APPENDIX K.

AIR RESOURCES IMPACT ASSESSMENT TECHNICAL REPORT FOR THE ALTON COAL LEASE BY APPLICATION DRAFT ENVIRONMENTAL IMPACT STATEMENT

AIR RESOURCES IMPACT ASSESSMENT TECHNICAL REPORT FOR THE ALTON COAL LEASE BY APPLICATION

DRAFT ENVIRONMENTAL IMPACT STATEMENT

Prepared for

Bureau of Land Management
Kanab Field Office
Kanab, Utah

Bureau of Land Management
Utah State Office
Salt Lake City, Utah

Prepared by

Marquez Environmental Services, Inc.
Golden, Colorado

September 2010

In coordination with

SWCA Environmental Consultants
Salt Lake City, Utah

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SWCA Project 12033

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ABBREVIATIONS

ACD	Alton Coal Development, L.L.C.
ANC	Acid neutralizing capacity
AQRV	Air quality related value
ARS	Air resource specialists
BACT	Best achievable control technology
BLM	Bureau of Land Management
CFR	Code of Federal Regulations
CO	Carbon monoxide
DAT	Deposition analysis threshold
Dv	Deciview
EIS	Environmental impact statement
EPA	Environmental Protection Agency
FLAG	Federal Land Managers' Air Quality Related Values Workgroup
FLM	Federal land managers
HAP	Hazardous air pollutant
HNO_3	Nitric acid
IDLH	Immediately Dangerous to Life or Health
IWAQM	Interagency Workgroup on Air Quality Modeling
kg/ha/yr	Kilograms per hectare per year
LAC	Level of acceptable change
LBA	Lease by Application
LNCM	Lands necessary to conduct mining
LOP	Life of project
MEI	Maximally exposed individual
MEQ	Microequivalents per liter

MLA	Mineral Leasing Act of 1920
MLE	Most likely exposure
N	Nitrogen
NAAQS	National ambient air quality standards
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NO_2	Nitrogen dioxide
NO_3	Nitrate
NO_x	Oxides of nitrogen
NH_4	Ammonia
NSR	New Source Review
OSM	Office of Surface Mining Reclamation and Enforcement
O_3	Ozone
PAP	Permit application package
PM_{10}	Particulate matter less than or equal to a nominal 10 microns in aerodynamic size
$PM_{2.5}$	Particulate matter less than or equal to a nominal 2.5 microns in aerodynamic size
ppb	Parts per billion
Protocol	Air resources impact assessment protocol
PSD	Prevention of significant deterioration
QA/QC	Quality assurance/quality control
REL	Reference exposure level
RfC	Reference concentrations for chronic inhalation
RFD	Reasonably foreseeable development
RFFA	Reasonably foreseeable future actions
RMP	Resource management plan
S	Sulfur
SO_2	Sulfur dioxide

SO_4	Sulfate
TSP	Total suspended particulate
UAAQS	Utah ambient air quality standards
UDNR-DOGM	Utah Department of Natural Resources – Division of Oil, Gas, and Mining
$\mu g/m^3$	Micrograms per cubic meter
URF	Unit risk factor
USGS	U.S. Geological Survey
VOC	Volatile organic compound

1 INTRODUCTION

Marquez Environmental Services, Inc. (MESI) has prepared this Air Resources Impact Assessment Technical Report to quantify potential air resource impacts from mining operations on and related to the Alton Coal Lease by Application Tract (the Alton Coal Tract or tract). The analysis provided herein was performed in accordance with the Air Resources Impact Assessment Protocol (Protocol) prepared by SWCA Environmental Consultants (SWCA) in partnership with MESI, with exceptions and justifications for changes noted herein. The methodologies in the protocol were provided prior to study initiation to ensure that the approach, input data, and computation methods are acceptable to the Bureau of Land Management (BLM). Air resource stakeholders had the opportunity to review the Protocol and provide input before the study was initiated. The tract location in southwestern Utah requires the examination of mining and cumulative source impacts within the proposed air resources modeling domain shown on Map 1.1 from emission sources in southwestern Utah (all maps are contained in Appendix A).

The analysis was based on a conceptual mine design and a set of planned and known mitigation strategies. The analysis is intended to be conservative to accommodate foreseeable emissions under a various mining scenarios. A detailed mine plan has not yet been developed. An approved detailed mine plan would be subject to state permitting requirements and would be subject to appropriate dispersion modeling at that time, as well as detailed operation and mitigation strategies.

The modeling domain was dimensioned in accordance with guidance provided by an interagency air resources stakeholder group. The modeling area covers nearly 40 million acres of land including sensitive areas such as Bryce Canyon National Park, Capitol Reef National Park, Great Basin National Park, Grand Canyon National Park, and Zion National Park, and various other public lands surrounding the tract (see Map 1.1). The air impact assessment used the EPA's recommended guideline model, AERMOD, to analyze potential near-field impacts of mining operations on the tract on ambient levels of criteria pollutants near the Alton Coal Tract. In addition to the near-field analysis, potential impacts from mining operations on the tract on air quality related values (AQRV) at more distant, sensitive locations were analyzed. This far-field modeling analysis used the CALMET/CALPUFF modeling systems.

1.1 Work Tasks

The air resources analysis addressed the impacts to ambient air quality and AQRVs from (1) potential air emissions from coal mining on the tract; (2) potential air emissions from transporting mined coal from the mine site to the reasonably foreseeable loadout location (see Map 1.5); and (3) air emissions from other documented regional emission sources in the modeling domain (cumulative air resource impacts). Ambient air quality impacts were quantified and compared to applicable state and federal standards, and AQRV impacts (impacts on visibility [regional haze], acid deposition, and potential increases in acidification to acid sensitive lakes) were quantified and compared to applicable thresholds as defined in the Federal Land Managers' (FLMs') Air Quality Related Values Workgroup (FLAG), IWAQM guidance documents (FLAG 2000; IWAQM 1998), and other state and federal agency guidance. Carbon dioxide emissions resulting from mining and transporting coal and from coal combustion were estimated and are included in the EIS greenhouse gas analysis. Impact assessment criteria are discussed further in Section 5.0.

The assessment of impacts included completion of the following tasks:

- Generate emission inventories for mining operations on the tract and coal haul transportation operations on the reasonably foreseeable coal haul transportation route (see Section 2.0);
- Compile a regional emission inventory including specified permitted sources, reasonably foreseeable development (RFD), and reasonably foreseeable future actions (RFFA) (see Section 2.0);
- Assess near-field ambient impacts from emissions resulting from mining operations on the tract and coal haul transportation operations on the reasonably foreseeable coal haul transportation route (see Sections 3.0 and 5.0);
- Assess far-field ambient direct and cumulative impacts including pollutant concentration, visibility and acid deposition impacts at Class I areas and at selected Class II areas within the modeling domain (see Sections 4.0 and 5.0);
- Estimate carbon dioxide emissions resulting from mining and transporting coal, and coal combustion.

2 EMISSION INVENTORY

The project emission inventory considered emissions of oxides of nitrogen (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter less a nominal 10 micrometers in aerodynamic diameter (PM_{10}), particulate matter less a nominal 2.5 micrometers in aerodynamic diameter ($PM_{2.5}$), volatile organic compounds (VOCs), hazardous air pollutants (HAPs) (i.e., acetaldehyde, acrolein, benzene, formaldehyde, toluene, and xylenes for generators), and carbon dioxide (CO_2). Emission estimates were compiled for mining and related operations and for other existing and reasonably foreseeable future sources.

Although it is recognized that secondarily formed $PM_{2.5}$ and ozone emissions will be generated, only primary pollutant emissions were included as part of the emissions inventory. The $NO_{x,,}$ SO_x, and VOC gases emitted have the potential to secondarily form $PM_{2.5}$ particles. $PM_{2.5}$ formation from these precursors is highly uncertain, and varies both regionally and seasonally due to atmospheric conditions. Typically, emission inventory calculations lead to higher values than those derived from receptor models, and there is no consensus on differences in $PM_{2.5}$ emission estimates from re-entrained dust (FHA, 2010). Ozone formed secondarily from photochemical reactions occurs away from a source and is therefore, not regarded as a near field pollutant.

The pollutants considered in the impacts analysis are discussed in Sections 3.0 and 4.0. Results of the mining emission inventory are included in Appendix B.

2.1 Project Emissions

Emissions from construction activities and coal production activities were considered as project emissions. Primary sources are related either to fuel use in internal combustion engines or to dust emitted into the air from various sources. Both of these sources are described in detail below. For coal production emissions the maximum development year was considered as representative of all years of mining. This approach results in a more conservative estimate of yearly emissions and a more conservative analysis. However, most years of mining would result in fewer emissions than the maximum development year.

2.1.1 *Construction Emissions*

The initial construction activities would include development of the access road, site preparation for the fixed facilities (e.g., crushers, conveyors, generators, office and maintenance buildings, etc.), development of the main haul road, delivery of materials and equipment to the mine, and other construction vehicle activity. Because detailed construction plans have not been developed, the construction emission inventory focused exclusively on particulate matter. The total suspended particulate (TSP) emission factor for heavy-construction operations from Section 13.2.3 of *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Areas Sources* (AP-42) (EPA 2008) is E = 1.2 tons/acre/month. Based on the emission factors for unpaved roads (AP-42, Section 13.2.2), the PM_{10} emission factor is 30% of the TSP factor, and the $PM_{2.5}$ emission factor is 10% of the PM_{10} factor. For the purpose of this inventory, it was assumed that 36 acres would be disturbed by construction activities. Six acres would be disturbed each month for six months. For a copy of AP-42 Sections 13.2.2, Unpaved Roads, and 13.2.3, see Appendix C.

2.1.2 *Production Emissions*

Sources of pollutant emissions during coal production include particulate matter emissions and fuel-combustion emissions. Both surface and underground mining were considered. For surface mining, both a 200-foot and 300-foot overburden thickness was evaluated for Alternatives B and C. Emissions were calculated for 24 hours per day, 7 days per week, 52 weeks per year. The total number of operating days per year was assumed to be 365.

Particulate matter emissions from surface mining (fugitive dust) can come from

- topsoil loading, unloading, and hauling (two options: scrapers or front-end loader and trucks);
- overburden blasting, overburden truck loading, unloading, and hauling;
- coal loading, unloading, hauling, crushing, screening, conveying, and storage;
- vehicle traffic on improved and unimproved gravel or dirt roads as well as paved roads;
- wind erosion of disturbed areas;
- train loading;
- bulldozer and front-end loading activities; and
- underground mining operations.

Emissions were calculated for 200-foot and 300-foot overburden removal thickness for Alternatives B and C. Dust mitigation measures such as watering and chemical spraying were considered in the emissions inventory. The fugitive dust emission factors for particulate sources were taken from AP-42 Sections 13.2.1 and 13.2.2 as well as Section 11.9 – Western Surface Coal Mining (see Appendix C) (EPA 2008). Use of these emission factors requires detailed specifications for production activities and equation variables. Because no detailed mine plan has been developed, a list of assumptions was established for the reasonable maximum year of mining activities. These assumptions are provided in tabular form in Appendix B along with the results of the emission inventory. On-road motor vehicle emissions for employee vehicles and haul trucks were calculated using Utah Department of Environmental Quality, Division of Air Quality (DAQ) mobile source emission factors.

Particulate emissions from underground mining were estimated for additional coal handling, loading, and hauling. Because no detailed conceptual underground mining plan exists, it is assumed that the auger mining method would be used. The auger mining assumption is conservative. Other methods could be used, but auger mining would probably result in the most coal dust emissions. Coal haul trucks and coal loading for the underground operations were assumed to be the same as the surface mining operations. The train loading emission factor from AP-42 11.9-4 was used to estimate emissions from coal dumping from two highwall miners.

Fuel-combustion emissions (NO_x, SO_2, CO, PM_{10}, $PM_{2.5}$, VOCs, HAPs, and CO_2) can come from generators and vehicles. Generating capacity requirements for the surface mining operations were assumed to be 2,000 kW, and the underground mining operations were assumed to require an additional 3,000 kW of power. New Source Performance Standards (NSPS) required by 40 CFR 60 Subpart IIII were applied to the generators; however, the regulation requires the use of Tier 4 emission standards developed by the Environmental Protection Agency (EPA 2004) for nonroad diesel engines. The Tier 4 standards were used for the generators and the nonroad diesel engines. Use of ultra-low-sulfur diesel fuel for vehicles and generators was also considered in the inventory. Vehicle and generator emission factors were derived from the above referenced rules as well as manufacturer information for specific vehicles and equipment that match the assumptions in Appendix B.

From a modeling perspective and in line with the logistics of auger or highwall mining, the generators would be located outside the underground workings.

On-road vehicles would include coal haul trucks (see Appendix B) and employee vehicles. The coal haul trucks would travel 110 miles each way. The average employee would travel 30 miles each way. On-road motor vehicle emissions were calculated using the Utah Division of Environmental Quality (UDEQ) 2005 mobile source (Mobile 6) emission factors for Kane County. These data were the most recent available. The Mobile 6 sulfur dioxide emission factors were adjusted to account for a more restrictive gasoline sulfur standard than was assumed in the state's analysis. The Mobile 6 data did not include emission factors for HAPs.

2.2 Cumulative Emission Inventory

The cumulative emission inventory is composed of 1) an inventory of the currently planned coal haul transportation route emissions; and 2) an inventory of proposed emission sources within a 300 × 300–km area (see Map 1.1). The cumulative inventory includes the identification/evaluation of permitted source changes (increases or decreases), RFFA, and RFD. A summary of the cumulative emission inventory is presented in Appendix D.

2.2.1 *Existing Source Modifications Inventory/Reasonably Foreseeable Future Actions Inventory*

It is assumed that all existing permitted emission sources are included in the background concentrations estimates presented in Table 3.1. There will be some reasonable emission variations over time for these sources. Unless information obtained from the state(s) shows that a source went through a permit modification, the emission changes are assumed to be part of expected variation and are not included in the inventory of changed or added sources.

As such, the emission inventory was developed for Title V major modifications and new minor or major source permits that occurred after September 1, 2008. The data were obtained from the state air quality regulators (e.g., Utah, Nevada, and Arizona) within the emission inventory domain shown in Map 1.1.

2.2.2 *Reasonable Future Development Sources*

RFD sources are proposed sources and include new sources expected from BLM- and USFS-related activity such as oil and gas development and mining. Oil and gas commissions in the various states and other state agencies also provided information on planned new emission-producing sources. Due to the uncertainty in projected traffic increases on the existing road network, only project related transportation increases were considered. RFFA and RFD data sources are listed in Table 2.1.

Table 2.1. Sources of Information for Potential Reasonably Foreseeable Future Actions and Reasonably Foreseeable Development in the Modeling domain

NEPA Documents, Land Use Plans, and Personnel	Disposition	Notes	Reference
Oil and Gas Leasing on Lands Administered by the Dixie National Forest DEIS	Dixie and Fishlake NF oil field development are included as point sources in cumulative modeling. Tables in Appendix D (see Tables for Dixie Point Sources, Volume Sources, and Area Sources; Fishlake Point Sources, Volume Sources, and Area Sources).		USFS 2008.
BLM Kanab Field Office RMP	90 new production wells over 20 years (4.5 wells per year); no production or drilling of coalbed methane wells; no oil wells.	In addition to Oil and Gas, the following sources are included in the Kanab report:	BLM 2006.
BLM Kanab Field Office Mineral Potential Report	**Use highest projected pollutant emissions for oil and gas + area sources listed below; incorporate as an area source (2631 acres ~4 square miles=total area disturbed by new wildcat drilling, O and G development wells, and seismic data in KPA); Tables in Appendix D.**	Coal Mining: the projected mine is Alton	BLM 2006.
	- Will include Lands and Realty, Livestock grazing, off-hwy vehicles, resource roads, saleable minerals, vegetation	Lands and Realty, Livestock Grazing: small area source, Off highway vehicles	
	- Eliminated coal mining (projected mine is Alton)	Resource Roads, Saleable Minerals, Vegetation	
	- Eliminated prescribed burning because it is intermittent and regulated such that it occurs during favorable met conditions.	Prescribed burns: 103,000 cumulative acres	
	See Kanab Tables in Appendix D		

Table 2.1. Sources of Information for Potential Reasonably Foreseeable Future Actions and Reasonably Foreseeable Development in the Modeling domain

NEPA Documents, Land Use Plans, and Personnel	Disposition	Notes	Reference
BLM Richfield Field Office RMP	Oil Well and non- oil well activities, Alt A and B have the same emissions; 30 wells per year; Disturbance area not available so ratioed from Kanab - 6X as big as Kanab.	In addition to Oil and Gas, the following sources are included in the Richfield report:	BLM 2008b.
	Use highest projected pollutant emissions for oil and gas + area sources listed below; incorporate as an area source (24 square miles); Tables in Appendix D.	Coal: Appears these are the coal mines north of I70 that are not in our domain	
	- Will include Lands and Realty, Livestock grazing, off-hwy vehicles, resource roads, saleable minerals, vegetation	Lands and Realty, Livestock Grazing: small area source, Off highway vehicles	
	- Eliminated coal mining (outside domain)	Resource Roads, Saleable Minerals, Vegetation	
	See Richfield Tables in Appendix D		
BLM Cedar City Field Office Personnel	No sources to add: Geothermal activity is not included for the following reasons: Emissions from geothermal are from short term drilling. Area has been developed for geothermal so activity is a continuation of an on-going development pattern, therefore should be considered part of baseline.	Four new geothermal wells annually in Sulfurdale Area	BLM 2009.
BLM St. George Field Office Personnel	No sources to add	Kanab data and Utah DEQ (St George turbines) represent activity in this area. Lorraine Christian did not provide additional data.	BLM 2009a.
BLM Ely Field Office	No sources to add	No contact; very edge of domain; narrow eastern part of Nevada; indications from other Nevada research indicate there is little if any activity in this area; therefore this was not pursued further.	
BLM Las Vegas Field Office	No sources to add	Lisa Christiansen did not provide additional data.	BLM 2009a.
BLM Arizona Strip Field Office	No sources to add: EIS for the Arizona Strip did not consider Air Quality	Lorraine Christian did not provide additional data.	BLM 2007; 2009b.
Utah DEQ: Permit Actions	Two new gas turbines at St George City Power; Table attached (see Utah Tab)	Stack height and diameter estimated; other stack parameters available	UDAQ 2009.

Table 2.1. Sources of Information for Potential Reasonably Foreseeable Future Actions and Reasonably Foreseeable Development in the Modeling domain

NEPA Documents, Land Use Plans, and Personnel	Disposition	Notes	Reference
Arizona DEQ: Permit Actions	EPA PSD permit: Modification to Navajo Generating Station carbon monoxide increase 36,750 TPY, NOx decrease 22,386 TPY; Three emission units: each 775 feet tall, 34.75 feet in diameter, 122 deg F, exhaust, 2,130,000 ACFM, 106 ft/sec; Coordinates of the center stack are: UTM Zone 12, 465346 E, 4084322 N. no new Title V sources	AZ DEQ did not provide additional data.	EPA 2009; ADEQ 2009.
Nevada DEQ: Permit Actions	No sources to add	Have list of Mesquite/Bunkerville sources; Clark City sources existed prior to cut-off date; no new sources in Lincoln City portion of domain; Toquop Energy Project is outside domain.	CCN 2009; NDEP 2009.
Utah DOT	No Sources to add	Studies are primarily for the northern corridors. Exceptions: St George Dixie Drive Interchange EA had a Finding of No Significant Impact (8/25/2009). The project is not expected to have air quality impacts.	

3 CRITERIA POLLUTANT NEAR-FIELD MODELING

Near-field analysis, as used here, means the airshed within a 50 × 50–km area with the Alton Coal Tract in the center. Near-field analysis was conducted to assess impacts to public health and welfare and to estimate potential impacts to lakes and viewsheds in nearby (near-field) national parks.

To disclose the environmental consequences of the development of the Alton Coal Lease, a detailed analysis of the potential near-field impacts of the applicable pollutants was required. In particular, a near-field ambient air quality impact assessment was performed to quantify maximum-modeled pollutant impacts near the tract. To demonstrate that air quality–related standards and parameters are protected requires the development of short-term (hourly and daily) and long-term emission rates of regulated pollutants, application of regulatory-approved models to quantify predicted concentrations, and a comparison of predicted impacts plus applicable background concentrations (RFD/RFFA sources) with applicable standards.

The EPA's guideline model, AERMOD (version 09292), was the refined air dispersion model used to assess these near-field impacts and to verify compliance with the applicable NAAQS in the ambient airshed that encloses the Alton Coal Lease Tract. As development of the lease spans a 19–23-year window with varying degrees of surface disturbance and associated air emissions, the modeling analysis focused on the reasonable maximum development year (therefore, the reasonable maximum emission year) for the mine. Using this anticipated maximum potential emission year, the AERMOD dispersion model was used to analyze potential near-field impacts from direct emissions of PM_{10}, $PM_{2.5}$, nitrogen dioxide (NO_2), carbon monoxide, and sulfur dioxide. Regulatory changes to the NAAQS NO_2 and SO_2 standards occurred during the project analysis. Due to the timing of these regulatory changes in relation to the project analysis, assessment of the new 1-hour NO_2 and SO_2 standards was not incorporated in the draft EIS. Photochemical conversion of NO_x and VOCs to O_3 and the secondary formation of $PM_{2.5}$ concentrations from NO_x and SO_2 emissions were not included in the analysis. These chemical reactions are not considered to be near-field impacts, and they cannot be simulated with the recommended near-field model (AERMOD).

For each modeled pollutant, a significant impact analysis was conducted to help assess the areal extent of the potential impact of emissions associated with the development of the Alton Coal Lease Tract. The AERMOD predicted concentrations were used to verify compliance/non-compliance with the applicable NAAQS, Class II PSD increments, and other standards deemed applicable such as visibility parameters defined by the FLAG. The analysis considered existing regional sources using background ambient pollutant concentrations and RFD sources. An inventory of representative background pollutant concentrations was compiled from the involved agencies (e.g., UDAQ and BLM) to represent cumulative near-field impacts from the existing regional sources surrounding the proposed tract (see Table 3.1). In addition, a proposed inventory of RFD sources was incorporated into the final cumulative dispersion modeling analysis. The following paragraphs outline our proposed approach in detail.

3.1 Modeling Methodology

The most recent version of the EPA-promulgated AERMOD dispersion model (version 09292) was used for this analysis. AERMOD was run in regulatory default mode and deposition was only considered for assessing the final PM_{10} modeled ambient air impacts. Deposition was not considered for any other pollutants, including $PM_{2.5}$. The BEEST (Oris Solutions, version 9.82a) graphical modeling interface was used to set up the near-field modeling runs, including the source layout of the overburden removal areas, coal pits, reclamation area, facilities area, and onsite road layouts. However, for the final cumulative near-field model runs it was necessary to utilize the BEEST generated input files and run AERMOD on machines equipped with multi-core processors to complete all of the runs. The same source locations in the near-field analysis were incorporated into the far-field CALPUFF modeling. Base elevations for all sources associated with the Alton Coal Tract were determined using the AERMAP terrain processor. Thus, for consistency, the modeled receptor grid and modeled mine source elevations were determined using the same method by utilizing the seamless National Elevation Data (NED) terrain files downloaded from the USGS as derived from satellite data.

Appropriate surface characteristics representative of the terrain surrounding the surface meteorological station, Cedar City, were provided by Mr. Dave Prey of UDAQ (UDAQ 2009) as part of the AERMOD-ready dataset. No changes were made to any of the meteorological files provided by UDAQ. Given the expansive nature of the surface-mining operations that may occur on the Alton Coal Tract, building downwash was not a factor in determining reasonable maximum development year potential impacts at the lands necessary to conduct mining (LNCM) boundaries (for Maximum Development Year Layout see Map 1.6).

3.1.1 *Receptors*

As part of this near-field modeling analysis, a defined Cartesian receptor grid and reasonable estimate of the proposed facility boundary was established to ascertain the potential impacts in publicly accessible areas surrounding the Alton Coal Tract. Receptors were placed along the proposed LNCM boundary. Because the primary pollutants of concern are fugitive dust, including PM_{10} and $PM_{2.5}$, maximum impacts from the proposed mining sources would be along or near the LNCM boundary. Nested receptor grids were used beyond the fence line, centered on the Alton Coal Tract LNCM. A fine grid using 100-m spacing was used out to 1 km from the LNCM boundary, and a coarse grid using 500-m spacing was employed from 1 km out to 10 km from the applicable LNCM. Finally, an outer grid with 1,000-m spacing from 10 km out to 25 km and 2,500-m spacing out to 50km was used. Individual discrete receptors were placed within each Class I area and selected Class II area. Specifically, receptors from the NPS website were used for modeling potential impacts at Class I areas. Furthermore, additional receptors with 500-m spacing were placed along the western boundary of the Bryce Canyon National Park, as this is the closest aspect to the Alton Coal Tract of all of the Class I areas of concern.

Receptors were placed along the SR-136 road, which will have to be relocated during the lifetime of the mine and will still be open to public use. This road will run through the tract and will remain at least 100 feet from the right-of-way (ROW). Modeled receptors were placed at 100-m intervals along the proposed relocated road in the tract and extend up to the intersection with Main Street in the Town of Alton. Potential receptors along the road were assumed to be a minimum of 25 m from the edge of the road.

Receptor elevations were determined utilizing the seamless National Elevation Data (NED) terrain files downloaded from the USGS website. Terrain data were processed with the AERMAP terrain processor utilizing the NED files in GeoTIFF format as required in the most recent version of AERMAP. This processor assigns an actual satellite-derived elevation to each receptor.

3.1.2 *Meteorological Data*

Based on correspondence with Mr. David Prey of the UDAQ, the surface meteorological data most representative for this site are from Cedar City, Utah (UDAQ 2008). These surface data were processed with upper air data collected at Desert Rock, Nevada, which is the closest upper air station to Cedar City. For this near-field analysis, a four-year meteorological dataset (from 2005–2008) was utilized. These data were processed by the air group at UDAQ and received via email in August of 2009 (UDAQ 2009). No additional processing had to be completed and the data were model-ready for use in AERMOD.

The AERMET system uses both surface and upper air measurements to estimate profiles of wind, turbulence, and temperature in the planetary boundary layer. Minimum meteorological data requirements to run AERMET generally include horizontal wind speed, horizontal wind direction, ambient temperature, surface characteristics (albedo, Bowen ratio, and surface roughness), solar radiation and temperature change with height or cloud cover, and a morning upper air sounding. The surface characteristics determinations were made by UDAQ as part of their processing of the four-year meteorological dataset. These surface characteristics are representative of the area around Cedar City, the surface meteorological station. A representative windrose from Cedar City (Figure 3.1) indicates that prevailing winds are from the south-southwest. A distinct bimodal trend is not apparent at this location.

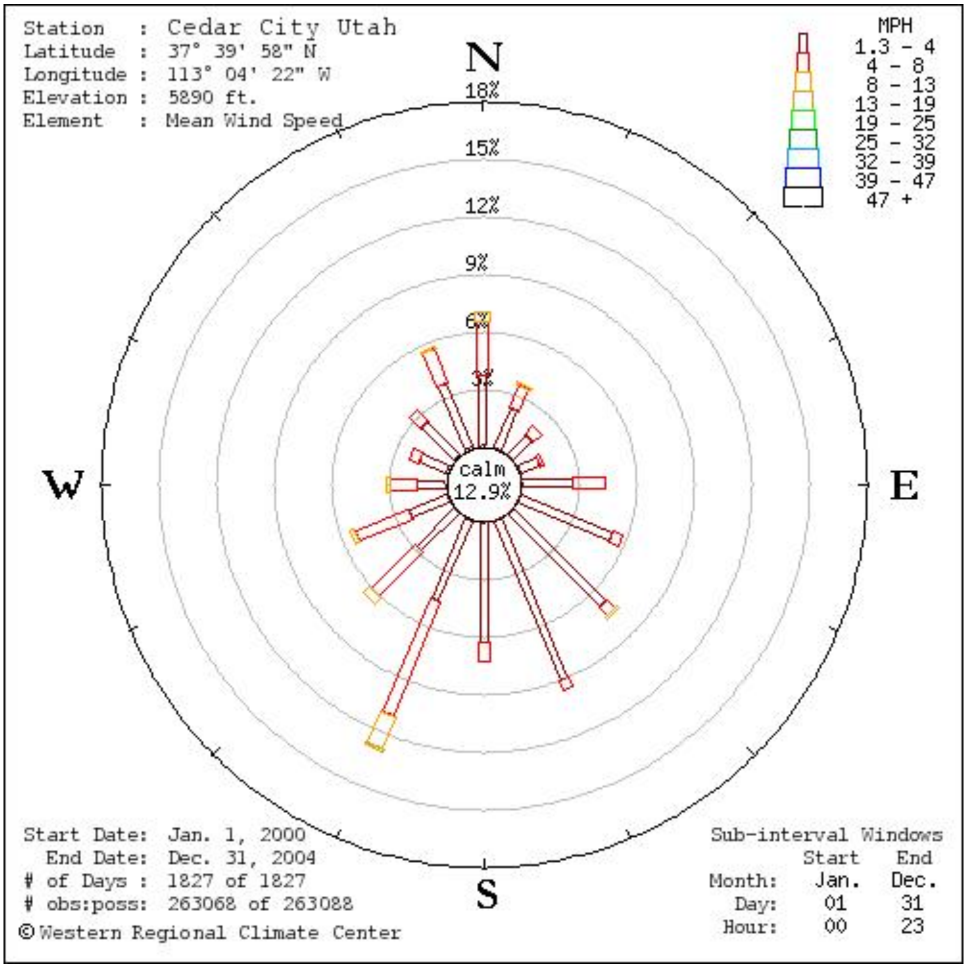


Figure 3.1. Windrose generated from Cedar City meteorological data.

3.1.3 *Alton Coal Lease Emission Inventory*

The proposed emission inventory development for the reasonable maximum development year of mining operations on the Alton Coal Tract is provided in Chapter 2 and Appendix B. Based on proposed development projections, the model year chosen for the emission inventory is the reasonable maximum development year of mine progression. It is anticipated that the maximum development year would occur near the end of overall mine development. However, the reasonable maximum development year of mine progression is intended to be representative of the potential emissions associated with any single year of mining.

Because the exact location of fugitive dust and tailpipe emissions from project traffic and coal removal is impossible to pinpoint, a series of area or volume sources was used to estimate emissions from these sources. The total annual fugitive dust and tailpipe emissions were apportioned equally to be representative of area sources in the tract. Travel distances were based on the assumptions in the inventory development. For the purpose of modeling the coal loading and overburden removal activities areas, the open pit source option in AERMOD was utilized, given that both of these activities will occur well below grade in the main pit.

It was anticipated that some blasting will occur as part of the overburden and coal removal process. These emissions represent short-term sources of nitrogen oxides and PM_{10} that were modeled as area sources in this near-field analysis.

Electrical power generation for mining operations will be supplied through a combination of diesel generators as described in Section 2. The two generators were modeled as point sources at the anticipated location within the facilities area.

Base elevations for all sources associated with the Alton Coal Tract were determined using the AERMAP terrain processor. Thus, the modeled receptor grid and modeled mine source elevations were determined using the same method and most recent NED data available from the USGS website for consistency.

3.1.4 *Cumulative Sources (RFD, RFFA, and existing source modifications)*

The cumulative impacts modeling analysis considered both the maximum development year from the proposed Alton tract development sources as well as an inventory of proposed emission sources. These sources were described in Section 2. For the purpose of this analysis, it is assumed that all existing permitted emission sources are included in the background concentration estimates presented in Table 3.1.

For the near-field analysis, emissions from hauling coal along the circuitous route from the town of Alton to the rail loadout facility near Cedar City were not explicitly modeled, given the vast number of additional volumes sources that needed to be added to the model. Any impacts from the offsite coal haul road are remote and will not impact the modeled concentrations around the proposed Alton mine. However, the potential impacts from coal hauling on this long road were assessed by modeling an individual segment of road as a means of verifying that the coal haul truck traffic would not pose any NAAQS issues (see Section 3.1.6). Refer to Section 4.0 for a discussion of the planned coal haul transportation route and how it was handled in the far-field modeling.

Table 3.1. Near-field Analysis Background Ambient Air Quality Concentrations (µg/m^3)

Pollutant	Averaging Period	Measured Background Concentration
Carbon monoxide[1]	1-hour	1 ppm (1,150 µg/m^3)
	8-hour	1 ppm (1,150 µg/m^3)
NO_2[1]	Annual	17 µg/m^3
PM_{10}[2]	24-hour	72 µg/m^3
$PM_{2.5}$[3]	24-hour	8.6 µg/m^3
	Annual	3.6 µg/m^3
SO_2[1]	3-hour	20 µg/m^3
	24-hour	10 µg/m^3
	Annual	5 µg/m^3

[1] UDAQ 2008. Data based on estimates from the UDAQ.

[2] UDAQ 2010. PM_{10} data from UDAQ used for private Alton Mine.

[3] Measured $PM_{2.5}$ data obtained from NPS website for Bryce Canyon National Park.

3.1.5 *Criteria Pollutant NAAQS Analysis – AERMOD Results*

Background pollutant concentrations were used as an indicator of existing conditions in the region, and were assumed to include those from industrial emission sources in operation and from mobile, urban, biogenic, and other non-industrial emission sources. These background concentrations were added to modeled near-field mining–related impacts to calculate total ambient air quality impacts.

The primary pollutants of concern for this analysis are PM_{10}, $PM_{2.5}$, carbon monoxide, nitrogen dioxide, and sulfur dioxide. Model-predicted concentrations resulting from emissions due to mining operations on the tract were added to the currently acceptable background levels, and the resulting cumulative concentrations were compared to the relevant NAAQS to determine potential health impacts at nearby receptors. For this air resources assessment, modeled concentrations are compared to the PSD increments. These comparisons are made for informational purposes only, and the analyses described herein are not intended to be, nor should be interpreted as a regulatory increment consumption analysis. Modeled concentrations using the indicated averaging periods were compared to the following applicable thresholds.

Table 3.2. Applicable Ambient Air Quality Criteria

Pollutant	Averaging Period	NAAQS ($\mu g/m^3$)[1]	PSD Class II increment ($\mu g/m^3$)[2]
NO_2 [3]	Annual	100	25
PM_{10}	24-hour (highest fifth high)	150	30
$PM_{2.5}$	Annual	15	N/A
	24-hour (average of highest 1st high)	35	N/A
CO	8-hour (highest second high)	10,000	N/A
	1-hour (highest second high)	40,000	N/A
SO_2 [3]	Annual	80	20
	24-hour (highest second high)	365	91
	3-hour (highest second high)	1,300	512

[1] National Ambient Air Quality Standards from 40 CFR Part 50

[2] PSD increments from 40 CFR Part 51.166

[3] The impacts assessment does not include the recently promulgated 1-hour NO2 and SO2 standards due to their promulgation dates.

Compliance with the respective annual standards was based on the highest modeled value for each year of the four-year meteorological dataset. Demonstration of compliance with the short-term NAAQS (24-hour, 8-hour, 3-hour, and 1-hour) for carbon monoxide, nitrogen dioxide, and sulfur dioxide was based on the highest second-high modeled concentration for each year of the four-year meteorological period, added to the respective background concentrations listed above. Per an EPA memo from March 23, 2010, *Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS*, compliance demonstrations with the 24-hour $PM_{2.5}$ standard can use the average of the first highest 24-hour concentration in each year over the length of the meteorological data period. This approach is a conservative surrogate for comparison to the highest second-high modeled concentration for each modeled year. Finally, compliance with the 24-hour PM_{10} standard was verified against the highest fifth-high modeled concentration over the 4-year period (as documented in EPA 40 CFR Part 51, Appendix W). Only four years of meteorological data were available for the modeling. Based on UDAQ recommendations, the highest fifth high concentration was used for the comparison to the NAAQS, rather than the highest sixth high associated with five years of meteorological data. All modeled concentrations were rounded to match the form of the appropriate NAAQS. A detailed description of the modeling results for each pollutant follows.

3.1.5.1 PM_{10} AERMOD RESULTS

The modeled PM_{10} concentrations associated with the maximum development year are summarized here. Both the 200-foot overburden and 300-foot overburden removal scenarios were modeled for compliance under each action alternative. Alternative B is based on the assumption that one primary pit would be used for the coal extraction, whereas Alternative C is based on the assumption that there would two pits used for the coal extraction. Results are presented in the tables below for the 24-hour highest fifth-high PM_{10} concentration over the four-year modeled dataset for both 200-foot and 300-foot scenarios.

Table 3.3. Highest Fifth-high PM_{10} Modeling Results

Pollutant	Modeled Years	Receptor Location		Modeled (μg/m³)	Background (μg/m³)	Total (μg/m³)	NAAQS (μg/m³)
200-foot Overburden Removal Scenario, Alternative B							
		UTME	UTMN				
PM_{10}	2005-2008	368000	4142900	82.7	72	150	150
200-foot Overburden Removal Scenario, Alternative C							
		UTME	UTMN				
PM_{10}	2005-2008	368000	4142900	83.6	72	160	150

Table 3.4. Highest Fifth-high PM_{10} Modeling Results

Pollutant	Modeled Years	Receptor Location		Modeled (μg/m³)	Background (μg/m³)	Total (μg/m³)	NAAQS (μg/m³)
300-foot Overburden Removal Scenario, Alternative B							
		UTME	UTMN				
PM_{10}	2005-2008	368000	4142900	86.3	72	160	150
300-foot Overburden Removal Scenario, Alternative C							
		UTME	UTMN				
PM_{10}	2005-2008	368000	4142900	92.9	72	160	150

The 200-foot overburden scenario under Alternative B complies with the NAAQS at all modeled receptors. However, under the dual pit Alternative C, there is a modeled exceedance off of the northwest side of the LNCM. Similarly, the 300-foot modeling results indicate modeled exceedances at a few receptors off of the northwest side of the LNCM.

3.1.5.2 $PM_{2.5}$ AERMOD RESULTS

Modeled $PM_{2.5}$ concentrations associated with the maximum development year are summarized here. Both the 200-foot overburden and 300-foot overburden removal scenarios were modeled for compliance under each action alternative. Alternative B is based on the assumption that one primary pit would be used for the coal extraction, whereas Alternative C is based on the assumption that there would be two pits used for the coal extraction. Model results in the tables below for the 24-hour averaging period indicate the highest first-high for each modeled year for both 200-foot and 300-foot scenarios. For comparison to the NAAQS, the average of the high first-high 24-hour values is compared to the standard of 35 µg/m³.

Table 3.5. $PM_{2.5}$ Modeling Results

200-foot Overburden Removal Scenario, Alternative B

Pollutant	Model Year	Average Period	Receptor Location UTME	Receptor Location UTMN	Modeled (µg/m³)	Background (µg/m³)	Total (µg/m³)	NAAQS (µg/m³)
$PM_{2.5}$	2005	24-hour	370466	4142644	17.2	8.6	26	35
		Annual	370466	4142644	4.2	3.6	8	15
	2006	24-hour	370466	4142644	21.0	8.6	30	35
		Annual	370466	4142644	4.4	3.6	8	15
	2007	24-hour	370466	4142644	17.3	8.6	26	35
		Annual	370466	4142644	4.7	3.6	8	15
	2008	24-hour	370466	4142644	21.8	8.6	30	35
		Annual	370466	4142644	4.2	3.6	8	15
	Average	24-hour			19.3	8.6	28	35

200-foot Overburden Removal Scenario, Alternative C

Pollutant	Model Year	Average Period	Receptor Location UTME	Receptor Location UTMN	Modeled (µg/m³)	Background (µg/m³)	Total (µg/m³)	NAAQS (µg/m³)
$PM_{2.5}$	2005	24-hour	370466	4142644	18.8	8.6	27	35
		Annual	370466	4142644	4.5	3.6	8	15
	2006	24-hour	370466	4142644	22.9	8.6	32	35
		Annual	370466	4142644	4.8	3.6	8	15
	2007	24-hour	370466	4142644	18.9	8.6	28	35
		Annual	370466	4142644	5.1	3.6	9	15
	2008	24-hour	370466	4142644	23.7	8.6	32	35
		Annual	370466	4142644	4.6	3.6	8	15
	Average	24-hour			21.1	8.6	30	35

Table 3.6. $PM_{2.5}$ Modeling Results

300-foot Overburden Removal Scenario, Alternative B

Pollutant	Model Year	Average Period	Receptor Location		Modeled (μg/m^3)	Background (μg/m^3)	Total (μg/m^3)	NAAQS (μg/m^3)
			UTME	UTMN				
$PM_{2.5}$	2005	24-hour	370494	4143467	21.5	8.6	30	35
		Annual	370478	4142741	5.0	3.6	9	15
	2006	24-hour	370465	4142595	23.8	8.6	32	35
		Annual	370470	4142741	5.5	3.6	9	15
	2007	24-hour	370470	4142741	20.4	8.6	29	35
		Annual	370470	4142741	6.0	3.6	10	15
	2008	24-hour	370600	4143660	25.1	8.6	34	35
		Annual	370470	4142741	5.8	3.6	9	15
	Average	24-hour			22.7	8.6	31	35

300-foot Overburden Removal Scenario, Alternative C

Pollutant	Model Year	Average Period	Receptor Location		Modeled (μg/m^3)	Background (μg/m^3)	Total (μg/m^3)	NAAQS (μg/m^3)
			UTME	UTMN				
$PM_{2.5}$	2005	24-hour	370494	4143467	23.3	8.6	32	35
		Annual	370478	4142741	5.4	3.6	9	15
	2006	24-hour	370465	4142595	25.7	8.6	34	35
		Annual	370470	4142741	6.0	3.6	10	15
	2007	24-hour	370470	4142741	22.1	8.6	31	35
		Annual	370470	4142741	6.5	3.6	10	15
	2008	24-hour	370600	4143660	27.0	8.6	36	35
		Annual	370470	4142741	6.2	3.6	10	15
	Average	24-hour			24.5	8.6	33	35

Both the 200-foot and 300-foot modeled concentrations comply with the NAAQS at all modeled receptors and for both action alternatives.

3.1.5.3 NITROGEN DIOXIDE AERMOD RESULTS

The modeled nitrogen dioxide concentrations associated with the maximum development year are summarized below in Table 3.7 and 3.8. Both the 200-foot overburden and 300-foot overburden removal scenarios were modeled for compliance. Because the estimated nitrogen oxide emissions for Alternative B and C are the same, separate model runs were not necessary within each of the overburden scenarios. A 75% ozone correction was applied to all annual nitrogen oxide modeling results in accordance with EPA's Ambient Ratio Method as a way to estimate ambient annual nitrogen dioxide concentrations from modeled nitrogen oxides emission rates. For comparison to the annual NAAQS, the highest annual concentration from each modeled year was compared to the standard of 100 µg/m^3.

Table 3.7. Annual Maximum Nitrogen Dioxide Modeling Results

200-foot Overburden Removal Scenario

Pollutant	Model Year	Receptor Location		Modeled (µg/m^3)	Background (µg/m^3)	Total (µg/m^3)	NAAQS (µg/m^3)
		UTME	UTMN				
NO_2	2005	370466	4142644	27.8	17	45	100
	2006	370466	4142644	29.6	17	47	
	2007	370466	4142644	31.6	17	49	
	2008	371610	4140400	30.2	17	47	

Table 3.8. Annual Maximum Nitrogen Dioxide Modeling Results

300-foot Overburden Removal Scenario

Pollutant	Model Year	Receptor Location		Modeled (µg/m^3)	Background (µg/m^3)	Total (µg/m^3)	NAAQS (µg/m^3)
		UTME	UTMN				
NO_2	2005	370473	4142837	83.9	17	101	100
	2006	370471	4142789	92.7	17	110	
	2007	370471	4142789	99.9	17	117	
	2008	370471	4142789	97.4	17	114	

The 200-foot modeled concentrations indicate compliance with the annual NAAQS at all modeled receptors. However, under the 300-foot overburden removal scenario, there are a few exceedances of the annual NAAQS along the northwest side of the LNCM just west of the primary pit activity area.

3.1.5.4 CARBON MONOXIDE AERMOD RESULTS

The modeled carbon monoxide concentrations associated with the maximum development year are summarized below. Both the 200-foot overburden and 300-foot overburden removal scenarios were modeled for compliance. Because the estimated carbon monoxide emissions for Alternative B and C are the same, separate model runs were not necessary within each of the overburden scenarios. The applicable averaging periods for comparison to the carbon monoxide NAAQS include the 1-hour and 8-hour averaging periods.

Table 3.9. Carbon Monoxide Modeling Results

200-foot Overburden Removal Scenario

Pollutant	Model Year	Average Period	Receptor Location		Modeled (μg/m^3)	Background (μg/m^3)	Total (μg/m^3)	NAAQS (μg/m^3)
			UTME	UTMN				
CO	2005	1-hour	370487	4143273	2,283	1,150	3,433	40,000
		8-hour	370471	4142789	582	1,150	1,732	10,000
	2006	1-hour	370484	4143176	2,567	1,150	3,717	40,000
		8-hour	370466	4142644	485	1,150	1,635	10,000
	2007	1-hour	370481	4143079	2,639	1,150	3,789	40,000
		8-hour	371610	4140400	519	1,150	1,669	10,000
	2008	1-hour	370479	4143031	2,416	1,150	3,566	40,000
		8-hour	370466	4142644	486	1,150	1,636	10,000

Table 3.10. Carbon Monoxide Modeling Results

300-foot Overburden Removal Scenario

Pollutant	Model Year	Average Period	Receptor Location		Modeled (μg/m^3)	Background (μg/m^3)	Total (μg/m^3)	NAAQS (μg/m^3)
			UTME	UTMN				
CO	2005	1-hour	370700	4143660	5,358	1,150	6,508	40,000
		8-hour	370474	4142789	1,383	1,150	2,533	10,000
	2006	1-hour	370700	4143660	5,643	1,150	6,793	40,000
		8-hour	370700	4143660	1,060	1,150	2,210	10,000
	2007	1-hour	370650	4143660	4,980	1,150	6,130	40,000
		8-hour	370473	4142837	1,047	1,150	2,197	10,000
	2008	1-hour	370650	4143660	5,249	1,150	6,399	40,000
		8-hour	370700	4143660	939	1,150	2,089	10,000

Both 200-foot and 300-foot modeled concentrations indicate compliance with the 1-hour and 8-hour NAAQS at all modeled receptors.

3.1.5.5 SULFUR DIOXIDE AERMOD RESULTS

The modeled sulfur dioxide concentrations associated with the maximum development year are summarized below. The potential sulfur dioxide emissions associated with the mining activities are nominal but modeling was still completed. Both the 200-foot overburden and 300-foot overburden removal scenarios were modeled for compliance. Because the estimated sulfur dioxide emissions for Alternative B and C are the same, separate model runs were not necessary within each of the overburden scenarios. The applicable averaging periods for comparison to the sulfur dioxide NAAQS include the 3-hour, 24-hour, and annual averaging periods.

Table 3.11. Sulfur Dioxide Modeling Results

200-foot Overburden Removal Scenario

Pollutant	Model Year	Average Period	Receptor Location		Modeled ($\mu g/m^3$)	Background ($\mu g/m^3$)	Total ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
			UTME	UTMN				
SO_2	2005	3-hour	370479	4143031	1.49	20	21	1,300
		24-hour	370466	4142644	0.41	10	10	365
		Annual	370466	4142644	0.09	5	5	80
	2006	3-hour	370484	4143176	1.51	20	22	1,300
		24-hour	370466	4142644	0.41	10	10	365
		Annual	370466	4142644	0.09	5	5	80
	2007	3-hour	370481	4143079	1.64	20	22	1,300
		24-hour	370466	4142644	0.41	10	10	365
		Annual	370466	4142644	0.10	5	5	80
	2008	3-hour	370478	4142983	1.47	20	21	1,300
		24-hour	370468	4142692	0.47	10	10	365
		Annual	371610	4140400	0.09	5	5	80

Table 3.12. Sulfur Dioxide Modeling Results

300-foot Overburden Removal Scenario

Pollutant	Model Year	Average Period	Receptor Location		Modeled ($\mu g/m^3$)	Background ($\mu g/m^3$)	Total ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
			UTME	UTMN				
SO_2	2005	3-hour	370700	4143660	1.71	20	22	1,300
		24-hour	370473	4142837	0.45	10	10	365
		Annual	370471	4142789	0.11	5	5	80
	2006	3-hour	370700	4143660	1.90	20	22	1,300

Table 3.12. Sulfur Dioxide Modeling Results

300-foot Overburden Removal Scenario

Pollutant	Model Year	Average Period	Receptor Location UTME	UTMN	Modeled ($\mu g/m^3$)	Background ($\mu g/m^3$)	Total ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
		24-hour	370471	4142789	0.47	10	10	365
		Annual	370471	4142789	0.13	5	5	80
	2007	3-hour	370600	4143660	1.84	20	22	1,300
		24-hour	370650	4143660	0.47	10	10	365
		Annual	370471	4142789	0.14	5	5	80
	2008	3-hour	370700	4143700	1.76	20	22	1,300
		24-hour	370494	4143467	0.46	10	10	365
		Annual	370471	4142789	0.13	5	5	80

Both 200-foot and 300-foot modeled concentrations indicate compliance with the respective 3-hour, 24-hour and annual NAAQS at all modeled receptors.

3.1.6 *Assessing Coal Haul Road Impacts*

The haul roads within the mine and the access road were included in the mine modeling. Due to model limitations, the entire long haul road could not be incorporated into the model. Impacts associated with the circuitous, offsite coal haul road were assessed using two methods. First, the long haul road was incorporated in the near-field modeling by attaching 39 volume sources depicting a segment of the long haul road starting from the intersection of the access road and long haul road. This segment of the long haul road extended into the less densely spaced receptors and was included to assure that impacts from the long haul road were incorporated at the high receptor locations during the maximum emissions year.

In addition, to assess potential impacts from this paved coal haul road in areas well removed from the proposed mining activity area, another method was used to determining maximum potential impacts at receptors along the road. In particular, a 1 km segment of theoretical road, using emissions determined in the inventory, was modeled using receptors spaced at 25-m intervals out to 250 m from the edge of the road. It was assumed that the closest potential receptor to the paved roadway used for coal transport would not be any closer than 25 m from the edge of the road to account for roadway easements. Also, a few different source-receptor elevation couplings were used to verify that the impacts from the coal truck traffic would not pose any violations of the applicable NAAQS. Per the AERMOD users manual guidance (EPA 2004b), in the case of long and narrow volume sources such as a haul road, the spacing between individual volume sources should not be greater than twice the width of the volume source. Given the modeled haul road width of up to 30 m, the 1 km segment of road was broken up into 50-m segments, for a total of 20 volume sources. The total emissions for the length of the road were then apportioned accordingly down to 1 km segments and then down to 50-m segments. The 1 km road segment was modeled at the same elevation as the receptors, 25 m above and below the receptors, and both 50 m above and below the receptors. Given the relatively hilly nature of the haul road route close to Alton, an assumed hill height of 300 m was used as input to AERMOD, which requires this parameter. In addition, both a north-south and east-west road orientations were modeled to verify that any juxtaposition of the road and receptors would be captured.

The modeled PM_{10}, $PM_{2.5}$, nitrogen dioxide and carbon monoxide impacts associated with the coal haul road truck traffic do not contribute to offsite NAAQS compliance concerns. The apportioned modeled emission rates from each 50 m spaced volume source along the 1 km road are the same for all coal removal scenarios and are as follows:

- 0.00914 g/s PM_{10}
- 0.000365 g/s $PM_{2.5}$
- 0.001449 g/s nitrogen dioxide
- 0.001582 g/s carbon monoxide

The highest modeled concentrations occurred when the source-receptor elevations were set to the same elevation, assumed flat terrain. In addition, of the two modeled orientations of the road (north-south and east-west), the maximum impacts were associated with the theoretically placed north-south oriented road, which was expected based on the Cedar City windrose. The maximum modeled concentrations always occurred at a the closest row of receptors located 25 m from the edge of the haul road and when the source-receptor pairings were all at the same elevation. Table 3.13 lists the maximum modeled concentrations for each pollutant and applicable averaging period, all of which comply with the NAAQS.

Table 3.13. Haul Road Only (representative segment) Maximum Modeling Results

Pollutant	Modeled Years	Averaging Period	Modeled ($\mu g/m^3$)	Background ($\mu g/m^3$)	Total ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
PM_{10}	2005-2008	24-hour	55.1	72	127	150
$PM_{2.5}$	2005-2008	24-hour	1.8	8.6	10	35
		Annual	0.7	3.6	4	15
NO_2	2005-2008	Annual	3.2	17	20	100
CO	2005-2008	1-hour	53	1,150	1,181	40,000
		8-hour	17	1,150	1,166	10,000

* All max modeled values occur when source-receptors are at same elevation

sulfur dioxide emissions from the additional coal truck traffic on the paved haul road were not modeled as they were deemed insignificant. This analysis verifies that there should be no NAAQS concerns associated with the long, paved haul road and it also alleviates the issue of having to model a 100-mile long volume source, which severely impacts the AERMOD model iteration time by orders of magnitude.

3.1.7 *HAP Impact Assessment*

Hazardous air pollutants can cause various adverse health effects. They are not part of the NAAQS, but high levels at the property boundary could indicate the need for further analysis and/or mitigation strategies. Therefore, HAPs have been included in the emission inventory and were modeled in the AERMOD near-field analysis. The modeled concentrations have been compared with known health exposure levels as a means of assessing potential impacts. The Reference Exposure Levels (RELs) are for assessing acute inhalation exposures (i.e. one-hour average) and represent the concentration at or below which no adverse health effects are expected. The Reference Concentrations (RfC) represent an estimate of the chronic inhalation exposure (i.e. annual average) rate to humans, including sensitive subgroups (children and elderly), without an appreciable risk of harmful effects. Both the RfC and REL guideline values listed below are for non-cancer effects.

Table 3.14. Acute RELs

HAP	Averaging Period	REL (µg/m^3)
Benzene	1-hour	1,300 [1]
Toluene	1-hour	37,000 [1]
Xylene	1-hour	22,000 [1]
n-Hexane	1-hour	390,000 [2]
Formaldehyde	1-hour	94 1

[1] EPA Air Toxics Database, Table 2 (EPA 2007).

[2] No REL available for these HAPs. Values shown are from Immediately Dangerous to Life or Health (IDLH/10), EPA Air Toxics Database, Table 2 (EPA 2007).

Table 3.15. Non-carcinogenic HAP RfCs

HAP	Averaging Period	Non-carcinogenic RfC 1 (µg/m^3)
Benzene	Annual	30
Toluene	Annual	5,000
Xylenes	Annual	100
n-Hexane	Annual	700
Formaldehyde	Annual	9.8

EPA Air Toxics Database, Table 1 (EPA 2007).

In addition to the RfC and REL, the State of Utah has adopted Toxic Screening Levels (TSLs), which are applied during the air permitting process to assist in the evaluation of potential HAP emissions. The TSLs are derived from Threshold Limit Values (TLVs) published in the American Conference of Government Industrial Hygienists (ACGIH) – "Threshold Limit Values for Chemical Substances and Physical Agents." These TLVs are based on exposure limits to a healthy adult in the work place. The TSLs adopted by UDAQ are more stringent and represent screening levels that, if exceeded, would suggest that additional information is needed to substantiate that the model-predicted concentrations would not expose sensitive individuals to potential health risks. Thus, the TSLs in Table 3.16 were compared against modeled concentrations for each HAP in the emissions inventory.

Table 3.16. Utah Toxic Screening Levels (TSLs)

HAP	Averaging Period	Toxic Screening Levels [1] (µg/m^3)
Benzene	24-hour	53
Toluene	24-hour	2,512
Xylene	24-hour	14,473
n-Hexane	24-hour	5,875
Formaldehyde	1-hour	37

[1] Utah Department of Environmental Quality (2007).

To assess long-term exposure from carcinogenic HAP emissions, traditional risk assessment methods were used and the risk for the maximally exposed individual (MEI) and most likely exposure (MLE) were compared to the significance criterion of one additional cancer per one million exposed persons (1x10-6). For the MEI risk, it is assumed that a person is exposed continuously for the life of the mine, assumed to be up to 23 years in this case. For the MLE risk, an exposure adjustment is made to assess the amount of time that a family stays away from the home (64% of the day) and how long a family lives at a given residence (nine years) (EPA 2007). Exposure adjustment factors of 0.33 for the MEI (23/70) and 0.095 for the MLE [(9/70)*((0.64*1)+(0.36*0.25))] were applied to the estimated cancer risk to account for the actual time that an individual could be exposed during a 70-year lifetime. Table 3.17 lists the applicable chronic inhalation cancer risk factors for benzene and formaldehyde.

Table 3.17. Carcinogenic HAP RfCs and Exposure Adjustment Factors

Analysis[1]	HAP Constituent	Carcinogenic Annual RfC (Risk Factor) [2] 1/(μg/m^3)	Exposure Adjustment Factor
MLE	Benzene	7.8 × 10-6	0.0949
MLE	Formaldehyde	1.3 × 10-5	0.0949
MEI	Benzene	7.8 × 10-6	0.33
MEI	Formaldehyde	1.3 × 10-5	0.33

[1] MLE = most likely exposure; MEI = maximally exposed individual.

[2] EPA Air Toxics Database, Table 1 (EPA 2007).

3.1.8 *HAP AERMOD Results*

The potential emissions of HAPs associated with this project are relatively insignificant. The only quantifiable source of HAPs from the Alton Coal lease in the emissions inventory is the proposed generators. The potential HAP emissions are the same for the 200-foot and 300-foot overburden scenarios, as well as the Alternative B and C pit layouts. As such, only one model iteration was completed for each HAP to estimate potential impacts in the immediate vicinity of the mine. No additional background sources were modeled given the localized nature of the mine impacts. As seen in Tables 3.18a and 3.18b, no adverse impacts associated specifically with the Alton sources are anticipated.

Table 3.18a. HAPs AERMOD Modeling Results

Pollutant	Model Years	Average Period	Receptor Location		Modeled (µg/m^3)	Threshold (µg/m^3)
			UTME	UTMN		
Benzene	2005-2008	1-hour	371800	4140300	0.440	1,300 (REL)
		24-hour	368400	4142500	0.046	53 (TSL)
		Annual	370060	4140000	0.003	30 (RfC)
Toluene	2005-2008	1-hour	371800	4140300	0.160	37,000 (REL)
		24-hour	368400	4142500	0.017	2,512 (TSL)
		Annual	370060	4140000	0.001	5,000 (RfC)
Xylenes	2005-2008	1-hour	371800	4140300	0.110	22,000 (REL)
		24-hour	368400	4142500	0.011	14,473 (TSL)
		Annual	370060	4140000	0.001	100 (RfC)
Formaldehyde	2005-2008	1-hour	371800	4140300	0.045	37 (TSL)
		Annual	370060	4140000	0.0003	9.8 (RfC)

Table 3.18b. HAPs Risk Analysis

Analysis[1]	HAP Constituent	Carcinogenic Annual RfC (Risk Factor)[2] 1/(µg/m^3)	Exposure Adjustment Factor	Modeled (µg/m^3)	Calculated Risk	Significance Criterion
MLE	Benzene	7.80E-06	0.0949	0.003	2.2E-09	1.00E-06
MLE	Formaldehyde	5.50E-09	0.0949	0.0003	1.6E-13	1.00E-06
MEI	Benzene	7.80E-06	0.33	0.003	7.7E-09	1.00E-06
MEI	Formaldehyde	5.50E-09	0.33	0.0003	5.4E-13	1.00E-06

[1] MLE = most likely exposure; MEI = maximally exposed individual.

[2] EPA Air Toxics Database, Table 1 (EPA 2007).

3.2 Near-field VISCREEN Analysis

The VISCREEN model was designed to determine whether a plume from a facility may be visible from a given vantage point. The primary variables that affect whether a plume is visible or not at a given location include the quantity of emissions, type of emissions, relative location of the emission source and the observer, and the background visibility range. Typically, VISCREEN is used for analyzing plume impacts from point sources. However, it can also be applied to virtual point sources, such as mining operations.

Specifically, VISCREEN was used to assess potential visibility impacts within the near-field modeling grid at Bryce Canyon National Park. The closest distance to Bryce Canyon National Park is approximately 18 km east-northeast of the proposed Alton mine. Two levels of VISCREEN were used for this analysis of the of the visibility impacts from the proposed mining of the Alton Coal Tract. The primary pollutants of concern that impact visibility in the near-field are particulate matter and nitrogen oxide.

3.2.1 *Level-1 Analysis*

The Level-1 screening used the maximum hourly emission rates of PM_{10} and nitrogen oxide as determined in the emission inventory section, a default particle size and density, and conservative meteorological conditions to assess potential plume impacts on visibility in Bryce Canyon National Park. The most conservative meteorological conditions are assumed to be category F stability and a wind speed of 1.0 m/s. The default thresholds used to determine if Level-1 screening results are favorable, include the following:

- A Delta E value of <= 2, and
- A green contrast value of <= absolute value of 0.05.

The Delta E value is the color difference parameter and was developed to specify the perceived magnitude of color and brightness changes. The Delta E value is used as the basis for determining the perceptibility of plume visual impacts. The green contrast value is the contrast at a given wavelength of two colored objects such as plume/sky or plume/terrain. If all Delta E and green contrast values are below the respective thresholds within the Bryce Canyon National Park Class I area, then the visibility impacts are not expected to be significant.

The PM_{10} and nitrogen oxide emission rates used for this analysis are 152 tpy and 209 tpy, respectively, which correspond to the emissions under the 200-foot overburden scenario under Alternative B. A second screening was performed for the 300-foot overburden scenario under Alternative B, which utilized PM_{10} and nitrogen oxide emission rates used of 200 tpy and 550 tpy, respectively. The default Level-1 screening criteria were used. In addition, a background visibility range of 200 km was used for the VISCREEN analysis based on typical annual background visibility at Bryce Canyon per FLAG guidance. The default background ozone concentration of 40 ppb was utilized. The results of the Level-1 analysis indicate potential visibility impacts above the significance thresholds within the Bryce Canyon National Park Class I area. As a result, a Level-2 analysis was conducted as described below for both the 200-foot overburden removal and the 300-foot overburden removal Alternative B scenarios.

3.2.2 *Level-2 Analysis*

The Bryce Canyon National Park is located approximately 18 km northeast of the proposed Alton mine and also several hundred meters higher than the mine location. Because the Level-1 analysis indicates potential visibility impacts inside of Bryce Canyon National Park, an additional Level-2 screening is warranted. The Level-2 screening allows the use of user-specified particle size, density, and the most conservative meteorological conditions specific to the proposed Alton Coal tract development area. Specifically for Level-2 screening, the VISCREEN model is used to find the maximum wind speed during the daytime (D stability) where delta-E and contrast in the park could potentially be exceeded.

Meteorological data for the Level-2 screening were based on the four years of hourly surface data from the Cedar City, Utah airport for the 2005-2008 met dataset used in the near-field modeling. The hourly data were extracted and summarized for each of the sixteen wind directions and a joint frequency and cumulative frequency developed to summarize the most conservative meteorological combinations of stability, wind direction and wind speed. These calculations were performed using the CEMP website that allows the user to query data and obtain frequency distributions. The worst-case 1-percentile meteorology (occurs on approximately 4 days a year) is assumed to be indicative of worst-day plume visual impacts. In accordance with EPA guidance, dispersion conditions with transport times of more than 12 hours to reach the Class I areas of concern were not considered in the cumulative frequency. In this case, given the short distance to Bryce Canyon National Park, all wind speeds of 1 mph or greater are capable of transporting plume impacts to the park. Also, the meteorological wind direction that could potentially transport the plume to the park ranges from approximately 210 degrees to approximately 260 degrees. For the Level-2 analysis, only daylight hours from 6am to 6pm are considered as potential periods when plume visual impacts could occur within the Class I area. It should be noted that the most stable daytime stability class is considered to be slightly stable, or category D.

Using this screening, the 1-percentile atmospheric stability and wind speed are determined to be Stability D with wind speed of 2 m/sec. However, because Bryce Canyon National Park has an elevation more than 500 m above the Alton Coal Tract, when determining most conservative dispersion characteristics, the most conservative stability class should be shifted one class less stable (VISCREEN Users Manual, EPA 1992). This shift is applicable when considering an observer located on terrain at least 500 m above the emission source under stable conditions. This adjustment is made to account for the existence of complex terrain and try to simulate conditions that could facilitate transport of a relatively stable plume to a sensitive area (e.g., Bryce Canyon National Park), which must be lifted over or around elevated terrain. Thus, for the Level-2 most conservative meteorology a stability class of C with wind speed of 2 m/second was utilized. The Level-2 VISCREEN visual impacts using this most conservative dispersion category inside of Bryce Canyon National Park are summarized below:

Table 3.19a. Visual Impacts inside of Bryce Canyon National Park, 200-foot Overburden Results

Background	Theta	Azimuth	Distance from Alton (km)	Alpha	Delta E		Contrast	
					Criteria	Plume	Criteria	Plume
SKY	10	157	35	11	6.21	0.267	0.13	0.005
SKY	140	157	35	11	3.41	0.074	0.13	-0.002
TERRAIN	10	84	18	84	6.8	0.691	0.28	0.003
TERRAIN	140	84	18	84	4.05	0.029	0.28	0.00

These results demonstrate that the maximum impacts inside of Bryce Canyon National Park from a potential Alton mine plume under the 200-foot overburden removal scenario will be less than the VISCREEN acceptance criteria for both color change (Delta E) and contrast.

A similar Level-2 screening analysis was performed for the 300-foot overburden removal scenario under Alternative B. Emissions are substantially higher under this scenario with potential PM_{10} and nitrogen oxide emission rates of 200 tpy and 550 tpy, respectively. Again, a stability class of C and wind speed of 2 m/s was utilized as representative of the most conservative meteorology, as described above. The Level-2 VISCREEN visual impacts inside of Bryce Canyon National Park are summarized below.

Table 3.19b. Visual Impacts inside of Bryce Canyon National Park, 300-foot Overburden Results

Background	Theta	Azimuth	Distance from Alton (km)	Alpha	Delta E		Contrast	
					Criteria	Plume	Criteria	Plume
SKY	10	157	35	11	6.21	0.372	0.13	0.006
SKY	140	157	35	11	3.41	0.149	0.13	-0.003
TERRAIN	10	84	18	84	6.8	0.904	0.28	0.004
TERRAIN	140	84	18	84	4.05	0.041	0.28	0.000

These results demonstrate that the maximum impacts inside of Bryce Canyon National Park from a potential Alton mine plume under the 300-foot overburden removal scenario will be less than the VISCREEN acceptance criteria for both color change (Delta E) and contrast.

3.3 Near-field Class I and Class II Area Impacts

AERMOD was also used to model impacts at the Class I and sensitive Class II areas within the 50 km near-field domain. Bryce Canyon National Park is a Class I area approximately 18 km to the northeast of the Alton Tract, whereas Grand Staircase-Escalante National Monument is a sensitive Class II area that lies farther to the east. The following tables (3.20 and 3.21) summarize the Alton source only impacts under the 200-foot overburden scenario for both action alternatives. None of the increment levels are exceeded.

Table 3.20. Alton Tract Near-Field Class I and Class II Impacts, 200-foot Overburden, Alternative B

High First-Highs					
Pollutant	Averaging Period	Bryce Canyon National Park			
		2005 (μg/m^3)	2006 (μg/m^3)	2007 (μg/m^3)	2008 (μg/m^3)
PM_{10}	Annual	0.01	0.017	0.01	0.00
	24-hour	0.27	0.368	0.34	0.41
SO_2	Annual	0.00	0.00	0.00	0.00
	24-hour	0.00	0.00	0.00	0.00
	3-hour	0.01	0.02	0.01	0.03
NO_x	Annual	0.02	0.01	0.01	0.01
$PM_{2.5}$	Annual	0.00	0.00	0.00	0.00
	24-hour	0.06	0.08	0.07	0.09
CO	8-hour	2.9	3.9	4.1	4.6
	1-hour	18	27	25	31

Table 3.20. Alton Tract Near-Field Class I and Class II Impacts, 200-foot Overburden, Alternative B

Class I Increment, High First (Annual), Second-Highs

Pollutant	Averaging Period	Bryce Canyon National Park				Class I Increment	Exceed Increment?
		2005 (µg/m^3)	2006 (µg/m^3)	2007 (µg/m^3)	2008 (µg/m^3)		
PM_{10}	Annual	0.01	0.02	0.01	0.01	4	N
	24-hour	0.15	0.18	0.21	0.23	8	N
SO_2	Annual	0.00	0.00	0.00	0.00	2	N
	24-hour	0.00	0.00	0.00	0.00	5	N
	3-hour	0.00	0.01	0.01	0.01	25	N
NO_x	Annual	0.03	0.01	0.01	0.01	2.5	N
$PM_{2.5}$	Annual	0.00	0.00	0.00	0.00	NA	NA
	24-hour	0.03	0.04	0.04	0.05	NA	NA
CO	8-hour	1.3	1.5	1.8	2.7	NA	NA
	1-hour	7.7	12	14	16	NA	NA

Class II Increment, High First (Annual), Second-Highs

Pollutant	Averaging Period	Grand Staircase-Escalante NM				Class II Increment	Exceed Increment?
		2005 (µg/m^3)	2006 (µg/m^3)	2007 (µg/m^3)	2008 (µg/m^3)		
PM_{10}	Annual	0.22	0.26	0.23	0.31	17	N
	24-hour	1.70	2.14	1.99	2.02	30	N
SO_2	Annual	0.00	0.00	0.00	0.00	20	N
	24-hour	0.02	0.02	0.02	0.02	91	N
	3-hour	0.10	0.12	0.09	0.12	512	N
NO_x	Annual	0.55	0.65	0.53	0.71	25	N
$PM_{2.5}$	Annual	0.06	0.07	0.06	0.07	NA	NA
	24-hour	0.58	0.84	0.61	0.67	NA	NA
CO	8-hour	28	27	25	33	NA	N
	1-hour	169	207	160	226	NA	N

Table 3.21. Alton Tract Near-Field Class I and Class II Impacts, 200-foot Overburden, Alternative C

High First-Highs

Pollutant	Averaging Period	Bryce Canyon National Park			
		2005 (μg/m³)	2006 (μg/m³)	2007 (μg/m³)	2008 (μg/m³)
PM_{10}	Annual	0.01	0.01	0.01	0.01
	24-hour	0.29	0.39	0.37	0.45
SO_2	Annual	0.00	0.00	0.00	0.00
	24-hour	0.00	0.00	0.00	0.00
	3-hour	0.00	0.02	0.01	0.02
NO_x	Annual	0.02	0.03	0.01	0.01
$PM_{2.5}$	Annual	0.00	0.00	0.00	0.00
	24-hour	0.06	0.08	0.08	0.10
CO	8-hour	2.9	3.9	4.1	4.6
	1-hour	18	27	25	31

Class I Increment, High First (Annual), Second-Highs

Pollutant	Averaging Period	Bryce Canyon National Park				Class I Increment	Exceed Increment?
		2005 (μg/m³)	2006 (μg/m³)	2007 (μg/m³)	2008 (μg/m³)		
PM_{10}	Annual	0.01	0.01	0.01	0.01	4	N
	24-hour	0.16	0.20	0.23	0.21	8	N
SO_2	Annual	0.00	0.00	0.00	0.00	2	N
	24-hour	0.00	0.00	0.00	0.00	5	N
	3-hour	0.00	0.01	0.01	0.01	25	N
NO_x	Annual	0.02	0.01	0.03	0.01	2.5	N
$PM_{2.5}$	Annual	0.00	0.00	0.00	0.00	NA	NA
	24-hour	0.03	0.04	0.05	0.05	NA	NA
CO	8-hour	1.3	1.5	1.8	2.7	NA	NA
	1-hour	7.7	12	14	16	NA	NA

Table 3.21. Alton Tract Near-Field Class I and Class II Impacts, 200-foot Overburden, Alternative C

Class II Increment, High First (Annual), Second-Highs (carbon monoxide comparison to significance levels)							
Pollutant	**Averaging Period**	**Grand Staircase-Escalante NM**				**Class II Increment**	**Exceed Increment?**
		2005 (μg/m^3)	**2006 (μg/m^3)**	**2007 (μg/m^3)**	**2008 (μg/m^3)**		
PM_{10}	Annual	0.24	0.28	0.25	0.33	17	N
	24-hour	1.87	2.34	2.17	2.23	30	N
SO_2	Annual	0.00	0.00	0.00	0.00	20	N
	24-hour	0.02	0.02	0.02	0.02	91	N
	3-hour	0.10	0.12	0.09	0.12	512	N
NO_x	Annual	0.55	0.65	0.53	0.71	25	N
$PM_{2.5}$	Annual	0.07	0.08	0.07	0.10	NA	NA
	24-hour	0.84	1.15	0.89	0.94	NA	NA
CO	8-hour	28	27	25	33	NA	N
	1-hour	169	207	160	226	NA	N

The following tables (3.22 and 3.23) summarize the Alton source only impacts under the 300-foot overburden scenario for both action alternatives. None of the increment levels are exceeded.

Table 3.22. Alton Tract Near-Field Class I and Class II Impacts, 300-foot Overburden, Alternative B

High First-Highs					
Pollutant	**Averaging Period**	**Bryce Canyon National Park**			
		2005 (μg/m^3)	**2006 (μg/m^3)**	**2007 (μg/m^3)**	**2008 (μg/m^3)**
PM_{10}	Annual	0.01	0.01	0.01	0.01
	24-hour	0.39	0.51	0.49	0.59
SO_2	Annual	0.00	0.00	0.00	0.00
	24-hour	0.00	0.00	0.00	0.00
	3-hour	0.01	0.02	0.02	0.02
NO_x	Annual	0.04	0.03	0.03	0.04
$PM_{2.5}$	Annual	0.00	0.00	0.00	0.00
	24-hour	0.08	0.10	0.10	0.12
CO	8-hour	5.9	7.8	8.8	9.6
	1-hour	36	55	53	67

Table 3.22. Alton Tract Near-Field Class I and Class II Impacts, 300-foot Overburden, Alternative B

Class I Increment, High First (Annual), Second-Highs

Pollutant	Averaging Period	Bryce Canyon National Park				Class I Increment	Exceed Increment?
		2005 (μg/m^3)	2006 (μg/m^3)	2007 (μg/m^3)	2008 (μg/m^3)		
PM_{10}	Annual	0.01	0.01	0.01	0.010	4	N
	24-hour	0.21	0.274	0.29	0.347	8	N
SO_2	Annual	0.00	0.00	0.00	0.000	2	N
	24-hour	0.00	0.00	0.00	0.002	5	N
	3-hour	0.01	0.01	0.01	0.010	25	N
NO_x	Annual	0.04	0.03	0.03	0.035	2.5	N
$PM_{2.5}$	Annual	0.00	0.00	0.00	0.002	NA	NA
	24-hour	0.04	0.05	0.06	0.066	NA	NA
CO	8-hour	2.7	3.7	3.4	5.3	NA	NA
	1-hour	16	26	27	32	NA	NA

Class II Increment, High First (Annual), Second-Highs (carbon monoxide comparison to significant levels)

Pollutant	Averaging Period	Grand Staircase-Escalante NM				Class II Increment	Exceed Increment?
		2005 (μg/m^3)	2006 (μg/m^3)	2007 (μg/m^3)	2008 (μg/m^3)		
PM_{10}	Annual	0.29	0.33	0.29	0.39	17	N
	24-hour	2.43	2.90	2.88	2.81	30	N
SO_2	Annual	0.00	0.00	0.00	0.00	20	N
	24-hour	0.02	0.02	0.02	0.02	91	N
	3-hour	0.12	0.13	0.11	0.15	512	N
NO_x	Annual	1.36	1.57	1.26	1.73	25	N
$PM_{2.5}$	Annual	0.07	0.08	0.07	0.09	NA	NA
	24-hour	0.79	1.07	0.83	0.87	NA	NA
CO	8-hour	65	57	51	67	NA	N
	1-hour	387	441	361	497	NA	N

Table 3.23. Alton Tract Near-Field Class I and Class II Impacts, 300-foot Overburden, Alternative C

Class I High First-Highs

Pollutant	Averaging Period	Bryce Canyon National Park			
		2005 ($\mu g/m^3$)	2006 ($\mu g/m^3$)	2007 ($\mu g/m^3$)	2008 ($\mu g/m^3$)
PM_{10}	Annual	0.01	0.01	0.01	0.01
	24-hour	0.41	0.54	0.52	0.62
SO_2	Annual	0.00	0.00	0.00	0.00
	24-hour	0.00	0.00	0.00	0.00
	3-hour	0.01	0.02	0.02	0.02
NO_x	Annual	0.04	0.03	0.03	0.04
$PM_{2.5}$	Annual	0.00	0.00	0.00	0.00
	24-hour	0.08	0.11	0.11	0.13
CO	8-hour	5.9	7.8	8.8	9.61
	1-hour	36	55	53	67

Class I Increment, High First (Annual), Second-Highs

Pollutant	Averaging Period	Bryce Canyon National Park				Class I Increment	Exceed Increment?
		2005 ($\mu g/m^3$)	2006 ($\mu g/m^3$)	2007 ($\mu g/m^3$)	2008 ($\mu g/m^3$)		
PM_{10}	Annual	0.01	0.01	0.00	0.01	4	N
	24-hour	0.22	0.29	0.31	0.36	8	N
SO_2	Annual	0.00	0.00	0.00	0.00	2	N
	24-hour	0.00	0.00	0.00	0.00	5	N
	3-hour	0.01	0.01	0.01	0.01	25	N
NO_x	Annual	0.04	0.03	0.03	0.04	2.5	N
$PM_{2.5}$	Annual	0.00	0.00	0.00	0.00	NA	NA
	24-hour	0.04	0.06	0.06	0.07	NA	NA
CO	8-hour	2.8	3.7	3.5	5.3	NA	NA
	1-hour	16	26	27	32	NA	NA

Table 3.23. Alton Tract Near-Field Class I and Class II Impacts, 300-foot Overburden, Alternative C

Class II Increment, High First (Annual), Second-Highs (carbon monoxide comparison to significance levels)							
Pollutant	**Averaging Period**	**Grand Staircase-Escalante NM**				**Class II Increment**	**Exceed Increment?**
		2005 (μg/m³)	**2006 (μg/m³)**	**2007 (μg/m³)**	**2008 (μg/m³)**		
PM_{10}	Annual	0.31	0.35	0.31	0.42	17	N
	24-hour	2.60	3.11	3.11	3.05	30	N
SO_2	Annual	0.00	0.00	0.00	0.00	20	N
	24-hour	0.02	0.02	0.02	0.02	91	N
	3-hour	0.12	0.13	0.11	0.15	512	N
NO_x	Annual	1.36	1.57	1.26	1.73	25	N
$PM_{2.5}$	Annual	0.07	0.08	0.07	0.10	NA	NA
	24-hour	0.84	1.15	0.89	0.94	NA	NA
CO	8-hour	65	57	51	67	NA	N
	1-hour	387	441	361	497	NA	N

The cumulative near-field runs including the Alton sources and all regional background sources (Kanab, Richfield, Fishlake, Dixie, Navajo Generating Station, and St. George) indicate that all of the Class I and Class II increments are not exceeded. See Table 3.24 below.

Table 3.24. Alton Tract Cumulative Near-Field Class I and Class II Impacts, 300-foot Overburden, Alternative C

Class I Increment, High First (Annual), Second-Highs

Pollutant	Averaging Period	Bryce Canyon National Park				Maximum Regional Impact (μg/m^3)*	Maximum Total (μg/m^3)	Class I Increment	Exceed Increment?
		2005 (μg/m^3)	2006 (μg/m^3)	2007 (μg/m^3)	2008 (μg/m^3)				
PM_{10}	Annual	0.01	0.01	0.01	0.01	0.00	0.01	4	N
	24-hour	0.22	0.29	0.31	0.37	0.05	0.42	8	N
SO_2	Annual	0.00	0.00	0.00	0.00	0.00	0.01	2	N
	24-hour	0.00	0.00	0.00	0.00	0.01	0.01	5	N
	3-hour	0.01	0.01	0.01	0.01	0.05	0.06	25	N
NO_x	Annual	0.04	0.03	0.03	0.04	0.00	0.04	2.5	N
$PM_{2.5}$	Annual	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA
	24-hour	0.04	0.06	0.06	0.07	0.02	0.09	NA	NA
CO	8-hour	3.0	3.7	3.5	6.0	25	31	NA	NA
	1-hour	19	26	27	48	43	91	NA	NA

Table 3.24. Alton Tract Cumulative Near-Field Class I and Class II Impacts, 300-foot Overburden, Alternative C

Class II Increment, High First (Annual), Second-Highs (carbon monoxide comparison to significance levels)

Pollutant	Averaging Period	Grand Staircase-Escalante NM 2005 (μg/m³)	2006 (μg/m³)	2007 (μg/m³)	2008 (μg/m³)	Maximum Regional Impact (μg/m³)	Maximum Total (μg/m³)	Class II Increment	Exceed Increment?
PM_{10}	Annual	0.31	0.36	0.31	0.42	0.00	0.42	17	N
	24-hour	2.61	3.11	3.11	3.05	0.05	3.16	30	N
SO_2	Annual	0.00	0.00	0.00	0.00	0.00	0.00	20	N
	24-hour	0.02	0.02	0.02	0.02	0.01	0.03	91	N
	3-hour	0.12	0.13	0.11	0.15	0.05	0.20	512	N
NO_x	Annual	1.37	1.58	1.26	1.73	0.00	1.73	25	N
$PM_{2.5}$	Annual	0.08	0.09	0.07	0.10	0.00	0.10	NA	NA
	24-hour	0.84	1.15	0.89	0.94	0.02	1.17	NA	NA
CO	8-hour	65	57	51	67	25	92	NA	N
	1-hour	387	441	367	497	44	541	NA	N

* - The maximum regional impact is the highest 1st-high from the 3 CALPUFF model years, 2001-2003

4 FAR-FIELD ANALYSIS

The purpose of the far-field analysis is to quantify potential air quality impacts to both ambient air concentrations and AQRVs from air pollutant emissions of nitrogen oxide, carbon monoxide, sulfur dioxide, PM_{10}, and $PM_{2.5}$ that are expected to result from mining operations on the tract. Ambient air quality impacts beyond the tract and throughout the modeling domain were analyzed, as were AQRVs at Class I areas and selected Class II areas. Cumulative impacts also were quantified by including in the analyses other documented sources of air pollutant emissions within the modeling domain (identified in Map 1.1). The analyses were performed using the EPA-recommended CALMET/CALPUFF/ CALPOST modeling system (V5.8 Level 070623) to predict air quality direct and cumulative impacts at far-field PSD Class I areas and selected Class II areas. Except where explicit reference to pre- and post-processors is necessary for clarity, in this Technical Report the term "CALPUFF" is generally used to represent the entire modeling system, including the pre- and post-processors. The PSD Class I areas and Class II areas of special interest to be analyzed are shown on Map 1.1 and include the following:

- Bryce Canyon National Park (Class I) –(See Section 4.2.3)
- Zion National Park (Class I)
- Capitol Reef National Park (Class I)
- Grand Canyon National Park (Class I)
- Grand Staircase-Escalante National Monument (Class II)
- Navajo Lake (Acid deposition on a sensitive lake)
- A 4 km spaced grid of receptors located over the near-field modeling domain (Class II) to include potential far-field impacts in the near-field cumulative results (i.e., evaluate source impacts from sources greater than 50 km from the Alton mine)

In addition, analyses were performed for one lake (Navajo Lake in Dixie National Forest, Utah) to allow for the assessment of potential lake acidification from atmospheric deposition impacts. Sulfur and nitrogen deposition on the lake surface was calculated using CALPUFF. However, there are currently no data on acid neutralizing capacity (ANC) for Navajo Lake. To assess potential lake acidification it would be necessary to gather ANC data for the lake.

CALPUFF was used to model dispersion of nitrogen oxide, carbon monoxide, sulfur dioxide, PM_{10} and $PM_{2.5}$ from mining operations on the Alton Coal Tract, associated activities such as coal haulage, and regional emissions as described in Section 2.0. Photochemical conversion of NO_x and VOCs to O_3 and the secondary formation of $PM_{2.5}$ concentrations from NO_x and SO_2 emissions were not included in the Protocol. These chemical reactions cannot be simulated with the recommended far-field model (CALPUFF). A description of the emission inventory procedures is included in Section 2.0 of this Technical Report. CALPUFF results were post-processed with CALPOST to derive

- air concentrations for comparison to ambient air standards, significance thresholds, and Class I and II increments;
- AQRV impacts due to deposition rates for comparison to sulfur (S) and nitrogen (N) deposition thresholds[1]; and

[1] For Navajo Lake, deposition rates for S and N will be calculated. However, ANC calculations will not be performed until there are sufficient data for the lake.

- AQRV impacts due to light extinction change for comparison to visibility impact thresholds in Class I and other sensitive areas.

A discussion of the post-processing methodology used is provided in Section 4.3.

4.1 Modeling Methodology

The far-field analysis used the CALPUFF modeling system, which incorporates a non-steady-state puff-model approach for simulating the dispersion of pollutants to assess potential air quality impacts. The model is best applied when assessing complex flow situations, far-field impacts, and situations where winds are calm. CALPUFF is also appropriate for estimating AQRV impacts such as degradation of visibility and deposition of inorganic compounds resulting from fuel combustion (e.g., nitrates formed from nitrogen oxide). The CALPUFF modeling system has three main components: CALMET (a diagnostic 3D meteorological model); CALPUFF (the transport and dispersion model); and CALPOST (a post-processing package). CALMET is a meteorological model that includes a diagnostic wind field generator containing objective analysis and parameterized treatments of slope flows, kinematic terrain effects, terrain blocking effects, a divergence minimization procedure, and a micrometeorological model for overland and overwater. CALPUFF is a non-steady-state Lagrangian Gaussian puff model containing modules for complex terrain effects, overwater transport, coastal interaction effects, building downwash effects, and wet and dry removal. CALPOST is a post-processing program with options for the computation of time-averaged concentrations and deposition fluxes predicted by the CALPUFF model. CALPOST computes visibility impacts in accordance with IWAQM and FLAG recommendations.

As mentioned, three consecutive years (2001–2003) of MM5 model meteorological data were used as input to the CALMET model simulations. CALPUFF then used the meteorological fields generated by CALMET to assess the far-field impacts of the pollutants of concern on the Class I areas and selected Class II areas. CALPOST was used to process the hourly concentration or deposition output files generated by CALPUFF to present the data in the desired averaging period for each pertinent pollutant or AQRV. The modeling domain is shown in Map 1.1.

The CALMET and CALPUFF models were used in this analysis following the methods described herein as well as the following guidance sources:

- *Guideline on Air Quality Models, 40 Code of Federal Regulations (CFR), Part 51*, Appendix W, November 9, 2005;
- *Interagency Work Group on Air Quality Modeling Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts*, EPA-454/R-98-019, Office of Air Quality Planning and Standards, December 1998 (IWAQM 1998); and
- *FLAG, Phase I Report*, December 2000 (FLAG 2000).

4.2 Model Inputs

Model inputs consisted of meteorological data and terrain data (see Section 4.2.1), estimated emissions from mining operations on the tract (see Section 4.2.2.1), cumulative emissions (see Section 4.2.2.2), receptors (see Section 4.2.3), and background data (see Section 4.2.4). Each of these is discussed below.

4.2.1 *Meteorological Data Selection and Settings*

The Arizona-New Mexico CALMET dataset developed by the Western Regional Air Partnership (WRAP) was used to produce three years of CALMET wind fields. Supplementing the WRAP data are 7 upper air stations that were used in the Navajo Generating Station (NGS) BART modeling. The original WRAP modeling did not include upper air stations, and the availability of upper air data for the Arizona-New Mexico domain was one of the primary factors for its selection.

The EPA approved version of CALMET (5.8 – Level 070623) was used to generate the meteorological data fields. The CALMET fields were reproduced exactly as they were in the NGS modeling – with identical MM5, surface, upper air, precipitation and geophysical data.

As an “initial guess” field, three years of MM5 data (2001–2003) were used. CALMET uses the MM5 (36-km resolution) data as an “initial guess” field for the fine grid (4 km) wind field simulations using a diagnostic wind field module. The CALMET methodology accounts for local terrain effects on the wind field (e.g., CALMET includes the local up- and down-valley diurnal flow that is missed by most meteorological observations and coarse grid simulations). The meteorological grid size is 288 x 225 cells (using 4-km spacing). The computational grid is a subset of the meteorological grid, due to the large areal extent of the domain and the extremely long run times that would have resulted had the entire domain been included. The computational grid begins at cell 93,126 and extends to 197,225. The computational grid extents are sufficient to cover all areas of interest, plus an additional 50 km buffer on all sides. The cell face heights (in meters) were set to 0, 20, 100, 200, 350, 500, 750, 1000, 2000, 3000, 4000, and 5000. The meteorological domain is illustrated in Map 1.7.

4.2.2 *Emissions*

Estimated emissions based on the emission inventory described in Section 2.0 were used per FLAG guidance and standard CALPUFF procedure. The sections below describe the consideration of mining-related and cumulative emissions in the modeling.

4.2.2.1 MINING-RELATED EMISSIONS

Pollutant emission rates estimated as described in Section 2.0 were input to CALPUFF to predict air quality impacts (concentrations of pollutants) from mining and related activities. Mining operations were modeled as a combination of point, area and volume sources within the tract.

Alton generators were modeled as point sources, and roads as volume sources. All other emissions associated with the mine were modeled as area sources. One slight difference from the near-field modeling is that the near-field modeling included the use of "AREAPOLY" sources - irregular shaped area sources with multiple vertices. CALPUFF has no areapoly type of input. So, in some cases several area sources were necessary to cover the same area one near-field areapoly source covered.

Coal haulage–related emissions were modeled as volume sources along the reasonably foreseeable coal haul transportation route. Volume spacing along this route was varied, with a 2 km spacing the usual, but a decreased spacing of 500 m near and between several developed areas: Panguitch, Paragonah, Parowan, Enoch and Cedar City. The increased density of receptors near these towns allowed for a more detailed appraisal of potential impacts on certain sensitive entities, such as schools and hospitals.

Several small sources located offsite from the Alton facilities were included in the far-field modeling that were not included in the near-field modeling. These include coal dumping at the loadout, coal storage at the loadout, and train loading. These emissions were combined into a single area source and located near the end of the long haul road near Cedar City.

4.2.2.2 CUMULATIVE SOURCE EMISSIONS

Regional sources not included in the background concentrations—including new minor sources, major modifications to Title V permitted sources, RFD, and RFFA—inventoried according to the methodology described in Section 2.0, were input to the CALPUFF model as point area or volume sources, as appropriate. As part of the emission inventory, source location and stack exit parameter data were obtained.

Pollutant emissions from stacks were generally modeled as point sources in the CALPUFF model. Multiple stacks within single facilities were modeled individually with the stack parameters identified in the emission inventory compilation process. The Fishlake and Dixie oil field developments stacks were modeled differently. Because there were quite a number of stacks present at each, emissions were combined into a single, conservative stack. This approach allowed CALPUFF to treat the emissions as stack emissions, while at the same time reducing model run time issues.

Fugitive emissions (e.g., well heaters, other surface mines, gravel pits, etc.) were modeled as area sources, with emissions aggregated into single area sources. The area source locations were either source location-specific or regional, depending on the nature of the fugitive emission sources. For example, the BLM Kanab Field Office and the BLM Richfield Field Office RMPs were each modeled as single, large regional area sources. Multiple disturbed areas at the Fishlake and Dixie oil field developments (both the volume and area sources compiled in the emission inventories) were modeled as aggregate area sources situated at the development locations. The choice to model in aggregate instead of individually once again improved run time performance, and will not significantly impact concentration calculations, because the transport distances are large. The locations of area sources input to the model can be found in Appendix D.

Regional paved and unpaved roadway travel, urban, biogenic, and other non-industrial sources are considered to be included in the ambient air background concentrations described in this Technical Report. Therefore, those fugitive sources were not modeled.

4.2.3 *Receptors*

Model receptors were input to CALPUFF where concentration, deposition, and other impacts were calculated. At the selected PSD Class I, and other sensitive Class II areas, ambient air and AQRV impacts were determined. The Class I and Class II areas of special interest within the modeling domain that were modeled include:

- Bryce Canyon National Park (Class I)
- Zion National Park (Class I)
- Capitol Reef National Park (Class I)
- Grand Canyon National Park (Class I)
- Grand Staircase-Escalante National Monument (Class II)
- Navajo Lake (Acid deposition on a sensitive lake)
- A 4 km spaced grid of receptors located over the near-field modeling domain (Class II)

CALPUFF modeling used receptors provided by the National Park Service for each of the areas above, except for Navajo Lake, where a single receptor was located at its location, and the gridded receptors. In addition, the Grand Staircase-Escalante receptors included in the far-field analysis were only those ones that are greater than 50 km from the Alton project. Bryce Canyon receptors were included in the CALPUFF receptor list, but no post-processing was performed because the entire area is well within 50 km. Zion National Park has a portion of its area within 50 km, and a portion outside 50 km. For the post-processing the entire park was considered, regardless of whether the particular receptor was plus or minus 50 km. This approach was used for the simplicity of dealing with all receptors in one pass, and also because it produces conservative results.

Because there are a number of regional sources that are farther than 50 km from the Alton facility, and AERMOD is not approved for use beyond 50 km, CALPUFF was used to generate a 4 km-spaced receptor grid over the near-field modeling domain to include potential far-field impacts in the near-field cumulative results. This grid was used to calculate total cumulative impacts from all sources. The near-field cumulative modeling included only the Kanab Field Office RMP as it was the only regional source within 50 km.

4.2.4 *Background Data*

4.2.4.1 CRITERIA POLLUTANTS

Background values for criteria pollutants were used as described in Table 4.1 below.

4.2.4.2 CHEMICAL SPECIES

The CALPUFF chemistry algorithms require hourly estimates of background ozone concentrations for the conversion of sulfur dioxide and nitrogen oxide to sulfates and nitrates, respectively. An extensive hourly ozone database was developed for use in the WRAP modeling, and that data were used for model years 2001-2003.

A background ammonia concentration of 1.0 ppb, as suggested in IWAQM for "arid lands," was used.

Table 4.1. Far-field Analysis Background Ambient Air Quality Concentrations (μg/m^3)

Pollutant	Averaging Period	Measured Background Concentration
CO[1]	1-hour	1 ppm (1,150 μg/m^3)
	8-hour	1 ppm (1,150 μg/m^3)
NO_2[1]	Annual	17 μg/m^3
PM_{10}[3]	24-hour	72 μg/m^3
	Annual	36 μg/m^3
$PM_{2.5}$[2]	24-hour	8.6 μg/m^3
	Annual	3.6 μg/m^3
SO_2[1]	3-hour	20 μg/m^3
	24-hour	10 μg/m^3
	Annual	5 μg/m^3

[1] UDAQ 2008. Data based on estimates from the UDAQ.

[2] Measured $PM_{2.5}$ data obtained from NPS website for Bryce Canyon National Park.

[3] UDAQ 2010. PM_{10} data based on monitoring at St. George, Utah and used for private Alton Mine.

4.2.4.3 VISIBILITY

CALPOST was used to estimate change in light extinction from CALPUFF model concentration results. FLAG background visibility data were used for this analysis. The visibility calculation method used CALPOST visibility method 6 (MVISBK=6, i.e., method 6) for computing light extinction change in combination with FLAG background data. Method 6 uses monthly averaged humidity factors, and is not sensitive to synoptic weather events that lead to high extinction events and subsequent explanation as to why certain events should be discounted. A second visibility calculation used the FLAG background data in combination with hourly relative humidity data from the CALMET windfields (MVISBK=2; i.e., method 2).

The FLAG method 6 uses seasonal natural background visibility conditions and relative humidity factors at Class I areas. FLAG method 2 uses the seasonal natural background visibility conditions and hourly relative humidity data from surface observations in the CALMET wind field data. For the FLAG methods utilized in this analysis, estimated natural background visibility values provided in Appendix 2.B of FLAG (2000) were used. For FLAG method 6, monthly relative humidity factors provided in the *Guidance for Estimating Natural Visibility Conditions under the Regional Haze Rule* (EPA 2003b) were used. Because natural background data are provided for Federal Class I areas only, data from the nearest Federal Class I area were used for the sensitive Class II areas. In this case, the Grand Staircase-Escalante Class II receptors used Capitol Reef National Park background data. The natural background visibility data, in units of inverse megameters (Mm^{-1}), were used with the FLAG visibility analysis for each area analyzed are shown in Table 4.2

Table 4.2. FLAG Report Background Extinction Values[1]

Site	Season	Hygroscopic (Mm-1)	Non-hygroscopic (Mm-1)
Bryce Canyon National Park	Winter	0.6	4.5
	Spring	0.6	4.5
	Summer	0.6	4.5
	Fall	0.6	4.5
Zion National Park	Winter	0.6	4.5
	Spring	0.6	4.5
	Summer	0.6	4.5
	Fall	0.6	4.5
Capitol Reef National Park	Winter	0.6	4.5
	Spring	0.6	4.5
	Summer	0.6	4.5
	Fall	0.6	4.5
Grand Canyon National Park	Winter	0.6	4.5
	Spring	0.6	4.5
	Summer	0.6	4.5
	Fall	0.6	4.5

[1] FLAG (2000).

4.2.4.4 DEPOSITION

No background data were used in determining deposition impacts at either the Class I/Class II areas or at Navajo Lake. Total sulfur (S) and nitrogen (N) impacts were quantified for the tract proper and cumulative source scenarios, and compared to the minimum green line values outlined in *A Screening Procedure to Evaluate Air Pollution Effects on Class I Wilderness Areas* (Fox et al, 1989).

4.2.4.5 LAKE CHEMISTRY

Navajo Lake is the only known lake to be potentially impacted by acid deposition. This site was identified as a sensitive receptor, and acid deposition rates on the lake were calculated. There are no data on lake chemistry at Navajo Lake to assess potential impacts related to ANC.

4.3 Post-processing

For each far-field sensitive area, CALPUFF-modeled concentration impacts were post-processed with CALPOST and POSTUTIL, as necessary, to derive (1) concentrations for comparison to ambient air quality standards, and PSD Class I and II Increments; (2) deposition rates for comparison to sulfur and nitrogen deposition levels of concern; and (3) light extinction changes for comparison to visibility impact thresholds.

4.3.1 *Concentration*

CALPOST was used to process the CALPUFF concentration output files to compute appropriate concentration values for sulfur dioxide (3-hour, 24-hour, and annual average), $PM_{2.5}$ (24-hour and annual average), nitrogen dioxide (annual average), PM_{10} (24-hour and annual average) and carbon monoxide (1-hour and 8-hour averages).

The NAAQS and ambient standards adopted by state regulatory agencies set absolute upper limits for specific air pollutant concentrations (expressed in $\mu g/m^3$) at all locations with public access. Modeled concentrations occurring from construction, mining operations, and cumulative sources were added to the existing ambient air quality background concentrations shown in Table 3.1 and Table 4.2, and the total concentrations are compared to the corresponding NAAQS shown in Table 4.3. Ambient air quality standards, significance levels, and PSD Class II Increments are shown in Table 4.3.

Table 4.3. Ambient Standards, Class II PSD Increments Comparison to Near-field Analysis Results ($\mu g/m^3$)[1]

Pollutant/Averaging Time	National Ambient Air Quality Standards	PSD Class II Increments
CO		
1-hour[1]	40,000	--
8-hour[1]	10,000	--
NO_2		
Annual[2]	100	25

Table 4.3. Ambient Standards, Class II PSD Increments Comparison to Near-field Analysis Results (µg/m³)[1]

Pollutant/Averaging Time	National Ambient Air Quality Standards	PSD Class II Increments
Ozone (O_3)		
1-hour	235	--
8-hour[3]	157	--
PM_{10}		
24-hour[1]	150	30
Annual[4]	50	17
$PM_{2.5}$		
24-hour	35	NA
Annual	15	NA
SO_2		
3-hour[1]	1,300	512
24-hour[1]	365	91
Annual[2]	80	20

[1] No more than one exceedance per year.

[2] Annual arithmetic mean.

[3] Average of annual fourth-highest daily maximum 8-hour average.

[4] Standard revoked.

Under federal and state PSD regulations, increases in ambient air concentrations in Class I areas are limited by PSD Class I Increments. Specifically, emissions associated with a particular development may increase ambient concentrations above baseline levels only within those specific increments developed for sulfur dioxide, PM_{10}, and nitrogen dioxide. PSD Class I Increments are set forth in federal and state PSD regulations, and are shown in Table 4.5. PSD Class II Increments are applicable in Class II areas and are shown in Table 4.3.

Table 4.4. PSD Class I Increments (µg/m^3)

Pollutant	**Averaging Period**	**Class I Increment**
SO_2	Annual	2
	24-hour	5
	3-hour	25
PM_{10}	Annual	4
	24-hour	8
NO_2	Annual	2.5

Modeled concentrations predicted in Federal PSD Class I areas from mining operations on the tract proper were compared to Class I Increments, and cumulative modeling results predicted within Federal PSD Class I areas were compared to Class I Increments. Project and cumulative impacts predicted at sensitive areas designated as PSD Class II areas were compared to Class II Increments.

Tables 4.5-4.8 summarize the Alton tract impact in the Class I areas and at Grand Staircase-Escalante NM. There is one table for each of the operational scenarios, i.e., 200-foot overburden removal, Alternative B; 200-foot overburden removal, Alternative C; 300-foot overburden removal, Alternative B; and 300-foot overburden removal, Alternative C. Impacts were significantly less than the Class I increments in all cases. Impacts at Grand Staircase-Escalante were far below the Class II increments.

Table 4.5a. Alton Tract Far-field Class I and Class II Impacts, 200-foot Overburden, Alternative B

Pollutant	Averaging Period	Bryce Canyon NP	Zion NP			Grand Canyon NP			Capitol Reef NP		
			2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)
PM_{10}	Annual	*	0.09	0.14	0.11	0.01	0.01	0.01	0.01	0.01	0.01
	24-hour	*	1.01	1.17	0.95	0.25	0.15	0.19	0.13	0.17	0.12
SO_2	Annual	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	24-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO_x	Annual	*	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
$PM_{2.5}$	Annual	*	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	24-hour	*	0.04	0.05	0.04	0.02	0.01	0.02	0.01	0.01	0.01
CO	8-hour	*	1.63	1.40	1.46	0.39	0.33	0.36	0.26	0.23	0.27
	1-hour	*	4.91	5.90	5.12	2.37	1.03	1.48	0.54	0.42	0.50

Table 4.5b. Alton Tract Far-field Class I and Class II Impacts, 200-foot Overburden, Alternative B

Class I Increment, High First (Annual), Second-Highs

Pollutant	Averaging Period	Bryce Canyon NP	Zion NP 2001 (ug/m^3)	Zion NP 2002 (ug/m^3)	Zion NP 2003 (ug/m^3)	Grand Canyon NP 2001 (ug/m^3)	Grand Canyon NP 2002 (ug/m^3)	Grand Canyon NP 2003 (ug/m^3)	Capitol Reef NP 2001 (ug/m^3)	Capitol Reef NP 2002 (ug/m^3)	Capitol Reef NP 2003 (ug/m^3)	Class I Increment	Exceed Increment?
PM_{10}	Annual	*	0.09	0.14	0.11	0.01	0.01	0.01	0.01	0.01	0.01	4	N
	24-hour	*	0.85	1.06	0.82	0.11	0.11	0.14	0.12	0.12	0.09	8	N
SO_2	Annual	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2	N
	24-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5	N
	3-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.0	N
NO_x	Annual	*	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.5	N
$PM_{2.5}$	Annual	*	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA
	24-hour	*	0.03	0.04	0.03	0.01	0.01	0.01	0.01	0.01	0.01	NA	NA
CO	8-hour	*	1.12	0.86	1.21	0.28	0.25	0.25	0.16	0.18	0.20	NA	NA
	1-hour	*	3.68	2.35	2.51	1.59	0.79	1.36	0.45	0.41	0.41	NA	NA

Table 4.5c. Alton Tract Far-field Class I and Class II Impacts, 200-foot Overburden, Alternative B

Class II Increment, High First (Annual), Second-Highs (carbon monoxide comparison to significance levels)

Pollutant	Averaging Period	Grand Staircase-Escalante NM			Class II Increment	Exceed Increment?
		2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)		
PM_{10}	Annual	0.026	0.031	0.029	17	N
	24-hour	0.149	0.238	0.226	30	N
SO_2	Annual	0.000	0.000	0.000	20	N
	24-hour	0.000	0.000	0.000	91	N
	3-hour	0.001	0.001	0.001	512	N
NO_x	Annual	0.004	0.003	0.003	25	N
$PM_{2.5}$	Annual	0.002	0.002	0.002	NA	NA
	24-hour	0.012	0.015	0.017	NA	NA
CO	8-hour	0.302	0.411	0.520	500	N
	1-hour	0.745	0.831	0.960	2000	N

Table 4.6a. Alton Tract Far-field Class I and Class II Impacts, 200-foot Overburden, Alternative C

Pollutant	Averaging Period	Bryce Canyon NP	Zion NP			Grand Canyon NP			Capitol Reef NP		
			2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)
PM_{10}	Annual	*	0.09	0.14	0.11	0.01	0.01	0.01	0.01	0.01	0.01
	24-hour	*	1.01	1.17	0.95	0.25	0.15	0.19	0.14	0.17	0.12
SO_2	Annual	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	24-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO_x	Annual	*	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
$PM_{2.5}$	Annual	*	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	24-hour	*	0.04	0.05	0.04	0.02	0.01	0.02	0.01	0.01	0.01
CO	8-hour	*	1.63	1.40	1.46	0.39	0.33	0.36	0.26	0.23	0.27
	1-hour	*	4.91	5.90	5.12	2.37	1.03	1.48	0.54	0.42	0.50

Table 4.6b. Alton Tract Far-field Class I and Class II Impacts, 200-foot Overburden, Alternative C

Class I Increment, High First (Annual), Second-Highs

Pollutant	Averaging Period	Bryce Canyon NP	Zion NP			Grand Canyon NP			Capitol Reef NP			Class I Increment	Exceed Increment?
			2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)		
PM_{10}	Annual	*	0.09	0.14	0.11	0.01	0.01	0.01	0.01	0.01	0.01	4	N
	24-hour	*	0.85	1.06	0.82	0.12	0.12	0.14	0.12	0.13	0.09	8	N
SO_2	Annual	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2	N
	24-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5	N
	3-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25	N
NO_x	Annual	*	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.5	N
$PM_{2.5}$	Annual	*	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA
	24-hour	*	0.03	0.04	0.04	0.01	0.01	0.01	0.01	0.01	0.01	NA	NA
CO	8-hour	*	1.12	0.86	1.21	0.28	0.25	0.25	0.16	0.18	0.20	NA	NA
	1-hour	*	3.68	2.35	2.51	1.59	0.79	1.36	0.45	0.41	0.41	NA	NA

Table 4.6c. Alton Tract Far-field Class I and Class II Impacts, 200-foot Overburden, Alternative C

Class II Increment, High First (Annual), Second-Highs (carbon monoxide comparison to significance levels)

Pollutant	Averaging Period	Grand Staircase-Escalante NM			Class II Increment	Exceed Increment ?
		2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)		
PM_{10}	Annual	0.03	0.03	0.03	17	N
	24-hour	0.15	0.24	0.23	30	N
SO_2	Annual	0.00	0.00	0.00	20	N
	24-hour	0.00	0.00	0.00	91	N
	3-hour	0.00	0.00	0.00	512	N
NO_x	Annual	0.00	0.00	0.00	25	N
$PM_{2.5}$	Annual	0.00	0.00	0.00	NA	NA
	24-hour	0.01	0.02	0.02	NA	NA
CO	8-hour	0.30	0.41	0.52	500	N
	1-hour	0.74	0.83	0.96	2000	N

Table 4.7a. Alton Tract Far-field Class I and Class II Impacts, 300-foot Overburden, Alternative B

Class I High First-Highs

Pollutant	Averaging Period	Bryce Canyon NP	Zion NP			Grand Canyon NP			Capitol Reef NP		
		*	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)
PM_{10}	Annual	*	0.09	0.14	0.11	0.01	0.01	0.01	0.01	0.01	0.01
	24-hour	*	1.01	1.17	0.95	0.29	0.16	0.21	0.14	0.18	0.13
SO_2	Annual	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	24-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO_x	Annual	*	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
$PM_{2.5}$	Annual	*	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	24-hour	*	0.05	0.05	0.04	0.03	0.01	0.02	0.01	0.01	0.01
CO	8-hour	*	3.00	2.49	2.65	0.79	0.58	0.63	0.44	0.39	0.49
	1-hour	*	11.16	6.23	10.31	5.04	2.02	2.89	0.92	0.98	0.89

Table 4.7b. Alton Tract Far-field Class I and Class II Impacts, 300-foot Overburden, Alternative B

Class I Increment, High First (Annual), Second-Highs

Pollutant	Averaging Period	Bryce Canyon NP	Zion NP			Grand Canyon NP			Capitol Reef NP			Class I Increment	Exceed Increment ?
		*	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)		
PM_{10}	Annual	*	0.09	0.14	0.11	0.01	0.01	0.01	0.01	0.01	0.01	4	N
	24-hour	*	0.85	1.06	0.82	0.13	0.13	0.15	0.12	0.13	0.10	8	N
SO_2	Annual	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2	N
	24-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5	N
	3-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25	N
NO_x	Annual	*	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	2.5	N
$PM_{2.5}$	Annual	*	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA
	24-hour	*	0.04	0.04	0.04	0.01	0.01	0.01	0.01	0.01	0.01	NA	NA
CO	8-hour	*	2.04	1.54	2.27	0.54	0.42	0.44	0.29	0.30	0.37	NA	NA
	1-hour	*	6.95	4.54	5.60	3.17	1.42	2.70	0.76	0.73	0.70	NA	NA

Table 4.7c. Alton Tract Far-field Class I and Class II Impacts, 300-foot Overburden, Alternative B

Class II Increment, High First (Annual), Second-Highs (carbon monoxide comparison to significance levels)

Pollutant	Averaging Period	Grand Staircase-Escalante NM			Class II Increment	Exceed Increment?
		2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)		
PM_{10}	Annual	0.03	0.03	0.03	17	N
	24-hour	0.15	0.24	0.23	30	N
SO_2	Annual	0.00	0.00	0.00	20	N
	24-hour	0.00	0.00	0.00	91	N
	3-hour	0.00	0.00	0.00	512	N
NO_x	Annual	0.01	0.01	0.01	25	N
$PM_{2.5}$	Annual	0.00	0.00	0.00	NA	NA
	24-hour	0.01	0.02	0.02	NA	NA
CO	8-hour	0.56	0.72	0.93	500	N
	1-hour	1.32	1.65	1.78	2000	N

Table 4.8a. Alton Tract Far-field Class I and Class II Impacts, 300-foot overburden, Alternative C

Class I High First-Highs

Pollutant	Averaging Period	Bryce Canyon NP	Zion NP			Grand Canyon NP			Capitol Reef NP		
		*	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)
PM_{10}	Annual	*	0.09	0.14	0.11	0.01	0.01	0.01	0.01	0.01	0.01
	24-hour	*	1.01	1.17	0.95	0.30	0.17	0.21	0.14	0.18	0.13
SO_2	Annual	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	24-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO_x	Annual	*	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
$PM_{2.5}$	Annual	*	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	24-hour	*	0.05	0.05	0.05	0.03	0.01	0.02	0.01	0.01	0.01
CO	8-hour	*	3.00	2.49	2.65	0.79	0.58	0.63	0.44	0.39	0.49
	1-hour	*	11.16	6.23	10.31	5.04	2.02	2.89	0.92	0.98	0.89

Table 4.8b. Alton Tract Far-field Class I and Class II Impacts, 300-foot overburden, Alternative C

Class I Increment, High First (Annual), Second-Highs

Pollutant	Averaging Period	Bryce Canyon NP	Zion NP			Grand Canyon NP			Capitol Reef NP			Class I Increment	Exceed Increment ?
		*	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)		
PM_{10}	Annual	*	0.09	0.14	0.11	0.01	0.01	0.01	0.01	0.01	0.01	4	N
	24-hour	*	0.85	1.06	0.82	0.13	0.13	0.15	0.12	0.13	0.10	8	N
SO_2	Annual	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2	N
	24-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5	N
	3-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25	N
NO_x	Annual	*	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	2.5	N
$PM_{2.5}$	Annual	*	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA
	24-hour	*	0.04	0.04	0.04	0.01	0.01	0.01	0.01	0.01	0.01	NA	NA
CO	8-hour	*	2.04	1.54	2.27	0.54	0.42	0.44	0.29	0.30	0.37	NA	NA
	1-hour	*	6.95	4.54	5.60	3.17	1.42	2.70	0.76	0.73	0.70	NA	NA

Table 4.8c. Alton Tract Far-field Class I and Class II Impacts, 300-foot overburden, Alternative C

Class II Increment, High First (Annual), Second-Highs (carbon monoxide comparison to significance levels)

Pollutant	Averaging Period	Grand Staircase-Escalante NM			Class II Increment	Exceed Increment ?
		2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)		
PM_{10}	Annual	0.03	0.03	0.03	17	N
	24-hour	0.16	0.24	0.23	30	N
SO_2	Annual	0.00	0.00	0.00	20	N
	24-hour	0.00	0.00	0.00	91	N
	3-hour	0.00	0.00	0.00	512	N
NO_x	Annual	0.01	0.01	0.01	25	N
$PM_{2.5}$	Annual	0.00	0.00	0.00	NA	NA
	24-hour	0.02	0.02	0.02	NA	NA
CO	8-hour	0.56	0.72	0.93	500	N
	1-hour	1.32	1.65	1.78	2000	N

Because the results of the Alton alone modeling showed values far below the relevant increments, cumulative results were only produced for the maximum emission rate case (300-foot overburden removal, Alternative C) and are presented in Table 4.9. Once again the impacts are significantly below both the Class I and Class II increments.

Even though there are no increments for $PM_{2.5}$ or carbon monoxide, results are presented in the above tables so that a general impression of impact levels can be conveyed.

These demonstrations are informational only and not regulatory PSD increment consumption analyses, which would be completed as necessary during state permitting processes.

Table 4.9a. Cumulative Far-field Class I and Class II Impacts, 300-foot Overburden, Alternative C

Class I Increment, High First (Annual), Second-Highs

Pollutant	Averaging Period	Bryce Canyon NP	Zion NP			Grand Canyon NP			Capitol Reef NP			Class I Increment	Exceed Increment ?
		*	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)	2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)		
PM_{10}	Annual	*	0.09	0.15	0.11	0.01	0.02	0.01	0.02	0.02	0.02	4	N
	24-hour	*	0.85	1.06	0.82	0.13	0.14	0.16	0.15	0.18	0.14	8	N
SO_2	Annual	*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2	N
	24-hour	*	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	5	N
	3-hour	*	0.01	0.01	0.00	0.01	0.01	0.01	0.06	0.06	0.04	25	N
NO_x	Annual	*	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.01	2.5	N
$PM_{2.5}$	Annual	*	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA
	24-hour	*	0.06	0.06	0.09	0.01	0.02	0.02	0.05	0.04	0.04	NA	NA
CO	8-hour	*	11.00	13.47	20.18	25.05	23.89	20.33	15.55	16.36	16.26	NA	NA
	1-hour	*	65.05	88.59	107.81	55.85	59.20	50.62	42.41	33.56	37.27	NA	NA

Table 4.9b. Cumulative Far-field Class I and Class II Impacts, 300-foot Overburden, Alternative C

Class II Increment, High First (Annual), Second-Highs (carbon monoxide comparison to significance levels)

Pollutant	Averaging Period	Grand Staircase-Escalante NM			Class II Increment	Exceed Increment ?
		2001 (ug/m^3)	2002 (ug/m^3)	2003 (ug/m^3)		
PM_{10}	Annual	0.03	0.04	0.03	17	N
	24-hour	0.17	0.25	0.23	30	N
SO_2	Annual	0.00	0.00	0.00	20	N
	24-hour	0.01	0.01	0.01	91	N
	3-hour	0.07	0.04	0.06	512	N
NO_x	Annual	-0.04	-0.01	-0.02	25	N
$PM_{2.5}$	Annual	0.00	0.00	0.00	NA	NA
	24-hour	0.03	0.03	0.02	NA	NA
CO	8-hour	52.04	38.29	38.83	500	N
	1-hour	117.55	106.03	117.59	2000	N

4.3.1.1 CUMULATIVE CONCENTRATIONS IN THE NEAR FIELD

Receptors were set in the near field to assess impacts from far field cumulative sources on near field receptors near the tract. Figures 4.1 and 4.2 illustrate the results of this analysis. Maximum near field impacts due to near field cumulative sources occurred north of the Alton tract along the haul road as described in Section 3.The PM_{10} impacts near the tract from the far field cumulative sources would be 0.01 to 0.02 µg/m^3, whereas the NO_x impacts would be -0.01 to -0.02 µg/m^3. Negative NO_x values indicate an improvement due to the large reduction in NO_x emissions at the Navajo Generating Station in New Mexico. The results indicate that there would be virtually no impact in the near field due to the far field cumulative sources.

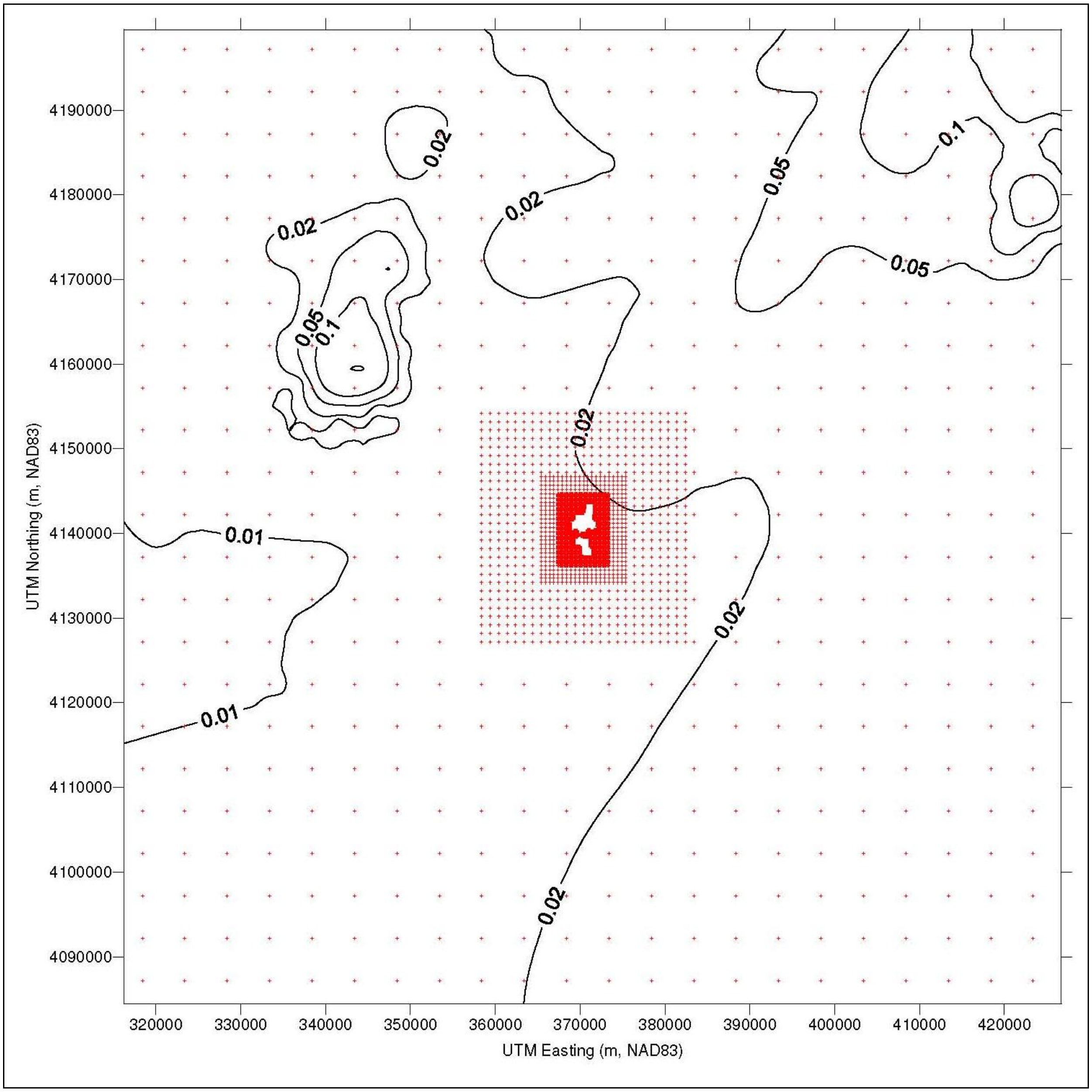


Figure 4.1. Maximum 2001-2003 PM_{10} impact ($\mu g/m^3$) from far-field sources.

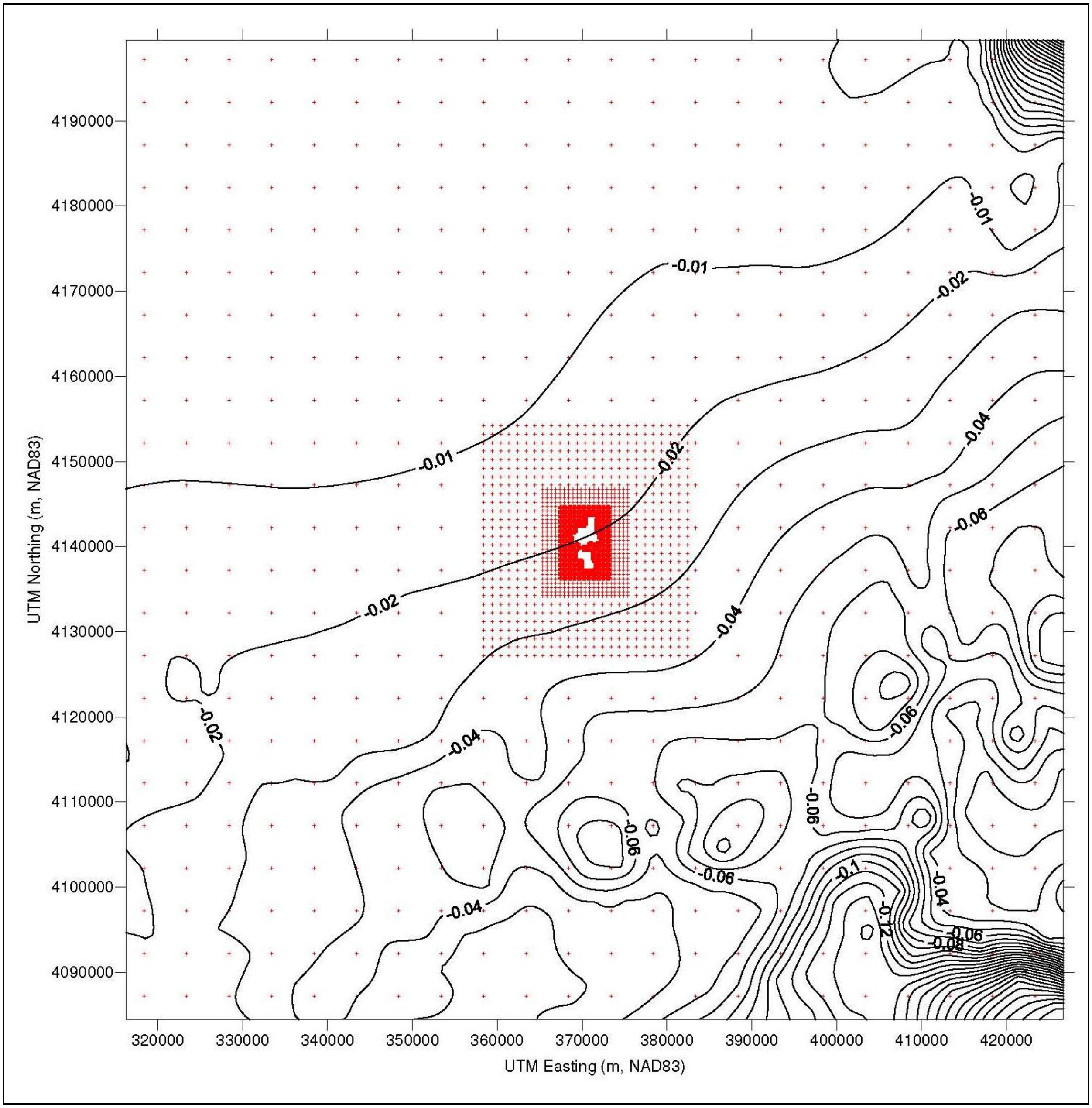


Figure 4.2. Maximum 2001–2003 NO_x impact (µg/m^3) from far-field sources.

4.3.2 *Deposition*

The POSTUTIL utility provided with the CALPUFF modeling system was used following IWAQM guidance to estimate total S and N fluxes from CALPUFF-predicted wet and dry fluxes of sulfur dioxide, SO_4, nitrogen oxide, nitrate (NO_3), and nitric acid (HNO_3). CALPOST was used to summarize the annual S and N deposition values from the POSTUTIL program.

Maximum predicted S and N deposition impacts were estimated for two direct project and cumulative source scenarios: the 200-foot overburden under Alternative B and the 300-foot overburden under Alternative C. As above, this approach gives a good representation of impacts from both the lowest and highest Alton emission scenarios.

Predicted direct project impacts were compared to the minimum "green line" deposition analysis thresholds for total N and S deposition in the western U.S., which are defined as 3.0 kilogram per hectare per year (kg/ha-year) for both N and S (Fox et al, 1989). The green line represents a value below which no significant change in the forest ecosystem will occur. These results are presented in Tables 4.10-4.29. Impacts for both S and N deposition are below the minimum green line value in all cases.

Table 4.10a. Soils and Vegetation Deposition Impacts at Bryce Canyon, 200-foot Overburden, Alternative B

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	2.32E-13	3,600	8,760	7.32E-06	7.32E-05
2002	2.55E-13	3,600	8,760	8.05E-06	8.05E-05
2003	2.68E-13	3,600	8,760	8.45E-06	8.45E-05

Table 4.10b. Soils and Vegetation Deposition Impacts at Bryce Canyon, 200-foot Overburden, Alternative B

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	3.11E-11	3,600	8,760	9.82E-04	9.82E-03
2002	3.94E-11	3,600	8,760	1.24E-03	1.24E-02
2003	3.71E-11	3,600	8,760	1.17E-03	1.17E-02

Table 4.10c. Soils and Vegetation Deposition Impacts at Bryce Canyon, 200-foot Overburden, Alternative B

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	7.32E-05	2001	9.82E-03
2002	8.05E-05	2002	1.24E-02
2003	8.45E-05	2003	1.17E-02
Max. Annual Dep.	8.45E-05	Max. Annual Dep.	1.24E-02
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.11a. Soils And Vegetation Deposition Impacts At Bryce Canyon, 300-foot Overburden, Alternative C

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	2.57E-13	3,600	8,760	8.10E-06	8.10E-05
2002	2.81E-13	3,600	8,760	8.86E-06	8.86E-05
2003	2.95E-13	3,600	8,760	9.30E-06	9.30E-05

Table 4.11b. Soils And Vegetation Deposition Impacts At Bryce Canyon, 300-foot Overburden, Alternative C

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	6.64E-11	3,600	8,760	2.10E-03	2.10E-02
2002	8.29E-11	3,600	8,760	2.62E-03	2.62E-02
2003	7.68E-11	3,600	8,760	2.42E-03	2.42E-02

Table 4.11c. Soils And Vegetation Deposition Impacts At Bryce Canyon, 300-foot Overburden, Alternative C

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	8.10E-05	2001	2.10E-02
2002	8.86E-05	2002	2.62E-02
2003	9.30E-05	2003	2.42E-02
Max. Annual Dep.	9.30E-05	Max. Annual Dep.	2.62E-02
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.12a. Soils And Vegetation Deposition Impacts At Capitol Reef, 200-foot Overburden, Alternative B

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	1.09E-14	3,600	8,760	3.44E-07	3.44E-06
2002	9.34E-15	3,600	8,760	2.94E-07	2.94E-06
2003	1.13E-14	3,600	8,760	3.57E-07	3.57E-06

Table 4.12b. Soils And Vegetation Deposition Impacts At Capitol Reef, 200-foot Overburden, Alternative B

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	1.33E-12	3,600	8,760	4.21E-05	4.21E-04
2002	1.13E-12	3,600	8,760	3.55E-05	3.55E-04
2003	1.37E-12	3,600	8,760	4.32E-05	4.32E-04

Table 4.12c. Soils And Vegetation Deposition Impacts At Capitol Reef, 200-foot Overburden, Alternative B

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	3.44E-06	2001	4.21E-04
2002	2.94E-06	2002	3.55E-04
2003	3.57E-06	2003	4.32E-04
Max. Annual Dep.	3.57E-06	Max. Annual Dep.	4.32E-04
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.13a. Soils And Vegetation Deposition Impacts At Capitol Reef, 300-foot Overburden, Alternative C

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	1.21E-14	3,600	8,760	3.83E-07	3.83E-06
2002	1.03E-14	3,600	8,760	3.26E-07	3.26E-06
2003	1.26E-14	3,600	8,760	3.98E-07	3.98E-06

Table 4.13b. Soils And Vegetation Deposition Impacts At Capitol Reef, 300-foot Overburden, Alternative C

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	2.65E-12	3,600	8,760	8.35E-05	8.35E-04
2002	2.18E-12	3,600	8,760	6.88E-05	6.88E-04
2003	2.76E-12	3,600	8,760	8.72E-05	8.72E-04

Table 4.13c. Soils And Vegetation Deposition Impacts At Capitol Reef, 300-foot Overburden, Alternative C

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	3.83E-06	2001	8.35E-04
2002	3.26E-06	2002	6.88E-04
2003	3.98E-06	2003	8.72E-04
Max. Annual Dep.	3.98E-06	Max. Annual Dep.	8.72E-04
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.14a. Soils And Vegetation Deposition Impacts At Escalante, 200-foot Overburden, Alternative B

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	2.63E-14	3,600	8,760	8.30E-07	8.30E-06
2002	2.86E-14	3,600	8,760	9.02E-07	9.02E-06
2003	3.00E-14	3,600	8,760	9.46E-07	9.46E-06

Table 4.14b. Soils And Vegetation Deposition Impacts At Escalante, 200-foot Overburden, Alternative B

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	3.832E-12	3,600	8,760	1.21E-04	1.21E-03
2002	4.038E-12	3,600	8,760	1.27E-04	1.27E-03
2003	4.115E-12	3,600	8,760	1.30E-04	1.30E-03

Table 4.14c. Soils And Vegetation Deposition Impacts At Escalante, 200-foot Overburden, Alternative B

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	8.30E-06	2001	1.21E-03
2002	9.02E-06	2002	1.27E-03
2003	9.46E-06	2003	1.30E-03
Max. Annual Dep.	9.46E-06	Max. Annual Dep.	1.30E-03
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.15a. Soils and Vegetation Deposition Impacts at Escalante, 300-foot Overburden, Alternative C

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	2.92E-14	3,600	8,760	9.21E-07	9.21E-06
2002	3.16E-14	3,600	8,760	9.98E-07	9.98E-06
2003	3.33E-14	3,600	8,760	1.05E-06	1.05E-05

Table 4.15b. Soils and Vegetation Deposition Impacts at Escalante, 300-foot Overburden, Alternative C

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	6.95E-12	3,600	8,760	2.19E-04	2.19E-03
2002	7.45E-12	3,600	8,760	2.35E-04	2.35E-03
2003	7.62E-12	3,600	8,760	2.40E-04	2.40E-03

Table 4.15c. Soils and Vegetation Deposition Impacts at Escalante, 300-foot Overburden, Alternative C

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	9.21E-06	2001	2.19E-03
2002	9.98E-06	2002	2.35E-03
2003	1.05E-05	2003	2.40E-03
Max. Annual Dep.	1.05E-05	Max. Annual Dep.	2.40E-03
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.16a. Soils and Vegetation Deposition Impacts at Grand Canyon, 200-foot Overburden, Alternative B

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	7.66E-15	3,600	8,760	2.42E-07	2.42E-06
2002	8.15E-15	3,600	8,760	2.57E-07	2.57E-06
2003	8.83E-15	3,600	8,760	2.79E-07	2.79E-06

Table 4.16b. Soils and Vegetation Deposition Impacts at Grand Canyon, 200-foot Overburden, Alternative B

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	8.86E-13	3,600	8,760	2.79E-05	2.79E-04
2002	8.79E-13	3,600	8,760	2.77E-05	2.77E-04
2003	9.15E-13	3,600	8,760	2.89E-05	2.89E-04

Table 4.16c. Soils and Vegetation Deposition Impacts at Grand Canyon, 200-foot Overburden, Alternative B

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	2.42E-06	2001	2.79E-04
2002	2.57E-06	2002	2.77E-04
2003	2.79E-06	2003	2.89E-04
Max. Annual Dep.	2.79E-06	Max. Annual Dep.	2.89E-04
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.17a. Soils And Vegetation Deposition Impacts At Grand Canyon, 300-foot Overburden, Alternative C

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	8.64E-15	3,600	8,760	2.73E-07	2.73E-06
2002	9.11E-15	3,600	8,760	2.87E-07	2.87E-06
2003	9.91E-15	3,600	8,760	3.13E-07	3.13E-06

Table 4.17b. Soils And Vegetation Deposition Impacts At Grand Canyon, 300-foot Overburden, Alternative C

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	1.90E-12	3,600	8,760	5.99E-05	5.99E-04
2002	1.84E-12	3,600	8,760	5.80E-05	5.80E-04
2003	1.93E-12	3,600	8,760	6.09E-05	6.09E-04

Table 4.17c. Soils And Vegetation Deposition Impacts At Grand Canyon, 300-foot Overburden, Alternative C

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	2.73E-06	2001	5.99E-04
2002	2.87E-06	2002	5.80E-04
2003	3.13E-06	2003	6.09E-04
Max. Annual Dep.	3.13E-06	Max. Annual Dep.	6.09E-04
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.18a. Soils And Vegetation Deposition Impacts At Zion, 200-foot Overburden, Alternative B

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m²-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m²-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	7.36E-14	3,600	8,760	2.32E-06	2.32E-05
2002	6.06E-14	3,600	8,760	1.91E-06	1.91E-05
2003	5.81E-14	3,600	8,760	1.83E-06	1.83E-05

Table 4.18b. Soils And Vegetation Deposition Impacts At Zion, 200-foot Overburden, Alternative B

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m²-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m²-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	1.21E-11	3,600	8,760	3.82E-04	3.82E-03
2002	9.51E-12	3,600	8,760	3.00E-04	3.00E-03
2003	9.10E-12	3,600	8,760	2.87E-04	2.87E-03

Table 4.18c. Soils And Vegetation Deposition Impacts At Zion, 200-foot Overburden, Alternative B

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	2.32E-05	2001	3.82E-03
2002	1.91E-05	2002	3.00E-03
2003	1.83E-05	2003	2.87E-03
Max. Annual Dep.	2.32E-05	Max. Annual Dep.	3.82E-03
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.19a. Soils And Vegetation Deposition Impacts At Zion, 300-foot Overburden, Alternative C

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	8.40E-14	3,600	8,760	2.65E-06	2.65E-05
2002	6.77E-14	3,600	8,760	2.14E-06	2.14E-05
2003	6.49E-14	3,600	8,760	2.05E-06	2.05E-05

Table 4.19b. Soils And Vegetation Deposition Impacts At Zion, 300-foot Overburden, Alternative C

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	2.77E-11	3,600	8,760	8.73E-04	8.73E-03
2002	2.09E-11	3,600	8,760	6.58E-04	6.58E-03
2003	1.97E-11	3,600	8,760	6.22E-04	6.22E-03

Table 4.19c. Soils And Vegetation Deposition Impacts At Zion, 300-foot Overburden, Alternative C

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	2.65E-05	2001	8.73E-03
2002	2.14E-05	2002	6.58E-03
2003	2.05E-05	2003	6.22E-03
Max. Annual Dep.	2.65E-05	Max. Annual Dep.	8.73E-03
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	5.0000E-03
Above Green Line?	NO	Above Green Line?	NO

Table 4.20a. Soils and Vegetation Deposition Impacts at Bryce Canyon, 200-foot Overburden, Alternative B, Cumulative

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	6.06E-13	3,600	8,760	1.91E-05	1.91E-04
2002	9.22E-13	3,600	8,760	2.91E-05	2.91E-04
2003	8.19E-13	3,600	8,760	2.58E-05	2.58E-04

Table 4.20b. Soils and Vegetation Deposition Impacts at Bryce Canyon, 200-foot Overburden, Alternative B, Cumulative

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2002	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2003	0.0E+00	3,600	8,760	0.0E+00	0.0E+00

Table 4.20c. Soils and Vegetation Deposition Impacts at Bryce Canyon, 200-foot Overburden, Alternative B, Cumulative

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	1.91E-04	2001	0.0E+00
2002	2.91E-04	2002	0.0E+00
2003	2.58E-04	2003	0.0E+00
Max. Annual Dep.	2.91E-04	Max. Annual Dep.	0.0E+00
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.21a. Soils and Vegetation Deposition Impacts at Bryce Canyon, 300-foot Overburden, Alternative C, Cumulative

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	6.30E-13	3,600	8,760	1.99E-05	1.99E-04
2002	9.47E-13	3,600	8,760	2.99E-05	2.99E-04
2003	8.45E-13	3,600	8,760	2.67E-05	2.67E-04

Table 4.21b. Soils and Vegetation Deposition Impacts at Bryce Canyon, 300-foot Overburden, Alternative C, Cumulative

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	0.00E+00	3,600	8,760	0.00E+00	0.00E+00
2002	3.49E-11	3,600	8,760	1.10E-03	1.10E-02
2003	1.75E-11	3,600	8,760	5.53E-04	5.53E-03

Table 4.21c. Soils and Vegetation Deposition Impacts at Bryce Canyon, 300-foot Overburden, Alternative C, Cumulative

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	1.99E-04	2001	0.00E+00
2002	2.99E-04	2002	1.10E-02
2003	2.67E-04	2003	5.53E-03
Max. Annual Dep.	2.99E-04	Max. Annual Dep.	1.10E-02
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.22a. Soils and Vegetation Deposition Impacts at Capitol Reef, 200-foot Overburden, Alternative B, Cumulative

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	1.84E-12	3,600	8,760	5.80E-05	5.80E-04
2002	2.03E-12	3,600	8,760	6.40E-05	6.40E-04
2003	2.12E-12	3,600	8,760	6.67E-05	6.67E-04

Table 4.22b. Soils and Vegetation Deposition Impacts at Capitol Reef, 200-foot Overburden, Alternative B, Cumulative

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2002	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2003	0.0E+00	3,600	8,760	0.0E+00	0.0E+00

Table 4.22c. Soils and Vegetation Deposition Impacts at Capitol Reef, 200-foot Overburden, Alternative B, Cumulative

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	5.80E-04	2001	0.0E+00
2002	6.40E-04	2002	0.0E+00
2003	6.67E-04	2003	0.0E+00
Max. Annual Dep.	6.67E-04	Max. Annual Dep.	0.0E+00
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.23a. Soils and Vegetation Deposition Impacts at Capitol Reef, 300-foot Overburden, Alternative C, Cumulative

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	1.84E-12	3,600	8,760	5.80E-05	5.80E-04
2002	2.03E-12	3,600	8,760	6.40E-05	6.40E-04
2003	2.12E-12	3,600	8,760	6.68E-05	6.68E-04

Table 4.23b. Soils and Vegetation Deposition Impacts at Capitol Reef, 300-foot Overburden, Alternative C, Cumulative

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2002	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2003	0.0E+00	3,600	8,760	0.0E+00	0.0E+00

Table 4.23c. Soils and Vegetation Deposition Impacts at Capitol Reef, 300-foot Overburden, Alternative C, Cumulative

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	5.80E-04	2001	0.0E+00
2002	6.40E-04	2002	0.0E+00
2003	6.68E-04	2003	0.0E+00
Max. Annual Dep.	6.68E-04	Max. Annual Dep.	0.0E+00
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.24a. Soils and Vegetation Deposition Impacts at Escalante, 200-foot Overburden, Alternative B, Cumulative

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	2.60E-12	3,600	8,760	8.19E-05	8.19E-04
2002	2.81E-12	3,600	8,760	8.86E-05	8.86E-04
2003	3.04E-12	3,600	8,760	9.58E-05	9.58E-04

Table 4.24b. Soils and Vegetation Deposition Impacts at Escalante, 200-foot Overburden, Alternative B, Cumulative

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2002	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2003	0.0E+00	3,600	8,760	0.0E+00	0.0E+00

Table 4.24c. Soils and Vegetation Deposition Impacts at Escalante, 200-foot Overburden, Alternative B, Cumulative

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	8.19E-04	2001	0.0E+00
2002	8.86E-04	2002	0.0E+00
2003	9.58E-04	2003	0.0E+00
Max. Annual Dep.	9.58E-04	Max. Annual Dep.	0.0E+00
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.25a. Soils and Vegetation Deposition Impacts at Escalante, 300-foot Overburden, Alternative C, Cumulative

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	2.60E-12	3,600	8,760	8.20E-05	8.20E-04
2002	2.81E-12	3,600	8,760	8.86E-05	8.86E-04
2003	3.04E-12	3,600	8,760	9.59E-05	9.59E-04

Table 4.25b. Soils and Vegetation Deposition Impacts at Escalante, 300-foot Overburden, Alternative C, Cumulative

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2002	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2003	0.0E+00	3,600	8,760	0.0E+00	0.0E+00

Table 4.25c. Soils and Vegetation Deposition Impacts at Escalante, 300-foot Overburden, Alternative C, Cumulative

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	8.20E-04	2001	0.0E+00
2002	8.86E-04	2002	0.0E+00
2003	9.59E-04	2003	0.0E+00
Max. Annual Dep.	9.59E-04	Max. Annual Dep.	0.0E+00
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.26a. Soils and Vegetation Deposition Impacts at Grand Canyon, 200-foot Overburden, Alternative B, Cumulative

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	1.96E-13	3,600	8,760	6.19E-06	6.19E-05
2002	2.94E-13	3,600	8,760	9.28E-06	9.28E-05
2003	2.76E-13	3,600	8,760	8.69E-06	8.69E-05

Table 4.26b. Soils and Vegetation Deposition Impacts at Grand Canyon, 200-foot Overburden, Alternative B, Cumulative

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2002	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2003	0.0E+00	3,600	8,760	0.0E+00	0.0E+00

Table 4.26c. Soils and Vegetation Deposition Impacts at Grand Canyon, 200-foot Overburden, Alternative B, Cumulative

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	6.19E-05	2001	0.0E+00
2002	9.28E-05	2002	0.0E+00
2003	8.69E-05	2003	0.0E+00
Max. Annual Dep.	9.28E-05	Max. Annual Dep.	0.0E+00
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.27a. Soils and Vegetation Deposition Impacts at Grand Canyon, 300-foot Overburden, Alternative C, Cumulative

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	1.97E-13	3,600	8,760	6.22E-06	6.22E-05
2002	2.95E-13	3,600	8,760	9.31E-06	9.31E-05
2003	2.77E-13	3,600	8,760	8.72E-06	8.72E-05

Table 4.27b. Soils and Vegetation Deposition Impacts at Grand Canyon, 300-foot Overburden, Alternative C, Cumulative

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2002	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2003	0.0E+00	3,600	8,760	0.0E+00	0.0E+00

Table 4.27c. Soils and Vegetation Deposition Impacts at Grand Canyon, 300-foot Overburden, Alternative C, Cumulative

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	6.22E-05	2001	0.0E+00
2002	9.31E-05	2002	0.0E+00
2003	8.72E-05	2003	0.0E+00
Max. Annual Dep.	9.31E-05	Max. Annual Dep.	0.0E+00
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.28a. Soils and Vegetation Deposition Impacts at Zion, 200-foot Overburden, Alternative B, Cumulative

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	2.91E-13	3,600	8,760	9.18E-06	9.18E-05
2002	2.87E-13	3,600	8,760	9.05E-06	9.05E-05
2003	2.79E-13	3,600	8,760	8.80E-06	8.80E-05

Table 4.28b. Soils and Vegetation Deposition Impacts at Zion, 200-foot Overburden, Alternative B, Cumulative

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2002	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2003	0.0E+00	3,600	8,760	0.0E+00	0.0E+00

Table 4.28c. Soils and Vegetation Deposition Impacts at Zion, 200-foot Overburden, Alternative B, Cumulative

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	9.18E-05	2001	0.0E+00
2002	9.05E-05	2002	0.0E+00
2003	8.80E-05	2003	0.0E+00
Max. Annual Dep.	9.18E-05	Max. Annual Dep.	0.0E+00
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Table 4.29a. Soils and Vegetation Deposition Impacts at Zion, 300-foot Overburden, Alternative C, Cumulative

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	3.02E-13	3,600	8,760	9.51E-06	9.51E-05
2002	2.94E-13	3,600	8,760	9.27E-06	9.27E-05
2003	2.86E-13	3,600	8,760	9.02E-06	9.02E-05

Table 4.29b. Soils and Vegetation Deposition Impacts at Zion, 300-foot Overburden, Alternative C, Cumulative

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2002	0.0E+00	3,600	8,760	0.0E+00	0.0E+00
2003	0.0E+00	3,600	8,760	0.0E+00	0.0E+00

Table 4.29c. Soils and Vegetation Deposition Impacts at Zion, 300-foot Overburden, Alternative C, Cumulative

3. Comparison of Maximum Total Annual Sulfur (S) and Nitrogen (N) Deposition to the Minimum Green Line Value for each element

Model Year	Dry and Wet Annual S Deposition (kg/ha-yr)	Model Year	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	9.51E-05	2001	0.0E+00
2002	9.27E-05	2002	0.0E+00
2003	9.02E-05	2003	0.0E+00
Max. Annual Dep.	9.51E-05	Max. Annual Dep.	0.0E+00
Green Line (kg/ha-yr)	3.00	Green Line (kg/ha-yr)	3.00
Above Green Line?	NO	Above Green Line?	NO

Total deposition impacts from direct project and regional sources were also compared to the Fox et al, green lines, and are presented in Tables 4.20-4.29. Background deposition values were never provided, and hence not considered. Once again all S deposition impacts are below the green line thresholds. All N deposition impacts are also considerably below the green line values. The improvements in the cumulative cases versus the Alton alone cases is due to the large nitrogen oxide emission decrease from the Navajo generating station. In fact, the majority of the N deposition values turned out to be 0 - signifying that the Navajo emission decrease over the annual period exceeded the increased impacts from other sources. CALPUFF was used to predict annual deposition fluxes of S and N at Navajo Lake for one scenario - the 300-foot overburden Alternative C case. This is the highest emission scenario for Alton, and provides a conservative estimate. These results are shown in Table 4.30. However, because no data on lake chemistry at Navajo Lake are available, no estimates of ANC change in Navajo Lake were performed.

Table 4.30a. Deposition Impacts at Navajo Lake, 300-foot Overburden, Alternative C (tract only)

1. Annual Total Sulfur (S) Deposition estimated by CALPOST from dry and wet deposition of SO_2 and $(NH_4)_2SO_4$ modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Sulfur Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual S Deposition (g/m^2-yr)	Dry and Wet Annual S Deposition (kg/ha-yr)
2001	5.39E-14	3,600	8,760	1.70E-06	1.70E-05
2002	5.01E-14	3,600	8,760	1.58E-06	1.58E-05
2003	4.59E-14	3,600	8,760	1.45E-06	1.45E-05

Table 4.30b. Deposition Impacts at Navajo Lake, 300-foot Overburden, Alternative C (tract only)

2. Annual Total Nitrogen (N) Deposition estimated by CALPOST from dry and wet deposition of $(NH_4)_2SO_4$, NOx, and HNO_3 modeled by CALPUFF

Model Year	Maximum Average Annual Dry and Wet Nitrogen Deposition (g/m^2-s)	No. of Seconds in One Hour	No. of Hours in One Year	Dry and Wet Annual N Deposition (g/m^2-yr)	Dry and Wet Annual N Deposition (kg/ha-yr)
2001	1.39E-11	3,600	8,760	4.40E-04	4.40E-03
2002	1.19E-11	3,600	8,760	3.74E-04	3.74E-03
2003	1.04E-11	3,600	8,760	3.29E-04	3.29E-03

4.3.3 *Visibility*

CALPOST was run using the FLAG data to calculate the change in light extinction from natural background conditions. This procedure computes light extinction changes from seasonal estimates of natural background aerosol concentrations and either monthly relative humidity factors (method 6) or hourly relative humidity data from the CALMET. visb.dat file (method 2), and CALPUFF-predicted particle species concentrations. Seasonal background extinction values used for the FLAG method are shown in Table 4.3. Those values were input to CALPOST as variables BKSO4 (dry hygroscopic - the value from Table 4.3 divided by 3) and BKSOIL (non-hygroscopic). Using these parameters, CALPOST calculated the change in daily (24-hour) visibility at each receptor, with the results reported in percent change in light extinction and change in deciview (dv). The CALPOST switch "MVISBK" was set to 6 in one test (method 6) and set to 2 in the other test (method 2). The relative humidity data cutoff in CALPOST was set to 90 for the method 2 test. The FLAG method conservatively assumes that the seasonal natural visibility conditions occur every day during the entire season.

Atmospheric light extinction relative to background conditions is used to measure regional haze. Analysis thresholds for atmospheric light extinction are set forth in FLAG (2000). The thresholds are defined as 5% and 10% of the reference background visibility (or 0.5 and 1.0 dv) for sources as a result of mining operations on the tract alone and cumulative source impacts, respectively. In general, if impacts are greater than these thresholds, FLMs may consider the conditions (magnitude, frequency, duration, etc.) of the impact on a case-by-case basis. These thresholds and the FLAG guidelines were developed for NSR applications where an AQRV analysis is required as part of a PSD permit application.

Visibility results for the Alton tract alone are presented in Table 4.31 (200-foot overburden removal, Alternative B) and Table 4.32 (300-foot overburden removal, Alternative C). These tables represent both the lowest and highest emission cases, and summarize method 2 and method 6 processing. For the 200-foot overburden scenario under Alternative B, only Zion NP has an extinction change that exceeds 5%. Results from the 300-foot overburden scenario under Alternative C show that in addition to Zion NP, Grand Canyon NP and Grand Staircase-Escalante also have extinctions in excess of 5%. There are no extinction changes exceeding 10% in any of the areas of interest (maximum change of 5.45% at Grand Canyon).

Cumulative visibility results are presented in Tables 4.33 and 4.34 (the same two Alton emission cases as above). For the 200-foot overburden scenario under Alternative B, no areas with the exceptions of Capital Reef and Bryce Canyon National Parks exceed the 10% change threshold. The same holds true for the 300-foot overburden scenario under Alternative C. Capitol Reef NP has visibility extinction changes that surpass 10%, on only one day during the modeled three year period(maximum of 17.56% for method 2 and 10.74% for method 6). This impact is due to one of the regional sources, as the Alton alone impacts at Capitol Reef NP were small (maximum change of 1.80%). This single impact at Capitol Reef occurred on Dec 4, 2001 – and was located at receptor number 1431 – on the northeast side of the park (the opposite side from the Alton complex). Bryce Canyon had a total of four days using method 2 processing that exceeded a 10% change for the 300-foot overburden scenario, and also four days using method 6. For the 200-foot overburden case, Bryce Canyon only had one day that exceeded 10%, and that was using method 2.

Table 4.31. Tract-only Visibility Impacts, 200-foot Overburden, Alternative B

METHOD 2	**Year**			**Year**			**Year**		
	2001	**2001**	**2001**	**2002**	**2002**	**2002**	**2003**	**2003**	**2003**
Class I/Class II Area	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**
Capitol Reef NP	0	0	0.95	0	0	1.08	0	0	0.87
Grand Canyon NP	0	0	2.42	0	0	1.70	0	0	1.75
Zion NP	1	0	5.13	2	0	5.33	0	0	4.46
Grand Staircase-Escalante NM	0	0	1.55	0	0	2.77	0	0	2.06
METHOD 6	**Year**			**Year**			**Year**		
	2001	**2001**	**2001**	**2002**	**2002**	**2002**	**2003**	**2003**	**2003**
Class I/Class II Area	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**
Capitol Reef NP	0	0	1.13	0	0	1.19	0	0	0.96
Grand Canyon NP	0	0	2.85	0	0	1.32	0	0	1.37
Zion NP	0	0	4.89	1	0	5.38	0	0	4.59
Grand Staircase-Escalante NM	0	0	1.50	0	0	2.13	0	0	2.54

Table 4.32. Tract-only Visibility Impacts, 300-foot Overburden, Alternative C

METHOD 2	**Year**			**Year**			**Year**		
	2001	**2001**	**2001**	**2002**	**2002**	**2002**	**2003**	**2003**	**2003**
Class I/Class II Area	**# Days > 5%**	**# Days > 10%**	**Max Change(%)**	**# Days > 5%**	**# Days > 10%**	**Max Change(%)**	**# Days > 5%**	**# Days > 10%**	**Max Change(%)**
Capitol Reef NP	0	0	1.68	0	0	1.50	0	0	1.61
Grand Canyon NP	0	0	4.44	0	0	3.32	0	0	3.39
Zion NP	1	0	5.15	2	0	5.33	0	0	4.46
Grand Staircase-Escalante NM	0	0	2.75	1	0	5.37	0	0	3.70
METHOD 6	**Year**			**Year**			**Year**		
	2001	**2001**	**2001**	**2002**	**2002**	**2002**	**2003**	**2003**	**2003**
Class I/Class II Area	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**
Capitol Reef NP	0	0	1.69	0	0	1.71	0	0	1.80
Grand Canyon NP	1	0	5.45	0	0	2.35	0	0	2.35
Zion NP	0	0	4.91	1	0	5.38	0	0	4.74
Grand Staircase-Escalante NM	0	0	2.69	0	0	3.83	0	0	4.84

Table 4.33. Cumulative Visibility Impacts, 200-foot Overburden, Alternative B

METHOD 2	**Year**			**Year**			**Year**		
	2001	**2001**	**2001**	**2002**	**2002**	**2002**	**2003**	**2003**	**2003**
Class I/Class II Area	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**
Bryce Canyon NP	0	0	4.73	6	1	13.45	2	0	5.92
Capitol Reef NP	3	1	17.14	2	0	7.12	3	0	7.84
Grand Canyon NP	0	0	2.45	0	0	1.54	0	0	2.14
Zion NP	1	0	5.00	2	0	5.36	0	0	4.47
Grand Staircase-Escalante NM	1	0	5.31	3	0	5.37	0	0	4.87
METHOD 6	**Year**			**Year**			**Year**		
	2001	**2001**	**2001**	**2002**	**2002**	**2002**	**2003**	**2003**	**2003**
Class I/Class II Area	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**
Bryce Canyon NP	0	0	4.74	5	0	9.63	1	0	5.57
Capitol Reef NP	2	1	10.48	3	0	6.50	6	0	7.33
Grand Canyon NP	0	0	2.87	0	0	1.86	0	0	2.01
Zion NP	0	0	4.78	1	0	5.38	0	0	4.61
Grand Staircase-Escalante NM	0	0	4.96	2	0	5.87	3	0	6.18

Table 4.34. Cumulative Visibility Impacts, 300-foot Overburden, Alternative C

METHOD 2	**Year**			**Year**			**Year**		
	2001	**2001**	**2001**	**2002**	**2002**	**2002**	**2003**	**2003**	**2003**
Class I/Class II Area	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**
Bryce Canyon NP	4	0	7.92	14	3	29.07	6	1	12.44
Capitol Reef NP	3	1	17.56	2	0	7.16	4	0	7.85
Grand Canyon NP	0	0	4.47	0	0	2.17	0	0	3.78
Zion NP	2	0	5.64	2	0	5.36	0	0	4.47
Grand Staircase-Escalante NM	1	0	5.95	4	0	5.79	1	0	5.02
METHOD 6	**Year**			**Year**			**Year**		
	2001	**2001**	**2001**	**2002**	**2002**	**2002**	**2003**	**2003**	**2003**
Class I/Class II Area	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**
Bryce Canyon NP	3	0	7.11	17	4	21.67	4	0	8.97
Capitol Reef NP	2	1	10.74	3	0	6.55	6	0	7.34
Grand Canyon NP	1	0	5.48	0	0	2.46	0	0	2.71
Zion NP	0	0	4.92	1	0	5.38	0	0	4.61
Grand Staircase-Escalante NM	0	0	4.96	2	0	5.92	4	0	6.21

5 ASSESSMENT OF AIR QUALITY IMPACTS

5.1 Near-field Air Quality Impacts

Near-field analysis means the airshed within a 50 × 50–km area with the Alton Coal Tract in the center. Near-field analysis was conducted to assess impacts to public health and welfare and to estimate potential impacts to lakes and viewsheds in nearby (near-field) national parks.

In particular, a near-field ambient air quality impact assessment was performed to quantify maximum-modeled pollutant impacts near the tract. To demonstrate that air quality–related values and standards are protected requires the development of short-term (hourly and daily) and long-term emission rates of regulated pollutants, application of regulatory-approved models to quantify predicted concentrations, and a comparison of predicted impacts plus applicable background concentrations (RFD/RFFA sources) with applicable standards.

The EPA's guideline model, AERMOD, was the refined air dispersion model used to assess these near-field impacts and to verify compliance with the applicable NAAQS in the ambient airshed that encloses the Alton Coal Lease Tract. The modeling analysis focused on the reasonable maximum development year (therefore, the maximum emission year) for the mine. Using this anticipated maximum potential emission year, the AERMOD dispersion model was used to analyze potential near-field impacts of PM_{10}, $PM_{2.5}$, nitrogen dioxide, carbon monoxide, and sulfur dioxide. Photochemical conversion of NO_x and VOCs to O_3 and the secondary formation of $PM_{2.5}$ concentrations from NO_x and SO_2 emissions were not included in the Protocol. These chemical reactions are not considered to be near-field impacts, and they cannot be simulated with the recommended near-field model (AERMOD).

Compliance with the respective annual standards was based on the highest modeled value for each year of the four-year meteorological dataset. Demonstration of compliance with the short-term NAAQS (24-hour, 8-hour, 3-hour, and 1-hour) for carbon monoxide, nitrogen dioxide, and sulfur dioxide was based on the highest second-high modeled concentration for each year of the four-year meteorological period, added to the respective background concentrations

Compliance demonstrations with the 24-hour $PM_{2.5}$ standard use the average of the first highest 24-hour concentration in each year over the length of the meteorological data period. Compliance with the 24-hour PM_{10} standard was verified against the highest fifth-high modeled concentration over the 4-year period. All modeled concentrations were rounded to match the form of the appropriate NAAQS.

5.1.1 *PM_{10} AERMOD Results*

The modeled PM_{10} concentrations associated with the maximum development year are summarized below. Both the 200-foot overburden and 300-foot overburden removal scenarios were modeled for compliance under each action alternative. Results are presented below for the 24-hour highest fifth-high PM_{10} concentration over the four-year modeled dataset for both 200-foot and 300-foot scenarios.

Table 5.1. Highest Fifth-high PM_{10} Modeling Results

Overburden Thickness (feet)	Alternative	Modeled (µg/m3)	Background (µg/m^3)	Total (µg/m^3)	NAAQS (µg/m^3)
200	B	82.7	72	150	150
200	C	83.6	72	160	150
300	B	86.3	72	160	150
300	C	92.9	72	160	150

The 200-foot modeled concentrations indicate compliance with the NAAQS at all modeled receptors. However, the 300-foot results indicate a modeled exceedance at a receptor along the northwest side of the LNCM.

5.1.2 *$PM_{2.5}$ AERMOD Results*

The modeled $PM_{2.5}$ concentrations associated with the maximum development year are summarized below. Both the 200-foot overburden and 300-foot overburden removal scenarios were modeled for compliance under each action alternative. Model results in the tables below for the 24-hour averaging period indicate the average first-high concentration over all modeled years for both 200-foot and 300-foot scenarios. The highest predicted annual concentration over all modeled years for both 200-foot and 300-foot scenarios is presented in the table. Model results in the tables below for the 24-hour averaging periods represent the average concentrations over the four-year meteorological dataset for both 200-foot and 300-foot scenarios.

Table 5.2. $PM_{2.5}$ Modeling Results

Overburden Depth (feet)	Alternative	Averaging Period	Modeled (µg/m^3)	Background (µg/m^3)	Total (µg/m^3)	NAAQS (µg/m^3)
200	B	Annual	4.7	3.6	8	15
		24-hour	19.3	8.6	28	35
	C	Annual	5.1	3.6	9	15
		24-hour	21.1	8.6	30	35
300	B	Annual	6.0	3.6	10	15
		24-hour	22.7	8.6	31	35
	C	Annual	6.5	3.6	10	15
		24-hour	24.5	8.6	33	35

Both the 200-foot and 300-foot modeled concentrations indicate compliance with the NAAQS at all modeled receptors and for both Alternative B and Alternative C.

5.1.3 *Nitrogen Dioxide AERMOD Results*

The maximum-modeled nitrogen oxide concentrations associated with the maximum development year are summarized below. Both the 200-foot overburden and 300-foot overburden removal scenarios were modeled for compliance. The estimated nitrogen oxide emissions are the same for each overburden scenario under both action alternatives. A 75% ozone correction was applied to all annual nitrogen oxide modeling results in accordance with EPA's Ambient Ratio Method as a way to estimate ambient annual nitrogen dioxide concentrations from modeled nitrogen oxides emission rates.

Table 5.3. Annual Maximum Nitrogen Dioxide Modeling Results

Overburden Thickness (feet)	Modeled (μg/m^3)	Background (μg/m^3)	Total (μg/m^3)	NAAQS (μg/m^3)
200	31.6	17	49	100
300	99.9	17	117	100

The 200-foot modeled concentrations indicate compliance with the annual NAAQS at all modeled receptors. However, under the 300-foot overburden removal scenario, there are a few exceedances of the annual NAAQS. The disparity between the 200-foot and 300-foot scenarios is due to the higher emissions associated with the 300-foot scenario in conjunction with the location of the additional emissions on-site.

5.1.4 *Carbon Monoxide AERMOD Results*

The maximum-modeled carbon monoxide concentrations associated with the maximum development year are summarized below. Both the 200-foot overburden and 300-foot overburden removal scenarios were modeled for compliance. The estimated carbon monoxide emissions are the same for each overburden scenario under both action alternatives. Separate model runs were not necessary within each of the overburden removal depth scenarios.

Table 5.4. Carbon Monoxide Modeling Results

Overburden Thickness (feet)	Averaging Period	Modeled (μg/m^3)	Background (μg/m^3)	Total (μg/m^3)	NAAQS (μg/m^3)
200	8-hour	582	1,150	1,732	10,000
	1-hour	2,639	1,150	3,789	40,000
300	8-hour	582	1,150	1,732	10,000
	1-hour	2,639	1,150	3,789	40,000

Both 200-foot and 300-foot modeled concentrations indicate compliance with the 1-hour and 8-hour NAAQS at all modeled receptors.

5.1.5 *Sulfur Dioxide AERMOD Results*

The modeled sulfur dioxide concentrations associated with the maximum development year are summarized below. The potential sulfur dioxide emissions associated with the mining activities are nominal but modeling was still completed. Both the 200-foot overburden and 300-foot overburden removal scenarios were modeled for compliance. Because the estimated sulfur dioxide emissions for Alternative B and C are the same, separate model runs were not necessary within each of the overburden scenarios. The applicable averaging periods for comparison to the sulfur dioxide NAAQS include the 3-hour, 24-hour, and annual averaging periods.

Table 5.5. Sulfur Dioxide Modeling Results

Overburden Thickness (feet)	Averaging Period	Modeled (µg/m^3)	Background (µg/m^3)	Total (µg/m^3)	NAAQS (µg/m^3)
200	3-hour	1.64	20	22	1,300
	24-hour	0.47	10	10	365
	Annual	0.10	5	5	80
300	3-hour	1.90	20	22	1,300
	24-hour	0.47	10	10	365
	Annual	0.14	5	5	80

Both 200-foot and 300-foot modeled concentrations indicate compliance with the 1-hour and 8-hour NAAQS at all modeled receptors.

5.1.6 *HAP Impact Assessment*

Hazardous air pollutants can cause various adverse health effects. They are not part of the NAAQS, but high levels at the property boundary could indicate the need for further analysis and/or mitigation strategies. Therefore, HAPs have been included in the emission inventory and were modeled in the AERMOD near-field analysis. The modeled concentrations were compared with known health exposure levels as a means of assessing potential impacts.

The potential emissions of HAPs associated with this project are relatively insignificant. The only quantifiable source of HAPs from the Alton Coal lease in the emissions inventory is the proposed generators. The potential HAP emissions are the same for both the 200-foot and 300-foot overburden removal scenarios, as well as the Alternative B and C pit layouts. As seen in Tables 5.6a and 5.6b, no adverse impacts associated specifically with the Alton sources are anticipated.

Table 5.6a. Hazardous Air Pollutants AERMOD Modeling Results

Pollutant	Model Years	Average Period	Receptor Location		Modeled ($\mu g/m^3$)	Threshold ($\mu g/m^3$)[1]
			UTME	UTMN		
Benzene	2005-2008	1-hour	371800	4140300	0.440	1,300 (REL)
		24-hour	368400	4142500	0.046	53 (TSL)
		Annual	370060	4140000	0.003	30 (RfC)
Toluene	2005-2008	1-hour	371800	4140300	0.160	37,000 (REL)
		24-hour	368400	4142500	0.017	2,512 (TSL)
		Annual	370060	4140000	0.001	5,000 (RfC)
Xylenes	2005-2008	1-hour	371800	4140300	0.110	22,000 (REL)
		24-hour	368400	4142500	0.011	14,473 (TSL)
		Annual	370060	4140000	0.001	100 (RfC)
Formaldehyde	2005-2008	1-hour	371800	4140300	0.045	37 (TSL)
		Annual	370060	4140000	0.0003	9.8 (RfC)

[1] REL = recommended exposure limit; TSL = Toxic Screening Level; RfC = Reference Concentration

Table 5.6b HAPs Risk Assessment

Analysis[1]	HAP Constituent	Carcinogenic Annual RfC (Risk Factor)[2] $1/(\mu g/m^3)$	Exposure Adjustment Factor	Modeled ($\mu g/m^3$)	Calculated Risk	Significance Criterion
MLE	Benzene	7.80E-06	0.0949	0.003	2.2E-09	1.00E-06
MLE	Formaldehyde	5.50E-09	0.0949	0.0003	1.6E-13	1.00E-06
MEI	Benzene	7.80E-06	0.33	0.003	7.7E-09	1.00E-06
MEI	Formaldehyde	5.50E-09	0.33	0.0003	5.4E-13	1.00E-06

[1] MLE = most likely exposure; MEI = maximally exposed individual.

[2] EPA Air Toxics Database, Table 1 (EPA 2007).

5.1.7 *Near-Field VISCREEN Analysis*

VISCREEN was used to assess potential visibility impacts within the near-field modeling grid at Bryce Canyon National Park. The primary pollutants of concern that may impact visibility in the near-field are particulate matter and nitrogen oxide.

The Level-2 VISCREEN visual impacts using this most conservative dispersion category inside of Bryce Canyon National Park are summarized below in Tables 5.7a and 5.7b.

Table 5.7a Visual Impacts Inside of Bryce Canyon National Park, 200-foot Overburden Results

Background	Theta	Azimuth	Distance from Alton (km)	Alpha	Delta E		Contrast	
					Criteria	Plume	Criteria	Plume
SKY	10	157	35	11	6.21	0.267	0.13	0.005
SKY	140	157	35	11	3.41	0.074	0.13	-0.002
TERRAIN	10	84	18	84	6.8	0.691	0.28	0.003
TERRAIN	140	84	18	84	4.05	0.029	0.28	0.00

Table 5.7b. Visual Impacts inside of Bryce Canyon National Park, 300-foot Overburden Results

Background	Theta	Azimuth	Distance from Alton (km)	Alpha	Delta E		Contrast	
					Criteria	Plume	Criteria	Plume
SKY	10	157	35	11	6.21	0.372	0.13	0.006
SKY	140	157	35	11	3.41	0.149	0.13	-0.003
TERRAIN	10	84	18	84	6.8	0.904	0.28	0.004
TERRAIN	140	84	18	84	4.05	0.041	0.28	0.000

These results demonstrate that the maximum impacts inside of Bryce Canyon National Park from a potential Alton mine plume under the 200-foot and 300-foot overburden removal scenarios will be less than the VISCREEN acceptance criteria for both color change (Delta E) and contrast.

5.1.8 *Far-field Analysis*

The purpose of the far-field analysis is to quantify potential air quality impacts to both ambient air concentrations and AQRVs from air pollutant emissions of nitrogen oxide, carbon monoxide, sulfur dioxide, PM_{10}, and $PM_{2.5}$ that are expected to result from mining operations on the tract. Photochemical conversion of NO_x and VOCs to O_3 and the secondary formation of $PM_{2.5}$ concentrations from NO_x and SO_2 emissions were not included in the Protocol. These chemical reactions cannot be simulated with the recommended far-field model (CALPUFF).

The analyses were performed using the EPA-recommended CALMET/CALPUFF/CALPOST modeling system to predict air quality direct and cumulative impacts at far-field PSD Class I areas and selected Class II areas. The term “CALPUFF” is generally used to represent the entire modeling system, including the pre- and post-processors.

5.1.8.1 CLASS I AND CLASS II INCREMENTS

Under federal and state PSD regulations, increases in ambient air concentrations in Class I areas are limited by PSD Class I Increments. Specifically, emissions associated with a particular development may increase ambient concentrations above baseline levels only within those specific increments developed for sulfur dioxide, PM_{10}, and nitrogen dioxide. The modeling results for the maximum cumulative scenario are presented in Table 5.8.

Table 5.8. Class I and Class II Results

Pollutant	Averaging Period	Class I Analysis Results		Class II Analysis Results	
		Cumulative Concentration	Class I Increment	Cumulative Concentration	Class II Increment
PM_{10}	Annual	0.15	4	0.04	17
	24-hour	1.06	8	0.25	30
SO_2	Annual	0.00	2	0.001	20
	24-hour	0.02	5	0.01	91
	3-hour	0.06	25	0.07	512
NO_x	Annual	0.01	2.5	-0.01	25
$PM_{2.5}$	Annual	0.01	NA	0.004	NA
	24-hour	0.09	NA	0.03	NA
CO	8-hour	25	NA	52	NA
	1-hour	108	NA	118	NA

All of the results for the Alton alone modeling showed values far below the relevant increments. Cumulative results were produced for the maximum emission rate case (300-foot overburden removal, Alternative C) and are presented above. The impacts are significantly below both the Class I and Class II increments. Even though there are no increments for $PM_{2.5}$ or carbon monoxide, results are presented in the above table to convey a general impression of impact levels.

5.1.9 *Visibility*

Atmospheric light extinction relative to background conditions is used to measure regional haze. Analysis thresholds for atmospheric light extinction are set forth in FLAG (2000). The thresholds are defined as 5% and 10% of the reference background visibility (or 0.5 and 1.0 dv) for sources as a result of mining operations on the tract alone and cumulative source impacts, respectively.

Visibility results for the Alton tract alone are presented in Table 5.9 (200-foot overburden removal, Alternative B and 300-foot overburden removal, Alternative C). These results represent both the lowest and highest emission cases, and summarize method 2 and method 6 processing. For the 200-foot overburden scenario under Alternative B, only Zion NP has an extinction change that exceeds 5%. The 300-foot Alternative C results show that in addition to Zion NP, Grand Canyon NP and Grand Staircase-Escalante also have extinctions in excess of 5%. There are no extinction changes exceeding 10% in any of the areas of interest (maximum change of 5.5% at Grand Canyon).

Table 5.9. Visibility Results, Alton

Method 2	**200-foot Overburden, Alternative B**		**300-foot Overburden, Alternative C**	
Class I/Class II Area	**# Days > 5%**	**Max Change (%)**	**# Days > 5%**	**Max Change (%)**
Capitol Reef NP	0	1.1	0	1.5
Grand Canyon NP	0	1.7	0	3.3
Zion NP	2	5.3	2	5.3
Grand Staircase-Escalante NM	0	2.8	1	5.4
Method 6	**200-foot Overburden, Alternative B**		**300-foot Overburden, Alternative C**	
Class I/Class II Area	**# Days > 5%**	**Max Change (%)**	**# Days > 5%**	**Max Change (%)**
Capitol Reef NP	0	1.2	0	1.7
Grand Canyon NP	0	1.3	1	5.5
Zion NP	1	5.4	0	4.9
Grand Staircase-Escalante NM	0	2.1	0	2.7

Cumulative visibility results are presented in Table 5.10 (the same two Alton emission cases as above). For the 200-foot overburden scenario under Alternative B, all areas except Grand Canyon NP have extinction changes that exceed 5%. For the 300-foot overburden scenario under Alternative C, all areas have changes that exceed 5%. Only Capitol Reef and Bryce Canyon National Parks have visibility extinction changes that surpass 10%., For Capitol Reef, that is only on one day (maximum of 17.6% for method 2 and 10.7% for method 6). This impact is due to one of the regional sources, as the Alton alone impacts at Capitol Reef NP were small (maximum change of 1.80%). Bryce Canyon had a total of four days using method 2 processing that exceeded a 10% change for the 300-foot overburden scenario, and also four days using method 6. For the 200-foot overburden case, Bryce Canyon only had one day that exceeded 10%, and that was using method 2.

Table 5.10. Visibility Results - Cumulative

Method 2	**200-foot Overburden, Alternative B**			**300-foot Overburden, Alternative C**		
Class I/Class II Area	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**
Bryce Canyon NP	8	1	13.5	24	4	29.1
Capitol Reef NP	3	1	17.1	3	1	17.6
Grand Canyon NP	0	0	2.5	0	0	4.5
Zion NP	1	0	5.0	2	0	5.6
Grand Staircase-Escalante NM	1	0	5.3	1	0	6.0
Method 6						
Class I/Class II Area	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**	**# Days > 5%**	**# Days > 10%**	**Max Change (%)**
Bryce Canyon NP	6	0	9.6	24	4	21.7
Capitol Reef NP	2	1	10.5	2	1	10.7
Grand Canyon NP	0	0	2.9	1	0	5.5
Zion NP	0	0	4.8	0	0	4.9
Grand Staircase-Escalante NM	0	0	5.0	0	0	5.0

5.1.10 *Deposition*

Maximum predicted S and N deposition impacts were estimated for two direct project and cumulative source scenarios: the 200-foot overburden, Alternative B and the 300-foot overburden, Alternative C. As above, this approach gives a good representation of impacts from both the lowest and highest Alton emission scenarios.

Predicted direct project impacts were compared to the Fox et al, green line deposition values for total N and S deposition in the western U.S., which are defined as 3.00 kilogram per hectare per year (kg/ha-year) for both N and S. These results are presented in Table 5.11. Impacts for S deposition are below the green line value in all cases. The same is true for N deposition - no impacts exceed the green line value.

Total deposition impacts from direct project and regional sources were also compared to the green line value. Once again all S and N deposition impacts are below the green line thresholds. The improvements in the cumulative cases versus the Alton alone cases are due to the large nitrogen oxide emission decrease from the Navajo generating station. In fact, the majority of the N deposition values turned out to be 0 - signifying that the Navajo decrease over the annual period exceeded the positive impacts of the other sources.

Table 5.11. Deposition Results

Location	Overburden Thickness (feet)	Alt.	Alton Coal Tract				Cumulative Sources			
			Maximum Dry and Wet Annual S Deposition, (kg/ha-yr)	>Green Line?	Maximum Dry and Wet Annual N Deposition, (kg/ha-yr)	>Green Line?	Maximum Dry and Wet Annual S Deposition, (kg/ha-yr)	>Green Line?	Maximum Dry and Wet Annual N Deposition, (kg/ha-yr)	>Green Line?
Bryce Canyon	200	B	0.0001	No	0.0124	No	0.0003	No	0.0000	No
	300	C	0.0001	No	0.0262	No	0.0003	No	0.0110	No
Capitol Reef	200	B	0.0000	No	0.0004	No	0.0007	No	0.0000	No
	300	C	0.0000	No	0.0009	No	0.0007	No	0.0000	No
Grand Staircase Escalante	200	B	0.0000	No	0.0013	No	0.0010	No	0.0000	No
	300	C	0.0000	No	0.0024	No	0.0010	No	0.0000	No
Grand Canyon	200	B	0.0000	No	0.0003	No	0.0001	No	0.0000	No
	300	C	0.0000	No	0.0006	No	0.0001	No	0.0000	No
Zion	200	B	0.0000	No	0.0038	No	0.0001	No	0.0000	No
	300	C	0.0000	No	0.0087	No	0.0001	No	0.0000	No
Navajo Lake	300	C	0.0000	No	0.0044	No				

5.1.11 *Acid Neutralizing Capacity*

CALPUFF was used to predict annual deposition fluxes of S and N at Navajo Lake for one scenario - the 300-foot overburden scenario under Alternative C. This scenario produces the highest emissions for Alton, and provides a conservative estimate. These results are shown in Table 5.11. Because no data on lake chemistry at Navajo Lake are available, no estimates of acid neutralizing capacity change in Navajo Lake were performed.

5.2 Greenhouse Gases

Naturally occurring greenhouse gases (GHGs) include water vapor, carbon dioxide, methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Other man-made greenhouse gases include, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). Water vapor accounts for the largest percentage of greenhouse effect. Next to water vapor, carbon dioxide is the most abundant GHG. Because carbon dioxide is relatively stable in the atmosphere and uniformly mixed throughout the troposphere and stratosphere, the climatic impact of carbon dioxide emissions does not depend on the carbon dioxide source location on earth. The Proposed Actions would produce GHG emissions from the combustion of fuel by the vehicles and generators.

Research on how emissions of GHGs influence global climate change and associated effects has focused on the overall impact of emissions from aggregate regional or global sources. This approach is required primarily because GHG emissions from single sources are small relative to aggregate emissions. The climate change research community has not yet developed tools specifically intended for evaluating or quantifying end-point impacts attributable to the emissions of GHGs from a single source. The current tools for simulating climate change generally focus on global and regional-scale modeling. Global and regional-scale models lack the capability to represent explicitly many important small-scale processes. As a result, confidence in regional- and sub-regional-scale projections is lower than at the global scale. There is thus limited scientific capability in assessing, detecting, or measuring the relationship between emissions of GHGs from a specific single source and any localized impacts.

Globally, approximately 30,377 million (MM) metric tons of carbon dioxide was added to the atmosphere through the combustion of fossil fuels in 2008 (EPA 2010). The highest on-site plus off-site carbon dioxide emission from the alternatives evaluated occur in the 300-foot overburden thickness alternatives (i.e, Alternatives B and C). The 77,153 tons (69,992 metric tons) of carbon dioxide calculated for these alternatives represents approximately 0.00023% of the global emissions, an insignificant fraction of that total.

The annual coal production from the Alton Mine is estimated to be approximately 2 million tons. The annual worldwide primary coal production based on 2008 data is approximately 7.3 billion tons (EIA 2008). The coal produced for the Alton mine could therefore be expected to produce approximately 0.028% of the total worldwide production.

Because site-specific data are not available, EPA's default emission factor of 4,810 pounds per ton of coal for subbituminous coal (EPA 2008) was used to approximate the annual emissions from combusting the 2 million tons of coal produced at the Alton Mine.

2 MMtons/yr Coal * 4,810 lbCO_2/ton of Coal / 2,000 lb/ton = 4.8 MM TPY CO_2

The resulting emissions of 4.8 million tons carbon dioxide per year (4.4 MM metric tons) would be emitted by the end user of the coal produced at the Alton Mine. This total represents 0.014% of the total carbon dioxide emissions from global fossil fuel combustion. A summary of these comparisons is presented in Table 5.12.

Table 5.12. Greenhouse Gas Comparisons

Comparison	Global	Alton Project	Alton Coal	Alton % of Global
CO2 Emissions from Fossil Fuel Combustion, MM metric tons/yr	30,377	0.067	4.4	0.015
Annual Coal Production, million tons	7271	2	–	0.028

6 REFERENCES

Arizona Department of Environmental Quality (ADEQ), 2009. Website for Title V sources, and newly permitted sources. Personal communication, Trevor Baggiore, Air Quality Permits Section Manager (October)

BLM 2006. Kanab Field Office RMP AQ analysis assumptions and input data

______. 2006. Mineral Potential Report for the Kanab Planning Area Kanab Field Office, March 22, 2006

______. 2007. Arizona Strip Field Office, Arizona Strip EIS

______. 2008. Representative pollutant measured concentrations and temperature trend data. Email spreadsheet from Ms. Susan Caplan, July 2008.

______. 2008a. Kanab Field Office Record of Decision and Approved Resource Management Plan. October 2008. Salt Lake City. BLM-UT-PL-09-006-1610, UT-110-2007-022

______. 2008b. Richfield Field Office RMP Spreadsheets (April and July)

______. 2009. Personal communication, Cedar City, Field Office; Ed Ginouves (October)

______. 2009a. Personal communication, St. George Field Office, Lorrain Christian (October).

______. 2009b. Personal Communication, Arizona Strip Field Office, Lorrain Christian (October).

Countess, R. J.; W. R. Barnard; C. S. Claiborn; D. A. Gillette; D. A. Latimer; T. G. Pace; J. G. Watson. 2001. Methodology for Estimating Fugitive Windblown and Mechanically Resuspended Road Dust Emissions Applicable for Regional Scale Air Quality Modeling. Report No. 30203-9. Western Regional Air Partnership, Denver, Colorado.

Clark County, Nevada (CCN). 2009. Personal communication, Christian Francis.

DOE (U.S. Department of Energy) 2010. U.S. Energy and Information Administration, Energy Kids, Energy and Environment, Greenhouse Gases.

EIA (US Energy Information Administration) 2008. Independent Statistics and Analysis, Total Primary Coal Production (Thousand Short Tons), 2008 Worldwide data summary.

Environmental Protection Agency. 1995. Compilation of Air Pollutant Emission Factors (AP-42), Vol. 1, Stationary Point and Area Sources, Fifth Edition. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

______. 2002. Air Toxics Database. Dose-Response Assessment for Assessing Health Risks Associated With Exposure to Hazardous Air Pollutants, Table 2. Office of Air Quality Planning and Standards (OAQPS). Technology Transfer Network Air Toxics Website. <http://www.epa.gov/ttn/atw/toxsource/summary.html>. Data accessed June 20, 2003.

______. 2003a. Guidelines on Air Quality Models, 40 Code of Federal Regulations (CFR), Part 51, Appendix W (EPA 2003a).

_______. 2003b. Guidance for Estimating Natural Visibility Conditions Under the Regional Haze Rule. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

______. 2004. 40 *Federal Register* [FR], Vol. 69, No. 1245, page 39219 Table 7, June 24, 2004.

_______. 2004b. AERMOD user's manual guidance, EPA-454/B-03-001, 2004.

_______. 2005a. Guideline on Air Quality Models. Updated 2005. Environmental Protection Agency Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. Published in the *Federal Register,* Vol. 70, No. 216, November 9, 2005.

________. 2006. 40 CFR Part 50 Appendix K, Section 1.0 General, used for definition for exceedance. 71 FR 61224, Oct. 17, 2006.

________. 2007. Air Toxics Database. Dose-Response Assessment for Assessing Health Risks Associated With Exposure to Hazardous Air Pollutants, Table 1 and Table 2. Office of Air Quality Planning and Standards (OAQPS). Technology Transfer Network Air Toxics Website. <http://www.epa.gov/ttn/atw/toxsource/summary.html>. Tables revised 6/12/2007.

______. 2008. **AP42 Fifth Edition,** *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources.*

______. 2009. Region 9 PSD Permit Website, EPA PSD permit: Modification to Navajo Generating Station.

______. 2010. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008. EPA 430-R-10-006. April 15, 2010.

Federal Highway Administration (FHA) 2010. William R. Barnard and William M. Hodan, MACTEC Federal Programs. Evaluating the Contribution of PM2.5 Precursor Gases and Re-entrained Road Emissions to Mobile Source PM2.5 Particulate Matter Emissions. Project Completed Under Federal Highway Administration Contract. http://www.epa.gov/ttn/chief/conference/ei13/mobile/hodan_pres.pdf

Federal Land Managers' Air Quality Related Values Workgroup (FLAG). 2000. Phase I Report. U.S. Forest Service-Air Quality Program, National Park Service-Air Resources Division, U.S. Fish and Wildlife Service-Air Quality Branch. December 2000.

Fox, Douglas; Ann M. Bartuska; James G. Byrne; Ellis Cowling; Rich Fisher; Gene E. Likens; Steven E. Lindberg; Rick A. Linthurst; Jay Messer; and Dale S. Nichols. 1989. A Screening Procedure to Evaluate Air Pollution Effects on Class I Wilderness Areas. General Technical Report RM-168. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 36 pp.

Gas Research Institute. 1999. GRI-HAPCalc® Version 3.01. Gas Research Institute. Des Plaines, Illinois.

Interagency Workgroup on Air Quality Modeling. 1998. Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts. EPA-454/R-98-019. Office of Quality Planning and Standards. U.S. EPA, Research Triangle Park, North Carolina. December 1998.

Midwest Research Institute (MRI). 2006. Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors.

Nevada Department of Environmental Protection (NDEP). 2009. Personal communication, Mathew DeBuile (October)

Oris. 2008. Oris Solutions LLC, BEE-LINE Software, modeling manager for AerMod dispersion modeling.

U.S. Bureau of Land Management. 2008. Representative pollutant measured concentrations and temperature trend data. Spreadsheet received electronically from Susan Caplan, July 2008.

U.S. Department of the Interior. 1980. Southern Utah Petition Evaluation. Final 522 SMCRA Evaluation and Environmental Statement. OSM-PE-1; OSM-EIS-4.

______. 1980a. Development of coal resources in southern Utah. Part 2 Site specific analysis of the proposed Alton Mine. U.S. Department of the Interior, Kane, Utah.

U. S. Forest Service. 2000. Screening Methodology for Calculating ANC Change to High Elevation Lakes, User's Guide. U.S. Department of Agriculture (USDA) Forest Service, Rocky Mountain Region. January 2000.

_______. 2008. Technical Report 13.0 Air Quality Resources Oil and Gas Leasing EIS on Lands Administered by the Dixie National Forest, prepared by JBR Environmental Consultants, Inc. October 2008

Utah Division of Air Quality (UDAQ) 2008. Personal communication between David Prey, and Jerry Dismukes, Cornerstone Environmental Services, December 8–9, 2008.

______. 2008. State of Utah Department of Environmental Quality Division of Air Quality, Mr. Dave Prey, UDAQ Modeler, communication with Lori Marquez, MESI, representative meteorological data and background air quality data Kane County, 6/30/08.

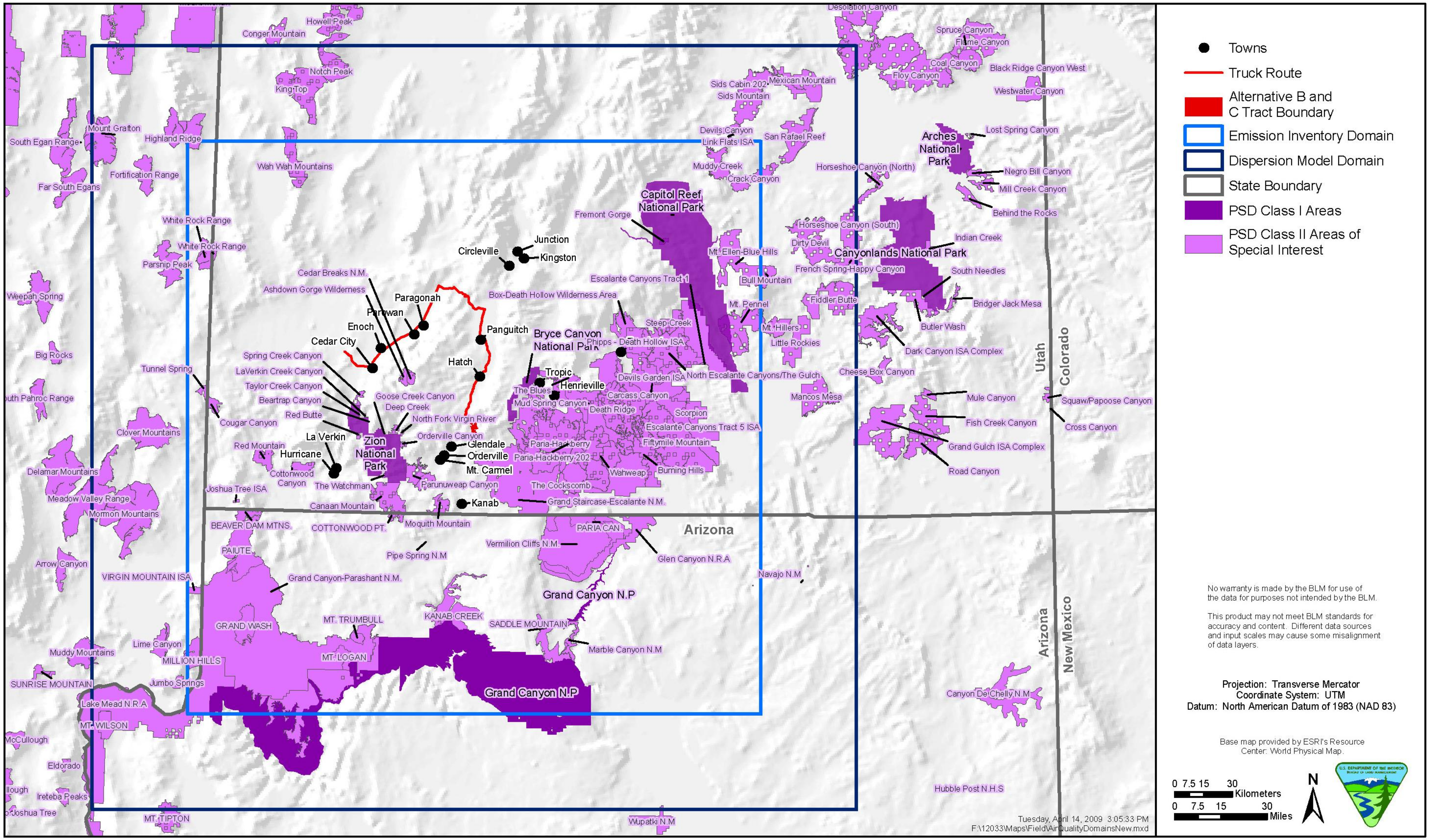
______. 2009. Personal communication and data transfer (meteorological data) between David Prey, and Jerry Dismukes, Cornerstone Environmental Services, August 2009.

______. 2009. Personal communication, Tom Orth and Molly Bringhurst (October)

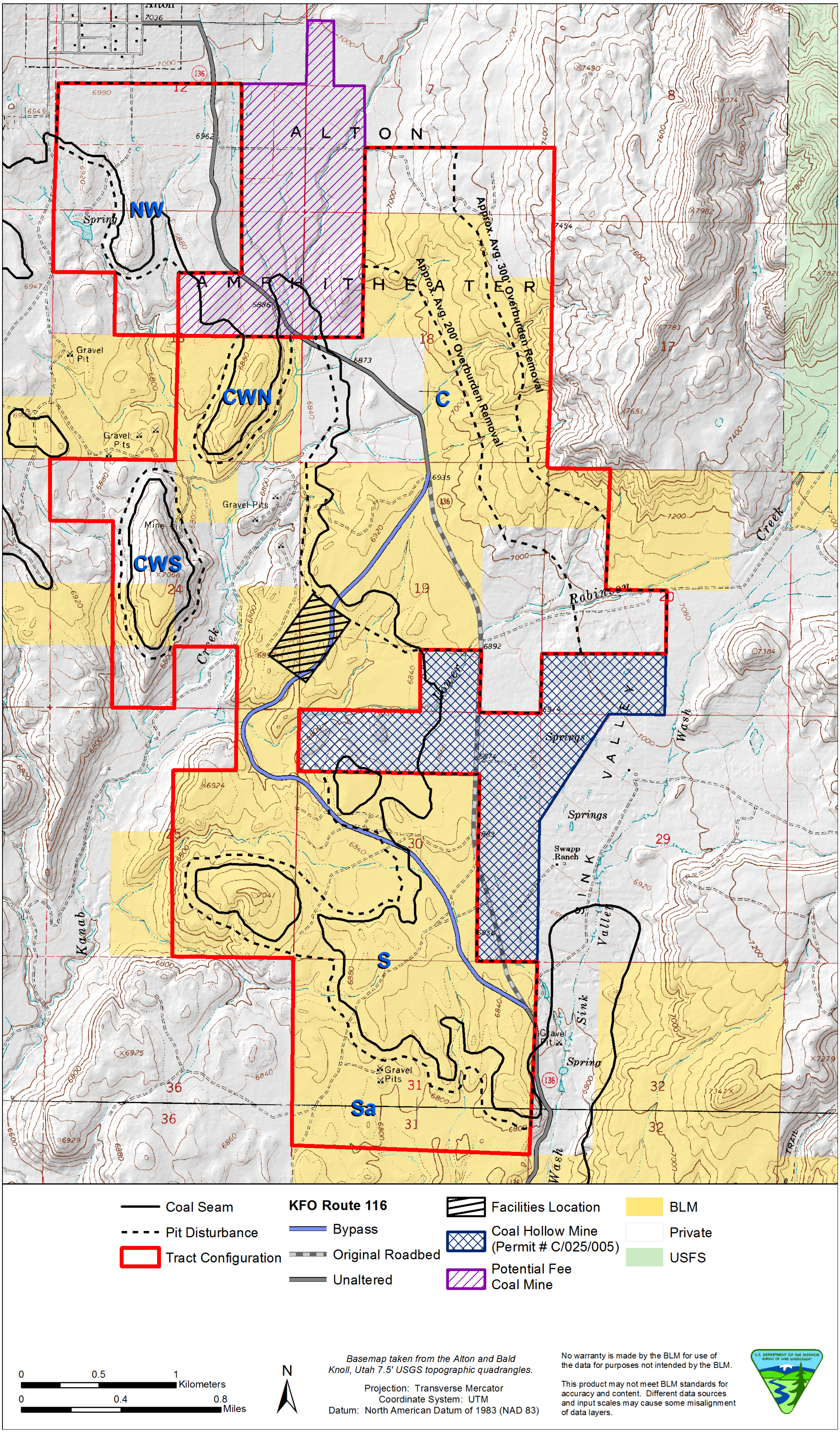
______. 2010. PM_{10} background concentration from St. George, Utah used for the private Alton Mine.

Westar. 2010. http://www.westar.org/PSD/psd%20increment%20modeling.pdf PSD increment consumption trigger dates.

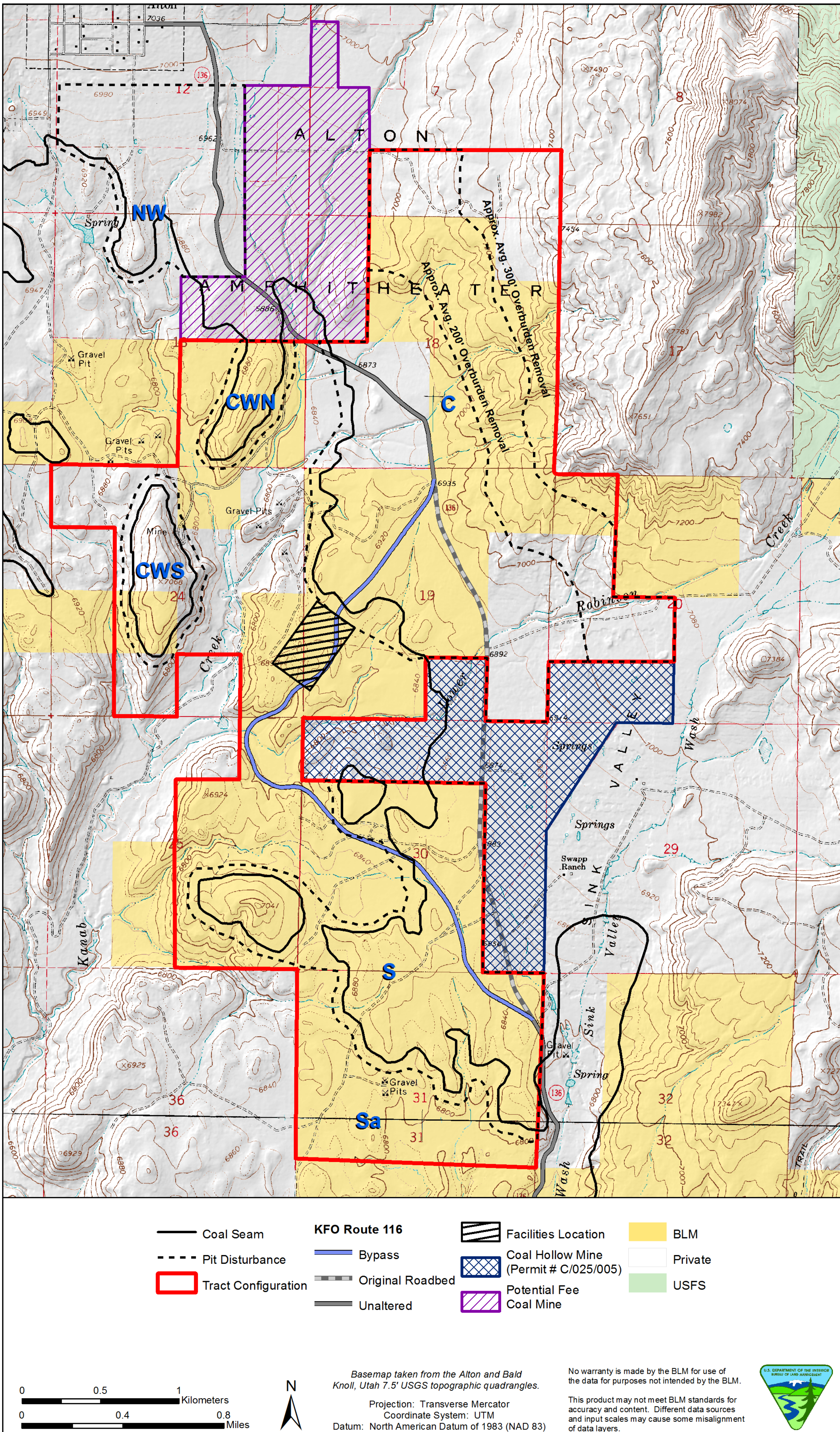
Appendix A: Maps



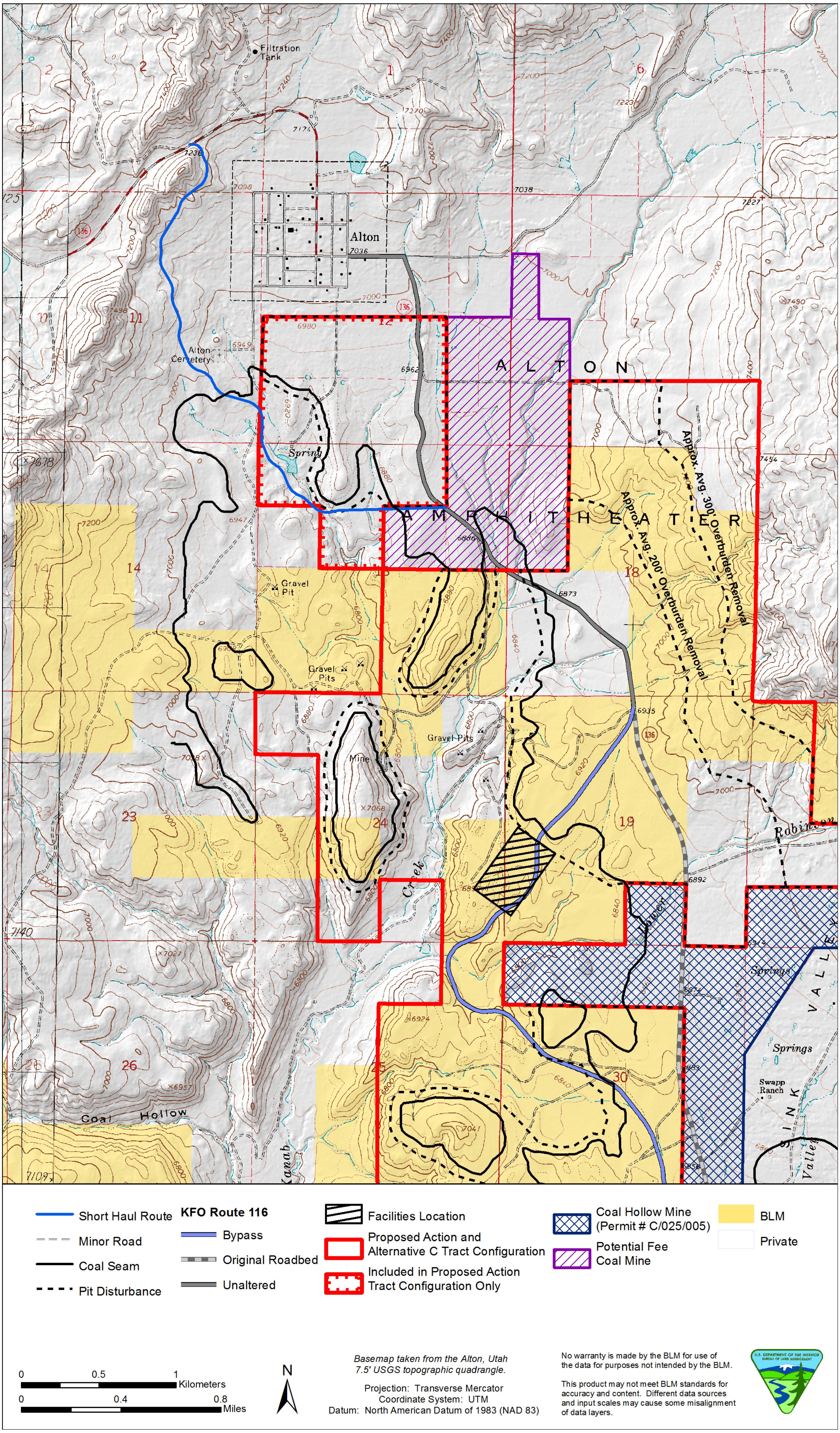
Map 1.1. Emission inventory and modeling domain (air resource modeling domain).



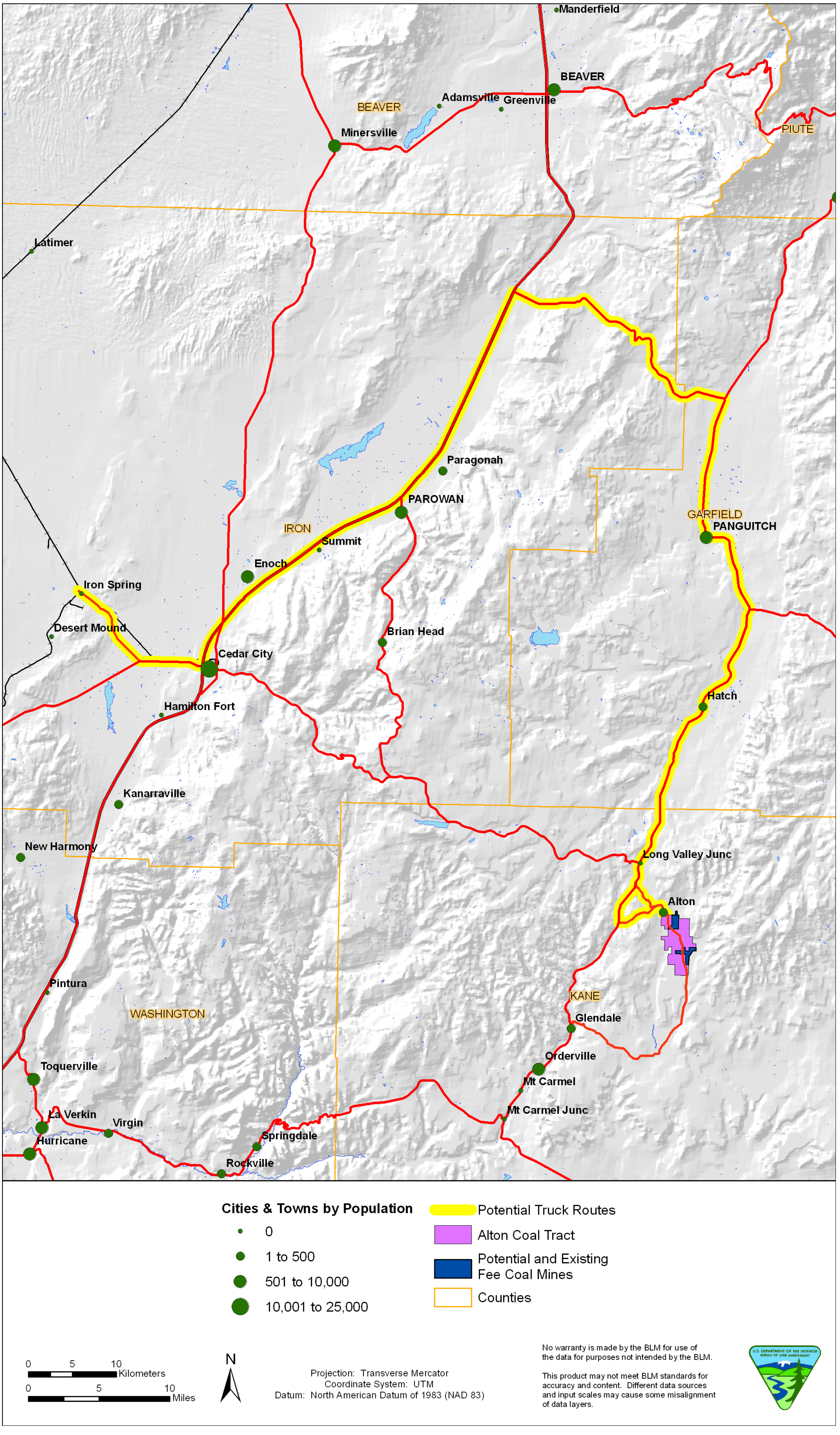
Map 1.2. Alton Coal Tract under Alternative B.



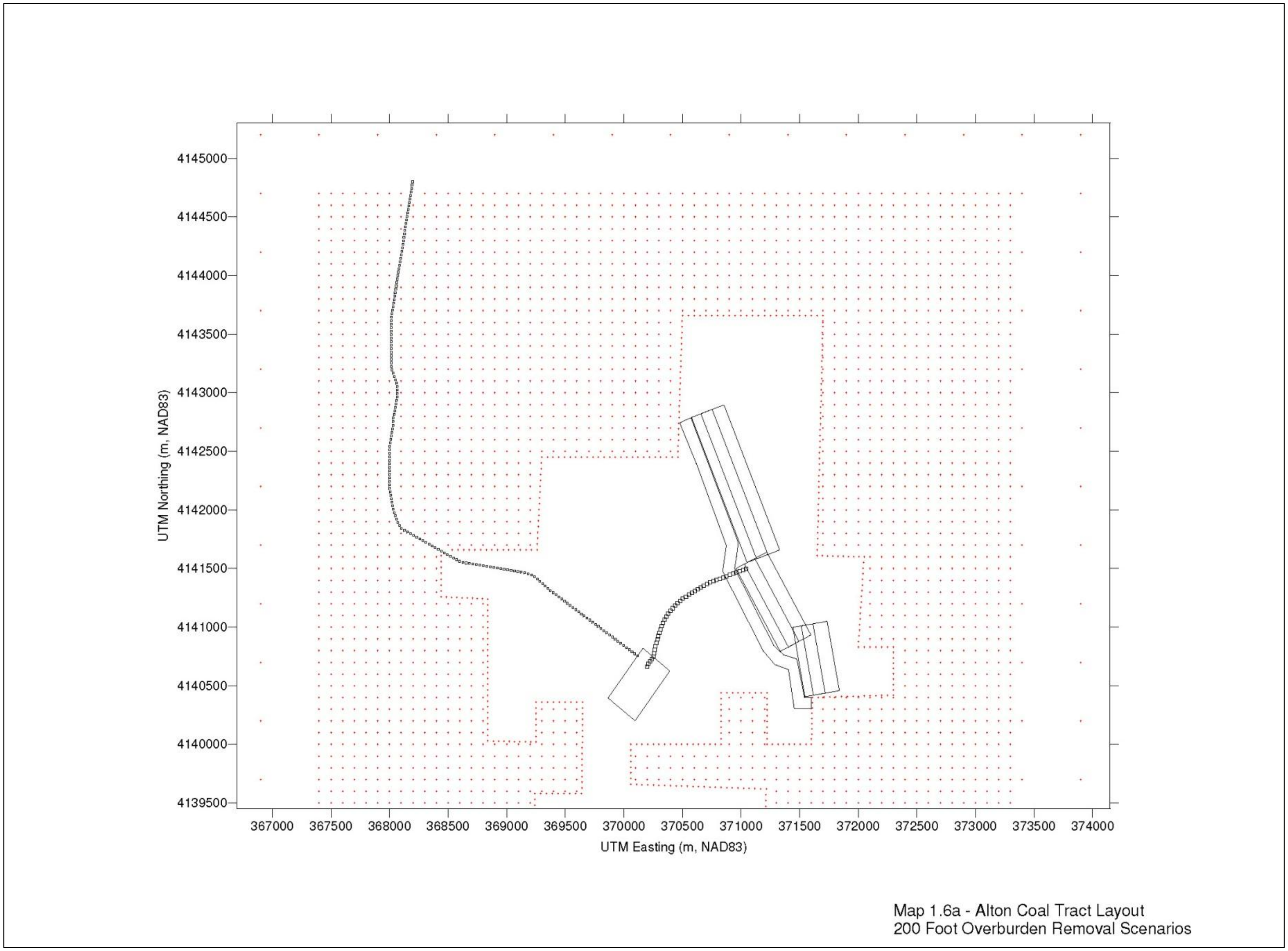
Map 1.3. Alton Coal Tract under Alternative C.



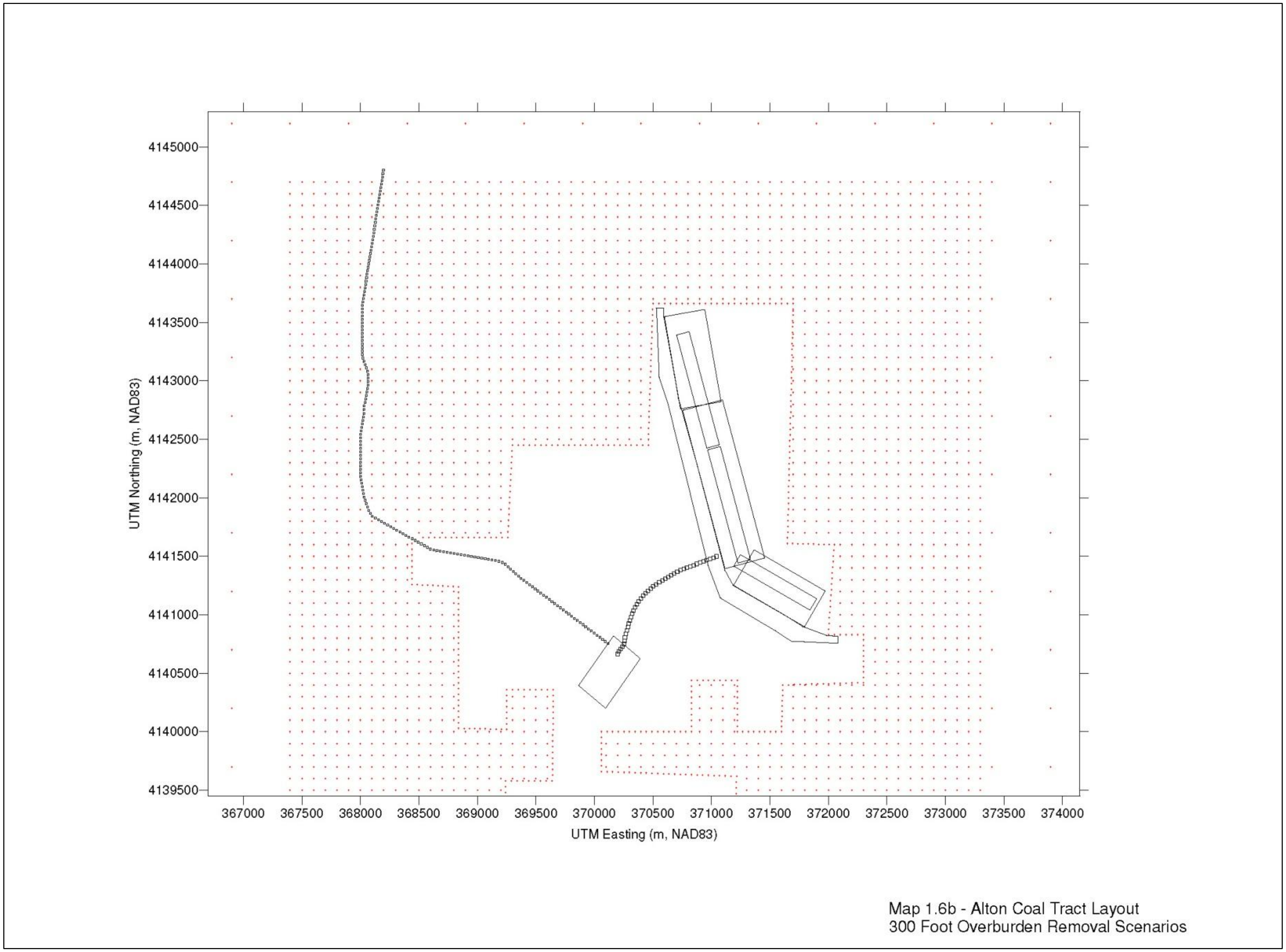
Map 1.4. Reasonably foreseeable short haul route (mine site to KFO Route 116 north of the Town of Alton).



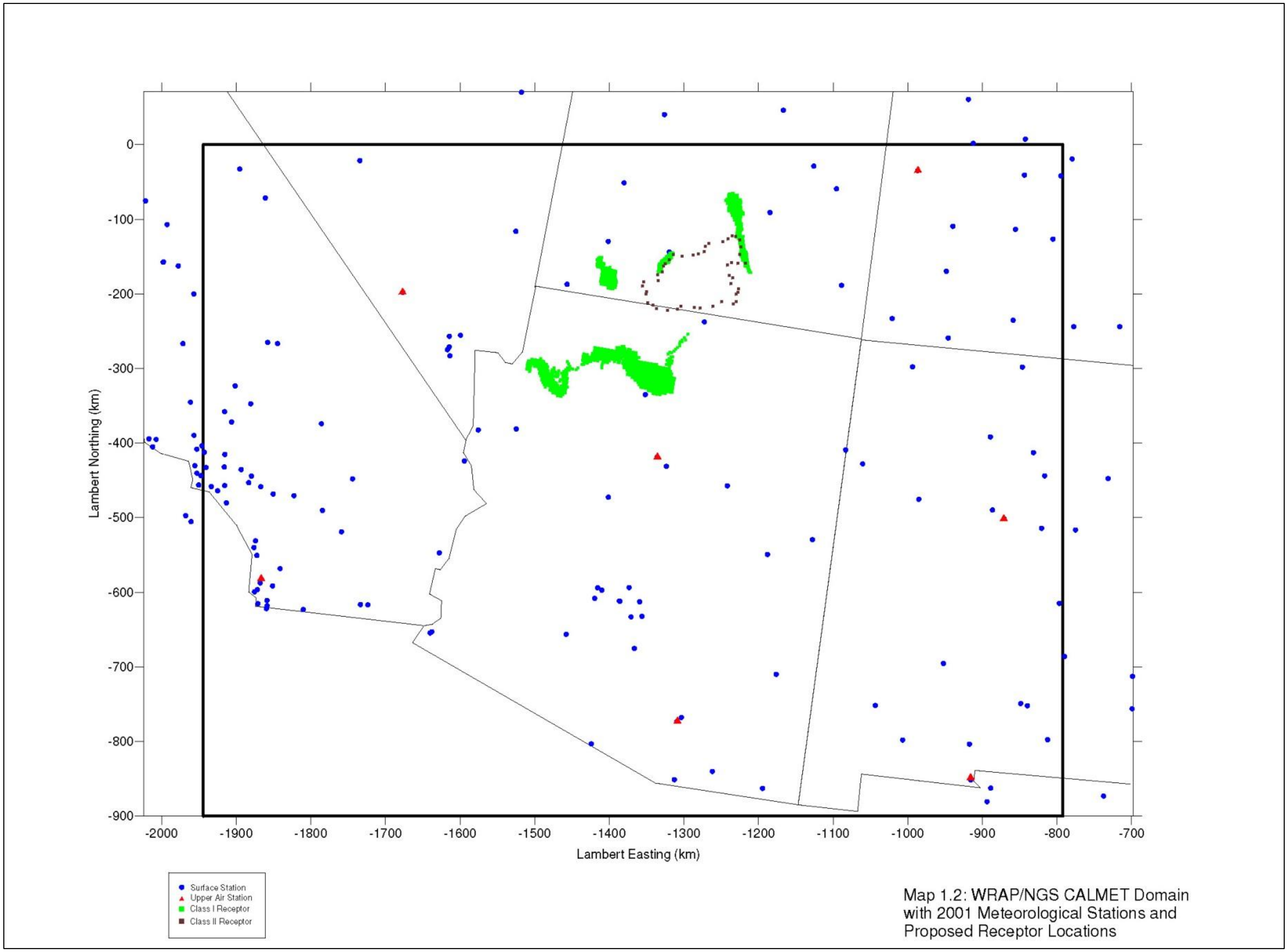
Map 1.5. Reasonably foreseeable rail loadout facility and coal haul transportation route.



Map 1.6a. Maximum development year layout (200-foot overburden scenario).



Map 1.6b. Maximum development year layout (300-foot overburden removal scenario).



Map 1.7. WRAP/NGS CALMET domain with 2001 meteorological stations and proposed receptor locations.

Appendix B: Mining Emission Inventory Results

Alton 200-foot Overburden Scenario, Alternative B

Alton Tract - Alternative B

AERMOD Area Source CO Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual CO Q(g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.2878	0.1439	0.0576			0.0863		0.2878
Bulldozers	0.8702	0.4351	0.2610	0.1740				0.8702
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	4.8865	3.4205	1.4659					4.8865
Topsoil Scraping	0.4453			0.4453				0.4453
Coal Loading	0.4550		0.4550					0.4550
Blasting	0.2891	0.2024	0.0867					0.2891
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.3188						0.3188	0.3188
Coal Haul Truck	0.6806	0.0681	0.1361			0.4764		0.6806
Service Vehicles (separated from graders line item)	0.0151	0.0076	0.0030			0.0045		0.0151
Total	**8.23**	**4.27**	**2.46**	**0.62**	**0.00**	**0.56**	**0.32**	8.2331
	286.18							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		4 2699	2 4624	0 6193	0 0000	0 5627	0 3188	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		3 39995E-06	8 10024E-06	2 34246E-06	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 00853	0 00223	
						0 01076	Haul road and access road overlap	

Alton Tract - Alternative B

AERMOD Area Source NOx Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual NOx Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.0329	0.0164	0.0066			0.0099		0.0329
Bulldozers	0.0994	0.0497	0.0298	0.0199				0.0994
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	4.8865	3.4205	1.4659					4.8865
Topsoil Scraping	0.0509			0.0509				0.0509
Coal Loading	0.0520		0.0520					0.0520
Blasting	0.0734	0.0513	0.0220					0.0734
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.1230						0.1230	0.1230
Coal Haul Truck	0.6806	0.0681	0.1361			0.4764		0.6806
Service Vehicles (separated from graders line item)	0.0339	0.0169	0.01			0.0102		0.0339
Total	**6.03**	**3.62**	**1.72**	**0.07**	**0.00**	**0.50**	**0.12**	6.03
	209.69							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		3 6230	1 7192	0 0708	0 0000	0 4964	0 1230	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		2 88486E-06	5 6556E-06	2 6771E-07	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 0075	0 00086	
						0 00838	Haul road and access road overlap	

Alton Tract - Alternative B

AERMOD Area Source PM-10 Modeling Emissions

		Emissions by Area (g/s)							
Emission Activities	**Total Annual PM-10 Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	**Check**	
Graders	0 0390	0 0195	0 0078			0 0117		0 0390	
Bulldozers	0 4846	0 2423	0 1454	0 0969				0 4846	
Overburden Loading	0 1156	0 0809	0 0347					0 1156	
Overburden Haul Truck	0 8578	0 4615	0 3963					0 8578	
Topsoil Scraping	0 2956			0 2956				0 2956	
Coal Loading	0 0060		0 0060					0 0060	
Blasting (within pit)	0 0073	0 0051	0 0022					0 0073	
Wind Erosion	0 2854	0 1427	0 0856	0 0571				0 2854	
Coal Processing (increase to 25' release height)	0 3351				0 3351			0 3351	
Access Road Traffic	1 4287						1 4287	1 4287	
Coal Haul Truck	0 3647	0 0303	0 1218			0 2126		0 3647	
Service Vehicles (separated from graders line item)	0 1415	0 0590	0 0471			0 0354		0 1415	
Total Emissions by Area	**4.3613**	**1.04**	**0.85**	**0.45**	**0.34**	**0.26**	**1.43**	4 3613	
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**		
Area (m^2)		806,600	274,081	274,713	152,856				
Emissions (g/s)		1 0413	0 8469	0 4496	0 3351	0 2597	1 4287		
Initial Lateral Width (m)									
Road Segment Length (m)									
Model Emission Rate (g/s-m2)		1 29098E-06	3 08996E-06	1 63661E-06	2 19215E-06				
Road Segments						44	140		
Volume Source Emission Rate (g/s)						0 0059	0 01021		
Open Pits Source Calculations	have to model volume sources as independent adjacent sources with emissions input as g/s (BEEST figures out g/sec-m2 by area and volume inputs)								
Coal Pit Volumes(Assumes 180ft Depth)	**Leg 1**	**Leg 2**	**Leg 3**						
Xinit(m)	100.58	100.58	100.58						
Yinit(m)	1325	800	600						
Depth(m)**	54.9	54.9	54.9	**Total Volume of Open pits**					
Volume (m3)	7,311,643	4,414,577	3,310,933	15037152.55					
Equivalent Surface Area (m2)	133268.5	80464	60348	274080.5					
Emissions (g/s)	0.411794851	0.248630854	0.18647314	0.8469	(Matches main coal pit emissions above)				
Model Emission Rate (g/s-m2)				3.0900E-06					
Main Pit (Overburden removal, etc.)	**Leg 1**	**Leg 2**	**Leg 3**						
Assumes 120 foot average depth									
Xinit(m)	296	296	296						
Yinit(m)	1325	800	600						
Depth(m) **	36.58	36.58	36.58	**Total Volume of Open pits**					
Volume (m3)	14,345,107	8,661,197	6,495,898	29502201.60					
Equivalent Surface Area (m2)	392200	236800	177600	806600					
Total (g/s)	0.506323242	0.305704599	0.229278449	1.0413	(Matches total development area emissions above)				

Model Emission Rate (g/s-m2)				1.2910E-06					
** The BEEST AERMOD processor figures out the pit depth by using the input volume and surface area for the source									

Alton Tract - Alternative B

AERMOD Area Source PM-2.5 Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual PM-2.5 Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.0027	0.0014	0.0005			0.0008		0.0027
Bulldozers	0.2652	0.1326	0.0796	0.0530				0.2652
Overburden Loading	0.0175	0.0123	0.0053					0.0175
Overburden Haul Truck	0.0858	0.0462	0.0396					0.0858
Topsoil Scraping	0.0296			0.0296				0.0296
Coal Loading	0.0009		0.0009					0.0009
Blasting	0.0004	0.0003	0.0001					0.0004
Wind Erosion	0.0428	0.0214	0.0128	0.0086				0.0428
Coal Processing	0.0338				0.0338			0.0338
Access Road Traffic	0.1463						0.1463	0.1463
Coal Haul Truck	0.0365	0.0030	0.0122			0.0213		0.0365
Service Vehicles (separated from graders line item)	0.0141	0.0071	0.0028			0.0042		0.0141
Total, g/sec	**0.676**	**0.22**	**0.15**	**0.09**	**0.03**	**0.03**	**0.15**	0.6757
Total, ton/yr	23.49							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		806,600	274,081	274,713	152,856			
Emissions (g/s)		0 2242	0 1539	0 0912	0 0338	0 0263	0 1463	
Initial Lateral Width (m)								
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		2 77941E-07	5 61463E-07	3 3186E-07	2 21334E-07			
Road Segments						44	144	
Volume Source Emission Rate (g/s)						0 00060	0 00102	
						0 001614	Haul road and access road overlap	
Open Pits								
Coal Pit Volumes (210' below grade)	**Leg 1**	**Leg 2**	**Leg 3**					
Xinit(m)	110	110	110					
Yinit(m)	1000	1000	750					
Depth(m)	62.5	62.5	62.5					
Volume (m3)	6873240	6873240	5154930	18901410				
Equivalent Surface Area (m2)	110000	110000	82500	302500				
Emissions at Pit Bottom (g/s)				0.0009				
Emissions assumed at 1/2 depth of pit g/s)				0.1380				
Emissions (g/s)	0.013772862	0.050500493	0.03787537	0.1389	0.102148725			
Model Emission Rate (g/s-m2)				4.5910E-07				
Main Pit (Overburden removal, etc.)	**Leg 1**	**Leg 2**	**Leg 3**					
assume 100' below grade								
Xinit(m)	350	350	350					

Yinit(m)	800	1400	700					
Depth(m)	30	30	30					
Volume (m3)	8,400,000	14,700,000	7,350,000					
Equivalent Surface Area (m2)	280000	490000	245000	1015000				
emissions in main pit overburden removal area (g/s)				0.0584				
other emissions assumed at 1/2 depth of main pit area				0.1557				
Total (g/s)	0.05905856	0.10335248	0.05167624	0.2141				
Model Emission Rate (g/s-m2)				2.1092E-07				

Alton Tract - Alternative B

AERMOD Area Source SO2 Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual SO2 Q(g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.0001	0.0001	0.0000			0.0000		0.0001
Bulldozers	0.0012	0.0006	0.0004	0.0002				0.0012
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	0.0014	0.0010	0.0004					0.0014
Topsoil Scraping	0.0004			0.0004				0.0004
Coal Loading	0.0006		0.0006					0.0006
Blasting	0.0086	0.0060	0.0026					0.0086
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.0002						0.0002	0.0002
Coal Haul Truck	0.0003	0.0000	0.0001			0.0002		0.0003
Service Vehicles (separated from graders line item)	0.0000	0.0000	0.0000			0.0000		0.0000
Total	**0.0129**	**0.0078**	**0.0041**	**0.0006**	**0.0000**	**0.0002**	**0.0002**	0.0129
	0.45							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		0 0078	0 0041	0 0006	0 0000	0 0002	0 0002	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		6 1817E-09	1 34214E-08	2 34853E-09	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 000004	0 000001	
						0 000005	Haul road and access road overlap	

Alton 200-foot Overburden Scenario, Alternative C

Alton Tract - Alternative C

AERMOD Area Source CO Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual CO Q(g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.2878	0.1439	0.0576			0.0863		0.2878
Bulldozers	0.8702	0.4351	0.2610	0.1740				0.8702
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	4.8865	3.4205	1.4659					4.8865
Topsoil Scraping	0.4453			0.4453				0.4453
Coal Loading	0.4550		0.4550					0.4550
Blasting	0.2891	0.2024	0.0867					0.2891
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.3188						0.3188	0.3188
Coal Haul Truck	0.6806	0.0681	0.1361			0.4764		0.6806
Service Vehicles (separated from graders line item)	0.0151	0.0076	0.0030			0.0045		0.0151
Total	**8.23**	**4.27**	**2.46**	**0.62**	**0.00**	**0.56**	**0.32**	8.2331
	286.18							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		4 2699	2 4624	0 6193	0 0000	0 5627	0 3188	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		3 39995E-06	8 10024E-06	2 34246E-06	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 00853	0 00223	
						0 01076	Haul road and access road overlap	

Alton Tract - Alternative C

AERMOD Area Source NOx Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual NOx Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.0329	0.0164	0.0066			0.0099		0.0329
Bulldozers	0.0994	0.0497	0.0298	0.0199				0.0994
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	4.8865	3.4205	1.4659					4.8865
Topsoil Scraping	0.0509			0.0509				0.0509
Coal Loading	0.0520		0.0520					0.0520
Blasting	0.0734	0.0513	0.0220					0.0734
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.1230						0.1230	0.1230
Coal Haul Truck	0.6806	0.0681	0.1361			0.4764		0.6806
Service Vehicles (separated from graders line item)	0.0339	0.0169	0.01			0.0102		0.0339
Total	**6.03**	**3.62**	**1.72**	**0.07**	**0.00**	**0.50**	**0.12**	6.03
	209.69							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		3 6230	1 7192	0 0708	0 0000	0 4964	0 1230	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		2 88486E-06	5 6556E-06	2 6771E-07	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 0075	0 00086	
						0 00838	Haul road and access road overlap	

Alton Tract - Alternative C

AERMOD Area Source PM-10 Modeling Emissions

		Emissions by Area (g/s)								
Emission Activities	**Total Annual PM-10 Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	**Check**		
Graders	0 0390	0 0195	0 0078			0 0117		0 0390		
Bulldozers	0 4846	0 2423	0 1454	0 0969				0 4846		
Overburden Loading	0 1156	0 0809	0 0347					0 1156		
Overburden Haul Truck	0 8578	0 4615	0 3963					0 8578		
Topsoil Scraping	0 2956			0 2956				0 2956		
Coal Loading	0 0060		0 0060					0 0060		
Blasting (within pit)	0 0073	0 0051	0 0022					0 0073		
Wind Erosion	0 5708	0 2854	0 1712	0 1142				0 5708		
Coal Processing (increase to 25' release height)	0 3351				0 3351			0 3351		
Access Road Traffic	1 4287						1 4287	1 4287		
Coal Haul Truck	0 3647	0 0303	0 1218			0 2126		0 3647		
Service Vehicles (separated from graders line item)	0 1415	0 0590	0 0471			0 0354		0 1415		
Total Emissions by Area	**4.6467**	**1.18**	**0.93**	**0.51**	**0.34**	**0.26**	**1.43**	4 6467		
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**			
Area (m^2)		806,600	274,081	274,713	152,856					
Emissions (g/s)		1.1840	0.9325	0.5067	0.3351	0.2597	1.4287			
Initial Lateral Width (m)										
Road Segment Length (m)										
Model Emission Rate (g/s-m2)		1.4679E-06	3.40236E-06	1.84439E-06	2.19215E-06					
Road Segments						44	140			
Volume Source Emission Rate (g/s)						0.0059	0.01021			
Open Pits Source Calculations	have to model volume sources as independent adjacent sources with emissions input as g/s (BEEST figures out g/sec-m2 by area and volume inputs)									
Coal Pit Volumes(Assumes 180ft Depth)	**Leg 1**	**Leg 2**	**Leg 3**							
Xinit(m)	100.58	100.58	100.58							
Yinit(m)	1325	800	600							
Depth(m)**	54.9	54 9	54.9	**Total Volume of Open pits**						
Volume (m3)	7,311,643	4,414,577	3,310,933	15037152.55						
Equivalent Surface Area (m2)	133268.5	80464	60348	274080.5						
Emissions (g/s)	0.453427041	0.27376727	0 205325452	0.9325	(Matches main coal pit emissions above)					
Model Emission Rate (g/s-m2)				3.4024E-06						
Main Pit (Overburden removal, etc.)	**Leg 1**	**Leg 2**	**Leg 3**							
Assumes 120 foot average depth										
Xinit(m)	296	296	296							
Yinit(m)	1325	800	600							
Depth(m) **	36.58	36.58	36 58	**Total Volume of Open pits**						
Volume (m3)	14,345,107	8,661,197	6,495,898	29502201.60						
Equivalent Surface Area (m2)	392200	236800	177600	806600						
Total (g/s)	0 575710224	0.347598626	0 260698969	1.1840	(Matches total development area emissions above)					
Model Emission Rate (g/s-m2)				1.4679E-06						

** The BEEST AERMOD processor figures out the pit depth by using he input volume and surface area for the source										

Alton Tract - Alternative C

AERMOD Area Source PM-2.5 Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual PM-2.5 Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.0027	0.0014	0.0005			0.0008		0.0027
Bulldozers	0.2652	0.1326	0.0796	0.0530				0.2652
Overburden Loading	0.0175	0.0123	0.0053					0.0175
Overburden Haul Truck	0.0858	0.0462	0.0396					0.0858
Topsoil Scraping	0.0296			0.0296				0.0296
Coal Loading	0.0009		0.0009					0.0009
Blasting	0.0004	0.0003	0.0001					0.0004
Wind Erosion	0.0856	0.0428	0.0257	0.0171				0.0856
Coal Processing	0.0338				0.0338			0.0338
Access Road Traffic	0.1463						0.1463	0.1463
Coal Haul Truck	0.0365	0.0030	0.0122			0.0213		0.0365
Service Vehicles (separated from graders line item)	0.0141	0.0071	0.0028			0.0042		0.0141
Total, g/sec	**0.718**	**0.25**	**0.17**	**0.10**	**0.03**	**0.03**	**0.15**	0.7185
Total, ton/yr	24.97							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		806,600	274,081	274,713	152,856			
Emissions (g/s)		0 2456	0 1667	0 0997	0 0338	0 0263	0 1463	
Initial Lateral Width (m)								
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		3 04478E-07	6 08322E-07	3 63027E-07	2 21334E-07			
Road Segments						44	144	
Volume Source Emission Rate (g/s)						0 00060	0 00102	
						0 001614	Haul road and access road overlap	
Open Pits								
Coal Pit Volumes (210' below grade)	**Leg 1**	**Leg 2**	**Leg 3**					
Xinit(m)	110	110	110					
Yinit(m)	1000	1000	750					
Depth(m)	62.5	62.5	62.5					
Volume (m3)	6873240	6873240	5154930	18901410				
Equivalent Surface Area (m2)	110000	110000	82500	302500				
Emissions at Pit Bottom (g/s)				0.0009				
Emissions assumed at 1/2 depth of pit g/s)				0.1508				
Emissions (g/s)	0.015046561	0.055170725	0.041378044	0.1517	0.111595331			
Model Emission Rate (g/s-m2)				5.0155E-07				
Main Pit (Overburden removal, etc.)	**Leg 1**	**Leg 2**	**Leg 3**					
assume 100' below grade								
Xinit(m)	350	350	350					

Yinit(m)	800	1400	700						
Depth(m)	30	30	30						
Volume (m3)	8,400,000	14,700,000	7,350,000						
Equivalent Surface Area (m2)	280000	490000	245000	1015000					
emissions in main pit overburden removal area (g/s)				0.0584					
other emissions assumed at 1/2 depth of main pit area				0.1771					
Total (g/s)	0.064963451	0.113686039	0.05684302	0.2355					
Model Emission Rate (g/s-m2)				2.3201E-07					

Alton Tract - Alternative C

AERMOD Area Source SO2 Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual SO2 Q(g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.0001	0.0001	0.0000			0.0000		0.0001
Bulldozers	0.0012	0.0006	0.0004	0.0002				0.0012
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	0.0014	0.0010	0.0004					0.0014
Topsoil Scraping	0.0004			0.0004				0.0004
Coal Loading	0.0006		0.0006					0.0006
Blasting	0.0086	0.0060	0.0026					0.0086
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.0002						0.0002	0.0002
Coal Haul Truck	0.0003	0.0000	0.0001			0.0002		0.0003
Service Vehicles (separated from graders line item)	0.0000	0.0000	0.0000			0.0000		0.0000
Total	**0.0129**	**0.0078**	**0.0041**	**0.0006**	**0.0000**	**0.0002**	**0.0002**	0.0129
	0.45							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		0 0078	0 0041	0 0006	0 0000	0 0002	0 0002	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		6 1817E-09	1 34214E-08	2 34853E-09	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 000004	0 000001	
						0 000005	Haul road and access road overlap	

Alton 300-foot Overburden Scenario, Alternative B

Alton Tract - Alternative B

AERMOD Area Source CO Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual CO Q(g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.2878	0.1439	0.0576			0.0863		0.2878
Bulldozers	1.0442	0.5221	0.3133	0.2088				1.0442
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	14.6594	10.2616	4.3978					14.6594
Topsoil Scraping	0.4453			0.4453				0.4453
Coal Loading	0.4550		0.4550					0.4550
Blasting	0.2891	0.2024	0.0867					0.2891
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.3188						0.3188	0.3188
Coal Haul Truck	0.6806	0.0681	0.1361			0.4764		0.6806
Service Vehicles (separated from graders line item)	0.0151	0.0076	0.0030			0.0045		0.0151
Total	**18.18**	**11.20**	**5.45**	**0.65**	**0.00**	**0.56**	**0.32**	18.1801
	631.94							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		11 1980	5 4465	0 6541	0 0000	0 5627	0 3188	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		8 91646E-06	1 79166E-05	2 47411E-06	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 00853	0 00223	
						0 01076	Haul road and access road overlap	

Alton Tract - Alternative B

AERMOD Area Source NOx Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual NOx Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.0329	0.0164	0.0066			0.0099		0.0329
Bulldozers	0.1193	0.0597	0.0358	0.0239				0.1193
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	14.6594	10.2616	4.3978					14.6594
Topsoil Scraping	0.0509			0.0509				0.0509
Coal Loading	0.0520		0.0520					0.0520
Blasting	0.0734	0.0513	0.0220					0.0734
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.1230						0.1230	0.1230
Coal Haul Truck	0.6806	0.0681	0.1361			0.4764		0.6806
Service Vehicles (separated from graders line item)	0.0339	0.0169	0.01			0.0102		0.0339
Total	**15.83**	**10.47**	**4.66**	**0.07**	**0.00**	**0.50**	**0.12**	15.83
	550.09							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		10 4740	4 6571	0 0748	0 0000	0 4964	0 1230	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		8 34001E-06	1 53199E-05	2 82755E-07	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 0075	0 00086	
						0 00838	Haul road and access road overlap	

Alton Tract - Alternative B

AERMOD Area Source PM-10 Modeling Emissions

		Emissions by Area (g/s)							
Emission Activities	**Total Annual PM-10 Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	**Check**	
Graders	0 0390	0 0195	0 0078			0 0117		0 0390	
Bulldozers	0 5815	0 2908	0 1745	0 1163				0 5815	
Overburden Loading	0 1908	0 1336	0 0572					0 1908	
Overburden Haul Truck	1 6041	0 8630	0 7411					1 6041	
Topsoil Scraping	0 3683			0 3683				0 3683	
Coal Loading	0 0060		0 0060					0 0060	
Blasting (within pit)	0 0073	0 0051	0 0022					0 0073	
Wind Erosion	0 3437	0 1718	0 1031	0 0687				0 3437	
Coal Processing (increase to 25' release height)	0 3351				0 3351			0 3351	
Access Road Traffic	1 4287						1 4287	1 4287	
Coal Haul Truck	0 7294	0 0605	0 2436			0 4252		0 7294	
Service Vehicles (separated from graders line item)	0 1415	0 0590	0 0471			0 0354		0 1415	
Total Emissions by Area	**5.7753**	**1.60**	**1.38**	**0.55**	**0.34**	**0.47**	**1.43**	5 7753	

Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**		
Area (m^2)		806,600	274,081	274,713	152,856				
Emissions (g/s)		1 6033	1 3826	0 5533	0 3351	0 4723	1 4287		
Initial Lateral Width (m)									
Road Segment Length (m)									
Model Emission Rate (g/s-m2)		1 98774E-06	5 04454E-06	2 01420E-06	2 19215E-06				
Road Segments						44	140		
Volume Source Emission Rate (g/s)						0 0107	0 01021		

Open Pits Source Calculations	have to model volume sources as independent adjacent sources with emissions input as g/s (BEEST figures out g/sec-m2 by area and volume inputs)								
Coal Pit Volumes(Assumes 180ft Depth)	**Leg 1**	**Leg 2**	**Leg 3**						
Xinit(m)	100.58	100.58	100.58						
Yinit(m)	1325	800	600						
Depth(m)**	54.9	54.9	54.9	**Total Volume of Open pits**					
Volume (m3)	7,311,643	4,414,577	3,310,933	15037152.55					
Equivalent Surface Area (m2)	133268.5	80464	60348	274080.5					
Emissions (g/s)	0.672278452	0.405903971	0.304427978	1.3826	(Matches main coal pit emissions above)				
Model Emission Rate (g/s-m2)				5.0445E-06					
Main Pit (Overburden removal, etc.)	**Leg 1**	**Leg 2**	**Leg 3**						
Assumes 120 foot average depth									
Xinit(m)	296	296	296						
Yinit(m)	1325	800	600						
Depth(m) **	36.58	36.58	36.58	**Total Volume of Open pits**					
Volume (m3)	14,345,107	8,661,197	6,495,898	29502201.60					
Equivalent Surface Area (m2)	392200	236800	177600	806600					
Total (g/s)	0.77959016	0.470695946	0.353021959	1.6033	(Matches total development area emissions above)				

Model Emission Rate (g/s-m2)				1.9877E-06					
** The BEEST AERMOD processor figures out the pit depth by using the input volume and surface area for the source									

Alton Tract - Alternative B

AERMOD Area Source PM-2.5 Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual PM-2.5 Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0 0027	0 0014	0 0005			0 0008		0 0027
Bulldozers	0 3183	0 1591	0 0955	0 0637				0 3183
Overburden Loading	0 0289	0 0202	0 0087					0 0289
Overburden Haul Truck	0 1604	0 0863	0 0741					0 1604
Topsoil Scraping	0 0368			0 0368				0 0368
Coal Loading	0 0009		0 0009					0 0009
Blasting	0 0004	0 0003	0 0001					0 0004
Wind Erosion	0 0516	0 0258	0 0155	0 0103				0 0516
Coal Processing	0 0338				0 0338			0 0338
Access Road Traffic	0 1463						0 1463	0 1463
Coal Haul Truck	0 0729	0 0061	0 0244			0 0425		0 0729
Service Vehicles (separated from graders line item)	0 0141	0 0071	0 0028			0 0042		0 0141
Total, g/sec	**0.867**	**0.31**	**0.22**	**0.11**	**0.03**	**0.05**	**0.15**	0 8672
Total, ton/yr	30 14							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		806,600	274,081	274,713	152,856			
Emissions (g/s)		0.3062	0.2225	0.1108	0.0338	0.0476	0.1463	
Initial Lateral Width (m)								
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		3.79651E-07	8.11793E-07	4.03302E-07	2.21334E-07			
Road Segments						44	144	
Volume Source Emission Rate (g/s)						0.00108	0.00102	
						0.002097	Haul road and access road overlap	
Open Pits								
Coal Pit Volumes (210' below grade)	**Leg 1**	**Leg 2**	**Leg 3**					
Xinit(m)	110	110	110					
Yinit(m)	1000	1000	750					
Depth(m)	62 5	62 5	62.5					
Volume (m3)	6873240	6873240	5154930	18901410				
Equivalent Surface Area (m2)	110000	110000	82500	302500				
Emissions at Pit Bottom (g/s)				0.0009				
Emissions assumed at 1/2 depth of pit g/s)				0.1944				
Emissions (g/s)	0.019369262	0.071020628	0.053265471	0.1953	0.143655361			
Model Emission Rate (g/s-m2)				6.4564E-07				
Main Pit (Overburden removal, etc.)	**Leg 1**	**Leg 2**	**Leg 3**					
assume 100' below grade								
Xinit(m)	350	350	350					
Yinit(m)	800	1400	700					
Depth(m)	30	30	30					
Volume (m3)	8,400,000	14,700,000	7,350,000					
Equivalent Surface Area (m2)	280000	490000	245000	1015000				
emissions in main pit overburden removal area (g/s)				0.1065				
other emissions assumed at 1/2 depth of main pit area				0.1866				
Total (g/s)	0.08085511	0.141496442	0.070748221	0.2931				
Model Emission Rate (g/s-m2)				2 8877E-07				

Alton Tract - Alternative B

AERMOD Area Source SO2 Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual SO2 Q(g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.0001	0.0001	0.0000			0.0000		0.0001
Bulldozers	0.0015	0.0007	0.0004	0.0003				0.0015
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	0.0043	0.0030	0.0013					0.0043
Topsoil Scraping	0.0004			0.0004				0.0004
Coal Loading	0.0006		0.0006					0.0006
Blasting	0.0086	0.0060	0.0026					0.0086
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.0002						0.0002	0.0002
Coal Haul Truck	0.0003	0.0000	0.0001			0.0002		0.0003
Service Vehicles (separated from graders line item)	0.0000	0.0000	0.0000			0.0000		0.0000
Total	**0.0160**	**0.0099**	**0.0050**	**0.0007**	**0.0000**	**0.0002**	**0.0002**	0.0160
	0.56							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		0 0099	0 0050	0 0007	0 0000	0 0002	0 0002	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		7 88455E-09	1 65062E-08	2 53601E-09	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 000004	0 000001	
						0 000005	Haul road and access road overlap	

Alton 300-foot Overburden Scenario, Alternative C

Alton Tract - Alternative C

AERMOD Area Source CO Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual CO Q(g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.2878	0.1439	0.0576			0.0863		0.2878
Bulldozers	1.0442	0.5221	0.3133	0.2088				1.0442
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	14.6594	10.2616	4.3978					14.6594
Topsoil Scraping	0.4453			0.4453				0.4453
Coal Loading	0.4550		0.4550					0.4550
Blasting	0.2891	0.2024	0.0867					0.2891
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.3188						0.3188	0.3188
Coal Haul Truck	0.6806	0.0681	0.1361			0.4764		0.6806
Service Vehicles (separated from graders line item)	0.0151	0.0076	0.0030			0.0045		0.0151
Total	**18.18**	**11.20**	**5.45**	**0.65**	**0.00**	**0.56**	**0.32**	18.1801
	631.94							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		11 1980	5 4465	0 6541	0 0000	0 5627	0 3188	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		8 91646E-06	1 79166E-05	2 47411E-06	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 00853	0 00223	
						0 01076	Haul road and access road overlap	

Alton Tract - Alternative C

AERMOD Area Source NOx Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual NOx Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.0329	0.0164	0.0066			0.0099		0.0329
Bulldozers	0.1193	0.0597	0.0358	0.0239				0.1193
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	14.6594	10.2616	4.3978					14.6594
Topsoil Scraping	0.0509			0.0509				0.0509
Coal Loading	0.0520		0.0520					0.0520
Blasting	0.0734	0.0513	0.0220					0.0734
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.1230						0.1230	0.1230
Coal Haul Truck	0.6806	0.0681	0.1361			0.4764		0.6806
Service Vehicles (separated from graders line item)	0.0339	0.0169	0.01			0.0102		0.0339
Total	**15.83**	**10.47**	**4.66**	**0.07**	**0.00**	**0.50**	**0.12**	15.83
	550.09							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		10 4740	4 6571	0 0748	0 0000	0 4964	0 1230	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		8 34001E-06	1 53199E-05	2 82755E-07	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 0075	0 00086	
						0 00838	Haul road and access road overlap	

Alton Tract - Alternative C

AERMOD Area Source PM-10 Modeling Emissions

		Emissions by Area (g/s)							
Emission Activities	**Total Annual PM-10 Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	**Check**	
Graders	0 0390	0 0195	0 0078			0 0117		0 0390	
Bulldozers	0 5815	0 2908	0 1745	0 1163				0 5815	
Overburden Loading	0 1908	0 1336	0 0572					0 1908	
Overburden Haul Truck	1 6041	0 8630	0 7411					1 6041	
Topsoil Scraping	0 3683			0 3683				0 3683	
Coal Loading	0 0060		0 0060					0 0060	
Blasting (within pit)	0 0073	0 0051	0 0022					0 0073	
Wind Erosion	0 6874	0 3437	0 2062	0 1375				0 6874	
Coal Processing (increase to 25' release height)	0 3351				0 3351			0 3351	
Access Road Traffic	1 4287						1 4287	1 4287	
Coal Haul Truck	0 7294	0 0605	0 2436			0 4252		0 7294	
Service Vehicles (separated from graders line item)	0 1415	0 0590	0 0471			0 0354		0 1415	
Total Emissions by Area	**6.1190**	**1.78**	**1.49**	**0.62**	**0.34**	**0.47**	**1.43**	6 1190	
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**		
Area (m^2)		806,600	274,081	274,713	152,856				
Emissions (g/s)		1.7752	1.4857	0.6221	0.3351	0.4723	1.4287		
Initial Lateral Width (m)									
Road Segment Length (m)									
Model Emission Rate (g/s-m2)		2.20078E-06	5.42073E-06	2.26441E-06	2.19215E-06				
Road Segments						44	140		
Volume Source Emission Rate (g/s)						0.0107	0.01021		
Open Pits Source Calculations	have to model volume sources as independent adjacent sources with emissions input as g/s (BEEST figures out g/sec-m2 by area and volume inputs)								
Coal Pit Volumes(Assumes 180ft Depth)	**Leg 1**	**Leg 2**	**Leg 3**						
Xinit(m)	100.58	100.58	100.58						
Yinit(m)	1325	800	600						
Dep h(m)**	54.9	54 9	54.9	**Total Volume of Open pits**					
Volume (m3)	7,311,643	4,414,577	3,310,933	15037152.55					
Equivalent Surface Area (m2)	133268.5	80464	60348	274080.5					
Emissions (g/s)	0.722412548	0.436173614	0.327130211	1.4857	(Matches main coal pit emissions above)				
Model Emission Rate (g/s-m2)				5.4207E-06					
Main Pit (Overburden removal, etc.)	**Leg 1**	**Leg 2**	**Leg 3**						
Assumes 120 foot average depth									
Xinit(m)	296	296	296						
Yinit(m)	1325	800	600						
Dep h(m) **	36.58	36.58	36.58	**Total Volume of Open pits**					
Volume (m3)	14,345,107	8,661,197	6,495,898	29502201.60					
Equivalent Surface Area (m2)	392200	236800	177600	806600					
Total (g/s)	0.863146988	0.521145351	0.390859013	1.7752	(Matches total development area emissions above)				
Model Emission Rate (g/s-m2)				2.2008E-06					
** The BEEST AERMOD processor figures out the pit depth by using the input volume and surface area for the source									

Alton Tract - Alternative C

AERMOD Area Source PM-2.5 Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual PM-2.5 Q (g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.0027	0.0014	0.0005			0.0008		0.0027
Bulldozers	0.3183	0.1591	0.0955	0.0637				0.3183
Overburden Loading	0.0289	0.0202	0.0087					0.0289
Overburden Haul Truck	0.1604	0.0863	0.0741					0.1604
Topsoil Scraping	0.0368			0.0368				0.0368
Coal Loading	0.0009		0.0009					0.0009
Blasting	0.0004	0.0003	0.0001					0.0004
Wind Erosion	0.1031	0.0516	0.0309	0.0206				0.1031
Coal Processing	0.0338				0.0338			0.0338
Access Road Traffic	0.1463						0.1463	0.1463
Coal Haul Truck	0.0729	0.0061	0.0244			0.0425		0.0729
Service Vehicles (separated from graders line item)	0.0141	0.0071	0.0028			0.0042		0.0141
Total, g/sec	**0.919**	**0.33**	**0.24**	**0.12**	**0.03**	**0.05**	**0.15**	0.9187
Total, ton/yr	31.94							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		806,600	274,081	274,713	152,856			
Emissions (g/s)		0 3320	0 2380	0 1211	0 0338	0 0476	0 1463	
Initial Lateral Width (m)								
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		4 11608E-07	8 68222E-07	4 40835E-07	2 21334E-07			
Road Segments						44	144	
Volume Source Emission Rate (g/s)						0 00108	0 00102	
						0 002097	Haul road and access road overlap	
Open Pits								
Coal Pit Volumes (210' below grade)	**Leg 1**	**Leg 2**	**Leg 3**					
Xinit(m)	110	110	110					
Yinit(m)	1000	1000	750					
Depth(m)	62.5	62.5	62.5					
Volume (m3)	6873240	6873240	5154930	18901410				
Equivalent Surface Area (m2)	110000	110000	82500	302500				
Emissions at Pit Bottom (g/s)				0.0009				
Emissions assumed at 1/2 depth of pit g/s)				0.2099				
Emissions (g/s)	0.02090307	0.07664459	0.057483442	0.2108	0.155031102			
Model Emission Rate (g/s-m2)				6.9677E-07				
Main Pit (Overburden removal, etc.)	**Leg 1**	**Leg 2**	**Leg 3**					
assume 100' below grade								
Xinit(m)	350	350	350					

Yinit(m)	800	1400	700					
Depth(m)	30	30	30					
Volume (m3)	8,400,000	14,700,000	7,350,000					
Equivalent Surface Area (m2)	280000	490000	245000	1015000				
emissions in main pit overburden removal area (g/s)				0.1065				
other emissions assumed at 1/2 depth of main pit area				0.2123				
Total (g/s)	0.087965866	0.153940266	0.076970133	0.3189				
Model Emission Rate (g/s-m2)				3.1416E-07				

Alton Tract - Alternative C

AERMOD Area Source SO2 Modeling Emissions

		Emissions by Area (g/s)						
Emission Activities	**Total Annual SO2 Q(g/s)**	**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck Road**	**Access Road**	
Graders	0.0001	0.0001	0.0000			0.0000		0.0001
Bulldozers	0.0015	0.0007	0.0004	0.0003				0.0015
Overburden Loading	0.0000	0.0000	0.0000					0.0000
Overburden Haul Truck	0.0043	0.0030	0.0013					0.0043
Topsoil Scraping	0.0004			0.0004				0.0004
Coal Loading	0.0006		0.0006					0.0006
Blasting	0.0086	0.0060	0.0026					0.0086
Wind Erosion	0.0000	0.0000	0.0000	0.0000				0.0000
Coal Processing	0.0000				0.0000			0.0000
Access Road Traffic	0.0002						0.0002	0.0002
Coal Haul Truck	0.0003	0.0000	0.0001			0.0002		0.0003
Service Vehicles (separated from graders line item)	0.0000	0.0000	0.0000			0.0000		0.0000
Total	**0.0160**	**0.0099**	**0.0050**	**0.0007**	**0.0000**	**0.0002**	**0.0002**	0.0160
	0.56							
Source Description		**Total Development Area**	**Main Coal Pit**	**Reclamation**	**Facilities**	**Coal Haul Truck**	**Alton to Facilities area**	
Area (m^2)		1,255,880	303,991	264,387	152,856			
Emissions (g/s)		0 0099	0 0050	0 0007	0 0000	0 0002	0 0002	
Initial Lateral Width (m)						45 77	45 77	
Road Segment Length (m)								
Model Emission Rate (g/s-m2)		7 88455E-09	1 65062E-08	2 53601E-09	0			
Road Segments						66	143	
Volume Source Emission Rate (g/s)						0 000004	0 000001	
						0 000005	Haul road and access road overlap	

Appendix C: AP-42 Emission Factor Sections

Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors

Prepared by

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MRI Project No. 110397

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Responses to Comments Received on Proposed AP-42 Revisions

Commenter and Date	Source Category	Comment	Response
John Hayden, National Stone, Sand and Gravel Association (NSSGA); June 14, 2006	Unpaved Roads	NSSGA-sponsored tests (report dated Oct. 15, 2004) at California aggregate producing plants support the proposed fine fractions.	This comment reference a test report prepared by Air Control Techniques for the National Stone, Sand & Gravel Association, dated October 4, 2004. The report gives the results of tests to determine unpaved road emissions factors for controlled (wet suppression only) haul roads at two aggregate processing plants. A variation of the plume profiling method using TEOM continuous monitors with PM-2.5 and PM-10 inlets was employed. Tests with road surface moisture content below 1.5 percent were considered to be uncontrolled. Based on the example PM-10 concentration profiles presented in the report, the maximum roadside PM-10 dust concentrations in the subject study were in the range of 300 micrograms per cubic meter. This is an order of magnitude lower than the concentrations typically found in other unpaved road emission factor studies. For the range of plume concentrations measured in the NSSGA-sponsored test program, an average fine fraction (PM-2.5/PM-10 ratio) of 0.15 was reported. This fine fraction value is consistent with the results of the MRI dust tunnel testing in the same concentration range. At plume concentrations more typical of unpaved road emission factor studies, the proposed value of 0.1 is applicable. There is no need for any revisions to the proposed changes to AP-42 as a result of the cited study.
Hao Quinn, Sacramento Metro AQMD; July 20, 2006	Paved vs. unpaved roads	For a particular industrial facility, the PM-10 emission factor equations show higher emissions from paved roads rather than unpaved roads.	***This comment does not relate to the proposed changes to the fine particle fractions***. It is possible that the emissions from a heavily loaded paved road can exceed emissions from an unpaved road with a low-to-moderate silt content at the same industrial facility, even if traveled by the same vehicles. This is the case in the cited example, for which the paved road silt loading is 70 g/m^2.

Commenter and Date	Source Category	Comment	Response
Brian Leahy, Horizon Environmental; July 26, 2006	Unpaved roads	The k value for PM-2.5 does not appear to have changed in the proposed revision.	The latest (2003) approved AP-42 k values for PM-2.5 in Table 13.2.2-2 are 0.23 and 0.27 lb/VMT for industrial and public roads, respectively. The proposed values are 0.15 and 0.18 lb/VMT, which are equivalent to 10 percent of the respective k values for PM-10. There is no need for revisions to the proposed changes to AP-42 as a result of this comment.
Shengxin Jin, NYSDOT Environmental Analysis Bureau; undated	Paved roads	The conversion of proposed k values from g/VMT to g/VKT does not appear correct	Regarding the revised k values for PM-2.5, when the k value of 0.66 g/VKT is multiplied by 1.6 km/mi, it becomes 1.06 g/VMT, which rounds to 1.1 g/VKT given in the proposed revision. Because the k values are given only to two significant figures, the converted values can vary by up to five digits in the second figure, depending on which direction the units conversion is made. For example, when k value of 1.1 g/VKT is divided by 1.6 km/mi, the resulting value rounds to 0.69 g/VKT, but if 1.06 g/VKT is divided by 1.6 km/mi, the resulting value rounds to 0.66 g/VKT. There is no need for revisions to the proposed changes to AP-42 as a result of this comment.
		The stated silt loading impact of antiskid abrasive does not appear correct	***This comment does not relate to the proposed changes to the fine particle fractions***. The commenter is correct in that 500 lb/mi of antiskid abrasive with a 1% silt content produces a silt loading in the range of 0.5 g/m^2 rather than 2 g/m^2. EPA may elect to make a separate modification to correct this discrepancy at a later time.

Proposed Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors

ABSTRACT

A number of fugitive dust studies have indicated that the $PM_{2.5}$ / PM_{10} ratios measured by US EPA federal reference method (FRM) samplers are significantly lower than predicted by AP-42 emission factors. As a result, the $PM_{2.5}$ emission estimates are biased high. The controlled exposure study described in this report was conducted to compare fine fraction ratios derived from FRM samplers to those derived from the cyclone/impactor method that had been used to develop AP-42 emission factors for fugitive dust sources. The study was conducted by the Midwest Research Institute using the same cyclone/impactor samplers and operating method that generated the original AP-42 emission factors and associated $PM_{2.5}$ / PM_{10} ratios. This study was sponsored by the Western Regional Air Partnership.

The study found that concentration measurements used to develop $PM_{2.5}$ emission factors in AP-42 were biased high by a factor of two, as compared to $PM_{2.5}$ measurements from FRM samplers. This factor-of-two bias helps to explain why researchers have often seen a discrepancy in the proportion of fugitive dust found in $PM_{2.5}$ emission inventories and modeled ambient air impacts, as compared to the proportion on ambient filter samples. This study also shows that the $PM_{2.5}$ / PM_{10} ratios for fugitive dust should be in the range of 0.1 to 0.15. Currently, the ratios in AP-42 range from 0.15 to 0.4 for most fugitive dust sources.

It is recommended that the results of this study be used to revise the AP-42 $PM_{2.5}$ emission factors for the following four fugitive dust source categories: paved roads, unpaved roads (public and industrial), aggregate handling and storage piles, and industrial wind erosion (AP-42 Sections 13.2.1, 13.2.2, 13.2.4, & 13.2.5, respectively). Emission estimates for other fugitive dust producing activities, such as construction and demolition will also be affected since they are based on these four source categories.

INTRODUCTION

The Dust Emissions Joint Forum (DEJF) of the Western Regional Air Partnership (WRAP) is engaged in gathering and improving data pertaining to the $PM_{2.5}$ and PM_{10} components of fugitive dust emissions. Most of the $PM_{2.5}$ emission factors in EPA's AP-42 guidance for fugitive dust sources (USEPA, 2005) were determined by using high-volume samplers, each fitted with a cyclone precollector and cascade impactor. Typically, AP-42 recommends that $PM_{2.5}$ emission factors for dust sources be calculated by using PM_{10} emission factor equations along with $PM_{2.5}/PM_{10}$ ratios that have been published by EPA in AP-42.

Beginning with the introduction of the cyclone/impactor method, it was realized particle bounce from the cascade impactor stages to the backup filter may have resulted in inflated $PM_{2.5}$ concentrations, even though steps were taken to minimize particle bounce. This led to an EPA-funded field study in the late 1990s (MRI, 1997) to gather comparative particle sizing data in dust plumes downwind of paved and unpaved roads around the country. The test results indicated that dichotomous samplers produced consistently lower $PM_{2.5}/PM_{10}$ ratios than generated with the cyclone/impactor system. Dichotomous samplers are federal reference method (FRM) samplers that are used to measure compliance with federal air quality standards for particulate matter measured as $PM_{2.5}$ and PM_{10}. Pending the eventual collection of additional data, the decision was made that the true ratios would best be represented by an averaging of the cyclone/impactor data with the dichotomous sampler data.

Based on the results of the EPA-funded field program, modifications were made to the appropriate sections of AP-42 for dust emissions from paved and unpaved roads. The $PM_{2.5}/PM_{10}$ ratio for emissions from unpaved roads (dominated by fugitive dust) was reduced from 0.26 to 0.15, and the $PM_{2.5}/PM_{10}$ ratio for the dust component of emissions from paved roads was reduced from 0.46 to 0.25. In the 2003 revision to AP-42, the non-dust component of paved road emissions was assigned a $PM_{2.5}/PM_{10}$ ratio of 0.76, accounting for vehicle exhaust and brake and tire wear.

Subsequent to the modifications of the $PM_{2.5}/PM_{10}$ ratios in AP-42, additional field test results (mostly from ambient air samplers) indicated that further reductions to the ratios were warranted (Pace, 2005). For example, ambient air monitoring data suggested that the fine fraction dust mass is of the order of 10 percent of the PM_{10} mass, based on chemical fingerprinting of the collected fine and coarse fractions of PM_{10} impacted by dust sources. It is important to note, however, that particle size data applicable to fugitive dust emission factors should be gathered either from the emissions plume or near the point where emissions are generated (within 10 m of the downwind edge of the source).

METHODOLOGY

This led DEJF to fund Midwest Research Institute (MRI) in conducting a controlled study of particle sizing in dust plumes. The objective of the study was to resolve the fine particle bias in the cyclone/impactor system, so that reliable $PM_{2.5}/PM_{10}$ ratios could be developed for as many dust source categories as possible. For this purpose, an air exposure chamber connected to a recirculating supply air stream was used in conjunction with a fluidization system for generating well-mixed dust plumes from a variety of western soils and road surface materials. R&P Model 2000 Partisol samplers were selected as the ground-truthing FRM samplers for PM_{10} and $PM_{2.5}$.

This study was performed in two phases (see below), as described in the attached test report (Cowherd and Donaldson, 2005). The test report serves as the background document to support the recommended revisions to AP-42, and it contains all the quality assurance procedures and results of the testing.

Phase I – Compare $PM_{2.5}$ Measured by Cyclone/Impactor to FRM Sampler

In the first testing phase of the project, $PM_{2.5}$ measurements using the high-volume cascade impactors were compared to simultaneous measurements obtained with EPA FRM samplers for $PM_{2.5}$. As stated above, these tests were conducted in a flow-through wind tunnel and exposure chamber, where the PM_{10} concentration level and uniformity were controlled. The results of the tests provided the basis for quantifying more effectively any sampling bias associated with the cascade impactor system.

Phase 2 – Compare $PM_{2.5}$ to PM_{10} Ratios for Different Geologic Soils

With the same test setup, a second phase of testing was performed with reference method samplers, for the purpose of measuring $PM_{2.5}$ to PM_{10} ratios for fugitive dust from different geologic sources in the West. This testing provided needed information on the magnitude and variability of this ratio, especially for source materials that are recognized as problematic with regard to application of mitigative dust control measures.

RESULTS

The tests that were performed are listed in Tables 6 and 7 of the attached report. The Phase I tests were performed in March and April of 2005. The Phase II tests were performed in June through August of 2005. A total of 100 individual tests were performed, including 17 blank runs (for quality assurance purposes). The raw and intermediate test data are summarized in the tables presented in Appendix A of the attached report.

Based on the 100 wind tunnel tests that were performed in the wind tunnel study, the findings support the following conclusions:

1. $PM_{2.5}$ concentrations measured by the high-volume cyclone/impactor system used to develop AP-42 emission factors for fugitive dust sources have a positive bias by a factor of 2, as compared to the $PM_{2.5}$ concentration measurements from reference-method samplers (see Figure 1). The geometric mean bias is 2.01 and the arithmetic mean bias is 2.15.
2. The $PM_{2.5}$ bias associated with the cyclone/impactor system, as measured under controlled laboratory conditions with dust concentrations held at nearly steady values, closely replicates the bias observed in the prior EPA-funded field study at distributed geographic locations across the country.

3. The $PM_{2.5}/PM_{10}$ ratios measured by the FRM samplers in the current study for a variety of western soils show a decrease in magnitude with increasing PM_{10} concentration (see Figure 2). Soils with a nominally spherical shape are observed to have somewhat lower ratios (at given PM_{10} concentrations) than soils with angular shape. A very similar dependence of $PM_{2.5}/PM_{10}$ ratio on PM_{10} concentration was also observed in the prior field study that used dichotomous samplers as FRM devices.
4. The test data from the current study support a $PM_{2.5}/PM_{10}$ ratio in the range of 0.1 to 0.15 for typical uncontrolled fugitive dust sources (see Figure 2). The $PM_{2.5}/PM_{10}$ ratio of 0.1 is also supported by numerous other studies including the prior EPA-funded field study that used dichotomous samplers as reference devices. It is possible that a ratio as low as 0.05 (as was found in the prior field tests of unpaved road emission factors) might be appropriate for very dusty sources, but this would require extrapolation of the current test data from the wind tunnel study.

DISCUSSION

Peer Review

The test report on the wind tunnel study (Cowherd and Donaldson, 2005) was issued first in draft form for external peer review. Three peer reviewers (having no prior contact with the study) were selected by the DEJF: Patrick Gaffney (California Air Resources Board), John Kinsey (U.S. Environmental Protection Agency), and Mel Zeldin (Private Consultant). In addition, peer review comments were provided by Duane Ono (Great Basin UAPCD) and Richard Countess (Countess Environmental) who helped to develop this study. After the review comments on the draft test report were received, comment/ response logs were prepared by MRI, listing each comment and the response to each comment. The next step was to modify the draft test report in accordance with the responses to the review comments. The final test report was issued on October 12, 2005.

Recommended Particle Size Ratios

Based on the results of the WRAP/DEJF study (see attached test report) and the prior EPA-funded field study, it is proposed that new $PM_{2.5}/PM_{10}$ ratios be adopted for several categories of (uncontrolled) fugitive dust sources, as addressed in AP-42. The proposed ratios (given to the nearest 0.05) are summarized in Table 1. It should be noted that these fine fraction ratios and the emission factors could change in the future if field studies show other differences than those identified through this study.

The proposed $PM_{2.5}/PM_{10}$ ratios in Table 1, apply to dry surface materials, having moisture contents in the range of 1% or less. Such materials when exposed to energetic disturbances produce dust plumes with core PM_{10} concentrations in the range of 5,000 micrograms per cubic meter, near the point of emissions generation. The wind tunnel test data show that dust plumes with lower core concentrations have higher $PM_{2.5}/PM_{10}$

ratios. This might occur, for example, at higher soil (or other surface material) moisture contents. However, the emissions from such sources typically are substantially lower with correspondingly less impact on the ambient environment.

Table 1. Proposed Particle Size Ratios for AP-42

Fugitive dust source category	AP-42 section	$PM_{2.5}/PM_{10}$ Ratio	
		Current	Proposed
Paved Roads	13.2.1	0.25	0.15
Unpaved Roads (Public & Industrial)	13.2.2	0.15	0.1
Construction & Demolition	–	0.208 [1]	0.1
Aggregate Handling & Storage Piles	13.2.4	0.314	0.1 (traffic) 0.15 (transfer)
Industrial Wind Erosion	13.2.5	0.40	0.15
Agricultural Tilling	–	0.222 [2]	0.2 (no change)
Open Area Wind Erosion	–	-	0.15

Notes:

[1] AP-42 Section 13.2.3 suggests using emission factors for individual dust producing activities, e.g., materials handling and unpaved roads. The WRAP Fugitive Dust Handbook recommends using a fine fraction ratio of 0.208 from a report prepared for the US EPA, Estimating Particulate Matter Emissions from Construction Operations (MRI, 1999).

[2] Agricultural tilling was dropped from the 5th edition of AP-42. The WRAP Fugitive Dust Handbook recommends using a fine fraction ratio of 0.222 from Section 7.4 of the California Air Resources Board's Emission Inventory Methodology (CARB, 2003).

The justification for each proposed ratio in Table 1 is provided by source category in the sections below. In each case, reference is made to test reports that contain supporting data.

Paved Roads

For the dust component of particulate emissions from paved roads, a $PM_{2.5}/PM_{10}$ ratio of 0.15 is recommended. The proposed ratio is based on the factor-of-two bias in the cyclone/impactor data for the wind tunnel study, which tested western soils and road surface materials. As shown in Table 1, the current AP-42 ratio is 0.25. It should be recalled that the nondust component of paved road particulate emissions has been assigned a much higher ratio of 0.76, based on inputs from the EPA's MOBILE 6 model.

Unpaved Roads

For the dust component of particulate emissions from unpaved roads, which dominates the total particulate emissions from this source category, a $PM_{2.5}/PM_{10}$ ratio of 0.1 is recommended. The proposed ratio is justified from the test results of the wind tunnel study for a variety of western surface materials. It is also consistent with the factor-of-two bias in the cyclone/impactor data from the wind tunnel study and with the results of the prior field study that used dichotomous samplers as FRM devices (MRI, 1997).

Construction and Demolition

The dust component of particulate emissions from construction and demolition dominate the total particulate emissions from this source category. A $PM_{2.5}/PM_{10}$ ratio of 0.1 is recommended for dust emissions from construction and demolition. The proposed ratio is justified by the fact that the dominant dust source associated with construction and demolition projects is emissions from vehicle travel over unpaved surfaces. This is shown by case studies that calculate particulate emissions from representative construction activities (road, building, and nonbuilding construction). For example, the fine fraction ratio for scraper travel averages about 0.2 (Muleski et al., 2005), before correcting for the factor-of- two bias in the cyclone/impactor system. Moreover this includes the diesel emissions that are contained within the fine fraction component.

It should be noted that if large open areas are disturbed (such as in land clearing) and left unprotected, and the areas are exposed to high winds, open area wind erosion can also be an important contributor to dust emissions from this source category. The recommended fine fraction ratio identified below should be used for the open area wind erosion component.

Aggregate Handling and Storage Piles

Although usually not a major source in comparison with traffic around storage piles, the transfer of aggregate associated with bucket loaders and unloaders or conveyor transfer points is addressed directly in this section of AP-42. A $PM_{2.5}/PM_{10}$ ratio of 0.15 is recommended for transfer operations. This is half the current value in AP-42 and reflects adjustment for the factor-of-two bias in the cyclone/impactor test results.

The dominant dust component of particulate emissions from aggregate handling and storage piles typically consists of loader and truck traffic around the storage piles. AP-42 refers the reader to the unpaved roads section to find appropriate emission factors. A $PM_{2.5}/PM_{10}$ ratio of 0.1 is recommended for this source. The proposed ratio is consistent with that recommended above for traffic on unpaved surfaces.

Industrial Wind Erosion

For the dust component of particulate emissions from industrial wind erosion, a $PM_{2.5}/PM_{10}$ ratio of 0.15 is recommended. Industrial wind erosion is associated with crushed aggregate materials, such as coal or metallic ore piles. Examples would include open storage piles at mining operations. The proposed ratio is justified by portable wind tunnel tests of industrial aggregate materials which produced $PM_{2.5}/PM_{10}$ ratios averaging 0.4, as indicated by the current AP-42 fine fraction ratio given in Table 1. When these results are corrected for the bias associated with the cyclone/impactor system at very high PM_{10} concentrations observed in the effluent from the portable wind tunnel (exceeding 10,000 $\mu g/m^3$), the result is 0.15.

Agricultural Tilling

For the dust component of particulate emissions from agricultural tilling and related land preparation activities, which dominates the total particulate emissions from this source category, no new $PM_{2.5}/PM_{10}$ ratio can be recommended at this time, because of the lack of published test data. However, the current factor of 0.2, as listed in Table 1, appears to be generally consistent with the results of the current wind tunnel tests. It was found that the agricultural soils tested in the wind tunnel produced slightly higher ratios than the other test materials. In addition, the dust plume core concentrations from agricultural operations are generally observed to be less intense because of the lower equipment speeds involved and the lack of repeated travel over the same routes.

Open Area Wind Erosion

For the dust component of particulate emissions from open area wind erosion (not currently addressed in AP-42), a $PM_{2.5}/PM_{10}$ ratio of 0.15 is recommended. Open area wind erosion is associated with exposed soils that have been disturbed, removing the protection afforded by natural crusting. Examples would include freshly tilled agricultural fields prior to planting of crops. The proposed ratio is justified by wind tunnel tests of exposed soils (MRI, 1994), which produced $PM_{2.5}/PM_{10}$ ratios averaging 0.3. When these results are corrected for the bias associated with the cyclone/impactor system, the ratio becomes 0.15. This is consistent with the $PM_{2.5}/PM_{10}$ ratios in the range of 0.12 measured during dust storms on Owens Dry Lake (Ono, 2005).

Specific Revisions to AP-42

This section presents a listing of specific revisions to AP-42, for the purpose of incorporating the proposed $PM_{2.5}/PM_{10}$ ratios. As shown in Table 2, five subsections of AP-42 Section 13.2, Fugitive Dust, are impacted by the proposed changes. However, one of the five sections (13.2.3, Heavy Construction Operations) is impacted only indirectly because it refers to other sections of AP-42 for fugitive dust emission factors.

In most cases, the change in the $PM_{2.5}/PM_{10}$ ratio is accomplished by changing the appropriate PM-2.5 particle size multiplier (k-factor) for the respective emission factor equation. In addition, the changes need to be referenced to the WRAP test report (Cowherd and Donaldson, 2005).

Table 2. Specific revisions to AP-42 that are incorporated into the AP-42 sections included in Attachment A.

Source category	Sub-section	Title	Revision	Comments
13.2.1 Paved Roads	13.2.1.3	*Predictive Emission Factor Equation*	In Table 13.2.1-1, reduce k values for PM-2.5 by 40 percent, e.g., the new value is 1.1 g/VMT (and equivalent values for the other units)	Add ref. number for WRAP test report
	13.2.1.5	*Changes since Fifth Edition*	Modify statement (1) to reflect change in fine fraction	
		References	Add WRAP test report as Ref. 22	
13.2.2 Unpaved Roads	13.2.2.2	*Emission Calculation and Correction Parameters*	In Table 13.2.2-2, reduce k values for PM-2.5 by 33%, e.g., the new value is 0.15 lb/VMT for industrial roads and 0.18 lb/VMT for public roads (and equivalent values for the other units)	Add ref. number for WRAP test report
	13.2.2.4	*Updates since Fifth Edition*	Add sentences describing change in fine fraction	
		References	Add WRAP test report	
13.2.3 Heavy Construction Operations	–	–	No changes required	Refers to other AP-42 sections for emission factors
13.2.4 Aggregate Handling and Storage Piles	13.2.4.3	*Predictive Emission Factor Equations*	In k-factor table for Equation 1 for transfer operations, change PM-2.5 multiplier to 0.053 (dimensionless)	Add ref. number for WRAP test report
		References	Add WRAP test report	
13.2.5 Industrial Wind Erosion	13.2.5.2	*Emissions and Correction Parameters*	In k-factor table for Equation 1, change PM-2.5 multiplier to 0.075 (dimensionless)	Add ref. number for WRAP test report
		References	Add WRAP test report	

CONCLUSION

This study found that concentration measurements used to develop $PM_{2.5}$ emission factors for AP-42 were biased high by a factor of two, as compared to $PM_{2.5}$ measurements from FRM samplers. This factor-of-two bias helps to explain why researchers have often seen a similar discrepancy in the proportion of fugitive dust found in $PM_{2.5}$ emission inventories and modeled ambient impacts, as compared to the proportion observed on ambient filter samples. This study also shows that the $PM_{2.5}$ / PM_{10} ratios for fugitive dust should be in the range of 0.1 to 0.15. Currently, the fine fraction ratios in AP-42 range from 0.15 to 0.4 for most fugitive dust sources.

It is recommended that the results of this study by used to revise the AP-42 $PM_{2.5}$ emission factors for the following four fugitive dust source categories: paved roads, unpaved roads (public and industrial), aggregate handling and storage piles, and industrial wind erosion (AP-42 Sections 13.2.1, 13.2.2, 13.2.4, & 13.2.5, respectively). Emission estimates for other fugitive dust producing activities, such as construction and demolition, will also be affected since they are based on these four source categories. It is recommended that revisions to the current AP-42 sections for these fugitive dust sources be adopted as shown in Attachment A to this report.

IMPLICATIONS

The proposed revisions to AP-42 are needed to ensure the most accurate $PM_{2.5}$ and PM_{10} fugitive dust emissions inventories that are possible for regional haze regulatory purposes, given the available resources and the significant contribution of fugitive dust to visibility impairment. In particular, the revisions will affect the quantity of dust apportioned to the fine ($PM_{2.5}$) versus coarse ($PM_{2.5-10}$) size modes, which have significantly different effects on visibility and long-range transport potentials. This will reduce $PM_{2.5}$ emission estimates for fugitive dust sources to about half their current level. It will also increase the coarse-mode size fraction for fugitive dust, which would be important in the event that a PM coarse standard is adopted by the US EPA and emission inventories are developed.

The revisions will be helpful in developing accurate emission inventories for PM nonattainment, maintenance, and action plan areas throughout the country. Finally, the proposed modifications to the fine fractions associated with EPA's AP-42 emission factors will ensure widespread availability of the most recent and accurate scientific information.

References

Cowherd, C. and J. Donaldson. 2005. *Analysis of the Fine Fraction of Particulate Matter in Fugitive Dust.* Final report prepared for the Western Governors' Association, Western Regional Air Partnership (WRAP), MRI Project No. 110397, October 12, 2005. **[Describes wind tunnel study to determine fine fraction ratios]**

Midwest Research Institute. 1994. *OU3 Wind tunnel Study: Test Report.* Prepared for EG&G Rocky Flats, Golden CO. **[Describes portable wind tunnel tests of emissions from soils and sediments]**

Midwest Research Institute. 1997. *Fugitive Particulate Matter Emissions*. Final report prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park NC. April, 1997. **[Prior emission factor field study for paved and unpaved roads, comparing performance of cyclone/impactor system with reference method samplers for PM2.5]**

Muleski, G. E., C. Cowherd, and J. S. Kinsey. 2005. "Particulate Emissions from Construction Activities," *J. Air & Waste Manage. Assoc.* **55:** 772-783. **[Summarizes field test results for emissions from major components of construction projects]**

Ono, Duane. 2005. "Ambient PM2.5/PM10 ratios for Dust Events from the Keeler Dunes." Great Basin UAPCD, Bishop, CA. **[Describes FRM test results for high-wind events on Owens Dry Lake]**

Pace, T. G. 2005. "Examination of Multiplier Used to Estimate $PM_{2.5}$ Fugitive Dust Emissions from PM_{10}." Presented at the EPA Emission Inventory Conference. Las Vegas NV. April 2005. **[Summarizes other field studies that can be used to develop $PM_{2.5}/PM_{10}$ ratios for fugitive dust emissions]**

USEPA. 2005. *Compilation of Air Pollutant Emission Factors, AP-42.* 6th Edition. Research Triangle Park, NC. **[EPA's emission factor handbook]**

CARB, 2003. *Emission Inventory Procedural Manual Volume III: Methods for Assessing Area Source Emissions,* California Air Resources Board, Sacramento, CA. November. **[Summarizes the recommended calculation procedures for agricultural emissions and other sources]**

Midwest Research Institute. 1999. *Estimating Particulate Matter Emissions from Construction Operations*. Prepared for USEPA, Research Triangle Park NC, September. **[Gives field test results for construction operations]**

Figure 1. Phase I test results show that the Cyclone/ Impactor method measured $PM_{2.5}$ concentrations that were two times higher than those measured by Federal Reference Method samplers when simultaneously exposed to the well-mixed dust environment in the wind tunnel.

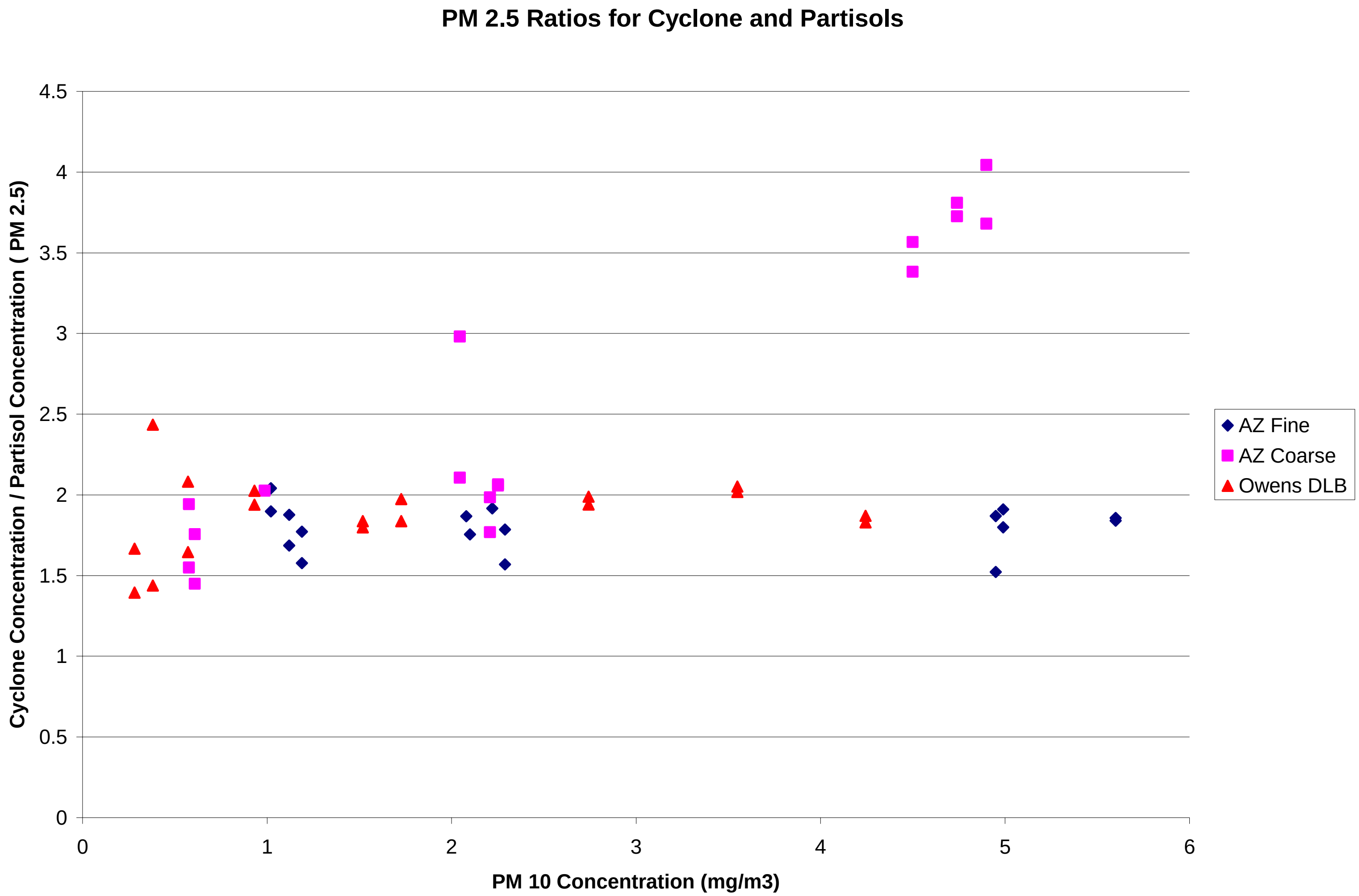
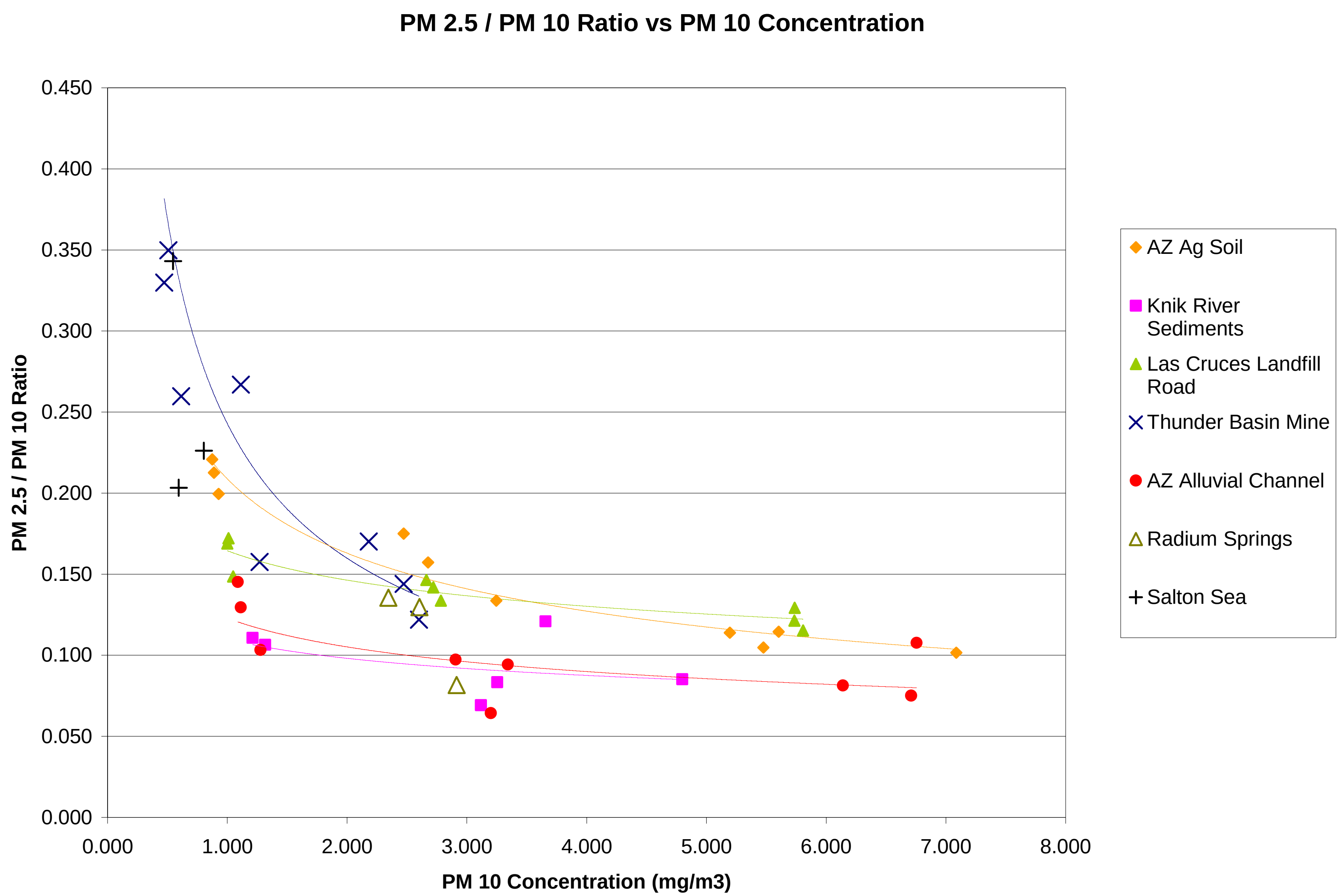


Figure 2. Phase II tests show that the $PM_{2.5}/PM_{10}$ ratio decreased with increasing PM concentrations, and could be expected to be in the range of 0.1 at concentrations that are typical of fugitive dust emission plumes.



11.9 Western Surface Coal Mining

11.9.1 General[1]

There are 12 major coal fields in the western states (excluding the Pacific Coast and Alaskan fields), as shown in Figure 11.9-1. Together, they account for more than 64 percent of the surface minable coal reserves in the United States.[2] The 12 coal fields have varying characteristics that may influence fugitive dust emission rates from mining operations including overburden and coal seam thicknesses and structure, mining equipment, operating procedures, terrain, vegetation, precipitation and surface moisture, wind speeds, and temperatures. The operations at a typical western surface mine are shown in Figure 11.9-2. All operations that involve movement of soil or coal, or exposure of erodible surfaces, generate some amount of fugitive dust.

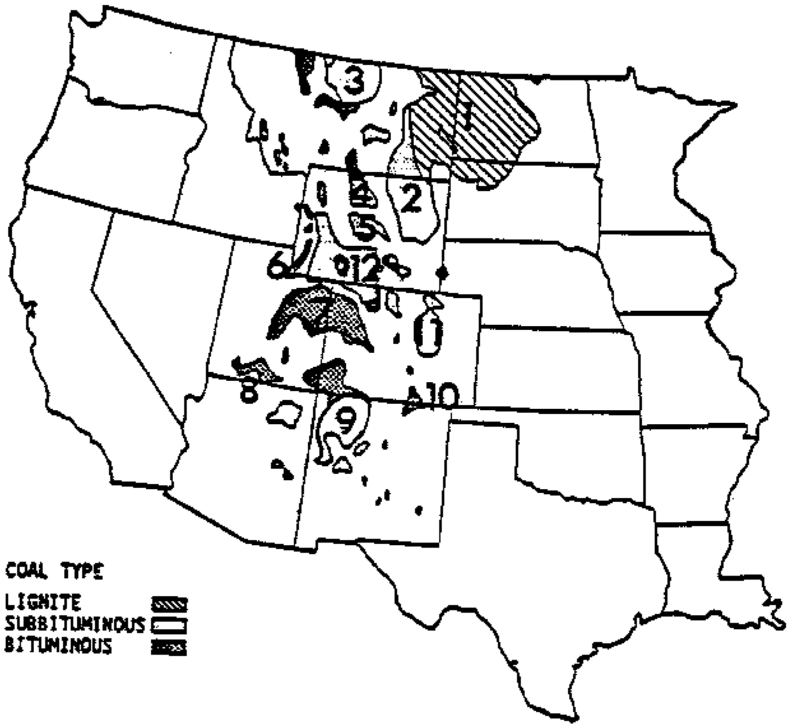
The initial operation is removal of topsoil and subsoil with large scrapers. The topsoil is carried by the scrapers to cover a previously mined and regraded area as part of the reclamation process or is placed in temporary stockpiles. The exposed overburden, the earth that is between the topsoil and the coal seam, is leveled, drilled, and blasted. Then the overburden material is removed down to the coal seam, usually by a dragline or a shovel and truck operation. It is placed in the adjacent mined cut, forming a spoils pile. The uncovered coal seam is then drilled and blasted. A shovel or front end loader loads the broken coal into haul trucks, and it is taken out of the pit along graded haul roads to the tipple, or truck dump. Raw coal sometimes may be dumped onto a temporary storage pile and later rehandled by a front end loader or bulldozer.

At the tipple, the coal is dumped into a hopper that feeds the primary crusher, then is conveyed through additional coal preparation equipment such as secondary crushers and screens to the storage area. If the mine has open storage piles, the crushed coal passes through a coal stacker onto the pile. The piles, usually worked by bulldozers, are subject to wind erosion. From the storage area, the coal is conveyed to a train loading facility and is put into rail cars. At a captive mine, coal will go from the storage pile to the power plant.

During mine reclamation, which proceeds continuously throughout the life of the mine, overburden spoils piles are smoothed and contoured by bulldozers. Topsoil is placed on the graded spoils, and the land is prepared for revegetation by furrowing, mulching, etc. From the time an area is disturbed until the new vegetation emerges, all disturbed areas are subject to wind erosion.

11.9.2 Emissions

Predictive emission factor equations for open dust sources at western surface coal mines are presented in Tables 11.9-1 and 11.9-2. Each equation applies to a single dust-generating activity, such as vehicle traffic on haul roads. The predictive equation explains much of the observed variance in emission factors by relating emissions to three sets of source parameters: (1) measures of source activity or energy expended (e. g., speed and weight of a vehicle traveling on an unpaved road); (2) properties of the material being disturbed (e. g., suspendable fines in the surface material of an unpaved road); and (3) climate (in this case, mean wind speed).



	Coal field	Strippable reserves (10^6 tons)
1	Fort Union	23,529
2	Powder River	56,727
3	North Central	All underground
4	Bighorn Basin	All underground
5	Wind River	3
6	Hams Fork	1,000
7	Uinta	308
8	Southwestern Utah	224
9	San Juan River	2,318
10	Raton Mesa	All underground
11	Denver	All underground
12	Green River	2,120

Figure 11.9-1. Coal fields of the western United States.[3]

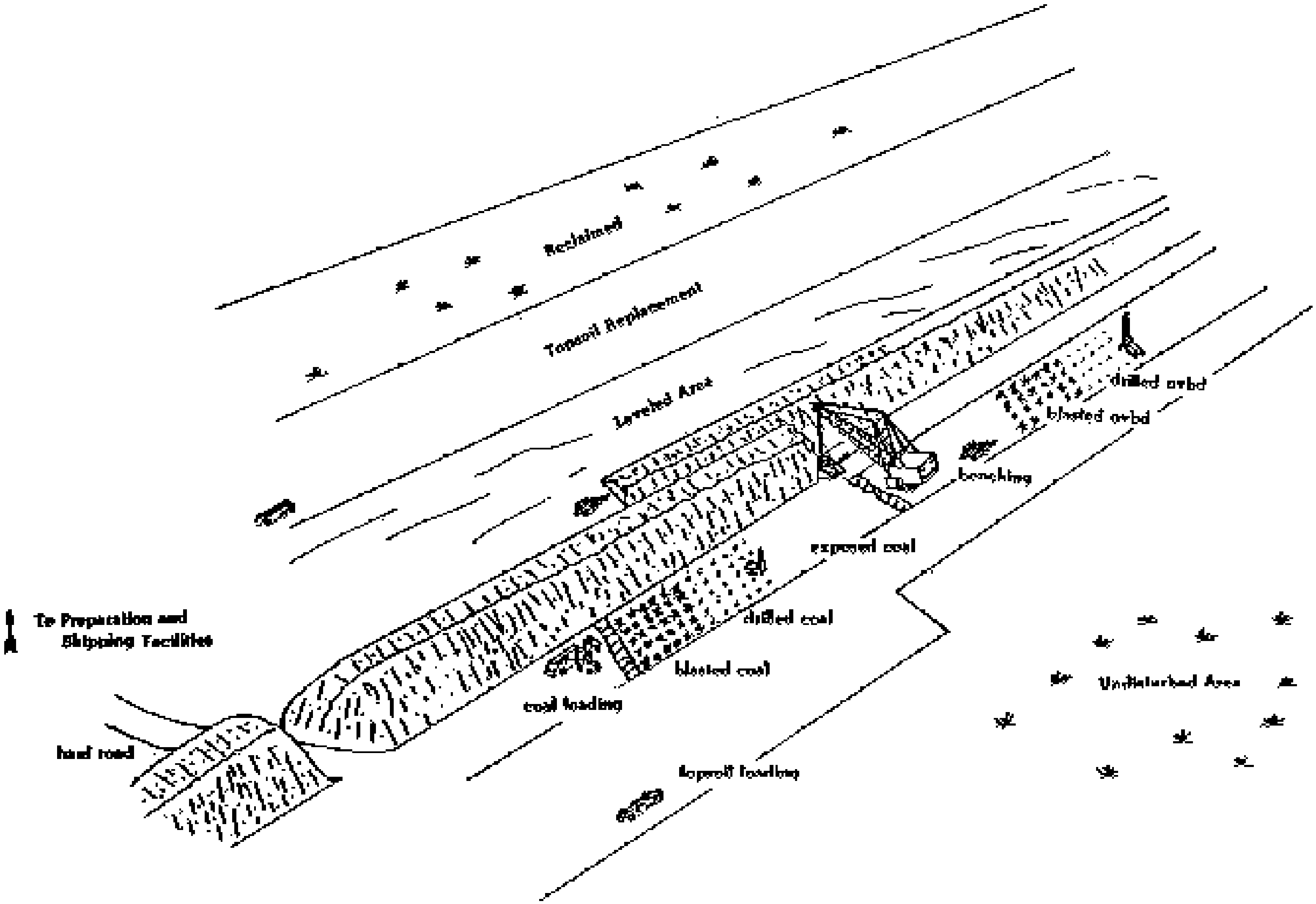


Figure 11.9-2. Operations at typical western surface coal mines.

The equations may be used to estimate particulate emissions generated per unit of source extent or activity (e. g., distance traveled by a haul truck or mass of material transferred). The equations were developed through field sampling of various western surface mine types and are thus applicable to any of the surface coal mines located in the western United States.

In Tables 11.9-1 and 11.9-2, the assigned quality ratings apply within the ranges of source conditions that were tested in developing the equations given in Table 11.9-3. However, the equations should be derated 1 letter value (e. g., A to B) if applied to eastern surface coal mines.

In using the equations to estimate emissions from sources found in a specific western surface mine, it is necessary that reliable values for correction parameters be determined for the specific sources of interest if the assigned quality ratings of the equations are to be applicable. For example, actual silt content of coal or overburden measured at a facility should be used instead of estimated values. In the event that site-specific values for correction parameters cannot be obtained, the appropriate geometric mean values from Table 11.9-3 may be used, but the assigned quality rating of each emission factor equation should be reduced by 1 level (e. g., A to B).

Emission factors for open dust sources not covered in Table 11.9-3 are in Table 11.9-4. These factors were determined through source testing at various western coal mines.

The factors in Table 11.9-4 for mine locations I through V were developed for specific geographical areas. Tables 11.9-5 and 11.9-6 present characteristics of each of these mines (areas). A “mine-specific” emission factor should be used only if the characteristics of the mine for which an emissions estimate is needed are very similar to those of the mine for which the emission factor was developed. The other (nonspecific) emission factors were developed at a variety of mine types and thus are applicable to any western surface coal mine.

As an alternative to the single valued emission factors given in Table 11.9-4 for train or truck loading and for truck or scraper unloading, two empirically derived emission factor equations are presented in Section 13.2.4 of this document. Each equation was developed for a source operation (i. e., batch drop and continuous drop, respectively) comprising a single dust-generating mechanism that crosses industry lines.

Because the predictive equations allow emission factor adjustment to specific source conditions, the equations should be used in place of the single-valued factors in Table 11.9-4 for the sources identified above, if emission estimates for a specific western surface coal mine are needed. However, the generally higher quality ratings assigned to the equations are applicable only if: (1) reliable values of correction parameters have been determined for the specific sources of interest, and (2) the correction parameter values lie within the ranges tested in developing the equations. Caution must be exercised so that only the unbound (sorbed) moisture (i. e., not any bound moisture) is used in determining the moisture content for input to the Chapter 13 equations.

Table 11.9-1 (English Units). EMISSION FACTOR EQUATIONS FOR UNCONTROLLED OPEN DUST SOURCES AT WESTERN SURFACE COAL MINES[a]

Operation	Material	Emissions By Particle Size Range (Aerodynamic Diameter)[b,c]				Units	EMISSION FACTOR RATING
		Emission Factor Equations		Scaling Factors			
		TSP ≤30 µm	≤15 µm	≤10 µm[d]	≤2.5 µm/TSP[e]		
Blasting[f]	Coal or overburden	$0.000014(A)^{1\ 5}$	ND	0.52[e]	0.03	lb/blast	C_DD
Truck loading	Coal	$\frac{1.16}{(M)^{1\ 2}}$	$\frac{0.119}{(M)^{0\ 9}}$	0.75	0.019	lb/ton	BBCC
Bulldozing	Coal	$\frac{78.4\ (s)^{1\ 2}}{(M)^{1\ 3}}$	$\frac{18.6\ (s)^{1\ 5}}{(M)^{1\ 4}}$	0.75	0.022	lb/hr	CCDD
	Overburden	$\frac{5.7\ (s)^{1\ 2}}{(M)^{1\ 3}}$	$\frac{1.0\ (s)^{1\ 5}}{(M)^{1\ 4}}$	0.75	0.105	lb/hr	BCDD
Dragline	Overburden	$\frac{0.0021\ (d)^{1\ 1}}{(M)^{0\ 3}}$	$\frac{0.0021\ (d)^{0\ 7}}{(M)^{0\ 3}}$	0.75	0.017	lb/yd^3	BCDD
Vehicle traffic[g]							
Grading		$0.040\ (S)^{2\ 5}$	$0.051\ (S)^{2\ 0}$	0.60	0.031	lb/VMT	CCDD
Active storage pile[h] (wind erosion and maintenance)	Coal	0.72 u	ND	ND	ND	$\frac{lb}{(acre)(hr)}$	C[i]_ _ _

[a] Reference 1, except as noted. VMT = vehicle miles traveled. ND = no data. Quality ratings coded where "Q, X, Y, Z" are ratings for ≤30 µm, ≤15 µm, ≤10 µm, and ≤2.5 µm, respectively. See also note below.

[b] Particulate matter less than or equal to 30 µm in aerodynamic diameter is sometimes termed "suspendable particulate" and is often used as a surrogate for TSP (total suspended particulate). TSP denotes what is measured by a standard high volume sampler (see Section 13.2).

[c] Symbols for equations:

A = horizontal area (ft^2), with blasting depth ≤ 70 ft. Not for vertical face of a bench.
M = material moisture content (%)
s = material silt content (%)
u = wind speed (mph)
d = drop height (ft)
W = mean vehicle weight (tons)
S = mean vehicle speed (mph)
w = mean number of wheels

Table 11.9-1 (cont.).

[d] Multiply the ≤15-μm equation by this fraction to determine emissions, except as noted.
[e] Multiply the TSP predictive equation by this fraction to determine emissions.
[f] Blasting factor taken from a reexamination of field test data reported in Reference 1. See Reference 4.
[g] To estimate emissions from traffic on unpaved surfaces by vehicles such as haul trucks, light-to-medium duty vehicles, or scrapers in the travel mode, see the unpaved road emission factor equation in AP-42 Section 13.2.2.
[h] Coal storage pile factor taken from Reference 5. To estimate emissions on a shorter time scale (e. g., worst-case day), see the procedure presented in Section 13.2.5.
[i] Rating applicable to mine types I, II, and IV (see Tables 11.9-5 and 11.9-6).

Note: Section 234 of the Clean Air Act of 1990 required EPA to review and revise the emission factors in this Section (and models used to evaluate ambient air quality impact), to ensure that they did not overestimate emissions from western surface coal mines. Due to resource and technical limitations, the haul road emission factors were isolated to receive the most attention during these studies, as the largest contributor to emissions. Resultant model evaluation with revised emission factors have improved model prediction for total suspended particulate (TSP); however, there is still a tendency for overprediction of particulate matter impact for PM-10, for as yet undetermined causes, prompting the Agency to make a policy decision not to use them for regulatory applications to these sources. However, the technical consideration exists that no better alternative data are currently available and the information should be made known. Users should accordingly use these factors with caution and awareness of their likely limitations.

Table 11.9-2 (Metric Units). EMISSION FACTOR EQUATIONS FOR UNCONTROLLED OPEN DUST SOURCES AT WESTERN SURFACE COAL MINES[a]

Operation	Material	Emissions By Particle Size Range (Aerodynamic Diameter)[b,c]				Units	EMISSION FACTOR RATING
		Emission Factor Equations		Scaling Factors			
		TSP ≤30 µm	≤15 µm	≤10 µm[d]	≤2.5 µm/TSP[e]		
Blasting[f]	Coal or overburden	$0.00022(A)^{1\ 5}$	ND	0.52[e]	0.03	kg/blast	C_DD
Truck loading	Coal	$\frac{0.580}{(M)^{1\ 2}}$	$\frac{0.0596}{(M)^{0\ 9}}$	0.75	0.019	kg/Mg	BBCC
Bulldozing	Coal	$\frac{35.6\ (s)^{1\ 2}}{(M)^{1\ 4}}$	$\frac{8.44\ (s)^{1\ 5}}{(M)^{1\ 4}}$	0.75	0.022	kg/hr	CCDD
	Overburden	$\frac{2.6\ (s)^{1\ 2}}{(M)^{1\ 3}}$	$\frac{0.45\ (s)^{1\ 5}}{(M)^{1\ 4}}$	0.75	0.105	kg/hr	BCDD
Dragline	Overburden	$\frac{0.0046\ (d)^{1\ 1}}{(M)^{0\ 3}}$	$\frac{0.0029\ (d)^{0\ 7}}{(M)^{0\ 3}}$	0.75	0.017	kg/m^3	BCDD
Vehicle traffic[g]							
Grading		$0.0034\ (S)^{2\ 5}$	$0.0056\ (S)^{2\ 0}$	0.60	0.031	kg/VKT	CCDD
Active storage pile[h] (wind erosion and maintenance)	Coal	1.8 u	ND	ND	ND	$\frac{kg}{(hectare)(hr)}$	C[i]_ _ _

[a] Reference 1, except as noted. VKT = vehicle kilometers traveled. ND = no data. Quality ratings coded as "QXYZ", where Q, X, Y, and Z are quality ratings for ≤30 µm, ≤15 µm, ≤10 µm, and ≤2.5 µm, respectively. See also note below.

[b] Particulate matter less than or equal to 30 µm in aerodynamic diameter is sometimes termed "suspendable particulate" and is often used as a surrogate for TSP (total suspended particulate). TSP denotes what is measured by a standard high volume sampler (see Section 13.2).

[c] Symbols for equations:

A = horizontal area (m^2), with blasting depth ≤ 21 m. Not for vertical face of a bench.
M = material moisture content (%)
s = material silt content (%)
u = wind speed (m/sec)
d = drop height (m)
W = mean vehicle weight (Mg)
S = mean vehicle speed (kph)
w = mean number of wheels

Table 11.9-2 (cont.).

[d] Multiply the ≤ 15-µm equation by this fraction to determine emissions, except as noted.
[e] Multiply the TSP predictive equation by this fraction to determine emissions.
[f] Blasting factor taken from a reexamination of field test data reported in Reference 1. See Reference 4.
[g] To estimate emissions from traffic on unpaved surfaces by vehicles such as haul trucks, light-to-medium duty vehicles, or scrapers in the travel mode, see the unpaved road emission factor equation in AP-42 Section 13.2.2
[h] Coal storage pile factor taken from Reference 5. To estimate emissions on a shorter time scale (e. g., worst-case day), see the procedure presented in Section 13.2.5.
[i] Rating applicable to mine types I, II, and IV (see Tables 11.9-5 and 11.9-6).

Note: Section 234 of the Clean Air Act of 1990 required EPA to review and revise the emission factors in this Section (and models used to evaluate ambient air quality impact), to ensure that they did not overestimate emissions from western surface coal mines. Due to resource and technical limitations, the haul road emission factors were isolated to receive the most attention during these studies, as the largest contributor to emissions. Resultant model evaluation with revised emission factors have improved model prediction for total suspended particulate (TSP); however, there is still a tendency for overprediction of particulate matter impact for PM-10, for as yet undetermined causes, prompting the Agency to make a policy decision not to use them for regulatory applications to these sources. However, the technical consideration exists that no better alternative data are currently available and the information should be made known. Users should accordingly use these factors with caution and awareness of their likely limitations.

Table 11.9-3 (Metric And English Units). TYPICAL VALUES FOR CORRECTION FACTORS APPLICABLE TO THE PREDICTIVE EMISSION FACTOR EQUATIONS[a]

Source	Correction Factor	Number Of Test Samples	Range	Geometric Mean	Units
Blasting	Area blasted	17	100 - 6,800	1,590	m^2
	Area blasted	17	1100 - 73,000	17,000	ft^2
Coal loading	Moisture	7	6.6 - 38	17.8	%
Bulldozers					
Coal	Moisture	3	4.0 - 22.0	10.4	%
	Silt	3	6.0 - 11.3	8.6	%
Overburden	Moisture	8	2.2 - 16.8	7.9	%
	Silt	8	3.8 - 15.1	6.9	%
Dragline	Drop distance	19	1.5 - 30	8.6	m
	Drop distance	19	5 - 100	28.1	ft
	Moisture	7	0.2 - 16.3	3.2	%
Scraper	Silt	10	7.2 - 25.2	16.4	%
	Weight	15	33 - 64	48.8	Mg
	Weight	15	36 - 70	53.8	ton
Grader	Speed	7	8.0 - 19.0	11.4	kph
	Speed		5.0 - 11.8	7.1	mph
Haul truck	Silt content	61	1.2 - 19.2	4.3	%
	Moisture	60	0.3 - 20.1	2.4	%
	Weight	61	20.9 - 260	110	mg
	Weight	61	23.0 - 290	120	ton

[a] Reference 1,6.

Table 11.9-4 (English And Metric Units). UNCONTROLLED PARTICULATE EMISSION FACTORS FOR OPEN DUST SOURCES AT WESTERN SURFACE COAL MINES

Source	Material	Mine Location[a]	TSP Emission Factor[b]	Units	EMISSION FACTOR RATING
Drilling	Overburden	Any	1.3 0.59	lb/hole kg/hole	C C
	Coal	V	0.22 0.10	lb/hole kg/hole	E E
Topsoil removal by scraper	Topsoil	Any	0.058 0.029	lb/ton kg/Mg	E E
		IV	0.44 0.22	lb/ton kg/Mg	E E
Overburden replacement	Overburden	Any	0.012 0.0060	lb/ton kg/Mg	C C
Truck loading by power shovel (batch drop)[c]	Overburden	V	0.037 0.018	lb/ton kg/Mg	E E
Train loading (batch or continuous drop)[c]	Coal	Any	0.028 0.014	lb/ton kg/Mg	E E
		III	0.0002 0.0001	lb/ton kg/Mg	E E
Bottom dump truck unloading (batch drop)[c]	Overburden	V	0.002 0.001	lb/ton kg/Mg	E E
	Coal	IV	0.027 0.014	lb/ton kg/Mg	E E
		III	0.005 0.002	lb/ton kg/Mg	E E
		II	0.020 0.010	lb/ton kg/Mg	E E
		I	0.014 0.0070	lb/T kg/Mg	E E
		Any	0.066 0.033	lb/T kg/Mg	D D

Table 11.9-4 (cont.).

Source	Material	Mine Location[a]	TSP Emission Factor[b]	Units	EMISSION FACTOR RATING
End dump truck unloading (batch drop)[c]	Coal	V	0.007 0.004	lb/T kg/Mg	E E
Scraper unloading (batch drop)[c]	Topsoil	IV	0.04 0.02	lb/T kg/Mg	E E
Wind erosion of exposed areas[d]	Seeded land, stripped overburden, graded overburden	Any	0.38	$\frac{T}{(acre)(yr)}$	C
			0.85	$\frac{Mg}{(hectare)(yr)}$	C

[a] Roman numerals I through V refer to specific mine locations for which the corresponding emission factors were developed (Reference 5). Tables 11.9-4 and 11.9-5 present characteristics of each of these mines. See text for correct use of these "mine-specific" emission factors. The other factors (from Reference 7, except for overburden drilling from Reference 1) can be applied to any western surface coal mine.

[b] Total suspended particulate (TSP) denotes what is measured by a standard high volume sampler (see Section 13.2).

[c] Predictive emission factor equations, which generally provide more accurate estimates of emissions, are presented in Chapter 13.

[d] To estimate wind erosion on a shorter time scale (e. g., worst-case day), see Section 13.2.5.

Table 11.9-5 (Metric And English Units). GENERAL CHARACTERISTICS OF SURFACE COAL MINES REFERRED TO IN TABLE 11.9-4[a]

Mine	Location	Type Of Coal Mined	Terrain	Vegetative Cover	Surface Soil Type And Erodibility Index	Mean Wind Speed		Mean Annual Precipitation	
						m/s	mph	cm	in.
I	N.W. Colorado	Subbitum.	Moderately steep	Moderate, sagebrush	Clayey loamy (71)	2.3	5.1	38	15
II	S.W. Wyoming	Subbitum.	Semirugged	Sparse, sagebrush	Arid soil with clay and alkali or carbonate accumulation (86)	6.0	13.4	36	14
III	S.E. Montana	Subbitum.	Gently rolling to semirugged	Sparse, moderate, prairie grassland	Shallow clay loamy deposits on bedrock (47)	4.8	10.7	28 - 41	11 - 16
IV	Central North Dakota	Lignite	Gently rolling	Moderate, prairie grassland	Loamy, loamy to sandy (71)	5.0	11.2	43	17
V	N.E. Wyoming	Subbitum.	Flat to gently rolling	Sparse, sagebrush	Loamy, sandy, clayey, and clay loamy (102)	6.0	13.4	36	14

[a] Reference 4.

Table 11.9-6 (English Units). OPERATING CHARACTERISTICS OF THE COAL MINES REFERRED TO IN TABLE 11.9-4[a]

Parameter	Required Information	Units	Mine I	Mine II	Mine III	Mine IV	Mine V
Production rate	Coal mined	10^6 ton/yr	1.13	5.0	9.5	3.8	12.0[b]
Coal transport	Avg. unit train frequency	per day	NA	NA	2	NA	2
Stratigraphic data	Overburden thickness	ft	21	80	90	65	35
	Overburden density	lb/yd^3	4000	3705	3000	ND	ND
	Coal seam thicknesses	ft	9,35	15,9	27	2,4,8	70
	Parting thicknesses	ft	50	15	NA	32,16	NA
	Spoils bulking factor	%	22	24	25	20	ND
	Active pit depth	ft	52	100	114	80	105
Coal analysis data	Moisture	%	10	18	24	38	30
	Ash	%, wet	8	10	8	7	6
	Sulfur	%, wet	0.46	0.59	0.75	0.65	0.48
	Heat content	Btu/lb	11000	9632	8628	8500	8020
Surface disposition	Total disturbed land	acre	168	1030	2112	1975	217
	Active pit	acre	34	202	87	ND	71
	Spoils	acre	57	326	144	ND	100
	Reclaimed	acre	100	221	950	ND	100
	Barren land	acre	ND	30	455	ND	ND
	Associated disturbances	acre	12	186	476	ND	46
Storage	Capacity	ton	NA	NA	ND	NA	48000
Blasting	Frequency, total	per week	4	4	3	7	7[b]
	Frequency, overburden	per week	3	0.5	3	NA	7[b]
	Area blasted, coal	ft^2	16000	40000	ND	30000	ND
	Area blasted, overburden	ft^2	20000	ND	ND	NA	ND

[a] Reference 5. NA = not applicable. ND = no data.
[b] Estimate.

11.9.3 Updates Since the Fifth Edition

The Fifth Edition which was released in January 1995 reformatted the section that was dated September 1988. Revisions to this section since these dates are summarized below. For further detail, consult the memoranda describing each supplement or the background report for this section. These and other documents can be found on the CHIEF WEB site (home page http://www.epa.gov/ttn/chief/).

Supplement E

- The predictive equations for emission factors for haul trucks and light/medium duty vehicles were removed and replaced with a footnote refering users to the recently revised unpaved road section in the Miscellaneous Sources chapter.

- The emission factor quality ratings were revised based upon a revised predictive equation and single value criteria.

- The typographical errors for the TSP equation and the omission of the PM-2.5 scaling factor for blasting were corrected.

References For Section 11.9

1. K. Axetell and C. Cowherd, *Improved Emission Factors For Fugitive Dust From Western Surface Coal Mining Sources*, 2 Volumes, EPA Contract No. 68-03-2924, U. S. Environmental Protection Agency, Cincinnati, OH, July 1981.

2. *Reserve Base Of U. S. Coals By Sulfur Content: Part 2, The Western States*, IC8693, Bureau Of Mines, U. S. Department Of The Interior, Washington, DC, 1975.

3. *Bituminous Coal And Lignite Production And Mine Operations - 1978*, DOE/EIA-0118(78), U. S. Department Of Energy, Washington, DC, June 1980.

4. G. E. Muleski, *Update Of AP-42 Emission Factors For Western Surface Coal Mines And Related Sections*, Summary Report, Prepared for Emission Factors And Inventory Group (MD-14), Emissions, Modeling And Analysis Division, Office Of Air Quality, Planning, And Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC 27711.

5. K. Axetell, *Survey Of Fugitive Dust From Coal Mines*, EPA-908/1-78-003, U. S. Environmental Protection Agency, Denver, CO, February 1978.

6. G. E. Muleski, *et al.*, *Surface Coal Mine Emission Factor Field Study*, EPA-454/R-95-010, U. S. Environmental Protection Agency, Research Triangle Park, NC, January 1994.

7. D. L. Shearer, *et al.*, *Coal Mining Emission Factor Development And Modeling Study*, Amax Coal Company, Carter Mining Company, Sunoco Energy Development Company, Mobil Oil Corporation, and Atlantic Richfield Company, Denver, CO, July 1981.

13.2.1 Paved Roads

13.2.1.1 General

Particulate emissions occur whenever vehicles travel over a paved surface such as a road or parking lot. Particulate emissions from paved roads are due to direct emissions from vehicles in the form of exhaust, brake wear and tire wear emissions and resuspension of loose material on the road surface. In general terms, resuspended particulate emissions from paved roads originate from, and result in the depletion of, the loose material present on the surface (i.e., the surface loading). In turn, that surface loading is continuously replenished by other sources. At industrial sites, surface loading is replenished by spillage of material and trackout from unpaved roads and staging areas. Figure 13.2.1-1 illustrates several transfer processes occurring on public streets.

Various field studies have found that public streets and highways, as well as roadways at industrial facilities, can be major sources of the atmospheric particulate matter within an area.[1-9] Of particular interest in many parts of the United States are the increased levels of emissions from public paved roads when the equilibrium between deposition and removal processes is upset. This situation can occur for various reasons, including application of granular materials for snow and ice control, mud/dirt carryout from construction activities in the area, and deposition from wind and/or water erosion of surrounding unstabilized areas. In the absence of continuous addition of fresh material (through localized trackout or application of antiskid material), paved road surface loading should reach an equilibrium value in which the amount of material resuspended matches the amount replenished. The equilibrium surface loading value depends upon numerous factors. It is believed that the most important factors are: mean speed of vehicles traveling the road; the average daily traffic (ADT); the number of lanes and ADT per lane; the fraction of heavy vehicles (buses and trucks); and the presence/absence of curbs, storm sewers and parking lanes.[10]

The particulate emission factors presented in the previous version of this section of AP-42, dated October 2002, implicitly included the emissions from vehicles in the form of exhaust, brake wear, and tire wear as well as resuspended road surface material. EPA included these sources in the emission factor equation for paved roads since the field testing data used to develop the equation included both the direct emissions from vehicles and emissions from resuspension of road dust.

This version of the paved road emission factor equation only estimates particulate emissions from resuspended road surface material [28]. The particulate emissions from vehicle exhaust, brake wear, and tire wear are now estimated separately using EPA's MOBILE6.2 [27]. This approach eliminates the possibility of double counting emissions. Double counting results when employing the previous version of the emission factor equation in this section and MOBILE6.2 to estimate particulate emissions from vehicle traffic on paved roads. It also incorporates the decrease in exhaust emissions that has occurred since the paved road emission factor equation was developed. The previous version of the paved road emission factor equation includes estimates of emissions from exhaust, brake wear, and tire wear based on emission rates for vehicles in the 1980 calendar year fleet. The amount of PM released from vehicle exhaust has decreased since 1980 due to lower new vehicle emission standards and changes in fuel characteristics.

13.2.1.2 Emissions And Correction Parameters

Dust emissions from paved roads have been found to vary with what is termed the "silt loading" present on the road surface as well as the average weight of vehicles traveling the road. The term silt loading (sL) refers to the mass of silt-size material (equal to or less than 75 micrometers [μm] in physical diameter) per unit area of the travel surface. The total road surface dust loading consists of loose material that can be collected by broom sweeping and vacuuming of the traveled portion of the paved road. The silt fraction is determined by measuring the proportion of the loose dry surface dust that passes through a 200-mesh screen, using the ASTM-C-136 method. Silt loading is the product of the silt fraction and the total loading, and is abbreviated "sL". Additional details on the sampling and analysis of such material are provided in AP-42 Appendices C.1 and C.2.

The surface sL provides a reasonable means of characterizing seasonal variability in a paved road emission inventory. In many areas of the country, road surface loadings [11-21] are heaviest during the late winter and early spring months when the residual loading from snow/ice controls is greatest. As noted earlier, once replenishment of fresh material is eliminated, the road surface loading can be expected to reach an equilibrium value, which is substantially lower than the late winter/early spring values.

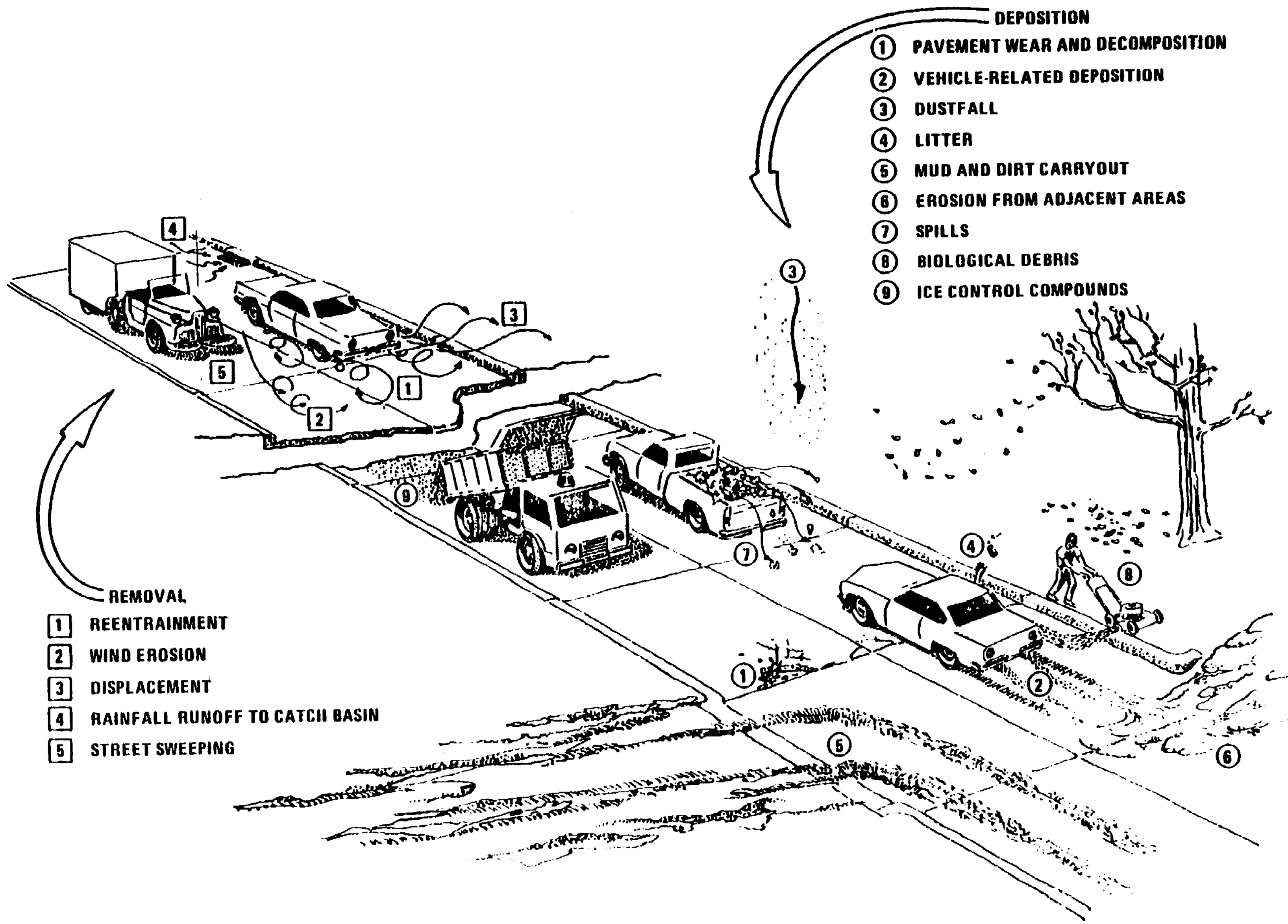


Figure 13.2.1-1. Deposition and removal processes.

13.2.1.3 Predictive Emission Factor Equations [10]

The quantity of particulate emissions from resuspension of loose material on the road surface due to vehicle travel on a dry paved road may be estimated using the following empirical expression:

$$E = k\left(\frac{sL}{2}\right)^{0.65} \times \left(\frac{W}{3}\right)^{1.5} - C \qquad (1)$$

where:
- E = particulate emission factor (having units matching the units of k),
- k = particle size multiplier for particle size range and units of interest (see below),
- sL = road surface silt loading (grams per square meter) (g/m^2),
- W = average weight (tons) of the vehicles traveling the road, and
- C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.

It is important to note that Equation 1 calls for the average weight of all vehicles traveling the road. For example, if 99 percent of traffic on the road are 2 ton cars/trucks while the remaining 1 percent consists of 20 ton trucks, then the mean weight "W" is 2.2 tons. More specifically, Equation 1 is *not* intended to be used to calculate a separate emission factor for each vehicle weight class. Instead, only one emission factor should be calculated to represent the "fleet" average weight of all vehicles traveling the road.

The particle size multiplier (*k*) above varies with aerodynamic size range as shown in Table 13.2.1-1. To determine particulate emissions for a specific particle size range, use the appropriate value of k shown in Table 13.2.1-1.

The emission factors for the exhaust, brake wear and tire wear of a 1980's vehicle fleet (*C*) was obtained from EPA's MOBILE6.2 model [28]. The emission factor also varies with aerodynamic size range

Table 13.2-1.1. PARTICLE SIZE MULTIPLIERS FOR PAVED ROAD EQUATION

Size range[a]	Particle Size Multiplier k[b]		
	g/VKT	g/VMT	lb/VMT
PM-2.5[c]	0.66	1.1	0.0024
PM-10	4.6	7.3	0.016
PM-15	5.5	9.0	0.020
PM-30[d]	24	38	0.082

[a] Refers to airborne particulate matter (PM-x) with an aerodynamic diameter equal to or less than x micrometers.

[b] Units shown are grams per vehicle kilometer traveled (g/VKT), grams per vehicle mile traveled (g/VMT), and pounds per vehicle mile traveled (lb/VMT). The multiplier k includes unit conversions to produce emission factors in the units shown for the indicated size range from the mixed units required in Equation 1.

[c] Ratio of PM-2.5 to PM-10 taken from Reference 22**.**

[d] PM-30 is sometimes termed "suspendable particulate" (SP) and is often used as a surrogate for TSP.

as shown in Table 13.2.1-2.

Table 13.2.1-2. EMISSION FACTOR FOR 1980'S VEHICLE FLEET EXHAUST, BRAKE WEAR AND TIRE WEAR

Particle Size Range[a]	*C*, Emission Factor for Exhaust, Brake Wear and Tire Wear[b]		
	g/VMT	g/VKT	lb/VMT
$PM_{2.5}$	0.1617	0.1005	0.00036
PM_{10}	0.2119	0.1317	0.00047
PM_{15}	0.2119	0.1317	0.00047
PM_{30}[c]	0.2119	0.1317	0.00047

[a] Refers to airborne particulate matter (PM-x) with an aerodynamic diameter equal to or less than x micrometers.

[b] Units shown are grams per vehicle kilometer traveled (g/VKT), grams per vehicle mile traveled (g/VMT), and pounds per vehicle mile traveled (lb/VMT).

[c] PM-30 is sometimes termed "suspendable particulate" (SP) and is often used as a surrogate for TSP.

Equation 1 is based on a regression analysis of numerous emission tests, including 65 tests for PM-10.[10] Sources tested include public paved roads, as well as controlled and uncontrolled industrial paved roads. All sources tested were of freely flowing vehicles traveling at constant speed on relatively level roads. No tests of "stop-and-go" traffic or vehicles under load were available for inclusion in the data base. The equations retain the quality rating of A (B for PM-2.5), if applied within the range of source conditions that were tested in developing the equation as follows:

Silt loading:	0.03 - 400 g/m^2 0.04 - 570 grains/square foot (ft^2)
Mean vehicle weight:	1.8 - 38 megagrams (Mg) 2.0 - 42 tons
Mean vehicle speed:	16 - 88 kilometers per hour (kph) 10 - 55 miles per hour (mph)

Note: There may be situations where low silt loading and/or low average weight will yield calculated negative emissions from equation 1. If this occurs, the emissions calculated from equation 1 should be set to zero.

Users are cautioned that application of equation 1 outside of the range of variables and operating conditions specified above, e.g., application to roadways or road networks with speeds below 10 mph and with stop-and-go traffic, will result in emission estimates with a higher level of uncertainty. In these situations, users are encouraged to consider alternative methods that are equally or more plausible in light of local emissions data and/or ambient concentration or compositional data.

To retain the quality rating for the emission factor equation when it is applied to a specific paved road, it is necessary that reliable correction parameter values for the specific road in question be determined. With the exception of limited access roadways, which are difficult to sample, the collection and use of site-specific silt loading (sL) data for public paved road emission inventories are strongly recommended. The field and laboratory procedures for determining surface material silt content and surface dust loading are summarized in Appendices C.1 and C.2. In the event that site-specific values cannot be obtained, an appropriate value for a paved public road may be selected from the values in Table 13.2.1-3, but the quality rating of the equation should be reduced by 2 levels. Also, recall that Equation 1 refers to emissions due to freely flowing (not stop-and-go) traffic at constant speed on level roads.

Equation 1 may be extrapolated to average uncontrolled conditions (but including natural mitigation) under the simplifying assumption that annual (or other long-term) average emissions are inversely proportional to the frequency of measurable (> 0.254 mm [0.01 inch]) precipitation by application of a precipitation correction term. The precipitation correction term can be applied on a daily or an hourly basis [26].

For the daily basis, Equation 1 becomes:

$$E_{ext} = \left[k \left(\frac{sL}{2} \right)^{0.65} \left(\frac{W}{3} \right)^{1.5} - C \right] \left(1 - \frac{P}{4N} \right) \qquad (2)$$

where *k*, *sL*, *W*, *and C* are as defined in Equation 1 and

E_{ext} = annual or other long-term average emission factor in the same units as *k*,
P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period, and
N = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly).

Note that the assumption leading to Equation 2 is based on analogy with the approach used to develop long-term average unpaved road emission factors in Section 13.2.2. However, Equation 2 above incorporates an additional factor of "4" in the denominator to account for the fact that paved roads dry more quickly than unpaved roads and that the precipitation may not occur over the complete 24-hour day.

For the hourly basis, equation 1 becomes:

$$E_{ext} = \left[k \left(\frac{sL}{2} \right)^{0.65} \left(\frac{W}{3} \right)^{1.5} - C \right] \left(1 - \frac{1.2P}{N} \right) \qquad (3)$$

where k, sL, and W, and *C* are as defined in Equation 1 and

E_{ext} = annual or other long-term average emission factor in the same units as *k*,
P = number of hours with at least 0.254 mm (0.01 in) of precipitation during the averaging period, and
N = number of hours in the averaging period (e.g., 8760 for annual, 2124 for season 720 for monthly).

Note: In the hourly moisture correction term (1-1.2P/N) for equation 3, the 1.2 multiplier is applied to account for the residual mitigative effect of moisture. For most applications, this equation will produce satisfactory results. However, if the time interval for which the equation is applied is short, e.g., for one hour or one day, the application of this multiplier makes it possible for the moisture correction term to become negative. This will result in calculated negative emissions which is not realistic. Users should expand the time interval to include sufficient “dry” hours such that negative emissions are not calculated. For the special case where this equation is used to calculate emissions on an hour by hour basis, such as would be done in some emissions modeling situations, the moisture correction term should be modified so that the moisture correction “credit” is applied to the first hours following cessation of precipitation. In this special case, it is suggested that this 20% “credit” be applied on a basis of one hour credit for each hour of precipitation up to a maximum of 12 hours.

Note that the assumption leading to Equation 3 is based on analogy with the approach used to develop long-term average unpaved road emission factors in Section 13.2.2.

Figure 13.2.1-2 presents the geographical distribution of "wet" days on an annual basis for the United States. Maps showing this information on a monthly basis are available in the *Climatic Atlas of the United States*[23] . Alternative sources include other Department of Commerce publications (such as local climatological data summaries). The National Climatic Data Center (NCDC) offers several products that provide hourly precipitation data. In particular, NCDC offers *Solar and Meteorological Surface Observation Network 1961-1990* (SAMSON) CD-ROM, which contains 30 years worth of hourly meteorological data for first-order National Weather Service locations. Whatever meteorological data are used, the source of that data and the averaging period should be clearly specified.

It is emphasized that the simple assumption underlying Equations 2 and 3 has not been verified in any rigorous manner. For that reason, the quality ratings for Equations 2 and 3 should be downgraded one letter from the rating that would be applied to Equation 1.

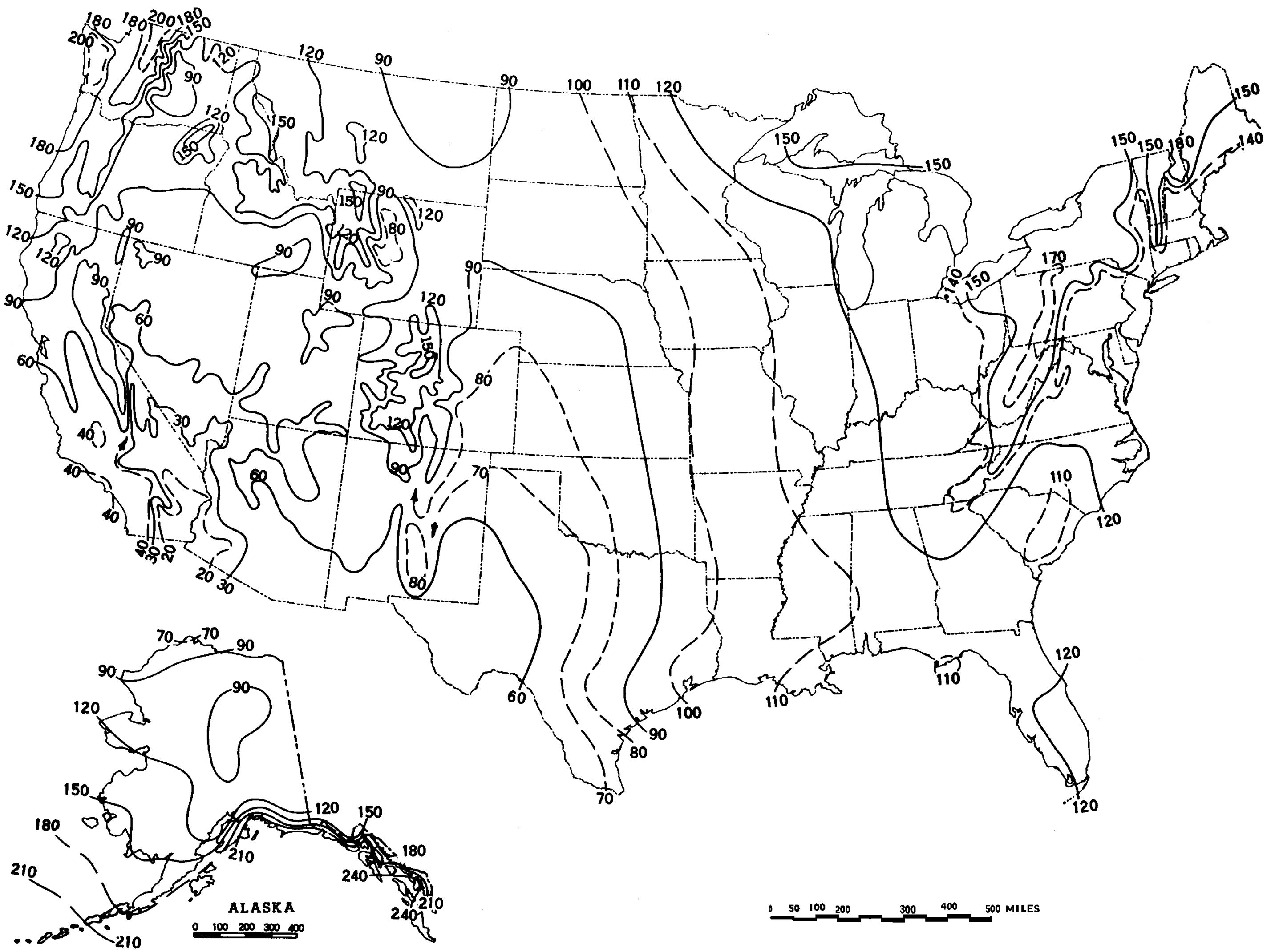


Figure 13.2.1-2. Mean number of days with 0.01 inch or more of precipitation in the United States.

Table 13.2.1-3 presents recommended default silt loadings for normal baseline conditions and for wintertime baseline conditions in areas that experience frozen precipitation with periodic application of antiskid material[24]. The winter baseline is represented as a multiple of the non-winter baseline, depending on the ADT value for the road in question. As shown, a multiplier of 4 is applied for low volume roads (< 500 ADT) to obtain a wintertime baseline silt loading of 4 X 0.6 = 2.4 g/m^2.

Table 13.2.1-3. Ubitiguous Silt Loading Default Values with Hot Spot Contributions from Anti-Skid Abrasives (g/m^2)

ADT Category	< 500	500-5,000	5,000-10,000	> 10,000
Ubiquitous Baseline g/m^2	0.6	0.2	0.06	0.03 0.015 limited access
Ubitiguous Winter Baseline Multiplier during months with frozen precipitation	X4	X3	X2	X1
Initial peak additive contribution from application of antiskid abrasive (g/m^2)	2	2	2	2
Days to return to baseline conditions (assume linear decay)	7	3	1	0.5

It is suggested that an additional (but temporary) silt loading contribution of 2 g/m^2 occurs with each application of antiskid abrasive for snow/ice control. This was determined based on a typical application rate of 500 lb per lane mile and an initial silt content of 1 % silt content. Ordinary rock salt and other chemical deicers add little to the silt loading, because most of the chemical dissolves during the snow/ice melting process.

To adjust the baseline silt loadings for mud/dirt trackout, the number of trackout points is required. It is recommended that in calculating PM-10 emissions, six additional miles of road be added for each active trackout point from an active construction site, to the paved road mileage of the specified category within the county. In calculating PM-2.5 emissions, it is recommended that three additional miles of road be added for each trackout point from an active construction site.

It is suggested the number of trackout points for activities other than road and building construction areas be related to land use. For example, in rural farming areas, each mile of paved road would have a specified number of trackout points at intersections with unpaved roads. This value could be estimated from the unpaved road density (mi/sq. mi.).

The use of a default value from Table 13.2.1-3 should be expected to yield only an order-of-magnitude estimate of the emission factor. Public paved road silt loadings are dependent upon: traffic characteristics (speed, ADT, and fraction of heavy vehicles); road characteristics (curbs, number of lanes, parking lanes); local land use (agriculture, new residential construction) and regional/seasonal factors (snow/ice controls, wind blown dust). As a result, the collection and use of site-specific silt loading data is highly recommended. In the event that default silt loading values are used, the quality ratings for the equation should be downgraded 2 levels.

Limited access roadways pose severe logistical difficulties in terms of surface sampling, and few silt loading data are available for such roads. Nevertheless, the available data do not suggest great variation in silt loading for limited access roadways from one part of the country to another. For annual conditions, a default value of 0.015 g/m^2 is recommended for limited access roadways.[9,22] Even fewer of the available data correspond to worst-case situations, and elevated loadings are observed to be quickly depleted because of high traffic speeds and high ADT rates. A default value of 0.2 g/m^2 is recommended for short periods of time following application of snow/ice controls to limited access roads.[22]

The limited data on silt loading values for industrial roads have shown as much variability as public roads. Because of the variations of traffic conditions and the use of preventive mitigative controls, the data probably do not reflect the full extent of the potential variation in silt loading on industrial roads. However, the collection of site specific silt loading data from industrial roads is easier and safer than for public roads. Therefore, the collection and use of site-specific silt loading data is preferred and is highly recommended. In the event that site-specific values cannot be obtained, an appropriate value for an industrial road may be selected from the mean values given in Table 13.2.1-4, but the quality rating of the equation should be reduced by 2 levels.

Table 13.2.1-4 (Metric And English Units). TYPICAL SILT CONTENT AND LOADING VALUES FOR PAVED ROADS AT INDUSTRIAL FACILITIES[a]

Industry	No. Of Sites	No. Of Samples	Silt Content (%)		No. Of Travel Lanes	Total Loading x 10^{-3}			Silt Loading (g/m^2)	
			Range	Mean		Range	Mean	Units[b]	Range	Mean
Copper smelting	1	3	15.4-21.7	19.0	2	12.9-19.5 45.8-69.2	15.9 55.4	kg/km lb/mi	188-400	292
Iron and steel production	9	48	1.1-35.7	12.5	2	0.006-4.77 0.020-16.9	0.495 1.75	kg/km lb/mi	0.09-79	9.7
Asphalt batching	1	3	2.6-4.6	3.3	1	12.1-18.0 43.0-64.0	14.9 52.8	kg/km lb/mi	76-193	120
Concrete batching	1	3	5.2-6.0	5.5	2	1.4-1.8 5.0-6.4	1.7 5.9	kg/km lb/mi	11-12	12
Sand and gravel processing	1	3	6.4-7.9	7.1	1	2.8-5.5 9.9-19.4	3.8 13.3	kg/km lb/mi	53-95	70
Municipal solid waste landfill	2	7	—	—	2	—	—	—	1.1-32.0	7.4
Quarry	1	6	—	—	2	—	—	—	2.4-14	8.2

[a] References 1-2,5-6,11-13. Values represent samples collected from *industrial* roads. Public road silt loading values are presented in Table-13.2.1-2. Dashes indicate information not available.

[b] Multiply entries by 1000 to obtain stated units; kilograms per kilometer (kg/km) and pounds per mile (lb/mi).

13.2.1.4 Controls[6,25]

Because of the importance of the silt loading, control techniques for paved roads attempt either to prevent material from being deposited onto the surface (preventive controls) or to remove from the travel lanes any material that has been deposited (mitigative controls). Covering of loads in trucks, and the paving of access areas to unpaved lots or construction sites, are examples of preventive measures. Examples of mitigative controls include vacuum sweeping, water flushing, and broom sweeping and flushing. Actual control efficiencies for any of these techniques can be highly variable. Locally measured silt loadings before and after the application of controls is the preferred method to evaluate controls. It is particularly important to note that street sweeping of gutters and curb areas may actually increase the silt loading on the traveled portion of the road. Redistribution of loose material onto the travel lanes will actually produce a short-term increase in the emissions.

In general, preventive controls are usually more cost effective than mitigative controls. The cost-effectiveness of mitigative controls falls off dramatically as the size of an area to be treated increases. The cost-effectiveness of mitigative measures is also unfavorable if only a short period of time is required for the road to return to equilibrium silt loading condition. That is to say, the number and length of public roads within most areas of interest preclude any widespread and routine use of mitigative controls. On the other hand, because of the more limited scope of roads at an industrial site, mitigative measures may be used quite successfully (especially in situations where truck spillage occurs). Note, however, that public agencies could make effective use of mitigative controls to remove sand/salt from roads after the winter ends.

Because available controls will affect the silt loading, controlled emission factors may be obtained by substituting controlled silt loading values into the equation. (Emission factors from controlled industrial roads were used in the development of the equation.) The collection of surface loading samples from treated, as well as baseline (untreated), roads provides a means to track effectiveness of the controls over time.

13.2.1.5 Changes since Fifth Edition

The following changes were made since the publication of the Fifth Edition of AP-42:

1) The particle size multiplier was reduced by approximately 55% as a result of emission testing specifically to evaluate the PM-2.5 component of the emissions.

2) Default silt loading values were included in Table 13.2.1-2 replacing the Tables and Figures containing silt loading statistical information.

3) Editorial changes within the text were made indicating the possible causes of variations in the silt loading between roads within and among different locations. The uncertainty of using the default silt loading value was discussed.

4) Section 13.2.1.1 was revised to clarify the role of dust loading in resuspension. Additional minor text changes were made.

5) Equations 2 and 3, Figure 13.2.1-2, and text were added to incorporate natural mitigation into annual or other long-term average emission factors.

6) The emission factor equation was adjusted to remove the component of particulate emissions from exhaust, brake wear, and tire wear. The parameter *C* in the new equation varies with aerodynamic size range of the particulate matter. Table 13.2.1-2 was added to present the new coefficients.

7) The default silt loading values in Table 13.2.1-3 were revised to incorporate the results from a recent analysis of silt loading data.

8) The PM-2.5 particle size multiplier was reduced by 40% as the result of wind tunnel studies of a variety of dust emitting surface materials.

9) References were rearranged and renumbered.

References For Section 13.2.1

1. D. R. Dunbar, *Resuspension Of Particulate Matter*, EPA-450/2-76-031, U. S. Environmental Protection Agency, Research Triangle Park, NC, March 1976.

2. R. Bohn, *et al.*, *Fugitive Emissions From Integrated Iron And Steel Plants*, EPA-600/2-78-050, U. S. Environmental Protection Agency, Cincinnati, OH, March 1978.

3. C. Cowherd, Jr., *et al.*, *Iron And Steel Plant Open Dust Source Fugitive Emission Evaluation*, EPA-600/2-79-103, U. S. Environmental Protection Agency, Cincinnati, OH, May 1979.

4. C. Cowherd, Jr., *et al.*, *Quantification Of Dust Entrainment From Paved Roadways*, EPA-450/3-77-027, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 1977.

5. *Size Specific Particulate Emission Factors For Uncontrolled Industrial And Rural Roads*, EPA Contract No. 68-02-3158, Midwest Research Institute, Kansas City, MO, September 1983.

6. T. Cuscino, Jr., *et al.*, *Iron And Steel Plant Open Source Fugitive Emission Control Evaluation*, EPA-600/2-83-110, U. S. Environmental Protection Agency, Cincinnati, OH, October 1983.

7. J. P. Reider, *Size-specific Particulate Emission Factors For Uncontrolled Industrial And Rural Roads*, EPA Contract 68-02-3158, Midwest Research Institute, Kansas City, MO, September 1983.

8. C. Cowherd, Jr., and P. J. Englehart, *Paved Road Particulate Emissions*, EPA-600/7-84-077, U. S. Environmental Protection Agency, Cincinnati, OH, July 1984.

9. C. Cowherd, Jr., and P. J. Englehart, *Size Specific Particulate Emission Factors For Industrial And Rural Roads*, EPA-600/7-85-038, U. S. Environmental Protection Agency, Cincinnati, OH, September 1985.

10. *Emission Factor Documentation For AP-42, Sections 11.2.5 and 11.2.6 — Paved Roads*, EPA Contract No. 68-D0-0123, Midwest Research Institute, Kansas City, MO, March 1993.

11. *Evaluation Of Open Dust Sources In The Vicinity Of Buffalo, New York*, EPA Contract No. 68-02-2545, Midwest Research Institute, Kansas City, MO, March 1979.

12. *PM-10 Emission Inventory Of Landfills In The Lake Calumet Area*, EPA Contract No. 68-02-3891, Midwest Research Institute, Kansas City, MO, September 1987.

13. *Chicago Area Particulate Matter Emission Inventory — Sampling And Analysis*, Contract No. 68-02-4395, Midwest Research Institute, Kansas City, MO, May 1988.

14. *Montana Street Sampling Data*, Montana Department Of Health And Environmental Sciences, Helena, MT, July 1992.

15. *Street Sanding Emissions And Control Study*, PEI Associates, Inc., Cincinnati, OH, October 1989.

16. *Evaluation Of PM-10 Emission Factors For Paved Streets*, Harding Lawson Associates, Denver, CO, October 1991.

17. *Street Sanding Emissions And Control Study*, RTP Environmental Associates, Inc., Denver, CO, July 1990.

18. *Post-storm Measurement Results — Salt Lake County Road Dust Silt Loading Winter 1991/92 Measurement Program*, Aerovironment, Inc., Monrovia, CA, June 1992.

19. Written communication from Harold Glasser, Department of Health, Clark County (NV).

20. *PM-10 Emissions Inventory Data For The Maricopa And Pima Planning Areas*, EPA Contract No. 68-02-3888, Engineering-Science, Pasadena, CA, January 1987.

21. *Characterization Of PM-10 Emissions From Antiskid Materials Applied To Ice- And Snow-Covered Roadways*, EPA Contract No. 68-D0-0137, Midwest Research Institute, Kansas City, MO, October 1992.

22. C. Cowherd, *Background Document for Revisions to Fine Fraction Ratios &sed for AP-42 Fugitive Dust Emission Factors*. Prepared by Midwest Research Institute for Western Governors Association, Western Regional Air Partnership, Denver, CO, February 1, 2006.

23. *Climatic Atlas Of The United States*, U.S. Department of Commerce, Washington, D.C., June 1968.

24. C. Cowherd, Jr., *et al.*, *Improved Activity Levels for National Emission Inventories of Fugitive Dust from Paved and Unpaved Roads*, Presented at the 11th International Emission Inventory Conference, Atlanta, Georgia, April 2002.

25. C. Cowherd, Jr., *et al.*, *Control Of Open Fugitive Dust Sources*, EPA-450/3-88-008, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1988.

26. Written communication (Technical Memorandum) from G. Muleski, Midwest Research Institute, Kansas City, MO, to B. Kuykendal, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 27, 2001.

27. EPA, 2002b. MOBILE6 User Guide, United States Environmental Protection Agency, Office of Transportation and Air Quality. EPA420-R-02-028, October 2002.

28. Written communication (Technical Memorandum) from P. Hemmer, E.H. Pechan & Associates, Inc., Durham, NC to B. Kuykendal, U. S. Environmental Protection Agency, Research Triangle Park, NC, August, 21, 2003.

13.2.2 Unpaved Roads

13.2.2.1 General

When a vehicle travels an unpaved road, the force of the wheels on the road surface causes pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed.

The particulate emission factors presented in the previous draft version of this section of AP-42, dated October 2001, implicitly included the emissions from vehicles in the form of exhaust, brake wear, and tire wear as well as resuspended road surface material[25]. EPA included these sources in the emission factor equation for unpaved public roads (equation 1b in this section) since the field testing data used to develop the equation included both the direct emissions from vehicles and emissions from resuspension of road dust.

This version of the unpaved public road emission factor equation only estimates particulate emissions from resuspended road surface material [23, 26]. The particulate emissions from vehicle exhaust, brake wear, and tire wear are now estimated separately using EPA's MOBILE6.2 [24]. This approach eliminates the possibility of double counting emissions. Double counting results when employing the previous version of the emission factor equation in this section and MOBILE6.2 to estimate particulate emissions from vehicle traffic on unpaved public roads. It also incorporates the decrease in exhaust emissions that has occurred since the unpaved public road emission factor equation was developed. The previous version of the unpaved public road emission factor equation includes estimates of emissions from exhaust, brake wear, and tire wear based on emission rates for vehicles in the 1980 calendar year fleet. The amount of PM released from vehicle exhaust has decreased since 1980 due to lower new vehicle emission standards and changes in fuel characteristics.

13.2.2.2 Emissions Calculation And Correction Parameters[1-6]

The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. Field investigations also have shown that emissions depend on source parameters that characterize the condition of a particular road and the associated vehicle traffic. Characterization of these source parameters allow for "correction" of emission estimates to specific road and traffic conditions present on public and industrial roadways.

Dust emissions from unpaved roads have been found to vary directly with the fraction of silt (particles smaller than 75 micrometers [µm] in diameter) in the road surface materials.[1] The silt fraction is determined by measuring the proportion of loose dry surface dust that passes a 200-mesh screen, using the ASTM-C-136 method. A summary of this method is contained in Appendix C of AP-42. Table 13.2.2-1 summarizes measured silt values for industrial unpaved roads. Table 13.2.2-2 summarizes measured silt values for public unpaved roads. It should be noted that the ranges of silt content vary over two orders of magnitude. Therefore, the use of data from this table can potentially introduce considerable error. Use of this data is strongly discouraged when it is feasible to obtain locally gathered data.

Since the silt content of a rural dirt road will vary with geographic location, it should be measured for use in projecting emissions. As a conservative approximation, the silt content of the parent soil in the area can be used. Tests, however, show that road silt content is normally lower than in the surrounding parent soil, because the fines are continually removed by the vehicle traffic, leaving a higher percentage of coarse particles.

Other variables are important in addition to the silt content of the road surface material. For example, at industrial sites, where haul trucks and other heavy equipment are common, emissions are highly correlated with vehicle weight. On the other hand, there is far less variability in the weights of cars and pickup trucks that commonly travel publicly accessible unpaved roads throughout the United States. For those roads, the moisture content of the road surface material may be more dominant in determining differences in emission levels between, for example a hot, desert environment and a cool, moist location.

The PM-10 and TSP emission factors presented below are the outcomes from stepwise linear regressions of field emission test results of vehicles traveling over unpaved surfaces. Due to a limited amount of information available for PM-2.5, the expression for that particle size range has been scaled against the result for PM-10. Consequently, the quality rating for the PM-2.5 factor is lower than that for the PM-10 expression.

Table 13.2.2-1. TYPICAL SILT CONTENT VALUES OF SURFACE MATERIAL ON INDUSTRIAL UNPAVED ROADS[a]

Industry	Road Use Or Surface Material	Plant Sites	No. Of Samples	Silt Content (%)	
				Range	Mean
Copper smelting	Plant road	1	3	16 - 19	17
Iron and steel production	Plant road	19	135	0.2 - 19	6.0
Sand and gravel processing	Plant road	1	3	4.1 - 6.0	4.8
	Material storage area	1	1	-	7.1
Stone quarrying and processing	Plant road	2	10	2.4 - 16	10
	Haul road to/from pit	4	20	5.0-15	8.3
Taconite mining and processing	Service road	1	8	2.4 - 7.1	4.3
	Haul road to/from pit	1	12	3.9 - 9.7	5.8
Western surface coal mining	Haul road to/from pit	3	21	2.8 - 18	8.4
	Plant road	2	2	4.9 - 5.3	5.1
	Scraper route	3	10	7.2 - 25	17
	Haul road (freshly graded)	2	5	18 - 29	24
Construction sites	Scraper routes	7	20	0.56-23	8.5
Lumber sawmills	Log yards	2	2	4.8-12	8.4
Municipal solid waste landfills	Disposal routes	4	20	2.2 - 21	6.4

[a]References 1,5-15.

The following empirical expressions may be used to estimate the quantity in pounds (lb) of size-specific particulate emissions from an unpaved road, per vehicle mile traveled (VMT):

For vehicles traveling on unpaved surfaces at industrial sites, emissions are estimated from the following equation:

$$E = k\ (s/12)^{a}(W/3)^{b} \qquad (1a)$$

and, for vehicles traveling on publicly accessible roads, dominated by light duty vehicles, emissions may be estimated from the following:

$$E = \frac{k\ (s/12)^{a}(S/30)^{d}}{(M/0.5)^{c}} - C \qquad (1b)$$

where k, a, b, c and d are empirical constants (Reference 6) given below and

E = size-specific emission factor (lb/VMT)
s = surface material silt content (%)
W = mean vehicle weight (tons)
M = surface material moisture content (%)
S = mean vehicle speed (mph)
C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.

The source characteristics s, W and M are referred to as correction parameters for adjusting the emission estimates to local conditions. The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows:

1 lb/VMT = 281.9 g/VKT

The constants for Equations 1a and 1b based on the stated aerodynamic particle sizes are shown in Tables 13.2.2-2 and 13.2.2-4. The PM-2.5 particle size multipliers (k-factors) are taken from Reference 27.

Table 13.2.2-2. CONSTANTS FOR EQUATIONS 1a AND 1b

Constant	Industrial Roads (Equation 1a)			Public Roads (Equation 1b)		
	PM-2.5	PM-10	PM-30*	PM-2.5	PM-10	PM-30*
k (lb/VMT)	0.15	1.5	4.9	0.18	1.8	6.0
a	0.9	0.9	0.7	1	1	1
b	0.45	0.45	0.45	-	-	-
c	-	-	-	0.2	0.2	0.3
d	-	-	-	0.5	0.5	0.3
Quality Rating	B	B	B	B	B	B

*Assumed equivalent to total suspended particulate matter (TSP)
"-" = not used in the emission factor equation

Table 13.2.2-2 also contains the quality ratings for the various size-specific versions of Equation 1a and 1b. The equation retains the assigned quality rating, if applied within the ranges of source conditions, shown in Table 13.2.2-3, that were tested in developing the equation:

Table 13.2.2-3. RANGE OF SOURCE CONDITIONS USED IN DEVELOPING EQUATION 1a AND 1b

Emission Factor	Surface Silt Content, %	Mean Vehicle Weight		Mean Vehicle Speed		Mean No. of Wheels	Surface Moisture Content, %
		Mg	ton	km/hr	mph		
Industrial Roads (Equation 1a)	1.8-25.2	1.8-260	2-290	8-69	5-43	4-17[a]	0.03-13
Public Roads (Equation 1b)	1.8-35	1.4-2.7	1.5-3	16-88	10-55	4-4.8	0.03-13

[a] See discussion in text.

As noted earlier, the models presented as Equations 1a and 1b were developed from tests of traffic on unpaved surfaces. Unpaved roads have a hard, generally nonporous surface that usually dries quickly after a rainfall or watering, because of traffic-enhanced natural evaporation. (Factors influencing how fast a road dries are discussed in Section 13.2.2.3, below.) The quality ratings given above pertain to the mid-range of the measured source conditions for the equation. A higher mean vehicle weight and a higher than normal traffic rate may be justified when performing a worst-case analysis of emissions from unpaved roads.

The emission factors for the exhaust, brake wear and tire wear of a 1980's vehicle fleet (*C*) was obtained from EPA's MOBILE6.2 model [23]. The emission factor also varies with aerodynamic size range as shown in Table 13.2.2-4

Table 13.2.2-4. EMISSION FACTOR FOR 1980'S VEHICLE FLEET EXHAUST, BRAKE WEAR AND TIRE WEAR

Particle Size Range[a]	*C*, Emission Factor for Exhaust, Brake Wear and Tire Wear[b] lb/VMT
$PM_{2.5}$	0.00036
PM_{10}	0.00047
PM_{30}[c]	0.00047

[a] Refers to airborne particulate matter (PM-x) with an aerodynamic diameter equal to or less than x micrometers.
[b] Units shown are pounds per vehicle mile traveled (lb/VMT).
[c] PM-30 is sometimes termed "suspendable particulate" (SP) and is often used as a surrogate for TSP.

It is important to note that the vehicle-related source conditions refer to the average weight, speed, and number of wheels for all vehicles traveling the road. For example, if 98 percent of traffic on the road are 2-ton cars and trucks while the remaining 2 percent consists of 20-ton trucks, then the mean weight is 2.4 tons. More specifically, Equations 1a and 1b are *not* intended to be used to calculate a separate emission factor for each vehicle class within a mix of traffic on a given unpaved road. That is, in the example, one should *not* determine one factor for the 2-ton vehicles and a second factor for the 20-ton trucks. Instead, only one emission factor should be calculated that represents the "fleet" average of 2.4 tons for all vehicles traveling the road.

Moreover, to retain the quality ratings when addressing a group of unpaved roads, it is necessary that reliable correction parameter values be determined for the road in question. The field and laboratory procedures for determining road surface silt and moisture contents are given in AP-42 Appendices C.1 and C.2. Vehicle-related parameters should be developed by recording visual observations of traffic. In some cases, vehicle parameters for industrial unpaved roads can be determined by reviewing maintenance records or other information sources at the facility.

In the event that site-specific values for correction parameters cannot be obtained, then default values may be used.In the absence of site-specific silt content information, an appropriate mean value from Table 13.2.2-1 may be used as a default value, but the quality rating of the equation is reduced by two letters. Because of significant differences found between different types of road surfaces and between different areas of the country, use of the default moisture content value of 0.5 percent in Equation 1b is discouraged. The quality rating should be downgraded two letters when the default moisture content value is used. (It is assumed that readers addressing industrial roads have access to the information needed to develop average vehicle information in Equation 1a for their facility.)

The effect of routine watering to control emissions from unpaved roads is discussed below in Section 13.2.2.3, “Controls”. However, all roads are subject to some natural mitigation because of rainfall and other precipitation. The Equation 1a and 1b emission factors can be extrapolated to annual average uncontrolled conditions (but including natural mitigation) under the simplifying assumption that annual average emissions are inversely proportional to the number of days with measurable (more than 0.254 mm [0.01 inch]) precipitation:

$$E_{ext} = E\ [(365 - P)/365] \quad (2)$$

where:

E_{ext} = annual size-specific emission factor extrapolated for natural mitigation, lb/VMT

E = emission factor from Equation 1a or 1b

P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation (see below)

Figure 13.2.2-1 gives the geographical distribution for the mean annual number of "wet" days for the United States.

Equation 2 provides an estimate that accounts for precipitation on an annual average basis for the purpose of inventorying emissions. It should be noted that Equation 2 does not account for differences in the temporal distributions of the rain events, the quantity of rain during any event, or the potential for the rain to evaporate from the road surface. In the event that a finer temporal and spatial resolution is desired for inventories of public unpaved roads, estimates can be based on a more complex set of assumptions. These assumptions include:

1. The moisture content of the road surface material is increased in proportion to the quantity of water added;
2. The moisture content of the road surface material is reduced in proportion to the Class A pan evaporation rate;
3. The moisture content of the road surface material is reduced in proportion to the traffic volume; and
4. The moisture content of the road surface material varies between the extremes observed in the area. The CHIEF Web site (http://www.epa.gov/ttn/chief/ap42/ch13/related/c13s02-2.html) has a file which contains a spreadsheet program for calculating emission factors which are temporally and spatially resolved. Information required for use of the spreadsheet program includes monthly Class A pan evaporation values, hourly meteorological data for precipitation, humidity and snow cover, vehicle traffic information, and road surface material information.

It is emphasized that <u>the simple assumption underlying Equation 2 and the more complex set of assumptions underlying the use of the procedure which produces a finer temporal and spatial resolution</u> have not been verified in any rigorous manner. For this reason, the quality ratings for either approach should be downgraded one letter from the rating that would be applied to Equation 1.

13.2.2.3 Controls[18-22]

A wide variety of options exist to control emissions from unpaved roads. Options fall into the following three groupings:

1. <u>Vehicle restrictions</u> that limit the speed, weight or number of vehicles on the road;

2. Surface improvement, by measures such as (a) paving or (b) adding gravel or slag to a dirt road; and

3. Surface treatment, such as watering or treatment with chemical dust suppressants.

Available control options span broad ranges in terms of cost, efficiency, and applicability. For example, traffic controls provide moderate emission reductions (often at little cost) but are difficult to enforce. Although paving is highly effective, its high initial cost is often prohibitive. Furthermore, paving is not feasible for industrial roads subject to very heavy vehicles and/or spillage of material in transport. Watering and chemical suppressants, on the other hand, are potentially applicable to most industrial roads at moderate to low costs. However, these require frequent reapplication to maintain an acceptable level of control. Chemical suppressants are generally more cost-effective than water but not in cases of temporary roads (which are common at mines, landfills, and construction sites). In summary, then, one needs to consider not only the type and volume of traffic on the road but also how long the road will be in service when developing control plans.

Vehicle restrictions. These measures seek to limit the amount and type of traffic present on the road or to lower the mean vehicle speed. For example, many industrial plants have restricted employees from driving on plant property and have instead instituted bussing programs. This eliminates emissions due to employees traveling to/from their worksites. Although the heavier average vehicle weight of the busses increases the base emission factor, the decrease in vehicle-miles-traveled results in a lower overall emission rate.

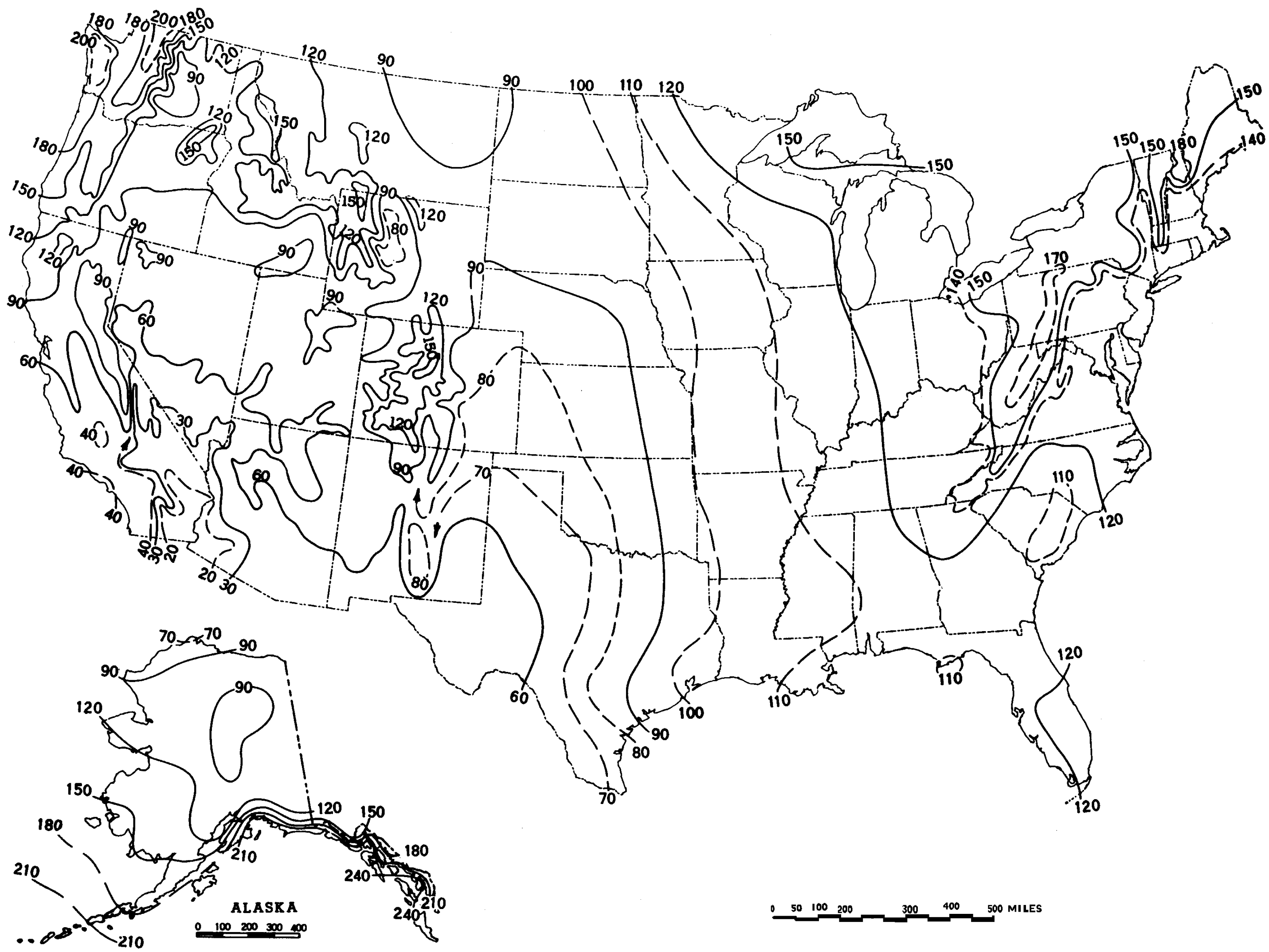


Figure 13.2.2-1. Mean number of days with 0.01 inch or more of precipitation in United States.

Surface improvements. Control options in this category alter the road surface. As opposed to the "surface treatments" discussed below, improvements are relatively "permanent" and do not require periodic retreatment.

The most obvious surface improvement is paving an unpaved road. This option is quite expensive and is probably most applicable to relatively short stretches of unpaved road with at least several hundred vehicle passes per day. Furthermore, if the newly paved road is located near unpaved areas or is used to transport material, it is essential that the control plan address routine cleaning of the newly paved road surface.

The control efficiencies achievable by paving can be estimated by comparing emission factors for unpaved and paved road conditions. The predictive emission factor equation for paved roads, given in Section 13.2.1, requires estimation of the silt loading on the traveled portion of the paved surface, which in turn depends on whether the pavement is periodically cleaned. Unless curbing is to be installed, the effects of vehicle excursion onto unpaved shoulders (berms) also must be taken into account in estimating the control efficiency of paving.

Other improvement methods cover the road surface with another material that has a lower silt content. Examples include placing gravel or slag on a dirt road. Control efficiency can be estimated by comparing the emission factors obtained using the silt contents before and after improvement. The silt content of the road surface should be determined after 3 to 6 months rather than immediately following placement. Control plans should address regular maintenance practices, such as grading, to retain larger aggregate on the traveled portion of the road.

Surface treatments refer to control options which require periodic reapplication. Treatments fall into the two main categories of (a) "wet suppression" (i. e., watering, possibly with surfactants or other additives), which keeps the road surface wet to control emissions and (b) "chemical stabilization/ treatment", which attempts to change the physical characteristics of the surface. The necessary reapplication frequency varies from several minutes for plain water under summertime conditions to several weeks or months for chemical dust suppressants.

Watering increases the moisture content, which conglomerates particles and reduces their likelihood to become suspended when vehicles pass over the surface. The control efficiency depends on how fast the road dries after water is added. This in turn depends on (a) the amount (per unit road surface area) of water added during each application; (b) the period of time between applications; (c) the weight, speed and number of vehicles traveling over the watered road during the period between applications; and (d) meteorological conditions (temperature, wind speed, cloud cover, etc.) that affect evaporation during the period.

Figure 13.2.2-2 presents a simple bilinear relationship between the instantaneous control efficiency due to watering and the resulting increase in surface moisture. The moisture ratio "M" (i.e., the x-axis in Figure 13.2.2-2) is found by dividing the surface moisture content of the watered road by the surface moisture content of the uncontrolled road. As the watered road surface dries, both the ratio M and the predicted instantaneous control efficiency (i.e., the y-axis in the figure) decrease. The figure shows that between the uncontrolled moisture content and a value twice as large, a small increase in moisture content results in a large increase in control efficiency. Beyond that, control efficiency grows slowly with increased moisture content.

Given the complicated nature of how the road dries, characterization of emissions from watered roadways is best done by collecting road surface material samples at various times between water truck passes. (Appendices C.1 and C.2 present the sampling and analysis procedures.) The moisture content measured can then be associated with a control efficiency by use of Figure 13.2.2-2. Samples that reflect average conditions during the watering cycle can take the form of either a series of samples between water applications or a single sample at the midpoint. It is essential that samples be collected during periods with active traffic on the road. Finally, because of different evaporation rates, it is recommended that samples be collected at various times during the year. If only one set of samples is to be collected, these must be collected during hot, summertime conditions.

When developing watering control plans for roads that do not yet exist, it is strongly recommended that the moisture cycle be established by sampling similar roads in the same geographic area. If the moisture cycle cannot be established by similar roads using established watering control plans, the more complex methodology used to estimate the mitigation of rainfall and other precipitation can be used to estimate the control provided by routine watering. An estimate of the maximum daytime Class A pan evaporation (based upon daily evaporation data published in the monthly Climatological Data for the state by the National Climatic Data Center) should be used to insure that adequate watering capability is available during periods of highest evaporation. The hourly precipitation values in the spreadsheet should be replaced with the equivalent inches of precipitation (where the equivalent of 1 inch of precipitation is provided by an application of 5.6 gallons of water per square yard of road). Information on the long term average annual evaporation and on the percentage that occurs between May and October was published in the Climatic Atlas (Reference 16). Figure 13.2.2-3 presents the geographical distribution for "Class A pan evaporation" throughout the United States. Figure 13.2.2-4 presents the geographical distribution of the percentage of this evaporation that occurs between May and October. The U. S. Weather Bureau Class A evaporation pan is a cylindrical metal container with a depth of 10 inches and a diameter of 48 inches. Periodic measurements are made of the changes of the water level.

The above methodology should be used <u>only for prospective analyses</u> and for designing watering programs for existing roadways. The quality rating of an emission factor for a watered road that is based on this methodology should be downgraded two letters. Periodic road surface samples should be collected and analyzed to verify the efficiency of the watering program.

As opposed to watering, chemical dust suppressants have much less frequent reapplication requirements. These materials suppress emissions by changing the physical characteristics of the existing road surface material. Many chemical unpaved road dust suppressants form a hardened surface that binds particles together. After several applications, a treated road often resembles a paved road except that the surface is not uniformly flat. Because the improved surface results in more grinding of small particles, the silt content of loose material on a highly controlled surface may be substantially higher than when the surface was uncontrolled. For this reason, the models presented as Equations 1a and 1b cannot be used to estimate emissions from chemically stabilized roads. Should the road be allowed to return to an uncontrolled state with no visible signs of large-scale cementing of material, the Equation 1a and 1b emission factors could then be used to obtain conservatively high emission estimates.

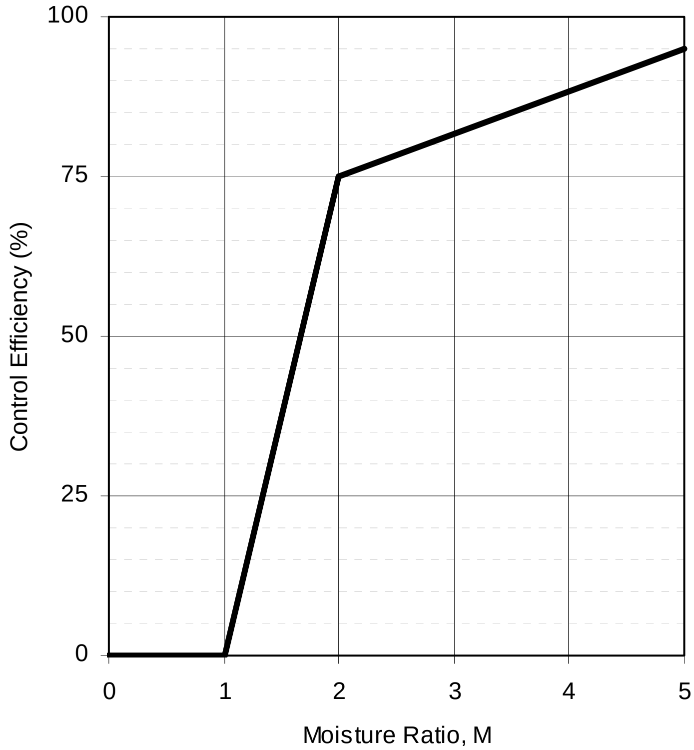


Figure 13.2.2-2. Watering control effectiveness for unpaved travel surfaces

The control effectiveness of chemical dust suppressants appears to depend on (a) the dilution rate used in the mixture; (b) the application rate (volume of solution per unit road surface area); (c) the time between applications; (d) the size, speed and amount of traffic during the period between applications; and (e) meteorological conditions (rainfall, freeze/thaw cycles, etc.) during the period. Other factors that affect the performance of dust suppressants include other traffic characteristics (e. g., cornering, track-on from unpaved areas) and road characteristics (e. g., bearing strength, grade). The variabilities in the above factors and differences between individual dust control products make the control efficiencies of chemical dust suppressants difficult to estimate. Past field testing of emissions from controlled unpaved roads has shown that chemical dust suppressants provide a PM-10 control efficiency of about 80 percent when applied at regular intervals of 2 weeks to 1 month.

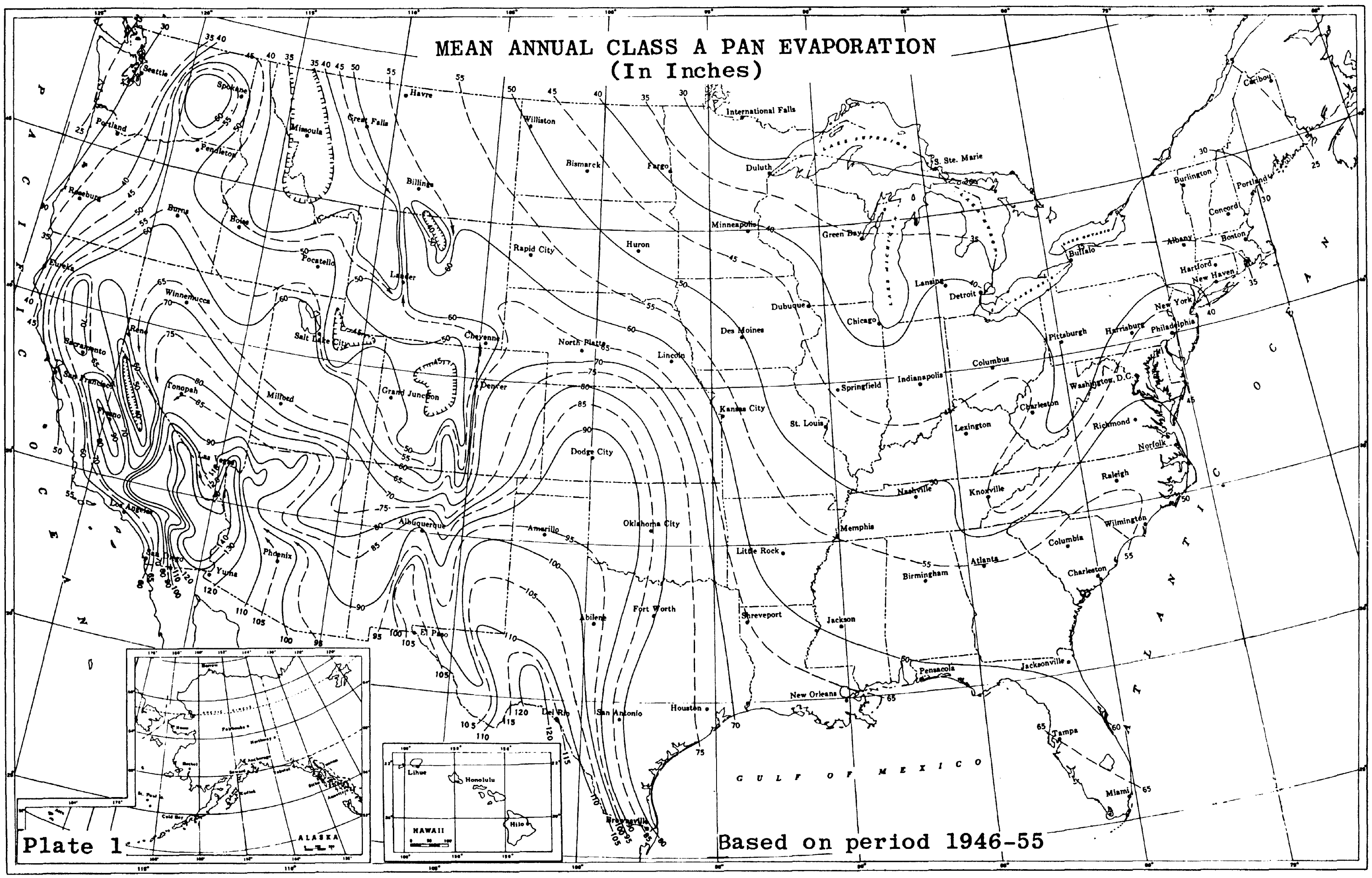


Figure 13.2.2-3. Annual evaporation data.

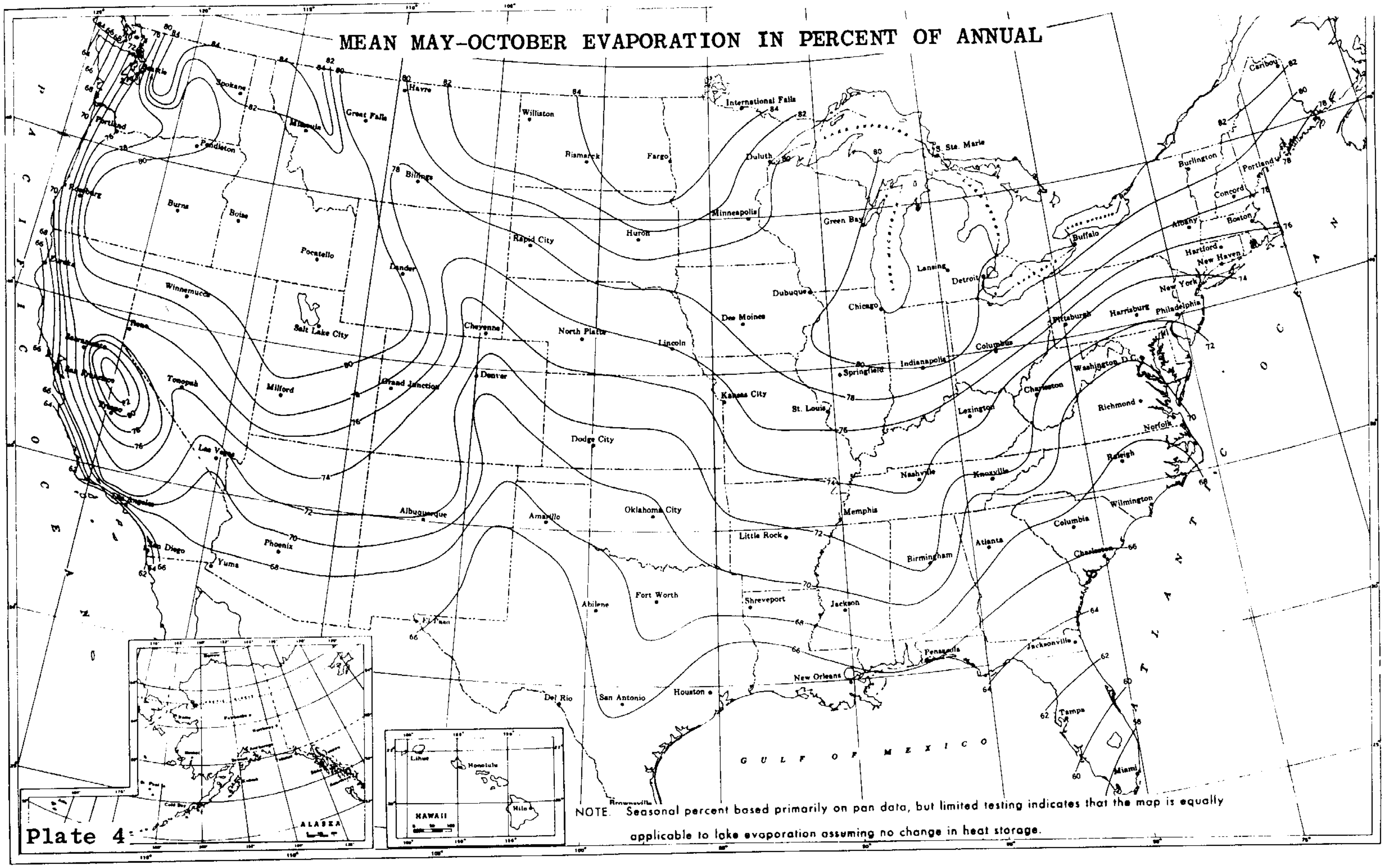


Figure 13.2.2-4. Geographical distribution of the percentage of evaporation occurring between May and October.

Petroleum resin products historically have been the dust suppressants (besides water) most widely used on industrial unpaved roads. Figure 13.2.2-5 presents a method to estimate average control efficiencies associated with petroleum resins applied to unpaved roads.[20] Several items should be noted:

1. The term "ground inventory" represents the total volume (per unit area) of petroleum resin concentrate (*not solution*) applied since the start of the dust control season.

2. Because petroleum resin products must be periodically reapplied to unpaved roads, the use of a time-averaged control efficiency value is appropriate. Figure 13.2.2-5 presents control efficiency values averaged over two common application intervals, 2 weeks and 1 month. Other application intervals will require interpolation.

3. Note that zero efficiency is assigned until the ground inventory reaches 0.05 gallon per square yard (gal/yd^2). Requiring a minimum ground inventory ensures that one must apply a reasonable amount of chemical dust suppressant to a road before claiming credit for emission control. Recall that the ground inventory refers to the amount of petroleum resin concentrate rather than the total solution.

As an example of the application of Figure 13.2.2-5, suppose that Equation 1a was used to estimate an emission factor of 7.1 lb/VMT for PM-10 from a particular road. Also, suppose that, starting on May 1, the road is treated with 0.221 gal/yd^2 of a solution (1 part petroleum resin to 5 parts water) on the first of each month through September. Then, the average controlled emission factors, shown in Table 13.2.2-5, are found.

Table 13.2-2-5. EXAMPLE OF AVERAGE CONTROLLED EMISSION FACTORS FOR SPECIFIC CONDITIONS

Period	Ground Inventory, gal/yd^2	Average Control Efficiency, %[a]	Average Controlled Emission Factor, lb/VMT
May	0.037	0	7.1
June	0.073	62	2.7
July	0.11	68	2.3
August	0.15	74	1.8
September	0.18	80	1.4

[a] From Figure 13.2.2-5, $\leq$10 µm. Zero efficiency assigned if ground inventory is less than 0.05 gal/yd^2. 1 lb/VMT = 281.9 g/VKT. 1 gal/yd^2 = 4.531 L/m^2.

Besides petroleum resins, other newer dust suppressants have also been successful in controlling emissions from unpaved roads. Specific test results for those chemicals, as well as for petroleum resins and watering, are provided in References 18 through 21.

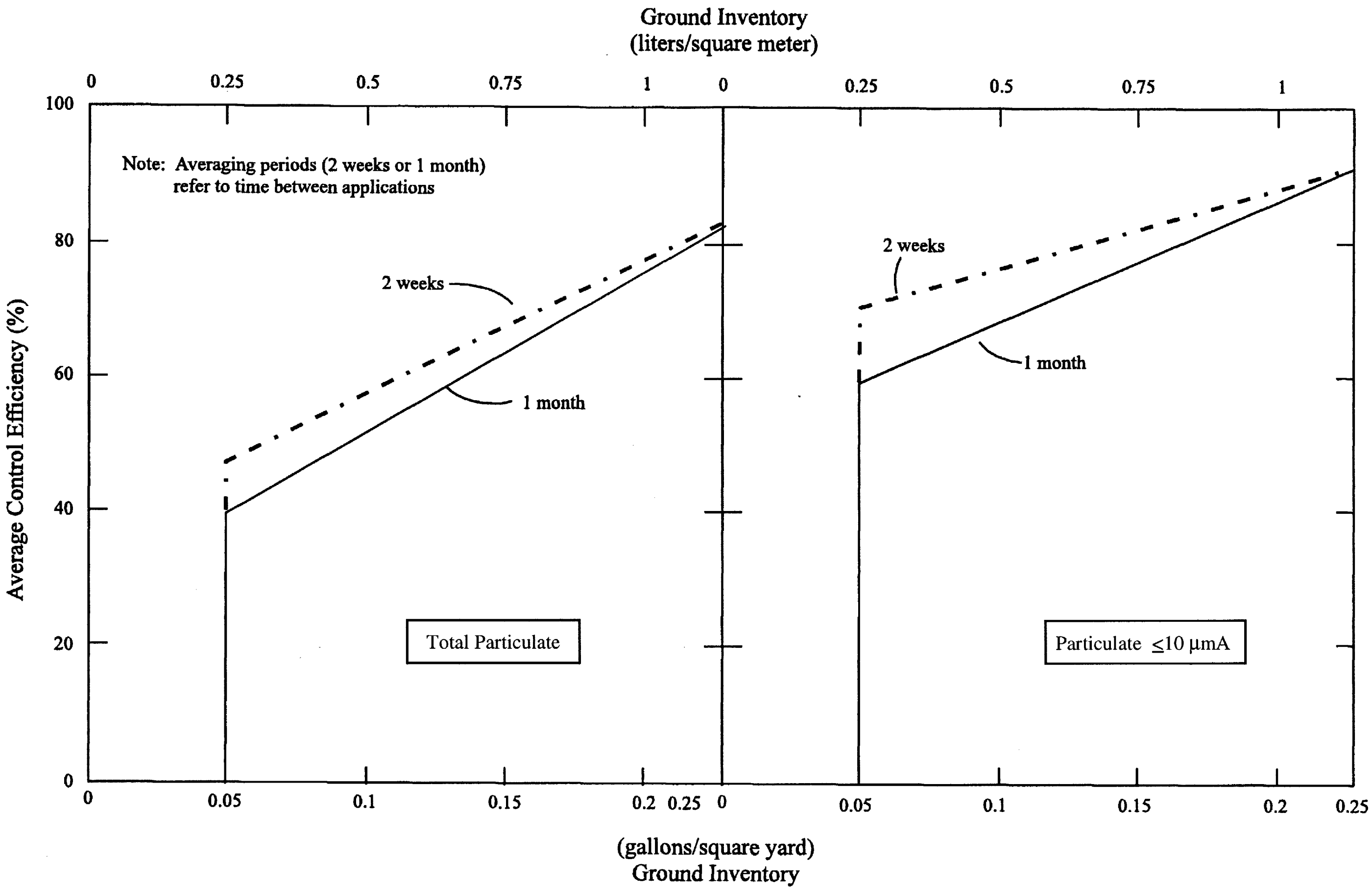


Figure 13.2.2-5. Average control efficiencies over common application intervals.

13.2.2.4 Updates Since The Fifth Edition

The Fifth Edition was released in January 1995. Revisions to this section since that date are summarized below. For further detail, consult the background report for this section (Reference 6).

October 1998 (Supplement E)– This was a major revision of this section. Significant changes to the text and the emission factor equations were made.

October 2001 – Separate emission factors for unpaved surfaces at industrial sites and publicly accessible roads were introduced. Figure 13.2.2-2 was included to provide control effectiveness estimates for watered roads.

December 2003 – The public road emission factor equation (equation 1b) was adjusted to remove the component of particulate emissions from exhaust, brake wear, and tire wear. The parameter *C* in the new equation varies with aerodynamic size range of the particulate matter. Table 13.2.2-4 was added to present the new coefficients.

January 2006 – The PM-2.5 particle size multipliers (i.e., factors) in Table 13.2.2-2 were modified and the quality ratings were upgraded from C to B based on the wind tunnel studies of a variety of dust emitting surface materials.

References For Section 13.2.2

1. C. Cowherd, Jr., *et al.*, *Development Of Emission Factors For Fugitive Dust Sources*, EPA-450/3-74-037, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.

2. R. J. Dyck and J. J. Stukel, "Fugitive Dust Emissions From Trucks On Unpaved Roads", *Environmental Science And Technology, 10*(10):1046-1048, October 1976.

3. R. O. McCaldin and K. J. Heidel, "Particulate Emissions From Vehicle Travel Over Unpaved Roads", Presented at the 71st Annual Meeting of the Air Pollution Control Association, Houston, TX, June 1978.

4. C. Cowherd, Jr, *et al.*, *Iron And Steel Plant Open Dust Source Fugitive Emission Evaluation*, EPA-600/2-79-013, U. S. Environmental Protection Agency, Cincinnati, OH, May 1979.

5. G. Muleski, *Unpaved Road Emission Impact*, Arizona Department of Environmental Quality, Phoenix, AZ, March 1991.

6. *Emission Factor Documentation For AP-42, Section 13.2.2, Unpaved Roads, Final Report*, Midwest Research Institute, Kansas City, MO, September 1998.

7. T. Cuscino, Jr., *et al.*, *Taconite Mining Fugitive Emissions Study*, Minnesota Pollution Control Agency, Roseville, MN, June 1979.

8. *Improved Emission Factors For Fugitive Dust From Western Surface Coal Mining Sources*, 2 Volumes, EPA Contract No. 68-03-2924, Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC.

9. T. Cuscino, Jr., *et al.*, *Iron And Steel Plant Open Source Fugitive Emission Control Evaluation*, EPA-600/2-83-110, U. S. Environmental Protection Agency, Cincinnati, OH, October 1983.

10. *Size Specific Emission Factors For Uncontrolled Industrial And Rural Roads*, EPA Contract No. 68-02-3158, Midwest Research Institute, Kansas City, MO, September 1983.

11. C. Cowherd, Jr., and P. Englehart, *Size Specific Particulate Emission Factors For Industrial And Rural Roads*, EPA-600/7-85-038, U. S. Environmental Protection Agency, Cincinnati, OH, September 1985.

12. *PM-10 Emission Inventory Of Landfills In The Lake Calumet Area*, EPA Contract 68-02-3891, Work Assignment 30, Midwest Research Institute, Kansas City, MO, September 1987.

13. *Chicago Area Particulate Matter Emission Inventory — Sampling And Analysis*, EPA Contract No. 68-02-4395, Work Assignment 1, Midwest Research Institute, Kansas City, MO, May 1988.

14. *PM-10 Emissions Inventory Data For The Maricopa And Pima Planning Areas*, EPA Contract No. 68-02-3888, Engineering-Science, Pasadena, CA, January 1987.

15. *Oregon Fugitive Dust Emission Inventory*, EPA Contract 68-D0-0123, Midwest Research Institute, Kansas City, MO, January 1992.

16. *Climatic Atlas Of The United States*, U. S. Department Of Commerce, Washington, DC, June 1968.

17. National Climatic Data Center, *Solar And Meteorological Surface Observation Network 1961-1990*; 3 Volume CD-ROM. Asheville, NC, 1993.

18. C. Cowherd, Jr. *et al.*, *Control Of Open Fugitive Dust Sources*, EPA-450/3-88-008, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1988.

19. G. E. Muleski, *et al.*, *Extended Evaluation Of Unpaved Road Dust Suppressants In The Iron And Steel Industry*, EPA-600/2-84-027, U. S. Environmental Protection Agency, Cincinnati, OH, February 1984.

20. C. Cowherd, Jr., and J. S. Kinsey, *Identification, Assessment And Control Of Fugitive Particulate Emissions*, EPA-600/8-86-023, U. S. Environmental Protection Agency, Cincinnati, OH, August 1986.

21. G. E. Muleski and C. Cowherd, Jr., *Evaluation Of The Effectiveness Of Chemical Dust Suppressants On Unpaved Roads*, EPA-600/2-87-102, U. S. Environmental Protection Agency, Cincinnati, OH, November 1986.

22. *Fugitive Dust Background Document And Technical Information Document For Best Available Control Measures*, EPA-450/2-92-004, Office Of Air Quality Planning And Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1992.

23. Written communication (Technical Memorandum) from P. Hemmer, E.H. Pechan & Associates, Inc., Durham, NC to B. Kuykendal, U. S. Environmental Protection Agency, Research Triangle Park, NC, August, 21, 2003.

24. MOBILE6 User Guide, United States Environmental Protection Agency, Office of Transportation and Air Quality. EPA420-R-02-028, October 2002.

25. Written communication (Technical Memorandum) from G. Muleski, Midwest Research Institute, Kansas City, MO, to B. Kuykendal, U. S. Environmental Protection Agency, Research Triangle Park, NC, Subject "Unpaved Roads", September 27, 2001.

26. Written communication (Technical Memorandum) from W. Kuykendal, U. S. Environmental Protection Agency, to File, Subject "Decisions on Final AP-42 Section 13.2.2 Unpaved Roads", November 24, 2003.

27. C. Cowherd, *Background Document for Revisions to Fine Fraction Ratios &sed for AP-42 Fugitive Dust Emission Factors*. Prepared by Midwest Research Institute for Western Governors Association, Western Regional Air Partnership, Denver, CO, February 1, 2006.

13.2.3 Heavy Construction Operations

13.2.3.1 General

Heavy construction is a source of dust emissions that may have substantial temporary impact on local air quality. Building and road construction are 2 examples of construction activities with high emissions potential. Emissions during the construction of a building or road can be associated with land clearing, drilling and blasting, ground excavation, cut and fill operations (i.e., earth moving), and construction of a particular facility itself. Dust emissions often vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. A large portion of the emissions results from equipment traffic over temporary roads at the construction site.

The temporary nature of construction differentiates it from other fugitive dust sources as to estimation and control of emissions. Construction consists of a series of different operations, each with its own duration and potential for dust generation. In other words, emissions from any single construction site can be expected (1) to have a definable beginning and an end and (2) to vary substantially over different phases of the construction process. This is in contrast to most other fugitive dust sources, where emissions are either relatively steady or follow a discernable annual cycle. Furthermore, there is often a need to estimate areawide construction emissions, without regard to the actual plans of any individual construction project. For these reasons, following are methods by which either areawide or site-specific emissions may be estimated.

13.2.3.2 Emissions And Correction Parameters

The quantity of dust emissions from construction operations is proportional to the area of land being worked and to the level of construction activity. By analogy to the parameter dependence observed for other similar fugitive dust sources,[1] one can expect emissions from heavy construction operations to be positively correlated with the silt content of the soil (that is, particles smaller than 75 micrometers [µm] in diameter), as well as with the speed and weight of the average vehicle, and to be negatively correlated with the soil moisture content.

13.2.3.3 Emission Factors

Only 1 set of field studies has been performed that attempts to relate the emissions from construction directly to an emission factor.[1-2] Based on field measurements of total suspended particulate (TSP) concentrations surrounding apartment and shopping center construction projects, the approximate emission factors for construction activity operations are:

$E = 2.69$ megagrams (Mg)/hectare/month of activity
$E = 1.2$ tons/acre/month of activity

These values are most useful for developing estimates of overall emissions from construction scattered throughout a geographical area. The value is most applicable to construction operations with: (1) medium activity level, (2) moderate silt contents, and (3) semiarid climate. Test data were not sufficient to derive the specific dependence of dust emissions on correction parameters. Because the above emission factor is referenced to TSP, use of this factor to estimate particulate matter (PM) no greater than 10 µm in aerodynamic diameter (PM-10) emissions will result in conservatively high estimates. Also, because derivation of the factor assumes that construction activity occurs 30 days per month, the above estimate is somewhat conservatively high for TSP as well.

Although the equation above represents a relatively straightforward means of preparing an areawide emission inventory, at least 2 features limit its usefulness for specific construction sites. First, the conservative nature of the emission factor may result in too high an estimate for PM-10 to be of much use for a specific site under consideration. Second, the equation provides neither information about which particular construction activities have the greatest emission potential nor guidance for developing an effective dust control plan.

For these reasons, it is strongly recommended that when emissions are to be estimated for a particular construction site, the construction process be broken down into component operations. (Note that many general contractors typically employ planning and scheduling tools, such as critical path method [CPM], that make use of different sequential operations to allocate resources.) This approach to emission estimation uses a unit or phase method to consider the more basic dust sources of vehicle travel and material handling. That is to say, the construction project is viewed as consisting of several operations, each involving traffic and material movements, and emission factors from other AP-42 sections are used to generate estimates. Table 13.2.3-1 displays the dust sources involved with construction, along with the recommended emission factors.[3]

In addition to the on-site activities shown in Table 13.2.3-1, substantial emissions are possible because of material tracked out from the site and deposited on adjacent paved streets. Because all traffic passing the site (i. e., not just that associated with the construction) can resuspend the deposited material, this "secondary" source of emissions may be far more important than all the dust sources actually within the construction site. Furthermore, this secondary source will be present during all construction operations. Persons developing construction site emission estimates must consider the potential for increased adjacent emissions from off-site paved roadways (see Section 13.2.1, "Paved Roads"). High wind events also can lead to emissions from cleared land and material stockpiles. Section 13.2.5, "Industrial Wind Erosion", presents an estimation methodology that can be used for such sources at construction sites.

13.2.3.4 Control Measures[4]

Because of the relatively short-term nature of construction activities, some control measures are more cost effective than others. Wet suppression and wind speed reduction are 2 common methods used to control open dust sources at construction sites, because a source of water and material for wind barriers tend to be readily available on a construction site. However, several other forms of dust control are available.

Table 13.2.3-2 displays each of the preferred control measures, by dust source.[3-4] Because most of the controls listed in the table modify independent variables in the emission factor models, the effectiveness can be calculated by comparing controlled and uncontrolled emission estimates from Table 13.2.3-1. Additional guidance on controls is provided in the AP-42 sections from which the recommended emission factors were taken, as well as in other documents, such as Reference 4.

Table 13.2.3-1. RECOMMENDED EMISSION FACTORS FOR CONSTRUCTION OPERATIONS[a]

Construction Phase	Dust-generating Activities	Recommended Emission Factor	Comments	Rating Adjustment[b]
I. Demolition and debris removal	1. Demolition of buildings or other (natural) obstacles such as trees, boulders, etc.			
	a. Mechanical dismemberment ("headache ball") of existing structures	NA		—
	b. Implosion of existing structures	NA		—
	c. Drilling and blasting of soil	Drilling factor in Table 11.9-4		-1
		Blasting factor NA	Blasting factor in Tables 11.9-1 and 11.9-2 not considered appropriate for general construction activities	NA
	d. General land clearing	Dozer equation (overburden) in Tables 11.9-1 and 11.9-2		-1/-2[c]
	2. Loading of debris into trucks	Material handling emission factor equation in Section 13.2.4		-0/-1[c]
	3. Truck transport of debris	Unpaved road emission factor in Section 13.2.2, or paved road emission factor in Section 13.2.1		-0/-1[c]
	4. Truck unloading of debris	Material handling emission factor equation in Section 13.2.4	May occur offsite	-0/-1[c]

Table 13.2.3-1 (cont.).

Construction Phase	Dust-generating Activities	Recommended Emission Factor	Comments	Rating Adjustment[b]
II. Site Preparation (earth moving)	1. Bulldozing	Dozer equation (overburden) in Tables 11.9-1 and 11.9-2		-1/-2[c]
	2. Scrapers unloading topsoil	Scraper unloading factor in Table 11.9-4		-1
	3. Scrapers in travel	Scraper (travel mode) expression in Tables 11.9-1 and 11.9-2		-0/-1[c]
	4. Scrapers removing topsoil	5.7 kg/vehicle kilometer traveled (VKT) (20.2 lb/vehicle mile traveled [VMT])		E[d]
	5. Loading of excavated material into trucks	Material handling emission factor equation in Section 13.2.4		-0/-1[c]
	6. Truck dumping of fill material, road base, or other materials	Material handling emission factor equation in Section 13.2.4	May occur offsite	-0/-1[c]
	7. Compacting	Dozer equation in Tables 11.9-1 and 11.9-2	Emission factor downgraded because of differences in operating equipment	-1/-2[c]
	8. Motor grading	Grading equation in Tables 11.9-1 and 11.9-2		-1/-2[c]

Table 13.2.3-1 (cont.).

Construction Phase	Dust-generating Activities	Recommended Emission Factor	Comments	Rating Adjustment[b]
III. General Construction	1. Vehicular traffic	Unpaved road emission factor in Section 13.2.2, or paved road emission factor in Section 13.2.1		-0/-1[c] -0/-1[c]
	2. Portable plants			
	a. Crushing	Factors for similar material/operations in Section 11.19.2		-1/-2[c]
	b. Screening	Factors for similar material/operations in Section 11.19.2		-1/-2[c]
	c. Material transfers	Material handling emission factor equation in Section 13.2.4		-0/-1[c]
	3. Other operations	Factors for similar material/operations in the Mineral Products Industry, Chapter 11 of this document		—

[a] NA = not applicable.

[b] Refers to how many additional letters the emission factor should be downrated (beyond the guidance given in the other sections of AP-42) for application to construction activities. For example, "-2" means that an A-rated factor should be considered of C quality in estimating construction emissions. All emission factors assumed to have site-specific input values; otherwise, additional downgrading of one letter should be employed. Note that no rating can be lower than E.

[c] First value for cases with independent variables within range given in AP-42 section; second value for cases with at least 1 variable outside the range.

[d] Rating for emission factor given. Reference 5.

[e] In the event that individual operations cannot be identified, one may very conservatively overestimate PM-10 emissions by using Equation 1.

Table 13.2.3-2. CONTROL OPTIONS FOR GENERAL CONSTRUCTION OPEN SOURCES OF PM-10

Emission Source	Recommended Control Method(s)
Debris handling	Wind speed reduction Wet suppression[a]
Truck transport[b]	Wet suppression Paving Chemical stabilization[c]
Bulldozers	Wet suppression[d]
Pan scrapers	Wet suppression of travel routes
Cut/fill material handling	Wind speed reduction Wet suppression
Cut/fill haulage	Wet suppression Paving Chemical stabilization
General construction	Wind speed reduction Wet suppression Early paving of permanent roads

[a] Dust control plans should contain precautions against watering programs that confound trackout problems.
[b] Loads could be covered to avoid loss of material in transport, especially if material is transported offsite.
[c] Chemical stabilization usually cost-effective for relatively long-term or semipermanent unpaved roads.
[d] Excavated materials may already be moist and not require additional wetting. Furthermore, most soils are associated with an "optimum moisture" for compaction.

References For Section 13.2.3

1. C. Cowherd, Jr., *et al.*, *Development Of Emissions Factors For Fugitive Dust Sources*, EPA-450/3-74-03, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.

2. G. A. Jutze, *et al.*, *Investigation Of Fugitive Dust Sources Emissions And Control*, EPA-450/3-74-036a, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.

3. *Background Documentation For AP-42 Section 11.2.4, Heavy Construction Operations*, EPA Contract No. 69-D0-0123, Midwest Research Institute, Kansas City, MO, April 1993.

4. C. Cowherd, *et al.*, *Control Of Open Fugitive Dust Sources*, EPA-450/3-88-008, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1988.

5. M. A. Grelinger, *et al.*, *Gap Filling PM-10 Emission Factors For Open Area Fugitive Dust Sources*, EPA-450/4-88-003, U. S. Environmental Protection Agency, Research Triangle Park, NC, March 1988.

Appendix D: Cumulative Emission Sources

Dixie NF 20-Well Oil Field Development Verification Scenario
Model Sources and Source Parameters

Source ID	Source Description	Easting (X)	Northing (Y)	Base Elev.	Stk. Ht.	Temp.	Exit Vel.	Stk. Dia.	PM_{10}	$PM_{2.5}$ *	NO_x	SO_2
POINT SOURCES		(m)	(m)	(ft)	(ft)	(°F)	(fps)	(ft)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)
DRE	Drill Dig Engine	427831	4209861	9448	15	950.0	75	1.0	0.56	0.56	19.2	0.32
FLARE	Production Flare	427781	4209911	9480	100	1000.0	55	1.5	0	0	2.45	0
CM1	Compressor Engine	427831	4209961	9455	25	760.0	95	1.0	0.05	0.05	3.98	0
HT1	Heater Treater	426936	4208986	9472	20	180.0	15	0.7	0	0	0.05	0
HT2	Heater Treater	427489	4208796	9416	20	180.0	15	0.7	0	0	0.05	0
HT3	Heater Treater	428269	4208686	9431	20	180.0	15	0.7	0	0	0.05	0
HT4	Heater Treater	428861	4208911	9486	20	180.0	15	0.7	0	0	0.05	0
HT5	Heater Treater	429086	4209503	9524	20	180.0	15	0.7	0	0	0.05	0
HT6	Heater Treater	429086	4210319	9462	20	180.0	15	0.7	0	0	0.05	0
HT7	Heater Treater	428861	4210911	9542	20	180.0	15	0.7	0	0	0.05	0
HT8	Heater Treater	428269	4211136	9472	20	180.0	15	0.7	0	0	0.05	0
HT9	Heater Treater	427453	4211136	9538	20	180.0	15	0.7	0	0	0.05	0
HT10	Heater Treater	426861	4210911	9425	20	180.0	15	0.7	0	0	0.05	0
HT11	Heater Treater	426636	4210319	9409	20	180.0	15	0.7	0	0	0.05	0
HT12	Heater Treater	426636	4209508	9381	20	180.0	15	0.7	0	0	0.05	0
HT13	Heater Treater	427236	4209286	9383	20	180.0	15	0.7	0	0	0.05	0
HT14	Heater Treater	428486	4209286	9440	20	180.0	15	0.7	0	0	0.05	0
HT15	Heater Treater	428486	4210536	9527	20	180.0	15	0.7	0	0	0.05	0
HT16	Heater Treater	427236	4210536	9447	20	180.0	15	0.7	0	0	0.05	0
HT17	Heater Treater	427161	4209911	9373	20	180.0	15	0.7	0	0	0.05	0
HT18	Heater Treater	427861	4209211	9386	20	180.0	15	0.7	0	0	0.05	0
HT19	Heater Treater	428561	4209911	9464	20	180.0	15	0.7	0	0	0.05	0
HT20	Heater Treater	427861	4210611	9554	20	180.0	15	0.7	0	0	0.05	0
DHY1	Dehydrator	426906	4208956	9482	30	200.0	8	1.0	0	0	0.05	0
DHY4	Dehydrator	428831	4208881	9488	30	200.0	8	1.0	0	0	0.05	0
DHY7	Dehydrator	428831	4210881	9507	30	200.0	8	1.0	0	0	0.05	0
DHY10	Dehydrator	426831	4210881	9420	30	200.0	8	1.0	0	0	0.05	0
WP1	Well Pump	426906	4209016	9472	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP2	Well Pump	427459	4208826	9418	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP3	Well Pump	428239	4208716	9426	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP4	Well Pump	428831	4208941	9482	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP5	Well Pump	429056	4209533	9524	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP6	Well Pump	429056	4210349	9462	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP7	Well Pump	428831	4210941	9544	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP8	Well Pump	428239	4211166	9471	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP9	Well Pump	427423	4211166	9533	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP10	Well Pump	426831	4210941	9422	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP11	Well Pump	426606	4210349	9409	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP12	Well Pump	426606	4209538	9380	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP13	Well Pump	427206	4209316	9380	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP14	Well Pump	428456	4209316	9440	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP15	Well Pump	428456	4210566	9524	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP16	Well Pump	427206	4210566	9447	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP17	Well Pump	427131	4209941	9372	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP18	Well Pump	427831	4209241	9390	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP19	Well Pump	428531	4209941	9459	10	775.0	45	0.7	0.33	0.33	4.65	0.31
WP20	Well Pump	427831	4210641	9551	10	775.0	45	0.7	0.33	0.33	4.65	0.31

From Table 4.1-1 of the Technical report Dixie and Fishlake oil field development sources

* PM 2.5 was not included in the Dixie data. For combustion sources, PM2.5 assumed to equal PM10.

Dixie NF 20-Well Oil Field Development Verification Scenario
Model Sources and Source Parameters

Source ID	Source Description	Easting (X)	Northing (Y)	Base Elev.	Release Ht.	Horz. Dim.	Vert. Dim.	PM_{10}	$PM_{2.5}$ *	NO_x	SO_2
VOLUME SOURCES		(m)	(m)	(ft)	(ft)	(ft)	(ft)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)
ORD1	outer road	427831	4208536	9414	2.0	100	6.0	0.5705	0.0570	0.0560	
ORD2	outer road	427183	4208891	9445	2.0	75	6.0	0.5705	0.0570	0.0560	
ORD3	outer road	426719	4209207	9476	2.0	75	6.0	0.5705	0.0570	0.0560	
ORD4	outer road	426456	4209911	9427	2.0	100	6.0	0.5705	0.0570	0.0560	
ORD5	outer road	426719	4210615	9413	2.0	75	6.0	0.5705	0.0570	0.0560	
ORD6	outer road	427127	4211024	9483	2.0	75	6.0	0.5705	0.0570	0.0560	
ORD7	outer road	427831	4211286	9477	2.0	100	6.0	0.5705	0.0570	0.0560	
ORD8	outer road	428535	4211024	9469	2.0	75	6.0	0.5705	0.0570	0.0560	
ORD9	outer road	428944	4210615	9469	2.0	75	6.0	0.5705	0.0570	0.0560	
ORD10	outer road	429206	4209911	9471	2.0	100	6.0	0.5705	0.0570	0.0560	
ORD11	outer road	428944	4209207	9495	2.0	75	6.0	0.5705	0.0570	0.0560	
ORD12	outer road	428535	4208799	9460	2.0	75	6.0	0.5705	0.0570	0.0560	
IRD1	inner road	427519	4209249	9391	2.0	75	6.0	0.5705	0.0570	0.0560	
IRD2	inner road	427169	4209599	9367	2.0	75	6.0	0.5705	0.0570	0.0560	
IRD3	inner road	427169	4210224	9392	2.0	75	6.0	0.5705	0.0570	0.0560	
IRD4	inner road	427519	4210574	9511	2.0	75	6.0	0.5705	0.0570	0.0560	
IRD5	inner road	428144	4210574	9567	2.0	75	6.0	0.5705	0.0570	0.0560	
IRD6	inner road	428494	4210224	9521	2.0	75	6.0	0.5705	0.0570	0.0560	
IRD7	inner road	428494	4209599	9452	2.0	75	6.0	0.5705	0.0570	0.0560	
IRD8	inner road	428144	4209249	9393	2.0	75	6.0	0.5705	0.0570	0.0560	

From Table 4.1-1 of the Technical report Dixie and Fishlake oil field development sources

* PM 2.5 was not included in the Dixie data. For unpaved road sources, PM2.5 assumed to equal 10% of PM10

MRI, 2006 (Background document for Revisions to Fine Fraction Ratios Used in AP-42 - Table 1, unpaved roads)

Dixie NF 20-Well Oil Field Development Verification Scenario
Model Sources and Source Parameters

Source ID	Source Description	Easting (X)	Northing (Y)	Base Elev.	Release Ht.	Radius of Circle	Vert. Dim.	PM_{10}	$PM_{2.5}$ *	NO_x	SO_2
CIRCULAR SOURCES		(m)	(m)	(ft)	(ft)	(ft)	(ft)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)
WELLPAD1	Disturbed Area - Well Pad	426831	4208911	9491	0	282.7	2.00	0.02	0.002		
WELLPAD2	Disturbed Area - Well Pad	427423	4208686	9430	0	282.7	2.00	0.02	0.002		
WELLPAD3	Disturbed Area - Well Pad	428239	4208686	9428	0	282.7	2.00	0.02	0.002		
WELLPAD4	Disturbed Area - Well Pad	428831	4208911	9485	0	282.7	2.00	0.02	0.002		
WELLPAD5	Disturbed Area - Well Pad	429056	4209503	9524	0	282.7	2.00	0.02	0.002		
WELLPAD6	Disturbed Area - Well Pad	429056	4210319	9462	0	282.7	2.00	0.02	0.002		
WELLPAD7	Disturbed Area - Well Pad	428831	4210911	9526	0	282.7	2.00	0.02	0.002		
WELLPAD8	Disturbed Area - Well Pad	428239	4211136	9474	0	282.7	2.00	0.02	0.002		
WELLPAD9	Disturbed Area - Well Pad	427423	4211136	9533	0	282.7	2.00	0.02	0.002		
WELLPAD10	Disturbed Area - Well Pad	426831	4210911	9422	0	282.7	2.00	0.02	0.002		
WELLPAD11	Disturbed Area - Well Pad	426606	4210319	9409	0	282.7	2.00	0.02	0.002		
WELLPAD12	Disturbed Area - Well Pad	426606	4209508	9385	0	282.7	2.00	0.02	0.002		
WELLPAD13	Disturbed Area - Well Pad	427206	4209286	9385	0	282.7	2.00	0.02	0.002		
WELLPAD14	Disturbed Area - Well Pad	428456	4209286	9437	0	282.7	2.00	0.02	0.002		
WELLPAD15	Disturbed Area - Well Pad	428456	4210536	9532	0	282.7	2.00	0.02	0.002		
WELLPAD16	Disturbed Area - Well Pad	427206	4210536	9442	0	282.7	2.00	0.02	0.002		
WELLPAD17	Disturbed Area - Well Pad	427131	4209911	9372	0	282.7	2.00	0.02	0.002		
WELLPAD18	Disturbed Area - Well Pad	427831	4209211	9386	0	282.7	2.00	0.02	0.002		
WELLPAD19	Disturbed Area - Well Pad	428531	4209911	9458	0	282.7	2.00	0.02	0.002		
WELLPAD20	Disturbed Area - Well Pad	427831	4210611	9550	0	282.7	2.00	0.02	0.002		
CENTPROC	50 acres dist center proc	427831	4209911	9453	0	832.6	2.00	0.169	0.0169		

From Table 4.1-1 of the Technical report Dixie and Fishlake oil field development sources
* PM 2.5 was not included in the Dixie data. For construc & demolition, PM2.5 assumed to equal 10% of PM10.
MRI, 2006 (Background document for Revisions to Fine Fraction Ratios Used in AP-42 - Table 1, Construc & Demolition)

Fishlake NF Directional Drilling Oil Field Development Verification Scenario Model Sources and Source Parameters

Source ID	Source Description	Easting (X)	Northing (Y)	Base Elev.	Stack Ht.	Temp.	Exit Vel.	Stk. Dia.	PM_{10}	$PM_{2.5}$ *	NO_x	SO_2
POINT SOURCES		(m)	(m)	(ft)	(ft)	(°F)	(fps)	(ft)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)
DRE	Drill Rig Engine	381262	4277427	8200	15	950.0	75	1.0	0.56	0.56	19.2	0.32
PFLAR	Production Flare	381212	4277417	8184	100	1000.0	55	1.5	0	0	2.45	0
COMPR	Compressor Engine	381312	4277417	8222	25	760.0	95	1.0	0.05	0.05	3.98	0
HT1	Heater Treater	380332	4276797	8081	20	180.0	15	0.67	0	0	0.05	0
HT2	Heater Treater	380392	4276797	8081	20	180.0	15	0.67	0	0	0.05	0
HT3	Heater Treater	380392	4276737	8081	20	180.0	15	0.67	0	0	0.05	0
HT4	Heater Treater	380332	4276737	8081	20	180.0	15	0.67	0	0	0.05	0
HT5	Heater Treater	382332	4277497	8521	20	180.0	15	0.67	0	0	0.05	0
HT6	Heater Treater	382392	4277497	8483	20	180.0	15	0.67	0	0	0.05	0
HT7	Heater Treater	382392	4277437	8481	20	180.0	15	0.67	0	0	0.05	0
HT8	Heater Treater	382332	4277437	8519	20	180.0	15	0.67	0	0	0.05	0
HT9	Heater Treater	381032	4278147	8162	20	180.0	15	0.67	0	0	0.05	0
HT10	Heater Treater	381092	4278147	8151	20	180.0	15	0.67	0	0	0.05	0
HT11	Heater Treater	381092	4278087	8163	20	180.0	15	0.67	0	0	0.05	0
HT12	Heater Treater	381032	4278087	8166	20	180.0	15	0.67	0	0	0.05	0
DHY1	Dehydrator	381262	4277467	8213	30	200.0	8	1.0	0	0	0.05	0
DHY2	Dehydrator	381262	4277367	8203	30	200.0	8	1.0	0	0	0.05	0
WP1	Well Pump	380312	4276817	8081	10	775.0	45	0.67	0.33	0.33	4.65	0.31
WP2	Well Pump	380412	4276817	8082	10	775.0	45	0.67	0.33	0.33	4.65	0.31
WP3	Well Pump	380412	4276717	8081	10	775.0	45	0.67	0.33	0.33	4.65	0.31
WP4	Well Pump	380312	4276717	8081	10	775.0	45	0.67	0.33	0.33	4.65	0.31
WP5	Well Pump	382312	4277517	8531	10	775.0	45	0.67	0.33	0.33	4.65	0.31
WP6	Well Pump	382412	4277517	8481	10	775.0	45	0.67	0.33	0.33	4.65	0.31
WP7	Well Pump	382412	4277417	8472	10	775.0	45	0.67	0.33	0.33	4.65	0.31
WP8	Well Pump	382312	4277417	8525	10	775.0	45	0.67	0.33	0.33	4.65	0.31
WP9	Well Pump	381012	4278167	8164	10	775.0	45	0.67	0.33	0.33	4.65	0.31
WP10	Well Pump	381112	4278167	8151	10	775.0	45	0.67	0.33	0.33	4.65	0.31
WP11	Well Pump	381112	4278067	8166	10	775.0	45	0.67	0.33	0.33	4.65	0.31
WP12	Well Pump	381012	4278067	8172	10	775.0	45	0.67	0.33	0.33	4.65	0.31

From Table 4.2-1 of the Technical report Dixie and Fishlake oil field development sources

* PM 2.5 was not included in the Fishlake data. For combustion sources, PM2.5 assumed to equal PM10.

Fishlake NF Directional Drilling Oil Field Development Verification Scenario
Model Sources and Source Parameters

Source ID	Source Description	Easting (X)	Northing (Y)	Base Elev.	Release Ht.	Horz. Dim.	Vert. Dim.	PM_{10}	$PM_{2.5}$ *	NO_x	SO_2
VOLUME SOURCES		(m)	(m)	(ft)	(ft)	(ft)	(ft)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)
ORD1	outer road	381262	4276042	8116	2.0	100	6.0	0.0443	0.0044	0.0588	
ORD2	outer road	380558	4276305	8097	2.0	75	6.0	0.0443	0.0044	0.0588	
ORD3	outer road	380150	4276713	8072	2.0	75	6.0	0.0443	0.0044	0.0588	
ORD4	outer road	379887	4277417	8052	2.0	100	6.0	0.0443	0.0044	0.0588	
ORD5	outer road	380150	4278121	8283	2.0	75	6.0	0.0443	0.0044	0.0588	
ORD6	outer road	380558	4278530	7977	2.0	75	6.0	0.0443	0.0044	0.0588	
ORD7	outer road	381262	4278792	8219	2.0	100	6.0	0.0443	0.0044	0.0588	
ORD8	outer road	381966	4278530	8318	2.0	75	6.0	0.0443	0.0044	0.0588	
ORD9	outer road	382375	4278121	8527	2.0	75	6.0	0.0443	0.0044	0.0588	
ORD10	outer road	382637	4277417	8468	2.0	100	6.0	0.0443	0.0044	0.0588	
ORD11	outer road	382375	4276713	8450	2.0	75	6.0	0.0443	0.0044	0.0588	
ORD12	outer road	381966	4276305	8200	2.0	75	6.0	0.0443	0.0044	0.0588	
IRD1	inner road	380950	4276755	8184	2.0	75	6.0	0.0443	0.0044	0.0588	
IRD2	inner road	380600	4277105	8144	2.0	75	6.0	0.0443	0.0044	0.0588	
IRD3	inner road	380600	4277730	8225	2.0	75	6.0	0.0443	0.0044	0.0588	
IRD4	inner road	380950	4278080	8194	2.0	75	6.0	0.0443	0.0044	0.0588	
IRD5	inner road	381575	4278080	8334	2.0	75	6.0	0.0443	0.0044	0.0588	
IRD6	inner road	381925	4277730	8439	2.0	75	6.0	0.0443	0.0044	0.0588	
IRD7	inner road	381925	4277105	8321	2.0	75	6.0	0.0443	0.0044	0.0588	
IRD8	inner road	381575	4276755	8249	2.0	75	6.0	0.0443	0.0044	0.0588	

From Table 4.2-1 of the Technical report Dixie and Fishlake oil field development sources
* PM 2.5 was not included in the Fishlake data. For unpaved road sources, PM2.5 assumed to equal 10% of PM10.
MRI, 2006 (Background document for Revisions to Fine Fraction Ratios Used in AP-42 - Table 1, unpaved roads)

Fishlake NF Directional Drilling Oil Field Development Verification Scenario Model Sources and Source Parameters											
Source ID	Source Description	Easting (X)	Northing (Y)	Base Elev.	Release Ht.	Radius of Circle	Vert. Dim.	PM_{10}	$PM_{2.5}$ *	NO_x	SO_2
CIRCULAR SOURCES		(m)	(m)	(ft)	(ft)	(ft)	(ft)	(lb/hr)	(lb/hr)	(lb/hr)	(lb/hr)
WELLPAD1	Disturbed Area - Well Pad	380362	4276767	8081	0	282.7	2.00	0.1357	0.01357		
WELLPAD2	Disturbed Area - Well Pad	382362	4277467	8498	0	282.7	2.00	0.1357	0.01357		
WELLPAD3	Disturbed Area - Well Pad	381062	4278117	8156	0	282.7	2.00	0.1357	0.01357		
CENTPROC	50 acres dist center proc	381262	4277417	8199	0	832.6	2.00	1.1804	0.11804		

From Table 4.2-1 of the Technical report Dixie and Fishlake oil field development sources

* PM 2.5 was not included in the Fishlake data. For construc & demolition, PM2.5 assumed to equal 10% of PM10.

MRI, 2006 (Background document for Revisions to Fine Fraction Ratios Used in AP-42 - Table 1, Construc & Demolition)

KANAB RMP
EMISSIONS CALCULATIONS
SUMMARY OF ALL ACTIVITIES
LONG-TERM DEVELOPMENT

Kanab Field Office Emissions Summary
Difference between Alternative A and Baseline

Activity	PM_{10}	$PM_{2.5}$	NOx	SO2	CO	VOC	HAPs[b]
	Tons	Tons	Tons	Tons	Tons	Tons	Tons
Oil and Gas Well Development and Exploration							
Conventional Natural Gas -Construction	0	0	0	0	0	0	0
Conventional Natural Gas - Operations	6	1	5	0	2	4	0
Conventional Natural Gas - Maintenance	0	0	0	0	0	0	0
Sub-total: Conventional Natural Gas	**6**	**1**	**6**	**0**	**2**	**4**	**0**
Non-Oil and Gas Well Activities							
Coal Mining[a]	0	0	0	0	0	0	0
Lands & Reality	0	0	0	0	0	0	0
Livestock Grazing	0	0	0	0	0	0	0
Off-Highway Vehicles (OHV)[a]	8	8	4		690	254	25
Resource Roads	0	0	0	0	0	0	0
Saleable Minerals							
Vegetation	0	0	0	0	0	0	0
Prescribed burning	0	0	0	0	0	0	0
Sub-total: Non-Oil and Gas Well Activities	**8**	**8**	**4**	**0**	**690**	**254**	**25**
Total: Delta (Alternative A - Baseline)	**15**	**10**	**10**	**0**	**692**	**258**	**26**
	g/sec	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**
Total: Delta (Alternative A - Baseline)	**0.425**	**0.273**	**0.291**	**0.003**	**19.896**	**7.424**	**0.742**

Assume Area Source **4.00** **sq mi** **(approximate area of oil and gas disturbance)**

RICHFIELD EIS-ALTERNATIVE A EMISSION CALCULATIONS SUMMARY OF ALL ACTIVITIES LONG TERM DEVELOPMENT

Richfield Difference between 2022 Alternative A and Baseline 2007.

Activity	PM10	PM2.5	NOx	SO2	CO	VOC	HAPsb
	Tons	Tons	Tons	Tons	Tons	Tons	Tons
Oil Well Development and Exploration							
Oil Welll - Construction	23.90	7.35	185.93	3.13	24.21	7.48	0.75
Oil Well- Operations	7.29	1.71	41.50	0.70	9.61	1.23	0.12
Oil Well - Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub-total: Oil Wells	**31.19**	**9.05**	**227.42**	**3.83**	**33.82**	**8.72**	**0.87**
Non-Oil Well Activities							
Coal Mining[a]	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lands & Reality	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Livestock Grazing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Highway Vehicles (OHV)[a]	5.75	5.75	3.08		524.20	168.41	16.84
Resource Roads	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Saleable Minerals	0.00	0.00					
Vegetation	21.01	3.15	0.00	0.00	0.00	0.00	0.00
Sub-total: Non-Oil Well Activities	**26.76**	**8.90**	**3.08**	**0.00**	**524.20**	**168.41**	**16.84**
Total: Delta (Alternative A - Baseline)	**57.95**	**17.96**	**230.50**	**3.83**	**558.03**	**177.13**	**17.71**
	g/sec	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**	**g/sec**
Total: Delta (Alternative A - Baseline)	**1.665**	**0.516**	**6.624**	**0.110**	**16.035**	**5.090**	**0.509**

Assume Area Source **24.00** **sq mi** **(estimated area of oil and gas disturbance)**