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Off-site Ammonia Consequence Analysis

Hazardous Release Analysis For The

Palmdale Energy Project

Palmdale, California

Submitted to

California Energy Commission

Submitted by

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Palmdale Energy Project

Aqueous Ammonia Offsite Consequence Analysis

The Palmdale Energy Project (Project or PEP) is a proposed fast start (Flex Plant) 645 MW (nominal annual average) natural gas-fired combined-cycle power plant. The project is planning to operate as a base loaded power plant and is proposed to operate up to approximately 8,000 hours per year, with an expected facility capacity factor at 60 to 80 percent.

The PEP is required by both the Clean Air Act and the Antelope Valley Air Quality Management District to install Best Available Control Technology to control emissions of criteria air pollutants from the combustion turbines. The new PEP turbines will incorporate dry low NOx combustor technology that reduces emissions of oxides of nitrogen (NO_x). In addition, the turbines (and HRSG duct burners) emissions of NO_x will be further reduced through the use of selective catalytic reduction (SCR). The SCR control system utilizes ammonia as the reduction medium in the presence of a catalyst. Two forms of ammonia may be used in currently designed SCR systems, i.e., anhydrous ammonia or aqueous ammonia. The PEP is proposing to use aqueous ammonia in a <=20.0% (by weight) solution. Aqueous ammonia is a water based ammonia solution, which can be mixed and delivered, in a wide variety of solution ratios. Solution mix ratios less than or equal to 30% (weight basis) are the most common. Aqueous ammonia solutions typically have a boiling point of approximately 83 deg F. When spilled, aqueous ammonia solutions will slowly vaporize, releasing ammonia vapors. According to data prepared for the CEC by Ebasco (*Ammonia Release Risk Mitigation Guidance for Power Plants-Draft Report, November 1989*) when ammonia is diluted with water to solutions of less than or equal to 20% by volume, evaporation of ammonia gas from the fluid becomes negligible. The guidance further states that when ammonia is diluted with water at ambient temperatures to solutions less than 25% by weight, ammonia vapor pressure is reduced to atmospheric pressure, i.e., the evaporation of ammonia gas from the fluid would be negligible. A 29% solution of aqueous ammonia has an approximate vapor pressure of 118 torr at 20 deg C (~520 mm/Hg at 70 deg F).

The Code of Federal Regulations 40 (CFR) Part 68, and the California Code of Regulations (CCR), Division 2, Chapter 4.5 regulate the potential accidental release of hazardous materials. CCR Article 8, Section 2770.5 includes tables of federally and state regulated substances including threshold quantities for regulation under the accidental release prevention program. Because PEP will store ammonia in excess of 500 pounds, the facility is required to have a written Risk Management Plan and complete an Off-site Consequence Analysis (OCA). The complete RMP will be submitted to the CUPA prior to aqueous ammonia being brought on site.

Accidental releases of ammonia (all forms) 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 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 following accidental release scenarios and probabilities for ammonia in general.

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

PEP will store aqueous ammonia in a single horizontally mounted cylindrical storage tank. The tank capacity will be approximately 30,000 gallons. The tank will be enclosed by a containment berm capable of containing the full contents of the tank as well as incidental rainwater. The approximate berm dimensions are as follows:

- Length 60.0 ft.
- Width 20.0 ft.
- Depth 4.0 ft.
- Capacity ~= 36,000 gallons

The surface area of the containment basin will be 1200 sq. ft. (111.5 sq.m.), and the volume will be approximately 36,000 gallons. Maximum tank storage will be administratively limited to 25,500 gallons (85%). The delivery truck vessel is anticipated to have a capacity of approximately 6800 gallons.

An OCA was performed for the release scenario involving the complete failure and discharge of the storage tank contents into the secondary containment area. In addition, an alternative release scenario was also evaluated, i.e., failure of the truck unloading hose with a resultant spill forming a pool on the truck unloading pad. Table 1 shows the meteorological data and analysis assumption values used in the modeling scenarios.

Table 1 OCA Modeling Data Summary

Parameter	Worst Case (Tank Failure)	Alternate Case (Unloading Hose Failure)
Release Rate, lbs/min	48.4	0.49
Release Time, mins	10	10
Wind Speed, m/sec[1]	1.5	3.0
Stability Class[2]	F	D
Temperature, degree C[3]	45	25
Relative Humidity, percent[4]	50	50
Release Height, m[5]	0	0
Te, parts per million (ppm)[6]	201/150/75	201/150/75
Tav, mins[7]	60/60/30	60/60/30
z0, m[8]	0.1	0.1

Dispersion Coefficients[9]	Rural	Rural
Fence line Distance, m	97.5	97.5
Spill Surface Area, m2.[10]	111.5	5.93
Sump Containment Present	No	Yes
Spill Depth, cm[11]	NA	1.0
Dike Containment Present	Yes	No

Explanation of table values:

1. Wind speed values are the EPA/CalARP default values for worst case and alternative case evaluations.
2. Stability class values are the EPA/CalARP default values for worst case and alternative case evaluations.
3. Worst-case temperature is the highest daily temperature for the Palmdale AF Plt area as derived from historical records (WRCC, 1998-2008). Alternative case temperature is the recommended default value of 25 deg C.
4. RH values are the EPA default values for worst case and alternative case evaluations.
5. For all scenarios, the release height is 0 ft. agl.
6. Te value of 201 ppm is equivalent to 0.14 mg/l. CEC LOC of 75 ppm is equivalent to 0.052 mg/l.
7. The Te value is based on an exposure time of 60 minutes, therefore the OCA exposure values are also based on an Tav (averaging time) of 60 minutes. CEC LOC of 75 ppm based on 30-minute averaging time.
8. Surface roughness coefficients represent an average value for areas with flat terrain, low density vegetation per CalTech research.
9. Dispersion coefficients are based on the land use criteria (Auer) for the area within 3 km of the site.
10. Dike containment may be present and accounted for in some release scenarios.
11. EPA default value of 1 cm assumed for all spill depths outside of diked areas.

A total of six (6) modeling runs were conducted for the primary worst case and alternative release scenarios, i.e., tank failure and hose failure for the met scenarios listed in Table 1, which included the action levels as follows:

- CalARP RMP Toxic endpoint (Te) of 201 ppm (1-hour average)
- ERPG-2 level of 150 ppm (1-hour average)
- CEC level of concern (LOC) of 75 ppm (30-min average)

OCA modeling was conducted using the SLAB 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 current version of SLAB is accompanied by an external substance database which includes chemical specific data for ammonia. This data was used in all modeling runs without exception or modification except for the "cmedo" value which was conservatively calculated (0.0) for each release scenario.

Emissions of ammonia from the aqueous ammonia solution were calculated pursuant to the equations and guidance given in *RMP Offsite Consequence Analysis Guidance, EPA, April 1999*. See the attached emissions calculation summary.

Please note that per *Risk Management Program Guidance for WWTPs, EPA-OSWER, October 1998*, ammonia emissions from diked and/or surface area spills are only calculated for the first 10 minutes of the spill life. EPA states that the release of ammonia from the aqueous solution should only be used for the first 10 minutes after which the ammonia in the pool (diked area) will be more dilute than it was initially and will be evaporating much less rapidly. This assumption applies to both release scenarios. A sump is proposed to be constructed in the unloading area for containment of minor hose spills. This sump was assumed to represent a passive mitigation of 50% for the alternate release scenario.

Emissions from the surface area spill, i.e., alternative release scenario, are assumed (for purposes of a conservative alternate release analysis) to be a 100% loss rate of ammonia from the spilled solution over the 10-minute release period including any reductions due to passive mitigation as noted above.

The specified action level values for ammonia were delineated above. These values are based on either a one-hour or 30-minute exposure, therefore, the modeling concentrations at all offsite receptors will be given in terms of one-hour or 30 minute exposures dependent upon the action level being evaluated.

The ammonia storage and unloading area is located approximately 320 ft (97.9m) from the closest fence-line. Table 2 delineates the sensitive receptors (schools, hospitals, daycare centers, convalescent homes) within one (1) kilometer of the tank area.

Table 2
Sensitive Receptors Within 1 Kilometer of the Ammonia Storage Area.

Receptor Name	Receptor Type	Direction from WCP	Distance from WCP Tank Area
None	NA	NA	NA

Per Google Earth image dated 4/11/15.
Several potential residences lie to the NNW at the edge of the 1 KM radius.

Figures 1 through 3 (on the following pages) show the individual scenario results in terms of concentration vs. downwind distance for the worst-case scenarios and action levels delineated above. The alternative analysis resulted in a hazard footprint that was smaller than the tank failure presented in Figures 1-3 below. Thus, no figures are presented for the alternative analyses.

- Figure 1 - CalARP RMP Te of 201 ppm (1-hour average)
- Figure 2 - ERPG-2 level of 150 ppm (1-hour average)
- Figure 3 - CEC LOC of 75 ppm (30-min average)

As can be seen in the figures, ammonia concentrations at the closest fence-line location are well below the toxic endpoint values as noted above. The levels of exposure from the release scenarios, at the three toxic endpoints and averaging times, are considered insignificant, and would result in no known or discernable health impacts to any member of the surrounding population. Since the zones of impact for each of the scenarios are well within the site property line, i.e., no offsite concentrations approaching the toxic endpoint values are noted, no zone of impact figures are needed or presented in this analysis.

Attachment 1 contains copies of the emissions calculations for each release scenario as well as the climatic data (highest daily temperature data) used in the modeling analysis for the worst and alternate case release scenarios.

Analysis Conclusions

The following conclusions result from the above offsite consequence analysis:

- The zone of impact (based on the toxic endpoint value for ammonia) for all cases evaluated lies clearly within the facility fence line.
- No offsite areas are predicted to experience ammonia concentrations at levels that would exceed any of the ammonia toxic endpoint values, i.e., 75 ppm, 100 ppm, and 201 ppm.

A copy of the modeling input/output files and emissions spreadsheet are included with the OCA analysis on a compact disk.

		Aqueous Ammonia Emissions Calculations														
			RMP-OCA Analysis													
									Site:	Palmdale Energy Project						
Aqueous Ammonia % by Wt:			20.00													
Approx Wt of Solution, lbs/gal:			7.71													
Worst Case Scenario - Tank Rupture					**Alternate Release Scenario - Hose Rupture**											
Max Tank Capacity, gals:			30000			15.67			Hose Length, ft:			12				
Amount Spilled/Released, gals:			25500	Footnote 1		120.79			Hose Diameter, in.			4				
Weight of Release, lbs:			196605								area:	12.566	in2			
Ammonia portion, lbs:			39321			24.16						0.087	ft2			
									Hose Volume, ft3.			1.047				
Berm/dike contained:			Yes			No			Gals spilled:			7.833				
	Dike length, ft:		60.00			1.00	Spill Depth, cm		Multiplier:			2	**			
	Dike width, ft:		20.00			5.93	Spill Area, m2									
	Dike depth, ft:		4.00			63.83	Spill Area, ft2									
	Dike Volume, ft3:		4800													
	Dike Capacity, gals:		35904			0.5	Passive mitigation factor (Footnote 2)									
	Dike Sfc Area, ft2:		1200.00			0.5	Release multiplier									
Passive Mitigation Factor:			0.00											**TCF Calculation**		
Aqueous Ammonia LFA Value:			0.015			0.011								WCS	ARS	
Release Rate, lbs/min:			25.2			0.49					Release Temp, K			318	298	
10 Minute Release Rate, lbs:			252.0			4.92				Approx.	VP at Release Temp			594.7	290	mmHG
		g/sec:	190.7			3.72				Approx.	VP at 298 K			290	290	mmHG
		TCF:	1.9			TCF:	1.0									
TCF Corr. Emissions (g/sec):			**366.4**			**g/sec**	**3.72**						Int Calc 1	177220.6	86420	
		kg/sec:	**0.4**			**kg/sec**	**0.004**						Int Calc 2	92220	86420	
		lbs/min	**48.4**			**lbs/min**	**0.49**						**TCF**	**1.9**	**1.0**	
(1) Maximum spill amount accounting for administrative limitations on tank storage capacity (typical value is 85%).																
(2) Spill flows into specified passive mitigation device (sump located below grade).																
Ref: RMP Guidance for OCA, EPA 550-B-99-009, April 1999.																
Ref: Vapor Pressure data, LaRoche Industries Inc., Ammonia Technical Data Manual, 1997.																
** multiplier used to adjust spill volume to a conservative value for analysis.																

Figure 1

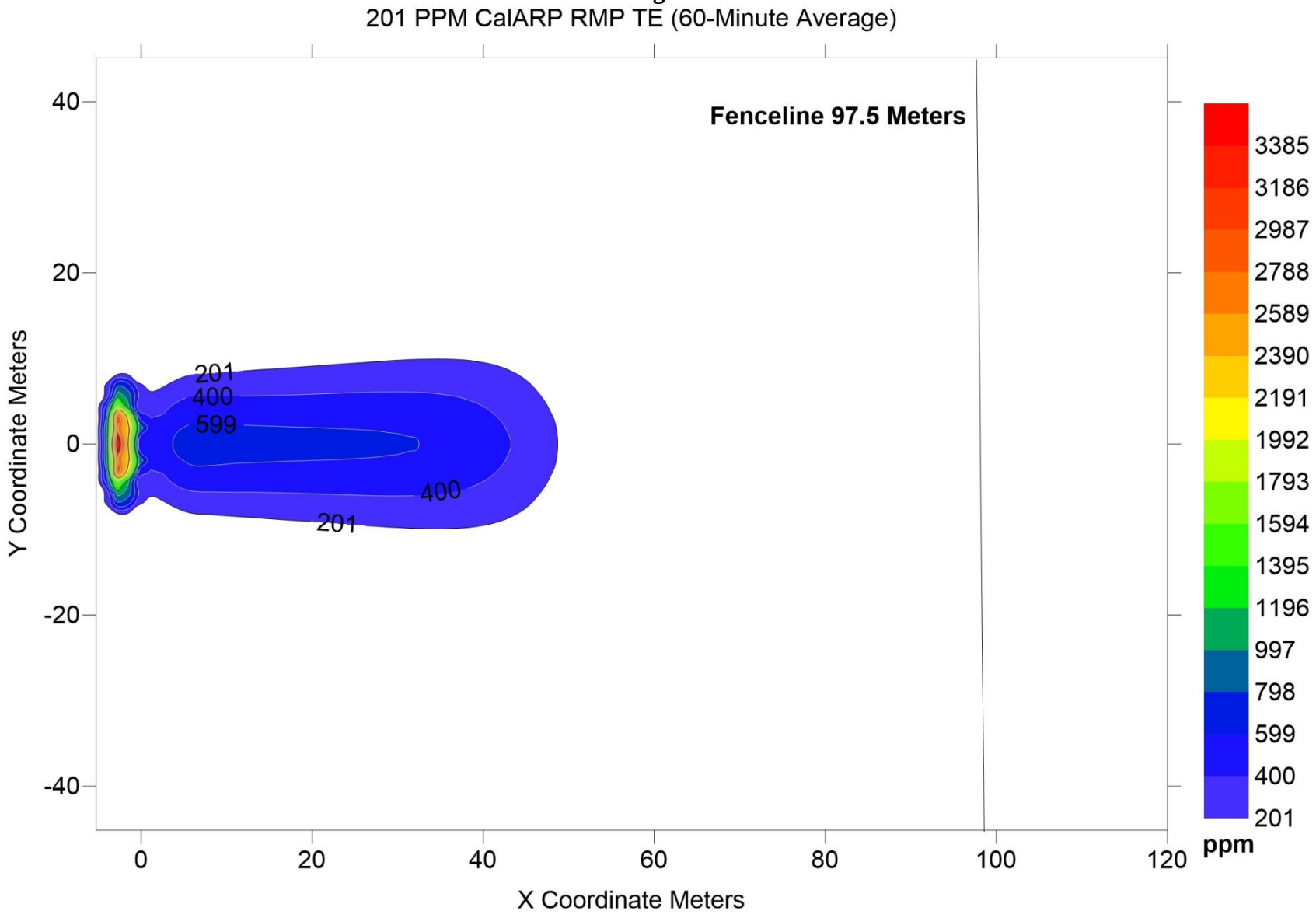
201 PPM CalARP RMP TE (60-Minute Average)
Fenceline 97.5 Meters
201
400
599
400
201
Y Coordinate Meters
X Coordinate Meters
40
20
0
-20
-40
0
20
40
60
80
100
120
3385
3186
2987
2788
2589
2390
2191
1992
1793
1594
1395
1196
997
798
599
400
201
ppm

Figure 2

150 PPM ERPG-2 (60-Minute Average)

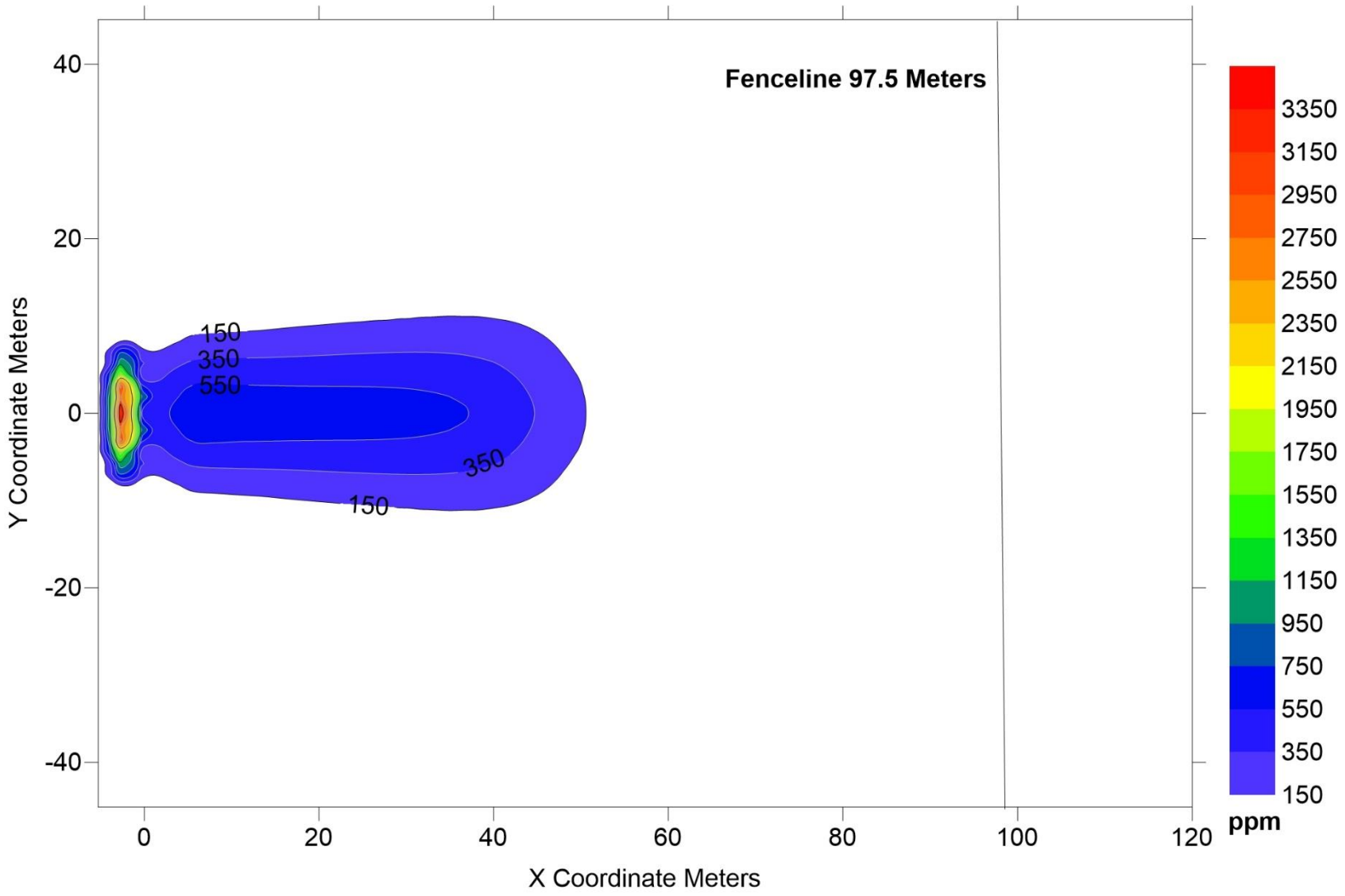

Figure 3

75 PPM LOC (30-Minute Average)