APPENDIX 5.5B

Offsite Consequence Analysis

TECHNICAL MEMORANDUM CH2MHILL

Off-Site Consequence Analysis
Carlsbad Energy Center Project

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Carlsbad Energy Center LLC is proposing to develop the Carlsbad Energy Center Project (CECP) to meet the needs of local load and contribute to the electricity reserves that will ensure a reliable energy supply in southern California. CECP will be a nominally rated 540 megawatt (MW) net, 558 MW gross combined-cycle generating facility configured using two trains with one natural-gas-fired combustion turbine and one steam turbine per train (or unit). The site is located north of the intersection of Carlsbad Blvd. and Cannon Road, in the City of Carlsbad, San Diego County.

The combustion turbine units selected for the project include state-of-the-art combustors designed to control emissions of NO_X. In addition, the heat recovery steam generators will include selective catalytic reduction (SCR) systems to further control NOx concentrations in the exhaust stacks. The SCR process will use 19 percent aqueous ammonia. The SCR equipment will include a reactor chamber, catalyst modules, ammonia storage system, ammonia vaporization and injection system, and monitoring equipment and sensors.

The CECP facility will store the 19-percent aqueous ammonia solution in two stationary aboveground storage tanks. The capacity of the tanks will be approximately 10,000 gallons each, however each tank will only be filled to 85 percent capacity or 8,500 gallons. The tanks will each be surrounded by covered secondary containment structures fitted with two 4.5-foot-square drainage grates. Each tank will be provided with its own secondary containment area capable of holding the full contents of the tanks, plus rainwater accumulation approximating a 24-hour period from a 25-year storm event.

Aqueous ammonia will be delivered to the plant by truck transport. The unloading area will be located on an unloading apron adjacent to the storage tank. The ammonia delivery truck unloading station will include a curbed and sloped pad surface that will slope to a collection trough which will drain into the ammonia tank secondary containment structure. The use of 19 percent aqueous ammonia will require an average of approximately 1 or 2 deliveries of ammonia per month, with a maximum of 5 deliveries per month during peak operations. The ammonia unloading area will be a bermed area approximately 1-foot deep.

An offsite consequence analysis (OCA) was performed for the accidental release of aqueous ammonia at CECP. The analysis consists of a worst case accidental release scenario involving the failure and complete discharge of the contents of one aqueous ammonia storage tank into the secondary containment structure. This analysis does not explore both tanks failing simultaneously because such an event carries an extremely low probability. Furthermore, due to the location of both tanks, the wind direction of a worst case scenario

involving both tanks simultaneously failing would be the determining factor, and discharge from one of the tanks would not leave the property. Therefore, only a one tank failure has been analyzed.

Analysis

An analysis of a tank failure and subsequent release of aqueous ammonia was prepared using a numerical dispersion model. The analysis assumed the complete failure of the storage tank, the immediate release of the contents of the tank and the formation of an evaporating pool of aqueous ammonia within the secondary containment structure. Evaporative emissions of ammonia would be subsequently released into the atmosphere. Meteorological conditions at the time of the release would control the evaporation rate, dispersion and transport of ammonia released to the atmosphere. For purposes of this analysis, the following meteorological data were used:

- U.S. Environmental Protection Agency (USEPA) default (worst case) meteorological data, supplemented by daily temperature data as defined by 19 CCR 2750.2.
- USEPA default meteorological data for the alternative case release, representing typical site meteorological conditions.

The maximum temperature recorded near the CECP in the past 3 years was 108°F or 315.3 Kelvin, measured at the Western Regional Climate Center Station in Oceanside Marina, California (http:// http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca6377). Maximum temperatures combined with low wind speeds and stable atmospheric conditions would be expected to result in the highest ammonia concentrations at the furthest distance downwind of the release site.

Table 1 displays the meteorological data values used in the modeling analysis.

Parameter	Worst Case Meteorological Data
Wind Speed meters/second	1.5
Stability Class	F
Secondary Containment Area, Square Meters	3.763
Relative Humidity, Percent	50
Initial Ammonia Emission Rate, Kilograms/Second	0.01701
Ambient Temperature, Kelvin (°F)	315.3 (108)

Model runs were conducted based on an evaporating pool release using the meteorological data presented in Table 1. Modeling was conducted using the SLAB numerical dispersion model. A complete description of the SLAB model is available in *User's Manual for SLAB: An Atmospheric Dispersion Model for Denser-Than-Air Releases, D. E. Ermak, Lawrence Livermore National Laboratory, June 1990*. The SLAB user manual contains a substance database, which includes chemical-specific data for ammonia. These data were used in modeling run without exception or modification.

Emissions of aqueous ammonia were calculated pursuant to the guidance given in *RMP Offsite Consequence Analysis Guidance, EPA, April 1999* and using the emission calculation tool for evaporating solutions provided in the Area locations of Hazardous Atmospheres (ALOHA) model provided by the EPA (http://www.epa.gov/ceppo/cameo/index.htm).

The ammonia emission rate from an evaporating 19-percent solution of aqueous ammonia was calculated assuming mass transfer of ammonia across the liquid surface occurs according to principles of heat transfer by natural convection. The ammonia release rate was calculated using ALOHA, meteorological data displayed in Table 1 and the dimensions of the secondary containment area. For the worst case condition, it was assumed that a complete failure of the storage tank occurred which resulted in an evaporating pool of aqueous ammonia within the secondary containment area. An alternative to the storage tank failure release scenario was also considered. The release of aqueous ammonia from a tank loading hose failure with a leak below the excess flow valves activation set-point and the subsequent impacts was considered. An alternative release analysis would normally be completed under typical or average meteorological conditions for the area. However, after review of the possible failure modes, it was determined that the impact of this leak would be captured by the complete tank failure as a worst-case for the hose failure since the tank loading hose failure would occur in the same location as the worst case scenario with less material potentially spilled.

During the worst case scenario, an initial ammonia emission rate was calculated and assumed to occur for one hour after the initial release (see Table 1). For concentrated solutions, the initial evaporation rate is substantially higher than the rate averaged over time periods of a few minutes or more since the concentration of the solution immediately begins to decrease as evaporation begins. Use of the initial ammonia emission rate results in a more conservative estimate of offsite ammonia impacts.

Although the edge of the tank containment area is raised above ground level, the release heights used in the model were set at 0 meters above ground level (AGL) to maintain the conservative nature of the analysis. Downwind concentrations of ammonia were calculated at heights of 0 and 1.6 meters above ground level. Reported distances to specified toxic endpoints are the maximum distances for concentrations at 0 and 1.6 meters above ground level. The California Office of Environmental Health Hazard Assessment (OEHHA) has designated 1.6 meters as the breathing zone height for individuals.

Toxic Effects of Ammonia

With respect to the assessment of potential impacts associated with an accidental release of ammonia, four offsite "bench mark" exposure levels were evaluated, as follows: (1) the lowest concentration posing a risk of lethality, 2,000 ppm; (2) the Occupational Safety and Health Administration's (OSHA) Immediately Dangerous to Life and Health (IDLH) level of 300 ppm; (3) the Emergency Response Planning Guideline (ERPG) level of 150 ppm, which is the American Industrial Hygiene Association's (AIHA) updated ERPG-2 for ammonia; and (4) the level considered by the California Energy Commission (CEC) staff to be without serious adverse effects on the public for a one-time exposure of 75 ppm (*Preliminary Staff Assessment-Otay Mesa Generating Project, 99-AFC-5, May 2000)*.

The odor threshold of ammonia is approximately 5 ppm, and minor irritation of the nose and throat will occur at 30 to 50 ppm. Concentrations greater than 140 ppm will cause detectable effects on lung function even for short-term exposures (0.5 to 2 hours). At higher concentrations of 700 to 1,700 ppm, ammonia gas will cause severe effects; death occurs at concentrations of 2,500 to 7,000 ppm.

The ERPG-2 value is based on a one-hour exposure or averaging time; therefore, the modeled distance to ERPG-2 concentrations are presented in terms of one-hour (or 60 minute) averaging time. The ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action. OSHA's IDLH for ammonia is based on a 30-minute exposure or averaging time; therefore, the IDLH modeling concentrations at all offsite receptors will be given in terms of a 30-minute averaging time.

Modeling Results

Table 2 shows the modeled distance to the four benchmark criteria concentrations: lowest concentration posing a risk of lethality, (2,000 ppm), OSHA's IDLH (300 ppm), AIHA's ERPG-2 (150 ppm), and the CEC significance value (75 ppm).

TABLE 2
Distance to EPA/CalARP and CEC Toxic Endpoints

Scenario	Distance in Meters to 2,000 ppm	Distance in Meters to IDLH (300 ppm)	Distance in Meters to AIHA's ERPG-2 (150 ppm)	Distance in Meters to CEC Significance Value (75 ppm)
Worst Case, 0 m AGL	14.04	21.09	24.31	27.33
Worst Case, 1.6 m AGL	20.04	32.68	36.43	41.34

The model input file and the output files are available upon request.
[a] Downwind ammonia concentrations did nor reach the 2000 ppm benchmark

The results of the off-site consequence analysis for the worst case release scenario of ammonia at CECP indicate that the concentrations above the most stringent benchmark criteria (CEC's significance value of 75 ppm) do not extend off the project site.

Assessment of the Methodology Used

Numerous conservative assumptions were used in the above analysis of the release scenarios. These include the following:

- Modeling & Meteorology
  - Worst case of a constant mass flow, at the highest possible initial evaporation rate for the modeled wind speed and temperature was used, whereas in reality the

evaporation rate would decrease with time as the concentration in the solution decreases.

- In the case of the tank rupture, worst case stability class was used which almost exclusively occurs during nighttime hours, but the maximum ambient temperature of 108°F was used, which would occur during daylight hours.
- Again worst-case meteorology corresponds to nighttime hours, whereas the worst-case release of a tank failure would most likely occur during daytime activities at the power plant. At night, maintenance activity at a power plant is typically minimal.

Risk Probability

Accidental releases of aqueous ammonia in industrial use situations are rare. Statistics compiled on the normalized accident rates for RMP chemicals for the years 1994-1999 from *Chemical Accident Risks in U.S. Industry-A Preliminary Analysis of Accident Risk Data from U.S. Hazardous Chemical Facilities, J.C. Belke, Sept 2000*, indicates that ammonia (all forms) averages 0.017 accidental releases per process per year, and 0.018 accidental releases per million pounds stored per year. Data derived from *The Center for Chemical Process Safety, 1989*, indicates the accidental release scenarios and probabilities for ammonia in general shown in Table 3.

TABLE 3
General Accidental Release Scenarios and Probabilities for Ammonia

Accident Scenario	Failure Probability
Onsite Truck Release	0.0000022
Loading Line Failure	0.005
Storage Tank Failure	0. 000095
Process Line Failure	0.00053
Evaporator Failure	0.00015

Conclusions

Several factors need to be considered when determining the potential risk from the use and storage of hazardous materials. These factors include the probability of equipment failure, population densities near the project site, meteorological conditions, and the process design. Considering the results of the above analysis, and accounting for the probabilities of a tank failure resulting in the modeled ammonia concentrations at the conditions modeled, the risk posed to the local community from the storage of aqueous ammonia at CECP is insignificant.

The results of the catastrophic scenario indicate that predicted distances to toxic endpoints will not extend off site. Thus, no significant danger to the public exists.

As described above, numerous conservative assumptions have been made at each step in this analysis. The conservative nature of these assumptions has resulted in a significant overestimation of the probability of an ammonia release at the CECP site, and the predicted distances to toxic endpoints do not pose a threat to the public. Therefore, it is concluded that risk from exposure to aqueous ammonia due to CECP is less than significant.

FIGURE 1
AMMONIA CONCENTRATIONS
OFFSITE CONSEQUENCE ANALYSIS
CARLSBAD ENERGY CENTER PROJECT
CARLSBAD, CALIFORNIA

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