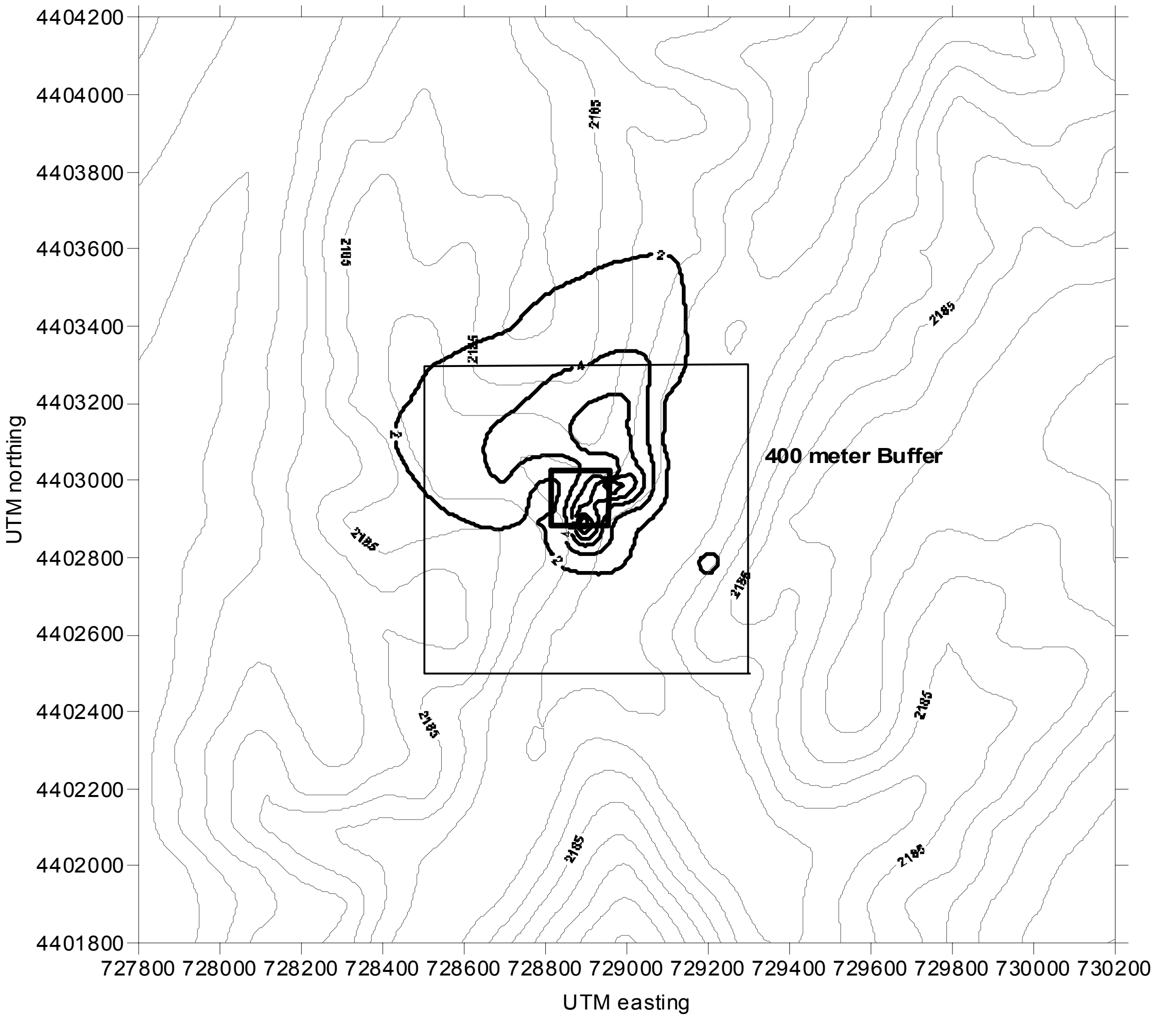
Benzene and formaldehyde are carcinogenic. Therefore, annual average concentrations of these two HAPs were modeled and expressed as a long-term cancer risk (based on 70 year life-span). Cancer risk was estimated for two exposure scenarios: a most likely exposure (MLE) corresponding to a resident that lives an average of 20 years at a particular location near the compressor station, and a maximally exposed individual (MEI) corresponding to an individual that could be exposed for the entire life of the compressor station (assumed as 40 years). Resultant exposure adjustment factors for the MLE and MEI scenarios of 0.286 (20/70) and 0.571 (40/70) were applied to the estimated cancer risk to account for the actual time that an individual would be exposed during an assumed 70-year lifetime.

Table 12 presents the unit risk factor and the exposure adjustment factor for the MLE and MEI exposure scenarios for benzene and formaldehyde. The unit risk factor is a slope factor that when multiplied by the ambient air concentration provides an estimate of the probability of one additional person contracting cancer based on the assumed exposure over a 70-year lifetime.

Table 12. Carcinogenic HAP Risk

Hazardous Air Pollutant	Exposure Scenario	Unit Risk Factor ($1/\mu g/m^3$)	Exposure Adjustment Factor	Modeled Annual Impact ($1/\mu g/m^3$)	Cancer Risk
Benzene	MLE	7.8×10^{-6}	0.286	4.2	9.4 in a million
Formaldehyde	MLE	5.5×10^{-9}	0.286	1.1	<1 in a million
Benzene	MEI	7.8×10^{-6}	0.571	4.2	18 in a million
Formaldehyde	MEI	5.5×10^{-9}	0.571	1.1	<1 in a million

The incremental risks for cancer are based on the maximum annual concentrations at least 400 meters from the compressor station on the assumption that a compressor station would not be built any closer than 400 meters to any residence. For example, as shown on Figure 3, the maximum annual benzene concentration 400 meters from the compressor station would be 4.2 μg/m^3. There are not currently any residences near the proposed compressor stations. The predicted incremental cancer ranging from nearly 4 to 18 cases in a million is at the low end of the range of cancer risks typically considered as acceptable when evaluating the health effects of a particular action (1 to 100 in a million).



Concentration Interval 2 micrograms per cubic meter

Contour Interval 25 meters

Figure 3. Annual Benzene Impacts

4.4 NEAR-FIELD IMPACTS

After all construction would be complete, the operation of the Figure Four wells would produce nitrogen dioxide, carbon monoxide, and PM_{10} emissions from the following emissions sources:

- compressor stations;
- separator heaters located at well pads;
- glycol dehydrator reboilers at compressor stations;
- vehicle tailpipe emissions; and
- road dust from vehicles.

The parameters used to model emissions from the sources listed above that contain exhaust stacks are shown in Table 13. Building downwash was calculated for the compressor buildings with the assumption that the buildings would be 30 meters long, 30 meters wide, and 6 meters tall.

Table 13. Stack Exhaust Modeling Parameters

Equipment	Temp (K)	Velocity (m/s)	Diameter (meters)	Height (meters)
Compressor	811	35	0.3048	15
Drill Rig	800	50	0.1	7.6
Boiler	700	1.6	0.3048	4.6
Glycol Dehydrator	366	0.001	0.05	3.65

SO_2 emissions would be less than one ton annually so these impacts were not modeled. Maximum predicted NO_2, CO, and PM_{10} concentrations that would occur are summarized in the Tables 14 and 15 and compared with the most stringent Colorado and National Ambient Air Quality Standards and the PSD Class II increments. As demonstrated below, potential increases in pollutant concentrations would occur at levels below the ambient standards would be less than the PSD Class II increment.

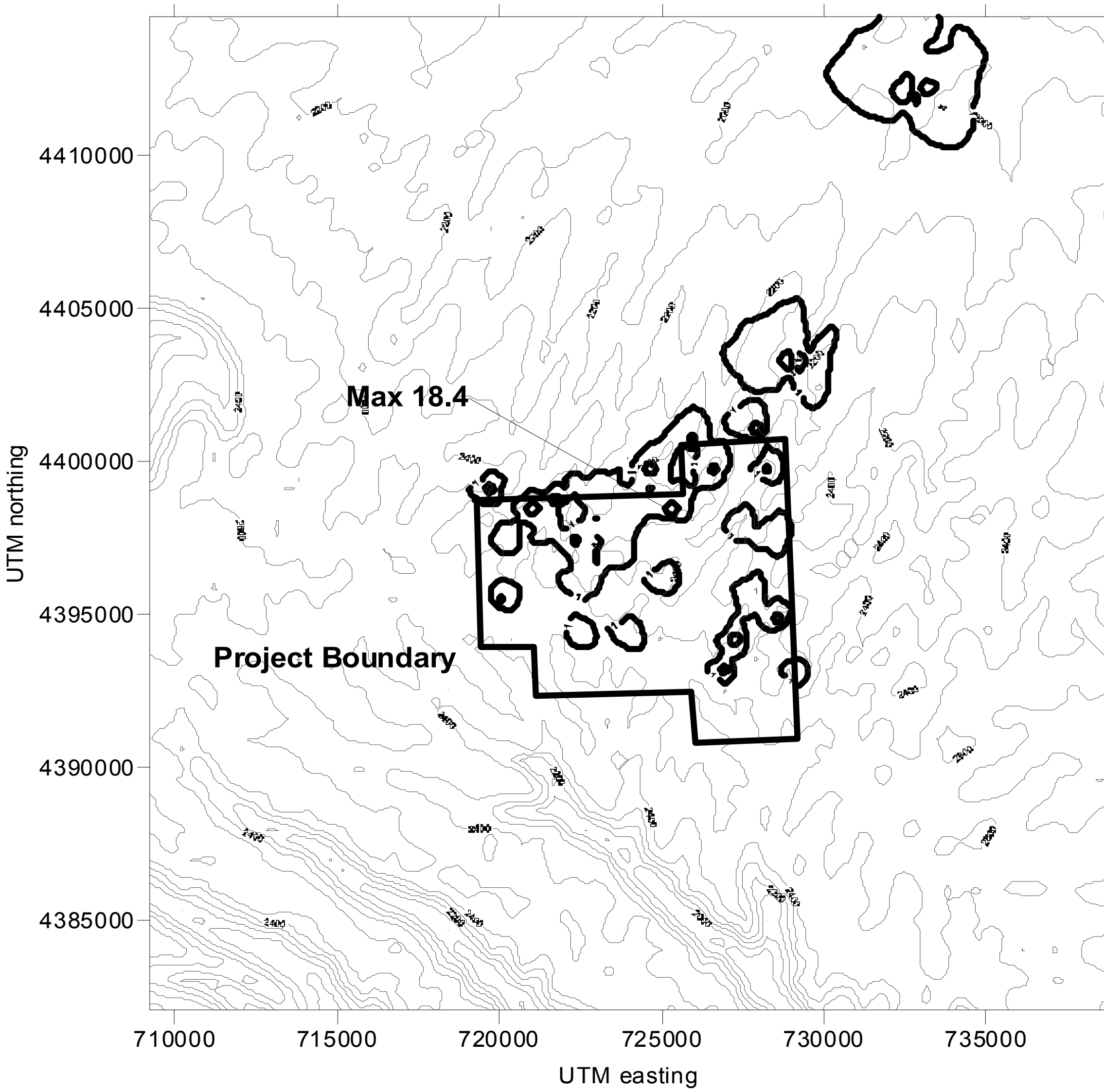
Table 14. Proposed Action Impact Comparison to Applicable Ambient Air Quality Standards

Pollutant	Averaging Time	Maximum Predicted Impact ($\mu g/m^3$)	Background Concentration ($\mu g/m^3$)	Background Plus Impact ($\mu g/m^3$)	CAAQS/ NAAQS Standard ($\mu g/m^3$)	Impact Percentage of CAAQS/ NAAQS
NO_2	Annual	18.4	34	52.4	100	52%
CO	1-hour	1267	8000	9267	40,000	23%
	8-hour	937	4444	5381	10,000	53%
PM_{10}	Annual	9.3	24	33.3	50	67%
	24-hour	21.3	54	75.3	150	50%

Table 15. Proposed Action Impact Comparison to PSD Class II Increment

Pollutant	Averaging **Time**	**Maximum** Predicted **Impact ($\mu g/m^3$)**	**PSD** Class II **Increment**	**Impact Percentage of PSD Increment**
NO_2	Annual	18.4	25	74%
PM_{10}	Annual	9.3	17	55%
	24-hour	21.3	30	71%

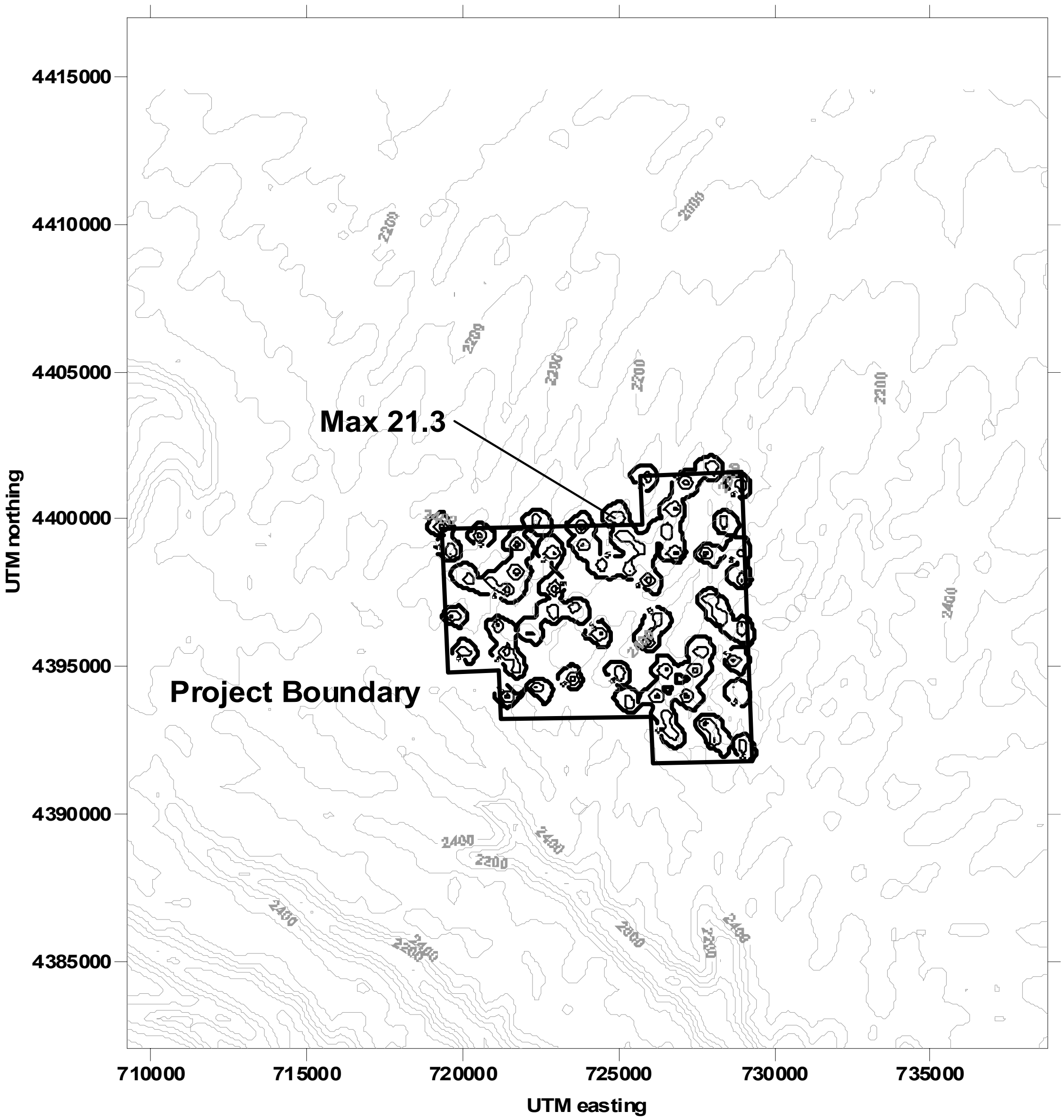
The spatial distribution of pollutant concentrations are shown on Figure 3 for the annual NO_2 concentrations and Figure 4 for the 24-hour PM_{10} concentrations.



NO2 contours 5.0and 1.0 micrograms/cubic meter

Elevation contour interval 100 meters

Figure 4. Figure Four Annual NO2 Impacts



PM10 contours 5, 10, 15 and 20 micrograms/cubic meter

Elevation contour interval 100 meters

Figure 5. Figure 4 24-Hour PM10 Impacts

4.5 FAR-FIELD IMPACTS

The far-field air quality analysis focused upon project-related impacts that could occur at areas of special concern (i.e., federal-designated Class I areas and other areas identified sensitive Class II areas). Figure 2 shows these areas and their relationship to the Figure Four project. The applicable areas and approximate distances from the Figure Four project are provided in Table 16.

Potential far-field impacts were evaluated using the CALPUFF set of dispersion models. The CALPUFF set of models (CALMET, CALPUFF, CALPOST, and associated utilities) were designed specifically to assess ambient air quality impacts at significant distances from the source and therefore long pollutant travel times. The predicted pollutant concentrations were compared to the applicable Class I PSD increments for informational purposes only.

Throughout this impact analysis, all comparisons with PSD increments are intended only to evaluate potential significance, and do not represent a regulatory PSD increment consumption analysis. PSD Increment consumption analyses are typically applied to large industrial sources during permitting, and are solely the responsibility of the State of Colorado and the Environmental Protection Agency.

Two scenarios were considered. Because development of the Proposed Action would proceed for 10 years, the first scenario considered the effect of the maximum annual construction impacts at the tenth year along with the full field development annual impacts during the tenth year. The second scenario considered the effects of operations in the 11th and subsequent years after all construction and development would be complete.

Table 16. Sensitive Areas

Sensitive Area	Federal Land Manager	PSD Designation	Distance from Proposed Action (kilometers)
Black Canyon of the Gunnison Wilderness Area	NPS	Class I	147
Eagle's Nest Wilderness Area	FS	Class I	185
West Elk Wilderness Area	FS	Class I	162
Flat Tops Wilderness Area	FS	Class I	78
Maroon Bells-Snowmass Wilderness Area	FS	Class I	148
Mt. Zirkel Wilderness Area	FS	Class I	166
Arches National Park	NPS	Class I	168
Colorado National Monument	NPS	Class II	89
Ouray National Wildlife Refuge	USFWS	Class II	122
Raggeds Wilderness Area	FS	Class II	134
Dinosaur National Monument	NPS	Class II	110
Holy Cross Wilderness Area	FS	Class II	163

PSD Increments

Predicted maximum pollutant concentrations that would occur are summarized in Tables 17 and 18 and compared with the applicable PSD increments. Table 17 describes the impacts associated with the combined final year of development and full-field production (327 wells and ancillary facilities). Table 18 shows the impacts of the full-field production after all development would be finished. As demonstrated, increases in pollutant concentrations are predicted to be less than 1 percent of all applicable PSD Increments.

Table 17. Pollutant Concentrations at Sensitive Areas (Development and Production)

Sensitive Area	NO_2 Annual Avg (µg/m^3)	% of Increment	PM_{10} Annual Avg (µg/m^3)	% of Increment	PM_{10} 24-Hour Max (µg/m^3)	% of Increment
Black Canyon of the Gunnison WA	5.92E-04	0.024	1.79E-03	0.045	2.76E-02	0.35
Dinosaur NM	4.35E-03	0.017	4.24E-03	0.014	1.20E-02	0.07
Eagle's Nest WA	1.01E-03	0.040	1.96E-03	0.049	2.52E-02	0.32
West Elk WA	3.20E-04	0.013	1.71E-03	0.043	3.18E-02	0.40
Flat Tops WA	1.14E-03	0.045	4.11E-03	0.103	4.16E-02	0.52
Holy Cross WA	2.02E-04	0.001	1.98E-03	0.007	2.42E-02	0.14
Maroon Bells-Snowmass WA	2.49E-04	0.010	2.53E-03	0.063	3.07E-02	0.38
Mt. Zirkel WA	6.26E-04	0.025	1.78E-03	0.044	2.43E-02	0.30
Arches NP	5.33E-04	0.021	1.19E-03	0.030	2.47E-02	0.31
Colorado NM	3.39E-03	0.014	4.47E-03	0.015	5.85E-02	0.34
Ouray NWR	4.15E-04	0.002	1.03E-03	0.003	6.56E-02	0.39
Raggeds WA	1.87E-04	0.001	1.75E-03	0.006	2.42E-02	0.14

NO_2 Class I increment = 2.5 µg/m3; Class II increment = 25 µg/m^3
PM_{10} Annual Class I Increment = 4 µg/m3; Class II increment = 30 µg/m^3
PM_{10} 24-Hour Class I increment = 8 µg/m3; Class II increment = 17 µg/m^3

Table 18. Pollutant Concentrations at Sensitive Areas (Production only)

Sensitive Area	NO_2 Annual Average (µg/m^3)	% of Increment	PM_{10} Annual Average (µg/m^3)	% of Increment	PM_{10} 24-Hour Maximum (µg/m^3)	% of Increment
Black Canyon of the Gunnison WA	1.89E-04	0.008	2.63E-04	0.007	3.79E-03	0.05
Dinosaur NM	1.63E-03	0.007	6.66E-04	0.002	9.54E-03	0.06
Eagle's Nest WA	6.88E-05	0.003	2.78E-04	0.007	3.53E-03	0.04
West Elk WA	1.18E-04	0.005	2.45E-04	0.006	4.36E-03	0.05
Flat Tops WA	3.85E-04	0.015	5.79E-04	0.014	5.80E-03	0.07
Holy Cross WA	6.77E-05	<0.001	2.86E-04	0.001	3.38E-03	0.02
Maroon Bells-Snowmass WA	9.13E-05	0.004	3.59E-04	0.009	4.20E-03	0.05

Mt. Zirkel WA	2.06E-04	0.008	2.62E-04	0.007	3.44E-03	0.04
Arches NP	1.41E-04	0.006	1.73E-04	0.004	1.02E-02	0.13
Colorado NM	1.06E-03	0.004	6.62E-04	0.002	2.02E-02	0.12
Ouray NWR	1.10E-04	<0.001	1.53E-04	0.001	7.69E-03	0.05
Raggeds WA	5.90E-05	<0.001	2.48E-04	0.001	3.36E-03	0.02

NO_2 Class I increment = 2.5 µg/m3; Class II increment = 25 µg/m^3
PM_{10} Annual Class I Increment = 4 µg/m3; Class II increment = 30 µg/m^3
PM_{10} 24-Hour Class I increment = 8 µg/m3; Class II increment = 17 µg/m^3

Acid Deposition

As shown in Table 19, incremental increases in total nitrogen deposition are predicted to be well below the significance threshold (3 kg/ha/yr) for both scenarios. In addition, potential changes in ANC at sensitive lakes located from operational emission sources were shown to be well below the USDA-Forest Service 10 percent change threshold for lakes with background ANC levels above 25 µeq/l (Table 20).

Table 19. Total Nitrogen Deposition at Sensitive Areas

Sensitive Area	Significance Threshold (kg/ha/yr)	During Construction and Operations (kg/ha/yr)	Percent of Significance Threshold	During Operations (kg/ha/yr	Percent of Significance Threshold
Black Canyon of the Gunnison WA	3.0	2.82E-04	0.01a	8.74E-05	<0.01
Dinosaur NM	3.0	1.89E-03	0.06	2.17E-04	0.01
Eagle's Nest WA	3.0	3.29E-04	0.01	1.03E-04	0.01
West Elk WA	3.0	2.69E-04	0.01	8.52E-05	<0.01
Flat Tops WA	3.0	1.08E-03	0.04	3.45E-04	0.01
Holy Cross WA	3.0	3.17E-04	0.01	9.82E-05	<0.01
Maroon Bells-Snowmass WA	3.0	1.12E-03	0.04	8.71E-05	<0.01
Mt. Zirkel WA	3.0	7.08E-04	0.02	2.13E-04	0.01
Arches NP	3.0	2.84E-04	0.01	8.73E-05	<0.01
Colorado NM	3.0	7.99E-04	0.03	2.38E-04	0.01
Ouray NWR	3.0	2.03E-04	0.01	6.63E-05	<0.01
Raggeds WA	3.0	1.76E-04	0.01	5.46E-05	<0.01

Table 20. Potential Acid Neutralizing Capacity Changes at Sensitive Lakes

Location	Sensitive Lake	Background ANC (µeq/l)	Potential Change in ANC (percent)
Eagle's Nest WA	Booth	84.1	0.001
Flat Tops WA	Ned Wilson	38.0	0.007
Holy Cross WA	Blodget	36.9	0.002
Maroon Bells WA	Moon	51.5	0.001
Raggeds WA	Deep Creek #1	44.3	0.001
West Elk WA	S. Golden	111.0	0.001

µeq/l – microequivalents per liter
ANC – Acid Neutralizing Capacity

Visibility

The emissions from the construction activities and operations after construction would not affect visual resources at Class I and II areas. As shown on Table 21, maximum levels of visibility degradation be well below the "Just Noticeable Change" significance threshold of 1.0 dv. In other words, the human eye would not be able to detect any difference less than a 1.0 Δdv. Therefore, it can be concluded that the Figure Four project will not cause any perceptible degradation of visibility at Class I and Class II areas.

Table 21. Predicted Visibility Impairment

Sensitive Area	Highest Δdv During Construction Period	Highest Δdv During Operational Period
Black Canyon of the Gunnison WA	0.20	0.07
Eagle's Nest WA	0.09	0.07
West Elk WA	0.12	0.07
Flat Tops WA	0.27	0.07
Maroon Bells-Snowmass WA	0.08	0.03
Mt. Zirkel WA	0.09	0.04
Arches NP	0.25	0.07
Colorado NM	0.34	0.11
Ouray NWR	0.34	0.07
Raggeds WA	0.07	0.02
Dinosaur NM	0.36	0.08
Holy Cross WA	0.09	0.03

5.0 NO ACTION ALTERNATIVE

Under the No Action Alternative, natural gas resources in and around the Figure Four Unit would only developed on privately-owned minerals leased by the proponent and previously permitted federal wells. Under the No Action Alternative, approximately 6 well pads (compared to 120 under the Proposed Action) with approximately 18 gas wells (compared to 327 under the Proposed Action) would be constructed on fee surface to develop fee minerals. The gas would be transported outside the Figure Four Unit by a smaller pipeline that would serve existing fee wells in the area. Additional compression would not be required.

Project-related pollutants during the construction phase would be 96 percent lower than those assumed for the Proposed Action because of the lower number of potential pads to be constructed and wells to be drilled. Because new compression would not be required, project-related emissions would be reduced more than 95 percent. Since the analysis has demonstrated that no significant air quality impacts would occur from implementation of the Proposed Action, the minor emissions associated with the No Action Alternative would be insignificant.

6.0 MITIGATION

Mitigation of air quality impacts would be accomplished through the permitting of all regulated air pollution sources through the Colorado Department of Public Health and Environment, Air Pollution Control Division. The construction and operating permitting processes, where applicable (compressor engines, large glycol dehydration units), typically require the use of clean burning engines and emissions controls to reduce air pollution emissions and impacts to air quality. For smaller, minor sources of air pollution (small dehydrators, condensate tanks), impacts are generally insignificant and mitigation is not warranted.

To reduce the emission of fugitive dust from access roads in the Project Area, routine road watering and/or application of magnesium chloride would be carried out when the roads are dry.

Appendix E
Near-Field Emissions Inventory

Buys & Associates, Inc. Environmental Consultants	Project: Encana - Figure 4 Field Development EA

Development Summary

Construction/		
Drilling/	For EA analysis, assume surface disturbance of 5 acres per pad	
Completion	By 2006, 125 pads and 332 wells, 141 MMscfd production	
	55 pads in 2004	45%
	30 pads in 2005	25%
	40 pads in 2006	30%
	Maximum scenario development rate: 55 pads and 33 wells drilled	
	50 miles of new roads	22.5 in 2004; 12.5 in 2005; 15.0 in 2006
	Maximum road development: 22.5 miles in 2004	
	Road ROW 30 ft with 18-ft running surface	
	Assume 625 acres for well pads (125 pads * 5 acres/pad)	
	Assume 182 acres for road (50 miles *5280 ft/mile * 30 ft ROW)	
	Average access road 0.41 mile = 0.41 miles x 5280 ft/mile x 30 ft ROW = 1.45 acres	
	Average Round Trip Distance for Construction/Drilling/Completion Traffic = 24 miles (estimated from project area road system)	
	Average drilling time = 30 days (based on Proponent's estimated 25-35 days)	
	Average completion time = 10 days	
Production		
	Separator for each well	
	Boiler size for separators: 750 Mbtu	
	Assume 95% destruction efficiency for dehy's to meet and federal MACT stds.	
	Condensate tanks - 200 to 500 barrels	
	Condensate production - 4 barrels/day/well	
	332 wells by year end 2006	
	90 MMscfd by end of 2006 - average 0.27 MMscfd per well	
	Compressor station 12,800 hp by 2006	
	Comp Building = 40 meters x 20 meters x 6 meters high	

Production Heater Emissions

Assumptions

Central Dehydrator Reboiler Size	1250	MBTU/hr (Reported by Project Proponents)
Firing Rate	30	minutes/hour on average for entire year (Typical value)
	4380	hours/year
Fuel Gas Heat Content	1078	Btu/scf-wet (Gas Analyses from Existing Wells)
Fuel Gas VOC Content	0.0816	by weight (Gas Analyses from Existing Wells)
Development size	332	wells

Equations

$$\text{Fuel Consumption (MMscf/yr)} = \frac{\text{Heater Size (MBtu/hr)} * 1{,}000 \text{ (Btu/MBtu)} * \text{Hours of Operation (hrs/yr)}}{\text{Fuel Heat Value (Btu/scf)} * 1{,}000{,}000 \text{ (scf/MMscf)}}$$

$$\text{NOx/CO/TOC Emissions (tons/yr)} = \frac{\text{AP-42 E.Factor (lbs/MMscf)} * \text{Fuel Consumption (MMscf/yr)} * \text{Fuel heating Value (Btu/scf)}}{2{,}000 \text{ (lbs/ton)} * 1{,}000 \text{ (Btu/scf - Standard Fuel Heating Value)}}$$

$$\text{VOC Emissions (tons/yr)} = \text{TOC Emissions (tons/yr)} * \text{VOC wt. fraction}$$

	Reboiler Heater Emissions		
Pollutant	Emission	Reboiler	Total
	Factor	Emissions	Emissions [e]
	(lb/MMscf)	(lb/hr)	(tons/yr)
NOx [a]	100	0.063	0.274
CO [a]	21	0.013	0.057
TOC [c]	8	0.005	0.022
VOC	N.A.	0.208	0.909
SOx [b]	0.00	0.000	0.000
TSP [c]	7.6	0.005	0.021
PM10 [c]	7.6	0.005	0.021
PM2.5 [c]	7.6	0.005	0.021
Benzene [d]	0.0021	0.000	0.000
Toluene [d]	0.0034	0.000	0.000
Hexane [d]	1.8	0.001	0.005
Formaldehyde [d]	0.075	0.000	0.000

a AP-42 Table 1.4-1, Emission Factors for Natural Gas Combustion, 2/98
b Assumes produced gas contains no sulfur
c AP-42 Table 1.4-2, Emission Factors for Natural Gas Combustion, 3/98 (All Particulates are PM1.0)
d AP-42 Table 1.4-3, Emission Factors for Organic Compounds from Natural Gas Combustion, 3/98
e Total heater emissions for project assuming full development of all wells

Buys & Associates, Inc. **Environmental Consultants**	Project: Encana - Figure 4 Field Development EA

Completion Related Vehicle Tailpipe Emissions

Assumptions:

Average Round Trip Distance	24.0	miles (Estimated from project area and existing road system)
Days of Operation	10	days (Proponent)
nber of Heavy Diesel Truck Trips	79	(Estimated from project description)
Number of Pickup Trips	104	(Estimated from project description)
Diesel Fuel sulfur content	0.05	% (Typical value)
Diesel Fuel density	7.08	lbs/gallon (Typical value)
eavy Haul Diesel Fuel Efficiency	10	miles/gallon (Typical value)
eavy Duty Pickup Fuel Efficiency	15	miles/gallon (Typical value)
Well Development Rate	33	wells per year

Equations:

For NOx, CO and VOC:

$$\text{missions (tons/year)} = \frac{\text{Emission Factor (g/mile) * \# Trips * Trip Distance (miles)}}{\text{453.6 (g/lb) * 2000 (lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO2 emissions are calculated on a mass balance basis utilizing the following equation:

$$\text{O2 E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal) * 453.6 (g/lb) * Fuel Sulfur Content * 2 (S / SO2)}}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Drilling Vehicles	**Heavy Haul Trucks**			**Heavy Duty Pickups**			**Total** [d]	
	E. Factor [a] (g/mile)	Emissions (lb/day)	Emissions tons/yr/wel	E. Factor [b] (g/mile)	Emissions (lb/day)	Emissions tons/yr/wel	Emissions (lb/day)	Emissions (tons/yr)
NOx	8.13	3.398	0.017	3.03	1.667	0.008	5.066	0.836
CO	17.09	7.143	0.036	33.64	18.511	0.093	25.654	4.233
VOC [c]	4.83	2.019	0.010	1.84	1.012	0.005	3.031	0.500
SO2	0.32	0.134	0.001	0.21	0.118	0.001	0.252	0.042

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes the maximum development rate

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Project: Encana - Figure 4 Field Development EA

Construction Traffic Fugitive Dust Emissions

Calculation AP-42, Chapter 13.2.1
December 2003

E (PM10) / VMT = 1.5 * (S/12)^0.9 * (W/3)^0.45 * (365-p)/365)
E (PM2.5) / VMT = 0.23 * (S/12)^0.9 + (W/3)^0.45

Silt Content (S)	11	
Round Trip Miles	24	
Precipitation Days (P)	88	WRCC Little Hills

	Vehicle Type	Average Weight (lbs)	Round Trips per Well	PM10 (lb/VMT)	PM10/Pad (lbs)	PM10/Pad (lb/day)	PM2.5/Pad (lbs)	PM2.5/Pad (lb/day)
Construction (days/pad and road)	10							
	Semi: Hvy Equip Hauler	74,000	3					
	Haul Truck:Gravel	48,000	2					
	Pickup Truck: Crew	7,000	10					
	Mean Vehicle Weight	25,867	15	2.031578	731.4	73.1	112.1	11.2
					PM10/55 Pads (tons)		**PM2.5/55 Pads (tons)**	
					20.1		3.1	

	Vehicle Type	Average Weight (lbs)	Round Trips per Well	PM10 (lb/VMT)	PM10/Well (lbs)	PM10/Well (lb/day)	PM2.5/Well (lbs)	PM2.5/Well (lb/day)
Drilling (days/well)	30							
	Semi: Rig Transport	60,000	22					
	Haul Truck:Fuel	48,000	55					
	Haul Truck: Mud	48,000	8					
	Logging Trucks	48,000	4					
	Haul Truck: Gravel	48,000	2					
	Haul Truck: Water	20,000	20					
	Pickup Truck: Rig Crew	7,000	110					
	Pickup Truck: Mechanic	8,000	8					
	Pickup Truck: Supervisor	7,000	8					
	Pickup Truck: Mud Logger	8,000	110					
	Pickup: Mud Engineer	7,000	55					
	Pickup: Bit/Tool Delivery	8,000	16					
	Mean Vehicle Weight	19,079	418	1.771536	17772.0	592.4	2725.0	90.8
					PM10/33 Wells (tons)		**PM2.5/33 Wells (tons)**	
					293.2		45.0	

	Vehicle Type	Average Weight (lbs)	Round Trips per Well	PM10 (lb/VMT)	PM10/Well (lbs)	PM10/Well (lb/day)	PM2.5/Well (lbs)	PM2.5/Well (lb/day)
Completion (days/well)	10							
	Semi: Casing	74,000	6					
	Cement Haul Trucks	74,000	6					
	Cement Pump Truck	48,000	2					
	Completion Rig	74,000	1					
	Completion Rig Equip Truck	48,000	4					
	Frac Trucks	80,000	12					
	Haul: Frac Tanks	48,000	6					
	Haul: Frac Sand	44,000	30					
	Haul: Frac Chemicals	44,000	4					
	Logging/Perf. Truck	48,000	8					
	Pickup: Comp.Foreman	7,000	40					
	Pickup: Casing Crews	7,000	4					
	Pickup: Cement Crew	8,000	4					
	Pickup: Completion Rig Crew	7,000	20					
	Pickup: Frac Crew	7,000	4					
	Pickup: Logging/Perf Crew	7,000	8					
	Welders	8,000	4					
	Roustabout Crews	8,000	4					
	Supply Trucks	8,000	16					
	Mean Vehicle Weight	28,055	183	2.107184	9254.8	925.5	1419.1	141.9
					PM10/33 Wells (tons)		**PM2.5/33 Wells (tons)**	
					152.7		23.4	

	Vehicle Type	Average Weight (lbs)	Round Trips per Well	PM10 (lb/VMT)	PM10/Day (lbs)	PM10/Day (lb/day)	PM2.5/Day (lbs)	PM2.5/Day (lb/day)
Field Development (days/pipeline mile)	1							
	Gathering Sys. Const. Crew	8,000	4					
	Haul Truck: Trencher	48,000	1					
	Haul Truck: Pipe	48,000	6					
	Surveyor	7,000	1					
	Welder	8,000	4					
	Reclamation Crew	8,000	1					
	Mean Vehicle Weight	24,412	17	1.979338	807.6	807.6	123.8	123.8
					PM10/22 Days (tons)		**PM2.5/22 Days (tons)**	
					9.1		1.4	
Annual Traffic Fugitive Dust Emissions (tons/year)					**475.14**		**72.85**	

Buys & Associates, Inc. **Environmental Consultants**	Project: Encana - Figure 4 Field Development EA

Gas Compression

Assumptions:

Required Compression: 12,800 Horsepower (Estimated by Project Proponents) BY 2006

Equations:

$$\text{Emissions (lbs/hr)} = \frac{\text{Emission Factor (g/hp-hr)} * \text{Power (hp)}}{\text{453.6 g/lb}}$$

Pollutant	Emission Factor (g/hp-hr)	Emissions (lb/hr)	Emissions (tons/yr)
NOx [1]	1.0	28.22	123.598
CO [1]	1.0	28.22	123.598
VOC [1]	0.5	14.11	61.799
PM10 [2]	0.022	0.62	2.719
PM2.5 [2]	0.022	0.62	2.719
SO2 [3]	0.0	0.00	0.000
Benzene [2]	0.00180	0.05	0.222
Toluene [2]	0.00064	0.02	0.079
Ethylbenzene [2]	0.00003	0.00	0.004
Xylenes [2]	0.00022	0.01	0.027
Formaldehyde [4]	0.10	2.82	12.360

1 - Average Manufacturer Specified Emission Rate
2 - AP-42 Table 3.2-3 Uncontrolled Emission Factors for 4-Stroke Rich-Burn Engines, 7/00
3 - Fuel gas is assumed to be free from sulfur compounds
4 - GRI published value

Buys & Associates, Inc. **Environmental Consultants**	Project: Encana - Figure 4 Field Development EA

Construction Related Light Vehicle Tailpipe Emissions

Assumptions:

Average Round Trip Distance	24.0	miles (Estimated from Project Area and existing road system)
Days of Construction	10	days (Proponent)
Number of Heavy Diesel Truck Trips	5	(Estimated)
Number of Pickup Trips	5	(Estimated)
Diesel Fuel sulfur content	0.05	% (Typical value)
Diesel Fuel density	7.08	lbs/gallon (Typical value)
Heavy Haul Diesel Fuel Efficiency	10	miles/gallon (Typical value)
Heavy Duty Pickup Fuel Efficiency	15	miles/gallon (Typical value)
Pad Development Rate	55	pads per year

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{\# Trips} * \text{Trip Distance (miles)}}{453.6 \text{ (g/lb)} * 2000 \text{ (lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO2 emissions are calculated on a mass balance basis utilizing the following equation:

$$\text{SO2 E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6 \text{ (g/lb)} * \text{Fuel Sulfur Content} * 2 \text{ (S / SO2)}}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Construction Vehicles	Heavy Haul Trucks			Heavy Duty Pickups			Total [d]	
	E. Factor [a] (g/mile)	Emissions (lb/day)	Emissions (tons/yr/well)	E. Factor [b] (g/mile)	Emissions (lb/day)	Emissions (tons/yr/well)	Emissions (lb/day)	Emissions (tons/yr)
NOx	8.13	0.215	0.001	3.03	0.080	0.000	0.295	0.081
CO	17.09	0.452	0.002	33.64	0.890	0.004	1.342	0.369
VOC [c]	4.83	0.128	0.001	1.84	0.049	0.000	0.176	0.049
SO2	0.32	0.008	0.000	0.21	0.006	0.000	0.014	0.004

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes the maximum development rate

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Construction Related Emissions Summary (based on 55 well pads, 22.5 miles road, 33 wells drilled and completed)

Pollutant	Development Emissions (tons/year)			
	Construction	Drilling	Completion	Total
NO_X	5.90	366.55	1.14	373.59
CO	1.49	94.31	5.86	101.66
VOC	0.26	11.68	0.86	12.80
SO_2	0.13	10.81	0.04	10.98
PM_{10}	20.44	301.95	152.70	475.09
$PM_{2.5}$	3.41	52.25	23.41	79.07
Benzene			0.00	0.00
Formaldehyde	0.10		0.00	0.10
Toluene			0.00	0.00
Hexane			0.01	0.01

Well Pad and Access Road Construction Emissions (Dozer and Backhoe)

Assumptions:

Well Pad and Access Road Area	6.45	acres (Proposed Action)
Hours of Construction	10	days per well pad (Proponent)
	8	hours/day
	80	hours per well pad
Watering Control Efficiency	50	percent
Soil Moisture Content	7.9	percent (AP-42 Table 11.9-3, 10/98)
Soil Silt Content	6.9	percent (AP-42 Table 11.9-3, 10/98)
PM10 Multiplier	0.75 * PM15	(AP-42 Table 11.9-1, 10/98)
PM2.5 Multiplier	0.105 * TSP	(AP-42 Table 11.9-1, 10/98)
Pad Development Rate	55	pads per year - indicates max the first year

Equations: From AP-42 tables 11.9-1 and 11.9-3 for
Bulldozing Overburden Emissions, Western Surface Coal Mining, 10/98

Emissions (TSP lbs/hr) = 5.7 * (soil silt content %)^1.2 * (soil moisture content %)^-1.3* Control Efficiency

Emissions (PM15 lbs/hr) = 1.0 * (soil silt content %)^1.5 * (soil moisture content %)^-1.4 * Control Efficiency

Emissions = 1.97 lbs TSP/hour/piece of equipment

Emissions = 0.50 lbs PM15/hour/piece of equipment

	Dozer and Backhoe Emissions [a]		
	lbs/hr	lb/day/well	tons/yr [b]
TSP	3.94	31.5260	69.36
PM15	1.00	8.0294	17.66
PM10	0.75	6.0221	13.25
PM2.5	0.41	3.3102	7.28

a Assumes one dozer and one backhoe. Backhoe emissions are conservatively estimated as equivalent to Dozer emissions.

b Assumes the maximum construction rate

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Drill Rig Engine Emissions

Assumptions:

Hours of Operation	720	hours/well (30 days @ 24 hrs/day - Specified by Proponent)
Development Rate	33	wells/year
Load Factor	0.4	(Typical value)
Rig Size	3200	hp (Proponent)
Diesel Fuel Sulfur Content	0.05	% (Typical value)

Equations:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (lb/hp-hr)} * \text{Rated Horsepower (hp)} * \text{Operating Hours (hrs)} * \text{Load Factor (Dimensionless)}}{\text{2000 (lb/tons)}}$$

SO2 E. Factor (lb/hp-hr) = Fuel sulfur content * 0.00809

Species	Drill Rig Emissions		
	E. Factor [a] (lb/hp-hr)	Emissions (lb/hr)	Emissions [e] (tons/yr)
NOx	0.024	30.720	364.954
CO	0.0055	7.040	83.635
VOC [b]	0.000705	0.902	10.721
PM10 [c]	0.000573	0.733	8.713
PM2.5 [d]	0.000479	0.613	7.284
SO2	0.0004045	0.518	6.151

a AP-42 Volume I, Large Stationary Diesel Engines Table 3.4-1, 10/96
b Emission Factor represents total Hydrocarbon Emissions
c Total particulate emission factor is 0.0007, PM10 fraction determined from Table 3.4-2
d Total particulate emission factor is 0.0007, PM2.5 fraction determined from Table 3.4-2
e Assumes the maximum development rate

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Drilling Related Vehicle Tailpipe Emissions

Assumptions:

Average Round Trip Distance	24.0	miles (Estimated from project area and existing road system)
Days of Operation	30	hours per site (Project Proponent)
Number of Heavy Diesel Truck Trips	111	(Estimated from project description)
Number of Pickup Trips	307	(Estimated from project description)
Diesel Fuel sulfur content	0.05	% (Typical value)
Diesel Fuel density	7.08	lbs/gallon (Typical value)
Heavy Haul Diesel Fuel Efficiency	10	miles/gallon (Typical value)
Heavy Duty Pickup Fuel Efficiency	15	miles/gallon (Typical value)
Well Development Rate	33	wells per year

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{\# Trips} * \text{Trip Distance (miles)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO2 emissions are calculated on a mass balance basis utilizing the following equation:

$$\text{SO2 E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\ \text{(g/lb)} * \text{Fuel Sulfur Content} * 2\ \text{(S / SO2)}}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Drilling Vehicles	Heavy Haul Trucks			Heavy Duty Pickups			Total [d]	
	E. Factor [a] (g/mile)	Emissions (lb/day)	Emissions (tons/yr/well)	E. Factor [b] (g/mile)	Emissions (lb/day)	Emissions (tons/yr/well)	Emissions (lb/day)	Emissions (tons/yr)
NOx	8.13	1.592	0.024	3.03	1.641	0.025	3.232	1.600
CO	17.09	3.346	0.050	33.64	18.214	0.273	21.560	10.672
VOC [c]	4.83	0.946	0.014	1.84	0.996	0.015	1.942	0.961
SO2	0.32	0.063	0.001	0.21	0.116	0.002	0.179	0.089

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes the maximum development rate

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Wind Erosion Fugitive Dust Emissions

Assumptions

Threshold Friction Velocity U_t* 1.02 m/s (2.28 mph) for well pads (AP-42 Table 13.2.5-2 Overburden - Western Surface Coal Mine
1.33 m/s (2.97 mph) for roads (AP-42 Table 13.2.5-2 Roadbed material)

Initial Disturbance Area 625.0 acres total initial disturbance for pads
2,529,281 square meters total initial disturbance for roads

Exposed Surface Type Flat

Meteorological Data 2002 Grand Junction (obtained from NCDC website)

Fastest Mile Wind Speed U_{10}^+ 20.1 meters/sec (45 mph) reported as fastest 2-minute wind speed for Grand Junction (2002)

Number soil of disturbances 2 for well pads and pipelines(Proposed Action assumption, disturbance at construction and reclamation)
Constant for dirt roads

Development Period 3 years (Proposed Action - 125 pads)

Equations

Friction Velocity $U^* = 0.053\ U_{10}^+$

Erosion Potential P (g/m^2/period) = $58^*(U^*-U_t^*)^2 + 25^*(U^*-U_t^*)$ for $U^*>U_t^*$, P = 0 for $U^* < U_t^*$

Emissions (tons/year) = Erosion Potential(g/m^2/period)*Disturbed Area(m^2)*Disturbances/year*(k)/(453.6 g/lb)/2000 lbs/ton/Develop Period

Particle Size Multiplier (k)

30 um	<10 um	<2.5 um
1.0	0.5	0.2

Maxium U_{10}^+ Wind Speed (m/s)	Maximum U* Friction Velocity m/s	Well/Pipeline U_t* Threshold Velocity[a] m/s	Well Pad Erosion Potential g/m^2	Road U_t* Threshold Velocity[a] m/s	Road Erosion Potential g/m^2
20.12	1.07	1.02	1.28	1.33	0.00

Wind Erosion Emissions Particulate Species	Pads (tons/year)
TSP	2.38
PM10	1.19
PM2.5	0.48

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Completion Flare Emissions

Assumptions

Hours of Operation	2	days (Typical)
Amount of Gas Flared	0.27	MMscf/day/well (Reported by Project Proponents)
Average Gas Heat Content	990	Btu/scf (Gas Analyses from Existing Wells)
Average Gas VOC Content	8	weight % (Gas Analyses from Existing Wells)
Average Mole Weight	18.6	lb/lb-mole (Gas analyses from Existing Wells)
Development rate	33	wells per year

Equations

NOx/CO Emissions (lb/well) = Emission Factor (lb/MM Btu) * Gas Amount (MMscf/well) * Heat Content (Btu/scf)

PM/HAP Emissions (lb/well) = Emission Factor (lb/MMscf) * Gas Amount (MMscf/well)

$$\text{Flare Gas Wt. (lb/well)} = \frac{\text{Flare Gas Volume (MMscf/well)} * 10^6 \text{ (scf/MMscf)} * \text{Mole Weight (lb/lb-mole)}}{379.49 \text{ (scf/mole)}}$$

VOC Emissions (lb/well) = Flare Gas Wt. (lb/well) * VOC wt. % * 0.02 (Assumes 98% destruction Efficiency)

	Emission Factor (lb/MMBtu)	Well Emissions (lb/well)	Well Emissions (lb/hr/well)	Total Emissions [e] (tons/yr)
NOx [a]	0.068	18.2	0.38	0.30
CO [a]	0.37	98.9	2.06	1.63
VOC	N.A.	21.6	0.45	0.36
SOx [b]	0.00	0.0	0.00	0.00

	Emission Factor (lb/MMscf)	Well Emissions (lb/well)	Well Emissions (lb/hr/well)	Total Emissions [e] (tons/yr)
TSP [c]	7.6	2.052	0.043	0.034
PM10 [c]	7.6	2.052	0.043	0.034
PM2.5 [c]	7.6	2.052	0.043	0.034
Benzene [d]	0.0021	0.000567	0.000	0.000
Toluene [d]	0.0034	0.000918	0.000	0.000
Hexane [d]	1.8	0.486	0.010	0.008
Formaldehyde [d]	0.075	0.02025	0.000	0.000

a AP-42 Table 13.5-1, Emission Factors for Flare Operations, 9/91
b Assumes produced gas contains no sulfur
c AP-42 Table 1.4-2, Emission Factors for Natural Gas Combustion, 3/98 (All Particulates are PM1.0)
d AP-42 Table 1.4-3, Emission Factors for Organic Compounds from Natural Gas Combustion, 3/98
e Assumes the maximum development rate

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Average Produced Gas Characteristics

Gas Heat Value (wet): 1078.0592 Btu/scf

C1-C2 Wt. Fraction:	0.8690
VOC Wt. Fraction:	0.0816
Non-HC Wt. Fraction:	0.0493
Total:	1.0000

COMPONENT	MOLE PERCENT	COMPONENT MOLE WEIGHT (lb/lb-mole)	NET MOLE WEIGHT (lb/lb-mole)	WEIGHT FRACTION	GROSS HEATING VALUE (BTU/scf)	NET DRY HEATING VALUE (BTU/scf)	LOWER HEATING VALUE (BTU/scf)	NET LOW HEATING VALUE (BTU/scf)
Methane	88.1453	16.043	14.141	0.759	1010.000	890.268	910.000	802.122
Ethane	6.7933	30.070	2.043	0.110	1769.800	120.228	1618.000	109.916
Propane	1.8421	44.097	0.812	0.044	2516.200	46.351	2316.000	42.663
i-Butane	0.4337	58.123	0.252	0.014	3252.100	14.104	3005.000	13.033
n-Butane	0.3390	58.123	0.197	0.011	3262.400	11.060	3013.000	10.214
i-Pentane	0.1328	72.150	0.096	0.005	4000.900	5.313	3698.000	4.911
n-Pentane	0.0799	72.150	0.058	0.003	4008.800	3.203	3708.000	2.963
Hexanes+	0.0433	86.177	0.037	0.002	4756.200	2.059	4404.000	1.907
Heptanes	0.0415	100.204	0.042	0.002	5502.500	2.284	5100.000	2.117
Octanes	0.0016	114.231	0.002	0.000	6249.100	0.100		0.000
Nonanes	0.0009	128.258	0.001	0.000	6996.400	0.063		0.000
Decanes	0.0000	142.285	0.000	0.000	7743.200	0.000		0.000
Benzene	0.0047	78.120	0.004	0.000	3715.500	0.175		0.000
Toluene	0.0020	92.130	0.002	0.000	4444.600	0.089		0.000
Ethylbenzene	0.0000	106.160	0.000	0.000	5191.500	0.000		0.000
Xylenes	0.0005	106.160	0.001	0.000	5183.500	0.026		0.000
n-Hexane	0.0196	86.177	0.017	0.001	4756.200	0.932		0.000
Helium	0.0000	4.003	0.000	0.000	0.000	0.000	0.000	0.000
Nitrogen	0.0929	28.013	0.026	0.001	0.000	0.000	0.000	0.000
Carbon Dioxide	2.0289	44.010	0.893	0.048	0.000	0.000	0.000	0.000
Oxygen	0.0000	32.000	0.000	0.000	0.000	0.000	0.000	0.000
Hydrogen Sulfide	0.0000	34.080	0.000	0.000	637.100	0.000	588.000	0.000
TOTAL	100.0020		18.623	1.000		1096.254		989.845

Gas Samples collected from North Chapita 43-31 and 23-31 wells.
HAP fractions estimated utilizing GRI published factors

Well Pad and Road Construction Emissions (Grader)

Assumptions:

Grading Length	4.51	0.41 miles/road plus 4.1 miles on 466ft^2 pad (10 ft swath for 466 ft * 46 lenghts) = 21,436 ft = 4.1 miles
Hours of Construction	1	days grading per well pad and road (Proponent Estimate)
	8	hours/day
	8	hours per well pad
Watering Control Efficiency	50	percent
Average Grader Speed	10	mph (Typical value)
Distance Graded	4.51	miles
PM10 Multiplier	0.6 * PM15	(AP-42 Table 11.9-1, 10/98)
PM2.5 Multiplier	0.031 * TSP	(AP-42 Table 11.9-1, 10/98)
Pad/Road Development Rate	55	per year - max during first year

Equations: From AP-42 tables 11.9-1 and 11.9-3 for
Bulldozing Overburden Emissions, Western Surface Coal Mining, 10/98

Emissions (TSP lbs) = 0.040 * $(\text{Mean Vehicle Speed})^{2.5}$ * Distance Graded * Control Efficiency

Emissions (PM15 lbs) = 0.051 * $(\text{Mean Vehicle Speed})^{2.0}$ * Distance Graded * Control Efficiency

Emissions = 28.52 lbs TSP/well

Emissions = 11.50 lbs PM15/well

	Grader Construction Emissions			
	lbs/well	**lbs/day/well**		**tons/yr [a]**
TSP	28.52	28.52		0.78
PM15	11.50	11.50		0.32
PM10	6.90	6.90		0.19
PM2.5	0.88	0.88		0.02

a Assumes the maximum construction rate

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Project: Encana - Figure 4 Field Development EA

Construction Related Heavy Equipment Tailpipe Emissions

Assumptions:

Hours of Operation	80 hours/site (10 days @ 8 hrs/day - Specified by Proponent)
Days of Operation	10 Specified by Proponent)
Development Rate	55 pads per year
Load Factor	0.4 (Assumed typical value)
Backhoe Size	100 hp (Assumed Typical value)
Dozer Size	150 hp (Assumed Typical value)
Motor Grader Size	135 hp (Assumed Typical value)

Equations:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/hp-hr)} * \text{Rated Horsepower (hp)} * \text{Operating Hours (hrs)} * \text{Load Factor (Dimensionless)}}{453.6 \text{ (g/lb)} * 2000 \text{ (lb/tons)}}$$

Heavy Const.		Backhoe			Dozer			Grader		Total	
Vehicles	E. Factor [a]	Emissions	Emissions[e]	E. Factor [a]	Emissions	Emissions[e]	E. Factor [b]	Emissions	Emissions[e]	Emissions	Emissions
	(g/hp-hr)	(lb/day/pad)	(tons/yr/pad)	(g/hp-hr)	(lb/day/pad)	(tons/yr/pad)	(g/hp-hr)	(lb/day/pad)	(tons/yr/pad)	(lb/day)	(tons/yr)
NOx	8.15	5.750	0.029	8.15	8.624	0.043	7.14	6.800	0.034	21.174	5.823
CO	2.28	0.201	0.001	2.28	2.413	0.012	1.54	1.467	0.007	4.080	1.122
VOC [c]	0.37	0.033	0.000	0.37	0.392	0.002	0.36	0.343	0.002	0.767	0.211
PM10 [d]	0.5	0.044	0.000	0.5	0.529	0.003	0.63	0.600	0.003	1.173	0.323
PM2.5 [d]	0.5	0.044	0.000	0.5	0.529	0.003	0.63	0.600	0.003	1.173	0.323
SO2	0.22	0.019	0.000	0.22	0.233	0.001	0.22	0.210	0.001	0.462	0.127
Formaldehyde	0.22	0.019	0.000	0.22	0.233	0.001	0.12	0.114	0.001	0.366	0.101

a AP-42 Volume II, Mobile Sources, Nonroad Vehicles, Table 11-7.1 Off-highway truck
b AP-42 Volume II, Mobile Sources, Nonroad Vehicles, Table 11-7.1 Motor Grader
c Emission Factor represents total Hydrocarbon Emissions
d All emitted particulate matter assumed to be PM2.5
e Assumes the maximum development rate

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Operations Traffic Fugitive Dust Emissions

E (PM10) / VMT = 1.5 * (S/12)^0.9 * (W/3)^0.45 * (365-p)/365)
E (PM2.5) / VMT = 0.23 * (S/12)^0.9 + (W/3)^0.45

Silt Content (S)	11		
Round Trip Miles	24	Within Project	25 *
Precipitation Days (P)	88	WRCC Little Hills	

* Each vehicle covers half the Unit in one day

	Vehicle Type	Ave. Weight (lbs)	Round Trips per Day	PM10 (lb/VMT)	Total PM10 (lbs)	PM10 (lb/day)	Total PM2.5 (lbs)	PM2.5 (lb/day)
Operations	365							
	Haul Truck:Condensate	48,000	2					
	Pickup Truck: Crew	7,000	2					
	Mean Weight	27,500	4	2.088335	149399.5	409.3	22907.9	62.8

Total PM10 (tons/year)	Total PM2.5 (tons/year)
74.70	11.45

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Operations Tailpipe Emissions

Assumptions:

Average Round Trip Distance 49.0 miles (Estimated from Project Area and existing road system)

Days 365 days (Proponent)

Number of Heavy Diesel Truck Trips 2 (Estimated)

Number of Pickup Trips 2 (Estimated)

Diesel Fuel sulfur content 0.05 % (Typical value)

Diesel Fuel density 7.08 lbs/gallon (Typical value)

Heavy Haul Diesel Fuel Efficiency 10 miles/gallon (Typical value)

Heavy Duty Pickup Fuel Efficiency 15 miles/gallon (Typical value)

Equations:

For NOx, CO and VOC:

$$\text{Emissions (tons/year)} = \frac{\text{Emission Factor (g/mile)} * \text{\# Trips} * \text{Trip Distance (miles)}}{453.6\ \text{(g/lb)} * 2000\ \text{(lb/tons)}}$$

The NOx, CO and VOC emission factors for the above equation are from AP-42, while the SO2 emissions are calculated on a mass balance basis utilizing the following equation:

$$\text{SO2 E. Factor (g/mi)} = \frac{\text{Fuel Density (lb/gal)} * 453.6\ \text{(g/lb)} * \text{Fuel Sulfur Content} * 2\ \text{(S / SO2)}}{\text{Vehicle Fuel Efficiency (miles/gal)}}$$

Vehicles	Heavy Haul Trucks			Heavy Duty Pickups			Total [d]	
	E. Factor [a] (g/mile)	Emissions (lb/day)	Emissions (tons/yr/)	E. Factor [b] (g/mile)	Emissions (lb/day)	Emissions tons/yr/wel	Emissions (lb/day)	Emissions (tons/yr)
NOx	8.13	1.756	1.484	3.03	0.655	0.553	2.411	2.037
CO	17.09	0.010	3.119	33.64	7.268	6.139	7.278	9.258
VOC [c]	4.83	0.00286	0.881	1.84	0.398	0.336	0.400	1.217
SO2	0.32	0.00019	0.059	0.21	0.046	0.039	0.046	0.098

a AP-42 Table 7.1.2 - H.D. Diesel Powered Vehicles, High Altitude, 1991 - 1997 Model Year, 50,000 miles (6/95)
b AP-42 Table 4.1A.2 - H.D. Gasoline Vehicles, High Altitude, 1991 - 1997 Vehicle Year, 50,000 miles (6/95)
c Emission factor is for total Hydrocarbons.
d Assumes the maximum development rate

Production Heater Emissions

Assumptions

Wellsite Separator Size 750 MBTU/hr (Reported by Project Proponents)

Firing Rate 30 minutes/hour on average for entire year (Typical value)
4380 hours/year

Fuel Gas Heat Content 989 Btu/scf-wet (Gas Analyses from Existing Wells)

Fuel Gas VOC Content 0.0816 by weight (Gas Analyses from Existing Wells)

Development size 332 wells

Equations

$$\text{Fuel Consumption (MMscf/yr)} = \frac{\text{Heater Size (MBtu/hr)} * 1{,}000 \text{ (Btu/MBtu)} * \text{Hours of Operation (hrs/yr)}}{\text{Fuel Heat Value (Btu/scf)} * 1{,}000{,}000 \text{ (scf/MMscf)}}$$

$$\text{NOx/CO/TOC Emissions (tons/yr)} = \frac{\text{AP-42 E.Factor (lbs/MMscf)} * \text{Fuel Consumption (MMscf/yr)} * \text{Fuel heating Value (Btu/scf)}}{2{,}000 \text{ (lbs/ton)} * 1{,}000 \text{ (Btu/scf - Standard Fuel Heating Value)}}$$

VOC Emissions (tons/yr) = TOC Emissions (tons/yr) * VOC wt. fraction

	Separator Heater Emissions		
Pollutant	Emission	Well	Total
	Factor	Emissions	Emissions [e]
	(lb/MMscf)	(lb/hr/well)	(tons/yr)
NOx [a]	100	3.792E-02	55.138
CO [a]	21	7.875E-03	11.452
TOC [c]	8	3.000E-03	4.362
VOC	N.A.	2.448E-04	0.356
SOx [b]	0.00	0.000E+00	0.000
TSP [c]	7.6	2.850E-03	4.144
PM10 [c]	7.6	2.850E-03	4.144
PM2.5 [c]	7.6	2.850E-03	4.144
Benzene [d]	0.0021	7.875E-07	0.001
Toluene [d]	0.0034	1.275E-06	0.002
Hexane [d]	1.8	6.750E-04	0.982
Formaldehyde [d]	0.075	2.813E-05	0.041

1.956E-03

a AP-42 Table 1.4-1, Emission Factors for Natural Gas Combustion, 2/98
b Assumes produced gas contains no sulfur
c AP-42 Table 1.4-2, Emission Factors for Natural Gas Combustion, 3/98 (All Particulates are PM1.0)
d AP-42 Table 1.4-3, Emission Factors for Organic Compounds from Natural Gas Combustion, 3/98
e Total heater emissions for project assuming full development of all wells

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Total Project Production Related Emissions Summary

	Total Project Production Related Emissions (tons/year)						Total
Pollutant	Separator	Dehydrator	Condensate	Central	Vehicle	Vehicle	
	Heater	Still Vent	Tank Flash	Compression	Tailpipe	Fugitive Dust	(tons/year)
NO_X	55.138			123.60	2.04		180.77
CO	11.452			123.60	9.26		144.31
VOC	0.356		2423.60	61.80	1.22		2486.97
SO_2	0.000			0.00	0.10		0.10
PM_{10}	4.144			2.72		74.70	81.56
$PM_{2.5}$	4.144			2.72		11.45	18.32
Benzene	0.001	7.81	11.63	0.22			19.67
Toluene	0.002	4.34					4.34
Ethylbenzene							0.00
Xylene		1.13					1.13
n-Hexane	0.982	0.51	33.93				35.42
Formaldehyde	0.041			12.36			12.40

Full Field Development 332 wells

0.035259001

Stack Parameters				
Equipment	**Temp**	**Velocity**	**Diameter**	**Height**
	(K)	**(m/s)**	**(meters)**	**(meters)**
Compressor	811	35	0.3048	9.1
Drill Rig	800	50	0.1	7.6
Boiler	700	1.6	0.3048	4.6
Tank	366	0.01	0.05	6.7
assumes 20-ft high tank with horizontal exhaust				
TEG Dehydrator	366	0.001	0.05	3.65

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Wellsite Condensate Storage Tank Flash/Working/Standing Emissions

Assumptions:

Average Condensate Production Rate : 4 bbls per day (Average reported by proponents for existing wells)

Size of Development: 332 wells

Calculations:

CDPHE APCD Tank Emissions Memo 12-30-02 re Condensate Storage tanks, Garfield and Rio Blanco Counties

VOC	10	lbs/barrel
Benzene	0.048	lbs/barrel
N-Hexane	0.14	lbs/barrel

Emissions:

Component	Well Emissions (tons/yr/well)	Project Emissions [a] (tons/yr)	per tank (g/s)
Total VOC	7.300	2423.600	
Benzene	0.035	11.633	1.008E-03
n-Hexane	0.102	33.930	2.940E-03
Total HAPS	0.137	45.564	

a Assumes total project development

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Project: Encana - Figure 4 Field Development EA

Central Dehydrator

GRI-GLYCalc VERSION 4.0 - EMISSIONS SUMMARY
Date: February 10, 2004

CONTROLLED REGENERATOR EMISSIONS			
Component	lbs/hr	lbs/day	tons/yr
Methane	0.7689	18.454	3.3678
Ethane	0.5522	13.252	2.4186
Propane	0.6367	15.281	2.7888
Isobutane	0.3509	8.422	1.5371
n-Butane	0.419	10.057	1.8354
Isopentane	0.2297	5.513	1.0061
n-Pentane	0.191	4.583	0.8364
n-Hexane	0.1164	2.793	0.5096
Cyclohexane	0.2788	6.69	1.2209
Other Hexanes	0.1772	4.253	0.7761
Heptanes	0.2724	6.539	1.1933
Methylcyclohexane	0.2845	6.829	1.2463
2,2,4-Trimethylpentane	0.0052	0.126	0.0229
Benzene	1.7834	42.802	7.8113
Toluene	0.9908	23.78	4.3399
Xylenes	0.2576	6.183	1.1284
C8+ Heavies	0.0017	0.041	0.0074
Total Emissions	7.3165	175.597	32.0464
Total Hydrocarbon Emissions	7.3165	175.597	32.0464
Total VOC Emissions	5.9954	143.89	26.26
Total HAP Emissions	3.1534	75.683	13.8121
Total BTEX Emissions	3.0319	72.765	13.2796

Total Project Annual Emissions Summary (tons/year)

	Project Phase		
Pollutant	**Development (tons/year)**	**Production (tons/year)**	**Maximum Annual (tons/year)**
NO_X	373.6	180.8	554.4
CO	101.7	144.3	246.0
VOC	12.8	2487.0	2499.8
SO_2	11.0	0.1	11.1
PM_{10}	475.1	81.6	556.7
$PM_{2.5}$	79.1	18.3	97.4
Benzene	0.0	19.7	19.7
Toluene	0.0	4.3	4.3
Ethylbenzene	0.0	0.0	0.0
Xylene	0.0	1.1	1.1
n-Hexane	0.0	35.4	35.4
Formaldehyde	0.1	12.4	12.5

Appendix F
Near-Field Cumulative Nox Sources

			Near-Field Cumulative NO_x Sources							
Source ID	**UTM e (m)**	**UTM n (m)**	**Elevation (m)**	**Distance From Figure Four Center (km)**	**Stack Height (m)**	**Temp (K)**	**Velocity (m/s)**	**Stack diameter (m)**	**Emissions (g/s)**	**Emissions (tons/yr)**
COP48	760875	4349098	1889	59.0	5.5	749.8	79.1	0.091	0.362	12.6
COP49	760875	4349098	1889	59.0	7.3	627.6	5.0	0.457	2.169	75.4
COP50	760875	4349098	1889	59.0	2.4	700.0	21.8	0.091	0.080	2.8
COP51	760875	4349098	1889	59.0	4.0	700.0	24.2	0.204	0.308	10.7
COP7	748093	4357210	1767	45.1	6.1	541.5	18.6	0.439	0.265	9.2
COP8	748093	4357210	1767	45.1	6.1	600.0	5.0	0.914	0.135	4.7
COP54	738407	4359476	1638	38.9	2.4	700.0	20.9	0.152	0.417	14.5
COP55	738407	4359476	1638	38.9	1.8	294.3	0.5	0.23	0.581	20.2
COP40	752882	4371954	1584	36.8	6.1	755.4	30.0	0.61	0.077	2.7
COP14	750441	4373835	1666	33.7	6.1	900.0	60.7	0.914	0.900	31.3
COP15	750441	4373835	1666	33.7	5.2	700.0	22.3	0.213	0.141	4.9
COP16	750441	4373835	1666	33.7	5.2	727.6	46.9	0.305	0.293	10.2
COP17	750441	4373835	1666	33.7	5.0	700.0	60.7	0.4	0.334	11.6
COP18	750441	4373835	1666	33.7	6.7	730.4	58.4	0.305	0.636	22.1
COP9	749595	4374326	1666	32.8	12.2	449.8	15.5	1.006	0.129	4.5
COP23	747815	4375388	1705	30.7	10.7	523.2	19.1	0.439	0.777	27.0
COP24	747815	4375388	1705	30.7	106.7	523.2	19.1	0.439	0.388	13.5
COP25	747815	4375388	1705	30.7	10.7	497.0	9.1	0.439	0.561	19.5
COP26	747815	4375388	1705	30.7	10.7	730.4	101.8	0.204	0.555	19.3
COP27	747815	4375388	1705	30.7	4.6	533.2	120.9	0.152	0.181	6.3
COP11	748817	4375426	1777	31.4	6.7	522.0	14.1	0.335	0.483	16.8
COP20	759062	4375447	1645	39.7	6.1	900.0	40.0	0.914	0.302	10.5
COP19	758671	4375452	1647	39.4	2.4	500.0	36.4	0.122	1.102	38.3
COP28	712936	4376645	2029	22.8	6.7	500.9	13.5	0.335	0.734	25.5
COP12	765988	4378561	1646	44.5	6.4	900.0	47.8	0.311	1.407	48.9
COP13	765988	4378561	1646	44.5	6.4	730.4	49.7	0.305	0.702	24.4
COP10	766399	4378596	1651	44.9	7.6	541.5	13.5	0.427	1.292	44.9
COP2	769558	4378980	1643	47.7	2.4	900.0	24.2	0.128	0.860	29.9
COP4	768777	4380712	1706	46.3	1.8	505.4	1.4	0.305	1.047	36.4
COP34	771584	4380889	1645	48.9	8.5	738.7	46.7	0.305	0.702	24.4
COP35	771584	4380889	1645	48.9	1.8	294.3	0.5	0.23	0.072	2.5

			Near-Field Cumulative NO_x Sources							
Source ID	**UTM e (m)**	**UTM n (m)**	**Elevation (m)**	**Distance From Figure Four Center (km)**	**Stack Height (m)**	**Temp (K)**	**Velocity (m/s)**	**Stack diameter (m)**	**Emissions (g/s)**	**Emissions (tons/yr)**
COP36	771584	4380889	1645	48.9	3.7	700.0	25.9	0.152	1.033	35.9
COP5	756452	4394825	2552	31.4	5.8	727.6	33.8	0.396	0.564	19.6
COP6	756452	4394825	2552	31.4	2.7	900.0	51.8	0.305	0.564	19.6
COP108	732151	4398370	2245	7.5	3.7	790.9	59.0	0.116	0.575	20.0
2002CO1	686861	4409043	2062	40.3	6.1	422.0	5.0	0.914	0.009	0.3
2002CO2	686861	4409043	2062	40.3	6.1	422.0	5.0	0.914	0.018	0.6
2002CO3	686861	4409043	2062	40.3	6.1	422.0	5.0	0.914	0.003	0.1
COP105	678386	4413645	2068	49.9	5.0	700.0	30.0	0.4	0.066	2.3
COP106	683603	4414746	2012	45.5	6.1	500.0	15.0	0.3	0.058	2.0
COP83	675328	4416723	1950	53.9	4.6	922.0	54.6	0.253	0.368	12.8
COP92	730925	4419851	1919	24.6	6.1	710.9	34.7	0.311	0.270	9.4
COP93	730925	4419851	1919	24.6	4.0	755.0	30.0	0.3	0.092	3.2
COP94	729000	4420493	1950	24.8	6.1	900.0	40.0	0.914	0.946	32.9
COP95	739003	4420530	2255	28.2	6.1	500.0	1.0	0.914	0.184	6.4
COP96	739003	4420530	2255	28.2	9.1	4219.8	1.7	0.305	0.754	26.2
COP97	739003	4420530	2255	28.2	9.1	900.0	46.1	0.305	3.768	131.0
COP98	739003	4420530	2255	28.2	9.1	700.0	31.7	0.305	0.762	26.5
COP99	739003	4420530	2255	28.2	5.0	700.0	30.0	0.4	0.762	26.5
COP86	742405	4421192	2255	30.6	7.6	734.8	49.4	0.305	1.145	39.8
COP80	725067	4425034	2011	29.0	6.1	600.0	5.0	0.914	0.929	32.3
COP87	719273	4425300	1981	29.9	22.9	560.9	0.2	1.387	0.371	12.9
COP88	719273	4425300	1981	29.9	29.0	366.5	0.2	1.679	0.112	3.9
COP85	728307	4426509	2011	30.7	6.1	780.9	229.2	0.229	0.213	7.4
COP91	753556	4434143	1889	47.6	6.1	738.7	49.5	0.244	0.230	8.0
COP107	752250	4436351	1889	48.7	2.4	900.0	39.9	0.101	0.538	18.7
COP81	738550	4443324	1800	49.2	4.3	855.4	26.4	0.354	0.155	5.4
COP82	738550	4443324	1800	49.2	6.4	563.7	5.8	0.335	0.187	6.5
COP100	738394	4443716	1812	49.5	7.3	866.5	44.6	0.341	0.972	33.8
COP101	738394	4443716	1812	49.5	7.3	727.6	48.3	0.305	0.604	21.0
COP102	738394	4443716	1812	49.5	8.2	477.6	1.3	0.762	0.774	26.9
COP103	738394	4443716	1812	49.5	7.3	616.5	3.3	7.102	0.076	2.7
COP104	738394	4443716	1812	49.5	6.1	755.4	19.9	1.868	0.035	1.2
Total										1,221

		Reasonably Foreseeable Development NO_x Sources								
Source ID	UTM e (m)	UTM n (m)	Elevation (m)	Distance From Figure Four Center (km)	Stack Height (m)	Temp (K)	Velocity (m/s)	Stack diameter (m)	Emissions (g/s)	Emissions (tons/yr)
RPT1	753346	4373120	1634	36.4	6.1	755.4	30.0	0.914	3.855	134.0
RPT2	747772	4375989	1910	30.3	6.1	755.4	30.0	0.914	3.855	134.0
RPT3	750576	4375956	2282	32.5	6.1	755.4	30.0	0.914	3.855	134.0
RPT4	753379	4375924	2260	34.7	6.1	755.4	30.0	0.914	3.855	134.0
RPT5	756183	4375891	1767	37.1	6.1	755.4	30.0	0.914	3.855	134.0
RPT6	758986	4375858	1671	39.5	6.1	755.4	30.0	0.914	3.855	134.0
RPT7	747805	4378793	2403	28.5	6.1	755.4	30.0	0.914	3.855	134.0
RPT8	750608	4378760	2448	30.8	6.1	755.4	30.0	0.914	3.855	134.0
RPT9	753412	4378727	2551	33.2	6.1	755.4	30.0	0.914	3.855	134.0
RPT10	756215	4378695	2111	35.7	6.1	755.4	30.0	0.914	3.855	134.0
RPT11	759019	4378662	2384	38.1	6.1	755.4	30.0	0.914	3.855	134.0
RPT12	761823	4378629	1864	40.7	6.1	755.4	30.0	0.914	3.855	134.0
RPT13	764626	4378597	1668	43.2	6.1	755.4	30.0	0.914	3.855	134.0
RPT14	767430	4378564	1706	45.8	6.1	755.4	30.0	0.914	3.855	134.0
RPT15	747837	4381596	2103	27.0	6.1	755.4	30.0	0.914	3.855	134.0
RPT16	750641	4381564	2521	29.4	6.1	755.4	30.0	0.914	3.855	134.0
RPT17	753444	4381531	2530	31.9	6.1	755.4	30.0	0.914	3.855	134.0

		Reasonably Foreseeable Development NO_x Sources								
Source ID	UTM e (m)	UTM n (m)	Elevation (m)	Distance From Figure Four Center (km)	Stack Height (m)	Temp (K)	Velocity (m/s)	Stack diameter (m)	Emissions (g/s)	Emissions (tons/yr)
RPT18	756248	4381498	2510	34.4	6.1	755.4	30.0	0.914	3.855	134.0
RPT19	759052	4381466	2635	37.0	6.1	755.4	30.0	0.914	3.855	134.0
RPT20	761855	4381433	2300	39.6	6.1	755.4	30.0	0.914	3.855	134.0
RPT21	764659	4381401	1886	42.2	6.1	755.4	30.0	0.914	3.855	134.0
RPT22	767463	4381368	1767	44.9	6.1	755.4	30.0	0.914	3.855	134.0
RPT23	770267	4381335	1731	47.5	6.1	755.4	30.0	0.914	3.855	134.0
RPT24	773071	4381303	1658	50.2	6.1	755.4	30.0	0.914	3.855	134.0
RPT25	747870	4384400	2007	25.6	6.1	755.4	30.0	0.914	3.855	134.0
RPT26	750673	4384367	2454	28.1	6.1	755.4	30.0	0.914	3.855	134.0
RPT27	753477	4384335	2427	30.7	6.1	755.4	30.0	0.914	3.855	134.0
RPT28	756281	4384302	2489	33.4	6.1	755.4	30.0	0.914	3.855	134.0
RPT29	759084	4384269	2621	36.0	6.1	755.4	30.0	0.914	3.855	134.0
RPT30	761888	4384237	2575	38.7	6.1	755.4	30.0	0.914	3.855	134.0
RPT31	764692	4384204	2763	41.4	6.1	755.4	30.0	0.914	3.855	134.0
RPT32	767495	4384172	2134	44.1	6.1	755.4	30.0	0.914	3.855	134.0
RPT33	770299	4384139	1839	46.8	6.1	755.4	30.0	0.914	3.855	134.0
RPT34	773103	4384107	1775	49.5	6.1	755.4	30.0	0.914	3.855	134.0
RPT35	77590	4384074	1697	52.2	6.1	755.4	30.0	0.914	3.855	134.0

		Reasonably Foreseeable Development NO_x Sources								
Source ID	**UTM e (m)**	**UTM n (m)**	**Elevation (m)**	**Distance From Figure Four Center (km)**	**Stack Height (m)**	**Temp (K)**	**Velocity (m/s)**	**Stack diameter (m)**	**Emissions (g/s)**	**Emissions (tons/yr)**
	7									
RPT36	747902	4387203	1981	24.5	6.1	755.4	30.0	0.914	3.855	134.0
RPT37	750706	4387171	2383	27.1	6.1	755.4	30.0	0.914	3.855	134.0
RPT38	753509	4387138	2438	29.8	6.1	755.4	30.0	0.914	3.855	134.0
RPT39	756313	4387106	2596	32.5	6.1	755.4	30.0	0.914	3.855	134.0
RPT40	759117	4387073	2673	35.2	6.1	755.4	30.0	0.914	3.855	134.0
RPT41	761920	4387041	2736	37.9	6.1	755.4	30.0	0.914	3.855	134.0
RPT42	764724	4387008	2741	40.7	6.1	755.4	30.0	0.914	3.855	134.0
RPT43	767528	4386976	2219	43.4	6.1	755.4	30.0	0.914	3.855	134.0
RPT44	770332	4386943	2015	46.2	6.1	755.4	30.0	0.914	3.855	134.0
RPT45	773136	4386911	1846	48.9	6.1	755.4	30.0	0.914	3.855	134.0
RPT46	775940	4386878	1706	51.7	6.1	755.4	30.0	0.914	3.855	134.0
RPT47	747935	4390006	2260	23.7	6.1	755.4	30.0	0.914	3.855	134.0
RPT48	750738	4389974	2377	26.4	6.1	755.4	30.0	0.914	3.855	134.0
Total										6432.0