INVISTA S.á r.l. ("INVISTA") purchased the assets and operations of the Seaford site, including the ash landfill, from E.I. DuPont de Nemours & Company ("DuPont") on April 30, 2004 and the ash landfill permit was transferred from DuPont to INVISTA on June 23, 2005. Therefore, by way of clarification, any references to activities, documents, data, reports and other information contained in this application that convey that such information occurred or are dated prior to June 23, 2005 were prepared or performed by or on behalf of DuPont.

ARCADIS

Infrastructure, environment, facilities

Imagine the result

INVISTA™

Ash Landfill Hydrogeologic Assessment

INVISTA Seaford Plant
Seaford, Delaware

Date: 31 August 2003
Revised: 30 May 2006

ARCADIS

Timothy D. Ratchford, P.G.
Senior Scientist/Hydrogeologist

Eric B. Schmidley, P.G.
Delaware Professional Geologist S4-0000756

STATE OF DELAWARE
ERIC B. SCHMIDLEY
REG. No. 756
REGISTERED PROFESSIONAL GEOLOGIST

Ash Landfill
Hydrogeologic Assessment

INVISTA Seaford Plant
Seaford, Delaware

Prepared for:
INVISTA S.à r.l.

Prepared by:
ARCADIS G&M, Inc.
10352 Plaza Americana Drive
Baton Rouge
Louisiana 70816
Tel 225 292 1004
Fax 225 218 9677

Our Ref.:
LA002664.0001.00001

Date:
30 May 2006

This document is intended only for the use of the individual or entity for which it was prepared and may contain information that is privileged, confidential, and exempt from disclosure under applicable law. Any dissemination, distribution, or copying of this document is strictly prohibited.

ARCADIS

Table of Contents

1.	**Introduction**	**1**
2.	**Site Location**	**4**
2.1	Regional Area	4
2.2	Landfill Location	4
3.	**Geology**	**5**
3.1	Regional Geology	5
3.2	Site Geology	5
3.2.1	Miocene	6
3.2.2	Pliocene	6
3.2.3	Holocene	6
4.	**Regional Hydrology**	**7**
4.1	Site Hydrogeology	7
4.2	Shallow Zone	7
4.2.1	Shallow Zone Flow Rates	8
4.3	Deep Zone	8
4.3.1	Deep Zone Flow Rates	9
5.	**Regional Groundwater Quality**	**10**
5.1	Site Groundwater Quality	10
5.2	Shallow Zone	10
5.2.1	Shallow Zone Potential Pathways of Contaminants	10
5.3	Deep Zone	10
5.3.1	Deep Zone Potential Pathways of Contaminants	11
6.	**References**	**12**

Figures

1	Site Location Map
2	Site Layout Map
3	Well Locations and Cross-Section Map
4A	Cross Section A-A'
4B	Cross Section B-B'
4C	Cross Section C-C'
5	Shallow Aquifer Piezometric Surface Map, April 2005
6	Deep Aquifer Piezometric Surface Map, April 2005
7	Area of Maximum Seasonal High Water Table

Appendix

A	Well Logs for Cross Sections A-A', B-B', and C-C'

1. INTRODUCTION

This Hydrogeologic Assessment is required as part of the application and renewal procedures for Delaware Department of Natural Resources and Environmental Control (DNREC) permitted industrial landfills. This report fulfills Section 4.B.1.e. of the Delaware Regulations Governing Solid Waste (DRGSW), described therein as a Hydrogeologic Assessment.

INVISTA S.à r.l. ("INVISTA") purchased the assets and operations of the Seaford site, including the Ash Landfill, from I.E. Du Pont de Nemours & Company ("DuPont") on April 30, 2004, and the Ash Landfill permit was transferred from DuPont to INVISTA on June 23, 2005. Therefore, by way of clarification, any references to activities, documents, data, reports, and other information contained in this application that occurred or are dated prior to June 23, 2005, were prepared or performed by or on behalf of DuPont. This includes the Hydrogeologic Assessment that was initially prepared by the URS Diamond Group for DuPont Seaford Plant during 2003. ARCADIS was retained to revise the existing Hydrogeologic Assessment in response to comments provided by DNREC in correspondence to INVISTA dated December 19, 2005. DuPont's *2005 Powerhouse Ash Landfill Annual Hydrogeologic Report* was used to revise the existing Hydrogeologic Assessment.

The INVISTA Seaford Plant (formerly known as DuPont Nylon Facility) is located at 25876 DuPont Road, outside the city limits of Seaford, Delaware (Figure 1). The 650-acre plant site contains a coal-burning powerhouse that generates the electricity needed to run the facility. Three steam boilers burn bituminous coal for steam and power generation in the Seaford Powerhouse.

The burning of the coal produces two by-products, bottom ash and fly ash. Of the ash generated from combustion of the coal, 85 percent, by volume, is fly ash; 15 percent is bottom ash. These percentages can vary from 5 to 10 percent as a function of the coal source or boiler operation. Physically, there is not much difference between the generated bottom ash and fly ash other than particle size. The bottom ash passes through a grinder as it is sluiced to two ash ponds and its particle size distribution becomes similar to that of the fly ash.

Two settling ponds (North Pond [No. 1] and South Pond [No. 2]) exist at the INVISTA Seaford Plant. These ponds are used for the collection of ash produced in the combustion of coal burned for power production for the Plant. One pond is filled with slurry of ash and water generated from the power boilers in the power plant. As the first pond becomes filled to capacity with ash (a process that historically takes approximately 30 months), the water-ash slurry inflow switches to the second pond. After settling and drying out (a 3- to 6-month process), the first pond is ready for excavation and removal of ash.

Prior to excavation of a dried ash pond for recycling, reuse, or storage of the removed ash, field personnel collect a composite sample of the ash bed. Concentrations of Toxicity Characteristic Leaching Procedure (TCLP) metals are measured in order to determine whether the ash exceeds the Resource Conservation and Recovery Act (RCRA) TCLP levels. To this date, the ash has contained metal values below RCRA TCLP standards for hazardous waste.

After receiving the analytical results on the ash, coal ash is disposed on site in a DNREC-permitted industrial landfill. The Powerhouse Ash Landfill has accepted coal ash under a DNREC permit since 1979. The permit requires extensive testing of groundwater and surface water in the area surrounding the landfill. The Solid Waste Permit (SW-91/02) for the Seaford Plant Ash Landfill was renewed by DNREC and issued as Permit SW 98/01 on January 30, 1998, pursuant to Sections 4.A.1.a of the DRGSW. In addition, approval was granted to DuPont (previous owners and operators of the Ash Landfill) by DNREC on November 29, 1994, to dispose of ash from the clean out of nine fuel oil fired dowtherm vaporizers into the landfill. Permit modifications have been made since this time for the following reasons:

- July 31, 2002: Permit SW-98/01 was modified to incorporate the TCLP Analysis Ash Pond Sampling Plan dated May 16, 2002. References to the Solid Waste Management Branch were replaced with the Solid & Hazardous Waste Management Branch (SHWMB). The Department considers this a minor modification of the permit.

- January 22, 2003: Permit SW-98/01 was modified to extend the expiration date until January 31, 2004. The Department considers this a minor modification in accordance with the DRGSW, Section 4.A.7.b.

- January 29, 2004: Permit SW-98/01 was modified to extend the expiration date until May 3, 2004, to allow the Department more time to review the permit application submitted by INVISTA. The Department considers this a minor modification in accordance with the DRGSW, Section 4.A.7.d.(3).

- April 30, 2004: Permit SW-98/01 was modified to extend the expiration date until July 31, 2004, to allow the Department more time to review the permit application submitted by INVISTA. The Department considers this a minor modification in accordance with the DRGSW, Section 4.A.7.d.(3).

- July 19, 2004: Permit SW-98/01 was modified to extend the expiration date until January 31, 2005, to allow the Department time to review the INVISTA application to transfer the permit from DuPont to INVISTA S.à r.l. The Department considers this a minor modification in accordance with the DRGSW, Section 4.A.7.d.(3).

- January 24, 2005: Permit SW-98/01 was modified to extend the expiration date until June 30, 2005, to allow the Department time to review the INVISTA application to transfer the permit from DuPont to INVISTA S.à r.l. The Department considers this a minor modification in accordance with the DRGSW, Section 4.A.7.d.(3).

- June 6, 2005: Permit SW-98/01 had a minor modification in order to aid in the transfer of the Solid Waste Permit from DuPont to INVISTA S.à r.l. These modifications exclude surface water monitoring in April and October for Staff Gauges SG-2 and SG-4 and outfall of Ash Settling Pond No. 2; April water quality sampling at Spring No. 1 and No. 2; groundwater monitoring in April and October for water levels at Wells 14S, 15S, 16S, and 14D; April water quality sampling at Wells 14S, 15S, 16S, and 14D; and October water quality sampling at Wells 14S, 15S, 16S, and 14D. The Department considers removal of these monitoring requirements a minor modification in accordance with the DRGSW, Section 4.A.7.d.(3). The monitoring requirements that were removed from the Solid Waste Permit are still required under DuPont's RCRA Corrective Action Program which is overseen by DNREC SHWMB.

- June 23, 2005: Groundwater Monitoring Requirement B.3 was removed due to an Administrative oversight, per DRGSW Section 4.7.d.(3)., and is therefore considered a minor modification. This requirement was originally added for the installation of Monitoring Wells 15S, 16S, and 17S, which was to be completed in time for the April 1999 sampling event. This requirement is no longer relevant to SW-98/01 and was removed before issuing the transferred permit to INVISTA. Permit SW-98/01 was transferred from DuPont to INVISTA after a public notice period of 15 days in accordance with the DRGSW, Section 4.A.2, and modified to extend the expiration date until January 15, 2007, to allow time for INVISTA to complete the renewal process and the Department ample time to review the renewal application documents. The Department considers this a minor modification in accordance with the DRGSW, Section 4.A.7.d.(3).

2. Site Location

2.1 Regional Area

Seaford is located in the southwest portion of the state, in Sussex County, Delaware, and is situated along U.S. Route 13, the main north-south artery running from Wilmington, Delaware, to Norfolk, Virginia. The INVISTA Seaford Plant is located to the south of downtown Seaford (Figure 1).

2.2 Landfill Location

The Ash Landfill consists of approximately 60 acres of land. This landfill parcel is located within the larger 650-acre INVISTA Seaford Plant. Approximately 12.5 acres of the landfill currently contain ash. The landfill parcel is bordered by the Plant ash ponds to the north, the site effluent ditch and the Nanticoke River to the east, Lewes Creek to the south, and the INVISTA Seaford Plant boundary along Woodland Road to the west (Figure 2).

The northern border of the active landfill parcel is approximately 600 feet from the edge of the South Ash Pond. The eastern border of the landfill parcel is approximately 1,000 feet from the Nanticoke River. The southern border of the landfill parcel is approximately 100 feet from Lewes Creek. At the Plant property boundary, Lewes Creek joins Chapel Branch (a navigable waterway). Chapel Branch is approximately 1,200 feet south of the southern border of the landfill. Woodland Road is approximately 100 feet from the western border of the landfill.

3. Geology

3.1 Regional Geology

Delaware lies within two geologic provinces, the Piedmont and the Atlantic Coastal Plain, separated by the Fall Line in New Castle County. The rolling hills of the Piedmont, north of the Fall Line, are composed mainly of gneisses and gabbro, mantled by a residual soil (clay and sandy clay). The Atlantic Coastal Plain of New Castle, Kent, and Sussex counties, south of the Fall Line, is composed of a thickening wedge of unconsolidated sedimentary beds, dipping gently to the southeast. In western Sussex County, where the Seaford Plant is located, the thickness of these sediments (generally comprised of sand, clay, and gravel), ranges from 4,200 feet in the northwest to 5,500 feet in the southeast (Sundstrom and Pickett 1970). The Wilmington Complex, which underlies the Coastal Plain, is equivalent to the pre-Cambrian to lower Paleozoic metamorphic and igneous rocks of the Piedmont, which are exposed in northern Delaware.

3.2 Site Geology

The landfill is situated in the Atlantic Coastal Plain physiographic province and is underlain by unconsolidated sediments of the Beaverdam Formation (Andres and Ramsey, 1996). Previous workers have suggested that the Beaverdam Formation is a down-dip facies of the early to mid-Pleistocene aged Columbia Formation; however, more recent work, including palynologic, lithologic, and fossil data, suggests that the Beaverdam Formation is Pliocene age, and is unconformably overlaid by the Columbia Formation (Andres and Ramsey, 1996). This report subscribes to the Pliocene-aged theory.

The Columbia Formation is widespread throughout northern Delaware, and the majority of the state's aquifers are composed of its sands and gravels. It appears, however, that the Beaverdam Formation is the geologic unit occurring at land surface over much of the Seaford area (Andres and Ramsey, 1996) and the younger, Pleistocene Columbia Formation is absent in this area of the state. Groundwater supplies in the vicinity of the INVISTA Seaford Plant are withdrawn primarily from the upper 100 feet of sediment; thus, the following description of the geology focuses on the Miocene, Pliocene, and Holocene era deposits. Three cross sections have been constructed to interpret the geology in the area of the Ash Landfill. The plan locations of these cross sections are shown on Figure 3. The cross sections themselves are Figures 4A through 4C. Well logs for cross sections are provided as Appendix A.

3.2.1 Miocene

The oldest of the units discussed in this report is the Miocene age Chesapeake Group, consisting of the Manokin Formation, St. Mary's Formation, and the Choptank Formation. The Chesapeake Group is predominantly gray and bluish gray silt containing beds of gray, fine- to medium-grained sand with some shell beds (Jordan, 1962).

3.2.2 Pliocene

The Beaverdam Formation unconformably overlies the Chesapeake Group. The Beaverdam Formation consists of two lithofacies: a lower light gray to light yellow-orange, medium to coarse sand, gravelly sand, and sandy gravel with rare beds of dark gray or blue- to green-gray silty clay to clayey silt; and an upper yellow-orange, light brown and light gray, silty fine to medium sand, sandy silt, clayey sandy silt, and clayey silt with a white to light yellow silt or clay matrix (Andres and Ramsey, 1996). The lower unit can be as much as 70 feet thick, and the upper unit can be as much as 35 feet thick. Total thickness of the Beaverdam Formation ranges from 55 to 100 feet (Andres and Ramsey, 1996). The shallow and deep wells surrounding the Ash Landfill are likely screened in the upper zone and lower zone, respectively.

3.2.3 Holocene

Geologically recent deposits in the Seaford area have been given the informal name of Nanticoke deposits, named for the river that deposited them (Andres and Ramsey, 1996). The Nanticoke deposits consist of light to medium brown to light gray, fine to medium quartz sand with scattered coarse sand, granules, and pebbles, and gray to brown, clayey sandy silt, and silty clayey sand, commonly containing granule- to pebble-sized irregularly shaped, rusty-colored mottles, and weakly cemented concretions. Composition of the Nanticoke deposit suggests that it is mostly made up of local reworking of weathered Beaverdam Formation. The Nanticoke deposits tend to parallel the Nanticoke River and larger tributary streams and are typically less than 15 feet thick.

4. Regional Hydrology

4.1 Site Hydrogeology

Under the previous permitted sampling program, monitor wells were classified into zones according to depths of the targeted aquifer zone. Wells with the designation "S" (i.e., MW-2S) are screened in the shallow ('groundwater') section of the aquifer (Shallow Zone), while those with "D" designations (i.e., MW-2D) are screened in the deep ('groundwater') section of the aquifer (Deep Zone).

Groundwater within both sections of the aquifer ultimately discharges to the Nanticoke River. A downward hydraulic gradient has been historically observed from the Shallow to the Deep Aquifer in the Ash Landfill Area. The difference in potential heads for paired Shallow and Deep Zone wells indicates that a confining layer between the zones within the aquifer prevents equilibrium from occurring. These hydrogeologic assumptions are based on 20 years of water level data collected under various permits for the Ash Landfill. Figure 5 presents a potentiometric map that has been prepared using the most recent water level data collected from the Shallow Zone monitor wells. Figure 6 presents a potentiometric map that has been prepared using the most recent water level data collected from the Deep Zone monitor wells. Groundwater occurrence and flow in each zone are discussed in the following sections.

4.2 Shallow Zone

The most recent piezometric surface contour map for the Shallow Aquifer (Figure 5) indicates that flow in the Shallow Zone is generally southwest toward the Nanticoke River and the site effluent ditch. Groundwater within the Shallow Zone ultimately discharges to the Nanticoke River. However, the Nanticoke River experiences daily tidal cycles and these cycles affect groundwater elevations beneath the Ash Landfill as well. Shallow Aquifer monitor wells surrounding the Ash Landfill appear to show a significant tidal response delay due to the increased resistance of passing the tidal flux through the granular aquifer material.

No information on differences between the tidal cycle response time for surface water and groundwater at the Ash Landfill is available. It appears that communication between the intermittent stream south of the Ash Landfill, drainage ditch, and the unconfined aquifer was not established. Fine-grained sediments comprising the intermittent stream bottom south of the Ash Landfill may prevent free transfer of water from the aquifer. Additionally, discharge of cooling water may create an artificial head within the effluent ditch, reducing the potential for groundwater migration into the ditch. Observed fluctuations in groundwater elevation are likely tidal or seasonal in nature.

Figure 7 shows those wells (INVISTA Wells MW-8S and MW-9S) which consistently have the highest water levels of all the wells in the aquifer in the vicinity of the landfill.

4.2.1 Shallow Zone Flow Rates

The average pore water velocity in the Shallow Zone was determined from the following relationship:

$$V = {}^{k\,i}/_{\theta}$$

Where V = groundwater velocity
k = hydraulic conductivity
i = hydraulic gradient
θ = porosity

Hydraulic conductivity was assumed from the Shallow Zone geology. The Shallow Zone consists typically of fine- to medium-grained sands with scattered gravel and some clay lenses. Fine- to medium-grained sand has a hydraulic conductivity that ranges between $2x10^{-7}$ meters per second (m/sec) and $5x10^{-4}$ m/sec (Fetter, 1994). Previous workers used a hydraulic conductivity of $5.4x10^{-4}$ m/sec when doing groundwater velocity calculations in the Seaford area (Egler, 1983), which is consistent for the Shallow Zone geology and was used in the above equation. The most recently measured hydraulic gradient was taken from water elevations measured in April 2005 and yielded a gradient of 0.00125 ft/ft. A porosity of 43 percent was assumed (Egler, 1983). Based on the above, the velocity of groundwater in the Shallow Zone was found to be 49.5 meters per year. Clay lenses impede or slow the flow of groundwater and gravel speeds the flow of groundwater; therefore, the above estimate of velocity is viewed as an average for the Shallow Zone.

4.3 Deep Zone

Historically, piezometric surface contour maps for the Deep Zone indicate groundwater generally flows east to the Nanticoke River. However, because one or both production wells (i.e., PW-11 and PW-12) may be running at any given time, groundwater below the landfill in the Deep Zone may be drawn into a cone of depression surrounding the well that is running at that time.

In April 2005, groundwater in the Deep Aquifer generally flowed either east to the Nanticoke River or west to PW-11 (Figure 6). Well PW-12 was not running during the gauging event.

Downward hydraulic gradients are noted for all Shallow and Deep Zone well pairs. The difference in potential heads at well pairs indicates that a confining unit prevents equilibrium from occurring between the two zones. The difference in potential heads between the Shallow and Deep Zones ranges from 0.18 foot (MW-3S/MW-3D) to 2.61 feet (MW-2S/MW-2D), and is smallest at MW-3S(R) and MW-3D adjacent to the effluent ditch.

4.3.1 Deep Zone Flow Rates

The Deep Zone average pore water velocity was determined from the equation described above. The Deep Zone lithology ranges from fine to coarse sand with clay lenses. The hydraulic conductivity of this mix of grain sizes ranges from $2x10^{-7}$ m/sec to $6x10^{-3}$ m/sec (Fetter, 1994). The most recently measured hydraulic gradient was taken from water elevations measured in April 2005 and yielded a gradient of $4.66x10^{-4}$. This gradient was taken between Wells MW-14D and MW 5D, on the outside of the zone of influence of the pumping wells. Assuming a hydraulic conductivity of $6x10^{-3}$ meters per second and a porosity of 43 percent, the groundwater velocity was found to be 209.07 meters per year.

5. Regional Groundwater Quality

5.1 Site Groundwater Quality

A review of the April 2005 groundwater sampling event and historical groundwater quality data beginning in 1983 indicates no detection of constituents of concern above the Federal Safe Drinking Water Act's Maximum Contaminant Level (MCL) from the Ash Landfill to the Shallow or Deep Zones except for the detection of arsenic in MW-17S in certain sampling events. MW-17S is being monitored and addressed in connection with the RCRA corrective action activities being conducted by DuPont. The historical data are available in the *Powerhouse Ash Landfill 2005 Annual Hydrogeologic Report*, submitted to DNREC on July 29, 2005.

5.2 Shallow Zone

Shallow Zone groundwater monitoring is conducted at the locations of INVISTA Monitor Wells 2S, 3SR, 4S, 5S, 8S, 9S, and 17S. Data collected during the April 2005 sampling event do not indicate any detections of parameters above federal drinking water standards at Shallow Zone Monitor Wells 2S, 3SR, 4S, 5S, 8S, and 9S. Arsenic above the federal drinking water standard was detected at Shallow Zone Monitor Well 17S during 2005. This is being monitored and addressed in connection with the RCRA corrective action activities being conducted by DuPont. Concentrations of other dissolved metals were detected in ranges indicative of background.

5.2.1 Shallow Zone Potential Pathways of Contaminants

There is one potential pathway for contaminants from the Ash Landfill: groundwater to surface water. Potential contaminants from the Ash Landfill may travel from beneath the landfill through the Shallow Zone, and ultimately into the Nanticoke River.

5.3 Deep Zone

During April 2005, groundwater samples were collected from the Deep Zone at INVISTA Monitor Wells 2D, 3D, 5D, and PW-11. Data collected during the April 2005 sampling event indicate no detections of any constituents of concern above federal drinking water standards at Deep Zone monitor wells (Appendix B). Concentrations of other dissolved metals were detected in ranges indicative of background.

5.3.1 Deep Zone Potential Pathways of Contaminants

There are two potential pathways of any contaminants in the Deep Zone of the aquifer. Groundwater from the Deep Zone discharges to either the Nanticoke River or is pumped out of PW-11 and PW-12 and utilized by the INVISTA Seaford Plant. The pumping wells are tested under the extended Permit SW-98/01 and have been historically below MCLs for analyzed constituents.

6. References

Andres, A. S., and K. W. Ramsey, 1996, Report of Investigations No. 53: Geology of the Seaford Area, Delaware, University of Delaware, Delaware Geological Survey.

E.I. Du Pont De Nemours & Company (prepared by A. P. Egler), 1983, Hydrogeological Study of Powerhouse Ash Landfill. DuPont Seaford Facility, Seaford, Delaware. April.

DuPont Corporation Remediation Group (DuPont and URS Diamond Group), 2005 Annual Hydrogeologic Report, INVISTA Seaford Plant, Seaford, Delaware, July.

Fetter, C. W., 1994, Applied Hydrogeology Third Edition, Prentice Hall, Upper Saddle River, New Jersey.

Paul C. Rizzo Associates, Inc., 1992, RCRA Facility Investigation Task I Description of Current Conditions. DuPont Seaford Facility, Seaford, Delaware. April 24.

Sundstrom, R. W., and T. E. Pickett, 1970, The Availability of Groundwater in Western Sussex County, Delaware: University of Delaware Water Resources Center.