PETITIONED
PUBLIC HEALTH ASSESSMENT
MILHAM BROOK AREA
(A.K.A. GLEN STREET NEIGHBORHOOD)
MARLBOROUGH, MASSACHUSETTS

Prepared by
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Center for Environmental Health
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Under a Cooperative Agreement with
Public Health Service
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

SUMMARY

The Milham Brook Area (a.k.a. Glen Street Neighborhood) in Marlborough, Massachusetts was an apple orchard until at least 1966. The site is bordered to the north by Route 20, to the east and south by Glen Street, and to the west by Ames Street (Figure 1). In 2000, the Glen Street neighborhood association petitioned that a public health assessment (PHA) be done for the site due to concerns related to past pesticide use, particularly lead arsenate and organochlorines. The primary contaminants present at the site were arsenic, DDT (1, 1, 1-trichloro-2, 2 bis[p-chlorophenyl ethane]) and its metabolites, as well as dieldrin in soil. Available data, while limited, indicated that these contaminants were not present at levels of health concern, particularly given the highly vegetated nature of the site currently. Therefore, according to the Agency for Toxic Substances and Disease Registry's (ATSDR's) criteria, the site currently poses "No Apparent Public Health Hazard." However, there is no lead soil sampling data, which is a data gap that the Massachusetts Department of Public Health (MDPH) recommends be filled pending site development through additional sampling, as lead is likely to be present at the site due to the past use of lead arsenate. Because of present data gaps and incomplete site characterization according to ATSDR criteria, the site poses a future "Indeterminate Public Health Hazard." Future exposure concerns regarding development of the site also relate to the potential for run-off (on-site surface water) to the public water supply reservoir and potential airborne fugitive dust. MDPH is also completing an investigation of cancer incidence for the city of Marlborough that will analyze incidence by smaller geographic areas. Additional cancer concerns expressed by the residents of the Glen Street neighborhood will be addressed in that document which will be released as a separate report.

BACKGROUND

A. Purpose and Health Issues

The federal Agency for Toxic Substances and Disease Registry (ATSDR) received a petition request from local residents of this area expressing concerns about illnesses, particularly cancers, in long-time neighborhood residents that have lived near the former orchard (Bocchino et al. 2000). The petitioners reported that they were aware of 22 people who had died or were in advanced stages of various cancers. The residents requested that a public health assessment (PHA) be prepared to address human health concerns in the Glen Street neighborhood in Marlborough, Massachusetts. They cited a number of reasons for their concerns, including neighborhood cancers, known use of pesticides in the former orchard, and cancer incidence data for Marlborough from Massachusetts Department of Public Health's (MDPH's) Massachusetts Cancer Registry (MCR) indicating significantly elevated rates of leukemia and lung cancer.

In response to the petition request from a resident of Marlborough, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH), Environmental Toxicology Program (ETP) evaluated available environmental sampling data (i.e., surface soil, near-surface soil, subsurface soil, surface water, and groundwater) and community health concerns (including cancer analysis and the evaluation of childhood blood lead levels) to assess the potential for health effects associated with historical pesticide use at a former apple orchard in Marlborough. The property owner, MetLife Real Estate Investments, hired a consultant to collect samples from this area because at the time of the public comment draft public health assessment, they were proposing to develop this land.

ATSDR advised the petitioners that after the MDPH has completed its initial review of the environmental data and the community health concerns, concerned residents and others will have an opportunity to review this, and the health agencies will then discuss any additional steps to address health concerns (ATSDR 2000). MDPH released the draft version of this public health assessment for public comment and presented the initial findings at a community meeting in June 2000. This final public health assessment contains a review of environmental data provided by residents and environmental consultants to MDPH, an updated review of readily available cancer incidence information for Marlborough as a whole, and revisions made based on comments received from the public. Detailed responses to public comments can be found in Appendix A. Based on this review, recommendations were made for the following public health follow-up activities: additional site investigation by environmental consultants pending development, and a review of cancer incidence in the Glen Street neighborhood by MDPH, CEH, and the Community Assessment Program (CAP), which will be released in a separate report.

B. Site Description and History

The Milham Brook Area (A.K.A. Glen Street Neighborhood) site comprises 82 acres and is bordered to the north by Route 20, to the east and south by Glen Street, and to the west by Ames Street (Figure 1). Milham Brook, a tributary of Milham Reservoir, and one of the drinking water

sources for Marlborough, runs through the site (Figure 1). At the time of this public health assessment, the site was primarily wooded, with some open grassland, low brush, and wetlands. Site conditions may change from season to season (e.g., higher vegetative growth in summer versus early spring or winter). What appear to be old orchard roads or trails are located on the site. There are residences along the eastern side of Glen Street and a larger residential community to the east. Most of the houses were built prior to 1970 (U.S. Census 2001). According to the Marlborough Board of Health, none of the residences in the neighborhood adjacent to the site have private wells that are used for drinking water purposes (Marlborough BOH 2005). Also, based on known topography at the site, groundwater beneath the site is most likely flowing away from homes and toward Milham Brook and Milham Reservoir (USGS 2001). Public drinking water serves all streets in this area. Several commercial buildings (e.g., office buildings, recreation hall) are located to the north of the property, across Route 20. Available historical research showed that at least a portion of the property was used as an apple orchard until at least 1966 (Hygienetics 2000b). Pesticides, including lead arsenate, were applied to the orchard (Hygienetics 1999a). According to local government officials, this site is currently zoned for business, light industrial and industrial development, and hence would not be expected to be developed for residences unless zoning rules were to change (Marlborough Department of Public Works 2004, Marlborough BOH/Conservation Commission 2005).

C. Site Visit

For the purposes of this public health assessment, MDPH staff conducted a site visit on March 8, 2000. MDPH staff observed the site from the perimeter, along Glen Street and Route 20 (i.e., the property line). The site was essentially unfenced. There were a couple of short sections of fence along Glen Street with 'No Trespassing' signs. However, there were no barriers preventing access to the site. Although there was some trash on the site visible from Glen Street, there was no obvious evidence of trespassing (e.g., broken bottles, tree houses, well dirt paths). No trespassing activities (e.g., people observed on the site) were witnessed during the site visit.

MDPH staff also conducted a site visit on May 23, 2005. Photographs from this site visit can be found in Appendix B. Conditions were similar to the previous site visit. No trespassing was noted, but there was indication of one worn path (Appendix B, Photograph 1). Also, vegetation was in full growth, and the site in general was heavily vegetated with mostly wooded areas and brush (Appendix B, Photographs 2 and 3). As in 2000, there were a couple of short sections of fence along Glen Street with 'No Trespassing' signs, but overall the site was unfenced (Appendix B Photograph 3). A physical hazard was also noted where Milham Brook enters the site at Glen and Ripley Streets where there is a 6 to 10-foot drop off with no fence or guardrail (Appendix B, Photograph 4).

D. Demographics

The 2000 U.S. Census showed a population of 36,255 living in Marlborough, Massachusetts. There are six census tracts (i.e., census tracts 3211, 3212, 3213, 3214, 3215, and 3216) in the city of Marlborough. Within Marlborough, the Milham Brook Area site is located in census tract

3214. The 2000 U.S. Census showed a population of 2,905 living in census tract 3214. The age, sex, and race breakdowns for Marlborough as a whole as well as for census tract 3214 are presented in Table 1 (U.S. Census 2001).

E. Health Outcome Data

a. Cancer Incidence

The primary contaminants of concern at the site include arsenic, dieldrin, 1,1,1-trichloro-2,2-bis[p-chlorophenyl-ethane] (DDT) and its metabolites (i.e., 1,1-dichloro-2,2-bis[p-chlorophenyl]ethylene (DDE) and 1,1-dichloro-2,2-bis[p-chlorophenyl]ethane (DDD)). Cancers or tumors of concern that have been associated or possibly associated with these compounds in either animal or human studies include cancers of the kidney (arsenic), liver (arsenic, DDT, dieldrin), lung and bronchus (arsenic), bladder (arsenic), thyroid (dieldrin), as well as Hodgkin's disease (DDT), and non-Hodgkin's lymphoma (DDT). The MDPH reviewed the incidence of these seven cancer types (i.e., kidney, liver, lung and bronchus, bladder, thyroid, Hodgkin's disease, and non-Hodgkin's lymphoma), as well as other cancer types in the city of Marlborough to determine whether any of these cancer types were elevated.

Cancer incidence data for the years 1996 through 2000, the latest years for which complete data are available, were obtained from the MCR, a division within the MDPH Center for Health Information, Statistics, Research and Evaluation (MPDH 2004). (The public comment draft contained MCR data for the period 1990 through 1995). To determine whether elevated numbers of cancer diagnoses have occurred in Marlborough, standardized incidence ratios (SIRs) and 95% confidence intervals (95% CIs) were calculated for the time period 1996 through 2000. A detailed explanation of the SIR and 95% CI is presented in Appendix C.

Table 2 summarizes cancer incidence data for the city of Marlborough during the years 1996 through 2000. Kidney cancer occurred as expected among males and females combined during this time period (18 diagnoses observed versus 18.21 expected). Separate evaluation of these data by gender revealed that females experienced kidney cancer less often than expected (2 diagnoses observed versus 7.1 expected), while males were diagnosed more often than expected in the city (16 diagnoses observed versus 11.1 expected, SIR = 144). This elevation was not statistically significant. The incidence of liver cancer was elevated among males and females combined in Marlborough (11 diagnoses observed versus 6.8 expected, SIR = 163). Both males and females experienced slight elevations in the incidence of this cancer type; however, none of the observed elevations was statistically significant, and the elevations represent two or three more individuals diagnosed than expected. Lung and bronchus cancer occurred more often than expected in Marlborough (117 diagnoses observed versus 105.6 expected, SIR = 111). This elevation was due primarily to an increased incidence of this cancer type among females in the city (60 diagnoses observed versus 49.7 expected, SIR = 121). Males in Marlborough experienced lung and bronchus cancer about as expected (57 diagnoses observed versus 55.86 expected, SIR = 102).

Hodgkin's disease also occurred more often than expected in Marlborough during 1996 through 2000 (10 diagnoses observed versus 6.1 expected, SIR = 163). Specifically, six males and four

females were diagnosed with this cancer type compared to 3.4 and 2.7 expected diagnoses, respectively. The elevations observed among males and females combined were not statistically significant. (Statistical significance could not be assessed for the incidence of Hodgkin's disease among females because fewer than five diagnoses were observed.) The overall incidence of non-Hodgkin's lymphoma was slightly elevated with respect to the state rate (32 diagnoses observed versus 29.4 expected, SIR = 109); however, this elevation was based on small numbers of additional diagnoses over the expected number and was not statistically significant. Males experienced non-Hodgkin's lymphoma about as expected (15 diagnoses observed versus 15.3 expected), while females were diagnosed slightly more often than expected (17 diagnoses observed versus 14.1 expected). Again, the elevation among females was not statistically significant. Finally, cancers of the bladder and thyroid occurred slightly less often than expected in Marlborough during 1996 – 2000 (see Table 2).

Review of available city-wide cancer incidence data for other cancer types in Marlborough that have not been shown in the scientific literature to be associated with the primary contaminants of concern at this site indicated that leukemia was nearly statistically significantly elevated overall. During the time period 1996 through 2000, 26 cases of leukemia were observed among males and females combined, when approximately 17 cases were expected (SIR = 151). Leukemia incidence among males (13 observed versus about 9 expected) and among females (13 observed versus about 8 expected) were both elevated, but neither elevation was statistically significant.

The occurrence of multiple myeloma also nearly achieved a statistically significant elevation overall (13 observed versus about 7 expected; SIR = 184). This elevation was primarily attributable to an elevation among males that nearly achieved statistical significance (8 observed versus about 4 expected).

This review of 1996 through 2000 cancer incidence data revealed that previous elevations in lung cancer and leukemia based on 1990 to 1995 data, continued through 2000, but to a lesser degree. During 1990 to 1995, lung cancer (150 observed versus about 117 expected) and leukemia (29 observed versus about 16 expected) were both statistically significantly elevated. Neither cancer was statistically significantly elevated during 1996 to 2000, but leukemia did nearly achieve statistical significance. Liver cancer incidence was about the same during both periods, with about five excess cancer cases in each period among males and females combined. Multiple myeloma nearly achieved statistical significance during 1996 to 2000, but this cancer occurred about as expected during 1990 to 1995 (8 observed versus about 7 expected).

b. Lead Poisoning Prevalence

Since lead is likely present at the site due to past pesticide use, MDPH reviewed childhood lead poisoning prevalence data both for Marlborough as a whole, and the Glen Street neighborhood abutting the site. Childhood lead poisoning prevalence data indicate that the rate of lead poisoning (i.e., blood lead level greater than or equal to 25 micrograms per deciliter (µg/dL)) over the time period from 1990 through 2002 was 0.81 per 1,000 for Marlborough children screened compared to 1.71 per 1,000 for Massachusetts children screened (MDPH 2005a). It should be noted that in 2002, the most recent year for which childhood lead poisoning prevalence data are available, no childhood lead poisoning cases were reported in the city of

Marlborough (MDPH 2005a). For streets near the Milham Brook Area, no lead poisoning cases were reported from 1990 through 2004, and a very small number of children had lead levels 10 µg/dL or above from 1990 through 2004, which is a level at which vigilance is needed in order to prevent lead poisoning (MDPH 2005b). Also, it should be noted that most of the houses in the Milham Brook Area were also built prior to 1978, when lead was still used in paint; therefore, lead paint layers in homes may provide opportunities for exposure.

ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

To evaluate if a site poses an existing or potential hazard to an exposed or potentially exposed population, health assessors review all available environmental contamination data on site and off site for all media (e.g., soil, surface water, groundwater, air). The quality of the environmental data is discussed in the Quality Assurance and Quality Control section. Physical conditions of the contaminant sources and physical hazards, if any, are discussed in the Physical and Other Hazards section. A plain language glossary of environmental health terms can be found in Appendix D.

A. On-Site Contamination

Surface soil, near-surface soil, subsurface soil, surface water, and groundwater data available from environmental sampling conducted on the property in 1991 and 1999 were reviewed, tabulated, and screened for this site (ATC 1999, Hygienetics 1991, 1999a).

Health assessors use a variety of health-based screening values, called comparison values, to help decide whether compounds detected at a site might need further evaluation. These comparison values include environmental media evaluation guides (EMEGs), reference dose media evaluation guides (RMEGs), cancer risk evaluation guides (CREGs), and maximum contaminant levels for drinking water (MCLs). These comparison values have been scientifically peer reviewed or were derived from scientifically peer-reviewed values and published by ATSDR and/or the U.S. Environmental Protection Agency (EPA). The Massachusetts Department of Environmental Protection (MA DEP) has established Massachusetts's maximum contaminant levels (MMCLs) for public drinking water supplies. EMEG, RMEG, MCL, and MMCL values are used to evaluate the potential for noncancer health effects. CREG values provide information on the potential for carcinogenic effects. For chemicals that do not have these comparison values available for the medium of concern, EPA risk-based concentrations (RBCs) developed by EPA regional offices, are used.

If the concentration of a compound exceeds its comparison value, adverse health effects are not necessarily expected. Rather, these comparison values help in selecting compounds for further consideration. For example, if the concentration of a chemical in a medium (e.g., soil) is greater than the EMEG for that medium, the potential for exposure to the compound should be further evaluated for the specific situation to determine whether noncancer health effects might be possible. Conversely, if the concentration is less than the EMEG, it is unlikely that exposure would result in noncancer health effects. EMEG values are derived for different durations of exposure according to ATSDR's guidelines. Acute EMEGs correspond to exposures lasting 14

days or less. Intermediate EMEGs correspond to exposures lasting longer than 14 days to less than one year. Chronic EMEGs correspond to exposures lasting one year or longer. CREG values are derived assuming a lifetime duration of exposure. RMEG values also assume chronic exposure. All the comparison values (i.e., CREGs, EMEGs, RMEGs, and RBCs) are derived assuming opportunities for exposure in a residential setting.

CREGs are estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (1×10^{-6}) persons exposed during their lifetime (70 years). ATSDR's CREGs are calculated from EPA's cancer slope factors for oral exposures or unit risk values for inhalation exposures. These values are based on EPA evaluations and assumptions about theoretical cancer risks at low levels of exposure.

Table 3a shows the minimum, mean, and maximum values of compounds detected in surface soil on the site that exceeded their respective health-based comparison values. For 0 to 3-inch deep soil, 26 samples were taken and tested for total arsenic and organochlorine pesticides. Of the compounds that were detected, the ones that exceeded health-based comparison values were arsenic, dieldrin, DDT, and DDE. The arsenic concentrations ranged from 3.8 milligrams per kilogram (mg/kg) to 217 mg/kg, with a mean concentration of 63.7 mg/kg. Background soil concentrations of arsenic in the eastern United States generally range from less than 0.1 mg/kg to 73 mg/kg and average 7.4 mg/kg (Shacklette 1984). The highest levels of arsenic (i.e., 123, 137, 139, 163, 176, and 217 mg/kg) were found in the central and eastern portions of the property. Seventeen of the samples had arsenic concentrations in excess of the chronic EMEG for a child's exposure (i.e., 20 mg/kg). Dieldrin concentrations ranged from non-detectable to 1.9 mg/kg, with a mean concentration of 0.72 mg/kg. Nineteen of the samples had dieldrin concentrations in excess of the CREG, which is 0.04 mg/kg; however, no samples were above the child chronic EMEG of 3 mg/kg. DDT concentrations ranged from non-detectable to 29.6 mg/kg, with a mean concentration of 3.95 mg/kg. Eleven of the samples had DDT concentrations in excess of the CREG (i.e., 2 mg/kg); however no samples exceeded the child intermediate EMEG of 30 mg/kg. DDE concentrations ranged from non-detectable to 9.4 mg/kg, with an average concentration of 2.81 mg/kg. Fourteen of the samples had DDE concentrations in excess of the CREG (i.e., 2 mg/kg). It should be noted that even though some compounds exceed the comparison values, it does not necessarily mean health concerns will occur, these compounds will be evaluated further in the Discussion section.

Table 3b shows the minimum, mean, and maximum values of compounds detected in near-surface soil on the site that exceeded their respective health-based comparison values. For 6 to 8-inch deep soil, six samples were taken and tested for total arsenic and organochlorine pesticides. Of the compounds that were detected, the ones that exceeded health-based comparison values were arsenic, dieldrin, DDT, and DDE. The arsenic concentrations ranged from 24.2 mg/kg to 128 mg/kg, with a mean concentration of 57.8 mg/kg. All samples had concentrations in excess of both the chronic EMEG for a child's exposure to arsenic in soil (i.e., 20 mg/kg) and the CREG value for arsenic in soil (i.e., 0.5 mg/kg). However, this CREG value is also below the natural background range of soil arsenic concentration, and thus is relatively conservative. It should be noted that if a compound exceeds the comparison value, it does not necessarily mean health concerns will occur. The dieldrin concentrations ranged from 0.52 mg/kg to 3.6 mg/kg, with a mean concentration of 1.22 mg/kg. Two of the samples had concentrations (i.e., 3.5 and 3.6 mg/kg) in excess of the chronic

EMEG for a child's exposure, and all samples had dieldrin concentrations in excess of the CREG (i.e., 0.04 mg/kg).

For surface water in Milham Brook, two samples were taken and tested for arsenic and organochlorine pesticides. No compounds were detected.

Some environmental samples were taken on-site in association with a fuel spill at 33 Boston Post Road (Gas Station) to the North of the site.

For subsurface soil (depth range 10 to 12 feet), nine samples were taken and six were tested for total petroleum hydrocarbons (TPHs); one for polychlorinated biphenyls (PCBs) and pesticides; one for volatile organic compounds (VOCs); and one for volatile petroleum hydrocarbons (VPHs) with target compounds, extractable petroleum hydrocarbons (EPHs) with diesel target compounds, and VOCs (ATC 2000). Target compounds are specific compounds within a group of compounds. Of the compounds that were detected, none exceeded health-based comparison values, but the maximum detection of TPH exceeded the MA DEP residential soil clean-up standard of 200 mg/kg. None of the other compounds tested for were detected.

Table 4 shows the minimum, mean, and maximum values of compounds detected in groundwater on the site that exceeded their respective health-based comparison values. For groundwater, five samples were taken (three on February 28, 1991 near Glen Street on the south end of the site, and two on December 20, 1999 on the northern part of the site adjacent to Route 20 in association with a leaking underground gasoline storage tank on Route 20 north of the site). The three groundwater samples collected near Glen Street were tested for VOCs and TPHs and the two groundwater samples were tested for VPH's and EPH's near route 20 (ATC 2000). Of the compounds that were detected, the one that exceeded a health-based comparison value was benzene. Benzene was detected once in groundwater at 1 microgram per liter (μg/L), which exceeds the CREG for benzene, which is 0.6 μg/L, but was below EPA's and MA DEP's standards for drinking water (i.e., 5 μg/L). In addition, the detection limit for benzene in three of the samples was 1 μg/l, which exceeds the CREG. The CREG is very conservative, and it should be noted that if a compound exceeds the comparison value, it does not necessarily mean health concerns will occur. Also, methyl-tertiary-butyl-ether (MTBE) was detected once at 107 (μg/l), which exceeds the MA DEP guideline of 70 μg/l. Since these samples were taken in association with a fuel spill, no pesticide analyses were done. It should be noted that response actions have taken place at the 33 Boston Post Road (Gas Station) fuel spill and, according to MA DEP, achieving a level of no significant risk, meaning all substantial hazards have been eliminated (MA DEP 2005).

B. Off-Site Contamination

There has been environmental sampling (i.e., subsurface soil and groundwater) performed by a consultant for the John Hancock Mutual Life Insurance Company (the owners) recently as part of a Phase I Environmental Site Assessment on land located at 33 Boston Post Road West (Gas Station), between Northborough Road and Boston Post Road West (Route 20) (Figure 1). The environmental site assessment was conducted after soil and groundwater contamination from a leaking former underground gasoline storage tank was identified on the eastern portion of the

land in June 1999. This land is north of the former orchard. The environmental site assessment determined that the groundwater from the property flows towards the former orchard (ATC 2000). For this reason, the available environmental data were reviewed.

For subsurface soil at depths ranging from 5 feet to 13 feet, 12 samples were taken and tested for VPHs and EPHs. Of the compounds that were detected, none exceeded health-based comparison values.

For groundwater, 18 samples were taken and tested for VPHs and EPHs. These samples were collected just north of the northeast corner of the site. Of the compounds that were detected, benzene exceeded health-based comparison values. Benzene was detected five times at levels (i.e., 1.2 µg/L, 2 µg/L, 2.8 µg/L, 4.7 µg/L, and 11 µg/L) exceeding the CREG for benzene (i.e., 0.6 µg /L); however, these levels average below the federal and state drinking water standard of 5 µg/L. Also, MTBE was detected 13 times at levels (i.e., ranging from 75 µg/L to 14,800 µg/L, with an average of 2,183 µg/L) exceeding the MA DEP guidance level of 70 µg/L. These compounds will be evaluated further in the Discussion section.

C. Quality Assurance/Quality Control (QA/QC)

Sampling results reviewed for this site indicate that QA/QC was performed appropriately for the samples. Batch spike and batch blank samples were analyzed as part of the laboratory's QA/QC program. The validity of the conclusions made in this final public health assessment depends on the accuracy and reliability of the data provided in the cited report.

In several of the surface soil samples, the detection limits were higher than the health-based comparison values for some compounds. The laboratory has stated that the detection limits were higher in some samples because it was necessary to dilute the samples in order to accurately quantify the concentrations of compounds that were detected (Hygienetics 1999b). The detection limits for soil samples in which the contaminants of concern were not detected were all below the respective health-based comparison values for those compounds.

D. Physical and Other Hazards

At the point where Milham Brook flows under Glen Street and into the property, there is a drop-off of approximately 6 to 10 feet (Appendix B, Photograph 4). There is no fence or guardrail preventing access to this area. This could present a physical hazard to persons walking by or playing near this area. No other physical hazards were observed during the site visit.

PATHWAY ANALYSIS

To determine whether nearby residents and people on site were, are, or could be exposed to contaminants, an evaluation was made of the environmental and human components that lead to human exposure. The pathway analysis consists of five elements: a source of contamination, transport through an environmental medium, a point of exposure, a route of human exposure, and a receptor population.

Exposure to a chemical must first occur before any adverse health effects can result. Five conditions must be met for exposure to occur. First, there must be a source of that chemical. Second, a medium (e.g., water) must be contaminated by either the source or by chemicals transported away from the source. Third, there must be a location where a person can potentially contact the contaminated medium. Fourth, there must be a means by which the contaminated medium could enter a person's body (e.g., ingestion). Finally, the chemical must actually reach the target organ susceptible to the toxic effects from that particular substance at a sufficient dose for a sufficient time for an adverse health effect to occur (ATSDR 1993a).

A completed exposure pathway exists when the above five elements are present. A potential exposure pathway exists when one or more of the five elements is missing and indicates that exposure to a contaminant could have occurred in the past, could be occurring in the present, or could occur in the future. An exposure pathway can be eliminated if at least one of the five elements is missing and will not likely be present. The discussion that follows incorporates only those pathways that are important and relevant to the site.

A. Completed Exposure Pathways

Surface Soil

At the time of this public health assessment, the opportunities for exposure to pesticide compounds in surface soil appear to be somewhat limited because the site is currently vacant and unused and there is a vegetative covering on the site. However, there are no fences preventing access to the site. Therefore, opportunities for exposure to pesticide compounds in surface soil through incidental ingestion, although limited, are present at the site. Opportunities for exposure to pesticide compounds in surface soil at the site could increase should development or excavation activities take place.

B. Potential Exposure Pathway

Near-surface Soil

Opportunities for exposure to contaminants are limited because the soil is mostly covered in vegetation and is not accessible. If the site is developed or excavation activities take place, opportunities for exposure could occur in the future.

Subsurface Soil

Limited subsurface sampling data (e.g., no testing for metals or pesticide residues, small number of samples) did not detect any compounds that exceeded health-based comparison values; however, one sample exceeded the MA DEP residential clean-up standard for TPH. Due to the limited nature of the sampling and the possible development or excavation activities at the site, opportunities for exposure could occur in the future.

Surface Water

Although the two surface water samples from Milham Brook that were analyzed for organochlorine and arsenic showed no detectable concentrations of pesticides and arsenic, it is possible that development activities could cause runoff resulting in higher levels of these compounds in Milham Brook in the future.

Surface Sediment

It should be noted that opportunities for exposure to surface sediment in Milham Brook are possible, but no surface sediment samples were available. No contaminants were detected in the surface water of Milham Brook.

Ambient Air

At the time of this public health assessment, there do not appear to be any opportunities for exposures through the ambient air pathway. In the future, it is possible that opportunities for exposure to contaminants in ambient air (e.g., fugitive dusts) might occur for residents living in adjacent neighborhoods and workers on the site should development or excavation activities take place. Past exposure opportunities to workers, trespassers and possibly neighborhood residents probably occurred during application of pesticides. It should be noted that no ambient air samples were collected on or near the site.

Groundwater via Surface Water

Groundwater releases from the site into Milham Brook, hence into the Milham Reservoir are unlikely, but cannot be ruled out. Therefore, opportunities for exposure cannot be ruled out. It should be noted that no contaminants were detected in Milham Brook.

C. Eliminated Exposure Pathway

Groundwater via Private Drinking Water Wells

Opportunities for exposure to the chemicals in groundwater are unlikely to occur at this site because according to the Marlborough Board of Health, none of the residences in the neighborhood adjacent to the site have private wells that are used for drinking water purposes (Marlborough BOH 2005). Also, based on known topography at the site, groundwater beneath the site is most likely flowing away from homes toward Milham Brook and Milham Reservoir

(USGS 2001). If there are residents with private drinking water wells MDPH would be happy to provide individual technical assistance or advice to those who may be concerned.

DISCUSSION

MDPH staff has summarized the available environmental data and exposure pathways for the Milham Brook Area property in this final public health assessment. The completed exposure pathway present at the site is contact with surface soil. The compounds of concern at the site are arsenic and pesticide compounds. In surface soil samples, the compounds that exceeded either health-based comparison values or typical background levels were arsenic, DDT, DDE, and dieldrin.

Opportunities for exposures to these compounds are primarily via incidental ingestion of surface soil at the site. Near-surface soil samples had compounds detected at levels exceeding health-based comparison values but since the soil is inaccessible, it does not present a completed exposure pathway. Subsurface soil samples collected on and off site were not tested for metals and one sample was tested for pesticides. However, since the soil is not accessible, subsurface soil does not present a completed exposure pathway under current conditions. The surface water samples collected from the site did not show arsenic or pesticide concentrations. Opportunities for exposure to compounds in subsurface soil and surface water might increase in the future, if the site is developed or excavation activities take place. Similarly, because the site is seasonally vegetated and undisturbed, it is unlikely that opportunities for exposure to compounds in ambient air are present, but these could increase in the future, if the site is developed or excavation activities take place (i.e., through fugitive dust). It is likely that opportunities for exposure to pesticides in ambient air occurred for workers, trespassers and possibly neighborhood residents in the past during active pesticide applications. However, such exposure opportunities are difficult to quantify. The residences adjacent to the site are not, according to the Marlborough Board of Health, using groundwater for drinking water purposes and hence, groundwater, either on or off site, does not present a completed exposure pathway. However, if there are residents with private drinking water wells MDPH would be happy to provide individual technical assistance or advice to those who may be concerned.

As previously mentioned, the surface soil, near-surface soil, and surface water samples collected were analyzed for organochlorine pesticides and arsenic. Historical research showed that lead arsenate was used as an insecticide at the apple orchard. Lead was not included as a target analyte in the environmental sampling. This constitutes a gap in the environmental data for the site.

A. Chemical-Specific Toxicity Information

As noted earlier in this public health assessment, four compounds (i.e., arsenic, DDT, DDE, and dieldrin) exceeded either comparison or typical background values in surface soil at the site. Lead in soil was a data gap at the site; however, it is likely to be present at the site, therefore, information about lead is included below.

In order to evaluate possible public health implications, estimates of opportunities for exposure to chemicals in soil must be combined with what is known about the toxicity of the chemicals. ATSDR has developed a minimal risk level (MRL) for many chemicals. The MRL is an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse noncancer health effects over a specified duration of exposure. MRLs are derived based on no-observed-adverse-effect levels (NOAELs) or lowest-observed-adverse-effect levels (LOAELs) from either human or animal studies. The LOAELs or NOAELs reflect the actual levels of exposure that are used in studies. ATSDR has also classified LOAELs into "less serious" or "serious" effects. "Less serious effects" are those that are not expected to cause significant dysfunction or whose significance to the organism is not entirely clear. "Serious" effects are those that evoke failure in a biological system and can lead to illness or death. When reliable and sufficient data exist, MRLs are derived from NOAELs or from less serious LOAELs, if no NOAEL is available for the study. To derive these levels, ATSDR also accounts for uncertainties about the toxicity of a compound by applying various margins of safety, thereby establishing a level that is well below a level of health concern.

Arsenic

Arsenic is a naturally occurring element that can be found in many kinds of rock, particularly copper or lead containing ores. Arsenic can be found in the environment in two different forms, organic arsenic and inorganic arsenic. The organic forms are usually less harmful than the inorganic forms. Ingesting arsenic in soil, water, or food is the most likely way for a person to be exposed near a waste site. Only a small amount of arsenic can be absorbed through the skin from contact with arsenic-contaminated soils or water. Some areas of the country contain naturally high levels of arsenic in rock, which often means that there are higher levels of arsenic in soil and water (ATSDR 1998).

The definitive symptom of long term exposure to elevated levels of arsenic include skin abnormalities such as darkening and the appearance of corns or warts on the palms, soles, and torso. However, there is some evidence that trace amounts of arsenic in the normal diet may be necessary for metabolism (ATSDR 1998, 1993b). The EPA has classified arsenic as a “human carcinogen”. Also, the International Agency for Research on Cancer (IARC) has classified arsenic as being “carcinogenic to humans”, based on sufficient human evidence. In humans, it has been observed that skin carcinomas develop from some of the corns or warts that appear as a result of exposure to arsenic. Large-scale epidemiological studies have been conducted in Taiwan showing clear associations and/or dose response trends for arsenic exposure from drinking water and tumors of bladder, kidney, liver and lung (ATSDR 1998).

Dieldrin

Dieldrin is a persistent organochlorine insecticide that, while no longer used, was widely utilized from the 1950s until 1970 as a pesticide for cotton and food crops. In 1970, the U.S. Department of Agriculture canceled all uses of dieldrin based on environmental and cancer concerns. In 1972, EPA lifted this cancellation for use in structural pest control (i.e., termites), and it was used for such until 1987 (ATSDR 2002a).

Aldrin, another synthetic insecticide with a similar chemical structure, changes to dieldrin quickly in the environment, and thus dieldrin is found more often. Residues of dieldrin can still be found in the environment, but generally at low levels, because aldrin and dieldrin were used until 1989 and dieldrin has a half life of five years in temperate soils, taking decades to fully break down. EPA has classified dieldrin as a "probable human carcinogen", based on sufficient animal studies and inadequate human data (ATSDR 2002a). According to IARC dieldrin is "not classifiable" as to its carcinogenicity. Because it is very difficult to show that a chemical causes cancer in humans, animal studies are used to identify chemicals that have the potential to cause cancer in humans. Several studies in mice demonstrated the ability of aldrin and/or dieldrin to cause liver tumors. In addition, a study in rats provided suggestive evidence that thyroid tumors may be associated with aldrin exposure (ATSDR 2002a).

DDT and Its Metabolites

DDT (1,1,1-trichloro-2,2-*bis*[p-chlorophenyl]ethane) is a persistent, synthetic organochlorine chemical used as an insecticide to protect agricultural (e.g., cotton, peanut, soybean) crops and to control insects that spread diseases like typhus and malaria. Two chemicals associated with DDT are DDE (1,1-dichloro-2,2-*bis*[p-chlorophenyl]ethylene) and DDD (1,1-dichloro-2,2-*bis*[p-chlorophenyl]ethane). DDE and DDD are found in the environment as a result of either contamination of DDT or the breakdown of it. DDD was also used as a pesticide to a limited extent in the past. The use of DDT in the United States was banned in 1972, with the exceptions of use by the Public Health Service officials and other health officials for control of vector-borne disease, use by the U.S. Department of Agriculture or military for health quarantine, and use in drugs for controlling body lice. DDT adheres strongly to soil particles, and thus can remain in soil for a long time.

EPA has determined that DDT, DDE, and DDD are "probable human carcinogens", based on sufficient animal studies and inadequate human data. Also, IARC has classified DDT and its metabolites as "possibly carcinogenic to humans", based on limited human evidence and less than sufficient evidence in animals. Studies have shown that DDT causes cancer in animals. Chronic oral exposure to DDT produced liver neoplasms (i.e., tumors) and malignant lymphomas in mice, and liver tumors in rats. Pulmonary adenomas (i.e., benign tumors on the lungs) were also observed in mice after chronic gavage administration (ATSDR 2002b).

Lead

Lead occurs naturally in the environment. Before EPA banned leaded gasoline in 1976, car exhaust was the major cause of lead being released into the environment. Other sources of lead released to the air include burning fuel such as coal or oil, industrial processes, and burning solid waste. Most lead in inner city soils comes from deteriorated housing, previous automotive

exhaust, and leaded paint. Landfills have waste from lead ore mining, ammunition manufacturing, and from other industrial activities such as battery production, disposal, and recycling (ATSDR 2005).

No MRLs have been developed for lead because a threshold has not yet been defined for the most sensitive effects of lead (i.e., neurotoxicity). The primary health concern for this compound is neurological effects. The neurological and renal systems are the primary target organs. EPA also considers lead to be "a probable human carcinogen," based on sufficient evidence in animal studies and insufficient evidence in human studies (ATSDR 2005).

MA DEP does, however, screen soil lead levels using their S-1 Soil Standards of 300 parts per million (ppm). Public health screening for lead in children indicates that lead paint in older housing stock continues to be the most important risk factor for lead exposure in children.

B. Evaluation of Possible Health Effects

Populations that could have opportunities for exposure to compounds in surface soil, in the future should this site be developed, workers associated with the development of this property, possibly persons trespassing on the site during development, or residents of Marlborough if there are significant releases to Milham Brook, which flows into Milham Reservoir, during site development. Past opportunities for exposure to pesticides during the active apple orchard operation likely occurred, and might have been significant, but are difficult to quantify. At the time of this public health assessment, there are opportunities for exposure via direct contact with soil (incidental ingestion), although this is somewhat mitigated by the seasonal vegetative cover that blankets the site.

Arsenic, dieldrin, DDT, and DDE exceeded either comparison or typical background values in surface soil at the site. To further evaluate the public health impact of these contaminants, opportunities for exposure based on ingestion of contaminated soil were evaluated for children playing on the site under current conditions of use (i.e., open space).

The estimated opportunities for exposure to arsenic for a trespassing child playing on the property for 4 days per week for 39 weeks per year are 0.00053 milligrams per kilogram per day (mg/kg/day) based on ingestion of the maximum level of arsenic (217 mg/kg) detected in surface soil[1]. This estimated value is slightly higher than ATSDR's chronic oral MRL for non-cancer health effects from exposure to arsenic, which is 0.0003 mg/kg/day, but lower than the LOAEL, which is 0.00065 mg/kg/day. It is appropriate to compare the estimated opportunities for exposure to the chronic oral MRL, though this is a conservative approach because the chronic oral MRL is based on an assumption of daily exposure. Since it is unlikely that a child would be continuously exposed to the maximum level of arsenic and the exposure dose is less than the LOAEL, adverse non-cancer health effects from exposure to arsenic in soil are not expected. Unusual cancer concerns would also not be expected from opportunities for exposure to arsenic at this site[2].

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[1] Trespassing Child Non-Cancer Exposure Factor = $\frac{(4 \text{ days/week} \times 39 \text{ weeks/year} \times 10 \text{ years})}{(10 \text{ years}) \times (365 \text{ days/year})} = 0.43$

Trespassing Child Non-Cancer Exposure Dose = $\frac{217 \text{ mg/kg} \times 200 \text{ mg/day} \times 0.43 \times 10^{-6} \text{ kg/mg}}{35 \text{ kg}} = 5.33 \times 10^{-4}$

[2] $\frac{(4 \text{ days/week} \times 39 \text{ weeks/year} \times 10 \text{ years})}{}$

The estimated opportunities for exposure to arsenic for a trespassing adult jogging or hiking on the property for 4 days per week for 39 weeks per year are 0.00013 mg/kg/day based on ingestion of the maximum level of arsenic (217 mg/kg) detected in surface soil[3]. This estimated value is lower than ATSDR's chronic oral MRL for non-cancer health effects from exposure to arsenic, which is 0.0003 mg/kg/day; therefore, adverse non-cancer health effects from exposure to arsenic in soil are not expected. Unusual cancer concerns would also not be expected from opportunities for exposure to arsenic at this site[4].

The estimated opportunities for exposure to dieldrin for a trespassing child playing on the property are 0.000005 mg/kg/day based on ingestion of the maximum level of dieldrin detected in surface soil (1.9 mg/kg)[5]. This estimated value is lower than ATSDR's chronic oral MRL for non-cancer health effects from exposure to dieldrin, which is 0.00005 mg/kg/day. Thus, adverse non-cancer health effects from exposure to dieldrin in soil are not expected. Unusual cancer concerns would also not be expected from opportunities for exposure to dieldrin at this site[6].

Trespassing Child Cancer Exposure Factor = $\frac{\text{(70 years) X (365 days/year)}}{}$ = 0.061

Trespassing Child Cancer Exposure Dose = $\frac{\text{217 mg/kg X 200 mg/day X 0.061 X } 10^{-6} \text{ kg/mg}}{\text{35 kg}}$ = 7.56×10^{-5}

Trespassing Child Cancer Risk = $(7.56 \times 10^{-5}) \text{ X } 1.5 = 1 \times 10^{-4}$

[3]
Trespassing Adult Non-Cancer Exposure Factor = $\frac{\text{(4 days/week X 39 weeks/year X 40 years)}}{\text{(40 years) X (365 days/year)}}$ = 0.43

Trespassing Adult Non-Cancer Exposure Dose = $\frac{\text{217 mg/kg X 100 mg/day X 0.43 X } 10^{-6} \text{ kg/mg}}{\text{70 kg}}$ = 1.33×10^{-4}

[4]
Trespassing Adult Cancer Exposure Factor = $\frac{\text{(4 days/week X 39 weeks/year X 40 years)}}{\text{(70 years) X (365 days/year)}}$ = 0.24

Trespassing Adult Cancer Exposure Dose = $\frac{\text{217 mg/kg X 100 mg/day X 0.24 X } 10^{-6} \text{ kg/mg}}{\text{70 kg}}$ = 7.44×10^{-5}

Trespassing Adult Cancer Risk = $(7.44 \times 10^{-5}) \text{ X } 1.5 = 1 \times 10^{-4}$

[5]
Trespassing Child Non-Cancer Exposure Factor = $\frac{\text{(4 days/week X 39 weeks/year X 10 years)}}{\text{(10 years) X (365 days/year)}}$ = 0.43

Trespassing Child Non-Cancer Exposure Dose = $\frac{\text{1.9 mg/kg X 200 mg/day X 0.43 X } 10^{-6} \text{ kg/mg}}{\text{35 kg}}$ = 5.0×10^{-5}

[6]
Trespassing Child Cancer Exposure Factor = $\frac{\text{(4 days/week X 39 weeks/year X 10 years)}}{\text{(70 years) X (365 days/year)}}$ = 0.061

Trespassing Child Cancer Exposure Dose = $\frac{\text{1.9 mg/kg X 200 mg/day X 0.061 X } 10^{-6} \text{ kg/mg}}{\text{35 kg}}$ = 6.0×10^{-7} (continued on next page)

Trespassing Child Cancer Risk = $(6.0 \times 10^{-7}) \text{ X } 1.5 = 9 \times 10^{-7}$

The estimated opportunities for exposure to dieldrin for a trespassing adult jogging or hiking on the property are 0.000001 mg/kg/day based on ingestion of the maximum level of dieldrin (1.9 mg/kg) detected in surface soil[7]. This estimated value is lower than ATSDR's chronic oral MRL for non-cancer health effects from exposure to dieldrin, which is 0.00005 mg/kg/day; therefore, adverse non-cancer health effects from exposure to arsenic in soil are not expected. Unusual cancer concerns would also not be expected from opportunities for exposure to dieldrin at this site[8].

The estimated opportunities for exposure to DDT and its related compounds (i.e., DDD and DDE) for a trespassing child playing on the property are 0.0001 mg/kg/day based on ingestion of the maximum levels of DDT, DDE, and DDD detected in surface soil (29.6, 9.4, and 2.2 mg/kg, respectively)[9]. This estimated value is lower than ATSDR's intermediate oral MRL for non-cancer health effects from exposure to DDT, which is 0.0005 mg/kg/day. Thus, adverse non-cancer health effects from exposure to DDT and its related compounds in surface soil are not expected.

Unusual cancer concerns would also not be expected from opportunities for exposure to DDT and its related compounds at this site[10].

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[7]

Trespassing Adult Non-Cancer Exposure Factor = $\frac{(4 \text{ days/week} \times 39 \text{ weeks/year} \times 40 \text{ years})}{(40 \text{ years}) \times (365 \text{ days/year})} = 0.43$

Trespassing Adult Non-Cancer Exposure Dose = $\frac{1.9 \text{ mg/kg} \times 100 \text{ mg/day} \times 0.43 \times 10^{-6} \text{ kg/mg}}{70 \text{ kg}} = 1.1 \times 10^{-6}$

[8]

Trespassing Adult Cancer Exposure Factor = $\frac{(4 \text{ days/week} \times 39 \text{ weeks/year} \times 40 \text{ years})}{(70 \text{ years}) \times (365 \text{ days/year})} = 0.24$

Trespassing Adult Cancer Exposure Dose = $\frac{1.9 \text{ mg/kg} \times 100 \text{ mg/day} \times 0.24 \times 10^{-6} \text{ kg/mg}}{70 \text{ kg}} = 6.0 \times 10^{-7}$

Trespassing Adult Cancer Risk = $(6.0 \times 10^{-7}) \times 1.5 = 9 \times 10^{-7}$

[9]

Trespassing Child Non-Cancer Exposure Factor = $\frac{(4 \text{ days/week} \times 39 \text{ weeks/year} \times 10 \text{ years})}{(10 \text{ years}) \times (365 \text{ days/year})} = 0.43$

Trespassing Child Non-Cancer Exposure Dose DDT= $\frac{29.6 \text{ mg/kg} \times 200 \text{ mg/day} \times 0.43 \times 10^{-6} \text{ kg/mg}}{35 \text{ kg}} = 7.27 \times 10^{-5}$

Trespassing Child Non-Cancer Exposure Dose DDE= $\frac{9.4 \text{ mg/kg} \times 200 \text{ mg/day} \times 0.43 \times 10^{-6} \text{ kg/mg}}{35 \text{ kg}} = 2.3 \times 10^{-5}$

Trespassing Child Non-Cancer Exposure Dose DDD= $\frac{2.2 \text{ mg/kg} \times 200 \text{ mg/day} \times 0.43 \times 10^{-6} \text{ kg/mg}}{35 \text{ kg}} = 5.4 \times 10^{-6}$

Total (DDT, DDE, DDD) Non-Cancer Exposure Dose = 1.0×10^{-4}

[10]

Trespassing Child Cancer Exposure Factor = $\frac{(4 \text{ days/week} \times 39 \text{ weeks/year} \times 10 \text{ years})}{(70 \text{ years}) \times (365 \text{ days/year})} = 0.061$

Trespassing Child Cancer Exposure Dose DDT= $\frac{29.6 \text{ mg/kg} \times 200 \text{ mg/day} \times 0.061 \times 10^{-6} \text{ kg/mg}}{35 \text{ kg}} = 1.0 \times 10^{-5}$

The estimated opportunities for exposure to DDT and its related compounds (i.e., DDD and DDE) for a trespassing adult jogging or hiking on the property are 0.000025 mg/kg/day based on ingestion of the maximum levels of DDT, DDE, and DDD detected in surface soil (29.6, 9.4, and 2.2 mg/kg, respectively)[11]. This estimated value is lower than ATSDR's intermediate oral MRL for non-cancer health effects from exposure to DDT, which is 0.0005 mg/kg/day. Thus, adverse non-cancer health effects from exposure to DDT and its related compounds in surface soil are not expected. Unusual cancer concerns would also not be expected from opportunities for exposure to DDT and its related compounds at this site[12].

The cumulative cancer risk from exposure to arsenic, dieldrin, DDT, and related compounds can be determined by adding the lifetime cancer risks calculated for each of the individual compounds. Based on the evaluation, unusual risks of cancer would not be expected from opportunities for exposure to these compounds at this site.

While the health implications of the environmental data provided to MDPH do not indicate health concerns, there are a number of important limitations (e.g., no lead soil samples, number

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Trespassing Child Cancer Exposure Dose DDE= $\frac{9.4 \text{ mg/kg} \times 200 \text{ mg/day} \times 0.061 \times 10^{-6} \text{ kg/mg}}{35 \text{ kg}} = 3.2 \times 10^{-6}$

Trespassing Child Cancer Exposure Dose DDD= $\frac{2.2 \text{ mg/kg} \times 200 \text{ mg/day} \times 0.061 \times 10^{-6} \text{ kg/mg}}{35 \text{ kg}} = 7.0 \times 10^{-7}$

Trespassing Child Cancer Risk DDT + DDE + DDD= $((1.0 \times 10^{-5}) \times 0.34) + ((3.2 \times 10^{-6}) \times 0.34) + ((7.0 \times 10^{-7}) \times 0.24) = 4.5 \times 10^{-6}$

[11]
Trespassing Adult Non-Cancer Exposure Factor = $\frac{(4 \text{ days/week} \times 39 \text{ weeks/year} \times 40 \text{ years})}{(40 \text{ years}) \times (365 \text{ days/year})} = 0.43$

Trespassing Adult Non-Cancer Exposure Dose DDT= $\frac{29.6 \text{ mg/kg} \times 100 \text{ mg/day} \times 0.43 \times 10^{-6} \text{ kg/mg}}{70 \text{ kg}} = 1.8 \times 10^{-5}$

Trespassing Adult Non-Cancer Exposure Dose DDE= $\frac{9.4 \text{ mg/kg} \times 100 \text{ mg/day} \times 0.43 \times 10^{-6} \text{ kg/mg}}{70 \text{ kg}} = 5.7 \times 10^{-6}$

Trespassing Adult Non-Cancer Exposure Dose DDD= $\frac{2.2 \text{ mg/kg} \times 100 \text{ mg/day} \times 0.43 \times 10^{-6} \text{ kg/mg}}{70 \text{ kg}} = 1.3 \times 10^{-6}$

Total (DDT, DDE, DDD) Non-Cancer Exposure Dose $= 2.5 \times 10^{-5}$

[12]
Trespassing Adult Cancer Exposure Factor = $\frac{(4 \text{ days/week} \times 39 \text{ weeks/year} \times 40 \text{ years})}{(70 \text{ years}) \times (365 \text{ days/year})} = 0.24$

Trespassing Adult Cancer Exposure Dose DDT= $\frac{29.6 \text{ mg/kg} \times 100 \text{ mg/day} \times 0.24 \times 10^{-6} \text{ kg/mg}}{70 \text{ kg}} = 1.0 \times 10^{-5}$

Trespassing Adult Cancer Exposure Dose DDE= $\frac{9.4 \text{ mg/kg} \times 100 \text{ mg/day} \times 0.24 \times 10^{-6} \text{ kg/mg}}{70 \text{ kg}} = 3.2 \times 10^{-6}$

Trespassing Adult Cancer Exposure Dose DDD= $\frac{2.2 \text{ mg/kg} \times 100 \text{ mg/day} \times 0.24 \times 10^{-6} \text{ kg/mg}}{70 \text{ kg}} = 7.0 \times 10^{-7}$

Trespassing Adult Cancer Risk DDT + DDE + DDD= $((1.0 \times 10^{-5}) \times 0.34) + ((3.2 \times 10^{-6}) \times 0.34) + ((7.0 \times 10^{-7}) \times 0.24) = 4.3 \times 10^{-6}$

of samples and extent not representative of entire site), and additional community-based health information that need to be considered. Thus, it is not possible without additional environmental information to fully characterize the public health concerns associated with this site in the past when opportunities for exposure were higher. If additional sampling for pesticides and metals were to be implemented, current or future risks could be more confidently determined.

Secondly, MDPH's review of cancer incidence information for Marlborough as a whole has identified that some cancers (e.g., lung) are significantly elevated. In addition, in their petition to ATSDR, the Glen Street area residents have also reported possible cancer occurrence (i.e., 22 persons who have or have died from various cancers) of concern in the area near the former orchard (Bocchino et al. 2000). It is possible that opportunities for exposure likely occurred in the past to site workers, trespassers and possibly neighborhood residents. Because of the uncertainties with regard to past use of pesticides (e.g., all the specific kinds, amounts used) and evidence of cancer concerns in the Glen Street neighborhood, further environmental and health follow-up would be helpful in attempting to better determine possible public health impacts.

C. ATSDR Child Health Section

ATSDR and MDPH, recognize that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination of their environment. Children are at a greater risk than adults from certain kinds of exposure to hazardous substances emitted from waste sites. They are more likely exposed because they play outdoors and because they often bring food into contaminated areas. Because of their smaller stature, they may breathe dust, soil, and heavy vapors close to the ground. Children are also smaller, resulting in higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if certain toxic exposures occur during critical growth stages. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care.

MDPH evaluated the likelihood of exposures to children from compounds in surface soil at the Milham Brook Area site. See section B above ("Evaluation of Possible Health Effects") for a discussion of these exposure scenarios.

CONCLUSIONS

Under current site conditions, the concentrations of the compounds detected in the soils of the Milham Brook Area site do not indicate public health concerns based on the environmental data available. However, there are a number of important data gaps that indicate that more evaluations should be done. While there do not appear to be unusual cancer risks associated with present and future opportunities for exposures to the pesticides for which data were generated, it is likely that other contaminants could be present. While the past application of lead arsenate is clearly acknowledged, MDPH is not aware of any hardcopy records for pesticide use at the former apple orchard. Given the amount of time that has lapsed, records from the 1960s are not required to be kept. Lead is an obvious data gap. Therefore, a more thorough site investigation would be advisable in association with development (e.g., more soil samples that in

general and more soil samples that include lead). According to the Marlborough Board of Health no residences near the site are using groundwater for drinking water (Marlborough BOH 2005). In addition, the likely opportunities for exposure in the past during active orchard operations, coupled with the findings of significantly or nearly significantly elevated SIRs for some cancers on a city-wide basis, indicate that follow-up should be done to examine cancer incidence on a smaller area (e.g., census tract 3214 where the Milham Brook site is located). This health concern was raised in the petition submitted to ATSDR.

ATSDR requires that one of five conclusion categories be used to summarize findings of health consultations and public health assessments. These categories are: 1) Urgent Public Health Hazard, 2) Public Health Hazard, 3) Indeterminate Public Health Hazard, 4) No Apparent Public Health Hazard, 5) No Public Health Hazard. A category is selected from site-specific conditions such as the degree of public health hazard based on the presence and duration of human exposure, contaminant concentration, the nature of toxic effects associated with site-related contaminants, presence of physical hazards, and community health concerns.

Based on ATSDR criteria, ATSDR would classify the Milham Brook Area site under past site conditions as an "Indeterminate Public Health Hazard". At the time of this public health assessment, because of ~~a~~ vegetative cover on the site that mitigates direct contact with the site soil, ATSDR would classify the Milham Brook Area site as a "No Apparent Public Health Hazard". Based on ATSDR criteria, the site could pose an "Indeterminate Public Health Hazard" in the future.

RECOMMENDATIONS

1. Additional site characterization for pesticides and metals, including arsenic and lead, for soil should be implemented to address data gaps (i.e., areas of the property that have not been sampled). In addition, the environmental consultants for the landowner should address the need for surface and groundwater sampling based on all available environmental information and site characteristics. This is particularly important in the future if the site is developed, as development could create run-off to the brook that could potentially impact the public water supply reservoir or create airborne fugitive dust.

2. Additional investigation of cancer incidence, including analyses of a smaller geographic area (i.e., the Glen Street neighborhood) should be done by MDPH.

3. MDPH recommends that the physical hazard (i.e., the culvert at Glen and Ripley Streets) may need to be further addressed, and MDPH will note the physical hazard to the site owners and to local officials when this final public health assessment is released.

PUBLIC HEALTH ACTION PLAN

Past Actions

1. MPDH conducted a public meeting in June 2000 in order to release the public comment draft version of this public health assessment and gather community concerns, which

included concerns about cancer incidence in the neighborhood and groundwater contamination.

2. MDPH participated in a legislative hearing on the development of former agricultural lands in 2000.

3. At ATSDR's annual meeting in 2001, MDPH did a presentation and participated in a discussion on concerns relating to residual pesticide contamination on former agricultural lands (e.g., orchards) proposed for redevelopment.

Ongoing Actions

1. Based on observations made in this public health assessment (e.g., potential past exposures to pesticides), MDPH is further evaluating the incidence of bronchial and lung cancer, liver cancer, and leukemia in order to determine whether any unusual or unexpected patterns of incidence exist and to completely address concerns expressed by residents living near the site. This assessment will be released in a separate report.

2. Upon request, should MDPH receive additional environmental data not included in this public health assessment or information that would be helpful in improving the characterization of opportunities for exposure, this information will be evaluated.

3. Upon request, MDPH will provide technical assistance to others in developing a sampling and analysis protocol or review such protocols as developed by environmental consultants for the property owner.

4. If there are residents with private drinking water wells MDPH would be happy to provide individual technical assistance or advice to those who may be concerned.

PREPARER OF PUBLIC HEALTH ASSESSMENT

This document was prepared by the Center for Environmental Health of the Massachusetts Department of Public Health. If you have any questions about this document, please contact Suzanne K. Condon, Assistant Commissioner, 7th Floor, 250 Washington Street, Boston, Massachusetts 02108.

TABLES 1 - 4

Table 1: Demographic Characteristics of Marlborough, Massachusetts (U.S. Census 2001).

Characteristics	Marlborough		CT 3214	
	Persons	%	Persons	%
Total Population	36,255	100.0	2,905	100.0
Age				
Under 5	2,554	7.0	185	6.4
5 – 14	4,745	13.1	365	12.5
15 – 44	16,958	46.8	1140	39.3
45 – 64	7,808	21.5	790	27.3
65 and over	4,190	11.5	425	14.6
Sex				
Male	17,869	49.3	1,418	48.8
Female	18,386	50.7	1,487	51.2
Race				
White	31,796	87.7	2,729	93.9
Black	787	2.2	42	1.4
American Indian or Alaska Native	72	0.2	5	0.2
Asian	1,364	3.8	69	2.4
Native Hawaiian and Other Pacific Islander	13	0.0	0	0.0
Other	1,186	3.3	12	0.4
Multi-race	1,037	2.9	48	1.7
Hispanic or Latino and Race				
Not Hispanic or Latino	34,059	93.9	2,858	98.4
Hispanic or Latino	2,196	6.1	47	1.6

CT = census tract

Table 2: Cancer Incidence in Marlborough, Massachusetts: 1996 through 2000.[1]

Cancer Type	Total						Males						Females					
	Obs	Exp	SIR	95% CI			Obs	Exp	SIR	95% CI			Obs	Exp	SIR	95% CI		
Bladder	22	24.0	92	58	--	139	17	16.9	101	59	--	161	5	7.1	71	23	--	166
Brain	7	11.9	59	24	--	122	3	6.5	NC	NC	--	NC	4	5.4	NC	NC	--	NC
Breast	132	121.0	109	91	--	129	2	0.9	NC	NC	--	NC	130	120.1	108	90	--	128
Cervix/Uteri	7	7.0	100	40	--	207	0.0	0.0	NC	NC	--	NC	7	7.0	100	40	--	207
Colon/Rectum	93	89.2	104	84	--	128	49	43.1	114	84	--	150	44	46.1	95	69	--	128
Esophagus	4	8.7	NC	NC	--	NC	3	6.5	NC	NC	--	NC	1	2.2	NC	NC	--	NC
Hodgkin's Disease	10	6.1	163	78	--	301	6	3.4	178	65	--	388	4	2.7	NC	NC	--	NC
Kidney	18	18.2	99	59	--	156	16	11.1	144	82	--	234	2	7.1	NC	NC	--	NC
Larynx	6	7.5	80	29	--	174	5	6.0	84	27	--	196	1	1.6	NC	NC	--	NC
Leukemia	26	17.2	151	99	--	221	13	9.3	139	74	--	239	13	7.9	165	88	--	282
Liver	11	6.8	163	81	--	292	7	4.8	147	59	--	303	4	2.0	NC	NC	--	NC
Lung/Bronchus	117	105.6	111	92	--	133	57	55.9	102	77	--	132	60	49.7	121	92	--	155

SIRs and 95% CI are not calculated when observed number of cases less than 5.

Obs= Observed number of cases

Exp= Expected number of cases

= Standardized Incidence SIRRatio

NHL= Non-Hodgkin's Lymphoma

95% CI= 95% Confidence Interval

= Not NCcalculated

*= Statistical significance

[1] Data Source: Massachusetts Cancer Registry. Cancer Incidence in Massachusetts 1996-2000: City/Town Supplement. Massachusetts Department of Public Health, Bureau of Health Statistics, Research & Evaluation. April 2004.

Table 2 (cont'd): Cancer Incidence in Marlborough, Massachusetts: 1996 through 2000.

Cancer Type	Total							Males						Females					
	Obs	Exp	SIR		95% CI			Obs	Exp	SIR	95% CI			Obs	Exp	SIR	95% CI		
Melanoma	14	24.7	57	*	31	--	95.1	9	13.5	66	30	--	126	5	11.2	45	14	--	105
Multiple Myeloma	13	7.1	184		98	--	315	8	3.6	224	96	--	442	5	3.5	144	46	--	335
NHL	32	29.4	109		74	--	154	15	15.3	98	55	--	162	17	14.1	120	70	--	193
Oral Cavity/Pharynx	26	17.5	148		97	--	217	19	11.6	163	98	--	255	7	5.9	118	47	--	244
Ovarian	10	14.1	71		34	--	130	0	0.0	NC	NC	--	NC	10	14.1	71	34	--	130
Pancreas	18	16.7	108		64	--	170	7	7.7	90	36	--	186	11	9.0	123	61	--	220
Prostate	122	112.7	108		90	--	129	122	112.7	108	90	--	129	0	0.0	NC	NC	--	NC
Stomach	14	12.6	112		61	--	187	9	7.5	121	55	--	229	5	5.1	98	32	--	230
Testis	8	5.8	138		59	--	272	8	5.8	138	59	--	272	0	0.0	NC	NC	--	NC
Thyroid	9	11.6	77		35	--	147	2	3.0	NC	NC	--	NC	7	8.6	81	32	--	167
Uteri	18	22.4	80		48	--	127	0	0.0	NC	NC	--	NC	18	22.4	80	48	--	127
All Sites/Types	792	750.0	106		98	--	113	400	369.5	108	98	--	119	392	380.5	103	93	--	114

SIRs and 95% CI are not calculated when observed number of cases less than 5.

Obs= Observed number of cases
Exp= Expected number of cases
= Standardized Incidence
SIRRatio
NH
L= Non-Hodgkin's Lymphoma

95% CI= 95% Confidence Interval
NC= Not calculated

*= Statistical significance

Table3a: Summary of 0 to 3-inch surface soil sampling results from the former apple orchard in the vicinity of Glen Street and Route 20 in Marlborough, Massachusetts.

Compounds	Detects/ Samples	Minimum (mg/kg)	Mean[1] (mg/kg)	Maximum (mg/kg)	Comparison Values (mg/kg)
Arsenic	26/26	3.8	63.7	217	Chronic EMEG (child) = 20 Chronic EMEG (adult) = 200 CREG = 0.5
4,4'-DDT	23/26	ND	3.95	29.6	RMEG (child) = 30 RMEG (adult) = 400 CREG = 2
4,4'-DDE	23/26	ND	2.81	9.4	CREG = 2
4,4'-DDD	16/26	ND	0.56	2.2	CREG = 3
Dieldrin	20/26	ND	0.72	1.9	Chronic EMEG & RMEG (child) = 3 Chronic EMEG & RMEG (adult) = 40 CREG = 0.04

ND = Not Detected
mg/kg = milligrams per kilogram
CREG = ATSDR Cancer Risk Evaluation Guide
EMEG = ATSDR Environmental Media Evaluation Guide
RMEG = ATSDR Reference Dose Media Evaluation Guide
DDT = 1,1,1-trichloro-2,2-*bis*[p-chlorophenyl]ethane
DDE = 1,1-dichloro-2,2-*bis*[p-chlorophenyl]ethylene
DDD = 1,1-dichloro-2,2-*bis*[p-chlorophenyl]ethane

[1] Mean values were calculated using one half the method detection limit for samples in which the compound was below detection.

Table 3b: Summary of 6 to 8-inch soil sampling results from the former apple orchard in the vicinity of Glen Street and Route 20 in Marlborough, Massachusetts.

Compounds	Detects/ Samples	Minimum (mg/kg)	Mean (mg/kg)	Maximum (mg/kg)	Comparison Values (mg/kg)
Arsenic	6/6	24.2	57.77	128	Chronic EMEG (child) = 20 Chronic EMEG (adult) = 200 CREG = 0.5
4,4'-DDT	6/6	0.85	6.16	18.3	RMEG (child) = 30 RMEG (adult) = 400 CREG = 2
4,4'-DDE	6/6	1.1	3.1	9.5	CREG = 2
4,4'-DDD	6/6	0.076	0.52	1.8	CREG = 3
Dieldrin	6/6	0.52	1.22	3.6	Chronic EMEG & RMEG (child) = 3 Chronic EMEG & RMEG (adult) = 40 CREG = 0.04

mg/kg = milligrams per kilogram
CREG = ATSDR Cancer Risk Evaluation Guide
EMEG = ATSDR Environmental Media Evaluation Guide
RMEG = ATSDR Reference Dose Media Evaluation Guide
DDT = 1,1,1-trichloro-2,2-*bis*[p-chlorophenyl]ethane
DDE = 1,1-dichloro-2,2-*bis*[p-chlorophenyl]ethylene
DDD = 1,1-dichloro-2,2-*bis*[p-chlorophenyl]ethane

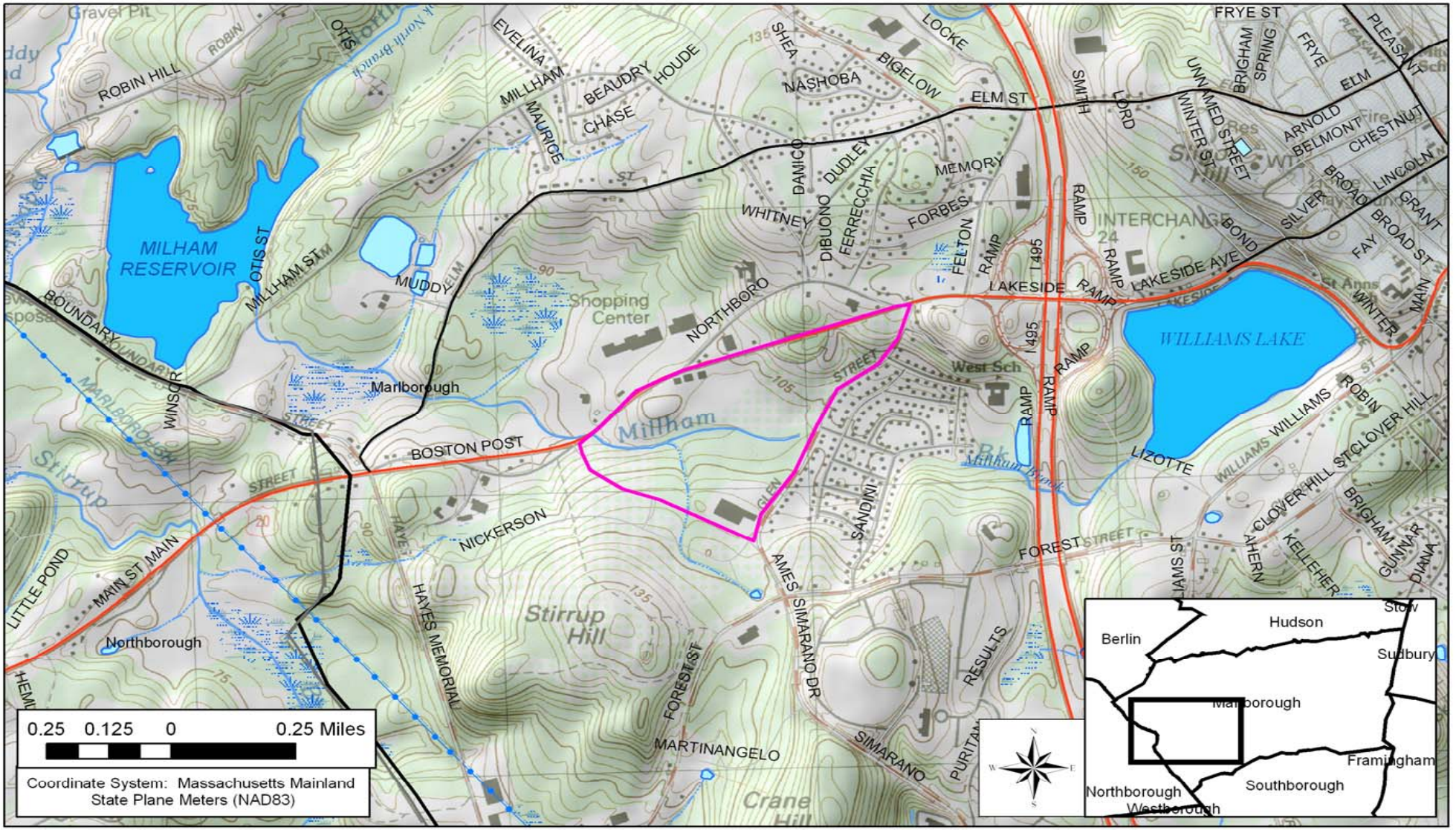
Table 4: Summary of groundwater sampling results from the former apple orchard in the vicinity of Glen Street and Route 20 in Marlborough, Massachusetts.

Compounds	Detects/ Samples	Minimum (µg/L)	Mean (µg/L)	Maximum (µg/L)	Comparison Values (µg/L)
Benzene	1/5	ND	NC	1	CREG = 0.6 MCL = 5
MTBE	1/2	ND	NC	107	Intermediate EMEG (child) = 3,000 Intermediate EMEG (adult) = 10,000 MA DEP drinking water guideline = 70

µg/L = micrograms per liter
MCL = Maximum Contaminant Level for drinking water
NC- Not calculated
ND = Not Detected
CREG = ATSDR Cancer Risk Evaluation Guide
EMEG = ATSDR Environmental Media Evaluation Guide
MA DEP = Massachusetts Department of Environmental Protection
MTBE = methyl *tertiary*-butyl ether

FIGURE 1

Figure 1
Area of Interest, Milham Brook Area, Marlborough, Massachusetts



Center for CEH Environmental Health

Legend

Massachusetts_Towns	Other Road Feature	Perennial Stream	Ditch/Canal	Pond, Lake, Ocean	Submerged Wetland
Former Orchard	Limited Access Highway	Intermittent Stream	Aqueduct	Reservoir	Cranberry Bog
Limited Access Highway	Primary Highway	Shoreline	Dam	Wetland	Tidal Flat
Primary Highway	Secondary Highway	Intermittent Shoreline	Channel in Water	Salt Wetland	Inundated Area
Secondary Highway	Local Road	Manmade Shoreline			

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CERTIFICATION

The public health assessment for the Milham Brook Area, Marlborough, Massachusetts, was prepared by the Massachusetts Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the public health assessment was initiated. Editorial review was completed by the Cooperative Agreement partner.

Technical Project Officer, CAT, DHAC

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this public health assessment and concurs with its findings.

Team Lead, CAT, DHAC, ATSDR

Appendix A
Responses to Public Comments

MDPH and ATSDR received and responded to the following comments/questions regarding the June 2000, Milham Brook Area (a/k/a Glen Street Neighborhood) public comment draft public health assessment. Comments were received from a resident, a neighborhood association, and an environmental consulting firm. The list of responses in this section does not include editorial comments concerning such things as word spelling or sentence syntax, or comments that voice agreement with that which is stated in the public health assessment.

General Comments

1) Comment: MDPH should take action or recommend to the proper authority: enjoin the property, issue a restraining order, and/or advise the real estate broker of mandatory disclosure, until the final review disposition (reference page 6, paragraph A).

1) Response: MDPH is not an environmental regulatory agency in this matter. MDPH's role is that of environmental public health assessment and consultation. Public health assessments and consultations are intended to determine the past, current or future public health implications of a specific site, and focus on the health concerns of the specific community. Public health assessments and consultations are based on environmental characterization information (including information on environmental contamination and exposure pathways), community health concerns associated with the site, and community-specific health outcome data. They make recommendations for actions needed to protect public health (which may include the development and issuing of health advisories), and they identify populations in need of further heath action or studies. Public health assessments and consultations are not used to establish allowable contaminant levels, to establish clean-up levels, or to select remedial measures to be taken at the site. MDPH will facilitate communication of this public health assessment to all interested parties.

2) Comment: If the public comment period ends June 30, 2000, when will HARP and EPA get involved?

2) Response: HARP (Health Activities Recommendation Panel) no longer exists at ATSDR. MDPH provided EPA with a copy of the public health assessment for review. However, in a letter from Linda Murphy, Director of the EPA New England Office of Ecosystem Protection at the time, regarding this issue, she states that the federal Superfund program is somewhat limited in how it can respond to registered pesticide issues on agricultural lands (letter from Linda Murphy to resident of Glen Street, Marlborough, November 8, 1999). In a letter from Mindy Lubber, EPA Regional Administrator at the time, regarding this issue, she states that "sites with pesticide contamination resulting from the routine and legal application of pesticides are not eligible for inclusion on the National Priorities List. Former agricultural lands contaminated with pesticide residues are only eligible for Superfund listing and subsequent cleanup if it can be shown that the contamination results from leaks, spills or improper disposal of bulk pesticides.

At this time, we [EPA] have no information which suggests that the contaminants detected at this site are anything other than pesticide residuals which might be found on agricultural properties anywhere in the United States (letter from Mindy Lubber to Senator Kennedy, March 13, 2000)."

3) Comment: The public health assessment missed the fact that the John Hancock Insurance Company is in possession of a Release Tracking Number (RTN 2-12955). On 12/7/99, they got permission from MetLife to drill monitoring wells on MetLife's property to observe an underground plume. A resident had notified MA DEP of this matter in a letter dated April 21, 2000.

3) Response: Environmental sampling data from these monitoring wells were added to this final blue cover public health assessment. The groundwater data were contained in the report "Monitoring Well Installation and Groundwater Quality Report, ATC Associates, January 19, 2000." These data are discussed in the Environmental Contamination and Other Hazards section of the final blue cover public health assessment.

4) Comment: Will the Glenbrook Neighborhood Association receive progress updates? If so, how often?

4) Response: MDPH will make copies of the final blue cover public health assessment available at the Marlborough Board of Health for distribution to any individual or group that commented on the Public Comment Release of the public health assessment, and to any concerned individual, community group, or interested party that requested a copy. MDPH would be happy to respond to any questions, provide technical assistance, on any additional environmental testing that may be conducted at the site, or evaluate new environmental data.

5) Comment: Hydrocarbon pollution is impacting already pesticide-contaminated soil on the east side of MetLife's former orchard land (see additional information from MA DEP's RTN 2-0012955 for 33 Boston Post Road West).

5) Response: MDPH included in this final public health assessment groundwater data collected by ATC Associates from the site and adjacent property. A description of the adjacent property has been added to the Site Description and History section in the public health assessment. Finally, MDPH has a potential exposure pathway for opportunities for exposure to contaminants in groundwater. The pathway is potential because the site has not been fully characterized and groundwater flows from the site to the brook and down gradient toward Milham Reservoir. According to the Marlborough Board of Health no homes in the area use private wells for drinking water. Any other follow up questions can be directed to MA DEP.

6) Comment: The final public health assessment must assess environmental impact to the 12 to 13 acres of on-site wetland adjacent to Milham Brook along with 3 additional unnamed streams and their related wetlands. All of these stream/wetland systems contribute local groundwater breakout, which flows to Marlborough's surface water supply.

6) Response: MDPH has evaluated in the final blue cover public health assessment available environmental sampling data. Some commenters provided additional reports containing environmental data, which were incorporated into this final public health assessment. Concerns about the possible future impacts of various sources on Marlborough's public drinking water supply are most appropriately addressed by the MA DEP.

7) Comment: The environmental compliance history of large and small-scale development on sloped land in Marlborough is not good. The fine silty nature of surface soil in Marlborough makes soil prone to erosion during rain events and to airborne transport when dry. The desirable developable acreage on the site is sloped. Runoff during any construction is a potential problem to the 12 to 13 acres and four streams on the site.

7) Response: As is stated in the Discussion section, if the site is developed or excavation activities take place, opportunities for exposure to contaminants in the soil and surface water may occur. In order to minimize the opportunities for exposure, certain precautions can be taken (e.g., silt fences near wetlands, wetting the soil to reduce airborne transport). MDPH, upon request has offered technical assistance in reviewing any plans.

8) Comment: The commenter knows of two men who, years ago, applied pesticides in the orchard. These men may be willing to assist in locating areas where storage, mixing, cleaning, and disposal took place.

8) Response: This information may be useful to MA DEP or EPA if cleanup is required. MDPH will share this final public health assessment with these agencies. This information may also be useful if additional environmental sampling is undertaken for the site as recommended by MDPH. MDPH has offered upon request to provide technical assistance with regard to this.

9) Comment: It would be useful for ATSDR to compare the ATSDR decision criteria to MA DEP decision criteria for determination of a public health risk that is defined in 310 CMR 40.0000. Since the property in question is in Massachusetts, citizens throughout the state should be protected to the same risk level.

9) Response: In the public health assessment, environmental data were evaluated using ATSDR's screening values, which are health-based, peer-reviewed and based on peer-reviewed literature, and published by ATSDR and/or EPA. MA DEP's standards and guidelines (i.e., Massachusetts maximum contaminant levels) for public drinking water supplies were also used to evaluate the potential for non-cancer health effects due to opportunities for exposure to contaminants in drinking water. MA DEP's regulatory standards regarding hazardous waste (the Massachusetts Contingency Plan) apply throughout the state and must be abided by. This public health assessment will be shared with MA DEP so that the agency can evaluate this information in relation to their enforceable site regulatory standards.

10) Comment: Massachusetts's environmental regulations calculate site average values differently.

10) Response: MDPH follows ATSDR guidance in performing public health assessments. ATSDR is the federal health agency that sets national policy on these types of health based concerns. Environmental regulatory agencies (e.g., MA DEP, EPA) use some similar and some different methodologies. This does not necessarily indicate a conflict since different or additional objectives likely need to be taken into account based on the agencies' unique missions. Regulatory requirements must be complied with to avoid environmental enforcement actions.

11) Comment: How does ATSDR determine whether there has been inappropriate use or application of pesticide? Is there an evaluation process or have decision criteria been developed for this determination. Please describe. Numerous historical Massachusetts specific pesticide spray guides are available at the University of Massachusetts at Amherst. At least one spray guide cautioned users of lead arsenate pesticide on the known health risks associated with this pesticide.

11) Response: MDPH and ATSDR do not determine whether pesticide application has been illegal or misapplied according to label directions. In Massachusetts, that is determined by the Department of Agricultural Resources (MDAR). Our role is to evaluate, based on very specific site conditions, potential opportunities for exposure and possible health concerns. We examine available data and make a public health judgment on possible health concerns. It should be emphasized that all pesticides are toxic and can be registered by EPA and states only if the benefits are considered to outweigh the risks for specific uses. Legal requirements for use are put on the label, which is a legally enforceable document. If a pesticide is used inconsistent with label requirements this can be a violation that can lead to enforcement actions being taken by MDAR or EPA, which is the pesticide regulatory agency on the federal level. MDPH has played a leadership role in taking action to remove older, more toxic persistent pesticides from use.

12) Comment: Logic indicates that if remnants of the former Rice's orchard can be found in the local area, then these areas are likely similarly contaminated. Shipley Company is undergoing expansion of its facility located in former orchard located nearby the Glen Street area. What is the ultimate destination of this potentially contaminated soil? Are workers protected from exposure to this potentially contaminated soil?

12) Response: This public health assessment evaluates the Glen Street site and public health impacts related to the site. The public health assessment does not address other environmental issues/situations that do not affect conditions at the Glen Street site. Concerns about potentially contaminated soil from other sites are noted by MDPH in the text and those concerns should be directed to MA DEP. The Shipley Company has had spills listed in the MA DEP release registry, but they have reached a remedial action outcome (RAO), which means concerns have been addressed to meet MA DEP regulatory requirements. This final public health assessment will be shared with MA DEP.

13) Comment: Compaq Computer property at the corner of Forest, Ames, and Crane Meadow features an ancient remnant of apple trees as a landscaping feature. Another MetLife property (Commonwealth parcel zoned residential) at Forest Street and Ames is another visible remnant of the former orchard. Some residences located north of Route 20 in the vicinity of the

Homestead Village Hotel have remnant orchard adjacent to homes. Homes and a school were built on the east side of Marlborough on two former orchards (Curtis and Barnes) and the orchard remnants are still visible. One of these orchards is being developed for homes (Orchard 1,2,3, and 4 Estates).

13) Response: This public health assessment evaluates the Glen Street site and public health impacts related to the site. The public health assessment does not address other environmental issues/situations that do not affect conditions at the Glen Street site. Concerns about potentially contaminated soil from other sites are noted by MDPH and those concerns should be directed to MA DEP. This final public health assessment will be shared with MA DEP.

14) Comment: A chemical manufacturing business called Shipley Company, which is located on Forest Street in Marlborough near the Glen Street area, is undergoing expansion. What is the ultimate fate of this former orchard soil? Are workers protected from exposure to contaminants in soil during construction activities? EPA indicated that Shipley Company had documented releases of hazardous materials to the environment. What type of hazardous materials has been released and has it come to rest on the former orchard land? What are the synergistic effects of these releases of hazardous materials on the remnant pesticides and Marlborough's water supply?

14) Response: MA DEP's Standard Release report has record of a propylene glycol and methyl ether spill on the property the Shipley Company on 455 Forest Street and remedial work has been completed to a level of no significant risk. Further concerns about the Shipley Company should be directed to MA DEP.

15) Comment: The public health assessment should include a comparison of the public health assessment with the baseline human health risk assessment. The Risk Characterization provides information regarding possible adverse health risks associated with current and future use of the site and is also helpful in identifying possible remedial measures at the site. The public health assessment used maximum site concentrations to calculate exposures and that is over-estimated.

15) Response: Public health assessments and risk assessments both investigate the impact or potential impact of hazardous substances at a specific site on public health. However, the two types of assessment differ in their goals and focus. Quantitative risk assessments are geared largely toward arriving at numeric estimates of the risk posed to a population by the hazardous substances found on a site. These calculations use statistical and biological models based on dose-response data from animal toxicological studies and (if available) human epidemiological studies. Risk assessments estimate the public health risk posed by a site, and their conclusions can be used to establish allowable contamination levels, or to establish clean-up levels and select remedial measures to be taken at the site.

ATSDR public health assessments are also intended to determine the current or future public health implications of a specific site, but focus more than risk assessments do on the health concerns of the specific community. Public health assessments are based on environmental characterization information (including information on environmental contamination and pathways), community health concerns associated with the site, and community-specific health

outcome data. They make recommendations for actions needed to protect public health (which may include the development and issuing of health advisories), and they identify populations in need of further health actions or studies.

16) Comment: The public health assessment provides a brief description of the property and describes its history as being an orchard (public health assessment pages 1-2). The implication is that the entire property was a working orchard. However, a review of historical documents shows that a portion of the property functioned as pasture land. The site also had wetlands and undeveloped or unused areas. Although it is unclear from the public health assessment, the supporting data from the Phase I Environmental Site Assessments (attached with comments) indicate that the general presence of pesticides and arsenic correlates well with the former orchard areas. Thus, the commenter recommends that ATSDR provide clarification concerning this aspect of the report.

16) Response: The Preliminary Environmental Assessment Report (Hygienetics 1999a) stated that their initial research had found evidence that most of the property was used as an apple orchard until the 1950's. The Phase I Site Environmental Site Assessment reports (Hygienetics 2000a, 2000b) included with this comment, which were not reviewed for the public comment draft public health assessment, state that a portion of the property was used as an apple orchard until at least 1966. This is based on historical aerial photographs of the area. This change will be incorporated into the Site Description and History section of the public health assessment.

17) Comment: The public health assessment does not include a separate section that directly evaluates those health concerns expressed by the community. This evaluation should use environmental contamination data, exposure pathways analyses and health outcome data and should explain the toxicological implications of the community's concerns. The public health assessment should discuss if the health outcomes are biologically plausible and clearly explain why or why not. A brief general description of the disease outcomes of concern should also be included, which should address where in the human body the disease occurs, the prevalence of the disease, and the causes of the disease.

17) Response: On page 1, MDPH does include those community health concerns that we were aware of (e.g., illnesses, particularly cancers, in long-term residents). To address those concerns, the public health assessment evaluated available environmental data and exposure pathways to explain the public health implications of opportunities for exposure to the chemicals detected at the site. A separate health consult prepared by the MDPH's CEH CAP will evaluate cancer incidence data for Marlborough. This evaluation will include an assessment of the geographic distribution of cancer cases within the town in relation to the site.

Background

1) Comment: There is another physical hazard besides the one mentioned in the public health assessment (reference page 5, paragraph D). Across the street from 88 Glen St, there is an unguarded culvert 6-10 ft down that flows very fast during a heavy rain.

1) Response: The physical hazards section refers to on-site physical hazards. MDPH has mentioned this culvert in the physical hazards section and has confirmed its presence with a site visit (Appendix B, Photograph 4) and has included a recommendation as to who will address this concern.

2) Comment: Available recent Geographic Information system maps from MassGIS show that the visual signature of remnant orchard is of greater extent than what was defined in the public health assessment. Besides, remnant orchard area is also visible on the east side of Marlborough and is not addressed in the public health assessment. Marlborough had three former orchards called the Rice, Curtis, and Barnes.

2) Response: As discussed in responses to earlier comments on other sites, this public health assessment evaluates the Glen Street site and not other environmental issues or sites throughout Marlborough.

3) Comment: There are 184 residences and a 500-child grammar school abutting the 82-acre fallow orchard land and were in part built on former orchard land.

3) Response: Examining aerial photographs of the area taken in 2001 by the MassGIS, which is a program within the Massachusetts Executive Office of Environmental Affairs, MDPH staff counted approximately 23 residences located directly across from the site on Glen Street. These residences are located at the edge of a residential development composed of approximately 160 residences [note: there could be as many as 185 residences, as the photo's are not crystal clear]. There is also a school (i.e., West School) located adjacent to the residential development. The Discussion section of the document addresses child health concerns.

4) Comment: The site is not open grassland. The grassland comment was made because of the vast wetland area. This wetland area, when viewed at a certain time of year may appear to be overgrown grassland. The site viewed during full summer growth looks much different, more like a new forest. View the site again in full summer growth.

4) Response: The first site visit was conducted in March 2000 at the beginning of spring. Pictures from the site visit showed that the site consisted of grassland that was open near the road with trees in the back. A second site visit was conducted on May 23, 2005, at full growth. The site was very heavily vegetated, and appeared to consist mostly of wood areas with some low brush and grasslands (Appendix B, Photographs 2 and 3). If there are additional questions with regard to wetlands identification at the site, these would best be directed to the Marlborough Conservation Commission or the MA DEP wetland program.

5) Comment: The former orchard land has been reforesting for more than 40 years and still includes many remnant orchard trees. Some remnant orchard roads still exist. A limited section of deteriorated pavement (300 to 500 feet in, a former orchard road perhaps or former Old Route 20) exists in a small central northern portion of the site.

5) Response: Examining aerial photographs of the area taken in 2001 by MassGIS, MDPH staff viewed what appeared to be several roads or trails located on the site, including one in the

central northern portion of the site. This information has been added in the Site Description and History section of the public health assessment.

6) Comment: The site visit date, March 8, 2000, is before leaf on and vegetative growth. It was also during the week and children were in school and not able to trespass on the site until after school hours. Permanent vegetation covering the site is best for human health and the protection of Marlborough's water supply.

6) Response: MDPH agrees that in general, vegetative cover reduces opportunities for exposures to contaminants in surface soil. Even in March, the site was heavily vegetated with high trees and grass. In summer months, grass and trees will grow even faster and will further limit opportunities for exposure to surface soil. A recent site visit on May 23, 2005 has confirmed these seasonal changes. The site visit description can be found in the Site Visit section of this document and photographs from the site visit can be found in Appendix B.

7) Comment: The public health assessment does not clearly describe the overgrown nature and dense scrub/brush character of the property in the section concerning physical and other hazards (public health assessment page 5), nor does the public health assessment indicate the prevalence of poison ivy. It would be reasonable to expect these conditions to decrease the amount and intensity of past and current direct soil exposure.

7) Response: At the time of the public health assessment and as observed during site visits in March 2000 and May 2005, the site had wooded areas with low brush and grassland, and no pavement was visible. The vegetative condition of the site might have helped mitigate direct exposure to contaminated soil.

8) Comment: Only a partial fence exists. The site needs a perimeter fence to keep children out and because additional elevated concentrations of pesticides are still a possibility. Heavy vegetation does not stop children from contacting soil. However, heavy vegetation stops airborne migration of dust. Massachusetts's regulations would require a fence if the pesticide contamination at current concentrations originated from any other source than agriculture. The site should be completely fenced to prevent site access by young children. The maximum pesticide contaminant level and any existence or any farm dump/spill areas are still unknown. Two drainage head wall areas are along Glen Street and both require fencing/attention to prevent injury from falls and drowning in from flash flooding during periods of heavy precipitation. The site is now a hazard – build a fence around the property now – keep the children from the unknown and known hazards in the soil.

8) Response: Based on the available data, current opportunities for exposures to site soil would not indicate public health concerns. There are data gaps, and MDPH has recommended additional sampling. MDPH is not aware of a regulation requiring fencing of the property, and the need for fencing is not supported by available data. The need for fencing or any other remedial action should be reevaluated if new environmental data are generated. The commenter may wish to discuss interpretations of regulations regarding fencing requirements with MA DEP. The Physical Hazards section of this document and site the visit pictures (Appendix B) from a May 2005 site visit illustrate the physical hazard.

9) Comment: Census tract 3214 covers too much area. The Glen Street neighborhood has been geographically isolated since it's building in the early 1960s by Routes 495 and 20. Until very recently, the Glen Street neighborhood was the only former orchard land to be reused for residences. Its use is unique on the west side of Marlborough and health effects should be examined on the local neighborhood scale as well as the larger census tract. The full census tract alone is too large an area and will dilute the epidemiological analysis.

9) Response: MDPH acknowledges that census tract 3214 would cover more than the Glen Street neighborhood mentioned in the public health assessment. However, readily available cancer incidence data obtained from the MCR were only available by towns or cities, in this case the city of Marlborough. Therefore, for the purposes of this public health assessment, MDPH has reported community-wide information. A separate health consult prepared by the MDPH's CEH CAP is evaluating cancer incidence data for Marlborough. This evaluation will include an assessment of the geographic distribution of cancer cases including analysis of smaller geographic areas across the entire community, including in relation to the site.

10) Comment: 1990 to 1995 cancer rates exclude earlier and later deaths and illnesses. The latency time exhibited in most cancers would exclude inclusion in this data. An article on June 16, 2000 was about a local news story regarding the cancer death of an 8-year-old girl. My neighborhood and the city of Marlborough in general need a more detailed examination of population health from the present to the historic data. Something is sickening and killing children in Marlborough and must be understood and stopped.

10) Response: Cancer rates from 1990 to 1995 were evaluated in the public comment draft public health assessment released in 2000. The final public health assessment evaluates more recent cancer rates, from 1996 to 2000. These are discussed in the Health Outcome Data section in the final public health assessment. Cancer concerns in Marlborough will be addressed in a report produced by the MDPH CEH CAP. This cancer analysis will include all ages including children.

Environmental Contamination and Other Hazards

1) Comment: At the time of the public health assessment, groundwater data were unavailable (public comment draft public health assessment page 7). However, ATC Associates, Inc. prepared a report in January 2000 regarding groundwater quality for the owners of the adjacent 33 Boston Post Road (Gas Station) west parcel, which included data from two monitoring wells installed at the subject property on behalf of the then owners of the 33 Boston Post Road property. Data from these monitoring wells indicate that none of the detected analytes exceeded MCP Method 1 GW-3 standards. The public health assessment should be amended to include this information.

1) Response: MDPH has incorporated the groundwater information contained in the January 2000 ATC Associates' report "Monitoring Well Installation and Groundwater Quality Report, 33 Boston Pod Road West, Marlborough, Massachusetts, 01752" into the final public health assessment.

2) Comment: Additional soil, surface water and groundwater testing should be conducted to determine if other potential pesticides, metals such as lead, and pesticide by-products or contaminants (including dioxin) are present on the site.

2) Response: As mentioned in the Recommendation section of the public health assessment, MDPH agrees that additional site characterization for a broad range of pesticides and metals should be implemented to address the data gaps.

3) Comment: Children of many ages and others are on site regularly. Several dirt paths exist – some are former orchard roads.

3) Response: In the Site Description and History section, language has been added about the paths on the property. In the Evaluation of Possible Health Effects section of the public health assessment, MDPH has taken into account children playing at the property to evaluate possible health effects under current conditions, and MPDH has offered to provide better technical assistance upon request (e.g., site use conditions change).

4) Comment: The detected pesticide and metals data presented to MDPH and ATSDR were from a very cursory study conducted on behalf of MetLife. The laboratory QA/QC of the soil and water analysis leaves many questions unanswered. Some of the soil data were reissued with no explanation and with different laboratory detection limits. Better lab QA/QC practices should be used in all future analysis and use of sample blanks or spikes of known concentration should also be used to provide the outside control of lab QA/QC. The lab should have conducted two analytical runs to provide proper resolution.

4) Response: As mentioned in the "Quality Assurance/Quality Control" (QA/QC) section of the public health assessment, the QA/QC was performed appropriately for all the samples. Batch spike and batch blank samples were analyzed as part of the QA/QC to assure and control the accuracy and reliability of the data. The laboratory explained that in several surface soil samples, detection limits were higher than the health-based comparison values because it was necessary to dilute the samples in order to accurately quantify the concentrations of compounds that were detected. Detection limits for soil samples in which contaminants of concern were not detected were all below the respective health-based comparison values for those compounds.

5) Comment: Soil analytical data have some problems – lab detection limits were changed without comment when reports were reissued and lab detection limits were adjusted to not trigger Massachusetts' reporting requirements.

5) Response: The laboratory reports explained that detection limits were higher than health-based comparison values for some compounds in some soil samples because it was necessary to dilute the samples to accurately quantify the concentrations of compounds that were detected. MDPH has no information indicating that detection limits were changed between reports.

6) Comment: Massachusetts's environmental regulations normally require 3 to 5 soil samples per acre, yielding a requirement for approximately 240 to 400 samples to adequately characterize the

site and to look for any hot spots. However, very limited soil and water data set is available for the 82-acre site (this averages 1 sample for 3 plus acres, which is analogous to searching 1 out of 12 homes in our neighborhood to find something hidden). Besides, no complete soil profile was analyzed and no groundwater was taken anywhere on the site. At least 2 and perhaps 3 groundwater monitoring wells exist on the site in addition to several deep soil borings. EPA has recently proposed significantly reduced arsenic levels in drinking water supplies. Additional groundwater and surface water samples should be gathered temporally, across the site and from the abutting residential area to determine if there is seasonal flux of contaminants. The logic of sampling surface water is flawed. The proper protocol would be to sample sediment in streams and surface water over a period of time, which would show any seasonal effects. If ATSDR believes that arsenic was applied as lead arsenate, then the public health assessment is incomplete because lead concentrations that would result from the application of lead arsenate are not estimated. It is true that analytical data is the best in determining contaminant concentrations, but if there were such a data gap, it would be useful to estimate what concentrations of lead that accompanied the arsenic in the pesticide application. This assumes that lead would not be present from other source. The public can then fully understand the potential impact of this chemical pesticide on the environment. DDT, DDD, and DDE along with other pesticides were not adequately sampled on the site. Additional soil testing is required to determine health risk to the abutting residential area. The commenter believes the Glenbrook neighborhood and other areas of Marlborough meet Mindy Lubber's (EPA Region One Administrator) requirements and necessitate EPA involvement.

6) Response: MDPH reviewed all available environmental data for this public health assessment. We recommended that additional sampling, including sampling for pesticides and metals associated with these pesticides, be done for the site and we would be happy to provide technical assistance to others in developing a sampling and analysis protocol or review such protocols as developed by environmental consultants for the property owner. Such a sampling and analysis protocol should also be provided to MA DEP for their review and comment. As of any guideline on sampling, MDPH does not have any specific guideline regarding number of samples. Five groundwater samples that were collected from the site in 1991 and 1999 are discussed in the On-Site Contamination section of the public health assessment. Groundwater via private wells was determined to be an eliminated exposure pathway for residents in the neighborhood because groundwater beneath the neighborhood is up gradient from the site and opportunities for exposure to the chemicals in groundwater are unlikely to occur at this site because according to the Marlborough Board of Health, none of the residences in the neighborhood adjacent to the site have private wells that are used for drinking water purposes.

7) Comment: Since the non-carcinogenic health risks of lead have been well publicized and resulted in the removal of lead from gasoline, it would be very useful to estimate the non-carcinogenic health risk that could arise from the presence of lead.

7) Response: MDPH can only estimate possible health effects based on available sampling data. For this public health assessment, lead concentrations are not available. This is mentioned in the Conclusions section of the final public health assessment as a data gap. However, MDPH recommended that additional samples be collected and analyzed for lead and other metals.

MDPH also included information on the health effects of lead exposure in the Chemical Specific Toxicity Information section of this document.

8) Comment: It would be useful to include the dermal contact risk scenario in the health risk calculation or at least explain why this exposure route is not considered.

8) Response: MDPH did not evaluate health effects from dermal contact with contaminated soil because the vegetative conditions of the site likely mitigate dermal exposure. For metals, usually little absorption occurs through skin.

9) Comment: It would help in understanding the public health assessment if ATSDR would describe the decision criteria and how they are used for determining whether a potential exposure and resulting risk calculation presents a public health risk. This is not covered in the document. The use of exposure factor, the multiplier for the soil concentration should also be explained.

9) Response: This was explained in detail in the section "Evaluation of Possible Health Effects" of the public health assessment. The estimated exposure doses of arsenic, dieldrin, DDT, DDD, and DDE for children through ingestion of contaminated soil were lower than levels at which health concerns would be expected. Estimated opportunities for exposure can then be combined with EPA's oral slope factor to calculate a cancer risk from exposure to these compounds. The cumulative cancer risk from exposure to these pesticides can then be determined by adding the lifetime cancer risks calculated for each of the individual compounds. Based on the evaluation, unusual risks of cancer would not be expected based on opportunities for exposure to pesticides (i.e., arsenic, dieldrin, DDT and related compounds) at this site.

10) Comment: Since the property was proposed for residential development in the recent past and will most likely be targeted for residential development in the future, please evaluate the data for potential residential use.

10) Response: Available environmental data were evaluated in this public health assessment for trespassing children and adults under current site use. These data were screened against health-based screening values established by ATSDR. Although some soil levels of arsenic, dieldrin, DDT, DDD, and DDE are higher than their screening values, the estimated exposure doses of these compounds for residents are lower than levels at which health concerns would be expected, and therefore, do not pose an apparent current public health hazard. Based on information available to MDPH, the site is not likely to be developed for residential use, because according to the Marlborough Department of Public Works and the Marlborough Conservation Commission, the site is currently zoned for commercial, light industrial and industrial uses. Based on ATSDR criteria, the site could pose an "Indeterminate Public Health Hazard" in the future, depending on future use of the site. MDPH has offered to provide additional technical assistance upon request in the future when more specific plans for development are known.

11) Comment: The highest concentrations of pesticides discovered to date are in part of property most desired to be developed. The comments also contain isopleth maps of DDT, dieldrin, and arsenic concentrations (data used in the public health assessment was from MetLife's consultant).

11) Response: MDPH evaluated all environmental data available for the entire property. According to the memorandum from the commenter to Elaine Krueger of MDPH on September 1, 1999, the three preliminary isopleth maps created by the commenter were based on data provided by Hygienetics Environmental. These maps are approximate and do not represent the final delineation but are useful as a starting point for evaluation. Therefore, MDPH did not use information derived from these maps in the public health assessment, but would like to receive additional information with regard to environmental sampling.

12) Comment: Background levels for arsenic are low in Marlborough. The site would not yield soil samples of 3.8 mg/kg if background arsenic level were high. The arsenic found in the site soils was a by-product of pesticide application.

12) Response: MDPH is not aware of information on background arsenic levels in Marlborough. The minimum level of arsenic detected in the surface soil at the site was 3.8 mg/kg. Background soil concentrations of arsenic in the eastern United States can generally range from less than 0.1 mg/kg to 73 mg/kg and averages approximately 7.4 mg/kg (USGS 1984). MDPH has evaluated available environmental data for this site with regard to potential health concerns.

13) Comment: Dieldrin concentrations in two soil samples are above Massachusetts's environmental standards upper concentration limit – by definition this is a big problem.

13) Response: MA DEP's standard for residential soil for dieldrin is 0.03 mg/kg, and for commercial soil is 0.04 mg/kg. Although dieldrin concentrations in some samples are above these standards, the calculated estimated exposure doses from exposure to these levels based on ingestion are lower than ATSDR's MRL from exposure to dieldrin. If the use of the site was to change and exposure opportunities increase, MDPH has offered, upon request, to provide additional technical evaluations.

14) Comment: The compounds DDT, DDD, and DDE are also additive in their effects with other pesticides and must be included for consideration.

14) Response: In the public health assessment, MDPH had considered cumulative cancer risk from exposure to arsenic, dieldrin, DDT, DDD, and DDE by adding the lifetime cancer risks calculated for each of the individual compounds. Based on the evaluation, unusual risks of cancer would not be expected from opportunities for exposure to these pesticides at the site. However, MDPH has recommended additional site characterization due to data gaps.

15) Comment: EPA is also lowering acceptable levels of arsenic in drinking water.

15) Response: The Safe Drinking Water Act requires EPA to revise the arsenic standard for drinking water. Effective on February 22, 2002, EPA lowered the arsenic in drinking water standard to 10 μg/L. Information on test results for the public drinking water supply can be obtained from the Marlborough Department of Public Works. The 2004 results, the most recent results available, did not indicate contamination from arsenic (Marlborough Department of Public Works 2005).

16) Comment: Did soil erosion take place during construction of the Ames street area or Best Western Hotel area because both of these are former orchard areas? Can this erosion signature of pesticide contaminated soil be found in Marlborough's historical drinking water analytical results?

16) Response: MDPH did not receive or evaluate information concerning soil erosion at these two off-site locations. Two surface water samples were collected on site in August 1999, one upstream and one downstream of the site. Analysis of these samples indicated that no arsenic and pesticide levels were detected. Marlborough obtains water from two in-town water bodies (i.e., Lake Williams and Milham Reservoir) and the Massachusetts Water Resources Authority (MWRA). About 75-80 percent of the water usually comes from the MWRA and 20-25 percent of the water from Williams Lake and Milham Reservoir (Marlborough Department of Public Works 2002). The MA DEP requires public water suppliers to test the drinking water for various contaminants (e.g., inorganics, VOCs, SVOCs) on a MA DEP approved sampling schedule. It lists the types of samples that should be taken (raw or finished water), the location where they should be taken, and the analytes that must be tested. Information on test results for the public drinking water supply can be obtained from the Marlborough Department of Public Works. The 2004 results, the most recent results available, did not indicate contamination from VOCs or arsenic.

Pathways Analysis

1) Comment: Dust is a major pathway for contamination, especially dust laden with lead would have a deleterious effect on children. Any construction activity or future development is likely to release much fugitive dust and may recontaminate the neighborhood and would create a public health hazard based on dust and water contamination potential.

1) Response: In the Pathway Analysis section, ambient air is considered to be a potential pathway, in part because in the future, if development or excavation activities take place, it is possible that opportunities for exposure to contaminants in ambient air (e.g., fugitive dusts) might occur for residents living in adjacent neighborhoods and workers on the site. In the public health assessment, MDPH concluded the site posed an "Indeterminate Public Health Hazard" for the future conditions. MDPH has also recommended dust control practices if site soil is disturbed in association with development and additional environmental sampling to more precisely estimate future exposure and health concerns.

2) Comment: There are 2 drinking water wells adjacent to the property. Site groundwater replenishes the 12 to 13 wetland acres and 4 streams located on the property. Groundwater is a pathway, at least if there is future disturbance on site that may cause water exposure. Groundwater breakout to wetlands and roadways also allows for potential of dermal contact and ingestion. Due to the increasing expense for public water supplies, more businesses and residences use wells to water lawns. This groundwater use may still allow for dermal exposure and therefore ingestion exposure to groundwater, even if drinking water is not the purpose for these water wells. The commenter believes that the sprawling business development at Ames

and Forest Street uses this type of water supply because they watered their lawns during the 1999 drought in spite of mandatory watering ban.

2) Response: According to the Marlborough Board of Health, none of the residences in the neighborhood adjacent to the site have private wells that are used for drinking water purposes. MDPH is not aware of drinking water wells adjacent to the property. If residents with private wells used for drinking water exist, MDPH would be happy to provide technical assistance in terms of developing a sampling protocol for entities hired to test (e.g., private consultants) the private wells.

In order for there to be a completed exposure pathway of health concern, contaminants must be present in the media at sufficient quantities to warrant health concerns. The groundwater sampling results reviewed as part of this public health assessment does not indicate the presence of contaminants at levels of health concern. As mentioned before, some targeted compounds were detected in these samples but levels for the data that are available were all below their drinking water standards.

Discussion

1) Comment: Water may need seasonal testing and sediment testing is essential in the vernal pool areas.

1) Response: In the public health assessment, MDPH already recommended site characterization for a broad range of pesticides, and additional sampling to address data gaps. Testing based on ecological and not human health concerns are not discussed in this final public health assessment. Sediment would pose fewer exposure opportunities because it is less accessible than soil, also it should be noted no contaminants of concern were found in the brook water. Questions with regard to vernal pools might best be addressed by the local conservation commission.

2) Comment: Absence of lead data is a big gap. The current arsenic data suggests 600 to 1,000 mg/kg of lead by using chemical formula for lead arsenate.

2) Response: MDPH agrees that more sampling should be conducted at the site and that samples should be analyzed for additional pesticides and metals. We are not speculating on what concentrations of various compounds may exist on the site.

3) Comment: Most recent studies suggest no safe exposure level for children. DDT was banned in 1972. DDT is a probable carcinogen. What is the effect of all these chemicals on children's mental development and health?

3) Response: The studies the commenter refers to were not provided with the comments. Therefore, MDPH cannot evaluate their findings. In the public health assessment, it was mentioned that the estimated opportunities for exposure to DDT and its related compounds (i.e., DDD and DDE) for a child playing on the property is 0.0001 mg/kg/day based on ingestion of contaminated soil. This estimated value is lower than ATSDR's intermediate oral MRL for non-

cancer health effects from exposure to DDT, which is 0.0005 mg/kg/day. EPA has determined that DDT and its related compounds are "probable human carcinogens", based on sufficient animal studies and inadequate human data. Studies have shown that DDT causes cancer in animals. Chronic oral exposure to DDT produces liver neoplasms (i.e., tumors) and malignant lymphomas in mice and liver tumors in rats. Chronic gavage administration produces pulmonary adenomas (i.e., benign tumors on the lungs) in mice. However, these effects were taken into account in addressing health concerns in this public health assessment. Studies that examined an association between developmental effects in humans and levels of DDT, DDD, or DDE in humans did not provide conclusive evidence for such an association (ATSDR 2001). Research is ongoing for this endpoint.

4) Comment: ATSDR calculates exposure doses (intakes) for arsenic, dieldrin, and DDT associated with the subject site. The commenter urges that this report should discuss the significance of these possible exposure doses in the Glen Street neighborhood in comparison with average daily intakes of these chemicals in a person's normal diet. Such information is readily available in ATSDR's respective toxicological profile. In general, the comparisons apply to adult intakes of chemicals from soil and the diet. Comparisons for younger age groups, e.g., children, were not made due to the lack of dietary intake information from ATSDR. ATSDR's calculated arsenic exposure dose was 0.00024 mg/kg/day, determined by assuming incidental soil ingestion in adults under current conditions. The ATSDR toxicological profile for arsenic reports that arsenic ingestion from food (meat, fish, poultry, grain, cereal) is 46 μg/day or 0.046 mg/day. In a 70-kg adult, this represents an exposure dose of 0.00066 mg/kg/day (0.046 mg/day ÷ 70 kg). This means that people in the neighborhood could receive an exposure dose to arsenic through their normal diet that is roughly 3 times greater than that from site soil. ATSDR's calculated dieldrin exposure dose was 0.000004 mg/kg/day, determined by assuming incidental soil ingestion in adults under current conditions. The ATSDR toxicological profile for dieldrin reports that intake from the diet ranged from 0.000007 mg/kg/day in adults to 0.00008 mg/kg/day in adolescents. This means that people in the neighborhood could receive an exposure dose to dieldrin through their normal diet that is roughly 2 to 20 times greater than that from site soil (for adults and adolescents, respectively). ATSDR's calculated DDT, DDE, and DDD exposure dose were 0.000047 mg/kg/day, determined by assuming incidental soil ingestion in adults under current conditions. The ATSDR toxicological profile for DDT reports that intake from diet ranged from 0.000031 mg/kg/day in a 70-kg person (1981 data) to 0.000034 mg/kg/day in a 70-kg person (1980 data). This means that people in the neighborhood could receive an exposure dose to DDT, DDE, and DDD through their normal diet that is approximately the same as that from site soil.

4) Response: In the public comment draft public health assessment, the arsenic, dieldrin, and DDT exposure doses for a child exposed to the maximum level in the surface soil were calculated to be 0.00024 mg/kg/day, 0.000004 mg/kg/day, and 0.000047, respectively. In the final public health assessment, the arsenic, dieldrin, and DDT exposure doses have been revised by using the ingestion rate of 200 mg/day for a child, which follows updated ATSDR guidelines. The revised arsenic, dieldrin, and DDT exposure doses are 0.0005 mg/kg/day, 0.00005 mg/kg/day, and 0.0001 mg/kg/day, respectively. Although intakes from diet may still be similar or higher than estimated exposures from site soil to arsenic, as well as, DDT and dieldrin, the purpose of calculating estimated exposures, is to estimate additional exposure above background

(e.g., from diet) in order to reduce additional exposure opportunities. If exposure in a population is already too high, any additional exposure would serve to add to health concerns. It should also be noted that a number of important dietary sources of arsenic (e.g., fish) are largely from organic arsenic, which leaves the body quicker, and is less toxic than inorganic arsenic. Arsenic in soil would be expected to be inorganic arsenic based on the understanding of the types of pesticides used historically, and thus would be more toxic.

5) Comment: Arsenic is something that we are suspected to ingest in trace arsenic in our food. We do not need more.

5) Response: Comment noted. Because arsenic is a natural part of the environment, low levels of arsenic are present in soil, water, food, and air. ATSDR estimates that individuals likely ingest an average of about 50 micrograms (µg) of arsenic per day, with 3.5 µg consisting of inorganic arsenic. This can vary widely depending on drinking water sources and diet. Background soil concentrations of arsenic in the eastern United States generally range from less than 0.1 mg/kg to 73 mg/kg and average 7.4 mg/kg (USGS 1984).

6) Comment: ATSDR should discuss the implications of potential site intake of pesticides on existing body burdens. For example, according to ATSDR's toxicological profile documents, DDT and its metabolites have been found in human adipose tissue at concentrations ranging from 5-8 parts per million (ppm). Serum concentrations of DDT as reported in the Second National Health and Nutrition Examination Survey averaged 0.0033 ppm in a sampling of over 3,000 persons. DDD was detected in the serum of 99% of these individuals, with a median concentration of 0.0118 ppm. Levels of DDT and DDE in human breast milk were reported to range as high as 1.7 ppm. Simple assumptions about pesticide pharmacokinetics would allow ATSDR to demonstrate that potential intake of pesticides from site soil will not increase existing body burdens of these chemicals.

6) Response: The public comment draft public health assessment did not discuss the implications of potential site intake of pesticides on existing body burdens because, as mentioned in the "Conclusion" section of the public health assessment, under current site conditions, the concentrations of the compounds detected in soils of the Milham Brook Area site do not indicate public health concerns based on the environmental data available. Body burdens are lower to day than the first NHANES, which was not a random sample. DTT is still being used in other parts of the world. Primary sources of population exposure to DDT in the United States today are from food.

7) Comment: Dieldrin, which EPA classified as probable carcinogen, is above Massachusetts' environmental upper concentration limits on this site.

7) Response: EPA classified dieldrin as probable human carcinogen based on inadequate human and sufficient animal studies. Although the levels of dieldrin found in soil at this site exceed health-based screening values, the estimated potential exposure calculated for children at this site are below ATSDR's chronic oral minimal risk level for non-cancer health effects from exposure to dieldrin. In addition, estimated exposures are not expected to result in unusual cancer risks.

8) Comment: The public health assessment has proved to be very interesting reading. It appears that ATSDR evaluated a child trespasser scenario for the health effects of ingestion of arsenic. The commenter refers to Attachment #3 for the commenter's calculation of health risk at the site. From Attachment #3, using the mean and maximum arsenic concentrations detected in the surface soil, the commenter calculated the risks posed by ingestion and dermal contact to residents as 7.2×10^{-05} and 2.5×10^{-04}, respectively.

8) Response: From the Evaluation of Possible Health Effects section of the public health assessment, the estimated opportunities for exposure to arsenic for a child playing on the property are 0.0005 mg/kg/day based on ingestion of the maximum level of arsenic detected in surface soil assuming no vegetation cover. This is a screening approach utilized because representative data are not available site-wide. The amount of arsenic assumed to be ingested under these assumptions is slightly higher than the MRL for arsenic, which is 3.0×10^{-4}, but lower than the LOAEL, which is 6.5×10^{-4}, therefore, health effects would not be expected. Given the estimated opportunities for exposure to arsenic in soil, the cancer risk is 1×10^{-4}, derived by using EPA's oral cancer slope factor. It is not clear how the commenter derived the risk levels mentioned in the comment, but nevertheless they are lower than the MRL.

9) Comment: The public health assessment should also review assumed concentrations of chemicals in site media, assumed absorptive capacity (bioavailability) of site chemicals and assumed parameters that determine potential intake of chemicals from site media.

9) Response: MDPH has used the most conservative approach regarding public's health to review all the available environmental data, health outcome data and community health concerns for all public health assessments as initial screening step. Therefore, bioavailability and chemical intake are assumed to be 100%.

10) Comment: MDPH has used a 70-pound child in the calculation. How about one- and two-year-old children at ¼ of the weight?

10) Response: The public health assessment followed ATSDR's guidance for estimating exposure dose for ingestion. Based on the guidance, MDPH assumed the body weight for a child to be 35 kg or approximately 70 pounds. MDPH also assumed that the exposure took place over a 10-year period. At this particular site, a one- or two-year old is unlikely to receive the same exposure dose as an older child. However, assuming that a two-year old at 17.5 kg (i.e., one-half of 35 kg, or approximately 39 pounds) was on the property for 2 days a week for 26 weeks a year for two years, and was exposed continuously to the maximum concentration of arsenic found on the property, the estimated exposure would be 0.0004 mg/kg/day. This estimated value is slightly higher than ATSDR's chronic oral MRL for non-cancer health effects from exposure to arsenic, which is 0.0003 mg/kg/day, but lower than the LOAEL, which is 0.00065 mg/kg/day. It is appropriate to compare the estimated opportunities for exposure to the chronic oral MRL, though this is a conservative approach because the chronic oral MRL is based on an assumption of daily exposure. Since it is unlikely that a child would be continuously exposed to the maximum level of arsenic and the exposure dose is less than the LOAEL, adverse non-cancer health effects from exposure to arsenic in soil are not expected. The estimated opportunities for exposure can then be adjusted for a 70-year lifetime with EPA's oral slope factor to calculate a

cancer risk from exposure to arsenic. The estimated cancer risk would be 2.0×10^{-5}, thus unusual risks of cancer would not be expected.

Estimate Arsenic Exposure for Child

Non-Cancer Exposure Factor =	$\frac{\text{(2 days/week X 26 weeks/year X 2 years)}}{\text{(2 years) X (365 days/year)}}$ = 0.14
Non-Cancer Exposure Dose =	$\frac{\text{(max. contaminant concentration) X (ingestion rate) X (exposure factor) x } 10^{-6}}{\text{Body Weight}}$ $\frac{\text{(217 mg/kg) X (200 mg/d) X (0.14) X } 10^{-6}}{\text{17.5 kg}}$ $= 4.0 \times 10^{-4}$ mg/kg/day
Cancer Exposure Factor =	$\frac{\text{(2 days/week X 26 weeks/year X 2 years)}}{\text{(70 years) X (365 days/year)}}$ = 0.004
Cancer Exposure Dose=	$\frac{\text{(max. contaminant concentration) X (ingestion rate) X (exposure factor) x } 10^{-6}}{\text{Body Weight}}$ $\frac{\text{(217 mg/kg) X (200 mg/d) X (0.004) X } 10^{-6}}{\text{17.5 kg}}$ $= 1 \times 10^{-5}$ mg/kg/day
Cancer Risk =	Exposure Dose X Oral Slope Factor 1×10^{-5} mg/kg/day X 1.5 mg/kg/day^{-1} $= 2 \times 10^{-5}$

11) Comment: MDPH has neglected tracking of soil into homes. A daily repeating exposure could take place due to tracking soil onto floors and rugs. Also, if arsenic is present, then lead is present also. Lead affects children's mental development.

11) Response: Background soil concentrations of arsenic in the eastern United States generally range from less than 0.1 mg/kg to 73 mg/kg and average 7.4 mg/kg. Using arsenic concentrations from soil samples, MDPH estimated opportunities for exposure to arsenic for a child playing on the property based on ingestion of contaminated soil. Although the estimated value is higher than ATSDR's chronic oral MRL for non-cancer health effects from exposure to arsenic, this assumes maximum exposure to the highest concentrations detected on the site, which is an unlikely scenario. Therefore, adverse non-cancer health effects from exposure to arsenic in soil are not expected. MDPH also combined this estimated value with EPA's oral slope factor to calculate cancer risk from exposure to arsenic and concluded that unusual cancer risks would not be expected from opportunities for exposure to arsenic in soil. There might be some lead concentrations in soil because, like arsenic, lead typically occurs in soil. However, MDPH has no data on lead concentrations and will not speculate on what concentrations could be present indoors or what other potential sources of lead might be present in a child's environment. Massachusetts is a universal screening state for lead for children. This means that all children must be screened for lead. Information on lead poisoning prevalence for Marlborough as a whole and the Glen Street neighborhood in particular has been added to the

Health Outcome section of this document. It should be noted that no lead poisoning cases have been reported for the Glen Street neighborhood from 1990 through 2004.

12) Comment: The public health assessment assumes that chemicals in the environment are absorbed unimpeded into the human body. It should take into account physical and human physiological barriers to chemical absorption, different sizes of soil particles. In general, the assumptions made in the public health assessment likely over-estimate the extent of exposure to the chemicals.

12) Response: The assumptions made in the public health assessment are based on conservative scenarios, which tend to over-estimate the extent of exposure to the chemicals. However, by doing this, MDPH will not miss evaluating any possible health effects from exposure to the chemicals.

13) Comment: The commenter's cancer analysis using Massachusetts's required criteria indicated a high cancer risk.

13) Response: For the Glen Street Neighborhood public health assessment, MDPH combined EPA's oral slope factor with the estimated opportunities for exposure to calculate cancer risks from exposure to the contaminants. It is not clear how the commenter derived the risk levels mentioned in the comment.

14) Comment: The Child Health Section is not protective enough. If ATSDR Child Health Section is so protective of children's health, take some orchard soil home for your children's playground.

14) Response: For the public health assessment, MDPH and ATSDR acknowledged the unique vulnerabilities of infants and children, therefore, putting them at a greater risk than adults from certain kinds of exposure to hazardous substances emitted from waste sites. Two characteristics of children that magnify their exposures to toxic substances in the environment are: 1) play activities close to the ground, which increase their exposure to toxic substances in dust, airborne particulate matter, and soil; and 2) typical hand-to-mouth behavior, which increases intakes of any toxic substances. Children or teenagers may accidentally wander or deliberately trespass onto restricted areas. Therefore, MDPH had evaluated possible health effects from opportunities for exposure to compounds found in surface soil at the site for children, assuming the most conservative scenarios.

15) Comment: With respect to arsenic, EPA's qualitative carcinogenic assessment rests in part on "an association" between arsenic exposures in smelter workers and lung cancer mortality. However, the public health assessment does not state that the arsenic/lung cancer "association" has been demonstrated only in individuals with high-dose exposure to arsenic via inhalation in an occupational setting. These conditions are vastly different from the potential arsenic exposure conditions in and around the Glen Street Neighborhood, i.e., low-dose exposure via incidental ingestion. This fact should be recognized and described in the public health assessment.

15) Response: As supporting evidence of its classification of arsenic as a human carcinogen, EPA cites one study that found that people living near a pesticide manufacturing plant were at excess risk of lung cancer and case reports of arsenical pesticide applicators that found an association between arsenic exposure and lung cancer (EPA 1998). However, it should be noted that there are numerous studies and expert scientific reviews that confirm associations between arsenic ingestion and internal cancers (NRC 1999, NRC 2001). Regardless, the comment would not affect the public health assessment's conclusions that opportunities for exposure to compounds found in soil at the site would not result in cancer health effects. Therefore, MDPH has not modified the public health assessment with regard to this comment.

16) Comment: ATSDR should provide a discussion concerning the lack of connection between chemicals detected in the study area and cancer types reported for Marlborough as a whole by the MCR. According to the public health assessment, the MCR notes "significant elevated rates of leukemia and lung cancer". However, none of the chemicals of concern at the site (arsenic, dieldrin, DDT and its metabolites – DDD and DDE) cause these types of cancer.

16) Response: In the public health assessment, MDPH noted that cancers or tumors of concern that have been associated or possibly associated with arsenic, dieldrin, DDT and related compounds in either animal or human studies include cancers of kidney (arsenic), liver (arsenic, DDT, dieldrin), lung (arsenic), bladder (arsenic), thyroid (dieldrin), skin (arsenic), Hodgkin's disease (DDT), and non-Hodgkin's lymphoma (DDT). These cancer types are noted here because they are the most consistently cited in the literature. A review of cancer incidence data from the MCR for the years 1990 through 1995 was done for the public comment draft version of the public health assessment and for the years 1996 through 2000 was done for the final public health assessment. This evaluation can be found in the Health Outcome Data section of the document.

17) Comment: The EPA's Integrated Risk Information System (IRIS) reports that for dieldrin, DDT and its metabolites, assessment of carcinogenicity rests on reported liver tumors in various strains of mice, rats, and hamsters, while EPA characterizes the human carcinogenicity evidence as "inadequate". This stems from the fact that available studies have failed to show any association between human exposure to dieldrin and cancer. EPA describes three studies in which tissue levels of DDT and DDE were higher in cancer victims than in those dying of other diseases. In contrast to EPA, ATSDR notes (public health assessment page 2) that DDT has been or is possibly associated with Hodgkin's disease and non-Hodgkin's lymphoma (both are forms of leukemia). ATSDR should strike this language and reflect in the public health assessment the EPA's assessment concerning DDT.

17) Response: Upon reviewing the Toxicological Profile for DDT, MDPH found that there were a case-control study and a few prospective cancer mortality studies regarding DDT. These studies showed that the association between DDT exposure and non-Hodgkin's lymphoma was weak and causality could not be established because of exposure to multiple pesticides. Also, a prospective cancer mortality study showed no relationship between cancer mortality and increasing levels of serum DDT.

Conclusions

1) Comment: The waste/spill locations are not known. Several people who worked in the orchard are available for comment regarding pesticide application.

1) Response: For the comment regarding pesticide application, it might be relevant to MDPH for developing sampling protocols for additional sampling in the future. MDPH will also share this final public health assessment with the Marlborough Board of Health, MA DEP, and EPA.

2) Comment: The commenter concurs with ATSDR and MDPH that based on the available information, no health concerns have been identified regarding current conditions at the MetLife property. Through the use of appropriate construction and engineering control measures such as environmental testing, the commenter believes that the MetLife property may be safely and successfully developed in the future.

2) Response: As mentioned in the public health assessment, MDPH recommended additional site characterization for a broad range of pesticides and metals to address data gaps. For example, as the pesticide lead arsenate was historically used at the site and lead was not analyzed for in the surface water, groundwater, and soil samples collected to date, additional environmental sampling should be done to determine the lead concentrations.

3) Comment: If no fence is installed, the site should be declared an indeterminate public health hazard.

3) Response: Although there is no fence at the site, the site is currently vacant, unused and mostly covered with vegetation. Thus, opportunities for exposure to contaminants in soil at the site are present but limited. Therefore, the site is categorized as "No Apparent Public Health Hazard".

Recommendations

1) Comment: An epidemiological study is needed locally and city wide – something is sickening and killing children and the pathway must be broken and children protected.

1) Response: Comment noted. The Recommendations and Public Health Action Plan sections of this document include follow-up health outcome cancer incidence analysis on a smaller geographic area basis.

Public Health Action Plan

1) Comment: Seek the help of the neighborhood to locate as many past residents or health information regarding them.

1) Response: Comment noted. MDPH will be completing a follow-up cancer incidence analysis, which will be issued as a separate document. The MCR records residence at the time of cancer diagnosis for all individuals for all years for which data is available.

Tables

1) Comment: Table 1 [of the submitted comment document] shows the comparison of assumptions used in public health assessments and Risk Characterization. In the table, chemicals of potential concern selection are defined as all chemicals detected at the site plus any additional chemicals identified as a community health concern plus any chemicals identified in EPA's Toxic Release Inventory. Environmental concentrations used in the assessment are maximum site media concentrations. Assumed bioavailability of COCs is that chemicals in environmental media are 100% bioavailable (by all routes). Assumed percentage of particulate deposition in lungs is 100%, assumed soil ingestion rate is 50 mg/day (18-70 year-old adult), and assumed soil adherence is 2.0 mg/cm^2 (all age groups).

1) Response: MDPH used standard assumptions in the public health assessment as a conservative approach to public health.

2) Comment: Commenter believed that the site can be safely and successfully developed and would not pose an "Indeterminate Public Health Hazard" in the future, like mentioned in the public health assessment. They agreed that there is the need for additional site investigation to address data gaps for lead and other pesticides.

2) Response: comment noted.

3) Comment: The public health assessment should be expanded to describe in a clearer and balanced fashion the factors that may mitigate or exacerbate the likely health outcomes identified in the toxicity information section of the public health assessment. The public health assessment should also be expanded regarding factors that are suggested as important in the health outcome data section.

3) Response: comment noted.

Appendix B
Site Visit Photographs

1. Worn path at Glen Street.

2. Milham Brook and surrounding vegetation as viewed from Glen Street.

3. Heavy vegetation and no trespassing sign as viewed from Glen Street.

4. Unfenced 6 to 10 foot drop by culvert at Glen and Ripley Streets.

Appendix C
Explanation of a Standardized Incidence Ratio (SIR) and 95% Confidence Interval (CI)

In order to evaluate cancer incidence a statistic known as a standardized incidence ratio (SIR) was calculated for each cancer type. An SIR is an estimate of the occurrence of cancer in a population relative to what might be expected if the population had the same cancer experience as some larger comparison population designated as "normal" or average. Usually, the state as a whole is selected to be the comparison population. Using the state of Massachusetts as a comparison population provides a stable population base for the calculation of incidence rates. As a result of the instability of incidence rates based on small numbers of cases, SIRs were not calculated when fewer than five cases were observed.

Specifically, an SIR is the ratio of the observed number of cancer cases to the expected number of cases multiplied by 100. An SIR of 100 indicates that the number of cancer cases observed in the population evaluated is equal to the number of cancer cases expected in the comparison or "normal" population. An SIR greater than 100 indicates that more cancer cases occurred than expected and an SIR less than 100 indicates that fewer cancer cases occurred than expected. Accordingly, an SIR of 150 is interpreted as 50% more cases than the expected number; an SIR of 90 indicates 10% fewer cases than expected.

Caution should be exercised, however, when interpreting an SIR. The interpretation of an SIR depends on both the size and the stability of the SIR. Two SIRs can have the same size but not the same stability. For example, an SIR of 150 based on 4 expected cases and 6 observed cases indicates a 50% excess in cancer, but the excess is actually only two cases. Conversely, an SIR of 150 based on 400 expected cases and 600 observed cases represents the same 50% excess in cancer, but because the SIR is based upon a greater number of cases, the estimate is more stable. It is very unlikely that 200 excess cases of cancer would occur by chance alone.

To determine if the observed number of cases is significantly different from the expected number or if the difference may be due solely to chance, a 95% confidence interval (CI) was calculated for each SIR. A 95% CI assesses the magnitude and stability of an SIR. Specifically, a 95% CI is the range of estimated SIR values that has a 95% probability of including the true SIR for the population. If the 95% CI range does not include the value 100, then the study population is significantly different from the comparison or "normal" population. "Significantly different" means there is less than 5% percent chance that the observed difference is the result of random fluctuation in the number of observed cancer cases.

For example, if a confidence interval does not include 100 and the interval is above 100 (e.g., 105-130), then there is statistically significant excess in the number of cancer cases. Similarly, if the confidence interval does not include 100 and the interval is below 100 (e.g., 45-96), then the number of cancer cases is statistically significantly lower than expected. If the confidence interval range includes 100, then the true SIR may be 100, and it cannot be concluded

with sufficient confidence that the observed number of cases is not the result of chance and reflects a real cancer increase or decrease. Statistical significance is not assessed when fewer than five cases are observed.

In addition to the range of the estimates contained in the confidence interval, the width of the confidence interval also reflects the stability of the SIR estimate. For example, a narrow confidence interval (e.g., 103 to115) allows a fair level of certainty that the calculated SIR is close to the true SIR for the population. A wide interval (e.g., 85 to 450) leaves considerable doubt about the true SIR, which could be much lower than or much higher than the calculated SIR. This would indicate an unstable statistic.

Source: Massachusetts Department of Public Health, Bureau of Environmental Health Assessment (December 1998).

Appendix D

ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption
The process of taking in. For a person or animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with **chronic**].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with **intermediate duration exposure** and **chronic exposure**].

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with **antagonistic effect** and **synergistic effect**].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems.

Aerobic
Requiring oxygen [compare with **anaerobic**].

Ambient
Surrounding (for example, *ambient* air).

Anaerobic
Requiring the absence of oxygen [compare with **aerobic**].

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Antagonistic effect
A biologic response to exposure to multiple substances that is **less** than would be expected if the known effects of the individual substances were added together [compare with **additive effect** and **synergistic effect**].

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation
Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study
A study that uses (a) **biomedical testing** or (b) the measurement of a substance [an **analyte**], its **metabolite**, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see **exposure investigation**].

Biologic monitoring
Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing
Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP
See **Community Assistance Panel**.

Cancer
Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk of for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number
A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see **Comprehensive Environmental Response, Compensation, and Liability Act of 1980.**]

Chronic
Occurring over a long time (more than 1 year) [compare with **acute**].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with **acute exposure** and **intermediate duration exposure**].

Cluster investigation

A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)
A group of people, from a community and from health and environmental agencies, who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see **exposure pathway**].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as **Superfund**, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect
A disease or injury that happens as a result of exposures that might have occurred in the past.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see **route of exposure**].

Descriptive epidemiology

The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention
Measures used to prevent a disease or reduce its severity.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD
United States Department of Defense.

DOE
United States Department of Energy.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [**dose**] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, **biota** (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and **biota** (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur.

The **environmental media and transport mechanism** is the second part of an **exposure pathway**.

EPA
United States Environmental Protection Agency.

Epidemiologic surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute exposure**], of intermediate duration, or long-term [**chronic exposure**].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a **source of contamination** (such as an abandoned business); an **environmental media and transport mechanism** (such as movement through groundwater); a **point of exposure** (such as a private well); a **route of exposure** (eating, drinking, breathing, or touching), and a **receptor population** (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a **completed exposure pathway**.

Exposure registry
A system of ongoing followup of people who have had documented environmental exposures.

Feasibility study

A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with **surface water**].

Half-life ($t_{½}$)
The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with **public health assessment**].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to estimate the possible association between the occurrence and exposure to hazardous substances.

Health promotion
The process of enabling people to increase control over, and to improve, their health.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with **prevalence**].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see **route of exposure**].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with **acute exposure** and **chronic exposure**].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with **in vivo**].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with **in vitro**].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Medical monitoring
A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of **metabolism**.

mg/kg
Milligram per kilogram.

mg/cm^2
Milligram per square centimeter (of a surface).

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR 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 calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, condition, or injury) is stated.

Mutagen
A substance that causes **mutations** (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see **National Priorities List for Uncontrolled Hazardous Waste Sites]**

Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see **exposure pathway**].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)
A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with **incidence**].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public availability session
An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public health action
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with **health consultation**].

Public health hazard

A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or **radionuclides** that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are **no public health hazard, no apparent public health hazard**, **indeterminate public health hazard**, **public health hazard**, and **urgent public health hazard**.

Public health statement
The first chapter of an ATSDR **toxicological profile**. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting
A public forum with community members for communication about a site.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [See **Resource Conservation and Recovery Act (1976, 1984)**]

Receptor population
People who could come into contact with hazardous substances [see **exposure pathway**].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see **exposure registry** and **disease registry**].

Remedial Investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)

This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD
See **reference dose**.

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [**inhalation**], eating or drinking [**ingestion**], or contact with the skin [**dermal contact**].

Safety factor [see **uncertainty factor]**
SARA [see **Superfund Amendments and Reauthorization Act**]

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see **population**]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an **exposure pathway**.

Special populations

People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Substance-specific applied research
A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's **toxicological profiles**. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].

Surveillance [see **epidemiologic surveillance**]

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see **prevalence survey**].

Synergistic effect
A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see **additive effect** and **antagonistic effect**].

Teratogen

A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents which, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a **safety factor**].

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other glossaries and dictionaries:
Environmental Protection Agency
http://www.epa.gov/OCEPAterms/
National Center for Environmental Health (CDC)
http://www.cdc.gov/nceh/dls/report/glossary.htm
National Library of Medicine

http://www.nlm.nih.gov/medlineplus/dictionaries.html