SUPPLEMENTAL SCOPE OF STUDY
FORMER NEW HAVEN WATER COMPANY PROPERTY
HAMDEN, CONNECTICUT

1.0 INTRODUCTION

This Supplemental Scope of Study was prepared by Leggette, Brashears & Graham, Inc. (LBG) on behalf of the South Central Connecticut Regional Water Authority (RWA). The Supplemental Scope of Study has been prepared to address data gaps identified in documents below and to satisfy paragraph B.3.b of the Connecticut Department of Environmental Protection (CTDEP) Consent Order SRD-128.

- "Phase III Environmental Site Investigation, Former New Haven Water Company Property, Hamden, Connecticut" dated December 2002, prepared by LBG on behalf of RWA;
- "Addendum to December 2002 "Phase III Environmental Site Investigation, Former Hew Haven Water Company Property, Hamden, Connecticut" Consent Order No. SRD-128" dated October 3, 2003, prepared by LBG on behalf of RWA; and
- CTDEP letter "Comments on Phase III Environmental Site Investigation, Former New Haven Water Company Property, Hamden, Connecticut, Consent Order No. SRD-128" dated March 8, 2004

CTDEP issued Order No. SRD-128 on July 10, 2001 to Town of Hamden, RWA, Olin Corporation and the State Board of Education. The order required that respondents investigate and remediate sources of pollution on a "Site" situated in Hamden, Connecticut and known as the Hamden Middle School, Newhall Street School/also known as Hamden Community Center, two Hamden Housing Authority Properties on Morse Street, Rochford Field, Mill Rock Park/also known as Rochford Field Annex and the sewage pump station, located at 1099 Winchester Avenue, Hamden ("the Public Properties") and certain privately owned properties in the vicinity of the Public Properties, where wetlands formerly existed or where waste materials were historically placed. This area is shown as exhibit 1 in attached Consent Order SRD-128 (Appendix I). The order was appealed by all parties, which resulted in the consent order SRD-128 (same number as original order) being accepted as final decision on April 16, 2003.

As part of this order, the "site" was divided three separate areas. This Supplemental Scope of Study focuses on areas identified as Hamden Middle School, athletic field, a portion of the Newhall Community Center and two residential properties (251-253 Morse Street and 253-255 Morse Street) which were formerly owned by the New Haven Water Company (NHWC). These areas are referenced as the "Middle School Site" and are shown on figure 1 and 2. Note that the aforementioned two residential properties are owned by the Hamden Housing Authority.

The December 2002 "Phase III Environmental Site Investigation, Former New Haven Water Company Property, Hamden, Connecticut" is referenced in this Supplemental Scope of Study and hereby should be considered part of this plan. This report is on file with the CTDEP, available at local repositories set up in Hamden (Miller Library and Town Hall) and available on the internet at the below web address:
http://www.newhallinfo.org/

2.0 REGULATORY ISSUES

The primary focus of this Supplemental Scope of Study is to fully characterize the extent and degree of soil, surface water, and ground-water pollution at the Middle School Site. In addition, the Supplemental Scope of Study presents plans to investigate halogenated volatile organic compound (VOC) impacted ground water that is flowing off of the Middle School Site. As part of determining the extent of pollution, the Supplemental Scope of Study also evaluates the extent of contaminants in various media with respect to the CTDEP RSRs. The current ground-water classification beneath the site is GAA-impaired. For GAA-impaired areas, the following criteria in the RSRs apply. As requested by the CTDEP, all investigations incorporate the CTDEP's Proposed Revisions to Volatilization Criteria dated March 2003.

2.1 Soils

Direct Exposure Criteria (DEC): The residential DEC is applicable to the top 15 feet of material at the site.

Pollutant Mobility Criteria (PMC): The GA PMC apply to soils above the seasonal low water table. For all parameters except metals, the listed criteria are based on total (mass) concentrations of the parameter in the soil. For metals and polychlorinated biphenyls (PCBs), the remediation criteria is based on the results of a leaching test, typically the synthetic precipitation leaching procedure (SPLP). For the other parameters, SPLP analyses can also be run and compared to GA ground-water protection criteria (GWPC); however, the total concentrations are usually determined first.

2.2 Ground Water

Ground-Water Protection Criteria: The GWPC apply to ground water beneath the site, and are generally consistent with drinking water standards.

Surface Water Protection Criteria (SWPC): The SWPC apply to ground water prior to it discharging into a surface-water body.

Proposed Residential Volatilization Criteria (RVC): The RVC apply to VOC concentrations in ground water within 30 feet of the ground surface. Compliance of RVC can also be met with analysis of VOCs in soil-vapor beneath a building. Compliance with the RVC for soil vapor may also be met through interior air sampling.

2.3 Alternatives

For all of the criteria listed above, there are numerous exemptions and alternative criteria that can be applied. The only alternative presented in the Conceptual Site Model (CSM) is self-implementing option (RCSA Section 22a-133k-2(c)(2)(C)) of the CTDEP RSRs. This alternative indicates:

For soils contaminated with metals, SVOCs PCBs and pesticides, the mass analysis may be compared 10 times the GA PMC or SPLP analysis may be compared to 10 times the GWPC if the following conditions are met: 1) the release area is within 25 feet from the nearest legal boundary; 2) no non-aqueous phase liquids are present; and 3) the water-table is at least 15 feet above the surface of the bedrock. All of the aforementioned conditions are met at the site and this option is self implementing, except that this option as stated is not available to any contaminant identified in a 25-foot boundary along the downgradient property boundary.

3.0 CONCEPTUAL SITE MODEL

3.1 Statement of the Problem

Environmental investigations completed at the Middle School Site document the historic filling of this former wetland area. The sources of fill have been documented to consist of industrial waste, general construction debris and municipal/domestic waste. The lateral and vertical extent and primary make up of the bulk fill has been substantially documented during a 2002 Environmental Site Investigation (ESI). A surficial cap was placed over the fill in the athletic field during 1995 and 1996. In addition, several emergency remedial measures were completed by the CTDEP to cover exposed fill on the remainder of the site.

According to CTDEP Consent Order SRD-128, RWA shall complete the investigation and remediation of the Middle School Site. Pursuant to the consent order, investigations shall "determine the extent and degree of soil, surface water and ground water pollution resulting from the disposal of waste materials at the Site" (paragraph B.3.b.(1) of Consent Order No. SRD-128). As referenced in the aforementioned statement, this investigation is not required to characterize any contaminate which are the result of potential releases related to the operation of the onsite fuel oil underground storage tank (UST), associated UST piping, storm-water drainage system, structural and/or operation of the school or the soil cap placed on the athletic field. Note that while the investigation of the sources potentially related to the operation of the school are not a focus of the Supplemental Scope of Study, many of the features are characterized through the investigation of the waste disposed of onsite. While extensive environmental investigation have been completed to characterize the waste materials at the Middle School Site and the resultant contamination to ground water, surface water and underlying soils, several data gaps remain. These general data gaps include:

1) Further definition of the extent of waste materials;
2) Determination if bulk material (i.e., drums) are present in the waste fill;
3) Additional characterization of fill (northern berm and beneath tenniks and basketball courts)
4) Characterization of halogenated VOC source area and resulting ground-water and potential surface water pollution;
5) Characterization of polychlorinated biphenyl (PCB) source area and potential impacts to ground water;

6) Surface-water quality;

7) Quality of surficial material at the athletic field not covered by the soil cap;

8) Further evaluation of ETPH in ground water; and

9) Further refinement of ground-water flow direction.

3.2 Evaluation of Existing Data

3.2.1 Physical Description

The approximate 23.9 acre Middle School Site (figure 1 and 2) consists of the following parcels:

- Hamden Middle School which is located at 550- 560 Newhall Street in Hamden Connecticut;
- The northern and western portion of the Hamden Community Center. This property is located at located at 496 Newhall Street in Hamden, Connecticut; and
- Two residential properties located at 251-253 Morse Street and 253-255 Morse Street in Hamden, Connecticut.

The Hamden Middle School consists of four interconnected brick and steel buildings which were constructed in 1956. Note that the southern middle school building is partially located on the Hamden Community Center property. Asphalt pavement covers portions of the property located to the east, north and east of the building. Entrance to the site is obtained from one of access ways located on Newhall Street. Tennis and basketball courts and several soccer fields (referenced as the Athletic Field) are located on the western portion of the property. The property does maintain one 10,000-gallon fuel UST which is located beneath a paved area on the west central portion of the property. As stated above, the investigation of the UST and associated piping are not part of this Supplemental Scope of Study. The topography of the property ranges from 42 to 61 feet high sea level. The topography east of the middle school building slopes moderately downward to the east and northeast. The topography on the athletic field and western paved parking area is generally flat. A relatively steep raise in grade elevation of approximately 3 to 6 feet occurs on the southern property line in which the athletic field abuts the Morse Street Parcels. This berm is shown along all southerly abutting residential parcels except 251-253 Morse Street and 253-255 Morse Street (Hamden Housing Authority owned properties). A berm is also shown on the north-central portion of the property, near the wetland corridor. As expected, the wetland corridor, which is located north of this property, is at a lower elevation than the northern edge of the property.

As shown on figure 1, the portion of the Hamden Community Center located on the Middle School Site consists of paved and grass areas and portion of the northern rectangular brick building. This structure was reportedly constructed in 1917 (ref. 1). This facility does maintain a 6,000-gallon fuel oil UST, however, it is located to the south of the Middle School Site. Access to this parcel is obtained from a paved asphalt entrance along Morse Street. A moderate downward slope to the east and north is located on the eastern portion of this parcel. A moderate downward slope to the north and northwest is shown on the northern portion of this parcel, while the southwestern portion of the parcel (parking and entrance area) is generally flat.

The approximate 1.4 acre residential parcels are located at 251-253 Morse Street and 253-255 Morse Street. These parcels consists of two residential structures, asphalt paved areas and open grass areas. A steel chain link fence surrounds the parcels. Asphalt paved entrances lead onto the parcels from Morse Street while an asphalt paved area is located on the northern portion of the parcels. The topography moderately slopes downward from the south to the north.

3.2.2 Background

The Middle School Site is located in an area formerly known as the Highwood District. As with much of the Highwood District, most of the Middle School Site was filled during the development of the area. The filling of the Highwood District, and specifically Middle School Site, occurred over a long period of time, and consisted of several different filling events.

From the 1970s through 1990s, several environmental investigations were completed by the United States Environmental Protection Agency (USEPA) and CTDEP at the Hamden Middle School property. Remedies to address environmental concerns identified by these agencies were implemented in 1995 and 1996 by the Town of Hamden. Preliminary environmental work completed for the expansion of the Middle School in 2000 created a renewed environmental awareness with the CTDEP of the historic waste present at the school.

Excluding the approximate 1.4-acre parcel consisting of 249-251 Morse Street and 253-255 Morse Street (Hamden Housing Authority owned properties) and a portion of the Newhall Community Center, NHWC acquired the Middle School Site in 1900. NHWC sold an approximate 1.4 acre rectangular parcel located on the southeast portion of the Middle School

Site to the Town of Hamden in 1924, while NHWC acquired the approximate 1 acre rectangular parcel that included the Hamden Housing Authority owned residential properties (249-251 Morse Street and 253-255 Morse Street). In 1947, NHWC sold approximately 6.2 acres of land to the Town of Hamden. This parcel abuts the community center, Newhall Street and Mill Rock Extension. NHWC sold the remaining portion of the Middle School Site to the Town of Hamden in 1950.

A summary of the environmental investigations completed at the Middle School Site and the historic filling and development of the Middle School Site and surrounding area is presented below. The summary of the historic filling and growth of the Highwood District was developed through review of historical maps, aerial photographs, materials available at Hamden Town Hall (aerial photographs, Sanborn maps, annual reports, tax assessor cards, etc. (ref. 2)), maps and literature reviewed at the Miller Historic Room in Town of Hamden Library, historic NHWC documents, Town of Hamden Sanitation Inspector Reports and communications provided by the CTDEP. Note that the CTDEP has requested that anecdotal information be included in the development of the CSM. LBG believes the information presented below reflect pertinent anecdotal information which was identified during the review of historical information. If there is specific anecdotal information missing from the description below that CTDEP believes is critical to the CSM, we would request the missing information be conveyed to LBG and RWA. Note that a description of regional and Middle School Site filling/development is discussed below. The history of the regional filling is pertinent because it presents potential sources and content of fill at the Middle School Site.

3.2.2.1 Filling and Development Summary of Middle School Site and Surrounding Area

The Highwood District area was settled in at least 1850. The 1850 map, located in Appendix II, shows this area to be sparsely developed with a stream extending from the wetlands that currently end on the northern boundary of the Hamden Middle School property. Historical maps presented in Appendix II show the 1850 stream located on the northeast portion of the Hamden Middle School property, extending through future locations of Rochford Field and Mill Rock Park and ending near the westerly edge of Prospect Court (figure 11 of Appendix II).

Moderate development was shown in the Highwood District from the mid to late 1800s (figures 1 through 3 of Appendix II). During the turn of the century, the area was utilized for farming (ref. 3). The United States Geological Survey (USGS) 1892 New Haven, Connecticut Quadrangle Map (Appendix II) shows a greater density of roads present, which more closely mirror the present road system of the area.

Wetlands remained a prominent feature in the Highwood District and their presence represented a significant breeding ground for mosquitoes (ref. 4). The large populations of mosquitoes in the area were identified as a contributing factor to an 1891 epidemic of malaria in the Town (ref. 4). During this period and through the turn of the century, the Highwood District was a disposal area for trash brought in from New Haven (ref. 3 and 5). This garbage was reportedly fed to swine (ref. 5). The dumping created a significant nuisance in the area; the odor of the garbage was noted to create a stench a mile in every direction of the disposal area. In addition to the dumping areas, sewage in this farming community was utilized as fertilizer (ref. 3). The dumping in the area continued through 1909 (ref. 6). To alleviate the disposal problems, the Town of Hamden Health Officer, along with several others, informed the New Haven Board of Health that due to numerous complaints concerning the disposal of garbage in the Town, no licenses would be issued after June 1, 1909. The 1909 Hamden Annual Report indicates that only two collectors were known to be bringing garbage into the town and those cases were to be dealt with (ref. 6).

Development of the Highwood District continued at a rapid pace through the early 1900s (ref. 7). In 1913, a section of Newhall Street between Auger and Morse Streets was hardened, with a sidewalk constructed along the west side (ref. 8). A 1914 map (figures 5 and 6 of Appendix II) of the area shows an increased density of dwellings. The map also shows areas of vegetation present on the northern side of Morse Street, approximately between Shelton Avenue and Wadsworth Street (figure 11 of Appendix II).

A moderate epidemic of typhoid fever occurred in the Highwood District in 1912 (ref. 8). To avoid the epidemic in 1913, the health officer distributed notices to every home in the Highwood District notifying them how to control the disease. The notice indicated that flies spread the disease and that they should be controlled by cleaning out privy vaults before hot weather arrives and should be regularly spreading ashes, crude carbolic acid and chloride of lime on it. Mosquitoes were also a problem of the area; the Hamden Health Officer reported in the 1913 Hamden Annual Report that he would try to have swamps near Newhall Street, Auger Street and Putnam Avenue drained and opened to sunlight (ref. 8).

During 1915, the State of Connecticut took an active role in controlling the mosquito population in the state by passing Chapter 264 of Public Acts of 1915. The legislation placed the problem of mosquito extermination in the hands of the Directors of The Connecticut Agriculture Experiment Station giving almost unlimited powers to carry on surveys and field work, ditching, etc.; however, the legislation failed to provide funds for the act (ref. 9). During this time, the mosquito population remained a concern of town officials for the area.

In 1915, when Town officials learned of Winchester Repeating Arms looking for dump sites for the "rejected industrial refuse and the thousands of tons of clean cinders from the furnaces in the factories", the Town gave permission for the company to fill in a marshy tract near Goodrich Street and Saint Mary Street. The area was reported to have been filled in a period of a few years (ref. 4).

The Town of Hamden Health Officer proposed in 1915 to establish Town public dumping areas under the control of Town officials and requested citizens to report infringements of the ordinance pertaining to the dumping (ref. 9). The 1916 Hamden Annual Report indicates that strives were made with respect to mosquito control by filling an area near the corner of Saint Mary and Morse Streets (figure 6 of Appendix II). Also in 1916, the NHWC and Winchester Repeating Arms were engaged in eliminating the largest single malaria swamp breeding grounds in the Town of Hamden by draining a large tract of land. The location of the tract of land was not identified in the annual report (ref. 10).

During 1917, the Town of Hamden maintained a dump in the Highwood District area (ref. 11) which was located on Shelton Avenue between Morse and Goodrich Streets (figure 11 of Appendix II). Also in 1917, the Town of Hamden installed a drain near Saint Mary and Goodrich Streets to alleviate surface water ponding; the drain discharged into the far corner of the Newhall Street swamp (ref. 12). Other notable events included the partial construction of the current Newhall Community Center in 1917. The block surrounded by Edwards Street, Saint Mary Street, Morse Street and Goodrich Street was reportedly filled in by Winchester Repeating Arms during World War I (1914 – 1918) (ref. 13). In 1919, Morse, Saint Mary and Edwards Streets were raised and sewer lines were installed, presumable when filling was completed in this area (ref. 14 and figure 7 of Appendix II)). Also in 1919, at the request of the Town Health Authorities, NHWC started clearing the approximate 30-acre Newhall Street Swamp. The clearing was requested because Town Health Authorities indicated the swamp was responsible for a great deal of malaria in the area. NHWC agreed to clear the brush and reopen the main drainage ditch to it (ref. 15).

By 1919, a significant amount of filling had already occurred in the Highwood District. Areas of documented fill occurred throughout the entire region through the construction of roads, public and private dumping grounds and planned filling areas. The stream identified in the 1850 and 1852 maps is not shown on maps, but remained as a swampy area north of Morse Street. The filling in of the Highwood District continued; however, as shown by the 1924 Sanborn Maps (Appendix II), structural development of the area was primarily complete with the exception of the areas surrounding the former 1850 stream. While roads were constructed on land crossing the former streams, no structures are identified on this land. The headwater area of the 1850 stream was part of a golf course used by Yale students during the early 1900s (ref. 13). It is unclear if any filling occurred during this period to make the land more suitable for this purposes.

By 1924, the southwestern portion of the Highwood District contained a high-density of structures. Excluding 249 - 251 and 253 - 255 Morse Street (Hamden Housing Authority owned properties), information contained in tax cards at Hamden Town Hall indicate all housing on the northern side of Morse Street which abuts the Hamden Middle School athletic field were constructed. Another highly developed area is the western side of Newhall Street, just north of Mill Rock (ref. 16).

By 1925, the swamp area near Newhall Street was identified as the Newhall Street dump by Walter Conner of NHWC in a January 1925 report. The dump was referenced to be operated by Winchester Repeating Arms (ref. 17). This is the first reference to filling of the Middle School Site identified during this investigation. The Town of Hamden Health Officer promoted dumping in wetlands as noted by conclusions in the 1925 Hamden Annual Report (ref. 18) which stated “The establishment of so-called dumps for wastes of all kinds would be far more sanitary and economical, in that such dumps can be located on waste land, swamps, etc., thereby eliminating breeding places and creating play-grounds and public parks, much needed in this community.”

By 1933, development of the Highwood District is nearly complete (figure 7 of Appendix II). The only significant region not completely developed is the area of the former 1850 stream. By 1933, the road system south of Mill Rock was nearly identical to the current road system, with the exception of a missing section of Bryden Terrace. As shown in the 1934 aerial photograph (figure 8 of Appendix II), filling appears to have occurred in Rochford Field and on the eastern portion of the Hamden Middle School property. The 1934 photograph shows evidence of the stream or wetland area crossing from the school property toward future Rochford Field. It is completely filled by 1939 (figure 9 of Appendix II). Rochford Field was completed by 1939. The 1939 aerial photograph also shows some filling had occurred in the Mill Rock Park area. This aerial photograph shows no remnants of the 1850 stream east of Newhall Street. The 1940 aerial photograph is similar to the 1939 photograph (figure 10 of Appendix II). During this time period (1936), the spreading of oil on wetlands was utilized for the control of mosquitoes (ref. 19). It is unclear how long this practice persisted in Hamden, who was responsible for the application of the oils and if this practice was a recommendation for mosquito control by Connecticut Health and Agricultural departments. In addition, no documentation was identified by LBG as to which locations in Hamden this type of mosquito control was utilized.

During the 1935 time frame, materials identified by a Hamden resident (ref. 20) to have been disposed of at the Middle School Site included: shotgun shells, globs of black material identified as grinding lubricants and metallic residue from the reaming process of the gun barrels, empty and full 50-gallon drums of liquid and domestic waste. Note that the resident indicated that fluids from some of the full drums would seep out of the containers as they fell on the ground. The resident also recall the materials dumped behind the Hamden Community Center primarily consisted of household waste disposed of by the local residents. The resident further stated that houses along the north side of Morse Street were existing at the time and were built on solid ground. The resident also recalls an approximate 100 foot deep buffer between the houses and the “dump.” The residence’s recollection of the filling on the southern portion of the site matches conclusions identified in the 2002 LBG ESI for this area.

Other than on the Hamden Middle School property, the 1949 and 1951 aerial photograph (figures 13 and 14 of Appendix II) shows no evidence of new filling occurring in Highwood District. As discussed above, NHWC sold its remaining portion of the Middle School Site to the town of Hamden in 1950. Prior to the start of construction of the school in 1955, the Hamden Middle School property was filled with industrial material from Winchester Repeating Arms and illegal dumping of domestic waste (refs. 21 and 22). However, predominant filing material up to the early 1950s consisted of the industrial waste from Winchester Repeating Arms (ref. 22). The

Michel J. Whalen Middle School was constructed in 1955 (ref. 23). After the construction of the school, the primary fill at the Middle School Site consisted of construction/building debris with sands and silt, incinerator ash and burn pit ash from the school and domestic waste (ref. 24 through 30). Ash from the school was generated from the interior incinerator operated in 1957 (ref. 24) and an exterior incinerator/burn pit operated from 1958 until at least 1965 (ref. 25, 26, 27 and 28). The construction/building debris may have been deposited by the Town of Hamden Department of Public Works (ref. 23). The department promised they would bulldoze the rear of the school property and cover it with adequate dirt in 1957 (ref. 24).

As shown in 1963 aerial photographs (figure 17 of Appendix II), all filling in the Highwood district is complete, with the exception of the Middle School Site. Areas of dense vegetation remain along the boundaries of the Athletic Field, and filling still appears to be occurring along the north-central boundary of the property.

In December of 1970 (ref. 29), the condition of the athletic field was identified as “tennis courts uplifted, basketball court of broken blocks of concrete, stagnant water breeding unhealthy bacteria, and a dumping ground for piles of concrete and asphalt rubble.” This excerpt was taken from a letter written to Dr. Frank Yulo, the Superintendent of Hamden Public Schools, from the Michael J. Whalen Jr. High P.T.A., in February 17, 1971. Dumping of refuse was reported behind the Hamden Middle School property to have occurred as late as July 1971 (ref. 30). Filling activities continued behind the school through the late 1970s (ref. 31). Reportedly large amounts of "acidic soils" were removed from behind the school and replaced with approximately 100,000 yards of “clean fill” from the West Woods school site.

The 1980 aerial photograph (figure 19 of Appendix II) shows the Middle School Athletic Field to be completely cleared. A pond is evident on the northwestern portion of the Middle School Site. It appears that the pond identified in the 1980 aerial photograph is filled by 1991 (figure 21 of Appendix II). A minimum of 18-inches of gravel cover material was placed on the Hamden Middle School athletic field sometime between March and May of 1995 as part of a lead encapsulation project (ref. 32). A March 24, 1995 Hamden Planning and Zoning Department interoffice memorandum (ref. 33) concerning the proposed placement of the soil cap on the athletic field also involved the excavation and removal of fill material.

Digital files provided to LBG by Barakos-Landino Design Group show the 1991 and 1995 topographic surveys of the athletic field. The 1995 topographic survey was taken after the installation of the 18-inch gravel layer. A comparison of surveyed maps show this layer was actually thicker than 18-inches in several areas of the athletic field. The review also showed that this initial cap was placed over all areas of identified fill in the athletic field (within property boundary) with the exception of a narrow area on the southeastern portion of the site, the raised undeveloped area north of the tennis and basketball courts and a narrow area east of the tennis and basketball courts (Appendix III). Note that the area east of the tennis court was mitigated through emergency remedial measures by the CTDEP in 2002. In addition, the southeastern area does coincide with an area mitigated through 2002 CTDEP emergency remedial measures (ref. 1).

The above area identified with the "18-inches" of gravel coincides well with an area described as "limits of earthwork" on an August 25, 1995 Barakos-Landino Design Group map entitled "Grading/Utility/Sec Plan." The "limits of earthwork" extend to the western, southern and northwestern property boundaries. The eastern "earthwork" boundary coincides with the rear asphalt pavement of the school and the fence located on the southeastern portion of the athletic field. The northeastern limit of the "earthwork" coincides with the undeveloped raised area north of the tennis and basketball courts.

Approximately a year after the installation of the initial soil cap, a minimum 6-inches of top soil was placed throughout the athletic field in 1996 (refs. 34 and 35). Prior to the placement of top soil, additional gravel was placed on the athletic field to account for settling of the initial "18-inch" gravel cap (ref. 36). Note that no as-built drawing has been identified for the soil cap covering the athletic field.

3.2.2.2 Investigation History at Middle School Site

The list below presents a chronology of events and historic environmental investigations and actions for the Hamden Middle School property. This list was generated from information on file at the CTDEP and contained in the 2002 Phase I ESA (ref. 1). The results on these investigations identified the presence of metals, semi-volatile organic compounds (SVOCs), VOCs and total petroleum hydrocarbons in the subsurface material of the athletic field. Of these constituents, various metals, SVOCs and total petroleum hydrocarbons were identified above the CTDEP RSRs RDEC and GA PMC. The results of the available analytical data from environmental investigations are presented on the MS Access database (CD) provided in the 2002 LBG Phase III ESI and in Appendix III.

1979 Local resident notifies Quinnipiac Health District of sunken areas on the playing field and history as disposal area.

1979 CTDEP collects 2 soil samples; locations and results were not identified for review.

1985 CTDEP completes Preliminary Assessment (PA) for Michael Whalen Jr. High School. Black material found on athletic field behind school. PA results identify metals in shallow soils.

1987 USEPA Site Discovery. Site added to CERCLIS List, No. CTD98254435.

1987 Site added to State Inventory of Hazardous Waste Disposal Sites.

1989 NUS corporation, on behalf of the USEPA conducts site investigation (SI) in which 11 shallow soil samples are collected between 0.5 and 1.5 ft bg (feet below grade) and analyzed for priority pollutant metals and VOCs. The results identified arsenic, lead and antimony above the CTDEP RDEC. Halogenated VOCs (1,1,1-trichloroethane (TCA), tetrachloroethylene (PCE) and 1,1,2,2-tetrachoroethane) are identified in the shallow soils on the central and northwest portion of the Athletic Field.

1991 Final USEPA SI completed. Report indicates that field area was used for community dumping for several years between 1940s and 1950. Local health department officials allege this was a disposal area of old batteries by the Winchester Repeating Arms.

1991 Roy F. Weston, on behalf of the USEPA conducts shallow soil investigation. Twenty (20) shallow soil samples were collected and analyzed for nickel, lead, chromium, mercury, SVOCs and VOCs. The results identify lead above the CTDEP RDEC (not promulgated at that time).

1992 Connecticut Department of Health Services (DOHS) letter to Quinnipiac Valley Health District states if athletic fields are kept grass-covered, they are safe for use. The DOHS used EPA lead exposure model assuming a concentration of 1,600 parts per million (ppm) and children would be exposed 4-hours a day.

1992 USEPA determines that Removal Action is not appropriate because *"the amount, quantity, or concentration released does not warrant Federal response."*

1993 CTDEP recommends the Town of Hamden to complete an environmental investigation at the school property. The Town retains HRP to conduct soil sampling for possible addition at school. Six samples were collected from 0 to 6 inches and four samples from 30 to 36 inches below grade. Lead detections ranged from 11.7 ppm to 5,680 ppm. Black ash-like material with traces of brick/wood pulp or cinders identified within the top 36 inches.

1993 HRP conducts shallow soil investigation in which 40 shallow soil samples were collected and analyzed for lead and/or leachable lead. The results identify lead above the above the CTDEP RDEC and GA PMC (not promulgated at that time).

1994 CTDEP receives anonymous complaint about landfill adjacent to Hamden Middle School. The complaint states that it is common knowledge that ammunition, radioactive waste, and other waste are buried in landfill behind school. Rochford Field identified with similar problem.

1994 USEPA Final Site Inspection Prioritization (SIP) completed. SIP states recent excavation to install an elevator at the school exposed domestic waste below the ground surface.

1995 CTDEP Water Bureau receives call from former athletic coach recalling that standing "black water with unnatural characteristics" was present in the ball field. Athletic coach sent letter to CTDEP showing location of standing black water at the northwest corner of the athletic field.

1995 Cap material placed on athletic field. Cap consisted of a minimum of 18-inches of gravel and was placed by United Excavating for Town of Hamden.

1996 Minimum of additional 6-inches of top-soil placed over athletic field by Furrey, Inc. for Town of Hamden.

2000 Phase I ESA completed by Town of Hamden Board of Education by Facility Support Services (FSS). The ESA noted the historical filling at the school.

2000 FSS conducts subsurface investigation in which 15 soil borings are drilled to depth ranging between 17 and 36.5 ft bg. Fill material was identified at depth starting at 2 and 3 ft bg, and extending to depths ranging from 7 to 26 ft bg. Forty-four (44) soil samples are collected and analyzed for total and TCLP metals, extractable total petroleum hydrocarbon, semi-VOCs (SVOCs) and VOCs. The results of the investigation identified concentrations of various metals, SVOCs and extractable total petroleum hydrocarbon (ETPH) above the RDEC and GA PMC.

2000 FSS conducts investigation in which 23 soil-vapor samples are collected from beneath the school foundation and analyzed for methane, hydrogen sulfide and/or VOCs. The results identified methane beneath the boiler room in two locations above the lower explosion limit. The Phase II and subsequent investigations included the collection of soil-vapor samples from beneath the floor of the school during October, November and December 2000. As a result of the soil-vapor investigations, the Town of Hamden installed methane monitoring and ventilation equipment to address this area of concern.

2000 CTDEP collects 10 soil-vapor samples from beneath the Middle School. The samples identify low level aromatic hydrocarbons and methane.

2000 Emergency remedial measures were completed, which included installation of geotextile and earthen caps at three areas surrounding the school. The areas consisted of approximately 120,000 square feet.

2001 CTDEP supervised the drilling of 26 soil borings to a depth of 4 ft bg throughout the school athletic field. Twenty-six (26) surficial samples were collected from these borings at a depth of 0 to 6 inches below grade. The samples were analyzed for priority pollutant metals (PPM), barium and SVOCs. The results showed no exceedances of criteria in the CTDEP RSRs. Fill material was identified at 7 of the 26 soil boring locations. The results of this investigation showed that the depth of the "cap" at the athletic field ranged from approximately 1.5 ft bg to at least 4 ft bg.

2001 CTDEP collects 39 shallow (0-3 inch bg) soil samples from the southeastern portion of the athletic field. The results of this shallow soil investigation identified concentrations of arsenic, lead and SVOCs above criteria in the CTDEP RSRs on the southeastern portion of the athletic field and around the tennis courts. Emergency remedial measures were initiated and included fencing the southeastern area and covering this area with wood chips.

2001 CTDEP issued an Administrative Order to the RWA, Olin Corporation, Town of Hamden and the State of Connecticut Board of Education on July 10, 2001, which requires the investigation and remediation of the Middle School Site, the town-owned Rochford Field and Annex, and several areas which have been developed for residential use.

2001 The Town of Hamden contracted Haley & Aldrich to complete a Phase I ESA of the Middle School Site, the town-owned recreational properties and residential properties in the Newhall area.

2002 Haley & Aldrich draft ESA issued January 2002. As part of the ESA, six test pits were completed in August 2001 at the Middle School Site under the supervision of Haley & Aldrich. Fill material was encountered in all of the test pits and the top of fill was observed at 2.5 ft bg to at least 7.3 ft bg. The fill material was observed to contain various industrial and domestic wastes.

2002 LBG completes extensive environmental site investigation of Middle School Site on behalf of RWA. Investigation is completed on a voluntary basis. Results of the investigation are documented in "Phase III Environmental Site (Consent Order was not signed) Investigation, Former New Haven Water Company Property, Hamden, Connecticut" Consent Order No, SRD-128", submitted in December 2002.

2003 Consent order (Appendix I) is accepted as a final decision in Order No. SRD-128 pursuant to RCSA 22a-3a-6(1)(2) on April 16, 2003.

2003 Compliance monitoring was completed between April 2003 and February 2004 by LBG on behalf of RWA. Ground-water results show generally consistency in 2002 ground-water quality results, with exception of a decline in volatile organic compound (VOC) concentrations observed on the southwestern portion of the Middle School Site.

2003 Pursuant to Consent Order No. SRD-128, quarterly progress reports are submitted to the CTDEP by LBG on behalf of RWA. The reports were submitted on a quarterly basis between June 2003 and March 2004. In addition to the quarterly reports, maps depicting the regional potentiometric surfaces are submitted to the CTDEP. The maps show regional ground-water flow is generally flowing to the west/southwest.

2004 In January 2004, the CTDPH issues final public health assessment (ref. 37) for Hamden Middle School. The report states "It must be emphasized that existing surface soils which were added as part of capping of the field have been tested and are not contaminated[1/]. The athletic field at the Hamden Middle School was evaluated previously in a health consultation (ATSDR 2001) and was found to present no public health threat, as long as digging through the soil cap did not occur." 1/ *"The athletic field has a covering of clean soil which ranges in depth from approximately 2 feet to four feet."*

3.2.3 Evaluation of Environmental Investigation Results

Little is known by LBG concerning quality assurance (QA) and quality control (QC) measures of the historic investigations completed by other firms. Therefore, LBG does not attest to the validity of the sample results discussed below.

3.2.3.1 Environmental Investigations Prior to Placement of Soil Cap in 1995 and 1996

Plate 1 shows the sampling locations for the following three environmental investigations that occurred prior to the placement of the soil cap in 1995 and 1996. Sample results are presented in Appendix IV.

- "Final Screening Site Inspection Report, Newhall Street Field, Hamden, Connecticut", dated July 23, 1991 and completed by NUS Corporation on Behalf of the USEPA;
- "Removal of Preliminary Assessment/Site Investigation (PA/SI) for the Newhall Street Field", dated August 1991 and completed by Roy F. Weston on behalf of USEPA; and

- "Evaluation of Newhall Street Screening Study and Recommendations for Subsequent Sample Collection/Analyses" dated May 1993 and completed by HRP Associated on behalf of the Town of Hamden.

3.2.3.1.1 1991 NUS Corporation Investigation

The eleven (11) soil samples collected as part of the 1991 NUS Corporation (ref. 38) environmental investigation were analyzed for priority pollutant metals (PPM) and VOCs. All samples were collected between 0.5 and 1.5 ft bg in November of 1989. The samples were collected from the central and northwest portion of the athletic field. Antimony, arsenic and/or lead were detected in four samples above the current RDEC. While arsenic was detected above the RDEC in three of the samples, the concentrations were generally low with a peak concentration of only 18.5 parts per million (ppm). The soil samples collected from the central portion of the athletic field (NU04 and NU12) generally contained the highest concentration of all inorganics analyzed, with elevated concentrations of zinc, copper, antimony, lead, manganese, nickel, barium and chromium detected in the samples. The samples collected from the northwest portion of the site generally consisted of low concentration of inorganics.

Chloroform was detected at 2 parts per billion (ppb) in three soil samples. The samples were collected from the central and northwest portion of the site.

The TCA, TCE and/or 1,1,2,2-tetrachoroethane were detected at relatively low concentrations in NU8, NU10, NU11 and NU12. Concentrations of the total halogenated VOCs ranged from 5 ppb to 37 ppb. The detections, if accurate, would indicate halogenated VOCs were present in the shallow soils in the central and northwestern portions of the parcel. Note that the presence of the parent halogenated VOCs (TCA and TCE) and detection of no significant breakdown constituents would suggest this release was relatively recent to the time of the investigation. The detection of these halogenated VOCs at these general locations was not confirmed during the 2002 LBG ESI. It is difficult to understand why these halogenated VOC detections which were identified in nearly all regions sampled in the athletic field would not be identified in any of the ground-water or soil samples collected from those locations during the 2002 ESI. Therefore, these results are viewed with significant skepticism.

3.2.3.1.2 1991 Roy F. Weston Investigation

Twenty (20) shallow soil samples were collected and analyzed for nickel, lead, chromium, mercury, iron, SVOCs and VOCs during the 1991 Roy F. Weston (Weston) environmental investigation (ref. 39). Note that not all samples were analyzed for each of the aforementioned inorganics. The samples were all collected from 0 to 3 inches below grade. *No VOCs or SVOCs were detected above the laboratory detection limit.* Note these samples were collected throughout the athletic field. These results contradict the VOC results identified in the 1989 NUS Corporation investigation.

Lead was detected in 11 of the 19 samples analyzed (Appendix IV), ranging from 100 ppm to 1,600 ppm. Five of the aforementioned lead detections exceed the RDEC (not promulgated at that time). Generally higher concentrations of lead were detected in the samples collected from the southwestern, southeastern and northwestern portions of athletic field. Chromium and nickel were detected at 400 ppm and 200 ppm, respectively, from sample S006 which was collected from the northwest portion of the athletic field. Neither concentration exceed the RDEC. No other notable detection was identified during the investigation.

3.2.3.1.2 1993 HRP Investigation

HRP completed two field investigations during 1993 at Hamden Middle School (ref. 40). The initial investigation occurred in April 1993 and included the collection and analyses of 40 shallow soil samples (this is pre-cap). The sampling event was primarily concentrated on the north-central and northeastern portion of the athletic field. The soil samples were analyzed for total lead, while three of the samples were analyzed for toxicity characteristic leaching procedure (TCLP) lead. The total lead results are shown on table 4 of Appendix IV. The locations of all forty samples are shown on plate 1. Of the samples reviewed, lead was sporadically detected throughout the athletic field. Eleven (11) of the 29 samples are above the RDEC (not yet promulgated). Of note, relatively high concentrations of lead (some above 500 mg/kg) were detected on the berm located on the north-central portion of the Middle School Site.

Samples HRP3, HRP5 and HRP38 were also analyzed by TCLP. The results identified for the TCLP lead in HRP3, HRP5 and HRP38 was of 13.2 mg/l, 0.06 mg/l and 8.08 mg/l, respectively. All of these results substantially exceed the current GA PMC of 0.015 mg/l. Note that these results do not correspond well with concentrations of SPLP lead analyses completed during the LBG 2002 ESI. However, TCLP is known to be much more aggressive in leaching lead than SPLP.

The second field investigation occurred in October 1993 and included the collection of six soil samples from a depth of 0 to 6 inches and four soil samples from 30 to 36 inches below grade (ref. 1) (this is pre-cap). The samples were collected from the six sample locations located on the southern side of Hamden Middle School. Note that the precise location was not identified during the review; therefore, the samples are not identified in plate 1. Lead was detected in all samples and ranged from 11.7 ppm to 5,680 ppm. Black ash-like material with traces of brick/wood pulp or cinders identified within the top 36 inches.

3.2.3.2 Environmental Investigations Post Soil Cap and Prior to 2002 LBG Investigation

Plate 2 includes sample locations for the following environmental investigations that occurred after the placement of the soil cap in 1995 and 1996. Sample results are presented in Appendix IV.

- "Soil Vapor Survey of Hamden Middle School", dated November 2000 by Facility Support Services, LLC (FSS) on behalf of Town of Hamden;
- Environmental Soil Quality Assessment of Hamden Middle School", dated November 2000 by FSS on behalf of Town of Hamden; and
- CTDEP environmental investigation completed at Hamden Middle School in February 2001.

3.2.3.2.1 FSS Environmental Investigations

In July 2000, a Phase I Environmental Site Assessment (ESA) was completed at the Hamden Middle School property to address environmental concerns related to a proposed school expansion (ref. 41). The ESA was completed for the Town of Hamden Board of Education by Facility Support Services (FSS) of Hamden, Connecticut.

To address concerns identified in the ESA, a Phase II ESA (ref. 42) was completed by FSS in November 2000. The Phase II investigation included the drilling of 15 soil borings to depths ranging from 17 to 36.5 ft bg (B1 through B15 on plate 2). Fill material was identified at depth starting at 2 and 3 ft bg, and extending to depths ranging from 7 to 26 ft bg. Depth to water was reported to range from 10 to 19 ft bg.

Thirty-one soil samples were collected for analyses of SVOCs, VOCs, ETPH, and/or Metals (20 metals, details shown in table 7 of Appendix IV). SVOCs (only polynuclear aromatic hydrocarbons (PAHs)) were detected in seven of the nine samples analyzed. The samples were collected from soil borings to the south, west and east of the school. No exceedances of the RDEC were identified in the analytical results for the shallow soil samples (0 to 2 feet below grade) collected from the athletic or other areas without pavement. Aromatic VOCs were detected at generally low concentrations in four of the 15 samples analyzed. All samples in which VOCs were detected appear to have been collected below the seasonal low water table.

Various metals were detected in all of the 31 samples analyzed. Of these samples, only antimony, arsenic and lead were identified above the RDEC. Note that barium was detected at concentrations greater than 100 ppm in 9 of the 31 samples. The elevated concentrations of metals were generally evenly distributed throughout the soil borings. Six of the soil samples were also analyzed for TCLP metals (same metal list as total analyses). Metals were detected above the GA PMC in all samples; the exceedances consisted of barium, cadmium, copper, nickel, lead, thallium and zinc.

The Phase II and subsequent investigations included the collection of soil-vapor samples from beneath the floor of the school during October, November and December 2000 (ref. 43). The results of the October and November samples identified concentrations of methane beneath the boiler room above the lower explosion level (LEL). The December 2000 soil-vapor results (ref. 39) showed that methane concentrations were well below the LEL. As a result of the soil-vapor investigations, the Town of Hamden installed methane monitoring and ventilation equipment to address this area of concern.

3.2.3.2.2 CTDEP Environmental Investigations

During February 2001, the CTDEP supervised the drilling of 26 soil borings to a depth of 4 ft bg throughout the school athletic field. Twenty-six (26) surficial samples were collected from these borings at a depth of 0 to 6 inches below grade. The samples were analyzed for priority pollutant metals (PPM), barium and SVOCs. Note that the results of the LBG 2002 ESI showed the most common constituents identified in the industrial waste material to exceed RSR criteria were SVOCs (only PAHs), arsenic, antimony and lead. The results of the CTDEP investigation showed no exceedances of criteria in the CTDEP RSRs. Fill material was identified at 7 of the 26 soil boring locations. The results of this investigation showed that the thickness depth of the soil cap at the athletic field to range from approximately 1.5 ft bg to at least 4 ft bg. As shown on plate 2, the CTDEP sample locations are generally evenly spaced throughout the athletic field.

A subsequent shallow soil investigation was completed by the CTDEP in response to an investigation completed by the USEPA at nearby residential properties. During this investigation, an additional thirty-nine (39) shallow (0-3 inch bg) soil samples were collected May 10, 2001. LBG requested the coordinates of these sample locations from the CTDEP in September of 2002; however, the data were never received. These locations will be included in future report submittals. It is known that the sampling did involve samples collected in the areas east of the tennis and basketball courts and on the southeastern portion of the athletic field. The results of this shallow soil investigation identified concentrations of arsenic, lead and SVOCs above criteria in the CTDEP RSRs on the southeastern portion of the athletic field and around the tennis courts. Emergency remedial measures were initiated and included fencing the southeastern area and covering this area with wood chips. Note the areas mitigated through emergency remedial measures coincide with areas identified by LBG that were not covered by the placement of the initial “18-inch” gravel cap. The only remaining area identified with fill in the athletic field which was identified through the review of the 1991 and 1995 survey not to have been covered by the “18-inch” soil cap is located on the northeast portion. This area is located north of the tennis and basketball courts and is noted by rise in grade.

3.2.3.3 LBG 2002 Environmental Site Investigation

Between July 15 and November 11, 2002, LBG completed extensive field investigations at the Middle School Site consisting of 70 soil borings, excavation of 8 test pits, collection and analyses of 105 soil samples, installation of 24 monitor wells and collection and analyses of 32 ground-water samples (ref. 44). Soil and ground-water samples were analyzed for pesticides, total and SPLP metals and cyanide, total and SPLP polychlorinated biphenyls (PCBs), VOCs, SVOCs and ETPH. Ground-water samples were also analyzed for herbicides and landfill leachate parameters. The goal of the investigation was to evaluate environmental conditions and compare concentrations of regulated substances to the CTDEP RSRs. The investigation also responded, in part, to CTDEP Administrative Order No. SRD-128, which required the investigation and remediation of historical fill areas in the Newhall Street area of Hamden, Connecticut. The environmental investigation was completed in accordance with the August 19, 2002, “Revised Work Plan Former New Haven Water Company Property Hamden, Connecticut”, which was revised to incorporate comments of the CTDEP (ref. 45).

In addition to this investigation, four consecutive quarters of compliance monitoring was completed between April 2003 and February 2004 for all site monitor wells. Depth to water level data was also collected on a quarterly basis and used to verify the direction of ground-water flow at the site.

3.2.3.2.1 Geology and Hydrogeology

3.2.3.2.1.1 Composition of Unconsolidated Materials

Detailed geologic cross sections of the site are shown in figure 3 through 13 of the 2002 LBG ESI report. The cross sections provide a good reference for viewing the complex mix of material deposited beneath the site; however, their presentation is not necessary as part of this discussion.

In general, the upper surficial material (primarily top 1 to 4 feet) consisted of a top soil and sand mixture. Much of this cover material was placed as part of remedial measures during 1995 and 1996. Immediately beneath the cover material is one of four primary materials. These materials are often found intermingled. The materials include:

1) Black matrix fill/industrial waste: The primary materials of the black matrix material are a black silt and/or slag. Numerous objects were encountered in this matrix; the most common were batteries, wood, ceramic and cardboard. Occasionally newspapers would be mixed in with this fill material. Newspapers were also identified as part of the domestic/municipal waste. Artifacts identified in this fill were often found with Winchester Repeating Arms labeling. The location and extent of this fill corresponds to areas known to be filled by Winchester Repeating Arms.
2) Construction debris: Construction materials were generally found as part of a reddish-brown sand. Material most commonly associated with the construction/ building debris were stone blocks (generally rectangular, cobble size), bricks, wood, glass and plastics.
3) Domestic/municipal waste: This is the most general category of fill at the site. Domestic/municipal waste was identified with silt to medium sand ranging in colors from gray to brown. Materials associated with the domestic/municipal waste

included bottles, household products (such as margarine containers), shoes, cinders, electrical conduits, newspapers, etc. The materials used as identifiers were generally unique and not found in other areas or in quantity, thus potentially representing an individual's waste.

4) Non-fill: Material primarily consists of reddish brown fine to medium grain sand with some silt. The nomenclature "non-fill" includes materials such identified as the soil cap and underlying native materials, thus natural constituents, only.

Fill was deposited on either a non-fill layer or the wetland organic layer. This wetland organic layer is identified as "organic silt and clay layer" on the cross sections in the 2002 LBG ESI report. The primary matrix of the organic wetland material is silt; however, it was also observed to contain some fine sand and/or clay. The organic materials observed were dense and primarily dark (generally grey to black) in color, with a musty wetland/organic type odor. This wetland organic layer was identified in fourteen soil borings at depths ranging from 12 to 30 ft bg. The layer was identified to be 1 to 4 feet thick and generally underlain by a fine to medium sand and silt material. The wetland organic layer was observed at the shallowest depths along the eastern property boundary (LBG-TB-8, 12 to 16 ft bg). On the eastern portion of the Middle School Site, the layer was observed in only in two locations (LBG-TB-7 and LBG-MW-8) and, therefore, is believed to not be a prominent feature on this portion of the site. The wetland organic layer was identified in several soil borings throughout the central portion of the athletic field. In this area the material was identified consistently at greater depths, ranging from 22 to 30 ft bg. The extent and orientation of the layer is consistent with the original stream and wetland system. The approximate extent and elevation of this layer is shown on plate 3. Note that on the east and central portion of the Middle School Site, the elevation of the top of this layer generally slopes downward to the southwest. The northwest edge of this layer appears to slope to the southeast, while the southwest portion of the layer appears to slope to the northeast. The extent and elevations shown for the wetland organic materials are approximate and will be further refined during subsequent investigations.

3.2.3.2.1.2 Cover Material

As discussed, the Town of Hamden placed approximately two feet of cover material over the Hamden Middle School athletic field in 1995 and 1996 to address environmental concerns of the USEPA and CTDEP. As part of this investigation, soil samples were collected continuously in the shallow throughout the Middle School Site to identify the thickness and extent of protective cover material. Plate 4 shows the extent and thickness of the cover material present at the Middle School Site above identified fill. In general, the athletic field has between 2 and 4 feet of this protective cover material. The remaining portion has approximately 1 to 2 feet of cover material. As shown on plate 4, areas of less than 1 foot of cover material are present in small areas near the north central property site boundary (near LBG-MW-11), eastern central boundary (LBG-TB-9) and south-central boundary (LBG-TB-42 through LBG-TB-45).

3.2.3.2.1.3 Extent and Thickness of Fill Materials

Plate 5 shows the approximate lateral extent of all types of fill observed at the site. As shown, a large portion of the Middle School Site is underlain with fill; however, the fill is shown to be primarily contained on the site. The fill was identified to be as much as 22 feet thick. Plate 5 shows the thickest sections of fill are generally identified on the western portion of the property. Relatively thin sections of fill ranging from 0.6 feet to 8.8 feet were identified on the eastern portion of the property near Newhall Street.

The black matrix fill is the predominant fill material located on the eastern and central portions of the property. Plate 6 shows the extent of the black matrix fill overlaid on a 1951 aerial photograph. The 1951 photograph is utilized because the last parcel was sold by NHWC to the Town in 1950. The extent of this fill identified during the field investigation reasonably corresponds to locations shown to have been filled during this time period. Winchester Repeating Arms filling activities ceased by 1955, which corresponds to when the middle school was constructed. The spreading of the black matrix fill may have occurred during future filling and grading activities. Note that no black matrix fill was identified to extend beyond the southern Middle School Site boundary. The only area in which the black matrix fill potentially extends off of the site is to the northeast near Mill Rock extension.

Plate 7 shows a large section of construction debris fill located on the western portion of the Middle School Site. This type of fill was also identified on the northeast corner and south eastern portion of the site. The materials on the western portion of the site may represent part of the approximate 100,000 yards of fill reportedly brought in from the West Wood school site. During excavation of test pit 3 (northwest portion of Middle School Site), an orange plastic caution tape (gas) was identified in the material along with wood and rectangular stone blocks. The condition and construction of the caution tape indicates a more recent filling event like that had reportedly occurred in the 1970s. Of note, similar stone blocks were identified in Test Pits 1 and 4.

Plate 8 shows scattered areas of domestic/municipal waste fill. These areas may be more extensive than shown because this fill was primarily identified during the excavation of test pits. Because of the nature of the materials associated with the fill (bottles, household products, shoes, cinders, electrical conduits, newspapers, etc.) it was difficult to identify in soil boring samples. The largest area of the domestic/municipal waste fill is shown on the southeastern portion of the Middle School Site. Newspapers included in the waste and collected from LBG-Test Pit-5 identify the date as 1955. The newspapers were collected from 4 to 5.5 ft bg. 1955 corresponds with the approximate period that Winchester Repeating Arms ceased filling on the Middle School Site. This domestic waste extends to the southern property boundary as shown in Test Borings LBG-TB-42 through LBG-TB-45. This domestic/municipal waste fill in the area of LBG-Test Pit-5 and LBG-Test Pit-12 was deposited on top of the black matrix fill.

Soil borings LBG-TB-42 through LBG-TB-46 were drilled on the top of a steep ridge along the southern property boundary (approximately 5 feet above the grade of the athletic field). As shown, a domestic/municipal waste was identified in the aforementioned borings; however, the soil matrix was not similar to that identified in LBG-Test Pit-5. Plate 8 shows domestic/municipal waste is shown to be located on several residential properties on the north side of Morse Street. Based on the aerial photographs shown in Appendix II of the LBG 2002 ESI, these houses and lots were fully developed before any filling occurred on the Middle School Site near their property lines. All of the houses located on the northern portion of Morse Street, which have a steep ridge at the rear edge of their properties, were developed in or before 1920.

It is likely that the filling that occurred on these residential properties actually slightly spilled over onto the Middle School Site. The domestic fill material identified in test borings

LBG-TB-42 through LBG-TB-46 along the ridge that straddles these residential properties is similar to that observed during the offsite investigation completed by the Olin Corporation on these properties. No domestic/municipal waste from that era (pre-1920) was identified in any other test borings or test pits completed on the Middle School Site. Waste such as black matrix fill which was deposited in the mid to early-1920s to the early-1950s on the portion of the school site that is located in the vicinity of the homes was identified approximately 10 feet lower than the grade elevation of the these previously developed Morse Street residential properties. *Therefore, any filling activities that occurred on the Middle School Site could not have spilled over onto the Morse Street residential properties (259 through 279 Morse Street), as it would have had to spill uphill and on top of previously developed residential properties.* This conclusion matches the recollection of a former Hamden resident (ref. 20).

3.2.3.2.1.4 Composition of Bedrock

Bedrock beneath the Middle School Site is mapped as New Haven Arkose (ref. 46), which is characterized as reddish, poorly-sorted arkose. Arkose is a granular sedimentary rock consisting of quartz and feldspar or mica. Depth to bedrock is mapped to be approximately 40 feet on the eastern edge of the Middle School Site, and approximately 140 feet on the western edge (ref. 47). Bedrock was not encountered during the investigation.

3.2.3.2.2 Characteristics of Ground Water

3.2.3.2.2.1 Depth to Water Levels

Depth to ground-water levels were measured at the site from July 2001 through February 2004 (table 1). The depth to ground water at the site at the site during the 2002 ESI ranged between 4.3 and 20.9 feet below the top of the well casing (ft bc). Ground water is shallowest on the eastern edge of the Middle School Site where the topography is the lowest. Ground water is deepest on the southwestern portion of the athletic field.

Table 1 shows that ground-water levels were observed to be generally the lowest during the August 21, 2002, while the highest water levels were observed during April 16, 2003. Depth to water levels remained relatively stable throughout the 1 ½ year recording period. The range of depth to water during the recording period for all site monitor wells fluctuated from 0.8 feet (LBG-MW-10A) to 3.3 feet (LBG-MW-1). Of note, the maximum average change in seasonal water levels at the monitor wells located above the organic wetland material (LBG-MW-7A, LBG-MW-10A and LBG-MW-14A) was approximately 1 foot, whereas their deeper counterparts (LBG-MW-7B, LBG-MW-10B and LBG-MW-14B) changed a maximum average of approximately 2.5 feet. The seasonal fluctuation in the deeper wells more closely matched the average seasonal fluctuation (approximately 2 feet) of the monitor wells screened outside of the wetland organic layer.

3.2.3.2.2.2 Vertical Flow Direction and Magnitude

A downward flow direction has been shown consistently throughout the recording period in monitor well clusters LBG-MW-7, LBG-MW-10 and LBG-MW-14. The screen setting on these shallow and deep monitor wells are separated by the wetland organic layer discussed above. In these three clusters, the head difference, showing downward flow, ranged from 0.88 to 4.53 feet. The magnitude of the downward flow was shown to be greatest in the winter and spring period when the water levels were at their highest. While this is anticipated, the cause of the changes in seasonal head difference is not related to seasonal water-level fluctuations in the shallow well, but rather the seasonal water-level fluctuations in the deeper well. As discussed above, seasonal changes in water levels were more accentuated in the deeper wells than the shallow wells. This likely occurs because the wetland organic layer is not widespread and, therefore, cannot sustain a significant rise in water levels without drainage to the main aquifer.

The head difference observed in well clusters outside of the organic wetland layer (LBG-MW-4 and LBG-MW-15 cluster) were generally minimal throughout the recording period.

3.2.3.2.2.3 Potentiometric Surface

When creating the ground-water flow maps, water elevations from all wells screened in a similar depth interval were initially mapped (i.e. including monitor wells that were screened above the discontinuous wetland organic layer). The initial data collected during 2002 resulted in a radial flow pattern off of the athletic field region of the school site, as well as isolated areas of apparent mounds. The attempt at mapping of subsequent seasonal data also resulted in radial mounds; however, no consistency was shown in gradients and flow directions. Closer analysis showed that these mounds were, in fact, reflecting the higher heads supported by the localized fine-grained wetland organic layer. These higher heads (table 2) do not reflect the actual regional ground-water flow direction; chemical data from the wells show that there is no horizontal flow component from the regions where there are elevated heads above the wetland organic layer to adjacent locations where the layer does not exist.

A potentiometric map was then prepared utilizing the water elevations in the regional geologic material: the deeper wells of the clusters and the shallow wells where the fine-grained layer did not exist. This produced a uniform flow direction that was consistent with chemical patterns in the ground water. LBG incorporated water elevations from a total of 21 onsite monitor wells and 10 offsite monitor wells in developing the potentiometric surfaces discussed below.

Plate 9 is a detailed potentiometric surface for the Middle School Site on September 12, 2002. As shown, ground-water flow at the Middle School Site is generally from the east to the west/southwest. The hydraulic gradient throughout the site is approximately 0.001 ft/ft.

Plate 10 shows the regional potentiometric surface for September 23, 2002. In addition to the wells incorporated in the previous potentiometric surface, this map incorporates ground-water elevations from Rochford Field, Mill Rock Park, 499 Newhall Street, 109 Morse Street, 113 Bryden Terrace and 1067 Winchester Avenue. The potentiometric contours shows that regional ground water generally flows from the east to the west/southwest. Near the Newhall Street community center, ground water is shown to flow to the northwest and then eventually discharging to the southwest. This is consistent with the topography and geology of the community center site. Note that the potentiometric contours on this map are presented at a greater interval than the detailed site map. This is because the hydraulic gradient off site is much larger than the hydraulic gradient on site. The hydraulic gradient east of the Middle School Site is 0.01 ft/ft, an order of magnitude larger than observed at the Middle School Site.

LBG has submitted maps of the regional potentiometric surface to the CTDEP for the various seasons of 2003. A regional ground-water flow pattern similar to the September 23, 2002 pattern is shown on all these maps. Regional and the site ground-water flow were determined to flow from the east to the west/southwest.

3.2.3.2.3 Soil and Ground-Water Quality

As discussed, during the summer and fall of 2002, LBG completed extensive field investigations at the Middle School Site which included the drilling of 70 soil borings, excavation of 8 test pits, installation of 24 monitor wells and collection and analyses of 105 soil samples and 32 ground-water samples. An additional 96 ground-water samples have been collected for analyses during compliance monitoring in 2003 and 2004. Soil samples were analyzed for pesticides, total and SPLP metals and cyanide, total and SPLP PCBs, VOCs, SVOCs and ETPH. Ground-water samples were also analyzed for herbicides and landfill leachate parameters (leachate parameters only during 2002 sampling).

As noted in the March 8, 2004 CTDEP Comment Letter concerning the 2002 ESI investigation, some analytical detection limits for soils (SPLP thallium and antimony) and ground water (limited SVOCs and VOCs) were not low enough to meet RSR numeric criteria. The laboratory which completed the analyses is currently reviewing the data and has indicated they will be reissuing the results with detection limits that meet or exceed RSR requirements. If the review of the recertified data indicates any additional data gaps, an addendum will be issued to address the concern(s).

3.2.3.2.3.1 Pesticides

Low concentrations of pesticides were sporadically detected primarily in the shallow soils at the Middle School Site. None of the concentrations exceeded regulatory criteria and pesticides detected in the site soils were shown not to be leaching at detectable concentrations to the site ground water. One pesticide, endrin aldehyde, was detected in one ground-water sample during compliance monitoring. Endrin aldehyde was not detected in the site soils. Review of the data suggests the detection in ground water was likely a false positive.

The source of low concentrations of pesticides in the site shallow soils is likely attributed to historic application. Pesticides have been sufficiently characterized and a further detailed investigation of pesticides is not warranted. Details of the investigation are discussed below.

3.2.3.2.3.1.1 Soil Quality

Table 3 and plate 11 present a summary of all detected pesticides. Low concentrations of pesticides were detected shallow soil samples collected from soil borings LBG-TB-4, LBG-TB-9, LBG-TB-18, LBG-TB-19, LBG-TB-20, LBG-TB-21, LBG-TB-22, LBG-TB-24 and LBG-TB-25. The detections consisted of 4,4'-DDD (DDD), 4,4'-DDT (DDT), 4,4'-DDE (DDE) and/or chlordane. The results show that the pesticides were detected in black matrix fill, construction debris fill and "non-fill" material. The pesticides were primarily detected in the samples collected immediately below the soil cap. The only deep detection of pesticide was identified at LBG-TB-23 at 18 to 20 ft bg (below seasonal low water-table). This saturated sample was identified with chlordane at a concentration of 511 ppb. Note that all of the aforementioned detections were below the RDEC. A GA PMC has not been established for DDD, DDT and DDE.

DDT and DDE were detected in 8 of the 105 samples analyzed, DDE in 7 of 105, while chlordane was detected in 2 of the 105 samples analyzed. No other pesticides were identified in the soil. The source of the pesticide is unknown; however, these pesticides were commonly used historically for the control of insects. As identified in the historical summary, prior to the placement of the soil cap, standing water was typical in the athletic field, and therefore, would potentially be a good breeding ground for mosquitoes. The pesticides identified in the site soils tend to bind strongly to soils and slowly degrade. In addition, the pesticides detected in the site soils were commercially available and, therefore, may have been applied to control insects.

3.2.3.2.3.1.2 Water Quality

The only pesticide detected in the 128 samples collected for analyses was endrin aldehyde (table 4). This constituent was detected in one sample collected on July 23, 2003 from LBG-MW-13 at a concentration of 0.015 ug/l. It was not detected in the previous samples collected in August 2002 or the subsequent samples collected in October 2003 and February 2004. In addition, endrin aldehyde was not detected above laboratory detection limits during the soil investigation. Considering this was the only detection on the entire property for this constituent, it was not detected in any of the other sampling rounds and the extremely low detection limit for the analyses, it is reasonable to conclude this detection may be a false positive. Note that a GWPC and SWPC have not been established for endrin aldehyde.

As discussed, none of the pesticides detected in the soils were detected in any of the ground-water samples collected for analyses. While a GA PMC has not been established for these constituents (DDD, DDT and DDE), their absence in the site ground water would indicate these pesticides are not leaching to ground water at a detectable concentration.

3.2.3.2.3.2 Cyanide and Metals

Thallium was not detected in the mass or SPLP soil analysis or in any of the ground water samples. Beryllium and selenium were sporadically detected at low concentration in the mass soil analyses, and were not detected during the SPLP or ground-water analyses. The aforementioned constituents have been shown not to be associated with the waste deposited at the Middle School Site, and should not be included in any subsequent sampling investigations.

While metals have been identified throughout all materials at the Middle School Site (metals naturally occur in soils), the source of elevated concentrations of metals is primarily associated with fill deposited at the site. Numerous metals were shown to exceed regulatory criteria for either the RDEC or GA PMC. However, it is clear that the bulk of the regulatory exceedances for total and SPLP metals were antimony, lead and arsenic. Of these inorganics, only lead was detected in the site ground water above the GWPC. The detections of lead in the site ground-water above the GWPC were generally sporadic except at one location which was screened across saturated black matrix fill located on the west-central portion of the site. This does indicate that for this site, the GA PMC does not correlate well with water-quality results.

While barium was not detected above the GA PMC, it is clearly the primary inorganic constituent that has impacted ground water. The highest concentrations of barium in ground water are shown in locations of saturated black matrix fill. Barium does appear to significantly sorb to the surrounding saturated materials, as evidence by the significantly lower concentrations shown in locations downgradient of the saturated fill.

Metals and cyanide have been sufficiently characterized at the site and further investigations to solely characterize their presence are not warranted.

3.2.3.2.3.2.1 Total Cyanide and Total Metals Soil Quality

One hundred and five (105) soil samples were analyzed for PPM plus barium, while 103 soil samples were analyzed for cyanide. As specified in the 2002 revised work plan, total chromium was replaced on the PPM list with hexavalent chromium. The priority pollutant metal list includes antimony, arsenic, beryllium, cadmium, copper, hexavalent chromium (replaced total chromium), lead, mercury, nickel, selenium, silver, thallium and zinc. Of the metals analyzed, only thallium was not detected, which is not unexpected because most naturally occur. Table 5 presents a summary of all detected total metals and cyanide.

No exceedances of the RDEC were identified for barium, beryllium, cadmium, cyanide, hexavalent chromium, nickel, selenium, silver, thallium and zinc. Antimony, arsenic, copper, lead and mercury were all detected at concentrations above the RDEC. Plate 12 summarizes the depth and locations of the detections and exceedances for these metals, and the types of material that were analyzed. Of note, hexavalent chromium was detected in 6 of 105 samples, while cyanide was detected in 10 of 103 samples.

Mercury was detected in 65 of 105 soil samples, while three of the samples exceeded the RDEC. All of the mercury soil samples that exceeded the RDEC were from black matrix fill samples.

Copper was detected in 32 of 105 soil samples, while 10 of the samples exceeded the RDEC. The copper RDEC exceedances were identified in both black matrix fill and construction debris.

Antimony was detected in 92 of 105 soil samples, while 13 of the samples exceeded the RDEC. All but two of the antimony RDEC exceedances were identified in black matrix fill. It is reasonable to conclude that the presence of antimony above the RDEC at the Middle School Site is primarily attributed to the black matrix fill.

Arsenic was detected in 51 of 105 soil samples, while 34 of the samples exceeded the RDEC. Twenty-nine (29) of the 34 arsenic RDEC exceedances were identified in black matrix fill. It is reasonable to conclude that the presence of arsenic above the RDEC at the Middle School Site is primarily attributed to the black matrix fill.

Lead was detected in all soil samples, with 36 of the samples exceeding the RDEC. The CTDEP requested that 400 mg/kg be utilized for the RDEC to be consistent with the RCRA corrective action program. Note that this is currently not a regulatory change and is being applied on a case by case basis. With few exceptions, when lead is identified above the RDEC, it is much higher than the criterion. Twenty-six (26) of the 35 lead RDEC exceedances were identified in black matrix fill soil sample; however, significant concentrations of lead were identified in other waste streams at the site.

Review of the inorganic results, shows that generally higher concentrations of arsenic and antimony can be attributed to the presence of the black matrix fill. While lead was widely detected in the black matrix fill, it was also detected at high concentrations in various other materials.

3.2.3.2.3.2.2 SPLP Cyanide and SPLP Metals Soil Quality

The protocol for analyzing metals through SPLP was as follows: Target metals identified in soil samples from above the seasonal low water-table greater than 1.5 times the local background concentrations or average concentration of the element found in uncontaminated soil in the Eastern United States (ref. 45) (whichever is lower) were analyzed by SPLP for the target metal. Because of cost savings achieved by analyzing the entire set of PPMs plus barium rather than analyzing a few individual metals, most samples were analyzed for all the metals regardless of which metal triggered the need to perform the analyses. All of the samples in which cyanide was detected were analyzed through SPLP. At minimum, 60 sets of PPM plus barium were analyzed through SPLP.

As shown on table 6, cyanide was not detected in any of the samples analyzed.

Sixty (60) soil samples were analyzed for SPLP thallium, while 61 soil samples were analyzed for SPLP selenium and beryllium. As shown on table 6, thallium, selenium and beryllium were not detected in any of the samples.

Sixty (60) soil samples were analyzed for SPLP barium, cadmium, chromium and silver, while 66 soil samples were analyzed by SPLP copper. SPLP barium, cadmium, chromium, copper and silver were detected in 60, 2, 11, 62 and 1 soil sample, respectively. None of the detections exceeded the GA PMC.

Antimony, arsenic, lead, mercury, nickel and zinc all were identified at concentrations above the GA PMC. Table 7 (shown below) summarizes the quantity of samples analyzed, those with detections, and quantity that exceeded the GA and GB PMC. Plate 13 and table 6 show the detailed distribution and individual concentrations of all metals that exceeded the GA PMC at the Middle School Site.

Table 7

Summary of Select SPLP Inorganic Results

	Quantity of Samples Analyzed	Quantity Detected	Quantity Exceed GA PMC	Quantity Exceed 10 Times GA PMC
Antimony	61	19	17	5
Arsenic	60	14	14	3
Lead	61	46	38	7
Mercury	63	10	2	0
Nickel	60	37	7	1
Zinc	63	63	4	0

All of the mercury, nickel and zinc GA PMC exceedances were from soil samples containing black matrix fill. Arsenic, antimony and lead GA PMC exceedances were identified in soil samples containing various fill and "non-fill" material. The distribution of exceedances was generally scattered throughout the site. Note that a review of the inorganic data showed little correlation has been shown between the total and SPLP metal results. Nonetheless, it is clear that the bulk of the regulatory exceedances for total and SPLP metals are antimony, lead and arsenic.

3.2.3.2.3.2.3 Cyanide and Metals Water Quality

Table 7 and plate 14 present a summary of all water-quality results for metals and cyanide. Antimony, arsenic, beryllium, cadmium, cyanide, mercury, selenium, silver, thallium and tin were not detected above the laboratory detection limit. Barium, chromium, cobalt, copper, lead, nickel, vanadium and zinc were detected. Note that with the exception of barium, detections of inorganics in the site ground water are somewhat sporadic. In addition, (excluding barium and in few instances lead) concentrations are generally not consistent throughout the period of record.

Plate 15 shows the distribution and concentration of all detected metals. Although some interior wells show an exceedance of SWPC, the furthest downgradient wells show compliance. Of the constituents detected, lead, nickel and barium were detected above the GWPC. Lead has been detected sporadically above the GWPC in LBG-MW-1, LBG-MW-11, LBG-MW-12 and LBG-MW-14B; however, it has been detected consistently above the GWPC in LBG-MW-14A.

Nickel was detected above the GWPC during one sampling event at LBG-MW-17.

As shown on plate 15, concentrations of barium in the ground water are generally consistent throughout the recording period. Higher concentrations of barium are shown in locations with saturated black matrix material. The concentrations are substantially lower (1 to 2 orders of magnitude) in monitor wells that are located outside of the black matrix material. It is clear that the presence of high concentrations of barium in the ground water is the result of saturated black matrix material.

Thirty-eight (38) exceedances of the GA PMC were identified for lead during the soil investigation. Note the distribution of the lead GA PMC exceedance does not indicate a single source location; however, with the exception of LBG-MW-14A, lead was only detected sporadically above the GWPC. Also note that the two other most prevalent inorganics identified above the GA PMC, arsenic and antimony, were not detected above the GWPC. This does indicate that for this site, the GA PMC does not correlate well with water-quality results.

While barium was not detected above the GA PMC, it is clearly the primary inorganic constituent that has impacted ground water. The highest concentrations of barium in ground water are shown in locations of saturated black matrix fill. Barium does appear to significantly sorb to the surrounding saturated materials, as evidence by the significantly lower concentrations shown in downgradient areas away from the black matrix fill.

3.2.3.2.3.3 Petroleum Hydrocarbons

Petroleum hydrocarbons were identified throughout the soils at the site. ETPH was identified at generally low concentrations at several locations in the underlying native materials. It is difficult to explain the widespread presence of ETPH throughout the site and presence in all fill material. Petroleum was clearly identified in some of the soil samples collected from the black matrix fill. Anecdotal information indicated that grinding materials with lubricating oils were deposited as part of the fill by Winchester Arms. However, other constituents such as lead, arsenic, antimony and barium, seem to also be related to the black matrix fill. These constituents were not identified in significant concentrations outside of this matrix. Therefore, one cannot presume ETPH was spread throughout the Middle School Site from grading activities. It is possible that ETPH was present in all fill material deposited at the Middle School Site; however, this seems to be unlikely considering all the different historic sources of fill. Another potential source may have been related to the historic application of oils to control insects, or possibly the presence of ETPH in the site soils is a combination of all the above.

While the source of the ETPH identified throughout the site soils is a bit of a mystery, the distribution of the presence of ETPH in the site materials has been adequately characterized and further investigations to solely characterize their presence are not warranted.

The source of ETPH in ground water has also not been determined. It would be logical to assume that ETPH is present in ground water because of the numerous detections in soil; however, it has only been detected in the ground water west of the Middle School. Note that the middle school fuel-oil UST is located on the western side of the school. In addition, ETPH detected in soil samples were primarily identified to contain motor oil; however, ETPH has only been identified in ground water as fuel oil. The source of the ETPH in water may be related to the operation of the middle school fuel-oil UST and associated piping, or a spill that may have occurred during filling of the UST. The presence of ETPH in the site ground water should be further evaluated.

3.2.3.2.3.3.1 Soil Quality

Table 8 and plate 15 show the detailed distribution and individual concentrations of all soil samples analyzed and compares the results to the RSRs. Of the 105 soil samples analyzed, ETPH was detected in 87. As shown on plate 15 and table 8, ETPH was identified throughout the Middle School Site at all depths and materials. Of the 87 detections, 28 exceeded the RDEC, while 30 exceeded the GA PMC. The RDEC and GA PMC are both 500 mg/kg; however, the RDEC does not apply to soils below 15 feet and the GA PMC does not apply to soils below the seasonal low water table.

While ETPH was detected throughout the site, the majority (all but one, LBG-MW-3 (3.5 to 4 ft bg)) of the samples that exceeded RSRs criteria were located away from the property boundary.

LBG requested the laboratory to identify the petroleum hydrocarbon carbon range and, if possible, the type of hydrocarbon detected. The results are presented on plate 15 and table 8. A wide range of carbon chains were identified; however, the most common range was C-16 to C-36. Of the 87 soil samples detected with ETPH, the laboratory was able to identify 49 sources of the petroleum hydrocarbons. Forty-seven (47) of the soil samples were identified to contain motor oil, one soil sample was identified to contain hydraulic oil and one contained diesel fuel. Hydraulic oil was identified in the shallow domestic debris/municipal waste located on the south central portion of the Middle School Site (LBG-TB-12 (2.2 to 3.1 ft bg)). Diesel fuel was identified in the relatively deeper construction debris located on the western portion of the site (LBG-TB-24 (13.5 to 14 ft bg)).

3.2.3.2.3.3.2 Water Quality

ETPH has been detected at eight wells at the site. Table 9 summarizes all detections and identifies the source compound of petroleum hydrocarbon for each of the samples collected during the second phase of the investigation. As shown on table 9, all detections exceed the

GWPC. Plate 16 shows the distribution and concentrations of ETPH detections and identifies the source compound of the oil when applicable.

As shown on plate 16, ETPH was detected in the eight wells west of the middle school building. The detections ranged from 0.12 to 0.49 mg/l. Of the detections, the laboratory was only able to fingerprint one of the samples. The ETPH detections identified at LBG-MW-7A and LBG-MW-15A were identified to be fuel oil No. 2. No ETPH detections were identified on the upgradient or downgradients portions of the site. It is reasonable to conclude that the source of the ETPH detections is located on the Middle School Site and that ETPH contaminated ground-water is not discharging off of the site.

The Town of Hamden completed an investigation of an onsite heating-oil UST during 2002 (ref. 46). ETPH was detected in the ground water near the UST. The laboratory was unable to fingerprint the ground-water ETPH detections. The data do not suggest the presence of a non-aqueous phase liquid (NAPL) source.

ETPH detected in soils samples were primarily identified to contain motor oil; however, ETPH in ground water has only been identified to contain fuel oil. Therefore, it cannot be concluded that the source of ETPH in the ground water is related to the ETPH present in the site fill. In addition, the occurrence of ETPH in the site soil was widespread and occurred on the western and eastern side of the site building. ETPH is only identified in the site ground-water west of the middle school. Therefore, the source of the ETPH in water may be related to the operation of the middle school fuel-oil UST and associated piping.

3.2.3.2.3.4 Semi-Volatile Organic Compounds

Phthalates and phenols have been sufficiently investigated and have been shown not to be related to the waste at the Middle School Site. Only carbazole of the tentatively identified compounds (TICs) was identified above regulatory criteria in ground water. Compliance monitoring has been completed for phthalates and phenols and TICs. Therefore, with the exception of carbazole, these constituents should no longer be considered a constituent of concern.

PAHs were identified in all materials at the Middle School Site, except materials identified as domestic waste. PAHs were only sporadically detected along the athletic field property boundary. Peak concentrations of PAHs were detected in the black matrix fill and are clearly associated with this material. The detection of PAHs outside the areas of black matrix fill may be related to the presence of asphalt or the presence of ETPH throughout the site materials. With the exception of a sample collected on the northwest portion of the athletic field, PAHs were not identified in the underlying native materials at notable concentrations.

PAHs were identified in the ground water during initial 2002 investigation above the GWPC; however no exceedance of the RSRs were identified for PAHs during compliance monitoring. It is believed that the concentrations of PAHs identified in 2002 may have been the result of agitation to the unconsolidated materials during drilling. Nonetheless, while PAHs are prevalent in the site materials, they are not leaching to the ground water at significant concentrations.

SVOCs have been sufficiently investigated in the site soils and ground-water and do not warrant additional investigations to solely identify their presence.

3.2.3.2.3.4.1 Soil Quality

Table 10 presents a summary of detected SVOCs and compares the results to regulatory criteria. Table 11 (shown below) presents a statistical summary of SVOC constituents detected and quantity that exceed regulatory criteria.

Table 11

Summary of Select SVOC Results

	Quantity of Samples Analyzed	Quantity Detected	Quantity Exceed RDEC	Quantity Exceed GA PMC	Quantity Exceed 10 Times GA PMC
SVOCs	105	51	32	36	4
Acenaphthene	105	2	0	0	0
Acenaphthylene	105	2	0	0	0
Anthracene	105	16	0	1	0
Benzo(k)fluoranthene	105	38	2	26	2
Benzo[a]anthracene	105	39	29	30	2
Benzo[a]pyrene	105	30	16	17	2
Benzo[b]fluoranthene	105	29	17	18	2
Benzo[g,h,i]perylene	105	2	0	0	0
Bis(2-ethylhexyl)phthalate	105	4	1	3	2
Chrysene	105	40	2	28	3
Dibenzofuran	105	3	0	1	0
Dibenz(a,h)anthracene	105	1	1	1	1
Fluoranthene	105	45	0	11	2

	Quantity of Samples Analyzed	Quantity Detected	Quantity Exceed RDEC	Quantity Exceed GA PMC	Quantity Exceed 10 Times GA PMC
Fluorene	105	9	0	1	0
Indeno(1,2,3-cd)pyrene	105	7	2	2	0
Naphthalene	105	16	0	1	0
Phenanthrene	105	38	0	14	2
Pyrene	105	44	0	14	2

The table above shows that the primary SVOCs detected at the site consists of polynuclear aromatic hydrocarbons (PAHs). Bis(2-ethylhexyl)phthalate is the only SVOC listed above which is not considered a PAH. Bis(2-ethylhexyl)phthalate is a common laboratory artifact and is associated with plastics, such as latex gloves used during field sampling. Therefore, since there were only 4 detections of bis(2-ethylhexyl)phthalate out of 105 soil samples analyzed, and bis(2-ethylhexyl)phthalate is a common lab and field artifact, it is unclear if the detections are related to the unconsolidated materials at the site.

PAHs are compounds that contain more than one benzene ring. They are commonly found in petroleum fuels, coal products, and tar. PAHs are released in considerable quantities from the combustion of fossil fuels such as coal, oil, gas and the burning of wood. They are also commonly associated with asphalt. Benzo(k)fluoranthene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, chrysene, fluoranthene, phenanthrene and pyrene were the most commonly detected SVOCs at the Middle School Site. Plate 17 shows the detailed distribution and individual concentrations of the primary SVOCs that exceeded the RDEC and GA PMC at the Middle School Site. SVOCs were detected in "non-fill" material, construction debris and black matrix fill soil samples. SVOCs were not identified in samples collected solely containing domestic debris. As shown on plate 17, SVOCs are detected throughout the site, with only sporadic detections along the athletic field property boundary.

Asphalt was identified in test pits and soil borings outside of the black matrix fill areas. The presence of SVOCs in these other areas may be related to asphalt. The SVOC detections may also be related the presence of ETPH throughout the site.

3.2.3.2.3.4.2 Water Quality

As shown on table 12 and plate 16, Bis(2-ethyl hexyl)phthalate was detected in monitor wells LBG-MW-6, LBG-MW-15B and LBG-MW-17 at concentrations ranging from 10 to

72 ug/l. The detections of bis(2-ethyl hexyl)phthalate exceed the GPWC of 2 ppb. Bis(2-ethyl hexyl)phthalate is a common laboratory artifact. In addition, bis(2-ethyl hexyl) phthalate is often identified in samples collected with latex gloves. LBG field personnel were wearing latex during the collection of the ground-water samples. While the sampling technique utilized nearly eliminates any potential contact with the water sample, there is the potential that the bis(2-ethyl hexyl)phthalate detections may be attributed to contamination caused during the ground-water sampling. The absence of bis(2-ethyl hexyl)phthalate in subsequent sampling rounds would suggest the detections were related to some type of field contamination.

Naphthalene, 2,4-dimethylphenol, dibenzofuran, fluorine, phenanthrene and carbazole were all detected in LBG-MW-7A. The detections of naphthalene and carbazole in the August 2002 sample were above the GWPC. The August 2002 exceedances of the GWPC were likely the result of agitation caused during the drilling of the monitor wells, or potentially dragging down of materials into the water-table. The results of the compliance monitoring show no exceedances of PAHs at LBG-MW-7A; however, naptahlene has also been consistently detected at low concentrations. In addition, phenanthrene was also detected during the February 2004 sampling round at LBG-MW-10B. Both detections were below the GWPC.

All PAH detections have occurred at either the LBG-MW-10 or LBG-MW-7 cluster. SWPC are met at the downgradient property line.

A large list of Tentatively Identified Compounds (TICs) were identified. All identified TICs are shown on table 12. Note that the previously discussed carbazole was a TIC. No other TICs exceeded established regulatory criteria.

The results of the compliance monitoring showed that PAHs did not exceed the GWPC. It is clear that while PAHs are prevalent in the fill at the site, it is not leaching in any notable quantities from the unsaturated zone.

3.2.3.2.3.5 Volatile Organic Compounds

A source area of halogenated VOCs is believed to be located in the area immediately to the west of the tennis and basketball courts. A plume emanating from this area has been shown to be migrating primarily to the southwest off of the site. Further investigations are necessary to characterize the source area and ground water plume (on and offsite).

Aromatic VOCs were detected at trace concentrations in the black matrix fill, construction debris and non-fill materials. It is speculated that the trace detections are associated with the presence of ETPH throughout the site. None of the detections exceed RSR criteria. Various trace aromatic VOCs have also been detected in the site ground water. Of these, only benzene and chloroform were detected above the GWPC. Benzene has been consistently detected at low concentrations at LBG-MW-7A and LBG-MW-15A, but above the GWPC. A source has not been identified; however, the detections are likely related to the detections of ETPH.

The most common aromatic VOC detected at the site was chloroform. The source of the low chloroform detection is unclear; however, may be related to public supplied water leaching to the ground water. This contaminant is not believed to be associated with the site fill materials because it easily volatilizes and is not a persistent contaminant in ground water.

Aromatic VOCs have been sufficiently investigated in the site soils and ground-water and do not warrant additional investigations to solely identify their presence.

3.2.3.2.3.5.1 Halogenated Volatile Organic Compounds Soil Quality

Table 13 and Plate 18 shows the detailed distribution and individual concentrations of all halogenated VOCs detected. Trichloroethylene, (cis) 1,2-dichloroethylene and vinyl chloride were detected in soil samples collected from soil boring LBG-TB-4 at 9 to 10 ft bg, 16 to 18 ft bg and 23 to 24 ft bg. No other halogenated VOCs were detected in soils at the Middle School Site. Table 14 (shown below) summarizes the halogenated VOC detections in LBG-TB-4.

Table 14

Summary of Halogenated VOC Detections in LBG-TB-14

Depth of Sample (ft bg)	Material Sampled	Trichloroethylene (ug/kg)	(cis) 1,2-Dichloroethylene (ug/kg)	Vinyl chloride (ug/kg)
9 to 10	Black Matrix Fill and Construction Debris	38	40	24
16 to 18	Black Matrix Fill	3,100	5,200	620
23 to 24	Non-Fill	6	7	13
CTDEP RSRs GA PMC		100	1,400	40
CTDEP RSRs RDEC		56,000	500,000	320

As shown above, soil sample LBG-TB-4 16 to 18 ft bg has the highest concentrations. However, the soil sample does not exceed RSR criteria because the RDEC does not apply to soils below 15 ft bg and the GA PMC does not apply to soils below the seasonal low water-table (LBG-TB-14,16 to 18 ft bg, was collected below the seasonal low water-table).

As shown, halogenated VOCs were also detected in the unsaturated zone at this soil boring. It is reasonable to conclude that the source of the deeper halogenated VOC detections are related to the shallow detections. Note that (cis) 1,2-dichloroethylene is a breakdown constituent of trichloroethylene, while vinyl chloride is a breakdown constituent of (cis) 1,2-dichloroethylene. The presence of the breakdown constituents would indicate that this is the result of a historic release. Additional investigations would be needed in this area to fully characterize the extent of the VOCs and determine if dense non aqueous phase liquids are present (DNAPLs).

3.2.3.2.3.5.2 Halogenated VOC Water Quality

Plate 19 shows the distribution and concentrations of all halogenated VOCs detected in the ground water. As shown, trichloroethylene, (trans) 1,2-dichloroethylene, (cis) 1,2-dichloroethylene, vinyl chloride and chloroethane were all detected in the site ground water.

As shown on table 15, trichloroethylene, (trans) 1,2-dichloroethylene, (cis) 1,2-dichloroethylene and vinyl chloride were all detected in the ground water samples collected from the LBG-MW-7 cluster. As discussed above, trichloroethylene, (cis) 1,2-dichloroethylene and vinyl chloride were all detected in the saturated and unsaturated soils near LBG-MW-7A. This location is presumed to be the source area of the halogenated VOC occurrences in the site ground water. LBG-MW-7 is hydraulically upgradient from each of the wells in which the halogenated VOCs have been detected (LBG-MW-4 cluster, LBG-MW-14 cluster and LBG-MW-15 cluster). No other halogenated VOCs were detected at the site. The halogenated VOC plume extends from LBG-MW-7 cluster, to the southwest towards LBG-MW-4, likely discharging off of the site. The plume is bounded to the southeast by LBG-MW-10 cluster and LBG-MW-16 and to the northwest by LBG-MW-2, LBG-MW-13, LBG-MW-1 and LBG-MW-17. The migration pathway of the halogenated VOC plume confirms that the ground water at the Middle School Site discharges to the southwest.

Vinyl chloride was detected above the Proposed Residential Volatilization Criteria (RVC) at Monitor Well LBG-MW-4A during the August 2002 and April 2003 sampling events, however, it was not detected in any of the subsequent sampling events. Note that vinyl chloride concentrations at LBG-MW-4B have significantly declined during the recording period. Vinyl chloride was initially detected during the summer of 2002 at concentrations of 440 ug/l and 560 ug/l; since then they have steadily declined down to 4 ug/l in February 2004. It is unclear why the concentrations have dropped so dramatically.

3.2.3.2.3.5.3 Aromatic Volatile Organic Compounds Soil-Quality

As shown on table 13, low concentrations of aromatic VOCs were detected 23 of 105 soil samples analyzed. The aromatic VOC detections consisted of benzene, ethylbenzene, toluene, xylenes, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 1,4-dichlorobenzene, n-butylbenzene, n-propylbenzene, sec-butylbenzene, tert-butylbenzene, isopropylbenzene and p-isopropyltoluene. These compounds were identified in the black matrix fill, construction debris and non-fill materials. None of the samples exceeded the RDEC or GA PMC.

With the exception of LBG-TB-10, no aromatic VOCs were detected in any borings completed along the Middle School Site boundary. 1,2,4-Trimethylbenzene was detected at 3 ug/kg at the 2 to 3 ft bg interval in LBG-TB-10.

Benzene was the only aromatic VOC identified in ground water (further discussed in section 6.2.4.2). As shown on plate 18, benzene was detected in three soil samples at soil borings LBG-TB-2 (5 to 6 ft bg), LBG-TB-4 (16 to 18 ft bg) and LBG-TB-23 (27 to 29 ft bg) at concentration ranging from 5 to 8 ug/kg. Soil samples LBG-TB-4 (16 to 18 ft bg) and LBG-TB-23 (27 to 29 ft bg) were collected from below the water table and soil samples collected in the unsaturated zones at those borings showed no detections of benzene. A soil sample collected at LBG-TB-2 in between the top of the water-table and LBG-TB-2 (5 to 6 ft bg) showed no detections of benzene. While benzene was detected in the one unsaturated soil sample at extremely low concentrations, the low concentrations of benzene detected in the ground water do not appear to be related to this detection.

3.2.3.2.3.5.4 Aromatic Volatile Organic Compounds Water Quality

Plate 20 and table 15 shows the distribution and concentrations of all aromatic VOCs detected in the ground water. As shown, benzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, acetone, xylenes, toluene, chloroform and methyl tertiary-butyl ether (MTBE) were all detected in the Middle School Site ground water.

The most common aromatic VOC detected at the site was chloroform. Chloroform was detected in LBG-MW-6, LBG-MW-7, LBG-MW-9, LBG-MW-10B, LBG-MW-14A, LBG-MW-14B and HA-B111-OW. Note that chloroform was detected above the GWPC for three consecutive quarters above the GWPC at LBG-MW-6. Chloroform can be formed at low concentrations when chlorine is added to water, as is typical of public supplied water. Chloroform easily volatilizes and is not a common persistent contaminant in ground water. Therefore the presence of chloroform in the Middle School Site ground water likely is unrelated to the historic filling activities. Other sources may include the Hamden Middle School sprinkler system. During the investigation, the athletic field sprinkler system was observed to be leaking at two locations. Because the system was broken prior to the start of the field investigation, RWA repaired the system.

Benzene has consistently been detected at low concentrations at LBG-MW-7A and LBG-MW-15A above the GWPC. Benzene has also been detected above the GWPC at LBG-MW-14A and LBG-MW-4C. Concentrations of benzene detected in the site ground water ranges from 1 to 4 ug/l. In general, trace concentrations of various other aromatic VOCs (toluene, xylenes, 1,2,4-trimethylbenzene and/or 1,3,5-trimethylbenzene) are detected along with benzene. No source of benzene or various other aromatic constituents were identified during the soil investigation. However, the detections may be related to the detections of ETPH. As discussed, the only petroleum hydrocarbon identified in the ground water was No. 2 fuel and it was identified as nearly all locations the trace aromatic VOCs have been detected.

MTBE is the only TIC identified. MTBE has been detected at trace concentrations at LBG-MW-16, LBGMW-7B and the upgradient well LBG-TB-9. The source of the detections is unknown.

3.2.3.2.3.6 Polychlorinated Biphenyls

PCBs were detected in soils located in the central and southern half of the Middle School Site. Additional investigations are necessary to characterize the presence of PCBs in these areas.

PCBs have not been detected in the site ground water.

3.2.3.2.3.6.1 Soil-Quality

Plate 21 and Table 16 show the detailed distribution and individual concentrations of all soil samples analyzed and compares the results to the RSRs. PCBs were detected above the laboratory detection limit in 11 of 105 soil samples analyzed. LBG reanalyzed several of the samples detected with PCBs. All initial analyses were below the RDEC; however, as shown on table 16, the second analyses of LBG-TB-25 (9.5 to 10 ft bg) resulted in a detection above the RDEC.

The PCB detections are located in the central and southern half of the Middle School Site. As shown on plate 21, the vertical extent of the PCB occurrences has been characterized. The lateral extent of PCB occurrences is not fully characterized, control points are necessary along the southern and western athletic field property boundary. In general, PCBs detected were at low concentrations; however, additional investigations are necessary near LBG-TB-25 and LBG-TB-12/TB-5.

3.2.3.2.3.6.2 Water Quality

No PCBs were detected above the laboratory detection limit in any of the ground-water samples analyzed.

3.2.3.2.3.7 Herbicides

No herbicides were detected above the laboratory detection limit in any of the ground-water samples analyzed. Herbicides should not be considered a constituent of concern.

3.3 Identification and Remedy of Data Gaps

The evaluation of the data identified a long history of filling at the Middle School Site and regional area. While numerous environmental investigations have been completed at the site, several data gaps remain. A discussion of these data gaps identified as part of the evaluation of the existing data is presented below. A summary of the proposed remedy for the data gaps is also presented below. A detailed scope of work describing the remedies is presented in the following sections of this Supplemental Scope of Study.

3.3.1 Extent and Content of Fill

The site was identified to have been filled with domestic wastes, industrial waste, construction debris and sand and gravel materials. Anecdotal information suggests that the materials deposited at the Middle School Site included larger metallic objects such as drums; however, these objects have not been identified during any of the investigation. In addition, the lateral extent of the fill has not been fully defined. It is not clear how far the fill extends into the berm located on the northern portion of the property and the southern limits have not been clearly defined in the two residential parcels owned by the Hamden Housing Authority and on the southeastern portion of the Middle School Site. Therefore, the content and extent of the waste at the Middle School Site needs to be further defined. In addition, the CTDEP has requested the materials beneath the tennis and basketball courts be characterized (ref. 48).

This data gap will be addressed through the use of geophysics (ground-penetrating radar (GPR) or electromagnetic (EM) scan), drilling of soil borings and possibly the excavation of additional test pits at the Middle School Site. Note that the extent of fill would be delineated until closure is reached, even if this includes investigating soils north of the Middle School Site into the wetland corridor owned by RWA.

3.3.2 Extent of Soil Cap Placed on the Athletic Field

No as-built drawings were identified for the soil cap placed over the athletic field in 1995 and 1996; however, subsequent investigation have defined most of the limits and thicknesses. Review of the site survey taken in 1991 and 1995 show that the initial placement of the gravel did not cover identified fill on the southeastern corner of the athletic field, east of the basketball and tennis courts and on the berm north of the tennis courts. The southeastern corner of the athletic field and east of the tennis and basketball courts were mitigated through CTDEP emergency remedial actions. Sampling data collected in 1993 identified sporadic high concentrations of lead in the surficial materials collected along the northern berm. While lead was identified throughout the materials of the site, higher concentrations of the constituent is generally associated with the presence of fill. Surficial soils on the northern berm area need to be characterized to determine if the cap was extended to this area.

This data gap will be addressed through the collection of surficial soil samples along the northern berm. Deeper soil samples will be collected in this area as part of the extent investigation described above.

3.3.3 Surface-Water Quality

The CTDEP has expressed concern for the surface-water quality present in the wetland corridor located immediately north of the Middle School Site in their March 8, 2004 comment letter (ref. 48) concerning the 2002 LBG ESI. The CTDEP identified the potential of ground-water flowing to the north and discharging into the wetland.

To address this data gap, a sample of surface water will be collected for laboratory analyses of constituents of concern (see section 5.0 concerning COCs).

3.3.4 Ground-Water Flow Direction

In the 2004 CTDEP comment letter, concerns were expressed concerning the evaluation of ground-water flow at the site. The CTDEP specifically requested the installation of a deep monitor well at the location of LBG-MW-11 and further evaluation of data. Part of the additional evaluation of data has been addressed in the above CSM.

To address this data gap, an additional deep monitor well will be installed at LBG-MW-11. A second monitor well (potentially a cluster if the wetland organic layer is identified) would be installed on the southwestern side of the wetland corridor. In addition, monitor wells will be installed in the interior and western portions of the athletic field as part of ground-water characterization investigations described below. Data from these wells will be used to further refine the interpretation of ground-water flow.

3.3.5 ETPH in Ground Water

ETPH was detected throughout the site soils and are considered to have been sufficiently characterized. In general, they are identified throughout the Middle School Site in all materials. However, the presence of ETPH in the site soils does not appear to be responsible for the ETPH identified in ground water. This is evident because ETPH is only detected in the site ground water west of the middle school and the type of TPH in soils does not match the TPH in ground water. The source may be related to the operation of the middle school fuel-oil UST and associated piping, or a spill that may have occurred during filling of the UST.

To address this data gap, ground water will be collected from the proposed expanded monitor wells network and analyzed for ETPH. In addition, soil borings drilled during various other focused investigations will include the analyses of ETPH (portions of the ground-water flow investigation and characterization of materials beneath the tennis and basketball courts). It will be determined after evaluation of the data if additional investigations are warranted.

3.3.6 Halogenated VOCs

A source area of halogenated VOCs is believed to be located in the area immediately to the west of the tennis and basketball courts. A plume emanating from this area has been shown to be migrating primarily to the southwest off of the site. Further investigations are necessary to characterize the source area and ground water plume (on and off site).

To address this data gap, a focused soil boring and ground-water investigation will be completed. The investigation will include the drilling of soil borings, installation of monitor wells and collection and analyses of soil samples for halogenated VOCs.

3.3.7 PCBs

PCBs were detected in soils located in the central and southern half of the Middle School Site. Note that PCBs have not been detected in the site ground water. This is not unanticipated because PCBs are not miscible. Additional investigations are necessary to characterize the presence of PCBs in these areas.

To address this data gap, a focused soil boring investigation will be completed which includes the continuous sampling and analyses for PCBs. If the results of the soil investigation identify a significant source of PCBs, monitor wells would be installed as part of the investigation.

4.0 CONTAMINANTS OF CONCERN

The results of extensive soil and ground-water environmental investigations and compliance monitoring have indicated the following should remain as constituents of concern

(COCs) at the site: VOCs (plus MTBE), PCBs, SVOCs (PAHs plus carbazole), ETPH, pesticides, total and SPLP metals. The metals list includes antimony, arsenic, barium, cyanide, cadmium, copper, chromium, lead, mercury, nickel, silver and zinc.

The following are not believed to be associated with wastes disposed at the Middle School Site: beryllium, thallium, selenium, tin, vanadium, phenols, phthalates, herbicides, and TICs associated with SVOCs and VOCs. Therefore these compounds have been removed from the COC list.

Note that several portions of the investigation presented below are focused and would only include the analyses of the compounds to be characterized.

5.0 SCOPE OF WORK

This scope of work has been prepared in a phased approach so that sample points would be optimally located, thereby reducing unnecessary investigative work. The following Scope of Work has been prepared to address data gaps identified in CSM.

The scope of work incorporates both direct push (Geoprobe®) and hollow-stem auger drill rigs to be utilized during the soil boring investigations. The 2002 ESI showed that direct push drill rigs could successfully penetrate the exterior fill materials without collapse of the borehole material. All samples will be analyzed by York Analytical Laboratories (York) of Stratford, Connecticut. York is a CTDPH certified laboratory. A description of general field procedures and investigations for each data gap is presented below.

5.1 Drilling of Soil Borings

Unless the wetland organic layer is encountered, all soil borings will be drilled to 15 ft bg or at least 3 feet below the base of the identified fill, which ever is deeper. If the wetland organic layer is encountered, drilling would cease at that point unless the boring is to be complete as a monitor well; then the procedure described in Section 5.2 would be followed.

Soil borings will be drilled utilizing the direct push method or hollow stem auger, depending on materials encountered, depth of boring and purpose of soil boring. Soil borings would be backfilled with cuttings until 4 ft bg. The top four feet of all soil borings will be filled with either top soil brought from offsite or grout/bentonite. All soil borings to be completed as monitor wells will be drilled with use of the hollow stem auger.

Soil samples will be collected continuously at all soil-boring locations until completion. At soil borings drilled by the direct push method, soil and fill samples will be collected utilizing a 2-inch outer diameter, 4-foot long steel macrocore sampler containing an acetate liner. At soil borings drilled with the hollow stem auger, soil and fill samples will be collected utilizing a 3-inch outer diameter, 2-foot long split spoon. Split spoons will be decontaminated before and between each use. Decontamination procedures include brushing with an Alconox wash and rinsing with deionized water.

Soil samples collected from split spoons and macrocores will be placed into dedicated, sealed plastic bags. The resultant headspace within each plastic bag will be screened for the presence VOCs with use of a photoionization detector (PID) that will be calibrated to an isobutylene standard. Any soil samples collected for analyses will be placed in a properly labeled laboratory-supplied container, and stored in a chilled cooler until delivery to the laboratory. All split spoon and macrocore samples will be photographed and geologically logged. Geologic logs will be completed for each boring and soils will be logged in accordance with ASTM D 2488 and ASTM D 2487.

5.2 Monitor Well Design and Installation

All monitor wells would be installed with hollow-stem augers. The wells will be constructed of 2-inch diameter SCH 40 PVC and 10-slot screen. Monitor well screen settings that cross the water table will measure 10 feet in length. A 5 foot screen length would be used for monitor wells completed below the water-table. Each monitor well will be installed with 0.010-inch slotted, flush-joint PVC screen set from the bottom of the borehole to above the water table observed in the field. Two-inch diameter PVC casing will be installed from the top of the screen to grade. The annular space in the vicinity of the well screen will be filled with FilterSil No. 1 gravel pack. A 2-foot bentonite seal will be placed 2 feet above the screen setting. Grout will then be used for backfill from the top of the bentonite seal to approximately 2 ft bg. The monitor wells will be completed with steel-cased road boxes set in cement. All the monitor wells will be covered with watertight locking well caps. If requested by Hamden’s Park and Recreation officials, the surface of the monitor wells will be completed subgrade so that dirt and grass could cover them.

After the wells are installed, a licensed surveyor will survey the top of the PVC casing and grade at each monitor well. Monitor wells will be developed 24 hours after installation. A minimum of three volumes of water will be removed from each well and development would be deemed complete when normal hydraulic conductivity with the aquifer has been restored. Well purging activities will be properly recorded. Water will be contained in 55-gallon drums for disposal offsite or to the sanitary sewer system (dependant on Town of Hamden discharge permit and approval).

5.3 Ground-Water Sampling

All ground-water samples will be collected using the low-stress purging and sampling technique. In general, the sampling procedure entails the removal of ground water through a bladder pump, centrifugal pump or even a peristaltic pump at extremely low flow rates (example, 0.1 to 0.4 l/min (liter per minute), even lower rates for low permeable materials). The sample is collected once stabilization for three consecutive readings is achieved for the following parameter and variance: turbidity (10 percent for values greater than 1 NTU), dissolved oxygen (10 percent), specific conductance (3 percent), temperature (3 percent), pH (0.1 units) and oxygen reduction potential (10 millivolts). The methodology for this technique is outlined in the July 30, 1996 USEPA Region I, “Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells” (ref. 49).

The aforementioned sampling technique is not intended for the collection of ground-water samples in instances where non-aqueous phase liquids (NAPLs) are present. If dense NAPLs are identified, a sample of the NAPL will be collected with a double check valve, bailer or if the dense NAPL is thick enough, a submersible pump may be used for extraction. In cases where light NAPLs are identified, a sample from the top of the water column will be collected with use of a single or double (depending on thickness) check valve bailer (EPA/530-R-93-001). Sampling procedures for light and dense NAPLS are presented in the November 1992 USEPA “RCRA Ground-Water Monitoring: Draft Technical Guidance” (ref. 50).

5.4 Investigation of Data Gaps

5.4.1 Extent and Content of Fill

5.4.1.1 Geophysics

LBG will employ geophysics to further characterize the extent of fill and identify bulk metallic objects potentially buried at the site. LBG will initially utilize ground penetrating radar (GPR) to complete the survey; however, if the signal is significantly degraded because of the high metal concentrations generally associated with the black matrix fill, an EM will then be utilized. The geophysical equipment will be used to map a 50-foot grid pattern of the site. A tighter grid spacing will be employed as necessary. Unconsolidated materials beneath the school building, residential buildings and community center will not be included in the survey.

5.4.1.2 Test Pits

After review of the geophysical survey data, up to three locations would be chosen as locations in which test pits would be completed to investigate anomalies. The test pits will be excavated with a standard backhoe. Cover material and fill material would be separated onto plastic covers. Each test pit will be logged and photographed. If any materials are encountered that appear different than what was encountered during the 2002 ESI, samples will be submitted to the laboratory for analyses of the following COCs:

- VOCs by EPA Method 8260 plus MTBE;
- SVOCs (PAHs plus carbazole) by EPA Method 8270;
- CTETPH (plus oil identification);
- SPLP and mass analyses of antimony, arsenic, barium, cyanide, cadmium, copper, chromium, lead, mercury, nickel, silver and zinc;
- Pesticides by EPA Method 8081; and
- PCBs by EPA Method 8082.

Samples collected for analyses would be placed in a properly labeled laboratory supplied container, and placed in a chilled cooler until delivered to the laboratory for analyses. Test pits would be filled up to 4 ft bg with materials excavated from the pit. Thereafter, the test pit would be filled with the excavated cap material and clean fill brought from offsite.

5.4.1.3 Soil Borings

5.4.1.3.1 Northern Wetland Corridor and Southern Extent of Fill

Plate 22 shows the initial location of soil borings to be drilled in the northern wetland corridor, two Hamden Housing Authority residential properties and north of the Hamden Community Center. These soil borings are to be drilled to verify the extent of fill in these areas. Soil borings will likely be drilled via direct push; however, a hand auger may be necessary in the area of the wetland corridor. Soil borings drilled with the direct push drill rig would be drilled to a minimum of 15 ft bg or 3 feet below any identified fill, which ever is deeper. If the extent is not determined with the initial soil borings shown on Plate 22, additional soil borings will be drilled to determine the extent of fill in those areas. The investigation will be deemed completed when either the fill limit is identified or fill is identified to extend to the Middle School Site limit. Because the northern wetland corridor is owned by RWA, drilling would continue until the limit of fill is identified. If hand augering is necessary, these soil borings would be completed to 4 ft bg or refusal.

5.4.1.3.2 Tennis and Basketball Courts

Plate 23 shows the location of four soil borings to be drilled inside the tennis and basketball court areas. All soil borings would be drilled with use of a direct push drill rig. As discussed in Section 5.1, soil samples would be continuously collected and screened with use of a PID. It is likely that this area is underlain by the wetland organic layer, therefore the soil borings would be drilled to the top of this layer. If this layer is not encountered, they would be drilled to 3 feet below fill or 15 ft bg, whichever is deeper.

Soil samples would be collected from the following intervals for laboratory analyses:

1) 0 to 2 ft bg;
2) 2 to 4 ft bg;
3) 4 ft bg to 10 ft bg (only fill: no sample collected if fill is not encountered);
4) 10 ft bg to end of fill (only fill: no sample collected if fill is not encountered); and
5) Unconsolidated material underlying fill material.

Samples analyzed within the zones of fill described above will be chosen based on the highest VOC measured with the PID. If no VOCs are detected, the sample will be chosen based on olfactory senses (i.e. discoloration, odor and/or texture). Samples would be analyzed for the COCs shown below:

- VOCs by EPA Method 8260 plus MTBE;
- SVOCs (PAHs plus carbazole) by EPA Method 8270;
- CTETPH (plus oil identification);
- SPLP and mass analyses of antimony, arsenic, barium, cyanide, cadmium, copper, chromium, lead, mercury, nickel, silver and zinc;
- Pesticides by EPA Method 8081; and
- PCBs by EPA Method 8082.

All samples would be placed in laboratory approved containers, properly labeled and placed in a chilled cooler until delivery to the laboratory.

5.5 Extent of Soil Cap Placed on the Athletic Field

Seven surficial soil samples will be collected from depth of 0 to 6-inches below grade along the northern berm as shown on Plate 23. The samples will be collected with a clean stainless steel trowel. All samples would be analyzed for the following COCs:

- VOCs by EPA Method 8260 plus MTBE;
- SVOCs (PAHs plus carbazole) by EPA Method 8270;
- CTETPH (plus oil identification);
- SPLP and mass antimony, arsenic, barium, cyanide, cadmium, copper, chromium, lead, mercury, nickel, silver and zinc;
- Pesticides by EPA Method 8081; and
- PCBs by EPA Method 8082.

Note that the extent of any fill in this area would be determined as part of the data gap investigation described in Section 5.4.3.

5.6 Surface-Water Quality

If water is identified in the wetland corridor, a surface-water sample will be collected via a clean stain less steel bailer for analyses of the following COCs:

- VOCs by EPA Method 8260 plus MTBE;
- SVOCs (PAHs plus carbazole) by EPA Method 8270;

- CTETPH (plus oil identification);
- SPLP and mass antimony, arsenic, barium, cyanide, cadmium, copper, chromium, lead, mercury, nickel, silver and zinc;
- Pesticides by EPA Method 8081; and
- PCBs by EPA Method 8082

If standing water is not present during the time of the field investigation (summer), a sample will be collected at a future date.

5.7 Ground-Water Flow Direction

To develop a better understanding of ground-water flow at the site, a minimum of three new monitor wells will be completed at the site. The location of the proposed monitor wells are shown on Plate 23. The monitor wells include a deep well at LBG-MW-11, a monitor well approximately 150 feet west of LBG-MW-11 and a monitor well on the western property boundary. The well to be drilled approximately 150 feet west of LBG-MW-11 would be completed as a cluster if the wetland organic material is identified in this area. The organic material is not anticipated to be encountered along the western property boundary; however, if it is identified, a deep and shallow well will also be installed at this location.

Monitor wells will be installed as described in section 6.2 and soil borings will be drilled as described in section 6.1. Note that monitor wells will also be installed on and offsite as part of the halogenated VOC investigation. All wells will be surveyed into the existing network by a licensed surveyor. Depth to water level data will be colleted from the full network, regional wells and wells located at the western abutting property (assuming permission is granted by SNET) for one year on a quarterly basis. During this period, precipitation will be recorded for a three day period prior to collection of measurements. In addition, potential impacts from utilities, the sprinkler system and storm-water drainage system will also be assessed. The data will be used to provide a more detailed description of ground-water flow.

Soil samples will also be collected for analyses of COCs from the proposed monitor well locations (three discussed above). Soil samples would be collected from the following intervals for laboratory analyses:

1) 0 to 2 ft bg (only fill: no sample collected if fill is not encountered);
2) 2 to 4 ft bg (fill or native soil sample);

3) 4 ft bg to 10 ft bg (only fill: no sample collected if fill is not encountered);
4) 10 ft bg to end of fill (only fill: no sample collected if fill is not encountered); and
5) Unconsolidated material underlying fill material.

Samples analyzed within the zones of fill described above will be chosen based on the highest VOC measured with the PID. If no VOCs are detected, the sample will be chosen based on olfactory senses (i.e. discoloration, odor and/or texture). Samples would be analyzed for the COCs shown below:

- VOCs by EPA Method 8260 plus MTBE;
- SVOCs (PAHs plus carbazole) by EPA Method 8270;
- CTETPH (plus oil identification);
- SPLP and mass analyses of antimony, arsenic, barium, cyanide, cadmium, copper, chromium, lead, mercury, nickel, silver and zinc;
- Pesticides by EPA Method 8081; and
- PCBs by EPA Method 8082.

All samples would be placed in laboratory approved containers, properly labeled and placed in a chilled cooler until delivery to the laboratory.

5.8 ETPH in Ground Water

A focused investigation to evaluate the presence of ETPH in ground-water is not proposed at this time. At the completion of this field investigation, the site will contain a more extensive monitoring well network and several new data points of ETPH soil-quality will have been generated. At minimum, one quarter of ground-water samples will be collected from this new network and analyzed for COCs. It will be determined after evaluation of the data if additional investigations are warranted.

5.9 Characterization of Halogenated VOCs

This initial phase of this investigation includes the drilling of four soils borings around the location of the halogenated VOC detection in soils (LBG-TB-4). The soil borings would be located approximately 40 feet north, south, east and west of soil boring LBG-TB-4. In addition, a soil boring would be drilled immediately adjacent to soil boring LBG-TB-4. All soil borings would be drilled to the top of the wetland organic layer. If the layer is not encountered, soil borings would be drilled at least 3 feet below the base of the fill, and at least 6 feet below the base of any appreciable VOC measurement identified with the PID (20 ppm or higher). Soil borings would be drilled with use of a hollow stem auger. Soil samples would be collected continuously from grade via split spoon until the end of the soil boring.

Assuming reasonable recovery, duplicate soil samples would be collected from each 2-foot split spoon and placed in properly labeled laboratory supplied containers and stored in a chilled cooler. One of the sets of samples would be delivered to the laboratory for analyses of halogenated VOCs by EPA Method 8021B. The second set of samples would be stored at the laboratory until the results of the VOC analyses has been reviewed.

Duplicate soil samples identified to contain halogenated VOCs would be sent to Xenobiotic Detection Systems of Durham, North Carolina to be stored for potential analyses of dioxins and furans using the Xenobiotic Detection System's Calux Bio-Assay. A subset of the samples identified to contain VOCs would be analyzed for dioxins and furans after guidance for the frequency and analyses is provided by the CTDPH and CTDEP. The Xenobiotic Detection System's Calux Bio-Assay provides a detection limit of 1 part per trillion for a full list of dioxins and furans. This analysis is utilized in the United States by the Food and Drug Administration has been certified in the European Union as an acceptable analysis for dioxins, furans and PCBs. Information concerning the Calux Bio-Assay is provided in Appendix V. Note that dioxins and furans have a hold time of one year.

After review of the initial soil sample results for halogenated VOCs, a second set of soil borings will be drilled to further characterize the source of the VOCs. If no VOCs are identified in the initial four surrounding soil borings, soil borings will be drilled closer to LBG-TB-4 (spaced approximately 20 feet around the soil borings). If halogenated VOCs are detected in all soil borings, additional soil borings would be drilled around the initial set of soil borings (eight soil borings approximately 40 feet outside of initial soil borings). However, if halogenated VOCs are identified in only some of the soil borings, a more focused soil boring layout would be developed to adequately characterize the halogenated VOCs in the soil. The same duplicate sampling approach described above would be used for all sets of soil borings drilled during this investigation. However, soil samples may not be collected for continuous analyses in perimeter soil borings if analytical results show the source of the spill has been identified, and the purpose of the perimeter soil borings is to define any type of DNAPL migration on the wetland organic layer. If this is the case, soil samples would only be collected from the zone of concern and areas identified with VOCs through PID measurements above background. The soil boring investigation will be deemed completed when the source area is adequately characterized.

After completion of the source investigation, monitor wells will be installed around the source area to further evaluate ground-water quality. A determination of monitor well locations and screen depths would be determined after review of the soil data results. Monitor wells would also be installed downgradient and/or along the edges of the plume to further define plume extent. Again, the location and quantity of monitor wells would be determined after review of the soil investigation data. As described in Section 5.7, a monitor well has been proposed for the southwestern portion of the site. Data from this well will aid in the characterization of the lateral extent of the plume.

The halogenated VOC plume will also be characterized offsite through the installation of monitor wells in areas of "right of way." Locations will be determined after the plume at the exit point of the Middle School Site has been further delineated. Considering compliance monitoring results suggests relatively low levels of halogenated VOCs are exiting the Middle School Site, LBG anticipates the offsite monitor well network to include approximately three to four monitor wells.

Ground-water samples will be collected from the monitor well network as it is developed. All samples will at minimum be analyzed for VOCs by EPA Method 8260 plus MTBE. As discussed in Section 5.8, the network would likely also be utilized to further define ETPH in ground water.

5.10 Characterization of PCBs

Plate 25 shows locations of proposed soil borings to be drilled for the characterization PCBs in unconsolidated materials located in the central and southern half of the Middle School Site. All soil borings would be drilled with use of a direct push drill rig. Unconsolidated materials in these areas were determined in the 2002 ESI investigation to be sufficiently competent for a direct push method drill rig.

Soil borings will be drilled 3 feet below the base of the identified fill or 15 feet below grade, which ever is deeper. If the wetland organic layer is encountered, the soil boring will ceases at that depth (this is not anticipated in a large portion of these areas). Soil samples will be collected every 2 feet, geologically logged, photographed and screened for VOCs with use of the PID. Assuming sufficient soil core recovery, duplicate soil samples will be collected every 2 feet and placed in laboratory supplied, properly labeled containers and stored in a chilled cooler.

One of the sets of soil samples would be delivered to the laboratory for analyses of PCBs by EPA Method 8082. The second set of samples would be stored in a refrigerator at LBG until the results of the PCB analyses has been reviewed. Duplicate soil samples identified to contain PCBs would be sent to a Xenobiotic Detection System's to be stored for potential analyses of dioxins and furans using their Calux Bio-Assay. A subset of the samples identified to contain PCBs would be analyzed for dioxins and furans after guidance for the frequency and analyses is provided by the CTDPH and CTDEP.

After review of the initial PCB soil quality data, a determination will be made if the presence of PCBs has been sufficiently characterized (i.e., lateral, vertical and distribution). If additional soil borings are deemed necessary, locations would be based on the results of the initial investigation. Sampling protocols identified for the initial soil boring investigation would remain the same during subsequent investigations. The soil investigation will be deemed complete when the distribution and extent of PCBs is fully characterized.

If the results of the soil investigation identify a single point source of substantial PCB concentrations, at minimum, a monitor well would be installed immediately down gradient of this area. Ground-water samples would be collected and analyzed for PCBs by EPA Method 8082.

5.11 Reporting

A report summarizing the field work completed and detailing the results of the investigation will be generated. Any additional data gaps will be identified. The report would be issued to the CTDEP for approval.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

The Quality Assurance Project Plan (QAPP) that follows is site-specific and has been prepared for the activities to be completed during this and any additional site characterization investigation.

The objective of the QAPP is to provide sufficiently thorough and concise descriptions of the measures to be applied during the investigation such that the data generated will be of a known and acceptable level of precision and accuracy. The QAPP sets forth specific procedures to be used during sampling of relevant environmental matrices and analyses of data.

6.1 Quality Assurance Objectives for Measurement Data

The overall QA objective is to develop and implement procedures for field sampling, sample preparation and handling, sample Chain of Custody, laboratory analyses and reporting, which will provide accurate data.

The purpose of this section is to define the goals for the level of QA effort, namely: accuracy; precision and sensitivity of analyses; and completeness, representativeness, and comparability of measurement data from the analytical laboratory. In addition, QA objectives for field measurements are also defined.

6.2 Level of QA Effort

6.2.1 Field QC Sampling

To assess the quality of data resulting from the field sampling program, field duplicate samples and field blanks and samples for matrix spike analyses will be collected (where appropriate) and submitted to the analytical laboratory.

Field QA/QC samples that will be provided by LBG to the analytical laboratory will be as identified below:

- Field duplicate samples will be collected at a frequency of one per 30 investigative samples.
- Field (rinse) blank samples will be collected at a frequency of one per 60 investigative samples (split spoon sampler only).

- Triple sample volume will be supplied to the laboratory by LBG in order to perform spike and duplicate analyses at a frequency of one per 60 investigative samples.

Field (rinse, equipment) blanks will be analyzed to check procedural contamination from sampling device cleaning procedures, and ambient conditions at the site. Field duplicate samples will be analyzed to assess sampling and analytical reproducibility.

6.3 Laboratory QC Effort

6.3.1 Accuracy, Precision and Sensitivity of Analyses

The fundamental QA objective with respect to the accuracy, precision and sensitivity of analytical data is to achieve the QC acceptance criteria of each analytical protocol. The purpose of the analytical work completed during the investigation is for the chemical characterization of site soil/fill and ground water.

The targeted quantitation limits for this investigation will be in accordance with the analytical methods specified. With the exception of dieldrin in water, the specified methods are capable of achieving detection limits at or below the applicable CTDEP Remediation Standard Regulation numerical criteria.

The method accuracy for samples will be determined by spiking selected samples (Matrix Spikes) with all spiking compounds specified in the analytical methods. Accuracy will be reported as the percent recovery of the spiking compound(s) and will be compared with the criteria given in the appropriate methods.

The method(s) precision (reproducibility between duplicate analyses) will be determined from the duplicate analysis of matrix spike samples for organic parameters.

Sampling and analytical precision will be determined from the collection and analysis of field duplicate samples.

6.3.2 Completeness, Representativeness and Comparability

It is expected that all analyses conducted in accordance with the analytical methods will provide data meeting QC acceptance criteria for 95 percent of all samples tested. Any reasons for variances will be investigated by the laboratory and documented.

Analytical methods used for this study are consistent with published USEPA methodologies to assure comparability of the data. All standards used by the laboratory will be traceable to reliable sources.

6.4 Field Measurements

Measurement data will be generated in many field activities. These data include, but are not limited to, the following:

i) documenting time and weather conditions;
ii) observation of sample appearance and other conditions;
iii) water quality field parameters for the low stress, low flow purging method.

The general QA objective for measurement data is to obtain reproducible and comparable measurements to a degree of accuracy consistent with the use of standardized procedures.

6.4.1 Sampling Procedures

The sampling procedures for the investigation of the unconsolidated materials are discussed in the scope of work (Section 5.0). The standard operating procedure for the collection of the ground-water samples is presented above in referenced EPA publications.

6.4.2 Sample Custody and Document Control

The following documentation procedures will be used during sampling and analyses to provide Chain of Custody control during transfer of samples from collection through analyses. Record keeping documentation will include use of the following:

- field log book (bound with numbered pages) to document sampling activities in the field;
- labels to identify individual samples; and
- Chain of Custody record sheet to document analyses to be completed.

6.4.3 Field Log Book

In the field, the sampler will record the following information in the field log book for each sample collected:

- sample number (all samples will have an unique identification with LBG as part of the nomenclature);
- sample matrix;
- name of sampler;

- sample source;
- time and date;
- pertinent data (e.g., location, sample interval);
- analysis to be conducted;
- sampling method (e.g., low flow stress purging sampling method or bailer)
- appearance of each sample (turbidity, color, smell, etc.);
- number of sample bottles collected; and
- pertinent weather data.

Each field log book page will be signed by the sampler.

A unique sample numbering system will be used to identify each collected sample. This system will provide a tracking number to allow retrieval and cross-referencing of sample information.

6.5 Chain-of-Custody Records

Chain-of-Custody forms will be completed for all samples collected during the investigation to document the transfer of sample containers. A typical sample of the Chain-of-Custody form is included in Appendix VI. All samples will be refrigerated at 4^0 C ("2 ^{0}C) using wet ice and delivered to the analytical laboratory within 48 hours of collection. All samples will be delivered to the laboratory by laboratory personnel, or by LBG field personnel. All samples will be maintained at 4^0 C ("2^0 C) by the laboratory.

The Chain-of-Custody record, completed at the time of sampling, will contain, but not be limited to, the sample number, date and time of sampling, and the name of the sampler. The chain-of-custody document will be signed, timed, and dated by the sampler when transferring the samples. LBG will retain one copy of the chain of custody form.

6.5.1 Sample Documentation in the Laboratory

Each sample or group of samples shipped to the laboratory for analysis will be given a unique identification number by the laboratory. The laboratory Sample Custodian will record the client name, number of samples and date of receipt of samples in the Sample Control Log Book. The temperature of one sample/cooler will be measured and recorded on the Chain of Custody.

Samples removed from storage for analyses will be documented in the Sample Control Log Book.

The laboratory will be responsible for maintaining analytical log books and laboratory data as well as a sample (on hand) inventory for submittal to LBG on an "as required" basis. Raw laboratory data produced from the analysis of samples submitted for this program will be inventoried and maintained by the laboratory for a period of five years at which time LBG will be notified by the laboratory prior to proper disposal. LBG may require the laboratory to maintain the samples for an extended period.

6.5.2 Storage of Samples

After the Sample Custodian has completed the Chain-of-Custody forms and the incoming sample log, the Chain of Custody will be checked to ensure that all samples are stored in the appropriate locations. All samples will be stored within an access controlled custody room and will be maintained at 4EC("2EC) until all analytical work is complete.

6.5.3 Sample Documentation

Evidentiary files for the entire project shall be inventoried and maintained by LBG and shall consist of the following:

- i) project related plans;
- ii) project log books;
- iii) field data records;
- iv) sample identification documents;
- v) Chain of Custody records;
- vi) report notes, calculations, etc.;
- vii) lab data, etc.;
- viii) references, copies of pertinent literature;
- ix) miscellaneous - photos, maps, drawings, etc.; and
- x) copies of all final reports pertaining to the project.

The evidentiary file materials shall be the responsibility of the project manager with respect to maintenance and document removal.

7.0 SCHEDULE

The geophysical and subsurface field investigation will initiate during the summer of 2004 after the approval of this Supplement Scope of Study by the CTDEP. Six months after characterization field investigations have been completed, a report summarizing the field work completed and detailing the results of the investigation will be generated. If the CTDEP indicates they are satisfied with the interpretation of ground-water flow generated during the quarterly monitoring and prior to the completion of the year of monitoring, a report would be issued 6-months after that point. The report would be issued to the CTDEP for approval.

LEGGETTE, BRASHEARS & GRAHAM, INC.

Michael Manolakas
Associate

Reviewed by:

Jeffrey B. Lennox, CPG, LEP
Vice President

cmm
April 16, 2004
H:\SCCRW\2004\Hamden\Work Plan\Work Plan and QUAPP.doc

"I have personally examined and am familiar with the information submitted in this document and all attachments thereto, and I certify, based on reasonable investigation, including my inquiry of those individuals responsible for obtaining the information, that the submitted information is true, accurate and complete to the best of my knowledge and belief. I understand that any false statement made in the submitted information is punishable as a criminal offense under §53a-157b of the Connecticut General Statutes and any other applicable law."

____

South Central Connecticut Regional Water Authority
Thomas V. Chaplik
Vice President

____

Leggette, Brashears & Graham, Inc.
Jeffrey B. Lennox
Principal

SUPPLEMENTAL SCOPE OF STUDY
FORMER NEW HAVEN WATER
COMPANY PROPERTY
HAMDEN, CONNECTICUT

VOLUME I OF IV
(text, tables and figures)

Prepared For:

Connecticut Department of Environmental Protection

On Behalf Of:

South Central Connecticut Regional Water Authority

April 16, 2004

Prepared By:

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SUPPLEMENTAL SCOPE OF STUDY
FORMER NEW HAVEN WATER
COMPANY PROPERTY
HAMDEN, CONNECTICUT

VOLUME II OF IV
(Appendices I - VI)

Prepared For:

Connecticut Department of Environmental Protection

On Behalf Of:

South Central Connecticut Regional Water Authority

April 16, 2004

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SUPPLEMENTAL SCOPE OF STUDY
FORMER NEW HAVEN WATER
COMPANY PROPERTY
HAMDEN, CONNECTICUT

VOLUME III OF IV
(Plates 1 – 12)

Prepared For:

Connecticut Department of Environmental Protection

On Behalf Of:

South Central Connecticut Regional Water Authority

April 16, 2004

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SUPPLEMENTAL SCOPE OF STUDY
FORMER NEW HAVEN WATER COMPANY PROPERTY
HAMDEN, CONNECTICUT

VOLUME IV OF IV
(Plates 13 – 25)

Prepared For:

Connecticut Department of Environmental Protection

On Behalf Of:

South Central Connecticut Regional Water Authority

April 16, 2004

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