APPENDIX 6.15-A – OFFSITE CONSEQUENCES ANALYSIS

OFFSITE CONSEQUENCE ANALYSIS

The offsite consequence analysis was performed for the following two hypothetical accidental release scenarios: "worst case" and "alternative." An alternative scenario is included because of the low probability of the worst-case scenario. The alternative scenario is also unlikely to occur, but has a slightly higher probability of occurrence than the worst case scenario. For both scenarios, distances to specified concentrations of ammonia were estimated. Where specified "level of concern" concentrations reach offsite, then potential public health impacts must be evaluated.

The offsite consequence analysis includes four components. The first is to describe the scenario in enough detail to allow quantitative analysis. The description includes passive features designed to minimize emissions. The second component is to estimate emission rates associated with each scenario. The third component is to use atmospheric dispersion modeling to predict the distances to the levels of concern in each scenario. The fourth component assesses the potential degree and extent of offsite consequences of the concentrations computed by the dispersion modeling.

Worst-Case Release Scenario

Potential accidental release scenarios due to aqueous ammonia handling and use include losses from a storage tank, losses during unloading of a tank truck to a storage tank, losses in the aqueous ammonia delivery system from the storage tank to the vaporizers, and losses of vaporized ammonia during delivery to the SCR catalyst beds. Because of safety shut-offs to these last two subsystems, potential ammonia release quantities from these delivery system components in the event of an upset condition are small compared to losses from a storage tank or from tank truck unloading.

The proposed location of the storage tank and unloading facility are shown in Drawing C100 in Appendix 2-A. The worst case is the hypothetical instantaneous release of a full storage tank induced by some improbable catastrophic event. Regardless of the improbability of the worst-case release scenario, the storage tank is assumed to instantaneously release its full contents of aqueous ammonia into the tank's secondary containment area. The secondary containment design serves as a passive control system to limit the potential maximum surface area of volatilization of any accidental release of aqueous ammonia to 1,000 square feet (ft^2).

Because the area available for volatilization directly affects the emission rate, a passive design feature was included to further reduce the emission rate and potential offsite consequences of an accidental release. Two layers of industrial-grade high-density polyethylene (HDPE) balls will be placed in the bottom of the 1,000 ft^2 containment structure (see Figure 6.15-1). The balls will be approximately 1.5 to 3 inches in diameter. If aqueous ammonia were accidentally released from a storage tank, the liquid would pass between the balls and spread out on the concrete base. Based on use of balls with 3 inches in diameter, they would reduce the area available for volatilization to approximately one-tenth (9.4 percent) of the total surface area of liquid. The balls would not be wetted by the solution because of their hydrophobic property. The balls

would also block the wind, another parameter that affects the rate of volatilization, greatly reducing the wind speed at the surface of the liquid. The analysis presented herein overestimates impact distance by neglecting the reduction in wind speed.

Alternative Release Scenario

The alternative release scenario involves the loss of aqueous ammonia during unloading of a tank truck. Under this scenario, a connector in the unloading piping is assumed to fail, allowing the aqueous ammonia to flow out freely through the 3-inch piping. In this scenario, the rate at which the aqueous ammonia escapes from the tank truck is determined by the 3-inch size of the piping used for unloading. The maximum rate of discharge is approximately 258 gallons per minute. The volume of liquid released from the tank truck is assumed to flow out into an area 21 feet long (i.e., one-half the length of the truck's tank) by 4 feet wide. The released aqueous ammonia would flow down the sloping base of the concrete ramp before entering the secondary containment vault. For the purpose of this analysis, it is assumed that the driver and facility personnel present during unloading, both of whom are specially trained to respond to emergencies of this nature, will be able to stop such a release within 30 seconds. The maximum estimated volume of liquid released during this 30 second period is approximately 125 gallons. The liquid does not accumulate to cover more of the ramp area because excess flow is directed to the secondary containment system associated with the above-ground storage tank. Also, administrative controls (e.g., written instructions such as standard operating procedures), physical indicators (e.g., truck position beepers), and physical constraints (e.g., unloading pipe length) will assure that the unloading connector is no further than 21 linear feet from the conduit between the loading ramp and secondary containment area.

Emission Rates and Meteorological Conditions

This section provides an estimation of emission rates and selection of meteorological parameters to be used as inputs to the modeling. The fundamental equations and assumptions used to estimate the emission rate of ammonia vapor from an aqueous solution are presented in Tables 6.15A-1 through 6.15A-5 at the end of this appendix.

Estimation of Emission Rates

The ammonia emission rates for the worst case and alternative release scenarios are influenced primarily by the following factors:

- Physical and chemical properties of the aqueous ammonia
- Temperature of the liquid
- Surface area of ammonia exposed to the wind
- Wind speed over the liquid surface

With regard to the physical and chemical properties of the aqueous ammonia, the partial vapor pressure is influenced by the temperature of the liquid. Table 6.15A-2 provides an overview of the temperature correction factor used to estimate the vapor pressure of ammonia at other than standard atmospheric temperature and pressure.

Worst-Case Release Scenario

Because the area available for volatilization directly affects the emission rate, a passive design feature was included to further reduce the emission rate and potential offsite consequences of an accidental release. Two layers of industrial-grade high-density polyethylene (HDPE) balls will be placed in the bottom of the 1,000 ft^2 containment structure. The balls will be approximately 1.5 to 3 inches in diameter. If aqueous ammonia were accidentally released from a storage tank, the liquid would pass between the balls and spread out on the concrete base. Based on using balls 3 inches in diameter, they would reduce the area available for volatilization to approximately one-tenth (9.4 percent) of the total surface area of liquid. The balls would not be wetted by the solution because of their hydrophobic property. The balls would also block the wind, another parameter that affects the rate of volatilization, greatly reducing the wind speed at the surface of the liquid. The analysis presented herein overestimates impact distance by neglecting the reduction in wind speed. Table 6.15A-3 provides an overview of the methodology used to calculate the effective mitigated surface area of the secondary containment area.

The calculated emission rate for ammonia under the worst case scenario is 3.91 pounds per minute (Table 6.15A-4).

Alternative Release Scenario

The alternative release scenario involves the loss of aqueous ammonia during unloading of a tank truck. Under this scenario, a connector in the unloading piping is assumed to fail, allowing the aqueous ammonia to flow out freely through the 3-inch piping. In this scenario, the rate at which the aqueous ammonia escapes from the tank truck is determined by the 3-inch size of the piping used for unloading. The maximum rate of discharge is approximately 258 gallons per minute. The volume of liquid released from the tank truck is assumed to flow out into an area 21 feet long (i.e., one-half the length of the truck's tank) by 4 feet wide. The released aqueous ammonia would flow down the sloping base of the concrete ramp before entering the secondary containment vault. For the purpose of this analysis, it is assumed that the driver and facility personnel present during unloading, both of whom are specially trained to respond to emergencies of this nature, will be able to stop such a release within 30 seconds. The maximum estimated volume of liquid released during this 30 second period is approximately 125 gallons. The liquid does not accumulate to cover more of the ramp area because excess flow is directed to the secondary containment system associated with the above-ground storage tank. Also, administrative controls (e.g., written instructions such as standard operating procedures), physical indicators (e.g., truck position beepers), and physical constraints (e.g., unloading pipe length) will assure that the unloading connector is no further than 21 linear feet from the conduit between the loading ramp and secondary containment area.

The calculated emission rate for ammonia under the alternative scenario is 2.25 pounds per minute (Table 6.15A-5).

Meteorological Conditions

The wind speed used in the equation is taken from measurements made at the standard height of 10 meters (33 feet). This wind speed is greater than it would be closer to the surface of the liquid and, hence, results in a higher emission rate.

The temperature of the liquid is assumed to be the same as the air temperature. This assumption overestimates the temperature of the liquid because: (1) the air temperature used in the worst-case meteorological conditions (114degrees Fahrenheit [ºF]) was the highest observed at the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) Temecula Station (Index No. 04-8844-6) on July 22, 2006 during the 3-year period (36 months of existing data) November 2003 through February 2007, and (2) the thermal inertia of a tank of liquid prevents it from heating up as high as the transient maximum air temperature.

Atmospheric stability is another important meteorological parameter used in modeling the dispersion of the ammonia that vaporizes from the liquid. The worst-case stability (i.e., most stable) classification is F, for which the atmosphere has the least mixing and, hence, the ammonia concentration would remain highest as the vapor is carried downwind.

Table 6.15A-1 – Accidental Release Scenarios

METEOROLOGICAL PARAMETER	UNITS	RELEASE SCENARIO	
		WORST-CASE STORAGE TANK LOSS	ALTERNATIVE CASE: TANK TRUCK UNLOADING SPILL
Temperature	Degrees Fahrenheit	114(2)	77(1)
Atmospheric Stability Class(1)	None	6 (very stable)	4 (neutral)
Wind Speed(1)	Meters per second	1.5	3.0
Urban/Rural Dispersion	None	Rural	Rural
Ammonia Containment Area (Surface Area for Alternative Scenario)	square feet	1,000	84
Effective Containment Surface Area with Mitigation(3)	square feet	93.1	84
Ammonia Vapor Pressure in Containment Basin	mm Hg	190	148
Ammonia Emission Rate	pounds/minute	3.91	2.25

(1) Default value of the RMP Offsite Consequence Analysis Guidance (USEPA, 1999).
(2) Temperature is the highest daily maximum temperature (July 22, 2006) during the past 36 months of existing data for the city of Temecula (NOAA NCDC, November 2003 through February 2007).
(3) Mitigated emissions calculated with plastic balls in the aqueous ammonia containment basin minimizes the spill surface area available for evaporation

The requirement that the worst case use a combination of the maximum observed temperature and maximum stability results in an implausible combination of conditions. The maximum temperature occurs during the afternoon when the air is unstable (e.g., Classification B for the

maximum average temperature of 114°F observed on July 22, 2006). In contrast, F stability occurs during nighttime or early morning before sunrise, when temperature is lowest. The use of the maximum observed temperature and stability conditions results in an overestimation of the actual emission rate and offsite consequence.

The low wind speed of 1.5 meters per second (m/sec) is a Cal-ARP requirement. Low wind speed results in a low volatilization rate, but also results in reduced dispersion of the vapor as it is carried downwind.

DISPERSION MODELING APPROACH

Analysis of the worst case and alternative aqueous ammonia accidental release scenarios was performed using the SCREEN3 computerized dispersion model. This model was provided by the USEPA for preliminary screening analyses of routine or upset emissions of contaminants to the atmosphere. The worst case scenario involves the assumption that the entire contents of the 10,000-gallon aqueous ammonia storage tank is instantaneously released due to a tank rupture. The alternative release scenario evaluates a release of the entire contents of approximately 125 gallons of aqueous ammonia from the tanker truck during a transfer event. Extreme weather and dispersion conditions that maximize evaporative ammonia emissions are assumed for the worst case scenario. The alternative release scenario incorporates weather and dispersion conditions that are more representative of “typical” conditions.

A summary of the SCREEN3 model input parameters for the worst case and alternative scenarios is provided in Table 6.15A-6.

DISPERSION MODELING RESULTS

At the ERPG-2 concentration (150 ppm) the predicted distances from the release sources are approximately 951 and 213 feet for the worst case and alternative scenarios, respectively. The results of the dispersion modeling for the worst-case and alternative release scenarios indicate that the ERPG-2 concentration of 150 ppm extends beyond the Project fence line in both scenarios. However, neither the ERPG-2 nor STPEL concentrations impact a residence or other public receptor in either the worst case or alternative scenario. Sensitive receptors and emergency response facilities are not located within the area potentially affected by these releases.

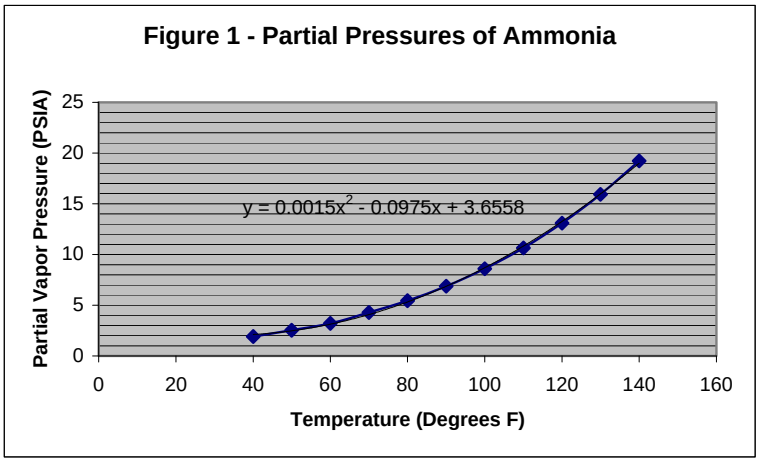
A tabular summary of the concentration endpoints and predicted distance to the concentration endpoints for the worst case and alternative release scenarios is provided in Table 6.15A-7. The SCREEN3 model output is provided in Appendix 6.15-B.

Table 6.15A-2 – Aqueous Ammonia Accidental Release Emission Rate

Aqueous Ammonia Accidental Release Emission Rate
Orange Grove Project - SPPE Application

Partial Vapor Pressure of Aqueous Ammonia Solution (from Perry's Chemical Handbook)

Temperature (Degrees F)	Partial Vapor Pressures of 19.1% Aqueous Ammonia (PSIA)
40	1.92
50	2.53
60	3.21
70	4.28
80	5.45
90	6.88
100	8.6
110	10.64
120	13.09
130	15.93
140	19.23



Temperature Correction Factor (from EPA, 1999)

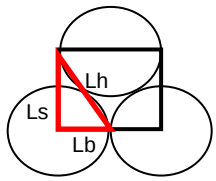
$$TCF_{WC} = \frac{VP_T \times 298}{VP_{298} \times T} \quad \text{Equation 1}$$

SYMBOLS AND DESCRIPTION	UNITS	VALUE	RATIONALE
T = temperature of worst case scenario	Degrees F	114	Highest daily maximum temp (July 22, 2006) during past 36 months of existing data for the city of Temecula (NCDC, November 2003 to February 2007)
	Degrees K	319	Conversion = (F + 459.67) x 5/9
VPT = vapor pressure of ammonia at temperature of worst case scenario	PSIA	12.0	Figure 1 using 114 degrees F (319 K)
	mmHg	621	Conversion = 51.56 mmHg / PSIA
VP298 = vapor pressure of ammonia at SATP	PSIA	5.04	Figure 1 using 77 degrees F (298 K)
	mmHg	260	Conversion = 51.56 mmHg / PSIA
TCFWC = temperature correction factor for worst case scenario	Unitless	2.23	Equation 1

Notes: F = Fahrenheit; K = Kelvin; PSIA = pounds per square inch absolute; SATP = standard ambient temperature and pressure; mmHg = millimeters of mercury

Table 6.15A-3 – Mitigation – Plastic Floating Balls

Mitigation - Plastic Floating Balls



SYMBOLS AND DESCRIPTION (WORST CASE SCENARIO)	UNITS	VALUE	EQUATION
r = radius of ball	In	1.5	
A_{Ball} = area of ball	in^2	7.1	πr^2
L_b = Length of base of triangle	In	1.5	
L_h = Lenth of hypotenuse of triangle	In	3.0	
L_s = Length of side of triangle	In	2.6	$Ls^2 = Lh^2 - Lb^2$
A_{Box} = area of box*	in^2	7.8	Ls x 2r
E = empty space	in^2	0.73	$A_{Ball} - A_{Box}$
Percent Empty Space	percent	9.36	$E / A_{Box} * 100$

Notes: in = inches; in^2 = square inches

* = the base of the box has a length that runs from the origin of one circle to the origin of one circle to the origin of the second circle, thereby representing two times the radius (3 inches); the height of the box has a length that is based on the Pythagorean Theorem (for the red triangle) with a base equal to the radius of one circle and a hypotenuse equal to the twice the radius (or diameter) of the circle.

Table 6.15A-4 – Emission Rate of Aqueous Ammonia Solutions – Worst Case Scenario

$$QR_{WCS} = \frac{0.284 \times U^{0.78} \times MW^{2/3} \times A \times VP \times TCF}{82.05 \times T} \quad \textbf{Equation 2}$$

SYMBOLS AND DESCRIPTION (WORSE CASE SCENARIO)	UNITS	VALUE	RATIONALE
U = windspeed	m/s	1.5	Worst case scenario default value (EPA, 1999)
MW = molecular weight	g/g-mol	17.0	Molecular weight of Ammonia
A = exposed area	ft2	93.6	Based on a 1000 ft2 containment berm and 9.36% empty space (From Page 2)
VP = 10 minute average vapor pressure	mmHg	190	EPA, 1999 - Exhibit B-3 (10-min average vapor pressure for wind speed of 1.5 m/s)
T = temperature	Kelvin	319	From Page 1
TCF = temperature correction factor	unitless	2.23	From Page 1
QRWCS = emission rate for worse case scenario	lb/min	3.91	Equation 2

Notes: m/s = meters per second; g/g-mole = grams per grams-mole; ft^2 = square feet
mmHg = millimeters of Mercury; lb/min = pounds per minute

Table 6.15A-5 – Emission Rate of Aqueous Ammonia Solutions – Alternative Scenario

$$QR_{AS} = \frac{0.284 \times U^{0.78} \times MW^{2/3} \times A \times VP}{82.05 \times T} \quad \textbf{Equation 3}$$

SYMBOLS AND DESCRIPTION (ALTERNATE SCENARIO)	UNITS	VALUE	RATIONALE
U = windspeed	m/s	3	Alternate scenario default value (EPA, 1999)
MW = molecular weight	g/g-mol	17.0	Molecular weight of Ammonia
A = exposed area	ft2	84	Based on a 21 foot long x 4 foot wide release area
VP = 10 minute average vapor pressure	mmHg	148	EPA, 1999 - Exhibit B-3 (10-min average vapor pressure for wind speed of 3 m/s)
T = temperature	Kelvin	298	Alternate scenario default value (EPA, 1999)
QRAC = emission rate for alternate scenario	lb/min	2.25	Equation 3

Notes: m/s = meters per second; g/g-mole = grams per grams-mole; ft^2 = square feet
mmHg = millimeters of Mercury; lb/min = pounds per minute

Table 6.15A-6 – SCREEN 3 Model Input for Worst Case and Alternate Scenarios

MODEL INPUT	UNITS OR CHOICE	WORST CASE	ALTERNATE	SOURCE/RATIONALE
Emission Rate	lb/min	3.91	2.25	From Tables 3 and 4, respectively
	g/s*m^2	0.32	2.18	Convert to g/s and divide by exposed area (Worst Case = 93.6 ft^2 or 8.649 m$^{2;}$ Alternative Case = 84 ft^2 or 7.8 m^2)
Release Height	m	0.00	0.00	Default value of ground level (EPA, 1999)
Side Length	m	15.20	6.40	Worst Case =1,000 square foot containment basin (50' x 20'); Alternative Case = 21 feet (6.4 meters)
Side Width	m	6.08	1.22	Worst Case =1,000 square foot containment basin (50' x 20'); Alternative Case = 4 feet (1.2 meters)
Receptor Height	m	0.00	0.00	Default value of ground level (EPA, 1999)
Urban/Rural	U or R	Rural	Rural	Community of Pala considered to be a rural area (flat terrain topography)
Search through range of wind directions?	Yes/No	Yes	Yes	Default (EPA, 1999)
Choice of Meteorology	1, 2, 3	3	3	Default value of single stability class and wind speed input for meteorology (EPA, 1999)
Stability Class	1 thru 6	6	4	Default values for worst case & alternate scenarios (F & D, respectively) (EPA, 1999)
Wind Speed	m/s	1.5	3	Default values for worst case & alternate scenarios (EPA, 1999)

Notes: lb/min = pounds per minute; g/s*m2 = grams per second meters squared;
m = meters; m/s = meters per second

Table 6.15A-7 – Endpoint Concentration and Distances

LEVEL	CONCEN-TRATION (PPM)	CONCEN-TRATION (UG/M3)	PREDICTED DISTANCE FOR WORST CASE SCENARIO (FEET)	PREDICTED DISTANCE FOR ALTERNATE SCENARIO (FEET)
IDLH - Immediately Dangerous to Life and Health	300	.209E+06	627	144
ERPG-2 - Emergency Response Planning Guideline Level 2	150	.104E+06	951	213
STPEL - Short-Term Public Emergency Limit	75	.521E+05	1434	312
OSHA PEL - Occupational Safety & Health Permissible Exposure Level	50	.348E+05	1818	387