Health Consultation

Evaluation of Current and Future Soil Exposures at a Former
Explosive Manufacturing Facility: On-Site Restricted Use Area Part 1

DUPONT – LOUVIERS SITE

VILLAGE OF LOUVIERS, DOUGLAS COUNTY, COLORADO

EPA FACILITY ID: COD007060981

Prepared by the
Colorado Department of Public Health and Environment

MARCH 3, 2010

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Acronyms and Abbreviations

AOC	Area of Concern
ATSDR	Agency for Toxic Substances and Disease Registry
CCPEHA	Colorado Cooperative Program for Environmental Health Assessment
CDPHE	Colorado Department of Public Health and Environment
COPC	Contaminant of Potential Concern
CV	Comparison Value
DNT	Dinitrotoluene
ESA	Environmental Site Assessment
EPA	Environmental Protection Agency
IARC	International Agency for Research on Cancer
IEUBK	Integrated Exposure Uptake Biokinetic Model
LOAEL	Lowest Observable Adverse Effect Level
ND	Not Detected
NG	Nitroglycerin
NOAEL	No Observable Adverse Effect Level
PAH	Polycyclic aromatic hydrocarbons
PCE	Tetrachloroethylene (perchloroethylene)
PETN	Pentaerythritol Tetranitrate
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SWMU	Solid Waste Management Unit
SVOC	Semi-volatile organic compound
TPH	Total Petroleum Hydrocarbons
VOC	Volatile organic compounds

Summary and Statement of Issues

INTRODUCTION The Colorado Cooperative Program for Environmental Health Assessments and the Agency for Toxic Substances and Disease Registry's top priority is to ensure that all stakeholders have the best health information possible to protect the community from current and future health hazards associated with the DuPont-Louviers site in Douglas County, Colorado.

The DuPont-Louviers site is a former explosives manufacturing facility that operated during most of the 20th century. The site spans over 1,500 acres and the former explosives manufacturing facilities were located on 310 acres, which is surrounded by a security fence. The available information suggests that individuals are currently trespassing onto the site.

The Hazardous Waste and Waste Management Division of the Colorado Department of Public Health and Environment requested that CCPEHA conduct a health consultation to evaluate the potential public health hazards associated with site-related contamination that remains on the property. Due to the size and varying former land-uses, the evaluation was split into three health consultations focusing on specific areas of the site. This health consultation addresses 7 areas within the former explosives manufacturing area at the DuPont-Louviers site. One health consultation has already been completed on this site, which focused on unrestricted use areas outside of the former explosives manufacturing area on DuPont property.

The primary environmental medium of concern in this health consultation is soil because individuals can come into contact with contaminants found in surface and sub-surface soil at the site. Three primary groups of people have been identified that could come into contact with soil contaminants inside of the security fence at the DuPont-Louviers site: 1) current and future trespassers, 2) future construction workers, and 3) future industrial workers. However, the only exposure pathway that is occurring at this time is trespassers that come into contact with soil contamination. Future potential exposures to construction workers and industrial workers are also evaluated because the area inside of the security fence on the DuPont property could be developed into industrial/commercial properties in the future following ongoing corrective actions.

OVERVIEW

CCPEHA and ATSDR have reached seven important conclusions regarding exposure of current and future trespassers, future construction workers, and future industrial workers to soil contamination in the most contaminated areas inside of the security fence at the DuPont-Louviers site.

CONCLUSION 1

Accidentally eating soil in Solid Waste Management Unit (SWMU) 36 could harm trespassers, construction workers, and industrial workers. This is considered a public health hazard.

BASIS FOR DECISION

This conclusion was reached because elevated levels of arsenic and lead are found in soil at SWMU 36. The amount of arsenic potentially swallowed by trespassers, construction workers, and industrial workers through incidental ingestion of soil is associated with a high increased risk of developing cancer and non-cancer health effects. In addition, the concentration of lead in soil could also harm the developing fetus of future female workers and trespassers.

NEXT STEPS

Arsenic is a known human carcinogen. To be prudent of public health, exposure to arsenic in soil at SWMU 36 should be reduced to CDPHE's long-term cancer risk goal of one in a million or to background levels. In addition, exposure to lead in soil at SWMU 36 should also be reduced to protect the developing fetus of future female workers.

CONCLUSION 2

Accidentally eating soil in SWMUs 23A could harm industrial workers. This is considered a public health hazard.
Accidentally eating soil in SWMUs 23A is not expected to harm trespassers and construction workers.

BASIS FOR DECISION

This conclusion was reached because elevated levels of 2,4 Dinitrotoluene (2,4-DNT) and 2,6-DNT are found in soil at SWMU 23A. The amount of 2,4-DNT potentially swallowed by industrial workers through incidental ingestion of soil is associated with a high increased risk of developing cancer.

For trespassers and construction workers, the amount of 2,4-DNT potentially swallowed through incidental ingestion of soil in SWMU 23A, is associated with a low increased risk of developing cancer.

NEXT STEPS

DuPont should reduce exposure to 2,4-DNT contamination found in soil at SWMUs 23A.

CONCLUSION 3 **Accidentally eating soil in SWMU 23C could harm trespassers and industrial workers. This is considered a public health hazard. Accidentally eating soil in SWMUs 23C is not expected to harm construction workers.**

BASIS FOR DECISION This conclusion was reached because elevated levels of 2,4-DNT are found in soil at SWMU 23C. For industrial workers and trespassers, the amount of 2,4-DNT potentially swallowed through incidental soil ingestion is associated with a high increased risk of developing cancer. For construction workers, the amount of 2,4-DNT potentially ingested through incidental soil ingestion is associated with a low increased risk of developing cancer and non-cancer health effects.

NEXT STEPS DuPont should reduce exposure to 2,4-DNT contamination found in soil at SWMUs 23C.

CONCLUSION 4 **Accidentally eating soil in SWMU 7 could harm trespassers, construction workers, and industrial workers. This is considered a public health hazard.**

BASIS FOR DECISION This conclusion was reached because elevated levels of arsenic are found in soil at SMWU 7. The amount of arsenic potentially swallowed by trespassers, construction workers, and industrial workers through incidental ingestion of soil is associated with a high increased risk of developing cancer and/or non-cancer health effects.

NEXT STEPS DuPont should reduce exposure to arsenic contamination found in soil at SWMU 7.

CONCLUSION 5 **It cannot currently be determined if accidentally eating soil in SWMU 6 could harm people's health now or in the future.**

BASIS FOR DECISION This conclusion was reached because the currently available data suggests high levels of pentaerythritol tetranitrate (PETN) are present (up to 7,800 mg/kg). Non-cancer and cancer health guidelines for PETN have not been established by the Agency for Toxic Substances and Disease Registry or the Environmental

Protection Agency. Therefore, the health risk from exposure to PETN-contaminated soil in SWMU 6 cannot be evaluated.

NEXT STEPS To be prudent of public health, DuPont should reduce exposure to PETN in soil at SWMU 6 since the potential for adverse health effects cannot be determined at this time.

CONCLUSION 6 **Accidentally eating soil in the S&D Garage and Underground Storage Tank Area of Concern (UST AOC) is not expected to harm trespassers, industrial workers, and construction workers.**

BASIS FOR DECISION This conclusion was reached because the amount of arsenic potentially swallowed by trespassers, industrial workers, and construction workers through incidental soil ingestion, at levels found in soil at S&D Garage and UST AOC, is associated with a low increased risk for developing cancer and non-cancer health effects.

NEXT STEPS Arsenic is a known human carcinogen. To be prudent of public health, DuPont should reduce exposure to arsenic in the area so that the estimated cancer risks are at the background level for arsenic or at the CDPHE long-term cancer risk goal of one in a million.

CONCLUSION 7 **Accidentally eating soil in SWMU 15 is not expected to harm trespassers, industrial workers, and construction workers.**

BASIS FOR DECISION This conclusion was reached because the amount of arsenic potentially swallowed by trespassers, industrial workers, and construction workers through incidental soil ingestion, at levels found in soil at SWMU 15, is associated with a low increased risk for developing cancer and non-cancer health effects.

NEXT STEPS No further public health action is necessary in SWMU 15.

FOR MORE INFORMATION If you have concerns about your health, you should contact your health care provider. Please call Thomas Simmons at 303-692-2961 for more information on the DuPont-Louviers site health consultation.

Purpose

The overall purpose of this health consultation is to evaluate the potential health hazards from exposure to soil contamination by current and future trespassers, construction workers, and industrial workers in the most contaminated portions of the former manufacturing area (area inside of the security fence) at the DuPont-Louviers site. The remaining Solid Waste Management Units (SWMUs) located within the former manufacturing area will be addressed in a follow-up health consultation. An initial health consultation conducted on this site, focused on the SWMUs and Areas of Concerns (AOCs) outside of the former manufacturing area (i.e. outside of security fence).

Background

Background information on the site has been detailed in a variety of documents conducted for site assessment and remediation at the DuPont-Louviers site. The information presented below is a synopsis of the pertinent background material for this health consultation. For more detailed site background information, refer to the Environmental Site Assessment (DuPont 1991), the RCRA Facility Investigation Reports (DuPont 2002, DuPont 2004), and the Human Health Risk Assessment document performed by DuPont (DuPont 2008).

Site History

E. I. DuPont de Nemours and Company (DuPont) and Explosives Technologies International (ETI) operated a commercial chemical explosives manufacturing facility near the village of Louviers, Douglas County, Colorado from 1908 to November 1989. DuPont acquired the DuPont-Louviers site in 1906 and dynamite production began in 1908. Dynamite production continued until May 1971 with a total production of approximately 1 billion pounds of dynamite. Other explosives manufactured at the plant over the years include pentaerythritol tetranitrate (PETN) as well as emulsion- type blasting agents and oxidizers. Ingredients for making explosives including nitroglycerin, nitric acid, and sulfuric acid were also manufactured onsite using basic raw materials such as nitrate ore. In January 1988, the site was purchased by ETI who operated the plant until November 1989. At this point, all manufacturing activities ceased and the property reverted to DuPont ownership in January 1990.

Under voluntary cooperation with the Colorado Department of Public Health and Environment (CDPHE), DuPont developed a workplan (June 1990) to assess soil, surface water, and groundwater conditions at the site. Solid explosive wastes were produced at the site as a byproduct of the manufacturing process. These wastes were stored in a U.S. Bureau of Firearms and Tobacco approved storage magazine and were typically burned or destroyed to render them non-hazardous. Non-hazardous and non-burnable wastes (such as metals and building materials) were deposited in onsite landfills, which were typically located in natural ravines. Most of the original buildings in the former manufacturing area have been removed and/or burned to the ground. However, some foundations, building rubble, and pavement are still visible. The main office building, two warehouses, and an explosives storage magazine are the only buildings that have

been left in place. In 1998, DuPont entered into a Compliance Order on Consent No. 98-08-28-01 with the CDPHE. Since this time, investigation and remediation has been underway.

Site Description

The DuPont-Louviers site is located approximately 25 miles south of Denver, Colorado near the Village of Louviers on a 1,520-acre parcel (Figure 1). The site is located along both sides of Plum Creek and north, west, and south of the Village of Louviers. To the west, DynoNobel and Plum Valley Estates bound the site. To the north, a gravel pit exists and to the south is an open space area. The local topography consists of an overall hilly terrain with swales and creeks ranging from 5,570 feet to 5,800 feet above mean sea level. Water drains from the site towards Plum Creek to the northeast. Plum Creek is a tributary of the South Platte River.

The site currently consists of four main areas, which are depicted in Figure 2:

- Former explosives manufacturing area (355 acres),
- Conservation easement (349 acres),
- Areas outside the security fence that are not part of the conservation easement (310 acres), and
- Donated property for open space preservation (506 acres).

A four-foot cattle fence surrounds the perimeter of the DuPont-Louviers site. Inside the perimeter fence, the former manufacturing area is secured by a seven-foot security fence. A part-time security guard patrols the site to control access by trespassers.

Following preliminary investigations at the site, possible or known sources of contamination were broken into areas referred to as Solid Waste Management Units (SWMUs). In 1990, DuPont developed a work plan in conjunction with the CDPHE to address site closure and removal of site wastes located in SWMUs. Initially, 20 SWMUs were thought to exist at the DuPont-Louviers site. Following the Environmental Site Assessment Investigation conducted in 1991, additional SWMUs were added to the list of areas designated for assessment and remediation prior to closure. In addition, 3 Areas of Concern (AOC) have also been designated for assessment and remediation. Figure 1 shows the location of each SWMU and AOC at the DuPont-Louviers site.

SWMUs and an AOC located outside of the security fence on DuPont property were addressed in the initial Health Consultation performed for this site. This consultation focuses on SWMUs and AOCs located inside the security fence in the former explosives manufacturing area. A brief description of the SWMUs and AOCs examined in this evaluation is included below.

Demographics

Louviers, Colorado was initially established as a company town for the DuPont-Louviers site. According to the 2000 decennial census, the current population is 237 with nearly equal portions of males and females. The median age of the population is 43.8 years, which is slightly older than the national median of 35.3 years. Many former DuPont employees still reside in the Village of Louviers, however, in recent years it appears that new residents have also moved into the area. Information gathered from the Census Bureau indicates that no one in the Village of Louviers is non-English speaking.

Community Health Concerns

As part of the Compliance Order on Consent for the DuPont-Louviers site, DuPont was required to submit a plan for communicating with the community and creating a mechanism for the community to express their opinions and concerns regarding site activities. The original "Public Involvement Plan" was published in 1999 and was updated in 2004 following a large turnover in the population of Louviers. A total of 51 stakeholder interviews were conducted by representatives from the state health department and DuPont between 1999-2004. From these interviews, no major community concerns were noted. No one expressed any specific health concerns. Since no one expressed health concerns, the community is provided opportunity to express any new concerns through annual community meeting. This opportunity will be continually provided in the future. Some people expressed concern about potential impacts to groundwater and their drinking water from site-related contamination. This concern has been addressed. Many people were concerned with the source of water that would be used for remedial activities because of the shortage of water in Douglas County already. This concern is associated with ongoing limited groundwater resources and is not site related. One person expressed concerns regarding site remediation activities affecting air quality. This concern will be addressed in the future at the time of remediation.

Discussion

The overall goal of the public health consultation process is to determine if site-related contamination poses a public health hazard and to make recommendations to protect public health if need be. The first steps include an examination of the currently available environmental data and how individuals could be exposed to contaminants of potential concern (COPCs). If exposure pathways to COPCs exist, exposure doses are estimated and compared to health-based guidelines established by the ATSDR and EPA. This is followed by an in-depth evaluation if the estimated exposure doses exceed health-based guidelines.

Environmental Data

Soil, groundwater, and surface water data have been collected from the DuPont-Louviers site during the RCRA facility closure process. Soil is the primary environmental medium evaluated in this health consultation because either no contamination has been found

(surface water) or no exposure pathway exists (groundwater). Soil borings were completed using a hand auger or Geoprobe® and samples were collected from surface and sub-surface depths at most SWMUs and AOCs at the DuPont-Louviers site. Soil samples were sent to Severn Trent Laboratory in Denver, CO for analysis of various constituents depending upon the location, former use, and the likely contaminants that could be present in that particular SWMU and/or AOC. Soil sampling activities specific to the SWMUs and AOC examined in this evaluation are discussed in greater detail below.

Solid Waste Management Unit 6

SWMU 6 consists of two intersecting ditches that were used to convey contact process water and non-contact cooling water from the plant dynamite manufacturing area to the recycle ponds (SWMU 15). The ditches, located in the northern section of the former manufacturing area, are approximately 1,400 feet (ft.) long, 6 ft. wide and 3ft. deep. Contact process water was discharged to the ditches from 1908-1973 and likely contained some nitroglycerin (NG), pentaerythritol tetranitrate (PETN), acetone, and nitric and sulfuric acids. All releases of NG were well documented by DuPont and most occurred as dissolved and/or entrained NG in wastewater. Only non-contact cooling water was discharged between 1973 and the plant's closure in 1989. Due to the possibility of residual explosive waste remaining in the ditches, the ditches were "shot" in the summer and fall of 1990 prior to environmental sampling activity. Shooting is a method of detonating residual explosive waste by setting a sympathetic trigger charge.

Soil samples were initially collected from SWMU 6 in 1993. These samples, which are not used in this evaluation, were analyzed for PETN, NG, nitrates/nitrites, metals, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs). No analytes were detected above the screening value and subsequent sampling focused only on NG, PETN, and nitrates/nitrites. As part of the Phase I RCRA Facility Investigation (2002-2003), 11 borings were completed in and around SWMU 6 in areas that would likely have been impacted from previous plant discharges (i.e. in areas of obvious sediment deposition and/or pooling). Soil samples were collected from the surface (0-2 feet below ground surface) and subsurface (6-8 ft. bgs.) portions of the borings and submitted for analysis of NG, PETN, and nitrate/nitrites (Figure 3).

Nitrates/nitrites and PETN were detected in both the surface and subsurface samples with higher concentrations found in the surface soil samples. As shown in Table 1, the concentration of PETN ranged from ND-7,800 milligrams per kilogram (mg/kg) in surface samples and ND-240 mg/kg in the subsurface samples with respective mean concentrations of 1,061 mg/kg and 133.6 mg/kg. Nitrates/nitrites ranged from ND-33 mg/kg (mean = 12.4 mg/kg) in surface samples and ND-17 mg/kg (mean = 6.11 mg/kg) in subsurface samples. The concentration of nitrates/nitrites does not exceed the residential comparison values used in this evaluation and was not considered further. No comparison values from ATSDR or EPA exist for PETN. Therefore, PETN is carried forward as a COPC.

Solid Waste Management Unit 7

SWMU 7, or Landfill #1, is an erosional feature located near the main gate through the security fence to the plant. The landfill was reportedly used between 1970 and 1975 for disposal of non-hazardous construction wastes. SWMU 7 is approximately 200 ft. long * 30 ft. wide * 20 ft. deep. Eight test pits were dug during the Phase I ESA conducted in 1990. The test pits revealed various debris including concrete, scrap steel, wood, bricks, glass, and green fiberglass. A PETN crystallizing vessel was also encountered. Interviews with former employees indicate that drums of Teflon, asbestos, powder line parts, paints, and powderhouse debris have been disposed of in SWMU 7 (ESA 1991). Sampling conducted during the Phase 1 RFI indicate that SWMU 7 may also have been used to dispose of pyrite ash from manufacturing sulfuric acid in the 1920's and 30's. The PETN crystallizing vessel has been removed and safely disposed of.

During the Phase I RFI, conducted in 2002-2003, 45 soil borings were completed in and around SWMU 7 to delineate any potential contamination associated with the landfill (Figure 4). Soil samples were gathered from the surface (0-2 ft.) and subsurface (6-8 ft., 12-14 ft., and 18-20 ft.) portions of the core. The borings were completed in a stepwise fashion until the lateral and vertical extent of contamination had been delineated.

The initial soil samples that were collected were analyzed for metals, nitrates, asbestos, VOCs, SVOCs, PETN, and NG. A summary of detected compounds in SWMU 7 soil sampling can be found in Table 1. Tetrachloroethylene and 1,2-dichloroethane were the only organic compounds that were detected at maximum concentrations of 0.006 ppm and 0.0091 ppm, respectively. Arsenic, barium, chromium, lead, mercury, nitrate/nitrite, and silver were also detected. However, arsenic and lead were the only major contaminants that were detected. In surface soil samples, the concentration of arsenic ranged from not detected to 2,500 mg/kg in over 40 samples collected and submitted for analysis (97.6% Detection Frequency). In subsurface soil (up to 14 ft. bgs.), the concentration of arsenic ranged from ND to 310 in 45 samples collected and submitted for analysis (97.8% Detection Frequency). The concentration of lead also exceeded the residential comparison value of 400 mg/kg in one surficial soil sample. The concentration of lead in all the remaining soil samples was below the CV.

Solid Waste Management Unit 15

The plant's former recycle ponds have been designated as SWMU 15. SWMU 15 consists of 3 ponds that were constructed to retain plant discharges to the NG ditches (SWMU 6). The first 2 ponds were created in 1972 by damming the NG Ditches stemming from the manufacturing area. The third pond, located to the south (upgradient) of the other two ponds, was constructed in 1977 to replace the original ponds. The ponds roughly measure 700ft. * 700ft., 125ft. * 210 ft., and 215ft. * 85ft. All of the ponds are currently dry and vegetated. Due to the possible presence of residual explosive material, the ponds were "shot" in a similar manner to SWMU 6 prior to environmental sampling activities.

During the Phase I RFI, 17 soil borings were completed to define the extent of contamination associated with SWMU 15. The borings were drilled in and around each of the ponds as shown in Figure 5. Surface (0-2 ft.) and subsurface (6-8 ft.) samples were collected from each sampling location for a total of 34 samples. The samples were sent for analysis of nitrates/nitrites, metals, PETN, NG, VOCs, and SVOCs. Arsenic, barium, chromium, lead, mercury, and nitrates were all detected in surface and subsurface samples at relatively low concentrations as shown in Table 1. Acetone was detected one time in surface soil at 0.10 ppm. Methylene chloride was detected twice in surface soil and 4 times in subsurface samples at relatively low concentrations (max. = 0.02 ppm). PETN was also detected in surface (3x) and subsurface (1x) at a maximum detected concentration of 82 ppm.

Solid Waste Management Unit 23 (23A and 23C)

SWMU 23 consists of areas that were used to offload DNT drums from railcars, store, and prepare them for later use on the powder line. SWMU 23 has been divided into 4 areas (A, B, C, D) that were used for similar purposes, but are not adjacently located. Portions of SWMU 23 are bare of vegetation and soil stains were visible during site work (DuPont 2002). SWMUs 23B and 23D have received No Further Action designation by the CDPHE's Hazardous Materials and Waste Management Division. Therefore, this evaluation focuses only on SWMUs 23A and 23C.

SWMU 23A is located near the box factory and measures approximately 32ft. by 61 ft. However, the actual area thought to be impacted is around 20ft. by 30ft. (DuPont 2002). Previous investigations conducted at SWMU 23A indicated that 2,4-DNT and 2,6-DNT were present in surface (0-2ft. bgs.) and subsurface (2-6 ft. bgs.) soil. In 2001, five soil borings were completed in and around SWMU 23A as part of the Phase I RFI (Figure 6). Soil samples were collected from each boring and were analyzed for VOCs, SVOCs, and PAHs. Acetone, benzo(b)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, ethylbenzene, fluoranthene, nitrobenzene, pyrene, tluene, and xylenes were all detected at relatively low concentrations. In addition, 2,4-DNT and 2,6-DNT were detected in one location at 1,200 ppm and 760 ppm, respectively.

SWMU 23C is the old tally house area, which is located near the center of the former manufacturing area. SWMU 23C measures approximately 30ft. by 35ft. Eleven soil borings were completed during the Phase I RFI between September 2001 and May 2002. Soil samples were collected from 0-2ft. bgs. and were analyzed for VOCs, SVOCs, and PAHs (Figure 7). Acetone, 2,4-DNT, and bis(2-ethylhexyl)phthalate were the only compounds detected in SWMU 23C. Acetone and bis(2-ethylhexyl)phthalate were detected at levels below the screening value. 2,4-DNT was detected in one surface soil sample at a concentration of 2,900 mg/kg, and in one subsurface soil sample at 5.7 mg/kg.

Solid Waste Management Unit 36

SWMU 36 is a bare area with little to no vegetation that was discovered while conducting the investigation of SWMU 7. SWMU 36 is located just north of SMU 7 in the east-

central portion of the site. The history and types of activities that took place in this area are unknown, but it appears to have been used as some type of dumping ground.

In 2006, during the Phase II RFI addendum, 17 soil borings were completed in and around SWMU 36 (Figure 8). Samples were collected from 0-2ft., 4-6ft., 8-10ft., 12-14ft., and 16-18ft. Since past activities at SWMU 36 are unknown, the samples collected from these borings were analyzed for SVOCs and explosives (nitroaromatics & nitroamines) in addition to arsenic, lead, and mercury. Pentachlorophenol was the only organic compound detected during this sampling event at a maximum concentration of 0.31 mg/kg, well below the comparison value of 3.0 mg/kg. The concentration of arsenic, lead, and mercury exceeded the CV. Arsenic was detected at all depths at a concentration range of ND-3,500 mg/kg over 46 samples. The highest detection of arsenic occurred in a surface soil sample (0-2 ft. bgs) and the concentration of arsenic appears to decrease with depth as shown in Table 1. Lead was detected in 100% of the soil samples collected from SWMU 36 with a concentration range of 1.5-130,000 mg/kg. The highest concentration of lead found in SWMU occurred in surface soil (0-4 in. bgs.). Once again the overall concentration trend of lead decreases with depth.

S&D Garage and Underground Storage Tank AOC

The S&D Garage AOC is located near the main gate to the former manufacturing area. Underground storage tanks (USTs) containing diesel and gasoline were used in this AOC between the 1930's through the early 1970's. DuPont removed the USTs in the early 1990's.

In 2004, one soil boring was completed during the initial investigation into contamination at the S&D Garage and UST AOC. Soil samples were collected below the UST excavation depth at 6-8 ft. bgs. and 10-12 ft. bgs (Table 1). The samples were analyzed for total petroleum hydrocarbons (diesel and gas range), VOCs, and arsenic. Arsenic was sampled due to the close proximity of the S&D Garage AOC to the former pyrite burner. At this time, diesel and gas range total petroleum hydrocarbons (TPH) were detected in both samples with higher concentrations found in the 10-12 ft. bgs. sample. Methyl ethyl ketone and tetrachloroethene were the only VOCs that were detected in this sampling event at respective concentrations of 9.5 mg/kg and 77 mg/kg. Arsenic was detected in both samples at a maximum concentration of 28 mg/kg in the 6-8 ft. bgs.

During the Phase II RFI, 4 soil borings were completed in the S&D Garage and UST AOC in November 2005 (Figure 9). The borings were drilled to a maximum depth of 20 ft. bgs. and five samples were collected from each boring at depths of 2-4, 6-8, 10-12, 14-16, and 18-20 ft. bgs. The samples were analyzed for arsenic, naphthalene, and tetrachloroethene. Arsenic was detected in all 20 soil samples and PCE was detected in 19 of the 20 soil samples. However, the analytical results for PCE were less than 0.8 mg/kg.

Contaminants of Potential Concern Selection

To identify contaminants of potential concern, the available environmental data was screened with comparison values established by the ATSDR and EPA. The comparison values (CVs) used in this evaluation are derived for residential exposure scenarios (i.e. residential exposure to surface soil). The comparison values used in this evaluation are based on 350 days exposure per year over a period of 30 years with built-in orders of protection beyond what is considered safe levels of exposure. The use of these CVs is considered conservative and protective of the individuals under consideration in this evaluation. Therefore, if the maximum concentration of a particular contaminant is below the CV, it is dropped from further evaluation. If the maximum concentration of the contaminant is above the CV, it is generally retained for further analysis as a COPC. However, exceeding the CV does not indicate that a health hazard exists; only that additional evaluation is warranted.

Overall, the number of COPCs is relatively small in comparison to the number of analytes sampled in the soil samples collected from inside the security fence. Of the six SWMUs and one AOC under consideration in this evaluation, arsenic, 2,4-DNT, 2,6-DNT, and lead were the only major contaminants. PETN is also retained as a COPC because no CV is available for this chemical. This information is summarized below in Table 2.

Table 2. COPC Selection Summary

Area	Contaminant	Maximum Concentration (mg/kg)	Comparison Value (mg/kg)	CV Source
SWMU 6	PETN	7,800	N/a	N/a
SWMU 7	Arsenic	2,500	0.39	EPA RSL-cancer
	Lead	650	400	EPA OSWER-non-cancer
SWMU 15	Arsenic	12	0.39	EPA RSL-cancer
SWMU 23A	2,4-DNT	1,200	1.6	EPA RSL-cancer
	2,6-DNT	760	61	EPA RSL non-cancer
SWMU 23C	2,4-DNT	2,900	1.6	EPA RSL-cancer
SWMU 36	Arsenic	3,500	0.39	EPA RSL-cancer
	Lead	130,000	400	EPA OSWER-non-cancer
S&D Garage and UST AOC	Arsenic	1,200	0.39	EPA RSL-cancer

Terms:
CV = Comparison Value
EPA RSL = Environmental Protection Agency's Regional Screening Levels
EPA OSWER: Environmental Protection Agency's Office of Solid Waste and Emergency Response

Exposure Evaluation

The exposure evaluation examines current and future land-use at the site to develop a conceptual site model that describes how people could come into contact with site-related wastes. Simply having contamination in the environment does not indicate there is a public health hazard. Therefore, it is necessary to determine if and how individuals can be exposed to the contamination. As mentioned previously, this health consultation focuses on portions of the former explosives manufacturing area at the DuPont-Louviers site.

Current and Future Land-Use

Currently, there is a very limited amount of activity and personnel at the DuPont-Louviers site. Explosives manufacturing ceased in 1989. Since this time, DuPont has been dismantling structures and implementing the RCRA facility closure process in conjunction with the state health department (CDPHE). An onsite laboratory connected to the main office building is one of the few remaining structures at the DuPont-Louviers site. Environmental investigation and remediation are the primary activities that are currently occurring. The individuals conducting the environmental investigation and remediation are trained professionals that are not considered in this evaluation because there is an inherent risk to these workers and health and safety plans are in place to protect them (including the use of personal protective equipment). Break-ins and vandalism provide evidence that indicates trespassers have bypassed the security fence and gained access to the former manufacturing area. Therefore, the current exposure scenario under consideration in this evaluation is individuals who trespass in the former manufacturing area.

Future land-use of the area within the security fence will remain industrial/commercial. An environmental covenant will be placed on the future development of the former manufacturing area to prevent residential development. Once all remedial activity of the former manufacturing area is complete, the area may be developed into industrial and/or commercial properties. Environmental covenants will be established to restrict the use of shallow groundwater in the area around the DuPont-Louviers site because some contamination has been found in the alluvial aquifer (primarily nitrates). In addition, the covenant will restrict activities at SWMUs where waste (i.e. landfills) and subsurface soil contamination may remain after all the corrective action process has been completed. Therefore, it appears that future exposure scenarios would possibly include industrial and commercial workers. It is also assumed that the current trespassing scenario is not likely to change in the immediate future, but it is possibly that the trespassing scenario may change after industrial/commercial development takes place.

Conceptual Site Model

Current Exposures

At this time only one exposure scenario is thought to occur at the DuPont-Louviers site and that is trespassing. The available information suggests that young people trespass onto the property by climbing over the perimeter fence and gaining access to the area located outside of the former manufacturing area (security fenced portion). It is also

possible that some of these same individuals access the former manufacturing area (within security fence). Trespassers could come into contact with site-related contamination in surface soil that has been affected by former operations. The probable routes of exposure to surface soil are incidental ingestion and dermal contact during play and hand-mouth activity. However, incidental ingestion is considered the major route of exposure for the COPCs evaluated in this health consultation.

There are people living near the site, but it does not appear that these residents come into contact with site-related contamination. The areas of soil contamination are not close to residential properties and it does not appear that soil contaminants are, or could be, transported to the residential properties by wind or some other mechanism. As noted previously, some contamination has been found in groundwater, which could be of concern if people were drinking it. However, there are no residential wells tapped into the shallow alluvial groundwater downgradient of the DuPont-Louviers site and an environmental covenant is to be put into place restricting the use of this water for any future development. In addition, the Village of Louviers water supply is a groundwater well located upgradient of the DuPont Louviers site. This well has been sampled and no site-related contamination was discovered. Therefore, a current residential exposure scenario to groundwater and soil was not evaluated further.

Future Exposures

Because of the uncertainties associated with future land-use, all potential future exposures are considered hypothetical that may or may not occur at some point in the future. Three hypothetical exposure scenarios were used to evaluate the potential future health risks of soil contamination at the site (inside security fence): trespassing, industrial, and construction work. As mentioned, it is not expected that the trespassing scenario will change in the near future. Thus, the same exposure factors that were used to assess the current trespassing exposure scenario were used to evaluate the future trespassing exposure scenario.

The former manufacturing area may be developed into industrial/commercial properties once all of the remedial activity has been completed. One of the primary purposes of this evaluation is to determine if corrective action is necessary to protect current and future public health. If the portion of the DuPont-Louviers facility is developed in the future, construction/excavation workers will be necessary. Construction/excavation workers were evaluated independently because of the nature of their work, which may include very “soil intrusive” activities as well as exposure to contaminants at depth. In addition, industrial workers are also a future possibility. Industrial workers could be exposed to contaminants in surface soil in the same manner as the other receptors; however, the exposure assumptions are slightly different for this group of individuals. As mentioned above, because of the environmental covenant restricting the use of this water for any future development, future potential exposures to groundwater are not evaluated at this time.

Table 3. Conceptual Site Model

Source	Point of Exposure	Affected Environmental Medium	Potentially Exposed Populations	Timeframe of Exposure	Route of Exposure
Industrial Waste	SWMU 6	Surface and Subsurface soils	Trespassers	Current (Complete), Future (Potential)	Incidental Ingestion and Dermal Exposure to Surface Soil
	SWMU 7				
	SWMU 15		Construction Workers	Future (Potential)	Incidental Ingestion and Dermal Exposure to Surface and Subsurface
	SWMU 23				
	SWMU 36		Industrial Workers	Future (Potential)	Soil Incidental Ingestion and Dermal Exposure to Surface Soil
	S&D Garage & UST AOC				

Note: Dermal contact exposure pathway is not evaluated because the incidental ingestion is considered the major exposure pathway and is evaluated in this health consultation.

Public Health Implications

Evaluating the public health implications of current and future exposure to soil contaminants located in the former manufacturing area of the DuPont-Louviers site is a multi-step process. For all contaminants that exceed the comparison value (COPC), exposure doses are estimated for non-cancer and cancer endpoints (if the COPC is a carcinogen). The estimated exposure doses are then compared with non-cancer health-based guidelines and the acceptable cancer risk range to evaluate if adverse health effects are likely from contacting soil contaminants inside the former manufacturing area. If the estimated exposure dose is higher than the health-based reference points, further evaluation is conducted. Because the areas of contamination inside the security fence are separate and vary in COPCs and levels of COPCs, exposure doses were estimated for each receptor in each SWMU and the S&D Garage AOC.

To estimate exposure doses, one must make assumptions such as how much soil will be accidentally ingested over a period of time. These assumptions, or exposure factors, can be based on scientific literature, site-specific information, or professional judgment. Due to a lack of site-specific data, the exposure factors used in this evaluation are the EPA and/or ATSDR standard default exposure factors. In addition, many factors determine individual responses to chemical exposures. These factors include the dose, duration, and individual factors such as age, gender, diet, family traits, lifestyle, and state of health. For these reasons, this evaluation cannot determine the actual health risk to any one particular individual. Rather, this evaluation provides estimates of risk using conservative and reasonable exposure factor assumptions. The same exposure factors were used for each area evaluated in this health consultation. More information regarding the exposure

factors used in this document and the toxic potential of risk driving chemicals is available in Appendix A and Appendix B, respectively.

SWMU 6

PETN was selected as a COPC in soil at SWMU 6 because no established health guidelines and comparison values for PETN currently exist. PETN has been used as a treatment for angina pectoris (heart pain), and congestive heart failure (Goodman et al., 1980). However, adverse health effects of PETN above the therapeutic dose have not been studied. As such, no health-based guidelines exist for PETN. This limitation prevents an evaluation of potential for adverse health effects. Therefore, it cannot be determined whether ingestion of PETN-contaminated soil at SWMU 6 could harm people's health.

SWMU 7

The concentrations of arsenic and lead in soil at SWMU 7 were retained as COPCs. Arsenic was detected at all soil depths sampled (0-2 ft. bgs, 6-8 ft. bgs.) at concentrations exceeding the comparison value. Arsenic can produce both non-cancer and cancer health effects in human beings. As such, non-cancer and cancer exposure doses were estimated for all receptors in this evaluation (trespasser, industrial worker, construction worker).

The estimated non-cancer exposure doses from incidental ingestion of soil for all receptors in this area exceed the health-based guideline for chronic exposure to arsenic (Table A3). It was estimated that construction workers would have the highest dose of arsenic primarily due to the soil intrusive nature of their work. The estimated dose for construction workers exceeds the chronic health-based guideline by a factor of 3. Since the estimated non-cancer exposure dose exceeds the health-based guideline for all receptors, further evaluation is necessary to determine the likelihood of non-cancer adverse health effects. The next step is to compare the doses to known health effect levels of arsenic. The two primary health effect levels used in this evaluation are referred to as the No-Observed-Adverse-Health-Effect-Level (NOAEL) and Lowest-Observed-Adverse-health Effect-Level (LOAEL), which are derived from human and/or animal data in scientific literature.

There are a large number of human and animal studies on oral exposure to inorganic arsenic. Both a NOAEL value of $8.0 * 10^{-4}$ mg/kg-day and a LOAEL value of $1.4 * 10^{-2}$ mg/kg-day have been established for inorganic arsenic for the ATSDR Minimal Risk Level (MRL). The estimated non-cancer doses to trespassers and industrial workers are below the known health effect levels for oral exposure to arsenic (Table 3). The estimated non-cancer dose of $9.2 * 10^{-4}$ mg/kg-day for arsenic to construction workers is slightly higher than the NOAEL value. The critical study examined a large group of Taiwanese individuals that were exposed to arsenic-contaminated well water. In this study, no effects were observed at the $8.0 * 10^{-4}$ mg/kg-day dose level and less serious effects on the skin (hyperpigmentation and hyperkeratosis) were observed at the $1.4 * 10^{-2}$ mg/kg-day dose level. The estimated non-cancer dose for construction workers is well below the

LOAEL value found in the critical study. Based on this data, incidental ingestion of soil over long periods by construction workers at SWMU 7 could cause harmful non-cancer health effects (e.g., dermal effects). This is considered a public health hazard.

Theoretical cancer risks were also estimated from exposure to arsenic in soil at SWMU 7 and were compared to the cancer risk range that is generally considered acceptable. The acceptable risk range for cancer is 1 excess cancer case per million exposed individuals (low-end of range) to 100 excess cancer case per 1,000,000 exposed individuals (high-end of range), which can be expressed $1 * 10^{-6} – 1 * 10^{-4}$ cancer risk. As shown in Table 4, the estimated theoretical cancer risks for trespassers ($1.1 * 10^{-4}$) and industrial workers ($4.1 * 10^{-4}$) exceed the acceptable cancer risk range. This indicates that the amount of arsenic potentially swallowed through incidental ingestion of soil during various activities by trespassers and industrial workers is associated with a high increased risk of developing cancer and is considered a public health hazard. The estimated theoretical cancer risk ($2.0 * 10^{-5}$ or 20 excess cancer cases per 1,000,000) for construction workers is below the mid-point of the acceptable cancer risk range. For construction workers, the amount of arsenic potentially swallowed through incidental ingestion of soil, at the levels of arsenic found in soil, is associated with a low increased risk of developing cancer. However, the theoretical cancer risk for all users exceeds CDPHE's target cancer risk level of $1 * 10^{-6}$. Due to the excessive cancer risks attributable to arsenic in soil at SWMU 7, it is recommended that exposure to arsenic be reduced.

Lead in SWMU 7 soil also exceeded the residential CV and was retained as a COPC. The evaluation of non-cancer exposure to lead is different than other contaminants because lead is found in a number of sources and much of what is known about the adverse health effects of lead has been described in terms of blood lead levels. To evaluate non-cancer exposure to lead, an IEUBK model is typically used to determine what the probable blood lead level would be following exposure. In SWMU 7, the concentration of lead exceeded the CV in only 1 surface soil sample (0-2ft.). For the lead model, the mean concentration of lead is generally used as the input value (EPA 2007). The mean concentration of lead in surface and subsurface soil is 152 mg/kg and 4.4 mg/kg, respectively. Both mean values are well below the residential CV, which indicates that elevated blood lead levels are not expected to occur from exposure to soil in SWMU 7.

SWMU 15

In SWMU 15, arsenic in soil exceeded the CV and was selected as a COPC. All of the estimated non-cancer exposure doses were below the respective health-based guidelines for chronic exposure to arsenic in soil at SWMU 15 (Table A3). The highest theoretical cancer risk estimated for exposure to arsenic in soil at SWMU 15 is for industrial workers ($2.7 * 10^{-6}$). As shown it Table 5, the estimated theoretical cancer risks for trespassers and construction workers is below the acceptable risk range. Thus, the estimated amount of arsenic potentially swallowed by all users through incidental ingestion of soil in SWMU 15, is associated with a low increased risk of developing cancer and non-cancer health effects. No further public health action is recommended for SWMU 15.

SWMU 23 A

Two COPCs were selected in soil at SWMU 23A, 2,4-DNT and 2,6-DNT. It has been shown that oral exposure to 2,4-DNT and 2,6-DNT can result in both non-cancer and cancer adverse health effects. Some evidence suggests that exposure to 2,4-DNT and 2,6-DNT may result in neurological, cardiovascular, and hematological adverse health effects in humans. Both 2,4- and 2,6-DNT can cause liver cancer in laboratory rats and may produce the same effect in humans. The International Agency for Research on Cancer (IARC) has determined that 2,4- and 2,6-DNT are possibly carcinogenic to humans. Non-cancer health guidelines are available for 2,6-DNT, but a cancer slope factor is available only for a mixture of 2,6-DNT and 2,4-DNT. Therefore, only non-cancer health effects of 2,6-DNT are considered in this evaluation.

In SWMU 23A, 2,4-DNT was detected in one of six surface soil samples at a concentration of 1,200 mg/kg. Similarly, 2,6-DNT was only detected in one surface soil sample at a concentration of 760 mg/kg. Both of these detections (2,4-DNT & 2,6-DNT) occurred in boring 3, which could indicate a "hot spot". Due to the limited amount of sampling data from this area, the maximum detected concentration of 2,4 DNT and 2,6-DNT was used as the assumed exposure point concentration in the dose equations.

Non-cancer exposure doses of incidental ingestion of contaminated soil in SWMU 23A were calculated for each receptor. The estimated non-cancer doses for trespassers and industrial workers were below the health-based guidelines or levels of health concern. This indicates that significant non-cancer adverse health effects are not expected. The non-cancer doses for the construction worker exceed the health-based guidelines for both 2,4-DNT and 2,6-DNT (Table A3). These doses were then compared with known health effects levels for 2,4-DNT and 2,6-DNT. For 2,4-DNT, the EPA has established a NOAEL value 2.0 * 10-1 mg/kg-day and LOAEL value of 1.5 mg/kg-day. The estimated exposure dose of 2,4-DNT for construction workers ($3.9 * 10^{-3}$ mg/kg-day) is below the NOAEL value. For 2,6-DNT, the only known health effect level that has been established by the ATSDR or EPA is a NOAEL value of 4 mg/kg-day. The estimated non-cancer exposure dose for construction workers of $2.5 * 10^{-3}$ mg/kg-day is well below the NOAEL value for oral exposure to 2,6-DNT. Overall, the amount of 2,4-DNT and 2,6-DNT potentially swallowed by construction workers through incidental ingestion of soil, at the levels found in soil at SWMU 23A, is below levels known to cause harmful effects but it enters a range of potential concern based on the exceedance of health guidelines.

Theoretical cancer risks were also estimated for exposure to 2,4-DNT in soil at SWMU 23A (Table 5). The theoretical cancer risk estimates range from $1.7 * 10^{-5}$ (construction workers) to $1.3 * 10^{-4}$ (industrial worker). The estimated theoretical cancer risk for trespassers ($3.4 * 10^{-5}$) and construction workers is near the mid-point of the acceptable cancer risk range. This indicates that the amount of 2,4-DNT potentially ingested by trespassers and construction workers through incidental ingestion of soil, at the levels of 2,4-DNT found in soil, is associated with a low increased risk of developing cancer. The cancer risk estimate for industrial workers is above the high end of the acceptable cancer risk range. This indicates that the amount of 2,4-DNT potentially ingested through

incidental ingestion of soil by industrial workers during various activities, at the levels of 2,4-DNT found in soil, is associated with a high increased risk of developing cancer and is considered a public health hazard. It is recommended that exposure to 2,4-DNT in SWMU 23A be reduced to protect industrial workers.

SWMU 23 C

At SWMU 23C, 2,4-DNT was the only COPC selected for further evaluation. 2,4-DNT was detected in only one surface soil sampling location (boring 6). Non-cancer exposure doses were estimated for all receptors for incidental ingestion of 2,4-DNT-contaminated soil. The estimated non-cancer exposure doses for industrial and construction workers exceed the health-based guideline for 2,4-DNT, and are slightly below the health guideline for trespassers (Table A3). Compared to the known health effect level established for 2,4-DNT, the estimated doses for industrial and construction workers are below the NOAEL value (Table 4). This indicates that the amount of 2,4-DNT potentially swallowed by industrial and construction workers through incidental soil ingestion , at the levels of 2,4-DNT found in soil at SWMU 23C, is below levels known to cause harmful effects; however, it enters a range of potential concern based on the exceedance of health guidelines.

The theoretical cancer risk range from exposure to 2,4-DNT-contaminated soil in SWMU 23C is $4.2 * 10^{-5}$ (construction worker) to $3.1 * 10^{-4}$ (industrial worker). The estimated cancer risk for trespassers ($8.1 * 10^{-5}$) approaches the maximum acceptable cancer risk. For construction workers, the amount of 2,4-DNT potentially ingested through incidental soil ingestion, at the levels found in soil at SWMU 23C, is associated with a low increased risk of developing cancer. For industrial workers and trespassers, the amount of 2,4-DNT potentially swallowed through incidental soil ingestion, at the levels found in soil at SWMU 23C, is associated with a high increased risk of developing cancer. This is considered a public health hazard. Overall, it is recommended that exposure to 2,4-DNT in SWMU 23C be reduced to protect all current and future receptors.

SWMU 36

Arsenic and lead were detected at very high concentrations in SWMU 36 and were the only COPCs selected in this area. Both metals were found at the highest site-wide concentrations that have been evaluated thus far. Lead can affect almost every organ and system in the body. The main target for lead toxicity is the nervous system, both in adults and children. Long-term exposure of adults can result in decreased performance in some tests that measure functions of the nervous system. Arsenic is a known human carcinogen. In addition, exposure to high levels of arsenic may cause nausea, vomiting, diarrhea, abnormal heart rhythm, blood vessel damage, or a pins and needle sensation in hands and feet. Long-term exposure to low levels of arsenic may lead to a darkening of the skin and the appearance of small corns or warts on the palms, soles, and torso.

The estimated non-cancer exposure doses for each receptor exceeded the chronic health-based guideline for arsenic. The largest estimated non-cancer dose of $3.8 * 10^{-3}$

(construction worker) exceeded the health-based guideline for arsenic by a factor of 13 (Table 3). The non-cancer doses were then compared to known health effect levels for arsenic (NOAEL and LOAEL). In each case, the non-cancer exposure dose exceeded the NOAEL value, but did not exceed the LOAEL value for arsenic (Table 4). This indicates that the amount of arsenic potentially ingested through incidental ingestion of soil, at the levels found in soil at SWMU 36, could harm people's health. In addition, lead was also selected as a COPC with a maximum detected concentration of 130,000 ppm. The mean value of lead (16,594 ppm) that is used in the IEUBK model for estimating lead uptake is also significantly above the residential CV of 400 ppm and industrial/construction worker CV of 780 ppm. This indicates the amount of lead potentially swallowed through incidental ingestion of soil by pregnant construction workers, industrial workers, and trespassers, at the levels found in soil at SWMU 36, could harm the developing fetus by impairing development of the brain and causing a decrease in IQ. This is considered a public health hazard.

Theoretical cancer risks were also estimated for all receptors in SWMU 36 since arsenic is a known carcinogen (Table 5). The estimated cancer risks from incidental ingestion of arsenic-contaminated soil in SWMU 36 range from $8.1 * 10^{-5}$ (construction worker) to $7.7 * 10^{-4}$ (industrial worker). The estimated cancer risk for trespassers is $2.0 * 10^{-4}$. All of the estimated cancer risks from exposure to arsenic in SWMU 36 are significantly above the high end or slightly below the acceptable cancer risk range. This indicates that the amount of arsenic potentially swallowed by trespassers, construction workers, and industrial workers through incidental ingestion of soil, at the levels found in soils at SWMU 36, is associated with a high increased risk of developing cancer. This is considered a public health hazard. Therefore, it is recommended that exposure to arsenic and lead in soils at SWMU 36 be reduced to protect the health of all receptors under consideration in this evaluation.

S&D Garage and UST AOC

Arsenic and tetrachloroethene (PCE) were selected as COPCs in the S&D Garage and UST AOC. However, exposure doses were not estimated for trespassers and industrials workers because PCE only exceeded the comparison value in subsurface soil. The estimated non-cancer exposure dose for construction workers slightly exceeds the health-based guideline for chronic exposure to arsenic (Table A3). However, the estimated non-cancer dose for construction workers does not exceed the NOAEL or LOAEL values for arsenic (Table 4). This indicates that the amount of arsenic potentially swallowed through incidental ingestion of soil by construction workers, at the levels found in soil at the S&D Garage & UST AOC, is below a level of known health effects; however, it enters a range of potential concern based on the exceedance of health guidelines. In addition, the estimated non-cancer exposure dose for trespassers and industrial workers are below the health-based guideline for arsenic. This indicates that the amount of arsenic potentially swallowed through incidental ingestion of soil by trespassers and industrial workers, at the levels found in soil at the S&D Garage & UST AOC, is below levels of health concern. Thus, significant non-cancer health effects are not expected to occur from incidental ingestion of arsenic in the S&D Garage & UST AOC.

Theoretical cancer risks of arsenic for all receptors range from $3.4 * 10^{-6}$ (trespasser) to $1.3 * 10^{-5}$ (industrial worker) and are at the low end of the acceptable cancer risk range (Table 5). In addition, the estimated cancer risk of tetrachloroethylene for construction workers ($1.2* 10^{-6}$) is at the low end of the acceptable cancer risk range. This indicates that the amount of arsenic potentially swallowed by trespassers, construction workers, and industrial workers through incidental ingestion of soil, at the levels found in soils at S&D Garage & UST AOC, is associated with a low increased risk of developing cancer.. However, to be prudent of public health, it is recommended that exposure to arsenic in this area be reduced to achieve CDPHE's target cancer risk level.

Uncertainty

This is not intended to be an in-depth discussion of all uncertainties. Rather, the focus is to highlight the major assumptions and limitations that are specific to this evaluation. In general, the uncertainties inherent in any risk assessment are likely to over- or underestimate exposures and health hazards. The magnitude of this uncertainty is generally unknown. Some of the major uncertainties of this evaluation are briefly noted below.

- The assumption of 100% metal bioavailability arsenic-contaminated soils. This is a conservative assumption based on what is known of the reduced bioavailability of metals in soils.
- Many of the surface soil samples were collected from a depth interval of 0-2 feet below ground surface. These samples may not be representative of actual exposures to soil at the surface and may under- or over-estimate the actual health risks.
- No cancer slope factor is available for 2,6-DNT. Therefore cancer risks for 2,6-DNT are underestimated.
- Soil ingestion was considered the major pathway of exposure in this evaluation. Therefore, risks were not evaluated through the dermal contact exposure pathway. This may slightly underestimate risk. Many metals are naturally occurring in the soils of Colorado. This is particularly relevant for arsenic. The concentrations found in some areas are consistent with background levels found elsewhere onsite. Thus, the risks associated with arsenic in some areas may not be attributable to site-related contamination.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical and behavioral differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are

dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

In this evaluation, no child exposure scenarios were evaluated since it is unlikely that children (ages 0-6) will be in the former manufacturing area now or in the future. However, the high concentration of lead in SWMU 36 (in excess of 100,000 mg/kg) could harm the developing fetus of female industrial, construction workers, and possibly trespassers.

Conclusions

CCPEHA and ATSDR have reached the following seven conclusions regarding current/future exposures by trespassers and future exposures by construction and industrial workers to soil contaminants in the areas of the former explosives manufacturing facilities under investigation in this evaluation (SWMUs 6, 7, 15, 23A, 23C, 36 and the S&D Garage and UST AOC) at the DuPont-Louviers site:

Accidentally eating soil in SWMU 36 could harm trespassers, construction workers, and industrial workers. This is considered a public health hazard. This conclusion was reached because elevated levels of arsenic and lead are found in soil at SWMU 36. The estimated cancer risks for arsenic are above or slightly below the acceptable cancer risk range for trespassers, construction workers, and industrial workers; however, the estimated cancer risk for industrial users is the highest. Also, the non-cancer hazards for arsenic are above levels known to cause harmful health effects (e.g., skin effects). This indicates that the amount of arsenic potentially swallowed by trespassers, construction workers, and industrial workers through incidental ingestion of soil, at the levels found in soils at SWMU 36, is associated with a high increased risk of developing cancer and non-cancer health effects. In addition, the concentration of lead in soil could also harm the developing fetus of future female workers and trespassers.

Accidentally eating soil in SWMUs 23A could harm industrial workers. This is considered a public health hazard. Accidentally eating soil in SWMUs 23A is not expected to harm current and trespassers and construction workers. This conclusion was reached because elevated levels of 2,4 Dinitrotoluene (2,4-DNT) are found in soil at SWMU 23 A. For industrial workers, the theoretical cancer risk estimate is above the high end of the acceptable cancer risk range. This indicates that the amount of 2,4-DNT potentially swallowed by industrial workers through incidental ingestion of soil during various activities, at the levels of 2,4-DNT found in soil, is associated with a high increased risk of developing cancer. For trespassers and construction workers, the estimated theoretical cancer risk is near the mid-point of the acceptable cancer risk range. This indicates that the amount of 2,4-DNT potentially ingested through incidental ingestion of soil, at the levels of 2,4-DNT found in soil, is associated with a low increased risk of developing cancer. In addition, the estimated non-cancer hazards for trespassers and industrial workers were below levels of health concern (i.e., "safe dose");

thereby indicating low potential for harmful health effects. For construction workers, the estimated non-cancer hazards for both 2,4-DNT and 2,6-DNT are above levels of health concern (i.e., "safe dose") but below levels know to cause harmful effects; thereby indicating a low potential for developing significant non-cancer health effects.

Accidentally eating soil in SWMUs 23C could harm trespassers and industrial workers. This is considered a public health hazard. Accidentally eating soil in SWMUs 23C is not expected to harm construction workers. This conclusion was reached because elevated levels of 2,4-DNT are found in soil at SWMU 23C. The theoretical estimated cancer risks for 2,4-DNT are above or slightly below the acceptable cancer risk range for trespassers and industrial workers. This indicates that the amount of 2,4-DNT potentially swallowed through incidental soil ingestion by industrial workers and trespassers, at the levels found in soil at SWMU 23C, is associated with a high increased risk of developing cancer. In addition, the estimated non-cancer hazards for industrial and trespassers are above levels of health concern (i.e. safe dose) but below levels known to cause harmful effects. This suggests a low potential for significant non-cancer health effect for trespassers and industrial workers. For construction workers, the theoretical estimated cancer risks for 2,4-DNT are above the mid point of the acceptable cancer risk range and estimated non-cancer hazards are slightly below a level of health concern (or "safe dose'). This indicates that the amount of 2,4-DNT potentially ingested through incidental soil ingestion by construction workers, at the levels found in soil at SWMU 23C, is associated with a low increased risk of developing cancer and non-cancer health effects.

Accidentally eating soil in SWMU 7 could harm trespassers, construction workers, and industrial workers. This is considered a public health hazard. This conclusion was reached because elevated levels of arsenic are found in soil at SMWU 7. The theoretical estimated cancer risk for trespassers and industrial workers in SWMU 7 is above the acceptable cancer risk range. Also, the non-cancer hazards for arsenic for all users are above levels of health concern (i.e., safe dose"), but below levels known to cause harmful health effects for trespassers and industrial workers. However, for construction workers the non-cancer hazards are above levels known to cause harmful non-cancer health effects (e.g., skin effects). This indicates that the amount of arsenic potentially swallowed by trespassers, construction workers, and industrial workers through incidental ingestion of soil, at the levels found in soils at SWMU 36, is associated with a high increased risk of developing cancer and/or non-cancer health effects.

It cannot currently be determined if accidentally eating soil in SWMU 6 could harm people's health now or in the future. This conclusion was reached because the currently available data suggests high levels of PETN (up to 7,800 mg/kg) are present. The ATSDR or the EPA has not established non-cancer and cancer health guidelines for PETN. Therefore, the health risk from exposure to PETN-contaminated soil in SWMU 6 cannot be evaluated.

Accidentally eating soil in the S&D Garage and UST AOC is not expected to harm trespassers, construction workers, and industrial workers. . This conclusion was reached because the theoretical cancer risks of arsenic for trespassers, construction workers, and industrial workers are at the low end of the acceptable cancer risk range. In addition, the non-cancer hazards for arsenic for construction workers slightly exceed levels of health concern (i.e., safe dose"), but are below levels known to cause harmful health effects. For trespassers and industrial workers, the non-cancer hazards for arsenic are well below levels of health concern (i.e., safe dose"). This indicates that the amount of arsenic potentially swallowed by trespassers, industrial workers, and construction workers through incidental soil ingestion, at levels found in soil at S&D Garage and UST AOC, is associated with a low increased risk for developing cancer and non-cancer health effects.

Accidentally eating soil in SWMU 15 is not expected to harm trespassers, industrial workers, and construction workers. This conclusion was reached because the theoretical cancer risks of arsenic for trespassers, construction workers, and industrial workers are below or near the low end of the acceptable cancer risk range. In addition, the estimated non-cancer hazards of exposure to arsenic in soil by trespassers, construction workers, and industrial workers are well below levels of health concern (i.e., safe dose"). This indicates that the amount of arsenic potentially swallowed by trespassers, industrial workers, and construction workers through incidental soil ingestion, at levels found in soil at SWMU 15 is associated with a low increased risk for developing cancer and non-cancer health effects. No further action in SWMU 15 is necessary to protect public health.

Recommendations

Based upon CCPEHA's review of the environmental data, exposure pathways, and potential public health implications of exposure to soil contaminants located inside of the security fence on the DuPont-Louviers property, the following actions are appropriate and protective of current and future users of the site.

DuPont should:

- Address arsenic contamination in SWMUs 7 and 36 to ensure a reduction in exposure by adopting various strategies such as remediation and/or institutional controls.

- Address 2,4-DNT contamination in SWMU 23A and 23C to ensure reduction in exposure by adopting various strategies such as remediation and/or institutional controls.

- Address lead contamination in SWMU 36 to ensure reduction in exposure by adopting various strategies such as remediation and/or institutional controls.

- Address PETN contamination in SWMU 6 to ensure reduction in exposure by adopting various strategies such as remediation and/or institutional controls.

- To the extent possible, reduce exposure to arsenic in all areas of this evaluation to achieve background levels of arsenic or CDPHE's target cancer risk level of $1 * 10^{-6}$.

Public Health Action Plan

The public health action plan for the site contains a description of actions that have been or will be taken by CCPEHA and other governmental agencies at the site. The purpose of the public health action plan is to ensure that this public health consultation both identifies public health hazards and provides a plan of action designed to mitigate and prevent harmful human health effects resulting from breathing, drinking, eating, or touching hazardous substances in the environment. Included is a commitment on the part of CCPEHA to follow up on this plan to be sure that it is implemented.

Public health actions that have or will be implemented:

- As necessary, CCPEHA will review any additional data collected from the DuPont-Louviers site and evaluate the public health implications of the new data.

- Upon request, CCPEHA will provide assistance to DuPont and State environmental officials on sampling plans and analysis.

- CCPEHA will provide the appropriate level of health education on the findings of this health consultation to stakeholders and the community.

- CCPEHA will conduct another health consultation on the DuPont-Louviers site for the remaining areas of the property (i.e., Restricted-use area inside the fence) that were not addressed in this evaluation.

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Additional Tables and Figures

Table 1. Summary of Detected Compounds in Surface and Subsurface Soil (DuPont-Louviers Site)

Area	Contaminant	Depth (in feet)	Concentration Range (in mg/kg)	Mean Concentration (in mg/kg)	Number of Samples	Percent Detected	Comparison Value (in mg/kg)	COPC
SWMU 6	Nitrate/Nitrite/Nitrogen	0-2	ND – 33	12.4	8	77.5%	5,000[1]	
	Nitrate/Nitrite/Nitrogen	6-8	ND – 17	6.11	9	88.9%	5,000[1]	
	PETN	0-2	ND – 7,800	1,061	11	72.7%	NA	X
	PETN	6-8	ND – 240	133.6	12	41.6%	NA	X
SWMU 7	Arsenic	0-2	ND – 2,500	155.1	42	97.6%	0.39[2]	X
	Arsenic	4-5	160	N/a	1	100%	0.39[2]	X
	Arsenic	6-8	ND – 310	31.3	31	96.8%	0.39[2]	X
	Arsenic	12-14	1.9 – 170	27.5	13	100%	0.39[2]	X
	1,2-Dichloroethane	0-2	ND – 0.0091	N/a	6	16.7%	0.45[2]	
	1,2-Dichloroethane	6-8	ND	N/a	7	0.0%	0.45[2]	
	Barium	0-2	23 – 120	68.7	6	100%	10,000[1]	
	Barium	6-8	9.9 – 49	28.3	7	100%	10,000[1]	
	Chromium	0-2	3.5 – 19	7.9	6	100%	280[2]	
	Chromium	6-8	1.5 – 5.1	3.1	7	100%	280[2]	
	Lead	0-2	6.8 – 650	151.9	8	100%	400[3]	X
	Lead	6-8	2.2 – 7.0	4.4	7	100%	400[3]	
	Mercury	0-2	ND – 0.46	0.21	6	50.0%	4.3[2]	
	Mercury	6-8	ND	N/a	7	0.0%	4.3[2]	
	Nitrate/Nitrite/Nitrogen	0-2	ND – 5.2	2.5	6	50.0%	5,000[1]	
	Nitrate/Nitrite/Nitrogen	6-8	ND	N/a	7	0.0%	5,000[1]	
	Silver	0-2	ND – 2.8	N/a	6	16.7%	300[1]	
	Silver	6-8	ND	N/a	7	0.0%	300[1]	

Table 1. Continued

Area	Contaminant	Depth (in feet)	Concentration Range (in mg/kg)	Mean Concentration (in mg/kg)	Number of Samples	Percent Detected	Comparison Value (in mg/kg)	COPC
SWMU 7 (Contd.)	Tetrachloroethene	0-2	ND – 0.006	N/a	6	16.7%	0.57[2]	
	Tetrachloroethene	6-8	ND	N/a	7	0.0%	0.57[2]	
SWMU 15	Acetone	0-2	ND – 0.10	N/a	17	5.9%	4,000[1]	
	Acetone	6-8	ND	N/a	19	0%	4,000[1]	
	Arsenic	0-2	2.2 – 12	4.26	17	100%	0.39[2]	X
	Arsenic	6-8	1.6 – 10	4.00	19	100%	0.39[2]	X
	Barium	0-2	21 – 200	93.9	17	100%	10,000[1]	
	Barium	6-8	18 – 620	89.6	19	100%	10,000[1]	
	Chromium	0-2	4.1 – 12	7.83	17	100%	280[2]	
	Chromium	6-8	2.7 – 14	7.43	19	100%	280[2]	
	Lead	0-2	6.7 – 310	86.0	17	100%	400	
	Lead	6-8	3.2 – 260	31.1	19	100%	400	
	Mercury	0-2	ND – 0.2	N/a	17	11.8%	4.3[2]	
	Mercury	6-8	ND – 0.081	N/a	19	10.5%	4.3[2]	
	Methylene Chloride	0-2	ND – 0.02	N/a	17	11.8%	11[2]	
	Methylene Chloride	6-8	ND – 0.0079	0.0071	19	21.1%	11[2]	
	Nitrate/Nitrite/Nitrogen	0-2	ND – 31	10.3	17	94.1%	5,000[1]	
	Nitrate/Nitrite/Nitrogen	6-8	ND - 52	9.45	19	63.2%	5,000[1]	
	Pentaerythritol Tetranitrate	0-2	ND – 82	45.3	17	17.7%	NA	X
	Pentaerythritol Tetranitrate	6-8	ND – 18	N/a	19	5.2%	NA	X
SWMU 23A	2,4-Dinitrotoluene	0-2	ND – 1,200	N/a	6	16.7%	1.6[2]	X
	2,6-Dinitotoluene	0-2	ND – 760	N/a	6	16.7%	61[2]	X
	Acetone	0-2	ND – 0.047	0.038	6	50.0%	50,000[1]	
	Benz(b)fluoranthene	0-2	ND – 0.48	N/a	6	16.7%	0.15[2]	X

Table 1. Continued

Area	Contaminant	Depth (in feet)	Concentration Range (in mg/kg)	Mean Concentration (in mg/kg)	Number of Samples	Percent Detected	Comparison Value (in mg/kg)	COPC
SWMU 23A (contd.)	Bis(2-ethylhexyl) phthalate	0-2	ND – 3.7	N/a	6	33.3%	35[2]	
	Chrysene	0-2	ND – 0.54	N/a	6	16.7%	15[2]	
	Ethylbenzene	0-2	ND – 0.62	N/a	6	16.7%	5.7[2]	
	Fluoranthene	0-2	ND – 1.7	N/a	6	16.7%	2,000[1]	
	Nitrobenzene	0-2	ND – 1.6	N/a	6	16.7%	4.4[2]	
	Pyrene	0-2	ND – 0.88	N/a	6	16.7%	1,700[2]	
	Toluene	0-2	ND – 0.9	N/a	6	33.3%	1,000[1]	
	Xylenes	0-2	ND – 3.2	N/a	6	33.3%	600[2]	
SWMU 23C	2,4-Dinitrotoluene	0-2	ND – 2,900	N/a	11	9.1%	1.6[2]	X
	Acetone	0-2	ND – 0.084	0.042	9	55.6%	50,000[1]	
	Bis(2-ethylhexyl) phthalate	0-2	ND – 4.6	N/a	9	22.2%	35[2]	
SWMU 36	Arsenic	0-0.34	2,100 – 2,200	N/a	2	100.0%	0.39[2]	X
	Arsenic	0-2	1.4 – 3,500	288.3	16	100.0%	0.39[2]	X
	Arsenic	4-6	ND - 91	12.33	15	80.0%	0.39[2]	X
	Arsenic	8-10	ND – 8.4	2.14	11	90.9%	0.39[2]	X
	Arsenic	12-14	1.1 – 3.0	N/a	2	100%	0.39[2]	X
	Barium	0-0.34	90 – 140	N/a	2	100%	10,000[1]	
	Cadmium	0-0.34	24 - 33	N/a	2	100%	10[1]	X
	Chromium	0-0.34	4.0 – 4.8	N/a	2	100%	280[2]	
	Lead	0-0.34	100,000 – 130,000	N/a	2	100%	400[3]	X
	Lead	0-2	5.9 – 1,700	192.6	12	100%	400[3]	X
	Lead	4-6	2.6 - 570	59.8	15	100%	400[3]	X
	Lead	8-10	1.5 – 8.9	6.05	11	100%	400[3]	

Table 1. Continued

Area	Contaminant	Depth (in feet)	Concentration Range (in mg/kg)	Mean Concentration (in mg/kg)	Number of Samples	Percent Detected	Comparison Value (in mg/kg)	COPC
SWMU 36 (contd.)	Lead	12-14	2.4 – 9.7	N/a	2	100%	400[3]	
	Mercury	0-0.34	3.1 – 6.8	N/a	2	100%	4.3[2]	X
	Mercury	0-2	ND – 0.15	0.02	13	92.3%	4.3[2]	
	Mercury	4-6	ND – 0.021	0.011	11	72.7%	4.3[2]	
	Mercury	8-10	ND – 0.017	0.008	11	90.9%	4.3[2]	
	Mercury	12-14	ND – 0.004	N/a	2	50.0%	4.3[2]	
	Pentachlorophenol	0-2	ND – 0.28	N/a	13	7.7%	3.0[2]	
	Pentachlorophenol	4-6	ND	N/a	11	0.0%	3.0[2]	
	Pentachlorophenol	8-10	ND – 0.31	N/a	11	9.1%	3.0[2]	
	Pentachlorophenol	12-14	ND	N/a	3	0.0%	3.0[2]	
	Selenium	0-0.34	26 – 40	N/a	2	100.0%	300[1]	
	Silver	0-0.34	64 - 70	N/a	2	100.0%	300[1]	
S&D Garage and UST AOC	Arsenic	0-2	ND – 45	10.7	15	93.3%	0.39[2]	X
	Arsenic	2-4	2.1 – 1,200	97.1	23	100%	0.39[2]	X
	Arsenic	3-4	31	N/a	1	100%	0.39[2]	X
	Arsenic	6-8	1.3 – 44	14.9	12	100%	0.39[2]	X
	Arsenic	10-12	ND – 120	24.9	12	75%	0.39[2]	X
	Arsenic	14-16	0.91 – 220	34.2	9	100%	0.39[2]	X
	Diesel Range Organics	10-12	3,700	N/a	1	100%	NA	
	Methyl Ethyl Ketone	10-12	9.5	N/a	1	100%	28,000[2]	
	Naphthalene	0-2	ND	N/a	1	0%	3.9[2]	
	Naphthalene	2-4	ND – 0.0005	N/a	4	50%	3.9[2]	
	Naphthalene	6-8	ND	N/a	4	0%	3.9[2]	
	Naphthalene	10-12	ND	N/a	4	0%	3.9[2]	

Table 1 Continued

Area	Contaminant	Depth (in feet)	Concentration Range (in mg/kg)	Mean Concentration (in mg/kg)	Number of Samples	Percent Detected	Comparison Value (in mg/kg)	COPC
S&D Garage and UST AOC (contd.)	Naphthalene	14-16	ND	N/a	4	0%	3.9[2]	
	Mercury	4-6	ND – 0.021	0.011	11	72.7%	4.3[2]	
	Tetrachloroethene	0-2	0.13	N/a	1	100%	0.57[2]	
	Tetrachloroethene	2-4	0.0057 – 0.071	0.025	4	100%	0.57[2]	
	Tetrachloroethene	6-8	0.00051 – 0.8	0.22	4	100%	0.57[2]	X
	Tetrachloroethene	10-12	ND - 77	19.3	5	80%	0.57[2]	X
	Tetrachloroethene	14-16	0.00032 – 0.0095	0.0042	4	100%	0.57[2]	
	TPH - Gas	6-8	7.4	N/a	1	100%	NA	
	TPH - Gas	10-12	93	N/a	1	100%	NA	

Note: Cadmium, mercury, and Benz(b)fluoranthene which were below the industrial worker CVs were not evaluated further because the use of residential CV is too conservative for non-residential exposure scenarios evaluated in this health consultation.

[1] ATSDR Soil Comparison Values 10/27/2008
[2] EPA Region 9 Regional Screening Level Table April 2009
[3] EPA OSWER Directive #9355.4-12

Table 4. Current and Future Non-cancer Hazard Quotients of Incidental Soil Ingestion

Area of Investigation	Contaminant of Potential Concern	Current and Future Trespasser Non-cancer Hazard Quotients	Future Construction Worker Non-cancer Hazard Quotients	Future Industrial Worker Non-cancer Hazard Quotients
SWMU 7	Arsenic	**1.64E+00**	**3.06E+00**	**2.53+00**
SWMU 15	Arsenic	1.09E-02	5.07E-02	1.69E-02
SWMU 23A	2,4-DNT	3.80E-01	**1.94E+00**	5.87E-01
	2,6-DNT	4.81E-01	**2.45E+00**	7.44E-01
SWMU 23C	2,4-DNT	9.18E-01	**4.68E+00**	**1.42E+00**
SWMU 36	Arsenic	**3.09E+00**	**1.27E+01**	**4.77E+00**
S&D Garage AOC	Arsenic	5.29E-02	**1.63E+00**	8.17E-02
	Tetrachloroethene	N/a	N/a	1.52E-02

Notes: Hazard Quotients are simply the estimated exposure dose for non-cancer health effects divided by the applicable health-based guideline. Hazard Quotients greater than 1 indicates that the estimated dose exceeds the health-based guideline. Bolded values are Hazard Quotients greater than 1.

Table 5. Comparison of Estimated Doses from Soil Ingestion and the Non-Cancer Health Effect Levels

Area	Contaminant of Potential Concern	Current and Future Trespasser Non-cancer Exposure Doses (mg/kg-day)	Future Industrial Worker Non-cancer Exposure Doses (mg/kg-day)	Future Construction Worker Non-cancer Exposure Doses (mg/kg-day)	NOAEL Value (mg/kg-day)	LOAEL Value (mg/kg-day)
SWMU 7	Arsenic	4.91E-04	7.59E-04	**9.18E-04**	8.00E-04	1.40E-02
SWMU 23A	2,4-DNT	7.60E-04	1.17E-03	3.87E-03	2.00E-01	1.50E+00
	2,6-DNT	4.81E-04	7.44E-04	2.45E-03	4.00E+00	N/a
SWMU 23C	2,4-DNT	1.84E-03	2.84E-03	9.36E-03	2.00E-01	1.50E+00
SWMU 36	Arsenic	9.26E-04	1.43E-03	3.80E-03	8.00E-04	1.40E-02
S&D Garage and UST AOC	Arsenic	1.59E-05	2.45E-05	4.88E-04	8.00E-04	1.40E-02

.

Table 6. Current and Future Theoretical Cancer Risks from Incidental Soil Ingestion

Area	Contaminant of Potential Concern	Current and Future Trespasser Theoretical Cancer Risks	Future Construction Worker Theoretical Cancer Risks	Future Industrial Worker Theoretical Cancer Risks
SWMU 7	Arsenic	**1.05E-04**	1.97E-05	**4.07E-04**
SWMU 15	Arsenic	7.03E-07	3.26E-07	2.72E-06
SWMU 23A	2,4-DNT	3.36E-05	1.72E-05	**1.30E-04**
SWMU 23C	2,4-DNT	**8.13 E-05**	4.15E-05	**3.14E-04**
SWMU 36	Arsenic	**1.98E-04**	**8.14E-05**	**7.66E-04**
S&D Garage AOC	Arsenic	3.40E-06	1.04E-05	1.31E-05
	Tetrachloroethylene	N/a	1.17E-06	N/a

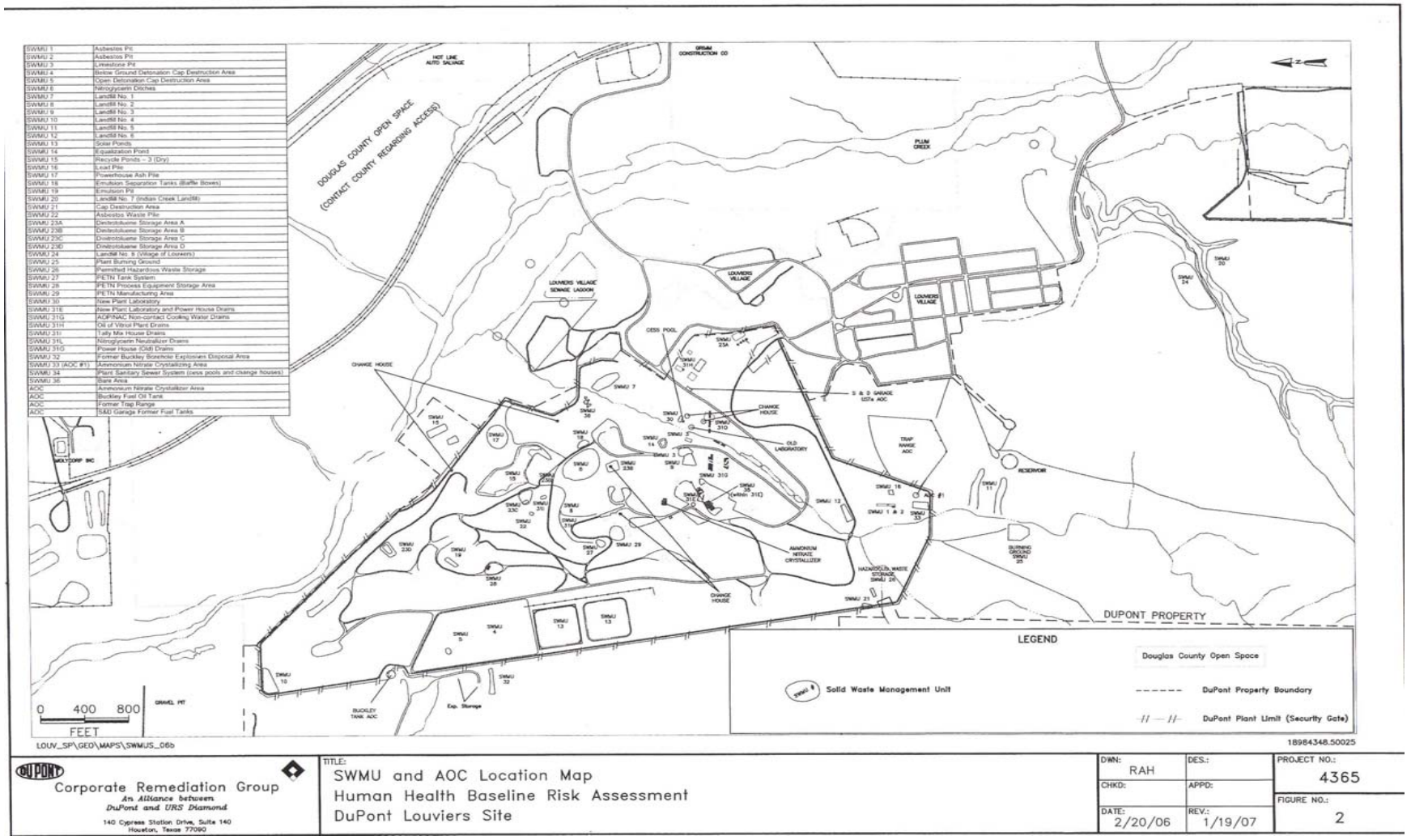
Notes : Bolded value exceeds the acceptable cancer risk range

Figures

Figure 1. DuPont-Louviers Site Location Map

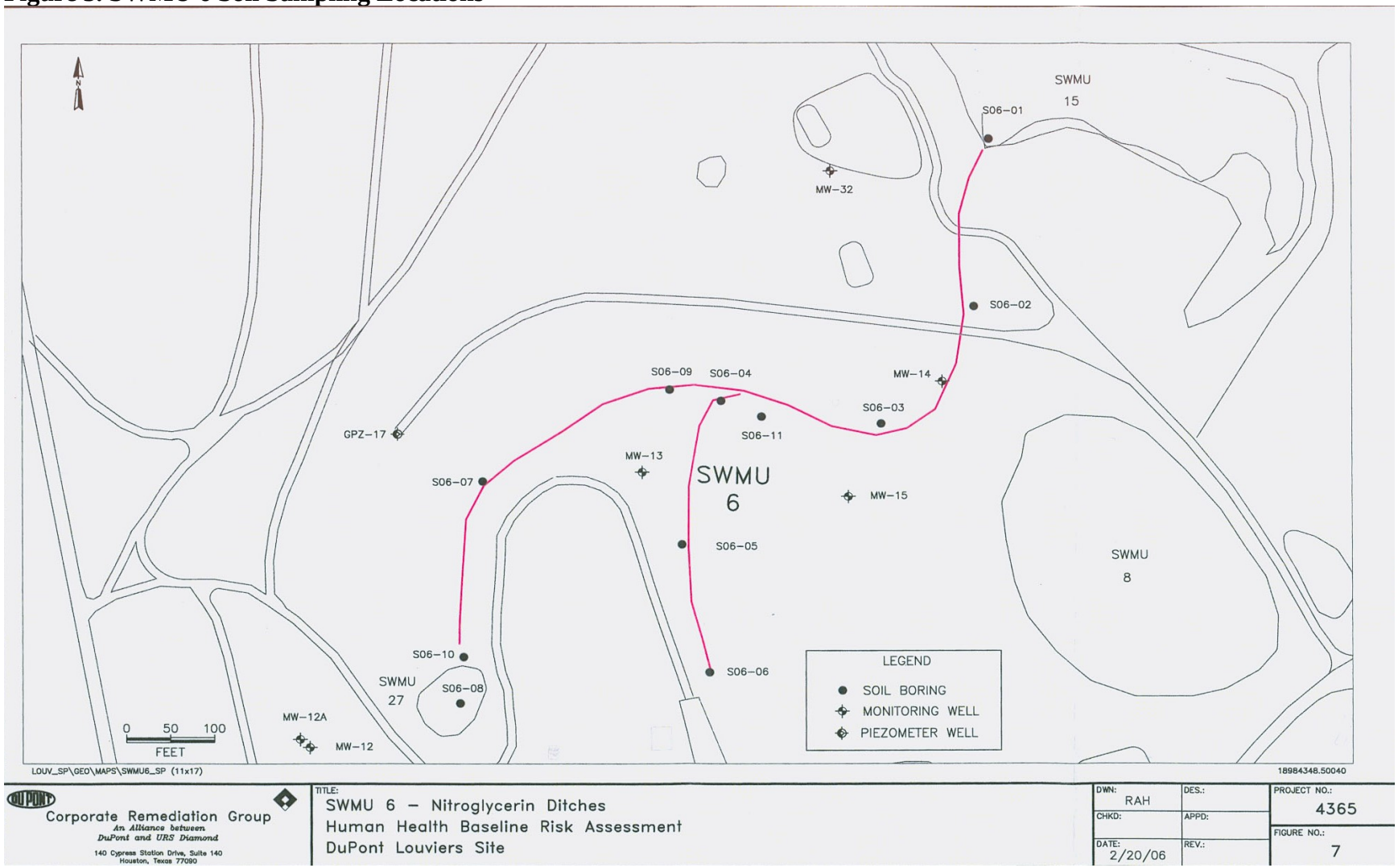
SOURCE: Google Earth

Figure 2. SWMU and AOC Locations on the DuPont-Louviers Site



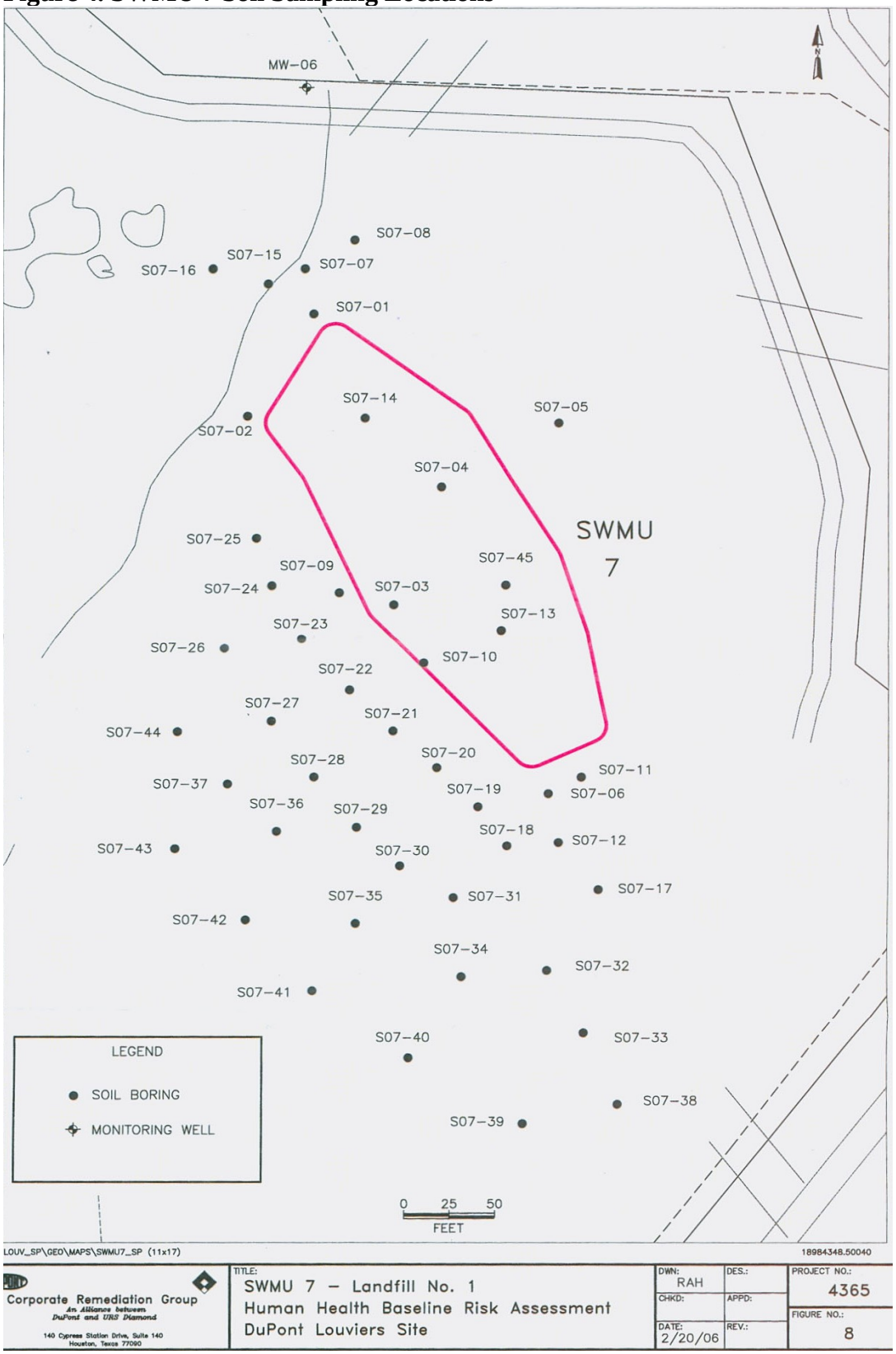
SOURCE: DuPont HHRA 2008

Figure 3. SWMU 6 Soil Sampling Locations



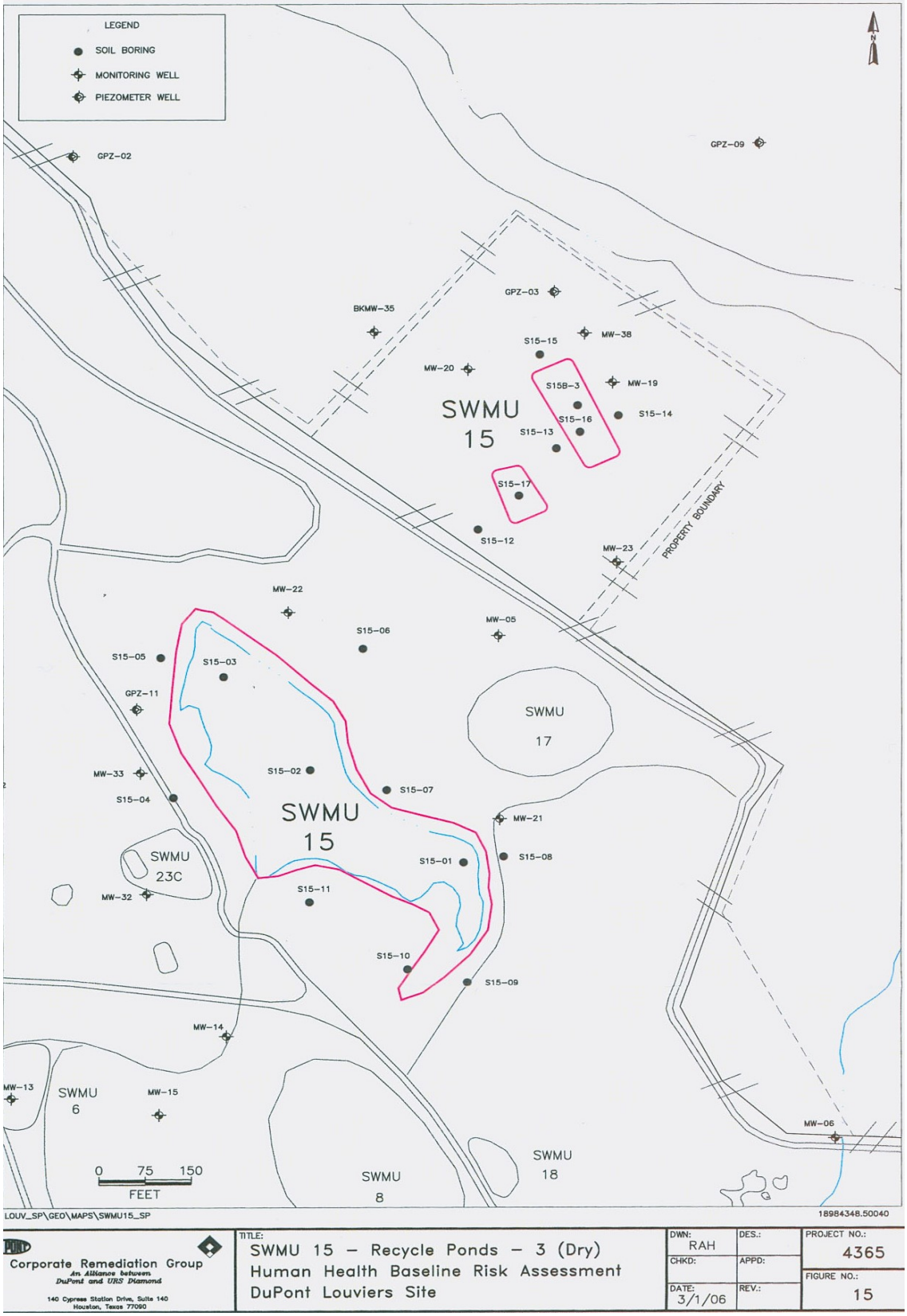
SOURCE: DuPont HHRA 2008

Figure 4. SWMU 7 Soil Sampling Locations



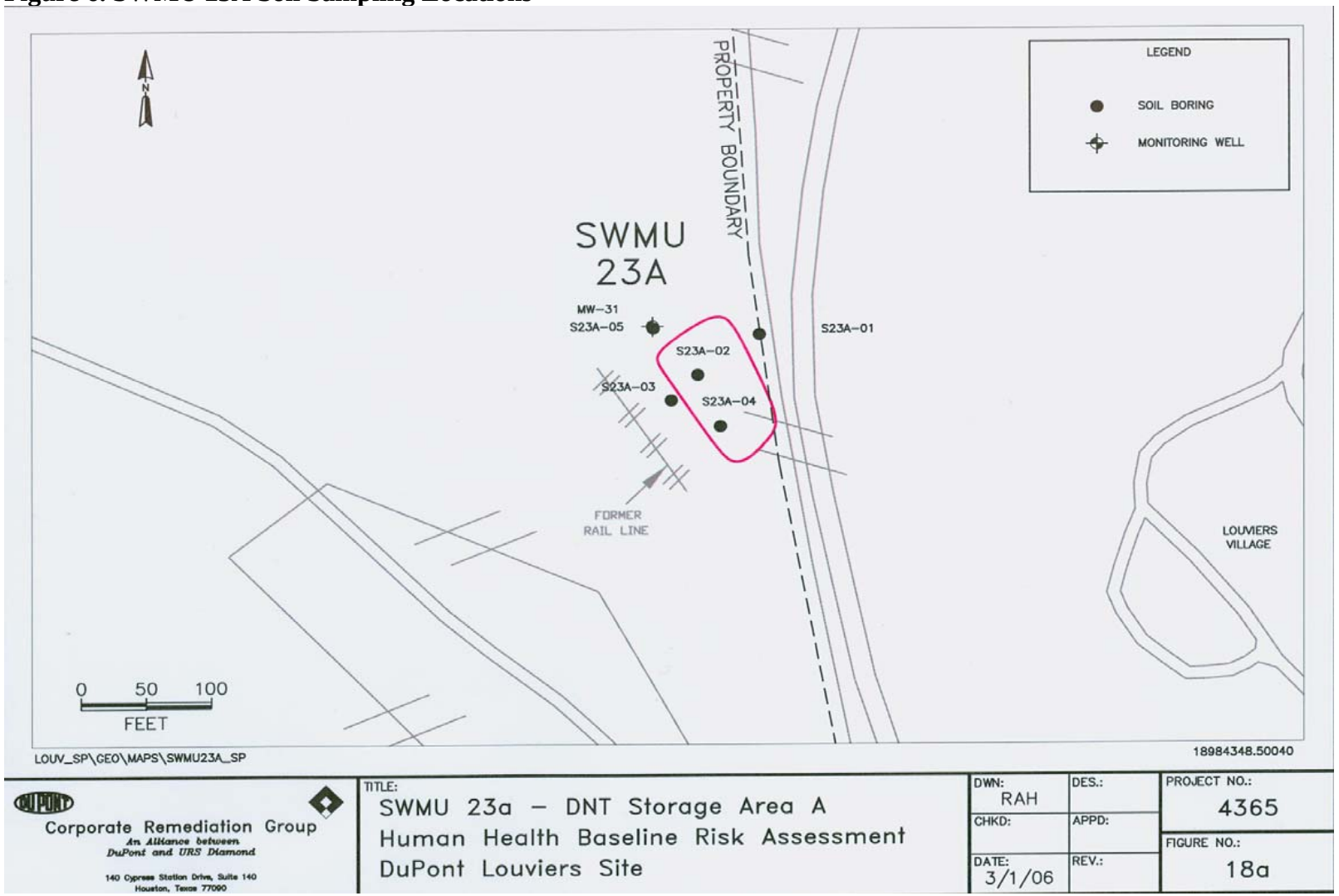
SOURCE: DuPont HHRA 2008

Figure 5. SWMU 15 Soil Sampling Locations



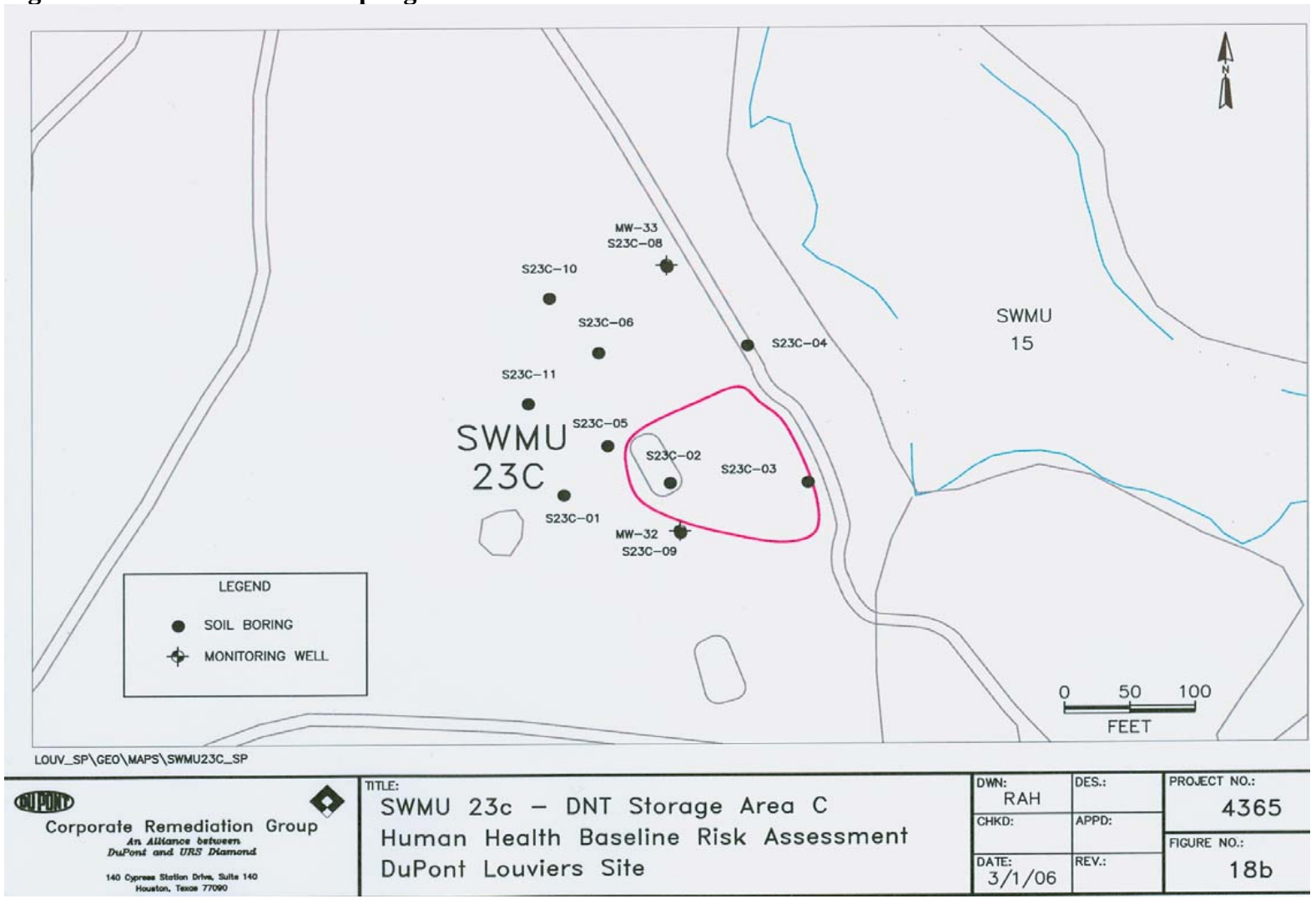
SOURCE: DuPont HHRA 2008

Figure 6. SWMU 23A Soil Sampling Locations



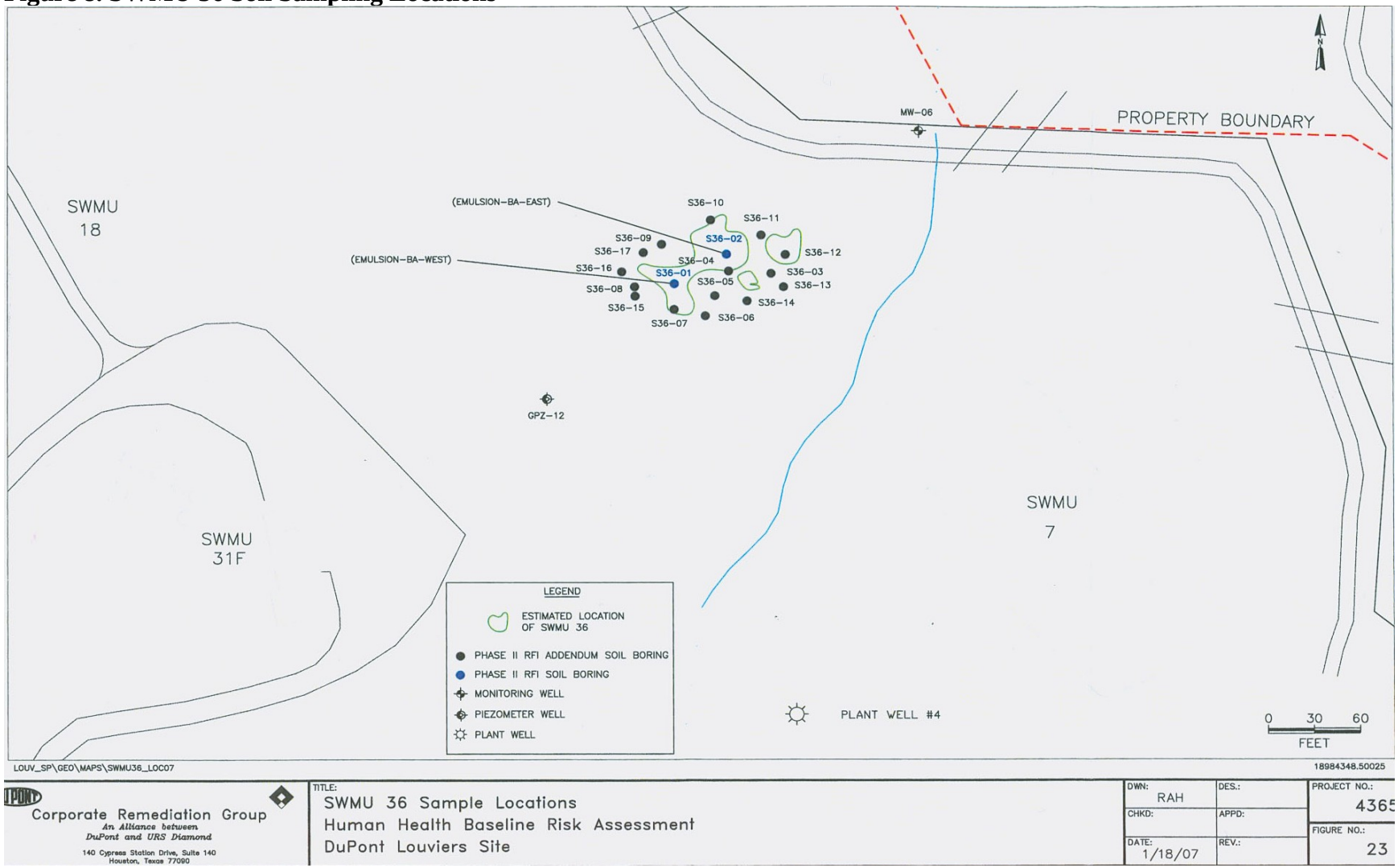
SOURCE: DuPont HHRA 2008

Figure 7. SWMU 23C Soil Sampling Locations



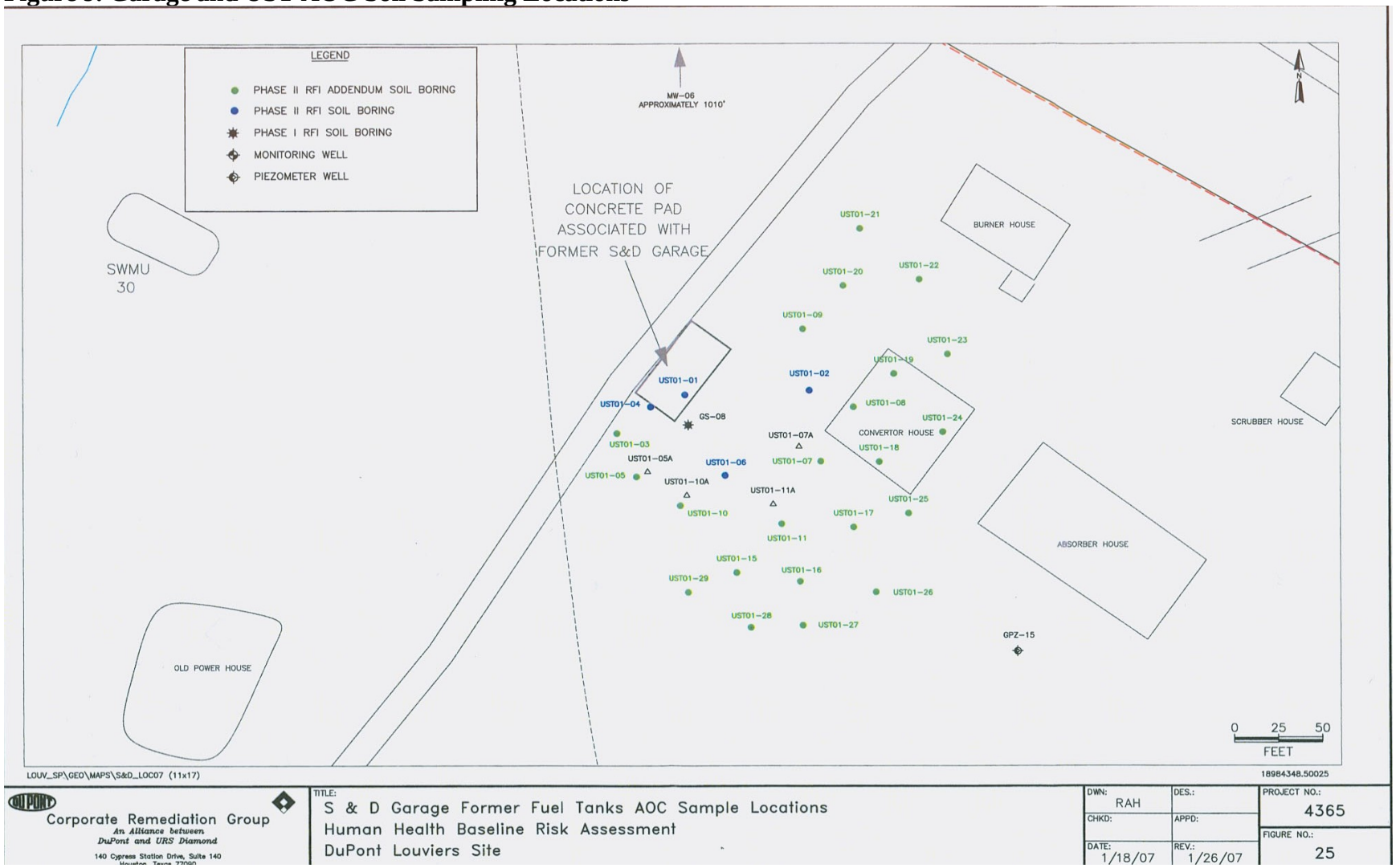
SOURCE: DuPont HHRA 2008

Figure 8. SWMU 36 Soil Sampling Locations



SOURCE: DuPont HHRA 2008

Figure 9. Garage and UST AOC Soil Sampling Locations



SOURCE: DuPont HHRA 2008

Appendix A. Additional Exposure Assessment Information

The first step to determine if adverse health effects are likely to occur from exposure to contamination found at the DuPont-Louviers site is to estimate exposure doses for each group of people that are likely to come into contact with site-related contamination. The estimated exposure doses are designed to be conservative estimations of actual contaminant intake, accounting for the majority of potential exposures at the site. As mentioned previously in the document, exposure doses are only estimated for Contaminants of Potential Concern, which have exceeded the comparison values (CVs) since the contaminants with concentrations below the CV are not likely to result in adverse health effects. Estimating the exposure dose requires assumptions to made regarding various exposure parameters such as the frequency of a particular activity, duration of exposure to site-related contamination, and the amount of a particular substance that is taken in by an individual during a given activity. Site-specific exposure information is always preferable when estimating exposure doses. In lieu of site-specific information, default exposure parameters that are established by the EPA and ATSDR are used in the exposure dose estimation. At times, professional judgment is used when default values are not available or seem unreasonable for the site exposures.

Three primary receptors were identified in this evaluation that are likely to come into contact with site-related contamination now or in the future: current/future trespassers, future industrial workers, and future construction workers. The major exposure factors used for each receptor are listed below in Table A1.

Table A1. Exposure Factors

Receptor	Body Weight (BW)	Exposure Frequency (EF)	Exposure Duration (ED)	Soil Ingestion Rate (IRS)	Averaging Time$_{Cancer}$ (AT$_{Cancer}$)
Trespassers (7-16 years)	45 kg.	52 days per year	10 years	200 mg. per day	25550 days
Construction Workers	70 kg.	250 days per year	1 year	330 mg. per day	25550 days
Industrial Worker	70 kg.	250 days per year	25 years	100 mg. per day	25550 days

Notes:
kg. = kilogram
mg. = milligram

Another critical component of the exposure dose estimation is the concentrations of chemicals that individuals are likely to be exposed to in a particular medium or the Exposure Point Concentration (EPC). The EPA has established guidelines for determining the EPC. In Region 8, if there are less than 10 samples available for a contaminant, the maximum detected concentration is used as the EPC since very little is known about the actual concentration in a particular medium and area. In situations where there are more than 10 samples for an analyte, the available data is inserted into a statistical software package designed to calculate EPCs called ProUCL. Generally

speaking, the resulting EPC is the 95% Upper Confidence Limit (UCL) on the mean (average) concentration assuming a normal distribution of the data. In this evaluation, the EPC for construction workers is different from the other receptors because it was assumed that construction workers could also be exposed to soil up to 15 feet in depth. Thus, the data from all depth intervals (up to 15 ft.) was combined for the EPC calculation for construction workers. Data from the 0-2 foot depth interval was used in the EPC calculation for current and future trespassers as well as future industrial workers. The EPCs used in this evaluation are presented in Table A2 below along with the method used to determine the value.

Table A2. Soil COPC Exposure Point Concentrations and Statistical Methods

Area of Investigation	Contaminant of Potential Concern	Receptor	Exposure Point Concentration	Recommended ProUCL 4.0 Statistical Method
SWMU 7	Arsenic	Trespasser & Industrial Worker	776.2	99% KM UCL (Chebyshev)
		Construction Worker	284.4	97.5% KM UCL (Chebyshev)
SWMU 15	Arsenic	Trespasser & Industrial Worker	5.18	95% Approximate Gamma UCL
		Construction Worker	4.71	95% Approximate Gamma UCL
SWMU 23A	2,4-Dinitrotoluene	All	1,200	Maximum Detected Value (n < 10 samples)
	2,6-Dinitrotoluene	All	760	Maximum Detected Value (n < 10 samples)
SWMU 23C	2,4-Dinitrotoluene	All	2,900	Maximum Detected Value (n < 10 samples)
SWMU 36	Arsenic	Trespasser & Industrial Worker	1,462	95% Adjusted Gamma UCL
		Construction Worker	1,177	99% KM UCL (Chebyshev)
	Lead	Trespasser & Industrial Worker	16,594 (130,000)	Mean (Recommended UCL Value Exceeds Max)
		Construction Worker	5,554 (43,924)	Mean (99% Chebyshev UCL (Mean, Sd)
	Arsenic	Trespasser & Industrial Worker	25.05	95% KM UCL (Chebyshev)
		Construction Worker	151	97.5% KM UCL (Chebyshev)

S&D Garage and UST AOC	Tetrachloroethene	Construction Worker	46.94	99% KM UCL (Chebyshev)

* ProUCL 4.0 recommended statistical method used to calculate EPC

Non-cancer and cancer health endpoints are evaluated differently so the estimation of exposure dose also differs slightly (non-cancer doses are averaged over the timeframe of exposure and cancer doses are averaged over a lifetime). The exposure dose equations used in this evaluation are presented below.

Non-Cancer Surface Soil Ingestion Dose

Non-cancer Dose = $\mathbf{(C_s * IRS * EF * CF) / BW}$

Where: $\mathbf{EF = (F * ED) / AT_{non\text{-}cancer}}$

Age-Adjusted Soil Ingestion Cancer Dose

Cancer Dose = $\mathbf{(C_s * IRS * CF * EF) / BW}$

Where: $\mathbf{EF = (F * ED) / AT_{cancer}}$

The estimated exposure dose results for this evaluation are shown below in Tables A3 and A4.

Table A3. Current and Future Estimated Non-cancer Exposure Doses from Incidental Soil Ingestion

Area	Contaminant of Potential Concern	Current and Future Trespasser Non-cancer Exposure Doses	Future Industrial Worker Non-cancer Exposure Doses	Future Construction Worker Non-cancer Exposure Doses	Health-based Guideline
SWMU 7	Arsenic	**4.91E-04**	**7.59E-04**	**9.18E-04**	3.00E-04
SWMU 15	Arsenic	3.28E-06	5.07E-06	1.52E-05	3.00E-04
SWMU 23A	2,4-DNT	7.60E-04	1.17E-03	**3.87E-03**	2.00E-03
	2,6-DNT	4.81E-04	7.44E-04	**2.45E-03**	1.00E-03
SWMU 23C	2,4-DNT	1.84E-03	**2.84E-03**	**9.36E-03**	2.00E-03
SWMU 36	Arsenic	**9.26E-04**	**1.43E-03**	**3.80E-03**	3.00E-04
S&D Garage and UST AOC	Arsenic	1.59E-05	2.45E-05	**4.88E-04**	3.00E-04
	Tetrachloroethene	N/a	N/a	1.52E-04	1.00E-02

Notes : Bolded values indicate that estimated dose exceeds health-based guideline

Table A4. Current and Future Estimated Cancer Exposure Doses from Incidental Soil Ingestion

Area	Contaminant of Potential Concern	Current and Future Trespasser Cancer Exposure Doses	Future Industrial Worker Cancer Exposure Doses	Future Construction Worker Cancer Exposure Doses
SWMU 7	Arsenic	7.02E-05	2.71E-04	1.31E-05
SWMU 15	Arsenic	4.69E-07	1.81E-06	2.17E-07
SWMU 23A	2,4-DNT	1.09E-04	4.19E-04	5.54E-05
SWMU 23C	2,4-DNT	2.62E-04	1.01E-03	1.34E-04
SWMU 36	Arsenic	1.32E-04	5.11E-04	5.43E-05
S&D Garage and UST AOC	Arsenic	2.27E-06	8.75E-06	6.97E-06
	Tetrachloroethene	N/a	N/a	2.17E-06

Appendix B. Toxicological Evaluation

The basic objective of a toxicological evaluation is to identify what adverse health effects a chemical causes, and how the appearance of these adverse effects depends on dose. The toxic effects of a chemical also depend on the route of exposure (oral, inhalation, dermal), the duration of exposure (acute, subchronic, chronic or lifetime), the health condition of the person, the nutritional status of the person, and the life style and family traits of the person. In this evaluation, chronic oral exposures were evaluated.

The major contaminants of concern identified in this consultation include arsenic, 2,4-DNT, and lead. It is important to note that estimates of human health risks may be based on evidence of health effects in humans and/or animals depending upon the availability of scientific data. The toxicity assessment process is usually divided into two parts: non-cancer health effects and cancer health effects of a chemical. The cancer health effects are only evaluated for known or likely human carcinogens by route of exposure. This evaluation quantitatively addresses chronic non-cancer health hazards for antimony and arsenic and qualitatively addresses chronic non-cancer health effects of lead. The only oral carcinogen that was considered a Contaminant of Potential Concern is arsenic.

Arsenic is a metal that occurs naturally in the environment. Exposure to high levels of arsenic may cause non-cancer nausea, vomiting, diarrhea, abnormal heart rhythm, blood vessel damage, or a pins and needle sensation in hands and feet. Long-term exposure to low levels of arsenic may lead to a darkening of the skin and the appearance of small corns or warts on the palms, soles, and torso. Ingesting sufficient amount of arsenic also has been reported to increase the risk of developing cancer in the liver, bladder, kidneys, and lungs (ATSDR, 2007a). Arsenic is classified as a Class 1 carcinogen by the U.S. Department of Health and Human Service's National Toxicology Program, which indicates that arsenic is a known human carcinogen. For additional health effect information on arsenic, refer to ATSDR's Toxicological Profile at: http://www.atsdr.cdc.gov/toxprofiles/tp2.html.

2,4-Dinitrotoluene is an organic compound formed by reacting toluene with nitric and sulfuric acids. 2,4-DNT is used in the manufacture of polyurethane foams, ammunition, explosives, and dyes. No solid human health effect data is currently available on 2,4-DNT. However, some evidence suggests that exposure to 2,4-DNT may result in neurological, cardiovascular, and hematological adverse health effects in humans. Animal data also supports these health effects as well as kidney and liver damage. The IARC has determined that 2,4-DNT is possibly carcinogenic to humans. For additional health effect information on 2,4-DNT, refer to the ATSDR's Toxicological Profile at: http://www.atsdr.cdc.gov/toxprofiles/tp109.html.

Lead is a naturally occurring element typically found at low levels in soil. However, lead is ubiquitous in the environment as a result of various industrial operations and activities that utilize and/or introduce lead into the environment. The main target organ of non-cancer toxicity of lead is the neurological system. In adults and children who have been exposed to high amounts of lead, non-cancer adverse health effects such as decreases in

neurologic function and mental capacity have occurred. However, young children (0-7 years) and developing fetuses appear to be the most sensitive to the toxic effects of lead. Lead is generally considered a probable human carcinogen by leading health authorities. For additional health effect information on lead, refer to ATSDR's Toxicological Profile at: http://www.atsdr.cdc.gov/toxprofiles/phs13.html.

The USEPA and the ATSDR have established oral reference doses (RfD) and minimal risk levels (MRL) for non-cancer effects. An RfD is the daily dose in humans (with uncertainty spanning perhaps an order of magnitude), including sensitive subpopulations, that is likely to be without an appreciable risk of non-cancer adverse health effects during a lifetime of exposure to a particular contaminated substance. An MRL is the dose of a compound that is an estimate of daily human exposure that is likely to be without an appreciable risk of adverse non-cancer effects of a specified duration of exposure. The acute, intermediate, and chronic MRLs address exposures of 14 days or less, 14 days to 365 days, and 1-year to lifetime, respectively. The health-based guidelines for the contaminants of potential concern for this evaluation are listed below.

Table B1. Oral Health-based Guidelines for the contaminants of potential concern

Contaminant	Health-based Guideline (mg/kg-day)	Source
2,4-DNT	0.002	EPA IRIS Chronic RfD
2,6-DNT	0.001	EPA PPRTV
Arsenic	0.0003	ATSDR Chronic MRL
Tetrachloroethene	0.01	EPA IRIS Chronic RfD

EPA IRIS: Chronic oral reference doses (RfDs) from EPA Integrated Risk Information System
ATSDR MRL: Chronic Minimal Risk Level from ATSDR Toxicological Profile

Table B2. Oral Health Effect Levels for soil contaminants of potential concern

Contaminant	NOAEL (mg/kg-day)	LOAEL (mg/kg-day)	Source
2,4-DNT	0.2	1.5	EPA IRIS Chronic RfD
2,6-DNT	4.0	N/a	EPA PPRTV
Arsenic	0.0008	0.014	ATSDR Chronic MRL

NOAEL: No Observable Adverse Health Effect Level
LOAEL: Lowest Observable Adverse Health Effect Level
NA: Not available

Table B3. Oral Cancer Slope Factors

Contaminant	Oral Cancer Slope Factor ($mg/kg\text{-}day^{-1}$)	Source
Arsenic	1.5	EPA IRIS
2,4-DNT	0.31	Cal EPA

CERTIFICATION

This DuPont-Louviers Health Consultation was prepared by the Colorado Department of Public Health and Environment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun. Editorial review was completed by the Cooperative Agreement partner.

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

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