



South Texas Project Electric Generating Station P.O. Box 289 Wadsworth, Texas 77483

June 17, 2010
U7-C-STP-NRC-100146

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

South Texas Project
Units 3 and 4
Docket Nos. 52-012 and 52-013
Response to Request for Additional Information

Attached is the response to an NRC staff question included in Request for Additional Information (RAI) letter number 346 related to Combined License Application (COLA) Part 2, Tier 2, Section 6.4. This completes the response to the letter. The attachment addresses the response to the RAI question listed below:

RAI 06.04-3

There are no commitments in this letter.

If you have any questions regarding this response, please contact me at (361) 972-7136, or Bill Mookhoek at (361) 972-7274.

DO91
HRO

STI 32693642

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 6/17/10



Scott Head
Manager, Regulatory Affairs
South Texas Project Units 3 & 4

jet

Attachment:

RAI 06.04-3

cc: w/o attachment except*
(paper copy)

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RAI 06.04-3**QUESTION:**

The applicant's response to RAI 06.04-2 was reviewed by the NRC staff in conjunction with the information presented during the May 6, 2010 STP 3&4, Chapter 6.4, Toxic Gas Review audit. The staff has identified that the following three issues still need to be addressed by the applicant through a docketed response.

- Justify the maximum puddle size of 100 m radius (31,400 m² area) for Acetic Acid (Offsite Storage) assumed by ALOHA, as no berm geometry or natural topography details are provided that would constrain the puddle size to within a 100 m radius. The staff's confirmatory calculations using HABIT demonstrate that if not confined, the Acetic Acid could spill far beyond 100 m radius and, consequently, lead to a concentration level inside the control room significantly exceeding the IDLH.
- All toxic gas analysis runs using ALOHA automatically stop at 1hr, while some results show that the control room inside and outside concentrations are still increasing. Complimentary HABIT runs have shown that some control room concentrations can exceed IDLH past the first hour. Demonstrate or justify that the 1-hr analysis cut-off is conservative enough to meet the NRC rules and regulations.
- During the audit, the applicant took a new position on Sodium Hypochlorite (Onsite Storage). Now, rather than modeling the entire mass of Sodium Hypochlorite (28589 kg) as liquid, it only accounts for the decomposed chlorine gas mass that gets released during 1 hr. The correlations for chlorine release presented during the audit were highly sensitive to temperature. Submit the correlations and the methodology to calculate the chlorine decomposition rate from Sodium Hypochlorite. Justify the assumed ambient temperature to be conservative enough by performing a sensitivity analysis of the released chlorine amount and the resulting chlorine concentration inside the control room, to the ambient temperature.

RESPONSE:

This response addresses each of the identified issues, as follows:

- Section 1.0 (Bullet Item 1) provides information on the berm geometry for the Acetic Acid Tank (Offsite Storage) as justification for the puddle size of 100 m radius (31,400 m² area).
- Section 2.0 (Bullet Item 2) provides both a demonstration that for each of the identified scenarios in RAI 06.04-2, the concentration outside the control room is below the Immediately Dangerous to Life and Health (IDLH) or other determined toxicity limit at the end of the 60-minute ALOHA runs and a justification as to why the 1-hr analysis cut-off is conservative enough to meet NRC rules and regulations.

- Section 3.0 (Bullet Item 3) provides the correlations and the methodology to calculate the chlorine decomposition rate from Sodium Hypochlorite and includes a temperature sensitivity analysis of the released chlorine amount and the resulting chlorine concentration inside the control room.

1.0 Acetic Acid (Offsite Storage) –Berm Geometry, Natural Topography, and Program Boundary Limitations

Berm Geometry

Acetic Acid is stored at the OXEA Bay City Plant. Based on information received from the OXEA Bay City Plant, the immediate containment area around this tank has a surface area of 5,422 ft² in area—any larger spills would overflow to a concrete lined channel spillway with a surface area of 3,700 ft². This spillway safely directs the flow to an Emergency Containment Area (ECA) which is a large surface impoundment area with a surface area of 97,782 ft².

The volume of the Acetic Acid immediate containment area, spillway and ECA is as follows:

- Immediate containment area: 5,422 ft² surface area—which is only a few inches deep, assuming a 2 inch depth, yields a volume of approximately 903 ft³.
- Spillway: 3,700 ft² surface area—10 feet wide, 3 feet deep, and 370 feet in length, yielding a volume of 11,100 ft³.
- Emergency Containment area: 97,782 ft² surface area—6 feet deep, yielding a volume of 586,692 ft³.

Thus,

Total Surface Area: 106,904 ft²

Total Volume: 598,695 ft³

Assuming a single tank conservatively contains the upper limit of the range designated in the SARA Title III, Tier II report, 9,999,999 pounds, this equates to a volume of approximately 1,140,174 gallons or approximately 152,420 ft³. Thus, the capacity of the immediate containment area, spillway and ECA, with a total volume of 598,695 ft³, far exceeds the 152,420 ft³ tank capacity conservatively estimated for the Acetic Acid tank and would completely confine the contents of a spill from this tank.

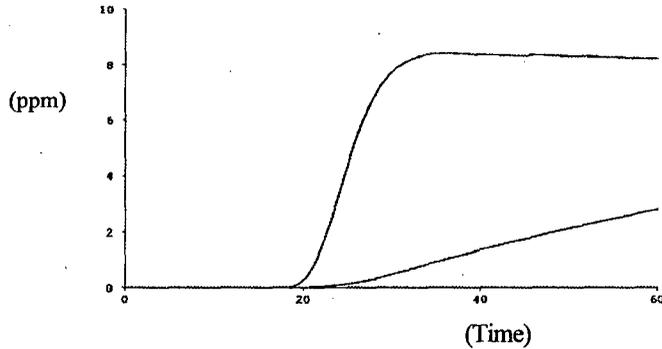
Accordingly, when accounting for the total surface area of the containment area for the Acetic Acid tank (i.e., 106,904 ft² or approximately 9,932 m²)—that yields a radius of 56.3 m. This is much less than the 100 m radius (31,400 m² surface area) used as a maximum puddle size in the ALOHA analysis and considered a realistic value for modeling purposes.

2.0 Justification for 1-hr Assumption

1-Hour Demonstration

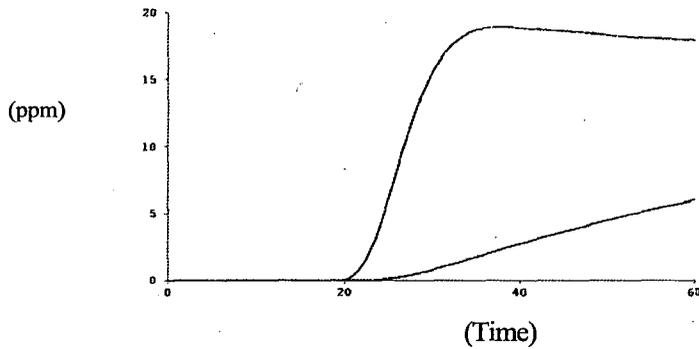
In the five scenarios identified in RAI 06.04-2, in every case the concentration outside the control room was well below the IDLH or identified toxicity limit at the end of the 60-minute run-time in ALOHA and, in all but one case, Sodium Hypochlorite (Onsite Storage), the outdoor concentration had also begun to decline. Even though the inside concentrations are still increasing they would not

become higher than the outside concentrations. This is demonstrated in the ALOHA concentration curves provided below for each of the identified scenarios: Acetic Acid (Offsite Storage), Acetic Acid (Water Transport), Gasoline (Water Transport), 1-Hexene (Offsite Storage), and Sodium Hypochlorite (Onsite Storage).



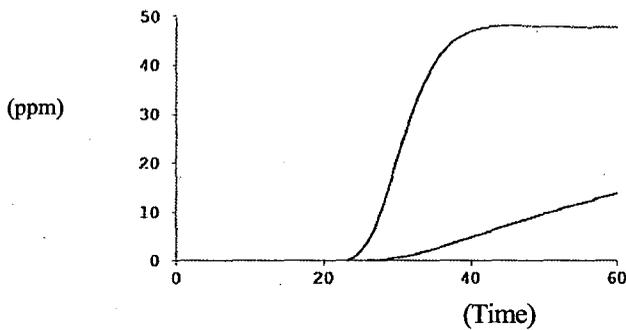
Acetic Acid (Offsite Storage) Sixty Minute Concentration Curve—IDLH 50 ppm

■ Outside Concentration
■ Inside Concentration



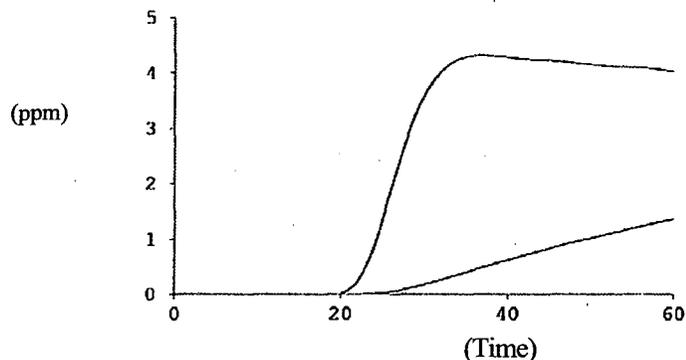
Acetic Acid (Water Transport) Sixty Minute Concentration Curve—IDLH 50 ppm

■ Outside Concentration
■ Inside Concentration



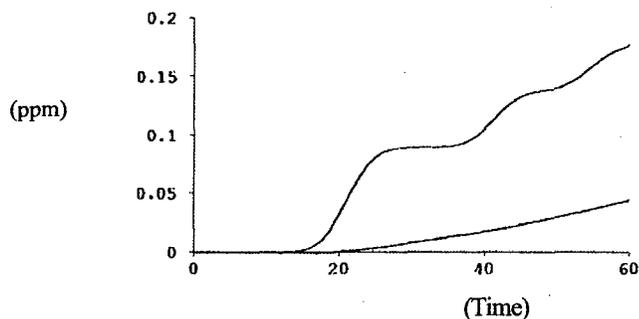
Gasoline (as n-heptane) (Water Transport) Sixty Minute Concentration Curve—TLV-TWA 300 ppm

■ Outside Concentration
■ Inside Concentration



1-Hexene (Offsite Storage) Sixty Minute Concentration Curve—TLV-TWA 30 ppm

■ -Outside Concentration
■ -Inside Concentration



Sodium Hypochlorite—as chlorine (Onsite Storage) Sixty Minute Concentration Curve—IDLH 10 ppm

■ -Outside Concentration
■ -Inside Concentration

As shown in the concentration curve above, the inside concentration of sodium hypochlorite at the end of the 60-minute run and the outside concentration (0.177 ppm) are both well below the IDLH of 10 ppm for chlorine.

Justification for the 1-hr Analysis

The following two main considerations are presented for justifying the reasonableness of the 1-hr cut-off in ALOHA. The first is that ALOHA assumes constant worst-case meteorological conditions for the 1-hr period and meteorological conditions are not likely to remain constant even for a 1-hr period. Secondly, measurements of the Pasquill-Gifford dispersion coefficients, which are used in both the ALOHA and HABIT software, were made over periods of 10 to 20 minutes. The basis for each of these considerations is presented below. (Note that there are several other papers and air quality manuals that substantiate this information; however, only a few are presented below.)

Consideration 1—Meteorological Conditions are likely to change after 1-hr:

- The ALOHA User's Manual cites that it does not model releases after one hour because meteorological conditions are likely to change after one hour. (Reference 1)
- In Regulatory Guide 1.78, the following statement is present to explain the reason for screening of chemicals stored at greater than 5 miles: "The probability of a plume remaining within a given sector for a long period of time is quite small". (Reference 8)
- NUREG/CR-5656 provides a description of the EXTRAN computer code, which is part of the HABIT software used for estimating concentrations of toxic substances at control room air intakes. In Section 2.4, page 2.21, the following statement is provided when discussing EXTRAN's output: "EXTRAN is based on a generally conservative set of assumptions that tend to maximize estimates of concentrations at the control room air intake. The most important of these assumptions is that the wind is blowing directly from the tank to the control room air intake when a release occurs. Even if the tank or release point were in the worst possible position with respect to the intake, the likelihood that the wind would be blowing directly toward the intake at the time of an accidental release is only a few percent. The likelihood that the wind direction would remain constant for more than a few seconds is also small." (Reference 9)
- The *Handbook of Chemical Hazard Analysis Procedures* presents the following discussion concerning wind meandering: "It is important to realize, however, that the direction of the wind is rarely steady over any significant period of time and that the wind direction tends to shift back and forth between various directions." Further the hazard zone boundaries, presented as a result of meandering in the *Handbook of Chemical Hazard Analysis Procedures* are for discharges up to one hour in duration. (Reference 2)
- As stated in the *Workbook of Atmospheric Dispersion Estimates*, "In the models that are approved for regulatory use by the modeling guidelines (EPA Guidelines on Air Quality Models), the Pasquill-Gifford parameters are used directly for making concentration estimates for one-hour periods for sources in rural areas. This is appropriate for periods with steady winds over one-hour periods....Since many of the models approved for regulatory use are used to estimate extreme conditions, the use of the Pasquill-Gifford parameters will assist in estimating higher one-hour concentrations." (Reference 3)

Consideration 2—Pasquill-Gifford Dispersion Coefficients were based on shorter periods of time:

- NUREG/CR-5656, Section 2.4.1, page 2.22, when discussing Model Uncertainty the following is stated: “The method of estimating diffusion coefficients was developed from data obtained in experiments with releases that were generally 15 min to 1 hr in duration. As a result, the coefficients are more appropriate for estimating 15- to 60-min average concentrations than they are for estimating 2-min average concentrations.” (Reference 9)
- In the paper, “*Air Dispersion Models: Tools to Assess Impacts from Pollution Sources*”, the following is discussed in relation to Pasquill-Gifford coefficients: “For different stability conditions, the typical Gaussian model uses standard dispersion parameters (such as Pasquill-Gifford coefficients) that describe concentration deviations about a plume’s centerline. Pasquill-Gifford coefficients were developed from research on dispersion over a five- to fifteen-minute averaging period on a grassy, relative flat terrain.... Commonly used Gaussian models have a special constraint—plume direction remains constant in any given direction for at least one hour, the minimum averaging time. Incidentally, the one-hour averaging time is much greater than the averaging period used to develop Pasquill-Gifford coefficients, which can lead to model over prediction of air concentrations.” (Reference 4)
- The *Handbook on Atmospheric Diffusion* provides the following discussion on dispersion coefficients: “Most published σ_y and σ_z curves as a function of downwind distance and stability are based on a few carefully performed diffusion experiments during the 1950’s and 1960’s. Project Prairie Grass (Haugen, 1959) is probably the most frequently quoted diffusion experiment. The terrain was uniform, releases were from near ground level, and concentration measurements were at downwind distances less than 1 km. These experiments resulted in Pasquill’s (1961) curves, which were adapted by Gifford (1961, 1968, 1976).... Note that, at distances beyond 1 km, the lines are dashed (i.e., a guess). They may work under certain ideal conditions at greater distances, but there is little basis in observations.” (Reference 5)
- As stated in the *Workbook of Atmospheric Dispersion Estimates*, “In Pasquill (1961), the paper that defines the parameters that have become known as the Pasquill-Gifford parameters, ... these parameters are for an averaging time of a few minutes. Turner (1967) interpreted a few minutes to be about 10 minutes.” (Reference 3)

3.0 Correlations and Methodology to Calculate the Decomposition Rate of Sodium Hypochlorite

The RAI question (Bullet Item 3) states that the applicant, during the audit, has taken a new position on sodium hypochlorite (Onsite Storage). However, the information presented during the audit is not a new position from the analysis presented in the STP 3&4 FSAR. The analysis presented in the FSAR relied on entering chemical properties for sodium hypochlorite into the ALOHA program. This analysis included a scenario entailing a sudden release of the entire contents of the sodium hypochlorite tank resulting in an unconfined 1-cm thick puddle—the analysis modeled the release as a solution of sodium hypochlorite and did not entail releasing the entire volume as chlorine. Whereas, in order to perform an appropriate modeling comparison for sodium hypochlorite using the HABIT software as presented during the May 6, 2010 audit, a decomposition analysis was performed.

This approach was taken primarily due to the number of chemical properties which are required to be entered for a chemical that is not a part of the models' chemical libraries. The HABIT software allows the user to enter chemical property data to analyze a chemical not present in its library; however, many of the required chemical properties for sodium hypochlorite are not available. Thus, in order to analyze sodium hypochlorite appropriately using the HABIT software in support of the May 6, 2010 audit, the amount of chlorine that would be released as a result of decomposition over a 60-minute period was calculated. That amount was then conservatively released as chlorine. This analysis was only presented as a comparison analysis for the May 6, 2010 audit.

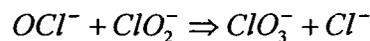
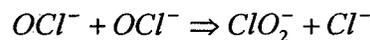
Sodium Hypochlorite Decomposition Methodology (References 6 and 7):

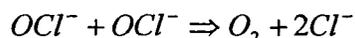
Sodium hypochlorite loses its strength by two decomposition pathways. Under normal conditions, the dominant pathway leads to the formation of two chlorine species, chlorate and chloride ions, and a slower second sodium hypochlorite decomposition pathway leads to oxygen and chloride formation.

Pathway 1: Chlorate and Chloride Ion (ClO_3^-) Formation



The decomposition of OCI^- involves chlorite ion ClO_2^- as an intermediate in the following generally accepted mechanism:



Pathway 2: Oxygen (O_2) and Chloride (ClO_3^-) Formation

The formation of oxygen from decomposing OCI^- is a very slow side reaction. However, in the presence of transition metal ions the rate of sodium hypochlorite decomposition by the oxygen pathway is increased.

The following equation was developed for an U.S. EPA Federal Insecticide Fungicide and Rodenticide Act registration for sodium hypochlorite from experimental data and is presented in the Chlorine Institute's Sodium Hypochlorite Manual for estimating the decomposition of sodium hypochlorite solutions (Reference 6):

$$\ln C = \ln C_o - KC_o^3 \theta$$

Where:

C is the final concentration (percent available chlorine)

C_o is the initial concentration (percent available chlorine) 10% to 15.5%

K is the decomposition rate constant

θ is the aging time (in days)

T is the temperature (degrees Rankine ($^{\circ}F + 460$))

\ln is the natural logarithm

The following assumptions were made when estimating the decomposition of sodium hypochlorite:

1. A 12.0 Trade Percent Solution was assumed.
2. A temperature sensitivity analysis was performed since a higher temperature will increase the decomposition rate—it is estimated that the rate of decomposition of 10 to 15 percent solutions nearly doubles with every $10^{\circ}F$ temperature rise. (Note $87^{\circ}F$ ($30.5^{\circ}C$) was used for the determination of the worst case stability class/wind speed and is the assumed temperature provided in the sample methodology analysis below.)

To determine K :

$$\ln K = 18.56 \ln T - 129.65$$

$$\ln K = 18.56 \ln (547) - 129.65$$

$$\ln K = -12.63943023$$

$$K = 3.24164309E-06$$

To determine C_o (Reference 7):

$$C_o = \text{Weight \% available } Cl_2 = \text{Trade Percent} / \text{Specific gravity of solution}$$

$$\text{Weight \% available } Cl_2 = 12.0 / 1.168$$

Weight % available $Cl_2 = 10.2739726\%$

Hence,

$$\ln C = \ln C_o - KC_o^3 \theta$$

$$\ln C = \ln (10.2739726) - 3.24164309E-06 (10.2739726)^3 (.04166)$$

$$\ln C = 2.329467288$$

$$C = 10.27246781\%$$

Next, the weight percent of available chlorine from the final concentration was determined.

$$\text{Trade Percent} / 1.168 = 10.27246781\%$$

$$\text{Trade Percent} = 11.9982424\%$$

Then, the g/L of available Cl_2 was determined

$$\text{Trade Percent} = \text{g/L available } Cl_2 / 10$$

(Reference 7)

$$\text{g/L available } Cl_2 = 119.982424 \text{ g/L}$$

Thus, the grams of available Cl_2 lost is calculated as follows:

The sodium hypochlorite tank is 7,200 gallons or 27,255 liters.

$$120 \text{ g/L} * (27,255 \text{ L}) = 3,270,600 \text{ g}$$

$$119.98 \text{ g/L} * (27,255 \text{ L}) = 3,270,120 \text{ g}$$

Therefore, grams of available Cl_2 lost = 480 grams (or 1.06 pounds)

The available chlorine that was lost (only 1.06 pounds in the sample methodology analysis above) during a sixty-minute decomposition period, was then conservatively released as chlorine gas. This quantity was released over a range of stability classes and wind speeds to determine the worst case stability class and wind speed.

Once the worst case stability class and wind speed were determined (stability class E with a wind speed of 4 m/s), a temperature sensitivity analysis was performed. The range of the temperatures, 77°F to 117°F, included in the decomposition sensitivity analysis bounds the site-specific maximum 0% dry bulb exceedance value, 43°C (109.4°F), as presented in STP 3&4 FSAR Table 2.0-2. Table 1 provides the results of the decomposition sensitivity analysis, whereas Table 2 provides the concentration results for inside control room for each of the analyzed temperatures.

Table 1: Sodium Hypochlorite Sensitivity Analysis

Temperature (°C)	Temperature (°F)	Available Chlorine Lost (Pounds)
25	77	0.75
30.5	87	1.06
36.1	97	1.48
41.7	107	2.06
47.2	117	2.85

Table 2: Temperature Sensitivity Analysis for Determined Worst Case Stability Class/Wind Speed—Sodium Hypochlorite (Onsite) Comparison Analysis Results

Stability Class	Wind Speed (m/s)	Cloud Cover (tenths)	Solar Radiation (W/m ²)	Temperature (°F)	Quantity Chlorine Released (kg)	Maximum Puddle Radius (m)	Delay Between Release and Intake (min)	Time (min) for Max Conc. [EXTRAN/HABIT]	EXTRAN (ppm)	HABIT Control Room Results (ppm) ^a
E	4	0	738	77	0.341	Run time exceeded				
E	4	0	738	87	0.481	0.09	1.83	1.25/7.50	0.0159	0.000567
E	4	0	738	97	0.672	0.10	1.83	1.25/7.50	0.0243	0.000796
E	4	0	738	107	0.935	0.12	1.83	1.25/7.50	0.0367	0.00112
E	4	0	738	117	1.30	0.14	1.83	1.25/7.50	0.0551	0.00158

^a The determined worst case meteorological condition (stability class and wind speed) was based upon those meteorological conditions yielding the highest concentration in the control room after performing a meteorological sensitivity analysis. (The control room concentrations were rounded up to three significant digits.)

Note that the results of this comparison and temperature sensitivity analysis yields a maximum Control Room concentration of 0.00158 ppm for sodium hypochlorite, which is much less than the reported maximum concentration of 0.0450 ppm for this chemical in FSAR Table 2.2S-11 and significantly less than the IDLH for chlorine of 10 ppm. Therefore, no changes to the current methodology presented in the STP 3&4 FSAR are needed.

No COLA revision is required as a result of this RAI response.

References:

1. National Oceanic and Atmospheric Administration, *ALOHATM (Areal Locations of Hazardous Atmospheres) 5.0 Theoretical Description*, NOAA Technical Memorandum NOS ORCA-65, Draft August 1992.
2. U.S. Department of Transportation, U.S. Environmental Protection Agency, and the Federal Emergency Management Agency, *Handbook of Chemical Hazard Analysis Procedures*, 1989.
3. Turner, Bruce D., *Workbook of Atmospheric Dispersion Estimates: An Introduction to Dispersion Modeling*, 2nd Edition, Lewis Publishers, 1994.
4. Westbrook, James A., *Air Dispersion Models: Tools to Assess Impacts from Pollution Sources*, Natural Resources & Environment, Vol 13, No. 4, Spring 1999.
5. Hanna, Steven R., Briggs, Gary A., and Hosker, Rayford P. Jr., Atmospheric Turbulence and Diffusion Laboratory, National Oceanic and Atmospheric Administration, *Handbook on Atmospheric Diffusion*, DOE/TIC-11223, 1982.
6. The Chlorine Institute, Inc., Pamphlet 96, *Sodium Hypochlorite Manual, Edition 3, Revision 1*, November 2008.
7. White, Geo. Clifford, *Handbook of Chlorination For Potable Water, Wastewater, Cooling Water, Industrial Processes, and Swimming Pools*, 1972.
8. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.78, *Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release*, Revision 1, December 2001.
9. U.S. Nuclear Regulatory Commission, NUREG/CR-5656, PNL-7510, *EXTRAN: A Computer Code for Estimating Concentrations of Toxic Substances at Control Room Air Intakes*, March 1991.