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ENVIRONMENTAL HEALTH AND SAFETY
http://www.dartmouth.edu/~ehs/

July 20, 2016

RECEIVED
JUL 25 2016
TOWN OF HANOVER

Town of Hanover
PO Box 483
Hanover, NH 03755

Re: Informational Letter
Hydrogeologic Investigation
Dartmouth College, Rennie Farm Site
DES Site No. 201111109, DES Project No. 277737

Dear Town of Hanover:

As you may know, Dartmouth has been working on a comprehensive investigation and clean-up of the animal burial area on Rennie Farm. This letter is intended to provide direct communication of the College's commitment to this work and to inform you of current and future activities. We continue to work with our consultants, the New Hampshire Department of Environmental Services (DES), and the New Hampshire Radiological Health Section (RHS), in compliance with State regulatory requirements and process, to identify limits of contamination, and to capture and contain contaminated groundwater on the site. We anticipate that this will be achieved using a system of groundwater pumps in wells on the site, and an associated groundwater treatment system constructed by this fall/winter. We recently completed additional sampling and a geophysical investigation of the source area as part of this work. The operation of the anticipated groundwater pumping and treatment systems, and groundwater quality monitoring will be performed under a Groundwater Management Permit issued by DES.

A compound known as 1,4-dioxane is the only contaminant detected at concentrations exceeding the New Hampshire Ambient Groundwater Quality Standards at the site. 1,4-dioxane is manmade and has been primarily used as an additive in solvents. It has also been used in varnishes and paint strippers, and can be present in certain personal care products. The 1,4-dioxane detected in groundwater samples collected at the Rennie Farm property is anticipated to be related to laboratory testing materials buried along with test animals within a small portion of the Rennie Farm property. This historical burial site was in compliance with a State permit at the time. We have attached summary sheets developed by the United States Department of Health and Human Services and the DES that provide information regarding 1,4-dioxane.

A history of the Rennie Farm property relevant to the investigation and a figure illustrating the locations of features referenced in the history are attached. From the mid-1960s to 1978, a less than ½-acre portion of the Rennie Farm was used by Dartmouth as a State-licensed burial site for animal remains used in laboratory research. This burial area was excavated and remediated in 2011, and groundwater monitoring has been ongoing since that time under the review and approval of DES.

Detection of 1,4-dioxane in groundwater samples collected from a well installed near the northeastern downgradient (down slope) property boundary of the Rennie Farm during July 2015 prompted Dartmouth to proactively collect groundwater samples from residential water supply wells in the general vicinity of the Rennie Farm property. Water supply well sampling has included wells selected by our consultant, GZA GeoEnvironmental, Inc. (GZA), and approved by DES to evaluate the potential transport of 1,4-dioxane from the site, and wells where property owners have requested their wells be sampled. Currently, samples have been collected and analyzed from 24 water supply wells. 1,4-dioxane has been detected in groundwater samples collected from one water supply well located adjacent to the

Rennie Farm property and downslope from the former test animal burial area. 1,4-dioxane has not been detected in the samples collected from the 23 other water supply wells that have been sampled and analyzed.

A recent geophysical survey of the former laboratory animal burial area, performed to provide information needed for the design of a remedial system, indicated the potential for buried materials within three areas along the western side of the burial site. The three areas were excavated, revealing boulders and innocuous metal debris within two of the three areas. Bagged laboratory waste was encountered within the excavation in the third area. Testing of that waste and soils did not indicate chemical or radiological contamination. Preliminary groundwater sampling performed adjacent to the location of the recently excavated laboratory waste did not detect 1,4-dioxane. This waste likely was not discovered during the 2011 clean up of the site because of high groundwater levels. Our recent geophysical survey included the entire historic burial area and surrounding adjacent areas of the site that would have been accessible for the burial of laboratory waste, and did not identify any other anomalous areas.

The animal carcasses that had been buried at the site were used in tests involving radionuclides. Soil and groundwater testing for radionuclides before remedial operations established background radiation levels at the site. Additional soil samples were collected after the removal of the animal carcasses and remediation of the site during 2011 and did not detect radionuclides above the release limits set by the State. Groundwater samples were recently collected from wells located adjacent to and downslope from the former burial area for analysis of a suite of radionuclides. Analysis of the samples did not indicate the presence of radionuclides above background levels.

Due to the presence of human remains within an approximate 100-square-foot area adjacent to the former laboratory animal burial area, groundwater samples were also collected from monitoring wells for analysis for formaldehyde. Laboratory analysis of the samples did not detect formaldehyde within the groundwater samples.

Ongoing activities related to the site include: the removal of the buried laboratory waste encountered in the recent excavation; design and construction of a groundwater remediation system to remove 1,4-dioxane from groundwater and control transport of 1,4-dixoane in groundwater from the Rennie Farm property; and the installation and sampling of wells adjacent to the Rennie Farm property to monitor the extent of the 1,4-dioxane in groundwater. Information regarding this work will be made available once the work plan has been reviewed and approved by the State. It will also be posted on the One Stop State website (http://des.nh.gov/onestop/index.htm).

I trust that this letter and the attachments are informative. If you have any questions, please feel free to contact me at (603) 646 1762 or Maureen.O'Leary@dartmouth.edu, or James Wieck of GZA at (603) 232-8732 or james.wieck@gza.com.

Very truly yours,

Maureen O'Leary, PhD, MBA, CBSP
Director of Environmental Health & Safety
Dartmouth College

Attachments: USDHHS Fact Sheet, NHDES Environmental Fact Sheet, Rennie Farm Site History, Figure

cc: Ms. Twila M. Kenna, Ph.D. – NH Radiological Health Section, NH DHHS Division of Public Health Services
Mr. Paul Rydel, P.G. – NHDES Hazardous Waste Remediation Bureau

1,4-Dioxane - ToxFAQs™

CAS # 123-91-1

This fact sheet answers the most frequently asked health questions (FAQs) about 1,4-dioxane. For more information, call the CDC Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to 1,4-dioxane occurs from breathing contaminated air, ingestion of contaminated food and drinking water, and dermal contact with products such as cosmetics that may contain small amounts of 1,4-dioxane. Exposure to high levels of 1,4-dioxane in the air can result in nasal cavity, liver, and kidney damage. Ingestion or dermal contact with high levels of 1,4-dioxane can result in liver and kidney damage. 1,4-Dioxane has been found in at least 31 of 1,689 National Priorities List (NPL) sites identified by the Environmental Protection Agency (EPA).

What is 1,4-dioxane?

1,4-Dioxane is a clear liquid that easily dissolves in water. It is used primarily as a solvent in the manufacture of chemicals and as a laboratory reagent. 1,4-Dioxane is a trace contaminant of some chemicals used in cosmetics, detergents, and shampoos. However, manufacturers now reduce 1,4-dioxane from these chemicals to low levels before these chemicals are made into products used in the home.

What happens to 1,4-dioxane when it enters the environment?

- 1,4-Dioxane can be released into the air, water, and soil at places where it is produced or used as a solvent.
- In air, 1,4-dioxane rapidly breaks down into different compounds.
- In water, 1,4-dioxane is stable and does not break down.
- In soil, 1,4-dioxane does not stick to soil particles, so it can move from soil into groundwater.
- Fish and plants will not accumulate 1,4-dioxane in their tissues.

How might I be exposed to 1,4-dioxane?

- Breathing air, drinking water, or eating foods that contain 1,4-dioxane. During showering, bathing, or laundering, 1,4-dioxane in tap water may volatilize and you can be exposed to 1,4-dioxane vapors.
- Your skin may contact 1,4-dioxane when you use cosmetics, detergents, bubble baths, and shampoos containing 1,4-dioxane.

How can 1,4-dioxane affect my health?

Few studies are available that provide information about the effects of 1,4-dioxane in humans. Exposure to very high levels of 1,4-dioxane can result in liver and kidney damage and death. Eye and nose irritation was reported by people inhaling low levels of 1,4-dioxane vapors for short periods (minutes to hours).

Studies in animals have shown that breathing vapors of 1,4-dioxane affects mainly the nasal cavity, liver, and kidneys. Ingesting 1,4-dioxane or having skin contact with 1,4-dioxane also affects the liver and kidneys.

How likely is 1,4-dioxane to cause cancer?

The limited number of studies available does not show whether 1,4-dioxane causes cancer in humans. Laboratory rats that breathed vapors of 1,4-dioxane during most of their lives developed cancer inside the nose and abdominal cavity. Laboratory rats and mice that drank water containing 1,4-dioxane during most of their lives developed liver cancer; the rats also developed cancer inside the nose. Scientists are debating the degree to which the findings in rats and mice apply to exposure situations commonly encountered by people.

The (DHHS) U.S. Department of Health and Human Services considers 1,4-dioxane as reasonably anticipated to be a human carcinogen.

CAS # 123-91-1

How can 1,4-dioxane affect children?

There are no studies of children exposed to 1,4-dioxane. However, children might experience health problems similar to those in adults if they were exposed to high concentrations of 1,4-dioxane.

Scientists do not know whether exposure of pregnant women to 1,4-dioxane can harm the unborn child.

How can families reduce the risk of exposure to 1,4-dioxane?

1,4-Dioxane may be a contaminant in cosmetics, detergents, bath products, shampoos, and some pharmaceuticals. 1,4-Dioxane is not intentionally added, but may occur as an unintentional byproduct in some ingredients that may be listed on the product label, including: PEG, polyethylene, polyethylene glycol, polyethoxyethylene,-eth or -oxynol . Many products on the market today (foods, pharmaceuticals, cosmetic products, detergents, etc.) contain 1,4-dioxane in very small amounts. However, some cosmetics, detergents, and shampoos may contain 1,4-dioxane at levels higher than recommended by the FDA for other products. Families wishing to avoid cosmetics containing the ingredients listed above may do so by reviewing the ingredient statement that is required to appear on the outer container label of cosmetics offered for retail sale.

1,4-Dioxane has been detected in some drinking water supplies. Bottled water may be less likely to be contaminated with 1,4-dioxane, and consumers should contact the bottler with specific questions on potential contaminants.

Is there a medical test to determine whether I've been exposed to 1,4-dioxane?

1,4-Dioxane and its breakdown products can be measured in your blood and urine, and positive results indicate you have been exposed to 1,4-dioxane. These tests do not predict whether exposure to 1,4-dioxane will produce harmful health effects. The tests are not routinely available at your doctor's office because they require special equipment, but the doctor can collect the samples and send them to a special laboratory. The tests need to be conducted within days after the exposure because 1,4-dioxane and its breakdown products leave the body fairly rapidly.

Has the federal government made recommendations to protect human health?

EPA has determined that exposure to 1,4-dioxane in drinking water at concentrations of 4 milligrams per liter (4 mg/L) for one day or 0.4 mg/L for 10 days is not expected to cause any adverse effects in children.

The Occupational Safety and Health Administration (OSHA) has set a limit for of 100 parts 1,4-dioxane per 1 million parts of air (100 ppm) in the workplace.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2012. Toxicological Profile for 1,4-Dioxane. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?

For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Human Health Sciences, 1600 Clifton Road NE, Mailstop F-57, Atlanta, GA 30333.

Phone: 1-800-232-4636

ToxFAQs™ Internet address via WWW is http://www.atsdr.cdc.gov/toxfaqs/index.asp.

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

29 Hazen Drive, Concord, New Hampshire 03301 • (603) 271-3503 • www.des.nh.gov

ARD-EHP-30 2011

1,4-Dioxane: Health Information Summary

1,4-Dioxane is a clear liquid with a slight, ether-like odor. At one time, it was added to chlorinated solvents as a stabilizer, but that use has been discontinued. Current uses of 1,4-dioxane are as a solvent in paints, varnishes, adhesives, detergent and cleaning preparations, cosmetics and pesticides. It is also used during the production of flame retardant chemicals, pharmaceuticals and magnetic tape. 1,4-Dioxane can be found in antifreeze from the breakdown of common antifreeze compounds. 1,4-Dioxane may be produced as a contaminant during the manufacture of chemicals commonly added to many consumer products, including cosmetics, soaps, shampoo and bubble bath.

Low levels of 1,4-dioxane exist in ambient air, but it is degraded within a few days. 1,4-Dioxane is resistant to degradation in soil and binds only weakly to it. 1,4-Dioxane will readily migrate to groundwater where it is likely to persist. It is completely soluble in water. 1,4-Dioxane does not accumulate in plants or animals. Therefore, consuming home produced vegetables, fruit or meat is not likely to be a significant source of exposure.

1,4-Dioxane is an "emerging contaminant," meaning it has recently been recognized as a potential or actual threat to the environment and human health. Until fairly recently, it was not possible to detect it at the low concentrations usually present in the environment. Because of the improved ability to detect 1,4-dioxane at lower levels, environmental officials have increased sampling efforts to determine how widespread its presence is in soil and groundwater.

Health Effects

Exposure and Metabolism

In human and animal studies of how 1,4-dioxane is absorbed into the body, almost all of 1,4-dioxane that is ingested is absorbed. Approximately 80 percent of what is breathed in is absorbed and less than 1 percent of what comes in contact with the skin is absorbed. Both human and animal studies indicate that after exposure, 1,4-dioxane and its metabolites rapidly leave the body, with almost all of it eliminated within one day after exposure ceases.

Short-Term (Acute) Effects

There are few studies available that provide information about the health effects of 1,4-dioxane in humans. Accidental exposure to extremely high levels of 1,4-dioxane in the workplace has resulted in deaths due to liver and kidney damage. Studies on animals have shown that exposures

to 1,4-dioxane affects the liver and kidneys. It should be noted that levels of 1,4-dioxane that are normally found in the environment or in consumer products are generally much lower than levels used in laboratory studies of animals.

Long-Term (Chronic) Effects
Exposure to 1,4-dioxane in animals for the majority of their lifespan has caused toxic effects to the liver and kidney such as swelling, degenerative changes, cell death, and lesions. The lowest concentration in animals that caused any of these toxic effects would be equivalent to a human exposed to 1,4-dioxane in drinking water at a concentration of approximately 3 million parts per billion (ppb, which is equal to micrograms per liter of water or ug/l).

Carcinogenic (Cancer-Causing) Effects
There are limited studies of humans exposed to 1,4-dioxane in the workplace relative to its ability to cause cancer. Several kinds of animals exposed to 1,4-dioxane in drinking water had increases in liver cancer. The U.S. Environmental Protection Agency has classified 1,4-dioxane as likely to be carcinogenic to humans based on the evidence from animal studies.

Reproductive/Developmental Effects
No studies are known regarding reproductive or developmental effects in humans. In the only known study specifically conducted to assess the reproductive and developmental effects of 1,4-dioxane, pregnant rats given very large amounts of the compound had some offspring with reduced body weight and minor bone malformations.

Health Standards and Criteria

The New Hampshire Ambient Groundwater Quality Standard (AGQS) for 1,4-dioxane is 3.0 ug/l. At the AGQS, there is a one-in-one-million increase in the risk of cancer for each 10 years of exposure assuming 2 liters of water are consumed daily. No non-cancer health effects are expected at 1,4-dioxane drinking water concentrations below 200 ug/l.

The Occupational Safety and Health Administration has developed a permissible exposure limit or PEL for 1,4-dioxane in workplace air of 100 parts per million (ppm) averaged over eight hours.

The Food and Drug Administration allows up to 10 ppm of 1,4-dioxane in the food supply for specific purposes where exposure is likely to be minimal, such as in some components of dietary supplement tablets and for adhesives used in food packaging.

For more information, please contact the DES Environmental Health Program, 29 Hazen Drive, Concord, NH 03302-0095; (603) 271-4608, or go on-line at http://des.nh.gov/organization/divisions/air/pehb/ehs/ehp/index.htm .

Suggested Reading and References

Casarett and Doull's Toxicology: The Basic Science of Poisons, Sixth Edition. Klaassen, C.D., ed. McGraw-Hill Publishing Co. Inc., New York, 2001.

ToxFAQs for 1,4-Dioxane. Agency for Toxic Substances and Disease Registry (ATSDR). Atlanta, Ga. September, 2007. At: http://www.atsdr.cdc.gov/tfacts187.html.

Toxicological Profile for 1,4-Dioxane (Draft Update). Agency for Toxic Substances and Disease Registry (ATSDR). Atlanta, Ga. September, 2007. At: http://www.atsdr.cdc.gov/toxprofiles/tp187.html .

Toxicological information for 1,4-dioxane. Integrated Risk Information System (IRIS). USEPA, Office of Health and Environmental Assessment. Last revision : August, 2010. At: http://www.epa.gov/iris/subst/0326.htm .

Voluntary Children's Chemical Evaluation Program (VCCEP). Tiers 1, 2 and 3. Pilot Submission for 1,4-Dioxane. Sponsor: Ferro Corporation. Cleveland, Ohio. Author: The Sapphire Group Inc. March, 2007. At: http://www.epa.gov/oppt/vccep/pubs/chem16.htm .

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RENNIE FARM SITE HISTORY

Historic Site Use. Since 1965, Dartmouth has owned the approximately 223-acre Rennie Farm in Etna, NH. From the mid-1960s until 1978, a less than ½-acre area on the property was used by Dartmouth as a State licensed burial site for animal carcasses from medical and other research. Human remains used in teaching by Dartmouth Medical School were buried in a separate approximately 10-foot by 10-foot area adjacent to the animal carcass burial area.

Initial Site Cleanup. Plans for excavation and remediation of the site began in 2010. Site remediation was approved by the New Hampshire Department of Health and Human Services, Radiological Health Section (RHS) and began in late October 2011. In November 2011, unexpected hazardous chemical waste was encountered. Dartmouth notified the New Hampshire Department of Environmental Services (DES) and removed the contaminated materials.

Source removal and remediation continued through December 2011. Prior to undertaking the remediation and throughout the excavation, numerous soil and groundwater samples were collected and analyzed, consistent with State regulations and with State oversight, for purposes of site closure. After analyzing samples taken from the site, RHS deemed the site free of radiological contamination and safe for unrestricted use.

Groundwater. The focus of Dartmouth's work with DES has been related to groundwater contamination beneath the Rennie Farm in the area near the excavation. Prior to site excavation, four groundwater monitoring wells were installed and have been regularly sampled for radiological and chemical contaminants. In April 2012, for the first time, groundwater sample analysis at Rennie Farm detected 1,4-dioxane (a volatile organic compound [VOC] used in laboratories) at concentrations exceeding the New Hampshire groundwater standard. No other contaminants have been discovered in excess of NH Groundwater Standards.

Phased Investigation. Since the detection of 1,4-dioxane in groundwater, Dartmouth has continued to monitor groundwater quality and has conducted a phased investigation consistent with State environmental requirements. Results have indicated decreasing concentrations of 1,4-dioxane near the excavation area, but testing results also indicate that concentrations are not yet below the NH Groundwater Standard within a portion of the former animal carcass burial area and an area downslope of the burial area.

The movement of water and 1,4-dioxane below ground at the Rennie Farm site is complex. For complex sites like Rennie Farm, investigations to determine the area where contaminants are present are often completed in phases in accordance with State regulations. The results of each phase are used to design the next phase of work to ultimately determine the area impacted by the contaminant. Work by Dartmouth at the Rennie Farm site has included installation of a total of 33 groundwater monitoring wells in five phases, groundwater and surface water monitoring, geologic mapping, and geophysical surveys and data evaluation. This work is focused on monitoring 1,4-dioxane beyond the former animal carcass burial area and remediation of 1,4-dioxane within the burial area.

Five out of the total 33 groundwater monitoring wells were installed during 2014. Results from those samples indicated 1,4-dioxane was present in groundwater at the Rennie Farm site beyond the excavation area, but within Dartmouth property boundaries. The results of the sampling and analyses were presented to DES along with a work plan proposing the installation of eight additional sample points at Rennie Farm in locations within Dartmouth property boundaries further from the burial area in the direction of groundwater flow. DES approved the work plan and the proposed wells were drilled during June 2015.

Samples collected during the summer of 2015, from the eight monitoring wells installed during June 2015, showed one sample point with 1,4-dioxane at levels in excess of the NH Groundwater Standard. In order to ensure the safety of our neighbors, and in consultation with DES, we sought permission to sample private water supply wells of neighbors in the vicinity of the Rennie Farm premises. Nine private water supply wells in the vicinity of the site were selected for sampling in concert with DES to ensure protection of public health in light of observed groundwater sampling results and groundwater flows in this area. Access was obtained to 8 of the 9 wells, and the 8 wells sampled during the late summer and early fall of 2015.

1,4-dioxane has been detected within one of the private water supply wells selected for sampling. The detected concentrations of 1,4-dioxane in samples collected from the well range from approximately 6 micrograms per liter (μg/L) to 4 μg/L, and exceed the New Hampshire Ambient Groundwater Quality Standard (NH AGQS) of 3 μg/L. The private water supply well is located adjacent to the Rennie Farm property. Bottled water was immediately provided to the home serviced by the private water supply well, and a treatment system installed in the home to remove 1,4-dioxane from the water pumped from the well.

In addition to wells selected for sampling, a total of 16 private water supply wells have been sampled at the request of the individual property owners. 1,4-dioxane has not been detected in the samples collected from these wells.

A recent geophysical survey of the former laboratory animal burial area, performed to provide information needed for the design of a remedial system, indicated the potential for buried materials within three anomalous areas. The three areas were excavated, and bagged laboratory waste was encountered within one of the anomalous areas. The remaining laboratory waste will be excavated and removed from the site. The recent geophysical survey included the entire historic burial area and surrounding adjacent areas of the site that would have been accessible for the burial of laboratory waste, and did not identify any other anomalous areas. Preliminary groundwater sampling performed adjacent to the location of the recently excavated laboratory waste did not detect 1,4-dioxane.

The animal carcasses that had been buried at the site were used in tests involving radionuclides. Soil and groundwater testing for radionuclides before, during, and after the removal of the animal carcasses during 2011 did not detect radionuclides above background levels. Groundwater samples were recently collected from wells located adjacent to and downslope from the former burial area for analysis of a suite of radionuclides. Analysis of the samples did not indicate the presence of radionuclides above background levels.

Due to the presence of the human remains within 10-foot by 10-foot area adjacent to the former laboratory animal burial area, groundwater samples were also collected from monitoring wells for analysis for formaldehyde. Laboratory analysis of the samples did not detect formaldehyde within the groundwater samples.

Work is ongoing to remediate the former burial area to remove the source of the 1,4-dioxane and control transport of 1,4-dioxane from the Rennie Farm property. Additional groundwater monitoring wells are also being installed to monitor the extent and attenuation of the 1,4-dioxane beyond the Rennie Farm property.

Dartmouth will remediate the site and continue monitoring groundwater wells and selected drinking water supply wells under a Groundwater Management Permit to be issued by the DES. The groundwater management permit will outline the scope and interval of groundwater and drinking water testing. Permits are issued with 5-year terms but can be modified or extended based on testing data.

Please feel free to contact the Environmental Health & Safety (EHS) Office of Dartmouth College with any questions at 603-646-1762.