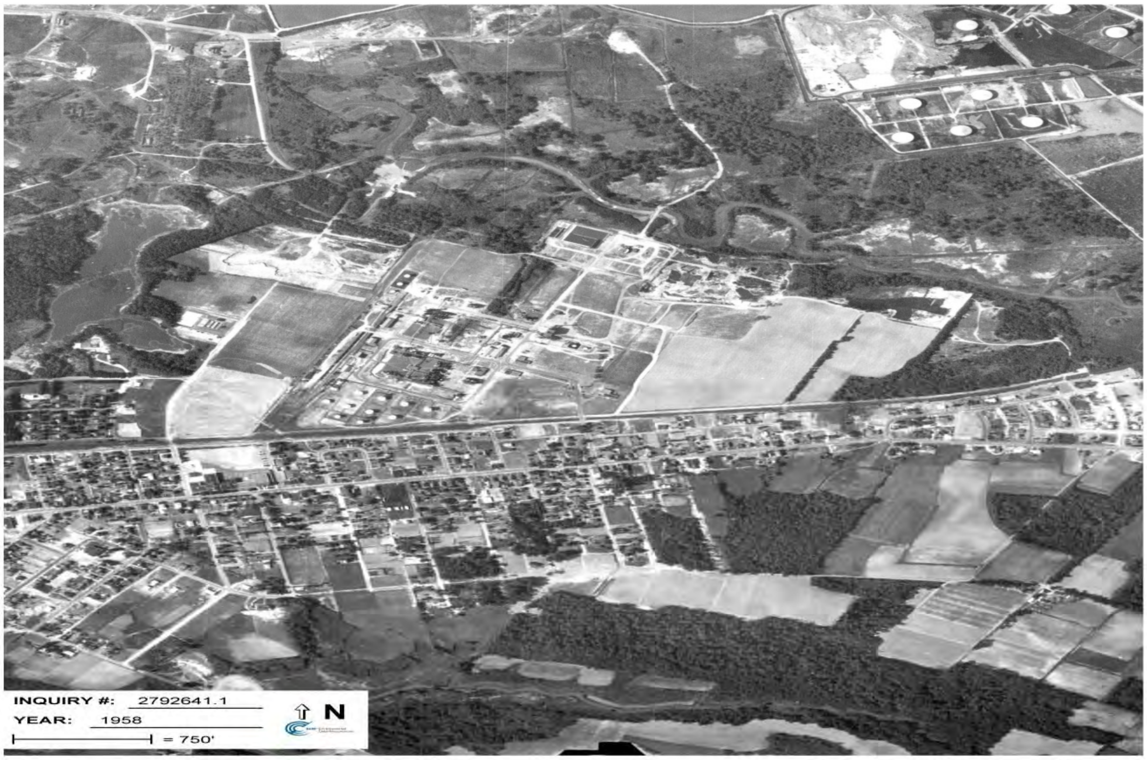
Prepared for

Hercules, LLC.
500 Hercules Road
Wilmington, Delaware 19808

REMEDIAL INVESTIGATION REPORT



Former Hercules Higgins Plant
Gibbstown, New Jersey
July 2018

Prepared by

CSI Environmental, LLC
401 Headquarters Drive
Suite 203
Millersville, MD 21108

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

Acronym List

ACO	Administrative Consent Order
AOC	Areas of Concern
APA	Active Process Area
API	American Petroleum Institute
ARI	Additional Remedial Investigation [CSI, 2015]
BERA	Baseline Ecological Risk Assessment
Bgs	Below Ground Surface
BHHRA	Baseline Human Health Risk Assessment
BIF	Boilers and Industrial Furnaces
CCW	Clonmell Creek and Wetlands
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	Cracking Furnace
CLA	Cumene Loading Area
CLF	Chemical Landfill
COC	Constituents of Concern
CPT	Cone Penetrometer Test
CSI	Construction Services International
CSM	Conceptual Site Model
CTDH	Cooling Tower/Dowtherm Heater
DGW	Discharge to Groundwater
DIB	Diisobutylene
Di-Cup	Dicumyl Peroxide
DPT	Direct Push Soil Study

EA	Exposure Area
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
ER-L	Effects Range Low
ERM	Environmental Resources Management
EVS	Environmental Visualization System
F&T	Fate and Transport
FEMA	Federal Emergency Management Agency
FI	Focused Investigation
FID	Flame Ionization Detector
FIWP	Focused Investigation Work Plan [CSI, 2008]
FP	Free Phase
FS	Feasibility Study
ft	feet
GEO	GEO Specialty Chemical Co.
GP	Gravel Pit
GTI	Groundwater Technology, Inc.
GWETS	Groundwater Extraction and Treatment System
HP	Helipad
IA	Investigation Areas
	Impact to Groundwater
IGW	
IGWSCC	Impact to Groundwater Soil Cleanup Criteria
IGW	Impact to Groundwater
IPA	Inactive Process Area
IGWSCC	Impact to Groundwater Soil Cleanup Criteria
IRM	Interim Remedial Measure
ISCO	In-Situ Chemical Oxidation
ISOC	In-Situ Oxygen Curtain
LDS	Laboratory Drum Storage
LIFS	Laser Induced Fluoroscopy
LLC	Limited Liability Company
LNAPL	Light Non-Aqueous Phase Liquids
MIP	Membrane Interface Probe
MNA	Monitored Natural Attenuation Membrane Interface Probe
MNR	Monitored Natural Recovery Remedial
MPP	Multi-Purpose Plant
msl	mean sea level
MW	Monitoring Well
N.J.A.C.	New Jersey Administrative Code
NAPL	Non-Aqueous Phase Liquids Code
NCL	Northern Chemical Landfill
ND	Nondetect

NDCSCC	Nonresidential Direct-Contact Soil Cleanup Criteria
NFAC	No Further Action
NJDCNRSRS	New Jersey Direct Contact Non-Residential Soil Remediation Standards
NJDEP	New Jersey Department of Environmental Protection
NJIGW	New Jersey Impact to Groundwater
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities Listing
NRD	National Resources Damages
NW	Northern Warehouse
OVA	Organic Vapor Analyzer
PAH	Polynuclear Aromatic Hydrocarbons
PBC	Paulsboro Refining Company, LLC.
PBF	PBF Energy, Inc.
PCB	Polychlorinated biphenyls
Ph I	Phase I Soils Investigation [ERM, 1988]
Ph II	Phase II Soils Investigation [ERM, 1995]
PID	Photoionization Detector
ppm	parts per million
PPNDP	Passively Placed Narrow Diameter Point
PRC	Paulsboro Refinery Corporation, LLC.
PRM	Potomac-Raritan-Magothy
PRT	Post-Run Tubing
PTS	PTS Laboratories, Inc.
PVC	Polyvinyl Chloride
PW	Production Well
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RBR	Risk Based Remedies, Inc.
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation / Feasibility Study
RMC	Repaupo Meadow Company
R-NAPL	Residual Non-Aqueous Phase Liquids
ROD	Record of Decision
Roux	Roux Associates, Inc.
SA	Settlement Agreement
SCB	Storm Water Catchment Basin
SCC	Soil Criteria Cleanup
SDB	Sludge Drying Beds

SF	Spray Field
SI	Surface Impoundment
SLERA	Screening Level Ecological Risk Assessment
SRI	Supplementary Remedial Investigation [ERM, 2003]
SSCOC	Site-Specific Constituents of Concern
SSTIC	Site-Specific Tentatively Identified Compounds
SVOC	Semi-Volatile Organic Compounds
SW	Stilling Well
SWDA	Solid Waste Disposal Area
TDS	Total Dissolved Solids
TEA	Terminal Electron Acceptors
TF	Tank Farm
TLA	Train Loading Area
TOC	Total Organic Carbon
TRA	Township Refuse Area
TSS	Total Suspended Solids
TW	Township Wells
UFA	Uniform Federal Policy
USFWS	United States Fish and Wildlife Services
USGS	United States Geological Survey
UST	Underground Storage Tank
UV	Ultraviolet
UVIF	Ultraviolet Induced Fluorescence
VI	Vapor Intrusion
VOC	Volatile Organic Compounds
WH	Warehouse
WMS	Waterloo Membrane Sampler
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This Remedial Investigation (RI) Report provides the comprehensive findings of environmental characterization activities conducted at the former Hercules Higgins Plant (the Site) in Gibbstown, Greenwich Township, Gloucester County, New Jersey. Environmental activities at the former Hercules Higgins Plant commenced in 1979 following discovery of benzene in a process water well (PW-4) along the Site property boundary. The final samples collected as part of this RI were obtained in 2017. The investigative history has resulted in extensive collection of samples and correspondingly extensive volume of analytical data in relevant media (air, groundwater, sediment, soil, pore water, soil gas and surface water). This RI Report summarizes the manufacturing and environmental investigation history of the Site and provides a comprehensive evaluation of the data obtained.

The processes used to evaluate the Site within this RI are defined in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) [EPA, Oct 1988] (1988 RI/FS Guidance) and related guidance published subsequently. Previous studies at the Site were conducted initially in accordance with an Administrative Consent Order (ACO) between Hercules and the New Jersey Department of Environmental Protection (NJDEP) dated 23 January 1986. The NJDEP remained the lead agency until the EPA assumed control as the lead regulatory agency in 2009, as described further below.

The 1986 ACO identified three operable units at the Site: groundwater, soils, and the Solid Waste Disposal Area (SWDA), as Operable Units 1, 2, and 3, respectively. The 1986 ACO defines Operable Unit 3, the SWDA, as an area “approximately 2,000 feet north of the manufacturing plant in a marsh between the plant and the Delaware River which had been used by the previous owner, DuPont.” The SWDA has been handled as a separate Operable Unit under the direct oversight of the NJDEP since 1986. As a result, environmental activities at the SWDA are beyond the scope of this RI Report and are excluded from further discussions herein.

In 2004, CSI was contracted by Hercules Incorporated to complete the RI sampling and reporting activities at the Site. Initially this effort was intended to address data gaps identified by NJDEP in previous RI investigation phases. This work was outlined in the Focused Investigation (FI) Work Plan [CSI, 2008] developed by CSI on behalf of Hercules and negotiated with NJDEP between 2004 and 2008. CSI conducted the FI field work in February/March 2009 after agency approval of the FI Work Plan was obtained.

Subsequent to completion of the FI field work the United States Environmental Protection Agency (EPA) filed to take the regulatory lead on the Site from the NJDEP. An Administrative Settlement Agreement (SA) and Order of Consent for Remedial Investigation/Feasibility Study (RI/FS), was executed on September 10, 2009 between the EPA and Hercules. Subsequent to this SA, all additional studies at the Site have been conducted as part of the ongoing SA activities to support the completion of the RI/FS and a Baseline Human Health Risk Assessment (BHHRA) and Baseline Ecological Risk Assessment (BERA).

The Site was divided into Exposure Areas (EAs) to facilitate completion of the BHHRA. These EAs are similar to the historical Investigation Areas/Areas of Concern (IAs/AOCs) referenced in previous investigation documents. The EAs include the entire Site with the exception of the SWDA, which was remediated as a separate unit under NJDEP lead as described previously. A large portion of the Site where no previous history of disposal or manufacturing processes had occurred (Open Area and Areas A and B) has been included in this RI. These areas were sampled during the final phase of investigation in 2015 designated as the Additional Remedial Investigation (ARI).

As outlined herein, numerous additional studies have been conducted in an attempt to finalize the RI/FS since the EPA took the regulatory lead for the Site in 2009. The supplemental studies conducted and the data obtained have been incorporated into this RI and will be used in the evaluation of remedial alternatives within the FS.

The lessons learned from each successive study and investigation phase resulted in the narrowing of the efforts for each subsequent investigative phase. With an investigation history of nearly 40 years, it is important to apply the lessons learned and decisions made in the past to refine ongoing decision making. As a result, a thorough summary of each investigative phase is provided herein.

The investigations at this Site have confirmed that the primary constituents of concern (COC) for this Site are benzene, isopropylbenzene (cumene), ethylbenzene, toluene, total recoverable phenolics (TRP) and the Site-specific tentatively identified compounds (SSTICs) acetophenone, diisopropylbenzene, alpha methyl styrene (a-methylstyrene), di-tert-butyl-p-cresol, and dimethylbenzyl alcohol. These compounds provide a distinct chemical signature for this Site and are collectively referred to herein as the Site-specific COCs (SSCOCs).

This chemical signature is an important tool for helping to discern between Site-related issues and those that are related to off-Site influences. In the vicinity of this Site there is an extensive regional industrial history that has contributed multiple constituents in the environment that are not related to Site activities. Distinguishing between the sources of these constituents, if known, will help in completing Site remedial activities.

CSI developed a set of RI screening values based upon applicable New Jersey and Federal screening levels to assess the nature and extent of SSCOCs at the Site. These RI screening values were provided for Agency review and approved by NJDEP and EPA prior to initiation of this RI report. These RI screening values have been used in conjunction with the findings of the BHHRA and BERA to determine if particular areas at the Site will require further consideration for remedial action within the pending Feasibility Study (FS).

The following is a summary of the BHRRA, BERA and RI findings by EA:

Active Process Area (APA)

The only risk identified within the BHHRA for the APA EA is direct contact with shallow A-level groundwater from benzene and cumene. A hypothetical risk resulting from the ingestion of B and C-level groundwater containing benzene, cumene, TRP and 1,2-dichloroethane was also identified. This risk is considered hypothetical because the ingestion of B- and C-level groundwater at the Site is not currently ongoing and is unlikely to occur at the Site: however, the aquifer is designated by NJDEP as Class II-A (potable).

Detections of SSCOCs in saturated and unsaturated soil at concentrations that exceed the applicable RI screening values were noted at depths ranging between two (2) and seventeen and a half (17.5) ft bgs throughout the central portion of the APA. The bulk of the mass in the APA EA is present in subsurface soils below the water table. Because the bulk of the SSCOC mass is present at depths below two (2) ft bgs, it does not result in an unacceptable direct contact risk for human health. Much of this mass is present as adsorbed phase SSCOCs or as dispersed residual non-aqueous phase liquids (R-NAPL) composed primarily of cumene and in some instances a-methylstyrene, but also containing minor concentrations of other SSCOCs.

The presence of SSCOCs in saturated and unsaturated soil at concentrations above applicable RI screening values in the central portion of the APA EA are contributing to concentrations of SSCOCs that exceed RI screening values in shallow A-level groundwater and in the B and C-levels as groundwater migrates primarily downwards in this vicinity. Remedial actions for addressing the SSCOCs in soils in the central portion of the APA will need to be considered in the pending FS.

Ongoing pumping and treatment of groundwater at the Site maintains hydraulic capture of groundwater and prevents SSCOCs from migrating toward off Site wells. Maintaining hydraulic capture of groundwater to minimize risk to off-Site receptors while reducing on-Site SSCOC mass will be a key component of future Site remedial actions. However, fate and transport calculations indicate that if groundwater pumping were to be suspended, then the SSCOCs in groundwater would naturally attenuate below applicable screening values after migrating a maximum of several hundred feet beyond the downgradient Site property boundary.

Area A/Open Area

There are no detections of note in the available soil and groundwater data or risk to human health and the environment in this EA thus no remediation is necessary.

Area B

Area B is an isolated wetland area located upstream along Clonmell Creek and away from any potential on-Site sources that would result in detectable concentrations of SSCOCs. No evidence of any waste disposal or historical Site process activities has been found in Area B. No pattern of detection of SSCOCs was noted in this EA, but concentrations of ubiquitously detected non-Site related compounds at concentrations above applicable RI screening values were found. Concentrations of these non-Site related compounds were found to be at or below background levels (see Appendix T). Thus, these detections are a regional issue and are related to background conditions at the Site. No further action is necessary for this EA because there is no discernible Site source area or area of concentrated detections above the RI screening values nor any risk associated with this EA from the BHHRA or BERA.

Chemical Landfill/Gravel Pit Area (CLF/GP)

Although no risk drivers were identified for this EA in the BHHRA, SSCOC concentrations were detected in surface water and shallow groundwater in the vicinity of the Chemical Landfill. The Chemical Landfill (see Figure 10-1) portion of this EA contains concentrations of SSCOCs benzene, cumene and ethylbenzene above their applicable RI screening values in unsaturated soils at depths of one (1) ft bgs to five (5) ft bgs. The surface water and groundwater detections are likely related to the SSCOCs present in unsaturated soils in the Chemical Landfill portion of the CL/GP EA. For this reason, the unsaturated soils in the portion of the Chemical Landfill identified on Figure 10-1 will need to be considered for further action within the pending FS.

No other issues were found in the CLF/GP EA.

Clonmell Creek and Wetland Area (CCW)

The results of the BERA indicate that the data from sample locations SED2-CC-4, SED2-CC-5, SED2-CC-8, SED2-CC-10, SED2-CC-11 and SED2-CC-13 in the 002 Outfall deltaic area (see Figure 10-2) indicate an impaired aquatic community in this area. This result correlates closely with the locations of the highest concentrations of SSCOCs in sediments in the 002 Outfall delta. The other BERA findings regarding risks in the CCW EA are related to food ingestion pathways. The BHHRA found that ingestion of fish that contain concentrations of gamma-chlordane; 4,4’-DDD; Aroclor 1254 and mercury resulted in unacceptable risk to children (0-6 years old).

To address the impaired aquatic community within the deltaic area of the 002 Outfall, remedial alternatives for sediments in the area shown on Figure 10-2 will need to be assessed within the pending FS.

The risk drivers for the fish ingestion pathway for sediments (dieldrin, Aroclor 1254 and mercury) and surface water (gamma-chlordane and 4,4’-DDD) are ubiquitously present in the sediments of Clonmell Creek as well as the surrounding area. The presence of gamma-chlordane and 4,4’-DDD in sediments likely resulted in the detection of those compounds in surface water because sediments were inadvertently incorporated in the surface water samples obtained. Thus, consideration of an active remedial action to address this risk is not practicable.

Inactive Process Area (IPA)

The only risk found in the IPA EA in the BHHRA was from direct contact with benzene and cumene in shallow groundwater. The area extending from the IPA pond to the south, toward the border of the APA is the area where concentrations of benzene and cumene were found to exceed the applicable RI screening values in unsaturated soil in the IPA EA. These soil exceedances are contributing to dissolved phase SSCOC concentrations detected in shallow groundwater in the IPA EA. This area will need to be considered for further action in the pending FS.

No other issues were found in the IPA EA.

Northern Chemical Landfill Area (NCL)

The only risk driver reported in the BHHRA in the NCL EA was from the hypothetical ingestion of B/C groundwater containing benzene and cumene. Although this is a hypothetical risk that will likely never be realized, there is evidence that SSCOCs detected at concentrations above the RI screening value in shallow, unsaturated soils in the central portion of the NCL (see Figure 10-4) are contributing to dissolved phase detections of SSCOCs in shallow A-level and, ultimately, to deeper B and C-level groundwater through downward groundwater migration. Mitigation of the shallow SSCOC detections in soils in the NCL EA should be considered in the pending FS.

Northern Warehouse Area (NW)

No risk drivers were reported for this EA and no further action is warranted.

Shooting Range (SR)

The Shooting Range is an active firing range used by the Borough of Greenwich Police Department. It is anticipated that the shooting range will remain in active use for the foreseeable future. Until that time best management practices will be implemented at the SR to minimize the potential for migration of lead impacted soils from the EA.

Stormwater Catchment Basin Area (SCB)

Concentrations of SSCOCs in sediment and surface water above applicable RI screening values were detected in the SCB basin. These detections correlate with the BERA finding that there is potential impairment to aquatic communities in the SCB. SSCOC and other constituents were detected in sediment above applicable RI screening values up to a depth of three (3) ft in the central portion of the SCB. Sediments within the SCB will need to be considered for future remedial action within the pending FS.

Concentrations of SSCOCs have been detected above applicable RI screening values in saturated and unsaturated soil in the SCB EA, beneath the former Multi-Purpose Plant (MPP) Surface Impoundments (SIs) (see Figure 10-5). Concentrations of these SSCOCs were also detected in the groundwater data from temporary and permanent well points in the vicinity of the MPP SIs.

SSCOCs also were detected at concentrations above the RI screening values in unsaturated soil in the bermed area on the north side of the SCB that forms a barrier preventing surface water flow to the 002 Outfall and Clonmell Creek. SSCOC detections in shallow groundwater from temporary well point samples were measured in the bermed area. SSCOC detections in sediment samples within the SCB and in several soil samples inside the bermed area may be associated with shallow groundwater detections in these temporary well points.

The only dissolved phase detections in the available SCB EA permanent groundwater wells at concentrations above RI screening values were Site-related VOC compounds consistently detected in groundwater samples from well MW-45B. A correlation between elevated VOC concentrations in soils beneath the former MPP SI and these groundwater detections is suspected based on review of available data.

Although no risk was identified in the BHHRA or BERA for the MPP SI or SCB berm area, the presence of soil concentrations that are contributing to detections of SSCOCs in groundwater at concentrations that exceed the applicable RI screening values should be considered for further action within the pending FS.

Tank Farm/Train Loading Area (TF/TLA)

The only risk driver found in the BHHRA for the TF/TLA EA was the hypothetical ingestion of deep B- and C-level groundwater containing benzene, cumene, TRP, and trichloroethene (TCE). There are three (3) locations within this EA where concentrations of SSCOCs were detected above applicable RI screening values in soil as shown on Figure 10-6. The presence of concentrations of SSCOCs in saturated and unsaturated soils above applicable RI screening values in the three areas identified on Figure 10-6 result in concentrations of SSCOCs in A-level groundwater in this EA. Thus, although no risk is identified for A-level groundwater in this EA, the SSCOC concentrations in soil in the three aforementioned areas should be considered for remedial action within the pending FS to address these source areas for SSCOCs in groundwater.

Township Refuse Area (TRA)

The only risk driver reported for the TRA EA in the BHHRA was related to blood lead levels because of the lead concentrations detected at location TLF-9 and its vicinity. Thus, remediation of the area of lead detections in the vicinity of sample TLF-9 will need to be considered within the pending FS.

The mixture of PAH, acetophenone and benzene concentrations above applicable RI screening values in unsaturated soil and sediment in the reach of the 002 Outfall starting at the SCB berm and extending to sample location 02OF-4 result in localized concentrations of these compounds in groundwater. Although no risk was found in the BHHRA from these 002 Outfall detections, the localized groundwater detections warrant further consideration within the pending FS.

Sitewide Groundwater

The three (3) areas where dissolved phase groundwater concentrations at the Site require further remedial consideration as follows:

- The area extending from the southern property boundary in the vicinity of extraction wells PW-8, PW-12, and PW-11 to the border between the APA and IPA, near the former API skimmer.
- An area downgradient of the former MPP SIs centered near wells MW-45B and MW-46B.
- The central portion of the NCL in the vicinity of wells MW-37, MW-38 and MW-50B.

Site-wide groundwater concentrations that exceed RI screening values are principally the result of dissolved phase migration of mobile SSCOCs from Site areas where appreciable SSCOC mass in saturated soil have been documented.

1.0 INTRODUCTION

1.1 PHYSICAL SETTING

The former Hercules Higgins Plant (the Site) is located in Gibbstown, Greenwich Township, Gloucester County, New Jersey (Figure 1-1). The Site comprises 350 acres of developed industrial area and undeveloped woodland and wetland. The Site is bound to the north by the Delaware River. East of the Site are the Paulsboro Refining Company, LLC (PRC) refinery tank farms and landholdings. To the south and southwest of the Site are residential and public properties in the city of Gibbstown, New Jersey. Access to the southern side of the Site is restricted by the presence of an active railroad line. The only crossing of this line is where North Market Street crosses the railroad line at the entrance to the Site. A public recreation area that includes ball fields and a street hockey rink is located west of the former Tank Farm (TF), Train Loading Area (TLA), Southern Warehouse, and Active Process Area (APA). Property owned by DuPont is located to the northwest of the Site. A Site Vicinity Plan is provided as Figure 1-2.

The southwestern portion of the Site, including the former plant process areas, is composed of uplands. North of the main plant areas are Clonmell Creek, wetlands, and the Delaware River. The area between Clonmell Creek and the Delaware River was initially improved through the utilization of land reclamation techniques in the late 1600's by the Repaupo Meadow Company (RMC). The RMC maintained the levee system along the Delaware and constructed the Repaupo flood gates in the early 1900's.

Clonmell Creek is a tidal tributary of the Delaware River which courses northwest through the middle of the property. On the plant property, the creek is approximately 75 to 120 feet wide and ranges in depth from approximately 0.25 to three (3) feet. Flow in Clonmell Creek is nominal the majority of the time as surface water levels are controlled by a tide gate at the confluence of Clonmell Creek with the Delaware River. The gate opens and shuts in response to pressure changes resulting from tidal fluctuations in the Delaware River. The Creek receives permitted discharges from upstream industrial and municipal facilities (as further detailed in Section 8.2.3) of the Plant [Environmental Resources Management (ERM), 2003]. Much of the Site is either considered wetlands, lies within 100 or 500 year flood plains or has been affected by former process activities. These land use restrictions are depicted on Figure 1-3.

DuPont formerly owned the Site, which was indentured to the Hercules Powder Company (Hercules) on 4 September 1952. Hercules constructed the industrial facility and began production of various industrial chemicals at the former Higgins Plant by 1959. GEO Specialty Chemical Co. (GEO) purchased the manufacturing assets covering approximately 80 acres in May 2001 and continued production of industrial chemicals until 2009. The industrial facilities at the Site were decommissioned in late-2009 and early-2010.

1.2 SITE BACKGROUND

1.2.1 Site Description Summary

Construction of the former Hercules Higgins Plant was begun in 1953; the plant was fully operational by 1959. The manufacturing portion of the facility occupied approximately eighty (80) acres of the Site during plant operations. Principal operating areas within the manufacturing area of the Plant are shown on Figure 1-4. Until 1970, the Plant manufactured phenol and acetone using a three-step chemical process. After 1970, the plant produced three primary products including: 1) cumene hydroperoxide; 2) diisopropylbenzene hydroperoxide; and 3) dicumyl peroxide. Five primary raw materials were used in the manufacturing process including cumene (isopropylbenzene); benzene; diisopropylbenzene; twenty-five (25) percent caustic soda (sodium hydroxide solution); and sulfuric acid. GEO purchased the manufacturing assets covering approximately eighty (80) acres in May 2001 and continued production of industrial chemicals until 2009, at which time manufacturing operations at the facility ceased. The former Higgins Plant was decommissioned as of April 2010 and the facility structures were removed with the exception of the former administrative office building (decommissioned in 2016) and the wastewater treatment plant (WWTP).

For the Supplementary Remedial Investigation (SRI) [ERM, 2003], which represents the third major RI phase conducted at the Site under the NJDEP regulatory lead there were twelve (12) Investigation Areas (IAs) of Potential Concern evaluated. These former IAs are as follows: Train Loading Area (TLA), Southern Warehouse, Tank Farm (TF), Active Process Area (APA), Inactive Process Area (IPA), Cooling Tower/Downtherm Heater (CTDH), Cracking Furnace (CF), Multi-Purpose Plant (MPP), Storm Water Catchment Basin (SCB), 002 Outfall, Northern Chemical Landfill (NCL) and Clonmell Creek. The SRI IAs are shown on Figure 1-4.

Subsequent to the SRI, the United States EPA, Region II took over the regulatory lead for the site. This meant that a BHHRA and BERA would need to be developed. For this purpose, the Site was divided into thirteen (13) EAs with the SWDA handled separately. The EAs were agreed upon by both the EPA and NJDEP and are used within this RI to discuss media impacts within each EA. The EAs are as follows: APA, Area A/Open Area (Area A), Area B, Chemical Landfill/Gravel Pits (CLF/GP) Area, Clonmell Creek and Wetlands (CCW), IPA, NCL, Northern Warehouse Area (WH), Solid Waste Disposal Area (SWDA), Shooting Range, SCB Area, TF/TLA and Township Refuse Area (TRA). The EAs are similar to the historical IAs but differ slightly so that the entire site could be assessed in the BHHRA, BERA and within this RI. Figure 1-5 shows the locations of the EAs at the Site.

The investigative history for the Site through which the above IAs and EAs were developed is detailed below. The details of this investigative history are important for understanding how the constituents of concern (COCs), site-specific tentatively identified compounds (SSTICs), geological and hydrogeological knowledge and process history of the Site were developed and relayed to both the NJDEP and EPA over the course of the thirty-seven (37) year investigative history of this Site.

1.2.2 Site Investigation History Details

During a regional groundwater study in 1979, The United States Geological Survey (USGS) discovered the presence of benzene, a Site-related chemical, in groundwater samples from Site production well PW-4, located in the southwest corner of the Site. The discovery of benzene in 1979 triggered further investigation. Hercules, in coordination with the NJDEP, performed expanded groundwater studies that led to the discovery of other Site-related chemicals in groundwater at the Site. As a result, the Site was added to the CERCLA National Priorities Listing (NPL) in December 1982.

The following is a summary of the numerous studies completed by Hercules in cooperation with the NJDEP and EPA that followed the Site's NPL listing. Since CSI began its work on completing the RI many efforts have been made to find documentation for each phase of the investigations conducted, however much of the documentation of the investigative phases prior to the 1988 Phase I Soils Investigation [ERM, 1988] could not be located. Summaries of the activities conducted during those "preliminary investigations" are provided below and where data are available, these have been included herein.

The results of each phase of investigation informed the following phases with each phase focusing on the identified constituents and "areas of concern" (AOC). As negotiated with both the EPA and NJDEP through various meetings and comment/review loops leading up to this RI Report, not all of the data generated from these historical investigations are included in this RI report or related BHHRA and BERA. However, a large majority of the data are included where appropriate. Details of which data are included from each investigation in this RI report are provided along with the investigation history below.

Preliminary Investigations

- In February 1983, Hercules installed four (4) shallow monitoring wells, as required by NJDEP, in an attempt to determine whether the benzene identified by the USGS in well PW-4 was related to the SWDA [ERM, 2003].

- In April and May 1983, a preliminary study (Phase I) was completed to review available data regarding hydrogeologic conditions at the Site and to make a preliminary determination as to the possible source(s) of the benzene that had been identified in well PW-4 [ERM, 2003].

- In December 1983, the report entitled "Installation of a Ground Water Monitoring System for Hercules Inc., Gibbstown, New Jersey" (Phase II) documented the installation of 14 monitoring wells and the collection of 11 soil samples in the area of the TF, APA, and IPA. Four (4) of the 11 soil samples from this event have been included within this RI. These samples were analyzed for cumene, benzene, and total recoverable phenol. The sample nomenclature for these samples is the Location ID followed by the depth in feet (ft) below ground surface (bgs) (e.g SS-1 02-05). Chemical analysis of the soil samples indicated that, in areas of sandy surficial deposits, organic compounds apparently passed through the unsaturated soils to ground water, leaving behind only low concentrations of compounds. In contrast, a soil sample taken from a silty clay zone contained relatively high concentrations of isopropylbenzene (also known as cumene) [ERM, 2003].

- In April 1984, the report entitled "Phase III Hydrogeologic Definition and Initiation of Remedial Activities for Hercules Inc., Gibbstown, New Jersey" (Phase III) documented the installation of ten (10) additional wells and the further delineation of affected groundwater underlying the Plant [ERM, 2003].

- In November 1984, the report entitled "Hydrogeologic Definition and Continuation of Remedial Activities for Hercules Inc., Gibbstown, New Jersey" (Phase IV) documented testing of the existing groundwater recovery wells at the Site, and the installation of new monitoring wells [ERM, 2003].

- In May 1985, the report entitled "Status Report of the Phase V Investigation" (Phase V) documented the drilling and installation of off-Site monitoring wells and four (4) additional groundwater recovery wells. Twenty-one (21) soil borings were installed and twenty-nine (29) soil samples from the APA, IPA, and TF were analyzed. A total of fifteen (15) samples from ten (10) soil borings were included within this RI from the May 1985 event. These samples were analyzed for cumene, benzene, and total recoverable phenol. The sample nomenclature for these samples is the Locations ID followed by the depth in ft bgs (e.g SS-1 02-05). A final Phase V report was not issued; however, data gathered during the study was submitted as part of the Status Report. Review of the soil analytical data revealed that the highest levels of benzene, phenol, and cumene were found in the APA and IPA. With the exception of one sample, soil samples from the TF contained no detectable concentrations above method detection limits [ERM, 2003].

NJDEP 1986 ACO

On July 2, 1986, Hercules and the NJDEP executed an ACO describing required Site evaluations, including areas to be investigated, sampling frequency and analysis, and deliverables for each investigation. The ACO identifies three operable units at the Site: groundwater, soils, and the SWDA as Operable Units 1, 2, and 3, respectively. Recovery and treatment of groundwater in the former plant portion of the Site has been ongoing since 1984. Site soil was identified as a source of groundwater impacts and a direct-contact hazard to Site workers. Details on the separate remedial history of the SWDA are provided below in Section 1.2.3.

As a requirement of the 1986 ACO, Hercules designed, installed, and continues to operate an on-Site groundwater recovery system [ERM, 2003], designated as an interim remedial measure

(IRM). Hercules continues to operate a network of groundwater pumping wells and monitoring wells to capture and treat groundwater at the Site and monitor onsite and offsite groundwater quality. Numerous studies performed in cooperation with the NJDEP and EPA have demonstrated that the GWETS has been and continues to be effective in containing impacted groundwater at the Site.

There are three ACO amendments on file as follows: i) in May 2001 an amendment was filed to allow Hercules to cease operation and lease the manufacturing assets of the Site to GEO, Inc.; ii) in December 2004 an amendment was filed allowing GEO to reorganize as part of a Chapter 11 bankruptcy filing prior to the remediation of the Site; and iii) in November 2008 an amendment was filed allowing the stock of Hercules, Inc. to be acquired by Ashland Inc. prior to completion of remediation.

Post-ACO Preliminary Investigation

In May 1987, the report entitled, “Ground Water Quality Assessment Program - Equalization Basin, Hercules Inc., Gibbstown, New Jersey” documents the results of a study of groundwater quality in the vicinity of the Equalization Basin (Surface Impoundments (SI)), tidal influences associated with Clonmell Creek in the area of the Equalization Basin, and a hand auger and soil gas survey. The results indicated the following:

- The hand auger survey, conducted in the area between Clonmell Creek and the Equalization Basin (generally the area referred to as the NCL, defined the boundaries of the area containing refuse materials. With the exception of one location, the soil gas survey detected total organic vapor concentrations of greater than 1,000 parts per million (ppm) at all locations; and

- The tidal influence study monitored minor groundwater level fluctuations, ranging from 0.2 to 0.4 feet in monitoring wells (MW) MW-30 and MW-38. No groundwater fluctuations were observed in wells south of the Equalization Basin. This investigation concluded that the influence from Clonmell Creek level changes is minimal and at most limited to within approximately 500 feet of the creek [ERM, 2003]. More recent tidal studies suggest minimal hydraulic communication between Clonmell Creek and the surrounding water table aquifer. Thus, minimal shallow groundwater recharge from Clonmell Creek may occur along the south side of the creek; however, areas north and upstream of the creek appear to have little to no interconnection with the surrounding water table aquifer.

Remedial Investigation Phases Under NJDEP Lead

Phase I Soils Investigation (1988)

In 1988, Phase I of a Site-wide soil investigation was completed. The *Soil Sampling Plan* [ERM, 1988] that detailed the work to be done also included an aerial photograph review that first identified areas where disposal activities and processes occurred on the Site. The 1988

Soil Sampling Plan [ERM, 1988] also outlines the results of the 1987 soil gas survey as well as historical site activity and process research. These studies helped identify the "hot spots" where further sampling was conducted as part of the Phase I Soils Investigation. The areas investigated, based upon this research included the following:

1. APA (generally the same as current EA)
2. IPA (generally the same as current EA)
3. North IPA (similar to current SCB EA)
4. TLA (part of current TLA and TF EA)
5. NCL (same as current NCL EA)
6. WWTP/Sludge Drying Beds (SDB) and Spray Field (SF) (part of current SCB EA)
7. GP and CLF (same as current Chemical Landfill (CLF) EA)
8. Northern Warehouse (NW- same as current WH EA)
9. Southern Warehouse (part of current SCB EA)
10. Small TF (located next to old boiler house, now part of the SCB EA)
11. Drum Storage Area (located next to old laboratory, now part of the SCB EA)
12. Background Borings (located on perimeters of the site where no past activities were known to occur)

This phase of the investigation included a comprehensive evaluation of soil quality through completion of sixty-five (65) soil borings in twelve (12) AOCs throughout the Site. The samples were obtained through the use of a split-spoon sampler ahead of a hollow stem auger drill bit. Continuous split-spoon samples were obtained every twenty-four (24) inches as the boring was advanced. Sampling was discontinued when the top of the confining clay was encountered, the capillary fringe above the water table was reached or a maximum depth of twenty-five (25) feet was reached. Each sample was then logged and screened with an organic vapor analyzer (OVA) flame ionization detector (FID). Samples were obtained either at the location with the highest OVA FID readings or at the top of the capillary fringe. If no reading or similar OVA FID readings were encountered then the sample was obtained based upon odor, appearance or proximity to the water table. The samples were labeled as B-1 through B-65 with the depth of the sample indicated in feet after each ID (e.g. B-1 04 – 06 indicates that this sample was obtained from 4-6 ft bgs). Additional samples were collected from seven (7) of these locations (B-16 – B-22) in early 1991.

Investigations prior to the Phase I identified that the primary COC at this Site were volatile organic compounds (VOCs) or phenolics. Thus, the majority of the samples obtained during this investigation were analyzed for VOCs and phenolics. Some analysis of semi-volatile organic compounds (SVOCs) and ammonia were also conducted. Six samples were analyzed for the full priority pollutant list. The data obtained were compared to the applicable NJDEP Soil Action Levels at that time. Based upon this comparison and review of historical investigation information, the following conclusions were drawn about the COC at this Site:

1. The primary VOC COCs are cumene, benzene, ethylbenzene and toluene.
2. Phenolics were identified at elevated concentrations only in the SF and in the North IPA MPP SI.
3. The source of ammonia nitrogen was identified as the North IPA MPP SI.

4. No SVOC detections of note were found. One spurious detection of n-nitrosodimethylamine was noted in a background location at concentration that exceeded screening levels, but no other detections of this compound were noted.
5. No priority pollutant polychlorinated biphenyls (PCBs) or pesticides were detected.
6. No metals were detected at concentrations above the NJDEP Soil Action Levels.

The results of this investigation were reported in the 14 September 1989 report “Higgins Plant, Revised 1988 Soils Investigation, Hercules Inc., Gibbstown, New Jersey” [ERM, 2003]. The primary findings of the report are summarized below:

1. Several areas were identified as requiring no further action, these include:
    a. Small Tank Area (located near old boiler house)
    b. SDB (located in the SCB EA)
    c. Percolation Field (located in the CLF/GP EA)
    d. Drum Storage Area (located near old laboratory)
    e. Majority of the SF (located in SCB EA)
    f. WWTP (located in SCB EA)
    g. Remaining portions of Site not specifically identified on Plate 4 (see Appendix A) of document

2. Several areas were identified as requiring additional investigation, these include:
    a. NCL (same as current NCL EA)
    b. MPP and MPP SI (part of current SCB EA)
    c. Gravel Pit CLF(part of current CLF/GP EA)
    d. IPA North and East of Boring B-31
    e. APA Drainage Swale (part of current APA EA)
    f. TLA (part of current TLA/TF EA)
    g. Cluster of Drums (part of CLF/GP EA, now removed)
    h. Stressed or non-vegetated area of the SF (part of current SCB EA)

Recommendations stemming from the Phase I Soils Investigation included:

1. Re-analysis of soils in the vicinity of soil boring B-62 (n-nitrosodimethylamine detection)
2. Additional contaminant delineation in AOCs.
3. Evaluation of Ground Water Quality in the GP Area
4. Evaluation of Ground Water Quality in the MPP Area
5. Enclosure of the GP with a Fence (to avoid dermal contact with elevated cumene concentrations at location B-3 and near cluster of drums)

All soil data obtained as part of the 1988 Phase I Soils Investigation has been included in this RI report and related risk assessments.

<u>Surface Impoundment Closure Investigation (1990)</u>

In 1990 a closure investigation of the SI was completed. Groundwater Technology, Inc. (GTI) performed a soil gas and soil sampling effort in conjunction with closure of the SI. The soil samples associated with this event are S-1 through S-5 and BG-1. This work was summarized in the January 30, 1990 report, "Results of Soil Gas Survey and Soil Sampling for the SI Closure Plan at Hercules Incorporated, Gibbstown, New Jersey" [GTI, 1990]. The report indicated that Site-related organics were present in soils beneath the impoundments, but that concentrations of these organics decreased with depth [ERM, 2003].

Phase II Soils Investigation (1995)

In 1995, Phase II of the Site-wide soils investigation was completed. This phase of the investigation focused on the APA and IPA located to the south of Clonmell Creek, but sample collection was conducted in other portions of the Site as well. The intent of this phase of the soil investigation was to complete the remedial investigation of Site soils and to support completion of a Risk Assessment and Feasibility Study for the soil medium. A total of nineteen (19) IAs were identified for this investigation through review of previous investigation results, aerial photography review, changes to physical Plant features, documented spills, comparison of the NJDEP Non-Residential Soil Cleanup Criteria with the pre-Phase II data, and specific NJDEP directives in a July 1989 letter. The following is a summary of the IAs used during this phase of the RI as stated in the Phase II report and shown on Figure 4 of CSI's 2009 FIWP in Appendix A, which uses the IAs from that report [ERM, 1995]:

Note: the below descriptions are from the 1995 Phase II report and reflect site conditions at that time. Due to activities associated with Site decommissioning, Site conditions have changed dramatically since that time as noted below.

1. TF: The TF is located in the southwest corner of the Plant. In the past, the TF accommodated sixteen (16) above ground storage tanks, currently six tanks are maintained and operated.
2. APA: The APA is located north of the TFTF. This area is the center of current chemical manufacturing operations.
3. IPA: The IPA is located north of the APA and formerly housed the para-cresol manufacturing operation. Most of the facility has been demolished; concrete building foundations still remain. The Maintenance Building Underground Storage Tank which was closed (in-place) as part of this investigation is located in the southeast portion of the IPA.
4. TLA: The former TLA is located along the western Plant boundary. The train tracks no longer exist but the overhead piping and transfer lines are still present.
5. Cumene Loading Area (CLA): The CLA is located between the TLA, TF, and APA. This area is in active use. Above ground tanks contain cumene, cumene hydroperoxide, diisopropylbenzene, and diisopropylbenzene hydroperoxide.
6. NW & Southern Warehouse: The NW and Southern Warehouse are located along the western Plant boundary. The three warehouse buildings are actively used.

7. CTDH: The CTDH Area is located adjacent to the IPA and the NW. This area is inactive, but formerly provided utilities to the para-cresol area. The foundations of the CTDH still remain.
8. MPP: The MPP is located northeast of the CTDH Area. This area is inactive but was a large-scale pilot plant which provided a variety of products including Herban and N-Dichloroethyl phthalimide.
9. 002 Outfall: The 002 Outfall is a NJPDES-permitted discharge to Clonmell Creek. The outfall has historically received surface water runoff from a large portion of the Plant via the stormwater drainage network. The outfall historically consisted of a culvert set into a wooden embankment and a dirt drainage swale which allowed open flow to the creek. A seep has been observed in the embankment. Drum remnants have been observed along the eastern bank near the SDB. In 1992 the SCB was constructed and a slide gate was installed to regulate discharge to Clonmell Creek.
10. SDB: The SDB border the eastern bank of the 002 Outfall. This area formerly received sludge from the bioaeration tank of the WWTP. Peat-like and black granular materials are present in the bottom of the beds.
11. SIs: The SIs are located between the SDB and the Treatment Plant. These impoundments formerly served as equalization basins for wastewater prior to processing at the Treatment Plant.
12. NCL: The NCL is located between the SI and Clonmell Creek. This area historically received waste materials from a number of the Plant chemical processes. Landfilling stopped in 1974.
13. Treatment Plant: The Treatment Plant utilizes a bioaeration process to treat wastewater and recovered ground water. The most prominent feature is the bioaeration tank which supports a suspended growth system referred to as "activated sludge."
14. SF: The SF is located south of the Treatment Plant. This area was formerly used for spray irrigation of effluent from the WWTP. The area is currently an open grassy field and a small non-vegetated area and a phenolic resinous material on the ground surface are the only indications of past activities.
15. CF: The CF Area is located east of the CTDH Area. This area was formerly used as a pilot plant for experimental hydrocarbon cracking and thermal processing. Cement foundations/pads and residual materials are present at the surface in a limited area.
16. Small TF: The Small TF has historically been the location of three above ground storage tanks which have stored a variety of fuel oils. One tank remains but is out of service.
17. Laboratory Drum Storage (LDS): The LDS Area encompasses the area surrounding the Laboratory and the Boiler House. An actively used concrete drum storage pad is located between these two buildings.
18. GP: The GP is located southeast of the SF and is a topographic low area which was formerly a quarry. Residual materials are present at the surface in limited areas.
19. GP/CLF: The GP/CLF is located within the GP. This area historically received waste materials from the Plant chemical processes. Landfilling stopped in 1965. This area

also encompasses a former percolation field where process water was discharged. [ERM, 1995]

A total of 289 soil borings were completed on-Site in the nineteen (19) IAs outlined above. A total of 743 soil samples were collected. Soil sample nomenclature was based off the IA, media type and depth in feet (e.g. APA-SB01A 02-04). At each soil sample location samples were typically obtained from the upper, middle, and lower depth intervals of the unsaturated zone above the groundwater table. All soil data obtained from this investigation have been included for analysis in this RI report and related risk assessment.

Groundwater samples were also collected during on-Site activities by means of Geoprobe® and lead-screened auger sampling. The groundwater and soil samples were analyzed by a field screening technique called ERM-FAST® that utilizes a portable gas chromatograph/mass spectrometer (GC/MS) to screen all soil and groundwater samples obtained from this event. A percentage of all samples obtained were also sent to a fixed base laboratory for confirmatory analysis. All samples were screened for VOCs plus cumene, SVOCs and SSTICs (acetophenone, diisopropylbenzene, alpha methyl styrene, di-tert-butyl-p-cresol, and dimethylbenzyl alcohol). The field screened groundwater data were used to focus the installation of permanent groundwater monitoring wells in areas where groundwater impacts are prevalent. Because a vast amount of more recent and more reliable groundwater data from permanent monitoring wells are available, these Geoprobe® groundwater samples are not utilized in this RI report or related risk assessment documents.

The results of the Phase II Investigation are reported in the October 4, 1995 report, "Hercules Incorporated, Phase II Soils Investigation, Hercules Higgins Plant, Gibbstown, New Jersey" (ERM, 1995). At the time, the soil data generated were screened against the NJDEP February 3, 1994 Non-Residential Direct Contact Soil Cleanup Criteria and groundwater data were screened against the NJDEP April 5, 1994 Ground Water Quality Standards. These criteria were used to determine if additional delineation was required. This allowed each investigation area to be thoroughly characterized during this event. Findings from the Phase II ecological investigation activities are not included herein. All ecological information from the Phase II Investigation has been incorporated into the BERA [RBR, 2017]. The following are the relevant conclusions from the Phase II Soils Investigation as described in the executive summary of that document [ERM, 1995]:

"TRA Investigation

The township refuse study area is approximately 99,000 square feet in size and borders Clonmell Creek. Geophysics and backhoe pits in the refuse area identified subsurface conditions. The western two-thirds of the area is largely comprised of natural undisturbed soils. The materials encountered in the remainder of the area are characteristic of municipal types of refuse, with glass bottles being the most common material observed. Drums, or drum remnants, were not observed in the TRA. The limited diversity of refuse materials suggests that this area likely did not serve as a primary repository for municipal waste from surrounding localities. The area was reportedly never used by the Plant, or the prior owners of the property.

The refuse materials appear to be inert, with no impact to soils and ground water relative to Soil Cleanup Criteria and Ground Water Quality Standards. No further action is recommended for the Township Refuse Area.

Soils Investigation

The shallow lithostratigraphy underlying the Plant (to a depth of approximately 20 feet below grade) consists of flat lying, interbedded, and interfingered, laterally discontinuous units of unconsolidated sand, gravel, silt, and clay sediments. Peat was encountered in limited areas adjacent to Clonmell Creek. These shallow sediments are underlain by a laterally discontinuous clay unit (the Shallow Clay) which ranges from approximately 4 to 19 feet thick. The depth to the Shallow Clay ranges from approximately 10 to 17 feet below ground surface. The shallow clay separates the Upper Aquifer above from the Lower Aquifer below. The Phase II Soils Investigation targeted the unsaturated portion of the shallow sediments which lie above the Shallow Clay.

The comprehensive soil analytical data base which consists of analytical data from the 19 Phase II soil investigation areas as well as historical data from previous phases of investigation was screened against the Non-Residential Direct Contact Soil Cleanup Criteria as a benchmark for delineating impacted soils. Eleven of the 19 areas had detectable concentrations in shallow unsaturated soils exceeding the Soil Cleanup Criteria. The maximum areal extent of soils exceeding Soil Cleanup Criteria for the Plant as a whole covers approximately 14,600 square feet and is presented as the shaded areas on Figure B (see Appendix A).

This area calculation does not include individual sample locations where specific compound exceedances of the Soil Cleanup Criteria occur. These individual sample locations are highlighted on Figure B (see Appendix A). Areas where residual materials have been observed (Spray Field, Cracking Furnace, Inactive Process Area, Sludge Drying Beds, Gravel Pit, Gravel Pit Chemical Landfill, Northern Chemical Landfill) were also not included in this calculation.

Eleven individual constituents were detected at concentrations above Non-Residential Direct Contact Soil Cleanup Criteria in shallow unsaturated soils. These compounds include cumene, benzene, ethylbenzene, xylene, 2-butanone, Polynuclear Aromatic Hydrocarbons (PAHs), n-nitrosodimethylamine, and chromium. VOCs were the most prevalent compounds detected in soil; cumene and benzene were the most commonly detected VOCs.

Eight of the 19 investigation areas are interpreted as requiring no further action with respect to shallow unsaturated soils, because detectable concentrations are below Soil Cleanup Criteria. These eight areas are the Northern and Southern Warehouses, Cooling

Tower/Dowtherm Heater, Sludge Drying Beds, Treatment Plant, Spray Field, Cracking Furnace, and Laboratory Drum Storage.

Ground Water Investigation

Percentage levels of benzene and toluene are present in the shallow ground water of the Upper Aquifer underlying the Multi-Purpose Plant. Additional investigation areas where compounds in ground water exceed Water Quality Standards include the Tank Farm, Train Loading, Cumene Loading, Active Process Area, Inactive Process Area, Warehouses, Cooling Tower/Dowtherm Heater, Northern Chemical Landfill, Cracking Furnace, and Gravel Pit. Compounds which exceed Ground Water Quality Standards include VOCs, SVOCs, SSTICs, and arsenic.

Similar to the soil data, VOCs were the most prevalently detected compounds in ground water, and were detected over the largest area and at the highest concentrations. Cumene and benzene account for the majority of the VOCs detected in ground water. VOCs are known to be present in ground water underlying the off-site area south of the Plant, and are monitored by a network of off-site ground water monitoring wells. VOCs are present in ground water at the western Plant property boundary adjacent to the Train Loading Area. SVOCs in ground water were only detected in very limited areas. SSTICs were detected in ground water at the western Plant property line, adjacent to the Train Loading and Northern Warehouse Areas.

Surface Water/Sediment Sampling

Impacts to surface water and sediments of the Plant drainage swales are the result of historical Plant spills which reached the stormwater drainage network. The swales which contain the highest concentration of chemical compounds are the Warehouse swale downgradient of the Train Loading Area, the swale downgradient of the Cracking Furnace, the Stormwater Catchment Basin, and the 002 Outfall.

The highest compound concentrations detected in Clonmell Creek sediment occur at the mouth of the 002 Outfall to the creek. VOCs (primarily cumene), SVOCs (primarily PAHs), metals and PCBs were detected in sediment. Only PAH compound concentrations in the creek sediment exceeded National Oceanic and Atmospheric Administration (NOAA) Effects Range Low (ER-L) values at each of the six sampling locations, including the background location where Clonmell Creek enters the Hercules property. The 1995 supplemental sediment sampling indicated SVOC, PCBs, and metals concentrations at upstream, offsite sampling locations which indicate sources of contamination upgradient of the Hercules facility. Furthermore, cumene concentrations downstream of the 002 Outfall decreased to non-detect at sampling location SED-1, indicating cumene may be limited to the area adjacent to the 002 Outfall. In addition, the petroleum odor noticed in the creek sediments during sampling suggests anthropomorphic impacts to Clonmell Creek from sources upgradient of the Hercules

Plant." [ERM, 1995]. More recent studies with improved sampling technique have confirmed the presence of cumene detections downstream of the 002 Outfall, as discussed in detail in Section 8.

The sample nomenclature used during the Ph II for surface water and sediment samples depended on the location of the sample. If collected within Clonmell Creek, surface water samples are labeled as SW–#–# and sediment samples are labeled as SED-#. If the sample was collected in one of the other IAs, the nomenclature is IA-SW-# for surface water or IA-#-SED for sediment (e.g. 002-POND-SW-01or APA-01-SED).

Post Phase II Soils Investigation Scope Negotiation

After completing the Ph II Soils Investigation ERM and Hercules began a series of negotiations with the EPA and NJDEP to determine what additional work is necessary to complete characterization of this Site. The following is a summary of the letters and meetings conducted as part of those negotiations:

- 14 November 1995 letter from EPA/NJDEP to Hercules,
- 8 December 1995 letter from Hercules to EPA/NJDEP,
- 19 August 1996 letter from EPA/NJDEP to Hercules,
- 21 November 1996 letter from Hercules to EPA/NJDEP,
- 12 September 1997 letter to EPA/NJDEP from Hercules,
- 15 January 1998 Environmental Visualization System (EVS) presentation to EPA/NJDEP by Hercules (in response to the 12 September 1997 EPA/NJDEP letter), and
- 6 February 1998 and 27 March 1998 letters from Hercules to EPA/NJDEP.

In the 27 March 1998 letter, Hercules committed to the submission of a work plan for further site investigation. In June 1998 the initial draft SRI Work Plan was submitted to NJDEP/EPA. Since that submission, EPA/NJDEP provided comments, to which Hercules responded in a series of letters and meetings, as follows:

- 1 October 1999 letter from EPA/NJDEP to Hercules,
- 21 January 2000 letter from Hercules to EPA/NJDEP,
- 3 July 2000 letter from EPA/NJDEP to Hercules,
- 25 October 2000 meeting between EPA/NJDEP and Hercules (at which time submittal of a revised SRI Work Plan was agreed to), and
- 14 November 2000 letter from Hercules to EPA/NJDEP containing a response to the 3 July 2000 EPA/NJDEP letter and a summary of the 25 October 2000 meeting.

The revised SRI Work Plan was submitted in January 2001, and was prepared in accordance with the NJDEP Technical Requirements for Site Remediation, N.J.A.C. 7:26E, 1999. In response, NJDEP/EPA submitted a comment letter dated 17 April 2001. Hercules provided a response to portions of this letter on 15 May 2001; ERM (on behalf of Hercules) submitted a response to the remainder of the letter on 18 May 2001. A follow-up NJDEP/EPA comment letter dated 17 October 2001 was responded to by ERM on behalf of Hercules on 13 November 2001. The agreements reached during these correspondences and the 25 October 2000 meeting was incorporated into the field effort for the SRI, whose findings are presented in the SRI Report [ERM, 2003]. Those agreements included the scope of the sampling to be done as well as the extent and specific laboratory analyses to be used (including the COCs and SSTICs). All subsequent work conducted on the Site has used similar laboratory analyses and has focused on filling the data gaps identified during the above described series of negotiations.

Supplemental Remedial Investigation (2003)

In 2002, the field work for the SRI was completed to address data gaps in several Site areas. The SRI consisted of the collection of fifty (50) soil, forty-seven (47) groundwater, thirty-three (33) sediment, and sixteen (16) surface water samples to refine previous environmental and hydrogeologic findings and to close data gaps in various plant areas.

All samples were screened for VOCs plus cumene, SVOCs and SSTICs (acetophenone, diisopropylbenzene, alpha methyl styrene, di-tert-butyl-p-cresol, and dimethylbenzyl alcohol). These SSTICs were identified within the Phase II Soils Investigation [ERM, 1995] as the primary SSTICs for the site. All subsequent investigation phases utilized these SSTICs as approved by both the EPA and NJDEP. Other analyses included in the SRI were pesticides/PCBs, metals, total suspended solids (TSS), total dissolved solids (TDS), total organic carbon (TOC), total phosphorous, various forms of nitrogen, hardness, alkalinity, pH and geotechnical analyses where applicable. The results of the investigation were reported in the January 2003 report, “Supplemental Remedial Investigation Report, Former Higgins Plant, Gibbstown, NJ” [ERM, 2003].

Sample nomenclature for SRI samples is as follows:

- Geoprobe groundwater – GP-Investigation Area-SRI-# (e.g. GP-APA-SRI-01)
- Geoprobe Soil – Investigation Area-SRI-# (e.g. IPA-SRI-07)
- Piezometers – SRI-PZ-#
- Temporary Well – SRI-TW-#
- Surface Soil – SRI-SS-#
- Wetland Soil – SRI-WS-#
- Sediment – SRI-SED-#
- Surface Water – SRI-SW-#

Based on the evaluation of historical and SRI data, the investigation areas were categorized as follows regarding the soil impacts found in each area:

- Areas requiring no further action (data met the soil cleanup criteria);
    - CTDH.

- Areas conditionally requiring no further action (because of special circumstances, acceptable ground water quality despite exceedances of the impact-to-ground water soil cleanup criteria, or specific chemical constituent issues); and
    - TRA,
    - SDB,
    - NW & Southern Warehouse
    - GP (excluding CLF),
    - SF Area,
    - CF Area,
    - Treatment Plant, and
    - Laboratory Drum Storage.

- Areas requiring consideration for remedial action (specific portions of a study area exceeded the nonresidential soil cleanup criteria and/or the impact-to-groundwater soil cleanup criteria, with corresponding ground water exceedances).

  Soil in portions of each of the following:
    - MPP Area,
    - IPA,
    - NCL,
    - APA,
    - TF,
    - CLA,
    - TLA,
    - 002 Outfall,
    - SI,
    - Small TF, and
    - CLF.

In addition, the following areas contain residuals that require consideration for remedial action:

- drums, spent catalyst, and lab bottles within the GP,
- surficial tarry material in the CF Area, and
- surficial resin/tar material from the SF Area.

Sample Methodology

The Geoprobe® groundwater samples were collected by installing a dedicated small diameter (0.5-inch inside diameter) Passively Placed Narrow Diameter Point (PPNDP). The PPNDP was then pushed to a depth of approximately two (2) to three (3) feet below the water table. Each sample point was purged of approximately three (3) volumes of water prior to sampling to assure that a continuous flow of water was available. Groundwater samples were collected using a small diameter bottom filled bailer.

Soil samples were collected using a hand-driven bucket auger or a stainless steel trowel, depending on the depth. Surface soil samples were collected from a range of zero to two (0-2) ft bgs. The soil samples were removed from the bucket auger using a pre-cleaned stainless steel scoop or spoon. Soil samples collected using the bucket auger or stainless steel trowels were placed directly into the sample container. An appropriately sized volume was transferred to a one-liter laboratory-cleaned glass jar, and a visual description of the soil will be logged by the ERM scientist.

Wetland soil samples were collected using a stainless steel trowel from 0 to 0.5 ft bgs. Soil samples collected using the stainless-steel trowels were placed directly into sample containers. An appropriately sized volume was transferred to a one liter laboratory-cleaned glass jar, and a visual description of the soil was logged by the ERM scientist.

Surface water samples were collected at each of the sampling locations by one of two methods consistent with the NJDEP *Field Sampling Procedures Manual* (NJDEP, 1992). Where possible, a laboratory-supplied and cleaned sample container was directly immersed in the water column. When direct sample collection is not possible due to physical characteristics of the water body and/or pre-preservation of sample containers, a pond sampler was used. This sampling device consists of a sampling beaker attached to a tube that serves as a handle. A laboratory-supplied and cleaned bottle was placed in the sampling beaker for sample collection. Once retrieved, the water sample was immediately transferred to an appropriate sample container. Samples were collected from downstream to upstream areas, during periods of normal downstream flow, at approximately a depth halfway between the water surface and the substrate of the water body, whichever is less. This was done to ensure that the samples are representative of mixed conditions and not affected by surface volatilization and cross contamination.

Surficial sediment samples were collected from downstream to upstream areas using a stainless hand corer sampler with an extension handle. This sampling device is equipped with a check valve on top to prevent wash-out during retrieval through the water column. The sampler was advanced to a depth of approximately 0.5 foot. The analytical sample was collected from the 0- to 0.5-foot interval. The sediment sample was removed from the corer using a stainless steel spoon or trowel and placed into a clean laboratory-supplied sample bottle.

The following summary is as published in the SRI [ERM, 2003]:

"Summary

The SRI provided additional characterization of the Gibbstown facility that generally confirmed and refined earlier understandings of the site and provided new information in areas in which there had been insufficient historical data to draw meaningful conclusions. There were no new findings that were in conflict with previous general conclusions or that foster particular or immediate concern over specific areas at the Plant.

Primary conclusions drawn from the SRI are the following:

The site ground water recovery system has successfully prevented continued migration of affected ground water toward downgradient township wells and has, in fact, contracted the limits of the off-site ground water contamination plume.

Groundwater does not discharge to Clonmell Creek, and groundwater discharges only intermittently to the SCB in the 002 Outfall area. More recent tidal studies suggest minimal hydraulic communication between Clonmell Creek and the surrounding water table aquifer. Thus, minimal shallow groundwater recharge from Clonmell Creek may occur along the south side of the creek; however, areas north and upstream of the creek appear to have little to no interconnection with the surrounding water table aquifer.

Public contact with areas exceeding nonresidential direct-contact soil cleanup criteria is restricted through limited access to the Plant. Thus, there is no imminent threat to human health or the environment that would necessitate implementation of interim remedial measures.

Despite some soils that may be saturated with nonaqueous-phase liquid, no nonaqueous-phase liquid was observed in measurable thicknesses on the groundwater table.

Some investigated soil areas do not require further action, but portions of the majority of soil areas will require some form of future action.

Areas exceeding nonresidential direct-contact soil cleanup criteria that are plant related and lie outside the ecological investigation study areas are adequately delineated.

Contamination in Clonmell Creek appears to originate off site for a significant number of constituents detected.

Sufficient ecological data have been collected to proceed with a SLERA.

The site is sufficiently characterized to support a Feasibility Study for the Plant." [ERM, 2003]

All relevant data obtained during the SRI has been incorporated into this RI Report.

After submission of the SRI to NJDEP in January 2003 the NJDEP provided significant comments to Hercules regarding the content of the SRI in a letter dated February 6, 2004. At this point Hercules decided to replace their consultant on this project. CSI was awarded the project in April 2004 and began preparing responses to the NJDEP comments and preparing for a meeting with NJDEP to discuss the path forward. A meeting was held with Hercules, CSI, National Oceanic and Atmospheric Administration (NOAA) and NJDEP representatives on December 1, 2004 where CSI's plan for addressing NJDEP's comments in their February 6, 2004 letter and completing the RI at the site were outlined. Subsequent to the meeting CSI provided meeting minutes in a letter dated December 3, 2004 to the NJDEP. NJDEP then provided a letter dated February 15, 2005 outlining some concerns regarding the proposed Screening Level Ecological Risk Assessment (SLERA) approach and indicating that the work plan for the FI additional studies was due on February 28, 2005.

CSI then submitted the FIWP on February 24, 2005 to the NJDEP. The following is a list of the comments and response letters between CSI and NJDEP to finalize the scope of work for the FI:

- <u>September 23, 2005:</u> Hercules received NJDEP/EPA comments regarding the FIWP, project plans and the SLERA.
- <u>October 28, 2005:</u> Hercules responded to NJDEP/EPA comments with a second iteration of the FIWP, SLERA and project plans.
- <u>April 19, 2006:</u> Hercules received NJDEP/EPA comments regarding the FIWP, project plans and the SLERA.
- <u>May 18, 2006:</u> Hercules responded to NJDEP/EPA comments with a third iteration of the FIWP, SLERA and project plans.
- <u>May 30, 2007:</u> Hercules received NJDEP/EPA comments regarding the FIWP, project plans and the SLERA.
- <u>August 17, 2007:</u> Hercules responded to NJDEP/EPA comments with the fourth iteration of the FIWP, SLERA and project plans.
- <u>February – April 2008:</u> Concern was raised regarding a potential preferential migration pathway between sewers in the main plant area and Clonmell Creek sediments. Hercules responded by evaluating previously obtained data, presenting the findings to the NJDEP and EPA. During the presentation Hercules proposed expanding data collection activities to evaluate the area from the process sewer system in the main plant area toward Clonmell Creek to address the concerns related to potential preferential migration pathways, receiving a verbal agreement from both the NJDEP and EPA that the proposed expanded scope would reasonably address the concerns. To outline the expanded scope the NJDEP agreed that an addendum to the FIWP would be used. Hercules provided the revised FIWP which was updated both textually, by inserts and by an addendum to incorporate the additional data collection and evaluation for the expanded scope.

A revised FIWP was submitted to NJDEP in May 2008 that was intended to address concerns regarding the possible presence of a preferential migration pathway toward Clonmell Creek from the process sewers, the SCB, the MPP, the NCL, a combination of these areas, or possibly unidentified sources. Additional comments on some of the figures and tables were received from NJDEP in August 2008. Revised tables and figures were then submitted to NJDEP in October 2008. This version of the FIWP was then approved by NJDEP on November 17, 2008.

<u>Sewer Replacement, Interim Remedial Measure (2009)</u>

While the scope of the FIWP was being finalized and preparation for the field investigation was underway an IRM was completed by Hercules that involved the removal of process sewer piping and impacted soils encountered during the sewer replacement. The sewer replacement project at the Site was conducted between April 2008 and January 2009. The sewer replacement project involved the removal of soils in the vicinity of the sewer lines. No analytical data from this event are included in the RI Report. The results were reported in a document entitled, "Interim Remedial Measures Report for Sewer Replacement at the Former Hercules Higgins Plant" [CSI, 2010].

Focused Investigation (2009)

In Feb/March 2009, the FI was conducted to address data gaps from the SRI and to respond to comments from the NJDEP and EPA. Efforts were expanded to model groundwater, evaluate soil gas constituents, enhance groundwater pumping efforts, and to evaluate impacts to Clonmell Creek (on-Site surface water body).

The FI was also expanded to include a BHHRA and BERA evaluation after the EPA assumed the regulatory lead for the Site (see below). A total of 114 soil samples and 112 groundwater samples were obtained from 114 soil boring locations completed during the FI. In addition, one background shallow soil sample was obtained and two B-level wells were installed. Other activities included extensive surface water and sediment sampling of Clonmell Creek, ultraviolet light inspection of soil cores for assessing the presence of non-aqueous phase liquids (NAPL) in soils and vapor intrusion/soil gas sampling in the plant and along the southern plant boundary. The work was conducted as outlined in the FIWP [CSI, 2008].

Samples collected in the field were identified with a unique alpha-numeric designation. Each designation was specific to the sample matrix. For example, a surface soil sample will be assigned the character identifier SS-xxx-##, where:

SS = the designation for a surface soil sample;
xxx = the section of the site where sample was collected (e.g. NCL);
= the sample location identifier (corresponds with location identified on appropriate figure).

Subsurface soil samples were designated with the character identifier SB-xxx-## (##) where:

SB = the designation for a surface soil sample;
xxx = the section of the site where sample was collected (e.g. NCL);
= the sample location identifier (corresponds with location identified on appropriate figure).
(##) = the depth that the sample was collected in inches.

Surface water samples were designated with the character identifier SW-xxx-## where:

SW = the designation for surface water samples;
xxx = the section of the site where sample was collected (e.g. NCL);
= the sample location identifier (corresponds with location identified on appropriate figure).

Groundwater were assigned the character identifier GW-xxx-##, where:

GW = the designation for groundwater samples;
xxx = the section of the site where sample was collected (e.g. NCL);
= the sample location identifier (corresponds with location identified on appropriate figure).

False designations will be used to designate blind duplicate samples. The location for a blind duplicate sample was noted on the appropriate sample log sheets.

All data obtained during this investigation is utilized within this RI. The temporary well point groundwater samples are used to assess impacts to groundwater from unconsolidated soils, but they are not included within the BHHRA or used to assess the nature and extent of groundwater impacts as there are now much more recent and comprehensive groundwater data from permanent monitoring wells that are used for this purpose.

EPA Assumes Regulatory Lead for Site

Subsequent to completion of the FI field work the EPA filed to take the regulatory lead on the Site from the NJDEP. An Administrative Settlement Agreement (SA) and Order of Consent for RI/FS, was executed on 10 September 2009 between the EPA and Hercules. Subsequent to this all additional studies at the Site have been conducted as part of the ongoing SA activities to support the completion of the RI/FS.

Additional Supplementary Remedial Investigation Studies under EPA Lead

- An off-Site Vapor Intrusion (VI) study along Railroad Avenue, immediately downgradient of the Site's southern property boundary was conducted between May 2010 and March 2011. This study concluded that that the pathway between shallow groundwater and indoor air in the neighborhood south of the Site was incomplete [CSI, 2011].

- Concurrent with the VI study, a shallow groundwater Geoprobe® investigation was conducted to better understand geology and the contaminant distribution in the TF and offsite area near Railroad Avenue. The study determined that a layer of coarse sand and gravel was acting as a conduit for water to flow past the shallow capture well at the property boundary. As a result, several new shallow monitoring wells and piezometers were installed along the southern property line and along Railroad Avenue and a new pumping well (PW-12) was installed along the southern property line [CSI, 2012].

- In June 2011, CSI conducted an expanded sediment study to add more detail to the delineation of constituents in Clonmell Creek sediments. An additional shallow sediment and pore water study was conducted in June 2013 in association with bathymetry measurements in Clonmell Creek. This study was aimed to add increased certainty to where cumene occurs in shallow sediments, determine if sediment is partitioning into pore water, and to better map the channel and depths of sediments in Clonmell Creek [CSI, 2014].

- Between 2009 and 2013, four (4) A-Level, six (6) B-level, and two (2) C-level wells have been installed to improve the understanding of how and where vertical groundwater migration is occurring (boring logs provided in Appendix B).

- In April 2013 the compilation and calibration of a numerical groundwater model for the Site was published by Environmental Simulations Inc (ESI), [ESI, 2013].

- Predictive indices to estimate Site-specific cumene saturation and solubility was derived to help quantify estimates for cumene concentrations and mass in subsurface soil and groundwater at the Site was developed and submitted to the EPA and NJDEP. This document was approved by the agencies (August 2016) after incorporating several revisions requested by EPA and the NJDEP [CSI, 2016].

- A detailed aerial photo report for the Site was completed on August 2013 to better understand when areas of the Site were in use, see Section 2.1.1. [CSI, 2014].

- An updated Uniform Federal Policy (UFA) Quality Assurance Project Plan (QAPP) was completed in March 2015 [CSI, 2015].

- A comprehensive cone penetrometer study and verification direct-push sampling work as completed between November 2012 and July 2013. A report discussing findings was published in July 2016 and is described in brief in Section 2.6.3. [CSI, 2016].

- Additional soil, sediment, surface water, and wetland soil samples were collected between April 2015 and March 2016 to address data gaps in areas that needed further characterization, mainly non-process areas of the Site. The ARI study report was published in May 2016 [CSI, 2016].

- Due to an elevated total xylenes concentration in a historic surface soil sample collected from location MPP-SB01B, in September 2016, several surface and one subsurface soil samples were collected near the historic location to assess residual impacts. This sample represents the final data collected to be included within the RI.

- Several pilot studies to help streamline the FS process. These studies included treatability studies for monitored natural attenuation (MNA) and bioremediation, testing of air sparging/soil vapor extraction techniques, in-situ chemical oxidation (ISCO), in-situ oxygen curtain (ISOC), and dredging and dewatering of Clonmell Creek. These studies will be discussed in detail within the Feasibility Study (FS) and used to assess the viability of various remedial alternatives for the Site.

1.2.3 Solid Waste Disposal Area (SWDA) History

The 1986 ACO defines Operable Unit 3, the SWDA, as an area "approximately 2,000 feet north of the manufacturing plant in a marsh between the plant and the Delaware River which had been used by the previous owner, Du Pont and, until 1974, by Hercules Incorporated for the disposal of solid wastes." Since the signing of the ACO, the SWDA has been handled as a separate Operable Unit with the regulatory lead being handled by the NJDEP. Remedy selection for the SWDA was completed in 1996 with NJDEP preparation of the Record of Decision (ROD). On April 6, 1996, the EPA approved the ROD for the SWDA. The selected remedy for Operable Unit 3 is an in-place containment remedy that included consolidation of tar and solid waste under an impermeable cap, removal of lead fragments, and installation of a fence and storm water controls. Implementation of environmental use restrictions, creation of a Classification Exception Area/Well Restriction Area, and groundwater monitoring were also required.

On October 29, 1996 Hercules and NJDEP entered into an ACO where Hercules agreed to design and construct the remedy as documented in the 1996 ROD. Remedial action objectives were to eliminate direct exposure to tar and to limit exposure pathways to hazardous substances in the SWDA. The containment remedy consisted of the construction of an engineered cap over top of the SWDA tar pits. This cap was constructed from March 2010 through July 2012 with breaks in the construction sequence for winter and summer weather. Full documentation of the SWDA remedy is reported in the Remedial Action Report prepared by Cummings Riter Consultants Inc. in September 2014.

Quarterly groundwater monitoring of the ten wells at the SWDA commenced during the fourth quarter of 2014. The monitoring frequency was reduced to semi-annual during the first quarter of 2017. Groundwater monitoring reports are provided by CSI to the NJDEP on behalf of Hercules.

1.2.4 RCRA-related Activities

Since submittal of a Part A application under the Resource Conservation and Recovery Act (RCRA) to the NJDEP on February 2, 1989, several units regulated under RCRA have been operated at the Plant. See Figure 1-6 for the locations of these units. The following is a summary of the status of the RCRA units that were in use at the Site:

Surface Impoundment (SI)

Background

The SI was previously used as an equalization basin for process wastewater and recovered groundwater prior to wastewater treatment. The phenol in the recovered groundwater was considered to be a hazardous waste (C377) under the NJ regulations in effect at that time (1984 – 1988). The SI was closed in 1988 when new federal regulations required all hazardous waste impoundments to have secondary containment. Sampling indicated that the soils beneath the SI were above screening levels.

Closure Activity

In 1989, the impoundment was emptied of all wastewater and accumulated sludge. The interior surface was then hydroblasted to remove any remaining residue. Hercules then requested that the gunnite structure be capped in place (the original closure plan was to dispose of the gunnite off-Site before capping), but NJDEP deferred any additional work until a remediation plan was developed for the adjacent NCL.

Current Status

The groundwater around the SI was sampled quarterly via ten monitoring wells until CSI requested a modification to the groundwater monitoring program in a letter dated October 23, 2012 on behalf of Hercules. The requested program modification was intended to streamline the ACO and RCRA groundwater monitoring programs at the Site into one program. The EPA approved this groundwater monitoring program modification in a letter dated December 6, 2012.

Additionally CSI requested in a March 19, 2010 letter that the SI and the other two open RCRA units (T61, T61A, T109 Tar Tanks and the MPP Pad) be closed out and placed under the purview of the Superfund remediation. In a January 3, 2013 letter the EPA indicated that these three RCRA units were transferred to the Superfund program on November 21, 2012. Any additional investigation or remediation of these units will now be handled under the Superfund program and the RCRA units were closed.

T61, T61A, T109 (Tar Tanks)

Background

These storage tanks were used to store flammable liquid wastes for burning in the plant boilers through 1990. Lacking secondary containment, the tanks were closed and two new tanks were installed.

Closure Activity

The old tar tanks were emptied, cleaned, and demolished, but contamination was found in the soils around T61 and T61A and a clean closure could not be certified (NJDEP did approve clean closure for T109).

Current Status

Further investigation and remediation of the soils contamination is being coordinated with the site-wide Superfund activities. As noted above, this unit was closed out and transferred to the Superfund program as of November 21, 2012.

Multi-Purpose Plant (MPP) Pad

Background

The concrete floor of this old production facility – relocated in the mid-1980's – was used for storage of drums of hazardous waste until 1990. Lacking a roof, and with sufficient covered storage space available in the #3 Warehouse, the MPP pad was then closed.

Closure Activity

The pad was cleaned via hydroblasting, but contamination was found in the soils around the MPP pad and a clean closure could not be certified.

Current Status

Further investigation and remediation of the soils is being coordinated with the site-wide Superfund activities. As noted above, this unit was closed out and transferred to the Superfund program as of November 21, 2012.

#3 Boiler

Background

Flammable liquid wastes were burnt for beneficial reuse as fuel for the boilers, supplementing commercial fuel oil and natural gas. Use of flammable liquid waste was discontinued in 1992 when federal BIF regulations required significant boiler upgrades to continue burning hazardous waste.

Closure Activity

All piping used for hazardous waste transfer to the boilers was cleaned and dismantled.

Current Status

Closure completed; no post-closure activities required.

#3 Warehouse

Background

A small section of this warehouse was designated as a Part B RCRA Storage Facility. It provided for the temporary storage of up to 120 drums of hazardous plant waste prior to offsite disposal. Following the sale of the manufacturing assets to GEO, Hercules closed the warehouse storage area in 2003.

Closure Activity
All wastes were shipped off-Site and the floor was decontaminated to remove any contaminants.

Current Status
Closure completed; no post-closure activities required. Part B permit terminated. However, Hercules maintains its RCRA identification number for possible hazardous waste generation resulting from future Superfund remediation.

1.3 REPORT ORGANIZATION

This RI Report is organized into the following sections:

- Section 1: Provides a summary of background information on the Site's physical setting and environmental history;
- Section 2: Provides an overview of the investigation activities;
- Section 3: Provides a summary of the EAs and their histories;
- Section 4: Provides a summary of data management activities;
- Section 5: Provides the Conceptual Site Model
- Section 6: Provides a discussion of the physical characterization based on observations and data collected during the RI;
- Section 7: Presents the BHHRA and BERA findings for the Site;
- Section 8: Presents data collected during the RI and a critical evaluation of the nature and extent of the impacts at the Site;
- Section 9: Provides an evaluation of the fate and transport of the primary chemical constituents detected during the RI;
- Section 10: Presents conclusions and recommendations; and
- Section 11: Provides a list of works cited or referenced to complete this RI Report.

2.0 INVESTIGATION ACTIVITIES

During the investigation history at this Site more than 8,000 samples and related analytical data have been obtained. Summaries of the historical investigations and conclusions developed from those investigations conducted prior to 2009 are provided in Section 1.2 above. Previous RI phases were documented under separate cover. References and summaries of those documents are included herein but extensive descriptions of those investigation phases are not repeated.

The data from these historical investigations that are included in the risk assessment and are provided in the data summary tables and graphics within this report are as discussed in Section 1.2 above. Figure 2-1 shows the sample locations at the Site throughout this investigative history. Figure 2-2 shows the location of the monitoring wells and piezometers that have been utilized for the various investigations on and off the Site.

The following are brief descriptions of the subsequent studies conducted by CSI from 2009 through 2017.

2.1 EPA DATA REQUEST

In January 2012, the EPA requested summary tables and figures showing the sampling locations and analytical results from historical investigations at the site. A summary of the historical investigations conducted at the IAs along with a summary of the Phase II and SRI findings was provided to the EPA in April 2012. In May 2012, the EPA requested that the data be provided in an editable format and that a conference call be scheduled to discuss the potential need for additional investigation activity at the Site. A conference call was held on June 7, 2012 that resulted in a call for a meeting at the site to discuss potential additional investigation activities. A site meeting was then held on June 14, 2012 to discuss the path forward.

In the fall of 2012, the EPA requested that additional investigation area process histories be summarized and provided for their review. This information was provided to the EPA in November 2012. In February 2013, the EPA requested that Hercules conduct an aerial photograph review of the site that covered the period between 1945 and 2009.

2.1.1 AERIAL PHOTOGRAPHY INVESTIGATION

A detailed aerial photography investigation was conducted by CSI and submitted to the EPA in August 2013 (*CSI, 2013)*. CSI compiled as many aerial photos as possible for the period between 1945 and 2010. CSI obtained photos through database management companies, private aerial photograph archives and by visiting the NJDEP aerial photograph archives.

A total of thirty-one (31) photos were selected for review. Photographs that either did not cover the study area or that were redundant to other photos were not reviewed. A previous aerial photography study was conducted by ERM as documented in the 1988 Soil Sampling Plan. CSI personnel reviewed this initial aerial photography interpretation and the results of subsequent investigations to become more familiar with the work previously conducted at the Site. This information combined with extensive historical investigation into the processes and history of the Site helped CSI refine and expand its comprehensive knowledge regarding historical Site use and operations.

The aerial photograph review focused on the IAs identified through previous investigation phases and described in detail in Section 2.3 as well as the open areas surrounding the IAs south and northeast of Clonmell Creek within the Site. The northern section of the Site that includes the SWDA was not scrutinized in this study as the SWDA was remediated under NJDEP lead and is not part of the *Administrative Settlement Agreement and Order of Consent for Remedial Investigation/Feasibility Study* [EPA, 2009] entered into by Hercules with the EPA in September 2009.

The key findings of this study are as follows:

- Previous investigation phases conducted at the Site properly identified the IAs where Site activities were concentrated.
- No Site-related activities of concern were observed in areas outside of the IAs.
- In general, the historical information obtained regarding the timeframes when IAs were active and the processes that took place in the IAs were corroborated by findings obtained during aerial photography review.
- An off-site area located west of the Site and north of where the ball fields currently are located appears to have been used historically as gravel borrow pits. These former borrow pits now contain shallow surface water bodies that likely influence the hydrogeology of shallow groundwater on the Site.
- The only activity noted in the SF IA appears in the 1962 photo where some mounded material is evident.
- The NCL area was cleared in 1971. Subsequent to 1971, the NCL becomes recovered in vegetation and no activity is visible in this IA.
- The area west of the MPP and north of the NW is active in the late 1970’s and early 1980’s. There are multiple tanks, drums and equipment visible in this area during this time frame.
- The photographs that were found to have decent resolution and were most useful in this investigation were from 1954, 1977, 1979, and 2002.

Subsequent to completion of the aerial photography review and submission of CSI’s findings in the Aerial Photo Interpretation [CSI, 2013] report the EPA requested that additional investigation be conducted in several areas of the site that were either not previously characterized or that had not been sufficiently characterized. This request led to the initiation of the Additional Remedial Investigation (ARI) as summarized in Sections 2.2.4 and 2.4.5 below.

2.2 CSI LED SOIL INVESTIGATIONS

During the FIWP and ARI investigations conducted by CSI, each soil boring was completed with either a split core sampler or a Geoprobe® direct-push rig. Continuous split-spoon samples were collected during the boring operations. The split-spoon was withdrawn from the borehole and the sample was immediately field screened with a photoionization detector (PID) for organic vapors. The soil core was logged by a CSI Field Geologist for information such as: soil type, odor, staining, free or residual product, and presence of groundwater. Copies of soil boring logs from the FI and ARI and Well Completion Reports are provided in Appendix C. Soil boring logs associated with the Shallow Groundwater Delineation Event and the CPT/DPT report were submitted in those reports. Data were compiled from the boring logs into a geodatabase for Site modeling.

Samples prior to March 2015 were collected in accordance with the QAPP and Field Sampling Plan (FSP), which were Appendices F and G, respectively, to the FIWP (CSI, 2008). The QAPP for the Site was updated in March 2015 (CSI, 2015) as part of the ARI activities. All samples collected since the QAPP was updated have been collected in accordance with that document and the relevant work plans (e.g. ARI WP [CSI, 2015]).

The soil sample(s) were collected in the core containing the soil/water interface. After initial characterization of the core, a proper sample increment was selected depending on the specific task of the sampling event. The first aliquot collected was for VOC analysis and was taken from an undisturbed portion of the segment using a teracore sampling kit. Next, the remaining portion of the increment was removed, homogenized in a clean, stainless steel bowl, and placed into laboratory-provide sampling containers. After sample collection, bottleware was immediately placed on ice in coolers. More in-depth sample methodology can be found in the FSP and QAPP documents.

2.2.1 FIWP

In January and February of 2009, CSI initiated the FIWP. The FIWP was designed to fill data gaps identified by the NJDEP regarding (i) the delineation of hydrogeologic conditions near several of the Site features located north of the main plant areas and (ii) characterization of ecological conditions.

Specific areas of the site identified by the NJDEP, where additional hydrogeological and ecological characterization were required, included the NCL, the 002 Outfall drainage channel, and Clonmell Creek and its interconnection, if any, with the latter two areas and wetlands. The MPP area also was cited as an area where further delineation was necessary to assess potential interconnection with the 002 Outfall and the SCB. 126 soil samples (including eleven (11) duplicates) were collected from 112 boring locations, two (2) test pit locations and one (1) background location as outlined in the FIWP [CSI, 2008].

The soil sample increment was selected from the location with the highest organic vapor measurement or, if no segment contained an elevated reading of organic vapors compared to other segments, from the soil/water interface. Test pit and background samples were collected with clean stainless steel or disposable sampling equipment.

2.2.2 Supplemental Shallow Groundwater Delineation Investigation

In June and July 2011, 35 soil borings were advanced in the former TF and residential area south of the property line. The main goal of this study was to define detailed geology of shallow soils and to improve the groundwater delineation in this area. Defining shallow soil chemistry was not a primary objective; however three (3) soil samples were collected from two (2) boring locations. Soil sampling locations and date from this investigation are included within the appropriate tables and figures for the relevant EAs, and the letter report is included as Appendix E. The soil sample increment was selected from the location with the highest organic vapor measurement.

2.2.3 Cone Penetrometer Direct Push Study

In November 2012, CSI and ConeTec advanced sixty-three (63) cone penetrometer borings in November 2012. The goal of the study was to refine our understanding of subsurface conditions for the upper 50 feet of soil in the areas of the APA, IPA, TLA and Southern Warehouses. The secondary goal of the study was to evaluate application of downhole laser induced fluoroscopy (LIF) as a supplemental method to estimate mass presence and distribution that will ultimately be instrumental in developing cost effective remedial strategies.

In June and July 2013, 17 soil samples (including 2 duplicates) were collected from 9 boring locations to confirm the geologic data provided by the Cone Penetrometer Test (CPT) and the chemical data generated by the LIF. A one (1) foot section was selected to collect the soil sample based off the results of the LIF log and in the field PID readings. Sample nomenclature for the direct push soil samples corresponded to the CPT location ID and the middle depth of the sample in feet [e.g. CPT-27(17)]. The Cone Penetrometer and Supplemental Direct Push Study Results Letter is included as Appendix D [CSI, 2016].

2.2.4 ARI

Various portions of the Site have been evaluated, some several times, which has resulted in an extensive database. However, several gaps in the data were identified by the EPA. The ARI Work Plan was based upon the scope of work negotiated with EPA and agreed upon via email on September 2, 2014. The ARI was intended to address areas of the Site that had not been investigated or only minimally investigated during previous RI phases at the Site as well as to enhance the available data for the GP, Clonmell Creek, MPP, TRA, and TLA.

Between April 2015 and March of 2016, 163 soil samples (including fourteen (14) duplicates) were collected from eighty-six (86) boring locations. Twenty-eight (28) of these soil samples from twenty (20) locations are classified as wetland soil samples collected from the wetland area around Clonmell Creek. In locations where subsurface sampling was required, the samples were collected using Geoprobe® techniques. In locations where only surface soil samples were necessary they were obtained with a split core sampler. Sample nomenclature followed a similar pattern as previous events. Soil boring nomenclature was Exposure Area (EA)-SB-# (depth range in feet) (e.g. GP-SB-04(0-1). Surface soil was collected from each boring. The subsurface soil sample increment was selected from the location with the highest organic vapor measurement or, if no segment contained an elevated reading of organic vapors compared to other segments, from the soil/water interface.

Wetland soil samples followed the same nomenclature as wetland soil samples collected as part of the SRI; WS-#(depth range in inches) (e.g. WS-37(0-6). Soil sampling locations and date from this investigation are included within the appropriate tables and figures for the relevant EAs and in the ARI Report [CSI, 2015]. Following the ARI, two small areas required further delineation (lead in the TRA and Wetland), and xylenes in the area of the historic sample MPP-SB01B.

2.2.4.2 ARI Lead Addendum

The goal of the ARI Lead Addendum (ARILA) was to close data gaps identified by the EPA, and further enhance the overall understanding of Site conditions. Additional wetland soil sample collections was deemed warranted to further delineate lead concentrations at two (2) locations in the wetlands north of Clonmell Creek and one (1) location in the TRA. Analysis was performed for lead at all locations, and tetraethyl lead in the samples from the upper aliquot of the center locations.

The sample nomenclature for the ARILA consisted of the original location ID followed by a letter designation and the depth range in feet [e.g. WS-19A(0-0.5)]. A total of sixteen (16) wetland soil samples were collected and analyzed from soil near Clonmell Creek. A total of ten (10) soil samples were collected and analyzed from soil near TRA-9 as shown on Figure 2-3. Soil samples were sent to Test America for total lead analyses while an additional aliquot was collected from the shallow sample at TRA-9A for tetraethyl lead analysis.

At both WS-19 and WS-32, CSI obtained four (4) 0 to 0.5-ft (ft) below ground surface (bgs) samples plus four (4) 0.5 to 1-ft bgs samples at a distance of approximately 10-ft from the original sample locations (WS-19 and WS-32) using a split-core sampler (sample locations are shown on Figure 2-3). Additionally, CSI obtained a new sample from the area adjacent to former locations WS-32 and WS-19 at depths of 0 to 0.5-ft and 0.5 to 1-ft bgs. The 0.5 to 1-ft bgs samples from the four locations around WS-32 and WS-19 were held until the initial sample results were available. In instances where the initial 0-0.5 ft bgs lead result was greater than 150 milligrams per kilogram (The agreed upon delineation step out threshold), the 0.5-1 ft bgs sample from that locations was sent to the laboratory and analyzed for total lead. ARI sample TLF-9 was obtained at a depth of 0 to 1-ft bgs. To complete the delineation of this sample location for lead, CSI obtained four (4) 0 to 1-ft bgs and four (4) 1 to 2-ft bgs samples at a distance of approximately 10-feet from around TRA-9 as shown on Figure 2-3 using a split-core sampler. Additionally, CSI obtained a new sample from the area adjacent to former location TLF-9 at a depth of 0 to 1-foot as well as at a depth of 1 to 2-ft bgs.

Tetraethyl lead was not detected in either sample collected from WS-19A, WS-32A, or TLF-9A. Lead was detected in all sixteen (16) wetland soil samples at concentrations ranging from 27 to 1,100 mg/kg. A total of ten (10) soil samples were collected and analyzed from soil near TRA-9. Lead was detected in all soil samples collected near TRA-9 at concentrations ranging from 640 to 2,300 mg/kg. The conclusion of the ARILA stated that additional lead delineation is necessary near WS-19 and TRA-9 to determine the full extent and volume of soil containing elevated lead prior to any potential remedial measure selected as part of the Record of Decision (ROD).

2.2.4.3 MPP-SS01B Resample

During internal review of the HHRA, one issue became apparent. There was one historical shallow sample location in the NW EA from 1994 (MPP-SS01B) that had an elevated detection of xylenes that was driving risk in that area. The reported result for MPP-SS01B shallow soil sample in the Ph II that had the high xylene concentration was analyzed using an onsite portable lab set up (ERM-FAST). A fixed base laboratory confirmation sample was also obtained for this location. The lab confirmation did not confirm the xylene detection and so it is considered a false positive. Based upon this the initial ERM-FAST sample should have been negated as a false positive and discarded from the data set.

Due to the confusion of concentrations of total xylenes in historic sample MPP-SS01B, it was determined by the EPA and CSI that the area required further delineation. On September 28, 2016, twenty-three (23) soil samples (including two (2) duplicates) were collected from five (5) soil boring locations in the vicinity of the Ph II sample location MPP-SS01B.

The sample nomenclature for this follow up sampling event consisted of the original location ID followed by a letter designation and the depth range in feet [e.g. MPP-SS01BA(0-0.5)]. Twenty-two (22) of these soil samples were collected from the upper two (2) feet of the soil column while one (1) soil sample was collected at a depth of nine to ten (9-10) ft bgs. Soil sampling locations and date from this investigation are included within the appropriate tables and figures for the relevant SCB EA.

The soil samples were collected in the vicinity of a sample from the Phase II investigation that contained concentrations of total xylenes above screening levels. Surface soil samples at depths of 0-0.5 ft bgs, 0.5-1 ft bgs, 1-1.5 ft bgs and 1.5-2 ft bgs were collected from the approximate location of the historic sample and in four directions to ensure horizontal delineation. A deeper sample was collected from nine to ten (9-10) ft bgs to determine the vertical extent of any historic xylenes.

2.3 GROUNDWATER INVESTIGATION

2.3.1 Routine Groundwater Monitoring Activities

Groundwater is routinely collected from monitoring wells and pumping wells as part of the groundwater monitoring program. Historically, there were two separate monitoring programs at the Site. The majority of the Site monitoring was conducted under the Administrative Consent Order (ACO), which required analysis for VOCs and Total Recoverable Phenols (TRP) and included all of the pumping wells, the majority of the monitoring wells on the main Sit, off-Site wells and ten (10) monitoring wells in the SWDA. A second monitoring program was the RCRA program that covered ten (10) monitoring wells surrounding the SI in the WWTP and NCL areas.

These programs were combined and streamlined in 2012. As a result, several extraneous analytical suites were discontinued (TAL Metals, and cyanide at RCRA wells and TRP at several ACO and RCRA wells). Additionally, emphasis of quarterly sampling was shifted from wells in the center of the plant to those along the property boundary to provide more sentinel monitoring program along the edge of the Site. Finally, the SWDA wells were removed from this program and the monitoring program and are now handled under the SWDA post-remedial monitoring program.

Groundwater samples are collected from twenty-four (24) monitoring wells (11 A-Level, 7 B-Level, 4 C-Level & 2 Township Wells) on a quarterly basis, with an additional seven (7) wells (5 A-Level, 1 B-Level, and 1 C-Level) for semi-annual sampling. All Site related monitoring wells are analyzed annually for VOCs. Wells MW-6B, MW-10R, PW-6, TW-4 and TW-5 are also analyzed for total recoverable phenols. Data obtained are reported to both the EPA and NJDEP on a quarterly basis. An analysis of the data obtained from this sampling program as it pertains to the entire Site is provided in Section 8.5 below. Assessment of groundwater quality for each EA is also discussed within the applicable portions of Section 8. Figure 2-2 shows the location of the monitoring wells and piezometers that have been utilized for the various investigations on and off the Site.

2.3.2 FIWP

As discussed in Section 2.2.1, CSI initiated the FIWP in January and February of 2009. The FIWP was designed to fill data gaps identified by the NJDEP related to the lack of clarity in the SRI Report regarding (i) the delineation of hydrogeologic conditions near several of the site features located north of the main plant areas and (ii) characterization of ecological conditions.

In conjunction with the completion of soil boring and soil sampling in January and February of 2009, 121 groundwater samples (including 10 duplicates) were collected from 111 temporary well points. The data from these temporary well points were used in the Impact to Groundwater (IGW) assessment when appropriate. Groundwater sampling locations for the most part, are the same as the soil sampling locations. Groundwater samples were collected from the same soil boring locations from which soil samples were obtained. Temporary monitoring points were installed at all soil boring locations; however one (1) location (APA-3) did not produce enough groundwater to collect a sample and, therefore, there is no groundwater sample record associated with this boring location. Groundwater sampling was conducted in the manner described in the FSP. The majority of monitoring points were sampled using a peristaltic pump and dedicated, disposable tubing. Only one (1) groundwater sample was obtained using a disposable bailer (MPP-3).

Piezometers were set at eighteen (18) of the 111 temporary monitoring points to document potentiometric surfaces in the shallow aquifer on the north side of the Site and its interactions with the A- and B-level aquifers and Clonmell Creek. All piezometers were constructed in accordance with New Jersey Administrative Code (NJAC), Part 7:9D. A 6-inch hollow-stem auger was used to install the piezometers. They were constructed of 1-inch diameter polyvinyl chloride (PVC) well casing and screen. Each piezometer was developed to yield a non-turbid discharge after installation.

In May 2009, two (2) B-level monitoring wells were installed in accordance with N.J.A.C. 7:9D. These wells were installed to further understand the potentiometric surfaces in the B-level aquifer; the presence and role of a shallow clay layer in their vicinity; and the vertical and horizontal extent of VOCs in the north side of the Site. Well installation was completed using an 8-inch mud rotary drilling rig. Samples from these wells were collected with a decontaminated submersible pump. The wells were constructed of 2-inch diameter PVC casing and screen. Both wells were developed to yield a non-turbid discharge after installation. Well installation reports were submitted on June 10, 2010 to the NJDEP documenting the well installation (A.C. Schultes, 2010).

Each sampling point was purged a minimum of three (3) times prior to collection of a sample to ensure a representative sample of aquifer water was being obtained. After sample collection, bottleware was immediately placed on ice in coolers. More in-depth groundwater sampling methodology can be found in the FSP provided with the FIWP (CSI, 2008). Results are discussed in section 4.1.3.

2.3.3 Supplemental Shallow Groundwater Delineation Investigation

In June and July 2011, thirty-five (35) soil borings were advanced in the former TF and residential area south of the property line. The main goal of this study was to gain detailed geology of shallow soils and to improve the groundwater delineation in this area. During this study, groundwater was collected from temporary wells installed in Geoprobe® borings at eleven (11) on-Site locations and eleven (11) off-Site locations. Additional samples were collected from an on-Site monitoring well.

Each sampling point was purged a minimum of three (3) times prior to collection of a sample to ensure a representative sample of aquifer water was being obtained. After sample collection, bottleware was immediately placed on ice in coolers. More in-depth groundwater sampling methodology can be found in the FSP and QAPP. The monitoring well locations and data from this investigation are included within the appropriate tables and figures for the relevant EAs, while the temporary well data was used in IGW assessment only. The Supplemental Shallow Groundwater Delineation Investigation Report is included in Appendix E.

2.3.4 Cone Penetrometer Direct Push Study

As stated in Section 2.2.3, in June and July 2013, CSI 10 groundwater samples (including 1 duplicate) were collected from 9 temporary well locations. The primary purpose of this study was to confirm geologic and chemical information obtained during the November 2011 CPT study.

Each sampling point was purged a minimum of three (3) times prior to collection of a sample to ensure a representative sample of aquifer water was being obtained. After sample collection, bottleware was immediately placed on ice in coolers. More in-depth groundwater sampling methodology can be found in the FSP. Temporary well data was used in IGW assessment only. The CPT and Supplemental Direct Push Study Results Letter is included in Appendix D.

2.4 SURFACE WATER, PORE WATER, AND SEDIMENT INVESTIGATIONS

Surface water, pore water, and sediment samples were collected as part of the RI during several sampling events at multiple bodies of water at the Site, including Clonmell Creek, the SCB, the IPA Pond and the GP Pond. Typically, when collocated, sediment samples were collected after surface water samples were collected. When available sediment samples were collected using either vibracore technology or wide diameter slap hammer. Cores were logged for geologic characteristics and scanned for elevated organic vapors using a PID. Unless otherwise specified, samples were collected at 6-inch intervals in the first foot and then 12-inch intervals until native soil was reached. The first aliquot collected was for VOC analysis and was collected from the undisturbed core using a teracore sampling kit. Next the 6- or 12-inch increment was removed, homogenized, and placed into laboratory-provide sampling containers. After sample collection, bottleware was immediately placed on ice in coolers. More in-depth sample methodology can be found in the FSP (CSI, 2008). After each sample, the surface water dipper and the vibracore head were decontaminated as described in QAPP of the FIWP (CSI, 2008).

2.4.1 FIWP

As mentioned above, the purpose of the FI was to fill data gaps from previous investigations. One of these data gaps was the delineation of the hydrogeologic conditions in the northern portion of the site, specifically Clonmell Creek and the adjacent wetlands. This information is important in understanding groundwater migration and the fate and transport of potential constituents of concern in these areas.

In February 2009, during initiation of FI activities, 4 surface water samples were collected (two (2) from the SCB, one (1) from Clonmell Creek, and one (1) from the 002-Outfall).

Subsequently, twenty-eight (28) surface water samples (including two (2) duplicate samples) and eighty-five (85) sediment samples (including seven (7) duplicate samples) were collected from thirty-one (31) on-site locations. These locations include twenty-two (22) within Clonmell Creek, 2 at the 002-Outfall area, one (1) from the IPA, and six (6) from the SCB. Additionally, in July 2009, four (4) surface water samples and ten (10) sediment samples (including one (1) duplicate) were collected from four (4) off-site locations on DuPont property along the downstream portion of Clonmell Creek.

It was suspected that concentrations of cumene in surface water above the applicable screening levels from the April 2009 investigation were due to the collection of surface water samples concurrent with the collection of sediment samples at other locations. The process of collecting the sediment sample caused a higher percentage of solids to be suspended in the water column, in turn causing higher cumene concentrations in the surface water. Confirmation samples of surface water from Clonmell Creek was conducted to confirm that elevated concentrations of site-related constituents observed during April 2009 were a result of sediment being entrained in the aqueous samples. Confirmation samples consisted of four (4) surface water samples from three (3) locations (including one (1) duplicate). Sampling locations and data from this investigation are included within the appropriate tables and figures for the relevant EAs

Samples were collected in accordance with the FSP presented in Appendix G of the FIWP (CSI, 2008). Surface water samples were collected with a decontaminated surface water dipper and poured directly into laboratory-supplied and preserved sample bottles, and immediately placed on ice in coolers. An additional surface water aliquot was collected for field measurements (pH, temperature, and specific conductivity).

2.4.2 Additional Ecological Sediment Characterization

In November 2010, thirteen (13) shallow sediment samples were collected from Clonmell Creek and the SCB (including one (1) duplicate in three (3) reference samples). These samples were collected as part of a sediment triad study in association with habitat assessments and macroinvertebrate surveys to aid in the BERA. All sediment samples were collected with a slap hammer at depths of zero (0) to six (6) inches.

The samples were located in the same general area as samples from April 2009, however they were biased to the sides of the water bodies where macroinvertebrate habitat was more likely to be present. The sample nomenclature consisted of SED2-Location ID (Midpoint sample depth in inches) [SED2-CC-8(3)]. Sampling locations and data from this investigation are included within the appropriate tables and figures for the relevant EAs

2.4.3 Expanded Sediment Characterization

In May and June 2011, 103 sediment samples (including ten (10) duplicates) were collected from twenty-one (21) locations in Clonmell Creek. The samples were collected with wide diameter slap hammers. The intention of this study was to confirm the 2009 results indicating that isopropylbenzene (cumene) is the primary VOC present in Clonmell Creek sediment and refine the horizontal and vertical delineation of cumene-impacted sediment in Clonmell Creek.

Samples were collected with a wide diameter slap hammer. Sample nomenclature was similar to previous sediment studies and consisted of SED2-Location ID (Midpoint sample depth in inches) [SED-CC-26(9)]. All samples were analyzed for with a subset being analyzed for TOC. Sampling locations and data from this investigation are included within the appropriate tables and figures for the relevant EAs

2.4.4 Shallow Sediment, Pore Water and Bathymetry Study

In June 2014, 21 sediment samples were collected from seven (7) locations. Additionally, fourteen (14) pore water samples were collected from six (6) locations (including two (2) duplicates) and one (1) pore water equipment blank, which was in essence a surface water sample. The goals of this sampling plan were met by performing the following three (3) principal tasks. The first was to obtain additional data from the “biologically active” zone in Clonmell Creek. The second was to obtain additional sediment depth and stream cross-section data to better assess the potential for downstream migration of sediments in the FS. Finally, the study intended to provide additional certainty for estimating the mass of cumene within the Clonmell sediments.

Sediment samples were collected, flash frozen with dry ice, and divided into 2-inch samples (0-2 inches, 2-4 inches, and 4-6 inches) to gain additional data in the biologically active zone of Clonmell Creek. Pore water peepers were installed from 0-6 inches below the sediment surface and 6-12 inches below the sediment surface. The peepers were constructed out of 2” PVC well screen with threaded caps on one end and a pointed tip on the other for driving into the sediments. The peepers are filled with a passive diffusion bag that contains laboratory grade water. The peepers were allowed to equilibrate in-Situ for one (1) month. After equilibration, the peepers were retrieved and the water within each peeper was transferred to laboratory provided bottleware. Sampling locations and data from this investigation are included within the appropriate tables and figures for the relevant EAs.

A bathymetric survey was conducted on Clonmell Creek to assess the potential for downstream sediment migration. CSI personnel measured the water depth, attempted to measure the thickness of sediment and obtained water velocity and temperature readings at various points in the water column. These measurements were collected every twenty (20) feet along eleven (11) transects of the creek starting approximately every 100 feet from the culvert to the downstream property boundary with Dupont.

The transect data were collected from a small boat using a stake on either side of the creek with a rope strung between the two stakes. The rope had marks every twenty (20) feet so that the sampling stations could be easily located. Gradated poles were used to measure the depth to the bottom of the creek relative to the current water level. To assess changes in the water level of the creek, CSI placed a gradated stake at an easily accessible location along the creek so that changes in the water level of the creek can be accounted for during future remedial and/or investigatory work. At each measuring point CSI also measured the thickness of unconsolidated sediments overlying the clay that forms the base of the creek bed. CSI used a 3/8” rebar rod with a sharpened tip to estimate the sediment thickness. CSI personnel also measured water velocity at each measuring point using a handheld velocimeter at the mid-point of the water column. No measurable water velocities were recorded during this event. Thus, the potential for sediment shearing during typical flow conditions is minimal to non-existent. However, flow does occur during heavy precipitation events and during separate studies CSI has obtained water velocity data during precipitation events to quantify this. The results of this bathymetric survey are provided in Appendix H.

2.4.5 ARI

As mentioned in Section 2.2.4, the ARI was intended to address areas of the Site that had not been investigated or only minimally investigated during previous RI phases at the Site as well as to enhance the available data for the GP, Clonmell Creek, MPP, TRA, and former TLA. While most of the ARI focused on unsaturated soil samples, surface water and sediment was collected as part of the ARI. Sampling locations and data from this investigation are included within the appropriate tables and figures for the relevant EAs

In April 2015, eight (8) shallow (0-6 inch) sediment samples were collected from eight (8) locations in Area B and the Wetlands adjacent to Clonmell Creek. All sediment samples collected as part of the ARI were analyzed for VOCs, SVOCs, PCBs, Pesticides, and metals. The sediment sample nomenclature for the ARI was, EA-SED-Location # (Depth range in inches) [e.g ARB-SED-9(0-6)].

In July 2015, two (2) surface water samples were collected from two (2) locations in the GP. All surface water samples collected as part of the ARI were analyzed for VOCs, SVOCs, pesticides, and metals. The surface water sample nomenclature for the ARI consisted of just the Location ID [e.g GP-11].

2.5 SOIL GAS/INDOOR AIR INVESTIGATIONS

In February 2009, eighteen (18) soil gas samples and one (1) duplicate sample were collected using post-run tubing (PRT) from a Geoprobe® direct push rig into summa canisters as part of the FI. These samples were collocated with groundwater and soil samples at locations in both the APA and IPA as well as along the property boundary to the south and west. The collocated soil gas and groundwater data along with monitoring well data from quarterly sampling events was used to delineate possible offsite vapor migration. From these data, it was determined that more data points were needed between the plant and possible receptors offsite, as such twelve (12) additional soil gas samples (including one (1) duplicate) from eleven (11) locations and two (2) ambient air samples were collected in May, 2010 beyond the south and west property boundary to further delineate vapor effects from impacted shallow groundwater.

Uncertainty regarding benzene and chlorinated solvents in soil gas collected in May 2010, lead to the March 2011 indoor air investigation. Thorough surveys were performed in homes located along Railroad Avenue, just south of the Site. Any potential VOC sources were noted, and removed from the home if possible. Samples were collected from a variety of areas including fourteen (14) soil gas samples (including one (1) duplicate) from thirteen (13) soil gas points installed along Railroad Avenue, thirteen (13) subslab soil gas samples (including one (1) duplicate) from soil gas beneath twelve (12) homes, one (1) air sample from the crawl space beneath one (1) home, twenty-five (25) indoor air samples from thirteen (13) homes, and nine (9) ambient air samples (including one (1) duplicate). An additional thirteen (13) samples (including one (1) duplicate) were collected from twelve (12) locations within the public sewer line to determine if vapors could be using the sewer as a preferential pathway.

The sewer samples were collected using passive Waterloo Membrane Sampler (WMS) samplers and analyzed using method TO-17. The report concluded that the groundwater to offsite indoor air pathway was incomplete. An important finding of this investigation was that an offsite source of chlorinated solvents was identified. Soil gas and off-Site groundwater samples indicated chlorinated solvent concentrations in the vicinity of a historical dry cleaner, which was formerly located at 95 W. Broad Street in Gibbstown, NJ. Sporadic detections of chlorinated solvents continue to be detected in offsite and onsite perimeter wells. The former dry cleaner is the likely source of these detections. Results are discussed in detail in the complete reports of the studies, provided in Appendix I.

2.6 LNAPL INVESTIGATIONS

Investigating for the potential presence of light non-aqueous phase liquids (LNAPLs) was included in the FI work plan to complete Site characterization and address regulatory concerns. Previous phases of investigation performed by others had detected elevated concentrations of petroleum constituents such as benzene and cumene at concentrations that raised regulatory concerns about the possible presence of LNAPL, primarily in and around the former APA. The previous studies also performed a membrane interface probe (MIP) evaluation designed to look for the presence or absence of LNAPL in areas where high concentrations were known to exist. Despite numerous attempts to identify potential LNAPL, the previous consultant reported that no LNAPL was identified using conventional techniques or the MIP.

2.6.1 Conventional LNAPL Evaluation

CSI used multiple approaches to assess for the possible presence of LNAPL. An extensive number of soil borings were completed in areas where the presence of LNAPL was considered possible (e.g. the APA, former TLA, etc.). Continuous soil cores were retrieved in the field from each boring and screened by the on-Site environmental professional. Field screening consisted of visual inspection of the soil cores combined with field screening with a PID meter. Particular emphasis was focused on soil samples obtained just above and across the water table to inspect for the presence of LNAPL. A soil sample was obtained either just above the water table interface, or where the highest PID reading was obtained. In most cases, the soil sample was collected from the soil column immediately overlaying the water table.

In several borings, temporary wells were subsequently installed in the soil borings and screened across the water table to ensure that LNAPL could be detected. Water level measurements were recorded to determine groundwater elevations. No LNAPL or sheen was detected in any of the temporary wells, piezometers, or existing monitoring wells.

2.6.2 LNAPL Evaluation Using Ultraviolet Induced Fluorescence

Further analysis for the possible presence of LNAPL was performed by screening select soil sample cores obtained from the most likely LNAPL locations using Ultraviolet Induced Fluorescence (UVIF). Petroleum compounds contain aromatic hydrocarbon molecules that emit fluorescence when excited by ultraviolet light. Exposing soil samples that contain petroleum LNAPL to ultraviolet light will create a clear visible signature specific to the type of petroleum product present. For this investigation, a small sample of cumene was obtained from Site personnel and exposed to ultraviolet light to obtain a signature for comparison to soil samples obtained in the field. The cumene control sample was analyzed in pure form and by mixing a small volume of cumene in representative soil obtained from the Site. The resultant UVIF signature obtained during analysis of the cumene control samples produced a distinct milky white fluorescence.

A total of seven (7) locations were identified during the 2009 investigation as candidates for further LNAPL screening using UVIF. These seven (7) locations were identified during the conventional LNAPL evaluation described in 2.6.1. Criteria used to select these locations included the presence of strong chemical odors, visible indicators such as discoloration or apparent staining, and elevated PID readings. In essence, the seven (7) locations represented conditions where LNAPL would be most likely to exist, if present. Dedicated soil borings were drilled in these seven locations for the sole purposed of obtaining soil samples for UVIF analyses to inspect for the presence or absence of LNAPL.

The seven (7) soil borings completed for LNAPL evaluation were drilled in the APA [APA-1, APA-6, APA-8], the IPA [IPA-10, IPA-14], the TLA [TL-3], and the MPP, or MPP [MPP-8]. These locations were selected because the exhibited the evidence of elevated impacts (e.g., high organic vapors reading, noticeable odor, and/or visual staining). Soil sample cores from these seven (7) boreholes were analyzed in the former Hazardous Response Building, located in the IPA. A Spectroline Cl-151 portable Ultraviolet (UV) analyzer was used for UVIF analysis of the soil cores. The samples were exposed to both short wave and long wave UV lamps for analysis. Optimal results were obtained using the long wave UV lamp, as expected.

At three (3) of the locations (APA-1, IPA-14, and TL-3) no UV fluorescence indicative of LNAPL was observed. MPP-8 showed very weak fluorescence throughout the saturated zone. Also, sample aliquots from IPA-10, APA-8 and APA-6 showed weak to moderate fluorescence. Weak and moderate fluorescence may be indicative of LNAPL smearing or historical LNAPL.

Screening logs reporting UVIF results for each of the seven (7) LNAPL boreholes are provided in (Appendix J). A summary of UVIF results for the seven (7) LNAPL boreholes is provided in (Table 2-1). The UVIF results did not detect a distinct LNAPL layer in any of the LNAPL dedicated boreholes, confirming conventional LNAPL analysis results. Weak to moderate fluorescence was detected intermittently in some of the soil samples. This dampened or muted UVIF response may be indicative of residual LNAPL smearing or a weathered sheen but is not indicative of a discrete LNAPL layer or zone.

Trace droplets or emulsified petroleum constituents potentially indicative of weathered residual LNAPL also were observed in several samples. No fluorescence was detected in soil from three (3) of the boreholes including APA-1; IPA-14, and TL-3. Very faint and scattered fluorescence was noted in samples from MPP-8. Low to moderate fluorescence indicative of residual smearing, weathered petroleum constituents, and the suspected presence of residual emulsified petroleum (R-NAPL) was observed in samples from APA-6, APA-8 and IPA-10. Interestingly, many of the soil intervals where mottled or weak fluorescence was observed occurred well below the water table.

2.6.3 Cone Penetrometer Laser Induced Fluorescence Study

Further use of fluorescence technology to delineate the location of potential R-NAPL within the APA and IPA was performed in November 2012. LIF was used as part of the CPT study in fifty-two (52) locations. The CPT/LIF study was able to identify several areas in the former process area which displayed strong UV fluorescence, indicating a strong presence of Site-related COC mass. While the majority of elevated UV fluorescence was observed near the water table, two (2) zones of high UV fluorescence were observed in several locations. Where present, one zone of high fluorescence was typically noted near the water table and a second UV response area with an even stronger signal was typically noted between sixteen (16) ft bgs and nineteen (19) ft bgs. Notably, the soil in the unsaturated zone did not show any measurable UV response. A direct push technology (DPT) soil study was conducted to confirm the finding of the CPT/LIF results in July 2013. The results of the DPT confirmed the general findings of the CPT/LIF study. The results of this CPT/LIF study are detailed in the Cone Penetrometer and Supplemental Direct Push Study Results Letter Report which is included as Appendix D.

2.6.4 NAPL Mobility Study

LIF results had indicated a few locations that were more likely to contain NAPL. Geoprobe® DPT drilling confirmed an oily liquid in both CPT-28 and CPT-44 at depths of seventeen to eighteen (17-18) ft bgs, well below the water table. These two (2) locations also allowed for the mobility study to look at two very different soil types, an interval where the predominant soil matrix consisted of coarse gravel (CPT-44) and a second location containing primarily of very fine, sandy-silt (CPT-28). A second boring was advanced at each location, and a one (1) -ft core was collected from seventeen to eighteen (17-18) ft bgs at CPT-44 and 17.5 -18.5 ft bgs at CPT-28. An additional sample was taken from Clonmell Creek sediment near the confluence with the 002 Outfall.

The cores were immediately capped and flash frozen on dry ice and sent to PTS Laboratories in Santa Fe Springs, California, where they were analyzed for pore fluid saturation and NAPL mobility via ASTM D425M methodology. In brief, once the cores were received at PTS, the laboratory calculated pore volume of air, water, and NAPL, effective (total) porosity, bulk density, air permeability and hydraulic conductivity. A centrifugal force of 1,000 times gravity was applied to the cores for one hour to quantify NAPL mobility. A second set of pore volume samples were collected after the cores were processed in the centrifuge. In this analysis, the centrifuge acts as an upper limit to quantify the potential maximum NAPL removal from each soil matrix using conventional recovery techniques.

Review of the R-NAPL mobility testing reveals that the R-NAPL is predominantly immobile. The R-NAPL exists within pore spaces along with water and air, and is held in place by interfacial tension. In samples sent for analysis where R-NAPL was present, the R-NAPL represented between 9.9% and 12.4% of the total pore space volume. Site-specific testing demonstrates that only 15% of the R-NAPL was found to be mobile. Thus, in areas where R-NAPL is present, only about 1.5% to 1.8% of the soil pore space contains mobile R-NAPL. As a result, the R-NAPL represents a diffuse distribution containing predominantly cumene and varying amounts of a-methylstyrene that are not mobile nor readily recoverable using conventional mechanical removal methods. The diffuse R-NAPL is predominantly located at or below the water table in saturated conditions and have a specific gravity less than 1.0. The results of NAPL Mobility Study are provided in Appendix K and data from the laboratory analysis of the R-NAPL are presented in Table 2-2. A detailed discussion of R-NAPL at the Site is included in Section 8.1.1.1.

2.7 ANCILLARY INVESTIGATIVE TASKS

2.7.1 Geological Investigation

Since the initiation of the FI in 2009, soil borings from 242 locations as well as sediment borings from 79 locations were used to bridge geological data gaps and further delineate the shallow clays at the Site. In additions sixty-three (63) wells (monitoring, pumping, injection, air sparge, soil vapor extraction, and piezometers) have been installed since 2009. Of these, fifty-five (55) wells were installed into the A-Level, six (6) were installed into the B-Level, and two (2) were installed into the C-Level. Finally, sixty-three (63) cone penetrometer (CPT) soil borings were advanced in the former process area and along the western property line. The additional geological data was used to further refine Site models and evaluate the interactions between the A- and B-level aquifers. Each soil and sediment core was logged for information such as: soil type, organic vapor readings, odor, staining, free or residual product, and the presence of groundwater. Data were compiled from the boring logs into a geodatabase. The geodatabase was used to create a 3-dimensional view of the site and its shallow soil strata which is presented in Section 5.

2.7.2 Hydrogeologic Characterization in SCB/002 Outfall/NCL and Clonmell Creek

Various hydraulic gauging events have occurred in and around Clonmell Creek during the major phases of the RI. Historically there was some concern that due to the tidal gate at the mouth of Clonmell Creek, that the creek would be receiving water from the shallow groundwater at certain times. However, the results from these studies demonstrate that while there is some minimal hydraulic connection between shallow groundwater and Clonmell Creek, the Creek is consistently higher than the surrounding water table.

Phase II

Flow measurements and stream profiling were conducted in Clonmell Creek in June and July 1994. Flow measurements were taken along upstream and downstream cross-sections. Cross-sectional profiles and flow measurement data for these locations are presented within the Phase II (ERM, 1995).

Flow data and observations indicated that flow direction is affected by the presence of the tide gate on Clonmell Creek. Flow measurements collected shortly after low tide in the Delaware River indicate flow in Clonmell Creek to the west, toward the Delaware River. Data collected shortly after high tide indicates flow in Clonmell Creek to the east, away from the Delaware River.

Findings from the Phase II Clonmell Creek study suggested that total creek discharge is ten times greater to the west (after low tide) as compared to easterly flow (after high tide) when water backs up behind the tide gates. The increased total discharge to the Delaware River occurs in response to low tide and the opening of the tide gate on Clonmell Creek. During low river tide, the tide gate opens and Clonmell Creek openly flows to the Delaware River. During high Delaware River tide, the closed tide gate on Clonmell Creek prevents flow to the river, and upstream flows of Clonmell Creek begin to back up behind the tide gate. Thus, even though flow reversals may be observed periodically in Clonmell Creek, it is not a true tidal stream [ERM, 1995].

SRI

A continuous water level study was conducted in Clonmell Creek and the surrounding areas in late-August and early-September 2002 in order to evaluate the relationship between surface water in the creek and shallow ground water. During the creek water level study, water levels were monitored in the newly installed temporary creek piezometers, temporary well points, and stilling wells as well as in monitoring wells MW-3, TW-8, MW-38 and MW-39. The one-week study period made it possible to evaluate the effect of tidal fluctuations and two separate rainfall events (occurring on 29 August and 1 September 2002) on the hydrology of the creek.

The study used four water level monitoring stations. Each station consisted of 1) a temporary creek piezometer to monitor water directly below the creek bed, 2) a temporary well point to monitor the shallow ground water immediately adjacent to the stream bank, and 3) a shallow ground water monitoring well farther inland from the creek. Additionally, two stilling wells (SW-2 and SW-3) were attached to temporary creek piezometers SRI-PZ-2 and SRI-PZ-3 to monitor the creek water level fluctuations upstream and downstream of the Clonmell Creek Bridge. The monitoring stations included the following locations:

Station Number	Station Location
Station 1	Approximately 600 feet upstream of the western property boundary.
MW-39	South of creek, in the NCL
SRI-TW-1	South bank of creek
SRI-PZ-1	Within the creek, screened below the creek bed
Station 2	Approximately 800 feet upstream of the western property boundary.
MW-38	South of creek, in the NCL
SRI-TW-2	South bank of creek
SRI-PZ-2	Within the creek, screened below the creek bed
SW-2	Within the creek
Station 3	Approximately 1,200 feet upstream of the western property boundary.
TW-8	South of creek on eastern border of the NCL
SRI-TW-3	South bank of creek
SRI-PZ-3	Within the creek, screened below the creek bed
SRI-PZ-4	Within the creek, screened below the creek bed
SW-3	Within the creek
Station 4	Approximately 2,200 feet upstream of the western property boundary.
MW-3	South of creek on eastern border of the GP
SRI-TW-4	South Bank of creek

Due to the low water levels in the creek at the time of installation, temporary creek piezometer SRI-PZ-4 could not be installed at Station 4 as intended. Therefore, it was installed at Station 3, serving essentially as a duplicate for SRI-PZ-3.

Continuous monitoring of water levels in the above listed points was conducted using In-Situ, Inc. Troll™ electronic data-logging pressure transducers. A transducer was installed in each of the above listed monitoring points and calibrated to the elevation of the monitoring point. The pressure transducers were programmed to collect readings synchronously at 10-minute intervals during the course of the study. In addition, flow data from Raccoon Creek near Swedesboro, New Jersey, were obtained from the USGS. These data were used in conjunction with the transducer data to evaluate Clonmell Creek-ground water relationships.

The SRI study data indicate that Clonmell Creek is losing water to the shallow ground water system, which then flows in a southerly direction. This finding is consistent with the 1987 Ground Water Quality Assessment Program, Equalization Basin Study (ERM, 1987). The historical water level data suggest a downward hydraulic gradient from Clonmell Creek toward the monitoring wells to the south. The highest water table elevations were observed in the creek and directly beneath the streambed, while the lowest water table elevations were observed at the monitoring wells. Thus, surface water from the creek was previously believed to be recharging the shallow aquifer system. Water levels recorded in creek piezometers indicate that shallow ground water under the creek is flowing toward the south away from the creek. This is consistent with regional southerly groundwater flow in this area. Since the wetlands associated with Clonmell Creek are at slightly higher elevations than the creek, the hydraulic characteristics of the creek would also indicate that the wetlands would not be affected by shallow ground water discharges. More recent tidal studies suggest minimal hydraulic communication between Clonmell Creek and the surrounding water table aquifer. Thus, minimal shallow groundwater recharge from Clonmell Creek may occur along the south side of the creek; however, areas north and upstream of the creek appear to have little to no interconnection with the surrounding water table aquifer.

Tide gates are present at the mouth of the creek, which open during low tide and close during high tide. The magnitude of the tidal fluctuations is influenced by the bridge that crosses the creek between Station 2 (e.g., SRI-PZ-02) and Station 3 (e.g., SRI-PZ-03). Water underflows the bridge through two large metal culverts, which restrict the natural flow of water. This creates less severe water level changes on the upstream side of the bridge. Smaller diurnal variations, likely due to the regional tidal effect, were present in transducer data from the inland monitoring wells MW-39, MW-38, and TW-8. Diurnal variations were not observed in well MW-3, however. This is likely because this well is situated above the culvert bridge over Clonmell Creek. As noted below, the bridge culvert elevation inhibits flow through the bridge, such that variations in creek water levels present downstream of the bridge are not propagated to locations above the bridge under low water conditions.

The SRI Clonmell Creek study was conducted during a time period when the region was in a severe drought. Surface water levels upstream of the bridge were observed to be lower than surface water levels downstream of the bridge during the days prior to the rain events. During the course of the study, water could typically be seen backing up and moving from downstream to upstream through the culverts under the bridge when the tide gate was closed. The inverts of the culverts under the bridge are too high for water upstream to flow through during low water conditions, such as those experienced during the creek study period. After the rain events, the upstream surface water level was higher and could flow through the culverts. Although surface water elevations changed during the course of the study, the surface water elevations consistently remained higher than those of shallow groundwater.

Each of the water level monitoring points responded relatively quickly to the two rainfall events (occurring on 29 August and 1 September 2002) during the study period. The data indicated that all wells readily responded to changes in the aquifer system. The total rainfall measured by the National Weather Service at the nearby Philadelphia International Airport was 1.31 inches for the first event and 1.36 inches for the second event. The transducer data from the stilling wells SW-2 and SW-3 in the creek indicated a 0.22-foot and a 0.45-foot increase in each well, respectively, during the first event and a 0.37-foot and a 0.40-foot increase, respectively, during the second event. The piezometers and stilling wells exhibited higher water level elevations immediately following each rain event. At these locations, water levels gradually decreased in elevation until the next rain event. The monitoring wells farther inland (MW-39, MW-38, MW-3, and TW-8) exhibited a slight initial increase in the water table after each rain event. The water table remained at a sustained higher elevation due to infiltration of water through the overburden to the ground water table in the days following the precipitation event.

The comparison of the water level responses of Clonmell Creek to those of the nearby Raccoon Creek, near Swedesboro, New Jersey, indicates that Clonmell Creek is behaving in a manner similar to that of other creeks in the region. [ERM, 2003].

FIWP

Delineation of the hydraulic conditions in the northern portion of the Site, near the NCL, the MPP, the SCB, the 002 Outfall, and at the adjacent wetlands and Clonmell Creek was outlined as a goal of the FIWP. In February 2009, eighteen (18) piezometers were installed in the areas around Clonmell Creek, the NCL, the SCB, and the Borrow Pits (Figure 2-2). Several rounds of water levels have been collected from these piezometers to help determine regional groundwater flow. Water levels collected from the eighteen (18) piezometers have added improved resolution to the understanding of the “A-Level” in the northern portion of the Site.

A continuous water level study was conducted on Clonmell Creek from April 20, 2009 to April 24, 2009. In-Situ, Inc. Troll™ electronic data-logging pressure transducers were installed at ten (10) monitoring points: four (4) on the south side of Clonmell Creek (piezometers NCL-4, NCL-10, and NCL-14 and monitoring well MW-32); four (4) on the north shore of Clonmell Creek (piezometers CC-15, CC-17, CC-18, and CC-20); and two (2) in Clonmell Creek on either side of the bridge running from the plant to the SWDA (piezometers SR-PZ-2 and SR-PZ-3). The transducers were set to record water level data every thirty (30) seconds. As described above, a tidal gate at the mouth of Clonmell Creek controls the flow of water draining into the Delaware River, opening during low tide and closing during high tides. During the week of the study (19 April 2009 through 25 April 2009), Philadelphia International Airport received 1.03 inches of rain (0.75 inches on 20 April 2009, 0.27 inches on 21 April 2009, and 0.01 inches on 22 April 2009).

A discussion of the results of the FIWP surface water level study is provided in Section 6 in Surface Water Hydrology.

2.7.3 Geochemical Analysis (Piper Diagrams)

To provide a characterization of Site surface and groundwater geochemistry as described in the Gibbstown FIWP, a total of forty-two (42) samples analyzed for the major anion/cation composition were evaluated. Of these, fifteen (15) were collected from shallow site groundwater wells constructed in the level A-Level, and twenty-seven (27) were collected from site surface waters. Sample locations are shown on Figure 2-4. The results from these samples were tabulated into Piper diagrams which are presented in Figures 2-5 and & 2-6, respectively. These diagrams were used to understand the relationships between shallow groundwater and the SCB and Clonmell Creek. The results of the geochemical analysis are presented in Section 6.3.2.

2.7.4 Interim Remedial Measures – Process Sewer System

A sewer replacement in the APA was performed at the Site between April 2008 and January 2009 as part of an IRM. A detailed description of the IRM is provided in the 2010 IRM Report for Sewer Replacement at the Former Higgins Plant included in Appendix L. The sewer replacement activities were completed as required by the sales agreement between Hercules and GEO. The work was performed in conjunction with ongoing RI activities underway at the Site. Approximately 1,200 feet of new aboveground sewers were installed near the alkylation, recovery and oxidation areas in the APA and IPA. The existing sewer system was either removed or flushed and sealed. The facility is currently not in use, however, potential future use of the sewer system will not increase mass loading of site-related constituents to the subsurface [CSI, 2010].

The sewer replacement project involved the removal of potentially impacted soils in the vicinity of the sewer lines undergoing replacement. Roux Associates Inc. (Roux) was contracted by Hercules to perform soil sampling and to document soil conditions encountered during the sewer replacement project. A total of seventy-seven (77) soil samples and seven (7) duplicate samples were collected from April 2008 through January 2009 from the oxidation, recovery, and alkylation sections of the sewer system. In general, review of the analytical results revealed only sporadic detections of chemical constituents that exceed one or more regulatory criteria (CSI, 2010).

Soil excavated during the sewer system installation was staged north of the boiler house in bermed holding areas and segregated into three separate stockpiles. Additionally, soil immediately adjacent to the portions of the sewer system that were replaced was excavated. The excavated soil from the alkylation, recovery, and oxidation areas was stockpiled separately as a precaution in case different constituents were present in excavated soil from each of the three (3) areas. The stockpiled soil was covered with plastic until transported off-site. Waste characterization samples were obtained from each of the three (3) stockpiles (alkylation, oxidation, and recovery area stockpiles) for laboratory analyses. The results were tabulated to profile the soil for off-site transport and disposal at a licensed disposal facility. A total of approximately 1,400 tons of soil were transported off-Site for disposal. Disposal of excavated soil was initiated in January 2009, while the last soil stockpile, containing 516 tons, was removed from the site on July 17th, 2009 (CSI, 2010).

2.7.5 ARI Waste Removal

In July 2015, CSI worked with a waste disposal contractor on behalf of Hercules to remove the pile of Dalpac catalyst and partial drums of asphalt that were in the CLF/GP EA. In addition, several rolloff containers of concrete waste and railroad ties that were found along the road way in Area B were removed. All material was properly characterized and removed from the facility as non-hazardous waste.

3.0 EXPOSURE AREAS – PROCESS AND INVESTIGATION HISTORICAL SUMMARIES

Twelve (12) IAs were identified at the Site in the Phase I Soils Investigation [ERM, 1989]. This was expanded to nineteen (19) IAs (see Figure 1-4) in the 1995 Phase II Soils Investigation [ERM, 1995]. These IAs were developed by reviewing the following information:

- Results of previous investigations at the Plant including those conducted under RCRA;
- Aerial photography review (1988 Soil Sampling Plan);
- 1987 soil gas screening survey (1988 Soil Sampling Plan);
- Evaluating changes to the physical features at the Plant since 1989;
- Documented spills at the Plant;
- Comparing the New Jersey Non-Residential Soil Cleanup Criteria (8 March 1993 version) with the pre-Phase II data; and
- Specific NJDEP directives in their July 1989 letter [ERM, 1995].

Based on results of previous investigations, each IA was generally understood in terms of the compounds present and the expected lateral limits of chemical compounds in soil. Roadways throughout the Site were generally referenced as boundaries to separate the IAs from each other. The type of chemical compounds used and the processes that have taken place in each IA typically are unique and support separation of the IAs.

The Phase II IAs were carried forward in the SRI [ERM, 2003] and the FI [CSI, 2009]. Addressing data gaps identified by NJDEP and EPA from the previous investigative phases at the Site was a primary goal of the FI. Thus, IAs that were not investigated as part of the FI were considered adequately characterized during previous investigations completed on behalf of the NJDEP and EPA prior to initiating the FI effort.

In preparation for the RI, the BHHRA and the BERA, the site was reorganized into EAs that encompass the entire site property. The previous IAs did not include areas where no evidence of process or disposal history had previously been found. These areas included Areas A and B, which are currently designated to be transferred to the state of New Jersey as part of a pending Natural Resources Damages (NRD) claim. Area A was combined with the adjacent “Open Area” which is the location of the former administration building, guard shack and parking lot at the entrance to the site. The “Open Area” was designated as such by CSI in discussions with the EPA as it is the only portion of the Site that is not encompassed by wetlands, flood plains or former process activities. Figure 1-3 depicts the land use restrictions on the site.

Area B is primarily wetlands and marshy upland areas along Clonmell Creek along the northeastern boundary of the Site property and adjacent to the PRC. The EAs represent areas that have been determined based on the historical and current use of the property, current land features, and anticipated future site use. Figure 1-4 depicts the boundaries of the historic IAs and Figure 1-5 depicts the boundaries of the EAs.

The following is a list of the EAs on the site, with a brief summary of each EA along with a summary of the conclusions for each EA from the Phase II and SRI investigations. The FI and ARI were completed subsequent to the Phase II and SRI investigations, thus the data from those investigations are interpreted as part of this RI. Detailed discussion about the potential risk to human health and the environment and the nature and extent of contamination associated with these EAs are discussed in further detail in Sections 7 & 8 of this report, respectively.

3.1 ACTIVE PROCESS AREA (APA)

The APA is located directly north of the TF/TLA. The APA EA is comprised of the entire APA IA, the southern third of the NW and Southern Warehouses IA, the former break room and the grassy area around the former break room (Figure 3-1).

The APA IA was the center of the Site's former chemical manufacturing operations. Prior to 1970, phenol and acetone were produced at the Site. The chemical process was a three-step process. Benzene was alkylated to cumene, which was oxidized to cumene hydroperoxide, and then cleaved to phenol and acetone. After 1970, the plant produced three products that were organic peroxides: cumene hydroperoxide (85% grade), diisopropylbenzene hydroperoxide (55% grade), and dicumyl peroxide. Five primary raw materials were used in the manufacturing process including cumene (isopropylbenzene); benzene; diisopropylbenzene; twenty-five (25) percent caustic soda (sodium hydroxide solution); and sulfuric acid. The plant was decommissioned in late 2009 through early 2010 and no aboveground structures remain in the former APA. However, extensive subsurface features such as utility lines and concrete pads are still present.

The NW and Southern Warehouses were located along the western Plant boundary and were part of the original plant construction in the mid to late 1950's. The three warehouse buildings in this IA were used for storage, however only the southernmost warehouse is within the APA EA. The warehouses were decommissioned along with the rest of the Site in 2009-2010. Concrete pads are all that remain of these buildings.

Status: This APA IA was investigated during the Ph II, SRI, FI, and CPT. The SRI concluded that this IA was a "soil area requiring consideration for remedial action" because of the exceedance of a single-compound's NJDEP nonresidential direct-contact soil cleanup criteria (NDCSCC); and multiple exceedances of the NJDEP impact to ground water soil cleanup criteria (IGWSCC), with corresponding underlying groundwater contamination.

The Warehouses IA was investigated during the Ph II, SRI and FI. In the Ph II document ERM proposed No Further Action (NFA) for shallow unsaturated soils in this IA because concentrations were below the applicable soil cleanup criteria. The SRI characterized this IA as a “soil area conditionally requiring no further action” because the sole NJDEP IGWSCC exceedance was for trace levels of acetophenone, which was not detected in excess of cleanup criteria in groundwater.

3.2 AREA A/OPEN AREA

The Area A/Open Area (Area A) EA is located directly east of the TF/TLA EA, The APA EA, the IPA EA, the SCB EA and GP EA, west and south of the Shooting Range EA, and south of the Clonmell Creek and Wetlands (CCW) EA (see Figure 3-2). The Area A EA footprint of fifty-two (52) acres does not include any of the historic IAs but instead includes the former administrative area and surrounding parking lot.

The former administration building and a guard shack that was located at the main entrance to the site were demolished in 2016. This portion of the site was designated as the “Open Area” by CSI during discussions with the EPA because it is the only portion of the site that is does not include wetlands, floodplains or former process activity areas (see Figure 1-3).

The remainder of this area consists of a field formerly used for agricultural purposes. Much of this area falls within a portion of the site that is intended to be deeded to the state of NJ under a pending NRD settlement and is designated as “Area A” within that agreement. The Aerial Photography Report and relevant historical research has shown no evidence of industrial use of this area. Area A was investigated during the Ph II, the SRI, the SWDA borrow area test pits sampling events (2003 and 2008) and the ARI. Approximately 9.5 acres in the southeast corner of Area A was excavated and the excavated soil was used to build the cap for the SWDA remediation in 2012 (see Figure 3-2).

3.3 AREA B

The Area B EA is located in the eastern most portion of the Site, north of Clonmell Creek and bordering with the PRC (Figure 3-3). The Area B EA footprint of sixty (60) acres does not include any of the historic IAs, but instead includes undeveloped wetlands and wooded areas. All of this area falls within a portion of the site that is intended to be deeded to the state of NJ under a pending NRD settlement and is designated as “Area B” within that agreement. The Aerial Photography Report showed no evidence of industrial use in this EA [CSI, 2013]. Historical drainage channels can be seen throughout this area can be seen. These are likely related to historical agricultural activities in this vicinity that were used to drain upland areas so they can be used for farming. Area B was investigated during the ARI. Additional samples were collected by PBF Energy in Area B as part of their RI of areas adjacent to their property.

3.4 CHEMICAL LANDFILL/GRAVEL PIT (CLF/GP)

The CLF/GP EA is located directly west of the SCB EA and north of Open Area/Area A EA, and South of the CCW EA. The CLF EA footprint includes all of the GP IA and CLF IA (Figure 3-4).

The GP is a topographic low area (approximately fifteen (15) ft. below the surrounding topography) which was historically used as a gravel quarry. This area was first noted in a 1940 aerial photo as an active gravel quarry in ERM's 1988 Soil Sampling Plan. The quarry is noted as still active in 1951 and possibly in 1954 as well when plant construction began. In the 1959 aerial photo, the quarry is noted as inactive with ponded water present and a pipeline from the treatment plant area present.

This IA also encompasses a former percolation field that consists of an approximately 650-foot pipeline. Process water was discharged from the treatment plant into the percolation field from 1955 to 1957. In the 1965 aerial photo, it is noted that there is possible activity in the western portion of the GP in the vicinity of what is known as the GP CLF. In the 1974 aerial photo, it is noted that quarry activities are being conducted in the western portion of the GP and that a ledge of white material is present in the eastern portion of the pit. This white material is a spent Dalpac catalyst. The material was filter pressed and steamed before disposal in this area [ERM, 1988]. Just east of the area where the Dalpac catalyst is visible multiple drums were found that contained a black asphalt material. Both the drums and the catalyst were characterized and removed from the site as part of the 2015 ARI [CSI, 2015]. None of this material was found to be hazardous or containing compounds that may have contributed to soil or groundwater impacts in this vicinity.

In the 1979 aerial photo, the GP is noted as being almost entirely filled with water, with some activity noted in the northwestern corner. In the 1984 aerial photo the western portion of the gravel pit is noted as having scour marks, while the eastern portion is ponded with water. There are no known activities in the gravel pit area after those noted above.

The CLF lies within the northwest portion of the former GP. The CLF is topographically higher than the adjacent GP area. This IA historically received waste materials from the phenol/acetone process, the para-cresol process, the MPP, the dicumylperoxide process, and spent clay catalyst. Records indicate that landfilling in the GP CLF stopped in 1965. However, the aerial photo review contained in ERM's 1988 Soil Sampling Plan indicates that active quarrying was taking place in this vicinity in 1974 and that scouring of the land was evident in a 1984 aerial photo. No records or personnel could be found to confirm the activities, if any, which took place here in 1974 or 1984.

Status: The GP IA was investigated during the Ph II, the SRI and the ARI. Some limited investigation was done here during the SRI with the following conclusion: "*Exceedances of IGWSCC in this IA were limited to the following: acetophenone that is not detected in ground water; arsenic concentrations below soil reference sample levels; and a single questionable identification of n-nitrosodimethylamine at depth in a location over 100 ft south of the Gravel Pit. N-nitrosodimethylamine was not found above soil cleanup criteria in any of the other IAs. In practice, these soil exceedances are not expected to adversely affect ground water quality, because of their lack of demonstrated ground water impact, low concentration, and isolated occurrence, respectively.*" This IA was determined to be a "*soil area conditionally requiring no further action*" (ERM, 2003). No additional work was done here during the FI, but some additional sampling and waste removal was done during the ARI.

The CLF IA was investigated during the Ph II, the SRI and the ARI. In the Ph II, ERM concluded that this IA required no further action for soils. Additional investigation was done here during the SRI, with the following conclusion for "*portions of the Chemical Landfill: because of exceedances for a limited number of NDCSCC and numerous IGWSCC. Despite these IGWSCC exceedances, only benzene exceeded ground water quality criteria in this IA, in one of five well points installed and sampled in this IA. Thus, despite the general pervious lithology of the Gravel Pit in which the Chemical Landfill is situated, the ground water data suggest that a localized limiting material (e.g. silt or clay) has prevented significant contamination from reaching the water table in the Chemical Landfill area.*" This IA was considered a "*soil area requiring consideration for remedial action*" (ERM, 2003). No additional investigation was conducted here during the FI, however soil samples were collected during the ARI.

3.5 CLONMELL CREEK AND WETLANDS (CCW)

The CCW EA has a footprint of approximately 67 acres. The CCW consists of all onsite portions of Clonmell Creek, the northern most portion of the 002 Outfall IA, and the wetland areas north of the TRA and north of Clonmell Creek but south of the SWDA and west of Area B (Figure 3-5a & 3-5b).

Clonmell Creek, a tidal tributary of the Delaware River, courses northwest through the middle of the property and passes through the Site north of the NCL. Data have been obtained from Clonmell Creek during the SRI, FI, ARI and the Expanded RI Characterization of Impacted Sediment investigations. Results have been previously provided to EPA and NJDEP. The SRI characterized the 002 Outfall IA (the only historical IA within the CCW EA) as a "*soil area requiring consideration for remedial action*" because of the detection of limited PAH exceedances of NDCSCC, plus multiple exceedances of IGWSCC for both Site- and Non Site-related constituents at sample location SRI-WS-4. It was noted that the drainage-way in which this sample is located will be the subject of future ecological evaluations. The sample locations in this EA are shown on Figure 3-5a & 3-5b.

3.6 INACTIVE PROCESS AREA (IPA)

The IPA is located directly north of the APA and south of the SCB and NW EAs. The IPA EA is comprised of the entire IPA IA, the central third of the NW & Southern Warehouses IA, the majority of the LDS IA, the entire Small TF IA, and the grassy area around the Small TF IA (Figure 3-6).

The IPA EA is located north of the APA and formerly housed the Site's para-cresol manufacturing operations. The para-cresol facility was in use from 1963 through 1972. Raw materials used in the para-cresol plant included p-cumene, air, sodium bicarbonate, sulfuric acid, and sodium hydroxide [Hercules Higgins Plant Personnel Manual, 1967]. Most of the para-cresol facility was demolished in 1991. The IPA Pond is located southeast of the para-cresol area and was formerly used for iron precipitation and removal.

The NW & Southern Warehouses were located along the western Plant boundary and were part of the original plant construction in the mid to late 1950's. The three warehouse buildings formerly located on the eastern side of this EA were used for storage, however only the middle warehouse is within the IPA EA. The warehouses were decommissioned along with the rest of the site in 2009-2010. Concrete pads are all that remain of these buildings.

The Small TF was the location of three aboveground storage tanks that stored a variety of fuel oils from initial plant construction in the mid-1950's until the late 1980's. All tanks and structures have been removed from this IA. Tanks T-61 and T-61A, which stored a variety of oils for fuel use, were RCRA-regulated tanks that underwent closure in 1991. Tank T-66 contained No. 6 fuel oil and was demolished in the late 1990's. These RCRA regulated tanks have been closed out of the RCRA program and are now part of this superfund remediation.

The LDS area encompassed the area surrounding the Laboratory and the Boiler House. The concrete drum storage pad was located between these two buildings. This area was used to store drums since plant construction in the mid-1950's until plant decommissioning in 2009. The area was expanded in the late-1980's to provide additional drum storage area. This area has since been decommissioned along with the rest of the Site. Only concrete pads remain.

Status: The IPA IA was investigated during the Ph II, SRI, FI, and CPT. The SRI concluded that this IA was a "*soil area requiring consideration for remedial action*" because of exceedances of NJDEP IGWSCC, with corresponding underlying groundwater contamination. A maintenance building was located within the southeast portion of the IPA. An Underground Storage Tank (UST) was located on the northeast side of the maintenance building. The maintenance building UST was investigated during Ph II and abandoned in place with an NFA recommendation provided by ERM in that document.

The NW & Southern Warehouses IA was investigated during the Ph II, SRI, and FI. In the Ph II document ERM proposed NFA for shallow unsaturated soils in this IA because concentrations were below the applicable soil cleanup criteria. The SRI characterized this IA as a "*soil area conditionally requiring no further action*" because the sole NJDEP IGWSCC exceedance was for trace levels of acetophenone, which was not detected in excess of cleanup criteria in groundwater.

The Small TF IA was investigated during the Ph II. ERM characterized this IA as requiring NFA for shallow unsaturated soils in that document because concentrations were below the soil cleanup criteria. No further investigation was done here during the SRI or FI.

The LDS Area IA was investigated during Ph II and ERM characterized this IA as requiring NFA for shallow unsaturated soils in that document because concentrations were below the soil cleanup criteria. Some limited investigation was done here during the SRI with the following conclusion: "*the low-level acetophenone soil exceedances of IGWSCC in this IA were not detected in downgradient ground water. For the reasons discussed for the Treatment Plant soils above, the soil acetophenone levels observed are not likely to cause an unacceptable future impact to ground water."* This IA was determined to be a "soil area conditionally requiring no further action" [ERM, 2003]. No further investigation was done here during the FI or ARI.

3.7 NORTHERN CHEMICAL LANDFILL (NCL)

The NCL EA has an identical footprint to the NCL IA. The NCL is located between the SCB EA and the CCW EA (Figure 3-7). This EA historically received waste materials from the phenol/acetone process, the para-cresol process, the MPP, and the dicumylperoxide process. Surface disposal in the Northern Chemical Landfill appears to have initiated in the early 1970's and was discontinued in 1974.

Status: This EA was investigated in the Ph II, SRI and FI. The SRI characterized this IA as a "*soil area requiring consideration for remedial action*" because of exceedances of NJDEP NDCSCC; and exceedances of NJDEP IGWSCC, with corresponding underlying groundwater contamination.

3.8 NORTHERN WAREHOUSE AREA (NW)

The NW Area is located directly north of the IPA and south of the TRA EA. The NW EA is comprised of the northernmost part of the Northern and Southern Warehouses IA and the wooded area west of the MPP defined as the Borrow Area in the FI (Figure 3-8).

The NW & Southern Warehouses IA was located along the western Plant boundary and was part of the original plant construction in the mid to late 1950's. The three warehouse buildings in this IA were used for storage, however only the northernmost WH is within the WH EA. The NWs were decommissioned along with the rest of the site in 2009-2010. Concrete pads are all that remain of these buildings.

A portion of the EA known as the NW was also referred to as the "Borrow Pit" during the FI. Prior to the FI fieldwork, Hercules identified an area of potential concern not investigated during the SRI in the "Borrow Pit" area. This area was used in support of the MPP while the MPP was in operation, and contained tanks surrounded by concrete walls. The tanks are gone, however the concrete walls remain. General concerns were raised about the possible presence of phenols in soils in the "Borrow Pit" area on DuPont property adjacent to the NW. Phenol-like odors had been reported in this area and soil samples were obtained during the FI. To remain consistent with historic nomenclature the data obtained from the "Borrow Pit" area has been incorporated into the NW IA.

Status: This IA was investigated during the Ph II, SRI and FI. In the Ph II document ERM proposed NFA for shallow unsaturated soils in this IA because concentrations were below the applicable soil cleanup criteria. The SRI characterized this IA as a "*soil area conditionally requiring no further action*" because the sole NJDEP IGWSCC exceedance was for trace levels of acetophenone, which was not detected in excess of cleanup criteria in groundwater. No evidence of phenols contamination was detected in soil samples obtained from the Borrow Pit portion of the Northern WH during the FI.

3.9 SHOOTING RANGE

The Shooting Range EA has a footprint of approximately 2.5 acres. The Shooting Range is located east and north of Area A and south of Clonmell Creek (Figure 3-9). This area comprises the easternmost portion of the historical gravel quarry. Thus, the area sits at an elevation below the surrounding ground surface with raised walls surrounding three sides of the shooting range. Access to the shooting range is obtained through a ramp built into the eastern wall of the gravel pit. The northern wall of the shooting range (adjacent to Clonmell Creek) has been built up into a barrier that provides the back stop for the munitions used in the range. Only one soil sample has been collected at the Shooting Range during the 2008 SWDA borrow area test pits sampling event. The Shooting Range is an active firing range used by the Borough of Greenwich Police Department.

3.10 STORMWATER CATCHMENT BASIN (SCB)

The SCB is located directly north of the IPA and east of the NW EAs. It also borders the NCL, the CCW, the GP, and Area A/Open Area EAs. The SCB EA is comprised of the entire CF IA, the CTDH IA, the MPP IA, the WWTP IA, the SDB IA, the SF IA, the SI IA, the northern portion of the LDS Area, much of the 002 Outfall and SCB IA, the wooded area around the SCB, and the grassy area around the SF IA (Figure 3-10).

The 002 Outfall IA was a formerly NJPDES-permitted discharge to Clonmell Creek. The outfall historically received surface water runoff from a large portion of the Plant via the Plant's stormwater drainage network. The outfall consisted of a culvert set into a wooden embankment and a dirt drainage swale which allowed open flow to Clonmell Creek. In 1992, the SCB was completed and a Parshell Flume and slide gate were installed to regulate discharge to Clonmell Creek. Discharge to Clonmell Creek has not occurred since October 1991. The SCB was permitted as a NJPDES-permitted discharge to groundwater unit from the mid-1990's until the plant was decommissioned in 2009-2010.

The CTDH IA was located adjacent to the IPA EA and the NW EA. This is an area formerly used to provide utilities to the para-cresol facility. The cooling tower provided cooling water and the heaters provided hot oil for various high temperature processes. The foundations of the three Dowtherm heaters and one cooling tower remain in place within this IA. The para-cresol facility was active from 1963 to 1972 and was demolished in 1991. While no specific records were found, it is assumed that the CTDH was used during this period as well and demolished along with the para-cresol facility.

The CF IA is located east of the CTDH Area. This IA was formerly used as a pilot plant for experimental hydrocarbon cracking and thermal processing. Unreacted and partially cracked hydrocarbons and process water were directed from the furnace to a recovery tank system after thermal processing [Phase II Soils Investigation Work Plan and Field Sampling Plan, ERM, 1989]. The only features remaining from these former processes are concrete foundations/pads. Review of historical documentation indicates that this furnace was constructed in the late-1950's and it was removed from service in the early 1960's.

The MPP was located northeast of the CTDH Area. The foundation and part of the former plant are still present. The MPP surface impoundments (SIs) and a tank pad are also present in this IA. The SIs in the MPP plant were used as neutralization basins. The MPP was a large-scale pilot plant that provided a variety of semi-commercial products on a trial basis. The MPP was in use from 1963 through 1980. The primary product produced was Herban. Raw materials used in Herban production include toluene, dicyclopentadiene, ammonium thiocyanate, water, sodium bicarbonate, dimethylamine, and filter aid. Hercoprime, BAPP salts, Merigraph, Resin 2064, Emulsion 2070 and diisobutylene (DIB) were also produced at the MPP plant for a short time. [Hercules Higgins Plant Personnel Manual, 1967].

The WWTP, initially constructed in 1954, formerly utilized a bioaeration process to treat wastewater and recovered ground water. The most prominent feature in this IA is the bioaeration tank which supported the suspended growth system referred to as "activated sludge." The original bioaeration tank was replaced with the current tank in 1991; the circular foundation of the original tank is still present. Spent "activated sludge" was dried and disposed of off-site. The bioaeration treatment process was discontinued in 2009 in conjunction with the shutdown of the plant. Once the plant was shut down, an activated carbon groundwater treatment unit was installed in the vicinity of the historical treatment plant in 2009. The historical treatment plant buildings and apparatus remain, but are largely unused.

The WWTP SIs are located between the SDBs and the WWTP. These impoundments formerly served as equalization basins for process water prior to processing at the Treatment Plant and were part of the original wastewater treatment process starting in the mid-1950's. They are referred to as "equalization basins" in many of the historical investigation documents. Their approximate capacity is 1,000,000 gallons. The impoundments are constructed of gunnite which remains intact as evidenced by rainwater that accumulates within the impoundments and does not appear to infiltrate through the impoundments sidewalls and bottoms. The SIs were taken out of service, cleaned and administratively closed in 1989 and have been unused since then.

The SDsB borders the eastern bank of the 002 Outfall. This IA formerly received sludge generated by the bioaeration tank of the WWTP. The SDBs were constructed as part of the original WWTP in the mid-1950's. A Soil Sampling Plan produced by ERM in June 1988 indicates that the sludge drying process was terminated sometime in early 1981 [Soil Sampling Plan, ERM, 1988]. A berm was constructed to surround the beds and approximately two feet of dry, peat-like and black granular material was present in the bottom of the beds. The bermed area remains today, but no evidence of the dry, peat-like and black granular material was found during recent investigations.

The SF IA is an approximately 40,000 square foot area [Soil Sampling Plan, ERM, 1988] located south of the WWTP. This IA was formerly used for spray irrigation of effluent from the WWTP. The IA is currently an open grassy field. Historically, small solidified tarry patches were found in a low-lying basin within the SF. Aerial photos taken in 1965 show scour marks in the northern section of the SF. This area was used for spray irrigation of effluent from the Treatment Plant from the mid-1960's until 1972.

The LDS area encompassed the area surrounding the Laboratory and the Boiler House. The concrete drum storage pad was located between these two buildings. This area was used to store drums since plant construction in the mid-1950's until plant decommissioning in 2009. The area was expanded in the late-1980's to provide additional drum storage area. This area has since been decommissioned along with the rest of the Site. Only concrete pads remain.

Status: The 002 Outfall IA was investigated during the Ph II, SRI and FI. The SRI characterized this IA as a "*soil area requiring consideration for remedial action*" because of the detection of limited PAH exceedances of NJDEP NDCSCC, plus multiple exceedances of

NJDEP IGWSCC for both Site- and Non Site-related constituents at sample location SRI-WS-4. SRI-WS-4 is located within the 002 Outfall IA, however, it is not located within the SCB EA (see Clonmell Creek and Wetlands below). It was noted that the drainage-way in which this sample is located will be the subject of future ecological evaluations. Remedy evaluation and selection in this area will incorporate the results of the ecological risk evaluation. Additional sampling was performed in this IA during the FI.

The CTDH IA was investigated during the Ph II, SRI and FI. In the Ph II document ERM proposed NFA for shallow unsaturated soils in this IA because concentrations were below the applicable soil cleanup criteria. The SRI characterized this IA as a "*soil area requiring no further action*" because the soil sample analytical data from this area met the cleanup criteria. Sampling in this IA during the FI was focused on historical subsurface utility lines running through this area.

The CF IA was investigated during the Ph II and was deemed as requiring NFA for shallow unsaturated soils in Ph II because concentrations were below the soil cleanup criteria. Limited investigation was done here during the SRI and the conclusion was: "*Trace levels of acetophenone in excess of IGWSCC are present in this IA. However, the absence of acetophenone in adjacent ground water, and the area's lithologic similarity to the Treatment Plant indicates that this IA is not likely to cause an unacceptable future ground water impact*." This IA was determined to be a "*soil area conditionally requiring no further action*" [ERM, 2003]. Some sampling was done in this IA during the FI to investigate potential impacts from historical pipelines that existed in this vicinity (part of sewer investigation).

The MPP IA was investigated during the Ph II, SRI, FI, and ARI. The SRI characterized this IA as a "*soil area requiring consideration for remedial action*" because of exceedances of NJDEP NDCSCC; and exceedances of NJDEP IGWSCC, with corresponding underlying groundwater contamination.

The WWTP IA was investigated during the Ph II and was characterized in the Ph II Report as requiring NFA for shallow unsaturated soils because concentrations were below the soil cleanup criteria. Some limited investigation was done at the WWTP IA during the SRI. The SRI concluded the following: "*Acetophenone, which exceeded IGWSCC in this IA at less than one-ppm levels, was not detected in ground water in a well situated directly downgradient from the soil exceedance locations. As with the Sludge Drying Beds, given the solubility of this compound and the sandy lithology in the Treatment Plant area, the soil acetophenone levels observed are not likely to cause an unacceptable future impact to ground water.*" This IA was determined to be a "*soil area conditionally requiring no further action*" (ERM, 2003).

The SI IA was investigated during the Ph II, SRI and FI. Groundwater monitoring in the vicinity of this unit is still underway. This former RCRA unit was administratively closed out with NJDEP and the EPA as noted in Section 1.2.4 above. The soils beneath the impoundment will need to be evaluated subsequent to the removal of the unit. The SRI characterized this IA as a "*soil area requiring consideration for remedial action*" because limited NJDEP IGWSCC exceedances were noted in this area. Although downgradient groundwater may have been receiving the majority of its loading from the NCL to the north of the SI, given that soil contamination in this area decreased with depth [GTI, 1990].

The SDB IA was investigated in the Ph II, SRI and FI. The IA was investigated during Ph II and ERM provided an NFA recommendation for shallow unsaturated soils because concentrations were below the soil cleanup criteria. The SRI concluded that: "*Despite moderate-level detections of acetophenone and alpha-methylstyrene, and a reference-sample-level arsenic detection above IGWSCC, these compounds were not detected in downgradient ground water. Given that the solubilities of acetophenone and alpha-methylstyrene are high, 5,500 and 600 mg/l in water, respectively, and that the lithology underlying this area is predominantly sandy, it is concluded that maximal leaching of these compounds should already have occurred in the years since this IA was taken out of service. Thus, the concentrations in soil are not a threat to ground water.*" This IA was determined to be a "*soil area conditionally requiring no further action*" [ERM, 2003].

The SF IA was investigated during the Ph II and was characterized in the Ph II Report as requiring NFA for shallow unsaturated soils because concentrations were below the soil cleanup criteria. Additional limited investigation was done here during the SRI and the conclusions were that "*levels of arsenic below SRI reference sample levels, and acetophenone concentrations that exceeded IGWSCC without ground water detections, indicate that these soils are not a source of site-related constituents to ground water. The lithology in this IA is similar to that at the adjoining Treatment Plant, with added clay lenses. This lithology, coupled with the high aqueous solubility of acetophenone, indicates that the soil acetophenone levels observed are not likely to cause an unacceptable future impact to ground water*." This IA was determined to be a "*soil area conditionally requiring no further action*" [ERM, 2003]. No further investigation was done here during the FI.

Only the northernmost portion of the LDS IA falls within the SCB EA. The LDS IA was investigated during the Ph II and ERM characterized this IA as requiring NFA for shallow unsaturated soils in that document because concentrations were below the soil cleanup criteria. Some limited investigation was done here during the SRI with the following conclusion: "*the low-level acetophenone soil exceedances of IGWSCC in this IA were not detected in downgradient ground water. For the reasons discussed for the Treatment Plant soils above, the soil acetophenone levels observed are not likely to cause an unacceptable future impact to ground water*." This IA was determined to be a "*soil area conditionally requiring no further action*" [ERM, 2003]. No further investigation was done here during the FI.

3.11 TANK FARM (TF)/TRAIN LOADING AREA (TLA)

This EA is located in the southwest corner of the Site and includes three (3) IAs, the TF, the TLA, and the CLA as well as a small field east of the TF IA (Figure 3-11).

The TF is located in the southwest corner of the Site. In the past, the TF accommodated sixteen (16) above ground storage tanks, each tank surrounded by an asphalt-covered soil berm. Chemicals stored in the TF included: benzene, cumene, phenol, acetone and para-cymene. This area was actively used for storing chemicals from the time the plant was built in 1954 until plant decommissioning was initiated in 2009. The TF was decommissioned in 2009-2010 and no tanks remain. However, remnants of the tank berms remain. The field to the east of the TF has never been used in the industrial process.

The former TLA is located along the western Plant boundary. The train tracks no longer exist but some of the underlying ballast remains. The TL area was primarily used for offloading, loading, and cleaning rail cars. Three abandoned USTs used in the rail car cleaning process remain in the area. Railroad spurs for the TL are present in aerial photos from 1958 suggesting that the TLA was in use early in the plant's history. Review of available records indicate that the rail car cleaning apparatus was abandoned prior to 1980, thus it is assumed that train loading activities were discontinued in the late 1970's. Interviews with former plant personnel indicate that the railroad tracks were removed from the plant in the mid-1980's and that the railroad ties were removed in the mid-1990's.

The CLA is located between the TLA, TF, and APA. Prior to plant decommissioning, above ground horizontal tanks located in this IA contained: cumene, diisopropylbenzene, diisopropylbenzene hydroperoxide, and cumene hydroperoxide. The CLA was primarily utilized for tanker loading and offloading. The CLA was likely active for the entire length of plant operations. The CLA is clearly present in aerial photos from 1958 and early plant drawings. The CLA was in use until the decommissioning of the Site in 2009.

Status: The Tank Farm IA was investigated during the Ph II, SRI, FI and the Supplemental Shallow Groundwater Investigation [CSI, 2011]. The SRI concluded that this IA was a "soil area requiring consideration for remedial action" because of exceedances of IGWSCC, with corresponding underlying groundwater contamination.

The TLA IA was investigated during the Ph II, SRI, FI, and ARI. The SRI concluded that this IA was a "soil area requiring consideration for remedial action" because of exceedances of NJDEP IGWSCC, with corresponding underlying groundwater contamination.

This CLA IA was investigated during the Ph II, SRI, and CPT. The SRI concluded that this IA was a "soil area requiring consideration for remedial action" because of exceedances of IGWSCC, with corresponding underlying groundwater contamination.

3.12 TOWNSHIP REFUSE AREA (TRA)

The TRA is located directly north of the NW EA and also borders the west side of the SCB EA. The CCW EA is north of the TRA and the western Site fence line lies to the west of this EA. The TRA EA is comprised of the TRA/Landfill Area IA and the wooded and wetland areas surrounding it (Figure 3-12).

The TRA/Landfill Area was not considered a site-related IA, however it was investigated historically as part of the site. The TRA/Landfill Area is a heavily vegetated area that has a non-engineered soil cover over a majority of the waste materials that are present. The area was in use in the late 1940's and operations in this area ceased by the mid 1950's. As indicated by the results of geophysical testing, hand augering, surface soil sampling, and backhoe test pit installation in the Ph II (1995), the western portion of the TRA consists largely of natural undisturbed soil, with only a few, small, isolated areas of surficial refuse. The eastern portion of this IA, particularly the northeastern portion of this IA, has shown evidence of non-putrescible municipal-type refuse material. The materials encountered were characteristic of municipal refuse, although typical municipal refuse would consist of a greater diversity of material. This suggests that only select types of materials were disposed of in the TRA/Landfill Area and that this IA did not serve as a primary repository for municipal waste from the surrounding localities.

Status: This IA was thoroughly investigated during the Ph II, the SRI, the FI and the ARI. The SRI indicated that metals and PAHs detected within the waste were the only detected constituents of concern. The compounds detected are not associated with the Hercules site and are thus only associated with the historical township waste disposal activities. This IA was determined to be a "*soil area conditionally requiring no further action*" [ERM, 2003].

4.0 DATA MANAGEMENT

A large amount of analytical data has been generated during the extensive Site investigation history, which necessitated the use of a comprehensive data management system. Historic data has been assessed to confirm both completeness and accuracy.

Both field and laboratory analytical data are electronically downloaded directly into the Sites database when possible. Most often this is done via an Electronic Data Deliverable (EDD) provided directly from the laboratory. This method of data management ensures a high degree of accuracy by eliminating transcription and other human errors. A copy of the database is kept on the CSI server in Millersville, MD. This server is secured behind a firewall. Furthermore, the database is password protected to ensure security.

After the analytical data are validated, modifications will be made to the existing database. These data are then uploaded to the EPA via the Region II EDD.

The database provides flexibility in terms of data presentation and screening capabilities that facilitate data interpretation. In addition, the database is electronically linked with ArcGIS to facilitate the generation of figures. This allows site analytical data to be electronically transferred directly on ArcGIS figures. This capability also ensures a high degree of accuracy by eliminating human error.

Electronic copies of the laboratory reports are stored on the CSI server. In an effort to conserve resources, hard copies of laboratory reports will not be generated unless specifically requested by the EPA. All records will be maintained in accordance with CERCLA record retention guidelines, for a minimum of 7 years after commencement of construction activities on the final remedy as specified in the SA [EPA, 2009].

4.1 DATA QUALITY ASSURANCE QUALITY CONTROL

Data collected from 2009 to present follows the following procedures outlined in the QAPP [CSI, 2015]. Analytical laboratories (primarily TestAmerica Savanah) performed in-house analytical data reduction and Quality Assurance (QA) review. Full detail on the data quality assurance and quality control can be found in the 2015 QAPP, included in Appendix F.

4.2 SAMPLE MANAGEMENT AND TRACKING

The possession of samples was traceable from the time they are obtained until the analytical laboratory disposes of them. Full detail on the sample management and tracking can be found in the 2015 QAPP, included in Appendix F.

4.3 DOCUMENT CONTROL AND INVENTORY

Data collected from samples prior to 1995 were managed in accordance with:

- Sections 2.3.4 and 2.4.4 in the Phase II Report (ERM, 1995); and,
- Sections 8 through 14 of the Phase II Remedial Investigation QAPP (ERM, 1994).

Data collected from samples between 1995 and 2008 were managed in accordance with:

- Section 2.11 of the SRI (ERM, 2003); and,
- SRI QAPP Addendum (ERM, 2002).

Data collected from samples between 2008 and 2014 were managed in accordance with the QAPP for the FIWP [CSI, 2008

Data collected from samples from 2015 through present were managed in accordance with a Federal Uniform Policy compliant QAPP [CSI, 2015]. A complete copy of this QAPP is included in Appendix F.

5.0 CONCEPTUAL SITE MODEL

According to the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA the Conceptual Site Models (CSM) should “include known and suspected sources of contamination, types of contaminants and affected media, known and potential routes of migration, and known or potential human and environmental receptors.” [EPA, 1988]

To achieve this goal, the CSM condenses and summarizes information from several sections of the RI document including: Site Background (Section 1.2), Contaminant Sources and Nature and Extent (Section 8), Fate and Transport (Section 9), Risk Assessment (Section 7), and Site Hydrology (Section 6).

5.1 SITE AND HISTORIC PROCESS OVERVIEW

The Site is situated north of the town of Gibbstown in the Township of Greenwich, in Gloucester County, New Jersey. Bordering the Site to the south is Gibbstown. Gibbstown covers approximately 1.6 square miles and has a population of just over 3,700 [Wikipedia, 2015].

The Site and its vicinity are depicted on Figures 1-1 & 1-2. The Site is bound to the north by the Delaware River. East of the Site are PRC tank farms and landholdings. To the south and west of the Site are residential and public properties in the city of Gibbstown, New Jersey. A public recreation area that includes ball fields and a street hockey rink is located west of the former TF, TLA, Southern Warehouse, and APA. Property owned by DuPont is also located to the northwest of the Site.

The layout of the plant operation areas corresponded with the former production process, with delivery of raw materials, followed by plant processing applications in sequence progressing across the layout of the plant. The majority of chemical production and storage related activities took place near the plant entrance in the southern portion of the facility. During processing, wastewater and waste product were separated. Waste product was recovered for reuse in the process while waste water was directed to facilities in the northwestern portion of the Site south of Clonmell Creek.

Prior to 1970, phenol and acetone were produced at the Site. The chemical process was a three-step process. Benzene was alkylated to cumene, which was oxidized to cumene hydroperoxide and then cleaved to phenol and acetone.

After 1970, the plant produced three products. All three were organic peroxides: cumene hydroperoxide (85% grade), diisopropylbenzene hydroperoxide (55% grade), and dicumyl peroxide. The four major raw materials used in the manufacturing processes were cumene (isopropylbenzene), diisopropylbenzene, 25% caustic soda (sodium hydroxide solution), and sulfuric acid.

The Site process sewer system carried all wastes fluids to an API skimmer, located between the APA and IPA, where the pH was adjusted to a range of 5-9 by addition of sulfuric acid. The oils were collected and pumped to the batch still to reclaim and recycle cumene. The skimmed waste was adjusted to a final pH between 6 and 8 and pumped to the equalization tank. The water was then treated at the WWTP.

5.2 HYDROGEOLOGY

The major stratigraphic units present in the area are, from oldest to youngest:

- Precambrian Age (greater than 600 million years old) bedrock;
- Cretaceous Age (135 to 60 million years old) deposits of the Potomac-Raritan-Magothy (PRM) Formation;
- Pleistocene Age (500,000 to 11,000 years old) deposits (that may include sediments belonging to the Trenton Gravel, Van Sciver Lake beds formation and the Spring Lake beds formation). The Pleistocene-age sediments subcrop near the Site and are poorly understood in the Study Area based on available literature review; and
- Holocene (11,000 years old to present) alluvial deposits on the Delaware River floodplain.

At the Site, the shallow (A-level) monitoring well network is screened into these Pleistocene deposits, the medium depth (B-level) monitoring well network is screened in the Upper Middle PRM aquifer, the deepest monitoring wells at the Site are screened into the C-level unit which correlates to the Lower-Middle PRM aquifer. The C-level is underlined by a continuous aquitard, which separates the Lower-Middle PRM from the Lower PRM. The lower PRM is not monitored at the Site. The above described hydrogeology is graphically depicted in a conceptual cross section of the Site on Figure 5-1.

Regional groundwater (B-level and C-level) generally flows from north to south. Historically, regional groundwater would have flowed north toward the Delaware River. However, decades of heavy pumping, including pumping for municipal and industrial uses, has reversed the flow to the southeast (Charles et al, 2011).

In general, shallow groundwater and Site-specific COCs in the overlying A-level sediments are migrating downward into the B-level predominantly through higher permeability gaps in the confining sediments separating the A- and the B-levels. Numerous hydraulic studies have been completed at the Site and indicate that there is a downward groundwater flow gradient and that the A- and B-levels are hydraulically interconnected. Moreover, these studies also have shown a high degree of hydraulic interconnection between the B-level and underlying C-level at the Site due to the discontinuous nature of the intervening clay deposits at the Site. This downward hydraulic communication has also been refined and thoroughly documented through numerical groundwater modeling for the Site and further verified through aquifer testing. Thus, while the actual flow paths are difficult and impractical to define precisely, the general groundwater migration patterns and tendencies are well understood and reflected accordingly in the detailed Site numerical groundwater model. Final calibrated model output results correlated closely with field data.

Groundwater flow in the A-level is complex due to the natural reworked depositional history and resultant heterogeneity within the A-level sediments. The configuration of the potentiometric A-level surface is indicative of localized mounding determined by the presence or relative absence and shape of the underlying low permeability silt and clay deposits that typically separate the A-level from the B-level in most Site areas. In locations where the low permeable silts and clays are less extensive or absent altogether, hydraulic elevations within the A-level more closely mimic potentiometric head levels in the underlying B-level, as expected, suggesting a higher degree of vertical communication in these locales. In general, groundwater in the A-level has a downward gradient toward windows in the clay separating the A-level from the underlying B-level.

In the northern portion of the Site, extensive low permeability peat, silt and clay lenses extend from ground surface to a depth of fifteen to twenty (15 – 20) ft. bgs along the boundary of the NCL and Clonmell Creek. As such, there is negligible hydraulic communication between Clonmell Creek and the local water table. The water level of Clonmell Creek is constantly above that of local groundwater table, so what limited hydraulic communication may exist would be from the creek to shallow groundwater. The overall geomorphology of this area reflects the varying nature of the Holocene-age terrace deposits. In essence, the configuration of the swampy wetlands and Clonmell Creek itself reflect the presence of underlying low permeability deposits which support or ‘bench’ these saturated features. This area also acts as a general recharge zone for the underlying B-level, especially where more permeable sandy terrace deposits are in hydraulic communication with the underlying B-level formation, such as along the east-central portion of the NCL.

Based on available historic information, surface water drainage at the Gibbstown Plant was formerly redirected from the southern portion of the site and routed overland in a northerly direction toward the back of the plant through a system of swales, ultimately draining into the SCB (Figure 5-2). Prior to 1991, storm water discharged directly through the swale system to Clonmell Creek through what is currently designated as the 002 Outfall. In the late 1980’s and early 1990’s the plant modified its storm water management system. Storm water from within the process areas was collected, stored, and ultimately treated at the WWTP. Storm water from non-process areas were routed to the SCB. An outfall was installed circa 1991 to restrict periodic storm water discharge from the SCB to the 002 Outfall and ultimately to Clonmell Creek. Storm water discharge through the 002 Outfall has not occurred since the installation of a berm and outfall structure separating the SCB from the 002 Outfall (circa 1991). A National Pollutant Discharge Elimination System (NPDES) discharge to groundwater (DGW) permit was formerly put in place by GEO for the SCB to regulate storm water recharge to groundwater at the SCB. The NPDES DGW Permit was discontinued in 2010 after the plant was decommissioned.

5.3 SITE-RELATED COC DISTRIBUTION

While there are a number of possible constituent release and transport mechanisms, specific mechanisms are unknown and can only be surmised based on the observed distribution of Site-related COCs relative to Site features. In general, COCs detected in soil and groundwater samples at the Site are believed to be the result of releases and fugitive emissions consistent with operation of a large scale chemical manufacturing facility for fifty (50) plus years. This generalization correlates reasonably well with the location of detected Site-related COCs and their mass distribution relative to the location of former plant process areas. In addition, historical subsurface process sewers in the former APA that were connected to the API skimmer located along the boundary of the APA and the IPA may also have contributed to subsurface cumene distribution. These processes are depicted conceptually on Figure 5-3. A conceptual overview depicting the subsurface conditions in the former process areas is depicted on Figure 5-3. This figure includes a generalized view of the hydrogeologic features in the primary process areas for the former chemical manufacturing facility, along with hypothetical release points, to illustrate the general occurrence and distribution of Site-related COCs in the primary process area.

The majority of the Site-related COC mass (constituent mass) is located in shallow subsurface soils from approximately ten to twenty-five (10 – 25) ft bgs near former plant operational areas. Cumene is the most abundant Site-related constituent at the Site and readily partitions to subsurface soil. R-NAPL composed of Site-related COCs has been identified in the subsurface near the former process sewers and API skimmer, suggesting a possible correlation. The R-NAPL consists predominantly of non-mobile and diffuse droplets adsorbed onto soil particles near the water table and within the saturated shallow water-bearing horizon. The hypothetical correlation between former process features at the Site and the general occurrence and distribution of Site-related COCs are conceptually displayed on Figure 5-3. The occurrence of dispersed R-NAPL in the subsurface is confined to the A-level formation, mostly from the top of the water table to the top of the underlying silt and clay deposits separating the A-level from the underlying B-level. Neither R-NAPL nor significant adsorbed-phase Site-related COCs are present below the base of the A-level (CSI, 2015a & 2015b).

The bulk of the Site-constituent mass consists of cumene adsorbed to soil and sporadically disbursed in the R-NAPL. The dispersed R-NAPL exists within pore spaces along with water and air, and is held in place by interfacial tension. As described in Section 2.6.4, in samples sent for analysis, dispersed R-NAPL represented between 9.9% and 12.4% of the total pore space volume. Review of the mobility testing reveals that the R-NAPL is predominantly immobile. Details associated with R-NAPL evaluation and mobility testing were defined and provided in a summary letter report that was submitted to the EPA. Site-specific testing demonstrates that only 15% of the R-NAPL was found to be mobile. Thus, in areas where dispersed R-NAPL is present, only about 1.5% to 1.8% of the soil matrix contains mobile R-NAPL (CSI, 2015 & 2015).

Mass distribution estimates are being refined but preliminary indications suggest that greater than 80% of the constituent mass is present as adsorbed phase and dispersed R-NAPL in A-level sediments underlying the former process areas. An estimated fifteen to twenty percent (15% to 20%) are adsorbed onto sediments or as R-NAPL within the pore spaces of the Clonmell Creek sediment and also adsorbed onto SCB sediments.

Dissolved-phase Site-related COCs in groundwater, though more widespread in extent, represent a smaller proportion of the overall constituent mass (less than 2% of the preliminary total constituent mass estimates as summarized above). Downward vertical hydraulic gradients combined with gaps in the underlying confining beds of clay and silt have contributed to the downward vertical migration of dissolved-phase cumene and other Site-related COCs to the underlying B- and C-level formations at the Site.

Extensive regional groundwater pumping in the underlying C-level of the PRM aquifer has also contributed to the downward migration of dissolved-phase constituents by increasing downward hydraulic gradients and flow rates. As a result, a network of strategically located groundwater extraction wells have been installed at the Site and pumped since the mid-1980's to establish hydraulic containment of Site-related COCs and prevent downgradient cumene and benzene migration to regional municipal water supply wells. To date, this network of groundwater extraction wells has been highly effective in maintaining hydraulic capture and containment. However, groundwater recovery and treatment is not an ideal remedial approach for mass reduction because the majority of the constituent mass is present as adsorbed phase and R-NAPL in shallow saturated soil as noted above. As previously described, a detailed Site-specific numerical groundwater model has been developed to quantify groundwater flow conditions as well as to optimize groundwater pumping and contaminant containment.

Extensive constituent mass, again predominantly cumene, also is present in sediments within Clonmell Creek and the SCB (the sediments contain an estimated fifteen percent to twenty percent (15% – 20%) of the total Site constituent mass as summarized above). This constituent mass is believed to have been transported to the SCB and to Clonmell Creek via overland surface water flow from the main plant areas. Prior to 1991, surface water drainage ultimately discharged to Clonmell Creek along the 002 Outfall. A new outfall structure was completed circa 1991 to restrict surface water drainage to Clonmell Creek via the 002 Outfall.

The highest cumene concentrations have been detected in sediment samples near the confluence of the 002 Outfall and Clonmell Creek. This is consistent with historical Site use and drainage patterns. Recent studies have shown that the cumene is entrained in sediments below the water-sediment interface where anaerobic conditions preside. Evidence suggests that dispersed R-NAPL is likely present in sediments where anaerobic conditions prevail. The dispersed R-NAPL is entrained within the organic silty sediments and is essentially immobile. Closer to the sediment-water interface, where aerobic conditions occur, cumene concentrations are significantly lower. In addition, pore water studies have shown that the partitioning of cumene from sediment to surface water is minimal. BERA criteria were evaluated to determine potential exposure pathways and ecological risks posed by the contaminated sediments in Clonmell Creek. Constituent mass is also present in the shallow soils and in a perched water zone within the NCL and CLA, adjacent to Clonmell Creek.

The NCL was in use at the Site from the early 1970s through 1974 and historically received waste materials from the various processes occurring at the Site (CSI, 2014). As summarized previously, low permeable soil including organic rich clayey silts along the bank of the creek and in the terraced deposits underlying the NCL hydraulically segregate Clonmell Creek (and the surrounding wetlands) from the local water table to a large extent. As stated previously, the water level of Clonmell Creek is constantly higher than the local groundwater table, thus what limited hydraulic communication there is would be from the creek to the groundwater. Localized terrace deposits that are more permeable (e.g. sand) have been sporadically identified in places such as along the eastern edge of the NCL and enable recharge to the underlying B-level formation. In general, the bulk of the contamination is in shallow soils; however, due to the highly variable nature of the geology, a seasonally perched water zone has been observed under high water level conditions (e.g. in the spring) to the east of monitoring well MW-39 (see Figure 5-4). Diffuse R-NAPL has been observed when the perched water zone is present, though this zone appears to have negligible hydraulic communication with Clonmell Creek. A conceptual depiction of this area is illustrated on Figure 5-5.

Continuous operation of the extensive Site groundwater pumping network has successfully achieved hydraulic containment of Site-related contaminants since the mid-1980’s, further reducing off-Site exposure potential. A detailed VI study was completed along the downgradient property boundary in 2010 – 2011 and it was concluded that no shallow groundwater or vapor migration exposure pathway exists for nearby residents. Further analysis of potential risks to human health and the environment has been completed and submitted in a Site-wide BHHRA and BERA (RBR, 2017 & RBR, 2017). Site conditions do, however, include potential direct exposure pathways associated with potential future on-Site workers. Potential historical exposure pathways such as the Site sewer system, tank releases, and wastewater outfall points have been eliminated with the decommissioning of the facility circa 2010. Remaining contamination is present as residual phases in Clonmell Creek sediment, Site soils, and in Site groundwater at the southwestern portion of the Site. Considering that SSCOCs are not detected above RI screening values, most of the remaining potential exposure pathways would be associated with Site re-use, redevelopment or (in the case of stream sediments and wetland areas) trespassing.

Complete ecological pathways evaluated in the BERA included:

- Direct contact with surface water, pore water and sediment by aquatic plants, invertebrates, or fish;
- Ingestion of surface water and incidental ingestion of sediment by semi-aquatic mammals or birds; ingestion of surface water by terrestrial mammals and birds;
- Ingestion of aquatic plants, invertebrates, and aquatic animal prey by semi-aquatic mammals or birds;
- Direct contact with wetland soil by plants or invertebrates;
- Incidental ingestion of wetland soil by mammals and birds (i.e., incidental ingestion of soil as a result of feeding or grooming); and
- Ingestion of plants, invertebrates and/or small animal prey from the wetland area by mammals and birds.

5.4 RISK TO HUMAN HEALTH AND THE ENVIRONMENT

A BHHRA and BERA were performed by RBR in preparation for the RI. The HHRA and the BERA apply a numeric risk value based on chemical concentration in various media at the Site and realistic exposure scenarios.

The results of the BHHRA and BERA are summarized in greater detail in Section 7. However, the results of the BHHRA and BERA corresponded closely to the contaminant mass distribution discussed in Section 5.3, with the highest risks associated with the former process areas and Clonmell Creek.

6.0 PHYSICAL CHARACTERIZATION OF STUDY AREAS

6.1 SOILS/GEOLOGY

The 1983 Ph II report, "Installation of Ground Water Monitoring System for Hercules, Inc., Gibbstown, New Jersey," describes in detail the regional geology in the vicinity of the Plant. In addition, the "Soil Sampling Plan, Higgins Plant, Gibbstown, New Jersey, (revised June 1988)," the "Revised 1988 Soils Investigation Report," the "Phase II Soils Investigation Report (September, 1995),"and the "Supplemental Remedial Investigation Report (January, 2003)," which have previously been submitted to NJDEP/EPA, describe the general local geology at the Plant. These reports are included in the project chronology included in Section 1.2.2 of this report.

The USGS Water Resource Investigation Report 90-4198, "Hydrogeology of the Region of Greenwich Township, Gloucester County, New Jersey, 1991," is a comprehensive reference on the local geology, and its documentation of the local geology and ground water is incorporated in this RI Report. Additional information from "Bedrock Geology of the Bridgeport and Marcus Hook Quadrangles, Gloucester and Salem Counties, New Jersey, Geologic Map Series GMS 06-1 [Stanford and Sugarman, 2006]," and "Surficial Geology of the Bridgeport and Marcus Hook Quadrangles, Gloucester and Salem Counties, New Jersey, Geologic Map Series GMS 06-2 [Stanford, 2006]"were used localized geology.

The plant property is located within the Atlantic Coastal Plain physiographic province. This geologic province is characterized by the presence of a sequence of thick unconsolidated sand, silt, gravel, and clay layers. The major stratigraphic units present in the area are, from oldest to youngest:

- Precambrian Age (greater than 600 million years old) bedrock;
- Cretaceous Age (135 to 60 million years old) deposits of the PRM Formation;
- Pleistocene Age (500,000 to 11,000 years old) deposits of the Trenton Gravel (formerly referred to as the Cape May Formation); and
- Holocene (11,000 years old to present) alluvial deposits on the Delaware River floodplain.

The PRM Formation constitutes the regional aquifer system supplying water resources to Greenwich Township and the surrounding area. The aquifer system subcrops in a three to five (3- to 5-) mile-wide band roughly paralleling the Delaware River in the Greenwich Township region. The Upper Aquifer of the PRM does not exist at the Site. Thus, regionally the formation is generally considered to consist of three aquifers (Upper Middle, Lower Middle, and Lower), which are separated by two confining units, with the Trenton Gravel sitting on top of the PRM over much of the Site. At the site, the shallow, or A-Level, monitoring well network is screened in the Trenton Gravel and Holocene deposits, the medium depth, or B-

Level, monitoring well network is screened in the Upper Middle PRM aquifer, the deep, or C-Level, monitoring well network is screened in the Lower Middle PRM aquifer.

6.2 GROUNDWATER HYDROLOGY

As depicted in Figure 6-1, surface geology at the Site consists of Trenton Gravel and Holocene Estuarine Deposits (Stanford, 2006). The majority of the sample locations collected as part of the RI were taken in the Trenton Gravel, with the exception of samples taken in the 002 Outfall, the NCL, the TRA, and Clonmell Creek and its surrounding wetlands. Ground surface elevations at the Site range from five (5) ft. above mean sea level (msl) near the SCB to fourteen (14) ft above msl at wells just southwest of the property boundary. The potentiometric surfaces from the 2nd Quarter 2017 groundwater monitoring event for the A-level and combined B and C-Levels can be found on Figures 6-2 and 6-3, respectively.

During the RI sampling investigation, groundwater was first encountered typically between one (1) ft below msl and one (1) ft above msl. The top of the confining layer for this unit ranged from one (1) ft below msl to fourteen (14) ft below msl, with the bottom of the confining layer typically ranging from seven (7) ft below msl to twenty-five (25) ft below msl. Regionally the unit slopes to the southeast at 0.75-1 % [USGS, 1991].

The clay confining the Trenton Gravel formation on the Site is semi-continuous with no clay in the areas around MW-11, MW-9, MW-5 and south of the property line southeast of the TF. In the northern portion of the APA the confining clay disappears completely north of the CTDH area, where the upper part of the middle PRM aquifer subcrops and the A-Level no longer exists.

The clay underlining the Trenton Gravel mounds under the southern portion of the APA through the central area of the TF and continues southward towards the town of Gibbstown as shown in Figure 6-4. General flow radiates outward from the highpoint in the clay mainly towards the gaps in the underling clay and into the B-Level aquifer. Currently only two A-level pumping wells, PW-8 and PW-12, are operating on-Site as part of the groundwater remediation system; removing two to ten (2 to 10) gallons of water per minute depending on available head.

Regionally the top of the B-Level, or Upper Middle part of the PRM, in the area of the Site ranges from zero (0) ft msl to thirty (30) ft below msl, while the top of the B-Level confining unit ranges from forty-five (45) ft below msl to eighty (80) ft below msl, sloping to the southeast at approximately 1% (USGS, 1991). Boring logs from the Site showed similar elevation ranges, with the top of the B-Level ranging from seven (7) ft below msl in the subcrop north of the CTDH area, ranging down to thirty (30) ft below msl just south of the property line, while the top of the confining unit ranged from fifty (50) ft below msl in the near Clonmell Creek to -80 ft south of the property boundary. Additionally, boring logs showed that while there were productive areas in the upper part of the B-Level, sands toward the top of the unit were finer and contained more silt and clays than the more productive coarse sands at the base of the unit. Flow through this unit is generally towards the south, however pumping wells at the site, in the town and at adjacent sites impact this flow locally. Gaps in the clay underlying the B-Level have been observed in the TF and in the north-western APA near MW-55B/C. The ultimate receptor for B-Level groundwater is down through some of the gaps in the underling low K unit into the C-Level aquifer. Currently the only pumping well operating in the B-Level is PW-10R removing approximately twenty-two (22) gallons of water per minute.

USGS shows the top of the C-Level, or Lower Middle part of the PRM, in the area of the site ranges from eighty (80) ft below msl to one hundred (100) ft below msl and the top of the C-Level confining unit ranging from -100 to -120 feet msl, with the unit sloping to the southeast at approximately one to two percent (1%-%-2%) (USGS, 1991). Boring logs are limited to the southern area of the Site, and show the top of the C-Level unit at a range from seventy-five (75) ft below msl to -115 ft below msl, and show the top of the confining unit ranging from -110 to -137.5 ft msl. The boring logs (appendix C) and USGS referred to the confining unit as red molted clay. Similar to the sands in the B-Level, sands in the C-Level showed a fining upward trend, with coarser, more productive sands near the top of the confining unit. Similarly to the B-Level aquifer, flow through this unit is generally towards the south, however pumping wells at the site, in the town and at adjacent sites impact this flow locally. Currently pumping wells PW-4R and PW-11 are operating onsite in the C-Level removing approximately ninety (90) gallons of water per minute.

6.3 SURFACE WATER HYDROLOGY

Historically the 002 Outfall received the majority of overland surface water runoff from the Site through the Site's stormwater runoff network. Until 1991, the outfall had historically consisted of a culvert set into a wooden embankment and a dirt drainage swale which allowed open flow to Clonmell Creek. In 1992, the SCB was contracted to handle stormwater from the southern area of the plant, as noted in Figure 5-2. A Parshell Flume and slide gate were installed to regulate discharge to Clonmell Creek. Discharge to Clonmell Creek has not occurred since the construction of the SCB [ERM, 1995]. Stormwater runoff from the TRA, the WWTP and the NCL still flows into the 002 Outfall or into Clonmell Creek.

Delineation of the hydraulic conditions in the northern portion of the site, near the NCL, the MPP, the SCB, the 002 Outfall, and at the adjacent wetlands and Clonmell Creek is important in understanding groundwater migration and the fate and transport of potential constituents of concern in these areas. As noted in Section 2.7.2, a transducer study was preformed from April 20, 2009 to April 24, 2009 to assess hydraulic connection between Clonmell Creek and the shallow groundwater in the NCL and across the creek from the NCL.

6.3.1 Transducer Study

Data from the transducer study is presented in Appendix M. There appears to be limited recharge from Clonmell Creek to the aquifer on the south side of the creek and very little on the north side, during the time of the study (Figures 6-5 through 6-8). This may be due to the heavy rainfall early in the week of the transducer study, which resulted in higher than average water levels in the creek. Locations MW-32, NCL-10 and NCL-14 (all on the south side of the creek) appeared to be the most hydraulically connected, both too each other and to Clonmell Creek. The crest and troughs of the water level elevations of these three (3) points, while diminished, closely align with the crest and troughs of the creek caused by the release of water through the tidal gate. There was less hydraulic connection at NCL-5 (south side), CC-15, and CC-17 (north side). There does not appear to be any hydraulic connection between wetland location CC-18 and upstream location CC-20 and the creek.

Clonmell Creek does not appear to ever receive water from the surrounding aquifer. Limited aquifer recharge from Clonmell Creek was shown in areas on the south side of the creek, however areas north of the creek and upstream of the creek appear to have very little to no interconnection with the surrounding aquifer.

6.3.2 Surface Water/Groundwater Geochemistry Study

In order to provide a characterization of site surface and groundwater geochemistry as a total of forty-two (42) samples analyzed for the major anion/cation composition were evaluated. Of these, fifteen (15) were collected from shallow site groundwater wells constructed in aquifer level A, and twenty-seven (27) were collected from site surface waters. Sample locations are shown on Figure 2-4.

Geochemical characterization was completed for both surface and groundwater samples based on predominant cations and anions measured in each sample. Additionally, calculated TDS, Hardness (as $CaCO3$), and Irrigation Salinity Hazard (a measure of dissolved salt load) were also determined for each sample. Measured and calculated parameter values are summarized on Table 6-2. Calculated TDS and Hardness are tabulated as mg/kg in order to allow compensation for density differences between samples. Piper diagrams were prepared for both surface and groundwater samples to provide a graphical comparison of the distribution of major ions within each data set and their individual subsets Figures 2-4 and 2-5.

Based on major anion chemistry, groundwater samples fell into two distinct groups depending on the predominance of either $SO4$ or $HCO3$. Cations in both groups were variable and included Al, Ca, Mg, and Fe. Na was the dominant cation only in the $SO4$ group. A single sample (GW-CC-15) included Na as the dominant cation and Cl as the dominant anion, indicating a NaCl influence presumably associated with saline marine water. Al was the primary cation in most of the $HCO3$ group, with Ca and Mg occurring at a lesser frequency. Groundwater samples were characterized by a considerably higher range of TDS and greater maximum hardness values than surface water. Unlike surface water, irrigation salinity values for groundwater reached medium to high levels in most samples with the highest values found in the HCO3 group.

Several factors may be responsible for the high dissolved solids concentrations observed in shallow groundwater, including the mineralogy/geochemistry of A-level aquifer sediments; a more chemically aggressive groundwater environment than present in surface waters, leading to greater leaching of soluble mineral components; and an extremely slow rate of A-level groundwater movement resulting in minimal flushing and dilution by surface water recharge.

Surface water samples also fell into two distinct groups (NaHCO3 and CaCO3/HCO3), but unlike groundwater samples which were differentiated on the basis of the dominant anion species, surface water samples were differentiated on the basis of the dominant cation species based on the data tabulated on Table 6-2. Surface water samples showed either HCO3 or CO3 as the dominant anion, with CO3 dominant in samples SW-SCB-12 through 16. Calcium was the dominant cation in samples SW-1, SW-2, as well as samples SW-SCB-12 through 16. Na was the dominant cation in all of the remaining samples.

Total dissolved solids and hardness were within the same range for both surface water groups, and all samples were characterized by low irrigation salinity hazard values. A single surface water sample (SW-CC-11) was dominated by Na as the dominant cation and Cl as the dominant anion, indicating a NaCl influence presumably associated with more saline marine-influenced water.

In terms of cation distribution, surface water samples showed a considerably more narrow variability than groundwater samples, and plot entirely within the groundwater sample fingerprint as shown on Figure 2-6 (lower left). SO4 values were measured in only six of the surface water data set samples, and where measured, were negligible compared with those measured in the groundwater data set. As a result, surface water samples plot on the HCO3/Cl axis of the major anion plot, with no overlap relative to the groundwater data set (Figure 2-5, lower right).

In comparison with available surface water data, groundwater samples show a pronounced SO4 component relative to surface water. In terms of the chloride component, with some minor overlap, surface water samples generally show low to moderate chloride concentrations, while groundwater samples range from relatively low to significantly higher chloride concentrations than found in the surface water samples.

Site groundwater is characterized by high total dissolved solids, higher hardness maxima, and higher irrigation salinity hazard due to accumulation of a high dissolved solids load associated with accumulation of salts derived from leaching of mineral components in the chemically aggressive, slow moving groundwater environment. Natural surface waters associated with Clonmell Creek are characterized as Na HCO3, while groundwater outside of the surface water impoundment and drainage areas is characterized as Al/Na SO4 waters. Background groundwater conditions characterized by high SO4 concentrations are consistent with a reducing environment in association the widespread occurrence of peat, grey to black colored sediments associated with the Cenozoic estuarine deposits, and the presence of former or existing wetland hydrologic conditions across the site

In the case of impounded storm waters and storm water drainage, CaCO3/HCO3 supplants Na HCO3 as the dominant surface water type, and Al HCO3 replaces Al/NaSO4 as the dominant groundwater species. As an exception, one sample (SW-SCB-14) combines Na as the dominant cation and CO3 as the dominant anion. SW-SCB-14 is included with the CO3/HCO3 group on Figures 2-5 and 2-6.

Overall, then, it would appear that Ca CO3/HCO3 storm water impounded or flowing at the ground surface creates a localized geochemical halo characterized by Al HCO3 groundwater. Beyond the influence of site surface waters, naturally occurring surface waters associated with Clonmell Creek are characterized as Na HCO3 waters, while groundwater outside of the surface impoundment influence is characterized by SO4 as the major anion. Besides the aqueous geochemical fingerprint, limited downward flow of site storm water is also consistent with northwest to southeast trending potentiometric mounding of A-Level groundwater.

6.4 ECOLOGY

Results of previous investigations at the Site are reported in the PhII and the SRI. Based on these results, the primary areas of ecological concern include portions of Clonmell Creek adjacent to the Site, and the SCB and associated drainageway for the 002 Outfall. Previous findings indicate that these areas appear to have been affected by historical releases (i.e., through runoff and possibly groundwater discharge) [ERM, 2003]. The potential for subsequent discharges to the 002 Outfall drainageway and Clonmell Creek were effectively eliminated by Hercules through the construction of the Stormwater Catchment Basin in 1991 and construction of the associated berm and outfall structure in 1992.

An ecological evaluation of the Site was conducted as part of the PhII. The purpose of the ecological study was to assess ecological impacts of the surface waters quality. As part of the ecological evaluation, ERM collected surface water and sediment samples and performed a limited aquatic biological assessment of Clonmell Creek. The remainder of this section summarizes the ecological information provided in the ERM report.

The ecological evaluation included the following tasks:

- A floodplain assessment;
- Wetlands and habitat assessment;
- Drainage pattern assessment;

- Stream flow measurement of Clonmell Creek;
- Surface water and sediment sampling; and
- Aquatic community assessment.

6.4.1 Floodplain Assessment

Information on the Site and surrounding areas has been compiled from several state and federal organizations to address NEPA requirements. Data from the Federal Emergency Management Agency (FEMA) and Greenwich, NJ Township indicated that the majority of the Site lies within the 500-year floodplain, and a large portion of the Site lies within the 100-year floodplain. A map depicting the FEMA and NEPA areas is presented in Figure 1-3.

6.4.2 Wetland and Habitat Assessment

Wetland and habitat assessments of the Site have been conducted to delineate and classify wetlands, to develop a cover type map, and to describe the various ecological habitats. ERM performed a wetland survey on April 29, 1994 in accordance with the methodology described in the Federal Interagency Committee for Wetland Delineation manual entitled "Federal Manual for Identifying and Delineating Jurisdictional Wetlands" (January, 1989). Wetlands areas at the Site are shown on Figure 1-3.

ERM prepared a habitat cover type map based on April 1992 aerial photography and a field reconnaissance survey, during which observations were made to describe each habitat cover type including: species identification and general classification of vegetation, dominant plant species present, relative size of each cover type, and the presence of wildlife. The assessment of cover types was limited to the area south of Clonmell Creek.

General habitat cover types that were observed on the Site property south of Clonmell Creek include:

- Palustrine scrub/shrub emergent wetlands,
- Palustrine emergent wetlands,
- Palustrine forested wetlands,
- Open water and open water/emergent wetlands,
- Successional old field and successional shrubland,
- Forested upland, and
- Main Site area and mowed lawn.

As part of the BERA, RBR completed Habitat Assessments for several locations in the SCB, Clonmell Creek and the 002 Outfall. Each sample location was evaluated for ten (10) different habitat parameters; including substrate composition, channel flow and alteration, bank vegetative cover, and riparian zone. The habitat parameters were scored on a scale of zero to twenty (0 to 20), and the results summed to achieve a total Habitat Score. Scores of 160 to 200 were considered to represent “Optimal” habitat; scores of 110 to 159 were considered to represent “Suboptimal” habitat; scores of 60 to 109 were considered to represent “Marginal” habitat; and scores less than 60 were considered to represent “Poor” habitat. The majority of sample locations fell into the “Suboptimal” quality category; two locations (CC-5 and 02OF10) were considered to represent “Marginal” habitat quality; and one location (SCB-12) was considered to represent “Optimal” habitat quality [RBR, 2017].

6.4.2.1 Wetlands

The wetlands on Site are described as disturbed, having undergone clearing, filling, and ditching to convert the land for agricultural use, and to aid in mosquito control. Construction of the Delaware River dike and floodgates at the northwest end of Clonmell Creek cut off the wetland from tidal flooding. These historical activities and other industrial activities in the area changed the hydrology and ecology of the wetland system. The wetlands were described as water-stressed, with areas having been invaded and dominated by the common reed (*Phragmites sp.)*. More diverse wetland plant communities were small in area and present as a fringe area around open-water wetlands.

Most of the wetlands on Site are classified as palustrine emergent wetland, dominated by common reed and palustrine forested wetland, dominated by young red maple. These wetland types were located south of and from Clonmell Creek to the western site boundary. Clonmell Creek and four small areas located between Clonmell Creek and the on-site GP were classified as open water/emergent wetlands. Some scrub/shrub-emergent wetland areas were also located in the area between Clonmell Creek and the GP.

6.4.2.2 Uplands

The uplands on site include successional old field, successional shrubland, forested upland, and the main Site area and mowed lawn. Successional old field and successional shrubland are upland areas that have been previously disturbed by man (i.e., by farming) and on which natural re-vegetation has occurred. Forested upland is dominated by woody vegetation twenty (20) feet or taller. Historically, the main plant area is comprised of buildings, tanks, parking areas, roadways, and mowed lawn, however, with the exception of the WWTP, the buildings and tanks have now been removed to the foundation. The SCB is located in the main plant area. These developed areas are in the active portion of the property, and do not provide habitat of ecological importance.

6.4.3 Endangered Species

Threatened and/or endangered species are those species that have been given special legal and protective designations by federal or state government agencies. An endangered species is one that is in danger of extinction throughout all or a significant portion of its range. A threatened species is one likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

The presence of state- or federally-listed threatened or endangered species has not been confirmed at the site, and none have been observed during previous ecological reconnaissance. As reported in the PhII [ERM, 1995], NJDEP Division of Parks and Forestry, Office of Natural Lands Management stated in a letter dated August 11, 1994 there are no records of rare plants, animals or natural communities on the property.

A recent review of information available from United States Fish and Wildlife Service (USFWS) indicates that the site occurs within the range of a few threatened species. According to the Environmental Conservation Online System (reviewed on July 1, 2016), the following three species are listed as federally threatened for Gloucester County: the swamp pink (Helonias bullata), the northern long-eared bat (Myotis septentrionalis) and the bog turtle (Clemmys muhlenbergii). Additionally, while there is no federally-designated critical habitat in the project area, the Red knot (*Calidris canutus rufa*) and bog turtle (*Clemmys muhlenbergii*) could occur in the project area or be affected by future proposed on-Site activities. Observation of these threatened species has not been documented at the site. No endangered species were listed as federally endangered for Gloucester County.

The New Jersey Natural Heritage Database also provides a list of rare plant species and ecological communities for each county. While a number of vascular plant species are identified as state-endangered, none of these species have been documented at the site.

The NJDEP also provides a GIS mapping tool (NJ-GeoWeb) that indicates habitats of ecological value as well as Natural Heritage Priority Sites and the Natural Heritage Grid Map. Natural Heritage Priority Sites are defined as the best habitats for rare plant and animal species, while the Natural Heritage Grid Map provides general geographic locations of rare plant species and ecological communities. The information obtained from the NJ-GeoWeb indicates that there are no Natural Heritage Priority Sites or rare plant species documented near or at the site. A review was also conducted for species-based habitat for the Piedmont Plains area, which delineates imperiled and special concern species habitat within New Jersey. Note that these classifications designate the potential for a species to occur; no threatened or endangered species were identified as being observed at the site [RBR, 2017].

6.4.4 Drainage Pattern Assessment

The stormwater drainage system features, 002 Outfall, and Clonmell Creek flow patterns were reviewed as part of the Site drainage pattern assessment. The stormwater drainage consisted of two main systems of shallow, unlined, open ditches with some underground piping. The 002

Outfall also received the Site’s non-contact cooling water and boiler blowdown, and was closed in October 1991.

The assessment of Clonmell Creek included flow measurements and development of stream cross section profiles. Cross sections were set up along Clonmell Creek, and flow and depth measurements were taken at several tidal stages. The assessment found that Clonmell Creek is a non-tidal system due to the flood gates located at its confluence with the Delaware River. However, at high tide when the flood gate is closed, Clonmell Creek will back up behind the gate, causing minor flooding of the adjoining wetland.

7.0 BASELINE RISK ASSESSMENT FINDINGS SUMMARY

7.1 BASELINE ECOLOGICAL RISK ASSESSMENT FINDINGS SUMMARY

The BERA was conducted in accordance with guidance from the EPA and the NJDEP. The BERA was written by Risk Based Remedies, Inc (RBR) and was approved by the EPA on May 3, 2017 [RBR. 2017]. The following executive summary is verbatim from the BERA [RBR, 2017] for reference in this RI report.

"*A Screening-Level Ecological Risk Assessment (SLERA) was previously completed for the site, and the conclusion was that supplemental data were needed to fill data gaps and that a BERA was necessary to further evaluate the potential for adverse ecological effects. An initial BERA was prepared in November 2013 and submitted to the USEPA. Because supplemental sampling was conducted at the site as part of the Additional Remedial Investigation (ARI), this revised BERA incorporates additional data collected from the site. This report also utilizes current approaches to refine the calculations presented in the previous ecological reports.*

The BERA summarizes relevant site background information and investigation results upon which the assessment is based. This includes: a site description, a summary of previous investigation activities, a discussion of the analytical data that are utilized in the assessment, the results of sediment toxicity testing, and the results of the benthic macroinvertebrate survey. The background information focuses on the relevant areas of the site that are evaluated in the BERA: the 002 Outfall and drainageway, the Stormwater Catchment Basin (SCB), Clonmell Creek, and the adjacent wetland areas.

The baseline problem formulation phase of the BERA includes all components outlined in USEPA guidance: (1) environmental setting; (2) constituents at the site; (3) mechanisms of toxicity; (4) conceptual site model; and (5) assessment and measurement endpoints. The following potentially complete exposure pathways are evaluated in the BERA:

- *Direct contact with surface water and sediment by aquatic plants, invertebrates, or fish;*
- *Ingestion of surface water and incidental ingestion of sediment by semi-aquatic mammals and birds;*
- *Ingestion of aquatic plants, invertebrates, and aquatic animal prey by semi-aquatic mammals and birds;*
- *Direct contact with wetland soil by plants or invertebrates;*
- *Incidental ingestion of wetland soil by mammals and birds; and*
- *Ingestion of plants, invertebrates, and/or small animal prey from the wetland area by mammals and birds.*

Specific assessment and measurement endpoints have also been identified to address the potentially complete exposure pathways. In general, the assessment endpoints relate to *sustainability (survival, growth, and reproduction), diversity, and abundance of populations of receptors including: aquatic plants, invertebrates, fish, semi-aquatic mammals and birds, wetland plants and invertebrates, and mammals and birds that inhabit the wetland area. The following representative species and receptor groups were evaluated as potential ecological receptors:*

- *aquatic plants, invertebrates, and fish that may inhabit the 002 Outfall and drainageway, the SCB, or Clonmell Creek;*
- *semi-aquatic mammals and birds, such as the mink, raccoon, and great blue heron, which inhabit and forage in the 002 Outfall and drainageway, the SCB, or Clonmell Creek;*
- *terrestrial plants and invertebrates that may be exposed to constituents in wetland soil;*
- *terrestrial mammals, such as the short-tailed shrew and muskrat, that inhabit and forage in the wetland area and may be exposed to constituents in wetland soil; and*
- *avian receptors, such as the American woodcock and red-tailed hawk, that inhabit and forage in the wetland area and may be exposed to constituents in wetland soil.*

The measurement endpoints selected for evaluation consist of a comparison of: estimated or measured exposure levels of constituents to levels reported to cause adverse effects, evaluation of macroinvertebrate community metrics, sediment toxicity testing, and comparison of observed effects at the site with those observed at reference locations.

The objectives of the baseline ecological effects evaluation are to identify constituents of potential ecological concern (COPCs), and to identify the potential effects of each COPC to the representative ecological receptors. COPCs were selected by comparing concentrations of constituents detected in sediment, surface water, pore water, and wetland soil to ecological benchmarks appropriate for the receptor group being evaluated. The potential effects are characterized with benchmark concentrations or toxicity reference values (TRVs) specific to the representative receptors. Both benchmark values and TRVs were obtained primarily from USEPA sources. In addition to these indirect measures of effect, the results from macroinvertebrate sampling and sediment toxicity testing were used to provide a more specific measure of effects for the aquatic habitats at the site.

The approaches for exposure characterization consist of calculation of exposure point concentrations (EPCs) and exposure estimates (e.g., intakes) for the representative receptors. EPCs were calculated using the USEPA statistical software, ProUCL. Exposure estimates were based on USEPA guidance. The exposure characterization presented in this BERA is a refined and site-specific update of that presented in the SLERA.

The BERA concludes with the characterization of potential ecological hazards and associated uncertainties. This step provides a resolution of the exposure potential and the estimate of a dose to assist in the identification of those constituents that may result in adverse ecological effects. In this step of the analysis, the characterization of exposure and the characterization *of ecological effects are integrated into quantitative and qualitative estimates to identify COPCs that might pose adverse ecological effects. The results are based on multiple lines of evidence, including the calculation of ecological hazard quotients (HQs) using both no- and low-observable-effects levels (NOAELs and LOAELs) derived from the scientific literature.*

For aquatic organisms, plants and invertebrates, the HQ represents a simple screening outcome and is the ratio of the EPC for each COPC to the toxicity benchmark. For mammals and birds, the HQ represents the ratio of the calculated constituent dose to the TRV. Generally, if the HQ is less than or equal to 1, there is no potential for increased mortality or decreased reproduction to the receptor. An ecological HQ greater than one does not necessarily indicate an adverse effect. Rather, these results must be evaluated in conjunction with other lines of evidence, such as the actual observed effects on the receptor species/habitats, and results from other quantitative analyses such as the macroinvertebrate survey and sediment toxicity testing. As part of the risk characterization, data collected as part of the macroinvertebrate survey and sediment toxicity testing are evaluated in comparison to reference locations to determine whether or not the site sampling locations would be considered "impaired" in a more realistic sense.

The risk characterization also reiterates the uncertainties, limitations, and other confounding factors that are inherent in the BERA process in order to provide perspective on the likelihood and significance of potential ecological hazards. Additional evaluation in certain cases may be necessary because conservatism is employed in the risk assessment in an effort to address the significant uncertainty in this process. Often that conservatism leads to assumptions of potential harm that would not be realized but could be used to direct remedial action.

The risk characterization for the Gibbstown site provided the following results:

002 Outfall and Drainageway

For the 002 Outfall and drainageway, results of the macroinvertebrate survey suggest a community with lower scores relative to the reference location. However the habitat quality was considered to be "marginal" (which is consistent with the intermittent and shallow nature of the surface water). Results of the sediment toxicity testing indicated no significant difference on survival or growth from the reference location. While some HQs greater than 1 were calculated for invertebrates and fish exposed to sediment, the majority of HQs were less than or greater than 1. Calculated HQs for aquatic plants, invertebrates and fish exposed to surface water exceeded 1 only for inorganic constituents. Based on these consolidated results, potential impairment to aquatic communities of the 002 Outfall and drainageway appears to be habitat-related and not associated with site-related constituent presence.

The calculated results for mammals and birds potentially exposed to COPCs in sediment and surface water from the 002 Outfall and drainageway indicate that the vast majority of HQs are below 1. HQs in excess of 1 were calculated only for inorganic COPCs and only when using the default area use factor of 100%. In all cases of HQs exceeding 1, the result was driven by the invertebrate ingestion pathway. It should be emphasized that, in the absence of site-specific tissue data, concentrations of COPCs in invertebrates were estimated using USEPA generic uptake factors and are overestimations. Based on these results, the potential *for adverse effects to populations of semi-aquatic mammals and birds exposed to site-associated COPCs in sediment and surface water from the 002 Outfall and drainageway is considered to be negligible.*

Stormwater Catchment Basin

Results for the SCB suggest lower scores for the macroinvertebrate community relative to the reference location. The SCB has historically been considered part of the operational portion of the site, and does not represent a high quality aquatic habitat. The area may be dry for extended periods and flooded at other times. These factors affect the ability of the SCB to support diverse populations of aquatic organisms. The results of the toxicity testing indicated a significant decrease in survival of Hyalella azteca from the reference location. HQs greater than 1 were calculated for invertebrates and fish exposed to some of the COPCs in sediment; however, HQs for the majority of COPCs in surface water were less than or marginally greater than 1. It should be noted that the sediment concentrations of site-related COPCs were not excessively high; rather, the elevated HQs were more a product of very low toxicity benchmarks. Furthermore, most of the VOCs were detected infrequently. Based on these consolidated results, the presence of site-related COPCs in sediments may contribute to potential impairment to aquatic communities of the SCB; however, the major cause is most likely the intermittent dry nature of the habitat and because of its historical operational function, the habitat is considered to have limited function and value.

The calculated results for mammals and birds potentially exposed to COPCs in sediment and surface water from the SCB indicate that the vast majority of HQs are below 1. HQs in excess of 1 were calculated only when using the generic area use factor of 100%. The highest HQs were calculated for: 1,2,4-trichlorobenzene; cumene; copper; nickel; and vanadium; in all cases, the result was driven by the invertebrate ingestion pathway. It should be emphasized that concentrations of COPCs in invertebrates were estimated using USEPA generic uptake factors and are overestimations. Furthermore, as noted above, the VOCs were detected very infrequently in the sediment samples, indicating that any potential effects associated with these COPCs would be minimal or localized. Based on these results, the potential for adverse effects to populations of semi-aquatic mammals and birds exposed to site-associated COPCs in sediment and surface water from the SCB is considered to be negligible.

Clonmell Creek

In Clonmell Creek, results of the macroinvertebrate survey suggest a moderately impaired community for locations SED2-CC-5, SED2-CC-8 and SED2-CC-4 relative to the reference location. The remaining locations were found to represent slightly impaired macroinvertebrate communities. Habitat quality was considered to be suboptimal for all locations with the exception of SED2-CC-5 (marginal). The results of the toxicity testing indicated a significant decrease in survival of H. azteca at locations SED2-CC-13, SED2-CC-5 and SED2-CC-8 in comparison to the reference location. HQs greater than 1 were calculated for invertebrates and fish exposed to many of the COPCs in sediment; however, HQs for surface water exceeded 1 only for inorganics, and were generally only marginally greater than 1, except in the case of iron. COPCs with the highest HQs include acetone, cumene, toluene, select SVOCs PAHs, and copper. Elevated concentrations of cumene were generally co-located with elevated *concentrations of other organic COPCs, with the highest concentrations predominantly located at the point where the 002 Outfall enters the creek, and just downstream (e.g., CC-4, CC-8, CC-10 and CC-11). Based on these results, there may be potential for adverse effects to aquatic organisms exposed to site-associated COPCs in sediment from Clonmell Creek in a localized area near the 002 Outfall.*

The calculated results for mammals and birds potentially exposed to COPCs in sediment and surface water from Clonmell Creek indicate that the majority of HQs are below 1. The majority of the HQs exceeding 1 were driven by the food ingestion pathways (invertebrates, aquatic plants or fish). It should be emphasized that concentrations of COPCs in these food sources were estimated using USEPA generic uptake factors and are overestimations. Elevated concentrations of cumene were generally co-located with elevated concentrations of other organic COPCs, with the highest concentrations predominantly located at the point where the 002 Outfall enters the creek, and just downstream (e.g., CC-4, CC-8, CC-10, and CC-11). The results of the pore water sampling indicate that even in locations of high cumene concentration in sediments, the cumene concentrations in pore water are relatively low. This suggests that partitioning (and bioavailability) are limited, and the potential for adverse effects would be much lower than that estimated using generic risk calculations. Based on these results, there may be potential for adverse effects to populations of semi-aquatic mammals and birds exposed to site-associated COPCs in food sources from Clonmell Creek in a localized area near the 002 Outfall; however, due to the significant amount of uncertainty associated with the generic uptake modeling (e.g., bioaccumulation from sediments), the results are considered to be overestimated. It should also be noted that many of the substances that were not associated with site operations (e.g. PAHs, PCBs, pesticides and metals) almost certainly originated from upstream sources such as the considerable industrial activities that occur upstream, and upstream waste disposal areas.

<u>Wetland Area</u>

Results for terrestrial plants and invertebrates potentially exposed to COPCs in wetland soils indicate that HQs were below or marginally above 1 for the majority of COPCs. The highest HQs were calculated for: cumene, 1,4-diisopropylbenzene; 4,4'-DDT; aluminum; and iron. A review of the wetland soil sample results indicates that out of 18 samples, 1,4-diisopropylbenzene was detected only once. Therefore, the likelihood of adverse effects as a result of potential exposure to this COPC is essentially nonexistent. 4,4'-DDT was detected more consistently in the wetland soil samples; however the distribution of pesticides (including 4,4'-DDT) in the wetland soil reflects the former agricultural use of the area, and may reflect past regional use of pesticides for mosquito control.

The calculated results for mammals and birds potentially exposed to COPCs in wetland soil indicate that the vast majority of HQs are below 1, with calculated LOAEL-based HQs exceeding 1 only for 1,4-diisopropylbenzene and mercury. The HQs exceeding 1 were mainly driven by ingestion of terrestrial invertebrates or mammals. It should be emphasized that concentrations of COPCs in terrestrial food sources were estimated using USEPA generic uptake factors and are overestimations. As noted above, out of 18 samples, 1,4-diisopropylbenzene was detected only once. Therefore, the likelihood of adverse effects as a result of potential exposure to this COPC is essentially nonexistent. Based on these results, the *potential for adverse effects to populations of terrestrial mammals and birds exposed to COPCs in wetland soil is considered to be negligible.*

Summary

Based on the results obtained from these analyses, and the observations that many of the factors incorporated into the equations are generic and overestimations, and the limited bioavailability observed in the pore water analyses, it appears that the potential for adverse ecological effects associated with site originated constituents is limited to the sediments of the SCB and a small area in Clonmell Creek near the 002 Outfall." [ERM, 2017]

7.2 BASELINE HUMAN HEALTH RISK ASSESSMENT FINDINGS SUMMARY

The following is the executive summary of the BHHRA prepared by RBR, for the Hercules LLC., a wholly owned subsidiary of Ashland Inc., Former Higgins Plant located in Gibbstown, NJ (site). This document was approved in its final form by the EPA on September 1, 2017.

"This risk assessment report has been prepared by RBR Consulting Inc. (RBR), for the Hercules Incorporated, a wholly owned subsidiary of Ashland Inc., Former Higgins Plant located in Gibbstown, New Jersey (site). The approaches used in this report are based on guidance provided by the United States Environmental Protection Agency (USEPA). This (BHHRA expands upon the Memorandum of Exposure Scenarios (MES), which presented a summary of the potential receptors and associated exposure pathways at the site, and the Pathway Analysis Report (PAR), which provided constituent-specific information. The BHHRA has been prepared in a manner consistent with Risk Assessment Guidance for Superfund (RAGS) Part D.

The site, which encompasses approximately 350 acres, is located in Gibbstown, Greenwich Township, Gloucester County, New Jersey. The site is bounded by the Delaware River to the north, PBF Energy (PBF) Paulsboro Refinery tank farms and landholdings to the east, residential communities to the south and west, and Greenwich Township Board of Education property and undeveloped land owned by E.I. DuPont de Nemours Incorporated (DuPont) to the west. Clonmell Creek is a tidal tributary of the Delaware River that courses toward the northwest through the middle of the site. Former plant manufacturing facilities covered approximately 80 acres and are concentrated in the southwest portion of the site, south of Clonmell Creek. This main plant area is contained within security fencing. Other areas south of Clonmell Creek, outside of the fenced main plant area consist of the historic northern chemical landfill, the chemical landfill, gravel pit, and undeveloped wooded shrubland. Areas immediately surrounding Clonmell Creek and areas to the north consist of undeveloped wetlands with forested, marshy areas.

The Upland Areas of the site were evaluated as several discrete Exposure Areas, which have been determined based on the historical and current use of the property, current land features, and anticipated future site use. Clonmell Creek and the Wetlands Area, although not included *as part of the "Upland Areas", were also evaluated as discrete Exposure Areas. The following is the complete list of discrete Exposure Areas for the site:*

- *Active Process Area (APA)*
- *Inactive Process Area (IPA)*
- *Northern Chemical Landfill (NCL) Area*
- *Northern Warehouse (NW) Area*
- *Area A / Open Area*
- *Area B*
- *Stormwater Catchment Basin (SCB) Area*
- *Tank Farm/Train Loading (TF/TL) Area*
- *Chemical Landfill/Gravel Pit (CL/GP) Area*
- *Shooting Range (SR)*
- *Township Refuse (TR) Area*
- *Clonmell Creek*
- *Wetland Area*

Constituents in samples of soil, groundwater, soil gas, surface water and sediment were included and considered on an area-by-area basis in the assessment. Chemicals of potential concern (COPCs) were identified for each medium in each applicable area based on a comparison of the analytical data to USEPA Regional Screening Levels (RSLs) and Vapor Intrusion Screening Levels (VISLs), with the exception of the surface water analytical data, which were compared to applicable human health water quality criteria (New Jersey Surface Water Quality Criteria for Toxic Substances or USEPA National Recommended Human Health Criteria). In the absence of water quality criteria, the USEPA Tapwater RSLs were used for screening. Analyzed constituents detected at concentrations greater than their respective comparison values were identified as COPCs. For direct contact with soil, the COPCs include a number of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs), metals, Aroclor-1254, 4,4'-DDT and ammonia. Several VOCs and total recoverable phenolics were identified as COPCs for direct contact with groundwater. For vapor intrusion from soil gas to indoor air, the COPCs consist of 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,2,4-trichlorobenzene, 1,2-dibromoethane, 1,3-butadiene, 1,3-dichlorobenzene, 3-chloropropene, benzene, bromodichloromethane, dibromochloromethane and hexachlorobutadiene. For vapor intrusion from groundwater to indoor air (evaluated for areas lacking soil gas data), the COPCs consist of benzene, cumene and ethylbenzene. For direct contact with sediment of the IPA Pond; SCB, Sludge Drying Beds (SDB) and Drainageways; and Clonmell Creek, the COPCs consist of several VOCs, SVOCs, PAHs, metals, pesticides and Aroclor-1254. For direct contact with surface water of these same three areas, the COPCs consist of PAHs, metals, pesticides, Aroclor-1254, and ammonia.

To satisfy regulatory requirements, constituents in soil samples were also compared to the NJDEP Direct Contact Remediation Standards and the Impact to Groundwater Soil Screening Levels. The results of the direct contact comparisons indicate that generally, the constituents exceeding NJDEP standards are a subset of the constituents exceeding USEPA RSLs. The results of the Impact to Groundwater comparisons indicate that several VOCs, SVOCs and inorganics were detected at concentrations above the standards.

Potential receptors and associated exposure pathways were identified separately for the individual Upland Exposure Areas, Clonmell Creek and the Wetland Area. As previously mentioned, the Upland Exposure Areas were evaluated for industrial use based on the current and expected future industrial use of the property. In addition, since groundwater at the site is designated Class II-A, the residential use of onsite groundwater as a drinking water source has been included as a quantitative exposure scenario in this risk assessment. This pathway is highly unlikely and will never be realized. Even though this is private property with restricted access, Clonmell Creek and the Wetland Area were evaluated for recreational use because these areas are currently undeveloped and future development is unlikely due to the presence of wetlands. While each of the discrete Upland Exposure Areas has been evaluated separately, it is possible that some receptors could be present across multiple Exposure Areas. The potential for site-wide exposure (as appropriate) has also been addressed both quantitatively and qualitatively in this BHHRA. The specific receptors and exposure pathways are discussed below.

In the Upland Exposure Areas, the outdoor industrial worker was evaluated for potential direct contact with surface soil (incidental ingestion, dermal contact, and inhalation of volatiles and particulates in ambient air) and direct contact exposure to A Zone shallow groundwater (incidental ingestion, dermal contact, and inhalation of volatiles in ambient air). Direct contact exposure to A Zone shallow groundwater is considered to be highly unlikely and was included for evaluation to satisfy regulatory comments. In addition to exposure to surface soil and A Zone shallow groundwater, the outdoor industrial worker for the IPA and the SCB was evaluated for direct contact with surface water (incidental ingestion, dermal contact, and inhalation of volatile emissions in ambient air) and sediment (incidental ingestion and dermal contact) of the IPA Pond and the SCB, SDB and Drainageways, respectively.

The construction/utility worker in each of the Upland Exposure Areas was evaluated for potential direct contact with surface and subsurface soil (incidental ingestion, dermal contact, and inhalation of volatiles and particulates), as well as inhalation of volatiles in ambient air (in a construction trench). The construction/utility worker was also evaluated for potential direct contact with A Zone shallow groundwater, which is present at depths ranging from ground surface at the most shallow locations, to 16 feet bgs in the deeper locations.

A future indoor worker was identified as a potential receptor for the Upland Exposure Areas. COPCs were identified for the vapor intrusion pathway based on a comparison to USEPA VISLs. Because constituents were detected in soil gas and groundwater at concentrations above the VISLs, the vapor intrusion pathway will be addressed in the Record of Decision. The use of vapor mitigation technology will be considered for future building construction at the site. Although not used as the basis for remedial decisions, quantification of risk for the indoor worker was included in this BHHRA. The indoor worker was evaluated for potential inhalation of volatile constituents in indoor air (vapor intrusion from soil gas or groundwater) of applicable Upland Exposure Areas.

The adult and youth trespassers were evaluated for potential direct contact exposure to surface soil (incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions *in ambient air) of the Upland Exposure Areas as well as the Wetland Area. The adult and youth trespassers were also evaluated for potential direct contact with surface water (incidental ingestion, dermal contact, and inhalation of volatile emissions in ambient air) and sediment (incidental ingestion and dermal contact) of the IPA Pond, the SCB, SDB, and Drainageways, and Clonmell Creek.*

It should be noted that because of the current industrial and recreational receptors being considered, evaluation of a trespasser scenario is somewhat redundant. The exposure routes for a trespasser are similar to the receptors already being evaluated; however, potential exposure would be significantly less. For trespassers in the Upland Areas, direct contact exposure to surface soil and the surface water and sediment of standing water features is being considered for the outdoor worker, which is a receptor experiencing a greater magnitude of exposure. In addition, for the Wetland Area and for Clonmell Creek, direct contact exposure to wetland soil and the surface water and sediment of Clonmell Creek are being considered for the adult recreational hiker and the recreational youth, which represent similar exposure scenarios to what would be assumed for a trespasser. For purposes of the BHHRA and to bound potential risk, an adult trespasser was included quantitatively for the Upland Areas, the Wetland Area, and for Clonmell Creek.

The recreational youth and the adult recreational hiker receptors were evaluated for potential direct contact exposure (incidental ingestion, dermal contact, and inhalation of particulate and volatile emissions in ambient air) to wetland soil. In addition, these receptors were evaluated for direct contact exposure to surface water (incidental ingestion, dermal contact, and inhalation of volatile emissions in ambient air) and sediment (incidental ingestion and dermal contact) of Clonmell Creek.

Recreational hunters and anglers were also considered for quantitative evaluation in the Clonmell Creek and Wetland Area. The recreational hunter has the potential for direct contact exposure to wetland soil and ingestion of recreationally caught game, such as deer and rabbits. The recreational angler has the potential for direct contact exposure to the surface water and sediment of Clonmell Creek and ingestion of recreationally caught fish. In this BHHRA, the recreational hunter was evaluated for ingestion of game in the wetland area, and the recreational angler was evaluated for ingestion of fish tissue in Clonmell Creek. Direct contact with wetland soil or with surface water and sediment of the creek has been addressed qualitatively for the hunter and angler, because the adult hiker and recreational youth are assumed to have a greater exposure frequency for these media. In addition, the offsite child resident was evaluated for ingestion of both game and fish tissue, based on the assumption that the adult hunter/angler would provide recreationally-caught meals to their family.

In addition, since groundwater at the site is designated Class II-A, an evaluation of potable use of groundwater by future adult and child residents was also conducted. However, the use of groundwater as drinking water at the site will not occur under current conditions. Pumping and treatment of groundwater at the site is ongoing and will continue. The Feasibility Study will indicate that future use of groundwater will be restricted by covenant.

Exposure point concentrations (EPCs) for COPCs in each exposure medium and exposure area were calculated based on analytical data (for soil, groundwater, soil gas, sediment and *surface water), or estimated based on fate and transport models (for ambient and indoor air and game and fish tissue). The intake assumptions utilized for each receptor were based on USEPA default values. For estimators of toxic potency for the constituents, USEPA values from the Integrated Risk Information System (IRIS) and other sources were employed.*

The risk calculations included in this risk assessment were performed without the assumption of health and safety controls, and therefore represent a highly conservative estimate of the potential for adverse effects. The analyses indicate that total non-cancer hazard indices (HIs), potential cancer risks and predicted blood lead levels for the following Exposure Areas meet the target benchmarks for all applicable receptors: NW Area, Area A / Open Area; Area B; SCB Area; CL/GP Area; and Wetland Area. No further evaluation is warranted for these areas.

For the following Exposure Areas (APA, IPA, NCL, TF/TL Area, TRA, SR and Clonmell Creek), as well as for site-wide exposure, one or more results exceeded the target benchmarks. These results are summarized in Table ES-1 and discussed below. As indicated in this table, for the outdoor worker in the NCL and TF/TLA, the total HIs slightly exceed 1, however all target organ-specific HIs are less than 1. As per USEPA guidance, HIs are most appropriately derived for constituents that act on the same target organ or have similar critical effect. Therefore, if the total HI across all COPCs exceeds 1, it is consistent with regulatory guidance to segregate the COPCs by toxic effect and mechanism of action and to derive separate HIs for each distinct target organ (USEPA, 1989). For the outdoor workers in the NCL and TF/TLA the results are deemed acceptable. The analyses indicate that total non-cancer hazard indices and potential cancer risks for the TRA meet the target benchmarks for all applicable receptors. However, the predicted blood lead levels for the TRA may require further evaluation (see discussion below). The need for further evaluation will be considered in the pending Feasibility Study.

For the APA and IPA, direct contact with A Zone shallow groundwater would be unacceptable if it were to occur as evaluated. Direct contact with A Zone shallow groundwater for the outdoor worker will not be realized due to the actual depth to groundwater (the average depth in these two areas is generally greater than 8 feet bgs). Direct contact with A Zone shallow groundwater for the construction worker is unlikely, but possible. In the unlikely event of direct contact with groundwater, unprotected exposure by construction workers might result in unacceptable risk. This issue will be addressed in detail in the Feasibility Study and the Record of Decision for the site. Vapor intrusion from soil gas to indoor air of a future building in the APA or IPA will be addressed in the Record of Decision as well. As previously noted, future construction at the site will include vapor mitigation technology. In the case of the adult and child resident exposed to B/C Zone deep groundwater at the site, as previously noted, much of the site is considered wetland and the only road onto the property is over an active rail line, therefore future use of the site for residential purposes is not considered a relevant exposure scenario. As such, exposure to B/C Zone deep groundwater at the site by adult and child residents will not occur. Risk characterization results for all remaining exposure pathways are acceptable.

Vapor intrusion from groundwater or soil gas to indoor air of a future building in the NCL or TF/TL Area will be addressed in the Record of Decision. As previously noted, future construction at the site will include vapor mitigation technology. Also for these two areas, the drinking water scenario (i.e., ingestion of B/C Zone deep groundwater) poses potential unacceptable non-cancer hazards and potential risks. Risk characterization results for all remaining receptors and exposure pathways are acceptable.

In their recent directive, USEPA recommended the use of 5 ug/dL as the blood lead reference value. The potentially exposed adult outdoor worker, construction worker and the fetuses of females in both populations in the TRA are calculated to result in blood lead concentrations higher than 5 ug/dL. The predicted blood lead concentration for the adult angler consuming fish tissue from Clonmell Creek slightly exceeds the blood lead reference value; however, the predicted fetal blood lead concentration is below the reference value. Selection of an appropriate cleanup goal will be completed as part of the pending Feasibility Study.

For the SR, the predicted blood lead concentrations for the outdoor worker exposed to surface soil and the construction worker exposed to surface and subsurface soil in the SR exceed 5 ug/dL. The average soil lead concentration (PbS) of 1,620 ug/g used in the calculation of predicted blood lead concentrations is based on the concentration from a single sample (TP11) collected from the SR in 2008 at a depth of 0 to 2 feet bgs. The results of this lead evaluation indicate that further evaluation of SR soil may be warranted. The area is still being actively used by the local police department as a shooting range.

With respect to the Site-Wide evaluation, the total HI and potential cancer risk for the outdoor worker that exceed benchmarks are driven by direct contact (incidental ingestion, dermal contact and inhalation of volatiles in ambient air) with benzene and cumene in A Zone shallow groundwater. Due to the actual depth to groundwater observed in the APA and IPA (locations of wells with highest concentrations of benzene and cumene), direct contact with A Zone shallow groundwater in these areas is not realistic. For the site-wide construction worker, the total HI exceeding 1 is driven by inhalation of benzene in trench air (volatilized from A Zone shallow groundwater) and, to a lesser extent, dermal contact with benzene and cumene in A Zone shallow groundwater. Although unlikely, it is possible that the construction worker would directly contact shallow groundwater in the APA and IPA. As stated above, unprotected exposure by construction workers may result in unacceptable risk; therefore, this pathway will be addressed in the Feasibility Study and Record of Decision for the site.

In Clonmell Creek, total HIs and potential cancer risks exceeding benchmarks for the recreational angler and offsite child resident ingesting fish are driven by ingestion of mercury, pesticides and PCBs in fish tissue. There is significant uncertainty associated with the actual number of fish meals obtained from Clonmell Creek that could be consumed per year, as well as the fish tissue concentrations predicted by extremely conservative bioaccumulation factors. In addition, based upon a review of upstream data collected as part of the Remedial Investigation/Feasibility Study, as well as data collected by others at an adjacent property, the presence of the COPCs may potentially be associated with background/upgradient sources.

In addition to the quantitative evaluations summarized above, select receptors were addressed qualitatively in this risk assessment. The qualitative evaluations indicate that the conclusions and recommendations for each Exposure Area would not be affected.

As presented in the previous sections, all quantitative results for the indoor worker meet the target benchmarks. However, at the request of USEPA, the VISL screening results are the decisive basis for vapor intrusion issues. Therefore, because constituents were detected in soil gas and indoor air at concentrations exceeding the default USEPA VISLs, the vapor intrusion pathway will be addressed in the Record of Decision. The use of vapor mitigation technology will be considered for future building construction at the site, including the APA, IPA, NCL and TF/TL Area.

In conclusion, this risk assessment indicates that there is negligible potential for adverse effects to current or potential future receptors exposed to environmental media from the following EAs: NW Area, Area A / Open Area; Area B; SCB Area; CL/GP Area; and Wetland Area. For the other Exposure Areas (APA, IPA, NCL, TF/TL Area, SR, TRA and Clonmell Creek), as well as for site-wide exposure, the exposures associated with unacceptable results are considered highly unlikely; however, at the request of USEPA, they will be addressed in the Feasibility Study and the Record of Decision for the site. While conclusions indicate unacceptable potential risk through excess fish tissue ingestion, exposure via the fish ingestion pathway is clearly associated with sources not originating from the site.”

8.0 NATURE AND EXTENT OF DETECTED CONSTITUENTS

The nature and extent of the detections of constituents in soil, groundwater, sediment and surface water at the Site for each EA are summarized in this section. Screening values developed through consultation with both the EPA and NJDEP are used to define the horizontal and vertical extent of detected constituents at concentrations above those screening values. Tables and figures for each media in each EA are referenced within the appropriate sections below. These tables and figures are the primary means of defining nature and extent in this RI Report. Section 8.1 provides a summary of the process used to develop the screening values applied within the tables and figures. Section 8.2 attempts to define the sources for constituents detected at the Site. Sections 8.3.1 through 8.3.12 summarize the information provided in the appropriate tables and figures for each media and within each EA. Section 8.4 reviews the soil gas data available for the site and Section 8.5 reviews groundwater data on a site wide basis.

8.1 SCREENING LEVEL DEVELOPMENT

Screening values based upon applicable or relevant and appropriate requirements were used to evaluate the nature and extent of detected constituents at concentrations above those screening values at the Site. The following section describes how CSI, in consultation with both EPA and NJDEP personnel, developed the screening levels used in this RI.

Screening values for each media were derived in a three-step process. The first step (primary screening values) assessed the available federal (EPA), regional (Region 2), state (NJDEP), and Site-specific screening values derived in earlier reports. With the exception of sediment, the lowest of the identified primary screening values was carried forward to the matrix specific screening table. The selection of the screening values for all media was reviewed by both EPA and NJDEP personnel in early 2017. The values developed are included in all summary detection tables for each media as noted in the sections below. The following summarizes the screening value selection process utilized.

Where no primary screening values could be identified, a secondary or tertiary screening value was selected. For soil and groundwater, these secondary values are the Site-specific screening values previously generated as part of the Ph II. To develop the secondary screening values for sediment and surface water and the tertiary values for soil and groundwater, a wider range of screening values was assessed by RBR on behalf of CSI and Hercules. RBR was requested to conduct this research because of their familiarity with the toxicology and chemical structure of the compounds where readily available primary screening criteria could not be found. If RBR could not find screening values via the primary, secondary, or tertiary screening assessment then they selected a surrogate compound as outlined in their Derivation of Screening Values Benchmark Tables Technical Memorandum (Appendix N).

Site-specific values were used for screening levels (i.e. hardness and total organic carbon), where appropriate. More detailed information on the secondary screening assessment and surrogate selection can be found in Appendix N (RBR, 2017). The sources used for the primary and secondary screening evaluation are identified below.

Soil – Direct Contact

1) Primary Screening Assessment Sources

    a) EPA Regional Screening Levels – Industrial Soil – May 2016 (https://www.epa.gov/sites/production/files/2016-06/documents/master_sl_table_01run_may2016_0.pdf)

    b) NJDEP Non-Residential Direct Contact Soil Remediation Standard – May 2012 (http://www.nj.gov/dep/rules/rules/njac7_26d.pdf)
    Note: These standards were revised on September 18, 2017. The revised standards are not incorporated herein as the screening levels had already been approved by both the EPA and NJDEP. The standard revisions are not expected to result in any substantive changes to the conclusions of this document.

2) Secondary Screening Assessment Sources

    a) Site Specific Screening Values developed as part of the Phase II Remedial Investigation – ERM 1995

3) Tertiary Screening Assessment Sources
    a) NJDEP Soil Cleanup Criteria – May 1999 (http://www.nj.gov/dep/srp/guidance/scc/)

    b) Calculated RSL – May 2016 (https://www.epa.gov/sites/production/files/2016-06/documents/master_sl_table_run_may2016.pdf)

Soil – Impact to Groundwater

1) Primary Screening Assessment Sources

    a) EPA Regional Screening Levels – SSL – May 2016 (https://www.epa.gov/sites/production/files/2016-06/documents/master_sl_table_01run_may2016_0.pdf)

    b) NJDEP Soil Remediation Standards Default Impact to Groundwater Soil Screening Levels for Contaminants – May 2012 (http://www.nj.gov/dep/srp/guidance/rs/igw intro.htm)
    Note: These standards were revised on September 18, 2017. The revised standards are not incorporated herein as the screening levels had already been

approved by both the EPA and NJDEP. The standard revisions are not expected to result in any substantive changes to the conclusions of this document.

Groundwater

1) Primary Screening Assessment Sources

    a) EPA Regional Screening Levels – Tapwater – May 2016 (https://www.epa.gov/sites/production/files/2016-06/documents/master_sl_table_01run_may2016_0.pdf)

    b) EPA Regional Screening Levels – MCL – May 2016 (https://www.epa.gov/sites/production/files/2016-06/documents/master_sl_table_01run_may2016_0.pdf)

    c) NJDEP Groundwater Quality Standards – July 2010 (http://www.nj.gov/dep/rules/rules/njac7_9c.pdf)

2) Secondary Screening Assessment Sources

    a) Site Specific Screening Values developed as part of the Phase II Remedial Investigation – ERM 1995

3) Tertiary Screening Assessment Sources

    a) Calculated RSL – May 2016 (https://www.epa.gov/sites/production/files/2016-06/documents/master_sl_table_run_may2016.pdf)

Sediment

1) Primary Screening Assessment Sources

    a) NJDEP Ecological Screening Criteria Freshwater Aquatic Life – March 2009 (http://www.nj.gov/dep/srp/guidance/ecoscreening/esc_table.pdf)

    b) EPA Freshwater Sediment Screening Benchmark – August 2006 (https://www.epa.gov/sites/production/files/2015-09/documents/r3_btag_fw_sediment_benchmarks_8-06.pdf)

    c) EPA Region 5 Ecological Screening Level – August 2003 (https://www3.epa.gov/region5/waste/cars/pdfs/ecological-screening-levels-200308.pdf)

    d) Clonmell Creek Site-Specific ESB

2) Secondary Screening Assessment Sources

   a) EPA Region 3 Biological Technical Assistance Group – August 2006 (https://www.epa.gov/sites/production/files/2015-09/documents/r3_btag_fw_sediment_benchmarks_8-06.pdf)

   b) EPA Assessment and Remediation of Contaminated Sediments Program Probable Effects Concentration – September 1996 (https://nepis.epa.gov/Exe/ZyPDF.cgi/2000BT5U.PDF?Dockey=2000BT5U.PDF)

   c) Florida Sediment Quality Assessment Guidelines – November 1994 (http://www.dep.state.fl.us/waste/quick_topics/publications/documents/sediment/volume1.pdf)

   d) National Oceanic and Atmospheric Administration Screening Quick Reference Tables – 2008 (http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf)

Surface Water

1) Primary Screening Assessment Sources

   a) EPA Water Quality Criteria – Freshwater Human Health – February 2017 (https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table)

   b) EPA Water Quality Criteria – Freshwater Aquatic Life – February 2017 (https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table)

   c) NJDEP Surface Water Quality Criteria – Freshwater Human Health - October 2016 (http://www.nj.gov/dep/rules/rules/njac7_9b.pdf)

   d) NJDEP Surface Water Quality Criteria – Freshwater Aquatic Life - October 2016 (http://www.nj.gov/dep/rules/rules/njac7_9b.pdf)

   e) NJDEP Ecological Screening Criteria Freshwater Aquatic Life – March 2009 (http://www.nj.gov/dep/srp/guidance/ecoscreening/esc_table.pdf)

   f) NJDEP Ecological Screening Criteria Freshwater Human Health – March 2009 (http://www.nj.gov/dep/srp/guidance/ecoscreening/esc_table.pdf)

2) Secondary Screening Assessment Sources
    a) EPA Region 3 Biological Technical Assistance Group – July 2006 (https://www.epa.gov/sites/production/files/2015-09/documents/r3_btag_fw_benchmarks_07-06.pdf)
    b) EPA RSL – Tapwater – May 2016 (https://www.epa.gov/sites/production/files/2016-06/documents/master_sl_table_01run_may2016_0.pdf)

8.2 SOURCES

This Site was an active chemical plant dating back to 1952. See Section 1.2.1 above for a detailed description of the Site history. Chemical manufacturing operations continued until 2009 when operations ceased and facility decommissioning commenced. A summary of facility manufacturing activities for the nearly sixty (60) year operational life of the plant are provided herein.

The activities associated with the chemical manufacturing process history are the primary sources of detected constituents at this Site. The manufacturing portion of the facility occupied approximately eighty (80) acres of the Site during plant operations. Principal operating areas within the manufacturing area of the Plant are shown on Figure 1-5. Until 1970, the plant manufactured phenol and acetone using a three-step chemical process. After 1970, the plant primarily produced three primary products including: 1) cumene hydroperoxide; 2) diisopropylbenzene hydroperoxide; and 3) Di-Cup. Four primary raw materials were used in the manufacturing process including cumene (isopropylbenzene); diisopropylbenzene; 25% caustic soda (sodium hydroxide solution); benzene; and sulfuric acid. GEO purchased the manufacturing assets covering approximately eighty (80) acres in May 2001 and continued production of industrial chemicals until 2009, at which time manufacturing operations at the facility ceased. The former Higgins Plant was decommissioned as of April 2010 and the facility structures were removed with the exception of the former administrative office building (decommissioned in 2016) and the WWTP.

Spills and releases from the above described chemical manufacturing processes resulted in the majority of the constituent detections described within this RI Report. Prior to plant decommissioning in April 2010 the process sewers throughout the process areas were replaced with above ground infrastructure and conveyances in a Sewer IRM.

During removal of the below ground sewer system at the Site, an estimated 1,400 tons of soil were excavated and consolidated into three discrete piles based on the process the soil was associated with. Impacted soil containing constituents above NJDEP SCC were staged for further waste profile characterization prior to shipment off-site for disposal at a certified disposal facility. Waste characterization samples were obtained from each of the three stockpiles (alkylation, oxidation, and recovery area stockpiles) for laboratory analyses. The results were tabulated to profile the soil for off-site transport and disposal at a licensed disposal facility. Results for waste characterization analyses revealed that the impacted soil was non-hazardous.

In addition to contaminant sources from the chemical manufacturing process, some additional historical sources of constituents exist at this Site. The TRA was in use from the late 1940s to the mid-1950s to dispose of non-putrescible municipal-type refuse material by Gloucester Township and local residents. An active shooting range utilized by the Borough of Greenwich Police Department also exists at the northeast corner of the Site. The rounds used at the shooting range are a likely source of lead in soils within the shooting range EA.

Soil gas and off-Site groundwater samples collected as part of a VI Investigation conducted by CSI in 2010/2011 indicated chlorinated solvent concentrations in the vicinity of a former dry cleaners that was located at 95 W. Broad Street in Gibbstown, NJ. Sporadic detections of chlorinated solvents continue to be detected in offsite and on-Site perimeter wells as well as on-Site deep extraction wells.

Finally, as detailed in Section 1.1, heavily industrial facilities adjoin the northwest and northeast portions of the Site. These neighboring properties as well as numerous other facilities located upstream of the Site on Clonmell Creek have resulted in sediment and surface water constituent detections within the Site that are now intermingled with Site-related SSCOCs.

8.2.1 R-NAPL

As mentioned above, the bulk of the Site-constituent mass consists of cumene that is either adsorbed to soil or sporadically dispersed R-NAPL. The dispersed R-NAPL exists within pore spaces along with water and air, and is held in place by interfacial tension. The majority of the dispersed R-NAPL encountered at the Site is below the water table within the A-Level aquifer. Studies completed by CSI have confirmed that the R-NAPL is dispersed or emulsified rather than in contiguous discrete lenses or layers. Furthermore, review of testing results confirms that the R-NAPL is not mobile. The presence of R-NAPL is principally associated with the former processing areas at the Site including the APA and IPA. Limited dispersed R-NAPL also may be present, to a lesser extent, in portions of the TF, MPP and in Clonmell Creek sediment.

Prior to the FI investigation, concerns were raised by the NJDEP that dissolved phase cumene concentrations approaching its solubility were present and further evaluation for the presence or absence of NAPL should be performed. However, previous studies had failed to document any discrete layer of NAPL at the Site. Since cumene is a light hydrocarbon (specific gravity or SG <1) it was expected that the NAPL would manifest as a distinct L-NAPL lens floating above the groundwater and creating a smear zone across the capillary fringe. However, no distinct L-NAPL layer had been found throughout the entire investigational history of the Site. Instead, R-NAPL was first documented during a UV study (described in Section 2.6) from soil samples obtained several feet below the water table. Results from the UV study describe the R-NAPL as being “scattered” or “molted” consistent with an emulsified R-NAPL under saturated conditions rather than being present in a discrete layer above the groundwater interface (Table 2-1).

The exact mechanism for how the R-NAPL became entrapped and dispersed in the saturated subsurface is not fully known. However, it is theorized that spills and releases both to the surface and through underground process sewers allowed raw materials and/or byproducts to enter the subsurface environment. The process fluids and byproducts, many of which have a SG slightly greater than 1, were able to migrate downward through the unsaturated soil and below the water table. Cumene would have a high affinity for raw products such as cumene hydroperoxide (SG of 1.05), enabling cumene to penetrate the soil matrix well below the water table. As weathering and other physio-chemical processes degraded the original raw products and process fluids, more persistent compounds such as cumene continued to persist in association with the soil matrix below the water table. Lighter, hydrophobic compounds such as cumene, became entrained within the saturated soils by interfacial tension and manifest as diffuse R-NAPL or even as R-NAPL ganglia but not as a discrete, mobile NAPL zone that can readily be mobilized and recovered, as discussed further herein.

In general, it is not feasible to recover the R-NAPL at the Site. An air sparge/soil vapor extraction (AS/SVE) test conducted in 2011 mobilized a small amount of the R-NAPL within the formation. Even after being freed, the NAPL behaved atypically compared to conventional L-NAPL. The small amount of freed NAPL manifested itself only in wells screened below the water table (not in those wells screened across the water table) and only at periods when the water table was above a threshold (approximate 0 ft above msl). Review of field results suggests that air sparging mechanically mobilized small amounts (<10%) of NAPL below the water table and created localized preferential channels, leading to intermittent NAPL occurrence in select wells screened below the water table. Further evaluation suggests that systematic recovery of NAPL by mechanical means may not be practicable at the Site for three principal reasons, including: 1) occurrence of dispersed emulsified R-NAPL below the water table; 2) low NAPL mobility (further described below); and, 3) complex heterogeneity of subsurface geology.

Small amounts of NAPL are sporadically observed in select wells in the AS/SVE test area that are screened below the water table. Small quantities of NAPL are periodically recovered and properly disposed. Prior to disposal, NAPL fingerprint analysis was performed. The results of this analysis are presented in Table 2-2. The NAPL consisted primarily of cumene and a-Methylstyrene (AMS) with lower concentrations of other hydrocarbons.

Following the AS/SVE and UV box tests, it was determined that more information was necessary to delineate the potential NAPL at the Site. As described in Section 2.6, an LIF meter was installed in line with the CPT probe. The results from this study allowed CSI to identify two locations within the APA most likely to contain NAPL. For confirmation purposes, direct push Geoprobe® soil cores were collected from these 2 locations (one containing fine grained soils and the one containing coarse grained soils), flash frozen, and sent to ALS Laboratory in Santa Fe Springs, California to determine the extent that R-NAPL could be freed from the surrounding formation. An initial pore space volume (water, air and NAPL filled) was measured, and then a centrifugal force of 1,000 times gravity was applied to the cores for one hour. After the centrifuge, a second pore space test was performed. The difference between the first NAPL pore space test and the second NAPL pore space test results represents the amount of NAPL that is potentially mobile. The results from both cores demonstrated that diffuse NAPL represented approximately 10 to 12.5% of the pore spaces (where NAPL is present) and only about 15% of the NAPL was recoverable using mechanical removal techniques (e.g. air sparging). As a result, the diffuse NAPL has been designated as residual NAPL, or R-NAPL, and is not readily recoverable [CSI, 2016].

During the CPT follow up direct push Geoprobe® soil sampling investigation, samples were also collected to determine a Site-specific C-Sat (soil *saturation* limit for a *chemical)* and Site-specific groundwater saturation limit for cumene. Data from the same two locations within the APA was used in these Site-specific calculations. This allowed for the development of a saturation limit and C-Sat value across multiple soil types (fine and coarse grained). The details of these calculations are covered in detail within the Site-Specific Cumene Solubility and Chemical Saturation Values (C-Sat) Summary Letter. The calculated Site-specific cumene solubility ranged from 42.6 mg/L to 107 mg/L for coarse grained and fine grained soil matrices, respectively, while the Site-specific cumene C-Sat ranged from 98.11 mg/kg to 149.37 mg/kg [CSI, 2016]. Locations with cumene concentrations above these Site-specific values are presented on Figure 8-1. It should be noted that AMS is not detected in every area where cumene has been detected above C-Sat (soil *saturation* limit for a *chemical)* in soil, and as such is not likely present in all areas of the Site where R-NAPL is present.

8.2.2 Sediment and Soil Background Sources and Statistical Analysis

A background statistical analysis was conducted to further evaluate the compounds that may be present within the soil and sediments of Clonmell Creek and surrounding wetlands that are driving either ecological risk as noted in Section 7.1 or human health risk as noted in Section 7.2. This analysis is documented in *Memorandum - Background Analysis of Inorganics Using Soil and Sediment Data (BERA Background Memorandum)* [RBR, 2017] and is provided in Appendix O for reference. This study was utilized to assess background inorganic sediment detections versus detections within the portions of Clonmell Creek, surrounding wetland areas, Outfall 002 and its drainageway and the SCB with known SSCOC detections in the BERA [RBR, 2017]. The BERA Background memorandum focused on inorganic compounds in soil and sediment samples collected by Hercules and will be discussed in more detail where applicable in the below nature and extent evaluations. The background sediment sample locations are shown on Figure 8-2.

As noted above, the BERA Background Memorandum [RBR, 2017] is provided in Appendix O for reference. The below briefly summarizes the findings of the BERA Background Memorandum [RBR, 2017]. The inorganic compounds that were found to be consistent with background conditions in on-Site sediments and soils (Wetland Area) were as follows:

- Wetland Area - aluminum, antimony, arsenic, cadmium, chromium, cobalt, iron, lead, selenium, silver, thallium and vanadium.

- Outfall 002 & drainageway - antimony, arsenic, beryllium, cadmium, lead, nickel and zinc.
- SCB – antimony, arsenic, beryllium, cadmium, iron, lead nickel and zinc.
- Clonmell Creek – aluminum, antimony, arsenic, beryllium, cadmium, cobalt, copper, lead, manganese, mercury, nickel, selenium silver, vanadium and zinc.

An additional background study (Appendix T) was conducted as part of the RI to reduce any uncertainty as to the source of ubiquitous compounds found in Clonmell Creek that were causing the unacceptable fish ingestion risk. The compounds assessed in this study were dieldrin, Aroclor 1254, mercury in sediment and 4,4’DDD and gamma chlordane in surface water. The background study looked at sediment, wetland soil, neighboring site data, and local and regional fish consumption advisories. The lines of evidence presented above, along with the uncertainties regarding the HHRA fish ingestion risk calculations, provides sufficient evidence to indicate that all five compounds (dieldrin, Aroclor 1254, mercury, 4,4’DDD and gamma chlordane) are present regionally in sediments and soils and are not related to Site activities. As part of the remedial efforts at the Site efforts can be made to educate the local populace regarding potential risk from ingesting fish caught in Clonmell Creek.

8.2.3 Upstream Permitted NJPDES Discharge Points in Clonmell Creek

Clonmell Creek is the receiving water for large portions of Gibbstown, Greenwich Township, and Paulsboro. As such it receives run off from residential, agricultural, commercial, municipal and industrial properties. A review of permitted NJPDES discharge points on Clonmell Creek via the NJ-GeoWeb website (http://www.nj.gov/dep/gis/geowebsplash.htm) listed four (4) total permitted NJPDES discharges (including three (3) industrial discharge points and one (1) municipal discharge point) into the portion of Clonmell Creek upstream from the Site. The following are the NJPDES discharge points upstream of the Site:

- 3 Industrial NJPDES
  - Air Products & Chemicals Permit - NJ0004278 Pipe 001N
  - Air Products & Chemicals Permit - NJ0004278 Pipe 001A
  - Air Products & Chemicals Permit - NJ0004278 Pipe 002A
- 1 Municipal NJPDES
  - Paulsboro Water Treatment Plant Well 4 - NJG0026191 Pipe 001N

8.3 EXPOSURE AREA INVESTIGATIVE HISTORY SUMMARIES AND NATURE AND EXTENT DISCUSSION BY MEDIA

8.3.1 Active Process Area Investigation History Summary

As noted in Section 3.1 in detail above, the APA EA was the center of the Site’s former chemical manufacturing operations. As such, this area has been thoroughly investigated during the multiple phases of the RI. The following is a summary of the samples that have been obtained in this EA and that are used to assess nature and extent in the APA EA in this RI.

A total of one (1) soil boring was advanced in the APA EA during the 1983 Phase II field investigation [ERM, 1983]. A total of two (2) samples were obtained from depths of two (2) to five (5) ft bgs and five (5) to eight (8) ft bgs. The samples were obtained in the former alkylation area to assess areas where spills/releases were likely.

A total of five (5) soil borings were advanced in the APA EA during the 1985 Phase V investigation. A total of nine (9) samples were obtained from the five (5) boring locations. The goal of these borings was to assess whether extensive pockets of contamination were present in unsaturated soils.

A total of eight (8) soil borings were advanced in the APA EA during the 1988 Ph I investigation. The borings ranged in depth from six (6) to twelve (12) feet and samples were obtained from between four (4) and twelve (12) feet. One of the primary objectives of this investigation was to investigate potential contaminant migration pathway from the unsaturated soils to groundwater.

A total of nine (9) soil samples were obtained in 1991 as part of an investigation around tank F259A in the alkylation area and tank F315A in the oxidation area. CSI was unable to locate any documentation for this investigation. However, the 1995 Ph II document indicates these samples were obtained for the above reasons and that some excavation of shallow soils was conducted in the area of tank F249 in the Recovery Area. Furthermore, it was noted that any residual soil exceedances in this vicinity are related to the historic spills in this area.

During the 1994 Ph II investigation a total of 130 samples were obtained from multiple borings in the APA (sample IDs starting with APA from 1994). Two of these samples are indicated as sediment samples (APA-1-SED and APA-2-SED). However, because the swale from which they were obtained (located just east of the former process area) in the APA is typically dry, these samples have been included with soils for the purpose of this RI Report. In addition, nine (9) samples were obtained from three (3) borings in the CLA (sample IDs starting with CL, now the southwest corner of the APA EA) and eighteen (18) samples were obtained from the warehouse area (sample IDs starting with WH, now the eastern portion of the APA EA) from four (4) different locations. Two of the Warehouse (WH) samples (WH-SED-1 and WH-SED-2) were designated as sediment samples during this investigation. However, similar to the APA sediment samples, the swale from which these samples were obtained is typically dry and thus these samples have been included with the soils for the purpose of this RI Report. One surface water sample (WH-SW-02) was also obtained from a puddle in this swale. The goal of this investigation was to thoroughly delineate detected constituents at concentrations above the RI screening values in each area. A Geoprobe™ was used to obtain samples from each boring at the ground surface, between the ground surface and the water table, typically in the vadose zone at most locations.

Two (2) MIP samples were obtained in the APA during the 2002 SRI to assess areas where free phase (FP) residual product was observed, but in insufficient quantity to sample. FP-SRI-02 was obtained in a drainage swale located in the east at a depth of 7.5 to 10 ft bgs, central portion of the APA just east of the process area. FP-SRI-03 was obtained just north of the API skimmer at a depth of thirteen to fifteen (13 to 15) ft bgs.

A total of thirteen (13) soil samples were obtained from thirteen (13) Geoprobe™ locations in the APA EA during the 2009 FI. A groundwater sample was obtained from twelve (12) of these locations through a temporary well point. The temporary well point data are not used to assess nature and extent of groundwater detections in this RI but are used to assess New Jersey IGW exceedances for unsaturated soil data in Section 8.3.1.1 below. The primary goal of the 2009 FI was to fill data gaps from previous investigation phases.

A total of fourteen (14) soil samples were obtained from seven (7) cone penetrometer boring locations during the 2013 CPT investigation in the APA EA. The goal of this investigation was to gather additional subsurface geology information and to further quantify the mass of contaminants entrained in subsurface soils.

In addition to the above described soil data there are a total of ten (10) monitoring wells and one B-level extraction well (PW-9) in the APA EA. Several of the B-level extraction wells, including PW-9 (plus PW-7B, PW-5B, and PW-8B), were turned off in 2013 as part of the extraction well system optimization. The monitoring wells are as follows: MW-6, MW-6B, MW-11, MW-11B, MW-51, MW-51B, MW-55B and MW-55C. In addition, former production well PW-10 still exists in this EA but has not been sampled since it was replaced by PW-10R in 2007. Analytical data from the second quarter 2013 through the second quarter of 2017 from samples obtained from these wells are used to assess the nature and extent of groundwater detections in the APA EA in this RI Report.

The sample locations for this EA are shown on Figure 3-1. The analytical data available for this EA are summarized on Table 8-1 (soil), Table 8-2 (groundwater wells), Table 8-3 (temporary well points) and Table 8-4 (surface water) along with a comparison of those data to the screening values developed for this RI as outlined in Section 8.1 above. Frequency of detection summary tables for soil, groundwater wells, temporary well points and surface water for this EA are provided in Tables 8-5, 8-6, 8-7 and 8-8, respectively.

The following sections outline the nature and extent of constituent detections in this EA by media.

8.3.1.1 Soil

A summary of the detections in the soil samples for this EA is provided in Table 8-1. Frequency of detection summary statistics for these data are provided in Table 8-5.

As discussed in Section 2.1.5.5 a UV survey of soils that were most likely to contain LNAPL was conducted as part of the 2009 FI. Sample APA-1 (from former alkylation area) showed no UV fluorescence indicative of LNAPL. Sample aliquots from APA-8 (from drainage swale in east central APA near AS/SVE test area) and APA-6 (from vicinity of former API skimmer) showed weak to moderate fluorescence. Weak and moderate fluorescence is typically indicative of LNAPL smearing, historical LNAPL, or dispersed R-NAPL (see Section 8.1.1.1 for more detailed discussion of NAPL).

PAHs

The following three (3) PAH compounds had detected concentrations in APA EA soil samples that exceed applicable RI screening values: benzo(a)pyrene, benzo(b)fluoranthene and dibenz(a,h)anthracene. The soil samples with the highest detected concentrations of these compounds are CPT-44 (11.5'), F315A-SS and APA-2-SED. Sample F315A-SS is located in the former oxidation area and was sampled because of historic spills in 1991. CPT-44 was obtained just east of this area and APA-2-SED was obtained from a swale located further east just outside of the former process area. The detection of these PAHs are in the vicinity of Tank F315 that was located in the former oxidation area.

SVOCs

There are twelve (12) detections of acetophenone (SSTIC) and one (1) detection of carbazole at concentrations that exceeded their applicable RI screening values for soil in the APA EA. The carbazole detection is from location FP-SRI-02. Acetophenone was also detected at this location at a concentration above the applicable RI screening value. This sample was obtained from a depth of seven and a half (7.5) to ten (10) ft bgs and was obtained to assess the potential for NAPL in the drainage swale area in the eastern portion of the APA during the 2002 SRI. The other acetophenone exceedances are found in this east central portion of the APA and stretch across the northern half of the APA to the west as far as location APA-2 where the highest concentration of acetophenone was detected at a depth of nine and a half (9.5) ft bgs. The detections of acetophenone in soils in the APA EA at concentrations that exceed the RI screening value are located at depths between four (4) and seventeen (17) ft bgs.

These results are consistent with those reported in the 2002 SRI and 1995 Ph II Reports. Localized high concentrations of acetophenone in the vicinity of the former API Skimmer, in the drainage swale located on the eastern perimeter of the former process area and in the vicinity of the former oxidation area continue to effect groundwater quality in this vicinity.

VOCs

There are eight (8) detections of benzene, twenty-one (21) detections of cumene and five (5) detections of ethylbenzene at concentrations that exceeded their applicable RI screening values for soil in the APA EA. The cumene detections that exceed the RI screening value are located in a ring around the center of the APA generally consistent with and adjacent to the former sewer lines and in the vicinity of former Tanks F259A and F315A. The benzene detections that exceed the RI screening value are mostly clustered in the area just south of the former process area near a swale that runs north/south in this vicinity. Additionally, three (3) isolated benzene detections at concentrations that exceed the RI screening value are located in the vicinity of former tank F315A (F315A-SS), adjacent to the former APA skimmer (FP-SRI-03) and just north of the former alkylation area (SB-7). The depth of all samples with exceedances of the RI screening values ranged from two (2) to seventeen and a half (17.5) ft bgs.

The locations that have the majority of the VOC detections are just south of the former process area, generally clustered around location FP-SRI-02, and just west of the former API skimmer and further west through the former oxidation area. These are the areas where historical investigations have consistently identified the highest concentrations of Site-related VOCs in all media.

New Jersey Impact to Groundwater (NJIGW) and New Jersey Direct Contact Non-Residential Soil Remediation Standards (NJDCNRSRS) Assessment

As requested by NJDEP, RBR conducted an assessment of available soil data against the NJIGW and NJDCNRSRS (see Appendix P). A summary of relevant groundwater results is included for comparative discussion to address NJIGW exceedances for soil.

The compounds with detected concentrations in soils that exceed the NJDCNRSRS in the APA EA were acetophenone, benzene, benzo(a)pyrene, benzo(b)fluoranthene and dibenz(a,h)anthracene. These NJDCNRSRS exceedances are consistent with the exceedances of the RI screening values and are discussed in detail above.

The compounds with detected concentrations in soils that exceed the NJIGW in the APA EA were: 2-butanone, acetone, benzene, bromoform, ethylbenzene, methylene chloride, tetrachlorethene, toluene, acetophenone, benzo(a)anthracene, aluminum, antimony, arsenic, beryllium and manganese.

The data from the temporary well points in the APA EA have been compiled on Table 8-3, and a frequency of detection summary of these data is provided on Table 8-7, to help further assess the NJIGW exceedances. The data from the temporary well points include additional analyses that are not part of the quarterly groundwater monitoring activities at the Site and are thus helpful in assessing the NJIGW exceedances of non-VOC compounds. As a result, groundwater conditions have long since reached dynamic equilibrium and Site-related contaminant concentrations are stable or decreasing (see Section 9 for more detailed discussions). Consequently, if the detected compounds in soil that exceed an NJIGW criteria are not present in the groundwater data from temporary or permanent wells, then it is reasonable to deduce that there are no resulting effects to groundwater from those soil exceedances. The data from the permanent well points compiled in Table 8-2 and frequency of detection summary provided in Table 8-6 were also reviewed to assess the NJIGW exceedances. The following is a compound specific summary reviewing the relevant data in locations where soil sampling results exceeded the NJIGW:

- 2-butanone – There are five (5) exceedances of the RI screening value in the permanent well MW-51B for this compound. The detections are all from the period between second quarter 2015 and second quarter 2017 and range in concentration from 400 J ug/L to 540 H ug/L. Well MW-51B was installed as part of air sparging testing in this portion of the APA. 2-butanone, also known as methyl-ethyl-ketone (MEK), has similar solvent properties to acetone but is not commonly detected at the Site. Though the origin of 2-butanone detections in this portion of the Site are not known, it is possible that these detections are related to the air sparging testing in this area in September/October 2011 [CSI, 2012]. Prior to air sparging in this area, 2-butanone was not detected in the groundwater data from the temporary well points installed during the 2002 SRI, 2009 FI or 2013 CPT sampling events.

- Acetone – eight (6) total exceedances of the RI screening value were noted in the data from the permanent wells. All of these detections are in samples from well MW-51B. One (1) exceedance of the RI screening value in the temporary wells was noted in the 2002 sample GP-APA-SRI-02. Acetone can be generated by oxidizing cumene. As a result, the acetone detections in samples from MW-51B may be related to the air sparging testing conducted in September/October 2011. The acetone detection at location, GP-APA-SRI-02, may also be related to a localized historical acetone release. No widespread acetone detections are noted in the groundwater data.

- Benzene – A total of nineteen (19) temporary well points and sixty-five (65) permanent well samples had detected concentrations that exceed the RI screening value for this compound. The highest concentrations were noted at location APA-8 for the temporary well points and at MW-6B for the permanent wells. All of the benzene groundwater detections are from the central portion of the APA. No benzene detections were noted from permanent or temporary wells located east or west of this area. These detections correlate to the locations of the benzene concentrations above applicable RI screening values detected in soils.

- Bromoform – There are no detection of bromoform in any of the samples from permanent or temporary well points in the APA EA.

- Ethylbenzene – Twenty (20) temporary well points and sixty-one (61) permanent well samples had detected concentrations that exceeded the RI screening value. The highest concentration detections were noted at location APA-8 for the temporary well points and at MW-6B for the permanent wells. The primary area of ethylbenzene detections appears to be just east of the former process area in the vicinity of FI sample locations APA-7 and APA-8. A second area of ethylbenzene detections appears to be just south of the former alkylation area in the vicinity of the MW-6 and MW-6B well cluster.

- Methylene chloride – There are no detected concentrations of methylene chloride in any of the permanent or temporary well points.

- Tetrachloroethene (PCE) – Five (5) permanent well samples from location MW-55C had detected PCE concentrations that exceeded the RI screening value. No temporary well points in the APA EA had detections. The only other detections of PCE were estimated concentrations in samples from MW-55B in 2013 and 2014. No exceedances of the RI screening value were noted for PCE and trichloroethene (TCE) in shallow A-level groundwater at the Site. The absence of shallow groundwater detections of PCE and TCE in the APA EA indicates that the noted B and C-level groundwater detections do not appear to be related to shallow soil and groundwater detections at the Site.

- Acetophenone – This is an SVOC compound. None of the permanent wells have SVOC data. Ten (10) temporary well point samples had detected concentrations that exceeded the RI screening value. The highest concentration detected was in the sample from location APA-8. The bulk of the ten (10) locations are located in the northeastern portion of the former process area with some detections located in the vicinity of sample location APA-2. These detections correlate with the locations of the acetophenone detections at concentrations above applicable RI screening values in soils as noted above and the areas of known SSSCOC groundwater detections.

- Benzo(a)anthracene - This is an SVOC compound. None of the permanent wells have SVOC data. Two (2) temporary well point samples had detected concentrations that exceeded the RI screening value. Location APA-5 and its duplicate have the only detections in groundwater samples for this compound. There were no soil samples that had detected concentrations of this compound above the RI screening value. However, this compound was detected in the vicinity of former tank F315A.

- Aluminum, antimony, arsenic, beryllium and manganese – no metals data are available for any of the temporary or permanent well points in the APA EA. All of these metals were identified as being present at concentrations in background samples above those in one or more of the exposure areas assessed, as noted in Section 8.2.2 above.

Based upon the above analysis there are detected concentrations in groundwater from Site-related COCs benzene, ethylbenzene and acetophenone in soils in the central portion of the former APA. None of the other detected compounds with concentrations that exceeded applicable NJIGW criteria appear to have had any widespread effects on groundwater quality within the APA EA. Some localized detections of constituents not considered SSCOCs are noted above; however, these would be addressed in conjunction with any SSCOC detections in this EA.

Soil Detection Summary

Consistent with historical investigations in the APA EA the primary areas for soil detections were found to be as follows:

- Weak to moderate fluorescence of soil samples from the API skimmer area (APA-6) and the drainage swale near the AS/SVE study area (APA-8) indicates possible NAPL smearing, historical NAPL, or dispersed R-NAPL in this area.

- PAH concentrations in soil were found in the vicinity of former storage tank F315 in the former oxidation area.

- Acetophenone concentrations in soil stretches from the vicinity of the API skimmer through the former oxidation area to west of the Anaerobic Biotreatability Pilot Study Area.

- Benzene, cumene and ethylbenzene soil concentrations were noted to be the highest in the area just east of the former APA near a drainage swale south of the AS/SVE Study Area. A secondary area of detected concentrations of these compounds has a similar footprint than the acetophenone area noted above and stretches from west of the API skimmer and west through the former oxidation area.

- The soil detections noted above were at depths between two (2) and seventeen and a half (17.5) ft bgs.

- Detected concentrations in groundwater of Site-related COCs benzene, ethylbenzene and acetophenone also found in soils were noted in the central portion of the former APA.

8.3.1.2 Groundwater

The data from permanent monitoring wells from 2013 through the second quarter of 2017 in the APA EA are summarized on Tables 8-2 (Detections) and 8-6 (Frequency of Detections). The data from the APA EA consist of VOC and total phenolics data. The bulk of the samples with detections that had concentrations that exceed the RI screening values were for the known Site-related VOCs as follows: acetone, benzene, cumene, ethylbenzene, toluene and the SSTIC a-methylstyrene. Total phenolics, also a Site related COC, have also been frequently detected in samples from wells MW-6B, MW-51 and MW-51B in this EA. Several chlorinated solvent and daughter products were also detected at concentrations that exceeded the RI screening values including: 1,1-dichloroethene, 1,2-dichloroethane, cis-1,2-dichloroethene, tetrachloroethene, trichloroethene and vinyl chloride. Almost all of the chlorinated solvent compounds were detected in B- and C-level groundwater. Only minimal chlorinated solvent detections have been noted in shallow A-level soil and groundwater and are discussed in more detail below.

The Site-related VOC and total phenolics detections at concentrations exceeding their applicable RI screening values are primarily noted in samples from wells located in the central portion of the APA EA (MW-6, MW-6B, MW-51, MW-51B, MW-55B and MW-55C). No detections of these compounds at concentrations exceeding their applicable RI screening values were noted in samples from MW-11 or MW-11B. This indicates that these compounds are not migrating to the west from this area. Detections at concentrations exceeding the RI screening values were noted in samples from PW-9 but were not noted in either MW-9 or MW-9B. This indicates no migration of detected constituents in groundwater to the east of the central APA area.

The chlorinated solvent and daughter product detections are primarily in samples from well MW-55C. Outside of two (2) estimated detections of PCE in samples from MW-55B in 2013 and 2014, all of the detections of cis-1,2-dichloroethene, PCE, TCE and vinyl chloride are from well MW-55C. One detection of 1,1-dichlorethene was noted in a 2013 sample from MW-6 but has not been detected there since. Similarly, one detection of 1,2-dichloroethane was noted in a sample from MW-6B in 2013 but has not been detected there since. The lack of additional detections at these locations make these initial detections suspect. Because the primary chlorinated solvent detections are noted in samples from well MW-55C with no nexus to A or B-level detections of these compounds in the APA EA or neighboring IPA EA, the source of these C-level detections is unknown.

Other VOC compounds detected at concentrations that exceeded their applicable RI screening value in the APA EA include: 2-butanone, 2-hexanone, chloroform and total xylenes. All four compounds were detected at their highest concentrations and only in samples from MW-51B, with one exception. Total xylenes was also detected in two samples from MW-6B in 2013, but has not been detected again at this location since that time. Outside of these lone total xylenes detections in samples from MW-6B, these compounds are exclusive to MW-51B which is located in the air sparging test area. It is suspected that air sparging testing may have contributed to the observed detections at MW-51B, either through mechanical agitation or possible oxidation of existing compounds in this vicinity.

8.3.1.3 Surface Water

A summary of the detections in the surface water sample for this EA is provided in Table 8-4. Frequency of detection summary statistics for these data are provided in Table 8-8.

There are no perennially flowing water bodies in this EA. Several swales exist in this EA that are normally dry or ephemeral. However, a swale located north of the former southern warehouse was found to contain water during the 1994 Ph II swale study and a surface water sample (WH-SW-2) was obtained there. This is the only surface water sample for this EA. Sample WH-SW-2 had detections of bis(2-ethylhexyl)phthalate, carbon disulfide and cumene that exceed the applicable RI screening values for these compounds. It should be noted that all three of these detections were flagged “J” for estimated and thus the accuracy of these detections is in question. The carbon disulfide detection (1 J ug/L) was only slightly above the RI surface water criteria of 0.92 ug/L. Due to the age of these detections and the volatile nature of these compounds it is expected that any residual concentrations from these compounds are now below applicable RI screening values.

8.3.1.4 Summary

As expected for this EA that served as the center of the chemical manufacturing activities at this Site for decades, there are concentrations in soils and groundwater in the central portion of this EA from Site-related compounds that will be evaluated within the FS. The SSCOC concentrations above applicable RI screening values appear to be limited to the central portion of the former APA with some soils and groundwater detections in the south/central portion of the IPA EA (between the IPA pond and the APA EA) and to the north/central portion of the Tank Farm EA (vicinity of the MW-6 well cluster) attributable to the APA EA. Soil detections above applicable RI screening values were noted at depths ranging between two (2) and seventeen and a half (17.5) ft bgs. Some non-Site related compounds were detected also detected at concentrations above applicable RI screening values but these detections appear to be related to degradation of Site-related compounds, small footprint releases or as a result of off-Site groundwater sources being detected in deeper B- and C-level groundwater.

8.3.2 Area A/Open Area Investigation History Summary

As noted in Section 3.2 in detail above, this EA is comprised of two distinct areas where no evidence of any historical disposal or process activity has been found. The “Open Area” was named as such by CSI because it consists of the only area on the main site that does not contain wetlands, flood plains or any historical process activity (see Figure 1-3). The only activities reported in the “Open Area” historically are the use of one brick building to house administrative personnel, one small building as a guard shack and a parking lot for plant personnel. The former administration building and guard shack were demolished and the debris removed from the Site in 2016. A portion of the administration building basement foundation was left in place and soil was placed on top.

Area A was added to the “Open Area” to create a larger EA where no detections of SSCOCs from Site activities are expected to be present. Area A is designated as such because this is how it is referred to in a pending Natural Resource Damage (NRD) claim by the State of New Jersey. Area A was historically used for agricultural purposes prior to the construction of the plant in the 1940’s. After the plant was constructed this area remained as an open field with some forested areas around its perimeter. No evidence of any disposal activities or processes has been found in Area A throughout the investigative Site history.

The following is a summary of the samples that have been obtained in this EA and that are used to assess nature and extent in this RI:

The oldest sample in this EA is from location B-62. This was a soil boring sample obtained as part of the 1988 Soils Investigation [ERM, 1988]. This sample location was obtained at a depth of ten (10) to twelve (12) ft bgs and was determined to be a background location because no evidence of past activities had been noted in this vicinity. The B-62 location is just south of the GP EA.

The next set of samples collected in Area A were obtained by ERM during the SRI in 2002. Four “reference” surface soil locations (SRI-SS-11R through SRI-SS-14R) were collected just south of the access road that runs along the edge of Area A and the GP EA. This area was selected by ERM and approved by NJDEP in 2002 because it was an area that “was never developed or used for such activities.”

Additional samples were then obtained from Area A in 2003 and 2008 as part of an investigation to determine if soils from this area would be appropriate for use as cap material for the SWDA Remedial Action. Test pit samples were obtained from multiple locations and are identified with sample IDs that start with TP. From 2010-2012 the construction of the SWDA cap was conducted. The soils used to construct the cap and for fill during other parts of this remedial effort were removed from the Borrow Pit area as shown on Figure 3-2. Soils were removed from this approximately 417,000 square foot area to an approximate depth of four (4) ft bgs. Thus, any samples obtained from this area are not shown or used in this remedial investigation as the sampled soils are now part of the SWDA cap.

One sample was obtained from behind the former administration building in the Open Area in 2009 as part of the FI [CSI, 2009]. This sample location was designated as “Background” since this area was far removed from any manufacturing or disposal activities and was intended to be used to assess Site background conditions during the FI.

The remaining sampling done in the Open Area and Area A were conducted as part of the 2015 ARI [CSI, 2015]. The ARI was conducted at the request of the EPA to characterize areas that had not previously been characterized or needed additional sampling. The samples obtained in Area A have “ARA” in their IDs and the Open Area samples have “OA” in their IDs.

In addition to the soil samples outlined above, there are two (2) monitoring wells located just south of the parking lot in the Open Area. The wells are designated MW-19B and MW-19C and are screened in the B- and C-level aquifers, respectively. These wells are perimeter monitoring wells that monitor groundwater in the southeast corner of the main Site.

There are no surface water bodies in this EA; thus, there are no sediment or surface water samples or data.

The sample locations for this EA are shown on Figure 3-2. The analytical data available for this EA are summarized on Tables 8-9 (soil) and 8-10 (groundwater) along with a comparison of those data to the screening values developed for this RI as outlined in Section 8.1 above. Frequency of detection summary tables for soil and groundwater for this EA are Tables 8-11 and 8-12, respectively.

The following sections outline the nature and extent of detections in this EA by media. Only soil and groundwater data are available for this EA.

8.3.2.1 Soil

A summary of the detections in the soil samples for this EA is provided in Table 8-9. Frequency of detection summary statistics for these data are provided in Table 8-11. As expected for this EA with no process or disposal history, there are minimal exceedances of the applicable RI screening criteria in the data available for this EA. Arsenic was detected at concentrations exceeding the RSL for industrial soils of three (3) mg/kg in forty-four (44) of the 136 available samples that were analyzed for metals in this EA. However, the recognized direct contact standard for arsenic in New Jersey based upon naturally occurring background levels is nineteen (19) mg/kg. None of the samples in this EA had a concentration of arsenic that exceeded this direct contact standard.

The only other compound where a detected concentration exceeded its applicable screening criteria was in one (1) 1988 Ph I Soils Investigation [ERM, 1989] sample (B-62). This sample had a reported concentration of 20.8 mg/kg of n-nitrosodimethylamine. Of the forty-two (42) samples analyzed for this atypical compound across the Site, no other detections were noted. This sample, B-62, was obtained from a depth of 10-12 ft bgs. The 1989 Ph I Soils Investigation report indicates that this result is suspect because no other samples contained detected concentrations of this compound [ERM, 1989]. As a result, no further action is warranted to address this single detection of a non-Site related compound.

New Jersey Impact to Groundwater (NJIGW) and Direct Contact Non-Residential Soil Remediation Standards (NJDCNRSRS) Assessment

As requested by NJDEP, RBR conducted an assessment of available soil data against the NJIGW and NJDCNRSRS (see Appendix P).

In the Area A/Open Area EA the only compound with a concentration that exceeded an applicable NJDCNRSRS was n-nitrosodiethylamine in the 1988 Ph I sample B-62 obtained from a depth of ten to twelve (10-12) ft bgs. As noted above, this result is suspect and does not correlate with any other detections of this compound on the Site.

Compounds with detected concentrations that exceeded applicable NJIGW criteria include: methylene chloride, dieldrin, aluminum and manganese. The lone methylene chloride detection is from the same 1988 Ph I sample B-62 in which n-nitrosodiethylamine was detected. No other detections of methylene chloride were found in any soil samples in this EA thus this detection is considered suspect along with the detection of n-nitrosodiethylamine.

The lone detection of dieldrin was in the 2008 sample TP-9, obtained during the borrow pit investigation for the SWDA. This sample was composited from depths of zero to six (0-6) ft bgs. This sample location is on the edge of both the Shooting Range EA in the gravel pit area. This lone detection of dieldrin from a composited soil sample is an outlier and may be related to laboratory/sampler error.

Aluminum and manganese are ubiquitously present in soils at the site. Of the 115 samples available in this EA aluminum was detected in 114 and manganese was detected in all 115 of those samples. No metals data are available for groundwater in this EA for comparative assessment of potential NJIGW exceedances. However, as noted previously and as supported by the other analytical data available for this EA, there is no history of any disposal or process activity within this EA. Thus, there is no reason to believe that the noted aluminum and manganese detections are not naturally occurring. Furthermore, as noted in Section 8.2.2 above, both aluminum and manganese were found to be at concentrations on Site similar to those found in background samples from Clonmell Creek.

Soil Detection Summary

No soil detections that warrant further action were found in the Area A/Open Area EA.

8.3.2.2 Groundwater

Quarterly groundwater analytical data for the two wells in this EA (MW-19B and MW-19C) are provided on Table 8-10. Frequency of detection statistics for those data are provided on Table 8-11. A review of these data indicates that only TCE has been detected above an applicable screening criterion in samples from these wells over the last five (5) years. Two (2) detections of TCE were noted in samples from MW-19B in 2013 and 2014 and two (2) detections in samples from MW-19C in 2016 and 2017. The highest TCE concentration detected was an estimated concentration of 0.91 J ug/L in a sample from MW-19B in May 2014. TCE was not detected in samples from MW-19B in 2016 and 2017 but was then detected in samples from MW-19C at estimated concentrations above the RI screening value but below the estimated concentrations in the samples from MW-19B in 2013 and 2014. These detections are isolated and do not appear to be related to Site activities.

No documentation or analytical evidence of historical chlorinated solvent use has been discovered for the Site. Chlorinated solvents are sporadically detected in perimeter wells such as MW-19B and MW-19C as well as deep extraction wells on the Site. No nexus between the sporadic detections of chlorinated solvents on the Site in the IPA EA and these perimeter wells is present. Thus, isolated low-level detections of chlorinated VOCs and related degradation products in this EA do not warrant further action.

8.3.2.3 Summary

There are no detections in this EA in the available soil and groundwater data that warrant further action. This comports with the lack of process history or waste disposal in this EA.

8.3.3 Area B Investigation History Summary

As noted in Section 3.1 in detail above, Area B is an area that was never used for any process or disposal activities historically. Area B is designated in an NRD settlement by the NJDEP. This EA is located just east and north of the Clonmell Creek & Wetlands EA. Clonmell Creek runs along the southern edge of this EA and is assessed separately in this RI and in the BHHRA and BERA. The PRC owns the property just to the north of this EA and south of Clonmell Creek off the southeast corner of the Site.

This EA has several historical drainage features that run through it as shown on Figure 3-3. Historical research indicates that these features date back to when the area along the Delaware River was reclaimed for agricultural purposes. The levee and flood gates along the Delaware River were put in place in the late 1600s by the RMC. These drainage features are typically a linear feature and represent the only evidence of anthropogenic influences in Area B. Because there is no evidence of process or disposal activity there are only a few sample locations in this area.

The following is a summary of the samples that have been obtained in this EA and that are used to assess nature and extent in this RI:

Two (2) sediment samples, SED-6 and SED-8A, were obtained in this EA during Ph II in 1994 from depths of zero (0) to six (6) inches bgs. Sample SED-6 was obtained as a background location. Sample SED-8A was obtained to assess conditions in the drainage ditch/feeder stream that enters Clonmell Creek in this area. This drainage ditch/feeder stream emanates from the PRC property located just north of this EA.

One (1) surface water sample, SRI-SW-8R, was obtained in this EA during the SRI in 2002. This location was obtained as an upstream reference location to be used to compare against surface water data obtained in areas closer to the manufacturing portion of the Site.

Three (3) soil and two (2) sediment samples were obtained in this EA during the ARI in 2015. The soil samples were composited from a depth of zero (0) to twelve (12) inches bgs and the sediment samples were composited from a depth of zero (0) to six (6) inches bgs. These samples were obtained to characterize the previously unsampled portions of Area B at the request of EPA.

There are no groundwater data available for the Area B EA.

The sample locations for this EA are shown on Figure 3-3. The analytical data available for this EA are summarized on Tables 8-13, 8-14, and 8-15 along with a comparison of those data to the screening values developed for this RI as outlined in Section 8.1 above. Frequency of detection summary tables for soil, sediment and surface water for this EA are provided in Tables 8-16, 8-17 and 8-18, respectively.

The following sections outline the nature and extent of detections in this EA by media.

8.3.3.1 Soil

A summary of the detections in the soil samples for the Area B EA is provided in Table 8-13. Frequency of detection summary statistics for these data are provided in Table 8-16. The only detected compound in the soil samples in this EA with a concentration that exceeded the applicable RI screening value is arsenic. However, the recognized background concentration for arsenic in soil in New Jersey is 19 mg/kg. None of the detections of arsenic in this EA have a concentration that exceeds 19 mg/kg.

Low concentration detections of several PAH and SVOC compounds in this area may be related to background sources. Detections of four (4) pesticide compounds at low concentrations were also noted. These are likely related to historic pesticide use in this vicinity for insect control.

New Jersey Impact to Groundwater (NJIGW) and Direct Contact Non-Residential Soil Remediation Standards (NJDCNRSRS) Assessment

As requested by NJDEP, RBR conducted an assessment of available soil data against the NJIGW and NJDCNRSRS (see Appendix P).

In the Area B EA the only compound with a concentration that exceeded an applicable NJDCNRSRS was benzo(a)pyrene in the 1994 Ph II sample SED-06. However, this sample is a sediment sample that was erroneously included in RBRs assessment of unsaturated soil data and thus should not be considered as an exceedance of the NJDCNRSRS in Area B.

Compounds with detected concentrations that exceeded applicable NJIGW criteria include: methylene chloride, benzo(a)pyrene, aluminum, beryllium, lead and manganese. As with the NJDCNRSRS analysis, the detections of methylene chloride and benzo(a)pyrene were in the 1994 Ph II sediment sample SED-06 that was erroneously included in this analysis for unsaturated soil samples. Thus, those sediment detections are not actually exceedances of the NJIGW in Area B. The detections of aluminum, beryllium, lead and manganese were all in 2015 ARI sample ARB-SB-10 (0-12). All four of these metals as noted in Section 8.2.2 above were found to be at concentrations on Site similar to those found in background samples from Clonmell Creek. Additionally, sample location ARB-SB-10 (0-12) is located in close proximity to the adjacent PRC property where lead is a constituent of concern. Thus, these metals concentrations in this remote area where no manufacturing or disposal activities have occurred are most likely related to background conditions in this industrial environment.

8.3.3.2 Sediment

A summary of the detections in the sediment samples for this EA is provided in Table 8-14. Frequency of detection summary statistics for these data are provided in Table 8-17.

Metals

The following metals were detected at concentrations that exceed the applicable RI screening values in sediments in the Area B EA: arsenic, barium, chromium, copper, iron, lead, mercury, nickel, selenium, vanadium and zinc. The highest concentration of arsenic was noted in sample SED-8A at a concentration of 15.4 mg/kg. Although this is above the sediment RI screening value of 6 mg/kg it is below the naturally occurring background concentration in NJ soils of 19 mg/kg. The other metals that had their highest concentration detections found in the sample SED-8A are copper, iron, lead, mercury, nickel and zinc. This sample location is from along the fence line of the neighboring PRC property at the head of a feeder stream/drainage ditch that leads from the PRC to Clonmell Creek. All of the metals with concentrations above the applicable RI screening values in sample location SED-8A are COPCs at the PRC [Langan, 2016].

The only metal that was detected in the Area B EA sediment samples that is not a COPC for the PRC is barium [Langan, 2016]. The highest concentration detection of barium was in the sample from location ARB-11. However, barium was detected in all four (4) sediment samples in this EA at concentrations above the applicable RI screening value. The concentration of barium in the sample from location SED-8A (147 mg/kg) is equivalent to that noted for location ARB-11 (150 mg/kg). Because barium has not been noted as a COC for the Site or for the PRC, the source of these barium detections is unknown and may be attributable to background conditions.

PAHs

A total of nine (9) PAH compounds had detected concentrations that exceed their applicable RI screening values in sample SED-6. Analytical results from sample location SED-8A contain detected concentrations of five (5) PAH compounds that exceed their applicable RI screening values. No other sediment sample in the Area B EA contained concentrations of PAHs above the RI screening values. Sample location SED-8A is located at the head of the southernmost feeder stream/drainage ditch that runs between the PRC and Clonmell Creek. Sample location SED-6 is located upstream of that feeder stream/drainage ditch in Clonmell Creek. Both locations are well upstream of any process or disposal activities at the Site. Thus, these detections are likely related to upstream sources along Clonmell Creek.

PCBs

The PCB, congener Aroclor-1254, was detected in two (2) of the four (4) sediment samples in the Area B EA. The highest concentration was detected in sample SED-8A, located at the head of the southernmost feeder stream/drainage ditch that runs between the PRC and Clonmell Creek. The other detection of Aroclor-1254 was from sample location ARB-7 located just north and west of location SED-8A. Aroclor-1254 is a COC at the PRC. The ecological impacts of overland transport associated with Aroclor-1254 along the PRC’s western perimeter are proposed to be further assessed in an Ecological Risk Assessment for this area as cited in the PRC RI Report [Langan, 2016].

SVOCs and VOCs

Similar to PCBs, five (5) SVOC compounds (2-methylnapthalene, bis(2-ethylhexyl) phthalate, carbazole, diethyl phthalate and di-n-octyl-phthalate) and two (2) VOCs (2-butanone and acetone) were detected in samples SED-6 and SED-8A. Sample SED-8A is located at the head of the southernmost feeder stream/drainage ditch that runs between the PRC and Clonmell Creek. Sample SED-6 is located upstream of this feeder stream/drainage ditch. Both locations are well upstream of any process or disposal activities at the Site. Thus, these detections are likely related to other upstream sources along Clonmell Creek.

8.3.3.3 Surface Water

A summary of the detections in the surface water sample for the Area B EA is provided in Table 8-15. Frequency of detection summary statistics for these data are provided in Table 8-18.

The analytical results for the lone surface water sample from the Area B EA (SRI-SW-8R) had detected concentrations of aluminum and gamma-chlordane (pesticide) that exceeded their applicable RI screening values. This sample location was obtained during the 2002 SRI as an upstream reference location to be used to compare against surface water data from other parts of the Site. The presence of aluminum and gamma-chlordane in this sample are thus likely attributable to upstream or background sources and were present in surface water because of sediment entrained in the sample. Aluminum was identified in the RBR BERA Background Study [RBR, 2016] as being present at concentrations in background samples that are consistent with those found in Clonmell Creek.

8.3.3.4 Summary

The primary issues in this EA are related to sporadic detections of metals, PAHs, the PCB congener Aroclor-1254 and SVOCs in sediments at concentrations above their RI screening values. Some detections of PAHs, SVOCs and pesticides in soils at concentrations above their RI screening values were also noted. In nearly all cases these detections are likely attributable to off-site sources or historical pesticide application for insect control within this EA.

8.3.4 Chemical Landfill/Gravel Pit Area Investigation History Summary

As noted in Section 3.4 in detail above, the CLF/GP EA was historically a gravel quarry prior to the construction of the Hercules plant in the mid-1950s. Other than being a gravel quarry, the central portion of this EA was also used as a percolation field for treated water from the onsite WWTP during the plant’s early operations in 1955-1957. The western portion of this EA, known as the CLF, was also subject to surficial disposal from plant operations. The disposal activities are reported to have been discontinued as of 1965. However, aerial photography review indicates that some additional activity may have been occurring as late as 1984 in this portion of the EA.

During the 1988 Ph I investigation a total of eight (8) soil boring locations were advanced in the CLF EA and twelve (12) soils samples were obtained from these locations, including duplicates. The samples were obtained from depths between two (2) and eight (8) ft bgs.

A total of thirty (30) boring locations were advanced in the CLF/GP EA during the 1994 Ph II Investigation. A total of eighty (80) soil samples were obtained from these locations, including duplicates. The samples were obtained between zero (0) and six (6) ft bgs.

A total of nine (9) surface soil and wetland soils samples were obtained from the CLF/GP EA during the 2002 SRI. For the purposes of this RI Report, wetland soils are being screened along with soil samples. All of these samples were obtained from zero (0) to six (6) inches bgs.

A total of fifteen (15) soil samples and two (2) surface water samples, including duplicates, were obtained from the CLF/GP EA during the 2015 ARI. The soil samples were obtained from zero (0) to six (6) ft bgs. The ARI was focused on filling data gaps in the CLF/GP EA as requested by the EPA and NJDEP. During the ARI, historical waste including a pile of Dalpac catalyst and multiple remains of drums were characterized and removed from this EA and disposed of as non-hazardous waste.

There is one monitoring well in the CLF/GP EA (MW-3). This well is considered background for the Site and has historically not had any detections of SSCOCs.

The sample locations for this EA are shown on Figure 3-4. The analytical data available for this EA are summarized on Tables 8-19 (soil), 8-20 (groundwater), 8-21 (surface water), and 8-22 (temporary well) along with a comparison of those data to the screening values developed for this RI as outlined in Section 8.1 above. Frequency of detection summary tables for soil, groundwater and surface water for this EA are provided in Tables 8-23, 8-24, 8-25, and 8-26 respectively.

The following sections outline the nature and extent of detections in this EA by media.

8.3.4.1 Soil

A summary of the detections in the soil samples for this EA is provided in Table 8-19. Frequency of detection summary statistics for these data are provided in Table 8-23.

Metals

Arsenic and mercury had detections in soils samples in the CLF/GP EA at concentrations that exceed the applicable RI screening value. Arsenic was detected three (3) times at concentrations above the RI screening value. However, the maximum concentration detected was 4.9 mg/kg at location CLF-SS03A and the recognized background soil concentration in NJ is 19 mg/kg. Mercury was detected once at a concentration above the RI screening value at a concentration of 5.5 mg/kg also at location CLF-SS03A. CLF-SS03A is in the center of the chemical landfill portion of this EA. Samples were obtained from both three (3) and five (5) ft bgs from this location. The samples with the highest arsenic and mercury concentrations were detected in the five (5) ft bgs sample.

PAHs

Two (2) PAH compounds were detected at concentrations that exceed their applicable RI screening values. Benzo(a)anthracene and benzo(a)pyrene were both detected at location B-02 from a depth of zero (0) to six (6) inches bgs.

SVOCs

Four (4) SVOC compounds were detected at concentrations that exceed their applicable RI screening values. All four (4) compounds, 2,4-dinitrotoluene, 2,6-dinitrotoluene, acetophenone and carbazole were detected at their highest concentrations in the five (5) ft bgs sample obtained from location CLF-SS03A in the center of the Chemical Landfill portion of the CLF/GP EA. All but one (1) of the four (4) compounds had only the one (1) exceedance of the applicable RI screening values. Acetophenone was detected six (6) times at concentrations above its RI screening value. Four (4) of those detections are located in the central portion of the CLF area. The other two (2) locations, CLF-SS06A and GP-SS-2A, were obtained at a depth of one (1) ft bgs in the northwest and southeast corners of the GP area, respectively.

Phenols

One (1) detection of phenol at location CLF-SS03A at a depth of five (5) ft bgs had a concentration that exceeded its applicable RI screening value.

VOCs

Three (3) Site-related COCs were detected at concentrations that exceed their applicable RI screening values. Benzene and ethylbenzene were each detected once at concentrations that exceeded their applicable RI screening values in the five (5) ft bgs sample from location CLF-SS03A. Cumene was also detected at this location and eight (8) other locations at concentrations that exceeded its applicable RI screening value. The maximum concentration detection for all three (3) VOC compounds were all found at the five (5) ft bgs sample from location CLF-SS03A. The other eight (8) locations with detected cumene concentrations above the applicable RI screening value were: CLF-SS01B (three (3) ft bgs), GP-14 (one (1) and three (3) ft bgs), CLF-SS02A (one (1) ft bgs), CLF-SS03A (three (3) ft bgs), B-03 (three (3) ft bgs) and CLF-SB01B (five (5) ft bgs). All of these locations are found in a small area clustered around sample location CLF-SS03A.

New Jersey Impact to Groundwater (NJIGW) and Direct Contact Non-Residential Soil Remediation Standards (NJDCNRSRS) Assessment

As requested by NJDEP, RBR conducted an assessment of available soil data against the NJIGW and NJDCNRSRS (see Appendix P). A summary of relevant groundwater results is included for comparative discussion to address NJIGW exceedances for soil.

The compounds with detected concentrations in soils that exceed the NJDCNRSRS in the CL EA were acetophenone, benzene, 2,4-dinitrotoluene and 2,6-dinitrotoluene. These NJDCNRSRS exceedances are consistent with the exceedances of the RI screening values and are discussed in detail above.

The compounds with detected concentrations in soils that exceed the NJIGW in the CLF/GP EA were: 1,2-dichloroethane, 2-butanone, acetone, benzene, carbon disulfide, ethylbenzene, methylene chloride, toluene, total xylenes, 2,4-dimethylphenol, 2,4-dinitrotoluene, 2,6-dinitrotoluene, 2-methylnapthalene, isophorone, n-nitrosodiphenylamine, phenol, acetophenone, dieldrin, lead, manganese, mercury, nickel, silver and zinc.

The data from the one temporary well point (SRI-TW-4) in the CLF/GP EA have been compiled on Table 8-22 and a frequency of detection summary of these data is provided on Table 8-26, to help further assess the NJIGW exceedances. The data from the temporary well point includes additional analyses that are not part of the quarterly groundwater monitoring activities at the Site and are thus helpful in assessing NJIGW exceedances of non-VOC compounds. The Site has been inactive since 2009: thus, all potential sources of Site-related contaminants have been eliminated for more than 8 years. As a result, groundwater conditions have long since reached dynamic equilibrium and Site-related contaminant concentrations are stable or decreasing (see Section 9 for more detailed discussions). Consequently, if the detected compounds in soil that exceed an NJIGW criteria are not present in the groundwater data from temporary or permanent wells, then it is reasonable to deduce that there are no resulting impacts to groundwater from those soil exceedances. The data from the permanent well point (MW-3) compiled in Table 8-20 and frequency of detection summary provided in Table 8-24 were also reviewed to assess the NJIGW exceedances.

The groundwater dataset available for this RI Report from the CLF/GP EA consists of one (1) 2002 temporary well point (SRI-TW-4) and one (1) permanent well (MW-3). Both of these points are located in the northeast corner of the GP area. No VOCs were detected at either of these locations.

During the 1995 Ph II investigation a series of temporary Geoprobe™ (four (4) total) and screened auger groundwater samples (three (3) total) were obtained from locations around the perimeter of the CLF/GP EA along with a sample from MW-3. Because of the age of these data they have not been carried forward for evaluation in this RI Report and are not reported herein. CSI has reviewed the historical investigation reports to determine what conclusions were drawn regarding NJIGW exceedances in the CLF/GP EA in the past.

The following is an excerpt from the SRI regarding their conclusion that the CLF is a "Soil Area Requiring Consideration for Remedial Action": *"Portions of the Chemical Landfill - because of exceedances for a limited number of NDCSCC* (non-residential direct contact soil cleanup criteria) *and numerous IGWSCC* (impact to groundwater soil contact criteria). *Despite these IGWSCC exceedances, only benzene exceeded ground water quality criteria in this area, in one of five well points installed and sampled in this area. Thus, despite the general pervious lithology of the Gravel Pit in which the Chemical Landfill is situated, the ground water data suggest that a localized limiting material (e.g. silt or clay) has prevented significant contamination from reaching the water table in the Chemical Landfill area. Relative to the exceedances of NDCSCC, the Gravel Pit encompassing the Chemical Landfill is fully fenced."* [ERM, 2002]

Subsequent to the SRI, no additional investigation of groundwater in the CLF or GP was requested by NJDEP or the EPA. Thus, no additional groundwater data subsequent to the 2002 SRI is available for this EA. The only significant VOC or SVOC detection noted from the 1995

Ph II temporary well point and permanent well samples was one (1) detection of benzene in a sample from a temporary well point that exceeded the applicable groundwater criteria at that time. The lack of other significant detections in this data set indicates that the other VOC and SVOC compounds indicated above as having concentrations in soils that exceed the applicable NJIGW criteria had not widely impacted shallow groundwater in this EA at that time.

The temporary well point sample obtained during the 2002 SRI (SRI-TW-4) included analyses of metals, PAHs, PCBs, pesticides, phenols, SVOCs and VOCs (see FOD Table 8-26). The only detected compounds in this sample included two pesticides (beta-BHC and gamma chlordane) at concentrations below their applicable RI screening values and several metals as discussed further below. This further supports the hypothesis that effects from detected VOC and SVOC soil constituents in the CLF are not occurring.

The permanent well point MW-3 has been sampled annually for VOCs and was also sampled once in 2015 for metals as part of a metals background study for the SWDA remediation. No VOCs have been detected in samples from MW-3 during the RI groundwater study period of 2013 to 2017. Several metals were detected and are discussed further below. Again, the lack of VOC detections in the samples from MW-3 indicates that no VOC groundwater detections are present in this portion of the EA.

As noted in Appendix O, lead, manganese, mercury, nickel, silver and zinc were the metals identified as having concentrations in soils that exceed their applicable NJIGW criteria. Manganese is the only one (1) of these metals that was also detected in the 2015 sample from MW-3 at a concentration exceeding its applicable RI screening value. Lead, manganese and zinc were detected in the temporary well point sample SRI-TW-4 at concentrations exceeding their applicable RI screening criterion. All six (6) of these metals were identified as being present at concentrations in background samples above those detected in one or more of the exposure areas assessed as noted in Section 8.2.2 above.

Based upon the above analysis there is no evidence that the detected constituents in soil that exceed applicable NJIGW criteria have had significant impacts to groundwater quality in this EA. Some localized benzene groundwater detections were noted in the 1995 Ph II investigation, but no further data have been generated to further assess those detections.

Soil Detection Summary

Outside of two (2) detections of PAHs at location, B-2, all of the detections at concentrations exceeding applicable RI screening values in this EA are either at sample location CLF-SS03A, obtained from five (5) ft bgs, or in the general vicinity of this sample location in the CLF portion of the EA. The remaining soil detections at concentrations above RI screening values in the CLF/GP EA are from one (1) ft bgs to five (5) ft bgs in the small portion of the CLF area around sample location CLF-SS03A. Some localized benzene groundwater detections were noted off the southeast corner of the chemical landfill from a temporary well point installed during the 1995 Ph II investigation, but no further data are available to characterize these detections further.

8.3.4.2 Groundwater

A summary of the detections in the groundwater samples for this EA is provided in Table 8-20. Frequency of detection summary statistics for these data are provided in Table 8-24.

As noted above in Section 8.3.4.2 in the NJIGW and NJDCNRSRS discussion, some historical Geoprobe™ and screened auger groundwater data were obtained from this EA during the 1994 Ph II investigation. Those data are too old to be utilized to assess nature and extent in this EA at this time. Furthermore, temporary well data cannot be used for risk assessment purposes as per EPA guidance. However, the data for one 2002 SRI temporary well point (SRI-TW-4) have been included in Tables 8-22 (detection summary) and 8-26 (FOD) for the purpose of assessing NJIGW exceedances in this EA.

The available data from the one permanent well point (MW-3) in this EA are thus the only data available to assess nature and extent for groundwater in the CLF/GP EA. MW-3 is sampled annually for VOCs and was also sampled once in 2015 for metals as part of a background assessment for the SWDA groundwater monitoring program. For the study period data 2013-2017, no VOCs have been detected in the samples from MW-3. The following metals were detected at concentrations exceeding their applicable RI screening values in the 2015 sample from MW-3: aluminum, arsenic, cobalt, iron, manganese and vanadium.

All of the metals noted above were also noted in Section 8.2.2 as being present in one or more of the assessed areas as being present in background samples at concentrations above those found on the Site. Thus, these metals detections in groundwater are the result of naturally occurring concentrations in the lithology at the Site. No evidence of the presence of these metals being related to site manufacturing or disposal activities exists.

8.3.4.3 Surface Water

A summary of the detections in the surface water samples for this EA is provided in Table 8-21. Frequency of detection summary statistics for these data are provided in Table 8-25.

As noted in Section 8.3.4.1 there are two (2) surface water samples for the CLF/GP EA that were obtained during the 2015 ARI. The following compounds were detected in those samples at concentrations that exceed their applicable RI screening value: aluminum, arsenic, copper, iron, lead, manganese, and cumene.

All five (5) of the metals noted above are discussed in Section 8.2.2 as being present in one (1) or more of the assessed areas as being present in background samples at concentrations above those found on the Site. Thus, these metals detections in surface water are likely the result of naturally occurring concentrations in the lithology at the Site. No evidence of the presence of these metals being related to site manufacturing or disposal activities exists.

The detection of cumene noted above is from sample location GP-11. This sample also contained detections of acetone, ethylbenzene and toluene. All of the detected compounds are site-related and may be related to soil detections noted in the CLF.

8.3.4.4 Summary

The bulk of this EA does not contain detections at concentrations above RI screening values. However, the area formerly known as the chemical landfill (see Figure 1-4) does contain concentrations of Site-related compounds above applicable RI screening values. The bulk of the these detections are from one (1) ft bgs to five (5) ft bgs in the small portion of the chemical landfill area around sample location CLF-SS03A. The presence of Site-related compounds in surface water sample GP-11 appears to indicate that site-related constituents in soils within the CLF may be impacting surface water conditions within the gravel pits.

8.3.5 Clonmell Creek and Wetlands Investigation History Summary

The CCW EA has a footprint of approximately sixty-seven (67) acres. The CCW EA consists of all on-Site portions of Clonmell Creek, the northern most portion of the 002 Outfall IA, and the wetland areas north of the TRA and north of Clonmell Creek but south of the SWDA and west of Area B (Figures 3-5a & 3-5b).

Clonmell Creek, a tidal tributary of the Delaware River, courses northwest through the middle of the property and transects the Site north of the NCL. Prior to 1991, the 002 Outfall historically received surface water runoff from the manufacturing portion of the Site via the plant's stormwater drainage network and discharged to Clonmell Creek just west of the NCL. The 002 Outfall historically consisted of a culvert set into a wooden embankment and a natural drainage swale, both upstream and downstream of the culvert. In 1991, the culvert was modified so that surface water no longer flowed off-Site to Clonmell Creek but instead infiltrated to groundwater upstream from the culvert. This modification resulted in the creation of the SCB. During this modification of the culvert, some impacted soils were noted in the vicinity of the current earthen dam located at the head of the former 002 Outfall. Some investigation of this area was conducted during the 1995 Ph II investigation. These samples are included in the SCB EA nature and extent discussion in Section 8.3.10 below.

The earliest samples for the CCW EA are four (4) surface water samples (SW-1 through SW-4) with sample dates of August 7, 1992. These samples were included with the data received from ERM during CSI’s transition to this project but did not include location information. The samples are not discussed in the Ph II investigation Report and there are four (4) surface water samples with the same IDs that were obtained during the Ph II investigation that are documented therein. For the purposes of this RI Report, CSI is assuming that the four (4) 1992 surface water samples were obtained at the same locations as the 1994 surface water samples.

During the 1994/1995 Ph II investigation a total of ten (10) sediment samples and five (5) surface water samples were obtained in the CCW EA. The initial five (5) samples were obtained in June 1994 from Clonmell Creek near the western property line, adjacent to the 002

Outfall discharge point, approximately one hundred (100) feet west of the SWDA access road and two (2) samples adjacent to the GP. Based upon the results of these samples additional sediment sampling was conducted in May 1995 between the western property line and the 002 Outfall and adjacent to the 002 Outfall. Additional off-Site reference sample locations were also obtained at that time. Surface water samples were obtained first to prevent potential disturbance of sediments prior to sampling. The surface water samples were collected from midstream and upstream of the sampler's position and placed directly into the appropriate sampling containers attached to a stainless steel sampling pole. The sediment samples were collected from a depth of zero (0) to six (6) inches using a Wildco Hand Corer Model 2420-655 coring device or by hand using a decontaminated stainless steel spoon.

During the 2002 SRI a total of twenty (20) sediment, fifteen (15) soils, nine (9) surface water, and six (6) groundwater samples from temporary well/piezometer points were obtained from in and around Clonmell Creek in the CCW EA. The samples were obtained to further delineate this EA. The sediment samples were obtained from a canoe using a Petite Ponar dredge with an extension handle. The sediments were dumped from the dredge into a stainless steel bowl and then the appropriate bottleware was filled. The soil samples were obtained with a decontaminated stainless-steel spoon from a depth of zero (0) to six (6) inches. The surface water samples were obtained from midstream and mid-depth using a 1,000 ml Nalgene bottle. Care was taken to avoid stirring up sediment that may impact the surface water results and inhibit representative analyses. The temporary well/piezometers were installed by driving a two (2) – inch steel pipe with slotted bottoms two (2) to four (4) ft into the ground or sediments with a slide hammer and tripod. The temporary well/piezometers were then developed using a disposable bailer until dry.

As part of the 2009 FI, CSI was tasked with further assessing the presence and source of cumene concentrations found in Clonmell Creek during previous investigations. CSI employed the best available sediment sampling technology available at the time to optimize results (full sampling methods and quality assurance detailed in associated project plans). Vibracore is a technique that uses a plastic lined stainless-steel tube with a weighted, motorized end that vibrates the sampler into the sediments. The sampler was driven to refusal into the stiff clay at the bottom of Clonmell Creek at all locations. The liner was then removed from the stainless steel tube, providing a continuous sediment core. In some locations a wide diameter slide hammer and tripod had to be used because of shallow water depths. The sediment was then screened with a PID and logged. Samples were obtained from multiple depths at each location for a total of sixty-seven (67) sediment samples, including duplicates. A total of twenty-five (25) surface water samples were also obtained at the same sediment sample locations. CSI obtained nine (9) soil and groundwater samples along the banks of Clonmell Creek using Geoprobe™ techniques. In addition, during a separate sampling event in July 2009, CSI obtained sediment and surface water samples from downstream locations on the neighboring DuPont Repauno site using direct dip techniques for surface water, as well as Vibracore and hand sampling techniques for sediment in areas where access with the Vibracore platform was not possible. The analytical suite for the samples obtained on the DuPont Repauno site were limited to cumene, acetophenone and the VOC and SVOC SSTICs (a-methylstyrene, 2,6-di-tert-butyl-cresol, a,a-dimethylbenzyl alcohol and diisopropylbenzene) as required by DuPont.

Subsequent to the EPA over filing and taking the regulatory lead of the site in 2009, it was necessary to complete an ecological assessment of the CCW EA as part of the BERA. In 2010, CSI and RBR personnel obtained ten (10) sediment samples from a depth of zero (0) to six (6) inches using a split core sampler. Samples from the ecological assessment are incorporated into this RI Report and the full ecological assessment is documented within the BERA [RBR, 2016].

In 2011, CSI performed further delineation of sediment in Clonmell Creek upstream and downstream of the 002 Outfall. Transects were run across the stream in an attempt to profile the depth of sediments across this portion of the creek. Wide diameter slide hammer/tripod sampling techniques were used during this investigation as well. A total of 103 sediment samples were obtained from various depths, including duplicates.

In 2013, CSI performed further evaluation of the sediments in the portion of Clonmell Creek near the 002 Outfall as well as upstream and downstream of that area. Sediment samples were collected from a total of seven (7) locations with a six (6) – inch stainless steel split core sampler. These samples, and the additional samples described below, were obtained to further evaluate concentrations of cumene that had been detected during the 2009 FI. Upon collection, the sediment samples were containerized and frozen using dry ice. Care was taken to keep the samples in a horizontal orientation after removal from the creek so that pore water migration within the sample did not impact sample results. The frozen cores were cut into three (3), two (2) – inch long sections, to obtain samples representing 0-2", 2-4" and 4-6" intervals. These three intervals are denoted by (1), (3) and (5) after the sample identifiers, indicating the midpoint of each of the intervals, respectively. These samples were used to help assess the distribution of SSCOC detections within the zero (0) to six (6) inch sediment horizon. Additionally, two (2) cores were obtained from the vicinity of location CC-8 where a very high (240,000,000 ug/kg) cumene concentration was detected in 2009. These samples (PS-4 and PS-4A) were frozen using dry ice and sent for pore fluid saturation analyses to determine the R-NAPL content in the samples. The percentage of the sample mass that was determined to consist of cumene and/or other constituents other than water ranged from 5.2% - 5.6% of the saturated pore fluid or 4.77% - 5.08% of the entire pore volume.

This 2013 investigation also included the use of peeper pore water samplers. The peepers were constructed out of two (2) – inch PVC well screen with threaded caps on one end and a pointed tip on the other for driving into the sediments. The peepers were filled with a passive diffusion bag that contained laboratory grade water. Two peepers were placed next to six (6) of the locations where frozen sediment samples were obtained at depths of zero (0) to six (6) inches (denoted with an "A" after the sample ID) and six (6) to twelve (12) inches (denoted with a "B" after the sample ID). The peepers were left in place for approximately one (1) – month to provide sufficient time for pore water to equilibrate through the passive diffusion bags. A bathymetric survey of this portion of Clonmell Creek was also conducted to map the depth of sediments in this vicinity. The results of this study were documented in the Additional

Clonmell Creek Studies Findings Report [CSI, 2014]. This report is attached to this document as Appendix H.

In 2015 as part of the ARI, CSI collected five (5) sediment and ten (10) soil samples in the CCW EA. The sediment samples were obtained in the portion of Clonmell Creek that is adjacent to Area B because no historical samples had previously been obtained in this area. The soil samples were obtained along potential migration pathways between the TRA and the SWDA and Clonmell Creek to assess potential lead migration from these areas. All soil samples were obtained from depths of zero (0) to six (6) inches or six (6) to twelve (12) inches bgs with stainless steel split core samplers. The sediment samples were obtained from a depth of zero (0) to six (6) inches also with stainless steel split core samplers [CSI, 2015].

As a follow up to the 2015 ARI, in March 2016 CSI further delineated lead in the vicinity of SRI sample location SRI-WS-19 and ARI sample location WS-32. A total of eighteen (18) soil samples were obtained from depths of zero (0) to six (6) inches and six (6) to twelve (12) inches bgs with stainless steel split core samplers surrounding these two locations. These were the last samples obtained in the CCW EA prior to generation of this RI Report.

The sample locations for this EA are shown on Figure 3-5a & 3-5b. All of the analytical data available for this EA are summarized on Tables 8-27 (soils), 8-28 (groundwater), 8-29 (sediment), 8-30 (surface water) and 8-31 (pore water) along with a comparison of those data to the screening values developed for this RI as outlined in Section 8.1 above. Frequency of detection summary tables for soil, groundwater, sediment, surface water and pore water for this EA are Tables 8-32, 8-33, 8-34, 8-35 and 8-36, respectively.

The following sections outline the nature and extent of detections in this EA by media.

8.3.5.2 Soils

Table 8-27 contains a summary of all soil data available from the CCW EA and Table 8-32 provides a frequency of detection statistical summary of those data.

No pesticide or VOCs were detected at concentrations exceeding their applicable RI screening values in soils in the CCW EA.

Metals

The following metals had detected concentrations in soil samples in the CCW EA that exceed applicable RI screening values: arsenic, cobalt, lead and thallium. Although arsenic was detected thirty-two (32) times above the RI screening value of 3 mg/kg, the recognized background concentration in New Jersey soils for arsenic is nineteen (19) mg/kg. Only four (4) samples have concentrations that exceed 19 mg/kg arsenic in soils in the CCW EA. The highest detected concentration of arsenic was in sample WS-30 (0-6) (26 mg/kg) located in the 002 Outfall area just west of the NCL. One of the other four (4) samples with exceedances (WS-29 (0-6) – 20 mg/kg) is also located in this vicinity. The other two locations, SRI-WS-19

(23.3 mg/kg) and SRI-WS-23 (21.5 mg/kg), are located south of the Clonmell Creek Bridge on the north side of the creek. This is an area where no evidence of Site activities or disposal is known to have occurred. The highest detected arsenic concentration was twenty-six (26) mg/kg or less. The New Jersey background concentration for arsenic is nineteen (19) mg/kg. Thus, no widespread arsenic detections are noted in the data and these concentrations are likely related to naturally occurring conditions and/or localized pesticide usage.

Cobalt was also detected at location WS-30 (0-6) at a concentration of thirty-seven (37) mg/kg, which is above the RI screening value of thirty (30) mg/kg. This lone detection at a concentration that is likely naturally occurring does not warrant further consideration.

As noted above, as a follow up to the 2015 ARI, in March 2016 CSI further delineated lead in the vicinity of SRI sample location SRI-WS-19 (1,120 mg/kg) and ARI sample location WS-32 (2,700 mg/kg). A total of eighteen (18) soil samples were obtained from depths of zero (0) to six (6) inches and six (6) to twelve (12) inches bgs with stainless steel split core samplers surrounding these two (2) locations. Of these samples, only one (1) (WS-19D (0.5-1)) also had a concentration exceeding the applicable RI screening value of 800 mg/kg. These three (3) sample locations (SRI-WS-19, WS-19D (0.5-1) and WS-32) are the only soil locations with lead concentrations that exceed the RI screening value in the CCW EA. These results indicate that these lead detections are isolated and surficial. The SRI-WS-19 and WS-32 locations are east and west of the Clonmell Creek Bridge on the northern bank of the Creek. Samples obtained between this area and the SWDA to assess a potential migration pathway from that area did not contain concentrations of lead of note. These lead concentrations are thus anomalous occurrences and may be related to deposition from Clonmell Creek.

Thallium was detected twice (2) in soil samples from the CCW EA at concentrations that exceed the RI screening value of 1.2 mg/kg. These samples, SRI-WS-2 (3.6 B mg/kg) and SRI-WS-8A (2.9 B mg/kg), are located in the wetlands area between the TRA and Clonmell Creek. Both detections are flagged with a “B” indicating method blank contamination during the laboratory analysis. This makes these detections suspect. Thus, the two detections at concentrations less than 2.4 mg/kg above the screening value do not warrant further action.

PAHs

The following PAHs had detected concentrations in soils samples in the CCW EA above applicable RI screening values: benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno[1,2,3-cd]pyrene. The highest concentrations were all detected in the sample from location SRI-WS-4 located in the 002 Outfall just west of the border between the NCL and SCB EAs. The other detections of PAHs at concentrations above the applicable RI screening value are also in this vicinity in the samples from locations WS-29 (0-6) and WS-30 (0-6). The only other soil sample location with a PAH concentration above the applicable RI screening in the CCW EA is location WS-31 (0-6). However, all of the PAH detections in sample WS-31 (0-6) are flagged with the “F1” qualifier indicating that MS/MSD recoveries were out of range for that sample. This indicates that the concentrations may be overestimated and are likely spurious. Review of the data thus indicates that a small portion of the 002 Outfall just north of the NCL and SCB EAs has limited concentrations of PAHs that exceed the applicable RI screening values at a depth of zero (0) to six (6) inches bgs. These detections are likely related to historical releases from the former plant that were transported through the 002 Outfall through surface water deposition mechanisms.

PCBs

The PCB, congener Aroclor 1254, was detected three (3) times in soil samples at concentrations that exceeded its applicable RI screening value of 970 ug/kg. The three (3) locations with detected concentrations of Aroclor 1254 are SRI-WS-4 (1,400 ug/kg), SRI-WS-22 (1,300 ug/kg) and SRI-WS-23 (1,900 ug/kg). Locations SRI-WS-22 and SRI-WS-23 are located on the north side of Clonmell Creek upstream of the Bridge and away from any site manufacturing and disposal activity. Location SRI-WS-4 is located in the 002 Outfall just west of the border between the NCL and SCB EAs. All of these locations are areas that are regularly inundated with water and are susceptible to deposition from upstream sources. Aroclor 1254 has been identified as being present in background samples at concentrations above those found on site by both CSI, as noted in Section 8.1.2, and by the PRC in their Ecological Remedial Investigation [Langan, 2016]. This indicates that these Aroclor 1254 detections are likely related to upstream sources.

SVOCs

The following SVOCs were detected once at a concentration in soil samples in the CCW EA above applicable RI screening values: 2,6-di-tert-butyl-p-cresol (SSTIC), acetophenone (SSTIC) and bis(2-chloroethyl)ether. The 2,6-di-tert-butyl-p-cresol (SSTIC) and acetophenone (SSTIC) detections were in the sample from location SRI-WS-4. SRI-WS-4, which is located in the 002 Outfall, just west of the border between the NCL and SCB EAs. These samples were obtained from a depth of zero (0) to six (6) inches bgs during the 2002 SRI. The concentrations of these compounds in the 2009 FI samples (WS-29 (0-6) and WS-30 (0-6)) from this same vicinity were below the RI screening value. This indicates that the concentrations of these compounds had naturally attenuated over the seven (7) year time interval between those investigations. Thus, the likelihood that any concentrations of these compounds remaining in shallow soils above the RI screening value at this time is minimal.

The detections of the two (2) SSTICs are likely associated with historic overland transport of Site-related constituents through the 002 Outfall prior to its being closed off in 1991. Bis(2-chloroethyl)ether was detected in the sample from location WS-29 which is just north of location SRI-WS-4 in the 002 Outfall stream channel. The source for the detection of bis(2-chloroethyl)ether is unknown. This compound is not associated with Site manufacturing activities. This detection in the sample from location WS-29 is the only detection of bis(2-chloroethyl)ether in any of the twenty-eight (28) soil samples or in the 112 sediment samples available for the CCW EA. This indicates that the detection may be spurious and is unrelated to historical Site activity.

New Jersey Impact to Groundwater and Direct Contact Non-Residential Soil Remediation Standards (NJDCNRSRS) Assessment

As requested by NJDEP, RBR conducted an assessment of available soil data against the NJIGW and NJDCNRSRS criteria (see Appendix P). A summary of relevant groundwater results is included for comparative discussion to address NJIGW exceedances for soil.

The compounds with detected concentrations that exceed the NJDCNRSRS in the CCW EA were acetophenone, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno[1,2,3-cd]pyrene, arsenic and lead. The NJDCNRSRS exceedances are consistent with the exceedances of the screening values developed for this RI and are assessed in the sections above.

The compounds with detected concentrations that exceed the NJIGW were benzene, toluene, bis(2-chloroethyl)ether, nitrobenzene, acetophenone, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, heptachlor epoxide, alpha-BHC, dieldrin, aluminum, antimony, arsenic, beryllium, lead, manganese, mercury, nickel, thallium and zinc. The data from the temporary well points in the CCW EA have been compiled on Table 8-26 and a frequency of detection summary of these data is provided on Table 8-30, to help further assess the NJIGW exceedances. The data from the temporary well points include additional analyses that are not part of the quarterly groundwater monitoring activities at the Site and are thus helpful to assess NJIGW exceedances of non-VOC compounds. The Site has been inactive since 2009: thus, all potential sources of Site-related contaminants have been eliminated for more than 8 years. As a result, groundwater conditions have long since reached dynamic equilibrium and Site-related contaminant concentrations are stable or decreasing (see Section 9 for more detailed discussions). Consequently, if the detected compounds in soil that exceed an NJIGW criteria are not present in the groundwater data from temporary or permanent wells, then it is reasonable to deduce that there are no resulting impacts to groundwater from those soil exceedances. There are no permanent well points in the CCW EA and thus, no permanent well data for comparative evaluation are available. Instead, groundwater data from fifteen (15) available temporary well point samples were evaluated. The following is a compound specific summary reviewing the available groundwater data in locations where soil sampling results exceeded the NJIGW

- Benzene – Five (5) of the fifteen (15) available temporary well point samples contained detections of benzene. All five (5) detections are at concentrations that exceed the RI screening value for benzene. Two (2) of these detections, GW-02OF-05 and GW-02OF-06, are located at the head of the 002 Outfall just west of the SCB and NCL. These detections may be related to soil concentrations in this vicinity as benzene was detected in soil samples in the 002 Outfall channel. The concentrations diminish as you travel northwards upstream along the channel. The other three (3) detections were in samples from temporary wells located in Clonmell Creek. These detections are thus not related to detections in soil, but attributable to benzene concentrations in the sediments of Clonmell Creek.

- Toluene – Two (2) of the fifteen (15) available temporary well point samples contained detections of toluene. One of these detections, collected from location GW-02OF-05 located in the 002 Outfall, may be related to soil detections at that location and the nearby SRI-TW-4. The other detection is from a temporary well in Clonmell Creek, SRI-PZ-1, and is likely related to toluene concentrations in sediment in that vicinity.

- Bis(2-chloroethyl)ether – None of the fifteen (15) available temporary well point samples contained detections of bis(2-chloroethyl)ether. As noted above, the detection in the sample from location WS-29 is the only detection of bis(2-chloroethyl)ether in any of the twenty-eight (28) soil samples or in the 112 sediment samples available for the CCW EA. This indicates that the detection may be spurious and has not resulted in any detections in groundwater.

- Nitrobenzene - None of the fifteen (15) available temporary well point samples contained detections of nitrobenzene.

- Acetophenone – Ten (10) of the fifteen (15) available temporary well point samples contained detections of acetophenone. None of the detections were at concentrations that exceed the RI screening value.

- Benzo(a)anthracene - None of the fifteen (15) available temporary well point samples contained detections of benzo(a)anthracene.

- Benzo(a)pyrene - None of the fifteen (15) available temporary well point samples contained detections of benzo(a)pyrene.

- Benzo(b)fluoranthene - None of the fifteen (15) available temporary well point samples contained detections of benzo(b)fluoranthene.

- Heptachlor epoxide - One (1) of the fifteen (15) available temporary well point samples contained a detection of heptachlor epoxide. A review of the soil and sediment data around the impacted point (SRI-TW-1) indicates that no concentrations above the applicable RI screening value of heptachlor epoxide were detected in the vicinity of this sample location. Thus, this groundwater detection does not appear to be related to soil or sediment detections. Sporadic detections of this pesticide are found throughout this EA, but no widespread groundwater detections were noted.

- Alpha-BHC - One (1) of the fifteen (15) available temporary well point samples contained a detection of alpha-BHC. The lone detection of this pesticide in groundwater was at the sample from location SRI-PZ-4. This piezometer is located in the middle of the creek and is thus not susceptible to leaching from unsaturated soils.

- Dieldrin - One (1) of the fifteen (15) available temporary well point samples contained a detection of dieldrin. The lone detection of this pesticide in groundwater was at the sample from location SRI-PZ-3. This piezometer is located in the middle of the creek and is thus not susceptible to leaching from unsaturated soils.

- Metals – aluminum, antimony, arsenic, beryllium, lead, manganese, mercury, nickel, thallium and zinc were detected in soils at concentrations that exceed the applicable NJIGW criteria. All of these metals, except thallium, were found by RBR to be present in background samples at concentrations higher than on Site as noted in Section 8.2.2 above. Furthermore, as part of the PRC RI background study [Langan, 2016] each of these metals, except antimony and thallium, were found to be at concentrations in background samples higher than applicable ecological screening criteria. No further discussion of background metals concentrations is warranted. Below is a summary review of antimony and thallium detections:
  - None of the fifteen (15) available temporary well point samples contained a detection of antimony. Thus, no groundwater leaching of antimony from soils was noted in the data.
  - Two (2) of the fifteen (15) available temporary well point samples contained detections of total thallium and one contained a detection of dissolved thallium at concentrations that exceeded the RI screening value. The highest total thallium concentration was detected in the sample from location 02OF-06. However, thallium was not detected in the soil sample obtained from this location, nor was it detected in neighboring soil sample locations 02OF-05 and 02OF-07. The lone dissolved thallium detection in groundwater is from the sample obtained from location SRI-PZ-2. This sample is located in the middle of the creek and thus is not be related to soil sample concentrations.

Soil Detection Summary

The above review of the available soil data indicates that some localized detections of SSCOCs at concentrations above applicable RI screening values are present in the portion of the 002 Outfall that lies just west of the NCL and north of the SCB in the CCW EA. Detections of arsenic, cobalt, thallium, PAHs and some SVOCs were noted to exceed applicable RI screening values in soil samples in this vicinity. Furthermore, exceedances of the applicable NJIGW criteria for benzene and toluene in this vicinity may have resulted in shallow, localized groundwater detections. Historical PAH and SVOC concentrations have likely diminished over time in this vicinity. No other soil detections of note were found in the available CCW EA soils data.

8.3.5.3 Groundwater

There are no permanent wells in the CCW EA. Temporary well data are discussed above in respect to NJIGW exceedances but will not be assessed for the purposes of nature and extent of groundwater detections.

8.3.5.4 Sediment

Table 8-31 contains a summary of all sediment data available from the CCW EA and Table 8-34 provides a frequency of detection statistical summary of those data. Table 8-37 contains a summary of the sediment data obtained downstream of the CCW EA on the neighboring DuPont Repauno site. Table 8-38 provides frequency of detection statistical summaries of those data. The locations of the DuPont Repauno property sediment and surface water samples are shown on Figure 8-3.

As part of the agreement with DuPont to access their property the analytical suite for the samples obtained there was limited to Site-specific VOC, SVOC, and SSTICs.

Metals

The following metals had detected concentrations in sediment samples in the CCW EA that were above applicable RI Screening values: antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium and zinc. As noted in Section 8.2.2 above, all of the metals, with the exception of barium, chromium and iron, were identified by RBR as being present in background sediments in Clonmell Creek at concentrations similar to those on Site. Chromium and iron were both noted in the PRC background study [Langan, 2016] as being present in background sediment samples at concentrations above applicable ecological screening values. Thus, the presence of all of these metals, with the exception of barium, are likely related to naturally occurring background conditions or have been deposited in Site sediments from upstream sources. To be conservative, CSI has further assessed the presence of barium, chromium and iron as summarized below:

- Barium – 108 of the 109 sediment samples with metals analysis in the CCW EA had concentrations that exceed the RI screening value of twenty (20) mg/kg. The highest concentration, 570 mg/kg, was detected in the sample from location CC-4 (30). In general, the barium detections that exceed the RI screening value range from about seventy-five (75) mg/kg to 300 mg/kg. However, a pocket of sediment samples with barium concentrations ranging from 400 mg/kg to 570 mg/kg in the vicinity of the 002 Outfall delta has been noted. The primary detections were noted at sample locations CC-4, CC-8, CC-10, CC-11 and CC-13. Detections were also noted in samples from downstream locations CC-2 and CC-3. The highest concentrations are primarily in the eighteen to thirty (18 to 30) – inch depth range. No source of barium is known to exist at the Site. All samples with concentrations above the applicable RI screening value were obtained during the FI using Vibracore techniques with samples obtained at multiple depth intervals. No previous investigations included obtaining samples from multiple depths.

- Chromium - 103 of the 109 sediment samples with metals analysis in the CCW EA had concentrations that exceed the RI screening value of twenty-six (26) mg/kg. The highest concentration, 2,090 "P" mg/kg, was detected in the sample from location SED-8C. This sample location is west of the SWDA road and north of the Clonmell Creek Bridge. Nearby sample locations WS-35 and WS-36 also had detections of chromium, but at a much lower concentration. Sample SED-8C had a "P" qualifier, which is undefined in the Ph II Report, but is believed to indicate that professional judgement should be used to determine if the data should be used. This result is thus suspect. Similar to the barium pattern of detections above, it appears that the area with the highest chromium detections is in the vicinity of the 002 Outfall Delta and just downstream of this deltaic area. Outside of the spurious detection at location SED-8C, the only samples with chromium concentrations above 900 mg/kg are the following: CC-2(18), a duplicate of CC-3 (18) (CC-105 (18) duplicate), CC-3 (30), CC-4(18) and CC-13 (18). All of these locations are from the FI and in the eighteen (18) to thirty (30) inch depth range, similar to barium detections noted above.

- Iron - All of the 109 sediment samples with metals analysis in the CCW EA had concentrations that exceed the RI screening value of 20,000 mg/kg. Similar to the detections of barium and chromium noted above, the iron detections at concentrations above 100,000 mg/kg are found in FI sample locations near the 002 Outfall/Delta and downstream of that deltaic area. The locations with detection above 100,000 mg/kg are as follows: CC-3(30), CC-4(18), CC-4(9), CC-4(30), CC-8(3), CC-8(9), CC-8(18), CC-104(18 – dup of CC-8), CC-10(9), CC-10(18), CC-10(3), CC-11(18) and CC-13(18). As with barium and chromium, the bulk of the concentrations above the RI screening values are at a depth of eighteen (18) inches in samples obtained during the FI.

Although a pattern of concentration detections above applicable RI screening values of barium, chromium and iron were noted in the vicinity of the 002 Outfall. It is important to note that nearly every sample analyzed for these elements in sediments in the CCW EA had concentrations that exceeded their applicable RI screening values. The pattern of detections noted above is likely biased by the extensive sampling done in close proximity to the 002 Outfall during the FI. Increased lateral and vertical sediment sampling was conducted in close proximity to the 002 Outfall including numerous samples at depths greater than one (1) foot. Previous investigations did not obtain samples at these depths. The concentrations above applicable RI screening values at depth are likely a reflection of historical deposition in Clonmell Creek from upstream sources as well as possibly from the Site.

PAHs

The following PAHs were detected in sediment samples in the CCW EA at concentrations that exceed the applicable RI screening values: acenapthene, acenapthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo-(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorine, indeno[1,2,3-cd]pyrene, naphthalene, phenanthrene and pyrene. Of these compounds, acenapthene, benzo(a)anthracene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene and dibenz(a,h)anthracene were found to be present in upstream, background sample locations at concentrations higher than applicable NJ ecological screening criteria as noted in the PRC study [Langan, 2016] and are thus suspected to be related to upstream sources. This is supported by the fact that nine (9) of the sixteen (16) highest concentrations of the PAH compounds detected at concentrations above the RI screening values are found at sample location SED-4. This on-Site location is upstream of the Clonmell Creek Bridge, upstream from known or suspected Site-related releases or disposal activities.

A review of the pattern of detections for PAHs does not provide any clear indication of source. However, it does appear that the bulk of the PAH concentration exceedances of RI screening values are in sediment samples obtained at depths of nine (9) inches or greater. This pattern, as with the metals detections noted above, appears to indicate that the bulk of the PAH detections are likely related to historical sediment deposition in the stream.

PCBs

Fifty-four (54) of the 109 sediment samples with PCB analysis in the CCW EA had concentrations of Aroclor-1254 that exceed the RI screening value of 60 ug/kg. One sample (CC-21(18)), located upstream of the Clonmell Creek bridge adjacent to the Open Area/Area A EA, also had an exceedance of the RI screening value for Aroclor-1260 of five (5) ug/kg. The highest concentration of Aroclor-1254 was detected in the sample from location CC-10(9) in the vicinity of the 002 Outfall, which had a reported concentration of 40,000 ug/kg.

As noted above for metals and PAHs, the pattern of concentrations for aroclor-1254 indicates that the highest concentrations are found in samples obtained from depths of nine (9) inches or greater. It is suspected that these detections are related to historical deposition from upstream sources. The adjacent PRC has noted Aroclor-1254 as a COC for their site and the PRC team is actively investigating ecological impacts from overland transport of Aroclor-1254 into the wetlands adjacent to their property [Langan, 2016]. Thus, although Aroclor-1254 is present in sediments throughout the CCW EA, there is no nexus of detections from the Site into Clonmell Creek sediments.

Pesticides

Of the 102 sediment samples in the CCW EA that had pesticide analyses the following compounds had exceedances of applicable RI screening values: 4,4’-DDD, 4,4’-DDE, 4,4’-DDT, aldrin, alpha-BHC, alpha-chlordane, beta-BHC, dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin ketone, gamma-BHC (Lindane), gamma-chlordane, heptachlor, heptachlor epoxide, methoxychlor and toxaphene. Because of the ubiquitous nature of these pesticide compounds, this review will only focus on those pesticide compounds that had more than twenty (20) detections and at concentrations that exceeded their applicable RI screening values. The following pesticides meet this criteria with the number of RI screening value exceedances noted in parentheses behind each compound: 4,4’-DDD (60), 4,4’-DDE (80), 4,4’-DDT (23), dieldrin (35), gamma-chlordane (22) and heptachlor epoxide (32).

- 4,4’-DDD – The highest concentration of 4,4’-DDD (730 J ug/kg) was detected in the sample from location SRI-SED-3B, just upstream of the Clonmell Creek Bridge. Of the sixty (60) sediment samples with concentrations that exceed the RI screening value of 4.88 ug/kg, only five had concentrations of 500 ug/kg or higher. These five samples are as follows: SRI-SED-2A, SRI-SED-3B, SRI-SED-9R, SRI-SED-17 and CC-13(3). These five locations are scattered from the 002 Outfall Delta (SRI-SED-2A) to an upstream reference location at the far eastern portion of Clonmell Creek (SRI-SED-9R). The somewhat random distribution of these detections is a good indication of the ubiquitous presence of this compound in the sediments of the CCW EA. No particular source for these detections can be ascertained from the data available.

- 4,4'-DDE - The highest concentration of 4,4'-DDE (510 ug/kg) was detected in the sample from location CC-7(3) near the 002 Outfall. Only eight (8) of the eighty (80) samples with concentrations above the RI screening value of 3.16 ug/kg had concentrations above 200 ug/kg. Those eight (8) samples are as follows (depth in inches noted in parentheses): CC-4(18), CC-6(3), CC-7(3), CC-8(18), CC-10(3), CC-10(9), CC-13(18) and SRI-SED-9R. The bulk of these samples are located in the deltaic area near the mouth of the 002 Outfall. However, as with 4,4'-DDD, the high concentration of 4,4'-DDE in the sample from upstream reference location SRI-SED-9R is an indication of the widespread and non-uniform (e.g. background source) nature of these detections in the CCW EA. As with the metals and PCB data noted above, the large amount of sampling in the 002 Outfall area has likely biased the detections in this 002 Outfall area as there is no known source of 4,4'-DDE at the Site nor is there a nexus of detections of this compound between Clonmell Creek and the Site.

- 4,4'-DDT - The highest concentration of 4,4'-DDT (630 ug/kg) was detected in the sample from location SRI-SED-2A near the 002 Outfall. Seven (7) of the twenty-three (23) sediment samples with concentrations that exceed the applicable RI screening value of 4.16 ug/kg had concentrations that exceed 200 ug/kg. These seven (7) samples are as follows: 02OF-10(3), SED2-CCref-2, SRI-SED-2A, SRI-SED-5B, SRI-SED-6, SRI-SED-9R and SRI-SED-17. Of these samples, two (2) are in the 002 Outfall just north of the NCL. Four (4) samples are in the vicinity of the large oxbow in Clonmell Creek located just north of the CLF/GP EA. The remaining sample with a concentration above its RI screening value for 4,4'-DDT is SRI-SED-9R, which is a reference sample located in the far eastern portion of the CCW EA. This sample detection pattern is also indicative of widespread, non-uniform detections throughout the CCW EA from historical regional pesticide usage.

- Dieldrin - The highest concentration of dieldrin (480 ug/kg) was detected in the sample from location CC-10(30) near the 002 Outfall. Eight (8) of the thirty-five (35) sediment samples with concentrations that exceed the applicable RI screening value of 1.9 ug/kg had concentrations that exceed 100 ug/kg. These eight (8) locations are as follows: CC-3(3), CC-4(18), CC-7(18), CC-8(3), CC-8(18), CC-10(30), CC-16(3) and CC-16(9). These locations are all FI samples in and around the 002 Outfall deltaic area. The highest concentrations are found in the samples from depths of eighteen (18) to thirty (30) inches. These deeper samples are likely indicative of regional historical releases from upstream sources that were detected in these FI sample locations. Other detections of dieldrin are spread throughout the CCW EA.

- Gamma-chlordane - The highest concentration of gamma-chlordane (170 ug/kg) was detected in the sample from location CC-3(30) near the 002 Outfall. Six (6) of the twenty-two (22) sediment samples with concentrations that exceed the applicable RI screening value of 3.24 ug/kg had concentrations that exceed seventy (70) ug/kg. These locations are as follows: CC-3(9), CC-3(18), CC-105(18 – dup of CC-3(18)), CC-4 (3), CC-4(18) and CC-8(3). These locations are all in the vicinity of the 002 Outfall or just downstream. Three (3) of the seven (7) are from one (1) location (CC-3), which is downstream of the 002 Outfall delta area. The pattern of these detections indicates a localized area of high concentration gamma-chlordane detections. However, the other lower concentration detections are found upstream of the Clonmell Creek Bridge, extending upstream as far as the SRI-SED-9R reference location. As noted previously with other pesticides, PCBs and metals; the highest concentrations appear to be primarily at depths greater than nine (9) inches and, thus, likely representative of historical, regional upstream source(s).

- Heptachlor epoxide - The highest concentration of heptachlor epoxide (170 ug/kg) was detected in the sample from location CC-4(18) just downstream of the 002 Outfall confluence with Clonmell Creek. Nine (9) of the thirty-two (32) sediment samples with concentrations that exceed the applicable RI screening value of 2.47 ug/kg had concentrations that exceed 30 ug/kg. These locations are as follows: CC-3(18), CC-105(18 – dup of CC-3(18)), CC-4(3), CC-4(18), CC-6(3), CC-8(3), CC-16(9), SRI-SED-2A and SRI-SED-9R. These samples are all located along the mid-line of Clonmell Creek and stretch from the westernmost reference location (SRI-SED-9R) to just downstream from the 002 Outfall confluence (CC-3(18)). This pattern of detections is indicative of the widespread, non-uniform nature of this and other pesticide detections in the CCW EA.

A clear, definitive finding of the review of the available pesticide data is that the highest concentrations are more prevalent in the samples obtained from sediment depths of nine (9) inches or greater. The abundance of samples with pesticide concentrations above the applicable RI screening values in the vicinity of the 002 Outfall confluence with Clonmell Creek is thus somewhat biased due to the extensive sampling done in this area during the FI and subsequent sampling events. It is clear that pesticides have been historically used regionally upstream of the Site, on the Site, and in the surrounding areas. Thus, the pesticide detections are prevalent throughout the sediments of the CCW EA and cannot be attributed to a single source area.

SVOCs

Of the 112 sediment samples in the CCW EA that had SVOC analyses, the following compounds had exceedances (number of exceedances in parentheses after compound) of applicable RI screening values: 1,1’-biphenyl (29); 1,4-diisopropylbenzene (1); 2,6-di-tert-butyl-p-cresol (67) (SSTIC); 2-methylnapthalene (47); 2-methylphenol (2); 3&4-methylphenol (10); a,a-dimethylbenzyl alcohol (7) [SSTIC]; acetophenone (28); benzaldehyde (6), bis(2-ethylhexyl)phthalate (25); carbazole (4); dibenzofuran (4); diethyl phthalate (2); diisopropylbenzene (39) [SSTIC]; di-n-butl phthalate (1); m&p-cresol (1); and phenol (34). Compounds with more than ten (10) RI screening value exceedances were considered significant and thus were thus were the focus of the SVOC evaluation along with SSTICs exceedances of RI screening values. The following is an analysis of these detections in sediments in the CCW EA:

- 1,1'-Biphenyl – The highest concentration of 1,1'-biphenyl (3,100,000 ug/kg) was detected in the sample from location CC-10(18) in the 002 Outfall delta area. Eight (8) of the twenty-nine (29) detections that had concentrations exceeding the RI screening value of 7,646 ug/kg, had concentrations that exceeded 100,000 ug/kg. All of these samples, with the exception of CC-10(3), were detected in samples at depths of nine (9) inches or greater. The samples with concentrations above 100,000 ug/kg are as follows: CC-4(30), CC-8(18), CC-8(30), CC-11(9), CC-11(18), CC-10(3), CC-10(9), CC-10(18) and CC-13(30). These samples are all located in the 002 Outfall deltaic area in FI or subsequent investigation samples. The depth of the highest concentration samples (9 inches or greater) indicates that the 1,1'-biphenyl is likely related to older, historical and/or regional creek sediment deposition.

- 2,6-Di-tert-butyl-p-cresol – This is an SSTIC that has been identified as being associated with historical manufacturing processes at the Site. The highest concentration of 2,6-di-tert-butyl-p-cresol (3,900,000 ug/kg) was detected in the sample from location CC-10(18) in the 002 Outfall deltaic area. Fifteen (15) of the sixty-seven (67) detections that had concentrations exceeding the RI screening value of 20.2 ug/kg had concentrations that exceeded 150,000 ug/kg. These locations are as follows: CC-4(30), CC-8(9), CC-8(18), CC-104(18 – dup of CC8(18)), CC-8(30), CC-10(3), CC-10(9), CC-10(18), CC-11(9), CC-11(18), CC-13(18), CC-13(30), SED2-CC-13(3)", SED2-CC-8(3)" and SRI-SED-2A. All of these locations are in close proximity to the 002 Outfall deltaic area. Numbers within the parenthesis are depths in inches. The highest concentrations are at depths between eighteen (18) and thirty (30) inches. This indicates that some of these detections may also be related to historical deposition. This compound was also detected in three sediment samples on the DuPont Repauno site. All three (3) detections were at concentrations that exceed the applicable RI screening value. The detections were in sample DPT-1(3), DPT-2(3) and DPT-2(9). These two sample locations are the two closest to the tide gate where Clonmell Creek intersects the Delaware River.

- 2-Methylnapthalene - The highest concentration of 2-methylnapthalene (90,000 ug/kg) was detected in the sample from location CC-10(18) in the 002 Outfall delta area. Thirteen (13) of the fifty (50) detections that had concentrations exceeding the RI screening value of 20.2 ug/kg had concentrations that exceeded 10,000 ug/kg. These locations are as follows: CC-4(30), CC-7(3), CC-8(18) and its duplicate CC-104(18), CC-8(30), CC-10(3), CC-10(9), CC-10(18), CC-10(30), CC-11(9), CC-13(3), SED-1B and its duplicate SED-1BB. All of these locations are in the vicinity of the 002 Outfall delta in Clonmell Creek and just downstream (CC-4 and SED-1B). The highest concentrations are at depths between eighteen (18) and thirty (30) inches. This indicates that these detections are likely related to historical deposition from the 002 Outfall and possibly from upstream background sources.

- a,a-Dimethylbenzyl alcohol - This is an SSTIC that has been identified as being associated with historical manufacturing processes at the Site. The highest concentration of a,a-Dimethylbenzyl alcohol (19,000 ug/kg) was detected in the sample from location CC-10(9) in the 002 Outfall delta area. The seven (7) detections that had concentrations exceeding the RI screening value of 650 ug/kg are as follows: CC-8(3), CC-8(9), CC-8(18) and its duplicate CC-104(18), CC-10(3), CC-10(9) and CC-11(9). These detections are all located in the 002 Outfall delta area and are likely related to historical deposition from the 002 Outfall.

- Acetophenone - The highest concentration of acetophenone (12,000 ug/kg) was detected in the sample from location CC-8(18) in the 002 Outfall delta area. Twelve (12) of the twenty-eight (28) detections that had concentrations exceeding the RI screening value of 650 ug/kg had concentrations that exceeded 3,400 ug/kg. These locations are as follows: CC-3(30), CC-4(30), CC-6(3), CC-7(3), CC-8(3), CC-8(9), CC-8(18) and its duplicated CC-104(18), CC-8(30), CC-11(9), CC-11(18) and CC-13(18). These detections are all located in the 002 Outfall delta area and are likely related to historical deposition from the 002 Outfall. In addition, this compound was detected once in the sediment samples located downstream on the DuPont Repauno site. This lone detection in sample DPT-4(3) was at a concentration that exceeded the RI screening value.

- Bis(2-ethylhexyl)phthalate - The highest concentration of bis(2-ethylhexyl)phthalate (18,000 ug/kg) was detected in the sample from location SRI-SED-4B upstream of the Clonmell Creek Bridge. Eight (8) of the twenty-five (25) detections that had concentrations exceeding the RI screening value of 182 ug/kg had concentrations that exceeded 1,000 ug/kg. These locations are as follows: CC-8(18) and its duplicate CC-104(18), SED-2, SED-5, SRI-SED-4A, SRI-SED-4B, SRI-SED-5, SRI-SED-8R and SRI-SED-9R. These detections are found along the length of Clonmell Creek in the CCW EA from upstream reference locations (SRI-SED-8R and SRI-SED-9R) to the 002 Outfall area (CC-8). The upstream concentrations above the Clonmell Creek Bridge are all higher than those found downstream of the bridge. This pattern of detections indicates that the source of these detections is upstream of the Site and likely a historical and/or regional issue.

- Diisopropylbenzene - This is an SSTIC that has been identified as being associated with historical manufacturing processes at the Site. The highest concentration of diisopropylbenzene (110,000 ug/kg) was detected in the sample from location CC-10(18) in the 002 Outfall area. Eighteen (18) of the thirty-nine (39) detections that had concentrations exceeding the RI screening value of 86 ug/kg had concentrations that exceeded 10,000 ug/kg. These locations are as follows: CC-3(30); CC-4(30); CC-7(3); CC-8(3); CC-8(9); CC-8(18) and its duplicate CC-104(18); CC-8(30); CC-10(3); CC-10(9); CC-10(18); CC-11(3); CC-11(9); CC-11(18); CC-102(30) a duplicate of CC-11(30); CC-13(18); CC-13(30); SED2-CC-8(3)"and (CC-8(2). These detections are all located in the 002 Outfall delta area. The highest concentrations are found in the eighteen (18) to thirty (30) inch depth range and thus are likely related to historical deposition from the 002 Outfall.

- Phenol – Phenol is a COC at the Site associated with the former manufacturing process. The highest concentration of phenol (6,000 ug/kg) was detected in the sample from location CC-10 in the 002 Outfall area. Fifteen (15) the thirty-four (34) detections that had concentrations exceeding the RI screening value of 49.1 ug/kg had concentrations that exceeded 800 ug/kg. These locations are as follows: CC-6(3); CC-7(3); CC-8(3); CC-8(9); CC-8(18) and its duplicate CC-104(18); CC-10(3); CC-10(9); CC-10(18); CC-10(30); CC-11(9); CC-13(18); SED-2; SRI-SED-2A and SRI-SED-17. These detections are all located in the 002 Outfall and delta area and are likely related to historical deposition from the 002 Outfall.

With the exception of bis(2-ethylhexyl)phthalate it appears that all of the compounds assessed above are likely related to historical discharges from the 002 Outfall. The highest concentrations are generally detected in the nine (9) to thirty (30) inch depth range in the deltaic area at the confluence of the 002 Outfall and Clonmell Creek. Some concentrations above the applicable RI screening value are found slightly upstream and downstream of this area as well. No evidence of bis(2-ethylhexyl)phthalate detections exist on the Site and the pattern of detections indicates that the detections of this compound did not originate from the Site. Instead, this compound is more likely to have originated upstream of the Clonmell Creek Bridge and thus is most likely attributable to off-Site sources.

VOCs

Of the 236 sediment samples in the CCW EA that had VOC analyses, the following compounds had exceedances (number of exceedances in parentheses after compound) of applicable RI screening values: 1,2,4-trimethylbenzene (1); 1,2-dichlorobenzene (2); 1,3,4-trimethylbenzene (1); 1,4-dichlorobenzene (2); 2-butanone (61); acetone (108); a-methylstyrene (21); benzene (11); carbon disulfide (16); chlorobenzene (1); cumene (67); ethylbenzene (6); methyl acetate (19); methylene chloride (2); toluene (33); and total xylenes (7). Compounds with more than ten (10) RI screening value exceedances were considered significant and thus were the focus of the VOC evaluation, in addition to SSTICs or COCs exceedances of RI screening values. The following is an analysis of these VOC detections in sediments in the CCW EA:

- 2-Butanone - The highest concentration of 2-butanone (1,000 ug/kg) was detected in the sample from location CC-16(3) south of the 002 Outfall delta area adjacent to the NCL. Seventeen (17) of the sixty-one (61) detections that had concentrations exceeding the RI screening value of 42.4 ug/kg had concentrations that exceeded 150 ug/kg. These locations are as follows: CC-16(3); CC-16(9); CC-16(18); CC-21(3) and its duplicate CC-100(3); CC-21(9); CC-21(18); CC-22(3); CC-22(9); CC-22(18); CC-22(30); CC-30(18) and its duplicated CC-Dup-506; CC-42(42); CC-44(42); PS-1(5); PS-4(1); and SED-2-CC-2(3)". In addition to these detections above 150 ug/kg, there were also lower concentrations (less than 100 ug/kg) in most of the samples located in Area B and well upstream of any Site influences. It was also noted that the detection limit for the SRI reference locations (SRI-SED-7R through SRI-SED-9R) for 2-butanone was greater than 3,000 ug/kg. 2-butanone may have been detected in these samples if the detection limit were lower. A review of the pattern of detections for the greater than 150 ug/kg concentration detections shows that they span the area from CC-21 just upstream of the GP area and extend close to the western property boundary (CC-42 and CC-44). None of the concentrations above 150 ug/kg are found in the 002 Outfall delta area suggesting that the former Site process areas and, specifically, the 002 Outfall was not a source for 2-butanone. The pattern of detections suggests an upstream/regional source for 2-butanone in Clonmell Creek. Locations CC-21 and CC-22 in particular had concentration detections above the RI screening value throughout the sediment column. Many of the 2-butanone detections were noted at depths of forty-two (42) inches or even greater, suggesting an older historical deposition period.

- Acetone – Acetone is associated with the manufacturing process at the Site. The highest concentration of acetone (15,000,000 ug/kg) was detected in the sample from location CC-8(3) in the 002 Outfall delta area. Sixteen (16) of the 108 detections that had concentrations exceeding the RI screening value of 9.9 ug/kg had concentrations that exceeded 65,000 ug/kg. These locations are as follows: CC-7(3); CC-8(3); CC-8(9); CC-8(18) and its duplicated CC-104(18); CC-10(3); CC-10(18); CC-10(30); CC-11(3); CC-11(9); CC-11(18); CC-11(30) and its duplicated CC-102(30); CC-13(18); CC-13(30); and PS-3(3). These high concentration detections are centered in the 002 Outfall delta area. The acetone detections may also be related to historical acetone usage at the Site.

- a-Methylstyrene - This is an SSTIC that has been identified as being associated with historical manufacturing processes at the Site. The highest concentration of a-methylstyrene (22,000,000 ug/kg) was detected in the sample from location CC-8(18) in the 002 Outfall delta area. The twenty-one (21) detections that had concentrations exceeding the RI screening value of 254 ug/kg are as follows: CC-3(30); CC-4(18); CC-4(30); CC-8(9); CC-8(18) and its duplicate CC-104(18); CC-10(3); CC-10(9); CC-10(18); CC-11(9); CC-11(18); CC-11(30) and its duplicate CC-102(30); CC-13(30); CC-13(42); CC-29(30); CC-29(42); CC-34(9); CC-34(18); and CC-36 and its duplicate CC-DUP-502. A review of the pattern of these detections shows that they are all located within the 002 Delta area and just west (CC-36) and east (CC-29) of that area. The highest concentrations are found in the nine (9) to eighteen (18) inch depth range indicating that these detections are likely the result of historical deposition from the 002 Outfall. Unlike many of the non-Site related constituents detected in the 002 Outfall delta area, this SSTIC is generally not detected upstream from the Clonmell Creek Bridge and thus is not likely associated with historical and/or regional upstream sources.

- Benzene - This is a Site COC that has been identified as being associated with historical manufacturing processes at the Site. The highest concentration of benzene (53,000 ug/kg) was detected in the sample from location CC-4(18) located just west of the 002 Outfall delta area. The eleven (11) detections that had concentrations exceeding the RI screening value of 142 ug/kg are as follows: CC-4(30); CC-10(3); CC-29(30); CC-29(42); CC-34(18); CC-34(30); CC-34(42); CC-36(30) and its duplicate Dup-502; SED-1B; and SRI-SED-2A. A review of the pattern of these detections shows that they are all located within the 002 Delta area and just west (SED-1B) and east (CC-29) of that area. The highest concentrations are found in the eighteen (18) to thirty (30) inch depth range indicating that these detections are likely the result of historical deposition from the 002 Outfall.

- Carbon disulfide - The highest concentration of carbon disulfide (39 ug/kg) was detected in the sample from location CC-16(3) located east of the 002 Outfall delta area and adjacent to the midpoint of the NCL EA. The sixteen (16) detections that had concentrations exceeding the RI screening value of 5.32 ug/kg are as follows: CC-2(3); CC-6(9); CC-16(3); CC-16(9); CC-21(3); CC-30(9) and its duplicate Dup-505; CC-38(3); CC-44(42); CC-44(54); CC-46(18); PS-1(5); SED2-CC-4(3)"; SED2-CCRef-1; and SED2-CCRef-2. These detections span a long stretch of Clonmell Creek from CC-21 located between the shooting range and the GP well east of the Clonmell Creek Bridge to the western property line (CC-46). None of the detections are located in the 002 Outfall or delta area. Many of the detections are found at the three (3) inch depth range, but near the western property boundary at location CC-44 the detections were very deep at forty-two (42) and fifty-four (54) inches in depth. Carbon disulfide was also detected at concentrations below the RI screening value at upstream locations ARB-3 and ARB-5. The pattern of detections indicates a non-Site related origin and is likely the result of transport from an upstream source over a long period of time.

- Cumene - This is a Site COC that has been identified as being associated with historical manufacturing processes at the Site. The highest concentration of cumene (240,000,000 ug/kg) was detected in the sample from location CC-8(18) located just west of the 002 Outfall delta area. Forty-three (43) of the sixty-seven (67) detections that had concentrations exceeding the RI screening value of 119,661 ug/kg had concentrations that exceeded 750,000 ug/kg. These detections span the 002 Outfall delta area from CC-13, located just east of the delta, to CC-46 located near the DuPont property boundary. The location of the highest concentration detections of cumene are in the central portion of the delta area at locations CC-8 and CC-11. These detections appear to emanate from the 002 Outfall area and extend downstream, decreasing in concentration with increased distance from the 002 Outfall area, as expected. Cumene was also detected in six (6) of the ten (10) sediment samples obtained downstream on the neighboring DuPont Repauno plant. However, none of the detected concentrations were above the RI screening value.

- Methyl acetate - The highest concentration of methyl acetate (1,700 ug/kg) was detected in the sample from location CC-6(3) in the 002 Outfall delta area. Nineteen (19) of the detections had concentrations exceeding the RI screening value of 9.9 ug/kg. These locations are as follows: CC-2(9); CC-6(30); CC-14(9); CC-41(18); SRI-SED-1; SRI-SED-1A; SRI-SED-1B; SRI-SED-2; SRI-SED-2B; SRI-SED-3A; SRI-SED-3; SRI-SED-3B; SRI-SED-4A; SRI-SED-4B; SRI-SED-5; SRI-SED-5A; SRI-SED-5B; SRI-SED-9R; and SRI-SED-17. These detections span the entire length of the creek within the CCW EA from upstream/easternmost location SRI-SED-9A to the western property boundary (SRI-SED-1). Although the highest concentration was detected at location CC-6(3) in the 002 Outfall area, the concentration range across the entire creek does not vary significantly. The highest upstream concentration was detected at SRI-SED-9R (1,100 J ug/kg) and the concentration furthest downstream at SRI-SED-1 was reported at 970 J ug/kg. A review of the off-Site reference wetland soil samples (SRI-WS-24R through SRI-WS-27R) reveals methyl acetate concentrations at these locations that range from 490 J ug/kg to 1,000 J ug/kg. Thus, it is likely that the methyl acetate is not Site related and that the source for the detections of this compound are likely located upstream from the Site.

- Toluene - This is a Site COC that has been identified as being associated with historical manufacturing processes at the Site. The highest concentration of toluene (15,000,000 ug/kg) was detected in the sample from location CC-8(18) located in the 002 Outfall delta area. Eighteen (18) of the thirty-three (33) detections that had concentrations exceeding the RI screening value of 1,220 ug/kg had concentrations that exceed 220,000 ug/kg. These sample locations are as follows: CC-4(9); CC-4(18); CC-4(30); CC-8(3); CC-8(9); CC-8(18) and its duplicate CC-104(18); CC-8(30); CC-10(3); CC-10(9); CC-10(18); CC-10(30); CC-11(3); CC-11(9); CC-11(18); CC-11(30) and its duplicate CC-102(30); CC-13(30); and CC-29(30). These detections are all centered in the 002 Outfall delta area to a sediment depth of thirty (30) inches. The detections extend upstream as far east as location CC-29(30) at concentrations above 220,000 ug/kg, but diminish in concentration downstream to location CC-36(30) [49,000 ug/kg]. With the highest concentrations found at depths between eighteen (18) and thirty (30) inches, it is apparent that these detections are most likely related to historical deposition that predominantly emanated from the 002 Outfall (pre-1991).

As noted in Section 8.3.5 above, in 2013 CSI conducted further investigation of Clonmell Creek sediments by obtaining pore water samples at depths of zero (0) to six (6) inches (denoted by A in sample ID) and six (6) to twelve (12) inches (denoted by B in sample ID) at seven (7) locations in and around the 002 Outfall delta area. These pore water samples help to identify how bioavailable the compounds entrained in the sediment are to biota in the sediments. Only VOC data were obtained from the pore water samples so the assessment of those data enhance our understanding of the VOC concentrations in this portion of the creek.

Table 8-31 contains a summary of all pore water data available from the CCW EA and Table 8-36 provides a frequency of detection statistical summary of those data.

The only compounds with detected pore water concentrations that exceed the applicable RI screening values for surface water are benzene, cumene, PCE, and TCE. Both the PCE and TCE detections were in sample PP-100(B). This sample was a duplicate of sample PP-4B where those compounds were not detected. In addition, acetone was detected in sample PP-100(B) but not in the parent sample PP-4B. The sediment samples obtained from this same location also do not contain any detections of chlorinated solvents. Thus, these detections of chlorinated solvents at estimated (J-flagged) concentrations are suspect.

The detections of benzene in pore water at concentrations exceeding the applicable RI screening value were at locations PP-3B, PP-100A, PP-4B and its duplicate PP-100B, and PP-5B. As with the chlorinated solvents above, benzene was detected in duplicate PP-100A, but not in its parent sample PP-4A. The other detections are all in the six (6) to twelve (12) inch depth range as denoted by the B in their sample IDs. Locations PP-3B and PP-4B are in the 002 Outfall delta area. Location PP-5B is further downstream to the west of the 002 Outfall area.

Cumene detections in pore water at concentrations exceeding the applicable RI screening value were observed at locations PP-3B, PP-100A, PP-4B and duplicate samples PP-100B, and PP-5B. As with the chlorinated solvents and benzene above, cumene was detected in duplicate PP-100A but not in its parent sample PP-4A. The other detections are all in the six (6) to twelve (12) inch depth range as denoted by the B in their sample IDs. These sample locations are the same as for benzene.

These pore water sample results are a reflection of the cumene and benzene detections noted above for sediments in the 002 Outfall area. It is suspected that some potential benzene detections in this area may have been masked by the cumene concentrations which resulted in elevated benzene detection limits. The pore water data indicate that some pore water bioavailability of these compounds may occur at depths below six inches, but not in the biologically active zero (0) to six (6) inch depth range.

Sediment Detection Summary

A review of the Site-related VOC sediment detections in the CCW EA, shows a clear correlation to the presence of these compounds in the 002 Outfall area and the historical prevalence of these compounds formerly used at the Site. Alternatively, the presence of other non-Site related compounds (e.g. carbon disulfide and methyl acetate) ubiquitously throughout the stretch of Clonmell Creek in the CCW EA indicates that these non-Site related constituents emanated from an off-Site historical/regional source(s). Although the non-Site related constituents are intermixed within the 002 Outfall area, the presence of these other constituents in sediments in other portions of the CCW EA are equivalent to off-Site conditions, which is suggestive of upstream/off-Site contributions that are not related to historical manufacturing activities at the Site.

8.3.5.5 Surface Water

Table 8-30 contains a summary of all surface water data available from the CCW EA. A frequency of detection statistical summary of those data is provided as Table 8-35. Table 8-39 provides frequency of detection statistical summary of the surface water data obtained downstream of the CCW EA on the neighboring DuPont Repauno site. There were no detections in the surface water samples obtained at the DuPont Repauno property; thus a data summary table was not prepared for these data. The locations of the DuPont Repauno property sediment and surface water samples are shown on Figure 8-3.

As part of the agreement with DuPont to access their property, the analytical suite for the samples obtained there were limited to Site-specific VOC and SVOC compounds.

Metals

The metals with detected surface water concentrations in the CCW EA that exceed the applicable RI screening values, with the number of exceedances in parentheses, are as follows: aluminum (14); aluminum (dissolved) (1); arsenic (5); cadmium (1); chromium (4); copper (6); copper (dissolved) (8); iron (12); lead (9); manganese (12); manganese (dissolved) (2); nickel (1); nickel (dissolved) (2); vanadium (5); zinc (1); and zinc (dissolved). All of these metals, with the exception of chromium, were identified by RBR in the BERA as noted in Section 8.2.2 above as being consistent with background conditions in Clonmell Creek. Chromium detections were identified as being consistent with background conditions in the wetland areas. Thus, these metals are likely related to background/upstream or naturally occurring conditions.

A further review of the pattern of lead detections indicates that the highest concentration of lead detected in a surface water sample was 21.5 ug/L in the sample from location SRI-SW-9R. This is a reference location obtained at the furthest point east in the CCW EA. This clearly indicates that lead from upstream sources is present in both surface water and sediments in the CCW EA.

PAHs

There were no PAHs with detected surface water concentrations in the CCW EA that exceed the applicable RI screening values.

PCBs

There were no PCBs with detected surface water concentrations in the CCW EA that exceed the applicable RI screening values.

Pesticides

The pesticides with detected surface water concentrations in the CCW EA that exceed the applicable RI screening values, with the number of exceedances in parentheses, are as follows: 4,4’-DDD (6), alpha-BHC (1) and gamma-chlordane (5). As noted for both 4,4’-DDD and gamma-chlordane for sediments in the CCW EA, these compounds are detected throughout the CCW EA. The surface water detections are similar with detections of both compounds at one or the other of the upstream reference locations (SRI-SW-7R and SRI-SW-9R). Surface water detections of pesticides are most likely related to entrained sediments within the sample. The lone detection of alpha-BHC at a concentration above the RI screening value in sample SRI-SW-17 may be an artifact of regional pesticide use. As with sediments, pesticide detections are found across the CCW EA with no localized source area identified.

SVOCs

The only SVOC with a detected surface water concentration in the CCW EA that exceeded the applicable RI screening value was bis(2-ethylhexyl)phthalate in two samples (SRI-SW-1 and SRI-SW-5). SRI-SW-1 is located near the western property boundary and SRI-SW-5 is well upstream of the Clonmell Creek Bridge. The sediment data concentrations and distribution indicate an upstream source of this compound with concentrations above the applicable RI screening value in the vicinity of SRI-SW-5. Thus, the source of these detections is likely upstream of the Site.

VOCs

There were no VOCs with detected surface water concentrations in the CCW EA that exceed the applicable RI screening values.

Surface Water Detection Summary

Multiple metals were detected in surface water at concentrations above applicable RI screening values. However, all of those metals have been identified as being present in background samples at concentrations above those found on the Site. To be conservative, a further review of the pattern of lead detections was conducted. This review indicates that lead from upstream sources is present in both surface water and sediments in the CCW EA.

As with sediments, pesticide detections are found across the CCW EA with no specific source area or clear distribution pattern identified.

Review of the sediment data indicated an upstream source of bis(2-ethylhexyl)phthalate with concentrations above the RI screening value in the vicinity of SRI-SW-5. Thus, the source of these detections is likely upstream of the Site.

No site related issues of note were found in review of the available surface water data for the CCW EA.

8.3.5.7 Summary

A review of the available data for the CCW EA reveals the industrial nature of Clonmell Creek and its environs. The detection of many compounds at concentrations above the applicable RI screening values that are not related to the Site (e.g. methyl acetate, carbon disulfide, etc.) and show a pattern of detections that indicates influence from upstream or regional source(s) is apparent. Also clear is the impact from Site-related compounds (e.g. cumene, benzene, a-methylstyrene, etc.) entrained in sediments in the portion of Clonmell Creek where the 002 Outfall emanates from the Site and including sediments immediately downstream and upstream of this deltaic area. However Site-related compounds are not commonly found upstream beyond the Clonmell Creek Bridge.

The location of the detections around the 002 Outfall delta area reflect the low energy environment observed and measured in Clonmell Creek through multiple investigative phases. The tide gate at the confluence with the Delaware River inhibits surface water flow in the creek that results in generally stagnant flow conditions most of the time. The tide gate opens when surface water levels in the creek measurably exceed the water level in the Delaware River, resulting in brief periods of moderate downstream flow until surface waters in the creek and river equilibrate. Also, surface water periodically discharged from the Site to Clonmell Creek via the 002 Outfall prior to construction of the berm at the head of the SCB (circa 1991). This outflow from the Site to the creek (pre-1991) occurred primarily during/after storm events and is believed to have transported Site-related compounds and sediments from the Site and deposited them in Clonmell Creek. The Site-related compounds appear to have adsorbed to sediment particles and then dropped out of the water column and settled to the bottom of the creek in this low-energy environment. This resulted in some deposition upstream of the 002 Outfall as well as downstream in a typical deltaic fan pattern.

The presence and distribution of Site-related compounds reflects the historic nature of these deposits. The highest concentrations of Site-related compounds were typically detected in sediment samples from the nine (9) to thirty (30) inch depth range, and in places as deep as forty-two (42) to fifty-four (54) inches. Concentrations of Site-related compounds generally aren’t present at concentrations above the RI screening values in the zero (0) to six (6) inch depth range. This is evidence of the discontinuation of deposition of Site-related compounds after the 002 Outfall was closed off in 1991 and likely increase microbial degradation in the zero (0) to six (6) inch depth range. Prior to 1991, as the Site-related VOCs were deposited and entrained beneath continued sediment deposition, the historically impacted sediments became embedded in an anaerobic environment that has allowed them to persist in the sediments of the creek bed for an extended period of time, much longer than the anticipated half-life of cumene in sediments.

As noted above, once the tide gate opens the downstream flow rate in the creek increases temporarily as the backed up water is allowed to enter the Delaware River at low tide. However, this periodic increased flow does not result in sufficient sediment shear energy to mobilize the embedded sediments further downstream. Thus, the bulk of the impacted sediments appear to have remained largely in place in the 002 Outfall delta area for several decades, which is supported by the Site-related constituent detections and distribution in Clonmell Creek sediments. Low level detections of Site-related constituents were noted in the downstream portion of Clonmell Creek located in the neighboring DuPont Repauno site. Thus, some limited downstream migration of Site-related conditions has occurred, though downstream sediment transport from the Site is thought to be negligible as discussed further in Section 9. In fact, as noted in Section 9, more than 99% of the Site-related COC mass in sediment is present in the reach of Clonmell extending from the Clonmell Creek Bridge downstream toward the property boundary with the DuPont Repauno site as a result of historical transport from the Site through the 002 Outfall (pre-1991).

As noted above, sporadic detections of a variety of other compounds, including PCBs (Aroclor-1254), pesticides, SVOCs and some VOCs that are not related to Site activities were found at concentrations exceeding the applicable RI screening values upstream of the Clonmell Creek

Bridge as well as in the 002 Outfall delta area. However, the pattern of detections of these compounds make it clear that the presence of these compounds is the result of the long history of regional industrial activity upstream of the Site as well as episodic pesticide usage in the region. No particular source area or well defined distribution of constituent concentrations could be identified for these compounds.

8.3.6 Inactive Process Area Investigation History Summary

See Section 3.6 above for a full description of this EA and the historical activities that occurred here. This area formerly served as the base of the para-cresol manufacturing operations on the Site. That facility was demolished in 1991. Other features formerly located in this EA include the southern warehouse; a laboratory and the LDS area; a maintenance shop; a boiler house and related fuel tanks (see Figure 3-6). The following is a summary of the samples that have been obtained in this EA that are used to assess nature and extent in this RI.

A total of 218 soil and four (4) sediment samples were obtained from this EA during the Ph I, Ph II and previous historical investigations at the Site. The samples were obtained to address concerns associated with several of the historical IAs including: southern warehouse, inactive process area, LDS area and the small TF.

One (1) soil sample was obtained in this EA during the SRI. A number of Geoprobe® borings (IPA-SRI-1 through 7) were installed in the vicinity of Ph II sample IPA-SS3B, to delineate the extent of a greenish oily liquid previously observed in this area [ERM, 2003]. No greenish liquid was encountered; however, the samples exhibited green-tinged soils at depths between 1 and 4 ft bgs. Since no 'greenish oily liquid' was observed, a soil sample of the green soil in IPA-SRI-7 was analyzed for VOCs, SVOCs, and SSTICs. None of the constituents analyzed were detected in the aforementioned samples. Additionally, during the SRI, one groundwater sample was obtained using Geoprobe® techniques (GP-WH-SRI-01) in the vicinity of the southern warehouse. Data from Geoprobe® borings are not included in the detection summary tables for this EA as they were not included in the risk assessment. Only data from permanent monitoring wells from 2013-2015 were included in that assessment. These data are summarized along with other Geoprobe® groundwater samples obtained during the FI in this EA on Table 8-41 and are further discussed in Section 8.3.6.2 below.

A total of twenty-four (24) soil/groundwater samples, two (2) sediment samples and one (1) surface water sample were obtained in this EA during the 2009 FI. The groundwater results are not included in the groundwater summary data provided in Table 8-41 because those data were obtained from temporary well points. The temporary well point data are provided in Table 8-47 and are further discussed in Sections 8.3.6.1 and 8.3.6.2 below.

As discussed in Section 2.2.1.1.2, two (2) soil cores were obtained from the IPA (IPA-10 and IPA-14) for UV light screening during the 2009 FI to assess for the potential presence of NAPL in soils in some of the most highly impacted portions of the Site. At location IPA-14, no UV fluorescence indicative of NAPL was observed. The sample aliquot from IPA-10 showed weak to moderate fluorescence. Weak and moderate fluorescence is typically indicative of NAPL smearing, or historical NAPL presence, or dispersed R-NAPL.

One sample location (CPT-11) was sampled for soils and groundwater during the CPT investigation in 2013 in this EA.

Historical production well, PW-2 is located along the eastern edge of this EA. Monitoring wells MW-10 (now MW-10R), MW-10B, MW-10C and former shallow production well, PW-6, are located along the southern edge of this EA adjacent to the APA. PW-6 used to recover shallow groundwater for transmission to the on-Site groundwater treatment system. Monitoring wells MW-17 and MW-17B are located near the former LDS area. Monitoring wells, MW-44 and MW-44B, were installed along the northwestern boundary of the IPA EA during the SRI.

The sample locations for this EA are shown on Figure 3-6. The analytical data used to assess the nature and extent of detections for this EA are summarized on Tables 8-40 (soil), 8-41 (groundwater), 8-42 (sediment), and 8-43 (surface water). Each of those tables contains a comparison of those data to the screening values developed for this RI as outlined in Section 8.1 above. Frequency of detection summary tables for soil, groundwater and sediment for this EA are provided in Tables 8-44, 8-45 and 8-46. Only one (1) surface water sample was obtained, thus no frequency of detection table was generated for this media.

The following sections outline the nature and extent of detections in this EA by media.

8.3.6.1 Soil

Table 8-40 contains a summary of all soil data available from the IPA EA and Table 8-44 provides a frequency of detection statistical summary of those data.

Metals

A total of eleven (11) samples in this EA were analyzed for metals. Only one (1) of these 11 sample locations had a detected concentration that exceeded the applicable RI screening values. Sample location IPA-4 from the FI had concentrations of arsenic and iron that exceeded the screening criteria. Six (6) other locations also had detections that exceeded the screening criteria for arsenic of three (3) mg/kg. However, the recognized background concentration in New Jersey soils for arsenic is 19 mg/kg. Only location IPA-4 had a concentration of arsenic (thirty-six [36] mg/kg) that exceeded nineteen (19) mg/kg. Sample IPA-4 was obtained at a depth of nine and a half (9.5) ft bgs in the vicinity of the former para-cresol area.

SVOCs

Only three (3) of the 210 samples, plus a duplicate obtained at location IPA-10, that were analyzed for the SVOC compound acetophenone (an SSTIC), had concentrations that exceeded the applicable screening value. The only other SVOC that had concentrations exceeding applicable screening values in the IPA EA is 1-1’-biphenyl in both the parent sample and duplicate obtained at FI location IPA-10. The maximum detected concentrations of both acetophenone and 1-1'-biphenyl in the IPA EA were in the sample or duplicate from FI location IPA-10, obtained at a depth of ten (10) ft bgs. The other two (2) locations where detections of acetophenone at concentrations above the screening value were found were Ph II locations, SB08A (depth of 0-2 ft bgs) and SB06A (depth of 4-6 ft bgs). All three (3) of these locations (IPA-10, SB08A and SB06) are located just south of the IPA pond and in the vicinity of the former waste water treatment equalization tank T-43 (see Figure 3-6).

VOCs

The only VOC compounds detected in soil samples that had concentrations of VOCs exceeding the applicable screening criteria were benzene and cumene. Only one (1) sample (FI sample IPA-100, a duplicate of sample location IPA-10) out of the 243 soil samples analyzed for benzene in this EA had a detected concentration above the screening value. Three (3) samples of the 241 soil samples analyzed for cumene had detected concentrations above the screening value. Two (2) of these cumene detections were also at location IPA-10 and its duplicate IPA-100 from a depth of ten (10) ft bgs. The final remaining sample with a cumene exceedance is from location CPT-11, obtained at a depth of sixteen (16) ft bgs. Location CPT-11 is in the southern central portion of the IPA EA in the vicinity of former production well PW-6, just south of location IPA-10.

New Jersey Impact to Groundwater and Direct Contact Non-Residential Soil Remediation Standards (NJDCNRSRS) Assessment

As requested by NJDEP, RBR conducted an assessment of available soil data against the NJIGW and NJDCNRSRS criteria (see Appendix P). A summary of relevant groundwater results is included for comparative discussion to address NJIGW exceedances for soil.

The compounds with detected concentrations that exceed the NJDCNRSRS in the IPA EA were acetophenone, arsenic and benzene. The NJDCNRSRS exceedances are consistent with the exceedances of the screening values developed for this RI with the exception of iron. Iron exceeded the RI screening value for iron but did not exceed the NJDCNRSRS for iron.

The compounds with detected concentrations that exceed the NJIGW were 2-butanone, acetone, benzene, bromoform, ethylbenzene, methylene chloride, PCE, acetophenone, benzo(a)anthracene, aluminum, antimony, arsenic, beryllium and manganese. The data from the temporary well points in the IPA EA have been compiled on Table 8-47 and a frequency of detection summary of these data is provided on Table 8-48 to help further assess the NJIGW exceedances. The data from the temporary well points include additional analyses that are not part of the quarterly groundwater monitoring activities at the Site and are thus helpful to assess NJIGW exceedances of non-VOC compounds. The Site has been inactive since 2009: thus, all potential sources of Site-related contaminants have been eliminated for more than 8 years. As a result, groundwater conditions have long since reached dynamic equilibrium and Site-related contaminant concentrations are stable or decreasing (see Section 9 for more detailed discussions). Consequently, if the detected compounds in soil that exceed an NJIGW criteria are not present in the groundwater data from temporary or permanent wells, then it is reasonable to deduce that there are no resulting impacts to groundwater from those soil exceedances.. The data from the permanent well points compiled in Table 8-41 and frequency of detection summary are provided in Table 8-45 were also reviewed to assess the NJIGW exceedances. The following is a compound specific summary reviewing the relevant groundwater data in locations where soil sampling results exceeded the NJIGW:

- 2-butanone – There were no exceedances of the RI screening value in either the temporary or permanent wells for this compound.

- Acetone – six (6) total exceedances of the RI screening value were noted in the data from the permanent wells with the highest detection being from well MW-10B. No exceedances of the RI screening value were noted in the temporary well data.

- Benzene – A total of eight (8) temporary well points and forty (40) permanent well samples had detected concentrations that exceed the RI screening value for this compound. The highest concentrations were noted at location IPA-10 for the temporary well points and at former extraction well PW-6 for the permanent wells. Both are in the same vicinity just south of the IPA pond.

- Bromoform – One (1) detection of bromoform in a 2014 sample from permanent well MW-44B exceeded the RI screening value. No detections subsequent to the 2014 sample point had a concentration that exceeded the RI screening value. No detected concentrations in the IPA temporary wells exceeded the RI screening value.

- Ethylbenzene – Seven (7) temporary well points and twenty-four (24) permanent well groundwater samples had detected concentrations that exceeded the RI screening value. The highest concentration detections were noted at location IPA-10 for the temporary well points and at former extraction well PW-6 for the permanent wells. Both are in the same vicinity just south of the IPA pond.

- Methylene chloride – No detected concentrations exceeded the RI screening value.

- Tetrachloroethene – One (1) temporary well (IPA-19) and one (1) 2013 permanent well (MW-10R) samples had detected concentrations that exceed the RI screening value. IPA-19 is not in the same vicinity as MW-10R, but is in the vicinity of the former maintenance shop.

- Acetophenone – This is an SVOC compound. None of the permanent wells have SVOC data. One (1) temporary well point sample, IPA-10, had a detected concentration that exceeded the RI screening value.

- Benzo(a)anthracene - This is an SVOC compound. None of the permanent wells have SVOC data. Three (3) temporary well point samples had detected concentrations that exceeded the RI screening value. The highest concentration was detected in the sample from IPA-2 in the northern part of the former para-cresol facility. Several other PAHs were also detected at concentrations exceeding the RI screening value at this location. IPA-2 is located just off one of the main Site roads.

- Aluminum, antimony, arsenic, beryllium and manganese – no metals data are available for any of the temporary or permanent well points in the IPA EA. All of these metals were identified as being present at concentrations in background samples above those in one or more of the exposure areas assessed as noted in Section 8.2.2 above.

Based upon the above analysis, there appears to be detections in groundwater of Site-related COCs acetone, benzene, ethylbenzene and acetophenone from soils in the area between the MW-10/PW-6 well cluster and the IPA pond. There also appear to be PAHs in soils at concentrations above applicable RI screening values in the vicinity of FI sample location IPA-2 located in the northern part of the former par-cresol area along the north-south trending Site road.

No other compounds that had measurable soil concentrations that exceed the NJIGW appear to have any significant detections in groundwater that may be related to these reported soil exceedances of the NJIGW.

Soil Detection Summary

Concentrations of arsenic, iron, acetophenone, 1-1'-biphenyl, benzene and cumene were detected in soil samples above their applicable screening values. However, of the more than 200 soil sample locations in the IPA EA, the number of detections at concentrations above screening values was minimal. The noted metals detections are centered at FI sample location IPA-4, which is in the central portion of the former para-cresol area. The SVOC and VOC detections are centered in the area just south of the IPA pond in the vicinity of former wastewater treatment equalization tank T-43 and the MW-10 monitoring well cluster. This area is just north of the API skimmer that was formerly located in the APA EA and is a suspected source of subsurface soil detections of SSCOCs. An assessment of the NJIGW exceedances also indicates localized detections of SSCOCs in the area between the MW-10/PW-6 well cluster and the IPA pond.

8.3.6.2 Groundwater

VOCs

The data from permanent monitoring wells from 2013 through the second quarter of 2017 in the IPA EA are summarized on Tables 8-41 (detection summary) and 8-45 (FOD). The vast majority of the data from the IPA EA consist of VOC data. The bulk of the samples with detections that had concentrations that exceed the RI screening values were for the known Site-related VOCs as follows: acetone, benzene, cumene and ethylbenzene. Total recoverable phenolics (TRP) have also been frequently detected in samples from wells MW-10 (and its replacement, MW-10R) and PW-6. Several chlorinated solvent and degradation products were also detected at concentrations that exceeded the RI screening values including: cis-1,2-

dichloroethene, PCE, TCE and vinyl chloride. The highest concentrations of these detected compounds are in samples from the MW-10/PW-6 well cluster.

The chlorinated compounds and their daughter compound detections are intermittent and may be related to historical operations at the former maintenance shop. The detections of these compounds are sporadic and historic in nature with no detections since 2015. The detections are not extensive or widespread and may be indicative of limited localized use of degreasers at the former maintenance shop. No documentation of widespread storage or use of chlorinated solvents at the Site has ever been identified.

TRP is regularly detected in shallow groundwater wells, MW-10, its replacement (MW-10R), and former shallow extraction well PW-6 at concentrations that exceed the RI screening value. No detections of TRP were noted in the deeper wells of the MW-10 cluster (MW-10B and MW-10C). This indicates that the TRP in the vicinity of these wells have predominantly attenuated and degraded prior to migrating into the deeper B- and C-level aquifer zones.

The only other compounds detected in groundwater samples at concentrations that exceed the RI screening values are bromoform and total xylenes. Bromoform was detected once in 2014 in a sample from well MW-44B and total xylenes were also detected once in 2014 in a sample from MW-17B. These isolated detections have not recurred since 2014.

8.3.6.3 Sediment

A summary of the detections in the sediment samples for this EA is provided in Table 8-42. Frequency of detection summary statistics for these data are provided in Table 8-46. Two (2) surface water bodies are present in the IPA EA. A swale located just west and north of the location of the former southern warehouse and the IPA pond located in the central portion of the EA. Two (2) sediment samples, WH-SED-3 and WH-SED-4 were obtained from the swale during the Ph II investigation. Two (2) sediment samples, IPA-POND-SED-1 and IPA-POND-SED-2, were obtained from the IPA pond during Ph II. Sample IPA-POND-SED-2 is not discussed in the Ph II document nor is there a location provided for this sample. A review of the data available for this sample as compared to the data from IPA-POND-SED-1 seems to indicate that it is a duplicate of IPA-POND-SED-1. For the purposes of this RI Report, IPA-POND-SED-2 is being treated as a duplicate of IPA-POND-SED-1. Two (2) sediment samples were obtained from depths of zero (0) to six (6) inches (IPA-11(3)) and six (6) to twelve (12) inches (IPA-11 (9)) at location IPA-11 in the IPA pond during the FI.

The Ph II sediment samples were manually obtained to a maximum depth of six (6) inches using a Wildco Hand corer Model 2420-655 coring device or a decontaminated stainless steel spoon. The FI sediment samples were obtained with a one (1) – foot stainless steel split core sampler to a depth of twelve (12) inches. Two aliquots from depths of zero (0) to six (6) inches (denoted by (3) after the sample ID) and six (6) to nine (9) inches (denoted by (9) after the sample ID were obtained from the single location IPA-11 in this EA.

Metals

The sediment samples obtained in the warehouse area swale (WH-SED-3 and WH-SED-4) were not analyzed for metals. The other four samples obtained from the IPA pond (IPA-11 (3), IPA-11 (9), IPA-SED-01 and its duplicate IPA-SED-02) do have metals data associated with them. The following metals were detected at concentrations that exceed their applicable RI screening value in those samples: iron, lead, manganese, mercury, nickel, arsenic barium, cadmium, chromium, cobalt, copper, and zinc.

The IPA pond was historically used for iron precipitation and removal as part of the para-cresol manufacturing process prior to 1991. Thus, the presence of metals at concentrations above the applicable RI screening values in the sediments of this pond is expected. The highest metals concentrations were predominantly detected in the FI sample IPA-11. The highest metals concentrations were present in the sample obtained from zero (0) to six (6) inches [IPA-11 (3)], except for chromium. Sample IPA-11 (9), collected from a depth of six (6) to twelve (12) inches, had the highest chromium concentration of sixty-one (61) J mg/kg. The detected concentrations of lead and mercury were slightly higher in samples IPA-POND-SED-2 and IPA-POND-SED-1 than those collected at IPA-11. The lead and mercury concentrations detected in the IPA pond sediments only slightly exceed the conservative RI Screening Values.

PAHs

The only sediment sample with detected concentrations that exceeded applicable RI screening values for PAHs was the Ph II sample location, WH-SED-3. The compounds with exceedances at that location include: benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, benzo(a)pyrene and dibenz(a,h)anthracene. This sample location is off the northwest corner of the former southern warehouse. Based on the age of this sample (1995) and its shallow depth, it is likely that concentrations of these PAH compounds have diminished over the intervening twenty-two (22) years.

SVOCs

The SVOCs with detected concentrations that exceeded applicable RI screening values and the location (in parentheses) of those detections are as follows: M&P cresol (WH-SED-4), phenol (WH-SED-3) and bis(2-ethylhexyl)phthalate (WH-SED-3). The detections are all located in the swale just north and west of the southern warehouse area. Based on the age of this sample (1995) and its shallow depth, it is likely that concentrations of these compounds have diminished over the intervening twenty-two (22) years.

VOCs

Cumene is the only VOC compound that was detected in sediments in the IPA EA. One detection of cumene in sample WH-SED-3 at a concentration well below the RI screening value was noted. Based on the age of this sample (1995) and its shallow depth, it is likely that concentrations of these compounds have diminished over the intervening twenty-two (22) years.

Sediment Detection Summary

Detections of concentrations of metals (iron, lead, manganese, mercury, nickel, arsenic barium, cadmium, chromium, cobalt, copper and zinc) above the applicable RI screening values in sediment samples from the bottom of the IPA pond are the only sediment detections of concern in the IPA EA. These detections were in samples obtained from depths of zero (0) to twelve (12) inches in the IPA pond.

8.3.6.4 Surface Water

A summary of the detections in the surface water sample for this EA is provided in Table 8-43. The one (1) surface water sample in this EA, SW-IPA-11, was collocated with sediment sample IPA-11 and was obtained during the FI. This sample contained exceedances of the applicable RI screening criteria for the following compounds: aluminum; arsenic; copper; lead; six PAHs at estimated (J-flag) concentrations; and 1,2,4-trichlorobenzene. All of the detected concentrations are relatively low, but the ecological based screening values for the IPA pond are also low. The IPA pond was not assessed as part of the BERA as it is not considered a viable ecological habitat. Shallow groundwater likely has at least partial hydraulic interconnection with the IPA pond based on water levels and shallow soil lithology in this area. Thus, the surface water in the IPA pond may have sporadic detections of constituents present in nearby shallow groundwater.

8.3.2.6 Summary

The primary issues within the IPA EA are the presence of localized metals and SVOC detections in soils and sediments along with VOC and SVOC detections in soils and sediments in a small subsection of this EA. The noted metals detections (arsenic and iron) are in the sample from FI location IPA-4, which was obtained in the central portion of the former para-cresol area at a depth of nine (9) and a half feet bgs. In addition, some concentrations of metals above applicable RI screening values were noted in the sediments of the IPA pond as previously discussed.

SVOC concentrations of note were found in samples from the swale that runs north and west of the former southern warehouse. However, the SVOC detections were in shallow soil samples that are over twenty (20) years old.

The VOC detections in soil and groundwater that are of note are centered in the area just south of the IPA pond in the vicinity of former wastewater treatment equalization tank T-43 and the MW-10 monitoring well cluster. This area is just north of the API skimmer that was formerly located in the APA EA and is a known source of subsurface soil and groundwater detections of SSCOCs. The remainder of the EA had no detections warranting further action. The area has been thoroughly characterized for every media vertically and laterally.

8.3.7 Northern Chemical Landfill Area Investigation History Summary

As noted in Section 3.7 above, this EA historically received waste materials from the phenol/acetone process, the para-cresol process, the MPP, and the dicumylperoxide process. Surficial landfilling in the NCL appears to have initiated in the early 1970's and was discontinued in 1974. The residual materials that have been encountered in the landfill through the various investigation phases consisted primarily of black oily liquid, lab bottles (some filled with a white, yellow, or orange material), fibrous material, copper pipe, plastic, decomposed fiber drums, gloves, bricks, concrete, scrap metal, and empty ammonium thiocyanate bags. Approximately thirty (30) fifty-five (55) – gallon metal drums were observed on the ground surface or were partially buried in this area. Additionally, approximately five (5) fifty-five (55) – gallon metal drums were observed on the ground surface along the eastern bank of the 002 Outfall, adjacent to the NCL and the SDB. CSI conducted a removal of easily removable surface debris, including the old drums, from the NCL in 2013. The following is a summary of the samples that have been obtained in this EA that are used to assess nature and extent in this RI.

During the 1988 Ph I [ERM, 1988] a total of six (6) soil samples were obtained from four (4) different locations in the NCL EA. Samples were obtained from zero (0) to six (6) inches bgs, two (2) to four (4) feet bgs and four (4) to six (6) feet bgs.

During the 1994 Ph II [ERM, 1995] a total of fifty-nine (59) soil samples were obtained from a total of twenty-three (23) locations. Samples were obtained from two (2) – ft intervals up to a depth of seven (7) ft bgs.

During the 2002 SRI [ERM, 2003] a total of two (2) surface soil, two (2) wetland soil, and thirteen (13) temporary well point groundwater samples were obtained from the NCL EA. The soil samples were obtained from a depth of zero (0) to six (6) inches bgs.

During the 2009 FI conducted by CSI, a total of two (2) soil samples and two (2) groundwater samples were obtained from two (2) soil boring locations. The groundwater samples were obtained from temporary well points at those sample locations. The locations were in the western portion of the NCL and were conducted as part of an investigation into the 002 Outfall drainageway. These samples have been assessed as part of the NCL EA in the risk assessment and as part of this RI Report. Additionally, sixteen (16) soil borings were advanced in the NCL area. One (1) soil sample and one (1) groundwater sample from a temporary well point at each boring location also were obtained. As per the FIWP [CSI, 2009], the soil samples were obtained at the depth where the highest PID reading was found or at the water table interface if no PID readings were noted.

One (1) year subsequent to the FI field work (March 29, 2010), CSI personnel were conducting quarterly groundwater monitoring activities in the NCL at well MW-39 when they noticed a chemical odor and surface soil staining along the western edge of the NCL. While documenting this issue, the field team noticed discolored fluids and a sheen on ponded water just east of well MW-39. This area is denoted as the "NCL-Perched Zone" on Figure 3-7. At this time, the water table was extremely high because of melting snow from a recent blizzard and a precipitation event. Ground pressure caused by walking and driving in this area was sufficient to force perched water to the surface producing small droplets of dark colored liquid. This liquid quickly volatilized and a sheen was noted on the ponded water in this vicinity.

CSI personnel obtained a sample of this surface water (NCL Puddle, see Table 8-49) and had it analyzed for VOCs + cumene on a 24-hour turnaround. Site-related compounds cumene, ethylbenzene, toluene and total xylenes were detected in this sample (see Table 8-49). Upon receipt of the data, CSI immediately notified the Hercules emergency response line. Based upon the information provided it was determined that this was not a reportable release. However, CSI quickly emplaced four sets of oil adsorbent booms to encircle the area and prevent any potential migration to the 002 Outfall and/or Clonmell Creek. Since this incident in 2010, CSI has sporadically observed the water in Clonmell Creek rise high enough to inundate this western portion of the NCL, though no further perched fluids releases or sheens have been observed.

As part of both the Ph II and SRI Reports, the lithology of the NCL was depicted in cross-section I-I' (see Plate 6 included in Appendix A). During the FI, CSI performed additional borings within the NCL that confirmed the lithology depicted in this cross-section. Additionally, CSI installed piezometers on both banks of Clonmell Creek, along the NCL and on the opposite northerly bank. Transducers were installed in these piezometers and readings were obtained over a five-day period (see section 2.1.5.3).

CSI also obtained cation/anion samples as part of the FI from the various water bodies at the site (IPA pond, SCB and Clonmell Creek) and from groundwater. A piper diagram assessment of these data was performed (see Section 6.3.1) to determine if there is interconnection between groundwater and surface water at the site. The conclusion of this study is that there is minimal evidence of interconnection between Clonmell Creek and groundwater at the NCL was evident based upon this analysis and supported by water level evaluation, low permeable soils separating groundwater at the NCL from Clonmell Creek, and direct observations, as described further herein.

The primary takeaway from the multiple phases of studies and the lithology encountered is that the groundwater level within the NCL is below the level of Clonmell Creek. Groundwater within the NCL is hydraulically inhibited from entering Clonmell Creek by a thick, low permeable peat/clay layer that extends well below the water table at the NCL (as deep as 17 feet bgs) and isolates shallow groundwater from the creek. This peat/clay layer is very tight and virtually impervious to groundwater flow. Additionally, the NCL is underlain in general by low-permeability sediments (the shallow clay between the A and B-level water-bearing zones), which impedes downward migration to deeper soil and ground water. As shown in the I-I' cross-section on Plate 6 (see Appendix A), the bulk of the waste material encountered at the NCL lies atop this low-permeability clay and between low-permeability silt and peat deposits.

The sample locations for this EA are shown on Figure 3-7. All of the analytical data available for this EA are summarized on Tables 8-50 (soil) and 8-51 (ground water) along with a comparison of those data to the screening values developed for this RI as outlined in Section

8.1 above. Frequency of detection summary tables for soil and groundwater for this EA are Tables 8-54 and 8-55, respectively.

The following sections outline the nature and extent of detections in this EA by media.

8.3.7.1 Soil

A summary of the detections in the soil samples for this EA is provided in Table 8-50. Frequency of detection summary statistics for these data are provided in Table 8-52.

Metals

The metals with detected soil concentrations in the NCL EA that exceed the applicable RI screening values, with the number of exceedances in parentheses, are as follows: antimony (1); arsenic (15); thallium (1); and vanadium (1). This minimal number of exceedances is not indicative of metals concentrations warranting further action in the NCL EA. However, further evaluation of metals detections in this EA is provided herein.

The lone exceedance of the antimony RI screening value of forty-seven (47) mg/kg was a detected concentration of 130 B mg/kg in sample NCL-2(24). This lone exceedance is less than an order of magnitude greater than the screening value and is qualified with a B indicating method blank contamination with antimony. The result is thus considered an outlier with no further action required.

The fifteen (15) detections of arsenic that had detected concentrations exceeding the RI screening value of three (3) mg/kg all had concentrations less than nineteen (19) mg/kg. The natural background concentration for arsenic in New Jersey is considered to be nineteen (19) mg/kg. Thus, no further action is warranted for these detections as well.

The lone thallium detection with a concentration that exceeds the RI screening value of 1.2 mg/kg was in the sample from location SRI-WS-9 at a concentration of 3.5 mg/kg. This concentration is less than an order of magnitude of the RI screening value. With no other thallium detections of note, this detection is considered an outlier and does not require further action.

The lone vanadium detection with a concentration that exceeds the RI screening value of 580 mg/kg was in the sample from location NCL-3(42) at a concentration of 950 J mg/kg. This concentration is less than an order of magnitude of the RI screening value and is flagged with a J indicating the concentration is a laboratory estimate. With no other vanadium detections of note, this detection is considered an outlier and does not require further action.

PAHs

The PAHs with detected soil concentrations in the NCL EA that exceed the applicable RI screening values, with the number of exceedances in parentheses, are as follows: benzo(a)anthracene (2), benzo(a)pyrene (3), benzo(b)fluoranthene (1), dibenz(a,h)anthracene

(1) and naphthalene (2). This minimal number of exceedances is not indicative of PAH detections warranting further action in the NCL EA. However, further evaluation of PAH detections in this EA is provided herein.

The above PAH detections are primarily found at sample locations NCL-13 (126) and B-08 (0-0.5). One (1) exceedance of benzo(a)pyrene was also found at location B-07 (0-0.5). Both B-07 and B-08 are from the 1988 Ph I Soils Investigation. These samples were both collected from a depth of zero (0) to six (6) inches bgs. The detected PAH concentrations in samples of this age (nearly 30 years old) and from a shallow depth like these are likely no longer representative as the PAHs have likely dissipated appreciably. Thus, of the newer samples available, the only sample with detections that exceed the applicable RI screening values is NCL-13(126). This sample location is in the southeast corner of the NCL along the access road, from a depth of ten (10) to eleven (11) ft bgs. At this depth, with no other corroborating data points in the vicinity, these detections are outliers and may not be generally representative. No further action is warranted for these isolated PAH detections in the NCL.

PCBs

There are no detections of PCBs in soil at concentrations that exceed the applicable RI screening values in the available samples for the NCL EA.

Pesticides

There are no detections of pesticides in soil at concentrations that exceed the applicable RI screening values in the available samples for the NCL EA.

Total Phenols

There are no detections of TRP in soil at concentrations that exceed the applicable RI screening values in the available samples for the NCL EA.

SVOCs

The SVOCs with detected soil concentrations in the NCL EA that exceed the applicable RI screening values, with the number of exceedances in parentheses, are as follows: 1,1-biphenyl (1) and acetophenone (8). The detection of 1,1-biphenyl was in the sample from location 02OF-08(84) located in the southwest corner of the NCL along the 002 outfall. This sample was obtained from a depth of six and a half (6.5) to seven and a half (7.5) ft bgs. This detection may be related to historical releases from the 002 Outfall. No other concentration detections above the RI screening value for 1,1-biphenyl were noted in soils in this area or in the 002 Outfall (part of the CCW EA). However, concentrations above the RI screening value for 1,1-biphenyl are noted in deep sediment samples in the 002 Outfall delta area, thus the detection at location 02OF-08(84) may be related to those detections.

The highest concentration detection of acetophenone is in the sample from location NCL-SB02B at a concentration of 1,261,983 ug/kg. This is located just east of the "NCL-Perched

Zone" (see Figure 3-7). The other detections with exceedances were obtained from two (2) samples (NCL-SB02A and NCL-SB02B) from depths of two (2) to six (6) ft bgs in the vicinity of the "NCL-Perched Zone". The one exception is sample location NCL-12(90), located in the eastern, middle portion of the NCL, and obtained from a depth of seven (7) to eight (8) ft bgs. Acetophenone is a Site-related COC, thus its presence in the vicinity of buried waste in the NCL is not surprising. Some buried waste is known to be present in the vicinity of location NCL-12 as well. The waste is believed to deeper on the eastern portion of the NCL than along the western portion of the NCL where the maximum depth of buried waste is approximately six (6) ft bgs.

VOCs

Only two (2) VOCs had detected concentrations of that exceeded their applicable RI screening values. These compounds are the Site-related compounds cumene and ethylbenzene. The detections with concentrations above the RI screening values were in two (2) sample locations for both compounds. Sample location NCL-4(72), collected from a depth of five and half (5.5) to six and a half (6.5) ft bgs, is located just north of the "NCL-Perched Zone." The other sample location was NCL-SB02B, obtained from a depth of zero (0) to two (2) ft bgs, and located just west of NCL-4. These detections correlate to the known locations of Site-related buried waste.

New Jersey Impact to Groundwater and Direct Contact Non-Residential Soil Remediation Standards (NJDCNRSRS) Assessment

As requested by NJDEP, RBR conducted an assessment of available soil data against the NJIGW and NJDCNRSRS criteria (see Appendix P). A summary of relevant groundwater results is included for comparative discussion to address NJIGW exceedances for soil.

The compounds with detected concentrations that exceed the NJDCNRSRS in the NCL EA were the following: acetophenone, benzo(a)anthracene, benzo(a)pyrene, dibenz(a,h)anthracene and naphthalene. The NJDCNRSRS exceedances are consistent with the exceedances of the screening values developed for this RI and are addressed above.

The compounds with detected concentrations that exceed the NJIGW were as follows: 1,1-dichloroethene, 2-butanone, acetone, benzene, chlorobenzene, ethylbenzene, methylene chloride, tetrachloroethene, total xylenes, 2-methylnapthalene, acetophenone, benzo(a)anthracene, benzo(a)pyrene, aluminum, antimony, beryllium, manganese, mercury, nickel, silver and thallium.

The data from the temporary well points in the NCL EA have been compiled on Table 8-53 and a frequency of detection summary of these data is provided on Table 8-54, to help further assess the NJIGW exceedances. The data from the permanent well points compiled in Table 8-53 and frequency of detection summary are provided in Table 8-54 were also reviewed to assess the NJIGW exceedances. The Site has been inactive since 2009: thus, all potential sources of Site-related contaminants have been eliminated for more than 8 years. As a result, groundwater conditions have long since reached dynamic equilibrium and Site-related contaminant concentrations are stable or decreasing (see Section 9 for more detailed discussions). Consequently, if the detected compounds in soil that exceed an NJIGW criteria are not present in the groundwater data from temporary or permanent wells, then it is reasonable to deduce that there are no resulting impacts to groundwater from those soil exceedances.. The data from the temporary well points include additional analyses that are not part of the quarterly groundwater monitoring activities at the Site and are thus helpful to assess NJIGW exceedances of non-VOC compounds. The following is a compound specific summary reviewing the relevant groundwater data in locations where soil sampling results exceeded the NJIGW for the NCL EA:

- 1,1-dichloroethene – There are no detections of this compound in any of the permanent or temporary well samples in the NCL EA. Thus, no groundwater detections have occurred from soil detections of this compound.

- 2-butanone – There are no detections of this compound in any of the permanent well samples in the NCL EA. Two (2) of the thirty-one (31) temporary well groundwater samples had detections of this compound, but neither had concentrations that exceeded the applicable RI screening value of 300 ug/L. The highest detected concentration was in sample SRI-TW-2 at 12 ug/L. These low concentration detections of 2-butanone are not indicative of significant groundwater quality diminishment in the NCL EA from this compound.

- Acetone – Nine (9) of the thirty-nine (39) permanent well point and ten (10) of the thirty-one (31) temporary well point samples had detections of acetone. However, none of these detections had concentrations that exceed the applicable RI screening value of 1,400 ug/L. The highest detected concentration of acetone is 260 ug/L in the sample from temporary well point NCL-6. This detection at less than twenty (20) percent of the RI screening value which, along with the other low level detections of acetone, indicates that significant adverse impacts to groundwater in the NCL EA from this compound are not present.

- Benzene – Fifty-two (52) of the seventy-three (73) permanent well point and eleven (11) of the thirty-one (31) temporary well groundwater samples had detections of this compound. Forty-eight (48) of the permanent well point and all eleven (11) of the temporary well point samples had detected concentrations that exceeded the applicable RI screening value of 0.46 ug/L. The noted detections in the temporary well point samples are in the central portion of this EA extending from the “NCL-Perched Zone” close to the access road entering the NCL (GP-NCL-SRI-10) near its southeast corner. All of the permanent well points have samples with exceedances with the exception of MW-30. This pattern of detections suggests that benzene concentrations and distribution in soils at the NCL EA likely correlate to locations where waste materials were historically disposed.

- Chlorobenzene – Three (3) of the thirty-nine (39) permanent well point and two (2) of the thirty-one (31) temporary well point samples had detections of Chlorobenzene. Of these samples, only one (1) of the temporary well point samples had a detected concentration that exceeded the applicable RI screening value of 7.8 ug/L. This detection was from the temporary well point at location NCL-2 where a concentration of 57 ug/L was reported. This location is on the western end of the NCL-Perched Zone and may be related to waste material in close proximity. However, the lack of widespread detections of this compound indicates that there is no appreciable impact to groundwater from chlorobenzene in soils at the NCL EA.

- Ethylbenzene – Forty-three (43) of the seventy-three (73) permanent well point and fifteen (15) of the thirty-one (31) temporary well groundwater samples had detections of this compound. Thirty-nine (39) of the permanent well point and all fifteen (15) of the temporary well point samples had detected concentrations that exceeded the applicable RI screening value of 1.5 ug/L. The pattern of detections is similar to those noted above for benzene and indicate a probable correlation with waste in the NCL EA.

- Methylene chloride – There are no detections of this compound in any of the permanent or temporary well samples in the NCL EA. Thus, no leaching to groundwater has occurred from soil detections of this compound.

- Tetrachloroethene – There are no detections of this compound in any of the permanent or temporary well samples in the NCL EA. Thus, no leaching to groundwater has occurred from soil detections of this compound.

- Total xylenes – Six (6) of the forty-three (43) permanent well point and eight (8) of the thirty-one (31) temporary well point samples had detections of total xylenes. Of these samples, two (2) of the permanent well point and seven (7) of the temporary well point samples had a detected concentration that exceeded the applicable RI screening value of nineteen (19) ug/L. The highest concentration of total xylenes in groundwater was detected in the temporary well point sample, NCL-2, at a concentration of 2,600 ug/L. The two permanent well point groundwater samples with detected concentrations that exceed the RI screening value were from MW-32 and MW-38 in 2013. Total xylenes have not been detected at a concentration above the RI screening value in any well in the NCL EA since 2013. The pattern of temporary well point detections is consistent with those found for benzene and ethylbenzene as noted above. However, groundwater data from the temporary well points do not correlate closely to groundwater data from permanent wells. Hence, review of all groundwater results suggests total xylenes in soils are not adversely impacting shallow groundwater quality at the NCL EA.

- 2-methylnapthalene – Only the temporary well points have SVOC analyses. Four (4) of the thirty-one (31) temporary well points had detections of this compound and two (2) of those (NCL-11 and NCL-13) had concentrations that exceed the RI screening value of 3.6 ug/L. These two points (NCL-11 and NCL-13) are located in the southeast corner of the NCL near the access road. Although this compound was not detected in soils at a concentration above the applicable RI screening value, several PAHs were detected in soils in this vicinity (particularly at location NCL-13). These groundwater detections may thus be generally related to the PAH detections in soils in this area.

- Acetophenone – Only the temporary well points have SVOC analyses. Twenty-three (23) of the thirty-one (31) temporary well points had detections of this compound and six (6) of those had concentrations that exceed the RI screening value of 190 ug/L. The samples with RI screening value exceedances are as follows: NCL-SRI-01; NCL-SRI-03; GP-NCl-SRI-06; GP-NCl-SRI-08; GP-NCL-SRI-10; and NCL-6. These locations are distributed across the central portion of the NCL EA and correlate with areas of known waste burial. Thus, the detections of this Site-related compound may be related to confirmed soil detections and distribution.

- Benzo(a)anthracene – Only the temporary well points have PAH analyses. None of the temporary well points had detections of this compound.

- Benzo(a)pyrene – Only the temporary well points have PAH analyses. None of the temporary well points had detections of this compound.

- The metals with NJIGW exceedances were compared to the sample data from the nineteen (19) available temporary wells with metals data. The detected metals with the number of detections in parentheses are as follows: aluminum (19), antimony (1), beryllium (16), manganese (19), mercury (2), nickel (17), silver (4) and thallium (1). The metals with high frequency of detections (aluminum, beryllium, manganese and nickel) have all been demonstrated by RBR (see section 8.2.2 above) or by the PRC [Langan, 2016] as being present in background samples at similar or higher concentrations compared to Site-related detections. Thus, the detections of aluminum, beryllium, manganese and nickel are likely related to total suspended solids/sediment entrained in the unfiltered groundwater samples from the temporary well points. Hence, reported detections of these four (4) metals are more likely an artifact of the native lithology and not related to Site activities or waste disposal in the NCL EA. Further review of the other metal detections is below.

    - Antimony – One (1) temporary well point sample (NCL-13) had a detected antimony concentration of 3.4 ug/L. This concentration exceeds the RI screening value of 0.78 ug/L. Antimony was also detected in the soil sample NCL-13(126) at a concentration of 1.4 B ug/kg at a depth of ten (10) to eleven (11) ft bgs. However, the highest concentration of antimony in soils was 130 B ug/kg at location NCL-2(24) while no corresponding groundwater detection for antimony was noted in the temporary well point sample from NCL-2. This lone groundwater detection at a concentration exceeding its RI screening value thus is not indicative of antimony leaching to groundwater from overlying soils.

    - Mercury – Of the two (2) temporary well point samples with detected mercury concentrations, only one (1) had a concentration that exceeded the RI screening value of 0.063 ug/L. The sample from location NCL-4 had a detected concentration of mercury of 0.16 ug/L. This sample is located just north of the

"NCL-Perched Zone" and does correlate to mercury detections in soils in this vicinity.

- Silver – Four (4) temporary well point samples had detected silver concentrations. Only one of these (NCL-13) had a concentration that exceeded its applicable RI screening value of 9.4 ug/L. Silver was also detected in the soil sample NCL-13(126) at a concentration of 6.7 ug/kg at a depth of ten (10) to eleven (11) ft bgs. This was the highest silver concentration detected in soils in the NCL EA. Thus, this detection combined with the antimony detection at the same location described above may indicate localized metals leaching to groundwater from soils in the vicinity of location NCL-13 located along the access road into the NCL in the southeast corner of the EA.

- Thallium - One (1) temporary well point sample had a detected thallium concentration. This sample, 02OF-08, had a concentration of 0.59 J ug/L that exceeded the RI screening value of 0.02 ug/L. Sample 02OF-8 is located in the northwest corner of the NCL EA and there are no nearby detections of thallium in soils. In fact, the only detection of thallium in the soil samples from the NCL EA is in the sample from location SRI-WS-9 located in the northeastern portion of the NCL EA. Thus, there appears to be no correlation between soil concentrations of thallium and the lone detection of thallium in groundwater at the NCL EA.

Soil Detection Summary

A review of the available soil data for the NCL EA indicates some detections of metals, PAHs and some SVOC compounds not typically associated with the Site in the vicinity of sample location NCL-13(126). Some potential leaching to shallow groundwater quality from soil detections in the central portion of the NCL EA from Site-related VOCs (benzene, ethylbenzene and total xylenes) and SVOC acetophenone were also noted. These detections appear to correlate with the areas of known historical waste disposal in the central portion of the NCL EA extending from location NCL-12 in the east-central portion of the NCL to the "NCL-Perched Zone" located in the west-central portion of the NCL EA.

8.3.7.2 Ground Water

A summary of the detections in the groundwater samples for this EA is provided in Table 8-51. Frequency of detection summary statistics for these data are provided in Table 8-52.

The data from permanent wells in the NCL EA consists of VOC only data from wells MW-30, MW-31, MW-32, MW38, MW-39 and MW-50B. The groundwater data set used to assess nature and extent in this RI Report consists of quarterly monitoring data for these wells from 2013 to the second quarter of 2017 (annual event). The compounds that were detected in these samples at concentrations exceeding their applicable RI screening values with the number of exceedances in parentheses are as follows: benzene (48), carbon disulfide (1), cumene (54), ethylbenzene (39) and total xylenes (2). All of these compounds, with the exception of carbon disulfide, are Site-related VOCs.

Monitoring well, MW-30 is the only well in the NCL that does not have any samples with detections that exceed the RI screening values. The only detections in samples from this well are detections of cumene that range between 1.6 and 6.1 ug/L. The RI screening value for cumene is 45 ug/L.

In the groundwater dataset, there are only three detections of carbon disulfide. Two of these detections were in samples from well MW-31 in 2013 (sixty-seven (67) ug/L) and in 2015 (170 J ug/L). The other detection was in 2015 in a sample from MW-32 at a concentration of 0.31 J ug/L. The RI screening value for carbon disulfide is eighty-one (81) ug/L. There are no detections of carbon disulfide in any NCL wells in 2016 or 2017.

Similar to carbon disulfide, total xylenes were detected twice at concentrations above the RI screening value of nineteen (19) ug/L in samples from MW-31 (forty-two (42) J ug/L) and MW-38 (twenty-four (24) J ug/L). Also in 2013, the sample from monitoring well MW-32 had a detected concentration of twelve (12) J ug/L. Since 2013 only two (2) detections of total xylenes were reported in samples from MW-38 (8.8 ug/L) and MW-39 (0.32 J ug/L). No detections of total xylenes have been reported in any of the NCL wells since 2014.

A review of the benzene, cumene and ethylbenzene detections in groundwater at the NCL EA indicates that wells MW-31, MW-32, MW-38 and MW-50B consistently have detections of these compounds at concentrations exceeding their applicable RI screening values. Samples from well MW-39 consistently reveal detections of benzene and cumene above their applicable RI screening values until October 2015. Subsequent to this time, the concentrations of benzene and cumene in samples from MW-39 have decreased with only cumene being detected in the April 2017 sample from this well at a concentration of 0.7 J ug/L.

The data indicate that groundwater conditions within the NCL EA are improving naturally over time. However, a distinct area of groundwater with SSCOC detections above applicable RI screening values was noted in the shallow A-level in the vicinity of wells MW-31, MW-32, and MW-38. Groundwater from the NCL then migrates downward into the B-level as indicated by review of the data from MW-50B. Groundwater in the vicinity of MW-50B ultimately migrates with regional groundwater flow toward the south-southwest and vertically downward into the C-level aquifer. Though the noted Site-related VOCs dissolved in groundwater in the vicinity of MW-50B migrate in the general direction of the on-Site extraction wells along the southern property line, Fate and Transport analyses (See Section 9) reveals that these compounds attenuate to concentrations below applicable RI groundwater screening values well before migrating to the southern property boundary.

8.3.7.3 Summary

After review of the soil and groundwater data from the NCL EA it is clear that there are some detections in soil of metals, PAHs and some SVOC compounds not typically associated with the Site in the vicinity of sample location NCL-13. However, the soil sample obtained at NCL-

13(126) was from a depth greater than twelve (12) ft bgs, which is below the water table. These detections will be addressed, if necessary, as part of any final groundwater remedy implemented at the NCL EA, if warranted.

Some detections in shallow groundwater were found in the central portion of the NCL EA from Site-related VOCs (benzene, cumene, ethylbenzene and total xylenes) as indicated by the permanent well data from shallow (A-level) wells MW-31, MW-32, and MW-38. Groundwater from this area ultimately migrates downward into the B-level as indicated by the dissolved groundwater data for samples from MW-50B.

The temporary well data from the NCL EA indicate shallow groundwater detections of the SVOC acetophenone in this central portion of the NCL as well. These detections, as well as those noted above, appear to correlate with the areas of known waste disposal in the central portion of the NCL EA extending from location NCL-12 in the east-central portion of the NCL to the “NCL-Perched zone” located in the west-central portion of the NCL EA. Notable declines in concentrations of Site-related compounds in the permanent well groundwater data have been documented and indicate that natural attenuation of Site-related VOCs in groundwater is effectively occurring at the NCL EA.

8.3.8 Northern Warehouse Area Investigation History Summary

As noted in Section 3.8 above, the Northern Warehouse Area (WH) is located directly north of the IPA and south of the TRA EA. The WH EA is comprised of the northernmost part of what was formerly referred to as the Northern and Southern Warehouses IA and the wooded area west of the MPP defined as the Borrow Area in the FI (Figure 3-8).

The Northern and Southern Warehouse IA was located along the western Plant boundary and was part of the original plant construction in the mid to late 1950’s. The warehouse buildings were used for storage, however only the northernmost warehouse is within the WH EA. The warehouses were decommissioned along with the rest of the site in 2009-2010. Concrete pads are all that remain of these buildings.

The investigation of the WH EA began with the collection of seven (7) soil samples from four (4) locations (B-12, B-18, B-19 and B-53) during the 1988 Ph I. These samples were obtained as part of a general characterization effort in what was then known as the northern IPA. The samples were obtained from depths of zero (0) to six (6) inches, six (6) to eight (8) feet and ten (10) to twelve (12) ft bgs.

During the 1994 Ph II, a total of seven (7) soil samples were obtained from three (3) locations (MPP-SS01B, MPP-SS02B and MPP-SS01C) as part of the investigation of the former MPP (samples with MPP IDs). An additional ten (10) soil samples were obtained from two (2) locations (WH-SS04A and WH-SB04A) as part of the investigation of the area formerly referred to as the northern warehouse (samples with WH IDs) area. These samples were obtained as part of the general characterization of both the warehouse and MPP areas.

During the 2002 SRI, one (1) temporary well point sample (GP-MPP-SRI-03) was obtained in the WH EA. This sample was obtained to verify MIP results in the vicinity of this sample location.

During the 2009 FI three (3) Geoprobe™ borings were advanced in the vicinity of the two (2) concrete lined impoundments in the southwest corner of the WH EA. Soil samples and groundwater samples using temporary well pints were obtained from each location to investigate this “Borrow Pit” area for potential phenols presence. Additionally, on the northern edge of the WH EA, two soil samples were obtained from zero (0) to one (1) ft bgs and ten (10) to eleven (11) ft bgs at location, TLF-4. This sample location was part of efforts to delineate the extent of the TRA, but the sample location falls in this WH EA.

After review of the initial draft of the HHRA, CSI found that risk was being driven in the WH EA as a result of total xylenes concentrations in one (1) shallow (zero to 12 (0-12) inch bgs) sample from location MPP-SS01B, a soil sample dating back to 1994 (ERM, 1995). The initial MPP-S01B sample that had the high total xylenes concentration was analyzed using an onsite portable lab set up (ERM-FAST). A fixed base laboratory confirmation sample was also obtained for this location, which did not reveal total xylenes concentrations of note and was thus not consistent with the ERM-FAST analysis. Thus, this sample should have been negated as a false positive in the Ph II Report. To address this issue, CSI proposed to conduct confirmatory sampling in the vicinity of the MPP-SS01B sample location on behalf of Hercules. This proposal was accepted and CSI obtained twenty-one (21) soil samples from four (4) locations (MPP-SS01BA, MPP-SS01BB, MPP-SS01BC and MPP-SS01BD) that surrounded the former MPP-SS01B location. These samples were then inserted into the data set in lieu of the MPP-SS01B results. These were the final samples obtained as part of this RI.

The sample locations for this EA are shown on Figure 3-8. All of the analytical data available for this EA are summarized on Tables 8-56 (soil) and 8-57 (groundwater) along with a comparison of those data to the screening values developed for this RI as outlined in Section 8.1 above. Frequency of detection summary tables for soil and groundwater for this EA are Tables 8-58 and 8-59.

The following sections outline the nature and extent of detections in this EA by media.

8.3.8.1 Soil

There are no soils samples in the WH EA that have concentrations of any compound that exceeds the applicable RI screening values.

New Jersey Impact to Groundwater and Direct Contact Non-Residential Soil Remediation Standards (NJDCNRSRS) Assessment

As requested by NJDEP, RBR conducted an assessment of available soil data against the NJIGW and NJDCNRSRS criteria (see Appendix P). A summary of relevant groundwater results is included for comparative discussion to address NJIGW exceedances for soil.

There are no compounds with detected concentrations that exceed the NJDCNRSRS in the WH EA.

The compounds with detected concentrations that exceed the NJIGW were as follows: 2-butanone, acetone, ethylbenzene, methylene chloride, and total xylenes.

The data from the temporary well points in the WH EA have been compiled on Table 8-60 and a frequency of detection summary of these data is provided on Table 8-61 to help further assess the NJIGW exceedances. The data from the temporary well points include additional analyses that are not part of the quarterly groundwater monitoring activities at the Site and are thus helpful to assess NJIGW exceedances of non-VOC compounds. The data from the permanent well points compiled in Table 8-57 and frequency of detection summary are provided in Table 8-59 were also reviewed to assess the NJIGW exceedances. The Site has been inactive since 2009: thus, all potential sources of Site-related contaminants have been eliminated for more than 8 years. As a result, groundwater conditions have long since reached dynamic equilibrium and Site-related contaminant concentrations are stable or decreasing (see Section 9 for more detailed discussions). Consequently, if the detected compounds in soil that exceed an NJIGW criteria are not present in the groundwater data from temporary or permanent wells, then it is reasonable to deduce that there are no resulting impacts to groundwater from those soil exceedances. The following is a compound specific summary reviewing the relevant groundwater data in locations where soil sampling results exceeded the NJIGW for the WH EA:

- 2-butanone – One (1) of the four (4) temporary well point samples in the WH EA had a detection of 2-butanone at a concentration of 0.92 ug/L. None of the permanent well point samples had a detected concentration of 2-butanone. The lone detection of this compound in groundwater from sample location BP-3 is at a concentration that is well below the applicable RI screening value of 300 ug/L. This detection does not represent an impact to groundwater and requires no further action.

- Acetone - One (1) of the four (4) temporary well point samples in the WH EA had a detection of acetone at a concentration of 6.4 ug/L. None of the permanent well point samples had a detected concentration of acetone. The lone detection of this compound in groundwater from sample location BP-3 is at a concentration that is well below the applicable RI screening value of 1,400 ug/L. This detection does not represent an impact to groundwater and requires no further action.

- Ethylbenzene - One (1) of the four (4) temporary well point samples in the WH EA had a detection of ethylbenzene at a concentration of two (2) ug/L. None of the permanent well point samples had a detected concentration of ethylbenzene. The lone detection of this compound in groundwater from sample location GP-MPP-SRI-03 is at a concentration that is just above the applicable RI screening value of two (2) ug/L. Detections of benzene and cumene at concentrations above the applicable RI screening value were also noted in the results for sample GP-MPP-SRI-03. These results indicate localized leaching from Site-related compounds in soil at this location.

- Methylene Chloride – There are no detections of methylene chloride in any of the temporary or permanent well point samples in the WH EA.

- Total Xylenes - There are no detections of total xylenes in any of the temporary or permanent well point samples in the WH EA.

Soil Detection Summary

Detections of benzene, cumene and ethylbenzene at concentrations above their applicable RI screening values in the temporary well point sample GP-MPP-SRI-03 were the only detections of note in the soil or temporary well point data. These results suggest minor leaching from Site-related compounds in soils to localized groundwater in the vicinity of this sample location.

8.3.8.2 Ground Water

The only permanent well in the WH EA is well MW-33B. One (1) detection of TCE was noted in the 2013 sample from this well at a concentration of 0.96 J ug/L. This concentration is above the RI screening value for TCE of 0.28 ug/L. However, TCE was not detected in groundwater samples from this well in 2014, 2015, 2016 or 2017, nor are there any detections of VOCs in this well since 2014. These results indicate minor concentrations of non-Site related compounds in B-level groundwater at this EA related to an unknown source.

8.3.8.3 Summary

The only finding of interest for this EA is the presence of localized detections in groundwater from Site-related compounds in the temporary well point sample GP-MPP-SRI-03. This sample was obtained in 2002. . No further action is warranted in the WH EA.

8.3.9 Shooting Range Summary

As outlined above in Section 3.9, the Shooting Range EA has a footprint of approximately 2.5 acres. The Shooting Range is located east and north of Area A and south of Clonmell Creek (Figure 3-9). This area comprises the easternmost portion of the historical GP. Thus, this EA occupies an area with an elevation below the surrounding ground surface with earthen berms surrounding three (3) sides of the shooting range.

It is unclear when this area started use as a shooting range. However, interviews with Site personnel indicate that the shooting range was already in use in the early 1980s.

Access to the shooting range is obtained through a ramp built into the eastern wall of the GP. The northern wall of the shooting range (adjacent to Clonmell Creek) has been built up into a barrier that provides the back stop for the munitions used in the range. Only one (1) soil sample has been collected at the Shooting Range (TP-11). This sample was obtained during the 2008 SWDA borrow area test pits sampling event. The sample, TP-11, was analyzed for lead only.

The Shooting Range is an active firing range leased by the Borough of Greenwich Police Department. It is anticipated that the shooting range will remain active for some time and that future remedial actions in this EA, if necessary, will be conducted by the Greenwich Police Department.

The sample locations for this EA are shown on Figure 3-9. The analytical data available for the lone sample in this EA are summarized on Table 8-62 along with a comparison of those data to the screening values developed for this RI as outlined in Section 8.1 above.

The TP-11 sample had a lead detection of 1,600 mg/kg. This is double the concentration of the RI screening value for lead of 800 mg/kg. This result is not surprising for an active shooting range of this age. Further delineation will be necessary to determine the horizontal and vertical extent of lead detections in the Shooting Range EA. As indicated above, no further action is warranted or necessary until shooting range activities cease in this EA.

8.3.10 Stormwater Catchment Basin Investigation History Summary

A full description of the SCB EA is provided in Section 3.10 above. As noted there, the SCB is located directly north of the IPA and east of the WH EAs. It also borders the NCL, CCW, the GP, and the Area A/Open Area EAs. The SCB EA is comprised of the entire CF IA, the CTDH IA, the MPP IA, the WWTP IA, the SDB IA, the SF IA, the SI IA, the northern portion of the LDS Area, much of the 002 Outfall and SCB IA, the wooded area around the SCB, and the grassy area around the SF IA (Figure 3-10). The following is a summary of the investigations conducted within the SCB EA.

The first investigation in the SCB EA was during the 1988 Ph. I with several follow-up investigations in 1990 and 1991. During these events, a total of thirty-seven (37) soil boring samples were obtained from depths ranging from zero (0) to sixteen (16) ft bgs to initiate characterization of the area.

The 1994 Ph. II samples were obtained in several portions of the SCB EA that were identified with their IA names as follows (sample ID nomenclature used for each area is in parentheses): 002 Outfall (002), cooling tower/dowtherm heater (CD), cracking furnace (CF), lab drum storage (LDS), multi-purpose plant (MPP), Surface Impoundment (SI), Sludge Drying Beds

(SDB), Spray Field (SF), and WWTP. As noted previously, these IAs have been combined into the SCB EA for assessment within this RI.

The sampling techniques used during the 1994 Ph II included Geoprobe™ techniques for soils, a Wildco hand corer for sediments to a depth of six (6) inches and direct collection with a surface water dipper for surface water samples. A total of eleven (11) soil samples from zero (0) to four (4) ft bgs, two (2) surface water samples, and three (3) sediment samples were obtained in the portion of the 002 Outfall that lies in the SCB EA. One (1) additional soil boring (S-01) was obtained in the 002 area as part of a follow up sampling event in 1995. A total of seventeen (17) soil boring samples were obtained from depths ranging from zero (0) to six (6) ft bgs in the CTDH area. A total of ten (10) soil samples from depths between zero (0) and nine (9) ft bgs, two (2) sediment samples and one (1) surface water sample were obtained in the CF area. A total of twelve (12) soil boring samples were obtained from depths ranging from zero (0) to fifteen (15) ft bgs in the LDS area. A total of thirty-one (31) soil boring samples were obtained from depths ranging from zero (0) to eight (8) ft bgs in the MPP area. A total of fifty-one (51) soil boring samples were obtained from depths ranging from zero (0) to nine (9) ft bgs in the SI area. A total of sixteen (16) soil boring samples were obtained from depths ranging from zero (0) to seven (7) ft bgs in the SDB area. A total of twenty-one (21) soil boring samples were obtained from depths ranging from zero (0) to nine (9) ft bgs in the SF area. A total of six (6) soil boring samples were obtained from depths ranging from zero (0) to nine (9) ft bgs in the WWTP area.

During the 2002 SRI a total of ten sediment samples were obtained from the bottom of the SCB using a petite Ponar dredge from a depth of zero (0) to six (6) inches below the surface of the basin. Two (2) temporary well point groundwater samples were also obtained in the MPP area in the vicinity of Ph II location GP-GW-3A.

During the 2009 FI, samples were obtained in several portions of the SCB EA that were identified with their area specific names as follows (sample ID nomenclature used for each area is in parentheses): cooling tower/dowtherm heater (CTDH), cracking furnace (CF), multi-purpose plant (MPP), 002 Outfall (02OF), stormwater catchment basin (SCB), SCB seep area (SP), surface impoundments (SI), and two (2) test pits (TP). During this investigation, Geoprobe™ techniques were used for the soil borings, temporary well points were used at most Geoprobe™ locations to obtain groundwater samples, Vibracore techniques were used to sample sediment and surface water samples were obtained with a surface water dipper. The scope of this investigation was negotiated with NJDEP and was intended to fill data gaps from previous investigations.

A total of nine (9) soil boring samples from depths ranging from three (3) to twelve ft bgs and eight (8) temporary well samples were obtained in the CTDH. A total of three (3) soil boring samples from depths ranging from nine (9) to ten (10) ft bgs and two (2) temporary well samples were obtained in the CF area. A total of twelve (12) soil boring samples at depths ranging from three (3) to twelve (12) ft bgs and thirteen temporary well point samples were obtained in the MPP area. A total of one (1) soil boring from a depth of six (6) ft bgs and two (2) temporary well point samples were obtained in the 02OF area. A total of eleven (11) soil boring samples from depths ranging from three (3) to ten (10) ft bgs, eleven (11) temporary well point samples, sixteen (16) sediment samples and seven (7) surface water samples were obtained in the SCB area. A total of four (4) soil boring samples were obtained from depths ranging from six (6) to ten (10) ft bgs and three (3) temporary well point samples were obtained in the SP area located between the SCB and 02OF areas. A total of two (2) soil samples were obtained from two (2) test pits that were created to investigate subsurface conditions near a historical subsurface transmission line that transmitted water to the WWTP.

Part of the FI involved an evaluation for the possible presence of NAPL. One sample from the SCB EA, MPP-8, was chosen to be evaluated for NAPL because of high PID readings and odor noted at this location. As discussed in Section 2.6.2, MPP-8 showed very weak fluorescence throughout the saturated zone. Weak and moderate fluorescence is typically indicative of NAPL smearing, historical NAPL, or dispersed, emulsified R-NAPL.

Two (2) additional sediment samples were obtained in the SCB in 2010 as part of the ecological evaluation incorporated into the BERA [RBR, 2016].

During the 2015 ARI, six (6) soil boring samples were obtained in the vicinity of a former helipad (HP) that was infrequently used when the plant was active. The HP was located along the eastern edge of the current SCB EA (see Figure 3-10). Also during the ARI, three (3) soil boring samples were obtained in the TRA to further delineate this area. The ARI scope was negotiated with the EPA to finalize characterization of the Site.

The permanent groundwater wells in the SCB EA are as follows: MW-2, MW-16B, MW-29R, MW-35, MW-36, MW-37, MW-45, MW-45B, MW-46 and MW-46B. The groundwater data obtained from these wells from the second quarter 2013 through the second quarter 2017 are used to help evaluate the nature and extent of groundwater detections in the SCB EA.

The sample locations for this EA are shown on Figure 3-10. All of the analytical data available for this EA are summarized on Table 8-63 (soil), Table 8-64 (groundwater), Table 8-65 (sediment) and Table 8-66 (surface water) along with a comparison of those data to the screening values developed for this RI as outlined in Section 8.1 above. Frequency of detection summary tables for soil, groundwater, sediment and surface water for this EA are summarized in Tables 8-67, 8-68, 8-69 and 8-70, respectively.

The following sections outline the nature and extent of detections in this EA by media.

8.3.10.1 Soil

A summary of the detections in the soil samples for this EA is provided in Table 8-63. Frequency of detection summary statistics for these data are provided in Table 8-67.

Metals

Arsenic is the only metal detected at a concentration exceeding its applicable RI screening value of three (3) mg/kg in the soil samples available for the SCB EA. Arsenic was detected twenty-seven (27) times at concentrations exceeding 3 mg/kg. However, none of these detections were higher than nineteen (19) mg/kg, which is the recognized naturally occurring background concentration in soils in New Jersey. The maximum detected arsenic concentration was 8.6 mg/kg in sample HP-3.

PAHs

The PAHs with detected concentrations above their applicable RI screening value in the available soil samples in the SCB EA are as follows: benzo(a)anthracene, benzo(a)pyrene and naphthalene. All of the detections are from 1990 samples obtained from beneath the WWTP SI with the exception of one detection of benzo(a)pyrene in the 2009 FI sample SCB-8(72). The isolated detection of benzo(a)pyrene in sample SCB-8(72) at a depth of six (6) ft bgs may be related to a nearby, historical pipeline. However, no other detections of concern were noted in this sample or in nearby sample locations SCB-7(36) or SCB-9(84).

PCBs, Pesticides, and Phenols

No detected concentrations of PCBs, pesticides or phenols exceeded their applicable RI screening values in the available soil samples for the SCB EA.

SVOCs

Two (2) SVOC compounds, 2,6-di-tert-p-cresol (SSTIC) and 1,1-biphenyl, were detected in one sample (MPP-11 (46)) at concentrations that exceed their applicable RI screening values. 1,1-biphenyl was also detected in sample MP-9 (42) at a concentration exceeding its RI screening value. Sample locations MP-9 (46) and MP-11 (42) are both located beneath the southern SI located in the MPP area. Both samples are from similar depths around four (4) ft bgs.

Acetophenone is the only other SVOC detected at a concentration exceeding its RI screening value of 5,000 ug/kg. The maximum detected concentration of acetophenone was in sample SDB-SS1A located adjacent to the former SDB just west of the WWTP SI. There are six (6) other samples with detected concentrations of acetophenone above the RI screening value. They are all located in the vicinity of the SDB and around the southern and eastern perimeter of the adjacent SI. The detections range from zero (0) to two (2) feet bgs to a depth of nine (9) ft bgs. All of these samples are from the 1994 Ph II study and are now twenty-three (23) years old.

VOCs

The VOCs with detected concentrations above their applicable RI screening value in the available soil samples in the SCB EA are as follows: 1,4-dichlorobenzene, benzene, cumene, ethylbenzene, toluene and total xylenes. All of these compounds are related to compounds used at the Site or their degradation products. The locations of these detections are all in the samples located within the SI in the MPP at depths ranging from two (2) to twelve (12) ft bgs, with the exception of two samples. Those two samples are S-8 and SI-SB04A (0-2) located in the vicinity of the WWTP SI. Sample S-8 is a 1988 Ph I sample obtained from zero (0) to six (6) inches beneath the northwest corner of the WWTP surface impoundment. .

New Jersey Impact to Groundwater and Direct Contact Non-Residential Soil Remediation Standards (NJDCNRSRS) Assessment

As requested by NJDEP, RBR conducted an assessment of available soil data against the NJIGW and NJDCNRSRS criteria (see Appendix P). A summary of relevant groundwater results is included for comparative discussion to address NJIGW exceedances for soil.

The compounds with detected concentrations that exceed the NJDCNRSRS in the SCB EA are as follows: 1,4-dichlorobenzene, acetophenone, benzo(a)pyrene and benzene. These compounds are consistent with the detections discussed above.

The compounds with detected concentrations that exceed the NJIGW were as follows: 1,1,1-trichloroethane, 1,4-dichlorobenzene, 2-butanone, acetone, benzene, carbon disulfide, ethylbenzene, methylene chloride, PCE, toluene, total xylenes, 1,1'-biphenyl, 2,4-dimethylphenol, acetophenone, TRP, benzo(a)anthracene, benzo(a)pyrene, aluminum, beryllium, manganese and mercury.

The data from the temporary well points in the SCB EA have been compiled on Table 8-71 and a frequency of detection summary of these data is provided on Table 8-72 to help further assess the NJIGW exceedances. The data from the temporary well points include additional analyses that are not part of the quarterly groundwater monitoring activities at the Site and are thus helpful to assess NJIGW exceedances of non-VOC compounds. The data from the permanent well points compiled in Table 8-63 and frequency of detection summary are provided in Table 8-67 were also reviewed to assess the NJIGW exceedances. The Site has been inactive since 2009: thus, all potential sources of Site-related contaminants have been eliminated for more than 8 years. As a result, groundwater conditions have long since reached dynamic equilibrium and Site-related contaminant concentrations are stable or decreasing (see Section 9 for more detailed discussions). Consequently, if the detected compounds in soil that exceed an NJIGW criteria are not present in the groundwater data from temporary or permanent wells, then it is reasonable to deduce that there are no resulting impacts to groundwater from those soil exceedances. The following is a compound specific summary reviewing the relevant groundwater data in locations where soil sampling results exceeded the NJIGW for the SCB EA:

- 1,1,1-trichloroeethane – There are no detections of this compound in either the temporary or permanent well data.

- 1,4-dichlorobenzene – There are six (6) detections of this compound in groundwater data from permanent wells MW-45B (five (5) detections) and MW-46B (one (1) detection). There are no detections of this compound in the temporary well groundwater data. All of the detected concentrations in the permanent wells are flagged “J” indicating they are estimated, low concentration detections. However, six (6) of the seven (7) detections have concentrations that are above the RI screening value of 0.48 ug/L. The only detections in soils of this compound are in samples MPP-10(92) and MPP-12(36) from beneath the MPP SI. Those detections are several hundred feet away from well MW-45B where the bulk of these groundwater detections are located. With no detections of this compound in samples from temporary well points between the MPP SI and wells MW-45B and MW-46B, it is unlikely that the noted soil detections are related to the more distant groundwater results several hundred feet away.

- 2-butanone – There are no detections of this compound in the permanent well data. Two (2) of the forty-one (41) temporary well samples had estimated (J-flagged) concentrations of this compound well below the RI screening value of 300 ug/L. Both of the temporary well point detections, MPP-1(138) and CTDH-2(144), were in 2009 FI samples. This compound was detected at a concentration of thirty-five (35) mg/kg in the MPP-1(138) soil sample, but not in the CTDH-2(144) sample. Thus, some localized leaching to groundwater from 2-butanone in soils may be occurring around location MPP-1, but at concentrations that do not warrant further action.

- Acetone – Two (2) of the fifty-five (55) permanent well samples and five (5) of the forty-one (41) temporary well samples had detections of this compound. The highest concentration of acetone in these groundwater samples was in CTDH-5 at 7.7 ug/L. This is well below the RI screening value for groundwater of 1,400 ug/L. The highest concentration of this compound in soil was in the 1994 Ph II sample SI-SB04A. This sample location is in the vicinity of well MW-29R near the WWTP SI. However, the lone detection of acetone in the samples from MW-29R was in 2013. Thus, leaching to groundwater from soils may have occurred in the past in this area, but they are currently minimal and are no longer ongoing. In the vicinity of CTDH-5 some low concentration detections of acetone were noted in soils in the samples from nearby sample locations MPP-SB-13(0-1) and MPP-SB-13(7-8). The detection of acetone in the temporary well point sample CTDH-5 may be related to these detections, but again is at a low concentration. Four (4) of the five (5) temporary well point detections of acetone were in CTDH samples. Thus, some minor leaching to groundwater may be occurring in the CTDH from acetone in soils, but at concentrations are well below the RI screening value and do not warrant further action.

- Benzene – Ten (10) of the fifty-five (55) permanent well samples and thirteen (13) of the forty-one (41) temporary well samples had detections of this compound. Seven (7) of the permanent well detections and twelve (12) of the temporary well detections had concentrations that exceed the RI screening value of 0.46 ug/L. The highest concentration detections were in permanent well MW-46B (160 ug/L) in 2017 and in the 2002 SRI temporary well sample GP-MPP-SRI-02 (1,200 ug/L). The highest concentration in soils was detected in the 1988 Ph I sample B-16. Soil sample B-16 is in the former MPP SI and temporary well sample GP-MPP-SRI-02 is located just west and south of this area. Based upon these detections, leaching to groundwater from benzene in soils located beneath the former MPP surface impoundment may be occurring.

- Carbon disulfide – None of the fifty-five (55) permanent well samples and nine (9) of the forty-one (41) temporary well samples had detections of this compound. Six (6) of the nine (9) temporary well sample detections had concentrations that exceed the RI screening value of eighty-one (81) ug/L. The highest concentration detection was in the 2009 FI temporary well sample MPP-11 (12,000 ug/L). The highest detected concentration of carbon disulfide in soil samples in the SCB EA was in sample MPP-10(92). Five (5) of the six (6) temporary well point sample concentrations that exceeded the RI screening value are located in the vicinity of the MPP SI. The remaining detection above the RI screening value was in sample SP-2 located in the bermed area that serves to retain surface water in the SCB. Groundwater detections from leaching of carbon disulfide from soils in the vicinity of the MPP SI appear to be ongoing. The source of the carbon disulfide in temporary well sample SP-2 is less clear. Some carbon disulfide detections were noted in the sediments of the SCB in the vicinity of SP-2, but no soil detections of note were found in that vicinity.

- Ethylbenzene – None of the fifty-five (55) permanent well samples and eleven (11) of the forty-one (41) temporary well samples had detections of this compound. Ten (10) of the eleven (11) temporary well sample detections had concentrations that exceed the RI screening value of 1.5 ug/L. The highest concentration detection was in the 2009 FI temporary well sample MPP-10 (30,000 ug/L). The highest detected concentration of ethylbenzene in soil samples in the SCB EA was in sample B-16. Nine (9) of the ten (10) temporary well point sample concentrations that exceeded the RI screening value are located in the vicinity of the MPP SI. The remaining detection above the RI screening value was in sample SP-2 located in the bermed area that serves to retain surface water in the SCB. Groundwater detections from ethylbenzene leaching from soils in the vicinity of the MPP SI appear to be ongoing. The source of the ethylbenzene in temporary well sample SP-2 is less clear. Some ethylbenzene detections were noted in the sediments of the SCB in the vicinity of SP-2, but no soil detections of note were found in that vicinity.

- Methylene chloride – There are no detections of this compound in either the temporary or permanent well data.

- PCE – One (1) of the forty-one (41) temporary well point samples and none of the permanent well samples had detections of this compound. No correlation between the lone temporary well point detection at location MPP-2 (0.29 ug/L) and the three (3) soils detections (MPP-10(92), MPP-12(36) and S-3) of this compound appears to exist. The one (1) temporary well point sample concentration is below the RI screening value of one (1) ug/L.

- Toluene – Four (4) of the fifty-five (55) permanent well samples and nine (9) of the forty-one (41) temporary well samples had detections of this compound. None of the permanent well samples and six (6) of the nine (9) temporary well sample detections had concentrations that exceed the RI screening value of 110 ug/L. The highest concentration detection was in the 2009 FI temporary well sample MPP-11 (14,000 ug/L). The highest detected concentration of toluene in soil samples in the SCB EA was in sample B-16 (5,100,000 mg/kg). Five (5) of the six (6) temporary well point sample concentrations that exceeded the RI screening value are located in the vicinity of the MPP SI. The remaining detection above the RI screening value was in sample SP-2 located in the bermed area that serves to retain surface water in the SCB. Groundwater detections from toluene leaching from soils in the vicinity of the MPP SI appear to be ongoing. The source of the toluene in temporary well sample SP-2 is less clear. No detected soil or sediment concentrations of toluene were noted in the vicinity of sample SP-2.

- Total xylenes – Eleven (4) of the fifty-five (55) permanent well samples and twelve (12) of the forty-one (41) temporary well samples had detections of this compound. None of the permanent well samples and eight (8) of the twelve (12) temporary well sample detections had concentrations that exceed the RI screening value of 19 ug/L. The highest concentration detection was in the 2009 FI temporary well sample MPP-8 (34,000 ug/L). The highest detected concentration of toluene in soil samples in the SCB EA was also in sample MPP-8(138) (7,600,000 mg/kg). Seven (7) of the eight (8) temporary well point sample concentrations that exceeded the RI screening value are located in the vicinity of the MPP SI. The remaining detection above the RI screening value was in sample SP-2 located in the bermed area that serves to retain surface water in the SCB. Groundwater detections from total xylenes leaching from soils in the vicinity of the MPP SI appear to be ongoing. The source of the total xylenes in temporary well sample SP-2 is less clear. However, some sediment concentrations above applicable RI screening values for total xylenes were noted in the vicinity of sample SP-2.

- 1,1’-biphenyl – This is an SVOC and there are no permanent well data for SVOCs. Seven (7) of the forty-one (41) temporary well point samples had detected concentrations of this compound and all of those samples had concentrations above the RI screening value of 0.083 ug/L. The highest detected concentration was in sample CTDH-2 at 770 ug/L. However, neither soil sample CTDH-2 (144) nor any nearby soil samples contained detectable concentrations of this compound. The same situation applies for the temporary well point sample detection in CF-1. A low concentration detection of 1,1’-biphenyl is noted in the soil sample CTDH-1(114) that may also explain the detection of this compound in the temporary well point sample from the same location. Similarly, a low concentration detection of 1,1’-biphenyl in soil sample SP-3(72) may account for the detection of this compound in the nearby temporary well point sample SP-2. The highest concentration detection of 1,1’-biphenyl in soil is in sample MPP-11(46). Temporary well point samples from MPP-7, MPP-8 and MPP-11 all contained concentrations of 1,1’-biphenyl that exceeds the RI screening value. Thus, it is clear that some groundwater detections from this compound in soils is likely occurring in the vicinity of those samples located in the MPP surface impoundment area.

- 2,4-dimethylphenol – This is an SVOC and there are no permanent well data for SVOCs. Five (5) of the forty-one (41) temporary well point samples had detected concentrations of this compound and three (3) of those samples had concentrations above the RI screening value of thirty-six (36) ug/L. The highest detected concentration was in sample MPP-10 at 2,500 ug/L. The other two temporary well point sample locations with concentrations above the RI screening value were MPP-8 and MPP-12. All three (3) of these locations are beneath or adjacent to the MPP surface impoundment area where the highest soil concentration is also located in sample MPP-9(42). Based upon these results, some impact to groundwater from this compound in soils is likely occurring in the vicinity of the MPP SI.

- Acetophenone – This is an SVOC and there are no permanent well data for SVOCs. Twenty-one (21) of the forty-one (41) temporary well point samples had detected concentrations of this compound and none of those samples had concentrations above the RI screening value of 190 ug/L. The highest detected concentration was in sample GP-MPP-SRI-02 at fifty-nine (59) ug/L. This sample is located off the southeast corner of the MPP SI where the bulk of the other temporary well point sample detections of this compound are located. Some detections are also located in the vicinity of the bermed area that serves to retain surface water in the SCB as well as just to the west of the bermed area (SCB-7 and SCB-8). Although some detections in groundwater from low concentrations of acetophenone in soils may be occurring in the areas mentioned, no further action is warranted for the detected acetophenone concentrations that are all below the applicable RI screening value.

- Total recoverable phenolics – TRP data aren't routinely analyzed for during the quarterly groundwater monitoring program at the Site, thus no permanent well data for TRP exists for the SCB EA. Fifteen (15) of the forty-one (41) temporary well point samples had detected concentrations of TRP though none of those samples had concentrations above the RI screening value of 580 ug/L. The highest detected concentration was in sample MPP-10 at fifty (50) ug/L. This sample is located beneath the MPP SI where the bulk of the other temporary well point sample detections of TRP are located. Some detections were also located in the vicinity of the bermed area that serves to retain surface water in the SCB (SP-2 and SP-4). Although some leaching to groundwater from low concentrations of TRP in soils may have occurred in the areas mentioned, no further action is warranted for the detected concentrations because all are below the applicable RI screening value.

- Benzo(a)anthracene – This is a PAH compound and there are no permanent well data for PAHs. Two (2) of the forty-one (41) temporary well point samples had detected concentrations of this compound and both of those samples (CF-1 and MPP-2) had concentrations above the RI screening value of 0.012 ug/L. The highest detected concentration was in sample CF-1 at 0.33 ug/L. The highest soil concentrations detected for this compound were in samples S-2 (3,200 ug/kg) and S-3 (3,300 ug/kg).

All other soil detections for this compound were at very low concentrations. No correlation between the two (2) temporary well point sample detections and concentrations in soil could be ascertained.

- Benzo(a)pyrene – This is an PAH compound and there are no permanent well data for PAHs. Five (5) of the forty-one (41) temporary well point samples had detected concentrations of this compound and all of those samples (from locations: CF-1, CTDH-1, MPP-2, MPP-11 and SP-2) had concentrations above the RI screening value of 0.031 ug/L. The highest detected concentration was in sample MPP-11 at 0.29 ug/L. The highest soil concentrations detected for this compound were in sample S-2 (1,600 ug/kg) and S-3 (1,300 ug/kg). This compound was not detected in the soil sample from MPP-11. However, the laboratory detection limit was elevated because of high concentrations of other compounds in this sample so the presence of this PAH may be masked at that location (MPP-11). Concentrations of other compounds above applicable RI screening values have been noted in the vicinity of the MPP SI where sample MPP-11 is located. However, no correlation between concentrations of this compound in soil samples and groundwater detections in the other temporary well point results (CF-1, CTDH-1, MPP-2 and SP-2) could be found.

- Aluminum, beryllium and manganese – No permanent well data for metals in groundwater exist. However, of the thirty-seven (37) temporary well samples with metals data, nearly all of them had detections of these common metals at concentrations that exceeded their respective RI screening values. All three of these metals were identified by the PRC site in their background study [Langan, 2016] as being naturally occurring in sediments at concentrations above those found on their site. Additionally, the RBR background study [RBR, 2017] identified one or more of these elements as being present at concentrations consistent with background in one or more of the BERA study areas (Wetland Area, 002 Outfall and Drainageway, SCB and Clonmell Creek). The nearly ubiquitous presence of these three metals in nearly all of the temporary well point samples suggests that these commonly occurring elements are likely related to naturally occurring conditions, which is consistent with the local soil lithology and regional background information for these metals. This is further supported by the fact that the temporary well point samples likely had high turbidity levels which would artificially elevate the metals concentrations in samples with acidic sample preservation.

- Mercury – This is a metal compound and there are no permanent well data for metals. One (1) of the thirty-seven (37) temporary well point samples had detected concentrations of this compound and that sample (MPP-11) had a concentration above the RI screening value of 0.063 ug/L. The highest detected concentration was in sample MPP-11 at 0.12 ug/L. The highest soil concentrations detected for this compound were in samples MPP-11(46) at 0.28 ug/kg and sample B-65 at 0.352 J ug/kg. Both of these samples are located beneath the former MPP SI. Thus, it seems likely that the lone temporary well point groundwater detection for mercury in sample MPP-11 is related to these detections in soil.

Soil Detection Summary

After review of the available soils data it appears that there is one primary and one secondary area of concern in the SCB EA that may require further action. The primary area of concern is the soils beneath the former MPP SI. Detections of the following compounds had concentrations that exceeded the applicable RI screening values in that area: 2,6-di-tert-p-cresol, 1,1'-biphenyl, 1,4-dichlorobenzene, benzene, cumene, ethylbenzene, toluene and total xylenes. The following compounds were noted to have detections in groundwater likely from soil concentrations in that area: 1,1'-biphenyl, benzene, ethylbenzene, toluene, total xylenes, carbon disulfide, 2,4-dimethylphenol and, possibly, benzo(a)pyrene. Based upon this information it is likely that further action will be warranted to address soil beneath the former MPP SI.

The secondary area of concern is the bermed area that prevents water from the SCB from flowing into the 002 Outfall. This area was previously investigated as a "seep" area because of odors and visual evidence of releases along the bermed swale area. Concentrations in groundwater from temporary well point samples with concentrations of benzene, ethylbenzene, toluene and total xylenes were noted in this area. However, detected soil concentrations did not correlate closely with the temporary well point groundwater results in this area so the historical context for observed soil and groundwater detections is not clearly understood. Some sediment impacts within the SCB or residual soil concentrations inside the bermed area may be present that are influencing these temporary well point concentrations in shallow groundwater.

8.3.10.2 Groundwater

A summary of the detections in the groundwater samples for this EA is provided in Table 8-65. Frequency of detection summary statistics for these data are provided in Table 8-69.

The permanent groundwater wells in the SCB EA are as follows: MW-2, MW-16B, MW-29R, MW-35, MW-36, MW-37, MW-45, MW-45B, MW-46 and MW-46B. The groundwater data obtained from these wells from the second quarter 2013 through the second quarter 2017 are referenced to assess the nature and extent of groundwater detections in the SCB EA. Because of the lack of groundwater detections in the SCB EA, all of the wells in this EA are monitored annually for VOCs. Thus, the available data consist of one VOC sample per year from each well obtained during the annual event during the second quarter of each calendar year.

The VOC compounds 1,4-dichlorobenzene, benzene and cumene are consistently detected in samples from well MW-45B at concentrations that exceed their applicable RI screening values. Detections of these compounds from the 2013 and 2017 sampling events were also noted in the samples from well MW-46B at concentrations above their RI screening values. Based upon the soils analysis discussed above in Section 8.3.10.1, there are concentrations of these compounds in soils beneath the former MPP SI above applicable RI screening values.

Wells MW-45 and MW-46 are screened at a shallow depth of approximately five (5) to ten (10) ft bgs just overlying a shallow confining clay layer in this area. Wells MW-45B and MW-46B are screened below that clay layer at approximately thirty-five (35) to forty-five (45) ft bgs. The soil concentrations beneath the MPP SI, as discussed above, were detected at depths up to twelve (12) ft bgs. Thus, downgradient detected groundwater concentrations from that area are noted in the B-level wells and not the A-level wells. As noted above in Section 8.3.10.1, further action is likely warranted to address soils beneath the former MPP SI area that are resulting in localized groundwater detections.

No other groundwater detections of note were identified in the available permanent well sample data from the SCB EA.

8.3.10.3 Sediment

A summary of the detections in the sediment samples for this EA is provided in Table 8-66. Frequency of detection summary statistics for these data are provided in Table 8-70.

Metals

The following metals were detected in nearly all of the twenty-eight (28) available sediment samples but were also identified by RBR as being present in background at concentrations consistent with those found in the SCB sediments (see Appendix O): antimony, arsenic, cadmium, iron, lead, nickel and zinc. Although some of the concentrations of these metals were at concentrations greater than their applicable RI screening value, it is clear that these metals are detected ubiquitously in sediments throughout the SCB as well as in background locations and no further action is warranted to address these detections.

The other metals with detected concentrations above their applicable RI screening values were as follows: barium, chromium, copper, manganese, mercury and vanadium. Of these metals, all but barium were identified by the PRC site in their background study [Langan, 2016] as being present in background sediments at concentrations higher than applicable NJ ecological screening criteria. All of these metals were detected in all twenty-eight (28) available sediment samples from the SCB EA and are thus ubiquitous in sediment within the SCB EA. For five (5) of these metals (barium, chromium, copper, manganese and vanadium) the sample location with the highest concentration was the 2010 ecological evaluation sample obtained from zero (0) to six (6) inches at location SCB-14(2). This location also had the highest concentrations of antimony, arsenic, iron, lead, nickel and zinc. The highest concentration of mercury was detected at location SCB-14, located immediately adjacent to location SCB-14(2), from six (6) to twelve (12) inches. The highest concentration of cadmium was detected at location SCB-16(9) obtained at a depth of six (6) to twelve (12) inches. Location SCB-16 is located in close proximity to sample location SCB-14(2) in the northwest corner of the SCB.

It is apparent that metals concentrations above applicable RI screening values are present in the northwest corner of the SCB based upon the assessment of the available sediment metals data for the SCB. The northwest corner of this EA is adjacent to the berm that was put in place around 1991 to eliminate flow from the former Site process areas to the 002 Outfall. The northwest corner of the SCB is also the area where sediments transported through overland surface water flow would be expected to drop out of solution after reaching the SCB. However, there is no apparent on-Site source for these metals concentrations based upon the pattern of detections upstream of the SCB.

PAHs

The following PAHs were detected at concentrations exceeding their applicable RI screening values and had their highest concentrations detected in the 2009 FI sample SD-SCB-12(9): acenapthene, acenapthylene, anthracene, fluorine and naphthalene. The following PAHs were detected at concentrations exceeding their applicable RI screening values and had their highest concentrations detected in the 2002 SRI sample SRI-SED-14: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene and pyrene. Phenanthrene was also detected at concentrations that exceed its applicable screening criteria with its highest concentration detected in sample SRI-SED-13C.

PAHs were detected in a total of eight (8) sample locations at concentrations exceeding applicable screening criteria: several of these eight (8) locations had exceedances at multiple depth intervals. The highest concentrations of PAHs detected were primarily in samples SCB-12(9) from a depth of six (6) to twelve (12) inches in the central portion of the SCB and SRI-SED-14 from a depth of zero (0) to six (6) inches in a swale extending from the CF area in the south-central portion of the SCB (south and just west of the SCB surface water feature).

In the vicinity of sample SCB-12(9), samples SCB-12(3), SCB-12(18), SCB-12(30), SCB-13(3), SRI-SED-13C and SRI-SED-13B also had detections of multiple PAHs at concentrations that exceeded their applicable screening criteria. These samples are all located in the central portion of the SCB with the SRI samples being obtained from a depth of zero (0) to six (6) inches. Only location SCB-12 had exceedances at multiple depths, including: three (3), nine (9), eighteen (18), and thirty (30) inches depth intervals. Sample aliquots at location SCB-13 were obtained from the same depths as SCB-12, but with only the shallowest (zero (0) – six (6) inch) sample having exceedances.

One (1) other primary area of PAH detections was noted in samples from the swale extending from the CF area in samples CF-1-SED and SRI-SED-14. Sample CF-02-SED is also located near sample SRI-SED-14, but the detection limits for PAHs were all elevated in this sample, likely due to high concentrations of Site-related COCs. It is suspected that this sample may contain PAH detections if lower laboratory detection limits were attained. Each of these samples was obtained from a depth of zero (0) to six (6) inches.

Finally, two (2) samples in the vicinity of the berm that helps retains surface water in the SCB also had detections of PAHs at concentrations above their applicable RI screening values. Sample 002-SEEP-SED is located on the northwest side of the berm and was obtained from a depth of zero (0) to six (6) inches. Sample SCB-16(9) is located on the southeast side of the berm and was obtained from a depth of six (6) to nine (9) inches. Sample SCB-16(9) only had detections of acenapthene and acenapthylene at concentrations above their RI screening values.

Sample 002-SEEP-SED had detections of ten different PAHs at concentrations above their screening values. Thus, these two samples do not appear related based upon review of available information. However, it is important to note that sample 002-SEEP-SED was obtained in 1994 and SCB-16(9) was obtained in 2009. Appreciable degradation of PAH concentrations at location SCB-16(9) are likely to have occurred during this twenty-three (23) year intervening time period.

PCBs

The available sediment samples with PCB analyses in the SCB EA are from the 2002 SRI and the 2010 ecological evaluation sampling for the BERA [RBR, 2016]. Three (3) of these samples from the 2002 SRI had detections of Aroclor 1254 at concentrations that exceed the RI screening value of 60 ug/kg. Samples SRI-SED-13B and SRI-SED-13D are located in the middle and southeastern portions of the SCB, respectively. Sample SRI-SED-16 is located in a swale that extends from the CDTH area and ephemerally discharges into the SCB. The only other detected PCB congener was Aroclor 1260 in the 2010 ecological evaluation sample SED-SCB-14(3) obtained at location SCB-14(2). The detection of Aroclor 1260 in this sample was at a concentration that exceeds the applicable RI screening value of five (5) ug/kg. All of the noted sediment samples were obtained from a depth of zero (0) to six (6) inches.

During the review of the available PCB data for the SCB EA, it was also noted that five (5) other sediment samples had tentative detections of Aroclor 1254 that were qualified with a Y. The Y qualifier indicates that “confirmation of the compound was not possible. The numeric value represents the sample quantitation/detection limit.” No further information regarding these samples or the validation of these data was found in the 2002 SRI [ERM, 2002]. As a result, the veracity of these qualified results cannot be confirmed and may be suspect. However, several unqualified detections of Aroclors 1254 and 1260 were reported for SCB EA sediments.

The following was the relevant conclusion from the 2002 SRI regarding PCBs in sediments [ERM, 2002]: “On-site surface soils and wetland soil south of Clonmell Creek exhibited the lowest concentrations of Aroclor 1254. Results for the 002 Outfall drainageway, SCB, Clonmell Creek sediments, wetland soils north of the creek, and reference area sediment and wetland soil samples were all comparable. Therefore, the Plant does not appear to be a source of Aroclor 1254 to environmentally sensitive areas.”

Subsequent to the 2002 SRI, PCBs were not included as a constituent of concern for the main Site and thus no further sediment samples were obtained for PCB analysis until the 2010 ecological evaluation sampling for the BERA [RBR, 2016].

Pesticides

The available sediment samples with pesticide analyses in the SCB EA are from the 2002 SRI and the 2010 ecological evaluation sampling for the BERA [RBR, 2016]. The samples with pesticide data associated with them are all in the SCB itself or in the swales extending from the CTDH and CF areas toward the SCB. Each of these samples has two (2) or more detections of the following compounds at concentrations exceeding their applicable RI screening criteria: 4,4-DDD, 4,4-DDE, 4,4-DDT, aldrin, alpha-chlordane, beta BHC, dieldrin, endosulfan I, endosulfan II, endrin, endrin ketone, gamma chlordane, heptachlor, heptachlor epoxide and methoxychlor. The presence of two (2) or more of these various pesticides in each of the available sediment samples reflects the ubiquitous nature of regional historical pesticide use. Detection of these persistent compounds within the sediments in this area is thus not unexpected.

The following was the relevant conclusion from the 2002 SRI regarding pesticides in sediments at the Site [ERM, 2002]: "The highest concentrations of pesticides (notably DDD, DDE and DDT) occurred in Clonmell Creek sediment and wetland soil samples. Concentrations were higher in wetland soils located on the northern bank of the creek as compared to wetland soils south of the creek. Reference location sediment and wetland soil samples exhibited comparable and higher concentrations. On-site samples, including the 002 Outfall drainageway soil and sediments, surface soils, and the SCB, exhibited lower concentrations than those observed in the creek sediment and wetland soils. Therefore, the Plant does not appear to be a source of pesticides to environmentally sensitive areas."

Subsequent to the 2002 SRI, pesticides were not included as a constituent of concern for the main Site and thus no further sediment samples were obtained for pesticide analysis until the 2010 ecological evaluation sampling for the BERA [RBR, 2016].

SVOCs

The following SVOC compounds had detected concentrations in sediment samples in the SCB EA above their applicable RI screening values: 1,1'-biphenyl; 1,4-diisopropylbenzene; 2,4,6-trichlorophenol; 2,6-di-tert-butyl-p-cresol (SSTIC); 2,-methylnapthalene; a,a-dimethylbenzyl alcohol (SSTIC); acetophenone; bis(2-ethylhexyl)phthalate; carbazole; dibenzofuran; diisopropylbenzene; and phenol. These compounds are related to Site activities or represent degradation products of Site-related compounds.

The bulk of the detections with concentrations above the RI screening values are found throughout the sediment column up to depths of three (3) ft in the central portion of the SCB with the highest concentrations noted in locations SD-SCB-12(9), SRI-SED-13B, SRI-SED-13C and SRI-SED-13D. Other detections at concentrations above the RI screening values are distributed around the perimeter of the SCB and extend into the swales leading to the CF and CTDH areas. Acetophenone is the primary SVOC detected at concentrations above applicable RI screening values in the CF swale and in the CTDH swale (sample SRI-SED-16). 2,6-di-tert-butyl-p-cresol was also detected at a concentration above its RI screening value in the CTDH swale (sample SRI-SED-16).

One lone detection of 2,4,6-trichlorophenol at a concentration above its RI screening value was noted in sample CF-1-SED. This sample is located at the head of the swale leading from the CF to the SCB.

The sediments of the SCB and the CF and CTDH swales may need further action to address these SVOC detections.

VOCs

The following VOC compounds had detected concentrations in sediment samples in the SCB EA above their applicable RI screening values: 1,2,4-trimethylbenzene; 1,2-dichlorobenzene; 1,3,5-trimethylbenzene; 1,4-dichlorobenzene; 2-butanone; acetone; benzene; carbon disulfide; chlorobenzene; cumene; ethylbenzene; methyl acetate; and total xylenes. Most of these compounds are related to Site activities or represent degradation products of those parent compounds.

The bulk of the detections with concentrations above the RI screening values are found throughout the sediment column up to depths of three (3) ft in the central portion of the SCB with the highest concentrations noted in locations SD-SCB-12(9), SD-SCB-13(9), SD-SCB-15(9), SRI-SED-13C, and SRI-SED-15. The highest concentrations are mostly found in the 2009 FI samples obtained from a depth of nine (9) inches. This pattern of detections is consistent with VOC detections found in Clonmell Creek and reflect the highly anaerobic nature of the buried sediments. Anaerobic conditions prevail at depths greater than a few inches of organic rich sediment, greatly reducing VOC degradation rates.

The one (1) compound that is detected in sediments outside of the SCB is methyl acetate. The highest concentration of methyl acetate (910 ug/kg) was noted in sample SRI-SED-15. This sample is located in the swale extending from the CF area. Methyl acetate was also detected at a concentration above its RI screening value of 9.9 ug/kg in the sample from location SRI-SED-16 located in the swale emanating from the CTDH area. Methyl acetate is a compound that is not typically associated with the former Site manufacturing processes but may have been associated with activities at the older CF and CTDH areas.

The sediments of the SCB and the CF and CTDH swales may need further action to address the noted VOC detections.

Sediment Detection Summary

Metals concentrations above applicable RI screening values are present in sediments in the northwest corner of the SCB adjacent to the berm that was constructed circa 1991 to prevent discharges from the former Site process areas to the 002 Outfall. It is the area where sediments transported via overland surface water flow would likely to drop out of solution entering the

SCB and losing energy. However, there is no apparent on-Site source for these metals concentrations based upon the pattern of detections upstream of the SCB.

Multiple PAHs were detected at concentrations above applicable RI screening values in the central portion of the SCB, primarily at depths between six (6) and twelve (12) inches. Additional detections were also noted in sediment samples in the CF swale and in the bermed area on the north side of the SCB.

Concentrations of the PCB congener Aroclor 1254 were detected in sediments in the CTDH and CF swales that flow into the SCB and in the central portion of the SCB. Aroclor 1260 was detected in a lone sediment sample in the northeast corner of the SCB.

Multiple pesticide compounds were detected in sediment samples throughout the SCB and the CF and CTDH swales at depths between zero (0) and six (6) inches.

Multiple SVOCs were detected at concentrations above applicable RI screening values in the central portion of the SCB at depths up to three (3) feet as well as in the CF swale in the zero (0) to six (6) inch depth range.

Typical Site-related VOCs (cumene, benzene, etc.) were detected in sediments at depths up to three (3) feet in the central portion of the SCB with the highest concentrations typically noted at a depth of nine (9) inches. Methyl acetate was also noted at concentrations above applicable RI screening values in sediments from zero (0) to six (6) inches in the CF and CTDH swales.

8.3.10.4 Surface Water

A summary of the detections in the surface water samples for this EA is provided in Table 8-66. Frequency of detection summary statistics for these data are provided in Table 8-70.

Metals

The following metals had detected concentrations in surface water samples in the SCB EA above their applicable RI screening values: aluminum, arsenic, copper, iron, lead, manganese, nickel and zinc. All of these metals were detected in nine (9) or more of the eleven (11) available surface water samples for the SCB EA. As noted above in Section 8.2.2, RBR identified multiple metals in their BERA Background Memorandum [RBR, 2017] as being present in sediments within the SCB at concentrations equal to or less than background. The metals identified by RBR that are also present in the available surface water samples at concentrations of note are arsenic, iron, lead, nickel and zinc.

A common issue associated with surface water sampling (even using optimal sampling techniques) is the incidental uptake of fine sediment with the surface water samples. Fine sediments inadvertently incorporated into the surface water samples will bias the analytical results following acidic preservation of the samples, artificially increasing metals concentrations. It was noted in the SRI [ERM, 2002] that the surface water samples from that event were obtained during drought conditions using a direct dip technique with a one (1) liter Nalgene bottle. This would result in less water than usual at these locations making the collection of a surface water sample without sediment in it even more difficult and likely less representative.

The fact that the 2002 SRI samples SRI-SW-13 and SRI-SW-15 contain the highest concentrations detected for all metals, with the exception of aluminum (SCB-15) and arsenic (SI-SW-2), provides further evidence suggesting that sediments entrained in those surface water samples impacted their analytical results. Sample locations SRI-SW-13 and SRI-SW-15 are in a very shallow swale located just south and east of the SCB. Collecting representative surface water samples from a shallow swale during low water conditions without also including fine particulates is challenging, if not impossible. The presence of naturally occurring background concentrations of arsenic, iron, lead, nickel and zinc from sediments in the eleven (11) available surface water samples is suspected to have impacted the results of those and the other 2009 FI samples.

The other metals detected in surface water samples at concentrations above their applicable RI screening values include aluminum, copper, and manganese. As noted above, the highest concentrations of both copper and manganese were both noted in the analytical results for sample SRI-SW-13. Surface water analytical results from this shallow swale are also likely impacted by sediments. Copper and manganese are both present in local lithology and likely skewed the results of this sample as well as the others in this data set.

Similarly, the highest concentration of aluminum was noted in the 2009 FI sample from location SCB-15. This sample location is along the bank of the SCB in its northeastern corner. Entrainment of sediment in this sample also likely impacted the final analytical results.

Whether the presence of sediment in the surface water samples impacted the results or not, the ubiquitous detection of these metals in nearly all surface water samples at concentrations that exceeds their applicable RI screening values does not provide any clear indication of their potential source. There is no history documenting the use or disposal of these metals from any of the processes conducted at the Site. However, there may be a correlation between concentrations of copper and manganese above applicable RI screening values in sediment samples and surface water samples in the swale emanating from the CF area, though it is difficult to ascertain if this correlation is anthropogenic or naturally occurring in nature. Copper and manganese are the only two (2) metals that were detected in both sediment and surface water samples at concentrations above their RI screening values that are not specifically identified as being present in background at similar concentrations as the SCB [RBR, 2016].

PAHs

No PAHs were detected in surface water samples in the SCB EA at concentrations that exceed their applicable RI screening values.

PCBs

Although only two (2) surface water samples that were analyzed for PCBs are available for the SCB EA, one (1) of those samples (SRI-SW-15) had a detection of Aroclor 1254 at a concentration that exceeded its applicable RI screening value. As noted above in Section 8.3.10.3 for sediments, Aroclor 1254 was detected in the nearby sediment sample location SRI-SED-15. That result was qualified with a “Y” indicating that the compound could not be positively identified. However, the detection of Aroclor 1254 in this nearby surface water sample likely indicates that there may be a localized occurrence of Aroclor 1254 in the vicinity of these two (2) sample locations. As noted above for metals, the surface water sample SRI-SW-15 was likely impacted by sediments inadvertently entrained in the sample collected during low water conditions using direct dip sampling methods. As a result, the Aroclor 1254 detection is more likely related to sediment than surface water as PCBs are typically insoluble and generally reside with sediments/soils.

Pesticides

Detections of 4,4’-DDD and gamma chlordane at concentrations exceeding their applicable RI screening values were noted for the two (2) available surface water samples with pesticide analysis in the SCB EA. The two (2) impacted samples are SRI-SW-13 (4,4’-DDD) and SRI-SW-15 (gamma chlordane). As noted above, these two (2) samples are located within a swale emanating from the CF area and draining to the SCB. As with the metals and PCB detections noted above, it is likely that these samples were impacted by sediments inadvertently entrained in the surface water samples. Nonetheless, the samples from this EA indicate the presence of these two (2) pesticides at concentrations above their applicable RI screening values in sediments from the CF area. One (1) detection of gamma chlordane in the nearby sediment sample SRI-SED-14 also contained a concentration above the RI screening value as noted above in Section 8.3.10.3. However, no detections of these compounds were noted in nearby soil samples.

SVOCs

Detections of bis(2-ethylhexyl)phthalate and phenol at concentrations exceeding their applicable RI screening values were noted for the fourteen (14) available surface water samples with SVOC analysis in the SCB EA. Bis(2-ethylhexyl)phthalate was detected in only one (1) of the fourteen (14) samples (002-POND-SW-02) at a concentration of one (1) ug/L, which exceeds the RI screening value for this compound of 0.3 ug/L. Bis(2-ethylhexyl)phthalate was also detected in the corresponding sediment sample (002-POND-SED) at a concentration exceeding the applicable RI screening value. These samples are located along the northwest corner of the SCB.

Phenol was detected in seven (7) of the fourteen (14) available surface water sampling locations with one detection above its applicable RI screening value in sample CF-SWALE. Although phenol was not detected in the collocated sediment sample from the CF-SWALE location (CF-02-SED), phenol was detected in two (2) nearby sediment samples (SRI-SED-13 and SRI-SED-14) at concentrations above the applicable RI screening value. These detections indicate that phenols concentrations above the applicable RI screening value from former Site activities are present near the former CF area.

VOCs

Cumene was the only VOC detected at concentrations that exceed its applicable RI screening value of 2.6 ug/L in the fourteen (14) surface water samples available for the SCB EA. The highest detected concentration of cumene in surface water was 1,600 ug/L in sample CF-SWALE-SW-02. This sample is located in the swale extending from the CF area and is collocated with sediment sample CF-02-SED where cumene concentrations above the RI screening value were also noted.

Samples 002-POND-SW-01, 002-POND-SW-02 and SW-SCB-15 are all located in the northern portion of the SCB where cumene concentrations above the applicable RI screening value in sediments were also noted.

The final surface water sample impacted by cumene was location SI-SW-1 obtained from the southern SI located next to the WWTP. Water within these basins is contained and thus has no relation to local media concentrations of cumene. It is not clear why a detection of cumene was found in this sample.

As expected, there were detections of cumene in surface water in the areas where cumene concentrations were detected in sediments. Considering the concentrations of cumene present throughout the SCB, the detections in surface water are minimal, likely as a result of the volatility and other physio-chemical properties of cumene. Hence, the presence of cumene in surface water is sporadic and ephemeral.

Surface Water Detection Summary

Metals were detected at concentrations above their applicable RI screening values throughout the SCB EA in surface water. However, it is suspected that many of these sample results are likely artificially elevated due to the inadvertent entrainment of surface water in the samples as noted above.

One detection of the PCB congener Aroclor 1254 in surface water sample SRI-SW-15 is likely due to the presence of Aroclor 1254 in sediments in the vicinity of the CF swale.

The pesticides 4,4’-DDD and gamma chlordane were both detected in surface water samples in the vicinity of the CF swale at concentrations above their applicable RI screening values. This indicates the presence of pesticide concentrations of note in soils and sediments in this area.

The SVOC compounds bis(2-ethylhexyl)phthalate and phenol were detected at concentrations above applicable RI screening values in surface water. The bis(2-ethylhexyl)phthalate sample of concern is located in the northeast corner of the SCB where this compound was also detected in sediments. The phenol detection in sample CF-SWALE was also located close to sediment samples with phenol concentrations above the applicable RI screening value in the CF swale area.

Cumene was detected at concentrations above the applicable RI screening value in surface water in the northern portion of the SCB and along the CF swale. These detections also correlate with detections of cumene of note in sediment samples from those areas.

8.3.10.5 Summary

The primary area of concern for soils in the SCB EA is the area beneath the former MPP SI. Concentrations of multiple VOCs above applicable RI screening values, some of which are likely resulting in shallow groundwater detections, were noted in that area. Based upon this information it is likely that further action is warranted to address soil beneath the former MPP SI.

The secondary area of concern for VOCs in soil in the SCB EA is the bermed area on the north side of the SCB that prevents water from the SCB from entering the 002 Outfall. Detections of SSCOCs in groundwater from temporary well point samples were noted in this area. Detections in sediment within the SCB or in soils inside the bermed area may be the reason for these temporary well point concentrations in shallow groundwater.

The only detections in the available SCB EA permanent groundwater wells of note were VOC compounds consistently detected in samples from well MW-45B. A correlation between VOC concentrations in soils beneath the former MPP SI and these groundwater detections are suspected.

Sediment detections warranting further assessment in the SCB EA were noted in several areas. These include the following:

- Metals concentrations above applicable RI screening values in the northwest corner of the SCB.
- Multiple PAHs in the central portion of the SCB at sediment depths between six (6) and twelve (12) inches, in the CF swale and in the bermed area on the north side of the SCB.
- Aroclor 1254 in sediments in the CTDH and CF swales that flow into the SCB and in the central portion of the SCB. Aroclor 1254 was also noted in a surface water sample from the CF swale.
- Aroclor 1260 in a lone sediment sample in the northeast corner of the SCB.
- Multiple pesticide compounds in sediment samples throughout the SCB and the CF and CTDH swales at depths between zero (0) and six (6) inches.

- SVOCs in the central portion of the SCB at depths up to three (3) feet as well as in the CF swale in the zero (0) to six (6) inch depth range.

- Site-related VOCs (cumene, benzene, etc.) in sediments at depths up to three (3) feet in the central portion of the SCB with the highest concentrations typically noted at a depth of nine (9) inches.

- Methyl acetate in sediments from zero (0) to six (6) inches in the CF and CTDH swales.

Surface water detections warranting further assessment in the SCB EA were noted in several areas. These include the following:

- The pesticides 4,4’-DDD and gamma chlordane in the vicinity of the CF swale that correlate with pesticide concentrations in soils and sediments in this area.

- Bis(2-ethylhexyl)phthalate in the northeast corner of the SCB where this compound was also detected in sediments.

- Phenol in surface water and sediments in the CF swale area.

- Cumene in surface water and sediment in the northern portion of the SCB and along the CF swale.

8.3.11 Tank Farm/Train Loading Area Investigation History Summary

As detailed in Section 3.11 above, the TF & TLA EA is located in the southwest corner of the Site and includes three (3) former IAs, the TF, the TL, and the CLA as well as a small field east of the TF IA (Figure 3-11).

The TF formerly accommodated sixteen (16) above ground storage tanks that stored benzene, cumene, phenol, acetone, and para-cymene. This area was actively used for storing chemicals from the time the plant was built in 1954 until plant decommissioning was initiated in 2009.

The former TLA is located along the western Site boundary. The train tracks no longer exist but some of the underlying ballast remains. The TLA was primarily used for offloading, loading, and cleaning rail cars. Three (3) abandoned USTs used in the rail car cleaning process remain in the area.

The CLA was located between the TLA, TF, and APA. The CLA was primarily utilized for tanker loading and offloading for the entire length of plant operations until decommissioning of the Site in 2009.

Investigations in the TF/TLA EA began in 1983 with the acquisition of two (2) subsurface soils samples from between two (2) and six (6) ft bgs.

During the 1988 Ph I, a total of six (6) subsurface soil samples were obtained from depths of zero (0) to twelve (12) ft bgs.

During the 1990 Shallow Aquifer Investigation along the southern property line, a total of seven (7) soil samples were obtained from depths ranging from four (4) to twenty-seven (27) ft bgs.

During the 1994 Ph II, a total of one-hundred sixty-nine (169) surface and subsurface soil samples were obtained from depths between zero (0) and twenty-seven (27) ft bgs throughout the TF/TLA EA.

During the 2002 SRI, one (1) soil and one (1) temporary well sample were obtained in the TF/TLA EA.

During the 2009 FI, nine (9) subsurface soil samples from depths between five (5) and thirteen (13) ft bgs and nine (9) temporary well samples were obtained in the TF/TLA EA. As discussed in Section 2.6.2, during the 2009 FI, sample TL-3 from the TLA was selected for NAPL screening using UV fluorescence. No UV fluorescence indicative of NAPL was observed.

In 2011, a supplementary TF investigation was conducted to further delineate this area. Part of the impetus for conducting this work was the discovery that three (3) releases of cumene had occurred in the vicinity of tank T-101 in July 2002, November 2002, and May 2004 during GEO Site operations. A total of three (3) soil samples were obtained from depths between two (2) and fourteen (14) ft bgs and eleven (11) temporary well groundwater samples were obtained in the TF/TLA EA.

In 2013, a CPT event was conducted to further characterize subsurface lithology; two (2) subsurface soil and two (2) temporary well samples were obtained in the TF/TLA EA during this event.

In the 2015 ARI, six (6) subsurface soil samples were obtained from depths between zero (0) and ten (10) ft bgs. These samples were obtained in the vicinity of the railroad tracks that were formerly present in the southwest corner of the Site to investigate potential subsurface PAH concentrations.

In addition to the soil and temporary well point samples noted above, there are also a total of twenty (20) permanent monitoring wells and extraction wells in the TL/TF EA. The data from these wells obtained between the second quarter of 2013 and the second quarter of 2017 have been compiled in the table noted below as part of the nature and extent assessment.

The sample locations for this EA are shown on Figure 3-11. All of the analytical data available for this EA are summarized on Table 8-73 (soil) and Table 8-74 (groundwater) along with a comparison of those data to the screening values developed for this RI as outlined in Section 8.1 above. Frequency of detection summary tables for soil and groundwater for this EA are Tables 8-75 and 8-76.

The following sections outline the nature and extent of detections in this EA by media.

8.3.11.1 Soils

A summary of the detections in the soil samples for this EA is provided in Table 8-73. Frequency of detection summary statistics for these data are provided in Table 8-75.

Metals

Arsenic was the only metal detected in soil samples in the TF/TLA EA at a concentration that exceeds its applicable RI screening value of three (3) mg/kg. However, the recognized background soil concentration in New Jersey for arsenic is nineteen (19) mg/kg. The highest detected concentration of arsenic in soil in the TF/TLA EA was 6.4 mg/kg. This is well below the recognized background concentration and thus no further action is warranted for these detections.

PAHs and TRP

No detected concentrations of PAHs or TRP in soils samples in the TF/TLA EA were above their applicable RI screening values.

SVOCs

The Site-related SVOCs acetophenone and phenol were detected at concentrations above their applicable RI screening values in soil samples in the TF/TLA EA. Phenol had only one detection above the RI screening value in sample TL-SB02B at a depth of zero (0) to two (2) ft bgs. Sample TL-SB02B is located in the vicinity of the abandoned USTs in the TLA.

Acetophenone was detected nine (9) times at concentrations above its applicable RI screening value. The highest concentration of acetophenone was detected in sample TF-SB02A at a depth of zero (0) to two (2) feet. Acetophenone was also detected at three other locations in the vicinity of sample TF-SB02A in the southwest corner of the TF area. The samples ranged in depth from zero (0) to six (6) ft bgs.

The other area with acetophenone detections is the vicinity of the abandoned USTs in the TLA. Two (2) sample locations (FP-SRI-01 and TL-SB02A) at depths from zero (0) to six (6) ft bgs had detected concentrations of acetophenone at concentrations above applicable RI screening values in that area.

VOCs

The Site-related VOCs benzene, cumene and ethylbenzene were detected at concentrations that exceed their applicable RI screening values in soil samples in the TF/TLA EA. Benzene had four (4) such detections. One (1) of these detections was in a 1990 Shallow Aquifer Investigation sample, TB-12 (25-27), this sample is annotated as being obtained from a depth of twenty-five (25) to twenty-seven (27) ft bgs along the southern property line. However, after review of the boring log for this location, the A-level confining clay was noted as being present around twenty (20) ft bgs. Thus, it is suspected that this sample was actually obtained from around eighteen (18) to twenty (20) ft bgs. Regardless, this detection of benzene is isolated vertically and laterally. No other nearby benzene detections of concern were noted nearby.

The primary area of benzene detections is in samples in the vicinity of the abandoned USTs in the TLA. Three samples in this area (FP-SRI-01, TL-SB02A 2-4 and TL-SB02A 4-6) had concentrations of benzene above the RI screening value. As indicated in the sample nomenclature, samples from location TL-SB02A were obtained from two (2) to four (4) and four (4) to six (6) ft bgs.

Cumene was the most commonly detected VOC with thirteen (13) exceedances of the RI screening value of 990,000 mg/kg. Four (4) of these samples from depths ranging from zero (0) to thirteen (13) ft bgs were located around the former tank T-101 location. Cumene releases were noted in this area in 2002 and 2004 during GEO operations at Site.

Cumene detections of note were also found in the southwest corner of the TF at sample locations TF-SB02A and TF-SB03A. Samples from these locations were obtained at depths between two (2) and four (4) ft bgs.

The final area with evident cumene detections is the vicinity of the former TLA USTs. Samples B-47, CPT-54, FP-SRI-01 and TL-SB02A had concentrations of cumene above its RI screening value. These samples were obtained at depths ranging from zero (0) to six (6) ft bgs. Six (6) samples with ethylbenzene concentrations exceeding its RI screening value also were present from the same locations and depth ranges.

New Jersey Impact to Groundwater and Direct Contact Non-Residential Soil Remediation Standards (NJDCNRSRS) Assessment

As requested by NJDEP, RBR conducted an assessment of available soil data against the NJIGW and NJDCNRSRS criteria (see Appendix P). A summary of relevant groundwater results is included for comparative discussion to address NJIGW exceedances for soil.

The compounds with detected concentrations that exceed the NJDCNRSRS in the TF/TLA EA are as follows: benzene and acetophenone. These compounds are consistent with the compounds already addressed above.

The compounds with detected concentrations that exceed the NJIGW in the TF/TLA were as follows: 2-butanone, acetone, benzene, ethylbenzene, methylene chloride, styrene, tetrachloroethene, toluene, PCE, 2,4-dimethylphenol, phenol, acetophenone, and manganese.

The data from the temporary well points in the TF/TLA EA have been compiled on Table 8-77 and a frequency of detection summary of these data is provided on Table 8-78 to help further assess the NJIGW exceedances. The data from the temporary well points include additional analyses that are not part of the quarterly groundwater monitoring activities at the Site and are thus helpful to assess NJIGW exceedances of non-VOC compounds. The data from the permanent well points compiled in Table 8-74 and frequency of detection summary are provided in Table 8-76 were also reviewed to assess the NJIGW exceedances. The Site has been inactive since 2009: thus, all potential sources of Site-related contaminants have been eliminated for more than 8 years. As a result, groundwater conditions have long since reached dynamic equilibrium and Site-related contaminant concentrations are stable or decreasing (see Section 9 for more detailed discussions). Consequently, if the detected compounds in soil that exceed an NJIGW criteria are not present in the groundwater data from temporary or permanent wells, then it is reasonable to deduce that there are no resulting impacts to groundwater from those soil exceedances. The following is a compound specific summary reviewing the relevant groundwater data in locations where soil sampling results exceeded the NJIGW for this EA:

- 2-butanone – The highest detected concentration of this compound in soils was in the sample from location CL-SB03A. Of the twenty-three (23) temporary well point and 115 permanent well samples available for the, TF/TLA EA the only detection of this compound was in the sample from location STF-14. The concentration of the STF-14 detection was thirty (30) ug/L and the RI screening value is 300 ug/L. STF-14 is not located close to soil sample location CL-SB03A and none of the groundwater samples from the temporary or permanent well points in the vicinity of CL-SB03A contained a detection of this compound.

- Acetone – The highest detected concentration of this compound in soils was in the sample from location TL-SB02A in the vicinity of the former TLA USTs. Three (3) of the twenty-three (23) temporary well points and two (2) of the 108 permanent well samples available for the TF/TLA EA had detections of acetone. The highest concentration detected in a temporary well point was in the sample from location GP-TLA-SRI-01 and in a permanent well was in a sample from MW-56B in May 2014. The detection in the MW-56B sample was eight (8) J B ug/L. This detection is estimated and also suspect because of method blank contamination (B flag). Also, no additional detections of this compound were noted in samples from MW-56B subsequent to May, 2014. However, temporary well point sample location GP-TLA-SRI-01 is located in close proximity just to the south and downgradient from soil sample location TL-SB02A. Thus, the soil detections at TL-SB02A may have have resulted in some historical, localized leaching to groundwater. However, the detected concentrations in groundwater were well below the applicable RI screening values.

- Benzene – As noted above, there are benzene groundwater detections in the vicinity of the former TLA USTs. Twelve (12) of the twenty-three (23) temporary well points and ninety-seven (97) of the 192 permanent well samples available for the TF/TLA EA had detections of this compound. All twelve (12) of the temporary well points and eighty-nine (89) of the permanent well point samples had detected concentrations above the applicable RI screening value. Benzene is a known Site-related compound and is included in the quarterly groundwater monitoring program for the Site. Further evaluation of the fate and transport of benzene and other Site-related compounds (e.g. cumene) is provided in Section 9.

- Ethylbenzene – There are ethylbenzene groundwater detections in the vicinity of the former train loading area USTs. Fifteen (15) of the twenty-three (23) temporary well points and thirty-nine (39) of the 192 permanent well samples available for the TF/TLA EA had detections of this compound. Fifteen (15) of the temporary well point and thirty-eight (38) of the permanent well point samples had detected concentrations above the applicable RI screening value. There were six (6) soil detections with concentrations above the applicable RI screening value. All six (6) of those were in the vicinity of the former TLA UST. Ethylbenzene is a known Site-related compound and is included in the quarterly groundwater monitoring program.

- Methylene Chloride – Although this compound was detected in 163 out of 184 available soil samples in the TF/TLA EA, none of the detected concentrations were above the applicable RI screening value. Two (2) of the twenty-three (23) temporary well points and two (2) of the 115 permanent well samples available for the TF/TLA EA had groundwater detections of this compound. The two (2) temporary well point detections in samples STF-14 and STF-17 had concentrations above the RI screening value. However, both of those detections were flagged J (estimated) and B (method blank contamination). Thus, the detected concentrations are suspect. There is no apparent correlation between these temporary well point detections and the highest soil concentrations detected in sample TL-SB02A in the vicinity of the former TLA USTs.

- Styrene – Only one (1) of the 178 soil samples in the TF/TLA EA had a detection of this compound. This detection was in the sample from location FP-SRI-01 in the vicinity of the former TLA USTs. The only temporary or permanent well samples with detections of styrene were also from this area (CPT-54 and its duplicate CPT-100). All of these concentrations were well below the applicable RI screening values. Thus, although there appears to be a correlation between the soil sample detection and the groundwater detection, this is a small, localized, residual detection.

- PCE – Only one (1) of the 184 soils samples in the TF/TLA EA had a detection of this compound. This detection was in the sample from location TF-SB10A located east of the former TLA USTs and just north of temporary well point sample STF-22 where this compound was also detected. The groundwater detection at STF-22 is likely the result of leaching to groundwater from soils in the vicinity of sample TF-SB10A. Just to the south of STF-22 are permanent wells MW-56B and MW-56C. This compound is detected consistently in samples from MW-56C at concentrations above the applicable RI screening value but was not detected in the samples from MW-56B. It is thus unlikely that the detections in samples from MW-56C are related to soil leaching as there are no detections between the shallow STF-22 and C-level MW-56C. Other detections of this compound at concentrations above the applicable RI screening value were noted in samples from temporary well points STF-14 and STF-17 and nearby C-level extraction well PW-11 in 2013 and 2014. These samples locations are near the southern property line. Because of the distances involved, it is unlikely that these groundwater detections are related to the lone shallow soil detection of this compound. Concentrations of this compound were also noted above the applicable RI screening value in samples from C-level extraction well PW-4R in 2013 and 2014. There are no nearby soil concentrations that may be related to these detections though the detections in PW-4R and PW-11 may be related to the detections in samples from MW-56C. The source of the concentrations of this compound in temporary well points STF-14 and STF-17 is unknown.

- Toluene – Although this compound was detected in 146 out of 191 available soil samples in the TF/TLA EA, none of the detected concentrations were above the applicable RI screening value. Seven (7) of the twenty-three (23) temporary well points and five (5) of the 192 permanent well samples available for the TF/TLA EA had detections of this compound. The highest groundwater concentration of this compound was detected in the temporary well point sample from location TL-3 just south and west of the former TLA USTs and was above the applicable RI screening level. This compound was also detected in nearby temporary well points CPT-54 and its duplicate CPT-100 as well as GP-TLA-SRI-01. These temporary well point detections may be related to leaching from soil at location TL-3. Other detections of this compound in groundwater were noted in temporary well points STF-14 and STF-17; and in permanent wells PW-8, PW-12 and MW-8C located along the southern fence line. Toluene is a known Site-related compound and shallow extraction wells PW-8 and PW-12 hydraulically induce impacted groundwater toward the southern property fence line. Thus, soil leaching throughout the TF/TLA EA may contribute to these low concentration detections. The only detected concentration of toluene in groundwater above the applicable RI screening value was in the sample from TL-3.

- TCE – Only one (1) of the 184 soils samples in the TF/TLA EA had a detection of this compound. TCE was detected in sample TL-2 just south of the former TLA UST area at a concentration below the applicable RI screening value. None of the twenty-three (23) temporary well points had concentrations of this compound. Fifteen (15) of the 115 permanent well points had detections of this compound and all of them were at concentrations exceeding the applicable RI screening value of 0.28 ug/L. The detections were evenly distributed between wells MW-56C and C-level extraction wells PW-11 and PW-4R. There does not appear to be a correlation between soil detections and these groundwater detections. However, the detections within the C-level may be interrelated as a result of long-term pumping with the highest concentrations noted in groundwater samples from MW-56C.

- 2,4 – dimethylphenol – This compound was detected in three (3) of the 171 soils samples available in the TF/TLA EA. None of the detections were at concentrations that exceed the applicable RI screening value. None of the ten (10) temporary well points with SVOC analyses had a detected concentration of this compound. None of the permanent well points have SVOC data associated with them. Thus, no evidence of any groundwater concentrations from soil detections of this compound was found.

- Phenol – Twenty (20) of the 171 soils samples in the TF/TLA EA had a detection of this compound. Only one (1) of those detections (TL-SB02B) had a concentration exceeding the applicable RI screening value. There is no phenol data for the permanent monitoring wells, but five (5) of the ten (10) temporary well points available had detections of phenol. None of those detections had concentrations that exceed the applicable RI screening value. There does appear to be a correlation between the highest concentration of this compound in soil at location TL-SB02B and the detections in nearby temporary well points TL-3, TP-TLA-SRI-01, and TL-2 in the vicinity of the former TLA USTs. There also appears to be a correlation between soil detections in the southwest corner of the TF (TF-SB01A, TF-SB02A, TF-SB03A and others) and the detection of this compound in temporary well TF-2 along the southern property boundary. No correlation between soil detections and the temporary well point detection at location TF-3 could be identified.

- Acetophenone – There are two (2) primary areas with acetophenone detections in soils. These are the southwest corner of the TF area just east of extraction well PW-7B (samples TF-SB02A, TF-SB01A, TF-SB03A and TF-SB03B) and the vicinity of the former TLA USTs (samples FP-SRI-01 and TL-SB02A). The depth of detections ranged from zero (0) to six (6) ft bgs. There are no permanent well SVOC data to assess, but five (5) of the ten (10) temporary well point samples had concentrations of acetophenone. Only one (1) of these samples, TL-3, had a detected concentration that exceeds the applicable RI screening value. Samples TL-4 and TL-2 had the next highest concentrations of this compound. All three (3) of those samples (TL-2, TL-3, and TL-4) are located in the vicinity of the former TLA USTs. Thus, a correlation between the soil detections in that area and detections in shallow groundwater may exist. There may be acetophenone leaching to shallow groundwater from soils in the southwest corner of the TF area as well, but there are few data points in this vicinity to assess this issue.

- Manganese – Metals have not historically been related to Site activities and thus there minimal metals data are available. Of the nine (9) soil samples with metals data in the TF/TLA EA, there is one (1) manganese detection at location TF-SS04A at 83.8 mg/kg, which exceeds the NJIGW of 65 mk/kg. There are no temporary or permanent well point samples that have metals data associated with them. Thus, no assessment of leaching to groundwater from this lone manganese detection is possible. However, because only one (1) of the nine (9) available samples exceeded the NJIGW criteria and there is no evidence associating Site activities with the use or disposal of manganese, no further action is warranted in this EA for manganese.

Soil Detection Summary

There are three (3) primary areas of soil detections in the TF/TLA EA. In the northwest corner of this EA is the former TL UST area. The primary detections are from Site-related compounds acetophenone, benzene, ethylbenzene, cumene and phenol at depths up to six (6) ft bgs. Some localized groundwater leaching from these soil detections were also noted.

Another area of soil detections is in the southwest corner of the former TF area in the vicinity of samples TF-SB01A, TF-SB02A, TF-SB03A and TF-SB03B. The primary soil detections in this vicinity are from acetophenone, cumene, and phenol at depths up to six (6) ft bgs. Some localized groundwater leaching from these soil detections were also noted.

Finally, in the vicinity of former tank T-101 in the northeast corner of the TF area, there were known cumene releases in 2002 and 2004 under GEO operations. Concentrations of cumene above the RI screening value were noted in soils in the vicinity of former tank T-101.

As noted above, some localized detections of TCE and PCE were also found in soils and in select temporary and permanent well points. These detections are interspersed with detections of benzene, cumene, ethylbenzene and toluene. Thus, it is difficult to assess the nature and extent of these detections with the available data; though no nexus or evidence of widespread detections from these chlorinated VOCs exists. In addition, there are known off-Site sources of chlorinated solvents that may be contributing to this issue as well.

8.3.11.2 Groundwater

A summary of the detections in the groundwater samples for this EA is provided in Table 8-74. Frequency of detection summary statistics for these data are provided in Table 8-76.

The twenty (20) permanent monitoring wells in the TF/TLA EA are sampled for VOCs and TRP only. The compounds with detected concentrations in samples from these wells that exceed the applicable RI screening values are as follows: TRP; 1,2-dichloroethane; a-methylstyrene (TIC); benzene; chloroform; cis-1,2-dichloroethene; cumene; ethylbenzene; PCE; TCE; vinyl chloride and total xylenes. The following is an assessment of the detections of each of these compounds within the available data set:

- Total recoverable phenols (TRP) – There are thirteen (13) detections out of the available thirty-six (36) groundwater samples with TRP detections that have concentrations that exceed the applicable RI screening value of 0.58 mg/L. All thirteen (13) of those detections are in samples from MW-56B. Some low concentration (less than 0.5 mg/L) detections of TRP are also noted in the samples from MW-57B, but no other detections are present in the data set. MW-56B is screened in the shallow portion of the B-level and MW-57B is screened at the bottom of the B-level in the central TF area. There are no available TRP soils data in the immediate vicinity of this well cluster;

thus, no assessment of a correlation with soils detections is possible. Based upon the consistent detections of TRP in samples from MW-56B, it appears that a localized source of TRP is likely present.

- 1,2-dichloroethane – There are four (4) detections of this compound in the 115 available groundwater samples in the TF/TLA EA. All four (4) of the detected concentrations exceed the applicable RI screening value of 0.17 ug/L. The highest detected concentrations of this compound were reported in the April 2013 sample from extraction well PW-5B. This well could not be sampled again until 2017 because it was taken offline as a pumping well and the pumping apparatus prevented sampling. The well was again sampled in 2017 with no detection of this compound. A review of all soil and groundwater data in the vicinity of PW-5B revealed no corroborating detections of this compound or related chlorinated solvents. Thus, it is suspected that this detection is anomalous and may be the result of laboratory or sampler error. The only other detections of this compound is in groundwater at low concentrations (less than one (1) ug/L) in 2013, 2016 and 2017 samples from MW-56C. These detections are consistent with other low level chlorinated solvent detections noted in the B- and C-level aquifers. Non-Site related VOCs detected in regional TF wells may be related to long-term groundwater pumping at the Site, which could be inducing groundwater flow toward the Site from offsite sources.

- A-methylstyrene (TIC) – There are a total of six (6) detections of this compound out of the available 152 groundwater sample locations. Three (3) of these detections had concentrations that exceed the applicable RI screening value of seventy-eight (78) ug/L. Two (2) of the three (3) detections, including the highest concentration of 340 ug/L, were in samples from former extraction well PW-7B. The other detection was in a 2013 sample from PW-5B. This compound is an SSTIC and concentrations of this compound are interspersed with other Site-related compounds. The presence of this compound in groundwater may be masked by elevated concentrations of these other, more prevalent Site-related compounds (e.g. benzene, cumene, ethylbenzene, and toluene). Thus, the noted detections are not unexpected and consistent with known groundwater detections at the Site.

- Benzene – This Site-related compound was detected in ninety-seven (97) of the available 192 groundwater samples for the TF/TLA EA. Eighty-nine (89) of these detections are at concentrations that exceed the applicable RI screening value of 0.46 ug/L. Benzene is consistently detected at concentrations above the RI screening value in extraction wells and monitoring wells located along the southern fence line as follows: PW-8, PW-8B, PW-12 and MW-8C. Benzene is also consistently detected at concentrations above the RI screening value in B-level extraction well PW-10R, former B-level extraction well PW-5B and C-level extraction well PW-11. The highest detected concentration of benzene from 2013-2017 was in a sample from PW-5B in 2017. Benzene was not detected in the 2013-2017 samples from wells MW-5B, MW-7B, MW-47, PW-4R and PW-7B. Improvements in detections of benzene subsequent to the shutdown of B-level extraction wells in 2014 were noted in the samples from

MW-8B and MW-56C. The detections noted with concentrations that exceed the applicable RI screening value are consistent with areas of known Site-related groundwater detections. It should be noted that benzene concentrations in general have decreased appreciably over time, especially along the southern property boundary, as discussed in detail in Fate & Transport (Section 9). Site groundwater pumping combined with ongoing natural attenuation processes have appreciably reduced the lateral and vertical extent of dissolved benzene concentrations.

- Chloroform – There is only one (1) detection of this compound in the 115 available groundwater samples for the TF/TLA EA. This detection was in a sample from PW-12 in 2013 at a concentration of 10 J ug/L, which exceeds the applicable screening value of 0.22 ug/L. With no other onsite detections of this compound, this detection in a sample from extraction well PW-12, located along the southern property fence line, is anomalous and may be related to offsite groundwater.

- Cis-1,2-dichloroethene – There are twenty (20) detections of this compound in the 115 available groundwater samples in the TF/TLA EA. Five (5) of these detections were at concentrations that exceed the applicable RI screening value of 3.6 ug/L. All five (5) of those detections were in samples from MW-56C. The highest concentration was detected in a sample from MW-56C in 2016. The remaining fifteen (15) detections are evenly spread between samples from MW-8C, PW-11 and PW-4R. All of these detections are in the C-level water-bearing zone. With no detections in permanent groundwater monitoring points in the overlying A and B-levels, there does not appear to be a correlation between historical Site activities and these detections.

- Cumene – This compound is most closely associated with the Site and was detected in 158 of the 192 available groundwater samples for the TF/TLA EA. A total of 118 of those detections were at concentrations that exceed the applicable RI screening value of 45 ug/L. The highest detected concentration of cumene was detected in a 2015 sample from MW-56B. Concentrations of cumene detected in samples from MW-56B have declined slightly since then. Monitoring well MW-47 is the only well in the TF/TLA EA that did not have any detections of cumene in the samples obtained from it. Samples from wells MW-56C, MW-5B, MW-7B, MW-8C and PW-4R have detections of cumene at concentrations that do not exceed the applicable RI screening value. Samples from all other wells in the TF/TLA EA have detections of cumene that consistently exceed the RI screening value.

- Ethylbenzene – This compound is also closely associated with the site and was detected in thirty-nine (39) of the available 192 groundwater samples in the TF/TLA EA. A total of thirty-eight (38) of those detections were at concentrations that exceed the applicable RI screening value. Ethylbenzene is most commonly detected in groundwater samples obtained in wells located along the southern property boundary, primarily in samples from shallow extraction wells PW-8 and PW-12 and nearby monitoring well MW-8. However, no detections of this compound were noted in the available groundwater samples from the nearby B-level monitoring well MW-8B or former B-level extraction well PW-8B. Detections of this compound also occur in the southeast corner of the Site in samples from former extraction well PW-7B and monitoring well MW-5. The detections in samples from MW-5 have only occurred in 2016 and 2017. Dynamic equilibrium of groundwater flow and quality conditions at the Site are not static and slight changes in conditions along the southeast corner of the Site may be responsible for observation fluctuations, particularly in response to cessation of four (4) B-level extraction wells that was implemented in 2014. Finally, the two (2) available samples from PW-5B from 2016 and 2017 had notable concentrations of ethylbenzene with the 2017 sample having the highest detected concentration of 150 ug/L.

- PCE – There are fourteen (14) detections of this compound in the 115 available groundwater samples for the TF/TLA EA. Nine (9) of these detections are at concentrations that exceed the applicable RI screening value of one (1) ug/L. The highest detected concentration of this compound was 9.3 ug/L in a 2016 sample obtained from MW-56C. All of the samples from MW-56C from 2013-2017 (five (5) total) contained concentrations of this compound that exceed the applicable RI screening value. The other four detected concentrations of this compound that exceed the RI screening value were samples from PW-11 and PW-4R in 2013 and 2014. All of the wells with concentrations of PCE are C-level wells. PW-11 and PW-4R are extraction wells. Historically this compound has not been associated with Site activities. Extensive pumping from C-level extraction wells has created a hydraulic capture zone that extends off-Site beyond the southern property boundary. As a result, groundwater pumping hydraulically induces groundwater flow in the C-level toward the Site pumping wells from off-Site.

- TCE - There are fifteen (15) detections of this compound in the 115 available groundwater samples for the TF/TLA EA. All fifteen (15) of these detections are at concentrations that exceed the applicable RI screening value of 0.28 ug/L. The highest detected concentration of this compound was twenty-nine (29) ug/L in a 2016 sample obtained from MW-56C. Similar to the PCE detections as noted above, these detections were evenly spread between samples from wells MW-56C and C-level extraction wells PW-11 and PW-4R. There does not appear to be a correlation between soil detections and these groundwater detections, but the detections in the C-level may be related with the highest concentrations noted in samples from MW-56C. As described above for PCE extensive groundwater pumping may be capturing chlorinated solvents from an unknown source near the southern property boundary.

- Vinyl Chloride - There are fifteen (15) detections of this compound in the 115 available groundwater samples for the TF/TLA EA. All fifteen (15) of these detections are at concentrations that exceed the applicable RI screening value of 0.019 ug/L. The highest detected concentration of this compound was 5.6 ug/L in a 2016 sample obtained from MW-56C. Similar to the TCE and PCE detections noted above, these detections were noted primarily in samples from MW-56C (five (5) detections), PW-11 (two (2) detections in 2016 and 2017) and PW-4R (four (4) detections). However, four (4) detections were noted in samples from MW-8C for vinyl chloride and no detections of

TCE or PCE were noted in samples from MW-8C. Cis-1,2-dichloroethene and vinyl chloride are one of the final degradation daughter compounds of PCE. The presence of these compounds in samples from MW-8C with a lack of detections of TCE or PCE indicates that natural attenuation of these compounds is occurring in the vicinity of MW-8C. As described above for PCE and TCE, extensive groundwater pumping may be capturing chlorinated solvents from an unknown source located near the southern property boundary.

- Total xylenes - There are nine (9) detections of this compound in the 121 available groundwater samples for the TF/TLA EA. Six (6) of these detections, all in samples from PW-12, are at concentrations that exceed the applicable RI screening value of nineteen (19) ug/L. The highest detected concentration of this compound was sixty-six (66) ug/L in a 2016 sample obtained from PW-12. PW-12 is a shallow extraction well along the southern property fence line. The other three (3) detections of this compound, all below the RI screening value and at estimated (J-flag) concentrations, were in 2013 samples from PW-8, PW-8B and MW-8. These detections are indicative of an off-Site source of xylenes in the vicinity of PW-12 where shallow pumping has concentrated groundwater in this vicinity.

Groundwater Detection Summary

Site related groundwater detections of a-methylstyrene, benzene, cumene and ethylbenzene were noted primarily in the vicinity of PW-5B located on the northern side of the TF/TLA EA and in close proximity to known groundwater and soil detections in the APA. As expected, these compounds are also commonly detected in the vicinity of the active A-level extraction wells along the southern property fence line (PW-8 and PW-12) and near B- and C-level extraction wells PW-10R, PW-11 and PW-4R. Cumene is detected throughout the TF/TLA Area at concentrations above the RI screening value, which may be related to localized cumene releases from tanks in the TF. Detections of benzene, ethylbenzene, and a-methylstyrene are more localized. A pocket of a-methylstyrene and ethylbenzene detections was noted in samples from PW-7B and MW-5. These may be associated with soil concentrations in this southwest corner of the TF/TLA EA. The benzene groundwater detections appear to be primarily associated with the APA.

TRP is also Site-related. Detections of TRP in groundwater appear to be localized in the vicinity of well MW-56B in the TF/TLA EA. No nearby soil detections of TRP were noted in the vicinity of MW-56B, but this is an area with less density of soil sampling than other portions of the TF/TLA EA.

Finally, detections of chlorinated solvents PCE and TCE, and their degradation daughter products 1,2-dichloroethane, cis-1,2-dichloroethene, and vinyl chloride were noted in the TF/TLA EA. Detections of these compounds are limited to wells in the C-level. The highest concentrations of the chlorinated solvent compounds are primarily noted in samples from MW-

56C, which is located between deep, C-level extraction wells PW-11 and PW-4R. Detections of chlorinated solvent degradation products vinyl chloride, and cis-1,2-dichloroethene were also noted in samples from C-level monitoring well MW-8C along the southern property fence line. With no detections of these compounds in the A- or B-level water-bearing zones, it is suspected that the source of these compounds are likely located off-Site and that C-level extraction well pumping is hydraulically inducing flow from off-Site. During an off-Site VI study in 2010-2011, it was found that an off-Site source of chlorinated solvents was present. At that time, it was hypothesized that these detections are related to a former dry cleaners that was located off of Main Street in Gibbstown. NJDEP is currently evaluating an investigation into chlorinated solvents in Gibbstown.

8.3.11.3 Summary

There are three (3) primary areas of soil detections in the TF/TLA EA as follows: the northwest corner of this EA in the vicinity of the former TLA UST; the southwest corner of the former TF area in the vicinity of samples TF-SB01A, TF-SB02A, TF-SB03A and TF-SB03B; and the vicinity of former tank T-101 in the northeast corner of the tank farm area. The soils in these areas have detections of the various Site-related compounds through releases from above or below ground storage tanks.

The areas of groundwater detections in the TF/TLA EA are either related to localized seepage from the above soil or migration of soil/groundwater concentrations from the adjacent APA. Pumping of groundwater in the A, B and C-levels has concentrated the impacted groundwater in the vicinity of the extraction wells. Decades of extensive groundwater pumping has created a hydraulic capture zone that extends off-Site and induces groundwater flow to these wells. As a result of groundwater pumping (from the C-level in particular), it is suspected that at least some, if not all, of the chlorinated solvents detected in C-level groundwater have migrated to the pumping wells from uknown off-Site sources. This is primarily the case for chlorinated solvents and their degradation compounds detected in C-level monitoring and extraction wells in the TF/TLA EA. However, some detections of total xylenes and ethylbenzene were also noted along the southern property fence line in A-level groundwater.

8.3.12 Township Refuse Area Investigation History Summary

As detailed in Section 3.12 above, The TRA is located directly north of the WH EA and also borders the west side of the SCB EA. The CCW EA is north of the TFA and the western Site fence line lies to the west of this EA. The TRA EA is comprised of the former Township Refuse/Landfill Area IA and the wooded and wetland areas surrounding it (Figure 3-12).

The area was in use in the late 1940’s as a local trash disposal area and operations ceased by the mid 1950’s. As indicated by the results of geophysical testing, hand augering, surface soil sampling, and backhoe test pit installation in the Ph II (1995), the western portion of the TRA consists largely of natural undisturbed soil, with only a few, small, isolated areas of surficial refuse. The eastern/northeastern portion of this EA shows evidence of non-putrescible municipal-type refuse material. The materials encountered were similar to municipal refuse.

Investigation of the TRA EA officially began during the Ph II. However, one (1) sample (002-Outfall-SEEP) from a 1991 investigation of the "seep" area located at the head of the SCB is included in the southeast corner of this EA because of the way the EA boundaries were drawn for the risk assessments. As indicated above, during the Ph II, geophysical testing, hand augering, surface soil sampling and test pitting were done in this area to define the extent and characterize the waste present. A total of four (4) surface soil samples were obtained from depths of zero (0) to two (2) ft bgs during this investigation.

During the 2002 SRI, an additional geophysical study was conducted in the TRA EA to further delineate the extent of waste. The extent of waste and fill defined by this study are shown on Figure 3-12. Two (2) surface soil samples in the vicinity of surficial metallic anomalies were also obtained in the TRA EA at this time.

During the 2009 FI, four (4) subsurface soil and temporary well point samples and one (1) wetland soil sample were obtained in the 002 Outfall area and one (1) subsurface soil and two (2) temporary well point samples (sample and duplicate) were obtained in the "seep" area at the head of the SCB. All of these sample points now lie within the TRA EA.

During the 2015 ARI a total of nine (9) subsurface soil samples were obtained in the vicinity of the TRA to delineate further the extent of waste. In 2016, as a follow-up to the ARI, an additional twelve (12) surface soil samples were obtained around location TLF-9 to delineate further lead detections in soils.

One (1) permanent well, TW-2, a C-level well, is located in the TRA EA. This well is sampled on an annual basis for VOCs only.

The sample locations for this EA are shown on Figure 3-12. The analytical data available for this EA are summarized on Table 8-79 (soil) and Table 8-80 (groundwater) along with a comparison of those data to the screening values developed for this RI as outlined in Section 8.1 above. Frequency of detection summary tables for soil and groundwater for this EA are Tables 8-81 and 8-82, respectively.

The following sections outline the nature and extent of detections in this EA by media.

8.3.12.1 Soil

Arsenic, iron, lead, mercury and thallium were metals detected in TRA EA soil samples at concentrations that exceed their applicable RI screening values. The following is an assessment of each of those detections:

- Arsenic – The metal was detected in each of the twenty (20) samples in the TRA EA. Fifteen (15) of those detections were at concentrations that exceed the applicable RI screening value of three (3) mg/kg. However, only two (2) of the detections, SRI-SS-02 and WS-28, had concentrations that exceeded nineteen (19) mg/kg, which is the recognized background concentration of arsenic in soil in New Jersey. Sample SRI-SS-02 is located in south-central portion of the waste disposal area in the TRA and WS-28 is a wetland soil sample located in the 002 Outfall. These samples may be impacted by wastes in the TRA, however the low frequency of detections at concentrations above the New Jersey background level indicates that arsenic is not a significant concern in the TRA.

- Iron – This metal was detected in all twenty (20) of the soils samples in the TRA EA. Only one (1) of those detections was at a concentration that exceeds the applicable RI screening value of 82,000 mg/kg. That sample, WS-28, had a concentration of 96,000 mg/kg. This concentration is not significantly greater than the screening value and is the lone detection with a concentration above the RI screening value. This indicates that there is not a significant concern for iron in soils in the TRA EA.

- Lead – This metal was detected in all thirty-two (32) of the available soil samples in the TRA EA. Thirteen (13) of the detected concentrations are above the applicable RI screening value of 800 mg/kg. All thirteen (13) of these lead detections are in the 2015 ARI sample, TLF-9, and the 2016 delineation samples around that point. Further delineation of this lead area will be necessary to determine the extent of lead requiring further action in this portion of the TRA EA.

- Mercury – This metal was detected in sixteen (16) of the twenty (20) available soil samples in the TRA EA. Only one of those detections was at a concentration that exceeded the RI screening value of 4.6 mg/kg. The mercury concentration (11 J mg/kg) was detected in sample TLF-9 (0-1). The 2016 samples obtained around TLF-9 were only analyzed for lead, thus no additional mercury delineation was done in this area. Additional mercury delineation is recommended in conjunction with the further lead delineation recommended above for this sample location.

- Thallium – This metal was detected in twelve (12) of the twenty (20) available soil samples in the TRA EA. Only two (2) of those detections (SRI-WS-5 and SRI-SS-02) were at a concentration (3.1B mg/kg and 2.1 mg/kg, respectively) that exceeded the RI screening value of 1.2 mg/kg. Sample SRI-WS-5 is a wetland soil sample located in the 002 Outfall area. SRI-SS-02 is a surface soil sample collected in the western portion of the EA, and does not appear to be related to any buried municipal waste. With no other thallium detections of concern, these samples are anomalous and do not warrant further action.

PAHs

There are four (4) PAH compounds that had detected concentrations exceeding their applicable RI screening values as follows: benzo(a)anthracene; benzo(a)pyrene; dibenz(a,h)anthracene and indeno[1,2,3-cd]pyrene. The highest concentrations of these compounds were all found in the 2002 SRI sample location SRI-SS-02 located in the eastern, central portion of the TRA just along the fence line. Three (3) of these compounds (benzo(a)anthracene, benzo(a)pyrene and dibenz(a,h)anthracene) were also detected at location WS-28 at concentrations above their applicable RI screening value. Benzo(a)pyrene was also detected in samples from 02OF-3 and 02OF-4 at concentrations above its RI screening value.

These three (3) sample locations (WS-28, 02OF-3(72) and 02OF-4(66)) are all from the 2009 FI, and they are located in the 002 Outfall in close proximity to each other. As indicated by their sample IDs, samples 02OF-3(72) and 02OF-4(66) were obtained from depths of six (6) ft bgs and five and a half (5.5) ft bgs, respectively. Samples WS-28 and SRI-SS-02 were obtained from depths of zero (0) to six (6) inches bgs.

These detections correlate with similar detections in the CCW EA in the 002 Outfall just downstream of this area in samples SRI-WS-4, WS-29 and WS-30 (all from a depth of zero (0) to six (6) inches). Some PAH detections in the SCB EA in the “seep” area located along the berm at the head of the SCB and in deep sediments in the SCB were also noted. Based upon this pattern of detections and the relative concentrations, it seems unlikely that the detections in the 002 Outfall are related to the detections at SRI-SS-02. The source of these PAH detections in the 002 Outfall are likely a combination of upstream sources settling into the 002 Outfall during high water events and historical operations at the Site that discharged through the 002 Outfall prior to 1991.

PCBs

One (1) detection of PCB Aroclor 1254 in the thirteen (13) available soil samples in the TRA EA was noted. The concentration of this detection in sample SRI-WS-5 (sixty-one (61) ug/kg) was well below the applicable RI screening value of 970 ug/kg.

Pesticides

Multiple detections of various pesticides were noted in the thirteen (13) available soil samples in the TRA EA. However, none of these detections had concentrations that exceeded their applicable RI screening values.

SVOCs

Acetophenone was the only SVOC detected at a concentration that exceeded its applicable RI screening value in the available soil samples from the TRA EA. One (1) sample, WS-28, had a detected concentration of 11,000 ug/kg that exceeds the RI screening value of 5,000 ug/kg. This 2009 FI sample is located in the 002 Outfall and was obtained from a depth of zero (0) to six (6) inches bgs. As noted above, sample WS-28 also had detections of PAHs at concentrations above their applicable RI screening values. Because acetophenone is closely associated with Site activities, this detection is likely related to surface water transport through the 002 Outfall from historical plant operations.

VOCs

Cumene was the only VOC detected at a concentration that exceeded its applicable RI screening value in the available soil samples from the TRA EA. One (1) sample, 002-OUTFALL-SEEP, had a detected concentration of 2,500,000 ug/kg that exceeds the RI screening value of 990,000 ug/kg. This 1991 sample is located just downgradient of the “seep” area along the berm at the head of the SCB.

New Jersey Impact to Groundwater and Direct Contact Non-Residential Soil Remediation Standards (NJDCNRSRS) Assessment

As requested by NJDEP, RBR conducted an assessment of available soil data against the NJIGW and NJDCNRSRS criteria (see Appendix O). A summary of relevant groundwater results is included for comparative discussion to address NJIGW exceedances for soil.

The compounds with detected concentrations that exceed the NJDCNRSRS in the TF/TLA EA are as follows: acetophenone, benzo(a)anthracene, benzo(a) pyrene, benzo(b)fluoranthene, dibenze(a,h)anthracene, indeno[1,2,3-cd]pyrene, arsenic and lead. These compounds are consistent with the compounds already addressed above.

The compounds with detected concentrations that exceed the NJIGW in the TF/TLA were as follows: 2-butanone, benzene, methylene chloride, total xylenes, acetophenone, benzo(a)anthracene, benzo(a) pyrene, benzo(b)fluoranthene, dibenze(a,h)anthracene, dieldrin, aluminum, antimony, arsenic, barium, beryllium, cadmium, lead, manganese, mercury, nickel, silver and zinc.

The data from the temporary well points in the TRA EA have been compiled on Table 8-83 and a frequency of detection summary of these data is provided on Table 8-84 to help further assess the NJIGW exceedances. The data from the temporary well points include additional analyses that are not part of the quarterly groundwater monitoring activities at the Site and are thus helpful to assess NJIGW exceedances of non-VOC compounds. The data from the permanent well points compiled in Table 8-80 and frequency of detection summary are provided in Table 8-82 were also reviewed to assess the NJIGW exceedances. The Site has been inactive since 2009: thus, all potential sources of Site-related contaminants have been eliminated for more than 8 years. As a result, groundwater conditions have long since reached dynamic equilibrium and Site-related contaminant concentrations are stable or decreasing (see Section 9 for more detailed discussions). Consequently, if the detected compounds in soil that exceed an NJIGW criteria are not present in the groundwater data from temporary or permanent wells, then it is reasonable to deduce that there are no resulting impacts to groundwater from those soil exceedances. The following is a compound specific summary reviewing the relevant groundwater data in locations where soil sampling results exceeded the NJIGW for the TRA EA:

- 2-butanone – None of the temporary or permanent well data for the TRA EA contain detections of this compound.

- Benzene – Three (3) of the six (6) temporary well point samples and none of the samples from permanent well TW-2 had detections of benzene. Two (2) of the three (3) temporary well point samples with benzene detections are SP-1 and its duplicate SP-200 located in the "seep" area next to the berm at the head of the SCB. The highest concentration detection of benzene in soil in the TRA EA was also located in this area in sample 002-OUTFALL-SEEP. Thus, these temporary well point detections are likely related to soil and/or sediment in the SCB and berm area. The other temporary well point sample detection of benzene was in sample 02OF-1 located in the 002 Outfall. Some low concentration detections of benzene were also noted in the soil sample from that location. Thus, there may be some correlation between the soil and groundwater detections in this vicinity as well.

- Methylene chloride – None of the temporary or permanent well data for the TRA EA contain detections of this compound.

- Total xylenes – None of the temporary or permanent well data for the TRA EA contain detections of this compound.

- Acetophenone – All six (6) of the temporary well point samples had detections of acetophenone. Samples from permanent well point TW-2 do not have SVOC data associated with them. Correlation between the detection of acetophenone in soil sample WS-28 and the temporary well point samples 02OF-1 through 02OF-4 appears to exist. There are no detections of acetophenone in soils in close proximity to temporary well point SP-1. However, the highest concentrations of acetophenone in the SCB EA are in the area around the SDB. These soil concentrations may relate to shallow groundwater detections in the 002 Outfall and "seep" areas.

- Benzo(a)anthracene – There is one (1) detection of benzo(a)anthracene in temporary well point sample 02OF-3. Samples from permanent well point TW-2 do not have PAH data associated with them. The soil sample from 02OF-3(72) from a depth of six (6) ft bgs had a detection of this compound as well as other PAHs. The temporary well point detection in sample 02OF-3 and the soil sample detection from the same location are likely related.

- Benzo(a)pyrene – There are two (2) detections of benzo(a)pyrene in temporary well point samples 02OF-3 and SP-200 (duplicate of SP-1). Samples from permanent well point TW-2 do not have PAH data associated with them. The soil sample from 02OF-3(72) from a depth of six (6) ft bgs had a detection of this compound as well as other PAHs. The temporary well point detection in sample 02OF-3 and the soil sample detection from the same location are likely related. Similarly, concentrations of benzo(a)pyrene were noted in sediment and soil samples (SP-2(72) and 002-SEEP-

SED) in the vicinity of temporary well point SP-1 that may be the cause of detections of this compound in that sample.

- Benzo(b)fluoranthene – There are two (2) detections of benzo(b)fluoranthene in temporary well point samples 02OF-3 and SP-200 (duplicate of SP-1). Samples from permanent well point TW-2 do not have PAH data associated with them. The soil sample from 02OF-3(72) from a depth of six (6) ft bgs had a detection of this compound as well as other PAHs. The temporary well point detection in sample 02OF-3 and the soil sample detection from the same location are likely related. Similarly, concentrations of benzo(b)fluoranthene were noted in sediment and soil samples (SP-2(72) and 002-SEEP-SED) in the vicinity of temporary well point SP-1 that may be the cause of detections of this compound in that sample.

- Dibenz(a,h)anthracene – There is one (1) detection of benzo(a) anthracene in temporary well point sample 02OF-3. Samples from permanent well point TW-2 do not have PAH data associated with them. The soil sample from 02OF-3(72) from a depth of six (6) ft bgs had a detection of this compound as well as other PAHs. The temporary well point detection in sample 02OF-3 and the soil sample detection from the same location are likely related.

- Dieldrin – There are no pesticide data associated with any of the temporary or permanent well point samples in the TRA EA.

- Antimony, arsenic, beryllium, lead, nickel, and zinc were all identified as being present in background sediments at higher concentrations than in the 002 Outfall and drainageway (see Appendix O and Section 8.2.2 above). Since all of the temporary well point samples available for the TRA EA are found in the vicinity of the 002 Outfall, detections of these metals are considered naturally occurring or related to background anthropogenic source. However, because lead was detected at concentrations above the RI screening value in the TRA EA soils it is further evaluated below.

- Aluminum – This metal was detected in all six (6) of the available temporary well point samples in the TRA EA and all six (6) detections were at concentrations that exceeded the applicable RI screening value. Samples from permanent well point TW-2 do not have metals data associated with them. A review of the aluminum detections in soils shows that the soil samples in the 002 Outfall all have concentrations that are an order of magnitude greater than samples outside of the 002 Outfall. Thus, a correlation does appear to exist between soil and temporary well point detections of aluminum in this area.

- Lead – This metal was detected in five (5) of the six (6) available temporary well point samples in the TRA EA and three (3) of those detections were at concentrations that exceeded the applicable RI screening value. Samples from permanent well point TW-2 do not have metals data associated with them. Those three (3) locations were 02OF-2, 02OF-3, and 02OF-4 in the 002 Outfall. Lead concentrations in the soil samples in the 002 Outfall are all below the applicable RI screening value. However, lead was detected in each of the soil samples obtained at each of the temporary well point sample locations with a lead concentration also present in the nearby sample location WS-28. It is likely that the concentrations of lead detected in those temporary well point samples were artificially elevated by incidental sediment incorporation within the sample matrix during sample collection. A review of the log sheets for these samples indicates that they were all grey in color and thus had high sediment concentrations entrained in them. Lead is not typically mobile in groundwater unless the groundwater has a depressed pH. The impacted temporary well point samples all had pHs of around 6. Thus, there does not appear to be a connection between these temporary well point detections of lead and the concentrations of lead found in soils in the vicinity of sample TLF-9.

- Manganese – This metal was detected in all six (6) available temporary well point samples in the TRA EA and all of those detections were at concentrations that exceeded the applicable RI screening value. Samples from permanent well point TW-2 does not have metals data associated with them. No soil samples in the TRA EA had concentrations of manganese that exceeded the applicable RI screening value. However, similar to lead above, there are detections of manganese in all of the soil samples in the 002 Outfall area. It is likely that the concentrations of manganese detected in those temporary well point samples were artificially elevated by incidental sediment incorporation within the sample matrix during sample collection. A review of the log sheets for these samples indicates that they were all grey in color and thus had high sediment levels entrained in them.

- Mercury – None of the temporary well data for the TRA EA contain detections of this compound. Samples from permanent well point TW-2 do not have metals data associated with them.

- Thallium – This metal was detected in one (1) of the six (6) available temporary well point samples in the TRA EA and that detection was at a concentration that exceeded the applicable RI screening value. Samples from permanent well point TW-2 do not have metals data associated with them. The lone temporary well point detection of thallium was in the sample from 02OF-4. Thallium was not detected in the soil sample from location 02OF-4 nor in nearby sample WS-28. A low concentration of thallium is noted in soil sample 02OF-3, but it is unlikely that leaching from this location resulted in the groundwater detection at location 02OF-4. It is more likely that this detection is again related to high sediment content in the temporary well point sample obtained at location 02OF-4.

Soil Detection Summary

In the area where waste was disposed in the TRA, the only two (2) areas of concern appear to be lead detections in sample TLF-9 and its vicinity and PAH detections in sample location SRI-SS-02.

The PAHs benzo(a)anthracene; benzo(a)pyrene; dibenz(a,h)anthracene and indeno[1,2,3-cd]pyrene were detected at concentrations above their applicable RI screening values in multiple samples in the 002 Outfall and "seep" area at the head of the SCB. These detections ranged in depth from six (6) inches to six (6) ft bgs and are most likely related to historical discharges (pre-1991) through the 002 Outfall. There does not appear to be a correlation between PAHs detected in the refuse area in sample SRI-SS-02 and those detected in the 002 Outfall. Some localized leaching to groundwater from these PAH compounds were also noted in samples extending from the "seep" area at the head of the SCB through the 002 Outfall and into the CCW EA in the 002 Outfall.

Acetophenone was detected at an concentration above its RI screening value in soil sample WS-28 in the 002 Outfall. Localized groundwater detections were also noted in the 002 Outfall and "seep" area in temporary well point samples. These groundwater detections are most likely related to acetophenone concentrations in soils noted in the nearby SDB in the SCB EA.

Concentrations of benzene above the RI screening value were noted in the 002 Outfall area as well as in the "seep" area at the head of the SCB. Localized groundwater detections likely related to these soil concentrations were also noted in those areas.

8.3.12.2 Groundwater

The lone permanent monitoring well in the TRA EA is C-level monitoring well TW-2. TCE was the only compound detected at a concentration that exceeds its applicable RI screening value of 0.28 ug/L in the 2013-2017 samples assessed from this well. TCE was detected once in 2013 at a concentration of 1.1 ug/L and then in 2017 at a concentration of 0.52 J ug/L. PCE, cis-1,2-dichloroethene, cumene and toluene were also sporadically detected at concentrations below their applicable RI screening values. The detections of chlorinated solvents in this C-level well are suspected to be related to off-Site sources. No nexus between these detections of chlorinated solvents and Site-related detections exists.

8.3.12.3 Summary

The only detections of note in the TRA EA are in soils. Those concerns are summarized above in Section 8.3.12.1 and not repeated here.

8.4 SOIL GAS

As part of the 2009 FI, at the request of the NJDEP, CSI obtained a total of nineteen (19) soil gas samples (including duplicates) spread across the APA, IPA, and TF/TLA EAs. The locations of these samples are shown on Figure 8-4. All of the soil gas samples were analyzed for VOCs only. The data from these samples are provided on Table 8-85 and a frequency of detection table for these data is provided as Table 8-86.

The following compounds had detected concentrations in these soil gas samples that exceeded their applicable RI screening value: 1,1-dichloroethane, 1,3-butadiene, benzene, cumene, cyclohexane, ethylbenzene, n-hexane, and vinyl chloride. A discussion of the noted soil gas detections for each compound and how they relate to soil and groundwater detections noted above is as follows:

- 1,1-dichloroethane – The detection of this compound in soil gas is unusual as this compound was infrequently detected on the Site. However, some chlorinated solvent detections have been noted in the vicinity of the former maintenance shop that was located in the southeast corner of the IPA EA. This compound was detected in soil gas from locations APA-6, APA-11, APA-12, IPA-13, and IPA-17. These locations are in the vicinity of the former maintenance shop. Thus some correlation between the soil detections in that area and these soil gas detections exist.

- 1,3-butadiene – Ten (10) of the nineteen (19) soil gas samples had detections of this compound. All ten (10) of those detections were at concentrations that exceeded the applicable RI screening value for that compound of 0.41 ug/m^3. This compound is commonly associated with air emissions from gasoline engines. Its presence in ten (10) samples ranging from the TF/TLA to the IPA area likely indicates that some cross contamination with vehicle emissions occurred during the sampling process. However, this compound is a gas at typical pressures and temperatures and is thus not included in typical soil and groundwater analytical suites. Thus, there are no soil and groundwater data for which to evaluate this soil gas detection.

- Benzene – This Site-related compound was detected in all nineteen (19) of the soil gas samples at concentrations that exceeded the applicable RI screening value of 1.6 ug/m^3. The highest concentration was detected in sample APA-8 located just south of the former process area. This is an area of known soil and groundwater detections. The detections of this compound throughout the main site area are consistent with historical data for the Site.

- Cumene – This Site-related compound was detected in seventeen (17) of the nineteen (19) soil gas samples from the Site. Nine (9) of those detections were at concentrations that exceeded the applicable RI screening value of 180 ug/m^3. The highest concentration was detected in sample APA-3 located in the former alkylation area in the northwest corner of the APA. This is an area of known soil and groundwater detections. The detections of this compound throughout the main site area are consistent with historical data for the Site.

- Cyclohexane – This compound was detected in fourteen (14) of the nineteen (19) soil gas samples from the Site. Two (2) of those detections, TL-3 and TL-5, had concentrations that exceeded the applicable RI screening value of 260 ug/m^3. These detections are consistent with the one (1) detection of this compound in soils (FP-SRI-01) in the TL/TF EA in the vicinity of the former TLA USTs.

- Ethylbenzene – This Site-related compound was detected in five (5) of the nineteen (19) soil gas samples from the Site. All five (5) of these detections were at concentrations that exceeded their applicable RI screening value of 4.9 ug/m^3. Two (2) of these samples, TL-3 and TL-5, are in the vicinity of the former TLA USTs where the highest concentration of ethylbenzene in the TL/TF EA was detected in sample TL-SB02A. Sample TF-3 in the TF area along the southern property line also had a concentration above the RI screening value, but had no direct correlation to soil samples in this vicinity. This detection of ethylbenzene in soil gas may be related to groundwater detections in this vicinity as this is the area where shallow groundwater extraction wells (PW-8 and PW-12) are present. These wells collect impacted groundwater and thus artificially increase the concentrations of Site-related constituents in groundwater in this area. Sample IPA-13 also had a concentration of ethylbenzene above its RI screening value. This sample is located in close proximity to sample location IPA-10 that had the highest concentration of this compound in soils. Finally, sample APA-3 located in the former alkylation area of the APA had a concentration above its RI screening value. This sample is not located close to soil sample FP-SRI-02 that had the highest detected concentration of ethylbenzene in soils in the APA. However, some concentrations of ethylbenzene in soils are located in the former alkylation area and are thus the likely cause of the soil gas detection in sample APA-3. These detections are consistent with known Site detections.

- N-hexane – Ten (10) of the nineteen (19) soil gas samples from the Site had detections of this compound. Two (2) of those detections, TL-3 and TL-5, were at concentrations that exceed their applicable RI screening value of 310 ug/m^3. The two (2) samples, TL-3 and TL-5, are both located in the vicinity of the former TLA USTs. However, this compound is a gas at typical pressures and temperatures and is thus not included in typical soil and groundwater analytical suites. Thus, there are no soil and groundwater data for which to evaluate this soil gas detection.

- Vinyl Chloride – The detection of this compound in soil gas is unusual as this compound was infrequently detected on the Site. However, some chlorinated solvent detections have been noted in the vicinity of the former maintenance shop that was located in the southeast corner of the IPA EA. This compound was detected in soil gas from locations APA-6 and IPA-13. These locations are the closest soil gas samples to the vicinity of the former maintenance shop. Thus some correlation between the soil detections in that area and these soil gas detections exist.

The soil gas detections of benzene, cumene, cyclohexane and ethylbenzene are consistent with Site-wide detections of these compounds in both soil and groundwater in the former process area of the Site.

The detections of 1,3-butadiene and n-hexane are difficult to assess as there are no correlating data in soil and groundwater to compare against. These compounds are typically gaseous at standard pressures and temperatures and are thus not typically included in soil and groundwater VOC analyses. N-hexane was detected in ambient air samples during the 2010-2011 VI study conducted along the southern property line. Thus, detections of this compound may be related to ambient conditions in the vicinity of the Site. The detections of 1,3-butadiene may also be related to ambient conditions from the neighboring refinery or car emissions in the area.

The detections of 1,1-dichloroethane and vinyl chloride appear to be associated with localized chlorinated solvent detections in the vicinity of the former maintenance shop in the southeast corner of the IPA EA. The presence of both 1,1-dichloroethane and vinyl chloride indicates that the historical chlorinated solvents in this area are naturally degrading.

8.4.1 Supplemental Off-Site Locations

As noted in Section 1.2.2, an off-Site VI study along Railroad Avenue, immediately downgradient of the Site's southern property boundary was conducted between May 2010 and March 2011. The study was requested by the EPA because of benzene concentrations in samples from extraction well PW-8 along the southern property boundary and the proximity of these detections to nearby residences. This study concluded that that the pathway between shallow groundwater and indoor air in the neighborhood south of the Site was incomplete. Results of this investigation are reported separately in the *Sub-slab, Soil Gas and Indoor Air Vapor Intrusion Investigation Report* [CSI, 2011].

8.4.2 Soil Gas Summary

The soil gas detections in general correlate with areas of known Site-related soil and groundwater detections. As noted above, a thorough investigation of off-site vapor intrusion risks was conducted and found that the pathway to nearby homes is incomplete. As noted in the HHRA [RBR, 2017] for the Site, future development at the Site will need to take into account the potential for vapor intrusion. However, no current risk to human health or the environment from these on-Site detections was noted because of the lack of buildings on the Site.

8.5 SITE WIDE GROUNDWATER

A thorough review of the groundwater hydrogeology at the Site is provided in Sections 5.2 and 6.2. This section will focus on the nature and extent of Site wide groundwater detections. The above nature and extent discussions for each EA touch on specific groundwater detections within each of those areas. This section will focus on the comprehensive groundwater detections at the Site from Site-related compounds benzene, cumene and ethylbenzene. Some localized detections of toluene and TRP are also present, but the extent of these detections are minimal and are thus covered under the EA discussions above and not reiterated herein. As noted above and covered extensively in Section 9.0 below, impacted groundwater at the Site is captured through extraction well pumping in key portions of the A-level, B-level, and C-level water-bearing zones beneath the Site. This pumping maintains capture to ensure that impacted groundwater is hydraulically contained.

The extent of groundwater detections of benzene, cumene, and ethylbenzene for the A-level, B-level and C-levels beneath the Site, based upon the 2017 second quarter annual sampling event data, are provided on Figures 8-5 through 8-13. These graphics present isoconcentration contours representing the extent of groundwater detections at concentrations above the applicable RI screening values for each of the three (3) compounds. The following is a discussion of the information presented in those graphical depictions of Site wide groundwater detections.

8.5.1 Benzene

Benzene was the compound first detected in a USGS monitoring well in 1979 that began the investigative history of this Site. It is the Site-related compound in groundwater with the highest toxicity and is thus the primary driver for risk related to groundwater.

8.5.1.1 A-level

As shown on Figure 8-5, there are four (4) primary areas of benzene detections in A-level groundwater. Traveling from south to north across the Site, the first area of benzene groundwater detections is centered on the shallow A-level extraction wells PW-8 and PW-12. These A-level extraction wells control flow in the A-level along the downgradient property line, nearly eliminating off-Site migration of Site-related detections in A-level groundwater. This pumping induces A-level groundwater flow toward these two (2) extraction wells, resulting in elevated concentrations of dissolved-phase constituents in close proximity to PW-8 and PW-12 as shown graphically on Figure 8-5.

To the north of this area on the border between the TF/TLA and APA EAs lies an area of benzene groundwater detections centered near monitoring well MW-6. Groundwater detections in this vicinity are believed to be an artifact related to soil detections in the former oxidation area of the APA. Shallow groundwater also migrates vertically downward into the underlying B- and C-levels where gaps in the underlying low permeability clay exist.

The primary area of benzene impacted groundwater in the A-level at the Site is located in the vicinity of PW-6. Groundwater detections in this area, near wells PW-6 and MW-10 in particular, are significant and likely from multiple contributions including the API Skimmer, the former underground process sewers, and nearly 60 years of operational activities in the former APA and IPA. These wells are where the highest concentrations of benzene in groundwater in the A-level are typically detected. From this area, groundwater flow migrates predominantly downward into the B- and ultimately the C-levels through gaps in the underlying clay.

Finally, the A-level benzene groundwater detections located the furthest north on the Site are found in the NCL centered near monitoring well MW-38. Detections in this vicinity are related to historical use in the NCL including waste disposal near the “perched zone” of the NCL. Groundwater in the NCL also preferentially migrates downward into the B-level where it enters the regional south-southwesterly flow pattern.

8.5.1.2 B-level

As shown on Figure 8-6, there are three (3) primary areas of B-level benzene detections beneath the Site. Starting from the south and moving northwards, the first area of detections are located near the border of the TF/TLA and the APA is the largest. This area, centered around former extraction well PW-5B is reflective of where groundwater with SSCOC detections from the A-level has migrated downwards to the B-level from multiple sources within the APA. Primary contributions for migration of groundwater with SSCOC detections to the B-level include: the API skimmer, the former underground process sewers plus nearly 60 years of operational activities in the former APA, IPA, and surrounding areas and, to a lesser extent, the TF/TLATF/TLA.

Moving to the north across the Site the next area of significant benzene detections in the B-level is in the SCB EA centered near wells MW-45B and MW-46B and migrating towards MW-44B in the IPA EA. The main contribution of SSCOC detections to these B-level groundwater wells is believed to be from soil underlying the former MPP SIs and the surrounding area. Concentrations of benzene above the RI screening value were noted in this area as discussed above in Section 8.3.10.1.

Finally, in the NCL EA, an area of B-level benzene detections is centered near monitoring well MW-50B. The source of these benzene groundwater detections is the historical use in the NCL including waste disposal near the “perched zone” of the NCL where concentrations of benzene above the RI screening value in soil were noted in Section 8.3.7.1.

8.5.1.3 C-level

As shown on Figure 8-7, there are only two (2) small areas of C-level benzene groundwater detections. The larger area is along the southern property boundary in the vicinity of C-level extraction well PW-11 and monitoring well MW-8C shows where C-level groundwater extraction captures water in this zone. The other area of C-level benzene groundwater detections occurs near monitoring well MW-10C. MW-10C has a detection of benzene that slightly exceeds the applicable RI screening value of 0.46 ug/L. As noted above, it is in the vicinity of MW-10C where the majority of A- and B-level groundwater migrates downward to the C-level through gaps in the semi-confining clay layers.

8.5.2 Cumene

Cumene is the Site-related compound most commonly detected in soil and groundwater at the Site. However, the toxicity of cumene is far lower compared to benzene, thus the applicable RI screening value for cumene is forty-five (45) ug/L compared to the 0.46 ug/L screening value for benzene.

8.5.2.1 A-level

As shown on Figure 8-8, there are five (5) distinct areas of the Site with appreciable cumene groundwater detections in the A-level. Starting in the southwestern corner of the Site there is one (1) area of cumene detections centered on monitoring well MW-5. Concentrations of cumene have risen slowly in this vicinity since the shutdown of most of the B-level extraction wells in 2014. The source of these detections is likely from shallow soil in the southwest corner of the TF/TLA EA and from the vicinity of the former TLA USTs as noted in Section 8.3.11.1 above. A-level groundwater in this southwest corner of the Site is expected to migrate downward through a gap in the A-level confining clay layer in this vicinity. There is no evidence of off-Site migration of groundwater with cumene concentrations MW-5. Moreover, the fate and transport evaluation (Section 9) confirms that A-level cumene (and benzene) will not migrate off-Site under current pumping conditions. The noted increase in cumene concentrations in samples from MW-5 simply reflects groundwater quality (and flow) fluctuations associated with the dynamic groundwater environment and the cessation of pumping in four (4) B-level wells.

Moving east along the southern property fence line, the next area of A-level cumene detections in groundwater is found in the vicinity of A-level extraction wells PW-8 and PW-12. These extraction wells are designed to capture A-level groundwater and thus elevated concentrations of cumene near these wells is anticipated. Recovered groundwater from these A-level wells is transmitted to the Site groundwater treatment system for treatment.

North of the A-level extraction wells, on the border between the TF/TLA and APA EAs, lies an area of groundwater with cumene detections centered around well MW-6. Groundwater detections in this vicinity are an artifact related to soil in the former oxidation area of the APA. Shallow groundwater near MW-6 also migrates vertically downward into the underlying B- and C-levels where gaps in the underlying low permeability clay exist.

The primary area of cumene detections in groundwater in the A-level at the Site is located near PW-6 along the border between the APA and IPA. Groundwater detections in this area, near wells PW-6 and MW-10 in particular, are significant. Additionally, detections of cumene above the applicable RI screening value are noted in samples from MW-51. These cumene concentrations are likely from multiple contributions including the API Skimmer, the former underground process sewers, and nearly 60 years of operational activities in the former APA and IPA. These wells are where the highest concentrations of cumene in groundwater in the A-level are typically detected. From this area, groundwater flow migrates predominantly downward into the B- and ultimately the C-levels through gaps in the underlying clay.

Just north of the large area of cumene detections in the IPA/APA is a small area of cumene detections centered on well MW-45. Groundwater detections in this vicinity are likely related to soil found beneath the former MPP SIs.

Finally, the A-level cumene groundwater detections located the furthest north on the Site are found in the NCL centered near monitoring wells MW-37 and MW-38. Groundwater detections in this vicinity are primarily related to soils in the NCL near the “perched zone.” Groundwater in the NCL also preferentially migrates downward into the B-level where it enters the regional south-southwesterly flow pattern.

8.5.2.2 B-level

As shown on Figure 8-9 and similar to benzene, there are three (3) primary areas of B-level cumene detections beneath the Site. Starting from the south and moving northward, the first area of detections is the largest. This large area in the vicinity of former extraction well PW-5B and monitoring well MW-6 is reflective of groundwater detections from the A-level migrating vertically downward into the B-level from multiple locations within the APA, IPA and TF/TLA EAs. Primary contributions for migration of groundwater with detected concentrations of SSCOCs to the B-level include the API skimmer, the former underground process sewers plus nearly 60 years of operational activities in the former APA, IPA, and the surrounding areas, and to a lesser extent the TF/TLA.

Moving north across the Site, the next area of significant cumene detections in the B-level is in the SCB EA in the vicinity of wells MW-45B and MW-46B and migrating toward MW-44B in the IPA EA. The primary source for these B-level groundwater detections is believed to be from soil underlying the former MPP SIs and surrounding area. Concentrations of cumene above the RI screening value were noted in this area as discussed above in Section 8.3.10.1.

Finally, in the NCL EA an area of B-level cumene detections is centered near monitoring well MW-50B. The source of these benzene groundwater detections is the soil in the NCL near the “perched zone” where concentrations of cumene in soil were noted at concentrations above the applicable RI screening value in Section 8.3.7.1.

8.5.2.3 C-level

As shown on Figure 8-10, there are two (2) notable areas of C-level cumene groundwater detections. Both are located along the southern property boundary. One of these areas is centered in the vicinity of C-level extraction well, PW-11. This is the primary C-level groundwater extraction well responsible for establishing and maintaining C-level hydraulic capture for the Site. One other C-level monitoring well, MW-48C, has been noted to have some increasing concentrations of cumene since the B-level extraction wells were shut down in 2014. Based upon the known presence of a gap in the B and C-level confining layer in this vicinity, it is believed that the increasing concentrations in MW-48C demonstrates that equilibrium conditions may have shifted slightly to the southwest and downward from the A-level into the underlying B- and C-levels near MW-48C. Groundwater at MW-48C is located within the hydraulic capture zone created by pumping C-level wells PW-4R and PW-11. In addition, fate and transport analysis (Section 9) confirms that appreciable off-Site groundwater detections of cumene and benzene will not occur under present pumping conditions.

8.5.2 Ethylbenzene

Ethylbenzene is also a Site-related compound that has groundwater detections similar to those for benzene and cumene as noted above. A review of Figures 8-11 (A-level), 8-12 (B-level), and 8-13 (C-level) shows very similar detections to those noted above with some minor differences. For instance, no A-level detections of ethylbenzene are noted in the southwest corner of the Site. In the B-level, there are no ethylbenzene groundwater detections emanating from the former MPP SIs that result in detections in monitoring wells MW-45B and MW-46B. Finally, in the C-level, ethylbenzene groundwater detections are noted only in a small area centered on extraction well PW-11. In general, therefore, the lateral and vertical distribution of dissolved ethylbenzene shows a similar pattern compared to benzene and cumene but to a lesser extent and at relatively lower concentrations.

8.5.3 Summary

It is clear from the above that the areas of most significant groundwater detections at the Site are centered in the following three (3) areas:

- An area extending from the southern property boundary in the vicinity of extraction wells PW-8, PW-12, and PW-11 to the intersection of the APA and IPA near the former API skimmer and former Site process areas.

- An area downgradient of the former MPP SIs centered near wells MW-45B and MW-46B.

- The central portion of the NCL in the vicinity of wells MW-37, MW-38 and MW-50B.

From each of the above areas, groundwater flow is generally southerly and vertical downward from the A-level, through the B-level and ultimately into the C-level through discontinuous clay layers separating the different water-bearing zones. Decades of groundwater pumping and optimization of hydraulic capture have successfully prevented off-Site migration of Site-related constituents. Groundwater pumping also has helped reduce the dissolved phase extent and magnitude of detected concentrations, particularly along the southern, downgradient property boundary. Groundwater recovered using the groundwater extraction well network is transmitted to the on-Site treatment system.

Future mitigation efforts will consider alternatives to reduce constituent mass and transport that is principally contributing to the observed distribution of dissolved phase constituents in A-, B- and C-level groundwater at the Site. Further evaluation regarding the fate and transport of Site-related constituents is provided in Section 9.

9.0 FATE AND TRANSPORT

The fate and transport (F&T) of Site-related COCs and TICs, which were identified in Section 1.2.2, are described in this section. The physical and chemical properties of the individual COCs/TICs as well as Site-specific characteristics (geology, groundwater, surface water, geochemistry and physical characteristics), all influence F&T at the Site.

This section also presents a summary discussion of F&T considerations applicable to non-Site related COCs found in soil, sediment, and groundwater during Site investigations.

9.1 ROUTES OF MIGRATION

A detailed evaluation of Site investigation data are summarized within the Nature and Extent section of the RI (Section 8). Completed pathways identified during the course of the RI that are discussed further in this section include the following:

- Volatization and transport of SSCOCs in vadose zone into soil gas with potential for atmospheric discharge;
- Dissolution of vadose zone mass into groundwater and diffuse transport;
- R-NAPL in saturated soil, including possible re-adsorption onto soil matrix and subsequent dissolution into groundwater as well as diffuse transport; and
- Particulate and dissolved phase transport of SSCOCs in surface and subsurface sediment into surface water.

As discussed in Section 6, overland transport of SSCOCs during former Site operations prior to 1991 is also suspected of contributing to the presence of SSCOC concentrations above the RI screening value in sediments within the SCB, 002 Outfall/drainageway and Clonmell Creek. Construction of the permitted 002 Outfall in late 1991 prevented further overland sediment deposition to Clonmell Creek from the former facility process areas. This historical transport pathway will be discussed in the context of where the SSCOCs currently reside in soil and sediment.

9.2 COC DISCUSSION

This section details F&T considerations for SSCOCs. Discussion of non-Site related constituents is provided in Section 8.0. For the purposes of the F&T discussion SSCOCs have been segregated into two categories, primary and secondary. In this section primary SSCOCs are those that are the most prevalent throughout the Site. The primary SSCOCs present the greatest risk to potential receptors through transport from the Site or from long-term persistence at the Site. Secondary SSCOCs are compounds identified above applicable RI screening values that are typically found in association with primary SSCOCs but at significantly lower concentrations and with a more limited extent. The SSTICs identified in previous sections are also included with the Secondary SSCOCs. The Secondary SSCOCs and SSTICs are relatively short-chained aromatic hydrocarbons with similar ranges of solubility, vapor pressures, and groundwater transport characteristics to the Primary SSCOCs. A few of the Secondary SSCOCs and SSTICs have specific gravities slightly above 1 whereas the Primary SSCOCs are all below 1.

Primary SSCOCs

Cumene

As discussed throughout this RI, cumene is the most widespread SSCOC at the Site. Cumene has been found at concentrations exceeding applicable RI screening values in vadose and saturated soil, sediment, soil gas, and groundwater. Cumene has a relatively low vapor pressure (4.5 mm Hg), making it only moderately volatile. It has a specific gravity of 0.862; meaning in pure, free-phase form, cumene would be expected to occur as LNAPL when in contact with groundwater. It also has a relatively low solubility compared to other aromatic hydrocarbons with a calculated Site-specific solubility range of 42.6 to 107 mg/L. In 2016, CSI developed a Site-specific C-Sat range for cumene, which represents the calculated maximum soil concentration for cumene before free-phase NAPL droplets are expected to be present in soil. The C-Sat values ranged from 98.11 to 149.37 mg/kg [CSI, 2016].

Like most simple light hydrocarbons with moderate to high volatility, cumene also serves as a readily available carbon source and typically will readily bioattenuate in the presence of oxygen and nutrients when concentrations are below saturation values. In vadose soil at concentrations below the saturation value, the high volatility and bioavailability of cumene generally results in rapid degradation. As discussed in Section 6, historical activities at the Site created conditions at the time of release that allowed cumene to become emplaced in subsurface soils as R-NAPL below the water table over a wide aerial extent (significant portions of the former APA and smaller portions of the IPA). Specifically, it is suspected that cumene was co-solved with other compounds in process fluids formerly used in the manufacturing processes, several of which have specific gravities slightly greater than 1 (for example, cumene hydroperoxide was formerly used extensively during historical Site operations and has a specific gravity of 1.05). This submerged R-NAPL emplacement combined with the low solubility and the relatively low C-Sat value indicate that submerged free phase cumene droplets will degrade relatively slowly under the steady state groundwater conditions at the Site.

Benzene

Benzene has been detected at concentrations exceeding applicable RI screening values in soil, sediment, soil gas, and groundwater. Benzene has a relatively high vapor pressure (94.8 mm Hg), making it volatile in natural conditions. It has a specific gravity of 0.876; meaning in pure, free-phase form benzene would be expected to occur as LNAPL when in contact with groundwater. Benzene has a relatively high solubility in water (1,800 mg/L). Benzene has not been found at concentrations above its solubility and thus is not present as a free-phase constituent. This has been confirmed by review of more than 30 years of investigation data. Furthermore, as discussed in Section 8.1.1, benzene was not detected as one of the hydrocarbons in a 2011 NAPL sample collected as part of AS/SVE pilot testing. Similar to cumene, benzene is a light hydrocarbon that readily acts as a carbon source for biological consumption in the presence of oxygen both in vadose zone soil and as a dissolved constituent in groundwater. This bioavailability combined with high solubility in groundwater and its relatively high volatility means that benzene will generally degrade rapidly in vadose zone soil as well as dissolved in groundwater where sufficient oxygen is present. This is particularly true for benzene at this Site which, unlike cumene, does not appear to be appreciably co-solved with the R-NAPL and other saturated hydrocarbons.

Secondary SSCOCs and SSTICs

- Ethylbenzene
- Toluene
- Total Recoverable Phenols (TRP)
- A-Methylstyrene
- Acetophenone
- Diisopropylbenzene
- Di-tert-butyl-p-cresol
- Dimethylbenzyl alcohol

The SSTICs and secondary SSCOCs all have characteristics or sufficiently low concentrations that they are not expected to persist in any media at the Site except in areas where significant concentrations of cumene or benzene are present. These SSTICs and SSCOCs are typically associated with the primary SSCOCs and are not found at concentrations exceeding the RI screening value independently at the Site.

a-Methylstyrene

The SSTIC a-methylstyrene has been found in vadose soil, saturated soil, sediment, and groundwater at the site. A-methylstyrene is similar to cumene in that it has low vapor pressure (1.9 mm Hg), a specific gravity less than 1.0, and a very similar octanol/water partition coefficient (K_{OW}) value to cumene. The solubility of a-methylstyrene (116 mg/L) is relatively low, although it is higher than the solubility of cumene. A-methylstyrene is also very similar to cumene with respect to chemical composition and its bioavailability for attenuation. Overall, it would be expected to have similar F&T characteristics to cumene. The nature and extent evaluation indicates that a-methylstyrene is generally found associated with cumene, though a-methylstyrene has a smaller aerial and vertical footprint compared to cumene. Additionally, a-methylstyrene has significantly higher RI screening values compared to cumene, mainly due to its comparatively low toxicity for human health and the environment. Based on the more limited extent of a-methylstyrene in soil, sediment, and groundwater along with the higher screening values, a-methylstyrene would not be expected to persist in areas where cumene doesn't exceed the applicable RI screening value. As a result, this F&T section assumes that a-methylstyrene does not warrant further independent scrutiny and that future remediation decisions for cumene will also adequately address a-methylstyrene at the Site. It should be noted that to maintain a conservative approach, this RI will incorporate the calculated mass assumption for a-methylstyrene into a normalized cumene total. Additionally, continued monitoring for this SSTIC during the remedy phase should be conducted to verify that a-methylstyrene diminishes over time, as anticipated.

Total Recoverable Phenols (TRPs)

TRPs consist of a suite of phenolic compounds that continue to be detected at concentrations above applicable RI screening values in groundwater. These exceedances are located within areas of where cumene concentrations were also detected above the applicable RI screening value. The distribution of TRPs above the applicable RI screening value at the Site is much smaller compared to the cumene footprint. The size of the TRP footprint has decreased significantly since pumping and treating of Site groundwater began in 1987. The highest recent TRPs concentration in groundwater (approximately 170 mg/L) is well below historically detected TRPs concentrations at the site (>450 mg/L). In general, the highest TRP concentrations in groundwater are found in shallow B-level wells under the central APA (MW-51B) and central TF/TLA (MW-56B), not adjacent to any extraction wells.

NAPL fingerprint samples collected in 2011 predominately consisted of cumene and a-methylstyrene but did contain approximately 3% TRPs (Table 2-2). This TRP mass is likely chemically entrained within the R-NAPL and only mobilizes as associated cumene and AMS partition to the dissolved phase. Although TRPs as a group have lower Kow values than cumene and a-methylstyrene, the mass of TRPs capable of keeping groundwater concentrations above applicable RI screening values will be expected to attenuate and diminish from the R-NAPL long before the R-NAPL fully attenuates. It should also be noted that TRPs are semi-volatile in nature with a lower vapor pressure (<1 mm Hg) compared to the primary SSCOCs. This indicates that the residual TRPs in groundwater are not likely to pose a risk for the generation of soil gas.

Similar to the primary SSCOCs, TRPs consist of short-chained hydrocarbons that readily act as a carbon source for biological consumption in the presence of oxygen both in vadose zone soil and as a dissolved constituent in groundwater. This bioavailability combined with high solubility in groundwater means that TRPs will generally degrade rapidly in vadose zone soil and when dissolved in groundwater where sufficient oxygen is present.

Additionally, TRPs that exceed RI screening values in groundwater have a relatively small lateral and vertical footprint limited to detections in wells MW-10R, MW-6B, MW-51B, MW-

56B and PW-6. Also, TRPs are present at concentrations that are more than an order of magnitude below cumene concentrations. As a result, it is anticipated that TRPs will diminish before cumene and a-methylstyrene attenuate as the dispersed R-NAPL degrades. Review of the historical Site data corroborates this, as historical detections of cumene in 1991 along the downgradient property boundary were higher and more extensive than those observed at the Site in 2017 (Figure 9-1).

There is no evidence to indicate that the TRPs will migrate beyond the extent of more mobile primary SSCOCs. This is supported by the much lower Kow values for TRPs compared to the primary SSCOC Kow values. Furthermore, the applicable RI screening values for TRPs are similar to or higher than the values for cumene. This further diminishes the risk that residual TRP concentrations above the RI screening values will persist after cumene attenuates. As a result of these factors, the specific F&T of TRPs will not be further evaluated.

9.2.1 Primary SSCOC persistence

Cumene and benzene have similar chemical characteristics at low concentrations (below saturation) in soil, soil gas, and as dissolved phase constituents in groundwater. Due to their moderate to relatively high vapor pressures and bioavailability as a carbon source, they both attenuate rapidly in vadose zone soil through volatilization and biodegradation. Once mobilized as soil gas, both compounds will generally continue to attenuate rapidly due to their bioavailability and volatility.

As dissolved phase constituents in groundwater, both cumene and benzene will generally degrade rapidly through natural biodegradation processes. Cumene, with its lower solubility and volatility, would be expected to persist longer in source areas as diffuse R-NAPL, where present, and as a dissolved constituent. Benzene would generally be expected to be more mobile than cumene and migrate further due to its chemical characteristics (see Section 9.2.2, below). However, it is not anticipated that benzene will accumulate or persist at high concentrations beyond the primary Site source areas in the more oxygenated groundwater observed downgradient from the on-Site source areas (see Natural Attenuation Groundwater Data included in Appendix Q and natural attenuation synopsis below). The relative proportion of on-Site benzene to cumene in groundwater is generally found at a 1:10 ratio at the Site. These observations are supported by decades of groundwater monitoring results which reveal negligible concentrations of benzene downgradient from the Site.

Natural attenuation groundwater data parameters evaluated during the last several years of Site groundwater monitoring are provided in Appendix Q. A reference map showing A-level ORP values in 2017 is also provided in Appendix Q along with ORP figures for 2012-2016. Review of the ORP figure and data reveals the transition from negative ORP values on-Site (reducing condition) to increasingly positive ORP values indicative of oxidizing conditions immediately downgradient from the Site. The A-level ORP trends shown on the 2017 ORP figure are also observed in the B- and C-levels (reducing conditions on-Site and increasingly oxidizing conditions downgradient from the Site). From an F&T perspective, this is significant as the increasingly oxidizing groundwater conditions observed downgradient will enhance microbial degradation of benzene, cumene and other Site-specific organic compounds.

Cumene, which occurs as dispersed R-NAPL at the Site (along with a-methylstyrene), appears to degrade rapidly in the vadose zone soil at concentrations at or above the calculated C-Sat value. This is due to the low vapor pressure and bioavailability of cumene as a carbon source. The cumene found below the saturated zone appears to be in a condition that is conducive to long-term persistence in saturated soils in its current anoxic condition. Due to the low solubility of cumene, its affinity to bonding with soil bound organic matter, and lack of bioavailability as submerged dispersed R-NAPL, cumene has a slow degradation rate and will likely persist for decades under current ambient conditions.

In the current steady state groundwater conditions, the presence of the diffuse R-NAPL will inhibit degradation and attenuation of cumene. The diffuse R-NAPL occupies some of the pore space in the soil limiting its dispersion and constricting pore volume flushing with oxygenated groundwater and nutrient recharge within these areas. Additionally, the surface tension of the submerged R-NAPL may interfere with the ability of microorganisms to utilize the hydrocarbons as a carbon source, or perhaps decrease the microbial degradation rate.

Under steady state equilibrium conditions, the principal mechanism for significant attenuation within this cumene R-NAPL zone is diffusion into groundwater. As discussed above, the diffusion of cumene into groundwater is limited due to the low solubility of cumene, the restricted groundwater flow into the area, and the surface tension of the hydrocarbon droplets. Along the outer edges of the saturated R-NAPL cumene zone, the presence of relatively higher levels of oxygen, nutrients, and terminal electron acceptors (TEAs) in the groundwater along with higher rates of groundwater flow will allow for a more rapid rate of attenuation. As a result, the extent of subsurface areas where diffuse R-NAPL predominates would be expected to contract over time rather than experience homogeneous volume reduction.

9.2.2 Primary SSCOC MOBILITY

9.2.2.1 Groundwater

Both cumene and benzene have relatively low K_{OW} values. This results in low Site-specific groundwater retardation factors as discussed below. Benzene has a lower K_{OW} than cumene. Combined with benzene's higher solubility, this indicates that benzene will mobilize more quickly than cumene from source areas and will have a potential to transport greater distances. As is often observed with benzene in typical hydrocarbon plumes, its high mobility combined with its bioavailability means that although it is often observed at the leading edge of a groundwater plume it generally attenuates rapidly in typical shallow groundwater conditions.

Groundwater conditions at the Site have been in a state of relative dynamic equilibrium for years. Groundwater pumping has been ongoing at the Site since early in the plant history although the active pump and treat groundwater remedially system in operation since 1987. Operations at the Site ceased in 2009. Hence, the Site source areas are expected to slowly contract over time, though the rate that this occurs will be relatively slow for the reasons previously cited. However, downgradient from the Site, in the increasingly oxygenated groundwater outside of the source zone (see natural attenuation groundwater data results in Appendix Q), cumene and benzene dissipate in a large part due to microbial degradation activities. Even in the absence of pumping or with reduced pumping, dissolved phase cumene and benzene will not migrate extensively, if at all, further downgradient from the Site. The mass transport calculations presented in Section 9.3 below support this assertion regarding increased attenuation rates as SSCOCs migrate away from historical source areas.

9.2.2.2 Soil

9.2.2.2.1 Vadose Zone Soil

As relatively light hydrocarbons, both cumene and benzene have a high mobility in soil. Benzene has not been measured in the R-NAPL dispersed in soil so it was likely emplaced into the subsurface as a minor constituent associated with historical subsurface releases in the primary manufacturing areas formerly operated at the Site. Documented historical surface releases at the Site and the historical presence of SSCOCs in storm water swales also contributed to the observed occurrence and distribution of benzene and cumene in the subsurface. Review of the Site data in Section 8 has shown that transport of benzene and cumene through the soil to groundwater has occurred and any remaining mass in soil will likely result in dissolved phase concentrations in groundwater. However, the relative mass of cumene and benzene in the vadose zone at the Site is generally low for reasons previously cited. The shallow nature of the groundwater at the Site generally minimizes risk of soil gas mobilizing horizontally from the known source areas.

Due to the moderate to high vapor pressures of benzene and cumene, both compounds have the potential to mobilize to the vapor phase in the vadose zone. Detailed discussion of the vapor mobility is discussed in Section 9.2.2.2.3.

9.2.2.2.2 Saturated Zone Soil

The multiple RI investigation phases have determined that saturated soil in multiple locations at the Site contains dispersed R-NAPL comprised principally of cumene and in some cases a-methylstyrene. Review of Site data and the nature of the hydrocarbons in the saturated zone indicate that this dispersed R-NAPL has limited mobility (See Section 8.1.1.1 for discussion of R-NAPL and R-NAPL mobility study in particular).

The R-NAPL has been found to be present as dispersed, emulsified droplets in saturated soils well below the top of the water table. It is believed that process fluids with a specific gravity greater than one (1) were formerly used in manufacturing and introduced to the subsurface. For example, large quantities of cumene hydroperoxide, which has a specific gravity of 1.05, were used on-Site. Appreciable quantities of cumene and a-methylstyrene were co-solved with the former process fluids and currently reside in saturated soil below the top of the water table, despite having individual specific gravities that are less than one (1). Historical and more recent phases of Site investigation have confirmed that this is representative of Site conditions. If cumene and a-methylstyrene had been introduced into the subsurface in relatively pure form, they would be expected to have settled at or near the top of the water table, with submerged mass limited to a smear zone from water table fluctuations.

A sheen has been observed in some shallow wells where some LNAPL accumulated subsequent to AS/SVE testing due to limited mobilization of some of the R-NAPL emulsion. Thus, the bulk of the R-NAPL is comprised of cumene and in some instances a-methylstyrene, as discussed in Section 9.2.1. The R-NAPL is predominantly entrained in the subsurface lithology of the Site as emulsified droplets resulting from former facility manufacturing processes. The R-NAPL emulsification has been documented to have low mobility and is expected to remain in place near the former manufacturing portions of the Site, notably the former APA and parts of the IPA, for an extended period of time.

Entrainment of light hydrocarbon NAPL mass below the water table is a relatively common occurrence observed at light hydrocarbon sites, although the process of entrainment into the subsurface varies. For many of the same reasons discussed in the SSCOC persistence discussion above (Section 9.2.1), the low mobility observed at the Site is also the predicted result, and one that is commonly observed, once the hydrocarbons become submerged and entrained.

9.2.2.2.3 Soil Vapor

Like most light hydrocarbons in vapor phase, the potential exists for mobilization and transport of mass in the vapor phase. However, due to Site conditions, stratigraphy, depth to water, and historical nature of SSCOC distribution, appreciable mass transport in the vapor phase is not anticipated nor has it been observed through sampling. Thus, this is not further evaluated as part of this F&T section.

The vapor phase portion of SSCOCs at the Site amounts to an insignificant portion of the overall mass. The shallow groundwater is predominantly in direct contact with detected soil concentrations and that direct transport is the most likely cause of SSCOCs found in groundwater. Soil vapor is a potential threat to indoor air associated with future Site redevelopment where Site conditions or soil gas data indicate a potential risk of soil gas transport to the surface and will be addressed in the pending Feasibility Study (FS). Due to the shallow groundwater table and high bioattenuation rate of the SSCOCs in the vadose zone, the expectation for soil vapor is that transport would be minimal and exposure risk would be limited to the areas in immediate proximity of R-NAPL. Occupied facilities are not currently present nor are any planned in the immediate vicinity of the former process area of the Site. However, future development would need to consider the possibility for soil vapor transport to indoor air.

9.2.2.3 Sediment and Surface Water

Multiple phases of the RI have focused on sediment and surface water in Clonmell Creek and the SCB. SSCOCs have been detected at concentrations in sediment that exceed the applicable

RI screening value. No SSCOC issues were noted in surface water sampling data. The principal SSCOC found in sediment is cumene, with trace detections of other SSCOCs as detailed in the Nature and Extent Section 8.2.5.4.

The cumene detections are present in the portion of Clonmell Creek extending from the bridge/culvert just north of the groundwater treatment system toward the downstream property boundary. The highest cumene concentrations and mass are present in a deltaic pattern at the confluence of the 002 Outfall and Clonmell Creek. Review of historical information suggests that these deltaic sediments were deposited prior to construction of the 002 Outfall circa 1991. Prior to 1991, it is suspected that cumene adsorbed with sediment was intermittently flushed along with storm water through the OO2 Outfall and deposited as deltaic sediments in the low energy environment of Clonmell Creek. Storm water flow from the Site to Clonmell Creek via the 002 Outfall ceased after its construction in 1991.

Results from the various RI phases have shown that the sediments in Clonmell Creek are comprised of fine grained materials, principally silt with some clay, and are organic rich. The conceptual process for SSCOC entrainment in sediments in this area is that as the sediments containing cumene accumulated in Clonmell Creek, natural deposition of organic rich sediments and additional inputs of sediments containing cumene covered them, and anaerobic conditions prevailed.

As would be expected, near surface sediments (e.g. 0 – 2 inches), are relatively free of cumene and other SSCOCs. Sediments with cumene concentrations above the RI screening value are generally more prevalent at depths of six (6)-inches or greater and extend as deep as forty-eight (48)-inches in certain locations. The significantly higher persistence (see Section 9.2.1) of cumene in an anaerobic state while being adsorbed onto organic rich sediments results in long-term persistence of cumene at these depths. In addition, some of the detected cumene concentrations at these depths exceed C-Sat levels. This suggests that localized R-NAPL may be present and entrained within subsurface sediments.

The pore-water mobility study [CSI, 2014] results are consistent with sediment delineation findings and confirm that cumene is not bioavailable through pore water and is thus virtually immobile while adsorbed onto the organic rich anaerobic sediments at depths below 2 inches. Moreover, the fine-grained and anaerobic nature of the sediments as well as the immobility of entrained cumene suggests that slow attenuation rates likely prevail. Though precise cumene half-life values in the anaerobic sediment column are not known, it is believed to be on the order of years based on empirical Site data.

9.3 SITE SPECIFIC FATE AND TRANSPORT DISCUSSION AND RESULTS

The Site-specific F&T discussion is broken down by individual media (soil, sediment, soil vapor, and groundwater) below. Within the media discussions, the locations identified in the nature and extent discussion (Section 8) as having exceedances of screening levels of site SSCOCs and SSTICs will be evaluated.

Many of these exceedances are Secondary SSCOCs, SSTICs or are compounds determined to be related to off-Site releases. These secondary exceedances or exceedances related to off-Site releases will be briefly discussed but will not be fully evaluated herein as they are not primary risk drivers for remedial action at this Site.

9.3.1 Groundwater

The most significant detections of SSCOCS in Site groundwater are cumene, benzene, and a-methylstyrene. Other secondary SSCOCs are present but at concentrations orders of magnitude less than those listed above. Investigations have determined that cumene and a-methylstyrene are present above saturation values (i.e. NAPL) in saturated zone soil. This results in a known continuing source to groundwater at the Site. Benzene has not been detected at or near saturation values but likely is present below saturation values in soil and may be present as a minor component in the R-NAPL mass. As discussed previously, a-methylstyrene has very similar chemical characteristics to cumene but has a much higher RI screening value, so all F&T calculations and assumptions are conservatively based on cumene.

Site data and long-term projections indicate that benzene and cumene in groundwater at the Site will not migrate more than several hundred feet downgradient above screening values under non-pumping conditions. This indicates that the large mass of these constituents in the subsurface at the Site presents a problem of persistence in groundwater near the source area rather than any significant threat to downgradient receptors. With a current estimate of approximately 1,400,000 pounds of SSCOCs mass in the vadose and saturated soil beneath the Site, localized groundwater concentrations of cumene at or near saturation values will be present for as long as this R-NAPL mass persists.

With source area inputs no longer present from facility operations, the dissolved phase concentrations will remain at or near equilibrium saturation in association with areas containing R-NAPL. However, with cessation of plant operations in 2009, the RNAPL mass will contract over time. As a result, the dissolved phase concentrations will also be expected to contract over time as TEAs and nutrients move into the system and the R-NAPL mass continues to diminish. The following sections discuss the anticipated F&T of the individual aquifer zones.

9.3.1.1 Mass Transport Calculations

F&T calculations for cumene and benzene in groundwater are based on Site-specific data as well as published chemical characteristics information, where available. Calibrating a model to account for a submerged R-NAPL mass and the number of unknown physical and chemical characteristics associated with the mass at this Site is extremely complex if not impossible. Thus, this F&T evaluation uses a number of highly conservative assumptions to demonstrate that cumene and benzene, while present at concentrations that exceed the RI screening value in source areas, do not pose a significant long-term threat to downgradient receptors. The inputs selected for the calculations presented below are intended to present scenarios that are more conservative than those that are anticipated to occur under existing or future Site conditions.

Simple 2D model projections were configured using conservative input parameters to allow more detailed evaluation of F&T considerations for key SSCOCs, chiefly cumene and benzene. Specifically, Bioscreen, which is an EPA screening model for evaluating natural attenuation of hydrocarbons, was used for the transport calculations. Bioscreen allows for the input of aquifer characteristics; chemical specific transport characteristics; simple plume characteristics including plume concentrations, widths, depths, and source area half-life; and performs two types of natural attenuation calculations (first order decay scenario and instantaneous reaction model) using Site and literature derived parameters. The instantaneous reaction model uses several direct measurement groundwater parameters (DO, nitrate, ferrous iron, sulfate, and methane) to calculate an attenuation rate. The first order decay scenario uses a single input of the SSCOC half-life to calculate the mass transport.

The concentrations used for the Bioscreen model were equal to or slightly greater than those observed in monitoring wells closest to the Site boundary. The data used are based on second quarter 2017 groundwater monitoring results. The aquifer properties used were taken from the 2013 groundwater flow model for the Site [ESI, 2013]. The chemical properties used were taken from the National Institutes of Health Toxnet Website (https://toxnet.nlm.nih.gov). The partition coefficients used were determined using formulas taken from EPA guidance [EPA, 1990]. Site data were used for inputs to the plume and natural attenuation parameters, although there were no data for ferrous iron and methane inputs outside of remediation pilot study areas, so zero values were used. This makes the calculations even more conservative.

To be as conservative as possible, the Bioscreen calculations also assumed a continuing source at the 2017 source area concentrations. Currently this is likely only occurring in the areas where R-NAPL is present near the former operating areas of the Site. The source area thicknesses for the dissolved phase B and C level aquifers were assumed to be 10 feet and 5 feet, respectively, which is likely significantly greater than the actual thickness of maximum concentrations, particularly when combined with the continuing source scenario. For the instantaneous reaction solution, a half-life of 4 months was used, which is much higher than previous estimates of approximately one month [ESI, 2013].

The Bioscreen calculations, which are discussed in more detail below, generally indicate that benzene, which has a higher solubility and lower K_{OW} value than cumene, moves more readily into the groundwater and also migrates ahead of cumene. These factors allow for more dilution of benzene in the groundwater system as well as causing benzene to be the first SSCOC to arrive in oxygen rich groundwater outside of the source area, allowing for more rapid biodegradation.

Cumene, which has a low solubility and higher K_{OW} than benzene is persisting as a significant mass in the shallow A-level aquifer which continues to provide dissolved phase mass to the A, B, and C-level aquifers. While this persistence means that cumene will be present in the source area for decades, it also indicates that the relatively low rate of diffusion into the water table is not greater than the biodegradation capacity of the aquifer downgradient of the current and historical source areas. As a result, in a steady state condition, the cumene mass will continue to slowly attenuate without creating a large dissolved phase plume downgradient of the former source areas.

Simple modeling calculations using the conservative assumptions discussed previously, indicate that the current pumping scenario may be hydraulically inducing downward migration of SSCOCs and cumene in particular. Appendix R contains the Bioscreen graphical outputs of all the cumene and benzene transport calculations in the A, B, and C level aquifers. Appendix R also contains images of the inputs used for the calculations along with a summary table of the inputs.

9.3.1.1.1 A-Level Aquifer

Saturated soil and R-NAPL in the A-Level aquifer at the site is currently assumed to be the primary source of SSCOCs in groundwater at the site. The submerged R-NAPL, which contains most of the remaining mass at the Site, is primarily present in the A-Level aquifer; although some R-NAPL is likely present in shallow soils and, possibly, sporadically within Clonmell Creek sediments. As a result of this R-NAPL, groundwater in the area of the R-NAPL contains dissolved phase cumene concentrations at or near saturation. Historical data and knowledge of historical operations indicates that although the current extent of R-NAPL is limited to a few relatively small areas, historical releases of cumene and other SSCOCs occurred throughout a larger area (see Figure 8-1). Review of the current data indicates that some of these areas now only have SSCOCS above the applicable RI screening value in dissolved phase groundwater, with the highest concentrations generally observed in the A-Level aquifer.

The simple mass transport calculations for the A-level indicate that the aquifer conditions and chemical properties of the SSCOCs will cause any mass that migrates away from source areas (Figure 8-1) to attenuate rapidly. The calculations assumed concentrations of up to 14,000 µg/L of cumene, which is slightly higher than the highest concentrations of cumene observed in the A-level at the Site boundary during the second quarter 2017 groundwater sampling event. Benzene was assumed to be at a concentration of 3,200 µg/L.

The transport results for cumene indicate that in the first order decay scenario, cumene will attenuate below the RI screening value within approximately 120 feet of the source area. In the instantaneous reaction model the concentrations will drop below the RI screening value within approximately 400 feet (see Figure 9-2).

For benzene, in the instantaneous reaction model, concentrations dropped below the RI screening value in approximately 120 feet. In the first order decay scenario benzene was below the RI screening value in approximately 300 feet (see Figure 9-3).

Overall, the A-level results indicate that cumene and benzene present limited risk to downgradient off-Site receptors under the current conditions. The projections presented in the conservative F&T model are unlikely to occur based on current Site data showing declining downgradient cumene and benzene concentrations combined with evidence of source area attenuation.

The mass transport calculations correlate well with the observed concentration trends at the Site. Concentrations of cumene and benzene in groundwater have dropped significantly from historic maximums in all areas of the Site, except for the wells in the center of the Site in close proximity to R-NAPL. As expected, benzene concentrations were observed to decline more drastically than cumene concentrations in the historical data.

Appendix S contains a number of trend graphs for concentrations of cumene and benzene that demonstrate the overall reduction in plume size outside of the R-NAPL areas. This overall reduction is not seen in the transport calculations which assumed infinite source mass. The implication of the short transport distances with continuous infinite source mass is that the plume will diminish rapidly as the source area mass depletes.

Review of historical and current Site data also indicates that as groundwater flow approaches the site boundary much of the A-Level flow moves downward into the shallow B-level. This downward movement, combined with the limited maximum extent of downgradient migration indicates that the current dissolved phase mass in the A-level near the Site boundary does not pose a significant threat to downgradient off-Site receptors. This conclusion is supported by over 30 years of chemical data from monitoring wells in the area. The continuing reductions in concentrations outside of the R-NAPL areas also indicates that the only significant long-term risk to the A-level aquifer is the overall persistence of SSCOCs due to the R-NAPL and concentrations of dissolved phase SSCOCs above RI screening values remaining in historical source areas.

9.3.1.1.2 Shallow B-Level Aquifer

The shallow B-level aquifer primarily beneath the former process areas of the Site contains concentrations of cumene and benzene above the applicable RI screening values. In some portions of the Site this aquifer unit, which is discontinuous and heterogeneous at the Site, is somewhat isolated (The B-zone of the PRM Aquifer at the Site subcrops beneath the Site as discussed in Section 6.1). As a result, areas with SSCOCs at concentrations above the RI screening values will require a longer duration to attenuate compared to other aquifer zones.

The natural attenuation groundwater data from groundwater samples collected at the Site during the second quarter annual sampling events from 2011 through 2017 (see natural attenuation groundwater data results in Appendix Q) indicate that if additional TEAs such as oxygen were present in the B-zone aquifer it would allow for increased attenuation of the SSCOCs. Review of the data also indicates that outside of the historical areas of known releases, where SSCOC migration has not overcome the attenuation capacity of the aquifer, cumene and benzene concentrations decrease rapidly. Based on the data from wells located in the deeper portion of the B-level aquifer, discussed below, vertical attenuation within the B-level occurs rapidly as deep B-level wells have concentrations of cumene and benzene below applicable RI screening values.

The 2017 groundwater data along with the simple mass transport calculations for the B-level indicate that cumene and benzene with concentrations above the RI screening value remain in a handful of on-Site wells within the shallow B-level (Figures 9-4 and 9-5). These concentrations will likely remain in those areas for some time due to limited flushing of the aquifer and continuing influx of new mass from the A-level aquifer. However, within the deeper B-level portion of the aquifer, the hydraulic conditions and chemical properties of the SSCOCs will cause any mass that migrates away from source areas to attenuate rapidly in this deeper B-level.

The Bioscreen calculations used assumed concentrations of up to 26,000 µg/L of cumene, which is the highest concentration currently observed in a B-level monitoring well relatively close to the Site boundary (MW-56B). Benzene was assumed to be present at a concentration of 11,000 µg/L. In order to accommodate the high retardation factor of cumene in an infinite source scenario, where the plume will continue to expand unrealistically for hundreds of years, a maximum model time of 100 years was used. This timeframe maintains the conservative approach for the model. When a source area half-life of 100 years is used, the maximum SSCOC migration distances traveled are less than those reported below. Since benzene has a much lower calculated retardation factor than cumene, the model runs of fifty (50) years extend well beyond the predicted timeframe when the plume is expected to reach equilibrium with the infinite source conservatively applied in the model.

The Bioscreen model results for cumene indicate that in the first order decay scenario, cumene will attenuate below the RI screening value within approximately 150 feet of the ongoing Site source area. Review of results for the instantaneous reaction model also reveals that the cumene concentrations will drop below the RI screening value within approximately 350 feet of the source area. The cumene projections are presented in Appendix R and Figure 9-4.

Benzene concentrations in the instantaneous reaction model decrease below the RI screening value within approximately 150 feet of the source area. In the first order decay scenario model, benzene decreased below the RI screening value within approximately 600 feet of the source area. Although the maximum transport distance calculated for benzene is 600 feet, it should be noted that the starting concentration of 11,000 ug/L was obtained for Well PW-5B, located along the southern edge of the former APA, approximately 620 feet upgradient from the Site boundary. Monitoring Well MW-56B, located approximately 220 feet upgradient from the Site boundary, had a 2017 benzene detection above the RI screening value at a concentration of 430 ug/L. The benzene projections are presented in Appendix R and Figure 9-5.

Overall, the B-level aquifer projections indicate that cumene and benzene present only limited risk to downgradient receptors under current conditions, even when applying very conservative assumptions to the model.

The mass transport calculations correlate relatively well with the observed concentration trends in the Site data. Overall there have been limited B-level detections of SSCOCS above the RI screening values observed outside of known historical source areas. Within these areas, the combination of low oxygen and nutrient input into the system as well as ongoing A-level inputs continue to keep concentrations above applicable RI screening values. As a result, concentrations of cumene and benzene in groundwater outside of the historical source areas have dropped significantly below historic maximums. However, within the known and suspected historical source areas, dissolved phase cumene and benzene concentrations are not attenuating as quickly as mass transport calculations would indicate. This is due to the lack of oxygen and other TEAs within these suspected source areas. As expected, benzene concentrations have declined more drastically than cumene concentrations in the B-level. Appendix S contains a number of trend graphs for concentrations of cumene and benzene, which demonstrate the continued lack of significant detections above the RI screening value outside of known and suspected source areas and general stability of groundwater concentrations in these areas. Though further potential mass contributions ceased following cessation of plant operations in 2009, significant B-level SSCOC concentration decreases are not anticipated until R-NAPL mass diminishes further.

9.3.1.1.3 C-Level Aquifer

The C-level aquifer is different in many ways from the other aquifers at the Site. As discussed in Section 8.4, the C-level aquifer appears to be receiving dissolved phase SSCOC concentrations primarily from near the center of the Site where overlying aquitards are more intermittent. As a result, concentrations near the Site boundary are much lower proportionally to the other aquifers than they are further upgradient, closer to the former plant operational areas where the majority of SSCOC mass resides. Additionally, based on the calibrated groundwater transport model [ESI 2013], groundwater velocity in the C-level is 2.5 to 4 times greater than flow in the A and B-levels. This means that more fresh water is able to enter the system providing additional TEAs and nutrients for biodegradation.

The simple mass transport calculations for the C-level indicate that limited new or residual SSCOC mass is currently present in the C-level, and what does remain does not present a significant risk to downgradient receptors. The calculations assumed concentrations of up to 500 µg/L of cumene, which is slightly higher than the highest concentration currently observed in a C-level well at the Site (PW-11). To maintain the conservative approach, a second calculation using a concentration of 1,000 µg/L, which is more than twice the RI screening value for cumene, was also used. Benzene was assumed to be present at a concentration of 20 µg/L, which is also slightly greater than the highest concentration currently observed in a C-level well at the Site (PW-11).

The conservative model results for cumene indicate that in the first order decay scenario, cumene will attenuate below the RI screening value within approximately 40 feet of the source area. For the instantaneous reaction model, the cumene concentrations will drop below the RI screening value less than 50 feet from the source area using the starting concentration of 500 µg/L. For the scenario with 1,000 µg/L as the source area concentration, cumene concentrations drop below the RI screening value approximately 40 feet from the source area using the first order decay scenario and 60 feet using the instantaneous model. The C-level model projections for cumene are presented in Appendix R and on Figure 9-6.

For benzene, the instantaneous reaction model projects that concentrations decrease below the RI screening value less than 30 feet from the source area, while the first order decay projection shows benzene decreasing below the screening level approximately 60 feet from the source area. The C-level model projections for benzene are presented in Appendix R and on Figure 9-7.

Overall, the C-level results indicate that cumene and benzene do not present any risk to off-Site receptors at the current conditions. Maximum Site concentrations are close to RI screening values and currently there are no detections of cumene off-Site. The two off-Site benzene detection concentrations are below the RI screening value and are likely attributable to off-Site petroleum sources unrelated to the Site.

The mass transport calculations correlate relatively well with the observed concentration trends at the Site. C-level groundwater concentrations have decreased significantly over time. This is most likely the result of active sources being attenuated and providing less mass to the deeper aquifer. Residual concentrations outside of the overlying R-NAPL source areas in the center of the Site have all declined below applicable RI screening values and are expected to continue to decline as any residual inputs from the A and B-levels attenuate.

Data from monitoring wells screened in the deep portions of the B-level aquifer have concentrations of cumene and benzene orders of magnitude lower than the shallow B-level, indicating that currently there is minimal vertical dissolved phase loading to the C-level across the Site. Additionally, the C-level aquifer appears to contain plenty of capacity to continue to attenuate dissolved phase SSCOC concentrations prior to it presenting a downgradient risk. Appendix S contains several trend graphs showing benzene and cumene concentrations which demonstrate the continued lack of detections above the RI screening values as well as declining groundwater concentrations in on-Site C-level wells.

9.3.2 Soil

As discussed in Section 8 above, RI screening value exceedances for SSCOCs in soil have been observed in multiple EAs. Outside of detections of cumene and associated SSCOCs in known cumene source areas, exceedances of RI screening values are relatively limited in extent and do not present a risk to receptors outside of the identified source areas, so they will not be discussed further in this section.

9.3.2.1 Vadose Soil

As discussed in Section 8 above, cumene, a-methylstyrene and benzene have all been detected above applicable RI screening values in vadose zone soil. These exceedances are all relatively limited in extent and the majority of the samples were collected as part of the Ph II or SRI investigations. The remaining vadose zone mass is relatively insignificant compared to the residual mass remaining in saturated soil (discussed below). As a result, these vadose zone concentrations do not represent a significant ongoing source of dissolved phase groundwater concentrations.

When current observations are compared to historical data, the extent of the vadose zone SSCOCs appears to have declined over time. Volatilization of the residual mass does continue to represent a potential transport pathway to soil gas receptors. However, the bioavailability of the SSCOCs in vapor phase and limited aerial extent of SSCOCs detected above the applicable RI screening values indicate vapor transport away from the source areas is insignificant.

9.3.2.2 Saturated Soil

Cumene and a-methylstyrene along with other minor fractions of primary and secondary SSCOCs and SSTICs have been detected in R-NAPL samples from the shallow saturated soils in the A-level at multiple locations associated with the former process areas at the Site (e.g. APA and IPA). The potential extent of areas which either contain or may have at one time contained R-NAPL is presented in Figure 8-1. As discussed in Section 9.2.2.2.2, the R-NAPL is submerged beneath the water table, has limited mobility and is not expected to migrate significantly from the current known source areas. Overall, as discussed in Section 9.2.1, the presence of R-NAPL in saturated soil appears to present a long-term consideration related exclusively to persistence in the source areas.

The cumene and in some locations a-methylstyrene in saturated soil represents the largest SSCOC mass at the Site. The estimates presented in Section 8.1.1 indicate that over 1.4 million pounds of SSCOCs are estimated to be present in saturated soils beneath the Site. As discussed above, the high persistence of R-NAPL caused by the general lack of bioavailability and an unknown rate of dissolution in the saturated soil makes it difficult to predict how long the SSCOCs will remain in soil above saturation values.

An additional complicating factor that makes it difficult to predict the overall attenuation duration is that it is not possible to accurately predict the specific mass in any one area. Hence, the overall reduction in mass can only be directly tracked by looking for reduction in the overall volume of material where R-NAPL is present. The historical data do indicate that the R-NAPL mass in saturated soil does not appear to have attenuated significantly since the investigations conducted in the 1990’s at the Site. However, estimates of this type are difficult to verify with available data since facility operations involving cumene did not cease until 2009.

Soil sample results as well as a fingerprint sample of the submerged R-NAPL indicate that benzene is not present above saturation values. It is most likely present as a residual fraction bound to the cumene and a-methylstyrene within the R-NAPL. Some portion of the detected benzene in the saturated zone is also likely present in the dissolved-phase groundwater fraction. The detections of benzene in saturated soil above the RI screening value indicate that concentrations still remain that could diffuse and migrate to shallow soil gas and act as an ongoing contribution of dissolved phase concentrations to groundwater.

The specific total mass of benzene in soil is not known due to the high detection limits of samples caused by the presence of cumene at or above saturation values throughout the suspected historical source areas. However, due to its higher solubility and bioavailability, benzene in the saturated soil will attenuate more rapidly compared to cumene. The historical Site groundwater data and mass transport calculations presented above support this finding. Based on the higher attenuation rate and the lower overall benzene concentrations in the saturated soil combined with similar attenuation pathways, any natural attenuation or remedial scenario that addresses the cumene in soil will likely cause benzene to attenuate below RI screening values before cumene attenuates below saturation values.

9.3.3 Sediment Fate & Transport

9.3.3.1 Sediment Fate

The subsurface cumene detections above the RI screening value in sediments are in an anaerobic state in association with organic-rich material. This indicates that these cumene detections will persist for an extended number of years and likely decades (indirectly confirmed by the fact that they were originally deposited pre-1991 and are currently present at concentrations well above the RI screening value). However, based on the physio-chemical characteristics of cumene and supported by the pore-water study results discussed previously, cumene entrained within the sediment is virtually immobile.

Clonmell Creek is a low energy environment with minimal flow so there is minimal downstream sediment transport. A tidal gate at the confluence of Clonmell Creek and the Delaware River represents a physical barrier that acts to inhibit flow within the creek. The tidal gate is closed most of the time causing surface water to slowly accumulate within in the creek behind the tidal gate. As surface water levels in the Delaware River decline, outward flow from Clonmell Creek to the Delaware River occurs but is generally subdued, limiting sediment scour in the Creek. Surface water conditions including flow and tidal gate considerations are discussed further in Section 6.3.

Cumene has also been measured in subsurface sediments within the SCB at concentrations above the RI screening value. From a persistence and mobility perspective, the sediments within the SCB have a similar profile compared to Clonmell Creek sediments. The cumene concentrations above the RI screening values are principally associated with subsurface sediments in an anaerobic, organic rich environment. Hence, sediments with cumene concentrations above the RI screening value within the SCB will likely persist for an extended period of time. However, the sediments within the SCB are even less mobile than in Clonmell Creek as there is essentially no flow in the SCB. The SCB essentially represents a static surface water feature that fluctuates seasonally based on precipitation. In addition, surface water in the SCB infiltrates downward and recharges shallow groundwater.

A few constituents not considered to be related to the Site have been detected at lower concentrations in sediments within Clonmell Creek and the SCB. Non-Site related compounds of note include: dieldrin; Aroclor 1254; and mercury. Though concentrations of these compounds were relatively low, they did exceed risk screening criteria for select pathways, chiefly related to fish ingestion from recreational activities.

Several other constituents, including a subset of PAHs, a few pesticides and metals were also detected sporadically. However, none of the latter compounds were found to pose a threat to human health and the environment in the risk assessments, with the exception of sporadic detections of the pesticides gamma chlordane and 4,4’-DDD in surface water. These two pesticides were used ubiquitously throughout the region and their intermittent low-level presence in surface water is not surprising.

From an F&T perspective, all of these constituents, with the exception of mercury, have low mobility within the subsurface sediment and, like cumene, are likely to persist for an extended time frame based on current conditions. All of these constituents are essentially entrained within the sediments and will not readily migrate to adjacent soil or groundwater due to the fine-grained low permeability characteristics of the organic-rich sediment. Mercury is highly soluble; however, migration of mercury through the sediment also is likely inhibited due to the highly organic and low permeability nature of the sediment. Sporadic low-level detections of select non-Site related compounds have occasionally been detected in surface water probably as a result of limited sediment disturbances during sampling. Detailed discussions regarding non-Site related constituents are included in Nature and Extent (Section 8) though further F&T analysis of these constituents is not provided.

9.3.3.2 Sediment Transport

Sediments containing cumene at concentrations above the RI screening value within Clonmell Creek and the SCB are essentially immobile as previously cited. The cumene is adsorbed onto fine-grained organic rich sediment in an anaerobic environment. Pore-water study results indicate that the cumene migration through the interstitial pores is negligible. Surface water sampling results reveal that cumene is essentially absent from surface water, providing further evidence to support the immobility and lack of cumene transport within subsurface sediment.

The potential presence of dispersed R-NAPL within subsurface sediments is consistent with C-Sat calculations. However, similar to the adsorbed phase cumene, the dispersed R-NAPL, if/where present, is virtually immobile and entrained within the buried sediments. In short, the adsorbed phase cumene and dispersed R-NAPL are entrained within highly organic, anaerobic sediments and are likely to persist for years if not decades.

Except for molecular diffusion, the transport of cumene from the sediment to other media is not anticipated. Thus, the overall distribution of cumene in sediment with concentrations above the RI screening value is unlikely to vary significantly. In-situ microbial degradation is likely occurring and reducing cumene mass in submerged sediment. However, in-situ sediment conditions are not conducive to robust biodegradation rates as a result of sediment conditions as previously described (minimal pore-water mobility and low sediment permeability combined with high organic content in anaerobic conditions that may be nutrient limited). In addition, the cumene half-life degradation rate in Clonmell Creek sediments is unknown at this time.

Non-Site related COCs (e.g. dieldrin, Aroclor 1254, PAHs) are sporadically detected in Site sediments within Clonmell Creek and are relatively immobile due to their physio-chemical characteristics. These compounds are adsorbed to the organic rich sediment and are not readily amenable to microbial degradation, with the potential exception of PAHs. Thus, it is anticipated that these non-Site related compounds will persist in the subsurface sediment for an extended time period of years, if not decades. Fortunately, their immobility combined with other physio-chemical traits indicates that transport of the compounds to other media is restricted and unlikely. Occasional agitation or disturbance of subsurface sediments may release small quantities of these non-Site related compounds on a sporadic, infrequent basis, which is supported by general absence of widespread detections of these compounds in surface water.

10.0 SUMMARY AND CONCLUSIONS

This section summarizes the RI Report findings and how they relate to the BHHRA and BERA findings as well as the fate and transport mechanisms associated with SSCOCs. The RI findings represent the foundations from which conclusions and recommendations for future work are developed to define the remedial action objectives (RAOs) for the Site.

10.1 SUMMARY

An important finding of this RI Report as well as the numerous historical phases of investigation previously conducted is that impacts at this Site are defined by a specific chemical signature that is distinguishable from naturally occurring and non-Site related anthropogenic influences (background conditions) from the surrounding area. As remediation proceeds at this Site the distinction between Site-related and background conditions will be an important factor.

10.1.1 Risk Assessment

The BHHRA and BERA found that there was no risk to human health or the environment in the following EAs:

- Area A/Open Area;
- Area B;
- Chemical Landfill/Gravel Pit Area;
- Northern Warehouse;
- 002 Outfall and Drainageway (assessed as separate area within the BERA); and,
- Wetland Area.

The BHHRA and BERA found that there was risk to human health or the environment in the following EAs:

- Active Process Area;
- Clonmell Creek;
- Inactive Process Area;
- Northern Chemical Landfill Area;
- Shooting Range;
- Sitewide Groundwater;
- Stormwater Catchment Basin Area;
- Tank Farm/Train Loading Area; and,
- Township Refuse Area.

The specific risks identified by the BHHRA and BERA in each EA are as follows:

- Active Process Area – benzene and cumene via direct contact with shallow A-level groundwater for the outdoor industrial worker and construction/utility worker scenarios and benzene, cumene, TRP and 1,2-dichloroethane via hypothetical ingestion of B/C zone groundwater for the lifetime receptor scenario.

- Clonmell Creek – ingestion of fish tissue related to detections of dieldrin, Aroclor 1254 and mercury in sediment and gamma-chlordane and 4,4'-DDD in surface water for the Recreational Angler and offsite child resident (0-2 years; 2-6 years; and 0-6 years) scenarios. In addition, moderately impaired aquatic communities resulting in potential adverse effects near the 002 Outfall from acetone, cumene, toluene, select SVOCs, PAHs and copper in sediment were found.

- Inactive Process Area - benzene and cumene via direct contact with shallow A-level groundwater for both the outdoor industrial worker and construction/utility worker scenarios.

- Northern Chemical Landfill Area – benzene and cumene via hypothetical ingestion of deep B/C-level groundwater.

- Shooting Range – exposure to lead in surface soil for the outdoor industrial worker scenario and exposure to lead in surface and subsurface soil for the construction/utility worker scenario.

- Site Wide Groundwater – benzene and cumene via direct contact with shallow A-level groundwater for both the outdoor industrial worker and construction/utility worker scenarios.

- Stormwater Catchment Basin Area – potential impairment to aquatic communities though habitat is considered to have limited function and value; and, negligible potential for adverse effects to mammals and birds. Both findings were related to sediment impacts in the SCB itself.

- Tank Farm/Train Loading Area – cumene, TRP, benzene, and TCE via hypothetical ingestion of deep B/C-level groundwater.

- Township Refuse Area - The potentially exposed adult outdoor worker, construction worker, as well as the fetuses of females in both populations are calculated to result in blood lead concentrations higher than 5 ug/dL in the TRA. This exceeds the current EPA directive for blood lead concentrations.

In general, the risks identified above correlate well with historical findings that identified portions of the Site where SSCOCs exceed remedial screening and/or risk criteria. Further details correlating principal findings for each EA from the Nature and Extent evaluation and the BHHRA and BERA are provided in Section 10.1.2.

10.1.2 Nature and Extent

A summary of the key nature and extent findings for each EA are outlined below:

Active Process Area (APA)

As noted above in Section 10.1.1, direct contact with benzene and cumene in A-level groundwater is the risk driver for the APA EA. As expected for this EA that formerly served as the center of the chemical manufacturing activities at this Site, there are SSCOCs that exceed soil and groundwater RI screening values in the central portion of this EA that need to be evaluated for remedial action in the pending FS. The SSCOC detections are most significant near the central portion of the former APA. In addition, there are some exceedances of RI screening values for SSCOCs in soils and groundwater in adjacent EAs, specifically the south/central portion of the IPA EA (between the IPA pond and the APA EA) and to the north/central portion of the Tank Farm EA (vicinity of the MW-6 well cluster), that are attributable to the APA EA. Soil SSCOC exceedances in the APA EA were noted at depths ranging between two (2) and seventeen and a half (17.5) ft bgs.

As noted in Section 8.1.1 above, most of the SSCOC mass in the APA EA is present in subsurface soils below the water table. Appreciable mass is present in the form of dispersed R-NAPL composed primarily of cumene but also containing lesser concentrations of other compounds. In some areas of the former APA, a-methylstyrene is found at similar levels to cumene in saturated soil, groundwater and R-NAPL. The saturated soils in the central portion of the APA EA are an ongoing source of SSCOCs to shallow A-level groundwater and subsequently to groundwater in the B- and C-levels as downward groundwater migration is significant in this vicinity. As noted above, the mass in this central portion of the APA EA will need to be evaluated for remedial action within the pending FS.

Area A/Open Area

There are no detections that exceed RI screening values in the available soil and groundwater data nor risk to human health and the environment in this EA. This comports with the lack of any evidence of process history or waste disposal in this EA.

Area B

No further action is necessary for this EA because there is no discernible Site source area or area of concentrated detections above the RI screening values, nor are there any risks associated with this EA as detailed in the BHHRA and BERA. Area B is an isolated wetland area located upstream along Clonmell Creek away from any potential on-Site sources that would result in detectable concentrations of SSCOCs. No evidence of any waste disposal or historical Site-related process activities has been found in Area B.

Sporadic detections of metals, PAHs, the PCB congener Aroclor -1254 and SVOCs in sediments at concentrations above their RI screening values were observed in this EA. There are also some detections of PAHs, SVOCs and pesticides in unsaturated soils at concentrations above their RI screening values in this EA. No pattern of detection of SSCOCs was noted in this EA, but concentrations of ubiquitously detected compounds at concentrations above applicable RI screening values were found. In nearly all cases these detections are likely attributable to off-Site sources or historical pesticide application for insect control within this EA.

Chemical Landfill/Gravel Pit Area (CLF/GP)

The BHHRA found no risk drivers in this EA and the bulk of this EA does not contain detections of concern. However, the area formerly known as the Chemical Landfill (see Figure 1-4) does contain concentrations of the SSSCOCs benzene, cumene and ethylbenzene above their applicable RI screening values. The bulk of the detections of concern are from one (1) ft bgs to five (5) ft bgs in the small portion of the Chemical Landfill area centered around sample location CLF-SS03A (see Figure 10-1).

There is evidence to indicate that the detected concentrations of Site-related VOCs in the Chemical Landfill area may be impacting surface water and shallow groundwater in this vicinity. Thus, further action should be considered to address unsaturated soils in the Chemical Landfill portion of the CL/GP EA where SSCOCs were detected at concentrations above the applicable RI screening values.

Clonmell Creek and Wetland Area (CCW)

The results of the BERA indicate that the data from sample locations SED2-CC-4, SED2-CC-5, SED2-CC-8, SED2-CC-10, SED2-CC-11 and SED2-CC-13 in the 002 Outfall deltaic area (see Figure 10-2) indicate an impaired aquatic community in this area. This result correlates closely with the locations of the highest concentrations of SSCOCs in sediments in the 002 Outfall delta. Further action to address detections of Site-related compounds in sediments, particularly cumene, is anticipated in this area.

Additional BERA and HHRA findings regarding risk from impacts in the CCW EA are related to food ingestion pathways. The HHRA found that ingestion of fish that contain gamma-chlordane, 4,4’-DDD, Aroclor 1254 and mercury resulted in unacceptable risk to children (0-

6 years old). The BERA also found that risk to mammals and birds from the ingestion of PAHs, PCBs, pesticides and metals that are not associated with the Site may occur, but that the calculations were significantly overestimated. There are no practical remedial alternatives to address the widespread nature of Non-Site related compounds present in upstream Clonmell Creek sediments and/or surface water.

Inactive Process Area (IPA)

The only risk found in this area in the BHHRA was from direct contact with benzene and cumene in shallow groundwater. Only a handful of soil samples contain SSCOCs at concentrations above the applicable RI screening value in this EA (Figure 10-3). The area extending from south of the IPA pond to the border of the APA is the area where concentrations of benzene and cumene were found to exceed the applicable RI screening values.

Further action to address SSCOC exceedances of RI screening values (principally cumene and benzene) to shallow groundwater and saturated soils in the portion of the EA identified above in the pending FS is warranted. The other detections of SSCOCs at concentrations that exceed RI screening values shown on Figure 10-3 are not driving risk and are either from pre-2000 samples with volatile compound detections that are likely degraded or at depth in soil and/or sediment and thus do not warrant further consideration.

Northern Chemical Landfill Area (NCL)

The only risk driver reported in the BHHRA in this EA was from the hypothetical ingestion of B/C groundwater containing benzene and cumene. However, the localized presence of concentrations of SSCOCs that exceed RI screening values in shallow soil near the Perched Zone in the NCL is responsible for SSCOC exceedances in shallow A-level groundwater in this EA. A-level groundwater then migrates downward into the underlying B-level aquifer. From there the B-level groundwater travels southward toward the on-site groundwater recovery wells and treatment system. Remedial actions to address shallow unsaturated soil sources of SSCOCs in the areas shown on Figure 10-4 should be considered in the pending FS to mitigate future groundwater detections in the NCL EA.

Northern Warehouse Area (NW)

No risk drivers were noted for this EA and no detections were noted that warrant further action.

Shooting Range (SR)

The Shooting Range is an active firing range used by the Borough of Greenwich Police Department. It is anticipated that the shooting range will remain in active use for the foreseeable future.

The lone sample from this EA did contain lead above its applicable RI screening value and the BHHRA noted risk from exposure to lead in surface and subsurface soil because of this lone detection. As noted above, action is warranted for this EA, but will be addressed at a later date if/when the range is no longer in use. Until that time best management practices will be implemented at the SR to minimize the potential for migration of lead impacted soils from the EA.

Stormwater Catchment Basin Area (SCB)

Both SSCOC and non-Site-related constituent detections were measured in sediment and surface water samples within the SCB EA as discussed in Section 8.2.10. SSCOC and non-Site related constituent detections measured in sediment samples were noted to a depth of three (3) ft in the central portion of the SCB. The sediment detections are also the probable source for detected surface water concentrations in the SCB. The sediment detections correlate with the BERA finding that there is potential impairment to aquatic communities in the SCB. This area is considered to have limited function and habitat value; however, the detections noted in sediments in the SCB are significant enough to warrant consideration for remedial action in the pending FS.

An additional area that will require remedial consideration for unsaturated soils in the SCB EA is the area beneath the former MPP SI (see Figure 10-5). Concentrations of multiple Site-related VOCs in shallow soils are likely contributing to SSCOC concentrations detected in groundwater in this EA. In addition, SSCOCs and non-Site-related constituents were also detected in sediments from swales in the CF and CTDH areas adjoining the SCB and should be incorporated into potential remedial evaluation considered for the SCB proper.

A secondary area for consideration of remedial action for unsaturated soil in the SCB EA is the bermed area on the north side of the SCB that forms a barrier preventing surface water flow to the 002 Outfall and Clonmell Creek. SSCOC detections in shallow groundwater from temporary well point samples were noted in the bermed area. Some SSCOC detections were noted in sediment samples within the SCB and in several soil samples inside the bermed area that may be associated with shallow groundwater detections in these temporary well points.

Tank Farm/Train Loading Area (TF/TLA)

The only risk driver identified in the BHHRA for the TF/TLA EA was the hypothetical ingestion of deep B- and C-level groundwater containing exceedances of cumene, TRP, benzene and TCE. As noted previously, the TCE in C-level groundwater is likely related to off-Site sources and the induced migration of off-Site groundwater as a result of pumping wells in this EA and the unlikely hypothetical groundwater ingestion scenario. However, the presence of concentrations of SSCOCs in unsaturated soils in the three areas shown on Figure 10-6 is likely contributing to SSCOC detections in the A-level groundwater in this EA. Thus, consideration of remedial action in the pending FS is warranted in these three areas to address

SSCOC concentrations noted in the unsaturated soil. These actions could help to mitigate dissolved SSCOCs detected in groundwater at the Site as well.

Township Refuse Area (TRA)

The only risk driver noted for the TRA EA in the BHHRA was related to blood lead levels because of the high lead concentrations at and adjacent to location TLF-9. Figure 10-7 shows the lead concentrations in all samples in the TRA EA. This figure shows that the lead concentrations above the RI screening level are limited to the area around TLF-9 where remedial action will be considered in the pending FS. Additional delineation of lead is needed in the vicinity of TLF-9 prior to any remedial action so that the extent of lead exceedances can be better determined.

In addition, a mixture of PAH, acetophenone and benzene detected in soil, sediment and groundwater in the reach of the 002 Outfall starting at the SCB berm and extending to sample location 02OF-4 appear to be causing localized groundwater detections. Further actions will be considered in the pending FS to mitigate these localized contributions to dissolved phase groundwater concentrations in this area.

Sitewide Groundwater

Review of RI results indicates that there are three (3) principal areas with dissolved phase concentrations of SSCOCs in groundwater:

- An area extending from the southern property boundary in the vicinity of extraction wells PW-8, PW-12, and PW-11 to the border between the APA and IPA in the vicinity of the former API skimmer;

- An area downgradient of the former MPP SIs centered around the MW-45/MW-45B and MW-46/MW-46B well clusters; and,

- The central portion of the NCL in the vicinity of wells MW-37, MW-38 and MW-50B.

The majority of the dissolved phase SSCOC RI screening value exceedances in groundwater have been measured in the A-level and diminish appreciably with depth, though some SSCOC exceedances in the upper B-level are present. This is particularly the case in the APA EA and to the south, in the TF/TLA EA.

The distribution of SSCOCs in groundwater is partly influenced by well-established groundwater flow patterns at the Site. Regional southerly groundwater flow coupled with long-term groundwater pumping at the Site have created hydraulic capture in the A-, B- and C-level near the Site's downgradient property boundary.

Generally speaking, A-level groundwater flow is laterally outward and vertically downward, through discontinuous gaps in the underlying clay lenses separating the A-level from the deeper B- and C-level formations. Upon entering the B- and C- level water-bearing zones, groundwater flow is southwesterly (see Figures 6-2 and 6-3), consistent with the prevailing regional flow pattern. Groundwater pumping at the Site maintains effective hydraulic control preventing off-Site migrations of SSCOCs.

Fate and transport analysis reveals that principal SSCOCs dissolved in groundwater; benzene and cumene in particular, are naturally attenuating and would not migrate far downgradient of the Site even under non-pumping conditions. Thus, remedial priorities for groundwater should focus on maintaining hydraulic containment while reducing SSCOC mass in the former operating areas of the Site. Prioritizing reductions in benzene and cumene mass in the A-level and upper B-level will help mitigate the primary human health risk drivers at the Site while also decreasing migration of dissolved phase SSCOCs into the B- and C-level formations.

10.1.3 Fate and Transport

The Fate and Transport evaluation focused on the Site-related compounds cumene, a-methylstyrene, benzene, and TRPs in groundwater; cumene in vadose and saturated zone soil; cumene and non-Site related compounds in sediment; and VOCs in soil vapor. Some of these media and constituents potentially pose a concern to downgradient receptors or conceivably represent a long-term SSCOC source of impact to groundwater or surface water. Evaluation of sediment and soil was performed with a focus on how these compounds could represent sources to groundwater and surface water, respectively. The fate and transport evaluation of groundwater also examined the persistence of contaminant mass in groundwater and its potential threat to downgradient receptors.

Soil

Both vadose and saturated zone soil were evaluated. Extensive empirical Site data show that the vadose zone SSCOC mass and concentrations have decreased significantly over the prior 20 to 30 years and only limited areas exist where SSCOC concentrations exceed RI screening values in the vadose zone. This SSCOC mass is generally limited to areas where releases have been documented (20002 and 2004) and/or significant SSCOC mass was previously documented in vadose zone soils. This vadose zone mass represents an ongoing source of SSCOCs to groundwater.

Shallow soil gas was carried forward as a potential migration pathway due to the volatile nature of some of the SSCOCs. However, SSCOC exceedances in shallow soil gas were limited in extent because of the attenuation of the volatile fraction of SSCOCs at the Site as detailed in the fate and transport evaluation in Section 9. As a precaution, soil vapor mitigation requirements will be prescribed for potential future Site redevelopment, at least until Site remediation is complete.

SSCOC concentrations in saturated soils consist predominantly of cumene and, in some locations a-methylstyrene, with minor fractions of benzene and TRPs. These SSCOCs are adsorbed in the soil matrix and are present as dispersed R-NAPL in several of the former process areas and are an ongoing source of dissolved phase SSCOCs in multiple locations within the IPA and APA.

The entrained nature of the dispersed R-NAPL bound to the saturated soils inhibits bioattenuation of the SSCOCs due to a lack of TEAs with dissolution being the primary mechanism for attenuation. Many factors influence partitioning of SSCOCs from the R-NAPL and adsorbed phase into dissolved phase groundwater, including interfacial surface tension, compound solubility, soil matrix and organic carbon content, to name a few. However, review of available Site data and fate and transport analysis suggests that the attenuation of SSCOCs from R-NAPL and adsorbed phase SSCOCs is recalcitrant at the Site and will likely continue to persist under current static conditions. Hence, by inference, the dissolution of SSCOCs from R-NAPL and adsorbed phase mass into groundwater is rate limited. Multiple treatability pilot tests have been conducted within the former process areas. The recently completed anaerobic biodegradation testing results show initial promise promoting degradation potential for SSCOCs, though further testing is warranted to quantify this more precisely.

Groundwater

The evaluation of groundwater primarily focused on the extent of current detections of SSCOCs in groundwater that could result in future sources to downgradient receptors. The overall persistence of the SSCOCs in groundwater was also evaluated for the purpose of determining whether future conditions will pose an increased or reduced risk to receptors.

The current and historical data set indicates that TRPs detections in groundwater are limited to on-Site areas where the highest dissolved cumene concentrations are detected, including the southern portion of the APA and south-central portion of the TF/TLA. Furthermore, the overall extent of dissolved phase TRPs has diminished during the prior 30 years of groundwater monitoring. Fate and transport evaluation of TRPs indicates that they will attenuate more rapidly than the dissolved phase cumene and will continue to diminish.

TRPs appear to be present as a minor fraction of the R-NAPL entrained in saturated soil beneath the former process areas at the Site. Due in part to TRPs higher solubility than cumene, TRP is expected to attenuate from the R-NAPL more rapidly than the cumene fraction.

To evaluate the potential for groundwater transport, conservative plume transport calculations for cumene and benzene were performed using Bioscreen, which is an EPA screening level model. The Bioscreen 2-D model was selected because Site complexities precluded the development of a comprehensive 3-D Site specific fate and transport model. Conservative assumptions were used during development of the 2-D Bioscreen model calculations to project fate and transport characteristics for benzene and cumene.

Review of Bioscreen 2-D model results demonstrates that cumene and benzene do not pose a long-term risk to downgradient receptors. In fact, using conservative modeling assumptions and inputting Site data, the Bioscreen results reveal that SSCOCs, principally benzene and cumene, will attenuate below RI screening values even under non-pumping conditions.

The projected fate and transport results generally demonstrate that dissolved phase cumene and benzene at concentrations exceeding RI screening values will not migrate more than 400 to 600 feet beyond the Site boundary in the A- and B- level and no more that 50 to 60 feet in the C-level under non-pumping conditions. The projected SSCOC transport distances within the C-level indicate that attenuation in the C-level aquifer is sufficient to restrict downgradient migration of SSCOCs above applicable RI screening values to within the property boundary under non-pumping conditions. Thus, fate and transport analysis shows that even under non-pumping conditions, Site related SSCOCs will diminish below RI screening values well before migrating to off-Site drinking water supply wells.

Soil Vapor

The presence of R-NAPL and lower concentrations of VOCs in shallow soil and groundwater at the Site indicate that soil vapor poses a potential risk to future receptors in and around source areas. Due to Site conditions, stratigraphy, depth to water, and the historical nature of subsurface contaminants, appreciable transport of contaminant mass as vapor phase away from these source areas is not anticipated nor has it been observed empirically through sampling. Occupied facilities are not currently present in the former process areas of the Site nor are any planned. However, future development will need to consider the possibility that soil vapor transport could theoretically influence indoor air quality.

Sediment

The fate and transport evaluation of sediment included both SSCOCs and non-Site related constituents and their potential for receptor exposure. Multiple non-Site related constituents have been detected in sediment above RI screening values. Cursory evaluation of these non-Site related constituents concluded that they are generally bound up within the organic-rich sediment and are likely to persist in their current state entrained in the sediment for years. A background study was performed and demonstrated that these non-Site related compounds are ubiquitous throughout the region (Appendix T).

Cumene has been detected at concentrations that exceed its RI screening value in sediments within Clonmell Creek and the SCB. Evaluation of the cumene concentrations and distribution within these areas indicates that the cumene exceedances are most prevalent in an anoxic zone that extends from a depth of six (6)-inches to depths as great as forty-eight (48)-inches in certain locations. Furthermore, the cumene concentrations may be associated with R-NAPL entrained within the sediment column, though the organic rich nature of the sediments complicates R-NAPL identification and delineation. The organic-rich nature of the sediments also acts to entrain potential R-NAPL within the sediments, restricting cumene mobility within the interstitial pore spaces. At depths shallower than six (6)-inches, cumene concentrations diminish appreciably with sediments in the zero (0) to two (2)-inch depth range being virtually cumene free. The fate and transport evaluation concludes that although the cumene mass in sediment will likely persist for years if not decades, due to its depth and location, it does not pose an appreciable risk for direct exposure or downstream transport.

10.2 CONCLUSIONS

As noted in Sections 10.1.1 and 10.1.2 above, there are several Site areas where concentrations of SSCOCs and non-Site related constituents in soil and sediment exceed RI screening values and are candidates for remedial action consideration within the pending FS. These areas are shown on Figure 10-8.

As part of the risk assessment process for the Site, an agreement was reached with EPA representatives that a deed notice will be put in place for the Site to restrict Site use to industrial/commercial purposes, eliminating the need to consider residential risk scenarios for the Site. However, NJDEP personnel have indicated that placing a deed notice on the Site will require verification that New Jersey residential direct contact soil remediation standard (NJRDCSRS) concentrations are not exceeded along the Site's property boundary and that neighboring properties are not impacted by SSCOCs.

Figures 10-9, 10-10, 10-11 and 10-12 were developed to demonstrate that off-site properties are not impacted by SSCOCs. These graphics show the locations of soil samples within 100-feet of the Site's boundary. The data from the depicted sample locations were then compared against the NJRDCSRSs for the primary SSCOCs acetophenone (Figure 10-9), benzene (Figure 10-10), cumene (Figure 10-11) and ethylbenzene (10-12). A review of the figures indicates that there are three sample locations that have exceedances of the applicable NJRDCSRSs for acetophenone and one for cumene. These exceedances of NJRDCSRSs are in the southeast corner of the tank farm EA that has been proposed for remedial action consideration. There are other soil samples between the samples that have exceedances and the property line at similar depths with concentrations below the applicable NJRDCSRSs.

During NJDEP's review of Figures 10-9, 10-10, 10-11 and 10-12, as well as related information contained within this RI Report, concerns were raised regarding adequate delineation to NJRDCSRSs of some samples in the TF/TLA EA and APA EA at particular depths. Additional discussions between Hercules, NJDEP and EPA are ongoing regarding this matter. If necessary, additional samples will be obtained as part of the Remedial Design process at specific locations and depths to verify if delineation to NJRDCSCCs is complete. This will allow a deed notice to be put in place for the Site without having to consider deed notices for neighboring properties.

The soil samples that contain concentrations of the primary SSCOOCs (benzene, cumene and ethylbenzene) above applicable RI screening values are shown in the graphics presented in Appendix U. The graphics in Appendix U are organized by soil sample depths. Samples from

0-2 ft bgs, 2-10 ft bgs and 10-20 ft bgs are shown separately as surface, subsurface and deep, respectively. The three depth ranges are shown for the Site as a whole and also segregated into individual Exposure Area views. The Appendix U graphics demonstrate that there are only five sample locations that have exceedances of the conservative RI screening values for the above mentioned SSCOCs that fall outside of the areas suggested for remedial consideration. The following provides rationale for why these locations have not been included in areas for remedial consideration:

- Three locations (S-8, S-3 and SI-SB04A) are surface locations under and just south (SI-SB04A) of the surface impoundments next to the WWTP. Location S-8 had a reported benzene concentration of 6,200 B ug/kg. The B qualifier indicates method blank contamination. Without other corroborating samples with elevated benzene detections in this area, this result is suspect. Samples S-3 and SI-SB04A are surface samples (0-2 ft bgs) with cumene concentrations above the screening value. These isolated detections are also not corroborated by other samples in this vicinity with elevated concentrations and thus do not warrant further action.

- Sample 002-Outfall Seep was obtained from 0-2 ft bgs in the berm located between the SCB and the 002-Outfall. This sample had a reported cumene concentration of 2,500,000 ug/kg, but is not corroborated by nearby samples. This isolated sample does not warrant further action.

- Sample NCL-4(72) was obtained at a depth of six ft bgs at the NCL and had reported concentrations of cumene and ethylbenzene that exceeded the applicable RI screening values. This location falls just outside of the current footprint for the area for remedial consideration in the NCL. However, that footprint is intended to address unsaturated soils from zero to four (4) ft bgs only. Location NCL-4(72) is below the top of the water table in this area. After remediation of the shallow soils at the NCL, sample NCL-4(72) will be an isolated detection. This sample location will be impacted by proposed remedial actions in the general vicinity but cannot be specifically addressed because of its depth.

Areas with soil concentrations that exceed RI screening values also correlate closely with shallow A-level groundwater exceedances in the APA and IPA that result in risk to human health as defined by the HHRA. The APA, NCL and TF/TLA were further identified within the HHRA as having hypothetical risk to human health from the ingestion of B and C-level groundwater. These risks are considered hypothetical because it is improbable that deep groundwater at the Site will be used as a drinking water source. However unlikely this scenario is, these SSCOC concentrations do result in exceedances of applicable RI screening values for Site-related compounds in deep groundwater at the Site. As a result, these exceedances of the applicable RI screening values will require further consideration for remedial action in the pending FS.

The conclusion of this RI is that remedial action should be considered for the areas identified on Figure 10-8 within the pending FS. Several remedial pilot studies (enhanced microbial degradation, air stripping/soil vapor extraction, dredging/dewatering, phytoremediation, etc.) have been conducted and are presented in detail within the FS. Reducing SSCOC concentrations in soils and sediment will be beneficial in reducing dissolved phase concentrations in groundwater that will reduce the timeline necessary for continued groundwater pumping and treatment while also reducing risk to human health and the environment.

10.2.1 Data Limitations and Recommendations for Future Work

As outlined within this RI Report, the accumulated data over the investigative history at this Site has resulted in a comprehensive Site characterization. Moreover, comparison of historical soil, sediment and groundwater SSCOC concentrations to current concentrations has allowed thorough characterization of trends necessary to develop conclusions regarding potential risks as well as the long-term fate and transport of SSCOCs in Site media.

Changes in sampling and analytical techniques over the investigative history of the Site have resulted in some bias in the sampling results. For instance, improved sediment sampling techniques enabled better characterization of SSCOC concentrations in Clonmell Creek sediment, creating the false impression that sediment concentrations were increasing over time. These data resulted in suspicion that the NCL was contributing to reported sediment concentrations in Clonmell Creek. However, no evidence of any significant contribution of contaminants to Clonmell Creek from the NCL has been found during extensive hydrogeologic evaluation of conditions at the NCL relative to Clonmell Creek.

Other potential data biases include masking of SSCOCs possibly present at concentrations below the laboratory detection limits where analytical dilutions were necessary. However, in areas of future recommended remedial actions, concentrations of cumene, and to a lesser extent benzene, are appreciably higher than other SSCOCs. As a consequence, remedial actions predicated upon mitigating benzene and cumene exceedances also will mitigate other SSCOCs potentially present at comparatively lower concentrations.

In the TRA, it was noted that additional delineation of lead in soil will need to be conducted in close proximity to sample location TLF-9 to complete the delineation of lead concentration exceedances of RI screening values. It is recommended that further lead delineation be incorporated into any future remedial design efforts in the TRA. Similarly, selected Site areas where soil and sediment concentration exceedances of RI screening values were identified that are being retained for remedial action consideration are shown on Figure 10-8. Some of the areas identified will likely need supplemental delineation as a component of the remedial design/action.

Non-Site related constituents were identified at concentrations above RI screening values in Clonmell Creek sediments centered on the deltaic area at the confluence of the 002 Outfall and Clonmell Creek as well as upstream and downstream of this area. These non-Site related constituents include PCBs; pesticides; and select VOCs and SVOCs. A limitation with the data available for this RI Report is the lack of a robust background dataset for sediments in upstream areas that are not affected by the Site or historical upstream industrial activities. Obtaining representative background data in this area is challenging because of the extensive regional industrial history and lack of pristine upstream background conditions. Although this has been noted as a data limitation for this report, a thorough analysis of the sediment detections as presented in Section 8.3.5.4 provides ample evidence to distinguish the areas of sediment detections within Clonmell Creek that are related to Site activities versus areas where the sediment detections reflect non-Site related contributions.

None of the above identified data limitations necessitate the need for further delineation prior to implementing the remedial design phase subsequent to the issuance of a ROD for this Site.

11.0 REFERENCES

CSI Environmental, LLC. (2008). *Focused Investigation Work Plan: Former Hercules Higgins Plant, Gibbstown, New Jersey*. Annapolis, Maryland: Author.

CSI Environmental, LLC. (2010). *Interim Remedial Measures Report for Sewer Replacement at the Former Hercules Higgins Plant, Former Hercules Higgins Plant, Gibbstown, New Jersey*. Annapolis, Maryland: Author.

CSI Environmental, LLC. (2011). *Sub-slab, Soil Gas and Indoor Air Vapor Intrusion Investigation Report: Former Hercules Higgins Plant, Gibbstown, New Jersey*. Annapolis, Maryland: Author.

CSI Environmental, LLC. (2012). Preliminary Focused Treatability Test Results Report*: Former Hercules Higgins Plant, Gibbstown, New Jersey*. Annapolis, Maryland: Author.

CSI Environmental, LLC. (2013). Aerial Photo Interpretation*: Former Hercules Higgins Plant, Gibbstown, New Jersey*. Annapolis, Maryland: Author.

CSI Environmental, LLC. (2014). *Additional Clonmell Creek Studies Findings Report: Former Hercules Higgins Plant, Gibbstown, New Jersey*. Millersville, Maryland: Author.

CSI Environmental, LLC. (2014). *Aerial Photo Interpretation: Former Hercules Higgins Plant, Gibbstown, New Jersey*. Millersville, Maryland: Author.

CSI Environmental, LLC. (2015). *Quality Assurance Project Plan Remedial Investigation and Remedial Alternatives Analysis for the Former Hercules Higgins Plant Gibbstown, New Jersey*. Millersville, Maryland: Author.

CSI Environmental, LLC. (2015). *Additional Remedial Investigation Results Summary Letter, Gibbstown, New Jersey*. Millersville, Maryland: Author.

CSI Environmental, LLC. (2016). *Additional Remedial Investigation Lead Addendum Results Summary Letter, Gibbstown, New Jersey*. Millersville, Maryland: Author.

CSI Environmental, LLC. (2016). *Cone Penetrometer and Supplemental Direct Push Study Results Letter, Gibbstown, New Jersey*. Millersville, Maryland: Author.

CSI Environmental, LLC. (2016). *Site-Specific Cumene Solubility and Chemical Saturation Values (C-Sat) Summary Letter, Gibbstown, New Jersey*. Millersville, Maryland: Author.

Environmental Simulations Inc. (2013). *Groundwater Flow Model for the Former Hercules Higgins Plant, Gibbstown, New Jersey*. Reinholds, Pennsylvania: Author.

Environmental Resources Management, Inc. (2003). *Supplemental Remedial Investigation Report: Former Hercules Higgins Plant, Gibbstown, New Jersey*. Exton, Pennsylvania: Author.

Environmental Resources Management, Inc. (1984). *Phase III Hydrogeologic Definition and Initiation of Remedial Activities for Hercules Inc., Gibbstown, New Jersey*

Environmental Resources Management, Inc. (1983). *Installation of a Ground Water Monitoring System for Hercules Inc., Gibbstown, New Jersey*

Environmental Resources Management, Inc. (1986). *Hydrogeologic Definition and Continuation of Remedial Activities for Hercules Inc., Gibbstown, New Jersey*

Environmental Resources Management, Inc. (1987). *Ground Water Quality Assessment Program - Equalization Basin, Hercules Inc., Gibbstown, New Jersey*

Environmental Resources Management, Inc. (1989). *Higgins Plant, Revised 1988 Soils Investigation, Hercules Inc., Gibbstown, New Jersey*

Environmental Resources Management, Inc. (1990). *Results of Soil Gas Survey and Soil Sampling for the Surface Impoundment Closure Plan at Hercules Incorporated, Gibbstown, New Jersey.*

Environmental Resources Management, Inc. (1995). *Hercules Incorporated, Phase II Soils Investigation, Hercules Higgins Plant, Gibbstown, New Jersey*

Environmental Resources Management, Inc. (2003). *Supplemental Remedial Investigation Report, Former Higgins Plant, Gibbstown, New Jersey.*

GTI. (1990). *Results of Soil Gas Survey and Soil Sampling for the Surface Impoundment Closure Plan* at Hercules Incorporated, Gibbstown, New Jersey. January.

Langan Engineering and Environmental Services Inc., *Final Remedial Investigation Report, Paulsboro Refinery*. Prepared for Paulsboro Refining Company, LLC. May 2016

Risk Based Remedies Consulting Inc. (2017). *Baseline Ecological Risk Assessment for the Former Hercules Higgins Plant, Gibbstown, New Jersey*. April.

Risk Based Remedies Consulting Inc. (2017). *Human Health Risk Assessment for the Former Hercules Higgins Plant, Gibbstown, New Jersey*. September.

United States Environmental Protection Agency. (1988). *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* Office of Emergency and Remedial Response, Washington, DC.

TABLES

FIGURES