AR226-2507

COMPILATION OF HISTORICAL C-8 DATA DUPONT WASHINGTON WORKS MAIN PLANT AND LANDFILLS

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Project No: D6WW7423

CORPORATE REMEDIATION GROUP
An Alliance between
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1.0 INTRODUCTION

A multi-media Consent Order was entered into between the West Virginia Department of Environmental Protection (WVDEP), the West Virginia Department of Health and Human Resources-Bureau for Public Health (WVDHHR-BPH) and DuPont on November 14, 2001. A copy of the Consent Order (Order No. GWR-2001-019) is contained in Appendix 1.

The Consent Order identified a series of requirements to be performed by the Parties (WVDEP, WVDHHR-BPH, and DuPont) in order to determine whether there has been any impact on human health and the environment as a result of releases of ammonium perfluorooctanoate (C-8), CAS Number 3825-26-1, to the environment from DuPont operations at the Washington Works main plant and the associated landfills (Local, Letart and Dry Run). The C-8 Groundwater Investigation Steering Team (GIST) was established in the Consent Order to oversee investigations and activities that will be conducted to assess the presence and extent of C-8 in drinking water, groundwater, and surface water at and around the main plant, and the Local, Letart and Dry Run Landfills.

Pursuant to Attachment A of the Consent Order, three tasks will be performed by DuPont and evaluated by the GIST, Tasks A, B, and C. This report addressed Task B. The primary objective of Task B is to develop and implement a monitoring plan that determines the presence and extent of C-8 in drinking water, groundwater and surface water in and around the main plant, and the Local, Letart and Dry Run Landfills, and to provide a compilation of available groundwater/surface water monitoring results and hydrogeologic characterization data for each location. This document was prepared to meet the data compilation objective.

1.1 Document Organization

Sections 2.0, 3.0, 4.0, and 5.0 present the historical data available for the main plant and the Local, the Letart and the Dry Run Landfills, respectively. Each section includes text, tables, and figures specific to the site being discussed in that section. At the end of each section, data gaps are identified. The same outline is used for each section. Data presented in each section includes information (to the extent that information was available) as requested in Table A-1 of the Consent Order. In addition, supplemental information is provided as needed to develop and present a site conceptual model for the four locations discussed.

1.2 C-8 Historical Laboratory Analysis of C-8

The analytical method, method detection limit, and laboratory utilized for C-8 analysis has changed over time. Prior to 1991, DuPont performed C-8 analysis at the DuPont Experimental Station in Wilmington, Delaware. In 1991, when the RCRA Verification Investigation was conducted, the analysis was contracted to the CH_2MHill Laboratory in Montgomery, Alabama. Both labs used a Gas Chromatography/Electron Capture

Dectector (GC-ECD) based analytical method with detection limits for C-8 that ranged from 0.1 to 1.0 ug/l.

CH_2MHill conducted C-8 analysis for DuPont into the fall of 1998 when the laboratory ceased operation. At that time, DuPont had completed one round of analysis for the RCRA Facility Investigation (RFI). The analytical work was transferred to Lancaster Laboratories, Lancaster, PA, for the RFI second round analysis in February 1999. Lancaster Laboratories continued to conduct C-8 analysis using GC-ECD for DuPont until October 2001, when development and testing was initiated on a new analytical method developed by Exygen Research, Inc. (located in State College, PA) that utilizes Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS). DuPont adopted the use of LC/MS/MS for C-8 analysis in November 2001.

1.3 Physicochemical Data for Ammonium Perfluorooctanoate (C-8)

C-8, also identified as FC-143, is a fluorinated surfactant used in the fluropolymer manufacturing at the main plant. Figure 1.0 shows the solubilities of C_7F_{15} COOM in water as a function of temperature (Figure 6.9 in Kissa, 1994). The following summary lists the physicochemical data available for C-8 (Kissa, 1994):

- Molecular Formula = $CF_3(CF_2)_6COO^-NH_4^+$
- Molecular weight = 431.098 g/mole
- LD_{50} acute oral rat = 680 mg/kg
- BCF = 1.8
- pH ~ 5 (0.5% aqueous)
- pKa = 2.8 (-COOH)
- Melting Point = 56-58°C (-COOH)
- COD = 700 mg/kg
- Koc = 25
- Water Solubility > 1000 mg C-8/L
- Vapor pressure (at 22°C) = 7.1 x 10^{-05} mm Hg
- Kraft Point = 2.5 °C
- Critical Micelle Concentration = 33 mmol/L

LD_{50}: Lethal Dose 50 – Dose having 50% probability of causing death
BOD_{20}: Biochemical Oxygen Demand – Standard measurement is made for 5 days at 20 degrees C
BCF: Bioconcentration Factor
pKa: Negative log of the ionization constant – Measure of acidity or acid strength
COD: Chemical Oxygen Demand
Koc: Organic Carbon Partitioning Coefficient

1.4 References

Kissa, E. 1994. Fluorinated Surfactants. New York: Marcel Dekker, Inc.

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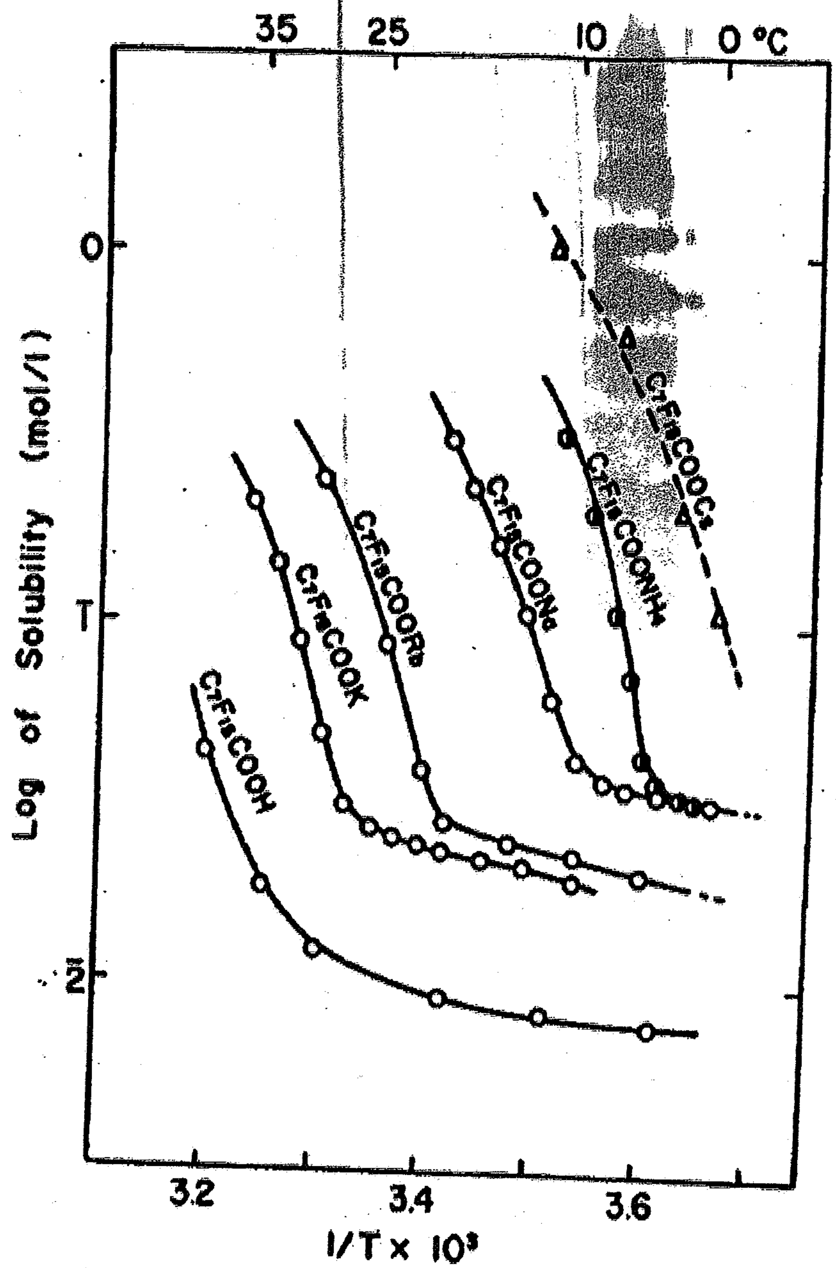

Figure 1.0
Solubilities of C_7F_{15} COOM in water as a function of temperature (Kissa, 1994).

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2.0 WASHINGTON WORKS MAIN PLANT

Tables

Figures

2.1 Introduction

The Washington Works Main Plant (main plant) is located along the Ohio River in Washington, West Virginia, approximately seven miles southwest of Parkersburg, West Virginia (Figure 2.0). A water use and well survey is currently being conducted for the area within a 1-mile radius of the main plant and Local Landfill property boundaries (Figure 2.1).

Significant historical hydrogeologic and groundwater quality data for C-8 at the main plant is available from previous investigations that have been conducted. The most significant study was a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) conducted in the fall of 1998 on four Solid Waste Management Units (SWMUs) at the main plant to satisfy requirements of the RCRA Hazardous and Solid Waste Amendments (HSWA) Permit Number WVD 04-587-2591 (DuPont, 1999). A brief description of each of the SWMUs investigated is presented below. SWMU locations are shown on Figure 2.0.

- SWMU A-3, Riverbank Landfill: The Riverbank Landfill is about 4,500-feet long and lies along the northern edge of the site near the Ohio River. It was operated between 1948 and the late 1960s and received powerhouse ash, incineration ash, plastics, rubble, and plant trash. After closure, it was covered with 6 to 35 inches of soil. Currently, the Riverbank Landfill is covered with dense vegetation (on the sloped area) or by buildings and pavement in the manufacturing area.
- SWMU B-4, Anaerobic Digestion Ponds (Digestion Ponds): Three former digestion ponds are co-located within a portion of the Riverbank Landfill. One pond dates from the 1950s and two others from the 1970s. The ponds received waste from the fluorocarbon manufacturing process (including C-8) until 1988, when the pond contents and upper few feet of clay liner and pond berm material were removed and disposed of off-site. The pond area was backfilled and capped with topsoil, and the area is currently vegetated with grass.
- SWMU C-6, Polyacetal Waste Incinerators (Waste Incinerators): The former Waste Incinerators consisted of two brick-lined pits in the western portion of the manufacturing area. The Waste Incinerators operated between 1959 and 1990. The Waste Incinerators have been excavated and backfilled with clean soil.
- SWMU H-14, Burning Ground: The Burning Ground is located in the central portion of the manufacturing area and was operated between 1948 and 1965. Since 1990, the Burning Ground has been leveled, backfilled with clean fill and gravel, and covered by buildings and asphalt.

A previous Verification Investigation (VI) found evidence of releases of C-8 to soil and groundwater at the Riverbank Landfill, Digestion Ponds, and Burning Ground (DuPont 1992). Little evidence of releases were found in soil at the site of the former Waste Incinerators. Further investigations and evaluations were performed during the RFI to determine the extent of releases in groundwater.

Plant-wide groundwater sampling was also conducted during two separate monitoring events, the first in November 1998 and the second in February 1999, during the RFI. The sampling events focused on evaluating groundwater quality at existing and newly installed wells associated with the Burning Ground and Riverbank Landfill/ Digestion Ponds SWMUs.

All plant wells sampled during the RFI were analyzed for C-8. C-8 was detected in all groundwater samples. C-8 concentrations and the extent in groundwater is discussed in Section 2.3 Water Quality.

2.2 Environmental Setting

2.2.1 Geology

The geology of the main plant is shown on six geologic cross-sections developed during the VI (DuPont, 1992) and revised based on additional findings from the RFI. The locations of the geologic cross-sections are shown in Figure 2.3. Two east-west cross-sections, A-A' and F-F', are shown on Figures 2.4A and 2.4F. Four north-south cross-sections, B-B', C-C', D-D', and E-E' are shown on Figures 2.4B, 2.4C, 2.4D and 2.4E, respectively. The cross-sections were developed from detailed geologic logs recorded during the VI and RFI, and from less detailed historic geologic logs from test and production wells and geotechnical borings drilled in the late 1950s through the early 1980s. Some monitoring wells shown in Figure 2-3 were later abandoned. The current site map (Figure 2.2) shows the monitoring wells that currently exist at the site.

The main plant rests on Quaternary alluvial terrace deposits in the Ohio River Valley. The alluvial terrace is topographically flat and lies approximately 50 feet above the Ohio River, which flows east to west past the main plant (see Figure 2.0). The alluvial terrace is underlain by a flat, river-scoured bedrock surface of the Dunkard Series that rises steeply and outcrops in the southern edge of the site to form the valley wall.

The Quaternary alluvium ranges from 60 to 100 feet in depth and consists of coarsening downward unconsolidated river deposits of poorly to well-sorted, brown and gray sand, silts, clay and gravel. The Dunkard Series bedrock consists primarily of red and varicolored sandy shale; gray, green and brown sandstone; and minor beds of coal, claystone, black carbonaceous shale, and limestone.

The average river water elevation is about 580 feet above Mean Sea Level (MSL) and the elevation of the Ohio River terrace deposits under the main plant are about 630 feet above MSL. Due to riverbank undercutting, some slumping of clay and silt exists along the northern boundary of the main plant along the river's edge. Figure 2.4C shows an example of the relationship of fill and clay layers along the riverbank.

2.2.2 Hydrology, Hydrogeology and Groundwater Flow

Hydrology

Regional water needs are primarily satisfied by the Ohio River and Little Kanawha River near Parkersburg. These sources provide water to the cities of Parkersburg,

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West Virginia and Belpre, Ohio. In less populated areas (i.e., near the main plant), the local communities receive water from small local water companies that obtain their water from production wells screened in the Quaternary river alluvium.

Surface water at the main plant discharges through drains and storm sewers, and drainage swales. Seeps located along the riverbank may originate from precipitation that has infiltrated topsoil or fill and that flows along the top of the underlying shallow clay and discharges along the riverbank. Two drainage swales, one located in the facility's southwest corner, and the other located on the extreme eastern end of the facility, convey surface runoff during rainy weather to the Ohio River. During dry weather, the drainage swales are dry.

Hydrogeology

Regional groundwater supplies are obtained from the Dunkard Group bedrock and Ohio River alluvial terrace deposits. The saturated portion of the Ohio River alluvial terrace deposits comprise the principal regional aquifer used for water supply purposes. Production wells completed in this aquifer have been known to yield up to 500 gallons per minute (gpm) (Schultz, 1984). Based on these high yields, numerous industrial and commercial water supply companies obtain water from the alluvial aquifer. The yield from alluvial aquifer wells is related to the well's position with respect to the river, as well as formation grain size and thickness.

The Ohio River alluvial terrace deposits contain a single key aquifer underlying the main plant. The water table occurs at a depth of about 60 to 70 feet below ground surface in the main plant area. The saturated zone is approximately 30 to 40 feet thick, extending to the surface of the underlying Dunkard Group. The on-site production water wells completed in the site aquifer yield 200 to 450 gpm. The underlying Dunkard Group is not a major aquifer. The upper zone of the Dunkard Group (Washington Formation), which consists primarily of shale and silt, likely bounds the lower extent of the site aquifer. In addition, regional groundwater communication between the Ohio River and bedrock will likely result in upward gradients to the alluvial aquifer.

Groundwater quality in the alluvium in this region tends to be naturally poor, having the highest median chloride, sulfate, hardness (as calcium carbonate), iron, and manganese concentrations of all hydrogeologic units in the region (Schultz 1984). Water from the alluvium generally is a calcium bicarbonate type, with near neutral pH and high dissolved solids content.

Natural recharge to the alluvial aquifer comes from various sources, including:

- Infiltration of precipitation falling directly on the alluvium
- Lateral movement of the river water through the alluvium via permeable sand and gravel zones
- Seepage from stream tributaries that discharge to the Ohio River

The maximum amount of water available to the alluvium depends on the degree of hydraulic connection to the river. The degree of hydraulic connection is a function of the permeability and thickness of the riverbed, permeability and thickness of the alluvium, and hydraulic gradient between the groundwater and the river. Pumping of on-site active well fields near and parallel to the river (i.e., the Ranney Well, the DuPont-Lubeck Well Field, and the East Well Field shown in Figure 2.2) lowers the groundwater level in the alluvial aquifer to below river stage. This induces water from the river to flow into the alluvium toward the wells, which replaces water pumped from storage in the aquifer, and helps sustain high-yield pumping wells.

Groundwater Flow

Groundwater generally flows to the south-southwest in the alluvial aquifer. However, groundwater elevations, flow directions, and flow rates on-site are strongly influenced by the Ohio River and by pumping of on-site production wells. The on-site production wells include the Ranney Well, a radial collector well which pumps 800 to 1,000 gpm; the seven wells in the East Well Field, which pump a combined average rate of 2,000 gpm; and the five DuPont-Lubeck wells, which pump about 700 gpm combined.

Groundwater elevation contour maps for the alluvial aquifer developed from data measured in November 2000, February 1999, and November 1998 are presented as Figures 2.5A, B, and C, respectively. The direction of groundwater flow is indicated by the flow arrows. As shown on the groundwater elevation contour maps, groundwater flow in the northeast part of the site is toward the East Well Field wells. In the north-central portion of the site, groundwater flow is toward the Ranney Well. In the central and western portion of the site, groundwater flow is south-southwest towards the DuPont-Lubeck Well Field. Pumping of the production wells (Ranney Well, East Well Field, and the DuPont-Lubeck Well Field) eliminates off-site migration of impacted groundwater that may originate from the SWMU areas. Additional groundwater elevation data was obtained from the General Electric (GE) property located to the west of the main plant. Data from the main plant and GE were used in calibrating the Washington Works groundwater model (DuPont, 1999). The groundwater model conclusions indicated that groundwater from the main plant area is contained to the DuPont property by operation of the site production wells.

In a 1990 hydrogeologic assessment, production well specific capacity testing of the DuPont-Lubeck Well Field and the East Well Field was conducted. The results were used to calculate the transmissivity and the hydraulic conductivity of the alluvial aquifer (DuPont 1990). In the vicinity of the DuPont-Lubeck Well Field, transmissivity values ranged between 114,900 and 127,500 gallons per day per square foot (gpd/ft^2). In the vicinity of the East Well Field, the transmissivity values ranged between 16,050 and 50,000 gpd/ft^2. Hydraulic conductivity values were calculated from the transmissivity values for the East Well Field. For Wells AX13-PW01 and AZ13-PW01, the hydraulic conductivity values ranged from 0.013 to 0.055 centimeters/second (cm/sec) and from 0.01 to 0.049 cm/sec, respectively.

Using the hydraulic conductivity values from the 1990 study and the hydraulic gradient values determined from groundwater elevations measured in 1990 and assuming an effective porosity value for sand and gravel of 35 %, the groundwater flow velocity for several well pairs was calculated. The groundwater flow velocity was estimated at 5 feet/day (ft/d) between monitoring wells T13-MW01 and L18-MW01 in the southwest portion of the site. A groundwater flow velocity of 3 ft/d was estimated between monitoring wells P06-MW01 and K14-MW01 in the western central portion of the site.

In the eastern portion of the site, a groundwater flow velocity of 2.5 ft/d was estimated for the site aquifer between monitoring wells AL10-MW01 and AO09-MW01.

Groundwater seeps at the Riverbank Landfill were identified and sampled during the VI (DuPont 1992). An active French-Drain groundwater collection has been in operation at the Riverbank Landfill since 1991. The RFI verified that the collection system effectively captures water at the seep area.

2.3 Water Quality

2.3.1 Surface Water Quality

Historical surface water C-8 concentrations are presented in Table 2.1A. Surface water sample locations are shown on Figure 2.2. Surface water C-8 concentrations were measured in 2000 and 2001 at two outfalls, 002 and 005 and at two river locations. The outfalls have been sampled monthly since February 2001. Outfall 005 C-8 concentrations have ranged from 1.43 ug/l to 199 ug/l, while Outfall 002 C-8 concentrations overall have been much lower, ranging from 0.436 ug/l to 8.54 ug/l. In general, Outfall C-8 concentrations have significantly declined in 2001. This is the result of installation of a carbon adsorption treatment system in the fluropolymers process. The system is designed to remove a major percentage of C-8 from the process wastewater.

2.3.2 Groundwater Quality

Concentrations of C-8 in groundwater sampled at the main plant have been evaluated since 1991 (Table 2.1B), however, the wells sampled and the sampling frequency has been variable. Some wells have been monitored annually since 1996 and others have been monitored quarterly starting in January 2001. Two plant-wide groundwater-sampling events were conducted as part of the RFI (November 1998 and February 1999) and are discussed below. The sampling events focused on evaluating groundwater quality from existing and newly installed wells associated with the Burning Ground and Riverbank Landfill/Digestion Ponds SWMUs.

All plant wells sampled during the RFI were analyzed for C-8. At the Riverbank Landfill/Digestion Ponds area (in the western portion of the Riverbank Landfill), C-8 was detected in groundwater and previous seep samples. Figures 2.6C and 2.6D depict the well locations and results for C-8. Measured concentrations ranged from <0.1 to 13,600 µg/L. Concentrations were below 40 µg/L in 28 of the 37 wells sampled; in the other 9 wells, maximum concentrations ranged from 380 to 13,600 µg/L. The highest concentrations were measured in monitoring wells P04-MW02 and R04-MW02, near the Digestion Ponds area.

The RFI C-8 concentration values were utilized for contouring. Isoconcentration maps were prepared and are presented in Figures 2.6A and 2.6B.

2.3.3 Drinking/Tap Water Quality

Production Well AM07-PW01 (historically known as well 336) supplies potable water to the main plant. C-8 concentrations in drinking/tap water have been measured at four distribution points on the plant periodically since May 1999 (Table 2.1C). Concentrations ranged from 0.213 ug/l to 0.589 ug/l. C-8 concentrations detected at three sampling points in the distribution system on October 11, 2001 were 0.507, 0.45, and 0.423 ug/l, respectively. No obvious trends are seen in the data.

2.4 Site Conceptual Model

The main plant site conceptual model describes the potential exposure routes for current and future human and ecological receptors. Potential exposure routes were evaluated and classified as complete or incomplete.

Direct exposure to C-8 bearing materials contained within the SWMUs is minimal or non-existent, because these materials have been removed and regraded or paved (Burning Ground, Waste Incinerators, and Digestion Ponds) or covered and vegetated. Therefore, contact with these materials is considered to be an incomplete exposure pathway.

A large portion of the plant site is covered with asphalt and concrete. Hence surface water contact with C-8 impacted soils or groundwater is not likely in these areas. Therefore, surface water contacting C-8 impacted soils is considered to be an incomplete exposure pathway. Much of the precipitation falling on site is routed toward drains and storm sewers, which ultimately discharge into the Ohio River. Precipitation falling on the riverbank slope either percolates into the soil or runs off to the river. The seeps that occur in places along the riverbank are probably caused by percolated water that accumulates above the slumped, low-permeability clay and silt of the Ohio River deposits that underlie topsoil and fill along the riverbank. Contact with impacted seep water is considered to be an incomplete exposure pathway due to the active french-drain groundwater collection system.

Direct exposure to groundwater impacted by C-8 is also considered to be an incomplete pathway because groundwater is located at about 60 feet bgs. The only potential contact route for groundwater is via contact with water pumped from production wells. Water pumped from production wells is used for two purposes, supplying drinking water and providing industrial process water.

Well AM07-PW01 is one of three production wells that provides drinking water to the main plant. Other wells are AO08-PW01 and AQ09-PW01. AM07-PW01 was sampled eight times. Measured concentrations of C-8 in this well suggested that this exposure pathway is considered to be complete. However, average concentrations of C-8 in drinking water at point of use (which is a mixture of water from the three wells) will be lower than the maximum concentrations detected in any single well. Contact with impacted drinking/tap water is a complete exposure pathway.

C-8 was detected in production wells providing industrial process water (K16-PW01, V05-PW01, and L04-PW01). The maximum concentration of C-8 was detected in well K16-PW01 (16.2 ug/l). Water from these wells is not used for drinking, but rather for industrial processes including non-contact and contact cooling water, fire water, process water, conversion to demineralized water to generate steam, and/or consumption in the manufacturing processes. There is a potential for limited contact, however, this contact is expected to be minimal. Average concentrations of C-8 in process water at the point of use (which is a mixture of water from several production wells) will be lower than maximum concentrations detected in any single well. Therefore, while this exposure pathway is complete, it is considered to be minimal.

The RFI ecological evaluation focused on identifying whether significant ecological resources may be exposed to site-related constituents released from the SWMUs. This evaluation concluded that surface soil at the Riverbank Landfill/Digestion Ponds is the only potential ecological exposure medium within the RFI study area. Surface water contact with C-8 impacted soils or groundwater is not likely because the Waste Incinerators and Burning Ground SWMUs are covered with gravel, asphalt, or buildings and do not provide ecological habitat. Subsurface soil (greater than 2 feet) and groundwater are not exposure media of concern for ecological receptors, and groundwater does not discharge to surface water at the site.

2.5 Data Gaps

The following data gaps were identified for the main plant:

- Additional monitoring wells are needed to further delineate C-8 concentrations in groundwater and to evaluate groundwater flow directions, particularly for groundwater flow in the bedrock below the unconfined alluvial aquifer.
- Continued refinement of the groundwater model for the main plant is required to reevaluate that groundwater capture by the pumping wells is occurring at the site and that no off-site migration of C-8 impacted groundwater is occurring.
- Surface water quality in the Ohio River should be evaluated. A separate work plan is currently being designed to address this issue.

Activities to fill the data gaps will be proposed and discussed in the work plan.

2.6 References

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Schultz, R.A. 1984. *Groundwater Hydrology of the Minor Tributary Basins of the Ohio River*, West Virginia.

Table 2.0
Monitoring Well Construction Data
DuPont Washington Works Main Plant
Washington, WV

Monitoring Wells		Surface Elevation (feet)	Total Depth (feet)	Well Diameter (inches)	Slot Size (inches)	Screen Length (feet)	Elevation of Screen Interval (feet)
New ID	Old ID						
Q04-MW02	Ron's MW-1	629.39	71	2		10	566.0 - 556.0
Q05-MW01	Ron's MW-2	598.76	42	2		10	567.0 - 557.0
P06-MW02	Ron's MW-3	629.29	71	2		10	567.0 - 557.0
P08-MW01	Ron's MW-4	630.82	75	2		5	559.0 - 554.0
N13-MW01	Ron's MW-5	625.87	70	2		5	560.0 - 555.0
M16-MW01	Ron's MW-6	627.14	70	2		10	565.0 - 555.0
AO08-PW01	331	632.91	95	18		20	558.7 - 538.7
AQ09-PW01	332	634.36	96	18		20	553.8 - 533.8
AT10-PW01	333	634.37	97	18		20	553.5 - 533.5
AV11-PW01	334	633.49	93.9	18		19	555.7 - 536.7
AX13-PW01	335	630.69	90	18		13	556.0 - 543.0
AM07-PW01	336	634.26	96	18		20	555.0 - 535.0
AZ13-PW01	337	628.04	92	18		20	555.0 - 535.0
L04-PW01	GALLERY	589.75				NA	
L17-PW01	L1(351)	633.93				18	
K18-PW01	L2(352)	634.92		18			
K19-PW01	L3(353)	634.2		18			
K16-PW01	L4(354)	623.24		18			
J17-PW01	L5(355)	624.78		18			
V05-PW01	RANNEY	632	92	NA		1	542.0 - 541.0
	TW-1 (tw-28)						
J08-MW01	TW-20	630.21	*95.21*	6		*20*	*555 - 535*
Q07-MW01	TW-21 (307)	630.35		6			
Z07-MW01	TW-22	632.49		6		*20*	*550 - 530*
G10-MW01	TW-23	631.4	*101.4*	6		*20*	*550 - 530*
T13-MW01	TW-24	632.69	*102.69*	6		*20*	*550 - 530*
U16-MW01	TW-25	638.23	*108.23*	6		*20*	*550 - 530*
AO09-MW01	TW-26	632.89		6			
L18-MW01	TW-27	635.82		6			
V09-MW01	TW-3 (pw-3)	628.5	*98.5*	6		*20*	*550 - 530*
N04-MW01	TW-32	594.48		6			
P06-MW01	TW-33	630.63		6			
AR09-MW01	TW-38	635.27	*105.27*	6		*20*	*550 - 530*
AX12-MW01	TW-39	635.23		6			
AG07-MW01	TW-40	632.87		6			
AJ06-MW01	TW-41	635.09		6			
	TW-46						
AO08-MW01	TW-48	636.02		6			
	TW-5						
	TW-60						
	TW-61						
	TW-E4						
Y05-MW01	TW-E5	631.16	*101.16*	4		*20*	*550 - 530*
AC05-MW01	TW-E6	635.22		6			
AL10-MW01	TW-M1	631.61	*101.61*	4		*20*	*550 - 530*

Table 2.0
Monitoring Well Construction Data
DuPont Washington Works Main Plant
Washington, WV

Monitoring Wells		Surface Elevation (feet)	Total Depth (feet)	Well Diameter (inches)	Slot Size (inches)	Screen Length (feet)	Elevation of Screen Interval (feet)
New ID	Old ID						
	TW-M2			-		*20*	*550 - 530*
I07-MW01	TW-M3	610.23		4			
K14-MW01	TW-M4	627.34	*97.34*	4		*20*	*550 - 530*
D08-MW01	TW-M5	600.67		4			
F06-MW01	TW-M6	601.14	*62.8*	4			
U03-MW01	TW-N2	592.44		6			
U05-MW02	TW-P12	631.17		6			
U05-MW01	TW-W1	632.11	*102.11*	6		*20*	*550 - 530*
L04-MW01	W00-577						
AA04-MW01	TW-70	597.4	43	2	10	10	564.4 - 554.4
AA05-MW01	TW-71	630.8	70	2	10	10	570.8 - 560.8
AB07-MW02	TW-72	630.6	72	2	10	10	568.6 - 558.6
AC07-MW02	TW-73	633.2	74	2	10	10	569.2 - 559.2
AE11-MW01	TW-74	629.51	72	2	10	10	567.51 - 557.1
AI06-MW01	TW-75	634.04	72	2	10	10	572.04 - 562.04
E13-MW01	TW-76	623.5	74	2	10	10	559.5 - 549.5
G17-MW01	TW-77	630.5	80	2	10	10	560.5 - 550.5
L06-MW01	TW-78	629.85	77	2	10	10	562.85 - 552.85
M04-MW02	TW-79	593.5	25	2	10	10	578.5 - 568.5
M04-MW03	TW-80	593.6	26	2	10	10	577.6 - 567.6
N04-MW02	TW-81	593.6	26	2	10	10	577.6 - 567.6
N05-MW01	TW-82	633.48	82	2	10	10	561.48 - 551.48
P04-MW02	TW-83	590.6	28	2	10	10	572.6 - 562.6
P05-MW02	TW-84	631.68	80	2	10	10	561.68 - 551.68
R04-MW02	TW-85	593.2	28	2	10	10	575.2 - 565.2
S05-MW02	TW-86	631.18	78	2	10	10	563.18 - 553.18
U04-MW01	TW-87	593.1	27	2	10	10	576.1 - 566.1
V06-MW01	TW-88	629.93	77	2	10	10	562.93 - 552.93
W05-MW01	TW-89	630.25	76	2	10	10	564.25 - 554.25
Y14-MW01	TW-90	629.93	90	2	10	10	549.93 - 539.93
Z06-MW02	TW-91	640.1	72	2	10	10	578.1 - 568.1
Z07-MW01	TW-92	629.64	74	2	10	10	565.64 - 555.64
Z09-MW01	TW-93	630.7	70	2	10	10	570.7 - 560.7
M16-MW01	TW-55	627.14					
N13-MW01	TW-54	625.87					
P08-MW01	TW-53	629.29					
Q04-MW02	TW-50	598.76					

Red and Italics* – *approximate* – *information taken off cross-section
Bold – Taken from RFI WP

Table 2.1A
Summary of Analytical Results:
C-8 In Surface Water Samples
DuPont Washington Works Main Plant
Washington, WV

Sample	Date	C-8 (ug/l)
OUTFALL 002	10/25/01	2.8
	9/19/01	0.118
	7/11/01	0.558
	6/14/01	0.594
	5/31/01	0.436
	4/11/01	1.5
	3/21/01	8.54
	2/14/01	1.74
OUTFALL 005	10/25/01	65.7
	9/19/01	2.86
	8/30/01	2.16
	7/11/01	120
	6/14/01	7.4
	5/31/01	1.43
	4/11/01	4.31
	3/21/01	199
	2/14/01	153
RIVER BELOW 005	6/14/01	0.034 J
RIVER BELOW PAGES RUN	6/14/01	0.075 J

J = estimated value (below laboratory quantitation limit)

JSO015061

EID620796

Table 2.1B
Summary of Analytical Results:
C-8 in Groundwater
DuPont Washington Works Main Plant
Washington, WV

Sample	Date	C-8 (ug/l)
AA04-MW01	2/5/99	5.43
	11/12/98	<0.1
	11/12/98 (dup)	0.42
AA05-MW01	2/4/99	1.46
	11/11/98	0.77
AB07-MW02	2/4/99	0.535
	11/16/98	<0.2 J
AC07-MW02	2/4/99	0.356
	11/16/98	0.79
AE11-MW01	2/2/99	0.69 L
	11/10/98	0.41
AI06-MW01	2/3/99	0.13 B
	11/16/98	<0.1
AM07-PW01	11/20/00	0.24
	8/16/00	0.071 J
	5/12/99	0.578
	2/3/99	0.082 B
	11/18/98	1.9 L
	6/19/98	0.4
	6/2/97	0.79
	4/2/96	0.48
AO08-PW01	11/20/00	0.4
	11/20/00 (dup)	0.28
	8/15/00	0.167
	5/12/99	0.307
	6/19/98	1
	6/2/97	0.55
	4/2/96	0.52
AQ09-PW01	10/11/01	0.498
	5/12/99	1.45
E13-MW01	5/12/99	0.882
	2/2/99	0.59 L
	11/11/98	2
F06-MW01	2/2/99	0.35 L
	11/11/98	<0.1
G17-MW01	5/12/99	2.47
	2/2/99	2.11 L
	11/11/98	13
K16-PW01	11/20/00	7.5
	2/9/99	16.2
	11/18/98	0.46 L
L04-PW01	7/11/01	0.202
	4/11/01	3.99
	11/20/00	13.8
	2/7/99	5.89
	11/18/98	7.9 J
	11/18/98 (dup)	3.9 J
L06-MW01	2/5/99	4.91
	11/13/98	870
L17-PW01	7/11/01	2.31
	4/11/01	1.58
	9/14/00	0.819
	6/3/99	1.63
	2/9/99	2.76
	11/18/98	0.33
	6/2/98	16
	5/29/97	7.9
	4/11/96	3.7
	2/16/94	2

Table 2.1 B
Summary of Analytical Results (con't.):
C-8 in Groundwater DuPont Washington Works Main Plant, Washington, WV

Sample	Date	C-8 (ug/l)
M04-MW02	2/7/99	17
	11/12/98	0.2
M04-MW03	2/7/99	21.1
	11/12/98	<0.1
M16-MW01	2/3/99	3.66 L
	11/10/98	0.88
N04-MW02	1/25/01	698
	1/25/01 (dup)	696
	2/7/99	329
	11/12/98	380
N05-MW01	2/5/99	815
	11/13/98	13
MW-AJP	4/18/96	<0.4
MW-MGM	4/18/96	0.69
MW-TWW	4/18/96	0.85
MWBG	4/2/96	<0.1
N13-MW01	2/2/99	29.6 L
	11/11/98	<0.1
P04-MW02	1/25/01	12600
	2/6/99	13600
	11/12/98	6300
P05-MW02	2/5/99	434
	11/13/98	1200
P06-MW02	2/5/99	414
	11/13/98	31
P08-MW01	2/4/99	43.4
	11/13/98	36
Q04-MW02	2/4/99	994
	11/13/98	660
Q05-MW01	11/13/98	38
R04-MW02	1/25/01	13800
	2/6/99	9420
	11/12/98	1300
V05-PW01	7/11/01	11.4
	4/11/01	5.48
	11/20/00	13.7
	2/7/99	12.4
	2/7/99 (dup)	3.95
	11/18/98	0.68 L
T13-MW01	2/3/99	0.64 L
	2/3/99 (dup)	1.30 L
	11/17/98	<0.1 R
U04-MW01	2/6/99	4.2
	11/12/98	1.6
U16-MW01	5/11/00	4.7
	5/20/99	2
	6/19/98	11
S05-MW02	2/5/99	174
	11/13/98	690
V08-MW01	2/4/99	1.91
	11/16/98	1.7
W05-MW01	2/8/99	0.729
	11/17/98	0.31
Y14-MW01	2/2/99	4.95 L
	11/10/98	12
Z06-MW02	2/4/99	0.803
	11/16/98	4.5
Z07-MW01	2/4/99	2.05
	11/16/98	3.8
Z09-MW01	2/6/99	2.74
	11/17/98	<0.1 R

Table 2.1 B
Summary of Analytical Results (con't.):
C-8 in Groundwater DuPont Washington Works Main Plant, Washington, WV

Sample	Date	C-8 (ug/l)
RBLMW1	12/5/91	140
	12/5/91 (dup)	140
RBLMW2	12/11/91	65
	12/11/91 (dup)	67
RBLMW3	12/11/91	7100
RBLMW4	12/5/91	550
RBLMW5	12/10/91	1300
RBLMW6	11/21/91	3300
RBLMW7	11/21/91	48
	11/21/91 (dup)	52
RBLMW8	12/10/91	2.4
RBLMW9	12/10/91	3.4
RBLMW10	11/20/91	14
RBLMW11	11/20/91	47
RBLMW12	12/10/91	4.8
BGMW2	12/13/91	2.3
BGMW3	12/13/91	4
	12/13/91 (dup)	3.8
BGMW5	12/11/91	5.5
ADPMW 1	12/6/91	7800
ADPMW 2	12/6/91	25
ADPMW 3	12/6/91	20000

R = unusable data result (relative to QA/QC)
J = estimated value (below laboratory quantification limit)
L = possible low bias result (relative to QA/QC)
B= compound detected in QC blank
< = Non-detect at stated laboratory method detection limit

Table 2.1C
Summary of C-8 Analytical Results: Drinking/Tap Water Samples
DuPont Washington Works Main Plant
Washington, WV

Sample	Date	C-8 (ug/l)
BLDG 1 MAIN	10/11/01	0.507
	10/11/01 (dup)	0.471
	8/15/00	0.589
BLDG 231	10/11/01	0.45
	5/12/99	0.308
	5/12/99 (dup)	0.269
BLDG 293	10/11/01	0.423
	5/12/99	0.496
BLDG 5	5/12/99	0.213

3.0 LOCAL LANDFILL

Tables

Figures

3.1 Introduction

The Local Landfill is located immediately adjacent to the main plant off the southern perimeter (Figure 3.0). The landfill and plant are located along the Ohio River in Washington, West Virginia, approximately seven miles southwest of Parkersburg, West Virginia. A water use and well survey is currently being conducted for the area within a 1-mile radius of the landfill perimeter (Figure 3.1).

The Local Landfill consists of three separate closed cells located on the heavily wooded 250-acre site. The cells were operated from 1964 to the middle 1980s under West Virginia/National Pollutant Discharge Elimination System (WVNPDES) Permit No. 0076538. The permit is currently undergoing renewal and is expected to be effective in January 2002. The permit requires monthly surface water sampling and semi-annual groundwater monitoring.

Materials landfilled included scrap product, scrap metal, wood pallets and bins, and Powerhouse ash. Approximately 144 tons of waste per year were disposed in the landfill. Powerhouse ash comprised about 70 percent of the total waste. The specific source of C-8 in historical groundwater and surface water samples collected from on-site locations has not yet been determined. The cells were closed and covered with approximately two feet of low permeability soil.

Figure 3.2 shows the location of the three cells, monitoring wells, and surface water sampling points. The cells have no compacted or synthetic bottom liners. However, a hydrogeologic evaluation indicated that the natural soil present under the cell materials is composed of reddish brown clay and weathered shale having a very low hydraulic conductivity of about 5×10^{-7} cm/sec (DuPont, 1990) and ranges from 3.5 to 19.5 feet in thickness.

3.2 Environmental Setting

3.2.1 Geology

The Local Landfill is situated in a hilly area with relief of approximately 30 to 40 feet. The slopes appear to be a combination of natural topography with terraced outcrops of massive sandstone and siltstone underlying varying amounts of soil cover and man-made landfill plateaus. The locations of two cross-sections developed for the Local Landfill are shown in Figure 3.3. The two cross-sections, A-A' and B-B', are shown in Figures 3.4A and 3.4B, respectively.

A shallow tight clay layer starting at ground surface ranges from three to 25 feet thick. The clay contains some minor sandy and silty zones, and some pebbles and fragments of sandstone in some locations. The clays are of low plasticity and appear to be well compacted, often displaying a laminar structure (DuPont, 1990). Underlying the shallow clay layer is weathered shale ranging from 10 to 35 feet thick. Below this competent bedrock is present at depths ranging from 21 to 40 feet below ground surface.

The bedrock at the Local Landfill consists of inter-bedded red and varicolored sandy or calcareous shale, and gray, green, and brown sandstone of the Permian age Dunkard Group. The maximum thickness of the Dunkard Group in this region is 570 feet. The cross-sections show that the sandstone layers dip gently towards the north. Most of the sandstone layers located in the upper portion of the stratigraphic section are lenticular and laterally discontinuous. Two laterally continuous sandstone layers are located in the lower stratigraphic section.

3.2.2 Hydrology, Hydrogeology and Groundwater Flow

Hydrology

In general, infiltration of precipitation is limited due to the very low hydraulic conductivity (5×10^{-7} cm/sec) of the surficial clays (where these clays exist) and the weathered bedrock (DuPont, 1992). In addition, infiltration of precipitation into the cells is limited by approximately 2-feet of low permeability soil and vegetative cover capping of the cells. Leachate from the southern cell and the eastern cell flows from the seeps in the steep valley walls to leachate collection ponds, Pond 1, 2 and 3 (Figure 3.2). Leachate from these ponds is discharged into a pipeline and conveyed to the main plant where it passes through storm water Outfall no. 001 into the Ohio River. Monitoring of combined pond effluent conveyed in the pipeline is conducted at Outlet 101.

Hydrogeology

Groundwater underlying the Local Landfill occurs in two zones. The discontinuous upper zone consists of the clays and underlying weathered bedrock and has a very low hydraulic conductivity (DuPont, 1992). The lower zone consists of the continuous and discontinuous sandstone layers having low permeability of 1×10^{-5} cm/sec. The sandstone layers are separated by laterally continuous shale layers. Well yields from the sandstone layers are very low, ranging from <0.5 gpm to 1.5 gpm (DuPont, 1992). The upper (and thicker) of the two laterally continuous sandstone layers located in the lower zone at elevations between 710-740 feet above Mean Sea Level (Figures 3.4A and 3.4B) has been designated as the "underlying significant aquifer" and is currently monitored semiannually as required by the permit.

In 1989, eight monitoring wells were installed at the Local Landfill by Tetra Tech Richardson (LLMW-1 through 8). However, five of these monitor wells (LLMW-1, -2, -3, -5, and –7) were closed in 1996 because they were screened in the discontinuous shallow clays and underlying weathered bedrock. LLMW-8, a bedrock well, was closed in 1997 because it was dry. Two additional bedrock wells, LLMW-9 and -10 were installed in 1995 and 1997, respectively. LLMW-9 was installed as a background well. These wells are screened within the significant underlying aquifer. Table 3.0 summarizes the well construction data for the existing monitoring wells.

Groundwater Flow

Groundwater elevations have been measured semiannually since 1994. Groundwater elevation contour maps for the significant underlying aquifer have been prepared from this data as required by the WVNPDES Permit No. 0076538. Figures 3.5A through 3.5G present maps for 2001 through 1996 and 1994. The groundwater contours were transferred from the original maps submitted for the permit to the updated Local Landfill base map.

Evaluation of limited groundwater elevation data for the closed wells (based on well installation information) indicates a downward vertical gradient between the upper discontinuous water bearing zone and the lower sandstone layers containing the underlying significant aquifer. In addition, C-8 present in the underlying significant aquifer provides further support for a downward vertical gradient.

The groundwater contour maps for the underlying significant aquifer show that flow is from the south to the north towards the plant. The sandstones of the underlying significant aquifer outcrop in the valley walls where discharge may occur as seeps. However, groundwater may also flow downslope within the fractured rocks of the valley walls and ultimately enter the alluvial terrace deposit on the main plant. Groundwater discharging to seeps ultimately migrates to the plant through a number of pathways. It can discharge downward to leachate collection ponds and pipes to the main plant where it enters storm sewers and discharges to the Ohio River. Groundwater also can seep to small streams draining the property to the north and flowing to the Quaternary alluvial terrace unconfined aquifer where pumping of on-site active well fields controls groundwater flow. Groundwater flow in the alluvial aquifer, adjacent to the valley walls of the Local Landfill, is towards the pumping wells located near and parallel to the Ohio River. The pumping of these well fields also lowers the groundwater level to below river stage, inducing surface water from the river to flow into the alluvium towards the pumping wells. Water from the pumping wells is used for non-contact cooling purposes and ultimately is discharged to the Ohio River.

3.3 Water Quality

3.3.1 Surface Water Quality

Table 3.1A presents the historical C-8 concentration data available for surface water. Figure 3.2 shows the surface water sampling locations, if the location currently exists. Samples from two outfalls, four outlets, two streams, and one leachate sampling location have been collected periodically since 1994. C-8 concentrations in the outfalls and outlets range from <0.2 ug/l to 80 ug/l. Stream sample C-8 concentrations ranged from 4.12 ug/l to 15 ug/l. The leachate sample, collected in the pipe from the leachate ponds, had a concentration of 31 ug/l (February 1994). For sample locations having more than two sampling events, the concentration of C-8 is decreasing with time although it is difficult to accurately identify trends in samples with the limited data set. The C-8 concentration at Outlet 101, located at the northeastern portion of the side, have decreased from 54 ug/l to 12 ug/l over the course of three sampling events.

3.3.2 Groundwater Quality

Analysis of C-8 in groundwater has been conducted annually on a voluntary basis since 1996. Table 3.1B presents the data available for C-8 in Local Landfill monitoring wells. Groundwater was sampled annually in 1996, and 1998 through 2001 for three wells, LLMW-4, -6, and –9. LLMW-10 was sampled twice in 1998 and 1999. The limited amount of data makes it difficult to develop concentration contour maps. In addition, the monitoring wells are located at three separate areas (cells) of the landfill; therefore, annual data for the past four years is posted in Figures 3.6A through 3.6D but is not contoured.

C-8 concentrations in LLMW-9 and -10 range from non-detectable to 0.22 ug/l. The other two wells, LLMW-4 and -6, have the highest concentrations, ranging from 1.4 to 39 ug/l and from 1.32 to 15 ug/l respectively. Although there is limited data, the data shows a distinct reduction in C-8 concentration over time for wells LLMW-4, -6, and -9.

3.4 Site Conceptual Model

The Local Landfill site conceptual model describes the potential exposure routes for current and future human and ecological receptors. Potential exposure routes were evaluated and classified as complete or incomplete.

Access to the Local Landfill is restricted by electronic and locked gates at the road entrances. However, a posted nature trail has been established on the east side of the landfill property. The trail loops around the eastern part of the landfill starting and ending near the landfill's electrically operated gate. The nature trail is a marked trail and does not cross the cells. Access to the site from surrounding roads is possible but is discouraged due to the heavily wooded nature of the property and the hilly terrain.

The three cells at the Local Landfill are covered with a low permeability soil and vegetative cover. This cover prevents human and ecological receptors' exposure to the landfilled materials and to the soils potentially impacted by the landfill materials. However, these materials could potentially be exposed by extensive digging or rooting in the soil by animals or unauthorized people. Therefore this pathway is considered to be potentially complete but minimal.

An additional potentially complete exposure pathway exists if the soil and vegetative cap is eroded by precipitation. Permit WV0076538 requires that the landfill surface will be inspected quarterly for evidence of cracking or erosion (which could allow surface water to enter the solid waste deposit) and evidence of settling of solid waste (causing ponding of surface water). Per Condition G-16 of the permit, a stormwater erosion inspection is conducted annually. Therefore, this potentially complete pathway is considered to be minimal.

At the landfill, precipitation is expected to take one of two paths. It may infiltrate downward through the vegetated soil cover and into the cells. However, the low permeability of the soil cover reduces the amount of infiltration. If the precipitation infiltrates the soil cover, it will possibly encounter the landfill materials and will continue downwards. It may be prevented from further downward migration by the low permeability clays and weathered bedrock. However, if this water migrated further downward, it should encounter the sandstones and shale layers. Groundwater flowing through the sandstone layers that outcrop in the valley walls located above the plant site's southern edge would be exposed at the surface in seeps, if seeps exist. The existence and location of seeps at some places on the property have been observed, particularly those mentioned near the leachate collection ponds. Much of the site remains unexplored, therefore, complete evaluation of this potential exposure pathway (surface water to groundwater to surface water) is currently not available.

Another possible migration route for precipitation is direct flow as surface water via overland flow downslope. In this case the water would not encounter the fill materials at any point it time. This potential exposure pathway is considered incomplete.

Contact with groundwater impacted by C-8 is another potential exposure route for current and future human and ecological receptors. However, contact with groundwater under the landfill is limited, although, contact with leachate that has reached the ground surface via seeps is possible in the vicinity of Pond 1, near the southern most cell. Ponds are open and accessible to limited number of DuPont employees. As stated previously, groundwater flowing through the sandstone layers that outcrop in the valley walls located above the plant site's southern edge would be a possible contact location. However, because seeps in this area are not evident, it is likely that groundwater flows downslope within the fractured rocks of the valley walls and discharges to the main plant alluvial terrace. Determining the existence and location of seeps on the property has not been completed therefore, this potential exposure pathway cannot be fully evaluated.

3.5 Data Gaps

The following data gaps were identified for the Local Landfill:

- Identify the locations of seeps in the valley walls and determine water quality with respect to C-8 concentration.
- Determine the C-8 concentration in streams and other surface water bodies.
- Acquire additional geological data to refine the Site Conceptual Model.
- Install additional monitoring wells to provide additional groundwater flow data and groundwater quality data.
- Gather additional C-8 concentration data from monitoring wells for plume delineation.

Activities to fill the data gaps will be proposed and discussed in the work plan.

3.6 References

DuPont. 1990. *Washington Works 1990 Preliminary Hydrogeologic Assessment.* Solid Waste & Geological Engineering Department.

_______. 1992. *Verification Investigation E.I. DuPont de Nemours Co.* Washington Works April 1992. (Vol. 1).

Table 3.0
Monitoring Well Construction Data
Local Landfill
Washington, WV

Monitoring Wells	Surface Elevation (feet)	Total Depth (feet)	Well Diameter (inches)	Slot Size (inches)	Screen Length (feet)	Elevation of Screen Interval (feet)
LLMW-4	844.7	155	4	0.020	20	717.2-697.2
LLMW-6	793.2	90	4	0.020	20	723.2-703.2
LLMW-9	788.54	80	4	0.020	20	728.54-708.54
LLMW-10	805.94	87	4	0.020	20	738.94-718.94

Table 3.1A
Summary of Analytical Results:
C-8 in Surface Water Samples
Local Landfill
Washington, WV

Sample	Date	C-8 (ug/l)
LEACHATE	2/16/1994	31
OUTFALL 004	9/27/2000	4.73
	12/10/1999	7.1
	6/3/1999	3.06
	6/2/1998	12
	5/29/1997	13
	4/2/1996	13
	2/16/1994	11
OUTFALL 005	9/27/2000	13.3
	12/10/1999	34
	6/3/1999	6.8
	6/2/1998	39
	5/29/1997	41
	4/2/1996	39
	2/16/1994	35
OUTLET 001	5/29/1997	80
	4/2/1996	61
OUTLET 002	5/29/1997	<0.2
	4/2/1996	72
OUTLET 003	5/29/1997	23
	4/2/1996	20
OUTLET 101	9/14/2000	12
	6/3/1999	15
	6/2/1998	54
STREAM 1	5/29/1997	11
	4/2/1996	7.2
STREAM 2	9/14/2000	4.12
	12/29/1999	10.7
	6/2/1998	15
	4/2/1996	14

Table 3.1B
Summary of Analytical Results:
C-8 in Groundwater
Local Landfill
Washington, WV

Sample	Date	C-8 (ug/l)
LLMW-4	5/16/2001	1.4
	5/11/2000	10
	5/19/1999	16.2
	5/27/1998	26
	4/11/1996	39
LLMW-6	5/16/2001	3
	5/10/2000	1.42
	5/19/1999	1.32
	5/27/1998	9
	4/11/1996	15
LLMW-9	5/16/2001	0.039 J
	5/10/2000	<0.029
	5/20/1999	0.046 J
	5/27/1998	<0.1
	4/11/1996	0.14
LLMW-10	5/20/1999	0.15
	5/28/1998	0.22

4.0 LETART LANDFILL

Tables

Figures

4.1 Introduction

The Letart Landfill is located just north of the town of Letart in Mason County, West Virginia (Figure 4.0). A water use and well survey is being completed for the area within a 1-mile radius from the landfill perimeter (Figure 4.1).

The landfill covers approximately 17-acres of a 205-acre parcel of land owned by DuPont Washington Works. It was in operation from the early 1960s to 1995. The landfill was operated and closed under West Virginia Solid Waste /National Pollutant Discharge Elimination System Permit No. WV 0076066. This permit requires quarterly groundwater monitoring, outfall and surface water monitoring and engineered cap maintenance.

Figure 4.2 shows the landfill extent, orientation, topography, and monitoring well locations. The landfill was constructed within a natural ravine and has no compacted or synthetic bottom liners. However, a hydrogeologic evaluation indicated that the natural soil present under the landfill material is composed of highly plastic clay and silt having a permeability of about 10^{-7} cm/sec (DuPont, 1993). The soil thickness ranges from 4 to 14 feet, averaging about 8 feet in thickness.

Letart Landfill received waste was from the Fluoropolymer manufacturing process at the plant that consisted primarily of scrap product, scrap metal, wood pallets and bins, and miscellaneous trash. Approximately 5,000,000 pounds of waste per year were disposed in the landfill. This waste is believed to be the source of C-8 in the historical groundwater and surface water samples collected from on-site locations.

The Letart Landfill was permanently closed by installing an engineered multi-layer geosynthetic and soil cap (DuPont, 2001). Included in the closure activities were the installation of a leachate collection system, erosion and drainage control measures and chain-link fencing. The cap construction was completed in April 2001.

4.2 Environmental Setting

4.2.1 Geology

The Letart Landfill is situated on a heavily dissected plateau consisting of several steep V-shaped valleys. Residual soil covers most landfill areas. In general, the soil at the site has been described as residual in nature, consisting primarily of heavy clays derived from the weathering of bedrock. At most landfill areas, the soil is less than ten feet thick, with a maximum thickness of 20.5 feet.

The underlying bedrock at the Letart Landfill consists of inter-bedded red and varicolored sandy or calcareous shale, and gray, green, and brown sandstone of the Permian age Dunkard Group. The maximum thickness of the Dunkard Group in this region is 570 feet. The location of two cross-sections, A-A' and B-B', crossing the landfill are shown in Figure 4.3. The two cross-sections of the underlying geology are shown on Figures 4.4A and 4.4B.

Geologic investigations conducted at the Letart Landfill identified six stratigraphic water-bearing zones that were designated as Zone A through Zone F, with Zone A being the shallowest zone and Zone F the deepest. These zones consist of massive, very fine to fine grained crystalline sandstone with occasional shale lenses. Zones A through F are separated by locally continuous shale units that are generally ten feet or greater in thickness. Zones A through D/E are discontinuous. Zone F is the first laterally continuous zone under the landfill. Zones A, C, D/E and F outcrop on the valley sides and along the Ohio River near the southern end of the landfill.

4.2.2 Hydrology, Hydrogeology and Groundwater Flow

Hydrology

The Letart Landfill engineered cap system prevents surface water from contacting landfilled materials. Precipitation falling on the engineered cap system takes one of two paths. It may infiltrate downward through the vegetated soil and encounter the impermeable geomembrane and then flow laterally downslope on top of the geomembrane. Alternatively, precipitation may flow via overland flow on top of the vegetative layer downslope. In either situation, this surface water does not contact the landfilled materials and migrates downslope towards drainage ditches constructed in or adjacent to the cap system. Precipitation falling on the northwest side of the upper part of the cap flows downslope towards the southwest, away from the landfill, into a drainage ditch that flows to a sediment trap near LMW-6. Precipitation falling on the remaining portions of the cap flow downslope and towards the south in drainage ditches.

Hydrogeology

Hydraulic conductivity testing [i.e., slug tests (Zone A) and borehole packer tests (Zones C, D/E and F)] of the bedrock zones indicates that these zones display low hydraulic conductivity (Tetra Tech Richardson, 1990). Zone A hydraulic conductivity is low, ranging from 10^{-4} cm/sec to less than 10^{-5} cm/sec. (There are no wells monitoring Zone B, therefore, it was not tested.) Zones C and F have very low hydraulic conductivities ranging from 10^{-6} cm/sec to less than 10^{-8} cm/sec. Zone D/E hydraulic conductivities are also very low and range from 10^{-5} cm/sec to 10^{-8} cm/sec.

Zone F has been designated the "underlying significant aquifer" as defined by to the West Virginia Solid Waste Management Regulations because it is laterally continuous under the landfill and is thought to be hydraulically connected to the Ohio River south of the landfill. Most current groundwater monitoring is conducted in Zone F.

The low hydraulic conductivity can be attributed to the very fine-grained nature of the water-bearing units. In addition, many sandstone units in the region typically display effective porosity as low as 1 percent. This low porosity results from pore space being filled in by authigenic minerals (e.g. kaolinite) sometime after original sediment deposition.

Zone F groundwater average linear velocities were calculated for flow from the north to the southwest and from the north to the southeast (DuPont, 2000). These values are relatively low, 0.01 and 0.003 ft/day respectively. The low velocities calculated in the F zone indicate that groundwater flow beneath the landfill is very slow, attributable to the low hydraulic conductivity present in the F zone and all the overlying units as well. Low vertical hydraulic conductivities in the overlying shallow zones limit infiltration and recharge down to the F zone.

The saturated thickness of Zone F ranges from 22 feet in the upgradient well (LMW-2A) to between 2 and 8 feet in five downgradient wells (LMW-5A, -6, -9, -10, and –11). In many instances, the monitoring wells at the landfill cannot be sampled until 48 hours (or longer) after purging, when a sufficient quantity of groundwater has recovered in the well screen interval.

Groundwater Flow

Thirteen monitoring wells have been installed at the Letart Landfill in the Zone A, C, D/E, and F sandstone units (Tetra Tech Richardson, 1989; 1990). Two of these wells, LMW-10 and LMW-11, were installed in October 2001 to provide additional data from Zone F to the north and south of the landfill. Table 4.0 lists the wells monitoring each zone and provides well construction information. Water level measurements and calculated groundwater elevations have been measured quarterly. Figures 4.5A through 4.5F provide available annual groundwater elevation contour maps for Zone F as required for the permit. This data was transferred from the original maps submitted for the permit to the updated Letart Landfill base map.

The location and limited number of monitoring wells within Zones A, C and D/E prevents determination of groundwater flow directions within these zones. However, elevations measured in the monitoring wells indicate a downward vertical gradient within the site groundwater system. Within Zone F, a groundwater divide exists under the center of the landfill in a north-south direction. Groundwater east of the divide flows southeast towards the Ohio River. Groundwater west of the divide flows towards the west and southwest. Groundwater elevation data, including the newly installed LMW-11, the most northern monitoring well, indicates a slight component of northward groundwater flow in Zone F in this area.

Rapid decreases in the observed volume of water discharging from the leachate collection system in 2001 indicate that groundwater flow under the landfill is being greatly reduced in response to the installation of the engineered cap system. In addition, this reduction indicates that a new equilibrium state for groundwater flow has not yet been reached. Continued monitoring of groundwater elevations of Zones A through F is required to evaluate long-term changes in groundwater flow resulting from closure activities.

4.3 Water Quality

4.3.1 Surface Water Quality

Voluntary surface water sampling for C-8 has been performed periodically since 1991. This data is presented in Table 4.1A. The two locations sampled most frequently, the Upper and Lower ponds, no longer exist. During construction of the engineered cap system, these ponds were de-watered and the sediments underlying the ponds were excavated and placed in low areas of the landfill prior to the installation of the cap. Currently, only two surface water locations still exist (due to landfill cap construction) and are being sampled. These locations include the leachate from the landfill [location 002(leachate basin)] and the stream located slightly east of the property line along Rt. 33. The locations of these surface water-sampling points are shown in Figure 4.2.

4.3.2 Groundwater Quality

Groundwater from the monitoring wells has also been voluntarily sampled and analyzed for C-8 periodically since 1991. However, sampling did not take place on an annual basis until 1996 and quarterly sampling began the second half of 1999, when C-8 was added to the permit as a monitoring parameter. Table 4.1B presents all historical analysis available for C-8 from monitoring wells at the Letart Landfill. The limited data set makes contouring the values difficult, therefore, the values were posted on maps and not contoured. Figures 4.6A through 4.6D present the C-8 concentration values for July 2001, January 2000, July 1999, and November 1991, respectively.

An initial examination of the groundwater data does not show any obvious overall concentration trends (Table 4.1B). For wells having data from 1991 through 2001, it appears that the concentrations measured in 1991 were the lowest. From 1991, the concentrations in all wells increased. Currently, concentrations are now decreasing again in the most recent sampling events. However, identifying trends in the data is complicated by the fact that three different analytical laboratories have been contracted to perform the analyses between 1991 and 2001. In addition, the effects of the installation of the engineered cap system (preventing further surface water infiltration) may or may not be observable in the limited recent data.

For the most recent sampling event and analysis (October 2001), the sampling and analytical procedures, and the analytical instrumentation used were modified to gain better accuracy in the C-8 analytical results. These modified procedures will be utilized for all future analysis of groundwater samples for C-8. Continued monitoring of C-8 concentrations in groundwater is required to accurately evaluate the long-term trends in groundwater quality.

If it is assumed that impacted groundwater flows from Zone A downward to Zone F and ultimately migrates to the Ohio River, the C-8 historical mean for LMW-5B (Table 4.1B) can be used along with the estimated groundwater flux to calculate the C-8 loading to the river. The following assumptions were made in this calculation.

- The saturated thickness is 25 ft at LMW-5B. This is higher than the most recent groundwater elevation measurement and therefore, is a conservative value.
- The length of the aquifer discharging to the Ohio River is 1000 ft based on the geologic cross-sections.
- The historical mean value of 855 ug/l for LMW-5B, a downgradient well, represents the concentration of C-8 in the aquifer.
- The velocity of groundwater in the aquifer is 0.01 ft/day. Groundwater average linear velocities for the F zone are calculated to be 0.01 ft/day from the north to the southwest and 0.003 ft/day from the north to the southeast (DuPont, 2000).

Using these assumptions, the calculation for loading to the Ohio River is shown below:

A = Area = 1000 ft length x 25 ft saturated thickness for Zone F = 25,000 ft^2

V = Velocity = 0.01 ft/day (estimated)

Q = flux = A x V = (25,000 ft^2) x (0.01 ft/day) x (7.48 gal/ft^3) x (365 day/yr.)

= 682,550 gal/yr

Mass = (855 ug/l) x (1g/10^9ug) x (1kg/1000g) x (1 lb/2.205 kg) x (4.785 l/gal)

= 1.47×10^{-9} lb/gal x 682,550 gal/yr

= 1×10^{-3} lb/yr

Estimated annual loading to the Ohio River is very low based on the calculated mass and should result in a very low C-8 concentration in the Ohio River. The low calculated mass is reasonable given the low hydraulic conductivities and low average linear velocities observed in the F zone.

4.4 Site Conceptual Model

The Letart Landfill site conceptual model describes the potential exposure routes for current and future human and ecological receptors. Potential exposure routes were evaluated and classified as complete or incomplete.

The Letart Landfill closure was completed in April 2001 with the installation of an engineered cap system. The engineered cap system prevents human and ecological contact with the landfilled materials. Contact with landfilled materials would only be possible if the cap system were to be intentionally breached by workers or trespassers or by extensive, vigorous digging by animals. However, dense vegetation and appropriately installed fencing restricts access by unauthorized individuals and animals. Therefore, direct exposure to landfilled materials is a potentially complete but very limited exposure pathway.

Exposure of landfilled material because of erosion of the engineered cap system due to storm runoff is also a potential human and ecological exposure pathway. However, cap system drainage controls were designed to convey the runoff from the landfill cap to a designated discharge point and to eliminate the potential for runoff-related erosion of the cap. In addition, the landfill cap is required to be inspected at least quarterly (permit requirement C.12.A) for evidence of erosion as part of the site Storm Water Pollution Prevention Plan. Therefore, this potential exposure pathway is also a potentially complete but minimal exposure pathway.

The Letart Landfill engineered cap system prevents surface water from contacting landfilled materials. Surface water migrates towards drainage ditches constructed in the cap system and is discharged at the southern edge of the landfill. Because this surface water does not contact the landfilled materials, it is not impacted by C-8. Therefore, contact with this surface water is an incomplete exposure pathway.

Groundwater contacting the landfilled material has been impacted by C-8. Contact with this impacted groundwater presents a possible human and ecological exposure pathway due to groundwater flow patterns. Groundwater flow under the landfill has shown that prior to the installation of the engineered cap, surface water impinging on the landfill migrated downward through the landfill material. These waters continued to flow as groundwater downward towards Zone F where it then flowed laterally to the west and south. Currently, the engineered cap prevents surface water from contacting the landfilled materials although groundwater migrating laterally and vertically underneath the landfill may still contact the landfilled materials. Groundwater under the engineered cap migrates to the leachate collection system. Discharge from the leachate collection system is piped to an outfall [002(leachate basin)] where it enters a small, shallow, wet weather stream that flows approximately 400 feet before it discharges to the Ohio River. Contact with leachate is a potential pathway exposure route for current and future human and ecological receptors, however, this pathway is considered complete but limited due to the restricted access to the area.

Zones D/E and F occur at elevations lower than the leachate collection system. Groundwater flowing from these zones to the south discharges to the Ohio River. Contact with this water is limited to the areas where these zones may outcrop on the valley walls. However, in general, groundwater flows downslope within the shallow soil, colluvium, and fractured rocks of the valley walls and would only be exposed at the surface if seeps exist. Currently, there is no data available on the existence or location of seeps on the slopes adjacent to the landfill or along the Ohio River. Therefore, evaluation of this potential pathway exposure route for current and future human and ecological receptors is not possible at this time.

Groundwater that flows to the west from Zone F is likely to discharge to nearby valley drainage systems and to ultimately migrate to the Ohio River. Again, groundwater flows downslope within the fractured rocks of the valley walls and would only be exposed at the surface if seeps exist. Currently, there is no data available on the existence or location of seeps in the valleys south of the landfill. Therefore, evaluation of this potential pathway exposure route for current and future human and ecological receptors is not possible at this time.

4.5 Data Gaps

The following data gaps were identified for the Letart Landfill:

- Identify the locations of seeps in the valley walls, particularly in the steep valley wall along the Ohio River, and determine water quality with respect to C-8 concentration.
- Determine the C-8 concentration in the Ohio River.
- Determine the C-8 concentration in streams and other surface water bodies.
- Acquire additional geological data to refine the Site Conceptual Model.
- Install additional monitor wells to provide additional groundwater flow data and groundwater quality data.
- Gather additional C-8 concentration data from monitoring wells for plume delineation.

Activities to fill the data gaps will be proposed and discussed in the work plan.

4.6 References

DuPont. 1993. *Letart Landfill Hydrogeologic Evaluation*, July 1993. Corporate Remediation Group.

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Tetra Tech Richardson. 1989. Monitoring Well Installation Program, October 1989.

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Table 4.0
Monitoring Well Construction Data
Letart Landfill
Letart, WV

Zone	Monitoring Wells	Surface Elevation (feet)	Total Depth (feet)	Well Diameter (inches)	Slot Size (inches)	Screen Length (feet)	Elevation of Screen Interval (feet)
A	LMW-1	768.53	33	2		5	738.53-733.53
	LMW-7	770.24	35	4		10	745.24-735.24
	LMW-8	777.06	38.5	4		9	748.06-739.06
C	LMW-3	673.1	30	2		5	650.1-645.1
D	LMW-3A	672.61	60.1	4	0.010	5	619.61-614.61
	LMW-4	649.17	28	2		5	626.17-621.17
	LMW-5A	645.23	28	4	0.010	10	627.23-621.23
F	LMW-2A	778.53	180.8	4	0.010	30	628.53-598.53
	LMW-5B	644.39	72	4	0.010	20	594.39-574.39
	LMW-6	754.22	183	4	0.010	30	606.22-576.22
	LMW-9	774.85	225	4	0.010	20	572.85-552.85
	LMW-10	732.37	189.85	4	0.010	20	562.52-542.52
	LMW-11	774.34	161.5	4	0.010	25	637.84-612.84

Table 4.1A
Summary of Analytical Results:
C-8 in Surface Water Samples
Letart Landfill
Letart, WV

Sample	Date	C-8 (ug/l)
002(LEACHATE BASIN)	7/25/2000	1350
	4/3/2000	1900
	1/14/2000	920
	10/21/1999	3240
LEACHATE	11/27/2001	53.2
	7/20/01	159
	7/25/2000	2250
	7/20/1999	1030
LOWER POND	1/14/2000	1410
	4/3/2000	1260
	10/21/1999	2530
	7/19/1999	1190
	5/28/1998	1100
	7/23/1997	1600
	4/17/1996	1900
	9/20/1994	2200
	3/15/1994	730
	12/27/1991	1300
	11/22/1991	1000
	4/26/1991	670
	3/22/1991	340
	2/8/1991	400
	1/18/1991	1200
N SPRING FLOW	3/12/1992	0.3
	3/12/1992	0.3
RT 33 STREAM	7/20/2001	2.01
	7/31/2000	0.573
	7/20/1999	2.23
	7/23/1997	2
	4/17/1996	1.8
STREAM MN RD	3/15/1994	0.5
	9/20/1994	0.9
SW SPRING FLOW	3/12/1992	1
UPPER POND	7/19/1999	517
	5/28/1998	480
	7/23/1997	<200
	4/17/1996	2100
	3/15/1994	4400
	12/27/1991	4100
	11/22/1991	790
	4/26/1991	930
	3/22/1991	500
	2/8/1991	2300
	1/18/1991	2900

Table 4.1B
Summary of Analytical Results:
C-8 in Groundwater
Letart Landfill
Letart, WV

F-Zone Wells		
Sample	**Date**	**C-8 (ug/l)**
LMW-2A	7/19/2001	242
	1/30/2001	423
	10/5/2000	248
	7/25/2000	275
	4/3/2000	306
	1/14/2000	453
	10/21/1999	370
	7/20/1999	350
	5/28/1998	990
	7/23/1997	460
	4/17/1996	460
	9/20/1994	270
	3/15/1994	260
	11/22/1991	63
	3/22/1991	50
LMW-5B	7/20/2001	483
	7/20/01(dup)	592
	1/31/2001	615
	10/5/2000	1190. J
	10/5/00 (dup)	780
	7/25/2000	900. J
	4/3/2000	1100
	4/3/00 (dup)	1020
	1/14/2000	1030
	10/21/1999	1750
	10/21/99 (dup)	1700
	7/20/1999	445
	7/23/1997	480
	9/20/1994	530
	3/15/1994	1200
	11/22/1991	380
	3/22/1991	340
LMW-6	1/13/2000	9.4
	5/28/1998	30
	11/22/1991	24
	3/22/1991	25
LMW-9	10/7/1992	0.2

J = estimated value (below laboratory quantitation limit).

D/E-Zone Wells		
Sample	**Date**	**C-8 (ug/l)**
LMW-3A	7/19/1999	60.3
	11/22/1991	350
	3/22/1991	380
LMW-4	4/3/2000	272
	1/14/2000	172
	11/22/1991	830
	3/28/1991	690
LMW-5A	11/22/1991	0.8
	3/22/1991	1.6

Table 4.1B
Summary of Analytical Results (Con't):
C-8 in Groundwater
Letart Landfill
Letart, WV

C-Zone Wells		
Sample	Date	C-8 (ug/l)
LMW-3	11/22/1991	1000
	3/22/1991	390

A-Zone Wells		
Sample	Date	C-8 (ug/l)
LMW-1	7/19/2001	6100
	1/31/2001	9190
	10/4/2000	10600
	7/24/2000	8990
	4/3/2000	13600
	1/13/2000	17400
	10/21/1999	12600
	7/20/1999	6920
	5/28/1998	24000
	7/23/1997	5100
	4/17/1996	1700
	11/22/1991	68
	3/22/1991	60
LMW-7	7/20/2001	242
	1/31/2001	249
	10/4/2000	231
	7/25/2000	158
	4/3/2000	211
	1/13/2000	219
	10/20/1999	339
	7/20/1999	78.3
	5/28/1998	260
	7/23/1997	53
	4/17/1996	15
	11/22/1991	0.1
LMW-8	7/19/2001	1120
	1/30/2001	2650
	10/4/2000	2300
	7/24/2000	2160
	4/3/2000	2180
	1/13/2000	2100
	10/20/1999	3260
	7/20/1999	1790
	5/28/1998	2700
	7/23/1997	2000
	4/17/1996	2200
	11/22/1991	280

5.0 DRY RUN LANDFILL

Tables

Figures

5.1 Introduction

The Dry Run Landfill is located west of the town of Lubeck, in Wood County, West Virginia (Figure 5.0) and is about eight miles southwest of the Washington Works main plant and the Local Landfill. A water use and well survey search is being completed for the area within a 1-mile radius from the Dry Run Landfill perimeter (Figure 5.1).

The Dry Run Landfill covers approximately 17-acres of a 535-acre parcel of land owned by DuPont. The landfill began operation in 1986 and is still active at present. The landfill is operated under West Virginia Solid Waste /National Pollutant Discharge Elimination System Permit No.WV 0076244. This permit requires quarterly groundwater monitoring and monthly outfall surface water monitoring.

Figure 5.2 shows the location of the landfill, monitoring wells and surface water sampling points. The landfill was constructed within the drainage basin of Dry Run, a tributary of the North Fork of Lee Creek, which is a tributary of the Ohio River. The Dry Run Landfill has no compacted or synthetic bottom liners. However, natural soil present under the landfill material is composed of clay and weathered shale.

The Dry Run Landfill receives waste from the main plant consisting of non-hazardous waste including scrap product, scrap metal, wood pallets, fly ash and bins, and miscellaneous trash. Approximately 50,000,000 pounds of waste per year have been disposed in the landfill. Currently, the C-8 source is believed to be the sludges from the closure of the main plant anaerobic digestion ponds that were landfilled at Dry Run in 1988. The Dry Run Landfill remaining capacity calculations for 2001 show 4.4 years of remaining life on the existing cell based on a 128,000 yd^3/yr net fill volume consumption (DuPont 2000).

5.2 Environmental Setting

5.2.1 Geology

The Dry Run Landfill is situated on a heavily dissected plateau consisting of several steep V-shaped valleys. Residual soil covers most landfill areas. In general, the soil at the site has been described as residual in nature, consisting primarily of heavy clays derived from the weathering of shale.

A geotechnical investigation for the Dry Run Landfill was completed by DuPont (1996). The investigation consisted of advancing soil test borings, test pits, laboratory testing of soil physical properties, stability analyses, and settlement analyses. DuPont (1996) determined that the natural residual soil underlying the landfilled materials consisted of stiff to very hard silty clay and clayey silt with occasional rock fragments and a trace of sand. The thickness of this natural soil ranged from 12 to 28 feet in the test borings within the landfilled area. A 1989 monitoring well installation program, prepared by Tetra Tech Richardson Inc., indicated similar silty clay and weathered shale overburden. Four overburden wells (DRMW 12A, 12B, 13A, 6A) were installed to depths ranging from 11 to 17 feet.

The underlying bedrock at the Dry Run Landfill consists of inter-bedded red and varicolored sandy or calcareous shale, and gray, green, and brown sandstone of the Permian age Dunkard Group (Tetra Tech Richardson, 1989). The maximum thickness of the Dunkard Group in this region is 570 feet. The location of two cross-sections, A-A' and B-B', crossing the landfill and downgradient of the landfill are shown in Figure 5.3. The two cross-sections are shown in Figures 5.4A and 5.4B.

There are only a limited number of deep monitoring wells around and upgradient from the landfill (DRMW-14). Dashed geologic contact lines were drawn on cross-section A-A' (Figure 5.4A) because there is not sufficient data to confidently extrapolate between DRMW-14, the upgradient well, and DRMW-13, the downgradient well. More geological data is available (DRMW-6, -11, -12, and -13) and was used in developing the downgradient cross-section, B-B' (Figure 5.4B) with more confidence. Cross-section B-B' supports the interpretations made in cross-section A-A' of rather flat lying stratigraphic units of sandstone layers separated by shale layers.

5.2.2 Hydrology, Hydrogeology and Groundwater Flow

Hydrology

The Dry Run Landfill is situated on a heavily dissected plateau consisting of several steep V-shaped valleys. Dry Run drains the valley in which the landfill is located. Many small tributaries discharge from the nearby valleys into Dry Run before it joins up with the North Fork of Lee Creek.

Potesta & Associates, Inc. (1989) completed a hydrologic and hydraulic analysis of the receiving stream below the Dry Run Landfill. They determined that the watershed soils are split between hydrologic soil groups (HSG) C and D and estimated the flow capacity at 481 cubic feet per second (that is greater than the 100-year 24-hour storm). Potesta (1989) also evaluated the 24-hour precipitation amount that would result in full flow conditions at the location where the capacity was estimated. Potesta determined that precipitation values between 5.25-5.99 inches in 24 hours would result in full flow.

The installation of a leachate collection system at the Dry Run Landfill encompassing the inactive lower half of the landfill was completed by Potesta & Associates Inc. in 1999. Leachate from the landfill discharges into a leachate collection sump located northwest of the landfill (Figure 5.2) through perforated pipes buried at the low edge of the fill area. The leachate is pumped from the collection sump to a 50,000-gallon collection tank located at the top of the hill. Leachate is pumped from the collection tank to a tanker truck, which is then hauled to the main plant for treatment in the site's wastewater treatment plant.

Hydrogeology

Groundwater is found in the overburden and the underlying bedrock aquifer. The bedrock aquifer is considered the underlying significant aquifer for NPDES permit required groundwater monitoring. A total of 15 monitoring wells have been installed at Dry Run to monitor the overburden and bedrock aquifers. At this time, four overburden wells (DRMW-6A, -12A, -12B, and 13A), and four bedrock wells (DRMW-12, -13, -14, and –15) still exist. The other seven wells were abandoned in 1999 by Potesta & Associates, Inc. as required by the permit because they were not being utilized for quarterly monitoring (Potesta, 1999). Table 5.0 provides the well construction data for existing monitoring wells.

Groundwater Flow

Water levels measured in November 2001 indicated overburden groundwater was encountered between 4 and 6 feet below ground surface. Although 3 of the 4 wells completed in the overburden monitor the same hydrogeologic unit, well DRMW-6A is completed at a relatively higher zone, which is discontinuous at lower topographic areas. No groundwater flow maps were prepared for the shallow water encountered in the overburden section.

Annual groundwater elevation maps for the underlying significant aquifer were available for the years 1992-1994, and 1998-2001. These maps are presented in Figures 5.5A through 5.5G. The groundwater contours were transferred from the original maps submitted for the permit to the updated Dry Run Landfill base map. These maps show that groundwater in the bedrock aquifer flows from the southeast towards the northwest. The groundwater elevations measured for nested wells (DRMW-12, -12A, and 12B, and DRMW-13 and –13A) are similar and the screened zones are constructed relatively close to each other, indicating that the overburden and bedrock aquifers may be in hydraulic communication downgradient of the landfill.

5.3 Water Quality

5.3.1 Surface Water Quality

Historical surface water C-8 concentrations are presented in Table 5.1A for six sampling points. Sampling location for surface water sampling points still in existence can be found on Figure 5.2. Surface water samples have been collected periodically from these locations since 1996 and have been collected consistently for three locations (DRLeachate, Outlet 001 and at the property boundary) since 1998. The concentration of C-8 in the leachate samples have been decreasing over time (from 62 ug/l down to 27.4 ug/l) while concentration from the other locations are variable and do not indicate a clear trend (Table 5.1A).

5.3.2 Groundwater Quality

Historical groundwater sampling began in 1996. For wells that currently exist, sampling continues (DRMW-6 was abandoned in 1999; Potesta, 1999). C-8 concentration were contoured for some of the sampling events for the overburden and bedrock wells. These concentration contours can be found in Figures 5.6A through 5.6 F. Data shown in Figure 5.6B was plotted but not contoured due to the data spread. The data for DRMW12-B and DRMW13-A for July 1999 appears anomalous compared to the other data for these two wells. The contour maps show that the highest concentration of C-8 exists in monitoring wells 13 and 13A, bedrock and overburden wells, respectively.

These two wells are located downgradient from the central axis of the landfill. For the majority of the sampling events for most of the other wells, both overburden and bedrock, the C-8 concentration has been less than 1 ug/l. The C-8 concentration for the 1999 sampling event in DRMW-14 was higher than other values measured for this well. Given that this well is an open bedrock well, and is relatively close to the landfill, this higher concentration may indicate communication of surface or shallow aquifer waters through the open well, particularly because groundwater flow in the underlying significant bedrock aquifer flows from DRMW-14 north west toward the landfill area as opposed to groundwater flowing from the landfill toward the DRMW-14 well.

5.4 Site Conceptual Model

The Dry Run site conceptual model describes the potential exposure routes for current and future ecological receptors. Potential exposure routes were evaluated and classified as complete or incomplete.

Access to the Dry Run Landfill by is controlled by electronic gates on the major roads and locked gates on smaller roads. In addition, because the landfill is active, there is a crew of workers on the landfill area during normal working hours. The daily activity discourages trespassers on the site. Therefore, direct contact with landfilled materials is a complete but minimal exposure route, limited to the workers in active portions of the landfill. Direct contact with landfill materials in the inactive, lower half of the landfill is incomplete due to the leachate collection system's geotextile and geomembrane cover. Contact with leachate at the landfill (or at the main plant where the leachate is treated) is considered a potentially complete but limited exposure route for the landfill and plant workers and samplers.

Currently, the inactive lower half of the landfill is covered by geotextiles and geomembranes of the leachate collection system. Therefore, precipitation falling on this portion of the landfill does not come in contact with the landfilled materials. This precipitation flows downslope via overland flow and discharges into storm water drainage ditches and eventually reaches Dry Run Creek. Therefore, this potential exposure route is considered incomplete.

Precipitation falling in the upper half of the landfill may also flow via overland flow down slope to the drainage ditches, again, an incomplete exposure route. Alternatively, this precipitation may infiltrate and come in contact with the landfilled materials as it migrates downgradient. However, this impacted water flowing within the landfill may be collected by the leachate collection system. If this impacted water migrates downward through the landfilled materials, it may eventually come in contact with the underlying shales and sandstone of the bedrock and migrate downgradient within the bedrock aquifer. Contact with impacted groundwater is a potentially complete exposure route although currently, not enough hydrogeologic data exists to accurately evaluate this exposure pathway.

Plans are underway for the expansion of the leachate collection system and for a final cap/cover system. These activities in the future will further reduce precipitation infiltrating and contacting landfilled materials.

5.5 Data Gaps

The following data gaps were identified for the Dry Run Landfill:

- Identify the locations of seeps in the valley walls and determine water quality with respect to C-8 concentration.
- Determine the C-8 concentration in streams and other surface water bodies.
- Acquire additional geological data to more accurately develop the Site Conceptual Model.
- Install additional monitor wells to provide additional groundwater flow data and groundwater quality data.
- Gather additional C-8 concentration data from monitoring wells for plume delineation.

Activities to fill the data gaps will be proposed and discussed in the work plan.

5.6 References

DuPont. 1996. *Report of Geotechnical Investigation Dry Run Landfill*, Washington Works Main Plant, Parkersburg, WV. Geotechnical Group, Civil Engineering Systems, DuPont Engineering. April 23, 1996.

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Tetra Tech Richardson. 1989. Monitoring Well Installation Program, October 1989.

Table 5.0
Monitoring Well Construction Data
Dry Run Landfill
Lubeck, WV

Monitoring Wells	Surface Elevation (feet)	Total Depth (feet)	Well Diameter (Inches)	Slot Size (inches)	Screen Length (feet)	Elevation of Screen Interval (feet)
DRMW-14	936.14	260	10	NA	NA	NA
DRMW-13	720.6	35	4	0.010	15	700.6-685.6
DRMW-13A	720.3	11	4	0.010	5	714.3-709.3
DRMW-12	730.5	35	4	0.010	15	710.5-695.5
DRMW-12A	730.3	17	4	0.010	5	718.3-713.3
DRMW-12B	730.5	15	4	0.010	10	725.5-715.5
DRMW-6A	744.93	12.2	2			
DRMW-15	730.87	45	2	0.010	20	705.87-685.87

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Table 5.1A
Summary of Analytical Results:
C-8 in Surface Water Samples
Dry Run Landfill
Lubeck, WV

Sample	Date	C-8 (ug/l)
DOWN STREAM	4/9/1996	25
DRLEACHATE	10/3/2000	27.4
	12/29/1999	34
	5/19/1998	56
	7/22/1997	62
OUTLET 001	10/3/2000	31.5
	12/29/1999	66
	5/19/1998	17
	4/9/1996	86
PROPERTY BOUNDARY	10/3/2000	10.3
	4/9/1996	9.9
	7/14/1998	0.88
	12/29/1999	39
STREAM SAMPLING POINT#1	10/3/2000	0.758
	12/29/1999	0.54
	5/19/1998	1
STREAM SAMPLING POINT#2	10/3/2000	27.6
	12/29/1999	87
	5/19/1998	4.6

Table 5.1B
Summary of Analytical Results:
C-8 in Groundwater
Dry Run Landfill
Lubeck, WV

Sample	Date	C-8 (ug/l)
DRMW-12	7/19/2000	0.16
	7/21/1999	0.134
	5/26/1998	<0.10
	7/22/1997	<0.1
	4/10/1996	<0.1
DRMW-12A	7/19/2000	0.128
	7/21/1999	0.081 J
	5/26/1998	<0.10
	7/22/1997	<0.1
	4/10/1996	<0.1
DRMW-12B	7/20/2000	ND (0.029)
	7/21/1999	5.4
	6/16/1998	<0.1
DRMW-13	7/20/2000	9.8
	7/21/1999	3.6
	5/26/1998	9.2
	7/22/1997	7
DRMW-13A	7/20/2000	9.9
	7/21/1999	0.070 J
	5/26/1998	8.7
	7/22/1997	15
	4/10/1996	8.2
	4/10/1996 (dup)	11
DRMW-14	7/20/2000	0.115
	7/21/1999	2.5
	6/16/1998	<0.1
	7/21/1997	<0.1
	4/10/1996	<0.1
DRMW-15	7/20/2000	0.763
	7/21/1999	0.263
DRMW-6	7/22/1997	1
	4/10/1996	0.97
DRMW-6A	7/20/2000	0.212
	7/21/1999	0.096
	5/26/1998	0.27
	7/22/1997	0.38
	4/10/1996	0.19

J = estimated value (below laboratory quantitation limit).

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FIGURES

Figures can be found on hard copy in central files.

APPENDIX 1

CONSENT ORDER
(ORDER NO. GWR-2001-019)