2.0 TECHNICAL APPROACH

2.1 Overview of Assessment Approach

The CALPUFF modeling system was used for this study to estimate potential impacts on near-field and far-field air quality and far-field AQRVs that would result from air pollutant emissions associated with base year (2002) emissions. The CALPUFF modeling domain for the PRB Coal Review was established to be identical to that used in the PRB Oil and Gas Final EIS (BLM 2003) analysis (**Figure 2-1**). Near-field receptor locations from that analyses were used to identify the maximum estimated concentrations that would result from operation of existing facilities. Receptors also were located along the boundaries and within each of the Class I areas and specified Class II areas of concern within the modeling domain (e.g., national parks and monuments, wilderness areas, the Northern Cheyenne Indian Reservation, the Wind River Reservation, and the Crow Indian Reservation). In general, it is expected that the same receptor sets used in the PRB Oil and Gas Final EIS analysis were used for far-field analysis, including the mandatory Class I areas, tribal-designated Class I areas, and Class II areas of concern. Since that project was completed, the NPS has prepared standardized receptor sets for all Class I areas, to be used in performing such air quality modeling analyses. For Class I areas that were not in the PRB Oil and Gas EIS (BLM 2003) ENSR contacted the appropriate federal land managers and obtained the updated receptor sets. Other Class II areas and sensitive lake receptors were obtained from Digital Elevation Model (DEM) files available electronically from U.S. Geological Survey (USGS).

This section provides a detailed description of the use of the CALPUFF model, the input data, and the receptors used in modeling. It also describes the overall approach for providing model results for the existing development-related activities in the study area.

2.2 Air Quality Modeling Protocol

An air quality modeling analysis was conducted for this study to assess potential impacts on ambient air quality and AQRVs in the modeling domain from existing sources in the study area. The CALPUFF modeling system (Scire et al. 1999a) recommended by the Interagency Workgroup on Air Quality Modeling (IWAQM) was used as the basis of the modeling analysis for both near and far-field impact assessments. The CALPUFF modeling system is recommended for a refined modeling analysis (as opposed to a screening-type analysis) to address the air quality impacts of pollution transported over relatively long distances (USEPA 1998).

The CALPUFF modeling system has three main components:

- CALMET (a diagnostic three-dimensional meteorological model);
- CALPUFF (the transport and dispersion mode); and
- CALPOST (a post-processing package).

The CALPUFF modeling system is designed to:

- Treat time-varying point and area sources;
- Model domains from tens of meters to hundreds of kilometers from a source;
- Predict results for averaging times ranging from 1 hour to 1 year;
- Be applied to inert pollutants and those subject to linear removal and chemical conversion mechanisms; and
- Be applied to rough or complex terrain situations.

CALPUFF is a lagrangian puff model with the capability to simulate regional-scale, long-range dispersion as well as local-scale, short-range dispersion (Scire et al. 1999a). The CALPUFF model was used to predict direct concentrations that result from specific sources.

The modeling domain for the current study is identical to that used in the CALMET/CALPUFF modeling conducted for the PRB Oil and Gas Final EIS, which is an area covering most of Wyoming, southeastern Montana, southwestern North Dakota, western South Dakota, and northwestern Nebraska. The study uses the same modeling domain in the interest of efficiency and consistency. The modeling domain is defined in the Lambert Conformal Projection (LCP) grid system as follows:

- Central reference LCP point (longitude, latitude) = (-105.0°, 44.0°);
- Standard latitude parallels at 30° and 60°; and
- Grid origin offset from central reference point = (-350 kilometer [km], -250 km).

The modeling domain (**Figure 2-1**) for the near-field impact assessment extends at least 50 km in all directions beyond the boundaries of the PRB Coal Review study area and beyond the Class I and sensitive Class II receptors of interest, as recommended by FLAG (2000). Near-field receptor locations were arranged to obtain the maximum estimated concentrations that result from the sources identified in the Task 2 Report for the PRB Coal Review, Past and Present and Reasonably Foreseeable Development (ENSR 2005a). These receptor locations are in areas with high emission density, with additional receptors in populated areas (e.g., where populations exceed 200 or more) within the near-field modeling domain. The near-field receptor grid initially is spaced at 1-km intervals. The elevation of each receptor was obtained by using Digital Elevation Model data for the 1:250,000 quads with 90-meter horizontal resolution (USGS 2000a).

Receptors also were located along the boundaries and within each of the following Class I areas and specified Class II areas of concern within the modeling domain:

- Badlands National Park (Class I, NPS);
- Wind Cave National Park (Class I, NPS);
- Bridger Wilderness Area (WA) (Class I, USFS);
- Fitzpatrick WA (Class I, USFS);
- Washakie WA (Class I, USFS);

- North Abasaroka WA (Class I, USFS);
- Northern Cheyenne Indian Reservation (Class I, Northern Cheyenne Tribal Council);
- Devils Tower National Monument (Class II, NPS);
- Mount Rushmore National Memorial (Class II, NPS);
- Jewel Cave National Monument (Class II, NPS);
- Agate Fossil Beds National Monument (Class II, NPS),
- Fort Laramie National Historic Site (Class II, NPS),
- Black Elk WA (Class II, USFS);
- Soldier Creek WA (Class II, USFS);
- Cloud Peak WA (Class II, USFS);
- Yellowstone National Park (Class I, NPS);
- Grand Teton National Park (Class I, NPS);
- Teton WA (Class I, USFS);
- Absaroka-Beartooth WA (Class II, USFS)
- Bighorn Canyon National Recreation Area (Class II, NPS);
- Popo Agie WA (Class II, USFS);
- Wind River Indian Reservation (Class II, Shoshone and Arapaho Joint Tribal Business Council);
- Crow Indian Reservation (Class II, Crow Tribal Council); and
- Theodore Roosevelt National Park (Class I, NPS).

The following areas are near the edge of the modeling domain. Modeled impacts at receptors within these areas near the edge of the modeling domain might be associated with model inaccuracies and uncertainties due to edge effects. Therefore, estimates of potential impacts to these areas near the edge of the modeling domain were made by placing representative receptors no nearer than 25 km from the edge of the modeling domain:

- Bob Marshall WA;
- Gates of the Mountains WA;
- Lee Metcalf WA, Spanish Peaks Unit;
- Lee Metcalf WA, Taylor Hillgard Unit;
- Red Rock Lakes WA;
- Jedediah Smith WA;
- Mount Naomi WA;
- Wellsville Mountain WA;
- U.L. Bend WA;
- Fort Peck Indian Reservation;
- Scapegoat WA; and
- Fort Belknap Indian Reservation.

The locations of these sensitive receptor areas as well as other sensitive areas within the modeling domain are shown in **Figure 2-2**. The receptors were defined with sufficient density to assure that maximum potential air quality impacts are evaluated (i.e., at 1-km intervals along the boundaries of the Class I areas, specified Class II areas of concern, at specified sensitive lake locations, and with a 2-km grid with the Class I areas and specified Class II areas of concern). As noted previously, the

Class I areas and sensitive receptor areas were identified in the modeling protocol and reviewed by the appropriate federal land managers, to confirm that the existing receptor sets for these areas are acceptable for this project.

In order to be able to evaluate impacts due to a specific source group or groups, the air quality modeling program for the current project was designed so that contributions from various source group(s) could be readily separated from cumulative impacts due to all modeled sources. The modeling evaluated a series of separate emissions source groups representing base year (2002) emissions.

Boundary conditions (e.g., the influx of air contaminants at the edges of the modeling domain from sources outside the domain) were handled using the same methodology as was used for the PRB Oil and Gas Final EIS. Specifically, nothing is advected in from the outside, and initial concentrations at the beginning of the run are assumed to be zero.

2.3 Model Input Data

The modeling effort used a single model (i.e., CALPUFF) to evaluate impacts and changes in impacts to air quality and AQRVs resulting from development-related activity in the PRB study area. The air quality analyses assessed impacts from coal mining, other coal-related activity, and other development activities for the base year (2002).

2.3.1 Emissions Inventory Data Overview

The base year (2002) emissions were estimated by using appropriate USEPA emission factors, equations, data, and MDEQ and WDEQ databases. Emissions from sources within the study area were based on available guidance from the WDEQ and MDEQ.

The emissions scenarios represent a key component of conducting the air quality analyses. The base year emissions scenarios were developed for sources in the Wyoming and Montana PRB study area. Although the study will be used as a basis for comparing foreseeable development in the PRB, this report focuses on the base year (2002) impacts only.

A base year emissions database representative of 2002 operations was prepared. Specific data were collected from WDEQ and MDEQ files for air permits and approved air permit applications from active sources. A full scenario of actual emissions from all source groups to be modeled for the base year was prepared and provided for review by the stakeholders. Comments or suggestions from the stakeholders were evaluated and considered by the BLM and reflected in the final emissions inventory database before the air quality modeling was initiated.

2.3.2 Construction-related Emissions

Estimates of construction-related emissions focused on emissions of particulate matter with aerodynamic diameters equal to or less than 10 microns (PM_{10}). Fugitive particulate matter emissions from the construction of facilities and roads were computed on the basis of USEPA emission factors for construction activity, along with WDEQ approaches for estimating emissions. Emissions of road dust generated from construction vehicles were estimated using the USEPA

unpaved road emission factor equation (USEPA 2003) and anticipated volume of project traffic. Fugitive dust emissions from construction equipment and vehicles were computed by using applicable USEPA emission factors (USEPA 2003) and estimated usage levels of construction equipment and vehicles. Construction site emissions were treated as area sources. Exhaust emissions and road dust emissions also were treated similarly. Vehicle traffic emissions from secondary population growth are not included in this analysis[4].

2.3.3 Operational Emissions

For the operational phase, emissions of criteria pollutants (NO_2, SO_2, and PM_{10}), and HAPs were estimated for compressors (including booster compressors, field compressors, and pipeline compressors), other equipment, road traffic, and road-maintenance activities. Emission estimates for HAPs were made for benzene, n-hexane, toluene, ethylbenzene, xylene, and formaldehyde.

Emission rates were computed on the basis of the emission factors and the anticipated level of operational activities (load factors and hours of operation per year). For far-field impact analysis modeling, similar emissions from individual stacks at a given facility were aggregated into emissions from a single stack.

Emissions of road dust from vehicles traveling on access roads were estimated using the USEPA unpaved road emission factor equation (USEPA 2003) and anticipated volume of project traffic. Fugitive dust emissions from access road maintenance activities were estimated on the basis of the USEPA emissions for construction activity (USEPA 2003) and the anticipated level of road maintenance activity.

2.3.4 Meteorological Data

Hourly three-dimensional meteorological data fields for 1996 recently were developed for the project domain, using Version V of CALMET (Scire et al. 1999b), a diagnostic meteorological model (ENVIRON International Corporation [EIC] 2000). The meteorological database with local wind variations at a 5 by 5-km resolution, which was developed for the Final EIS, Dakota, Minnesota, and Eastern Railroad PRB Expansion Project (Surface Transportation Board 2001) and employed in the PRB Oil and Gas Final EIS (BLM 2003), were used without modification as input to the CALPUFF model for the PRB Coal Review.

CALMET, one of the three main components of the CALPUFF modeling system, includes a diagnostic wind model that combines surface and upper-air meteorological data with diagnostic effects of terrain and other factors in order to generate three-dimensional wind fields (Scire et al. 1999b). It also includes other interpolation algorithms that generate three-dimensional temperature, pressure, and other meteorological variables, and two-dimensional precipitation fields. For areas with complex terrain and sparse wind observations, a diagnostic wind model cannot accurately depict the complex flow fields by using surface observation data alone. In those situations, CALMET defines the synoptic-scale flow features by using the output from a coarse grid (80-km) resolution simulation of a prognostic meteorological model (e.g., Penn State/NCAR MM5) and then better characterizes the local wind variations at a finer scale (e.g., 5 km) by using its diagnostic wind

[4] Work done by the Western Regional Air Partnership on fugitive road dust emissions modeling was reviewed and acknowledged where it may be applicable to the PRB Coal Review modeling. For current (2002) emissions, estimates provided by the WDEQ and MDEQ were employed.

algorithms and local surface observations. The detailed meteorological database for the project domain was developed using surface meteorological data as shown in **Figure 2-3**, and precipitation data as shown in **Figure 2-4**. Terrain and land use data from the USGS also were used (USGS 2000a,b).

Table 2-1 presents the user-defined parameters that define the CALMET domain and the weighting values used in developing the CALMET fields.

Wind roses at two elevations (10 meter [m] and 60 m) were prepared for several locations within the study area on the basis of hourly CALMET V output described above.

Figure 2-3 shows the surface weather status employed in the CALMET analysis, and **Figure 2-4** shows the weather station with precipitation data used in the CALMET modeling.

2.3.5 Ambient Air Quality and AQRV Data

The existing ambient air quality levels, visibility, wet nitrogen and sulfur deposition, and lake chemistry parameters in and around the study area are described in several recently published EISs for proposed activities in the modeling domain (e.g., BLM 1999; EIC 2000). Additional data, representative of 2002, were collected and summarized. These background data are used in the current study as follows:

- Base year concentrations for criteria pollutants based on the most recent long-term (annual average) and short-term (24-hour and less) maximum (or highest second-highest) concentrations consistent with applicable standards measured in the region were compared with predicted background concentrations and with ambient standards.

- Base year O_3 concentrations were used as input to the CALPUFF model based on WDEQ data collected at the TBNG and CASTNET sites and data collected at Centennial and Pinedale, Wyoming, and Theodore Roosevelt and Yellowstone National Parks. Background concentrations of particulate chemical species were combined with ambient and CALPUFF predicted chemical species concentrations for performing the sulfate (SO_4)/nitrate (NO_3)/ammonia (NH_3) equilibrium calculation needed to predict the secondary particulate concentration within CALPUFF[5].

- Base year levels of visibility and atmospheric deposition data were tabulated. The FLAG guidelines were used to judge the significance of predicted changes in visibility and atmospheric deposition.

The data selected for use in the PRB cumulative analysis are described in the following sections. Additional data on ambient air quality, visibility, and atmospheric deposition that have become available since the preparation of the recently published EISs was obtained and evaluated. ENSR looked at all available emissions inventories, including TRC Mariah's recently completed emissions inventory for Wyoming and the BLM's NH_3 inventory. Valid new data were included in defining the background ambient air quality and AQRV levels for this analysis.

[5] It is important to note that CALPUFF requires background levels of O_3, NH_3, and particulate in order to estimate secondary pollutant formation and visibility impacts. Providing the model with such values does not result in double-counting of emissions.

Table 2-1
CALMET User-defined Fields not Specified in IWAQM Appendix A

Variable	Description	Value
NX	Number of east-west grid cells	210
NY	Number of north-south grid cells	180
DGRIDKM	Meteorology grid spacing (km)	4
NZ	Number of vertical layers of input meteorology	8
ZFACE	Vertical cell face heights (m)	0, 20, 50, 100, 250, 500, 750, 1000, 3000
IEXTRP	Extrapolation of surface winds to upper layers	1
RMAX1	Maximum surface over-land extrapolation radius (km)	20
RMAX2	Maximum aloft over-land extrapolation radius (km)	50
RMAX3	Maximum over-water extrapolation radius (km)	500
TERRAD	Radius of influence of terrain features (km)	10
R1	Relative weight at surface of Step 1 field and observations	10
R2	Relative weight aloft of Step 1 field and observations	25
IPROG	Gridded initial prognostic wind field – MM5 data	14
RMIN	Minimum radius of influence for wind field interpolation	0.1
IKINE	Accounts for forced leinematic effects	Off

Ambient concentrations of criteria pollutants monitored within the modeling domain used to define background air quality levels are listed in **Table 2-2**. For the base year (2002), the analysis compares modeled concentrations to monitored data. The WDEQ and stakeholders have been consulted regarding these proposed background levels for this study. The data in **Table 2-2** were provided by the WDEQ.

Table 2-2
Air Pollutant Background Concentration
(µg/m^3)

Pollutant/Averaging Time	Measured Background Concentration	Data Source
CO 1-hour 8-hour	 3,336 1,381	Data collected by Amoco at Ryckman Creel for an 8-month period during 1978-1979, summarized in the Riley Ridge EIS (BLM 1983)
NO_2 Annual	 5	Data collected at TBNG, Campbell County, Wyoming, Year 2002 (WDEQ)
O_3 1-hour 8-hour	 167 140	Data collected at TBNG, Campbell County, Wyoming, Years 2001-2003 (8-hour); 2002 (1-hour) (WDEQ)
PM_{10} 24-hour Annual	 54 13	Data collected by AMAX Coal at the Eagle Butte Mine, Campbell County, Wyoming, Year 2002
SO_2 3-hour 24-hour Annual	 181 62 13	Data collected by Black Hills Power at Wygen 2, Campbell County, Wyoming, 2002

Note: µg/m^3 = micrograms per cubic meter.

2.3.6 Chemical Species

For use in the empirical chemical transformation algorithm of the CALPUFF model, the regional background O_3 concentration value is needed as an input to the model. A representative value for the regional background O_3 was estimated by examining the annual average O_3 value for monitoring sites within (or very close to) the modeling domain. CASTNET sites examined included O_3 monitoring sites at Yellowstone National Park, Pinedale, Wyoming, Centennial, Wyoming, and Theodore Roosevelt National Park. Data from the WDEQ's O_3 monitoring site at TBNG and other WDEQ O_3 monitoring sites, as available, were used in developing an annual background O_3 value for use in the model[6].

Chemical species data for ambient aerosol were determined by analyzing particulate matter samples collected at two IMPROVE monitoring sites in the vicinity of the modeling domain, located near Badlands National Park and Bridger WA and at the WDEQ-operated site at the TBNG. Particulate matter mass concentration data reconstructed from the speciated particulate matter data at the two monitoring sites were processed to generate monthly average particulate matter speciation profiles (EIC 2000). The Badlands, Bridger, Cloud Peak, and North Absaroka IMPROVE data were used to define the background concentrations of particulate SO_4, nitrate, and ammonium for those sensitive receptor areas located, respectively, east and west of the eastern boundary of the study area (**Figure 2-1**). The aerosol monitoring sites to be used for this purpose are listed in **Table 2-3**.

Table 2-3
IMPROVE Protocol Aerosol Monitoring Sites to be Used in Determining Background Monthly Average Particulate Matter Speciation Profiles

Site	Site Name	State	Elevation (above mean sea level)	Latitude	Longitude	Start Date
BADL1	Badlands	South Dakota	736	43.7435	-101.9412	March 2, 1988
BRID1	Bridger	Wyoming	2607	42.9749	-109.7570	March 2, 1988
CLPE1	Cloud Peak	Wyoming	2469	44.3335	-106.9565	February 2001
NOAB1	North Absaroka	Wyoming	2480	44.7488	-108.3817	January 29, 2000
NOCH1	Northern Cheyenne	Montana	1332	45.6493	-106.5573	Summer 2002
THBA	Thunder Basin	Wyoming	1193	44.6634	-105.2874	May 2001
WICA	Wind Cave	South Dakota	1300	43.5577	-103.4838	January 20, 2000
YELL2	Yellowstone	Wyoming	2425	44.5653	-110.4002	July 1, 1996

In addition to the chemical species data for airborne particulate matter, background concentration data for gaseous free NH_3 and nitric acid also were required. Where there were no measurements of gaseous NH_3 or nitric acid, values of 5 and 0.5 parts per billion (ppb), respectively, were used in

[6] Because a recompiled version of CALMET that uses MM5 fields without actual upper air observations was used, CALPUFF is constrained to a version compatible with this version of CALMET. This version of CALPUFF does not allow the use of monthly or seasonal background ozone, only a single representative value for the entire domain and modeling period.

the analysis for this study, as was used in the previous CALPUFF modeling analyses, in order to provide conservative estimates[7].

2.3.7 Visibility

The FLAG guidance has established a recommended procedure for identifying and evaluating potential visibility impairment primarily in mandatory federal Class I Areas (FLAG 2000). According to the FLAG procedure, predicted changes in visibility in terms of percent change in extinction (or change in deciview [dv]; a 10 percent change in extinction corresponds to 1.0 dv) due to emissions from proposed sources was computed, and compared to estimated seasonal natural background reference visibility levels, and the resulting percent change in extinction (or change in dv) was compared with FLAG-prescribed threshold levels for impact assessment. Estimated natural background visibility reference levels and associated parameter values, including site-specific, seasonal relative humidity adjustment factors, as recommended by FLAG are provided in **Table 2-4** for the Class I and Class II areas of concern (FLAG 2000) located within the PRB study modeling domain.

2.3.8 Lake Chemistry

Atmospheric deposition impacts were assessed by comparing predicted annual total atmospheric deposition fluxes to sensitive lakes in terms of acid neutralizing capacity (ANC) with the limits of acceptable change (LAC) threshold based on USFS-recommended prediction methods (USFS 2000). These lakes include:

- Black Joe Lake, Class I Bridger WA
- Deep Lake, Class I Bridger WA
- Hobbs Lake, Class I Bridger WA
- Upper Frozen Lake, Class I Bridger WA
- Florence Lake, Class II Cloud Peak WA
- Emerald Lake, Class II Cloud Peak WA
- Ross Lake, Class I Fitzpatrick WA
- Lower Saddlebag Lake, Class II Popo Agie WA

2.4 Air Quality Modeling and Post-processing

The air quality modeling analysis described above was performed by using the model input data to assess potential impacts on ambient air quality and AQRVs (visibility and atmospheric deposition) resulting from the background and the development scenarios of the PRB Coal Review.

The air quality modeling analysis used the actual annual emission rates for the PRB sources and long-term (estimated actual) emission estimates for the other sources. The IWAQM recommended

[7] The BLM has a NH_3 inventory that was distributed to agency stakeholders for review. While the NH_3 inventory provides a comprehensive county-by-county assessment of NH_3 emissions, it does not provide estimates of background NH_3 concentrations, so data from this inventory were not useable as background for CALPUFF input.

Table 2-4
Estimated Natural Background Visibility Reference Levels

Mandatory Federal Class I Area	Season[1]	Hygroscopic (Mm^{-1})	Non-hygroscopic (Mm^{-1})	Reyleigh (Mm^{-1})	f(RH)[2]	Particle b_{ext} with f(RH) (Mm^{-1})	Reference Level (Mm^{-1})
Badlands WA	Winter	0.6	4.5	10.0	3.1	6.4	16.4
	Spring	0.6	4.5	10.0	2.6	6.1	16.1
	Summer	0.6	4.5	10.0	2.2	5.8	15.8
	Fall	0.6	4.5	10.0	2.8	6.2	16.2
Bridger WA	Winter	0.6	4.5	10.0	2.9	6.2	16.2
	Spring	0.6	4.5	10.0	1.9	5.6	15.6
	Summer	0.6	4.5	10.0	1.5	5.4	15.4
	Fall	0.6	4.5	10.0	2.4	5.9	15.9
Fitzpatrick WA	Winter	0.6	4.5	10.0	2.9	6.2	16.2
	Spring	0.6	4.5	10.0	1.9	5.7	15.7
	Summer	0.6	4.5	10.0	1.5	5.4	15.4
	Fall	0.6	4.5	10.0	2.4	6.0	16.0
North Absaroka WA[3]	Winter	0.6	4.5	10.0	2.9	6.2	16.2
	Spring	0.6	4.5	10.0	2.1	5.8	15.8
	Summer	0.6	4.5	10.0	1.7	5.5	15.5
	Fall	0.6	4.5	10.0	2.5	6.0	16.0
Washakie WA	Winter	0.6	4.5	10.0	2.8	6.2	16.2
	Spring	0.6	4.5	10.0	2.0	5.7	15.7
	Summer	0.6	4.5	10.0	1.6	5.5	15.5
	Fall	0.6	4.5	10.0	2.5	6.0	16.0
National Park[4]	Winter	0.6	4.5	10.0	2.9	6.2	16.2
	Spring	0.6	4.5	10.0	2.5	6.0	16.0
	Summer	0.6	4.5	10.0	2.1	5.7	15.7
	Fall	0.6	4.5	10.0	2.6	6.1	16.1

[1] Winter: December, January, and February; Spring: March, April, and May; Summer: June, July, and August; Fall: September, October, and November.
[2] Site-specific, seasonal relative humidity (RH) adjustment factor for hygroscopic aerosols.
[3] Values also assumed to be representative of the re-designated Class I Northern Cheyenne Reservation, the Class II Bighorn Canyon National Recreational Area, and the Class II Cloud Peak WA.
[4] Values also assumed to be representative of the Class II Agate Fossil Beds, Devils Tower, and Jewel Cave national monuments, the Class II Black Elk and Soldier Creek WAs, the Class II Fort Laramie National Historic Site, and the Class II Mount Rushmore National Memorial.

Note: b_{ext} = instinction coefficient for visibility
Hygroscopic = moisture absorbing
Non-hygroscopic = less moisture absorbing
Reyleigh = molecular scattering of light
Mm = inverse megameters (10^{-6} meters)

default settings were used when they are consistent with the current version of CALPUFF. Thus, the default dry and wet deposition algorithms was used. In addition, the following CALPUFF options also were selected:

- Turbulence-based dispersion (based on similarity theory) [8];
- Transitional plume rise;
- Stack tip downwash;

[8] While previous CALPUFF modeling (for air permitting purposes) has employed Pasquill-Gifford (P-G) methodology, the turbulence-based dispersion method is better than the P-G method at alleviating under predictions in the near-field from tall stacks in simple terrain. Furthermore, because this analysis will constitute a planning tool, and not a construction permit application, technical accuracy is preferred over consistency with previous methodology.

- Transition of horizontal dispersion to time-dependent (Heffter) growth rates;
- Building downwash effects; and
- Chemical transformation based on RIVAD/ARM3 scheme, which treats the nitric oxide and NO_2 conversion processes in addition to the NO_2 to total NO_3 and SO_2 to SO_4 conversions with equilibrium between gaseous nitric acid and ammonium nitrate aerosol.

Other CALPUFF model options and assumptions on background concentrations of chemical species to be used in the current study were based on those used in the PRB Oil and Gas Final EIS (BLM 2003) modeling study. For example, the ambient ratio method, which assumes a conversion rate of 75 percent, was used for the NO_X to NO_2 conversion rate, according to USEPA guidance (40 Code of Federal Regulations 51, Appendix W).

Concentrations of SO_2, NO_2, PM_{10}, sulfur and nitrogen deposition, as well as visibility impairment (aerosol light extinction) were predicted at selected receptor locations described above Concentrations of HAPs (e.g., formaldehyde) due to the identified sources also were predicted at near field receptors described above.

NO_X would be a major component of the emissions in the region. CALPUFF simulates the oxidation of NO_X to nitrate and calculates the equilibrium between SO_4, nitrate, and NH_3 to determine how much of the converted NO_X is particulate nitrate and how much is gaseous nitric acid. The latest version of CALPUFF allows the background concentrations of pollutants such as SO_4 and nitrate (representing contributions due to existing sources) to be input to the model so that the contributions of background concentrations of these species to the overall cumulative impacts were included. For base year modeling, the predicted impacts are compared to the monitored data within the region.

The outputs from the modeling program are hourly values of direct concentrations, which are processed to compute 3-hour, 24-hour, and annual average direct concentration predictions. Visibility and deposition estimates were calculated for daily values, and annual total sulfur and nitrogen deposition flux increments are derived from the daily values.