Health Consultation

EXPOSURE TO BENZENE FROM EQUISTAR PYROLYSIS GASOLINE TANK

CLINTON, IOWA

JUNE 27, 2008

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

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HEALTH CONSULTATION

Exposure to Benzene from Equistar Pyrolysis Gasoline Tank

Clinton, Iowa

Prepared By:

Iowa Department of Public Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

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Purpose

The Iowa Department of Public Health (IDPH) has been asked by several citizens of Clinton, Iowa to evaluate potential health effects from exposure to benzene from an above ground tank located near a residential area. The above ground tank is managed by Equistar Chemicals, LP (Equistar) and is use to store pyrolysis gasoline prior to off-loading onto barges. The IDPH in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR) prepared this health consultation to review the air quality monitoring provided by Equistar and provide an evaluation of the health effects from exposure to benzene at the levels detected in ambient air near the tank. The information in this health consultation was current at the time of writing. Data that emerges later could alter this document's conclusions and recommendations.

Background

A large, approximately 500,000-gallon, above-ground storage tank is located near the Mississippi River in Clinton, Iowa. Figure 1 is an aerial view of the tank location. From this figure it can be seen that residential properties are located within 200 meters of the tank. This tank is operated by Equistar and is used to temporarily store pyrolysis gasoline prior to loading onto barges. According to Equistar, the tank contains a complex hydrocarbon mixture that is a product of the ethylene manufacturing process and contains 20-40 percent benzene, by volume (1). The tank is equipped with a floating roof that moves up and down depending upon the volume of the pyrolysis gasoline within the tank. Vents are located on the top edge of the tank and ventilate that area above the internal floating roof to maintain a non-explosive environment within the tank. These vents are the source of hydrocarbon emissions from the tank into the ambient air surrounding the tank.

Residents within the neighborhood near the tank have expressed concerns regarding the odors and potential health effects from exposure to emissions from this tank. The majority of the concerns have been about inhalation exposure to benzene. Equistar has completed some limited air monitoring prior to, during, and after barge loading. These air monitoring events were completed in August 2006 and in April 2007. The location of the air monitoring was downwind of the tank during the monitoring events. In addition to the air monitoring, Equistar completed emission modeling using U.S. Environmental Protection Agency (EPA) software, TANKS. TANKS is a Windows-based computer software program that estimates volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions from fixed- and floating-roof storage tanks.

Discussion

Air Monitoring and Modeling Results

Air Monitoring Completed by Equistar

Table 1, on the following page, includes the data collected during the August 2006 and April 2007 sampling events. The monitoring equipment was only able to detect benzene down to concentration of one-tenth of a part per million (0.1 ppm)

Table 1 – Air Monitoring Results (1)

Date	Time	Benzene Concentration (ppm)	Barge Loading Status	Location Description
8/21/2006	14:30	0.0	No Loading	On dike @ access road
8/21/2006	14.35	0.0	No Loading	10’ E of fence, 20’ S of gate
8/22/2006	11:00	0.2	Barge Loading	@ stair base over dike
8/22/2006	11:00	0.4	Barge Loading	20’ E of fence, 10” N of gate
8/22/2006	15:20	0.0	Barge Loading Complete	On dike at access road
8/22/2006	15:25	0.0	Barge Loading Complete	20’ E of fence, 30’ S of personnel gate
8/22/2006	17:20	0.0	After Loading	On dike, 100’ W of access road
8/22/2006	17:30	0.0	After Loading	20’ E of fence, 40’ S of gate
4/23/2007	15:27	0.0	No Loading	15’ E of fence, 8’N and 8’E of utility pole
4/23/2007	15:35	0.0	No Loading	75’ SE of fence 15’ S of tracks, 45’ E of utility pole
4/23/2007	15:51	0.0	No Loading	Dike Rd S of tank, 100’ E of gate to lower dock
4/24/2007	11:25	0.0	No Loading	20’ N of fence, 10’ W of No Trespassing sign
4/24/2007	11:48	0.0	No Loading	150’ NW of fence, 65’ S & 10’ E of fire hydrant
4/24/2007	15:01	0.0	No Loading	Curb @ alley, 210’ W of fence
4/25/2007	11:35	0.2	Barge Loading	50’ W of fence, 10’ N of concrete panels
4/25/2007	11:42	0.0	Barge Loading	170’ W of fence, above street drain
4/25/2007	16:15	0.2	Barge Loading	170’ W of fence, 40’ S of street drain
4/25/2007	16:28	0.1	Barge Loading	30’ W of fence, 10’ N of concrete panels
4/25/2007	17:56	0.0	Barge Loading Ccomplete	170’ W of fence, 30’ S of street drain
4/25/2007	18:04	0.0	Barge Loading Complete	50’ W of fence, 10’ N of concrete panels

The maximum concentration of benzene measured during barge loading was 0.4 ppm. This concentration was measured at 20 feet from the fence surrounding the tank. The maximum concentration of benzene measured near the residential area during barge loading was 0.2 ppm. Benzene was not detected by the monitoring equipment utilized by Equistar just prior to and just after loading of the barges.

Emission Modeling Results

The emission modeling completed by Equistar using TANKS modeling software from EPA determined that about 1,200 pounds of hydrocarbons are released from the pyrolysis gasoline tank each year (1). The modeling software also predicted the peak concentration of benzene 100 feet from the tank to be 0.03 ppm (1). This peak concentration represents the modeled concentration of benzene at the time a barge is being filled and is lower than the measure concentration of benzene in the vicinity of the tank.

Equistar also completed additional modeling of average benzene concentrations in the vicinity of the tank. The modeling completed by Equistar utilized emissions inventory results from 2006 that indicated that 300 pounds of benzene were emitted to the atmosphere from the tank during 2006. The modeling completed by Equistar predicted an average concentration of benzene from emissions from the tank in the neighborhood adjacent to the tank to be between 0.000006 ppm and 0.00002 ppm (Appendix 1). There is some uncertainty in the concentrations predicted by the modeling software.

Equistar completed dispersion modeling of the benzene emissions from the tank. This dispersion modeling predicted average concentrations of benzene at various distances and directions from the tank. This dispersion modeling predicts that the homes in the vicinity of the tank are exposure to benzene from the tank at concentrations less than 0.13 micrograms per cubic meter or 0.00004 ppm (Appendix 1).

Average Benzene Concentrations in the U.S. and in Clinton

Benzene is a chemical that is present everywhere in the atmosphere at low levels. There are many sources of benzene, both natural and man-made, although man-made sources are the most important. Benzene can be released into the atmosphere from gasoline vapors, auto exhaust, and chemical production. Benzene concentrations have been measured all over the U.S. in outdoor and indoor air in both rural and urban environments. Average daily concentrations in the U.S. have been reported to be 0.00016 ppm in remote areas, 0.00047 ppm in rural areas, 0.0018 ppm in suburban areas, 0.0018 ppm in urban areas, 0.0018 ppm within indoor air, and 0.0021 ppm within the workplace (2).

The EPA has also completed modeling of benzene concentrations on a county-wide basis. The EPA modeling utilizes data from emissions from local industry, mobil sources, and background estimates. The EPA modeling completed in 1996 indicates the average concentration of benzene within the atmosphere in Clinton County to be between 0.0002 and 0.0003 ppm (3).

Contaminant of Concern

The contaminant of concern is benzene vapors being emitted from the tank. The major effect of benzene from long-term exposure is on the blood. Exposure to benzene at high levels causes harmful effects on the bone marrow and can cause a decrease in red blood cells leading to anemia. It can also cause excessive bleeding and can affect the immune system, increasing the chance for infection (4).

Benzene is recognized as a known human carcinogen. Long-term exposure to high levels of benzene in the air can cause leukemia, particularly acute myelogenous leukemia, often referred to as AML. This is a cancer of the blood-forming organs (4).

This health consultation will examine the exposure pathways and estimated exposures to benzene at the levels monitored and modeled by Equistar.

Exposure Pathways

Exposure to contaminants of concern is determined by examining human exposure pathways. An exposure pathway has five parts:

1. a source of contamination,
2. an environmental medium such as air, water, or soil that can hold or move the contamination,
3. a point at which people come in contact with a contaminated medium, such as in drinking water or in surface soil,
4. an exposure route, such as drinking water from a well or eating contaminated soil on homegrown vegetables, and
5. a population who could come in contact with the contaminants.

An exposure pathway is eliminated if at least one on the five parts is missing and will not occur in the future. For a completed pathway, all five parts must exist and exposure to a contaminant must have occurred, is occurring, or will occur.

A benzene exposure pathway has been completed. Benzene is emitted from the tank and the residential populations living near the tank has been and is exposed.

Toxicological Evaluation

This toxicological evaluation is intended to evaluate the potential health effects from exposure to benzene within the residential neighborhood near the tank at the levels monitored and modeled by Equistar. At the present time there has been no long-term monitoring of the benzene levels in the residential area near the tank. As previously discussed, monitoring of benzene levels in the air surrounding the tank has been limited to several times during barge loading events. During these barge loading events the maximum level of benzene in the air has been measured at 0.4 ppm near the tank and 0.2 ppm near the residences. According to Equistar, these loading events last for about 6-7 hours. Measurable levels of benzene in the air surrounding the tank have not been detected prior to loading a barge and after the barge loading is completed. This does not mean that benzene was not present in the air, only that the equipment utilized by Equistar was not able to detect any benzene.

A calculation can also be made from the short-term measurements of benzene exposure near the tank and near the residences to provide an estimation of long-term exposure levels. According to Equistar officials barges are filled on an average of 18 times per year. Using this data a calculation of the average long-term levels near the tank and near the residences can be made using the following equation:

0.2 to 0.4 ppm x (7 hours per day) x (1/24 days per hour) x (1/365 year per day) x (18 events per year), or

0.003 to 0.006 ppm

Comparison Values

In order to determine if there is a potential for adverse health effects from inhalation exposure to benzene in the air surrounding the tank**,** this toxicological evaluation will first compare the monitored levels to the following published comparison values: minimum risk levels, the reference concentration, and the cancer risk evaluation guide. Comparison values are not to be used as cleanup levels or action levels. Comparison values are estimated levels, within an order of magnitude, where we can be confident that there will be no adverse health effects, even to the most sensitive portions of the human population.

Minimum Risk Levels

Minimum risk levels (MRLs) are established by ATSDR and are defined as, "an estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse) noncancerous effects." MRLs are based upon human and animal studies, include several safety factors, and are reported for acute exposure (less than or equal to 14 days), intermediate exposure (15–364 days), and chronic exposure (greater than or equal to 365 days). Three MRLs have been established for inhalation exposure to benzene. They are 0.009 ppm for acute exposure, 0.006 ppm for intermediate exposure, and 0.003 ppm for chronic exposure (5).

Reference Concentration

The reference concentration (RfC) is established by the EPA and is defined as "an estimate of a daily exposure to the general public (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects (noncarcinogenic) during a lifetime exposure." The RfC for inhalation exposure to benzene is 0.003 ppm (6).

Cancer Risk Evaluation Guide

The cancer risk evaluation guide (CREG) is derived by ATSDR and is based upon the cancer slope factor established by the EPA. The CREG is an estimated chronic level of exposure to a chemical at which there is a risk of an additional one-in-one million cancer incidence. That is, if a group of one million people was exposed to the chemical above the CREG, it is estimated that one additional person in the group of one million people would get cancer. The CREG for inhalation exposure to benzene is 0.00003 ppm (7).

Actual Exposures versus Comparisons Values

Measuring detected levels of exposure to benzene in the vicinity of the tank against comparison values can reveal if there is a potential for current exposures to cause adverse health effects. The highest level of benzene detected in the air surrounding the tank, 0.4 ppm, was during filling the barge. Exposure to this level of benzene would only be for a short time, 8 hours or less. This represents an acute or short-term exposure to benzene and it would be appropriate to compare this level of exposure to comparison values developed for acute exposure. The only comparison value developed for acute exposure is the acute MRL of 0.009 ppm.

The monitoring completed by Equistar prior to barge loading and after barge loading activities did not detect any measurable amount of benzene. As explained before, the non-detection of benzene in the air does not necessarily mean that benzene was not present in the air, only that it was not detected with the equipment and analysis techniques used at that time.

The highest measured level of benzene in the air during loading of a barge was 0.4 ppm near the tank and 0.2 ppm near the residences. These levels are above the appropriate comparison value, the acute MRL. In order to determine if there is a potential for adverse health effect it will be necessary to take a closer look at some of the studies involving human inhalation exposure to benzene.

Benzene Exposure Studies

Previous studies have been completed on human inhalation exposure to benzene and accompanying observed health effects. By comparing the levels of exposure to benzene in these studies to the levels that have been measured near the tank, we can possibly make some conclusions as to potential for adverse health effects to residents living near the tank. The following is a summary of some of the published studies on inhalation exposure to benzene in the Draft Toxicological Profile for Benzene prepared by ATSDR (2).

- It is estimated that 5 – 10 minutes of inhalation exposure to 20,000 ppm benzene is fatal to humans.

- Inhalation exposure to benzene levels in excess of regulated workplace limits (an average exposure level of 1 ppm during an 8-hour shift) for several months to several years can result in deficits in the relative numbers of circulating blood cells.

- An abnomal decrease in white blood cells was observed in workers exposed to 0.69–140 ppm (average of 6 ppm) benzene for more than 1 year.

- One study found no significant correlations between benzene exposure and the prevalence of abnormal blood cell levels among 200 workers exposed to benzene at estimated concentrations ranging from 0.01 to 1.4 ppm, relative to the prevalence of abnormal blood cell values obtained from 268 unexposed workers in the same plant.

- Another study found no significant correlation between exposures to benzene at 0.55 ppm for an 8-hour shift and blood cell diseases among a group of 387 workers exposed for more than 5 years at this exposure level.

- The lowest observed adverse effect level (LOAEL) in a long-term occupational study is 0.57 ppm benzene. In this study reduced white blood cell and platelet counts were observed in workers exposed to benzene as compared to workers in the same manufacturing facility not exposed to benzene.

- The LOAEL in a short-term occupational study is 60 ppm benzene. In this study workers were exposed from 1 to 21 days, 2.5 to 8 hrs/day. Among the health effects observed were mucous membrane irritation, reduced white blood cell levels, anemia, skin irritation, dizziness, nausea, and headache.

Most of the summaries discussed above include studies documenting health effects from exposure to chronic or long-term exposure to benzene. The lowest level of exposure to benzene where measurable adverse health effects in people were noticed in a long-term or chronic exposure study was 0.57 ppm benzene. Benzene was not detected in the air prior to and after barge loading by monitoring equipment utilized by Equistar, but an estimation of the average long-term levels of benzene near the tank and near the residences was determined to be from 0.003 ppm to 0.006 ppm. The levels are several orders of magnitude below lowest measured concentration of benzene where an adverse health effect was observed in a long-term occupational study.

The lowest level of exposure to benzene where measurable adverse health effects in people were noticed in a short-term or acute exposure study was 60 ppm benzene. The highest level of benzene detected during the barge loading events was 0.4 ppm. This is several orders of magnitude below the lowest level of benzene where an adverse health effect was observed in a short-term study.

Benzene and Cancer

As stated in the Draft Toxicological Profile for Benzene , "Epidemiological studies and case reports provide clear evidence of a causal relationship between occupational exposure to benzene and benzene-containing solvents and the occurrence of acute nonlymphocytic leukemia." (2) In one of the studies described in the Draft Toxicological Profile for Benzene, the risk for leukemia was increased in individuals that were exposed to levels above 10 ppm benzene and above a cummulative exposure measurement above 40 ppm-years. A cummulative exposure measurement is the mathematical product of the concentration of benzene and the number of years of exposure. (A 40 ppm-years cummulative exposure could be an exposure of 10 ppm benzene for 4 years or and exposure of 1 ppm benzene for 40 years).

In another large study there were no increased risks of mortality from cancer due to exposure to lower levels of benzene. This large epidemiological analysis was conducted on 19 groups of individuals of petroleum workers in the United States and the United Kingdom that were pooled into a single database for cell-type-specific leukemia analysis. This study included 208,741 workers in the analysis. These workers were mainly refinery employees. Benzene exposures were mainly from handling gasoline and the estimated mean and cumulative exposure measurement for the most exposed jobs were <1 ppm and <45 ppm-years, respectively. In this large study no increased risks were found for mortality from acute myelogenous leukemia, chronic myeloid leukemia, acute lymphocytic leukemia, or chronic lymphatic leukemia (2).

The cancer risk evaluation guide (CREG) was previously discussed in this health consultation. The CREG is an estimation, based upon mathematical modeling, of the level of benzene in the air that would produce a theoretical increased risk of one-in-one million cancer cases if a person was exposed at this level over a lifetime. The CREG for benzene in air is 0.00003 ppm. Exposure to benzene at the CREG level represents a very low cancer risk.

As previously discussed, the average concentration of benzene within outdoor air in urban areas is 0.0018 ppm – about 60 times larger than the CREG. The modeling completed by Equistar predicted average concentrations of benzene contributed by the tank in the residential neighborhood near the tank to be up to 0.00004 ppm – just slightly above the CREG. As previously stated there is much uncertainty in modeled concentrations and they are not based upon long-term monitoring results. The estimated average long-term levels of benzene near the tank and near the residences were determined to be from 0.003 ppm to 0.006 ppm – from 100 to 200 times larger than the CREG.

Although the estimated long-term levels of benzene exposure to the resident living near the tank is larger than the CREG, these estimated levels are below cumulative exposure values that have shown an increase risk of cancer in occupational studies. Using the estimated long term levels of benzene exposure to residents in the vicinity of the tank of 0.003 ppm to 0.006 ppm and multiplying by 70 years of exposure results in a cumulative exposure range of 0.21 to 0.42 ppm-years. This is about 100 times smaller than the cumulative exposure values that have shown an increase risk of cancer in occupational studies. The estimated long term level of exposure to benzene in the vicinity of the tank represents a 1 in 5,000 increased risk of developing cancer.

Summary of Toxicology Evaluation

The measured levels of benzene in the air near the tank completed by Equistar in August 2006 and April 2007 were detected above comparison values for benzene. Benzene levels above comparison values mean that we cannot conclude that the benzene levels in the air will not have any adverse health effects to even the most sensitive portions of the population and that further evaluation is needed. In order to draw any conclusions it was necessary to look more closely at some of the published information regarding adverse health effects from human exposure to benzene. The levels of benzene measured in the air near the tank during barge filling are below the levels of benzene where adverse health effects were observed in published short-term exposure studies. Short-term exposure to benzene during times that barges are loaded would most likely not adversely affect the health of individuals living in the neighborhood near the tank.

Benzene was not detected in the air near the tank during times that the barges were not being loaded. As explained before, non-detection of benzene does not mean that benzene was not present in the air, only that the monitoring equipment was not sensitive enough to measure benzene. If more sensitive equipment was utilized, benzene would most likely have been detected. The modeling completed by Equistar indicates that average concentrations of benzene in the air in the vicinity of the tanks would be below levels expected to produce adverse health effects, including cancer effects.

A calculation was also made of long-term exposure levels from the measured short term exposure benzene concentrations. These estimated long-term exposure levels are below levels expected to produce adverse health effects, including cancer effects.

This health consultation only reviewed monitoring data from several monitoring events, and utilized monitoring equipment that was only able to detect concentration of benzene in the air to the nearest 0.1 ppm. Additional monitoring events with more sensitive measuring equipment would provide additional data that would make any conclusions regarding any adverse health effects from exposure to benzene more definitive.

Community Health Concerns

Residents within the neighborhood near the tank have expressed concerns regarding the odors and potential health effects from exposure to emissions from this tank. The majority of the concerns have been with inhalation exposure to benzene. This health consultation has attempted to provide an evaluation of the measured and modeled levels of benzene in the vicinity of the tank. IDPH will continue to address health concerns of residents living near the tank if there are additional concerns after they have read this health consultation.

Conclusions

The following conclusions can be made after completing an evaluation of the measured and modeled benzene levels in the vicinity of the tank.

- Short-term (8-hour) exposure to the benzene levels measured during the barge loading events in August 2006 and April 2007 are not expected to produce adverse non-cancer health effects (No Apparent Public Health Hazard).

- There is insufficient data to determine the potential for adverse health effects from long-term exposure to the benzene levels determined by modeling software utilized by Equister or calculated from short-term monitoring results. (Indeterminate Public Health Hazard)**.** Based upon the model used by Equistar, the potential for adverse health effects from long term exposure to benzene in the vicinity of the tank is low, but there is some uncertainty in the modeled numbers.

Recommendations

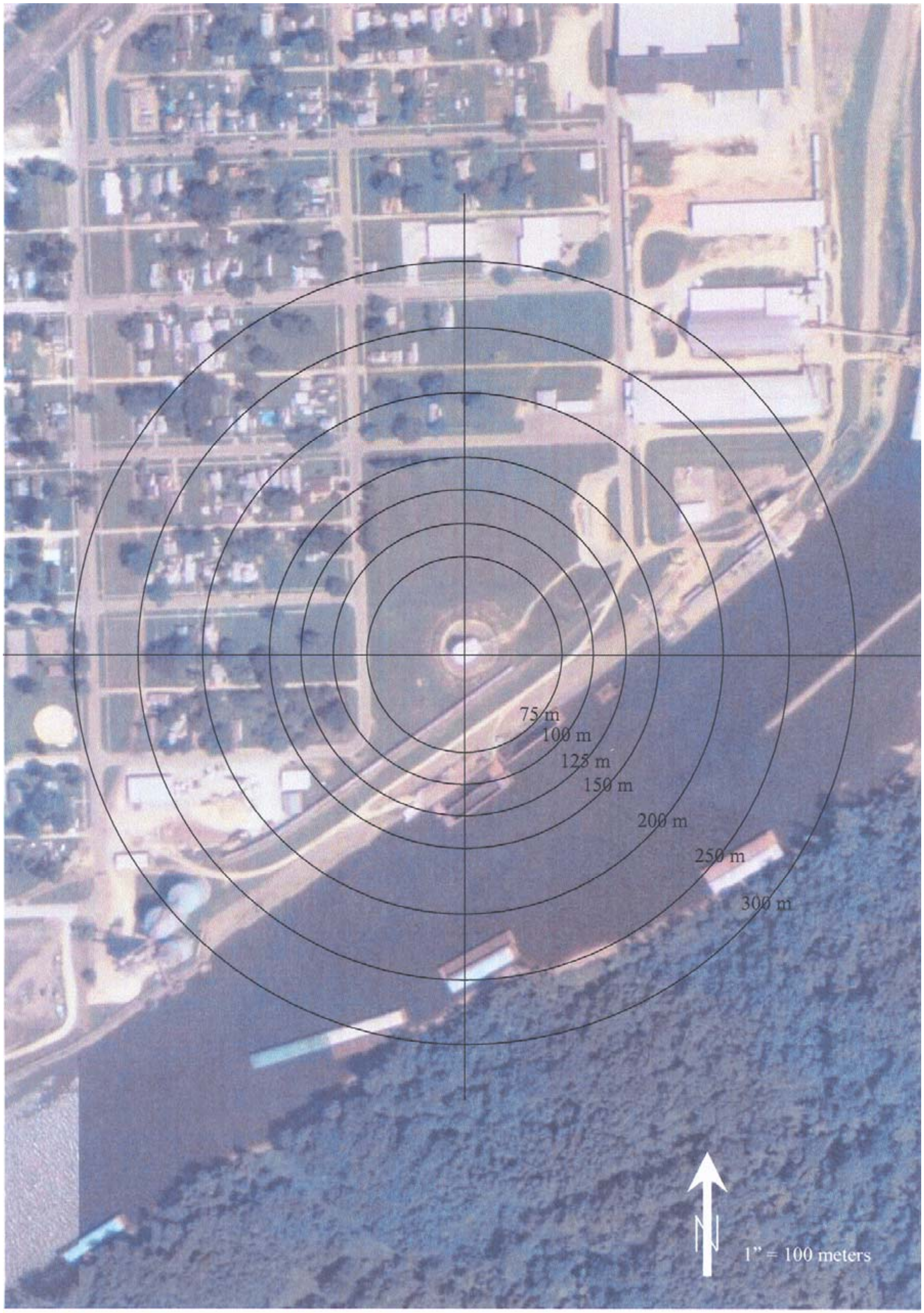
- A long-term monitoring program evaluating benzene levels should be implemented to better determine average benzene levels in the vicinity of the tank.

- Equipment that has a greater sensitivity than the equipment utilized by Equistar during the August 2006 and April 2007 should be utilized during any additional long-term monitoring program.

Public Health Action Plan

- IDPH will present the finding of this health consultation at a public meeting in Clinton.
- IDPH will respond to any community concerns that may arise.
- IDPH will evaluate any additional data on long-term benzene exposure levels if they become available.

Figure 1: Site Map



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1. Letter Report to Iowa Department of Public Health from Equistar Chemicals, LP dated September 4, 2007

2. Agency for Toxic Substances and Disease Registry. Draft Toxicological Profile for Benzene. Atlanta: US Department of Health and Human Services; September 2005

3. National Air Toxics Assessment, U.S. Environmental Protection Agency web link: http://www.epa.gov/ttn/atw/nata/mapconc.html

4. Benzene Fact Sheet, Agency for Toxic Substances and Disease Registry web link: http://www.atsdr.cdc.gov/tfacts3.pdf

5. Minimum Risk Levels for Hazardous Substances, Agency for Toxic Substances and Disease Registry web link: http://www.atsdr.cdc.gov/mrls/index.html

6. Integrated Risk Information System data for Benzene, U.S. Environmental Protection Agency web link: http://www.epa.gov/iris/subst/0276.htm

7. ATSDR Air Comparison Values, Agency for Toxic Substances and Disease Registry, February 2007.

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CERTIFICATION

The Iowa Department of Public Health, Hazardous Waste Site Health Assessment Program, has prepared this health consultation for the evaluation of benzene emissions from the Equister pyrolosis gasoline tank in Clinton, Iowa under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). The document is in accordance with approved methodology and procedures existing when the health consultation was being prepared.

Technical Project Officer, CAT, SPAB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with its findings.

Team Lead, CAT, SPAB, DHAC, ATSDR

Appendix 1 – Emission Modeling Results

F-2132 Barge area DAC tank Monitoring Summary

Date	time	Wind speed mph	Wind direction	Benzene value ppm	Hydrocarbon value ppm	Barge status	Location Description
8/21/2006	14:30	8.1	WNW	0.0	0.0	no loading	On dike @ access road
	14:35			0.0	0.0		10' E of fence, 20' S of gate
8/22/2006	11:00	9.2	W	0.2	2.0	barge loading	@ stair base over dike
	11:00			0.4	4.0		20' E of fence, 10' N of gate
	15:20	6.9	WNW	0.0	1.0	barge loading	On dike @ access road
				0.0	1.0	complete	20' E of fence, 30' S of personnel gate
		10.4	WNW	0.0	1.0	after loading	On dike, 100' W of access road
	17:30			0.0	1.0		20' E of fence, 40' S of gate
15:25							
4/23/2007	15:27	11.5	WNW	0.0	0.3	no loading	15' E of fence, 8'N & 8'E of utitlity pole
	15:35			0.0	0.3		75'SE of fence, 15' S of tracks, 45' E of utility pole
17:20							
	15:51			0.0	0.7		Dike Road S of F2132, 100' East of Gate to lower dock
4/24/2007	11:25	17.3	ESE	0.0	1.7	no loading	20' N of fence, 10' west of No Trespassing sign
	11:48			0.0	0.5		150' NW of fence, 65' south & 10' E of fire hydrant
	15:10	16.1	E	0.0	0.3		Curb @ alley 210' W of fence
4/25/2007	11:35	24.2	ENE	0.2	1.7	barge loading	50' W of fence, 10' N of concrete panels
	11:42			0.0	1.2		170' W of fence, above street drain
	16:15	16.1	E	0.2	0.5		170' W of fence, 40' S of street drain
	16:28			0.1	0.3		30' W of fence, 10' N of concrete panels
		18.4	E	0.0	0.5	barge loading	170' W of fence, 30' S of street drain
	18:04			0.0	0.9	complete	50' W of fence, 10' N of concrete panels

Sampling data collected by Joe Boss
Compiled by Jerry Tonneson

17:56

*** THE PERIOD (8760 HRS) AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL ***
INCLUDING SOURCE(S): STACK1 ,

*** NETWORK ID: POL1 ; NETWORK TYPE: GRIDPOLR ***

** CONC OF VOC IN MICROGRAMS/M**3 **

DIRECTION | (DEGREES) |	DISTANCE (METERS) 75.00	100.00	125.00	150.00	200.00	250.00	300.00	400.00
10.00 |	0.74329	0.43798	0.29127	0.20907	0.12427	0.08320	0.05996	0.03616
20.00 |	0.55438	0.32713	0.21855	0.15794	0.09534	0.06470	0.04720	0.02905
30.00 |	0.48151	0.28411	0.18965	0.13689	0.08233	0.05570	0.04052	0.02476
40.00 |	0.51381	0.30608	0.20621	0.15012	0.09150	0.06252	0.04584	0.02835
50.00 |	0.51358	0.30510	0.20490	0.14886	0.09068	0.06207	0.04562	0.02837
60.00 |	0.58867	0.35298	0.23905	0.17506	0.10816	0.07490	0.05554	0.03490
70.00 |	0.50345	0.30501	0.20828	0.15383	0.09683	0.06816	0.05128	0.03297
80.00 |	0.44180	0.26616	0.18090	0.13303	0.08294	0.05791	0.04327	0.02757
90.00 |	0.35777	0.21517	0.14578	0.10681	0.06626	0.04606	0.03429	0.02175
100.00 |	0.37867	0.22610	0.15198	0.11028	0.06692	0.04559	0.03332	0.02050
110.00 |	0.37458	0.22401	0.15064	0.10931	0.06633	0.04516	0.03301	0.02035
120.00 |	0.36672	0.21896	0.14775	0.10784	0.06624	0.04553	0.03351	0.02082
130.00 |	0.31949	0.19147	0.12921	0.09403	0.05725	0.03900	0.02847	0.01746
140.00 |	0.24788	0.14802	0.09927	0.07178	0.04322	0.02922	0.02121	0.01293
150.00 |	0.19533	0.11624	0.07779	0.05617	0.03383	0.02290	0.01667	0.01025
160.00 |	0.17698	0.10565	0.07078	0.05113	0.03078	0.02082	0.01514	0.00926
170.00 |	0.19993	0.12037	0.08109	0.05877	0.03542	0.02390	0.01731	0.01052
180.00 |	0.23293	0.13839	0.09246	0.06677	0.04026	0.02739	0.02007	0.01247
190.00 |	0.22021	0.13123	0.08770	0.06311	0.03758	0.02515	0.01811	0.01089
200.00 |	0.17770	0.10597	0.07105	0.05144	0.03115	0.02121	0.01552	0.00960
210.00 |	0.16694	0.09862	0.06559	0.04707	0.02794	0.01867	0.01344	0.00811
220.00 |	0.19654	0.11584	0.07691	0.05514	0.03275	0.02191	0.01579	0.00956
230.00 |	0.27074	0.15992	0.10632	0.07622	0.04515	0.03009	0.02160	0.01294
240.00 |	0.37892	0.22476	0.14994	0.10779	0.06405	0.04278	0.03075	0.01846
250.00 |	0.36925	0.21974	0.14700	0.10596	0.06333	0.04253	0.03073	0.01866
260.00 |	0.33127	0.19538	0.12995	0.09326	0.05537	0.03699	0.02662	0.01604
270.00 |	0.48858	0.29152	0.19591	0.14192	0.08556	0.05788	0.04206	0.02567
280.00 |	0.43441	0.25641	0.17060	0.12257	0.07300	0.04900	0.03542	0.02150
290.00 |	0.34985	0.20686	0.13777	0.09900	0.05896	0.03954	0.02856	0.01730
300.00 |	0.24901	0.14928	0.10027	0.07242	0.04330	0.02901	0.02089	0.01257
310.00 |	0.19958	0.11900	0.07963	0.05740	0.03428	0.02297	0.01655	0.00996
320.00 |	0.23002	0.13752	0.09245	0.06694	0.04028	0.02715	0.01966	0.01195
330.00 |	0.26729	0.15800	0.10512	0.07542	0.04473	0.02989	0.02151	0.01294
340.00 |	0.40034	0.23632	0.15728	0.11301	0.06742	0.04535	0.03284	0.01992
350.00 |	0.59002	0.34914	0.23338	0.16846	0.10122	0.06844	0.04973	0.03029
360.00 |	0.77752	0.46093	0.30856	0.22309	0.13454	0.09126	0.06650	0.04073

Key Yellow highlighted > 0.13 micrograms/cubic meter annual average