

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section summarizes the physical characteristics of the Area I study area and region in which the study area is situated. The surface features and land uses are described in Section 3.1. Discussions of related geology, hydrogeology, surface water hydrology, and meteorology are presented in Sections 3.2 through 3.5, respectively.

3.1 Surface Features and Land Use

The Area I study area is part of the Housatonic River Basin, a tidally influenced system. The study area covers approximately 28.5 acres, including approximately 2.84 acres of wetlands and/or open water, and encompasses portions of commercial and residential properties, and portions of Ferry Creek, and the Housatonic River. The Area I study area is bordered by residential or commercial properties, highways or streets, or by water bodies such as Ferry Creek and the Housatonic River. A description of the Area I study area is included in Section 1.3.4 and Figure 1-2. Areas A-1, A-2, and A-3 comprise the Area I study area.

The topography of the study area is relatively flat, with gentle slopes to portions of the Ferry Creek and Housatonic River. Portions of Ferry Creek in the Area I study area have been altered and rechanneled; these areas have steep slopes along Ferry Creek. Based on a review of USGS topographic maps, the majority of the Area I study area lies at topographic elevations of approximately 10 feet National Geodetic Vertical Datum (NGVD) 1929.

The Area I study area is located within the 100-year floodplain, as observed from Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps for Stratford, Connecticut (FEMA, 1992), and as presented in the U.S. Army Corps of Engineers Hydrologic Evaluation of the study area. This Hydrologic Evaluation is included in Appendix C. The 100-year frequency base flood elevation is 10.1 feet NGVD; the 10-year frequency flood elevation is 8.5 feet NGVD (USACE, 1998).

State or federally listed threatened species reported to exist in the vicinity of the Area I study area include the Least Tern, the Atlantic Sturgeon, the Piping Plover, and occasional transient Bald Eagles and Peregrine Falcons (NOAA, 1998; CT DEP, 1997; US DOI, 1997).

The principal industries within the Stratford community include manufacturing of aircraft, air conditioning, chemicals, plastic, paper, rubber goods, electrical and machine parts, and toys. The Stratford Town Clerk reported the latest (September, 1999) estimate for the population of the Town of Stratford as 49,271 residents within the 19.9 square miles (12,736 acres) of the town. This is a slight increase from the last census in 1997, when the population was listed as 47,230, residents.

3.2 Geology

This section provides a brief overview of the geology of the region, as well as that of the Area I study area. A more detailed evaluation of the geologic/hydrogeologic data including geologic cross sections, groundwater contour maps, and bedrock surface contour maps will be presented in the OU2 groundwater RI. The description of the Area I study area geology is a general discussion of soils (natural deposits and artificial fill deposits) and bedrock encountered in on-site borings, with an emphasis on surficial soils (fill and thickness of fill maps). For purposes of this report, fill is included within the category of a soil.

3.2.1 Regional Geology

The discussion of the regional geology is based on data collected during previous subsurface investigations and summarized in the *Final Remedial Investigation Report, Raymark Industries, Inc. Facility* (HNUS, 1995). Discussion of the regional geology is divided into two subsections: overburden and bedrock. The overburden is defined as the unconsolidated deposits of sand, silt, gravel, clay, and peat. The overburden is underlain by bedrock that consists of metamorphic rocks which is mainly schist and gneiss.

3.2.1.1 Regional Overburden Geology

The State of Connecticut has been covered by glacial ice at least twice in geologic time. During the last retreat, glaciers deposited a thin mantle of till overlying bedrock. Glacio-fluvial outwash deposits formed thicker, highly stratified sequences of silty sand to gravelly sand that overlies till, and filled bedrock valleys. Windblown sand and silt were also deposited on valley floors, however, these deposits are indistinguishable from present day organic topsoil deposits.

The study area is generally located in the Stratford outwash plain, on the western Housatonic River valley floor. Natural overburden deposits in the vicinity of Stratford consist of glacial deposits (outwash sediments, ice-contact stratified drift, and till) and recent swamp and marsh deposits.

Glacial till, deposited by glacier ice, is variable in thickness, forming a discontinuous mantle over bedrock. The till consists of a non-stratified, poorly sorted mixture of coarse (pebbles/cobbles/boulders) and fine (sand/silt/clay) fractions, with the coarse fraction generally not exceeding 20 percent.

Ice-contact stratified drift includes sand, gravel, silt, and clay, frequently poorly sorted with abrupt changes in grain size. These deposits were formed during glaciation in streams and local ephemeral lakes in close relation to melting glacier ice, and often grade into outwash sediments.

Glacial outwash deposits are predominant in the stream valleys, and consist of highly stratified sand, silty sand, and gravelly sand. Beds are not persistent, and individual lenses attain thicknesses of tens of feet, and thin out or are truncated over short distances. Outwash units in the vicinity of the study area generally consist primarily of sands with up to 50 percent gravel, grading up-valley (northward).

Swamp and marsh deposits are present in lowlands and in proximity to the Housatonic River. Tidal marshes are also present in this area. Swamp and marsh deposits consist of silt, sand, and clay-sized particles interbedded with organic fragments and peat deposits. The oldest marshes in the western coastal area of Connecticut (2,000 to 4,000 years old) have peat deposits of approximately 10 feet.

3.2.1.2 Regional Bedrock Geology

The study area is located in the Connecticut Valley Synclinorium of Connecticut's Western Uplands, according to the "Bedrock Geological Map of Connecticut" (CT GNHS, 1985). The regional bedrock setting consists of a series of meta-sedimentary and meta-volcanic rocks of the Early and Middle Paleozoic Age, generally foliated, with foliation trending northeast-southwest, in a large syncline. These rocks are mainly schists and gneisses. The sequence was tightly folded and subjected to progressive regional metamorphism, ranging from chlorite to kyanite grade. A high angle fault is mapped approximately one mile to the southeast of the study area, across the Housatonic River, generally trending southwest to northeast (CT GNHS, 1985). The implication of this fault and any related splay faulting to local geology and contaminant transport was not evaluated. Bedrock does not outcrop, i.e. occur at the surface, within the Area I study area.

3.2.2 **Site Geology**

The geology of the Area I study area is divided into two subsections: overburden and bedrock. The discussion of the Area I study area geology is based on overburden and bedrock data collected during soil boring activities conducted during several previous investigations, as summarized in Section 2.

3.2.2.1 Study Area Surficial Geology and Fill Thickness

The surficial deposits that occur at, and within, the shallow subsurface of the Area I study area are mapped as Stratford outwash sediments, fill deposits, and swamp/marsh deposits

(Flint, 1968). Based on borings advanced in or near the Area I study area by TtNUS and other investigators, the surficial deposits are characterized primarily by a variety of locally derived glacial outwash deposits and ice contact deposits, alluvial deposits, swamp and marsh deposits, and fill materials. This material comprises the overburden. Glacial till may be present locally. Overburden consists of a complex sequence of alluvial and outwash deposits (sand and gravel), ranging from silty sands to coarse gravels. Peat/organic silt deposits are common in the Area I study area, frequently underlying fill materials where present.

Fill consists of both natural and artificial materials placed as a result of human activity. Fill materials frequently include manufacturing, household, and construction debris usually mixed with natural materials such as silty sand and gravel. Fill was identified by visual descriptions of soil and sediment samples collected during the field investigations. Fill thickness maps (Figure 3-1 and 3-2) were created based on these descriptions.

Thickness-of-Fill Estimates

Estimated thickness-of-fill maps were prepared for those areas where sufficient data was collected to allow reasonable estimations of thickness of fill across the area (Figures 3-1 and 3-2). It is assumed that fill thickness varies uniformly between data points. The actual thickness of fill between data points may be different. Ferry Boulevard and East Broadway roadways are assumed to have been built prior to fill deposition (based on historical aerial photographs). Based on descriptions of soil/sediment samples collected from borings within Ferry Creek, it appears that fill underlies Ferry Creek.

Fill consists of a mixture of natural and man-made materials. Natural materials include various amounts of clay, silt, sand, and gravel. Man-made materials consist of charcoal, asphalt, metal, brick, glass, and other miscellaneous man-made materials, including manufacturing debris. Other fill materials that do not contain visual evidence of man-made debris are present throughout the Area I study area, generally consisting of sands with varying amounts of silt and gravel. This fill is frequently more difficult to distinguish from

natural/native deposits but it was included on the fill thickness maps (Figures 3-1 and 3-2). Specific information on presence or absence of artificial fill materials and contaminated soil intervals was determined from the borings logs (Appendix A). Note that some boring logs show single pieces of artificial materials that do not constitute fill for that boring location. A judgement was made that intermittent trash (a single metal or plastic piece) does not constitute a fill layer.

The Area I study area overburden geology is discussed below based on boring data from investigations by TtNUS and others, as summarized in Section 2.0. Area designations are described in Section 1.3.4 and shown on Figure 1-2.

For discussion purposes only, a series of geologic profiles were constructed using the available data collected from the borings advanced within the study area (Figure 3-3). The purpose of these profiles is to present a better description of the vertical distribution of fill at the site. These sections were located within the Area I study area at locations where data indicated the thickest fill material. The thickness of fill and the contacts between geologic materials between borings is an interpretation. The edge of fill and geologic contacts are indicated by question marks because that represents the extent of the subsurface data. The actual contacts may vary from those presented.

Area A-1 (Upper Ferry Creek)

The description of overburden geologic materials presented below is based on soil borings that were advanced in Area A-1 to depths up to 115 feet below grade (at MW-102D) by TtNUS in 1994 and 1997, as part of the Phase I RI (described in Section 2.4.1) and the Phase II Site Investigation (described in Section 2.8.1), respectively. These boring locations are presented on Figure 3-1, the Area A-1 Estimated Thickness-of-Fill Map. Fill thicknesses identified in borings in Area A-1 varied from depths of less than one foot (A1-SB1, A1-SB2, and A1-SB5) to 18 feet below ground surface (MF-SB2), as indicated in Figure 3-1. In the area of the Morgan Francis Property (west of East Broadway), fill

thickness generally increases toward the center of the property. In the area northeast of Ferry Creek, fill appears to thicken toward the southeast.

Observed fill materials generally consist of varying amounts of sand, silt, and gravel, with artificial fill materials intermixed at some locations, including "brake pad and gasket materials". At most borings in Area A-1, silty, sandy fill materials were underlain by a gray to black silt, organic silt, clayey silt, or peat layer, which was sometimes interbedded with sand or silty sand.

The peat/silt horizon was generally underlain by sands with varying amounts of silt and/or gravel, sand and gravel, and/or gravel deposits, to varying depths as detailed in the boring logs.

Area A-2 (Middle Ferry Creek - Commercial Properties)

The description of overburden geologic materials presented below is based on soil borings that were advanced in Area A-2 to depths up to 112 feet below grade (at MW-113B) by TtNUS in 1994 and 1997, as part of the Phase I RI (described in Section 2.4.1) and the Phase II Site Investigation (described in Section 2.8.1), respectively.

Fill thicknesses identified in borings from Area A-2 varied from depths of approximately 4.75 feet (SP-SB1) to greater than 16 feet bgs (A2-SB01), as indicated in Figure 3-2. The thickest fill area occurs in the center of the area near boring A2-SB1 (greater than 16 feet). Fill thickness decreases toward Ferry Creek and Ferry Boulevard. Fill thickness contours in Area A-2 are estimated based on data from widely scattered borings in the area; these estimated contours are projected in some areas without data points, and represent only one possible fill thickness scenario. Prior to filling activities, this area was a marsh environment with natural and artificial drainage channels throughout (based on historical aerial photographs). This area was also the location of the former Ferry Creek channel; therefore, a variable thickness of fill may occur in this former marsh area, due to

elevation differences that would be expected between creek or drainage channel basins and the intervening (higher) vegetated areas.

Observed fill materials generally consisted of sands with varying amounts of silt and gravel, with artificial fill materials intermixed at some locations, including "brake pad and gasket materials". In Area A-2, fill materials were underlain by a loose brown peat or organic silt or sandy clay, sometimes interlayered with sands with varying amounts of silt, clay, and peat. Where deeper overburden was observed (at deep borings MW-110D through MW-113B), the peat/silt/clay horizon was generally underlain by sands with varying amounts of silt and gravel, or by gravel deposits with varying amounts of silt and sand, to varying depths as detailed in the boring logs (Appendix A).

Area A-3 (Middle Ferry Creek – Wetlands)

The description of overburden geologic materials presented below is based on soil borings that were advanced in Area A-3 to depths up to 16 feet below grade by TtNUS, as part of the 1997 Phase II Site Investigation (described in Section 2.4.1), and on five borings which were advanced by Roy F. Weston in 1993, to depths up to 17 feet below grade. These borings were also used to estimate thickness of fill in the northern portion of Area A-3.

Boring locations are presented on Figure 3-2. Soil boring locations within Area A-3 that are in or near the wetland areas along Ferry Creek are evaluated as "wetland soils" (sediments), and are not included in thickness-of-fill maps and soil descriptions. As indicated in Figure 3-2, two borings located in the wetland area (A3-SB1 and SPDA-E310, S100) encountered peat/silt from the ground surface to the bottom of the boring (16.0 and 10.6 feet, respectively). Fill materials do not appear to be present in these areas.

Fill thicknesses identified in Area A-3 varied from less than one to approximately 12 feet (MW-110D), as indicated in Figure 3-2. Fill thickness generally increases toward the

center of the area, with the thickest fill (approximately 12 feet) in the area of boring MW-110D.

Fill materials in Area A-3 were described to be generally within a matrix of silty sand or silt, or within clayey silt/silty clay, with artificial fill materials frequently intermixed, including "potential asbestos tiles/brake pads". In Area A-3, fill materials were generally underlain by a brown peat or organic silt. At several borings, the silt/peat was underlain by fine to medium sand with varying amounts of silt present, as detailed in the boring logs. At A3-SB01, the surface sand was underlain by a sandy gravel/gravelly sand, to a depth of 16 feet.

3.2.2.2 Area I Study Area Bedrock Geology

A detailed evaluation of the Area I study area geology will be included in the OU2 Groundwater RI and is not presented in this document. However, the following summary is based on referenced geologic maps and the review of boring logs for eleven borings that were cored into bedrock or were advanced to the top of bedrock, in or near portions of the Area I study area. Six of these borings were cored into bedrock to confirm the depth of bedrock, and to provide rock core for evaluation and description. Five borings were advanced to the top of bedrock, however, coring was not conducted to confirm bedrock depths at these locations. Eight of the eleven borings were advanced during the TtNUS Phase I Remedial Investigation (HNUS, 1995). Three additional bedrock borings were advanced by TtNUS during the OU2 RI in September and October 1997, in or near the study area.

Bedrock does not outcrop (i.e. occur at the ground surface) within the Area I study area. At locations where bedrock was investigated in the study area, the elevation of the top of bedrock varies from a high of approximately 1.7 feet NGVD (19 feet below grade) at SB-215B, located immediately north of Area A-3, to a low of approximately -104.3 feet NGVD (114 feet below grade) at MW-102D, located in the southwestern portion of Area A-1. The bedrock surface elevation data from all bedrock borings indicate that the

bedrock surface generally slopes downward from east to west in this northern portion of the Area I study area.

Bedrock underlying the Area I study area is mapped as the Derby Hill Schist, a mainly medium- to fine-grained, thinly laminated, greenish-gray to medium dark-gray chloritic muscovite schist, which is Lower to Middle Ordovician in age. This rock type is composed mainly of quartz, muscovite, chlorite, and sodium plagioclase, with accessory minerals (Fritts, 1965). The boring logs from investigations by TtNUS within the Area I study area typically describe the observed rock core as a foliated, quartz-rich, chlorite-mica-schist, which is medium- to coarse-grained, and usually green or gray. In some coring runs, high angle schistosity was commonly observed and weathered vertical fractures were also noted.

3.3 Hydrogeology

This section provides a brief description of the regional hydrogeology; a more detailed discussion of hydrogeology will be presented in the OU2 RI, which focuses on groundwater under, and in the vicinity of, the former Raymark Facility

3.3.1 Regional Hydrogeology

Regional hydrogeologic units consist of unconsolidated overburden deposits, including till, stratified outwash, swamp and marsh deposits, and an upper fractured bedrock unit. Regional groundwater flow direction is generally toward the Housatonic River (HNUS, 1995).

Groundwater in the vicinity of the Area I study area is classified as GB (unsuitable for drinking without treatment) by the CT DEP. The Town of Stratford public drinking water is supplied primarily by the Bridgeport Hydraulic Company. The source of the public drinking water is Trapp Falls Reservoir in Shelton, Connecticut, located approximately five miles

from the study area. The remainder of the drinking water is supplied by private drinking water wells within Stratford, none of which is known to exist near the Area I study area.

3.3.2 Study Area Hydrogeology

This section presents an overview of the site hydrogeology based on the available site-specific information. The groundwater investigation is currently on going under W.A. No. 029-RICO-01H3 (OU2 groundwater RI). A more complete presentation and evaluation of the hydrogeologic data will be presented in the OU2 groundwater RI.

The hydrogeology of the Area I study area is complex because of the wide variety of unconsolidated units, the presence of fractured bedrock, and the local influence of surface water bodies, specifically the Housatonic River and Ferry Creek. Adding to the complexity, and in addition to the normal fluctuations that occur in streams and rivers, is the fact that the Housatonic River and lower Ferry Creek are influenced by tidal fluctuations.

The Area I study area is located in the Stratford outwash plain, on the western Housatonic River valley floor. The surficial deposits immediately underlying the study area are mapped as Stratford outwash sediments, artificial fill, and swamp/marsh deposits (Flint, 1968). Boring logs from this and previous investigations, indicate that the geology and unconsolidated deposits are consistent with that described for the region.

Stratified drift or outwash deposits consist of both fine and coarse grained materials. The fine-grained materials consist of silt and clay size particles and occur as both isolated lenses and layers. The coarse grained materials consist of sand and gravel that may contain varying amounts of fine-grained materials. In addition, natural organic deposits consisting of organic silt and peat have been encountered. The thickness of the overburden materials ranges from 59 to 88 feet in the vicinity of Ferry Creek.

On December 1, 1997, water levels were measured in 57 shallow overburden wells to obtain a synoptic measurement of the water levels. In addition, the water levels from the deep overburden and bedrock wells were measured. These measurements were used to construct groundwater maps for the OU2 groundwater investigation. Groundwater underneath the study area has been divided into two hydrostratigraphic units: the overburden and bedrock aquifers.

For the purpose of this Final Area I RI Report, estimated groundwater flow directions are presented as arrows on the fill thickness maps for areas A-1, A-2, and A-3 (see Figures 3-1 and 3-2). These flow arrows are for informational purposes only. In general, the groundwater flow direction at the water table is toward Ferry Creek. Flow direction is based on information from previous studies. As the OU2 groundwater RI is completed, further definition on the flow direction for the entire Area I study area will be detailed. The groundwater flow directions in different portions of the aquifer vary and are different for the deep overburden and bedrock aquifers. A more complete evaluation of groundwater flow directions will be presented in the OU2 groundwater RI.

Based on topography, groundwater in the shallow overburden is expected to discharge to Ferry Creek. Groundwater elevations in three piezometers in Ferry Creek support this interpretation. The water levels in these piezometers (FCP-1, FCP-2, and FCP-3) were higher than the surface water during the December 1, 1997 water level round. See Figures 3-1 and 3-2 for piezometer location. This observation indicates that the groundwater beneath Ferry Creek has the potential to discharge into Ferry Creek. The type and thickness of materials that underlie Ferry Creek and the difference in water levels control the actual rate of groundwater discharge into the creek.

A review of the boring logs for borings advanced in the vicinity of Ferry Creek indicate that the creek flows on organic silts and peat that overlie silty to clayey sands. The thickness of these underlying materials varies but has been observed to be over 20 feet thick in some locations. It is expected that a combination of the silt, peat, and underlying silty to

clayey sands represent a confining layer that restricts the rate of groundwater discharge to Ferry Creek.

3.4 Surface Water Hydrology

The Area I study area is located in the Housatonic Main Stem Regional Drainage Basin. Long Island Sound receives the areas entire surface drainage via the Housatonic River. Ferry Creek is the major surface water feature that lies within the Area I study area. Large areas of wetlands are also included in the study area, as detailed in Section 1.3.4.

Ferry Creek and the Housatonic River are tidally influenced. The Housatonic is tidally influenced 11 miles upstream of the mouth of Ferry Creek, as far up as the Derby Dam in Derby, Connecticut (Weston, 1993). Although tide gates are present at the Broad Street crossing of Ferry Creek, these gates are ineffective at preventing backwater from high tides from passing upstream into Ferry Creek, therefore, Ferry Creek is tidally influenced in the Area I study area (USACE, 1998). Ferry Creek is classified as a Class B/A water body, indicating the desire to improve the water quality with the Creek ().

The groundwater discharge study performed in 1999, indicated that VOC contaminated groundwater was discharging to Ferry Creek. Groundwater contamination is being investigated under the OU2 groundwater RI; however, any final cleanup remedy for Ferry Creek will need to be integrated into the solution for groundwater cleanup.

The Housatonic River is listed as Class SC/SB water, Coastal Marine Surface Waters, with an average discharge of 3,400 cubic feet per second at its mouth based on an average discharge (Weston, 1993). Based on the *Connecticut Water Quality Classification Map* (April 1997), Ferry Creek is classified as a class B/A water body, indicating the desire of the state to improve the water quality within the creek.

The groundwater discharge study performed in 1999, indicated that VOC contaminated groundwater was discharging to Ferry Creek. Groundwater contamination is being

investigated under the OU2 groundwater RI; however, any final cleanup remedy for Ferry Creek will need to be integrated into the solution for groundwater cleanup.

Appendix C contains additional detailed hydrologic information on delineation of drainage areas for each area and elevations within each watershed area, discussion of storm drain networks, overland flow, tidal hydraulics, and analysis of rainfall runoff.

3.5 Meteorology

The Town of Stratford, Fairfield County, Connecticut, is located in a temperate-humid climate characterized by highly changeable weather. Daily and annual temperature variations are influenced by Long Island Sound and the Atlantic Ocean. There are monthly, seasonal, and annual variations in temperature and wind, as well as precipitation, which is in the form of both rain and snow.

July is the warmest month with an average temperature of 73.7 degrees F. Average wind speed and direction for the warmest months is 10.2 miles per hour (mph) from the southwest. The coldest month is January, with an average temperature of 28.9 degrees F. Average wind direction and speed for the colder portion of the year is 13.3 mph from the northwest.

Normal annual precipitation for the area is 41.66 inches of rain, with a regular distribution throughout the year. Snow fall typically occurs between November and April, with a mean of 25 inches per year (NOAA, 1993).

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents a summary of results from the chemical characterization conducted to support completion of the RI. A discussion of the potential sources of contamination affecting the study area (see Figures 1-1 and Figure 1-2) is provided in Section 4.1. Section 4.2 presents an overview of the types of chemical compounds detected in the study area, and a brief discussion relating the presence of these chemicals to past operations at the Raymark Facility. Section 4.3 provides a discussion of the background concentrations developed for comparison with the study area values. Summaries of the nature and extent of contamination detected in each area within the study area are provided in Sections 4.4 through 4.6. Detailed discussions of the nature and extent of contamination for each subarea are presented in Appendix G. Analytical data used to evaluate the nature and extent of contamination can be found on the disk located in Appendix B. Although the evaluation of the nature and extent of contamination includes discussions of all the major classes of chemical contaminants analyzed, the RI focuses on chemical characterization of the four major contaminants (copper, lead, polychlorinated biphenyls (PCBs), and asbestos) associated with past activities conducted at the Raymark Facility. Figures depicting the presence and concentrations of these four contaminants are included to support the summaries included in Section 4.4 through 4.6.

4.1 Potential Sources of Contamination

This section includes a description of the potential sources of contamination affecting the study area associated with past operational and disposal practices of the Raymark Facility. The contamination sources include locations where Raymark soil-waste/fill materials were disposed of (dumped) at residential and commercial properties within, or adjacent to, the study area, locations where erosion and/or leaching of the Raymark soil-waste materials is occurring, and locations of discharge of contaminated groundwater to Ferry Creek and connecting waterways. Efforts to evaluate the groundwater as a potential contaminant source are being conducted by TtNUS as part of the OU2 groundwater RI under Work Assignment No. 029-RICO-01H3, Contract No. 68-W6-0045.

4.1.1 Raymark Soil-Waste/Fill Materials Disposal

The EPA and its contractors excavated and removed more than 37,000 cubic yards of contaminated soil-waste/fill material during time-critical removal actions conducted under CERCLA from 1994 to 1996. This material was removed from the yards of residences within the Town of Stratford (HNUS, 1995). Contaminants present in these areas were designated a human health threat (based on EPA-established criteria) and removed. Approximately 30,000 cubic yards of soil-waste material was also excavated and removed from the Wooster Middle School playing fields in 1995, by the CT DEP. All excavated areas were backfilled with clean fill. All excavated materials were transported to the Raymark Facility and placed under a RCRA type cap installed as part of the source control remedial action for the OU1 Raymark Facility. The Record of Decision (ROD) for this remedial action was signed July 3, 1995, and the cap was completed in 1997.

The excavation of contamination under the time-critical removal actions at residential properties that were located adjacent to wetland areas, was terminated at the boundary of the wetland area. These excavations were terminated because of the presence of saturated wetland soils and vegetation. It was decided that removal actions (excavations) would only be done on the soil of residential properties; not the wetland areas. Surficial wetland soil/sediment samples were collected at the termination point. These samples are included in the pertinent sections of this RI (HNUS, 1995 and Ebasco, 1995). The sampling locations included within the study area are discussed in further detail in Sections 4.4 through 4.6.

Additional field investigations and actions were completed in and around the Raymark Facility (see Section 2.0). Extensive sampling was conducted on commercial properties where disposal of Raymark waste was suspected. Based on sampling results, properties with surface contamination were fenced and/or the waste areas covered (by pavement or wood chips) by the CT DEP. The commercial and adjacent properties with surface and/or subsurface contamination are the subject of this RI.

4.1.2 Raymark Wastewater Discharge

As discussed in Section 1.3.1, the majority of the Raymark Facility's wastewater was collected and discharged to a series of four settling lagoons that, in turn, discharged directly into Ferry Creek (HNUS, 1995). These lagoons also received stormwater drainage and surface water runoff from the Raymark Facility. Evidence of impacts (deposition of contamination) from the wastewater discharge was observed in areas along Ferry Creek and the Housatonic River in Areas A-1 and A-3 (See Figure 1-2). The contaminants identified in river sediments are similar to those identified at the Raymark Facility.

4.1.3 Groundwater Discharge

Ongoing investigations show that groundwater within the study area is contaminated. Some of the contaminants are similar in nature to the contaminants found at the former Raymark Facility. Groundwater flow directions within the shallow overburden (water table) at the Area I study area are generally toward Ferry Creek (HNUS, 1995). As described in Section 2.9, the groundwater is discharging VOC contaminated water into Ferry Creek.

4.2 Overview of Chemical Compounds Detected

Brief descriptions of the major classes of chemical contaminants detected in the sediment, surface water, soil, and biota in the study area, and the common industrial uses of these chemicals, is provided in Sections 4.2.1 through 4.2.7. A list of the major classes and frequently detected contaminants in each class is provided in Table 4-1. Section 4.2.8 and Table 4-2 provide a summary of the specific chemicals known to have been stored, handled, and/or used at the Raymark Facility during its operation that may have contributed to contamination of the study area. A discussion of the terminology used for evaluating the analytical data collected in the study area is provided in Section 4.2.9. An evaluation of the usability of field screening data collected to support the RI is included in Section 4.2.10.

4.2.1 Volatile Organic Compounds (VOCs)

The VOCs detected in environmental samples collected from the study area may be separated into three major groups: chlorinated hydrocarbons, aromatic hydrocarbons, and ketones. Many of these VOCs are organic solvents commonly used in industrial processes to degrease parts; to prepare metal surfaces prior to painting, coating, or bonding; as constituents of paint thinners and resins; and to extract organic compounds from materials. Additionally, some of the detected VOCs are common components of gasoline and petroleum fuels.

VOCs used at the Raymark Facility consisted mainly of chlorinated hydrocarbons, aromatic hydrocarbons, alcohols, and ketones used as organic solvents.

4.2.2 Semivolatile Organic Compounds (SVOCs)

The SVOCs detected in environmental samples collected from the study area may be separated into three major groups: phenolic compounds, polynuclear aromatic hydrocarbons (PAHs), and phthalates. Other SVOCs detected include only a few isolated compounds. SVOCs are common constituents of various industrial products. Phenolic compounds are typically associated with fuels, coal, and petroleum products, and are used to manufacture friction materials. PAHs are common components of coal tar (bitumen and asphaltic tars), petroleum products (motor and fuel oil), and combustion by-products. Phthalates are typically used as plasticizers in the manufacturing of synthetic materials.

SVOCs used at the Raymark Facility included phenolic compounds, naphthalene, and phthalates. Phenolic resins were used in manufacturing friction materials.

4.2.3 Pesticides

Pesticides are typically used to control the presence, or population of, unwanted insects in both residential and commercial areas, as well as to prevent crop destruction in agricultural settings. Pesticide formulations may include chlorinated and organophosphorus varieties.

Pesticides may have been used at the Raymark Facility to control insect populations. However, no documentation of use has been identified.

4.2.4 Polychlorinated Biphenyls (PCBs)

The PCBs detected in the environmental samples collected from the study area consisted primarily of Aroclor 1262 and Aroclor 1268. PCBs are extremely stable chemicals with a wide range of physical properties. They have been historically used in plasticizers, adhesives, lubricants, heat transfer fluids, and as dielectric fluids in transformers and capacitors. Aroclor 1262 and Aroclor 1268, specifically, were commonly used as plasticizers in synthetic resins. Aroclor 1268 was also commonly used as a wax extender and plasticizer in rubbers.

No information has been provided directly by the Raymark Facility documenting the specific use of PCBs as part of their manufacturing process. However, EPA has reported that PCBs were used in manufacturing brake linings. The Raymark Facility was also known as having used and/or manufactured both rubber (gasket materials) and resins (phenolic resins in brake linings). Aroclor 1262 and Aroclor 1268 may have been used as plasticizers in these materials.

4.2.5 Dioxins and Furans

Environmental samples from the study area contained detectable concentrations of dioxins and furans. Dioxins and furans are not manufactured commercially. Chlorinated dioxins and furans are formed during the production of chlorinated compounds (such as, PCBs,

herbicides, pesticides, and chlorophenols), or as a result of incomplete combustion of chlorinated chemical compounds (such as PCBs). The term "dioxins" is commonly used to refer to a specific group of polychlorinated dibenzo-p-dioxin chemical compounds. The toxicity of one specific compound, 2,3,7,8-tetrachloro-dibenzo-p-dioxin (2,3,7,8-TCDD), has been studied more than other known dioxins and furans. The toxicity of all other dioxins and furans are expressed in relation to 2,3,7,8-TCDD, and are reported in terms of Toxic Equivalency (TEQ) concentrations.

4.2.6 Metals

Numerous metals were detected in the environmental samples collected from the study area. Metals are naturally occurring components of soil and/or localized mineral deposits, or are the result of decomposition of weathered bedrock. Metals may also be introduced into the environment through various industrial activities including disposal of waste materials or process sludges, and fugitive emissions from various thermal or combustion processes.

Barium, copper, lead, tin, and zinc were the primary metals used at the Raymark Facility to fabricate various brake and friction materials. Each was detected at elevated concentrations in the study area.

4.2.7 Asbestos

Asbestos was detected in sediment and soil samples collected from the study area. Asbestos was a group of magnesium silicate minerals that contains varying quantities of iron and calcium silicates. Because of its non-combustible and heat-resistant properties, asbestos was commonly used to manufacture brake linings, gaskets, fireproof fabrics, roofing materials, and electrical and heat insulation, and as a reinforcing agent in rubber and plastics.

Asbestos-containing materials were a primary component in the products manufactured at the Raymark Facility. Asbestos fibers were mixed with phenolic resins to manufacture brake pads and linings. Asbestos was also used to manufacture friction materials (clutches and transmission plates) and gaskets. Chrysotile was the most common commercial form of asbestos used.

4.2.8 Chemical Compounds Used or Handled at the Raymark Facility

A number of chemical compounds and materials were handled, stored, and/or used in manufacturing processes at the Raymark Facility during its operation. A list of these chemicals, presented in Table 4-2, was developed from information provided in the *RCRA Facility Investigation Report* (ELI, 1995), and the RCRA Part A application (August 15, 1980). No Part B application was ever filed for the facility.

4.2.9 Terminology for Evaluating Analytical Data

In order to evaluate the nature and extent of contamination in the study area, and to determine its relationship to past disposal and operational practices at the Raymark Facility, data generated from analysis of field samples are typically compared to background concentrations and reviewed in relation to the data collected throughout an entire area of concern. Definitions of the terms used to describe and compare the contaminant concentrations in the following sections are as follows:

- elevated - detected at a concentration either greater than its corresponding average background concentration, or greater than a specified concentration if no average background concentration was determined.
- high, higher, or highest - detected in one location at one or more orders of magnitude greater than at another location.

- comparable - detected in one location at the same order of magnitude as another location.
- low or lower - detected in one location at one or more orders of magnitude less than another location.

Discussion about the development of background concentrations is provided in Section 4.3. Detailed evaluations of the nature and extent of contamination at each study area are provided in Appendix G.

Definitions of terms related to sampling depths and media are as follows:

- surface samples – Samples collected at depths of up to 2.0 feet below surface (bgs).
- subsurface samples – Samples collected at depths of greater than 2.0 feet bgs.
- sediment samples – Samples collected from within Ferry Creek or within a delineated wetland or marsh area.
- soil samples – Samples collected outside of Ferry Creek and outside a delineated wetland or marsh area.

4.2.10 Evaluation of Usability of Field Screening Data

During the Phase I RI conducted by TtNUS under Work Assignment 42-1LH3, Contract No. 68-W8-0117, soil samples were collected from various properties in the study area. To characterize the depth of soil-waste/fill material in these areas, and to determine if the fill was associated with past disposal of Raymark soil-waste/fill materials, the samples were analyzed for asbestos and screened for lead, copper, and PCBs. A select number of these

lead, copper, and PCB samples were also submitted for confirmatory analysis through the EPA CLP.

The lead, copper, and PCB screening data were evaluated by two types of statistical analyses (linear regression and Wilcoxon Rank-Sum nonparametric t-test) to determine a potential correlation between the screening data and the results of CLP analyses. The linear regression analysis involved a point-by-point comparison of the data generated by the two methods. The nonparametric t-test approach compared the mean lead, copper, and PCB concentrations for two data sets.

The results of the statistical analyses indicated that the screening data collected for copper and lead could be used with the same level of confidence as the CLP data for concentrations within the ranges of 300-1000 mg/kg and 100-4000 mg/kg, respectively. A poor correlation was found between the PCB screening and CLP data. EPA, therefore, deemed the copper and lead screening data acceptable for quantitative use in the RI and risk assessment; the PCB screening data were determined to be acceptable for qualitative use only (B&RE, 1997b and 1997c).

4.3 Background Concentrations

As part of the investigation activities conducted by EPA, background samples were collected within the Town of Stratford and submitted for analysis. Samples were obtained from locations that were either not likely to have been impacted by past disposal of Raymark-type soil-waste/fill materials, or were not situated adjacent to any known disposal location. The locations and numbers of background samples were determined by EPA. Because of variability in the analytical data and/or heterogeneity of the samples, average background concentrations for each sample matrix (sediment, surface water, and soil) were developed by averaging the numerical data from samples deemed representative of background conditions (The numerical averages were calculated as the arithmetic average of the detected concentrations and half the detection limits for those compounds/analytes reported as undetected.).

For the purpose of evaluating the nature and extent of contamination, the average background concentrations serve as a basis to identify elevated contaminant concentrations in samples collected within the study area (see Sections 4.4 through 4.6). If contaminant concentrations exceeded the average background concentrations, a contaminant source was suspected and the contaminant concentrations were considered "elevated." Because of the industrial nature of the Stratford area, contaminant concentrations below the average background levels are not considered representative of an affected area and, therefore, did not warrant further discussion in the evaluation of nature and extent. Contaminants not analyzed in the background samples were evaluated based on their detected concentrations. However, it is important to note for the human health risk assessment, that background concentrations were not used to eliminate chemicals of potential concern (COPCs) except in the case of non-carcinogenic metals. Asbestos contamination is defined as a concentration of greater than one percent asbestos.

4.3.1 Sediment

Sediment samples were collected from Great Meadow (located in the southern portion of Stratford, along Long Island Sound and adjacent to the Bridgeport Municipal Airport) and Nells Island (located on the eastern side of the Housatonic River in the Town of Milford). The samples were analyzed for VOCs, SVOCs, pesticides/PCBs, dioxins/furans, and metals. Following a review of the analytical data, four samples from four locations were determined to be representative of background conditions. Representative background sediment concentrations were developed by averaging the concentrations from these four samples. The average background concentrations for VOCs, SVOCs, pesticides/PCBs, dioxins/furans, and metals are presented in Table 4-3.

4.3.2 Surface Water

Surface water samples were also collected from Great Meadow and Nells Island. The samples were analyzed for VOCs, SVOCs, pesticides/PCBs, and metals. The analytical results of eight samples from eight locations, determined to be representative of background conditions, were averaged to develop the representative background surface water concentrations. The average background concentrations for VOCs, SVOCs, pesticides/PCBs, and metals are presented in Table 4-4. No SVOCs were detected in the background samples.

4.3.3 Soil

Soil samples were collected from various locations around the Town of Stratford from schools, day care centers, and recreational areas. The samples were analyzed for pesticides/PCBs and metals. Metal results from 34 of the 39 sample locations and pesticides/PCB results from 27 of the 37 sample locations were determined to be representative of background conditions. These values were averaged to develop the representative background soil concentrations. The average background concentrations for pesticides/PCBs and metals are presented in Table 4-5. No background data was taken for VOCs and SVOCs in soil. It has continued to be an assumption that the primary site contaminants of lead, PCBs, and asbestos are the indicators of the cleanup boundaries. Soils that contain these indicators often contain VOCs and SVOCs.

4.4 Area A-1: Upper Ferry Creek (Morgan Francis Property) - Summary of Contamination

A summary of the nature and extent of contamination in sediment, surface water, and soil in Area A-1 is provided below. A detailed evaluation can be found in Appendix G.1. Sample locations are depicted on Figure 4-1. A list of samples collected and the analyses performed is provided in Table 4-6. Tables 4-7, 4-8, and 4-9 provide ranges of concentrations exceeding the average background concentrations, frequency of detections

above background concentrations, and locations of maximum concentration for contaminants detected in sediment, surface water, and soil, respectively.

4.4.1 Sediment

This section presents a summary of sediment results for Area A-1. See Table 4-7 for a numerical summary of these data.

VOCs

VOCs were detected infrequently in the sediment samples. The higher concentrations were detected in surficial samples from the northern reaches of Ferry Creek, the western arm of the wetlands adjacent to the Morgan Francis Property, and the area closest to the culvert at the southern-most end of the study area.

SVOCs

SVOCs were detected frequently in sediment samples. The higher concentrations of PAHs were detected in surficial samples collected near the bend in the Ferry Creek channel in the northern region, and in subsurface samples collected from depths of up to 4.0 feet from the south-central extent of the Ferry Creek channel and the triangular-shaped property between East Broadway and Ferry Boulevard. The higher concentrations of phthalates were detected in surficial samples from the western arm of the wetlands adjacent to the Morgan Francis Property, and in both surficial and subsurface samples collected near the bend in the Ferry Creek channel in the northern region.

Pesticides/PCBs

In sediment samples, pesticides and PCBs were detected frequently in both surficial and subsurface samples. Pesticides were detected at relatively comparable concentrations across the study area, except for lower levels in samples collected from the triangular-

shaped wetland property between East Broadway and Ferry Boulevard. The highest PCB concentrations were detected in surficial samples from the southern portion of the Ferry Creek channel. Lower concentrations were detected along the western arm of the wetlands adjacent to the Morgan Francis property. The PCBs consisted primarily of Aroclor 1262 and Aroclor 1268, with infrequent detections of Aroclor 1248 and Aroclor 1260. Figures 4-2 and 4-3 show the ranges of concentrations of total Aroclors detected above the average background concentration in surface and subsurface sediment in Area A-1.

Dioxins/Furans

Elevated TEQ concentrations were reported frequently in surficial sediment samples throughout the Ferry Creek channel, with the exception of the northern reaches of Ferry Creek at the boundary of the Area I study area. A high TEQ concentration was also reported in a subsurface sample collected at a depth of 2.0 to 4.0 feet in the middle area of Ferry Creek.

Metals

Elevated levels of metals were detected frequently in both surficial and subsurface samples. Two metals, copper and lead, are considered the most indicative of contamination associated with operations at the Raymark Facility and are the focus of this summary.

Elevated lead concentrations were detected in sediment samples collected in all locations. The higher lead levels were detected in surficial samples from the triangular area east of the Morgan Francis property, the northern reaches of Ferry Creek, in the western side of the wetlands adjacent to the Morgan Francis Property, and in the subsurface sample collected at a depth of 2.0 to 4.0 feet in the middle area of Ferry Creek. Figures 4-4 and 4-5 show the ranges of concentrations of lead, detected above the average background concentrations in surface and subsurface sediment in Area A-1.

Elevated copper concentrations were detected at all locations, except for a few surficial samples collected along the western arm of the wetlands adjacent to the Morgan Francis Property, from the northern reaches of Ferry Creek, in the south-central portion of the study area, and in the triangular-shaped property between East Broadway and Ferry Boulevard. In subsurface samples, elevated copper concentrations were detected in the south-central portion of the study area and the triangular-shaped property between East Broadway and Ferry Boulevard at depths of up to 4.0 feet. The highest concentrations were detected in surficial samples in the south portions of the study area. Figures 4-6 and 4-7 show the ranges of concentrations of copper detected above the average background concentrations in surface and subsurface sediment in Area A-1.

Asbestos

Asbestos concentrations greater than or equal to one percent were detected frequently in both surficial and subsurface sediment throughout the Ferry Creek channel. The higher concentrations were detected in the surficial samples along the central portion of the Ferry Creek channel, and in subsurface sediment samples collected from depths of up to 4.0 feet from the triangular-shaped property located between East Broadway and Ferry Boulevard. Figures 4-8 and 4-9 show the ranges of concentrations of asbestos detected at greater than one percent in surface and subsurface sediment in Area A-1.

4.4.2 Surface Water

This section presents a summary of surface water results for Area A-1. See Table 4-8 for a numerical data summary.

VOCs

Select VOCs, primarily chlorinated hydrocarbons, were detected frequently in the few surface water samples collected. The higher concentrations were detected in the western

arm of the wetlands adjacent to the Morgan Francis Property and in the northern portion of the Ferry Creek channel.

SVOCs

SVOCs were detected infrequently in the few surface water samples collected. Phthalates were detected at low concentrations in several of the samples. No PAHs were detected.

Pesticides and PCBs

Pesticides were detected infrequently in the few surface water samples collected. No pesticides were detected above background concentrations. No PCBs were detected.

Dioxins/Furans

No surface water samples were submitted for analysis of dioxins and furans.

Metals

Elevated concentrations of select metals were detected frequently in surface water samples. These metals included antimony, arsenic, and iron in select samples, and barium, manganese, and zinc in all samples. Copper and lead were not detected above background concentrations.

Asbestos

No surface water samples were submitted for analysis of asbestos.

4.4.3 Soil

This section presents a summary of soil results for Area A-1. See Table 4-9 for a numerical data summary.

VOCs

VOCs were detected infrequently in soil samples. The higher concentrations were detected primarily in subsurface soils at depths of up to 16.0 feet collected along the southwestern border, in the southeastern and south-central regions, and in the northern extent of the study area. No VOCs were detected in soil samples collected from the triangular-shaped property between East Broadway and Ferry Boulevard.

SVOCs

SVOCs, primarily PAHs and phthalates, were detected frequently in both surficial and subsurface soil. The higher levels of PAHs were detected in surficial samples from the southeastern region of the study area and in the central portion of the triangular-shaped property between East Broadway and Ferry Boulevard. Subsurface soils containing the higher PAH concentrations were located primarily at depths up to 16.0 feet in the south-central, east-central, and northern regions of the study area. The higher levels of phthalates were detected in surficial samples collected from the east-central and southwestern regions; and in subsurface samples from the southwestern, south-central, and east-central regions, primarily at depths up to 16.0 feet.

Pesticides and PCBs

Select pesticides/PCBs were detected frequently in both surficial and subsurface soil throughout Area A-1. Approximately half of the samples contained a single pesticide and/or PCB. The higher levels of pesticides were detected in surficial samples collected along the southwestern border, the central region, and along the eastern border of the

study area; and subsurface samples in the southeastern and west-central regions of the study area. The higher levels of PCBs were detected in surficial samples from scattered locations throughout the study area. The PCBs consisted primarily of Aroclor 1262 and Aroclor 1268, with infrequent detections of Aroclor 1248, Aroclor 1254, and Aroclor 1260. Figures 4-2 and 4-3 show the ranges of concentrations of total Aroclors detected above the average background concentrations in surface and subsurface soil in Area A-1.

Dioxins and Furans

Elevated TEQ concentrations were reported frequently in both surficial and subsurface soils. The higher TEQ concentrations were reported in surficial samples collected from scattered locations throughout the study area. Elevated TEQ concentrations were also reported in one sample collected at 46.0 to 48.0 feet in the central region and one sample collected at 78.0 to 80.0 feet in the southwestern region of the study area.

Metals

Elevated levels of metals were detected frequently in both surficial and subsurface soil samples. Two metals, copper and lead, are considered the most indicative of contamination associated with operations at the Raymark Facility and are the focus of this summary.

Elevated lead concentrations were detected in soil samples in the majority of locations. The higher lead levels were detected in surficial samples from the southwestern and central regions and subsurface samples in the southern, and northeastern regions of the study area. No elevated concentrations of lead were detected at depths of greater than 18.0 feet.

Elevated copper concentrations were detected in the majority of locations. The highest concentrations were detected in surficial samples from the southwestern and central eastern regions, and at depths of up to 18.0 feet from subsurface samples in locations

scattered throughout the study area. Elevated concentrations of copper were detected at depths of greater than 18.0 feet from one location in the central region of the study area.

Figures 4-4 and 4-5 show the ranges of concentrations of lead, and Figures 4-6 and 4-7 show the ranges of concentrations of copper detected above the average background concentrations in surface and subsurface soil in Area A-1.

Elevated concentrations of leachable lead (SLP metal analysis) were detected frequently in surficial and subsurface soil samples collected throughout Area A-1. Leachable copper was detected infrequently.

Asbestos

Elevated asbestos concentrations were detected frequently in both surficial and subsurface soil samples. Generally higher concentrations were detected in the surficial samples. No asbestos was detected in samples collected at depths of greater than 22.0 feet. Figures 4-8 and 4-9 show the ranges of concentrations of asbestos detected greater than one percent in surface and subsurface soil in Area A-1.

4.5 Area A-2: Upper Ferry Creek (Commercial Property) - Summary of Contamination

A summary of the nature and extent of contamination in soil in Area A-2 is provided below. A detailed evaluation can be found in Appendix G.2. Sample locations are depicted on Figure 4-10. A list of samples collected and the analyses performed is provided in Table 4-10. Table 4-11 provides ranges of concentrations exceeding the average background concentrations, frequency of detection above the average background concentrations, and locations of maximum concentrations contaminants detected in soil.

No sediment or surface water samples were collected from Area A-2.

4.5.1 Soil

This section presents a summary of soil results for Area A-2. See Table 4-11 for a numerical data summary.

VOCs

Elevated concentrations of VOCs were detected infrequently in surficial and subsurface soil samples. The higher concentrations were detected at depths of up to 10.0 feet in selected subsurface soils within the study area, including: the northwestern region of 326 Ferry Boulevard, the north-central and southeastern regions of 280 Ferry Boulevard, and the central region of 230 Ferry Boulevard. High levels of aromatic hydrocarbons were detected at each property. In addition, acetone and chlorinated hydrocarbons 1,2-dichloroethene and trichloroethene were detected in samples from 280 Ferry Boulevard. High concentrations of a single VOC, either acetone or carbon disulfide, were detected in subsurface samples collected from 250 Ferry Boulevard and the paved parking lot at 170 Ferry Boulevard. VOCs were detected in one sample collected at depths greater than 10.0 feet (a depth of 14.0 to 16.0 feet) from the southeastern region of 250 Ferry Boulevard.

SVOCs

Elevated concentrations of SVOCs, primarily PAHs and phthalates, were detected frequently in both surficial and subsurface soil samples. The higher levels of PAHs were detected in surficial samples collected from 250, 230, and 170 Ferry Boulevard, and at depths of up to 28.0 feet in subsurface samples collected in the north-central region of 280 Ferry Boulevard, and the southern and southeastern regions of 250 Ferry Boulevard. The higher levels of phthalates were detected in subsurface samples collected in the northwestern, southern, and southeastern regions of 250 Ferry Boulevard.

Pesticides/PCBs

Elevated concentrations of pesticides and PCBs were detected frequently in both surficial and subsurface soil samples. Of the subsurface samples containing pesticides, approximately half contained a single pesticide. The higher levels of pesticides and PCBs were detected in surficial samples. The higher levels of pesticides were detected in surficial samples collected from various locations at 300, 280, 250, and 230 Ferry Boulevard; and in subsurface samples collected from 326, 280, 250, and 170 Ferry Boulevard. The highest levels of PCBs were detected in the surface and subsurface samples collected from 300, 280, and 250 Ferry Boulevard. No pesticides or PCBs were detected in samples from depths of greater than 16.0 feet. The PCBs consisted primarily of Aroclor 1262 and Aroclor 1268, with infrequent detections of Aroclor 1242, Aroclor 1248, and Aroclor 1254. Figures 4-11 and 4-12 show the ranges of concentrations of total Aroclors detected above the average background concentrations in surface and subsurface soil in Area A-2.

Dioxins and Furans

Dioxin and furan concentrations, expressed as TEQ concentrations, were reported frequently in both surficial and subsurface soil samples. The higher TEQ concentrations were reported in the surficial samples collected from 250 and 230 Ferry Boulevard; and subsurface samples collected from 280, 250, 230, 200, and 170 Ferry Boulevard. No elevated TEQ concentrations were reported in samples collected at depths greater than 16.0 feet.

Metals

Elevated concentrations of metals were detected frequently in both surficial and subsurface soil samples. Two metals, copper and lead, are considered the most indicative of contamination associated with operations at the Raymark Facility, and are the focus of this summary.

Elevated levels of lead were detected in the majority of locations. The highest lead concentrations were detected in surficial samples from 300, 280, and 250 Ferry Boulevard; and in fewer subsurface samples from these properties and 230 Ferry Boulevard. No elevated concentrations of lead were detected at depths greater than 18.0 feet.

Elevated levels of copper were detected in the majority of locations. The highest copper concentrations were detected in surficial samples from scattered locations at 300, 280, and 250 Ferry Boulevard and two locations in the southern portion of Area A-2; and in subsurface samples distributed throughout the study area. No elevated concentrations of copper were detected at depths greater than 18.0 feet.

Figures 4-13 and 4-14 show the ranges of concentrations of lead, and Figures 4-15 and 4-16 show the ranges of concentrations of copper detected above the average background concentrations in surface and subsurface soil in Area A-2.

Elevated concentrations of leachable lead were detected frequently in surficial and subsurface soil samples collected for SPLP metals analysis throughout Area A-2. Leachable copper was also detected in the samples analyzed.

Asbestos

Asbestos concentrations greater than or equal to one percent were detected in various soil samples. The higher concentrations were detected in surficial samples collected from 300, 280, and 250 Ferry Boulevard and in subsurface samples collected from locations throughout Area A-2. No asbestos was detected in samples collected at depths greater than 20.0 feet. Figures 4-17 and 4-18 show the ranges of concentrations of asbestos detected greater than one percent in surficial and subsurface soil in Area A-2.

4.6 **Area A-3: Upper Ferry Creek (Wetlands) - Summary of Contamination**

A summary of the nature and extent of contamination in sediment, surface water, and soil in Area A-3 is provided below. A detailed evaluation can be found in Appendix G.3. Sample locations are depicted on Figure 4-19. A list of samples collected and the analyses performed is provided in Table 4-12. Tables 4-13, 4-14, and 4-15 provide ranges of concentrations exceeding the average background concentrations, frequency of detection above the average background concentrations, and locations of maximum concentrations for contaminants detected in sediment, surface water, and soil, respectively.

4.6.1 **Sediment**

This section presents a summary of sediment results for Area A-3. See Table 4-13 for a numerical data summary.

VOCs

VOCs were detected infrequently in sediment samples. The only VOC detected at a high concentration (above 10 times the background concentration) was 2-butanone in a single subsurface sample collected from 4.0 to 4.6 feet from the north-central region of the wetland area east of the Ferry Creek channel. Medium levels of acetone, 2-butanone, and/or carbon disulfide were detected in surficial samples collected from select locations in the central and southern regions of the Ferry Creek channel; and in a subsurface sample collected from 1.6 to 2.4 feet from the central region of the wetland area adjacent to and east of the channel. In addition, medium levels of benzene, ethylbenzene, and xylenes (total) were detected in two surficial samples from the northern region of the Ferry Creek channel.

Chlorinated hydrocarbons were detected infrequently in surficial sediment samples. Medium levels of 1,1-dichloroethane were detected in a few surficial samples from the Ferry Creek channel; and medium levels of trichloroethene (TCE) were detected in a single sample from the north-central region of the wetland area. No VOCs, other than 2-

butanone, were detected in subsurface sediment from the Ferry Creek channel and adjacent wetland area.

SVOCs

Elevated concentrations of SVOCs, primarily PAHs and phthalates, were detected frequently in surficial samples but infrequently in subsurface samples. The higher concentrations of PAHs were detected in one surficial sample from the south-central region of the Ferry Creek channel in the vicinity of an observed seep and one subsurface sample collected from 3.0 to 3.6 feet from the north-central region of the wetland area. The higher levels of phthalates included the detection of bis(2-ethylhexyl) phthalate in surficial samples from various locations along the length of the Ferry Creek channel. No phthalates were detected in subsurface samples.

Pesticides/PCBs

Pesticides and PCBs were detected frequently in surficial sediment samples and less frequently in subsurface samples. Pesticides were detected at relatively comparable concentrations across the study area (ranging from low to high levels of individual pesticides at most locations), except for lower levels in samples from the central region of the wetland area. In the subsurface samples, the higher pesticide concentrations were detected in the northern region of the Ferry Creek channel, the western reaches of the ditch extending from the Ferry Creek channel westward to Ferry Boulevard, and the central region of the wetland area opposite the convergence of the ditch with the Ferry Creek channel at depths of up to 8.0 feet.

The PCBs consisted primarily of Aroclor 1262 and Aroclor 1268, with infrequent detections of Aroclor 1248, Aroclor 1254, and Aroclor 1260. The concentrations of PCBs in surficial samples were comparable (ranging from low to high levels of individual PCBs at most locations) across the study area. In subsurface samples, the higher concentrations were detected in the northern regions of the Ferry Creek channel and the western reaches

of the ditch extending from the Ferry Creek channel westward to Ferry Boulevard. Figures 4-20 and 4-21 show the ranges of concentrations of total Aroclors detected above the average background concentrations in both surface and subsurface soil in Area A-2.

Dioxins/Furans

Elevated TEQ concentrations were reported frequently in surficial sediment but infrequently in subsurface sediment samples. The higher TEQ concentrations were reported in surficial samples collected throughout the Ferry Creek channel, the single location sampled in the western reaches of the ditch extending from the Ferry Creek channel westward toward Ferry Boulevard, and one location in the north-central region of the wetland area adjacent to and east of the Ferry Creek channel; and at depths of up to 4.0 feet in subsurface samples from the northern and north-central regions of the Ferry Creek channel.

Metals

Elevated levels of metals were detected frequently in both surficial and subsurface sediment samples. Two metals, copper and lead, are considered the most indicative of contamination associated with operations at the Raymark Facility, and the focus of this summary.

Elevated lead concentrations were detected in sediment samples collected at the majority of locations. The higher lead levels were detected in surficial samples from locations throughout the entire length of the Ferry Creek channel, the western reaches of the ditch extending between the Ferry Creek channel and Ferry Boulevard, and most of the wetland area; and subsurface samples from a few locations in the northern reach of the Ferry Creek channel, one location in the wetland area opposite the ditch that extends west from the Ferry Creek channel, and one location at the western end of the ditch. Elevated concentrations of lead were detected at depths of up to 4.0 feet throughout the Ferry Creek channel and in the western reaches of the ditch extending from the Ferry Creek

channel to Ferry Boulevard. In the wetland area, elevated lead concentrations were detected at depths of up to 11.2 feet.

Elevated copper concentrations were detected at the majority of surficial locations and fewer subsurface sediment locations. The highest levels were detected in surficial samples from most sections of the Ferry Creek channel and the northern wetland area; and subsurface samples from the northern extent of the Ferry Creek channel. Elevated concentrations of copper were detected at depths of up to 4.0 feet throughout the Ferry Creek channel and in the western reaches of the ditch extending from the Ferry Creek channel to Ferry Boulevard. In the wetland area, elevated copper concentrations were detected in the north and central regions at depths of up to 6.0 feet.

Figures 4-22 and 4-23 show the ranges of concentrations of lead, and Figures 4-24 and 4-25 show the ranges of concentrations of copper detected above the average background concentrations in surface and subsurface sediment in Area A-3.

Elevated concentrations of leachable lead were detected in the single subsurface sediment sample collected for SPLP metals analysis from the wetland area. Leachable lead was detected in the 4.0 to 6.0 foot sample from the northeastern corner of the north-central region.

Asbestos

Asbestos concentrations greater than or equal to one percent were detected frequently in surficial sediment, but less frequently in subsurface sediment. The higher concentrations were detected in the surficial samples from the northern and central regions of the Ferry Creek channel and the northern region of the wetland area; and at depths of up to 4.0 feet in subsurface samples from the northern region of the Ferry Creek channel. Figures 4-26 and 4-27 show the ranges of concentrations of asbestos detected greater than one percent in surface and subsurface sediment in Area A-3.

4.6.2 Surface Water

This section presents a summary of surface water results for Area A-3. See Table 4-4 for a numerical data summary.

VOCs

VOCs, primarily chlorinated hydrocarbons, were detected frequently in the few surface water samples collected. The higher concentrations were detected in the northern extent, the central region north of the convergence of the ditch with the Ferry Creek channel, and in the south-central region in the vicinity of an observed seep and further downgradient.

SVOCs

SVOCs were not detected above background concentrations in the surface water samples collected.

Pesticides/PCBs

In surface water samples, a low level of a single pesticide (beta-BHC) was detected above background concentrations at one location in the northern extent of the Ferry Creek channel. No PCBs were detected above background concentrations.

Dioxins/Furans

No surface water samples were submitted for analysis of dioxins and furans.

Metals

Elevated concentrations of metals were detected frequently in surface water samples. These metals included chromium, barium, and manganese (detected in more than 50

percent of the samples); zinc and mercury (detected in about 40 percent of the samples), and aluminum (detected in about 30 percent of the samples). Copper and lead were detected in 22 and 28 percent of the samples, respectively. The highest concentrations were detected in samples collected in the central region in the vicinity of the convergence of the ditch with the Ferry Creek channel. Figure 4-22 and 4-24 show the ranges of concentrations of lead and copper, respectively, detected above background in surface water in Area A-3.

Asbestos

No surface water samples were analyzed for asbestos.

4.6.3 Soil

This section presents a summary of soil results for Area A-3. See Table 4-15 for a numerical data summary.

VOCs

VOCs were detected infrequently in soil samples. The higher concentrations were detected primarily in subsurface soils at depths of up to 16.0 feet in the eastern portion of the northern region, and 5.0 feet in the central region south of the convergence of the ditch with the Ferry Creek channel. In each of these regions, acetone was the only VOC detected at high levels. Medium levels of 2-butanone were also detected in the subsurface soil from the central region. VOCs were not detected at concentrations exceeding 11 ug/kg at any other location.

SVOCs

SVOCs, primarily PAHs and phthalates, were detected frequently in both surficial and subsurface soil. The higher levels of PAHs were detected only in surficial samples from the

eastern portion of the northern region. Low to medium levels were detected elsewhere at depths of up to 16.0 feet. The phthalate concentrations were primarily low levels, except for medium levels of a single phthalate in subsurface samples from the eastern portion of the northern area and high levels of a single phthalate in the surficial sample from the north-central region.

Pesticides/PCBs

PCBs above background concentration were detected frequently in both surficial and subsurface soil throughout Area A-3. Pesticides were detected above background concentrations at several surficial locations, but fewer subsurface locations. Of the subsurface samples containing pesticides, approximately half contained a single pesticide. The higher levels of pesticides were detected in surficial samples collected in the northern region along the eastern border adjacent to the wetland area and in the south-central region; and at depths of up to 16.0 feet in subsurface samples collected in the eastern portion of the northern region. The highest levels of PCBs were detected in a few surficial samples collected in the northern region and one location in the southern region of Area A-3; and at depths of up to 16.0 feet in subsurface samples collected in the northern region. The PCBs consisted primarily of Aroclor 1262 and Aroclor 1268, with infrequent detections of Aroclor 1248 and Aroclor 1254. Figures 4-20 and 4-21 show the ranges of concentrations of total Aroclors detected above the average background concentrations in surface and subsurface soil in Area A-3.

Dioxins/Furans

Elevated TEQ concentrations were reported frequently in both surficial and subsurface soil samples. The higher TEQ concentrations were reported in surficial samples collected in the northern region, both in the eastern portion and along the eastern border adjacent to the wetland area, in the north-central region, and in the south-central region; and at depths of up to 10.0 feet in subsurface samples collected in the northern region in the eastern portion and along the eastern border adjacent to the wetland area.

Metals

Elevated levels of metals were detected frequently in both surficial and subsurface soil samples. Two metals, copper and lead, are considered the most indicative of contamination associated with operations at the Raymark Facility, and are therefore the focus of the summary.

Elevated concentrations of lead were detected in soil samples collected from the majority of surficial and subsurface locations. The highest concentrations were detected in the northern region and the central region, opposite and south of the convergence of the ditch and the Ferry Creek channel. Elevated concentrations of lead were detected in the northern region at depths of 10.0 to 16.5 feet; in the central region at depths of 5.0 to 10.5 feet; and in the southern region at depths of up to 10.5 feet.

Figures 4-22 and 4-23 show the ranges of concentrations of lead, and Figures 4-24 and 4-25 show the ranges of concentrations of copper detected above background in surface and subsurface soil in Area A-3.

Elevated concentrations of copper were detected in soil samples collected from nearly all surficial locations and half the subsurface locations. The highest copper concentrations were detected in surficial and subsurface samples from the northern region and at depths of up to 5.0 feet in subsurface samples in the central region south of the convergence of the ditch and the Ferry Creek channel. Elevated concentrations of copper were detected in the northern region at depths of up to 16.0 feet in various parts of the site.

Elevated concentrations of leachable lead and copper were detected in the surficial soil sample collected from the central portion and the subsurface soil sample collected from the eastern portion of the northern region. Leachable barium, nickel, and zinc were also detected at elevated concentrations in the subsurface sample analyzed.

Asbestos

Elevated asbestos concentrations were detected in surficial and subsurface soil samples primarily in the northern region of Area A-3. Elevated asbestos concentrations were detected infrequently in surficial and subsurface samples in the central region and were not detected in samples from the southern region. The highest concentrations were detected in both surficial and subsurface samples collected in the northern region. No asbestos was detected in samples collected at depths of over 11.3 feet, except for low levels at depths of up to 16.0 feet at one location the northern region. Figures 4-26 and 4-27 show the ranges of concentrations of asbestos detected greater than one percent in surface and subsurface soil in Area A-3.

5.0 CONTAMINANT FATE AND TRANSPORT

Complex factors govern the fate and transport of contaminants within the study area. The past operations and disposal history associated with the Raymark Facility, the varying geologic and hydrogeologic conditions of the study area and environs, and the transfer and cross-migration of contaminants between environmental media all influence the migration of contaminants in the sediment, surface water, soil, and groundwater. This section presents a summary of the fate and transport for contaminants within the study area. A detailed discussion of the general mechanisms and factors that govern fate and transport is presented in Appendix H.

Fate and transport issues related to groundwater are not fully addressed in this RI because groundwater is currently under investigation and evaluation as part of OU2.

Section 5.0 summarizes the fate and transport of contamination including;

- Section 5.1 - Contaminant Sources and Releases
- Section 5.2 - Contaminant Fate and Transport in the Area I Study Area

The location of the study area is shown on Figure 1-2 and defined in Section 1.0.

5.1 Contaminant Sources and Releases

Contaminants were released into the environment in the study area by various historical disposal and operational practices associated with the Raymark Facility, and potentially from other commercial and industrial operations within the OU3 area. A summary of past sources and releases of contamination is presented below. A detailed description of facility operations and manufacturing processes is presented in Section 1.0.

Throughout the history of the Raymark Facility, large quantities of organic and inorganic chemicals and fuels were handled in storage tanks, drums, and process equipment situated

throughout the property. The moving, opening, and emptying of drums and the loading and unloading of tanks, may have resulted in discharges or spills of solvents and fuel. Solvents and fuels reportedly also leaked to soils from above and underground storage tanks (ELI, 1995).

Unlined acid neutralization pits were located in the northwest part of the Raymark Facility, and received spent acids and caustic solutions laden with metals. Solvents may also have been disposed of in the acid neutralization pits.

In addition, a series of four unlined lagoons were used to retain and settle particulate matter from process waters generated as a by-product of the manufacturing activities. Liquid wastes bearing residual VOCs, heavier organic compounds, asbestos, and metals were directly discharged into the lagoons, which in turn discharged into Ferry Creek. A system of drains under the buildings of the Raymark Facility also conveyed process water, spills, and discharges to the lagoons. Storm drains throughout the facility also directed surface runoff into this discharge system. Thus, the Raymark Facility runoff, storm and facility drains, and process water all discharged to Ferry Creek, which then flowed to the Housatonic River and Long Island Sound. Discharge of process waters to the lagoons ceased in 1989, when the plant closed. The discharge of stormwater from the lagoons continued until 1995, when drainage was diverted around the lagoons directly into a stormwater drain.

Sludges excavated or dredged from the lagoons, "off-specification" materials that were discarded, and other waste products were disposed of as fill on a substantial portion of the Raymark Facility property, as well as at residential, commercial, and industrial properties within Stratford, including the OU3 area. The nature and concentrations of various contaminants in the fill materials changed over the 70-year operational life-time of the Raymark Facility due to alterations in manufacturing processes and product lines.

The study area encompasses other commercial and industrial properties that may have contributed to the contamination of the soil, surface water, sediment, and groundwater.

Past releases of petroleum hydrocarbons, volatile organic and semi-volatile organic compounds, and other contaminants from other properties are likely based on the long history of industrial and commercial activities in the area. Investigating and evaluating releases from these potential sources are not within the scope of this RI.

A summary of the distribution of contaminants in the study area follows:

Areas A-1, A-2, and A-3 were all directly impacted by Raymark Facility wastes. The upland portions of these areas received contaminated Raymark wastes as fill. Additionally, Ferry Creek and the wetland areas within A-1 and A-3 were directly and indirectly impacted by Raymark Facility wastes. Ferry Creek received direct discharges from the lagoons on the Raymark Facility, and contaminated soil-wastes washed into the creek by erosion of the contaminated fill from the properties surrounding the creek. The wetlands in these areas received waste directly as fill, and contaminated wastes washed in by erosion of soil and waste fill from surrounding properties. Based on the groundwater discharge study (seepage study), there is strong indication that contaminated groundwater is discharging as base-flow to Ferry Creek; further evaluation is being conducted as part of the OU2 RI.

Therefore, the main sources and releases of contaminants to the study area are summarized as follows;

- Disposal of contaminated Raymark wastes, including sludges from the lagoons, "off-specification materials" that were discarded, and other waste products from the facility that were used to fill in low topographic areas. These fill materials have become sources of further release to the wetlands, Ferry Creek, the Housatonic River, and other low lying topography in the Area I drainage areas through erosion, and possibly solute transport. Dissolved contaminant transport from the fill materials may have also contaminated underlying soils and sediments in the filled areas.

- Discharge of surface runoff, facility drainage, and process water from the Raymark Facility into Ferry Creek, and ultimately the Housatonic River and Long Island Sound.
- Spillage, leakage, and other sources of release of contaminants from the Raymark Facility into the groundwater and into the local drainage area.
- Spillage, leakage, and other sources of release of contaminants from other commercial and industrial properties within the drainage area.
- Potential discharge of contaminated groundwater as base-flow to Ferry Creek, which is being evaluated in OU2.

5.2 Contaminant Fate and Transport in the Area I Study Area

The fate and transport of contaminants within the study area were evaluated to support the human health and ecological risk assessments, and for use in the feasibility study that will evaluate potential remediation options, if required.

The following section describes the distribution and releases of contaminants, summarizes the physical state of contaminants in the environmental media (soil, sediment, and surface water), and discusses the primary pathways for contaminants from the potential source areas at the Raymark Facility to migrate into the environmental media within the study area. A detailed discussion of the mechanisms and factors governing the fate and transport is provided in Appendix H.

The fate and transport discussions are focused on the major contaminants of concern (COCs) identified from the human health risk assessment. These COCs include: PAHS, PCBs, dioxins/furans expressed as TEQ concentrations, metals (primarily copper and lead), and asbestos. A discussion of VOCs was also included to supplement the evaluation of VOCs in groundwater to be provided in the RI report for OU2.

The study area (Areas A-1, A-2, and A-3) includes Ferry Creek (from Interstate 95 in the north to the culvert under Broad Street in the south), as well as adjacent commercial, industrial properties, and portions of residential properties.

Contaminants are present in sediment, surface water, and soil samples collected throughout the study area; groundwater samples were also collected but will be evaluated under the OU2 RI. A summary of the activities resulting in contaminant release to the area, the physical state of the contaminants present in these environmental media, and the associated fate and transport mechanisms are presented below. Tables 4-7 through 4-16 list contaminants that exceeded background. The potential contaminant fate and transport mechanisms for the sediment/surface water and soil media are detailed in Appendix H.

Past disposal practices at the Raymark Facility resulted in the release and migration of contaminants throughout the study area. Direct discharge of both inorganic and organic contaminants from the Raymark Facility lagoon into the northern reaches of Ferry Creek, was an apparent source of sediment contamination throughout the Ferry Creek, until flow was diverted around the lagoon in 1995. Based on historical information, Ferry Creek was re-routed. Samples taken in this area indicated that the sediment and soil is contaminated along the former path of Ferry Creek (based on historical aerial photographs).

The disposal of Raymark wastes as fill on the properties adjacent to Ferry Creek, and the possible filling of portions of the creek itself with wastes, indicate that the contaminated soil-waste/fill probably contributed contaminated sediment to Ferry Creek, as well as to adjacent wetlands, to the ditch extending westward from Ferry Creek between 250 and 230 Ferry Boulevard, and to the triangular-shaped property located between East Broadway and Ferry Boulevard. Frequent detections of elevated levels of PAHs, PCBs, dioxins/furans, metals, and asbestos, as well as infrequent detections of VOCs, indicate that these sources and releases contributed to contamination of the sediment in these areas.

5.2.1 Soil

Properties in the study area received soil-waste/fill from the Raymark Facility. This fill is the primary source of soil contamination. This resulted in the direct release of contaminants in areas where fill materials were placed, and releases to the naturally occurring sediments and soils in contact with, underlying, or in close proximity to, the contaminated fill. The study area contains other commercial and industrial properties that may also be a source for contaminants in the soils. However, the Raymark soil-waste/fill is a significant contributor to the study area contamination. Soils in contact with, or in proximity to, the contaminated fill show frequent detections of elevated levels of PAHs, PCBs, dioxins/furans, metals, and asbestos, with less frequent detections of VOCs.

VOCs - Dissolution of the more soluble contaminants, such as VOCs, in the soil-waste/fill caused by runoff and/or groundwater infiltration may have resulted in a release of contamination downward into the subsurface soil and groundwater. Infiltration of mobilized contaminants may have contributed to subsurface soil contamination in the Ferry Creek area, as evidenced by a higher frequency of detections and higher concentrations of VOCs in the subsurface soils than in shallow soils. Some VOCs detected on commercial and industrial properties in the OU3 area may also have contributed to subsurface contamination.

Evidence of transport of dissolved contaminants is also indicated in the groundwater, where VOCs may be entering the sediment and surface water of Ferry Creek through base-flow recharge from contaminated groundwater. The groundwater is being evaluated in the OU2 RI.

SVOCs (PAHs) - The SVOCs are less soluble than the VOCs in soil, and sampling shows SVOCs are distributed in both the shallow surface and deeper subsurface soils, with a slightly higher frequency of detection in the surface soils. The primary SVOCs of concern are the PAHs, and the distribution of PAHs shows they are probably adsorbed onto the soil particles. The highest concentrations of PAHs were detected in surface soils in the vicinity

of paved roadways and/or parking lots in Areas A-1, A-2, and A-3, and may be the result of asphalt paving. High levels of PAHs were also detected in some subsurface samples associated with commercial and industrial properties in A-1 and A-2, and may be associated with releases from these properties.

PCBs, Dioxin/Furans, Metals, and Asbestos - PCBs, dioxins/furans (as TEQ concentrations), metals (primarily copper and lead), and asbestos were detected in both the surface and subsurface soils. These contaminants are relatively immobile in the soils, and are likely to remain where the fill was placed.

5.2.2 Sediment and Surface Water

Various chemical contaminants are present in the sediment and surface water in the Ferry Creek channel, in sediment in the wetlands adjacent to the channel, in the western reaches of the ditch extending from Ferry Creek westward between properties located at 230 and 250 Ferry Boulevard, and in the single sediment location sampled in the marshy area on the triangular-shaped property between East Broadway and Ferry Boulevard. Several pathways are available for contaminants to have entered these media, and for them to have been subsequently transported downstream and/or to adjacent media. The main pathways of surface water and sediment contamination in the study area are as follows:

- Transport and redeposition of contaminated soil and sediment particles via erosion from contaminated soils and Raymark soil-waste fill within the drainage area.
- Transport of dissolved contaminants into sediment and surface water via surface water runoff from private and commercial/industrial properties, and roadways.

- Transport of contaminants into the sediment and surface water via discharge of contaminated groundwater as base-flow seepage into Ferry Creek.
- Transport of adsorbed contaminants throughout Ferry Creek via erosion and redeposition of contaminated sediment caused by surface flow and tidal fluctuations.

Elevated levels of SVOCs or PCBs were not present in surface water samples in Ferry Creek. Samples were not collected for analysis of dioxins/furans and asbestos since these contaminants are virtually insoluble in water. Therefore, the surface water fate and transport discussion is limited to VOCs and metals.

VOCs - VOCs in the Ferry Creek area sediment/surface water environment tend to remain dissolved in and free to be transported by surface water. They do not appear to remain adsorbed to sediment particles at concentrations exceeding the average background concentrations. VOCs present in surface sediment have a tendency to volatilize into the atmosphere due to their high vapor pressures. VOCs present in surface water (especially in regions of high turbulence or aeration) also have a tendency to volatilize into the atmosphere due to their high vapor pressures and high air-water partition coefficients.

VOCs were infrequently detected in both surface and subsurface sediment throughout the Ferry Creek channel and the adjacent wetland areas, whereas they were frequently detected at elevated levels (particularly chlorinated hydrocarbons) in surface water throughout the length of Ferry Creek.

The highest concentration of an individual VOC (3,400 ug/kg 1,1-DCA) detected in sediment was detected in surface sediment, in the Ferry Creek channel just upgradient of the culvert under East Broadway in Area A-1. At this location, the surface water flow was slow moving and the channel was deep. These factors may cause deposition of sediment with a higher organic-silt content and a high potential for adsorption of VOCs onto sediment/silt particles. In addition, contamination of sediments from contaminated

groundwater that discharges as base-flow to Ferry Creek may be occurring. This is the subject of further investigation in the OU2 RI.

The higher concentrations in the surface water included: 1,1-DCE; 1,2-DCE; and 1,1,1-TCA. These compounds were detected in the northern reaches of Ferry Creek near the first major bend in the channel, and in the channel extending into the western arm of the wetlands. Both locations are adjacent to the Morgan Francis Property in Area A-1. The VOC 1,1,1-TCA was detected south of the culvert under East Broadway and in the vicinity of an observed seep in the south-central region of Area A-3. These results may have been caused by migration from a nearby source area due to surface runoff, or from base-flow discharge of contaminated groundwater.

SVOCs - SVOCs (primarily PAHs) in the Ferry Creek sediment/surface water environment are more readily adsorbed to sediment particles than are VOC contaminants, and are generally not as soluble as the VOCs. SVOCs present in surface sediment can volatilize, to some degree, into the atmosphere, but not as well as the VOCs. SVOCs are not being transported via groundwater as much as the VOCs, and therefore are not a significant source of sediment or surface water contamination from base-flow of contaminated groundwater.

SVOCs were not detected at significant levels in the surface water samples collected throughout Ferry Creek. SVOCs, primarily PAHs, were detected in the sediments at a higher frequency and at higher concentrations in the surface sediments than in the subsurface sediments of the Ferry Creek channel and the adjacent wetland areas. The higher frequency of PAH detection in surficial samples, especially in higher deposition areas in the Ferry Creek channel, suggests that the PAHs were adsorbed onto sediment particles that may have migrated to these areas with surface water flows, runoff, or tidal fluctuations.

The reduction of SVOCs with depth in the sediments is in contrast with the distribution of PCBs, that are present in both shallow and deeper sediments, as discussed below. The

vertical distribution of SVOCs may be the result of the SVOCs being deposited relatively recently, biodegradation in the deeper sediments, an affinity of the SVOCs to adsorb onto the lighter sediment particles that remain suspended during high flow when mixing of sediments may occur, or other factors that tend to result in higher concentrations in the shallow sediments than in the deep sediments.

The highest concentrations of PAHs were detected in surface sediment in the northern reaches of Ferry Creek near the first major bend in the channel adjacent to the Morgan Francis Property in Area A-1, and south of the culvert under East Broadway and in the vicinity of an observed seep in the south-central region of Area A-3. These results may have been caused by migration from a nearby source due to surface water runoff or groundwater discharge, and subsequent adsorption to sediment particles.

PCBs - PCBs in the Ferry Creek sediment/surface water environment are more readily adsorbed to sediment particles than VOC and SVOC contaminants, and they have very low solubility in water. PCBs have little or no tendency to volatilize into the atmosphere due to their low vapor pressures, compared to the highly volatile VOCs and somewhat volatile SVOCs.

PCBs were frequently detected in surface and subsurface sediments throughout Ferry Creek and the adjacent wetland areas, with Aroclor 1262 and Aroclor 1268 detected more frequently than Aroclor 1248, Aroclor 1254, and Aroclor 1260. The high frequency of PCB detections in the sediment suggests that the PCBs were adsorbed onto soil and waste particles that were placed there as fill material from the Raymark Facility, and by migration to these areas via runoff, surface water flow, and/or tidal fluctuations. The relatively similar frequency of detection in both surface and subsurface sediment in the Ferry Creek channel may be the result of erosional scour and redeposition of contaminated sediment over an extended period of time, and/or the resistance of PCBs to biodegradation in the natural environment.

The levels of PCBs were relatively consistent in sediment throughout the Ferry Creek channel and adjacent wetlands, with the highest levels detected in both surface and subsurface samples immediately upgradient of the culvert under East Broadway in Area A-1, and immediately downgradient of the culvert in Area A-3.

Dioxins and Furans - As with PCBs, dioxins and furans have low water solubilities, and a high tendency to adsorb to sediment particles in a sediment/surface water environment. Dioxins and furans have little or no tendency to volatilize into the atmosphere due to their low vapor pressures, and are not very biodegradable. Sediment samples, but not surface water samples, were analyzed for dioxins/furans (as TEQ concentrations).

Elevated TEQ concentrations were frequently detected in surface sediment throughout the Ferry Creek channel, and somewhat less frequently in subsurface sediment from the northern and southern reaches of the Ferry Creek channel. The high frequency of detection suggests that the dioxins and/or furans were absorbed onto sediment particles that migrated to these areas with surface water flows, runoff, or tidal fluctuations. The relatively similar frequency of detections in surface and subsurface sediment is similar to that of the PCBs, and may be the result of erosional scour and redeposition of contaminated sediment over an extended period of time, and/or the resistance of dioxins and furans to biodegradation in the natural environment.

The highest TEQ concentrations were detected in the same areas as the highest PCBs, in both surface and subsurface sediment samples immediately upgradient of the culvert under East Broadway in Area A-1, and immediately downgradient of the culvert in Area A-3.

Metals (Copper, Lead, and Barium) - Copper and lead metals tend to be less mobile in the environment than organic contaminants. Under natural conditions, some dissolution of copper and lead, and greater dissolution of barium, may occur in the presence of water due to surface water flows, runoff, or tidal fluctuations, as some metal ions may migrate. However, many of these dissolved metals readily precipitate out of solution and adsorb to sediment particles. Therefore, the main transport mechanism for these contaminants is

likely the transport and redeposition of metal-contaminated sediments via surface water flows, runoff, and tidal fluctuations. Copper and lead will be more soluble and remain in an aqueous state if the pH is sufficiently low, however, pH levels at which this occurs are not expected within the Ferry Creek area. Barium is more soluble in natural water than copper and lead.

Copper, lead, and barium were detected at levels higher than background in both surface and subsurface sediment throughout the Ferry Creek channel and adjacent wetlands. In the Ferry Creek sediment, the similar frequency of detections in surface and subsurface samples suggests that deposition of contaminated sediment has occurred over an extended period of time. This has resulted in similar deposition of contamination with depth as observed for PCBs and dioxins/furans. The highest levels were detected in the same areas as the highest PCBs and TEQ concentrations: in both surface and subsurface sediment samples immediately upgradient of the culvert under East Broadway in Area A-1, and immediately downgradient of the culvert in Area A-3.

The fact that copper and lead are not apt to dissolve in an aqueous environment under natural conditions (neutral pHs) is supported by their low frequency of detection in surface water from Ferry Creek. In particular, copper and lead were not detected above background concentrations in surface water from north of the culvert under East Broadway, and elevated levels were detected infrequently in surface water from south of the culvert.

Barium was detected at concentrations above background, at similar frequencies and with the highest concentrations at the same locations as the copper and lead. Elevated concentrations of barium (which is more water soluble) were detected in surface water throughout the length of Ferry Creek.

The highest concentrations of these three metals were detected in the high deposition area at the confluence of the Ferry Creek channel with the ditch that extends westward between 230 and 250 Ferry Boulevard in Area A-3. These metals may have been present

in suspended particulates in this area, or they may have been leached out of contaminated sediment or soils.

It is important to note that elevated levels of lead and/or copper were detected in sediment and soil samples submitted for SPLP analysis from regions north of the culvert under East Broadway and south of the culvert. This suggests that these materials may result in a continual release of copper and lead into the surrounding media.

Asbestos - Asbestos is relatively immobile in the environment, except through physical erosion and transport in surface water flows, through bulk advective movement, or dispersion in aqueous or airborne environments. Elevated levels of asbestos were detected frequently in both surface and subsurface sediment in the Ferry Creek channel north of the culvert under East Broadway and in the limited number of subsurface sediment samples collected in the triangular-shaped property located between East Broadway and Ferry Boulevard in Area A-1. Asbestos was analyzed for in the sediments, but not in the surface water.

Asbestos was detected frequently in surface and subsurface sediment in the northern portion of Ferry Creek, but less frequently in the sediment of Ferry Creek and adjacent wetlands south of the culvert in Area A-3. The similar frequency of detection in both surface and subsurface sediment in the northern section of the Ferry Creek channel suggests that deposition of contaminated sediment occurred over an extended period of time, resulting in similar deposition of contamination with depth. The findings further suggest that asbestos may have been transported in discharge from the Raymark Facility lagoons, as well as by transport in runoff from asbestos-laden fill materials placed in close proximity to the northern section of the Ferry Creek channel.

The highest concentrations of asbestos were detected in surface and subsurface samples north of the culvert under East Broadway along the central portion of the Ferry Creek channel in Area A-1, in subsurface samples from the triangular-shaped property between East Broadway and Ferry Boulevard in Area A-1, and in surface samples south of the

culvert from the Ferry Creek channel and adjacent wetlands in the northern and north-central regions of Area A-3.