PUBLIC COMMENT RELEASE DRAFT

HEALTH CONSULTATION

BROOKHAVEN LANDFILL

TOWN OF BROOKHAVEN, SUFFOLK COUNTY, NEW YORK

CERCLIS NO. NYD038150264

January 18, 1996

Prepared by:

New York State Department of Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

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BACKGROUND AND STATEMENT OF ISSUE

A. Introduction

The New York State Environmental Facilities Corporation (EFC) opened the Brookhaven Landfill in March 1974, and the Town of Brookhaven assumed ownership of the landfill in 1976. Throughout the history of this site, citizens have expressed many health concerns. Therefore, the local citizens petitioned a health consultation from the U.S. Agency for Toxic Substances and Disease Registry (ATSDR). Through a cooperative agreement, the New York State Department of Health (NYS DOH) and ATSDR will address the citizens' concerns by evaluating the potential for human exposure to contaminants from the landfill. People can be exposed to environmental contamination by eating contaminated food, soil, or water (ingestion); breathing contaminated air (inhalation); and directly touching contaminated materials (dermal contact). This health consultation includes recommendations for the Brookhaven Landfill.

B. Site Description and History

The Brookhaven Landfill is an active municipal solid waste landfill at the Town of Brookhaven Waste Management Facility, northwest of the Village of Brookhaven, in the Town of Brookhaven, Suffolk County, New York (Figure 1). The Town of Brookhaven Waste Management Facility Site consists of approximately 534 acres and is between Horseblock Road and Sunrise Highway. The existing landfill occupies 90 acres and the proposed expansion area will cover an additional 78 acres on the western portion of the site: 56 acres of landfill and 22 acres of additional facilities. Horizon Village, a major residential area, is 2,400 feet west of the nearest edge of the existing landfill and 800 feet west of the nearest edge of the proposed expansion. The Hampton Avenue School is 5,600 feet (about one mile) west southwest of the landfill.

The landfill has a gas collection system for methane. Methane is burned by generators, and the resulting energy is sold to the Long Island Lighting Company (LILCO). The existing landfill contains four lined cells (Cells 1-4), and the proposed expansion will consist of Cell 5. Cell 1 comprises 45 acres and was opened in 1974. It was closed in 1983, and partially capped with a polyvinyl chloride (PVC) liner and two feet of soil in 1985. The cap was partially removed and the cell was reactivated in 1990 and has since been closed. Cell 2 covers 36.5 acres, was opened in 1983, and was filled until 1989. Cell 3, which was opened and closed in 1989, consists of four acres. Cell 4 covers 4.5 acres and has been

used since it was opened in 1991. Cells 1, 2, and 3 accepted municipal solid waste and currently have a complete cap. The Town will be correcting some erosion problems with this cap that occurred when some of the vegetation for stabilization did not grow. Municipal solid waste and incinerator ash are currently disposed in separate units of Cell 4. The Town proposes to also accept municipal solid waste and incinerator ash in Cell 5.

During 1983-1984, 35 abandoned 55-gallon steel drums that were found along town highways were transported to the landfill for temporary storage. Analysis of the drum contents indicated that they contained flammable, non-chlorinated organic liquids. S & W Waste, Inc., removed the drums and transported them to its disposal facility in New Jersey in 1985.

The landfill was listed in the New York State Registry of Inactive Hazardous Wastes Sites because it was a temporary storage site for 35 barrels of hazardous waste. The New York State Department of Environmental Conservation (NYS DEC) investigated the site to verify this classification. Leachate and groundwater sampling on and near the site did not provide any obvious data indicating disposal of hazardous waste. The site was delisted in May of 1992 due to the lack of documentation of hazardous waste as defined in Part 371 of the Title 6 New York Codes, Rules and Regulations (NYCRR).

C. Site Visit and Physical Hazards

Ms. Jana Whalen and Mr. Lloyd Wilson of the NYS DOH visited the landfill on August 3, 1994. Representatives of the NYS DEC, the Town of Brookhaven Department of Waste Management, and the Town of Brookhaven Landfill were also present during the site visit. A flare, which burns landfill gases, was operating, and we did not notice any odor problems. We visually inspected the site and did not observe any dust problems. There was a large area of wooded land between the nearby houses and the outer edge of the proposed Cell 5. We saw piles of trees and brush on cleared land north of Cell 4. We only observed one physical hazard at the site: truck traffic.

D. Environmental Contamination and Exposure Pathways

Introduction to Pathways Analysis

This section of the health consultation identifies potential and completed exposure pathways associated with past, present and future use of the site. An exposure pathway is the process by

which an individual may be exposed to contaminants originating from a site. An exposure pathway has five elements, including (1) a contaminant source; (2) environmental media and transport mechanisms; (3) a point of exposure; (4) a route of exposure; and (5) a receptor population.

The source of contamination is the origin of the release to the environment (any waste disposal area or point of discharge); if the original source is unknown, it is the environmental media (soil, air, biota, water) which are contaminated at the point of exposure. Environmental media and transport mechanisms "carry" contaminants from the source to points where human exposure may occur. The exposure point is a location where actual or potential human contact with a contaminated medium may occur. The route of exposure is the manner in which a contaminant actually enters or contacts the body (i.e., ingestion, inhalation, dermal absorption). The receptor population is the person or people who are exposed or may be exposed to contaminants at a point of exposure.

Human exposure in this document is classified as either one of two types: a completed exposure pathway exists when the criteria for all five elements of an exposure pathway are documented; a potential exposure pathway exists when the criteria for any one of the five elements comprising an exposure pathway is not met. An exposure pathway is considered to be eliminated when any one of the five elements comprising an exposure pathway has not existed in the past, does not exist in the present or will never exist in the future.

Exposure pathways associated with the potential for off-site migration of contaminants in air and groundwater are of concern at this site. The landfill is a known past source of groundwater and air contamination. Public access to the landfill is restricted. Therefore, the potential for the public to have direct contact to contaminants in on-site air, water and soils is limited.

Air Contamination

On September 30, 1993, consultants hired by the Town of Brookhaven sampled ambient air for 24 hours. Samples were collected from five locations surrounding the landfill. Samples were collected at the Hampton Avenue School and at Horizon Village, because these locations are of particular interest to the community. The remaining three locations included one upwind, one 450 feet downwind, and one 800 feet downwind. The air samples were analyzed for total particulate matter (total dust), 43 volatile organic compounds (VOCs), and hydrogen sulfide. The total particulate

matter (total dust) was also analyzed for metals associated with incinerator ash. Environmental Health Associates interpreted the results and released the findings in the following report: "Results of the Ambient Air Study of the Town of Brookhaven Landfill", December 1993. Highlighted results from the report are included in Table 1 (Appendix B).

Environmental Health Associates compared the measured concentrations of the VOCs to the "Short-term Guideline Concentrations" (SGCs) and the "Annual Guideline Concentrations" (AGCs) established by NYS DEC. The SGCs and AGCs were established by the NYS DEC to set permit conditions and control emissions or air contaminants from industrial facilities.

The concentrations of the 43 VOCs analyzed were all lower than the SGCs. Benzene, arsenic, and cadmium were at concentrations higher than the AGCs in some of the sampling locations near the landfill. The highest benzene concentration was 2.8 micrograms per cubic meter (mcg/m^3) at the location 450 feet downwind from the landfill. The highest cadmium concentration was 0.001 mcg/m^3, 5,600 feet downwind from the landfill. The highest concentration of arsenic was 0.0012 mcg/m^3, 1,000 feet upwind of the landfill. However, these concentrations are within the background ranges for these contaminants in urban/suburban air (ATSDR, 1993a, b; NYS DOH, 1990a). Higher concentrations for some of the other contaminants were also detected at upwind locations. If the landfill was the significant source of contamination, a concentration gradient would exist. In other words, the order of the samples would be, from highest concentration to lowest concentration, as follows: 450 feet downwind, 800 feet downwind, 5,600 feet downwind and 1,000 feet upwind. These data do not reveal a concentration gradient, suggesting that the landfill is not the primary source of these contaminants. However, the closest downwind sample, which was near Sunrise Highway, did contain several VOCs that were also found at the landfill flare, including: toluene, 1,1,1-trichloroethane, trichlorotrifluoroethane and xylenes. The presence of these contaminants in the landfill gas and in the first downwind ambient air sample could indicate that the landfill may contribute a small amount of these contaminants to the ambient air 450 feet downwind from the landfill. However, the concentrations reported for each of these contaminants in this sample is within the background ranges in urban/suburban air (ATSDR, 1993e; Brodzinsky and Singh, 1982; Singh et al., 1981). Finally, other factors such as limited data, other potential nearby sources and the error associated with sample analysis, make it difficult to make definitive conclusions about these samples.

Five samples were also analyzed for total particulate matter. The highest concentration of particulate matter (129.0 mcg/m^3) was in the sample collected 1,000 feet upwind of the landfill. The closest downwind sample (450 feet downwind) had a total particulate matter concentration of 27 mcg/m^3. A sample collected 800 feet downwind had a concentration of 35.0 mcg/m^3. The higher level of total particulate matter in the upwind sample compared to the downwind samples suggests that there may be sources of particulate matter in the area other than the landfill. Samples collected at Horizon Village and Hampton Avenue School had concentrations of 56.0 mcg/m^3 and 45.0 mcg/m^3, respectively. All the measurements for total particulate matter were lower than 150 mcg/m^3, which is the federal (National Ambient Air Quality Standard) 24-hour particulate standard for respirable dust.

Hydrogen sulfide sampling has been done on several occasions. Forty-four air samples were measured during the 24-hour ambient air study of 1993. Thirty four of these samples showed non-detectable concentrations, nine showed 3 mcg/m^3 (2 parts per billion [ppb]) or less, and one showed 6 mcg/m^3 (4 ppb). These concentrations are lower than the New York State Ambient Air Quality Standard of 14 mcg/m^3 (10 ppb). It is important to note, however, that the reported concentrations cannot be directly compared to this standard. The objective of the New York State Ambient Air Standard for hydrogen sulfide is to prevent disagreeable odors, and the standard is the average concentration of hydrogen sulfide in a one hour period. In contrast, the measurements discussed in this document were instantaneous. The objective of these measurements was to determine if off-site ambient air had been contaminated with hydrogen sulfide and if so, was there a likelihood of resultant health effects?

In addition, a representative of the NYS DEC periodically collected and analyzed ambient air samples at and near the landfill for hydrogen sulfide between January 1992 and April 1993. Originally, air sampling was done daily, because the reported odors were intermittent. Later in the study, the ambient air samples were collected and analyzed 2-3 times per week. Air sampling was done at various times of the day including some in the middle of the night (12:00 am - 1:00 am) and many in the early morning (5:30 am - 7:00 am). These times were sampled to address concerns that odors were worst at night, especially during an atmospheric inversion. Three separate readings were taken for each sampling location during the sampling events. The hydrogen sulfide ambient air concentrations were all less than 14 mcg/m^3 (10 ppb) for the upwind locations. Most of samples collected from downwind locations were

also less than 14 mcg/m^3 (10 ppb), but some were in the 14-25 mcg/m^3 (10-18 ppb) range. The average hydrogen sulfide concentration at two locations on two days (03/03/92 and 12/08/92) was 32 mcg/m^3 (23 ppb). However, one of these elevated concentrations was measured directly downwind of drilling activity and, therefore, may not be representative of typical ambient air levels. After the Town of Brookhaven installed a temporary gas flare in March of 1993, all of the hydrogen sulfide concentrations were less than 14 mcg/m^3 for samples collected during March and April of that year.

Air Related Exposure Pathways

1. Completed Air Related Exposure Pathway

Inhalation of hydrogen sulfide, VOCs and dust is the pathway of concern with air emissions from the landfill. The monitoring for hydrogen sulfide during the years 1992-1993 show that nearby residents were exposed intermittently to low levels (less than 25.0 ppb) of hydrogen sulfide. Based on odor complaints, these exposures began in 1992 and were not continuous during 1992-1993. The typical measurements of hydrogen sulfide in ambient air off-site were less than 14 mcg/m^3 (10.0 ppb).

2. Potential Air Related Exposure Pathway

The monitoring data for dust and VOCs are limited to one set of 24-hour samples. Based on this set of 24-hour data, there is no measurable exposure resulting from the landfill. However, because data exist for only one day, this exposure pathway is not eliminated from further evaluation and is considered a potential exposure pathway.

Groundwater Contamination

Leachate was discovered overflowing the underliner early in the history of the landfill. Leachate samples collected in 1975 and in 1978 contained high levels of iron, manganese and lead. NYS DOH files do not contain data to evaluate if leachate was affecting the groundwater between 1975 and 1981.

As part of a study on the transport of contaminants in groundwater, the U.S. Geological Survey (USGS) conducted an investigation from 1981 to 1983 of the hydrogeology and chemical quality of groundwater in a four-square-mile area surrounding the landfill. The results of this study found elevated pH, temperature, specific conductance, chloride and ammonium concentrations in samples from

wells downgradient of the landfill. At that time, a leachate plume 3,700 feet long, 2,400 feet wide, and at least 90 feet deep was delineated. Consequently, residents downgradient of the landfill were supplied with public water. Repeated attempts to identify exactly when and where public water was provided have not been successful, but it is generally believed that public water was supplied in the early to mid-1980's.

Early groundwater monitoring data show elevated levels of some metals, including iron, manganese, and arsenic. In 1990, the Town hired a consulting firm to assess the groundwater quality near the landfill. The 1990 report shows that the plume had advanced in the direction of groundwater flow between 1,800 - 3,000 feet since 1982. Currently, there is not sufficient evidence to determine if the plume is still advancing.

In 1986 and 1987, 31 private wells downgradient of the landfill were tested for VOCs. Eight wells contained VOCs above the present NYS DOH drinking water standard. The compounds detected were vinyl chloride (four wells ranging from 3 to 13 micrograms per liter (mcg/L), 1,1-dichloroethane (five wells ranging from 7 to 28 mcg/L), 1,1,1-trichloroethane (seven wells ranging from 6 to 12 mg/L), and cis-1,2-dichloroethene (five wells ranging from 6 to 15 mcg/L). In January 1989, the NYS DOH drinking water guidelines for public water supplies for each of these compounds changed from 50 mcg/L to a standard of 5 mcg/L, except for vinyl chloride, when the guideline changed from 5 mcg/L to a standard of 2 mcg/L. These contaminants are at higher levels than the NYS DOH standards of 5 mcg/L for each of these compounds and 2 mcg/L for vinyl chloride. In 1991, 26 additional private wells downgradient of the landfill were tested for VOCs. Three wells contained contaminant levels above the NYS DOH drinking water guidelines. One well contained 6 mcg/L of 1,1-dichloroethane, another well contained 6 mcg/L of dichlorodifluoromethane, and the third well contained 17 mcg/L of 1,1-dichloroethane, 8 mcg/L of cis-1,2-dichloroethene, and 6 mcg/L of dichlorodifluoromethane.

Groundwater Related Exposure Pathways

1. Completed Groundwater Related Exposure Pathways

The groundwater exposure pathways of concern are the ingestion, inhalation and dermal absorption of VOCs through the use of contaminated private wells. The landfill is a known past source of groundwater contamination. Private wells in the area of the site in 1986 and 1987 were shown to be contaminated with VOCs. It is likely that some of the VOCs came from the landfill. Use of these wells probably resulted in residents ingesting low levels of VOCs. Additionally, activities such as bathing probably resulted in exposure through inhalation to volatilized contaminants and dermal

absorption from direct contact. The data are insufficient to accurately define the time when these exposures most likely occurred, although we can state that they started sometime after the landfill opened in 1974 and ended when public water was provided.

2. Potential Present and Potential Future Groundwater Related Exposure Pathways

The Suffolk County Health Department states that public water is available to all residences that have wells potentially contaminated by the landfill. However, citizens report that wells contaminated by the landfill are still used as potable supplies. Additionally, the plume of contamination from the landfill may be expanding. Based on these two factors we consider that there is a potential, although small, for present and future exposures. We anticipate that the potential for exposure will decrease because of remedial measures being implemented at the landfill.

E. Health Outcome Data

The NYS DOH maintains several health outcome data bases which can be used to generate site-specific data, if warranted. These data bases include the cancer registry, the congenital malformations registry, the heavy metals registry, the occupational lung disease registry, vital records (birth and death certificates) and hospital discharge information.

A study of cancer incidence requested specifically for an area near the Brookhaven Landfill is in progress. The study will use data from the New York State Cancer Registry for the years 1982-1991 and will include census tracts 1591.06, 1591.03, 1592.03, 1592.04 and 1593.00. The number of cases of cancer observed in the study area (as reported to the registry) will be compared to the numbers of cases that would be expected in similar areas, accounting for population size, age and sex distribution and population density. Comparison of observed and expected cases will be performed for all cancers combined and for a variety of different cancers. The study is expected to be completed in May 1996.

NYS DOH staff were asked by the South Country Central School District to investigate complaints of health problems among children at the Frank P. Long Intermediate School (also known as the Hampton Avenue School) as related to odors from the Brookhaven Landfill. Logs were kept by the school nurse for two periods during the 1993-1994 school year. The data are currently under analysis, and a report is expected by the end of 1995.

In 1990 the NYS DOH released a report titled the "Small Area Analysis of Breast Cancer Incidence Rates in Nassau and Suffolk Counties, New York, 1978-1987." This study examined the geographic distribution of breast cancer incidence and the relationship between breast cancer incidence and contaminated wells and hazardous waste sites in Nassau and Suffolk Counties. Each female breast cancer case diagnosed among Nassau and Suffolk County residents for the ten-year period 1978-1987 was assigned to a census tract based on her address at date of diagnosis. Using water district boundary maps from 1984 and 1985, census tracts served by public water supplies were grouped to approximately the water district boundaries. Water districts where one or more wells had been closed or restricted either voluntarily or for exceeding NYS DOH guidelines for organic chemical contamination (from 1976 to 1985) were identified. Locations of all inactive hazardous waste sites listed by the NYS DEC as of October 1, 1988 were also assigned to census tracts. Age-adjusted breast cancer rates were then calculated and compared for the groups of census tracts with and without potential exposures to contaminated wells and hazardous waste sites. The breast cancer incidence rate estimated for the water districts with well closures was not higher than the rate estimated for water districts with no well closures. Estimated breast cancer incidence in the census tracts with hazardous waste sites was not greater than breast cancer incidence in the census tracts with no hazardous waste sites. The study did not identify any factors involved in breast cancer incidence on Long Island other than the well-known association of higher breast cancer incidence with higher socio-economic status, which is thought to largely reflect the tendency among higher income women to delay childbearing.

Additionally, 118 community groupings defined by census tract boundaries were identified in Nassau and Suffolk Counties. Using the number of breast cancer cases from 1978 to 1987 and the female population in each five-year age group for each community grouping from the 1980 U.S. Census, age-adjusted breast cancer incidence rates were calculated for each community grouping. The study warns however, that these estimated rates may not accurately reflect true rates, particularly for the community groupings with small populations, because of the small number of cases upon which they are based. Because the 118 community groupings vary tremendously in population and number of breast cancer cases, interpretations based on comparison of these rates should be made with great caution. In addition, these rates are based on breast cancer cases' residences at time of diagnosis. Particularly for Suffolk County, where average householders in 1980 had lived at their current addresses for less time than the statewide average, these

rates may not represent the location of the cancer cases' residences during the time period of most importance in cancer initiation, usually considered to be at least ten years prior to diagnosis.

F. Community Health Concerns and Current Issues

In 1981, neighbors and a town employee witnessed trucks entering and leaving the site at night and this led to concerns of illegal dumping. There is no information available which confirms or resolves the allegations of illegal dumping.

Recently, citizens expressed health concerns about air and water quality issues. They voiced their concerns about the effects of the existing landfill and the proposed expansion at the November 10, 1992 Draft Environmental Impact Statement Public Hearing on the Brookhaven Landfill Expansion. The town responded to the oral comments made at the hearing and also to written comments in the Final Environmental Impact Statement for the Town of Brookhaven Landfill Expansion, August 1993. In November 1993, a representative of the ATSDR met with the petitioner of this health consultation, representing the South Sungate Homeowners Association, and other members of the community to discuss their concerns.

Air Quality Issues

Local residents fear that some of their health problems may be related to particulate emissions and airborne fungi from the landfill. The Town is currently accepting incinerator ash at the landfill and will continue to accept it after the proposed Cell 5 is opened. Citizens fear that they are being exposed to contaminants by breathing incinerator ash dust. The Town of Brookhaven uses measures to prevent emissions of incinerator ash. The incinerator ash is delivered to the site in covered trucks. To prevent the ash from becoming airborne, the ash is wetted before delivery. Water trucks are on site to wet the active disposal cell as needed. Cover is placed over areas which will not be used for disposal of fresh ash within 24 hours. Citizens have expressed concern that these dust control measures are not always properly implemented. Consultants hired by the Town of Brookhaven measured dust concentrations in the 1993 Ambient Air Study. Data in this study for dust sampling, as well as for VOC sampling, are limited. The town has been ordered by the NYS DEC to conduct a more thorough air sampling event as part of the permitting process for the proposed landfill expansion. The town is currently developing a protocol. The protocol will need to be approved by NYS DEC. NYS

DOH has made a request to the NYS DEC to be included in the approval process.

An informal survey of health complaints was conducted by a citizen in a residential neighborhood near the landfill. Many residents complained that they had experienced headaches, allergies, asthma, respiratory infections, rashes, ear infections, and sinus problems. The citizens have expressed concern that the town is composting yard waste at the site and that *Aspergillus fumigatus*, a fungus commonly found in compost, is causing these health problems. The Town of Brookhaven Landfill is not a licensed composting facility. It is, however, a leaf transfer facility, and the transfer of leaves is a registered activity. Leaves are brought to the site and temporarily stored there for the maximum time allowed by law, up to one week. Leaf stock piles of less than 3,000 cubic yards are exempt from composting regulations. The NYS DEC monitors the site to ensure that the leaves are removed within one week and that the stock piles do not exceed the 3,000 cubic yard limit. The NYS DEC will take appropriate action if nuisance conditions, such as off-site odors, are caused by this operation.

The NYS DEC reports that the Town completed the leaf transfer operations during 1993 without any significant problems or complaints. However, NYS DOH found the documentation of the leaf transfer activities to be unclear. Therefore, the NYS DOH and the NYS DEC conducted a more thorough investigation of the leaf transfer activities in late 1994. NYS DEC officials inspected the Town of Brookhaven Landfill site on November 30, 1994 and determined that the leaf stock piles were in excess of the 3,000 cubic yard exemption limit. To alleviate this problem the Town was asked to transfer the excess leaves to the permitted Manorville Compost Facility.

The Town also chips wood at the site and therefore stores trees and wood chips at the site. Again, the NYS DEC will take appropriate action if nuisance conditions, such as odors, occur off-site. The Town employs the wood chipping operation to reduce landfilling of recyclable material and uses the wood chips for municipal landscape projects. After the November 1994 NYS DEC inspection, the town agreed to minimize potential storage problems, such as odors or fires, by reducing the pile size from one large pile to several smaller piles.

The citizens have also expressed concerns about gaseous emissions and odors from the landfill. In November 1992, staff members of the Hampton Avenue School conducted an informal survey of the

teachers and parents of children attending this school. During this time period, teachers and students reported intermittent odor problems and the following health problems: headaches, eye irritation, allergies, asthma, and nausea.

The odors are likely to be caused by hydrogen sulfide in the ambient air. A representative of the NYS DEC analyzed the ambient air at the landfill and at various locations near the landfill for hydrogen sulfide gas in 1992 and 1993. The results of these studies are discussed in this health consultation.

The number of odor complaints has decreased since the beginning of 1993 when the Town began an odor reduction plan. The Town installed additional gas recovery wells, placed additional cover at the site , and installed a gas flare. The interim flare has been operating since March of 1993, and the Town plans to install a permanent flare.

Water Quality Issues

Community water quality concerns focus on whether the existing landfill has affected the drinking water and whether the proposed expansion will further affect the drinking water. Members of the community claim that there are active private potable wells south of Sunrise Highway.

The Town of Brookhaven has taken measures to prevent leachate contamination of the groundwater. Initially, the landfill was lined but lacked a leachate collection system. Today, each cell is lined and has its own leachate collection system. Cell 1 has a single layer liner of PVC. Cell 2 is double lined with PVC overlain by chlorinated polyethylene (CPE). Cells 3 and 4 are both lined with a high density polyethylene (HDPE) and with a PVC liner. The Town is proposing that Cell 5 have a double composite liner.

DISCUSSION

A. Description of the Evaluation of Health Risks

To evaluate the potential health risks from contaminants of concern associated with the Brookhaven Landfill site, the NYS DOH has assessed the risks for cancer and noncancer health effects. The health effects are related to contaminant concentration, exposure pathway, exposure frequency and duration. Additional information on the NYS DOH assessment for this site is in Appendix C.

B. Inhalation Exposures to Hydrogen Sulfide in Air

Past Inhalation Exposure to Hydrogen Sulfide in Off-Site Ambient Air.

In November 1992, teachers and students at the Hampton Avenue School, which is approximately one mile southwest of the Brookhaven Landfill site, complained of odor problems and adverse health effects including nausea, allergies, headache, breathing difficulties and eye irritation. Hydrogen sulfide gas is likely to be the cause of the odor complaints. This gas smells like rotten eggs and some people can smell it at very low levels, as low as 0.5 ppb in air. Ambient air studies conducted in 1992 detected some off-site ambient air levels as high as 10 ppb and 25 ppb. Exposures to hydrogen sulfide from the landfill are believed to have occurred intermittently for about a year and one-half.

Information on the health effects of exposure to hydrogen sulfide in air is summarized in Appendix E. Short-term (i.e., acute) exposure to hydrogen sulfide in amounts of 1,000 ppb or greater can cause eye, nose and throat irritation, nausea, headache and loss of appetite and sleep. People exposed chronically (i.e., longer term) to hydrogen sulfide are likely to have similar health effects as they do from acute exposures, except that the effects may occur at lower exposure levels and the symptoms may be more persistent. However, studies have not been conducted to determine if exposure to hydrogen sulfide for long periods of time (i.e., for a lifetime) can cause any lasting effects on sensitive organ systems such as the respiratory tract or nervous system.

Present and Future Potential Inhalation Exposure to Hydrogen Sulfide in Off-Site Ambient Air.

Remedial measures by the Town of Brookhaven in March of 1993 reduced hydrogen sulfide levels to less than 10 ppb, and the number of odor complaints decreased. However, the primary source of hydrogen sulfide, which apparently is the landfill, still exists. Therefore, any interruption in remedial measures could result in the release of hydrogen sulfide and increased health complaints.

C. Exposures to Volatile Organic Chemicals (VOCs) in Drinking Water

Past Ingestion, Dermal Contact and Inhalation Exposure to Chlorinated VOCs in Residential Private Drinking Water Wells

For an undetermined period of time, private residential water

supply wells near the Brookhaven Landfill site have been contaminated with chlorinated VOCs. Exposures could have been occurring for a period of less than 12 years, that is from sometime after the landfill opened in 1974 until 1986/1987, when 31 of these wells were tested for VOCs. Contaminant levels in the private wells prior to 1986/1987 are not known. The highest levels of vinyl chloride (13 mcg/L), 1,1-dichloroethane (28 mcg/L), 1,1,1-trichloroethane (12 mcg/L), cis-1,2-dichloroethene (15 mcg/L) and dichlorodifluoromethane (6 mcg/L) to which private well users have been exposed exceed the present NYS DOH standard of 5 mcg/L for each of these chemicals, except for vinyl chloride which has a standard of 2 mcg/L, and/or their public health assessment comparison values.

Exposures to contaminants in drinking water supplies can occur via ingestion, dermal contact and/or inhalation from water uses such as showering, bathing or other household uses. Although exposure varies depending on an individual's lifestyle, each of these exposure routes contributes to the overall daily uptake of contaminants and thus increases the potential for chronic health effects.

Vinyl chloride is a known human carcinogen (ATSDR, 1993d). It was found in four private wells with concentrations ranging from 3 to 13 mcg/L. Only one well contained 13 mcg/L. People chronically exposed in the past to vinyl chloride in drinking water at a level of 13 mcg/L are estimated to have a moderate increased risk of developing cancer. Toxicological data are inadequate to assess the carcinogenic effects of 1,1,1-trichloroethane, cis-1,2-dichloroethene and dichlorodifluoro-methane. Although toxicological data are inadequate to assess the carcinogenic potential of 1,1-dichloroethane, this chemical has been classified as a possible human carcinogen by the U.S. Environmental Protection Agency (ATSDR, 1990).

These five chlorinated VOCs also produce a variety of noncarcinogenic toxic effects, primarily to the liver, kidneys, and nervous system (ATSDR, 1990; 1993c,d; 1994). Chemicals that cause effects in humans and/or animals after high levels of exposure may also pose a risk to humans who are exposed to lower levels over long periods of time. Although the risks of noncarcinogenic effects from chronic past exposures to these chlorinated VOCs in residential drinking water supply wells are not completely understood, the existing data suggest that they could be high for vinyl chloride and minimal for the other contaminants.

Potential Present and Potential Future Ingestion, Dermal Contact, and Inhalation Exposure to Chlorinated VOCs in Residential Private Drinking Water Wells

Based on reports from citizens, some people are still using private wells and, therefore, are still exposed. Because the plume may be moving, other wells, if they exist, may become contaminated in the future. If this contamination occurs, then people using these private wells could be at risk for exposure and potential health effects.

CONCLUSIONS

Based on ATSDR's present public health hazard category classification (Appendix C), the Brookhaven Landfill was a public health hazard in the past because people may have been exposed to VOCs found in private wells prior to being supplied by public water. It is also considered a past public health hazard because of the release of hydrogen sulfide to ambient air. Remedial measures implemented in 1993 have been effective in reducing hydrogen sulfide levels; therefore, hydrogen sulfide emissions do not pose a current public health hazard. The classification assigned to current site conditions is an indeterminate public health hazard because it is possible some private wells affected by the landfill are still used for potable water and because ambient air data on dust and VOCs are limited.

A contaminant plume exists and may be advancing in the direction of regional groundwater flow. Many residents downgradient of the landfill were supplied with public water in the early to mid 1980's. However, private well information needs to be updated to evaluate if people are still using private wells that may be affected by the groundwater contamination from the landfill.

Citizens in the community surrounding the Town of Brookhaven Landfill were exposed intermittently to low levels of hydrogen sulfide in the ambient air between 1991 and 1993. Remedial measures implemented in 1993 have reduced the hydrogen sulfide levels to less than 10 ppb.

One 24-hour sampling event is not necessarily representative of the ambient air conditions over longer periods of time. The existing data do not adequately characterize the dust or landfill gas in ambient air. Furthermore, reports of quality control and quality assurance problems, the finding of contaminants at concentrations not unusual of urban/suburban environments, the limited number of data available, and the presence of a nearby highway, make it

difficult to determine if the landfill is a source of the ambient air contamination in the area. The limited number of ambient air data available to date will be supplemented by the additional air monitoring required by the NYS DEC for the landfill expansion permit.

During the investigation for this Health Consultation, NYS DOH and NYS DEC officials found leaf stock piles in excess of the 3,000 cubic yard exemption limits. The town agreed to transfer the excess leaves to the permitted Manorville Compost Facility.

RECOMMENDATIONS

Residents should be surveyed to identify if private wells that may be affected by contamination from the landfill are used for potable water.

The health risks from long term exposure to low levels of hydrogen sulfide are not well understood. Studies have not been conducted to determine if exposure to hydrogen sulfide for long periods of time can cause any chronic, long lasting effects on sensitive organ systems such as the respiratory tract or nervous system. The NYS DOH/ATSDR recommends that the potential for hydrogen sulfide to cause any chronic, long-lasting effects be evaluated in appropriate laboratory animal studies. These studies should also assess the potential, if any, for hydrogen sulfide to increase the risks of cancer or adverse effects on reproduction and development.

The data available do not show that present landfill conditions are a source of either dust or VOCs measured off-site. However, NYS DOH and ATSDR recommendations for additional air measurements are consistent with NYS DEC's order to the Town. The NYS DOH and ATSDR will participate in developing the air monitoring plan required by the NYS DEC.

The NYS DEC should continue to monitor the site to ensure that leaf, wood chip, and tree stock piles are not too large, do not create nuisance conditions such as off-site odors, are removed in a timely manner and that conditions of the leaf transfer permit are followed.

HEALTH ACTIVITIES RECOMMENDATION PANEL (HARP) RECOMMENDATIONS

The data and information developed in the health consultation for the Brookhaven Landfill site, Town of Brookhaven, New York, has been reviewed by ATSDR's Health Activities Recommendation Panel to determine appropriate follow-up actions. The panel determined that

community health education is indicated; however, the state has performed and is continuing to perform community health education, as needed. The panel determined that no follow-up health actions are indicated at this time; however, the panel determined that ATSDR should evaluate the toxicological data related to hydrogen sulfide to determine information on its carcinogenicity, reproductive and developmental effects, and other health effects of long term exposure to hydrogen sulfide (i.e., to the liver, heart, kidneys, lungs, and central nervous system).

PUBLIC HEALTH ACTION PLAN

The Public Health Action Plan (PHAP) for the Brookhaven Landfill site contains a description of actions to be taken by ATSDR and/or the NYS DOH at and near the site subsequent to the completion of this health consultation. For those actions already taken at the site, please see the Background and Site Conditions section of this health consultation. The purpose of the PHAP is to ensure that this health consultation not only identifies public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included, is a commitment on the part of ATSDR and NYS DOH to follow-up on this plan to ensure that it is implemented. The public health actions to be implemented are as follows:

A. ATSDR and NYS DOH will coordinate with the appropriate environmental agencies to implement the recommendations in this health consultation.

B. The NYS DOH and ATSDR will participate in the development of the air monitoring plan required by the NYS DEC. The NYS DEC is the agency that issues landfill operation permits, therefore, NYS DEC will have final approval of the air monitoring plan.

C. ATSDR will provide follow-up to this PHAP, as necessary, outlining the actions completed and those in progress. This follow-up report will be placed in repositories that contain copies of this health consultation, and will be provided to persons who request it.

D. NYS DOH is developing a registry of people exposed to VOCs in drinking water. People who were exposed in the past to VOCs in drinking water will be considered for inclusion to this registry.

E. The NYS DOH in conjunction with Suffolk County Health Department will conduct a private well survey to ensure that all citizens are supplied with public water.

F. The NYS DOH will continue community health education, as needed.

G. The ATSDR will evaluate the toxicological data related to hydrogen sulfide to determine the health effects of long term exposure.

ATSDR will reevaluate and expand the PHAP as needed. New environmental, toxicological, or health outcome data, or the results of implementing the above proposed actions may determine the need for additional actions at this site.

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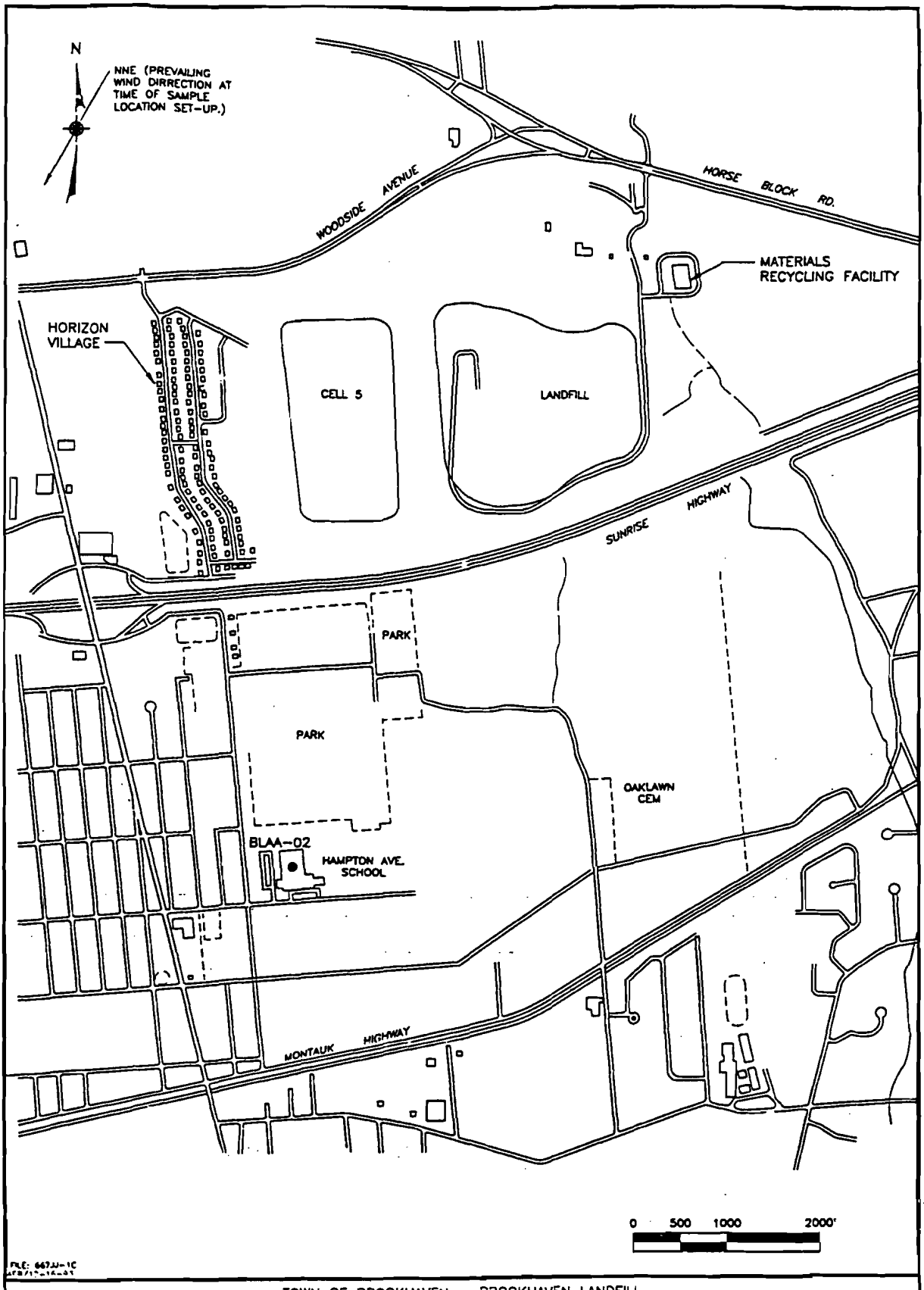
APPENDIX A

FIGURE



TOWN OF BROOKHAVEN – BROOKHAVEN LANDFILL

Dvirka and Bartilucci Consulting Engineers

FIGURE 1

APPENDIX B

TABLE

Table 1.

Brookhaven Landfill Off-Site Ambient Air Sampling Data
From the 1993 24-Hour Ambient Air Study
(All values in micrograms per cubic meter [ug/m^3])

Contaminant	Upwind	Downwind	SGC*	AGC*	Typical Background Range**
acetone	240	240	140,000	14,000	7.5-15.0
benzene	1.5	2.8	30	0.12	0.53-5.9
2-butanone (MEK)	17.0	17	140,000	300	<0.03
toluene	6.6	69	89,000	2,000	2.5-142
1,1,1-trichloroethane (TCA)	ND	10	450,000	1,000	0.6-2.3
trichlorotrifluoroethane	ND	5.6	1,800,000	90,000	--
xylenes (total)	ND	18	100,000	300	0.76-17.0
arsenic	0.0012	0.00058	0.2	0.00023	<0.001-0.030
cadmium	0.00046	0.001	0.2	0.0005	0.0006-0.0015
chromium	0.0055	0.007	120[1]	0.1[1]	0.0028-0.01
lead	0.031	0.020	--	0.1[2]	0.1
mercury	0.0003	0.0001	1.0	0.024[3]	0.01-0.02
nickel	0.0041	0.01	1.5	0.02	0.006-0.012
vanadium	0.0058	0.0045	100	0.2	0.006-0.087
particulate (total)	129	45	--	--	--
hydrogen sulfide		6	10[4]	--	1.0

[1]For chromium III
[2]For lead acetate
[3]For organic mercury
[4]One-hour guideline - New York State Ambient Air Quality Standard

*NYS DEC (1991) SCG: "Short-term Guideline Concentration"; AGC: "Annual Guideline Concentration"
**Brodzinsky and Singh (1982); ATSDR (1992a; 1993a,b,e,f); Bozzelli et al. (1980); Singh et al. (1981); NYS DOH (1989a; 1990a,b,c); US EPA (1990)

APPENDIX C

NYS DOH PROCEDURES FOR EVALUATING POTENTIAL HEALTH RISKS FOR CONTAMINANTS OF CONCERN

NYS DOH PROCEDURES FOR EVALUATING POTENTIAL HEALTH RISKS FOR CONTAMINANTS OF CONCERN

To evaluate the potential health risks from contaminants of concern associated with the Brookhaven Landfill site, the New York State Department of Health assessed the risks for cancer and noncancer health effects.

Increased cancer risks were estimated by using site-specific information on exposure levels for the contaminant of concern and interpreting them using cancer potency estimates derived for that contaminant by the US EPA or, in some cases, by the NYS DOH. The following qualitative ranking of cancer risk estimates, developed by the NYS DOH, was then used to rank the risk from very low to very high. For example, if the qualitative descriptor was "low", then the excess lifetime cancer risk from that exposure is in the range of greater than one per million to less than one per ten thousand. Other qualitative descriptors are listed below:

Excess Lifetime Cancer Risk

Risk Ratio	Qualitative Descriptor
equal to or less than one per million	very low
greater than one per million to less than one per ten thousand	low
one per ten thousand to less than one per thousand	moderate
one per thousand to less than one per ten	high
equal to or greater than one per ten	very high

An estimated increased excess lifetime cancer risk is not a specific estimate of expected cancers. Rather, it is a plausible upper bound estimate of the probability that a person may develop cancer sometime in his or her lifetime following exposure to that contaminant.

There is insufficient knowledge of cancer mechanisms to decide if *there exists a level of exposure to a cancer-causing agent below*

which there is no risk of getting cancer, namely, a threshold level. Therefore, every exposure, no matter how low, to a cancer-causing compound is assumed to be associated with some increased risk. As the dose of a carcinogen decreases, the chance of developing cancer decreases, but each exposure is accompanied by some increased risk.

There is no general consensus within the scientific or regulatory communities on what level of estimated excess cancer risk is acceptable. Some have recommended the use of the relatively conservative excess lifetime cancer risk level of one in one million because of the uncertainties in our scientific knowledge about the mechanism of cancer. Others feel that risks that are lower or higher may be acceptable, depending on scientific, economic and social factors. An increased lifetime cancer risk of one in one million or less is generally considered an insignificant increase in cancer risk.

For noncarcinogenic health risks, the contaminant intake was estimated using exposure assumptions for the site conditions. This dose was then compared to a risk reference dose (estimated daily intake of a chemical that is likely to be without an appreciable risk of health effects) developed by the US EPA, ATSDR and/or NYS DOH. The resulting ratio was then compared to the following qualitative scale of health risk:

Qualitative Descriptions for
Noncarcinogenic Health Risks

Ratio of Estimated Contaminant Intake to Risk Reference Dose	Qualitative Descriptor
equal to or less than the risk reference dose	minimal
greater than one to five times the risk reference dose	low
greater than five to ten times the risk reference dose	moderate
greater than ten times the risk reference dose	high

Noncarcinogenic effects unlike carcinogenic effects are believed to

have a threshold, that is, a dose below which adverse effects will not occur. As a result, the current practice is to identify, usually from animal toxicology experiments, a no-observed-effect-level (NOEL). This is the experimental exposure level in animals at which no adverse toxic effect is observed. The NOEL is then divided by an uncertainty factor to yield the risk reference dose. The uncertainty factor is a number which reflects the degree of uncertainty that exists when experimental animal data are extrapolated to the general human population. The magnitude of the uncertainty factor takes into consideration various factors such as sensitive subpopulations (for example, children or the elderly), extrapolation from animals to humans, and the incompleteness of available data. Thus, the risk reference dose is not expected to cause health effects because it is selected to be much lower than dosages that do not cause adverse health effects in laboratory animals.

The measure used to describe the potential for noncancer health effects to occur in an individual is expressed as a ratio of estimated contaminant intake to the risk reference dose. If exposure to the contaminant exceeds the risk reference dose, there may be concern for potential noncancer health effects because the margin of protection is less than that afforded by the reference dose. As a rule, the greater the ratio of the estimated contaminant intake to the risk reference dose, the greater the level of concern. A ratio equal to or less than one is generally considered an insignificant (minimal) increase in risk.

APPENDIX D

PUBLIC HEALTH HAZARD CATEGORIES

ATSDR

Public Health Assessment Guidance Manual

March 1992

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

Table 8.1. Criteria and Actions for Levels of Public Health Hazard

CATEGORY A URGENT PUBLIC HEALTH HAZARD	CATEGORY B PUBLIC HEALTH HAZARD
This category is used for sites that pose an urgent public health hazard as the result of short-term exposures to hazardous substances.	*This category is used for sites that pose a public health hazard as the result of long-term exposures to hazardous substances.*
Criteria:	**Criteria:**
Evidence exists that exposures have occurred, are occurring, or are likely to occur in the future; **and** the estimated exposures are to a substance or substances at concentrations in the environment that, upon short-term exposures (less than 1 year), can cause adverse health effects to any segment of the receptor population. The adverse health effect can be the result of either carcinogenic or noncarcinogenic toxicity from a chemical exposure. For a noncarcinogenic toxic effect, the exposure exceeds an acute or intermediate minimal risk level (MRL) established in the ATSDR Toxicological Profiles or other comparable value; **and/or** community-specific health outcome data indicate that the site has had an adverse impact on human health that requires rapid intervention; **and/or** physical hazards at the site pose an imminent risk of physical injury.	Evidence exists that exposures have occurred, are occurring, or are likely to occur in the future; **and** the estimated exposures are to a substance or substances at concentrations in the environment that, upon long-term exposures (greater than 1 year), can cause adverse health effects to any segment of the receptor population. The adverse health effect can be the result of either carcinogenic or noncarcinogenic toxicity from a chemical exposure. For a noncarcinogenic toxic effect, the exposure exceeds a chronic MRL established in the ATSDR Toxicological Profiles or other comparable value; **and/or** community-specific health outcome data indicate that the site has had an adverse impact on human health that requires intervention.
ATSDR Actions:	**ATSDR Actions:**
ATSDR will expeditiously issue a health advisory that includes recommendations to mitigate the health risks posed by the site. The recommendations issued in the health advisory and/or health assessment should be consistent with the degree of hazard and temporal concerns posed by exposures to hazardous substances at the site. Based on the degree of hazard posed by the site and the presence of sufficiently defined current, past, or future completed exposure pathways, the following public health actions can be recommended: • biologic indicators of exposure study; • biomedical testing; • case study; • disease and symptom prevalence study; (Continued on next page)	ATSDR will make recommendations in the health assessment to mitigate the health risks posed by the site. The recommendations issued in the health assessment should be consistent with the degree of hazard and temporal concerns posed by exposures to hazardous substances at the site. Based on the degree of hazard posed by the site and the presence of sufficiently defined current, past, or future completed exposure pathways, the following public health actions can be recommended: • biologic indicators of exposure study; • biomedical testing; • case study; • disease and symptom prevalence study; • community health investigation; (Continued on next page)

Table 8.1. Continued

CATEGORY A URGENT PUBLIC HEALTH HAZARD (continued)	CATEGORY B PUBLIC HEALTH HAZARD (continued)
• community health investigation; • registries; • site-specific surveillance; • voluntary residents tracking system; • cluster investigation; • health statistics review; • health professional education; • community health education; and/or • substance-specific applied research.	• registries; • site-specific surveillance; • voluntary residents tracking system; • cluster investigation; • health statistics review; • health professional education; • community health education; and/or • substance-specific applied research.

Table 8.1. Continued

CATEGORY C INDETERMINATE PUBLIC HEALTH HAZARD	CATEGORY D NO APPARENT PUBLIC HEALTH HAZARD
This category is used for sites with incomplete information.	*This category is used for sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.*
Criteria:	**Criteria:**
The limited available data do not indicate that humans are being or have been exposed to levels of contamination that would be expected to cause adverse health effects. However, data or information are not available for all environmental media to which humans may be exposed; **and** there are insufficient or no community-specific health outcome data to indicate that the site has had an adverse impact on human health.	Exposures do not exceed an ATSDR chronic MRL or other comparable value; **and** data are available for all environmental media to which humans are being exposed; **and** there are no community-specific health outcome data to indicate that the site has had an adverse impact on human health.
ATSDR Actions:	**ATSDR Actions:**
ATSDR will make recommendations in the health assessment to identify the data or information needed to adequately assess the public health risks posed by the site. Public health actions recommended in this category will depend on the hazard potential of the site, specifically as it relates to the potential for human exposure of public health concern. If the potential for exposure is high, initial health actions aimed at determining the population with the greatest risk of exposure can be recommended. Such health actions include: • community health investigation; • health statistics review; • cluster investigation; and • symptom and disease prevalence study. If the population of concern can be determined through these or other actions, any of the remaining follow-up health activities listed under categories A and B may be recommended. In addition, if data become available suggesting that human exposure to hazardous substances at levels of public health concern is occurring or has occurred in the past, ATSDR will reevaluate the need for any followup.	If appropriate, ATSDR will make recommendations for monitoring or other removal and/or remedial actions needed to ensure that humans are not exposed to significant concentrations of hazardous substances in the future. The following health actions, which may be recommended in this category, are based on information indicating that no human exposure is occurring or has occurred in the past to hazardous substances at levels of public health concern. The following health actions are recommended for sites in this category: • community health education; • health professional education; • community health investigation; and • voluntary residents tracking system. However, if data become available suggesting that human exposure to hazardous substances at levels of public health concern is occurring, or has occurred in the past, ATSDR will reevaluate the need for any followup.

Table 8.1. Continued

CATEGORY E
NO PUBLIC HEALTH HAZARD

This category is used for sites that do not pose a public health hazard.

Criteria:

There is no evidence of current or past human exposure to contaminated media;

and

future exposures to contaminated media are not likely to occur;

and

there are no community-specific health outcome data to indicate that the site has had an adverse impact on human health.

ATSDR Actions:

No public health actions are recommended at this time because no human exposure is occurring, has occurred in the past, or is likely to occur in the future that may be of public health concern.

APPENDIX E

FACT SHEET

Fact Sheet

Bureau of Toxic Substance Assessment
NYS Department of Health
February 14, 1991

HYDROGEN SULFIDE

Hydrogen sulfide is a colorless gas with a rotten-egg odor which is produced in nature primarily through the breakdown of plant and animal material by bacteria. It develops in stagnant water that is low in oxygen content, such as bogs and swamps. Some bacteria can break down calcium sulfate, the major component of wallboard, into hydrogen sulfide. Since construction and demolition debris usually contains large quantities of wallboard, large amounts of hydrogen sulfide can be formed at sites with this debris. Production is greatest when there is little oxygen, such as when the debris is buried, especially if it is wet.

Most of the information on human health effects from hydrogen sulfide exposure comes from accidental and industrial exposures to relatively high levels. Exposure to high concentrations can cause muscle cramps, low blood pressure, slow respiration, and loss of consciousness. Short-term exposure to moderate amounts of hydrogen sulfide in the workplace has produced eye, nose and throat irritation, nausea, headaches and loss of appetite and sleep. Continued exposure can cause irritation of the respiratory passages and can lead to a buildup of fluid in the lungs.

Hydrogen sulfide smells like rotten-eggs and some people can smell it at very low levels, as low as 0.5 parts per billion (ppb) in air. There is little information on the effects of long-term exposure to low levels of hydrogen sulfide. One report describes an investigation of complaints of foul odors and health effects in an Indiana community near a waste disposal lagoon. Hydrogen sulfide levels in the community ranged up to 300 ppb. During this episode there was an increased frequency of complaints of nausea, vomiting, eye and respiratory irritation, headache, insomnia, weight loss, chest pain, and asthma attacks. Although other chemicals were also present in the air, these effects are consistent with possible effects of hydrogen sulfide.

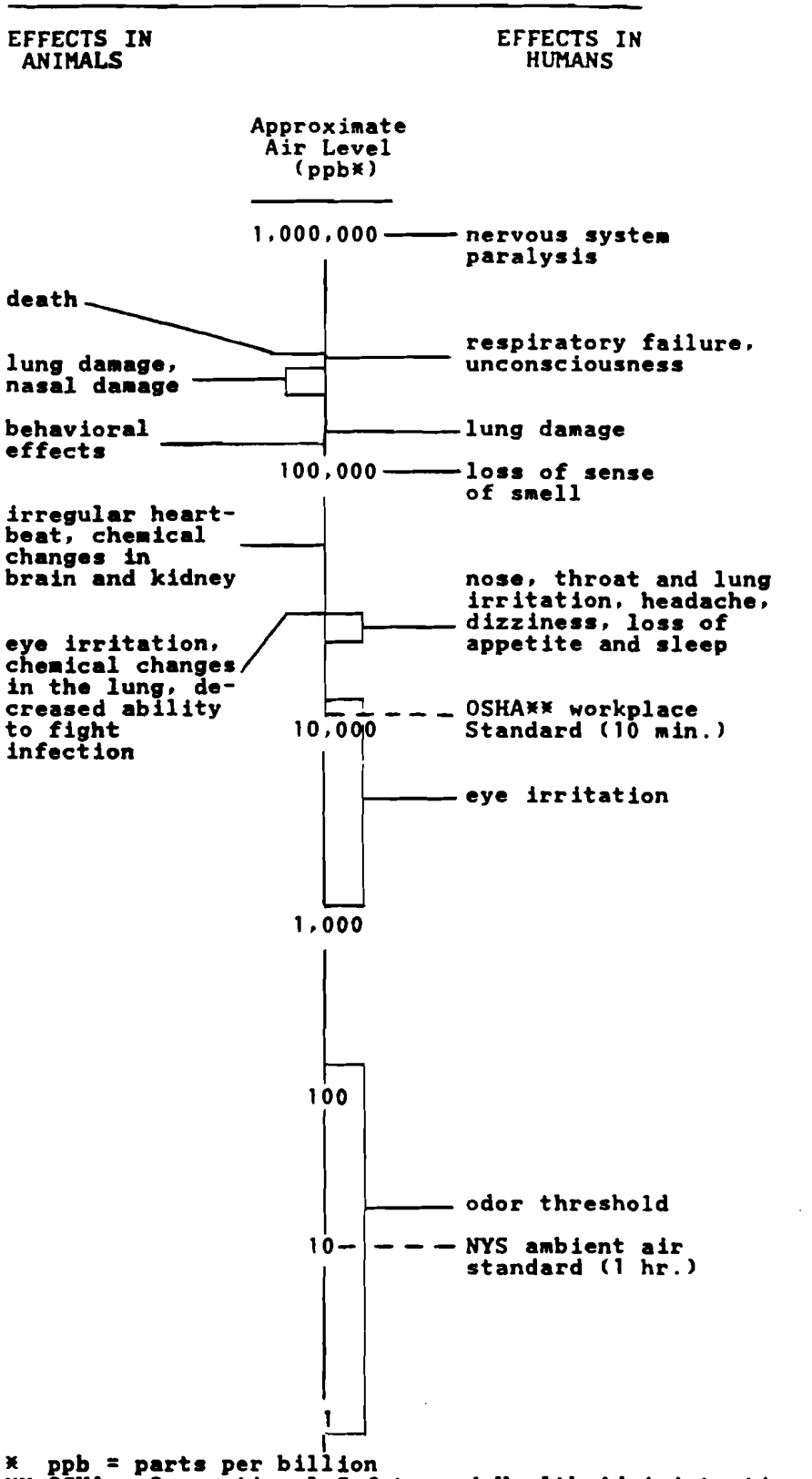
The effects of exposure to any chemical depend on the amount of the chemical to which a person is exposed and the length of exposure. The effects may also be influenced by a person's age, sex and general health. The figures on the following pages summarize the relationship between exposure to hydrogen sulfide and known health effects, including those at very high levels of exposure. The information comes from exposure of people as well as laboratory animals. Effects in humans are shown on the right side and effects in animals on the left side of each line in the diagram. Federal workplace standards and state ambient air standards are also shown on the diagram.

lmj/91044PR00923

Figure 1

HEALTH EFFECTS FROM INHALATION OF HYDROGEN SULFIDE

SHORT-TERM EXPOSURE



* ppb = parts per billion
** OSHA = Occupational Safety and Health Administration

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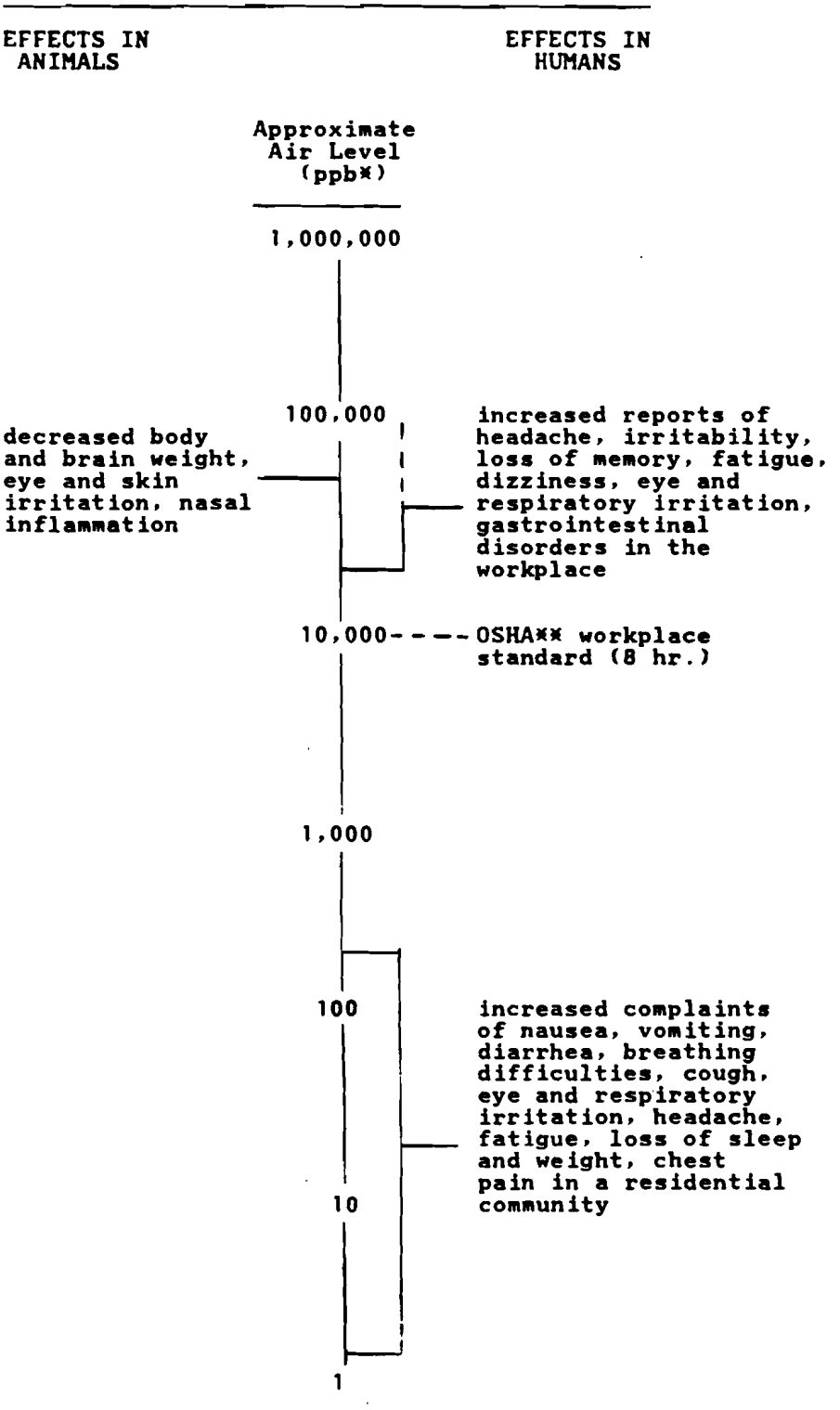
Figure 1 (continued)

HEALTH EFFECTS FROM INHALATION OF HYDROGEN SULFIDE

LONG-TERM EXPOSURE



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