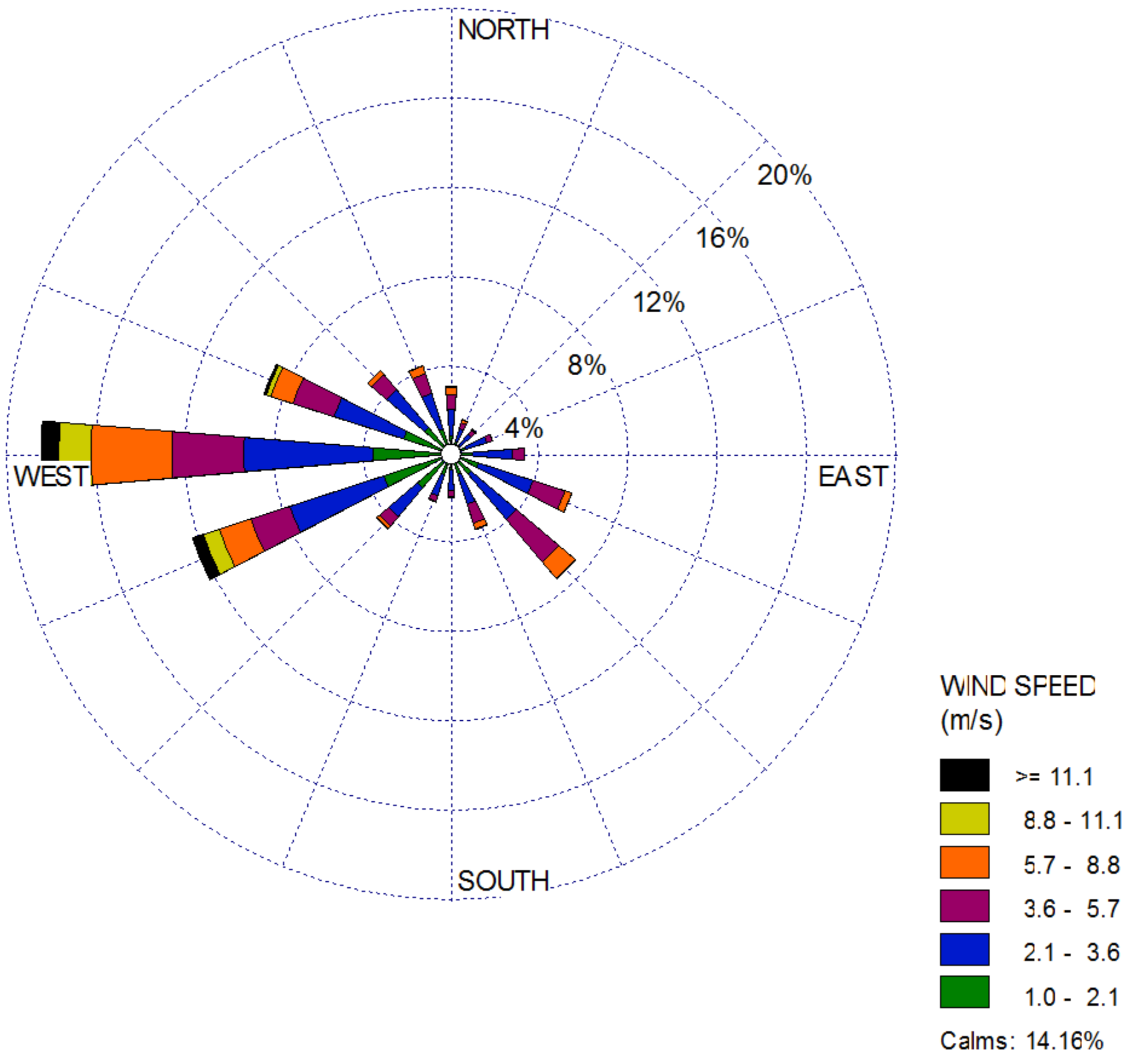
APPENDIX E

Air Quality Supporting Documentation

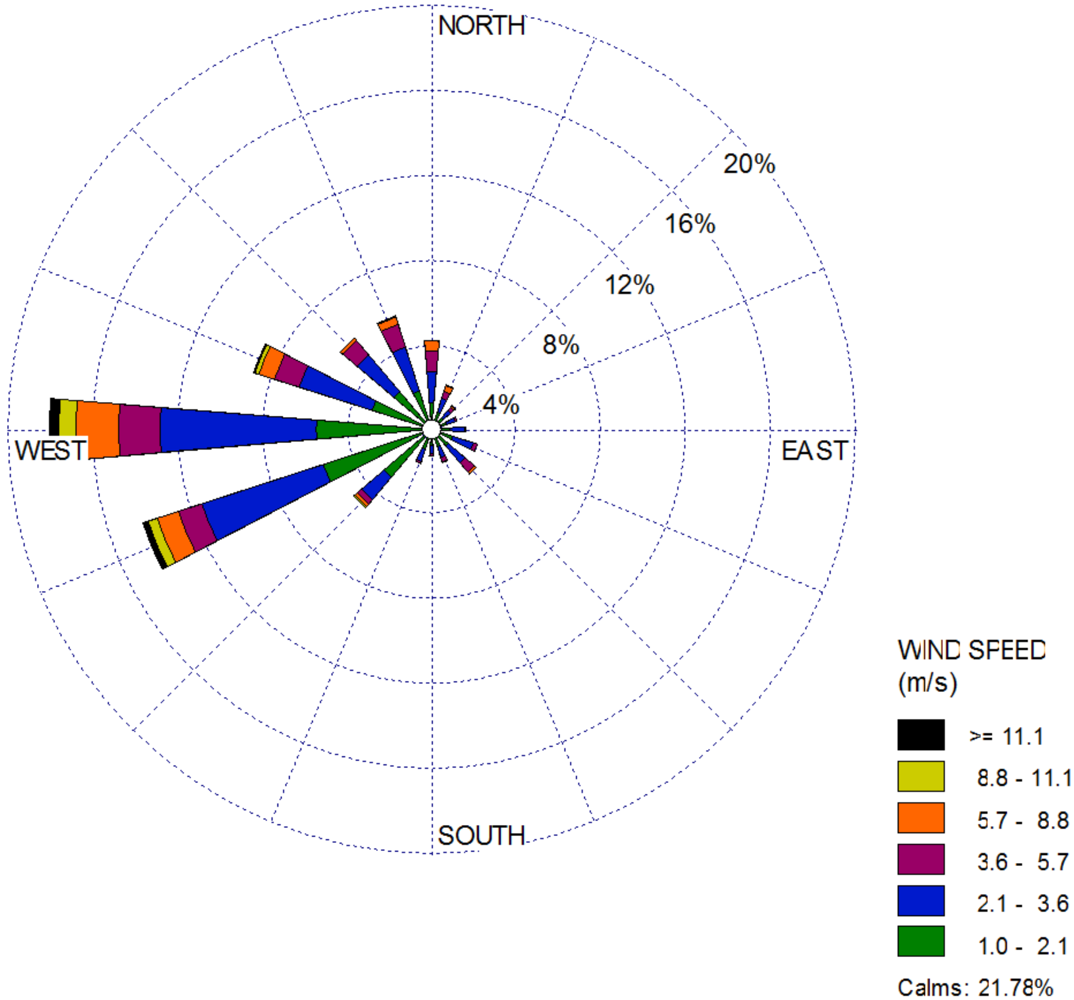
APPENDIX E.1

Quarterly Wind Roses

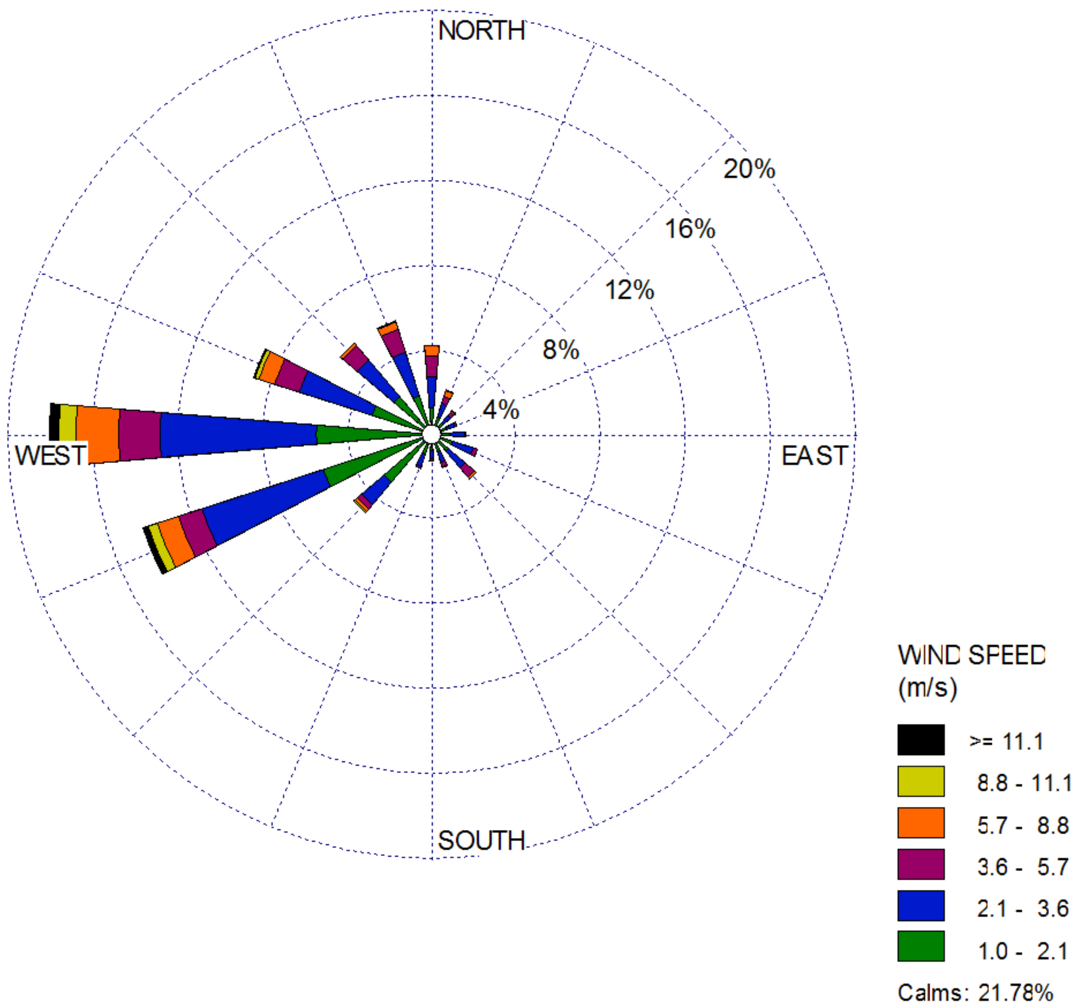
IMPERIAL COUNTY AIRPORT
ANNUAL WIND ROSE (2002-2006)



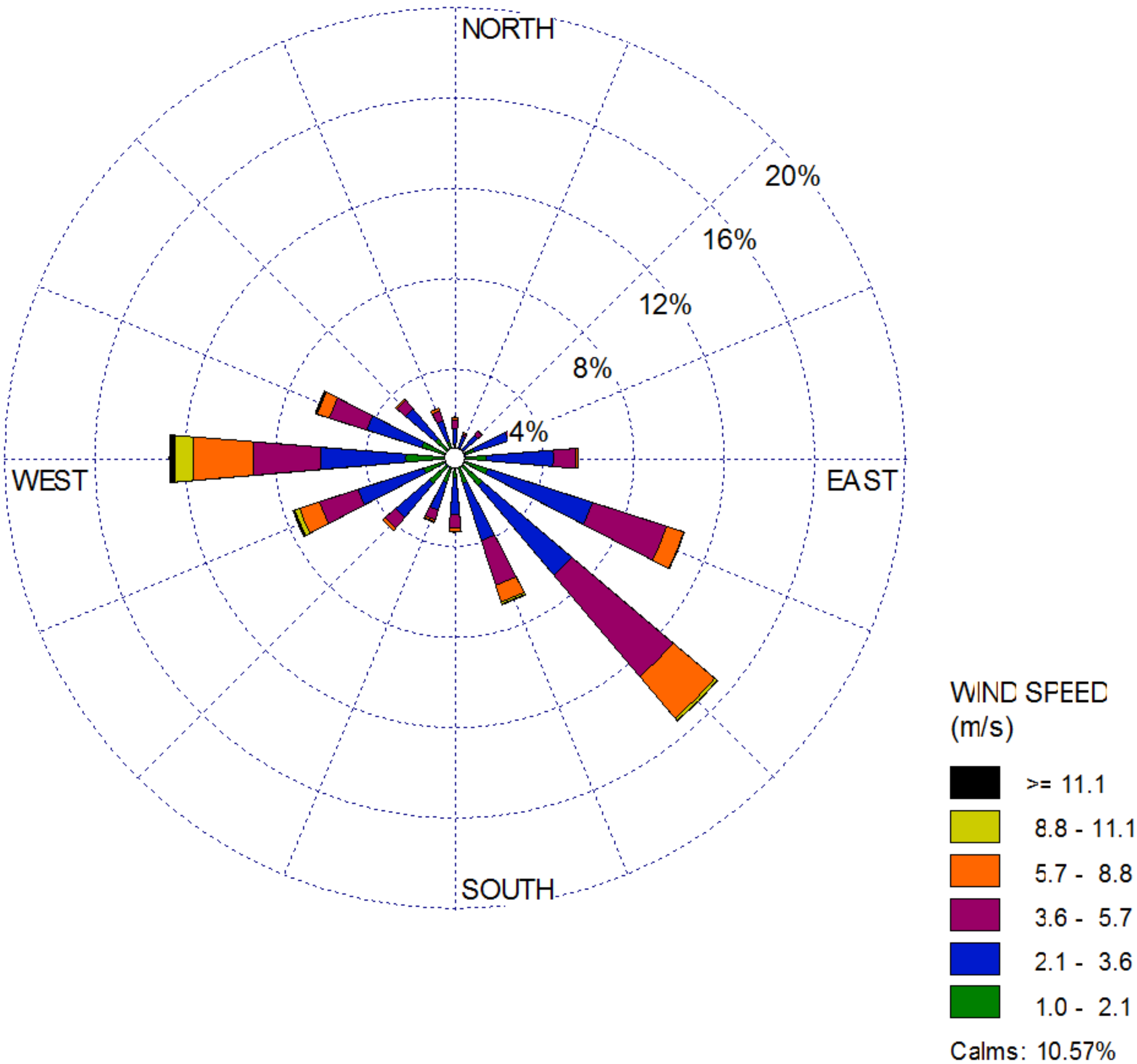
IMPERIAL COUNTY AIRPORT
FALL WIND ROSE (2002-2006)



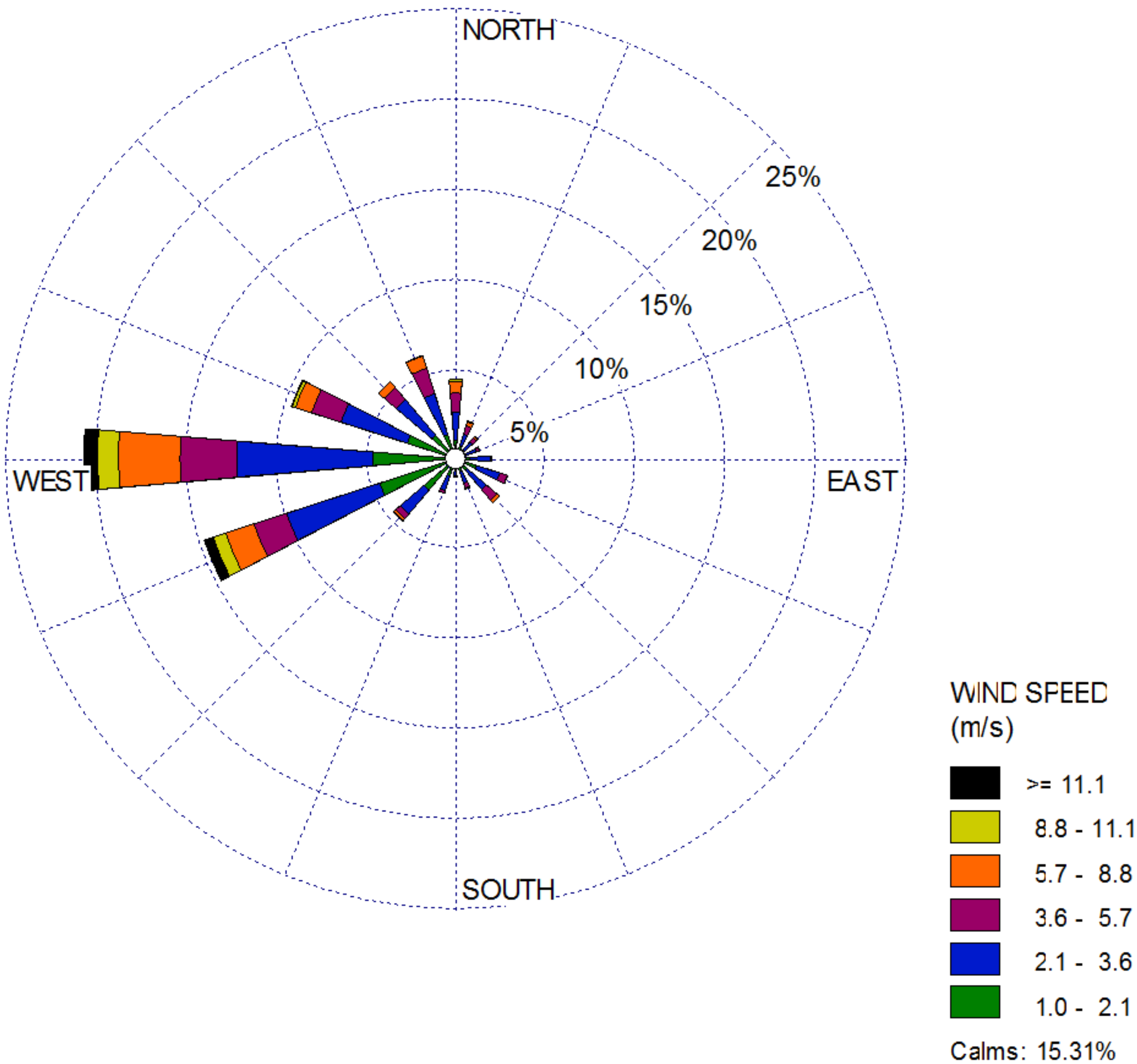
IMPERIAL COUNTY AIRPORT
FALL WIND ROSE (2002-2006)



IMPERIAL COUNTY AIRPORT
SUMMER WIND ROSE (2002-2006)



IMPERIAL COUNTY AIRPORT
WINTER WIND ROSE (2002-2006)



APPENDIX E.2

Modeling Protocol

Air Quality Modeling Protocol

For the:

Salton Sea Unit 6 AFC Amendment Petition

Prepared for:

Obsidian Energy, LLC
7030 Gentry Road
Calipatria, California 92233

Prepared by:

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July 2008

Table of Contents

1.0 INTRODUCTION

Obsidian Energy, LLC (OE) is proposing to amend the Salton Sea Unit 6 Application for Certification (AFC), which was licensed by the California Energy Commission (CEC) to build and operate a 185-megawatt (MW) geothermal electric power plant in Imperial County, California. The proposed amendment to the Salton Sea Unit 6 AFC will consist of three individual power plants when combined will produce 159 MW (net) of power generation (The Project). Each of the three units which will be located at one combined plant site and will share certain common auxiliary facilities. Each power plant will be comprised of a single flash unit with the capacity to generate 58 MW (gross). The location of the three single flash units will be at the same location previously selected for the Salton Sea Unit 6 project. The overall plant site will incorporate the three turbine/generator areas, resource production facilities, power generation facilities, electrical control building, cooling towers, electrical switchyard, brine ponds, facility rain water run off basin, common condensate, fire protection, raw water and purge water storage, H_2S/benzene abatement equipment, well test units, rock muffler/pressure relief vent system, parking area and construction lay-down area. In addition, nine production wells on three well pads and two each plant injection wells and aerated brine injection wells will be located on the plant site. The nine injection wells will be located south of the main blind fault approximately 8,000 – 10,000 feet from the plant site.

The CEC and the Imperial County Air Pollution Control District (APCD) will evaluate the project's potential and cumulative air quality impacts, appropriateness of the proposed mitigation measures, and the project conformance with applicable local, state and federal air quality rules and regulations. The purpose of this protocol is to establish the procedures to be used in assessing the Project's potential air quality impacts. Both agencies have in place regulations establishing the required review process. The CEC conducts their review through the California Code of Regulations, Title 20, Division 2, Chapters 1, 2, and 5, *Regulations Pertaining to the Rules of Practice and Procedure and Power Plant Site Certification Including Additional Provisions of Considering Expedited Applications Under Public Resources Code Section 25550*.

The APCD conducts their review under Rule 207(F), *Air Quality Impact Analysis*, and Rule

207(D.9), *Power Plants*, for procedures regarding CEC projects.

Except for those federal regulations already delegated to the APCD, no other federal regulations are expected to be applicable, mainly because the project will be below the Prevention of Significant Deterioration (PSD) thresholds.

The purpose of these regulations is to certify as expeditiously as possible, environmentally acceptable sites that demonstrate superiority with respect to environmental protection or efficiency in performance. Geothermal production of electricity has been shown to be an environmentally preferred process and OE intends to demonstrate these aspects.

2.0 PROPOSED PROJECT

2.1 PROJECT LOCATION

The Salton Sea Unit 6 project site is located approximately five miles west of Calipatria, California (Refer to Figure 1). The general UTM coordinates of the site are 628000 meters Easting and 3670500 meters Northing (Zone 11). The site elevation is approximately 228 feet below mean sea level. The site is within the Salton Sea Known Geothermal Resource Area (KGRA). The site is located in the middle of the existing OE facilities. Land use of the proposed site and surrounding area include existing geothermal power production, agriculture, wildlife management, and the Sonny Bono National Wildlife Refuge.

2.2 DESCRIPTION OF THE PROPOSED PROJECT

The Salton Sea Unit 6 project consists of three major components:

- Well fields, including production and injection wells and associated pipelines.
- Power plants.
- Transmission lines.

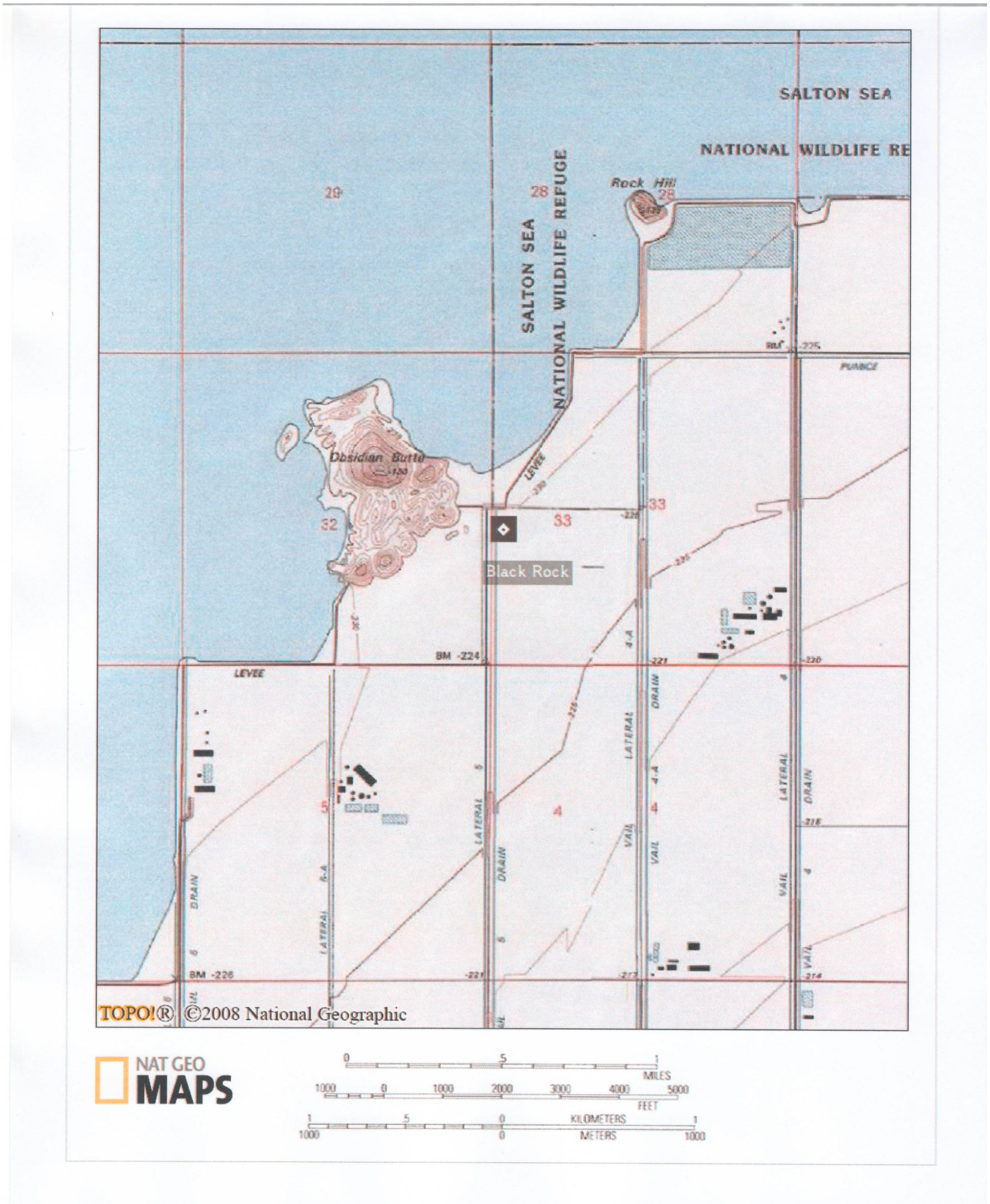

Figure 1: Topographic Map of Salton Sea Project Site

2.2.1 Well Field and Pipelines

OE is proposing the development of nine production wells on three well pads to be located on the main plant site. In addition to the nine (9) production wells, two (2) condensate injection wells and two (2) aerated brine injection wells will also be located on the main plant site. Nine (9) injection wells on three well pads are to be located near the plant site. The nine (9) injection wells will be located south of the main blind fault approximately 8,000 – 10,000 feet from the plant site. Drilling contractors, with equipment permitted under the County or the State Portable Source Program, are anticipated to be used to drill and develop the wells.

2.2.2 Power Plant

The power plant will consist of three, 58 MW (gross) individual units on one plant site with certain common auxiliary facilities. The location of the three single flash generation units will be at the same location previously selected for the Salton Sea Unit 6 project. Each generation unit will consist of:

15 Hp Diesel "pony" pump	4,160v – One, 1.5-MW Diesel generator
200 Hp diesel fire Pump	460v – One 1.0 MW Diesel Generator
NCG removal system	RTO H_2S/benzene emission control system
Five (5) cell cooling tower	Rock muffler/pressure relief vent system
Brine Injection System	Production Test Unit Brine pond
Re-injection Acid Injection System	

Together with their respective production and re-injection wells each unit is referred to as a "resource production facility" or RFP.

The three (3) generation units will share the following:

Electrical control building	Storm water runoff control basin
Fire protection water tank	Condensate storage tank
Purge water storage tank	Water pond
Construction lay-down area	Paved parking area
Aerated brine injection wells (2)	Plant condensate injection wells (2)

Each turbine generator system will consist of a condensing turbine generator set with high pressure (HP) steam entry pressures. The 3,600-revolutions-per-minute (RPM) turbine generator is a single-casing, single-pressure, dual flow, bottom exhaust condensing turbine. It will be nominally rated at 53 MW net. Nominal turbine inlet pressure is 245 pounds per square inch absolute (psia). Steam becomes a condensate through this process and is pumped to a wet cooling tower for cooling. The cooled condensate is pumped back to the condenser to complete the power generation cycle. Non-condensable gases (NCG), which are entrained in the mass flow, average approximately 0.2 percent of the total steam flow. These NCGs are mostly carbon dioxide gas.

The hydrogen sulfide (H_2S) and benzene emission control system for each unit will be based on recuperative thermal oxidation (RTO) incineration technology. RTO is a direct combustion process that allows for simultaneous destruction of benzene and H_2S in a compact unit that is easy to operate and maintain. During start-up the RTO unit burns a propane-air mixture to bring the temperature of the internal compartments up to 1,500 °F. When the appropriate temperature is reached suction created by a downstream blower causes the process stream and outside air to enter the combustion chamber. Flammable gases in the process stream (methane, benzene, H_2S, and hydrogen) are oxidized. During this process benzene and methane are converted into carbon dioxide and water while hydrogen sulfide becomes sulfur dioxide gas. Hydrogen is oxidized to water vapor. Following combustion, the gas stream enters a bypass that routes the 1,500 °F oxidized gases to a heat exchanger connected to the process stream inlet plenum. Process heat is removed from the hot gases lowering their temperature to approximately 700 °F. Heat removed from the hot gases is used to increase the inlet process stream to a temperature of 800 °F prior to entry into the combustion chamber. Heating of the inlet stream precludes creation of sulfuric acid mists that can damage equipment through aggressive corrosion. After releasing heat to the inlet process stream the cooled gases are routed to a quencher to further reduce their temperature prior to entry into a packed-bed scrubber for treatment of the acid gases created by the oxidation process.

Gases from the RTO enter a SO_2 scrubber where a sodium hydroxide solution (NaOH) is introduced. A reaction occurs in the presence of the NaOH converting the sulfur dioxide gas to a solution containing sodium sulfite and sodium sulfate. These latter two (2) compounds are highly water soluble. The sodium sulfite/sulfate solution created by operation of the SO_2 scrubber is of a sufficiently small volume that it can be safely introduced into the cooling tower basin for disposal. While leaving the scrubber, the water content of the gas stream is lowered by passing it through a mesh to reduce the possibility of PM_{10} formation from subsequent evaporation. Remaining gases are then vented into the atmosphere through a stack.

Each turbine generator will have a dedicated cooling tower containing five (5) cells. Three 50 percent capacity, vertical, wet-pit circulating water pumps will circulate water between the cooling tower and turbine condensers. A slip stream from the circulating water will be used for the plant auxiliary cooling loads. Plant auxiliary cooling water loads will include the NCG removal system, turbine oil cooling system, generator cooling system, and H_2S/benzene abatement system.

Liquid containing hydrogen sulfide from the turbine condenser will be directed to a treatment system that will be located in separate cell of the cooling tower array. The treatment system will convert dissolved hydrogen sulfide in the condensate to soluble sulfate. These types of treatment systems have been installed at other existing Salton Sea geothermal facility cooling towers significantly reducing hydrogen sulfide levels in the turbine condensate. Similar performance is expected in treating the condensate from the Salton Sea Unit 6 project. However, as the geochemistry of the brine varies slightly from well to well, it is likely that treatment performance will also vary. Therefore, for the purposes of developing the air dispersion model, a conservative treatment efficiency of 90% (Based on CalEnergy operating experience) has been assumed.

After treatment, condensate will flow into the cooling tower basin to offset water lost in evaporation. Condensate may also be routed to a condensate storage tank and used for other plant water demands such as the steam scrubbing water, and pump seal flush water. Any excess condensate not required for plant use will be sent to a dedicated condensate injection wells located on the plant site.

A rock muffler/pressure relief vent system is used during upset conditions when it is necessary to vent steam into atmosphere. This occurs during start-ups and upset conditions associated with plant trips or other controlled venting events. The proposed rock muffler vent system is a reinforced-concrete rectangular structure with dual chambers, designed to allow internal inspection of the diffuser at the bottom chamber through a man way into the vent chamber. The upper chamber is filled with volcanic rocks using expanded alloy metal inserts. This design minimizes the size of the muffler and substantially reduces the venting noise level. The muffler will allow steam loading of 4,600 lb/hr without fluidizing the bed. This design concept has been successfully deployed at Salton Sea Unit 5 and in other geothermal locations.

In case of a total loss of auxiliary power, or in a situation when the utility system is out of service, emergency power for critical loads (i.e., brine injection pumps air compressor; DC lube oil pump, turbine turning gear; emergency lighting; heating, ventilation, and air condition (HVAC) and other vital loads will be supplied by the standby emergency generators. One, 2-MW, 4,160-volt generators will be installed for each generating unit. These generators are sized to maintain reduced capacity operation of the RPF and critical loads associated with the plant's common facilities.

2.2.3 Transmission Lines

An electrical transmission line will connect the power plant to the Imperial Irrigation District (IID) electrical grid. The electrical transmission line will be operated and owned by IID.

3.0 REGULATORY SETTING

3.1 CEC REQUIREMENTS

The CEC requires that applicants prepare an AFC addressing all of the air quality items listed in *Appendix B: Information Requirements for an Application*.

3.2 APCD REQUIREMENTS

The APCD requires that applicants undergo a CEC permitting process following Rule 207(D.9), *Power Plant*. In general, the Air Pollution Control Officer, upon receipt of an AFC, will notify appropriate parties and submit a report that specifies Best Available Control Technology (BACT) for the proposed facility and states whether the facility can likely satisfy APCD regulations and under what conditions. Once the application is received, the Officer will conduct a compliance review to assure the application meets the requirements of the regulations. Certain deadlines are imposed once the application is accepted as complete. The Officer, if appropriate, will issue and submit a determination of compliance to the CEC and then a permit to operate with concurrence from the CEC.

The focus of this protocol is the proposed procedures required by Rule 207(F), *Air Quality Impact Analysis,* and also to meet the requirements of the CEC. The intent of the regulation is to determine the air quality impacts associated with constructing and operating a facility.

3.3 EPA REQUIREMENTS

As noted earlier, the PSD requirements are not expected to be applicable to the Salton Sea Unit 6 project. For this source to be defined a major source under the US EPA's PSD program, the potential to emit emissions of any criteria pollutant would need to equal or exceed 250 tons per year. The emissions anticipated are expected to be significantly below this threshold. Under Title I, Section 112 of the Clean Air Act, US EPA also regulates hazardous air pollutants (HAP). Geothermal power plants are not subject under this Title at this point because their expected HAP emissions are below threshold levels.

4.0 EXISTING ENVIRONMENT

4.1 AREA CLIMATE

The climate of Imperial County is a desert climate, characterized by low precipitation, hot summers, mild winters, low humidity and strong inversions. Local temperature and precipitation data from the nearest representative local cooperative station, Brawley 2 SW, over a 30-year record, 1961-1990, is used to define climatic normal, means and extremes. The hottest month, July, has an average maximum temperature of 106.5 °F, an average minimum temperature of 74.4 °F, and an average mean temperature of 90.5 °F. The coldest month, January, has an average maximum temperature of 69.3 °F, average minimum temperature of 38.7 °F, and average mean temperature of 54.0 °F. Annual average rainfall is 3.05 inches. The wettest month is December, averaging 0.41 inches; the driest month, June, averages 0.01 inches. Rainfall is highly variable with precipitation from a single heavy storm potentially exceeding the entire annual total rainfall during or following a drought year. Humidity levels have not been recorded at Brawley 2 SW. High winds are occasionally experienced in the Imperial Valley region. Monthly average wind speeds in the region range from 6.6 mph in October to 9.5 mph in July. On an annual basis, winds average 7.8 mph. Winds in the valley are primarily from west to east throughout the year, but have a secondary southeast component in the fall. These patterns are discussed more completely for the site in the following subsection. Solar isolation, again based on regional data, suggests that 90 percent of possible sunshine occurs in the region. The cloudiest periods occur in winter while the sunniest periods are in the summer.

The area's climatic conditions are strongly influenced by the large-scale sinking and warming of air in the semi-permanent subtropical high-pressure center over this area. The high-pressure ridge blocks out most mid-latitude storms except in winter when the high is weakest and the farthest south. The coastal mountains on the western edge of the Imperial Valley also have a major influence on climatic conditions by blocking the cool, damp marine air found in the California coastal environs. The flat terrain of the valley floor in the Salton Sea area and the strong temperature differentials created by intense solar heating produce moderate winds and deep thermal convection currents. The combination of subsiding air, protective mountains, and distance from the ocean all combine to severely limit precipitation. The valley area experiences surface inversions almost every day of the year. Solar heating usually breaks these inversions. Strong, persistent subsidence inversions, caused by the presence of a Pacific high-pressure system, can persist for one or more days, causing air stagnation conditions.

4.2 METEOROLOGICAL DATA AND SITE REPRESENTATION

Meteorological data will be used in the application in two ways. First a long-term record of meteorological data defines the overall climate of a region. These data were discussed previously in Section 4.1. Second, hourly meteorological observations of certain parameters are used to define the area's dispersion characteristics. These data are used in approved air dispersion models for defining a project's impact on air quality. These data must meet criteria established by the US EPA and the following discussion details the proposed data and its applicability to this project.

There are several National Weather Bureau Army Navy sites (WBAN) in the general area of the proposed facility. The closest most representative station relative to the proposed site is the Imperial County Airport site. This WBAN site provides meteorological data that can be readily converted to a site dispersion database that is directly used by atmospheric dispersion models. Other WBAN sites with current data in this area include Palm Springs Thermal, Blythe Airport, Yuma, AZ Airport and the San Diego Airport. As illustrated on Figure 2, the Imperial County site is the closest to the proposed site in the central valley area between the Santa Rosa, Laguna and Chocolate Mountains and to the southeast of the Salton Sea.

As discussed below, OE proposes to use the most recent five (5) years of meteorological data collected at the Imperial County Airport, which is located approximately 22 miles south from the project site, and believes use of this data would satisfy the definition of on-site data (See Figure 2). The Imperial County meteorological data was collected in ASOS format for the years 2001 through the present. The most recent five years of data (2003-2007) will be used in the air quality analysis.

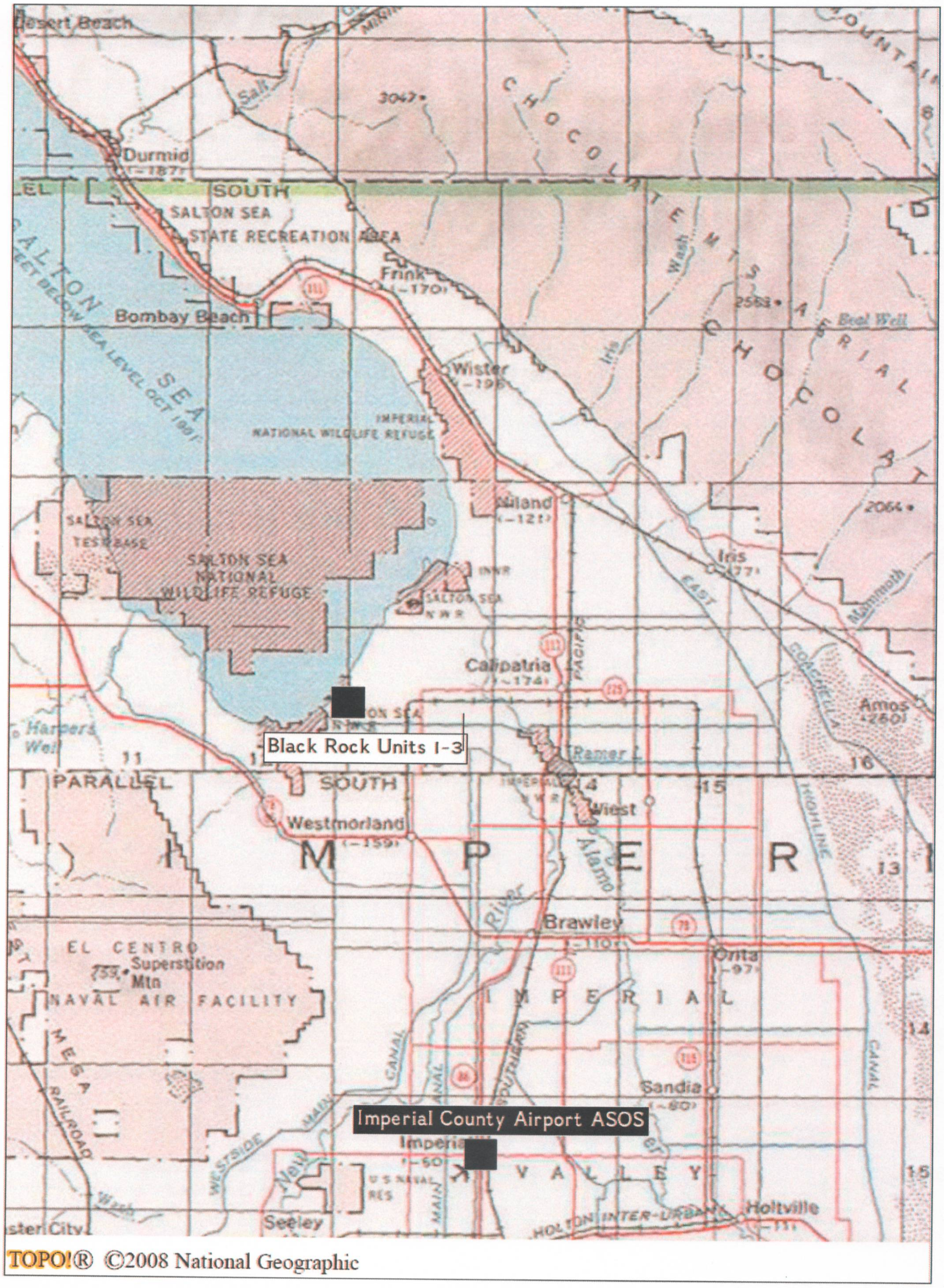

Figure 2: Proposed Meteorological Data Set Location

One of the main reasons that the use of Imperial County Airport data is considered representative of the proposed Salton Sea Unit 6 project is that there are no nearby (localized) terrain features between or surrounding the project site and the Imperial County Airport that would limit the use of the airport data set for the proposed project. The same large-scale geographic and topographic features that influence the Imperial County Airport site also influence the proposed project site. Five years of data are proposed to be used.

The Imperial County Airport site is shown in Figure 2. A graphical wind rose for an earlier five-year period is presented in Figure 3. A five-year quarterly wind rose analysis for the modeling data set will be provided in the application.

US EPA defines the term "on-site data" to mean data that would be representative of atmospheric dispersion conditions at the source and at locations where the source may have a significant impact on air quality. Specifically, the meteorological data requirement originates from the Clean Air Act in Section 165(e)(1), which requires an analysis "of the ambient air quality at the proposed site and in areas which may be affected by emissions from such facility for each pollutant subject to regulation under [the Act] which will be emitted from such facility."

This requirement and US EPA's guidance on the use of on-site monitoring data are also outlined in the *On-Site Meteorological Program Guidance for Regulatory Modeling Applications* (US EPA, 1987). The representativeness of meteorological data is dependent upon: (a) the proximity of the meteorological monitoring site to the area under consideration; (b) the complexity of the topography of the area; (c) the exposure of the meteorological sensors; and (d) the period of time during which the data are collected.

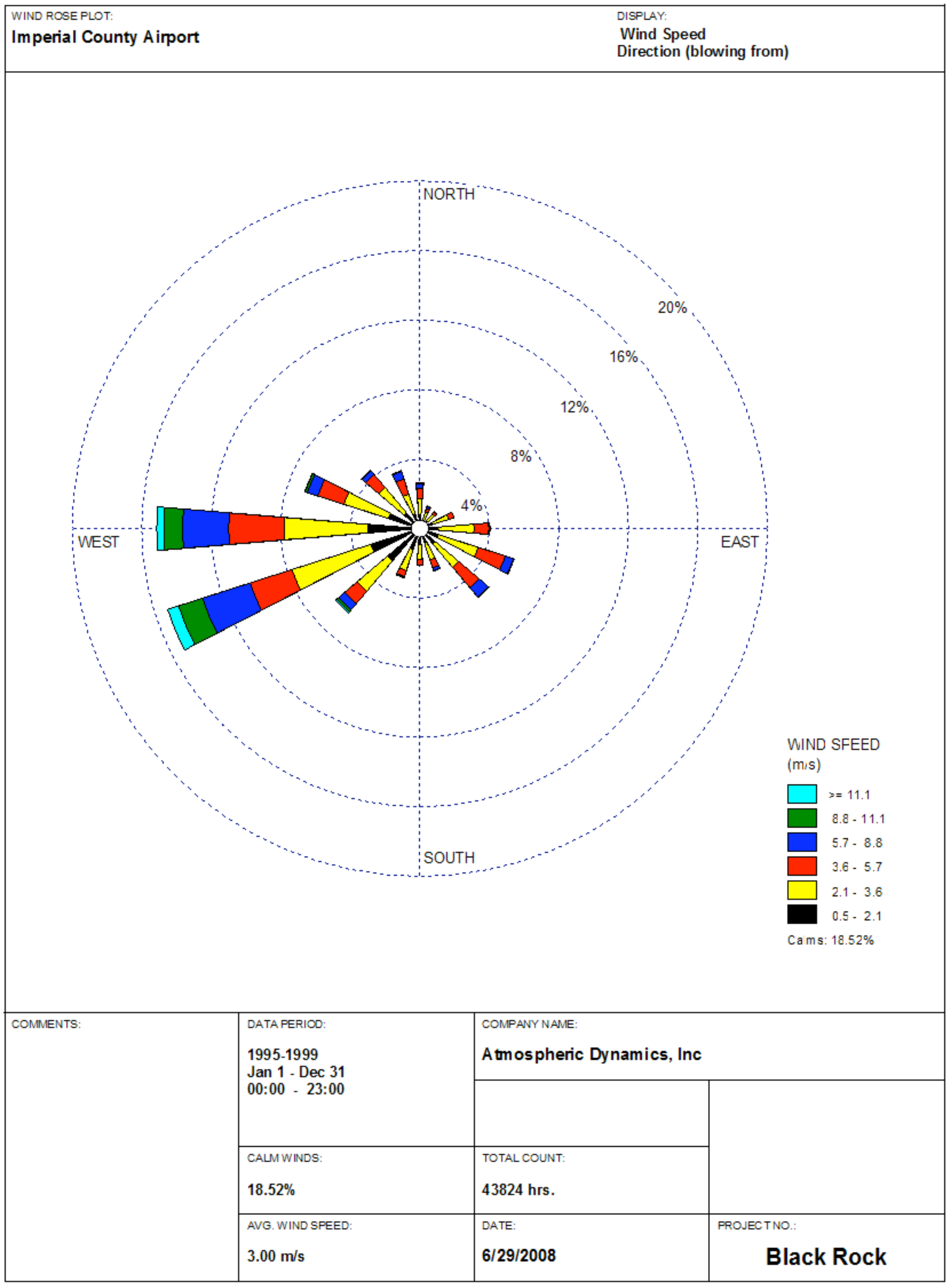

Figure 3: Annual Imperial County Airport Wind Rose for 1995-1999 Combined

Representativeness has been defined in the document "Workshop on the Representativeness of Meteorological Observations" (Nappo et. al., 1982) as "the extent to which a set of measurements taken in a space-time domain reflects the actual conditions in the same or different space-time domain taken on a scale appropriate for a specific application." Judgments of representativeness should be made only when sites are climatologically similar, as is the case with the Imperial County Airport and the project site location.

In determining the representativeness of the meteorological data set for use in the dispersion models at the project site, the following considerations were addressed:

- *Aspect ratio of terrain, which is the ratio of the height of terrain to the width of the terrain at its base* - The ratio of terrain heights to base widths is constant for the terrain surrounding the project site and the Imperial County Airport meteorological site.
- *Slope of terrain* - The slope of the terrain in the area of the project site is similar to the slope of terrain in the vicinity of the meteorological site. The surface roughness of the terrain in the area is also similar.
- *Ratio of terrain height to stack/plume height* - Since the terrain at the Imperial County Airport site and the project site are essentially flat and at elevations below mean sea level, terrain effects on plume dispersion would be similar at locations throughout the regional area, and the plume would disperse in an identical manner to the dispersion conditions monitored at the Imperial County Airport site.
- *Correlation of terrain features to prevailing meteorological conditions* - The orientation of terrain in the region, with respect to both the meteorological data and project sites is similar and correlates well with the prevailing wind field in the Imperial Valley Region. Thus, wind flow at the Imperial County Airport site would be similar to that at the project site. No local topographic features exist that would appreciably distort the local wind field. One feature, the Salton Sea, which is located next to the project site, will be accounted for with the use of shoreline fumigation dispersion modeling.

In summary, OE believes that the meteorological data collected at Imperial County Airport would accurately represent meteorological conditions at the project site. No terrain or other steering mechanisms exist that would have a significant affect on the meteorology at the project site. The surface roughness, height and length of the large-scale terrain features is consistent throughout the area, and plays a large role in the affect on the horizontal and vertical wind patterns. There is no slope aspect in the vicinity of the site that would reasonably affect the wind direction or speed. The mesoscale features at both the project site and the Imperial County Airport site are similar.

4.3 PREPARATION OF THE METEOROLOGICAL DATA SET

OE proposes to use ASOS formatted meteorological data collected at Imperial County Airport from 2003 through 2007 in the atmospheric dispersion modeling analyses. The data will be pre-processed for direct use by the AERMET (version 06341) preprocessor model. Surface data were acquired from the nearest available representative surface weather station at Imperial, California (WBAN 03144). As recommended by the US EPA in the *Guideline on Air Quality Models* (GAQM, EPA, 2000), 5 years of ASOS meteorological data are used. National Climatic Data Center (NCDC) provided the ASOS data. Upper air data for the same time period will be taken from the closest representative NWS radiosonde station that, when combined with the proposed surface dataset, meet the US EPA required data recovery rates of 90%. This radiosonde station is Tucson, Arizona.

Any missing data will substituted as per US EPA recommended procedures, as discussed in the US EPA memorandum (Lee, R. & Atkinson, D., 1992). Periods with more than one consecutive missing hour of wind speed or wind direction will be set to calm/missing to ensure that worst case predicted impacts were resulting from actual rather than interpolated meteorological conditions.

As part of the input requirements into AERMET and AERMOD, a land use classification must be made. The area surrounding the Imperial County Airport (source of meteorological data for

AERMOD modeling) and the proposed project site was determined to be primarily rural following the methods outlined by the Auer land use classification method for the area within a 3 km radius around the proposed project site. Therefore, normal AERMOD dispersion characteristics will be used for all modeled emissions sources at Salton Sea Unit 6. As part of the AERMET input requirements, Albedo, Bowen Ratio, and Surface Roughness must be classified. The AERSURFACE program was used to generate the surface characteristics for use in AERMET as specified in EPA's January 2008 AERMOD Guidance Document and AERSURFACE User's Guide using default settings where appropriate. AERSURFACE was executed for two sectors (Sector#1 = 110-355º and Sector#2 = 355-110º) to define surface roughness as shown in Figure 4. Other AERSURFACE inputs/outputs are listed in Table 4-1.

TABLE 4-1 AERSURFACE INPUTS/OUTPUTS FOR USE IN AERMET

Month	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
Surface Roughness (meters) and Albedo based on the following Seasonal Assumptions:												
Season	Fall	Fall	Fall	Fall	Summer	Summer	Summer	Summer	Summer	Summer	Fall	Fall
Arid	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Airport	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Surface Roughness (meters) for Sectors 1/2:												
	0.144/ 0.142	0.144/ 0.142	0.144/ 0.142	0.144/ 0.142	0.144/ 0.142	0.144/ 0.142	0.144/ 0.142	0.144/ 0.142	0.144/ 0.142	0.144/ 0.142	0.144/ 0.142	0.144/ 0.142
Albedo for Sectors 1/2:												
	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20	0.20/0.20
Bowen Ratio for each Month/Year based on the above inputs and the following surface moisture contents:[1]												
2003	Dry	Wet	Avg	Avg	Avg	Avg	Avg	Wet	Avg	Avg	Avg	Avg
2004	Avg	Wet	Avg	Wet	Avg	Avg	Avg	Avg	Avg	Wet	Wet	Wet
2005	Wet	Wet	Avg	Avg	Avg	Avg	Avg	Wet	Avg	Wet	Avg	Avg
2006	Dry	Dry	Avg	Avg	Wet	Avg	Avg	Dry	Avg	Avg	Avg	Avg
2007	Dry	Dry	Avg	Wet	Avg	Avg	Avg	Avg	Wet	Avg	Wet	Avg
Bowen Ratio												
2003	2.29	0.48	0.86	0.86	0.63	0.63	0.63	0.37	0.63	0.63	0.86	0.86
2004	0.86	0.48	0.86	0.48	0.63	0.63	0.63	0.63	0.63	0.37	0.48	0.48
2005	0.48	0.48	0.86	0.86	0.63	0.63	0.63	0.37	0.63	0.37	0.86	0.86
2006	2.29	2.29	0.86	0.86	0.37	0.63	0.63	1.73	0.63	0.63	0.86	0.86
2007	2.29	2.29	0.86	0.48	0.63	0.63	0.63	0.63	0.37	0.63	0.48	0.86
[1]Dry/Average/Wet designate total monthly rainfall amounts that fall into the lower 30th percentiles / middle 40th percentiles / upper 30th percentiles for a standardized 30-year climatological period (in this case, 1971-2000).												

As stated above, upper air data recorded in Tucson, Arizona were incorporated into the data set. The Tucson site is considered the most representative for upper air data for the proposed plant site which meets USEPA required data recovery rates. The upper air data from the San Diego, California and Flagstaff, Arizona monitoring sites are considered less representative because of the Pacific Ocean shoreline location at San Diego and the more mountain like character of the Flagstaff site. Data recovery rates for Yuma Proving Grounds and Phoenix (both in Arizona) were less than 90% when combined with the proposed surface dataset.

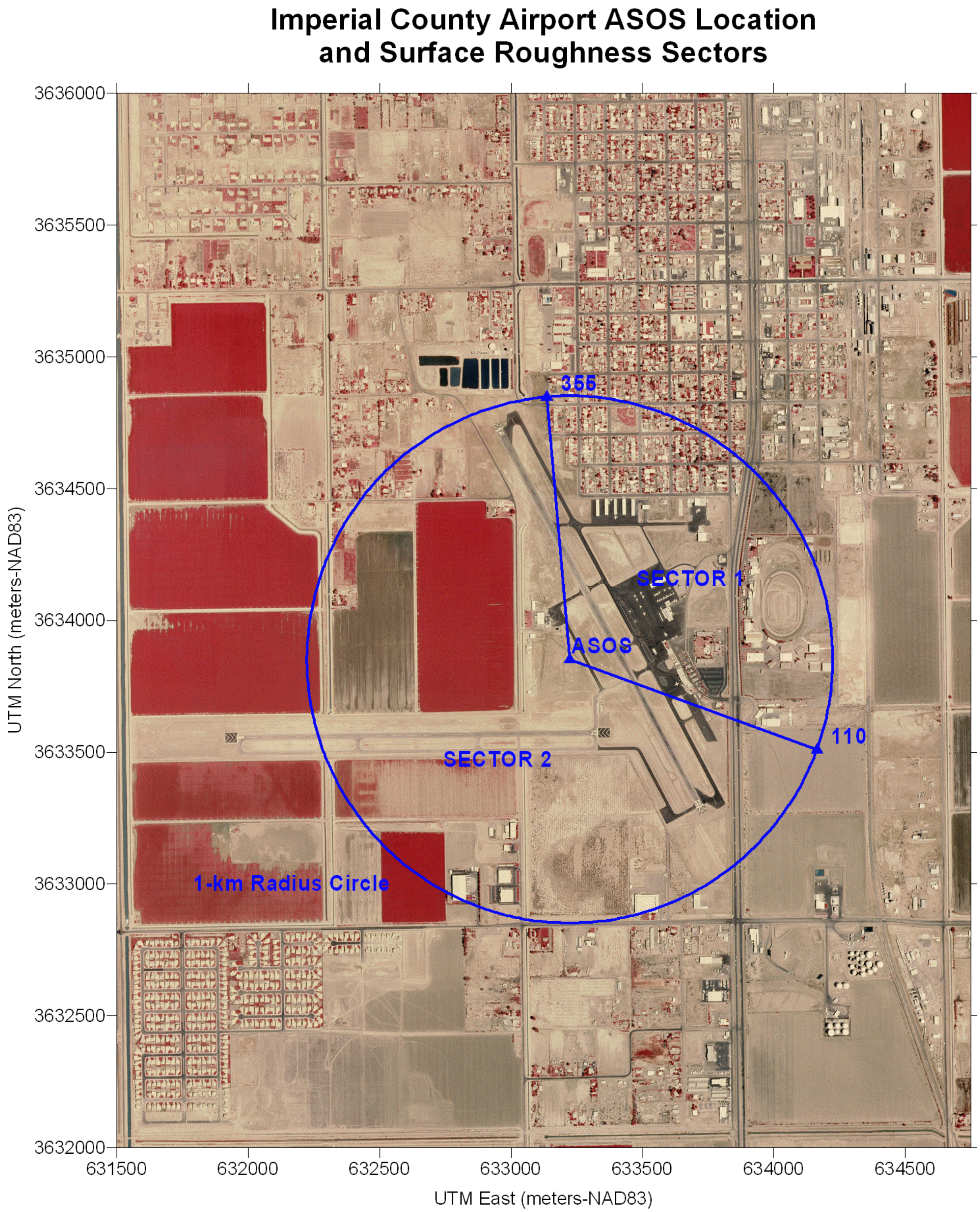

Figure 4: Imperial County Airport ASOS Location

4.4 EXISTING AIR QUALITY DATA

Existing air quality data are available from several monitoring sites in the regional area and have been used to derive background levels for several pollutants. The maximum air quality values over the past 5 years of data available in Imperial County or the Salton Sea Basin are presented below in Table 4-2.

Table 4-2 Air Quality Summary for Most Recent 3 Years

Pollutant	Site	Avg. Time	2005	2006	2007
Ozone, ppm	Brawley	8 Hr	-	.043	.067
	Calexico-East		.077	.078	.083
	El Centro		.086	.091	.083
	Niland		.072	.072	.078
	Westmorland		.090	.086	.085
PM10, ug/m^3	Brawley	24 Hr	71.0	127.0	291.0
	El Centro		81.0	146.0	200.0
	Niland		77.0	116.0	162.0
	Westmorland		54.0	182.0	226.0
PM10, ug/m^3	Brawley	Annual AM	35.4	45.1	56.4
	El Centro		33.8	44.0	50.1
	Niland		31.1	34.9	38.9
	Westmorland		31.4	50.4	49.1
PM2.5, ug/m^3	Brawley	24 Hr	37.8	30.4	19.5
	El Centro		57.9	33.8	30.5
PM2.5, ug/m^3	Brawley	Annual AM	-	-	-
	El Centro		9.4	8.8	8.5
CO, ppm	Calexico-East	8 Hr	7.76	5.80	4.50
	El Centro		2.23	2.59	1.67
CO, ppm	Calexico-East	1 Hr	-	-	-
	El Centro		-	-	-
NO_2, ppm	Calexico-East	1 Hr	.114	.095	.112
	El Centro		.065	.066	.071
NO_2, ppm	Calexico-East	Annual	.012	.012	.010
	El Centro		.011	.011	.011
SO_2, ppm	Calexico-Ethel	24 Hr	.002	.041	.004
SO_2, ppm	Calexico-Ethel	Annual	.000	.001	.001
Sulfate, ug/m^3	-	24 Hr	nd	nd	nd
H_2S	-	1 Hr	nd	nd	nd

Background hydrogen sulfide data are not available from the published information. Because OE proposes to offset hydrogen sulfide emissions from the operations, for a “no net increase in emissions”, the actual background concentration is not a necessary component in an air quality review. All except two of the Salton Sea facilities currently have hydrogen sulfide controls that normally control hydrogen sulfide emissions to non-detectable levels through the use of bioreactors. The APCD had previously recommended on the Salton Sea Unit 6 AFC a background concentration of 24.6 $\mu g/m^3$ based on their assessment of the area. This same background is also proposed for the Salton Sea Unit 6 Project.

The current air quality status of the County is listed below.

Pollutant	*CAAQS*	*NAAQS*
Carbon Monoxide	Unclassified/Attainment	Unclassified/Attainment
Nitrogen Dioxide	Attainment	Unclassified/Attainment
Hydrogen Sulfide	Unclassified/Attainment	---
Ozone (8-hour)	Non attainment	Non attainment
Sulfur Dioxide	Attainment	Attainment
Sulfates	Attainment	---
PM10	Non attainment	Non attainment
PM2.5	Attainment	Attainment
Lead	Attainment	---

5.0 PROPOSED MODELS AND ANALYTICAL APPROACH

USEPA dispersion models proposed for use to quantify pollutant impacts on the surrounding environment based on the emission sources operating parameters and their locations include the AERMOD modeling system (version 07026 with the associated meteorological and receptor processing programs AERMET and AERMAP versions 06341) for modeling most facility operational and construction impacts in both simple and complex terrain, the Building Profile Input Program for PRIME (BPIP-PRIME version 04274) for determining building dimensions for downwash calculations in the models, the SCREEN3 model (version 96043) for determining inversion breakup/shoreline fumigation impacts, and the use of the California Health Risk Assessment models/protocols for determining toxic impacts, which includes the HARP On-Ramp program. These models, along with options for their use and how they are used, are discussed below. These models will be used for the following:

- Comparison of operational and construction impacts to significant impact levels (SILs), ambient monitoring significance thresholds, California Ambient Air Quality Standards (CAAQS), and National Ambient Air Quality Standards (NAAQS) using AERMOD;
- Cumulative impacts analyses with AERMOD in accordance with local/state/USEPA/CEC requirements; and
- Toxics analyses using ARB algorithms as incorporated into state/CEC requirements.
- Assessment of impacts to soil and vegetation

5.1 LOAD SCREENING MODELING

The facility is anticipated to be operated at base load, and therefore, an initial load screening analysis will not be conducted to identify which operating conditions cause worst-case ambient air impacts. As a result, the approach will be to provide refined modeling for plant operations.

5.2 REFINED MODELING

The purpose of the refined modeling analysis is to demonstrate that air emissions from the Salton Sea Unit 6 project will not cause or contribute to a NAAQS/CAAQS violation; will not cause a significant health risk impact. For modeling the project's operational impacts under normal and startup, shutdown, or malfunction conditions due to emissions from the proposed sources (as well as temporary project construction impacts) on nearby simple, complex, and intermediate terrain, the AERMOD model will be used with five (5) years of hourly meteorological data from the Imperial County Airport. The federal rule adopting AERMOD as a preferred EPA model became effective December 9, 2005. Therefore, the most recent version of AERMOD will be used for the Project modeling analyses (AERMOD version 07026 and AERMAP version 06341). AERMOD is a steady-state plume dispersion model that simulates transport and dispersion from multiple point, area, or volume sources based on updated characterizations of the atmospheric boundary layer. AERMOD uses Gaussian distributions in the vertical and horizontal for stable conditions, and in the horizontal for convective conditions; the vertical distribution for convective conditions is based on a bi-Gaussian probability density function of the vertical velocity. For elevated terrain AERMOD incorporates the concept of the critical dividing streamline height, in which flow below this height remains horizontal, and flow above this height tends to rise up and over terrain. AERMOD also uses the advanced PRIME algorithm to account for building wake effects.

For regulatory applications of AERMOD, the regulatory default option will be set (i.e., the parameter DFAULT will be employed in the MODELOPT record in the COntrol Pathway). The DFAULT option requires the use of terrain elevation data, stack-tip downwash, sequential date checking, and does not permit the use of the model in the SCREEN mode. In the regulatory default mode, pollutant half life or decay options will not be employed. AERMOD incorporates the PRIME algorithms for the simulation of aerodynamic downwash induced by buildings. These effects are important because many of the emission points may be below Good Engineering Practice (GEP) stack height. As noted earlier, the area around both the meteorological monitoring location and project site are rural so urban options (either in COntrol or SOurce Pathways) will NOT be employed. The use of flagpole receptors are not expected. AERMAP will be used to calculate receptor elevations and hill height scales for all receptors from DEM data in accordance with US EPA guidance.

For the cooling tower assessment, two ambient operating conditions are proposed to be used to determine short-term worst-case air impacts. Short-term impact analysis would be based on worst-case short-term emissions and ambient conditions. Annual average conditions would be used to calculate the worst-case annual ambient air impact for the cooling tower. Concentrations for each pollutant would be expressed in terms of micrograms per cubic meter ($\mu g/m^3$). The emission rates calculated for each pollutant will be expressed in terms of grams per second (g/s).

Annual NO_2 concentrations will be calculated using the Ambient Ratio Method (ARM), adopted in Supplement C to the Guideline on Air Quality Models (USEPA, 1994). The Guideline allows a nationwide default conversion rate of 75% for annual NO_2/NO_x ratios.

If 1-hour NO_2 standards are exceeded, then the Ozone Limiting Method (OLM) will be used with hourly ozone data collected near the project site. The hourly ozone data will be input into the AERMOD dispersion model to calculate the 1-hour NO_2 impacts.

The SCREEN3 model will be used to evaluate fumigation impacts following the methodology in US EPA 454/R-92-019, *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised.* Fumigation impact analysis will include evaluating the impacts of the proposed facility during shoreline fumigation and inversion breakup events.

5.2.1 Receptor Grids

Receptor and source base elevations will be determined from USGS Digital Elevation Model (DEM) data using the most recent 7½-minute format (i.e., at this time, only DEM files with 30-meter spacing between grid nodes are available). All coordinates will be referenced to UTM North American Datum 1927 (NAD27), zone 11. The receptors from the DEM files will be placed exactly on the DEM nodes. Every effort will be made to maintain receptor spacing across DEM file boundaries.

Cartesian coordinate receptor grids will be used to provide adequate spatial coverage surrounding the project area for assessing ground-level pollution concentrations, to identify the extent of significant impacts, and to identify maximum impact locations. The maximum extent of the significant impact isopleth for any pollutant will be used to represent the impact radius.

For the full impact analyses, a nested grid will be developed to fully represent the significance area(s) and maximum impact area(s). The downwash receptor grid will have a receptor spacing of 30-meters along the facility fence line and out to 2 kilometers from the proposed facility; and the coarse receptor grid will have a 210-meter receptor spacing and will extend outwards at least 10 km (or more as necessary to calculate the significant impact area). When maximum impacts occur in areas outside the 30-meter spaced receptor grids, additional refined receptor grids with 30-meter resolution will be placed around the maximum impacts and extended as necessary to determine maximum impacts. Ambient concentrations within the facility fence line will not be calculated. DEM receptor data will be input into AERMAP (version 06341) to calculate hill height scales as per EPA guidance.

5.2.2 Model Options

The AERMOD model allows the selection of a number of options that affect model output. The regulatory default options will be used and include:

- Elevated terrain effects
- Stack tip downwash
- Calms processing

An analysis was performed to determine whether to if the urban option should be used. This analysis used the procedures of Auer (1978) and included drawing a 3 km radius around the project site. Within this region, land use is classified as either rural or urban. The rural land use classifications include the following:

- A1 – Metropolitan natural (golf courses, campuses, cemeteries, etc.)
- A2 – Agricultural rural
- A3 – Undeveloped, uncultivated wasteland
- A4 – Undeveloped rural
- A5 – Water surfaces (rivers, lakes, etc.)
- R1 – Common residential (single family)
- R4 – Estate residential (large homes)

Over 95 percent of the land use within 3 km of the project site is identified as rural. Therefore, no urban option will be used in the modeling analysis.

5.2.3 Building Wake Effects

Stack locations and heights and building locations and dimensions will be input to BPIP-PRIME. The first part of BPIP-PRIME determines and reports on whether a stack is being subjected to wake effects from a structure or structures. The second part calculates direction-dependent "equivalent building dimensions" if a stack is being influenced by structure wake effects. The BPIP-PRIME output is formatted for use in AERMOD input files.

5.3 MODELING EMISSIONS INVENTORY

5.3.1 Project Sources – Operations

The proposed geothermal facility is designed as a base load plant. Geothermal plants operate at a design capacity or are offline. Operational emissions are anticipated from the following sources:

Cooling Towers:	PM_{10}, Lead, H_2S, VOC and HAP
RTO H2S/Benzine Emissions Control:	PM_{10}, Lead, H_2S, VOC and HAP
Operating and Maintenance Equipment:	PM_{10}, SO_2, CO, NO_X, and VOC
Fire Pump Engine:	PM_{10}, SO_2, CO, NO_X, and VOC
Emergency Power Generator:	PM_{10}, SO_2, CO, NO_X, and VOC

Hazardous Air Pollutants (HAP) includes: Antimony, Arsenic, Arsine, Benzene, Beryllium, Cadmium, Chromium, Cobalt, Ethylbenzene, Manganese, Mercury, Nickel, Radium 226, Radium 228, Radon, Selenium, Toluene, and Xylenes. POC means pollutants of concern and includes: Ammonia, Boron, Copper, and Zinc. These pollutants are included because of their potential environmental effects. Most often these sources will be modeled based on anticipated stack parameters and emissions as point sources and the remainder will be modeled as volume or area sources.

5.3.2 Project Sources –Startups

At times, an individual well will be taken off-line and another well will be added. Before the new well is combined with the others, it is flowed to operating temperatures. The air emissions are vented at the well test unit and include PM_{10}, Lead, H2S, HAP and POC. Emissions from this activity will be based on anticipated hours of operations for this activity.

Less frequently, the entire facility is taken off-line for maintenance or other reasons and later restarted. These startup emissions are vented at the Emergency Relief Tanks (ERT). These emissions will also be based on the anticipated hours of operation for this activity and engineering design specifications.

5.3.3 Construction Sources

Prior to full facility operation, several construction activities are anticipated with corresponding air pollutant emissions. Construction of the proposed project will be divided into five main phases:

1. Site preparation and construction activities,
2. Well drilling,
3. Well testing,
4. Well reworking and
5. Commissioning.

5.3.3.1 Site Preparation and Construction Activities

Fugitive dust emissions from construction of the project can result from dust entrained during grading of the site; travel on paved and unpaved roads and across the site; soil loading and unloading operations; raw material transfers to and from material stockpiles; and wind erosion of areas being disturbed. Fugitive dust emissions will be calculated using the most appropriate South Coast Air Quality Management (SCAQMD) or US EPA AP-42 emission factors. Emissions for these activities will be modeled as a combination of volume and area sources. Combustion emissions will be generated from the heavy equipment used for excavation, grading and construction of on-site structures, the water truck used for controlling dust emissions, miscellaneous diesel-fired equipment, and gasoline-fueled trucks to transport workers and materials. These emissions will be based on current off-road and mobile emission rates and modeled as a series of equidistantly placed point sources.

5.3.3.2 Well Drilling

The diesel-fired well drilling equipment used by the drilling contractor will generate combustion emissions. This equipment will have state portable equipment air permits or APCD permits prior to use at a well pad. Four to six portable internal combustion engines rated between 400 to 600 brake horsepower are typically used for drilling wells in the Salton Sea area. These engines are equipped with turbochargers and aftercoolers. Emissions will be based on emissions information or data supplied by the manufacturers. These emissions will be modeled as point sources.

5.3.3.3 Well Testing

The test unit is used to flow test a well. A flow test usually runs for a short period. Air emissions during testing will be estimated at maximum throughput and load for the unit. These emissions will be modeled as a point source because of the short-term nature of this activity. It is expected that only one well will be tested at a time, however, a well may be tested more than once.

5.3.3.4 Well Reworking

During well reworking combustion emissions will be generated by the diesel-fired well drilling equipment used by the drilling contractor. This equipment will have state portable air permits or APCD permits prior to use at the well pad. Emissions from these units and the modeling approach are described above in Section 5.3.3.2.

5.3.3.5 Commissioning

The initial startup of the facility will be assessed and generally follow the emissions and conditions of an entire facility startup (refer to Section 5.3.2). These emissions will be based on engineering design specifications and the anticipated hours of operation for this activity. This period will be modeled based on anticipated stack parameters and emissions and the sources will be treated as point sources.

5.4 MODELING SCENARIOS

5.4.1 Compliance Review

The following activities will be reviewed separately for compliance with state and federal air quality standards:

Construction Activities		
	Site preparation and construction activities:	Short term and annual
	Well drilling:	Short term and annual
	Well testing:	Short term (only)
	Commissioning:	Short term (only)
Operations Activities		
	Base load operations:	Short term and annual
Temporary Activities		
	Plant startup operations:	Short term (only)
	Well testing	Short term (only)
	Well reworking	Short term (only)

The information developed in the above analyses for the noncriteria pollutants will be used as data input to assess the health risk impacts as discussed in Section 6.

5.4.2 Other Assessments

For impacts to soils, vegetation and other biological resources, a review of the annual emissions of the base loaded operations will be conducted. For any potential cumulative assessment both short term and annual impacts will be addressed, under base loaded operations.

6.0 MODELING RESULTS

6.1 AREA OF IMPACT ANALYSIS

Ground level concentrations caused by the project will be compared to ambient air quality impact significance levels defined by US EPA (Table 6-1). If maximum off-property pollutant concentrations for each pollutant are below these levels, then the project will not cause significant air quality impacts, thus it is proposed that no further modeling be conducted.

The maximum results from the AOI analysis will be presented in summary tables.

6.2 NAAQS AND CAAQS ANALYSIS

National Ambient Air Quality Standards/California Ambient Air Quality Standards analyses will be presented in a summary table. For CO, NO_X, SO_2, and PM_{10}, the highest short term and highest annual concentrations will be reported. For H_2S, the maximum 1-hour concentration over the five years will be presented. Background concentrations will be added to yield the total concentration, which will then be compared to the NAAQS and CAAQS.

An ambient impact significance level has not been developed for hydrogen sulfide by regulatory agencies. To provide a modeling review procedure similar to other pollutants, OE proposes the use of 6 $\mu g/m^3$ as the 1-hour significance level. This level is based upon the World Health Organization odor threshold value of 7 $\mu g/m^3$ or 5 ppb for 30 minutes (WHO, 1981). A power law relationship referenced by Turner (1970) was used to calculate a 1-hour odor threshold value based upon the WHO level. The California Office of Environmental Health Hazard Assessment in 1999 formally adopted 30 ppb (42 $\mu g/m^3$) as the acute reference exposure level and adopted in 2000 a level of 8 ppb (10 $\mu g/m^3$) as the chronic reference exposure level. The proposed significance level is consistent with US EPA's approach with the other criteria pollutants.

Table 6-1 Ambient air quality standards.			
Pollutant	**Averaging Time**	**California Standards Concentration**	**National Standards Concentration**
Ozone	1 hour	0.09 ppm (180 μg/m^3)	-
	8 hour	0.07 ppm (137 μg/m^3)	0.08 ppm (157 μg/m^3) (3-year average of annual 4th-highest daily maximum)
Carbon Monoxide	8 hour	9.0 ppm (10000 ug/m^3)	9 ppm (10000 ug/m^3)
	1 hour	20 ppm (23000 ug/m^3)	35 ppm (40000 ug/m^3)
Nitrogen dioxide	Annual Average	0.03 ppm (57 μg/m^3)	0.053 ppm (100 μg/m^3)
	1 hour	0.18 ppm (339 μg/m^3)	-
Sulfur dioxide	Annual Average	-	0.03 ppm (80 μg/m^3)
	24 hour	0.04 ppm (105 μg/m^3)	0.14 ppm (365 μg/m^3)
	3 hour	-	0.5 ppm (1300 μg/m^3)
	1 hour	0.25 ppm (655 μg/m^3)	-
Respirable particulate matter (10 micron)	24 hour	50 μg/m^3	150 μg/m^3
	Annual Arithmetic Mean	20 μg/m^3	-
Fine particulate matter (2.5 micron)	Annual Arithmetic Mean	12 μg/m^3	15 μg/m^3 (3-year average)
	24 hour	-	35 μg/m^3 (3-year average of 98th percentiles)
Sulfates	24 hour	25 μg/m^3	-
Hydrogen Sulfide	1 hour	0.03 ppm (42 μg/m^3)	-
Lead	30 day	1.5 μg/m^3	-
	Calendar Quarter	-	1.5 μg/m^3
ppm = parts per million μg/m^3 = micrograms per cubic meter CARB: 6/26/08			

6.3 HEALTH RISK IMPACT ANALYSIS

The screening health risk assessment will be conducted in accordance with the procedures developed by the California Air Resources Board and the Office of Environmental Health Hazard Analysis. The latest version of the Health Risk Assessment Program (HARP version 1.4) and the HARP On-Ramp program will be used to characterize risks from the proposed facility.

The HARP program is a tool that assists with the programmatic requirements of the Air Toxics Hot Spots Program, and it can be used for preparing health risk assessments for other related programs such as air toxic control measure development or facility permitting applications. HARP is a computer based risk assessment program, which combines the tools of emission inventory database, facility prioritization, air dispersion modeling, and risk assessment analysis. Use of HARP promotes statewide consistency in the area of risk assessment, increases the efficiency of evaluating potential health impacts, and provides a cost effective tool for developing facility health risk assessments. HARP may be used on single sources, facilities with multiple sources, or multiple facilities in close proximity to each other.

The screening health risk assessment will be carried out in three steps. First, emissions of toxic air pollutants from the project will be calculated. Next, AERMOD will be used to generate normalized emissions impacts on a source by source basis as input into the HARP On-Ramp program. Output from the On-Ramp program will be input into the HARP model will be used to predict the maximum concentration at each receptor due to the operation of the proposed project. A separate analysis will be conducted for construction generated PM_{10}, as per CEC requirements. The high-resolution receptor grids as derived from the facility AERMOD modeling will then be used in HARP. Finally, the ARB/OEHHA Health Risk Assessment Program (HARP) will be used to evaluate acute, chronic and cancer risks through inhalation and non-inhalation pathways based upon the maximum predicted concentration at each receptor. Some of the assumptions used in running the HARP program will be set as follows:

- Emission rates for non-criteria pollutants will be based upon the expected fuel use of the turbines as well as any compounds that could be re-circulated in the cooling tower water.
- Number of residents affected will be based upon the updated 2000 population data for those census tracts or portions of census tracts that lie within the maximum impact receptor radius of the proposed facility.
- Number of workers affected will be based upon the county average percentage of non-farm workers as compared to the total county population in 2000. This average was applied to all affected census tracts.
- Deposition velocity is taken to be 0.02 m/s, as recommended by ARB for controlled sources.
- Fraction of residents with gardens is taken to be 0.25, which is probably conservatively high for the urban area.
- Fraction of produce grown at home is taken to be 0.05, which is also believed to be conservatively high.

The receptor grids used for the HARP risk analyses are similar to those used for the refined modeling, with the addition of discrete receptor annotations representing the 1st, 2nd, and 3rd

highest impact points, i.e., MIR-1, MIR-2, and MIR-3. A complete list of the discrete sensitive receptors within 1 mile of the facility will be included in the application as well as census tract population data, census tract maps and affected tracts within 6 miles of the facility.

The HARP program results for acute and chronic inhalation and chronic non-inhalation exposures, cancer burden and individual cancer risk (workplace and residential) for the cooling tower and the combustion sources will be summarized. Separate calculations will be shown for each type of exposure and risk.

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ADDENDUM 1

Offset Identification and Cumulative Modeling Protocol

1. Offset Identification

CE is proposing to use the hydrogen sulfide emissions from the J. M. Leathers Power Plant, owned and operated by CalEnergy, as a source of hydrogen sulfide offsets. The Leathers Power Plant has a permitted emission rate of 100 tons per year. Actual noncondensible hydrogen sulfide emissions for the last three years have averaged approximately 71.1 tons per year.

2. Cumulative Modeling Analysis

Pursuant to the requirements of the CEC licensing process, a cumulative impacts analysis will be required and must consider the additional impacts of the following sources located within 6 miles of the project site.

Sources with impacts on existing air quality that are not reflected in the ambient air quality data used to establish background. These sources are generally those which have received permits authorizing construction but are not yet in operation and sources which have commenced operations subsequent to the data used to establish background air quality levels. Data derived from the ICAPCD, CARB, and the EPA AIRS data system indicates that air quality data for the project region is available up to the end of year 2007. As such, the cumulative analysis will concentrate on the above types of sources permitted or becoming operational after January 1, 2008.

APPENDIX E.3

Air Emission Calculations

(Provided on CD-ROM)

AECOM

Prepared for:

CalEnergy
Amended SSU6 Project

Appendix E.3
Construction and Operations Air Emissions Calculations

AECOM Environment
January, 2009
Document No.: 12672-001-App. E.3

AECOM

Prepared for:

CalEnergy
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Appendix E.3
Construction and Operations Air Emissions Calculations

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AECOM Environment
January, 2009
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Contents

1.0 Introduction

This appendix contains a description of the emission calculation methodologies and emission calculations for the Amended Project (Project). Section 2 describes the methodology used to calculate emissions related to construction of the Project. Criteria pollutant and Toxic Air Contaminant (TAC) emissions during operation of the Project are addressed in Section 3, and greenhouse gas emissions are addressed in Section 4. References are provided in Section 5. Tables of calculated emissions for the Project are provided in Attachment A.

2.0 Construction Emissions

During the construction of the Project there will be emissions similar to those associated with any large industrial construction project. Onsite emissions will arise primarily from heavy duty vehicles and equipment. Onsite fugitive dust emissions will be generated during site preparation and during construction. Offsite emissions will occur from construction worker vehicles and material delivery trucks. Offsite fugitive dust emissions will be generated during soil movement and conditioning activities at "borrow sites."[1] The construction-related emissions are transient in nature and may cause some unavoidable but minor localized short-term impacts.

The Project includes construction of the power block or the power generation facility (PGF) and resource production facility (RPF), which includes production, injection and plant wells and brine ponds and other ancillary process units. Onsite and offsite emissions during each month of construction were calculated separately for power block construction, well construction, and the earthwork necessary to construct all the facilities.

Subsections 2.1, 2.2 and 2.3 of this section describe the methodology used to develop emission factors and the activity data required to estimate the emissions. Section 2.4 briefly describes the emission calculations.

2.1 Earthwork Emission Calculation Methodology

This section describes the methodology used to estimate emissions during earthwork and site preparation. Emissions during earthwork are generated both onsite and offsite. Onsite emission sources include equipment and vehicle exhaust, fugitive emissions from vehicle travel on paved and unpaved roads, fugitive dust from excavation and bulldozing of topsoil and underlying soil for foundations, sumps, detention basin, and brine ponds, and filling and grading of conditioned soil.

Offsite emission sources include equipment and vehicle exhaust, fugitive emissions from vehicle travel on paved and unpaved roads, fugitive dust from excavation and bulldozing of soil from the borrow sites suitable as fill, exhaust from pugmill diesel engines, fugitive dust emissions from soil and cement processing in the pugmill, and fugitive dust from wind erosion of soil stockpiles.

Earthwork includes a number of activities, including the following tasks:

- Strip topsoil from Project site, including equipment areas and perimeter berm;
- Strip topsoil from borrow site;

[1] A "borrow site" is a site that is operated by the applicant from which soil is borrowed for construction of the Amended Project.

- Backfill Project site with conditioned fill[2];
- Construct perimeter berm with conditioned fill;
- Excavate for equipment foundations, detention pond, brine ponds;
- Stripped topsoil and excavated soil transported to an offsite stockpile; and
- Site grading.

2.1.1 Construction Equipment Exhaust Emissions

The combustion of fuel to provide power for the operation of various construction activities and equipment results in the generation of criteria pollutants (carbon monoxide [CO], reactive organic compounds [ROC], nitrogen oxides [NOx], sulfur oxides [SOx], respirable particulate matter [PM10] and fine particulate matter [PM2.5]) emissions. The following predictive emission equation was used to calculate exhaust emissions from each type of construction equipment:

$$\text{Exhaust Emissions}_{i,j}\,(\text{lb}) = E_{FC,i,j} \times T_{H,j} \qquad \text{(Eq. 2-1)}$$

Where: $EF_{C,i,j}$ = Emission factor for specific air contaminant i from construction equipment type j (lb/hr)

$T_{H,j}$ = Operating time for equipment of type j (hr)

The exhaust emission factors used for the calculations of CO, ROC, NOx, SOx and PM10 are composite horsepower-based off-road emission factors for 2010 derived from the California Air Resources Board's (CARB) OFFROAD2007 Model (version 2.0.1.2, December 15, 2007) (CARB, 2007a). The OFFROAD2007 Model calculates total daily emissions by equipment category (crane, dozer, grader, etc.) and type of fuel (diesel, gasoline, etc.) within engine horsepower ranges in a geographic area, such as the Imperial County Air Pollution Control District (ICAPCD) jurisdiction. The model also calculates total daily operating hours within the geographic area by equipment category, fuel, and horsepower range. The total daily emissions were divided by the total daily operating hours to calculate emission factors, in pounds per hour, by equipment category, fuel, and horsepower range.

The model can calculate the emissions and operating hours for equipment within individual model years or for equipment of all model years combined. The emission factors were calculated for all model years combined for all of the equipment.

The diesel and gasoline off-road equipment emission factors for all model years combined during 2010 are provided in Attachment A, Tables 1.1 and 1.2 at the end of this appendix.

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[2] "Conditioned fill" is soil that is amended with cement at approximately 5 to 10 percent by weight. The cement improves the structural properties of the fill.

PM2.5 emission factors were calculated from PM10 emission factors using the following equation:

$$EF_{C,PM2.5,j}\,(lb/hr) = EF_{C,PM10,j} \times F_{PM2.5,j} \qquad \text{(Eq. 2-2)}$$

Where: $EF_{C,PM2.5,,j}$ = PM2.5 emission factor for construction equipment type j (lb/hr)

$EF_{C,PM10,,j}$ = PM10 emission factor for construction equipment type j (lb/hr)

$F_{PM2.5,,j}$ = Mass fraction of PM2.5 emissions in PM10 emissions from equipment of type j (unitless)

The mass fractions of PM2.5 in PM10 emissions from construction equipment exhaust depend on the type of fuel (diesel or gasoline). The South Coast Air Quality Management District (SCAQMD) has compiled PM2.5 fractions in PM10 emissions from several emission source categories in "Final–Methodology to Calculate Particulate Matter (PM) 2.5 and PM 2.5 Significance Thresholds" (SCAQMD, 2006). These PM2.5 mass fractions are from PM profiles in the California Emission Inventory Data and Reporting System (CEIDARS) developed by CARB.

The construction equipment emission factors for the construction equipment to be used for construction of the Project are listed in Attachment A, Table 1.3, and the monthly and hourly emissions are provided in Attachment A, Tables 1.11 and 1.12, respectively.

Table 2.1 lists the data required to estimate the construction equipment exhaust emissions.

Table 2.1 Data Required for Equipment Exhaust Emissions

Parameter	Value	Reference	Location
E_{FC}– Equipment and fuel specific emission factor	Varies (lb/hr)	OFFROAD 2007 model run for ICAPCD 2010	Attachment A Tables 1.1, 1.2, and 1.3
T- Operating time	hours/month = hours/day * working days/month * monthly number of equipment of each type	AECOM estimation based on Worley Parsons' activity description	Attachment A Tables 1.11-A, B and 1.12-A, B
$F_{PM2.5}$ - fraction of PM2.5 emissions in PM10 emissions	Diesel exhaust = 0.920 Gasoline exhaust = 0.756	SCAQMD, 2006	Attachment A Table 1.3

2.1.2 Motor Vehicle Exhaust, Brake Wear and Tire Wear Emissions

The combustion of fuel in motor vehicle engines results in the generation of CO, ROC NOx, SOx, PM10 and PM2.5 emissions. Motor vehicle brake and tire wear results in the generation of PM10 and PM2.5 emissions. The following predictive emission equation was used to calculate emissions from both onsite and offsite motor vehicles:

$$\text{Exhaust Emissions}_{i,j}\,(lb) = EF_{V,i,j} \times VMT_j \qquad \text{(Eq. 2-3)}$$

Where: $EF_{V,i,j}$ = Emission factor for specific air contaminant i from motor vehicle type j (lb/mi)

VMT_j = Distance traveled each day by motor vehicle of type j (mi)

CO, ROC, NOx, SOx and PM10 emission factors were compiled by running the CARB's EMFAC2007 (version 2.3) Burden Model (CARB, 2007b) for the ICAPCD jurisdiction during calendar year 2010. Daily emissions by vehicle class (light-duty truck, heavy, heavy-heavy duty diesel vehicle, etc.) from the Burden model were divided by the daily mileage traveled by vehicles within the class from the Burden Model to calculate the emission factors. The emission factors account for the emissions from start, running and idling exhaust. In addition, the ROC emission factors take into account diurnal, hot soak, running and resting emissions, and the PM10 emission factors account for exhaust, brake wear and tire wear emissions separately.

PM2.5 emission factors were calculated by multiplying the PM10 emission factors by the mass fraction of PM2.5 emissions in motor vehicle exhaust, brake wear and tire wear PM10 emissions.

The motor vehicle emission factors from the Burden model and the calculated PM2.5 emission factors are listed in Attachment A, Table 1.4. The motor vehicle emission factors for the vehicles to be used for construction of Project are listed in Attachment A, Table 1.5-A, and the monthly and hourly emissions are provided in Attachment A, Tables 1.11 and 1.12, respectively.

Table 2.2 lists the data required to estimate the motor vehicle exhaust, brake wear and tire wear emissions.

Table 2.2 Data Required for Vehicle Exhaust and Wear Emissions

Parameter	Value	Reference	Location
E_V– Vehicle exhaust, wear and tear emission factor	Varies (lb/mile)- depending upon control technology, type and fuel	EMFAC 2007 model run for ICAPCD 2010	Attachment A Tables 1.4 and 1.5-A
VMT- distance traveled	miles/month = miles/day * working days/month * monthly number of equipment of each type	AECOM estimation based on Worley Parsons' activity description	Attachment A Tables 1.11-A, B and 1.12-A, B
$F_{PM2.5}$ - fraction of PM2.5 emissions in PM10 emissions	**PM10 Category** / **Tech.** / **PM2.5 Fraction** Exhaust / CAT / 0.928 Exhaust / NCAT / 0.756 Exhaust / DSL / 0.920 Tire Wear / N/A / 0.250 Brake Wear / N/A / 0.429	SCAQMD, 2006	Attachment A Table 1.4

2.1.3 Fugitive Emissions from Vehicle Travel

This section describes the methodology used to estimate fugitive dust emissions from vehicle travel on paved and unpaved roads.

<u>Motor Vehicle Entrained Paved Road Dust Emissions</u>

Vehicle travel on paved roads generates fugitive PM10 and PM2.5 emissions by entrainment of dust on the roads. The following predictive emission equation was used to calculate entrained paved road dust emissions:

$$\text{Entrained Dust PM10 Emissions}_j \text{ (lb)} = EF_{D,j} \times VMT_j \qquad \text{(Eq. 2-4)}$$

Where: $EF_{D,j}$ = Emission factor for entrained road dust PM10 from motor vehicle type j (lb/mi)

VMT_j = Distance traveled each day by motor vehicles of type j (mi)

The emission factor ($EF_{D,j}$) was calculated from the following equation from CARB Emission Inventory Methodology 7.9, "Entrained Paved Road Dust" (CARB, 1997):

$$EF_{D,j} \text{ (lb/mi)} = 7.26 / 453.6 \times (sL_j/2)^{0.65} \times (W_j/3)^{1.5} \qquad \text{(Eq. 2-5)}$$

Where: 7.26 = A constant for PM10 emissions (g/mi)

453.6 = Factor to convert from grams to pounds (g/lb)

sL_j = Silt loading on roads traveled by motor vehicle of type j (g/m^2)

W_j = Average weight of vehicles on roads traveled by vehicles of type j (tons)

As indicated in Attachment A, Table 1.5-B, offsite motor vehicles were assumed to travel on paved collector roads.

PM2.5 emission factors were calculated by multiplying the PM10 emission factors by the mass fraction of PM2.5 emissions in PM10 emissions from entrained paved road dust. The calculated PM10 and PM2.5 entrained paved road dust emission factors are in Attachment A, Table 1.5-B and the monthly and hourly emissions are provided in Attachment A, Tables 1.11 and 1.12, respectively.

Table 2.3 lists the data required to estimate the fugitive emissions from vehicle travel on paved roads.

Table 2.3 Data Required for Paved Road Dust Emissions

Parameter	Value	Reference	Location
VMT- distance traveled	miles/month = miles/day * working days/month * monthly number of equipment of each type	AECOM estimation based on Worley Parsons'[1] activity description	Attachment A Tables 1.11-A, B and 1.12-A, B

Table 2.3 Data Required for Paved Road Dust Emissions

Parameter	Value	Reference	Location
sL - Silt loading	0.32 g/m^2	Table 3 of CARB Emission Inventory Methodology 7.9	Attachment A Table 1.5-B
W = average weight of vehicles	2.4 tons	Table 3 of CARB Emission Inventory Methodology 7.9 for the Imperial County portion of the Southeast Desert Air Basin (SDAB)	Attachment A Table 1.5-B
$F_{PM2.5}$ - fraction of PM2.5 emissions in PM10 emissions	0.169 in paved road dust	SCAQMD, 2006	Attachment A Table 1.5-B
1. Worley Parsons is the Applicant's engineer for the Amended Project.			

Vehicle Travel on Unpaved Surfaces

Vehicles traveling on unpaved surfaces generate fugitive PM10 and PM2.5 emissions. The following equation was used to estimate these emissions:

$$\text{Emissions (lb)} = EF_U \times VMT_U \qquad \text{(Eq. 2-6)}$$

Where: EF_U = Controlled PM10 emission factor for vehicle travel on unpaved surfaces (lb/mi)

VMT_U = Distance traveled on unpaved surfaces (mi)

The controlled emission factor was calculated from:

$$EF_U \text{ (lb/mi)} = 1.5\ (s/12)^{0.9} \times (W/3)^{0.45} \times (1\text{-}CE/100) \qquad \text{(Eq. 2-7)}$$

Where: s = Surface silt content (percent)

W = Average vehicle weight (tons)

CE = Control efficiency from watering four times per day (percent)

Source: (EPA, 2006a)

The PM2.5 emission factor was calculated by multiplying the PM10 emission factor by the mass fraction of PM2.5 emissions in PM10 emissions from unpaved road dust. The emission factors are listed in Attachment A, Table 1.5-B and the monthly and hourly emissions are provided in Attachment A, Tables 1.11 and 1.12, respectively.

Table 2.4 lists the data required to estimate the fugitive emissions from vehicle travel on unpaved roads.

Table 2.4 Data Required for Unpaved Road Dust Emissions

Parameter	Value	Reference	Location
VMT- distance traveled	miles/month = miles/day * working days/month * monthly number of equipment of each type	AECOM estimation based on Worley Parsons' activity description	Attachment A Tables 1.11-A, B and 1.12-A, B
s - Surface silt content	7.5%	Table A9-9-F-1, SCAQMD CEQA Air Quality Handbook, default for overburden (SCAQMD, 1993)	Attachment A Table 1.5-B
W = average vehicle weight	20 tons	AECOM assumed based on the average of a 10 ton empty and a 30 ton full dump truck	Attachment A Table 1.5-B
CE - Control efficiency from watering thrice per day	75%	AECOM assumption	Attachment A Table 1.5-B
$F_{PM2.5}$ - fraction of PM2.5 emissions in PM10 emissions	0.212 in unpaved road dust	SCAQMD, 2006	Attachment A Table 1.5-B

2.1.4 Fugitive PM10 and PM2.5 Emissions

Excavation, filling and grading during construction will generate fugitive PM10 and PM2.5 emissions from soil handling (i.e., dropping), wind erosion of temporary storage piles, bulldozing and grading, and onsite vehicles traveling on unpaved roads and surfaces. Although fugitive dust emissions from construction activities are temporary, they may have an impact on local air quality. Fugitive dust emissions often vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. The following methodologies provide the predictive emission equations, emission factors, and default values used to calculate fugitive dust emissions for Project construction.

Emissions from Soil Handling

Fugitive PM10 and PM2.5 emissions are generated during excavation when excavated material is dropped onto the ground at the side of the excavation location or dropped into trucks for removal from the site. Fugitive PM10 and PM2.5 emissions are also generated during production and placement of conditioned fill. The following equation was used to estimate these emissions:

$$\text{Emissions (lb/day)} = EF_S \times V_s \qquad \text{(Eq. 2-8)}$$

Where: EF_S = Controlled PM10 emission factor for soil dropping (lb/yd^3)

V_S = Volume of soil handled (yd^3)

The controlled emission factor was calculated from:

$$EF_S\ (lb/yd^3) = 0.00112 \times (U/5)^{1.3} / (M/2)^{1.4} \times D \times N_D \times (1-CE) \quad \text{(Eq. 2-9)}$$

Where: U = Mean wind speed (mph)

M = Soil moisture content (percent)

D = Soil density (tons/yd^3)

N_D = Number of times soil is handled

CE = Control efficiency from watering four times per day (percent)

Source: (EPA, 2006b)

It was conservatively assumed that soil was dropped four times during onsite soil handling activities: 1) excavated topsoil dropped onto the ground at the side of the excavation; 2) excavated topsoil dropped into a truck for hauling offsite; 3) conditioned fill dropped on a temporary pile; and 4) conditioned fill dropped on the ground before grading.

It was also assumed that soil was dropped four times during the following offsite soil handling activities: 1) excavated soil from borrow site dropped onto the ground at the side of the excavation; 2) into a truck or loader to the pugmill; 3) conditioned soil dropped into a truck; 4) onsite topsoil dropped onto a temporary storage pile located offsite.

Processing of soil in the pugmill to produce conditioned fill was assumed to involve three soil transfer operations: 1) dump truck or loader unloading the soil onto a belt conveyor, 2) belt conveyor unloading into a hopper and 3) the hopper unloading into the mixer.

The PM2.5 emission factor was calculated by multiplying the PM10 emission factor by the mass fraction of PM2.5 emissions in PM10 emissions from construction dust. The emission factors are listed in Attachment A, Table 1.6-B and the monthly and hourly emissions are provided in Attachment A, Tables 1.11 and 1.12, respectively.

Table 2.5 lists the data required to estimate the PM10 and PM2.5 emissions from soil handling activities.

Table 2.5 Data Required for Soil Handling Emissions

Parameter	Value	Reference	Location
V_S - Volume of soil handled	Varies (Yd^3/month)	AECOM estimation based on duration of the activity provided by Applicant and total earthwork or structure dimensions provided by Worley Parsons	Attachment A Tables 1.6-A, 1.8, 1.11-K, N and 1.12-K, N
U - Mean wind speed	12 miles/hr	Table 9-9-G, SCAQMD 1993 CEQA Air Quality Handbook, Default (SCAQMD, 1993)	Attachment A Table 1.6-B
M - Soil moisture content	12%	Moisture content of conditioned soil provided by Worley Parsons	Attachment A Table 1.6-B
D - Soil density	1.215 tons per yd^3	Table 2.46, Handbook of Solid Waste Management (K. Frank et al., 2001)	Attachment A Table 1.6-B
N_D - Number of times soil is transferred	4 for soil handling during onsite and offsite excavation and filling activities. 3 for soil handling in pugmill to produce conditioned fill	AECOM assumption	Attachment A, Tables 1.6-B and 1.7-B
CE - Control efficiency from watering thrice per day	75%	AECOM assumption	Attachment A Table 1.5-B
$F_{PM2.5}$ - fraction of PM2.5 emissions in PM10 emissions	PM2.5 Fraction of PM10 in Construction Dust = 0.208	SCAQMD, 2006	Attachment A Table 1.6-B

Wind Erosion from Temporary Storage Piles

Wind erosion of temporary soil storage piles generates fugitive PM10 and PM2.5 emissions. An offsite location has been identified for storage piles and hence the fugitive emissions from the storage piles are included as offsite emissions. The following equation was used to estimate these emissions:

$$\text{Emissions (lb)} = EF_W \times A \qquad \text{(Eq. 2-10)}$$

Where: EF_W = Controlled PM10 emission factor for storage pile wind erosion (lb/acre-day)

A = Temporary storage pile surface area (acres)

The controlled emission factor was calculated from:

EF_W (lb/acre-day) = 0.85 x (s/1.5) x (365-p/235) x (U_{12}/15) x (1-CE/100) (Eq. 2-11)

Where: s = Soil silt content (percent)

p = Number of days per year with precipitation of 0.01 inches or more

U_{12} = Percentage of time unobstructed wind speed exceeds 12 mph

CE = Control efficiency from watering four times per day (percent)

Source: (EPA, 1992)

The PM2.5 emission factor was calculated by multiplying the PM10 emission factor by the mass fraction of PM2.5 emissions in PM10 emissions from construction dust. The emission factors are listed in Attachment A, Table 1.6-B and the monthly and hourly emissions are provided in Attachment A, Tables 1.11 and 1.12, respectively.

Table 2.6 lists the data required to estimate the fugitive PM10 and PM2.5 emissions from storage piles.

Table 2.6 Data Required for Storage Pile Emissions

Parameter	Value	Reference	Location
A - Temporary storage pile surface area	Varies (acres)	AECOM estimation based on duration of the activity provided by Applicant, total surface area of the storage piles provided by Worley Parsons and quantity of soil excavated each month	Attachment A Tables 1.6-A, 1.11-K, N and 1.12-K, N
s - Soil silt content	7.5%	Table A9-9-F-1, SCAQMD CEQA Air Quality Handbook, default for overburden (SCAQMD, 1993)	Attachment A Table 1.6-B
p - Number of days per year with precipitation of 0.01 inches or more	0 days	AECOM assumption	Attachment A Table 1.6-B
U_{12} - Percentage of time wind speed exceeds 12 mph	13.3%	Emissions Inventory Guidance, Mineral Handling and Processing Industries, p. 17 (MDAQMD, 2000)	Attachment A Table 1.6-B

Table 2.6 Data Required for Storage Pile Emissions

Parameter	Value	Reference	Location
CE - Control efficiency from watering twice per day	75%	AECOM assumption	Attachment A Table 1.6-B
$F_{PM2.5}$ - fraction of PM2.5 emissions in PM10 emissions	PM2.5 Fraction of PM10 in Construction Dust = 0.208	SCAQMD, 2006	Attachment A Table 1.6-B

Bulldozing, Scraping and Grading

Bulldozing, scraping and grading generate fugitive PM10 and PM2.5 emissions. The following equation was used to estimate these emissions:

$$\text{Emissions (lb)} = EF_B \times T_B \qquad \text{(Eq. 2-12)}$$

Where: EF_B = Controlled PM10 emission factor for bulldozing and grading (lb/hr)

T_B = Bulldozing and grading duration (hr)

The controlled emission factor was calculated from:

$$EF_B \text{ (lb/hr)} = 0.75 \times s^{1.5} / M^{1.4} \times (1\text{-CE}) \qquad \text{(Eq. 2-13)}$$

Where: s = Soil silt content (percent)

M = Soil moisture (percent)

CE = Control efficiency from watering four times per day (percent)

Source: (EPA, 1998a)

The PM2.5 emission factor was calculated by multiplying the PM10 emission factor by the mass fraction of PM2.5 emissions in PM10 emissions from construction dust. The emission factors are listed in Attachment A, Table 1.6-B and the monthly and hourly emissions are provided in Attachment A, Tables 1.11 and 1.12, respectively.

Table 2.7 lists the data required to estimate the fugitive PM10 and PM2.5 emissions from bulldozing and grading activities.

Table 2.7 Data Required for Bulldozing and Grading Emissions

Parameter	Value	Reference	Location

Table 2.7 Data Required for Bulldozing and Grading Emissions

Parameter	Value	Reference	Location
T_B - Bulldozing and grading duration	hours/month = hours/day * working days/month * monthly number of equipment of each type	AECOM estimation based on Worley Parsons' activity description	Attachment A Tables 1.11-A,B,K and 1.12-A,B,K
s - Soil silt content	7.5%	Table A9-9-F-1, SCAQMD CEQA Air Quality Handbook, default for overburden (SCAQMD, 1993)	Attachment A Table 1.6-B
M - Soil moisture content	12%	Moisture content of conditioned soil provided by Worley Parsons	Attachment A Table 1.6-B
CE - Control efficiency from watering twice per day	75%	AECOM assumption	Attachment A Table 1.6-B
$F_{PM2.5}$ - fraction of PM2.5 emissions in PM10 emissions	PM2.5 Fraction of PM10 in Construction Dust = 0.208	SCAQMD, 2006	Attachment A Table 1.6-B

2.1.5 Pugmill Operation Emissions

Pugmills will be operated offsite for the production of conditioned fill. Emissions from pugmill operation include exhaust from diesel engines used to power the pugmill and fugitive dust emissions from soil and cement transfer. Emissions from diesel engine and cement transfer are discussed in this section. Emissions from soil transfer were estimated as described in Section 2.1.4, Equations 2-8 and 2-9. Emission factor for soil transfer during pugmill operation is listed in Attachment A, Table 1.7-B, and the monthly and hourly emissions are provided in Attachment A, Tables 1.11 and 1.12, respectively.

Pugmill Diesel Engine Exhaust Emissions

Diesel engine is assumed to comply with ATCM (Airborne Toxic Control Measure) Tier 3 standards. Exhaust emissions for NOx, CO, ROC and PM10 were estimated using the Tier 3 emission limits specified in California Code of Regulations (CCR), Title 13, Division 3, Chapter 9, Article 4, Section 2423.

Under the New Source Performance Standard (NSPS) Subpart IIII, the emission limit for NOx is combined with non-methane hydrocarbons (NMHC). For these emission estimates, the NOx fraction is assumed to be 95 percent of the combined emissions, and the balance NMHC (Carl Moyer, 2003). NMHC is assumed to be equivalent to ROC.

Emission factors of NOx, CO, PM10, and ROC were calculated using the following equation:

$$EF\ (lbs/hr) = EL\ (g/kW\text{-}hr) \times Engine\ Capacity\ (kW) \div 453.6\ g/lbs \qquad (Eq.\ 2\text{-}14)$$

Where: EF = Emission factor (lb/hr)

EL = Tier 3 ATCM emission limit

SOx emission factors are based on fuel use and a fuel sulfur content of 15 ppmw. The emission factor for SOx was calculated by assuming that 100 percent of the sulfur present in the fuel is oxidized to SO_2, according to the following equation:

$$EF\ (lbs/hr) = (BSFC \times S \times MW_{SO2}) / (HV \times 100 \times MW_S) \times EC \qquad \text{(Eq. 2-15)}$$

Where: EF = Emission factor (lb/hr)

BSFC = Brake Specific Fuel Consumption (Btu/Hp-hr)

S = Sulfur content of diesel fuel (percent)

MW_{SO2} = Molecular weight of SO_2 = 64.07 lb/mole

HV = Heating value of diesel (Btu/lb)

MW_S = Molecular weight of sulfur = 32 lb/mole

EC = Engine capacity (Hp)

Monthly emissions were calculated using the following equation:

$$Emissions\ (lbs/month) = EF\ (lb/hr) \times DOH \times W \times N \qquad \text{(Eq. 2-16)}$$

Where: DOH = Daily operating hours (hours/day)

W = Working days per month (days/month)

N = number of pugmills used every month

Hourly emissions were calculated the following equation:

$$Emissions\ (lbs/hour) = Emission\ Factor\ (lb/hr) \times Operating\ hours\ (hr) \times N' \qquad \text{(Eq. 2-17)}$$

Where N' = number of pugmills used every hour

PM2.5 emission factors were calculated from PM10 emission factors using the mass fraction of PM2.5 in PM10 from exhaust of construction equipment using diesel fuel.

Emission factors for pugmill diesel engine are listed in Attachment A, Table 1.7-A, and the monthly and hourly emissions are provided in Attachment A, Tables 1.11 and 1.12, respectively.

Table 2.8 lists the data required to estimate the exhaust emissions from pugmill diesel engines.

Table 2.8 Data Required for Pugmill Diesel Emissions

Parameter	Value	Reference	Location
EL – Emission limits for NOx, CO, ROC and PM10	Varies depending upon the pollutant, engine capacity and equipment manufacturing date (g/kW-hr)	Tier 3 emission limits specified in CCR, Title 13, Division 3, Chapter 9, Article 4, Section 2423	Attachment A Table 1.7-A
Engine Capacity (kW)	75 kW	Rig Vendor	Attachment A Table 1.7-A
Activity rate	Operating hours/day, working days/month, number of rigs used per month or per hour	Provided by Applicant	Attachment A Tables 1.11-A, B and 1.12-A, B
S- Sulfur content in diesel	15 ppmw	AECOM assumed	Attachment A Table 1.7-A
BSFC - Brake Specific Fuel Consumption	7,000 Btu/Hp-hr	AP-42, Chapter 3.3 (EPA 1996)	Attachment A Table 1.7-A
Diesel Heating Value	19,300 Btu/lb	AP-42, Chapter 3.3 (EPA 1996)	Attachment A Table 1.7-A
$F_{PM2.5}$ - fraction of PM2.5 emissions in PM10 emissions	PM2.5 fraction of PM10 from diesel based construction equipment = 0.920	SCAQMD, 2006	Attachment A Table 1.3

Emissions from Cement Handling and Transfer

Excavated soil is mixed with cement and water in the pugmill to produce the conditioned fill. Fugitive PM10 and PM2.5 emissions will be generated due to the handling and transfer of cement during the pugmill operation. Activities involving cement handling include: 1) Cement unloading to elevated storage silo; 2) Cement unloading onto belt conveyor; and 3) Mixer loading.

Fugitive emissions from cement transfer were estimated using the following equation:

$$\text{Emissions (lb/month)} = EF_T \times V_C \quad \text{(Eq. 2-18)}$$

Where: EF_T = Total PM10 or PM2.5 emission factor for cement handling (lb/yd^3)

V_C = Volume of cement handled (yd^3/month)

$$EF_T = EF_{SS} + EF_{BC} + EF_{ML} \quad \text{(Eq. 2-19)}$$

Where: EF_{SS} = Emission factor for cement unloading to elevated storage silo (lb/yd^3)

EF_{BC} = Emission factor for cement unloading onto a belt conveyor (lb/yd^3)

EF_{ML} = Emission factor for mixer loading (lb/yd^3)

Emission factor for cement unloading to elevated storage silo was calculated using the following equation:

$$EF_{SS}\ (lb/yd^3) = EF_{SS}\ (lb/ton) \times D_C\ (tons/yd^3) \qquad \text{(Eq. 2-20)}$$

The following AP-42 equation (EPA, 2006b) was used to estimate the emission factor for cement unloading onto a belt conveyor:

$$EF_{BC}\ (lb/yd^3) = 0.00112 \times (U/5)^{1.3} / (M_C/2)^{1.4} \times D_C \qquad \text{(Eq. 2-21)}$$

The following AP-42 equation (EPA, 2006c) was used to estimate the emission factor for cement loading into a mixer:

$$EF_{ML}\ (lb/yd^3) = [(k \times 0.0032 \times U^a / M_C^b) + c] \times D_C \qquad \text{(Eq. 2-22)}$$

Where: EF_{SS} = Emission factor for cement unloading to elevated storage silo (lb/ton)

D_C = Cement density ($tons/yd^3$)

U = Mean wind speed (mph)

M_C = Cement moisture content (percent)

k, a, b, c = constants

Emission factors for fugitive emissions during cement transfer at the pugmill are listed in Attachment A, Table 1.7-B, and the monthly and hourly emissions are provided in Attachment A, Tables 1.11 and 1.12, respectively.

Table 2.9 lists the data required to estimate the PM10 and PM2.5 emissions from cement handling activities.

Table 2.9 Data Required for Cement Handling Emissions

Parameter	Value	Reference	Location
V_C - Volume of cement handled	Varies (Yd^3/month)	AECOM estimation based on duration of the activity provided by Applicant, and total conditioned fill requirement and cement content of fill provided by Worley Parsons	Attachment A Tables 1.6-A, 1.11-N and 1.12-N
EF_{SS} - Emission factor for cement unloading to elevated storage silo	0.00034 lb/ton cement	AP-42,Section 11.12 Table 11.12-2, controlled PM10 emission factor (EPA, 2006c)	Attachment A Tables 1.7-B

Table 2.9 Data Required for Cement Handling Emissions

Parameter	Value	Reference	Location
D_C - Cement density	1.26923 tons per yd^3	Density of Portland cement, Google search	Attachment A Tables 1.7-B
U - Mean wind speed	12 miles/hr	Table 9-9-G, SCAQMD 1993 CEQA Air Quality Handbook, Default (SCAQMD, 1993)	Attachment A Tables 1.7-B
M_C – Cement moisture content	0.095%	Final Test Report for USEPA Test Program Conducted at Chaney Enterprises Cement Plant, ETS, Inc., Roanoke, VA April 1994.	Attachment A Tables 1.7-B
k, a, b, c	See Table 2.10 below	AP-42,Section 11.12 Table 11.12-4, uncontrolled PM10 and PM2.5 (EPA, 2006c)	Attachment A Tables 1.7-B
$F_{PM2.5}$ - fraction of PM2.5 emissions in PM10 emissions	PM2.5 Fraction of PM10 in Construction Dust = 0.208	SCAQMD, 2006	Attachment A Tables 1.7-B

Table 2.10 Equation Parameters for Central Mix Operations

Pollutant	k	a	b	c
PM10	1.92	0.4	1.3	0.04
PM2.5	0.38	0.4	1.3	0

2.2 Power Block Construction Emission Calculation Methodology

Sources of emissions during power block construction include equipment and vehicle exhaust, fugitive dust from foundation construction, bulldozing and grading of soil, and fugitive emissions from vehicle travel on paved and unpaved roads.

Emissions from construction equipment were estimated as described in Section 2.1.1. Emissions from vehicle exhaust were estimated as described in Section 2.1.2. The methodology described in Section 2.1.3 was used to estimate fugitive dust emissions from vehicle travel on paved and unpaved roads. Fugitive PM10 and PM2.5 emissions generated during construction activities such as soil handling, bulldozing and grading during power block construction are the same as was described in Section 2.1.4. The moisture content of onsite soil required for soil handling emissions used in Section 2.1.4, Equation 2-9 was assumed to be 15 percent, from "Open Fugitive Dust PM10 Control Strategies Study" (MRI, 1990) for moist conditions. Routine watering (e.g. twice per day) will be used to maintain moist conditions.

Emission factors for various emission sources during power block construction are listed in Attachment A, Tables 1.1 through 1.5 and Table 1.9. Monthly and hourly emissions from power block construction are provided in Attachment A, Tables 1.13 and 1.14, respectively.

2.3 Well Construction Emission Calculation Methodology

Sources of emissions during well construction include diesel engines to power the drilling rigs, other construction equipment and vehicles and fugitive dust emissions from offsite mud sumps construction. Emissions from construction equipment were estimated using the methods described in Section 2.1.1. Emissions from vehicle exhaust were estimated using the methods described in Section 2.1.2. The methodology described in Section 2.1.3 was used to estimate fugitive dust emissions from vehicle travel on paved and unpaved roads. Fugitive emissions during the construction of offsite mud sumps (near injection well pads) were estimated using the methodology described in Section 2.1.4. Emissions from diesel engines on the drill rigs were estimated using the methodology described below. Fugitive dust emissions from soil displaced during drilling are assumed to be negligible because the soil will be pumped out and discharged into the mud sumps and brine ponds in a slurry with water.

Drilling Rig Diesel Engine Exhaust Emissions

Each drilling rig will operate with of three diesel engines, which are assumed to comply with ATCM Tier 4 standards. Exhaust emissions for NOx, CO, ROC and PM10 were estimated using the Tier 4 emission limits specified in CCR, Title 13, Division 3, Chapter 9, Article 4, Section 2423.

Emission factors for NOx, CO, PM10, and ROC were calculated using the following equation:

$$EF\ (lbs/hr) = EL\ (g/kW\text{-}hr) \times Engine\ Capacity\ (kW) \div 453.6\ g/lbs \times 3\ units/rig \quad (Eq.\ 2\text{-}23)$$

Where: EF = Emission factor (lb/hr)

EL = Tier 4 ATCM emission limit

ROC emission factors were assumed to be equal to Tier 4 non-methane hydrocarbon (NHMC) standards.

SOx emission factor is based on fuel use and a fuel sulfur content of 15 ppmw. SOx emission factor was calculated using Equation 2-15. Monthly and hourly emissions were calculated according to Equations 2-16 and 2-17.

PM2.5 emission factors were calculated from PM10 emission factors using the mass fraction of PM2.5 in PM10 from exhaust of construction equipment using diesel fuel.

Emission factors for drill rig diesel engines are listed in Attachment A, Table 1.10, and the monthly and hourly emissions are provided in Attachment A, Tables 1.15 and 1.16, respectively.

Table 2.11 lists the data required to estimate the exhaust emissions from drill rig diesel engines.

Table 2.11 Data Required for Drill Rig Emissions

Parameter	Value	Reference	Location
EL – Emission factors for NOx, CO, ROC and PM10	Varies depending upon the pollutant, engine capacity and equipment manufacturing date (g/kW-hr)	Tier 4 emission limits specified in CCR, Title 13, Division 3, Chapter 9, Article 4, Section 2423	Attachment A Table 1.10
Engine Capacity (kW)	1,645 kW	Drill Rig Vendor	Attachment A Table 1.10
Activity rate	Operating hours/day, working days/month, number of rigs used per month or per hour	Provided by Applicant	Attachment A Tables 1.15-A, B and 1.16-A, B
$F_{PM2.5}$ - fraction of PM2.5 emissions in PM10 emissions	PM2.5 Fraction of PM10 from diesel based construction equipment = 0.920	SCAQMD, 2006	Attachment A Table 1.3

2.4 Emission Calculations

Monthly and hourly emissions were calculated from estimates of (1) the types, number, horsepower rating and daily operating hours for construction equipment; (2) the types, number and daily miles traveled by onsite and offsite motor vehicles; and (3) the activity levels (e.g., hours of bulldozing, scraping and grading or cubic yards of soil handled) for fugitive PM producing activities. These estimates were made by construction month for earthwork activities and construction of the power block and wells. It was assumed that all onsite motor vehicle travel will be on unpaved surfaces and that all offsite motor vehicle travel will be on paved surfaces.

Daily emissions during each month were estimated by dividing the monthly emissions by number of working days in a month. Annual emissions were estimated by summing the monthly emissions during 12 consecutive months. Hourly, daily, monthly, and annual emissions were calculated for earthwork, and construction of the power block and wells. Onsite emission rates used to model impacts of construction emissions on ambient air quality were derived from the hourly, daily, and annual emissions.

Emission calculations during Project construction are provided in Attachment A. Calculations of monthly emissions during earthwork activities are in Tables 1.11-A through 1.11-P. Calculations of monthly power block construction emissions are provided in Tables 1.13-A through 1.13-M. Calculations of monthly well construction emissions are in Tables 1.15-A through 1.15-M. Tables 1.11-A, 1.13-A and 1.15-A list the daily operating hours, daily vehicle miles traveled and the number of pieces of construction equipment and motor vehicles by month for each type of equipment or motor vehicle; Tables 1.11-B, 1.13-B and 1.15-B list the monthly operating hours and vehicle miles traveled for each type of construction equipment or motor vehicles, based on 22 working days per month for earthwork and power block construction and 27 working days for well construction; Tables 1.11-C through 1.11-H, 1.13-C through 1.13-H and 1.15-C through 1.15-H list the monthly CO, ROC, NOx, SOx, PM10 and PM2.5 exhaust emissions for the three phases of construction (i.e. earthwork, power block and well); Tables 1.11-I through 1.11-J, 1.13-I through 1.13-J and 1.15-I through 1.15-J list the monthly motor vehicle fugitive PM10 and PM2.5 emissions; Tables 1.11-K and

1.13-K list the onsite monthly fugitive PM generating activity levels during earthwork and power block construction, respectively; Tables 1.11-L through 1.11-M and 1.13-L through 1.13-M list the onsite fugitive PM10 and PM2.5 emissions during earthwork and power block construction, respectively; Tables 1.11-N and 1.15-K lists the offsite monthly fugitive PM generating activity levels during earthwork and well construction, respectively; Tables 1.11-O through 1.11-P list the offsite fugitive PM10 and PM2.5 emissions during earthwork; and Tables 1.15-L and 1.15-M list the offsite fugitive PM10 and PM2.5 emissions during offsite well construction.

No offsite fugitive emissions other than vehicle travel on paved roads are expected from power block construction.

Peak hourly emissions were also estimated for each month of construction for earthwork activities, power block construction, and well construction. These estimates were made by assuming that all construction equipment used during each month will operate simultaneously during one hour and that all onsite motor vehicles will travel one-third of their daily mileage simultaneously during the same hour. These calculations are provided in Tables 1.12-A through 1.12-P for earthwork activities, Tables 1.14-A through 1.14-M for power block construction, and Tables 1.16-A through 1.16-M for well construction.

Construction emission summaries are provided in Tables 1.17-A through 1.17-L for construction of power block, Tables 1.18-A through 1.18-L for construction of onsite wells, Tables 1.19-A through 1.19-L for construction of offsite wells, Tables 1.20-A through 1.20-L for onsite earthwork activities, and Tables 1.21-A through 1.21-L for offsite earthwork activities. Tables A, C, E, G, I, and K summarize CO, ROC, NOx, SOx, PM10, and PM2.5 emissions, respectively. Each table lists running 12-month, monthly, daily and hourly emissions by month, as well as peak emissions. Tables B, D, F, H, J, and L list maximum hourly, daily and annual onsite emissions for each of these pollutants.

Emission rates, in pounds per hour, used to model air quality impacts from emissions during construction of the AP are listed in Attachment A, Table 1.22. The table lists the emission rate used for each pollutant, each averaging period and indicates how the emission rate was calculated.

3.0 Operating Emissions

Criteria pollutant and TAC emissions from the proposed Project were estimated for the following operating conditions and equipment:

- Production well backflow to the brine ponds;
- Production well testing at PTU;
- Injection and plant well testing at Mobile Test Unit (MTU);
- Plant commissioning at PTU, rock muffler, recuperative thermal oxidizer (RTO) stack and cooling tower;
- Cold start-up at PTU, rock muffler, RTO stack and cooling tower;
- Warm start-up at rock muffler, RTO stack and cooling tower;
- Shutdown at rock muffler; and
- Normal continuous operation at RTO stack and cooling tower.

Emissions were also estimated from emergency fire water pump and generator engines, and from operation and maintenance (O&M) equipment.

3.1 Commissioning

3.1.1 Well Backflow and Testing

The brine ponds will be used for backflowing of production wells to purge the wells of all the soil cuttings and for well testing. Steam will be flashed from the brine at atmospheric conditions in the brine ponds. This is a very conservative assumption (i.e., overestimates emissions), as the bulk of the materials backflowed from the wells are drill cuttings and drilling muds, with only a small percentage of brine. Remaining brine will be collected in the brine ponds and injected back into the formation through the injection wells. Components of steam include water vapor and non-condensable gases (NCG) such as H_2S, NH_3, methane, etc. The following equation was used to estimate the emissions of these NCG components from PTU:

$$E_i \text{ (lb/hr)} = M_i \times C_{NCG} \times Q_{steam} / 10^6 \qquad \text{(Eq. 3-1)}$$

Where: E_i = Emission rate of pollutant i (lb/hr)

M_i = Mass fraction of pollutant i in NCG (lb of i / lb of NCG)

C_{NCG} = Weighted average mass concentration of NCG in steam (ppmw)

Q_{steam} = Steam flow rate (lb/hr) through PTU stack

Mass fraction of a pollutant in the NCG stream was estimated using the following equations depending upon the data available:

M_i (lb of i / lb of NCG) = C_i / C_{NCG} (Eq. 3-2)

Where: C_i = Mass concentration of pollutant i in steam (ppmw)

or,

M_i (lb of i / lb of NCG) = Q_i / Q_{NCG} (Eq. 3-3)

Where: Q_i = Mass flow rate of pollutant i in a stream of NCG (lb/hr)

Q_{NCG} = Mass flow rate of NCG stream (lb/hr)

Steam flow rate was estimated using the following equation:

Q_{steam} (lb/hr) = Brine Flow (lb/hr) x Flash % / 100 (Eq. 3-4)

Where: Flash % = percentage of brine flashed as steam in PTU

Emissions during backflow and well testing events were estimated using the following equation:

E_i (lb/event) = E_i (lb/hr) x Duration (hr/well) x N (Eq.3-5)

Where: E_i = Emission rate of pollutant i

N = Number of wells flowed or tested = 3 wells per event

Annual emissions were estimated using the following equation:

E_i (tpy) = E_i (lb/event) x N' (events/year) /2000 (Eq.3-6)

Where: E_i = Emission rate of pollutant i

N' = Number of events per year

Table 3.1 lists the data required to estimate the emissions from NCG through PTU during backflow and testing.

Table 3.1 Data Required for NCG Emissions during Backflow and Testing

Parameter	Value	Reference	Location

Table 3.1 Data Required for NCG Emissions during Backflow and Testing

Parameter	Value	Reference	Location
C_{NCG} – Weighted average mass concentration of NCG in steam	18,174 lb NCG/10^6 lb steam or 18,174 ppmw	Source test of existing wellheads in Regions 1 and 2, conducted by Thermochem in 2005. Weighted average calculated by AECOM using steam flow at wellhead provided by Applicant.	Attachment A Table 2.1
C_i - Weighted average mass concentration of pollutant i in steam	Varies (lb of i / 10^6 lb steam) or (ppmw)- depending upon the pollutant	Source test of existing wellheads in Regions 1 and 2, conducted by Thermochem in 2005 and Applicant. Weighted average calculated by AECOM using steam flow at wellhead provided by Applicant.	Attachment A Table 2.1
Q_i - Mass flow rate of pollutant i in NCG stream	Varies (lb/hr)- depending upon the pollutant	Various source tests on NCG stream conducted by Applicant.	Attachment A Table 2.2 and 2.3
Q_{NCG} - Mass flow rate of NCG stream	9,500 lb/hr	Provided by Applicant.	Attachment A Table 2.2
Brine flow rate through PTU	Varies (lb/hr) – depending upon the event	Provided by Applicant.	Attachment A Table 2.4
Flash %	25%	Provided by Applicant.	Attachment A Table 2.4
Duration	Varies (hr/well) – 24 hr/well for backflow and 32 hr/well for well testing	Provided by Applicant.	Attachment A Table 2.4
N – number of wells tested per event	3 - each Amended Project plant will have 3 production well and all will be tested	Provided by Applicant.	Attachment A Table 2.4
N' – number of events per year	1 event/year each for flow back and well testing	Provided by Applicant.	Attachment A Table 2.4

Pollutant emission rates from the NCG stream through the PTU during well backflow and testing are provided in Attachment A, Table 2.4. Emission rates were similarly calculated for testing of injection and plant wells through MTU. These estimates are provided in Attachment A, Table 2.5. A summary of well backflow and testing emissions is provided in Attachment A, Table 2.19.

3.1.2 Power Block Commissioning Emissions

Project commissioning will take place in three phases, with each power block commissioned separately, approximately 10 months apart. Commissioning activities involve the following general steps:

- Production wells have a warm up duration of 12 to 16 hours for the first well, followed by 16 to 24 hours for the next two wells (combined). Steam from well warm-ups vents to the PTU at a rate of 250,000 pounds per hour (lbs/hr) per well.
- Production piping and equipment have a warm up duration of 24 to 32 hours. Steam is vented at a rate of 350,000 lbs/hr to the rock muffler.
- Steam blow has a duration of 16 to 24 hours with steam venting at 750,000 lbs/hr to the Rock muffler.
- Turbine and auxiliary loops preheat with a duration of 18 to 24 hours. The total steam flow rate is 350,000 lbs/hr; 50,000 lbs/hr steam flows through the turbine, condenser and RTO, and the balance of 300,000 lbs/hr of steam flows to the rock muffler.
- Turbine load test with a duration of 18 to 24 hours, full steam flow rate of 750,000 lbs/hr through the turbine, condenser and RTO, with no venting of steam directly to atmosphere.
- Turbine performance test has a duration of 18 to 24 hours, with a steam flow rate of 750,000 lbs/hr through the turbine, condenser and RTO, with no venting of steam to atmosphere.

Process units involved in commissioning of the Project include:

- PTU for well warm-up;
- Rock muffler for steam blow, production line and equipment warm-up and turbine and auxiliary loops pre-heating; and
- Steam turbine, followed by condenser, RTO, scrubber and cooling tower for turbine preheat, load and performance test of the turbine.

Point sources of emissions during commissioning include PTU stacks, rock muffler stacks, RTO stacks and the cooling towers. Emissions through the PTUs and rock mufflers were estimated using Equations 3-1, 3-2 and 3-3. Emissions during each event were estimated using the following equation:

$$E_i \text{ (lb/event)} = E_i \text{ (lb/hr)} \times \text{Duration (hr/event)} \qquad \text{(Eq. 3-7)}$$

Where: E_i = Emission rate of pollutant i

During some of the events such as well warm-up, the steam flow will be gradually increased from one well to three wells flowing at different rates. In such cases, the emission rate in pounds per event was estimated for each well and summed to get the total emission rate for the event.

During turbine and auxiliary loop pre-heating, some portion of the steam will be diverted from the rock muffler to the turbine. Steam from the back end of the turbine will be condensed in a shell and tube type condenser. The condensate will be discharged as make-up water to the cooling tower and the NCG stream will be routed to an RTO followed by a quencher and scrubber before being released to the atmosphere. Thus, during this stage of commissioning, there will be three point sources of emission- uncontrolled emissions from rock muffler and controlled emissions from RTO-scrubber stack and cooling tower. Emissions from rock muffler were calculated as described above. Emissions through RTO stack will include oxidized NCG stream components and exhaust from propane combustion in the RTO burner. The combined NCG and exhaust stream is quenched and scrubbed to remove pollutants before being released to the atmosphere. Emissions from the RTO-scrubber stack were calculated using the following equation:

$$E_i \text{ (lb/hr)} = [E_{i,\,burner} + E_{i,\,RTO,\,N} \times Q_{steam,\,C} / Q_{steam,\,N}] \times (1 - eff_i) \quad \text{(Eq. 3-8)}$$

Where: E_i = Emission rate of pollutant i through RTO-scrubber stack (lb/hr)

$E_{i,\,burner}$ = Emission rate of pollutant i from RTO burner exhaust (lb/hr)

$E_{i,\,RTO,\,N}$ = Emission rate of pollutant i due to combustion of NCG in RTO during normal operation (lb/hr)

$Q_{steam,\,C}$ = Steam flow rate through the turbine during commissioning stage (lb/hr)

$Q_{steam,\,N}$ = Steam flow rate through the turbine during normal operation (lb/hr)

eff_i = Control efficiency of scrubber for pollutant i (percent)

Emissions from burner exhaust and RTO during normal operation are described in Section 3.4. Cooling tower emissions during commissioning were assumed to be equal to cooling tower emissions during normal operation and are described in Section 3.5.

Emissions per commissioning event were calculated using Equation 3-7. Annual emissions were calculated using Equation 3-6.

Emissions from RTO-scrubber stack and cooling tower will also occur during turbine load test and turbine performance test. Emissions during these stages were calculated using Equation 3-8. The only difference would be the steam flow rate during various stages.

Table 3.2 lists the data required to estimate the emissions during commissioning.

Table 3.2 Data Required for Emissions During Commissioning

Parameter	Value	Reference	Location
$E_{i,\,burner}$ - Emission rate of pollutant i from RTO burner exhaust	Varies (lb/hr)- depending upon the pollutant.	AECOM estimated. Refer to Section 3.4 for methodology.	Attachment A Table 2.6

Table 3.2 Data Required for Emissions During Commissioning

Parameter	Value	Reference	Location
$E_{i, RTO, N}$ - Emission rate of pollutant i due to combustion of NCG in RTO during normal operation	Varies (lb/hr)- depending upon the pollutant.	AECOM estimated. Refer to Section 3.4 for methodology.	Attachment A Table 2.6
$Q_{steam, C}$ - Steam flow rate through the turbine during commissioning stage	Varies (lb/hr)- depending upon the commissioning stage.	Provided by Applicant.	Attachment A Table 2.6
$Q_{steam, N}$ - Steam flow rate through the turbine during normal operation	750,000 lb/hr of steam	Provided by Applicant.	Attachment A Table 2.10
eff_i - Control efficiency of scrubber for pollutant i	Varies (%)- depending upon the pollutant.	Provided by Applicant.	Attachment A Table 2.6
Duration	Varies (hr/event) – depending upon the event.	Provided by Applicant.	Attachment A Table 2.6

Pollutant emission rates from NCG stream during commissioning are provided in Attachment A, Table 2.6. A summary of commissioning emissions is provided in Attachment A, Table 2.19.

3.2 Start-up and Shut-down Emissions

SU/SD emissions are estimated assuming that each Amended Project plant will have one cold start-up event and three warm-start-up events per year. The plants are base-load facilities. The frequency and duration of unplanned outages is unknown and emissions from the shutdown periods associated with unplanned outages and the emissions associated with the plant re-start events are not estimated.

Cold Start-up Emissions

Cold start-up is similar to commissioning and will include the following process units, and stages:

- PTU for well warm-up;
- Rock muffler for production line and equipment warm-up, turbine and auxiliary loops pre-heating, auxiliary equipment start-up, and trip test; and

- Steam turbine, followed by condenser, RTO, scrubber and cooling tower for turbine preheat, auxiliary equipment start-up and gradual build-up of steam to full production flow rate.

Emissions from PTU and rock muffler were estimated as described above. The only difference will be the steam flow rate during various stages.

The last stage of cold start-up involves gradually increasing the flow of steam to the turbine from one well to three wells (from 250,000 lb/hr to 750,000 lb/hr) over a period of approximately six hours. For emission estimation purposes, it was assumed that the first well will run for six hours, the second well for four, and the third well for two hours. Emissions from RTO during this stage of start up were estimated using the following equation:

$$E_i \text{ (lb/event)} = [E_{i,\text{ burner}} \times (1- \text{eff}_i) \times 6] + [E_{i,\text{ RTO,N}} \times Q_{well} / Q_T \times (1- \text{eff}_i) \times (6+4+2)] \qquad \text{(Eq. 3-9)}$$

Where: E_i = Emission rate of pollutant i through RTO-scrubber stack (lb/event)

$E_{i,\text{ burner}}$ = Emission rate of pollutant i from RTO burner exhaust (lb/hr)

$E_{i,\text{ RTO, N}}$ = Emission rate of pollutant i due to combustion of NCG in RTO during normal operation (lb/hr)

Q_{well} = Steam flow through the turbine when one well is running (250,000 lb/hr)

Q_T = Steam flow through the turbine during normal operation or when all three wells are running (750,000 lb/hr)

eff_i = Control efficiency of scrubber for pollutant i (percent)

Cooling tower emissions during cold start-up were assumed to be equal to cooling tower emissions during normal operation and are described in Section 3.5.

Pollutant emission rates from the NCG stream during cold start-up are provided in Attachment A Table 2.7. A summary of annual cold start emissions is provided in Attachment A Tables 2.20 and 2.21.

Warm Start-up Emissions

The following assumptions were made to estimate the emissions during warm start-up:

1. The plant is not completely shut-down;
2. During plant trips, the steam is diverted from turbine to rock muffler at 750,000 lb/hr for four hours; and
3. Steam is gradually diverted from the rock muffler back to the turbine over a 4 hour period.

Therefore, the warm start-up involves two stages and three point sources of emissions: Stage 1) uncontrolled emissions from rock muffler for four hours at a steam flow of 750,000 lb/hr and Stage 2) gradually decreasing uncontrolled emissions (steam flow varying from 750,000 to 0 lb/hr) from rock muffler and gradually increasing controlled emissions (steam flow varying from 0 to 750,000 lb/hr) from RTO-scrubber and cooling tower.

Uncontrolled emissions from rock muffler during Stage 1 were estimated using the Equations 3-1, 3-2, 3-3, and 3-7. During the Stage 2, when the flow rate is gradually decreased, emissions from rock muffler were calculated using the following equation:

$$E_i \text{ (lb/event)} = \sum [(M_i \times C_{NCG} \times Q_n / 10^6)] \qquad \text{(Eq. 3-10)}$$

Where: Q_n = Average steam flow rate through rock muffler during n^{th} hour (lb/hr)

n = 1 through 4 hours

Average steam flow during n^{th} hour was calculated using the following equation:

$$Q_n \text{ (lb/hr)} = \{750,000 - (n-1) \times \Delta] + [750,000 - n \times \Delta]\}/2 \qquad \text{(Eq. 3-11)}$$

Where: Δ = (750,000-0)/4 = 187,500 lb/hr-hr

Emissions from RTO-scrubber stack were calculated using the following equation:

$$E_i \text{ (lb/event)} = [E_{i,\ burner} \times (1\text{-}eff_i) \times 4] + [E_{i,\ RTO,NI} \times \Delta / Q_T \times (1\text{-}eff_i) \times (4+3+2+1)] \qquad \text{(Eq. 3-12)}$$

Cooling tower emissions during warm start-up were assumed to be equal to cooling tower emissions during normal operation and are described in Section 3.5.

Pollutant emission rates from NCG stream during warm start-up are provided in Attachment A, Table 2.8. A summary of annual cold start emissions is provided in Attachment A, Tables 2.20 and 2.21.

<u>Shut-down Emissions</u>

During shut-down, the steam will be diverted to the rock muffler and the production wells will be gradually taken offline over a period of 12 hours. Therefore, the first well to be taken off-line will only operate for the first four hours during which the steam flow to the rock muffler will be reduced from 750,000 lb/hr to 500,000 lb/hr. During the second four-hour period, steam flow will be further reduced by 250,000 lb/hr, and by the end of the third four-hour period, the steam flow will be reduced to zero. Uncontrolled emissions during shut-down vent from the rock muffler. Total emissions during a shut down event were calculated using the following equation:

$$E_i \text{ (lb/event)} = \sum E_n \qquad \text{(Eq. 3-13)}$$

Where: n = 1 through 3 wells

E_n, = Average emissions when n^{th} well is taken off-line (lb/event)

$$E_n = [(M_i \times C_{NCG} \times Q_n / 10^6)] \times 4 \text{ hr/event} \qquad \text{(Eq. 3-14)}$$

Where: Q_n = Average steam flow rate through rock muffler when n^{th} well is taken offline hour (lb/hr)

Average steam flow during each stage of flow reduction was calculated using the following equation:

$$Q_n \text{ (lb/hr)} = \{750{,}000 - (n-1) \times 250{,}000] + [750{,}000 - n \times 250{,}000]\}/2 \quad \text{(Eq. 3-15)}$$

Pollutant emission rates from NCG stream during shut down are provided in Attachment A Table 2.9. . A summary of annual shut-down emissions is provided in Attachment A Tables 2.20 and 2.21.

3.3 Normal Operating Emissions

During normal operation, expended steam from the back end of the turbine will be condensed in a shell and tube type condenser. The condensate will be discharged as make-up water to the cooling tower (after treatment in the ChemOx system for H_2S removal and the NCG stream will be routed to an RTO followed by a quencher and scrubber before being released to the atmosphere. Thus, during normal operation there will be two point sources of emissions: controlled emissions from RTO-scrubber stack and cooling tower. Emissions through RTO stack will include both oxidized and unoxidized NCG stream components and exhaust from propane combustion in the RTO burner. The combined NCG and burner exhaust stream is scrubbed to remove some of the pollutants, specifically SO_2, however, As and Hg are also removed. Section 3.4.1 describes the methodology used to calculate the emissions from the combustion of NCG in RTO. Section 3.4.2 describes the methodology used to estimate the exhaust emissions from propane combustion in RTO burner. Total emissions from NCG stream are described in Section 3.4.3. Emissions from cooling tower are discussed in Section 3.5.

3.3.1 NCG Combustion Emissions

Emissions of components inherently present in the NCG stream were calculated using the following equation:

$$E_{i,\,RTO,N} \text{ (lb/hr)} = M_{T,i} \times \%\, P_i \times (1 - DRE_i) \quad \text{(Eq. 3-16)}$$

Where: $E_{i,\,RTO,\,N}$ = Emission rate of component i in NCG from RTO during normal operation (lb/hr)

$M_{T,i}$ = Mass flow rate of component i into the turbine (lb/hr)

$\%\, P_i$ = percentage of component i partitioned into NCG stream at the condenser

DRE_i = Destruction and removal efficiency of RTO for component i (percent)

Mass flow rate of component i into the turbine was calculated using the following equation:

$$M_{T,\,i} \text{ (lb/hr)} = M_i \times C_{NCG} \times Q_{steam,N} / 10^6 \quad \text{(Eq.3-17)}$$

Where: M_i = Mass fraction of pollutant i in NCG (lb of i / lb of NCG)

C_{NCG} = Weighted average mass concentration of NCG in steam (ppmw)

$Q_{steam,\,N}$ = Steam flow rate (lb/hr) through turbine (lb/hr)

Mass fraction of pollutant i in NCG was calculated using Equations 3-2 and 3-3.

Emissions of components formed in RTO due to oxidation such as NOx, SOx and CO_2 were calculated using the following equations:

$$E_{NOx, RTO,N} (lb/hr) = M_{T, NH3} \times \% P_{NH3} \times DRE_{NH3} \times 46 / 17 \quad \text{(Eq. 3-18)}$$

$$E_{SOx, RTO,N} (lb/hr) = M_{T, H2S} \times \% P_{H2S} \times DRE_{H2S} \times 64/ 34 \quad \text{(Eq. 3-19)}$$

$$E_{CO2, RTO,N} (lb/hr) = \sum[M_{T, ROC} \times \% P_{ROC} \times DRE_{ROC} \times 44/ MW_{ROC}] \quad \text{(Eq. 3-20)}$$

Where: $E_{NOx, RTO,N}$ = Emissions of NOx from RTO exhaust (lb/hr)

$E_{SOx, RTO,N}$ = Emissions of SOx from RTO exhaust (lb/hr)

$E_{CO2, RTO,N}$ = Emissions of CO_2 from RTO exhaust (lb/hr)

MW_{ROC} = Molecular weight of ROC such as benzene, toluene, xylene into the turbine (lb/hr)

Table 3.3 lists the data required to estimate the NCG emissions during normal operation.

Table 3.3 Data Required for Normal Operating NCG Emissions

Parameter	Value	Reference	Location
% P_i - percentage of component i partitioned into NCG stream at the condenser	Varies (percent)- depending upon the pollutant	Provided by Applicant.	Attachment A Table 2.10
DRE_i - Destruction and removal efficiency of RTO for component i	Varies (percent)- depending upon the pollutant	Provided by Applicant.	Attachment A Table 2.10
C_{NCG} – Weighted average mass concentration of NCG in steam	18,174 lb NCG/10^6 lb steam or 18,174 ppmw	Source test of existing wellheads in Regions 1 and 2, conducted by Thermochem in 2005. Weighted average calculated by AECOM using steam flow at wellhead provided by Applicant.	Attachment A Table 2.1
$Q_{steam, N}$ - Steam flow rate through the turbine during normal operation	750,000 lb/hr of steam	Provided by Applicant.	Attachment A Table 2.10

Emissions from RTO are provided in Attachment A, Tables 2.10 and 2.12.

3.3.2 RTO Burner Emissions

The RTO will be equipped with a 3.0 MMBtu/hr burner that uses propane for fuel. Emissions are calculated based on 8,760 hours per year of continuous operation, thus the emission estimates are conservative (i.e., overestimated) as the burner is unlikely to operate at full capacity for an entire year. Exhaust emissions from the burner due to combustion of propane were calculated using the following equation:

$$E_{i,\ burner}\ (lb/hr) = E.F_i \times Rating / HV_{propane} \qquad \text{(Eq. 3-21)}$$

Where: $E_{i,\ burner}$ = Emission rate of pollutant i from RTO burner exhaust (lb/hr)

$E.F_i$ = Emissions Factor of Pollutant i ($lb/10^3$ gallons)

Rating = burner rating (MMBtu/hr)

$HV_{propane}$ = heating value of propane ($MMBtu/10^3$ gallons)

Emission factors were obtained from AP-42, Chapter 1.5, Table 1.5-1 (EPA, 2008a). The ROC emission factor was calculated as a difference between the TOC and methane emission factors. The SOx emission factor was calculated using the following equation (EPA, 2008a):

$$E.F_{SOx}\ (lb/10^3\ gal) = 0.1 \times S \qquad \text{(Eq. 3-22)}$$

Where: $E.F_{SOx}$ = Emission factor of SOx from RTO burner exhaust ($lb/10^3$ gal)

S = Fuel sulfur content ($gr/100\ ft^3$ of gas)

TAC emissions from the RTO burner were also calculated using Equation 3-21. TAC emission factors for propane combustion were derived from the TAC emission factors for natural gas fired external combustion units. The emission factor for lead was obtained from AP-42, Chapter 1.4 (EPA, 1998b) and other TAC emission factors were obtained from Ventura County Air Pollution Control District, AB2588 Combustion Emission Factors (VCAPCD, 2001). The methodology described in footnote (a) of AP-42, Chapter 1.5, Table 1.5-1 (EPA, 2008a) and given by the following equation was used to calculate TAC emission factors for propane combustion:

$$E.F_{TAC,\ propane}\ (lb/10^3\ gal) = E.F_{TAC,\ natural\ gas} \times HV_{propane} / HHV_{natural\ gas} \qquad \text{(Eq. 3-23)}$$

Where: $E\ F_{TAC\ propane}$ = Emission factor of TAC in propane combustion exhaust ($lb/10^3$ gal)

$E.F_{TAC,\ natural\ gas}$ = Emission factor of TAC in natural gas combustion exhaust (lb/MMscf) (See note 1 in Table 3.4)

$HHV_{natural\ gas}$ = High heating value of natural gas (Btu/scf)

Table 3.4 lists the data required to estimate the emissions from RTO burner.

Table 3.4 Data Required for RTO Burner Emissions

Parameter	Value	Reference	Location
$E.F_i$ - = Emissions Factor of Pollutant i	Varies (lb/10^3 gal)- depending upon the pollutant	AP-42, Chapter 1.5, Table 1.5-1 (EPA, 2008a)	Attachment A Table 2.11
Burner rating	3 MMBtu/hr	Provided by Applicant.	Attachment A Table 2.11
$HV_{propane}$ - Heating value of propane	91.5 MMBtu/10^3 gallon, Higher heating value (HHV)	AP-42, Chapter 1.5, Table 1.5-1, footnote a (EPA, 2008a)	Attachment A Table 2.11
S - Fuel sulfur content	0.2 gr/100 scf	AECOM assumed	Attachment A Table 2.11
$E.F_{TAC,\ natural\ gas}$ - Emission factor of TAC in natural gas combustion exhaust	Varies (lb/MMscf)- depending upon the pollutant	Lead - AP-42, Chapter 1.4, Table 1.4-2. (EPA, 1998b) Other TACs - VCAPCD AB2588 combustion emission factors for natural gas fired external combustion equipment below 10 MMBtu/Hr (VCAPCD, 2001)	Attachment A Table 2.11
$HHV_{natural\ gas}$[1]	1,020 Btu/scf	AP-42, Chapter 1.4, Table 1.4-2, footnote a (EPA, 1998b)	Attachment A Table 2.11
1. Natural gas will not be used for the Amended Project; however, as EPA has not published TAC emission factors for propane use, the TAC emission factors for natural gas were applied. The natural gas TAC factors were adapted for use with propane using the ratio of heating value for the two fuels.			

Emissions from RTO burner are provided in Attachment A, Tables 2.11 and 2.12.

3.3.3 Total NCG Emissions

Total emissions from RTO include emissions of components inherently present in NCG stream, emissions of components formed due to oxidation of NCG components in the RTO, and exhaust emissions from RTO burner. All these emissions will be routed as a single stream to a caustic scrubber before being released to the atmosphere. Final emissions from the Scrubber stack were estimated using the following equation:

$$E_i\ (lb/hr) = [E_{i,\ burner} + E_{i,\ RTO,\ N}] \times (1 - eff_i) \qquad \text{(Eq. 3-24)}$$

Where: E_i = Emission rate of pollutant i through RTO-scrubber stack (lb/hr)

$E_{i,\ burner}$ = Emission rate of pollutant i from RTO burner exhaust (lb/hr)

$E_{i, RTO, N}$ = Emission rate of pollutant i due to combustion of NCG in RTO during normal operation (lb/hr)

eff_i = Control efficiency of scrubber for pollutant i (percent)

Annual emissions were calculated as a product of hourly emissions and 8,760 hours per year of operation.

Final emissions from RTO-scrubber stack are provided in Attachment A, Table 2.12.

3.4 Cooling Tower Emissions

Condensed steam from the turbine-condenser will be used as make-up water to the cooling tower. (Note that the Amended Project will also use water from the Imperial Irrigation District under certain circumstances to supplement condensate in the cooling tower.) The cooling tower will be used during normal operations and during some stages of commissioning and cold start-up. Emissions from the cooling tower are assumed to be same during all these operating scenarios. Emissions from cooling tower include PM formed from solids and off-gases from gases dissolved in circulating water. Section 3.5.1 describes the methodology used to estimate PM10 and PM2.5 emissions from cooling tower. Toxic emissions in the form of PM or gases are discussed in Section 3.5.2

3.4.1 Cooling Tower PM10 and PM2.5 Emissions

Because wet cooling towers provide direct contact between the cooling water and the air passing through the tower, some of the liquid water may be entrained in the air stream and be carried out of the tower as "drift" droplets. PM10 emissions are generated when the drift droplets evaporate and leave fine PM formed by crystallization of dissolved solids. Dissolved solids found in cooling tower drift can consist of mineral matter, chemicals for corrosion inhibition, etc. As described in EPA AP-42, Section 13.4, Wet Cooling Towers (EPA, 1995), PM emissions are calculated by multiplying the total liquid drift factor by the Total Dissolved Solids (TDS) fraction in the circulating water. PM10 emissions are estimated by assuming that once the water evaporates, all of the solid particles are within the PM10 size range. Hourly PM10 emissions were calculated according to the following equation:

$$\text{Emissions (lb/hr)} = \text{WCR} \times 60\ \text{min/hr} \times (\text{Drift \%} / 100) \times \text{Density}_W \times \text{TDS} \times \text{PM10 fraction} \qquad \text{(Eq. 3-25)}$$

Where: WCR = Water Circulation Rate, gallons per minute

$Density_W$ = Density of water (lb/gallon)

TDS = Total Dissolved Solids, ppm ($lb/10^6$ lb water)

Drift % = Drift eliminator efficiency (percent)

It was assumed that 100 percent of the PM emissions are PM10 and 100 percent of the PM10 emissions are PM2.5.

Table 3.5 lists the data required to estimate the PM emissions from cooling tower.

Table 3.5 Data Required for Cooling Tower PM10 and PM2.5 Emissions

Parameter	Value	Reference	Location
WCR - Water Circulation Rate	89,112 gpm	Provided by WorleyParsons.	Attachment A Table 2.13
$Density_W$ - Density of water	8.3453 (lb/gallon)	Perry's Chemical Engineer's Handbook	Attachment A Table 2.13
Drift %	0.0005%	Applicant/BACT	Attachment A Table 2.13
TDS - Total Dissolved Solids	7,952 ppmw	Existing cooling tower blowdown water quality analysis, Applicant.	Attachment A Table 2.13
PM10 fraction	1	AECOM assumption[1]	Attachment A Table 2.13
1. The assumption that 100 percent of PM is PM10 is a conservative assumption (i.e., overestimates emissions). This assumption is consistent with guidance that CEC has provided on several previous AFC submittals.			

Daily emissions were calculated based on the maximum daily operating schedule of 24 hours per day. Annual emissions were calculated assuming continuous operation for 8,760 hours per year. Cooling tower PM10 and PM2.5 emissions are presented in Attachment A, Table 2.13.

3.4.2 Cooling Tower TAC Emissions

The Project proposes to use a wet cooling tower for power plant cooling. Condensate will be used as cooling tower make-up water. As noted, the Amended Project will also use water from the Imperial Irrigation District under certain circumstances to supplement condensate in the cooling tower. Low levels of toxic inorganic and organic constituents were identified in the condensate at the existing geothermal power plants in the region. Non-volatile TAC emissions were calculated according to the following equation:

$$ER = (WCR \times 60 \text{ min/hr} \times 3.785 \text{ L/gal} \times TAC \times 1\text{g} / 10^6 \mu\text{g} \times DF \times CC) / (453.6 \text{ g/lb}) \quad \text{(Eq. 3-26)}$$

Where: ER = Emission Rate (lb/hr)

WCR = Water circulation rate (gal/min)

DF = Drift fraction (dimensionless)

TAC = TAC concentration (μg/liter)

CC = Cycles of concentration

Cycles of concentration were calculated using the following equation:

$CC = MR / (MR-ER)$ (Eq. 3-27)

Where: MR = Make up water rate (gpm)

ER = Evaporation water rate (gpm)

The following equation was used to calculate volatile TAC emissions:

$ER = MR \times 60 \text{ min/hr} \times 3.785 \text{ liters/gal} \times TAC \times VF / (10^6\ \mu g/g \times 453.6 \text{ g/lb})$ (Eq. 3-28)

Where: ER = Emission Rate (lb/hr)

MR = Make up water rate

TAC = TAC concentration (μg/liter)

VF = Volatilization Fraction (assumed to be one)

H_2S emissions were calculated using the following equation:

$ER_{H2S,CT} \text{(lb/hr)} = M_{T,H2S} \times (1- \% P_{H2S}) \times (1- \text{Control eff})$ (Eq. 3-29)

Where: $ER_{H2S,CT}$ = Emission Rate of H_2S from cooling tower (lb/hr)

$M_{T,H2S}$ = Mass flow rate of component H_2S into the turbine (lb/hr)

$\% P_{H2S}$ = percentage of component H_2S partitioned into NCG stream at the condenser

Control eff = Control efficiency of ChemOx control system (percent)

In addition, the cooling tower will be a source for chloroform emissions from the application of sodium hypochlorite as a biocide for cooling tower maintenance. Biocide usage is estimated by the AECOM based on experience with similar applications. Chloroform emissions are estimated using the following equation:

$E = EF \times \text{biocide usage (gal/hr)} \times \rho \times C \times ME$ (Eq. 3-30)

Where: E = Emissions (lbs/hr)

EF = emission factor of chloroform (lb of chloroform per lb of chlorine)

ρ = density of sodium hypochlorite (lb/gallon)

C = hypochlorite concentration (percent)

ME = molar equivalent (moles of chlorine per mole of sodium hypochlorite)

The emission factor is taken from study contracted by CARB for sources of chloroform in the South Coast Air Basin (M.B. Rogozen et al., 1998).

Table 3.6 lists the data required to estimate the TAC emissions from cooling tower.

Table 3.6 Data Required for Cooling Tower TAC Emissions

Parameter	Value	Reference	Location
WCR - Water Circulation Rate	89,112 gpm	Provided by Applicant.	Attachment A Table 2.15
TAC – TAC concentration	Varies (μg/liter) – depending upon the contaminant	Water Quality analysis of Unit 4 Hotwell	Attachment A Table 2.14
DF -Drift fraction	0.0005%	BACT	Attachment A Table 2.15
MR – Make-up water rate	1,329 gpm	Worley Parsons' water balance	Attachment A Table 2.15
ER- Evaporation rate	1,267 gpm	Worley Parsons' water balance	Attachment A Table 2.15
VF- Volatilization fraction	1	AECOM assumption[1]	Attachment A Table 2.15
$M_{T,H2S}$ - Mass flow rate of component H_2S into the turbine	Varies (lb/hr)- depending upon the steam flow rate to the turbine	AECOM estimated using Equation 3-17	Attachment A Table 2.10
% P_{H2S} - H_2S partitioned into NCG stream at the condenser	60 %	Provided by Applicant.	Attachment A Table 2.10
Control eff - Control efficiency of ChemOx	95%	Applicant	Attachment A Table 2.15
EF - emission factor of chloroform	0.0034 lb of chloroform per lb of chlorine	M.B. Rogozen et al., 1998	Attachment A Table 2.15
ρ - density of sodium hypochlorite	10 lb/gal	MSDS	Attachment A Table 2.15
C – Hypochlorite concentration in solution	12.5%	AECOM assumption	Attachment A Table 2.15
ME – Molar equivalent	0.95 moles of chlorine per mole of sodium hypochlorite	AECOM estimation	Attachment A Table 2.15

1. The assumption that 100 percent of the species volatilizes is a conservative assumption that ensures that emissions are not underestimated. In actual operation, it is likely that some portion of the specie would be discharged with the blowdown and injected in the formation.

TAC emissions from cooling tower are provided in Attachment A, Table 2-15.

3.5 Emergency Diesel-Fired Engines Emissions

3.5.1 Diesel Engine Criteria Pollutant Emissions

The assumptions made regarding emergency engine operation used as the basis for emission calculations include:

- One 146 kW diesel-fired, 2011 model year Tier 4 engine (fire water pump) for all three Amended Project plants;
- One 1.0-MW diesel-fired engine, 2011-2014 model year Tier 4 engine (generator engine) for each Amended Project plant;
- One 1.5-MW diesel-fired engine, 2011-2014 model year Tier 4 engine (generator engine) for each Amended Project plant;
- The calculations assume the use of ultra-low sulfur (15 ppm) diesel fuel;
- Each emergency generator engine will be operated for one one-hour test per week, not to exceed 20 hours per year;
- The fire water pump will be operated for one-hour test per day approximately biweekly, not to exceed 50 hours per year;
- Emissions do not reflect emergency use; and
- 100 percent of the PM10 emissions are assumed to be PM2.5.

The emergency diesel fire water pump engine will operate a maximum of 50 hours per year for testing and maintenance and will have an output of 146 kW. The pump engine will comply with ATCM (Air Toxic Control Measures) Tier 4 standards. Exhaust emissions for NOx, CO, ROC and PM10 were estimated using the Tier 4 emission limits specified in CCR, Title 13, Division 3, Chapter 9, Article 4, Section 2423 and shown in Attachment A Table 2.16. SOx emissions were calculated using a fuel sulfur content of 15 ppmw. Emergency fire water pump engine emissions are presented in Attachment A Table 2.16. Emission estimates do not include emergency use.

The six emergency diesel generators will operate a maximum of 20 hours per year for testing and maintenance; three will have an output of 1.0 MW and three will have an output of 1.5 MW. The generators will comply with ATCM (Air Toxic Control Measures) Tier 4 standards. Exhaust emissions for NOx, CO, ROC and PM10 were estimated using the Tier 4 emission limits specified in CCR, Title 13, Division 3, Chapter 9, Article 4, Section 2423, and shown in Attachment A Table 2.16. SOx emissions were calculated using a fuel sulfur content of 0.0015 weight percent (15 ppmw). Emergency diesel generator emissions are presented in Attachment A Table 2.16. Emission estimates do not include emergency use.

The calculation procedure for NOx, CO, PM10, and ROC are similar to one another; only the emission factors differ between the calculations. NMHC is assumed to be equivalent to ROC.

NOx, CO, ROC and PM10 Emission Calculations

The daily emissions are based on operating the engine no more than one hour during a day at full load for readiness testing. Therefore, the daily emissions are equal to the hourly emissions. Annual emissions are based on readiness testing up to 20 hours per year for generator engines and 50 for fire engines. Hourly emissions are calculated using the following equation:

Emissions (lbs/hr) = EL (g/kW-hr) x Engine Capacity (kW) ÷ 453.6 g/lbs (Eq. 3-31)

Where: EL = Tier 4 ATCM emission limit

SOx Emission Calculations

SOx emission factors are based on fuel use and a fuel sulfur content of 15 ppmw. The emission factor for SOx was calculated by assuming that 100 percent sulfur present in fuel is oxidized to SO_2. Following equation was used to calculate the SOx emission factor:

EF (lbs/Hp-hr) = (BSFC x S x MW_{SO2}) / (HV x 100 x MW_S) (Eq. 3-32)

Where: EF = Emission factor (lb/hr)

BSFC = Brake Specific Fuel Consumption (Btu/Hp-hr)

S = Sulfur content of diesel fuel (percent)

MW_{SO2} = Molecular weight of SO_2 = 64.07 lb/mole

HV = Heating value of diesel (Btu/lb)

MW_S = Molecular weight of sulfur = 32 lb/mole

Hourly SOx emissions were calculated using the following equation:

Emissions (lbs/hr) = EF (lb/Hp-hr) x Engine Capacity (Hp) (Eq. 3-33)

Annual emissions were estimated as a product of hourly emissions and the maximum annual operating hours.

Table 3.7 lists the data required to estimate the exhaust emissions from emergency engines.

Table 3.7 Data Required for Emergency Engine Emissions

Parameter	Value	Reference	Location
EL – Emission limits for NOx, CO, ROC and PM10	Varies depending upon the pollutant, engine capacity and equipment manufacturing date (g/kW-hr)	Tier 4 emission limits specified in CCR, Title 13, Division 3, Chapter 9, Article 4, Section 2423	Attachment A Table 2.16

Table 3.7 Data Required for Emergency Engine Emissions

Parameter	Value	Reference	Location
Engine Capacity	196 Hp for fire water pump; 1.0 and 1.5 MW for generators	Applicant	Attachment A Table 2.16
Annual operating hours	Generators- 20 hr/year, fire pump – 50 hr/year	Provided by Applicant.	Attachment A Table 2.16
S- Sulfur content in diesel	15 ppmw	AECOM assumed/BACT	Attachment A Table 2.16
BSFC - Brake Specific Fuel Consumption	7,000 Btu/Hp-hr	AP-42, Chapter 3.3 (EPA, 1996)	Attachment A Table 2.16
HV- Heating Value of diesel	19,300 Btu/lb	AP-42, Chapter 3.3 (EPA, 1996)	Attachment A Table 2.16

Table 2.16 in Attachment A present the emissions from the diesel generators and fire water pump engines.

3.5.2 Diesel Engine TAC Emissions

The Project will operate seven diesel-fueled emergency engines as described above. TAC emissions from these units were quantified for routine testing and maintenance operation only, which will be limited to no more than 50 hours per year for fire water pump and 20 hours per year for the six generators. TAC emissions were characterized as aggregate particulate emissions (diesel particulate matter [DPM]) from diesel-fired engines (OEHHA, 2003). DPM emissions are calculated according to Equation 3-31, and the DPM is assumed to be equal to the PM10 emissions. Note that the TAC emissions are estimated for maintenance and testing operations, and do not reflect emergency use. Emission estimates for TACs which are assumed to be PM10 for the diesel engines are shown in Attachment A, Table 2.16.

3.6 Operations & Maintenance Equipment Emissions

The facility will require periodic vehicle travel and equipment use for routine maintenance, inspections, and repairs. Criteria pollutant emissions are expected from the combustion of fuels in these equipment and vehicles. Fugitive PM10 emissions are also expected from vehicle traffic.

Criteria pollutant emissions from equipment used were calculated as described in Section 2.1.1. Vehicle criteria pollutant emissions were calculated as the anticipated miles traveled multiplied by the appropriate emission factor. The emission factors were derived using the methodology described in Section 2.1.2. Fugitive PM10 and PM2.5 emission factor from vehicle travel on paved and unpaved roads were calculated as described in Section 2.1.3. Annual equipment and vehicle usage rate (hours per year) and hourly vehicle distances were assumed based on knowledge of the operating practices at the existing geothermal facilities operated by the Applicant's affiliate. Emissions from O&M equipment are shown in Attachment A, Table 2.17.

3.7 Hydrochloric Acid Loading Emissions

This section describes the methodology and assumptions used to calculate emissions of hydrochloric acid (HCl) during truck offloading into a storage tank. It was assumed that the hydrochloric acid will be delivered offsite at a concentration of 37 percent by weight. Emission rates vary depending on the throughput which was assumed to be 8,000 gallons per hour (i.e. one full tank truck emptied in one hour). The following steps were performed to estimate HCl emission rates tank loading:

- HCl loading loss emission factor was calculated; and
- Loading loss factor was multiplied by the throughput resulting in an HCl emission rate.

The following equation from EPA AP-42 Section 5.2 (EPA, 2008b) was used to determine the loading loss emission factor:

$$L_L = 12.46 \times S \times P \times M / T \quad \text{(Eq. 3-34)}$$

where: L_L = Loading loss for products (lb/1000 gallons loaded)

S = saturation factor

P = Vapor pressure of material loaded (psia)

M = Vapor molecular weight (lb/lb-mole)

T = Loading temperature (°R)

Vapor molecular weight was estimated using the following equation (EIIP, 2005):

$$M = \sum(y_x \times M_x) \quad \text{(Eq. 3-35)}$$

Where: x = Species in the liquid product (HCl and water)

y_x = Vapor mole fraction of specie x (mole of x/mole of vapor)

M_x = Molecular weight of specie x (lb/mole)

Vapor mole fraction is given by the following equation (EIIP, 2005):

$$y_x = P_x / P \quad \text{(Eq. 3-36)}$$

Where: P_x = Partial pressure of species x (psia)

Total vapor pressure (P) of HCl solution was obtained from MSDS of 37 percent HCl. Partial pressure of water was calculated using the following equation:

$$P_x = m_x \times VP_x \quad \text{(Eq. 3-37)}$$

Where: m_x = Liquid mole fraction of specie x (moles of water/moles of liquid)

VP_x = True vapor pressure of species x (psia)

$m_x = (Z_x / M_x) / \sum(Z_x / M_x)$ (Eq. 3-38)

Where: Z_x = liquid mass fraction (lb/lb of liquid)

Partial pressure of HCl (P_{HCl}) was calculated, using Dalton's law of partial pressure, as total pressure (P) minus partial pressure of water (P_{H2O}).

Emissions of HCl were calculated using the following equation:

E_{HCl} (lb/hr) = L_L (lb/10^3 gal) x Q (gal/hr) x X_{HCl} (Eq. 3-39)

Where: E_{HCl} = Emission rate for HCl (lb/hr)

Q = Throughout of liquid loaded into the tank

X_{HCl} = Vapor mass Fraction (lb of HCl / lb of vapor)

Vapor mass fraction for HCl was calculated using the following equation:

$X_x = y_x \times M_x / M$ (Eq. 3-40)

Table 3.8 lists the data required to estimate the emissions during HCl loading into storage tanks.

Table 3.8 Data Required for HCl Loading Emissions

Parameter	Value	Reference	Location
S – Saturation Factor	1	AECOM assumed from EPA AP-42, Section 5.2 Table 5.2-1 (EPA,2008b)	Attachment A Table 2.18
P – vapor pressure of liquid	150 mm Hg or 2.9 psia for 37% HCl solution at 20 °C	MSDS	Attachment A Table 2.18
T – Liquid temperature	20 °C or 528 °R	AECOM assumed	Attachment A Table 2.18
M_x – Molecular weight	HCl – 36.46 lb/mole, water – 18 lb/mole		Attachment A Table 2.18
VP – true vapor pressure	Vapor pressure of water at 20 °C = 17.54 mm Hg	Perry's Chemical Engineer's Handbook	Attachment A Table 2.18
Z – Mass fraction of species in liquid	HCl = 0.37, water = 0.63	AECOM assumption	Attachment A Table 2.18

Table 3.8 Data Required for HCl Loading Emissions

Parameter	Value	Reference	Location
Q- Throughput	8,000 gallons/hr	AECOM assumption	Attachment A Table 2.18

HCl emissions from loading into a storage tank are shown in Attachment A Table 2.18.

3.8 Summary of Operational Emissions

Operational criteria pollutant and TAC emissions for the Project are shown in Attachment A Tables 2.19 for well flow back, testing and commissioning. Table 2.20 provides the normal annual emissions from one Amended Project plant and Table 2.21 provides the normal annual emissions from all three Amended Project plants.

4.0 Operating Greenhouse Gas Emissions

Geothermal NCGs are potential sources of greenhouse gases (GHG), including carbon dioxide (CO_2) and methane (CH_4). Other minor sources of GHG at the proposed Project will include RTO burner, diesel engines and O&M equipment. GHG emissions from these sources include CO_2, CH_4 and nitrous oxide (N_2O). The methodology used to calculate GHG emissions from these sources is explained below.

4.1 GHG Emissions from NCGs

GHG emitted from NCG stream mainly consist of CO_2 emissions, with lesser amounts of methane (which is oxidized in the RTO to CO_2 and water). CO_2 emissions were calculated along with other NCG components during normal operation. The methodology described in Section 3.4.1 was used to estimate CO_2 emissions from NCGs.

4.2 Propane Combustion GHG Emissions

Combustion of propane in RTO burner generates GHG emissions including CO_2, CH_4 and N_2O. Equivalent CO_2 emissions (CO_2e) were estimated using the following equation:

$$E_{GHG} = \text{fuel use (MMBtu/year)} \times EF_{GHG} \times \text{conversion factor} \qquad \text{(Eq. 4-1)}$$

Where: E_{GHG} = Emissions of a GHG (metrics tons/yr)

EF_{GHG} = emission factor for each GHG (kg GHG/MMBtu)

conversion factor = conversion factor for kg to metric tons

Emissions factors were obtained from “CARB Compendium of Emission Factors and Methods to Support Mandatory Reporting of Greenhouse Gas Emissions, Appendix A” (CARB, 2007c) for propane use in stationary combustion device.

4.3 Emergency Internal Combustion Engine GHG Emissions

GHG emissions from operation of the emergency diesel-fueled engines are based upon the estimated usage by the Project (50 hours per year for fire pump and 20 hours per year for each generator engine), the estimated fuel consumption and the emission factors listed in “CARB Compendium of Emission Factors and Methods to Support Mandatory Reporting of Greenhouse Gas Emissions, Appendix A” (CARB, 2007c) for stationary combustion devices. The emissions are calculated according to following equation:

$$E_{GHG} = \text{fuel use} \times EF_{GHG} \times \text{conversion factor} \qquad \text{(Eq. 4-2)}$$

Where: E_{GHG} = Emissions_{GHG}, (metrics tons/yr)

EF_{GHG} = emission factor for each GHG conversion factor = conversion factor for kg to metric tons

Emission calculations are shown in Attachment A Table 2.23. Note that the GHG emissions are estimated for maintenance and testing operations, and do not reflect emergency use.

4.4 Operations & Maintenance Equipment and Vehicle Emissions

GHG emissions from vehicles used during normal operation are based upon the predicted hourly miles traveled and annual hours of operation for the Project. The emissions factors for CO_2 for different vehicle types were derived, as described in Section 2.1.2, from the EMFAC2007 BURDEN model (CARB, 2007b) results for 2010. Emissions factors for CH_4 and N_2O were obtained from "CARB Compendium of Emission Factors and Methods to Support Mandatory Reporting of Greenhouse Gas Emissions, Appendix A" (CARB, 2007c) for mobile sources. Annual emissions of GHG were calculated using the following equations:

$$E_{GHG} = EF_{GHG} \times \text{Hourly usage} \times \text{annual usage} \times \text{conversion factor} \quad \text{(Eq. 4-3)}$$

Where: EF_{GHG} = Emission factor of GHG (lb/mile)

Hourly Usage = Vehicle-miles-traveled (miles/hr)

Annual Usage = Operating hours/year

conversion factor = conversion factor for lb to metric tons

Emission factors for GHG emissions from equipment use for operation and maintenance were derived by running the OFFROAD model, as described in Section 2.1.1. The following equation was used to estimate the annual GHG emissions:

$$E_{GHG} = EF_{CO2e} \times \text{annual usage} \times \text{conversion factor} \quad \text{(Eq. 4-4)}$$

Where: EF_{CO2e} = Equivalent CO_2e emission factor of (lb/hr)

Annual Usage = Operating hours/year

conversion factor = conversion factor for lb to metric tons

$$EF_{CO2e} = EF_{CO2} + (21 \times EF_{CH4}) + (310 \times EF_{N2O})$$

Where: EF_{CO2} = CO_2 emission factor of (lb/hr)

EF_{CH4} = CH_4 emission factor (lb/hr)

EF_{N2O} = N_2O emission factor (lb/hr)

Emission calculations are shown in Attachment A Table 2.22.

4.5 Summary of GHG Emissions

CO_2 equivalent emissions are calculated using the global warming potential (GWP) provided in "CARB Compendium of Emission Factors and Methods to Support Mandatory Reporting of Greenhouse Gas Emissions, Appendix A" (CARB, 2007c). For example, the GWP of methane is 21 times that of CO_2 and the GWP of nitrous oxide is 310 times that of CO_2. Total GHG emissions are shown in Attachment A Table 2.23.

5.0 References

40 Code of Federal Regulations Part 60, New Source Performance Standard (NSPS), Subpart IIII

CARB, 2007a. California Air Resources Board OFFROAD2007 Model, version 2.0.1.2, http://www.arb.ca.gov/msei/offroad/offroad.htm, December 15.

CARB, 2007b. California Air Resources Board EMFAC2007 (version 2.3) Burden Model available online at: http://www.arb.ca.gov/msei/onroad/latest_version.htm.

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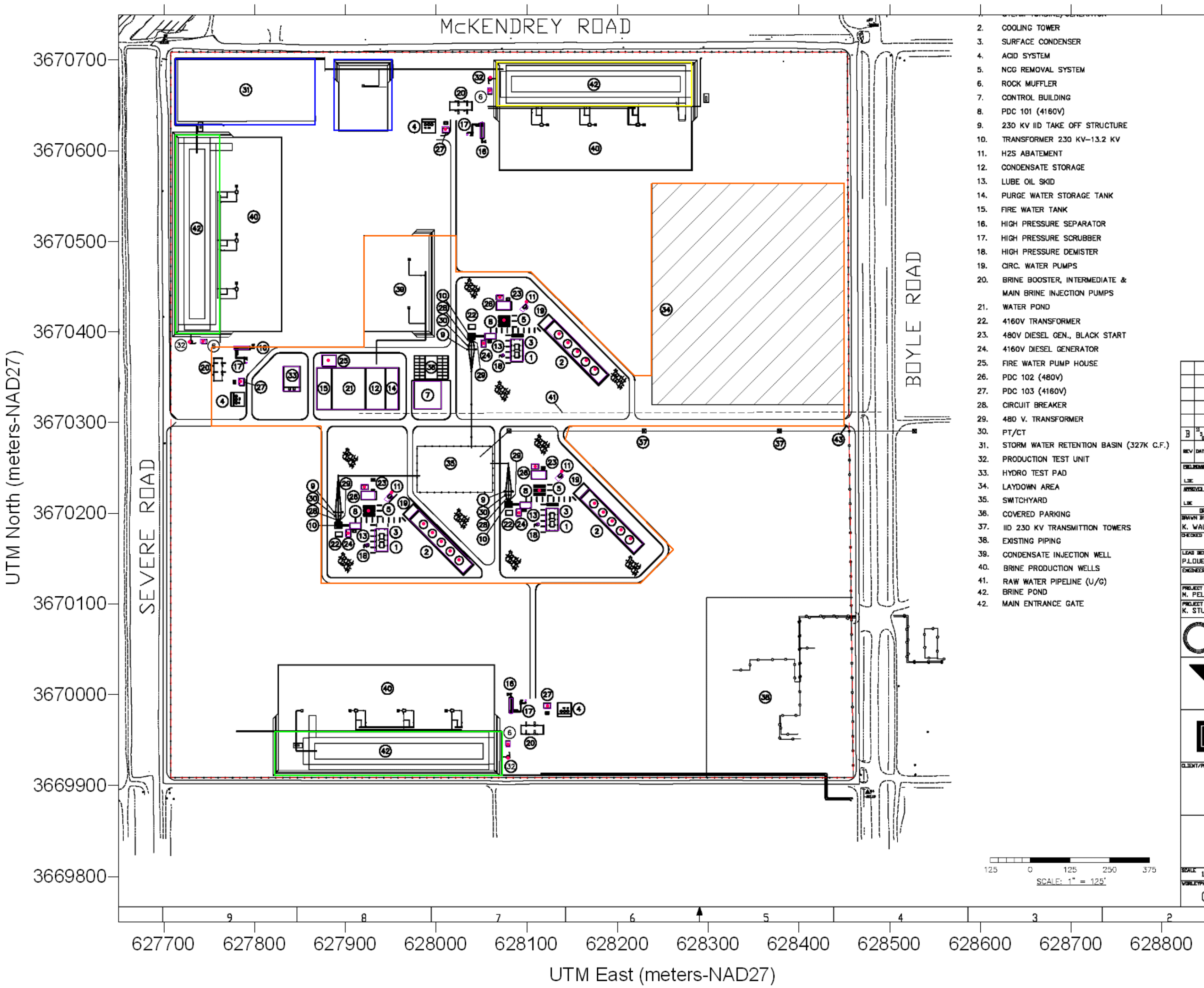
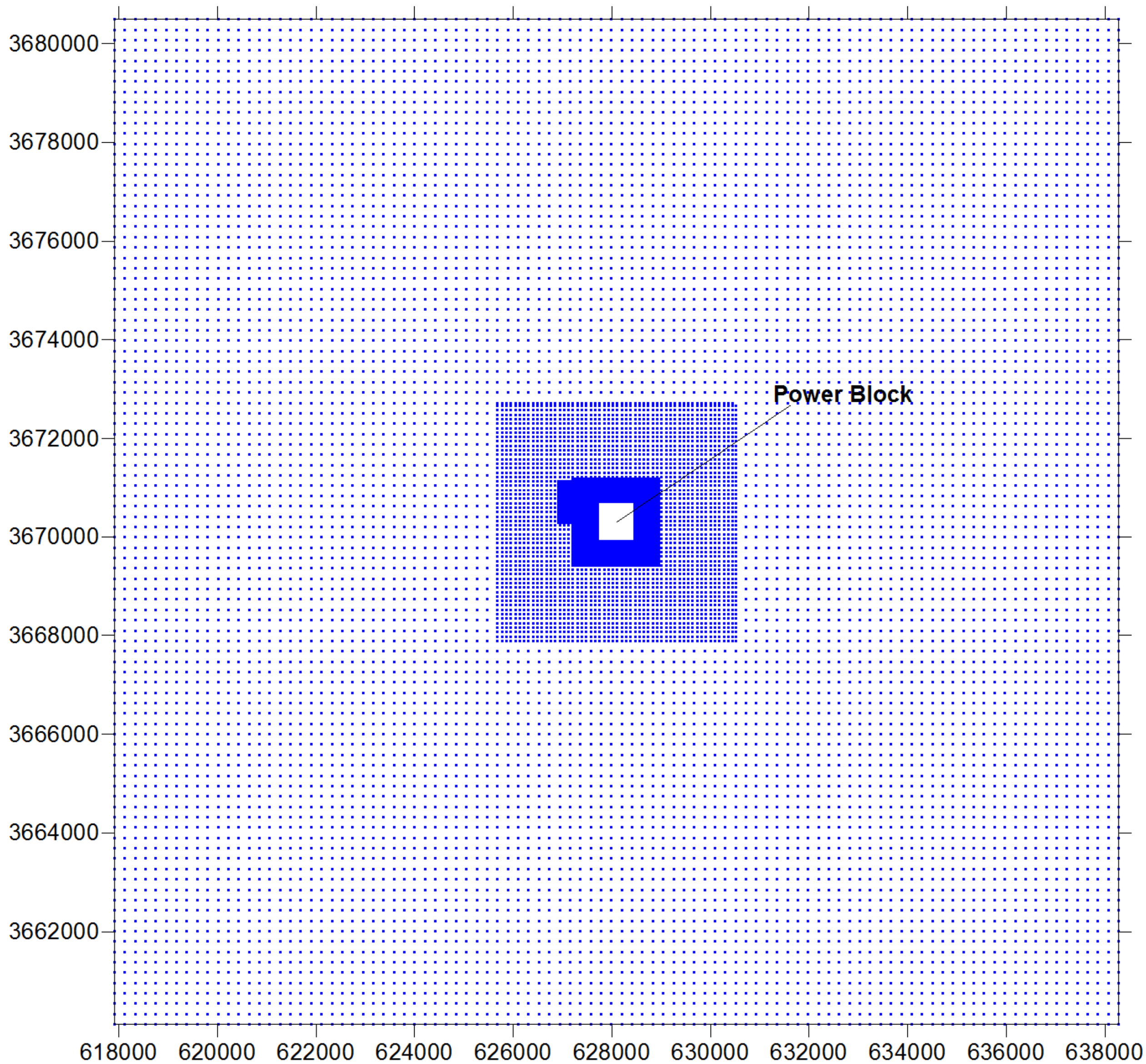
Attachment A
Emission Calculation Worksheets (provided on CD)

Black Rock Site Map Plot Plan



Coarse and Refined Receptor Grids (30m, 90m, 210m)



APPENDIX E.5

Modeling Archive
(provided on CD-ROM)