AMMONIUM PERFLUOROOCTANOATE (C-8) GROUNDWATER INVESTIGATION STEERING TEAM REPORT

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CONSENT ORDER NO. GW- 2001-019

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AMMONIUM PERFLUOROOCTANOATE (C-8) GROUNDWATER INVESTIGATION STEERING TEAM REPORT

EXECUTIVE SUMMARY

A multi-media Consent Order (GWR-2001-019) 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 14th, 2001.

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 3815-26-1, to the environment from DuPont operations at the Washington Works main plant and three associated landfills (Local, Dry Run, and Letart). C-8 is a material used by DuPont in its fluoroproducts manufacturing process at its Washington Works Facility's located in Washington, Wood County, West Virginia. C-8 has not been identified as a hazardous substance, hazardous waste, or otherwise specifically regulated under West Virginia or federal statute or regulation.

In accordance with Attachment A of the Consent Order, three tasks were to be performed by DuPont and evaluated by the Groundwater Investigation Steering Team (GIST). The GIST used a phased approach towards meeting these requirements.

TASK A:

Task A required Dupont to conduct a distance-phased public water supply service survey along the Ohio River on both the West Virginia and Ohio sides of the river. Subsequent to the Task A requirement, a one-mile (and possibly a two- and three-mile) radial distance of the Washington Works Facility and the Local, Letart, and Dry Run Landfills. The phased approach to the water and groundwater well use survey and sampling was intended to allow the GIST to focus efforts along potential C-8 impact transport pathways and eventually cease activities in directions where impacts were not present or where there were low concentrations.

WEST VIRGINIA PRIVATE WATER SUPPLY SOURCES:

Conclusions:

• Initial sampling within a one-mile radius of the Washington Works Facility and each of the three landfills resulted in varying levels of C-8 being found in private water sources.

• Private water sources within a one- to two-mile radius were sampled around the Washington Works Facility and the Local Landfill based on C-8 concentrations detected greater than 1.0 µg/l in the one-mile radius. No further private water sources sampling beyond the two-mile radius is necessary based on the lower concentrations detected in the one- to two-mile radius sampling area.

• No private water sources in West Virginia were found to exceed the C-8 drinking water screening level of 150 µg/l. The highest concentration detected was 10.4 µg/l.

Recommendations:

• Continued quarterly sampling of selected private water sources around the Washington Works Facility and Local and Dry Run Landfills for one year is recommended by the GIST. Annual sampling of the private water sources at the Letart Landfill is also recommended. Subsequently, the frequency of the sampling should then be re-evaluated.

OHIO PRIVATE WATER SUPPLY SOURCES:

Conclusions:

• Initial sampling within a one-mile radius of the Washington Works Facility resulting in varying levels of C-8 being found in approximately 94% of the water sources sampled.

• Private water sources within a one- to two-mile radius from the Washington Works Facility were sampled based on the levels of C-8 detected at the outer limits of the one-mile radius.

• No private water sources in Ohio were found to exceed the C-8 drinking water screening level of 150 µg/l. The highest concentration detected was 23.6 µg/l.

Recommendations:

• Continued quarterly sampling of selected water sources around the Washington Works Facility for one year is recommended by the Ohio EPA. Subsequently, the frequency of the sampling should then be re-evaluated.

WEST VIRGINIA PUBLIC WATER SUPPLY SYSTEMS:

Conclusions:

Ten public water supply systems along the Ohio River at various points up and downstream from the Washington Works Facility and Letart Landfill were sampled for C-8.

• No public water supply production wells in West Virginia were found to exceed the drinking water screening level of 150 µg/l. The highest concentration detected was 1.87 µg/l.

• The widespread distribution and low concentrations of C-8 indicate that the primary migration pathways to the public water supplies are air emissions from the Washington Works Facility and pumping-induced infiltration from the Ohio River, which receives C-8 from the National Pollutant Discharge Elimination System (NPDES) outfalls at the Washington Works Facility and the Letart Landfill.

Recommendations:

• Continued quarterly sampling at the Lubeck Public Service District (PSD), DuPont Washington Works Facility, and General Electric public water systems for two years is recommended by the GIST. Also, annual sampling of the Blennerhassett Island, Mason County PSD, and the Racine Lock and Dam Public Water System for two years is advised. Subsequently, the frequency of the sampling should then be re-evaluated.

OHIO PUBLIC WATER SUPPLY SYSTEMS:

Conclusions:

Six public water supply production wells along the Ohio River at various points up and downstream from the Washington Works Facility and the Letart Landfill were sampled for C-8.

• No public water supply production wells in Ohio were found to exceed the C-8 drinking water screening level of 150 µg/l. The highest concentration detected was 8.58 µg/l.

• The widespread distribution and the low concentrations of C-8 indicate that the primary migration pathways to the public water supplies are air emissions from the Washington Works Facility and pumping-induced infiltration from the Ohio River, which receives C-8 from NPDES outfalls at the Washington Works Facility and Letart Landfill.

Recommendations:

• Continued quarterly sampling of the Little Hocking Water Association Public Water System for two years is recommended by the GIST. Also, annual sampling of the Tuppers Plains-Chester Water District Public Water System for two years is advised. Subsequently, the frequency of the sampling should then be re-evaluated.

TASK B:

Task B required the development and implementation of a monitoring plan that would determine the extent and presence of C-8 in drinking water, groundwater, and surface water in and around the Washington Works Facility and the three landfills, and to provide a compilation of all available groundwater/surface water monitoring and hydrogeologic characterization data for each facility.

OHIO RIVER SURFACE WATER SAMPLING:

Conclusions:

• Twelve sampling locations in the Ohio River at points up to 28.6 miles upstream of the Washington Works Facility and downstream to the Letart Landfill were sampled for C-8.

• No samples collected from the Ohio River were found to exceed the C-8 drinking water screening level of 150 µg/l. The highest concentration detected was 1.04 µg/l.

Recommendations:

• No additional river sampling is recommended.

SURFACE WATER AND GROUNDWATER MONITORING:

This task included monitoring of the surface water and groundwater at the Washington Works Facility and the three landfills for four consecutive monthly events, followed by quarterly sampling thereafter.

DRY RUN LANDFILL:

Conclusions:

• C-8 is believed to be migrating, via groundwater and surface water, from the C-8-containing waste that has been disposed of within the landfill.

• Groundwater flow is toward the west and toward the Dry Run valley at this site.

• C-8 concentrations measured within the one-mile radius of the site show that some off-site migration of C-8 may have occurred.

• The Dry Run Landfill is located within eight miles of the Washington Works Facility. The transport of C-8 via air emissions from the plant could potentially be the source of the very low concentrations of C-8 detected within the one-mile radius sampling area.

• There are no known complete exposure pathways for human receptors that exceed the C-8 drinking water screening level of 150 µg/l.

Recommendations:

• Surface water and groundwater monitoring should continue at this site. The groundwater sampling should continue to be quarterly, while the outfall sampling can be either monthly or quarterly, as required by the site's NPDES permit.

• The C-8 concentrations in wells DRMW-13A and DRMW-13A should be monitored, as these wells appear to be the most vulnerable (down-gradient portion of the C-8 plume).

• The C-8 concentrations at the Dry Run leachate discharge location should be monitored.

LETART LANDFILL:

Conclusions:

• C-8 is believed to be migrating via surface water transport from the C-8 containing waste that has been disposed of within the landfill.

• Groundwater flow in the A Zone, D-E Zones, C Zone, and F Zone at the Letart Landfill is towards the Ohio River, and is away from the private water supplies in this area. Groundwater flow in the F Zone (the deepest zone) is generally believed to be towards the Ohio River and away from the private water supplies in this area; however, there may be a groundwater flow divide on the upper and northwestern side of the landfill.

• The annual C-8 loading from groundwater to the Ohio River indicates a very low concentration in the river from the landfill, and this is supported by the very low concentrations of C-8 in the Ohio River downstream of the landfill. It is possible, however, that this loading is contributing to the presence of low C-8 concentrations in some of the down river community water systems.

• Air emissions are not a viable migration pathway from the landfill because there

are no air emissions at the Letart Landfill.

• There are three complete exposure pathways for human receptors that exceed the CATT-established C-8 drinking water screening level of 150 µg/l. These are: contact with either surface water runoff (at the Cap Runoff location), leachate discharged to surface water at the toe of the Letart Landfill, and the resulting wet-weather stream that discharges into the Ohio River. However, these exposure routes are limited because of the remote location of the landfill, the very steep terrain, and the wet-weather nature of the stream. In addition, the fencing around the site limits trespasser access to the area, and the use of health and safety plans, standing operating procedures, and personal protective equipment also limits C-8 exposure for the on-site workers.

Recommendations:

• Surface water and groundwater monitoring should continue at this site. The groundwater sampling should continue to be quarterly, while the outfall sampling can be either monthly or quarterly, as required by the site's NPDES permit.

• All three of the Zone A groundwater monitoring wells (LMW-1, LMW-7, and LMW-8) should be monitored for C-8 concentrations and groundwater flow direction.

• Zone F groundwater wells LMW-2A and LMW-12 should be monitored for C-8 concentrations and groundwater flow direction.

LOCAL LANDFILL:

Conclusions:

• C-8 is believed to be migrating via surface water transport from the C-8 containing waste that has been disposed of within the landfill.

• Groundwater flow from the Local Landfill is toward the northwest at this site and toward the Ohio River valley. Flow is also towards the Washington Works Facility.

• C-8 detected within the one- and two-mile radius sampling areas near the Washington Works Facility and Local Landfill is likely to have been transported from the plant via air emissions.

• There are no known complete exposure pathways for human receptors that exceed the C-8 Assessment of Toxicity Team (CATT)-established C-8 drinking water screening level of 150 µg/l.

Recommendations:

• Surface water and groundwater monitoring should continue at this site. The groundwater sampling should continue to be semi-annually, while the outfall sampling can be either monthly or quarterly, as required by the site's NPDES permit.

• Three locations at the Local Landfill should be monitored: Outlet 101, Outlet LM1, and well LLMW-4.

WASHINGTON WORKS FACILITY:

Conclusions:

• The on-site Solid Waste Management Units (SWMUs) are believed to be the primary source of C-8 migration into the groundwater.

• Air deposition of C-8 onto the ground surface and its subsequent migration into the groundwater may also have occurred.

• No off-site migration of the groundwater is occurring, as long as DuPont's Western Well Field continues pumping.

• Some limited groundwater may migrate off-site in the northwest corner of the DuPont facility in response to the GE plant pumping their wells #3 and #4.

• Air emissions are believed to be the primary migration pathway of C-8 from the Washington Works Facility to adjacent areas in Ohio.

• Air emissions of C-8 from the Washington Works Facility are believed to be the source of C-8 detected in areas of West Virginia located adjacent to the facility and the Local Landfill.

• Air emissions of C-8 and the discharge of C-8 through the outfalls are believed to be the migration pathways of C-8 from the facility to the Ohio River, and—most likely—from the river to the public water supplies located downstream.

• Air emissions of C-8 from the plant are believed to be the source for C-8 along the Ohio River upstream of the plant.

• There are no known complete exposure pathways for human receptors that exceed the CATT-established C-8 drinking water screening level of 150 µg/l at the Washington Works Facility.

Recommendations:

• Surface water and groundwater monitoring should continue at this site. The groundwater sampling should continue to be quarterly, while the outfall sampling can be either monthly or quarterly, as required by the site's NPDES permit.

• The following groundwater monitoring wells and outfalls require further monitoring at the Washington Works Facility: RO4-MW02, PO4-MW-2, QO4-MW02, VO5-PW01, NO4-MW-01, and Outfall 005.

It is important that DuPont further investigates the high concentrations of C-8 in these wells, which are located at the Washington Works Facility adjacent to the Ohio River. DuPont has stated (in their February 2003 *Summary Report*) that C-8 is confined to a perched aquifer and that the deeper aquifer contains no C-8.

TASK C:

Task C required the determination of the vertical and horizontal extent of any and all C-8 impacted groundwater exceeding 1 µg/l. This task also included an assessment of C-8 impacted surface water and/or groundwater at the Letart Landfill and its impact on the Ohio River and nearby public water systems along the river.

GROUNDWATER MODELING:

Groundwater modeling of the Washington Works Facility and surrounding area was conducted to evaluate the groundwater flow pathways and determine the potential of C-8 migration to off-site receptors.

Conclusions:

• The Ohio River creates a groundwater divide in the Pleistocene alluvium under the river. As a result of production-well pumping at the Dupont Washington Works Facility and the neighboring GE facility, the C-8-impacted groundwater from the Washington Works Facility is not being drawn into either the Lubeck PSD municipal well field in West Virginia or the Little Hocking Water Association well field in Ohio. Some limited groundwater may migrate off-site in the northwest corner of the DuPont facility in response to GE pumping wells #3 and #4. Sources of C-8, for the Lubeck PSD and the Little Hocking Water Association, are coming from the Ohio River and dispersion by air.

Recommendation:

• The URS Diamond model should be accepted as representing real-world conditions in determining groundwater flow and contaminant transport.

INTRODUCTION

C-8 has been used by DuPont since the early 1950's in its fluoropolymer related manufacturing processes. Residues containing C-8 from the fluoropolymer manufacturing processes at the Washington Works Facility are or have been released to the air, discharged to the Ohio River, disposed of at the facility, and otherwise shipped off-site for destruction and/or disposal. DuPont also captures for recycling a portion of used C-8.

No permits issued to Dupont authorizing release of pollutants to the environment contain specific limitations on the amount of C-8 that may be released. Since as early as 1990, DuPont has performed regular, voluntary water sampling to detect the presence and level of C-8 in and around its facilities in West Virginia, and has reported the results of these samplings to WVDEP. As a result of DuPont's sampling, C-8 has been detected in varying concentrations in private and public water supplies. DuPont, by and through its use of C-8 in the fluoropolymer manufacturing process, was considered the likely source.

The federal Environmental Protection Agency (EPA), WVDEP, and WVDHHR-BPH determined that it was desirable to ascertain the source of C-8 in drinking water for persons potentially exposed to groundwater or surface waters in the area of these facilities. The EPA, WVDEP, and WVDHHR-BPH requested that DuPont submit all information and documents relating to the detection and presence of C-8 in and around these facilities. The agencies concluded that it would be of great importance to have sufficient data upon which to determine the potential exposure risk of the presence of C-8 in the environment.

Therefore, a C-8 Groundwater Investigation Steering Team (GIST) was established in the Consent Order to oversee investigations and activities that would 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, Dry Run, and Letart Landfills.

The GIST was made up of a team of scientists assembled from the WVDEP, WVDHHR-BPH, EPA Region III, and DuPont. In May 2002 a Memorandum of Understanding (MOU) was signed by WVDEP, WVDHHR-PBH, and DuPont with the Ohio EPA. The MOU established guidelines for Ohio EPA's participation in the GIST due to the discovery of C-8 in Ohio public drinking water supplies.

DuPont, through an agreed-upon third party and under the supervision of the GIST, conducted the groundwater use and well survey identification and sampling of groundwater wells and other water sources (*i.e.*, springs and cisterns) within the one-mile radius of the Washington Works Facility and the three landfills. Identification and sampling of private wells was contingent upon landowner permission. Based upon concentrations of C-8 found in water sources, the GIST through the Consent Order was empowered to possibly expand the radial survey distance to include wells within a two-

or three-mile radius of the Washington Works Facility and the three landfills.

Historical data and hydrogeologic information was evaluated in order to prioritize the initial scope of work for continuing groundwater monitoring and any additional investigation activities (*e.g.* monitoring well installations) required under Task C Plume Identification.

Upon conclusion of the Tasks set forth in the Consent Order, the GIST was charged with preparing a final report with findings and conclusions regarding groundwater quality, and the extent of groundwater impacts. The final GIST report provides conclusions and makes recommendations regarding the need to conduct further work, or to take actions necessary to assure protection of groundwater quality and human health. The following report summarizes those findings, conclusions, and recommendations of the GIST in fulfillment of the Consent Order.

WEST VIRGINIA PRIVATE WATER SUPPLY SOURCES

Pursuant to Attachment A of the Consent Order, the Groundwater Use and Well Survey involved evaluating C-8 in groundwater initially within a one-mile radius from the Washington Works Facility and the three landfills (Local, Letart, and Dry Run) by sampling water from wells, cisterns, and springs. The area was expanded to a two-mile radius at the Washington Works Facility and the Local Landfill based on the initial results obtained from the one-mile radius survey and sampling.

Between March 2002 and October 2002, DuPont's third-party contractor, Potesta Associates, Inc., performed a door-to-door well survey and collected samples following protocols established by the multi-media consent order. Representatives from the WVDEP and the Wood County Health Department accompanied Potesta Associates, Inc. personnel during the initial door-to-door survey.

WASHINGTON WORKS FACILITY AND LOCAL LANDFILL:

In April 2002, DuPont submitted a report to the GIST documenting the well survey and C-8 sample results within a one-mile radial distance around the DuPont Washington Works Facility and the Local Landfill. Because of the proximity of the Local Landfill to the DuPont Washington Works Facility, groundwater wells located within the combined one-mile radius (of both sites) in West Virginia were sampled. A total of 44 samples were collected from drinking water wells, non-drinking water wells, unused wells, springs, and cisterns.

The C-8 concentration from drinking water wells ranged from 0.328 µg/l to 2.8 µg/l. The highest concentration of C-8 from the category of non-drinking water wells and unused wells was 14.3 µg/l. C-8 was detected in all wells, springs, and cisterns sampled within the one-mile radius. A total of two samples collected in the one-mile radius had concentrations of C-8 above10 µg/l. Because of the levels found in the one-mile radius of the Washington Works Facility and the Local Landfill, the private water supply sources survey was extended by the GIST to a two-mile radius. In addition, private and industrial water supplies used for drinking water were sampled on a monthly basis until the CATT drinking water screening concentration of 150 µg/l was developed.

The private water supply sources survey and C-8 sampling results within the one- to two-mile radius of the DuPont Washington Works Facility and the local landfill were submitted on August 2002 to the GIST. A total of 65 samples were collected and analyzed for C-8 including drinking water wells. The C-8 concentrations measured in drinking water wells ranged from non-detect (<0.010 µg/l) to 0.889 µg/l. The highest concentration of C-8 from non-drinking water wells or unused wells was 1.57 µg/l. A spring sample, used for drinking water, had a concentration of 1.8 µg/l. Due to measured concentrations of C-8 in the two-mile radius indicating a decreasing trend in distance from the Washington Works Facility, the GIST determined that additional samples beyond the two-mile radius were not necessary.

In summary, C-8 was detected in 100% and 79% of the private water supply sources sampled in the one- and two-mile areas, respectively. The concentrations of C-8 were lower in the two-mile radius area as compared to the one-mile radius. No private water supply sources in the one- or two-mile radius area exceeded the CATT-established C-8 drinking water screening level of 150 µg/l. The widespread distribution of C-8 in private water supply sources, combined with the lack of groundwater flow to this area from the Washington Works Facility and the Local Landfill facilities, indicates that air emissions may be the primary migration pathway of C-8 from the facility to adjacent areas in West Virginia.

RECOMMENDATIONS:

Under the Consent Order, a significant number of private water supply samples have been collected that document the extent and current concentrations of C-8 in groundwater within the one- and two-mile radial areas. Most locations have been sampled at least once. It is unknown whether the concentrations detected in groundwater are the result of historic air deposition or result of air deposition in the last couple of years. Therefore, the GIST recommends that DuPont collect additional samples from the following selective locations to evaluate the current trend of C-8 concentrations in private water sources. Additional samples should be collected from the following sample locations, with the owner's permission:

- Drinking water wells with detected levels of C-8,
- Drinking water springs with detected levels of C-8,
- Non-drinking water wells with detected levels of C-8,
- Springs and cisterns with detected levels of C-8, and
- Wells or springs used for cattle above 5 µg/l (total 1).

The GIST recommends selecting ten of these locations, with at least one or more from each category, for quarterly sampling for one year. Subsequently, the frequency of the sampling should then be re-evaluated.

LETART LANDFILL:

In April 2002, DuPont submitted a report to the GIST documenting the well survey and C-8 sampling results within the one-mile radial area around Letart Landfill. A total of 30 samples were collected from drinking water wells, non-drinking water wells, unused wells, springs, and cisterns. The C-8 concentration from drinking water wells ranged from non-detect (<0.01 µg/l) to 0.139 µg/l. The highest concentration of C-8 from the category of non-drinking water wells was 0.636 µg/l, from Brinker Run, which was named for sampling purposes" Route 33 Unnamed Stream." This concentration may be the result of surface water infiltration from the Letart Landfill into Brinker Run. Due to the low C-8 concentrations found at the Letart Landfill, and in the private water supply sources the survey was not extended by the GIST to a two-mile radial area.

In summary, C-8 was detected in 6% of the private water supply sources sampled in the one-mile radial area. No private water supply sources samples exceeded the CATT-established C-8 drinking water screening level of 150 µg/l.

RECOMMENDATIONS:

Under the Consent Order, a significant number of private water supply samples were collected that document the extent and current concentrations of C-8 in private water supplies within a one-mile radius of the Letart Landfill.

Each location was sampled at least once. The C-8 concentrations measured in all Letart Landfill one-mile radius samples were non detect or not quantifiable, except for one sample collected from a well used for drinking water that had a concentration of 0.139 µg/l and one sample collected from an unused well that had a concentration of 0.639 µg/l. The GIST required that the drinking water well with the C-8 concentration of 0.139 µg/l be resampled. The resident refused to have the well resampled.

Each location has thus been sampled a single time, and there is no clear trend as to whether the concentrations of C-8 detected in groundwater are increasing or decreasing. Therefore, the GIST is recommending that DuPont collect yearly samples from the GERLACHIBA and the BRINKERA private water supply sources, contingent upon permission of the well-owners, to evaluate the trend of C-8 concentrations in the private drinking water supplies. This sampling frequency should then be re-evaluated.

DRY RUN LANDFILL:

In April 2002, DuPont submitted a report to the GIST documenting the well survey and C-8 sampling results within the one-mile radius area around Dry Run Landfill. A total of 53 samples were collected from drinking water wells, non-drinking water wells, unused wells, springs, and cisterns. The C-8 concentrations from drinking water wells ranged from non-detect (<0.01 µg/l) to 0.422 µg/l. The highest concentration of C-8 from the category of non-drinking water wells and unused wells was 0.839 µg/l. Due to the low levels of C-8 found at the Dry Run Landfill, the private water supply survey was not extended by the GIST to a two-mile radial area.

In summary, C-8 was detected in 60% of the private water supply samples collected in the one-mile area. No private water samples in the one-mile radius exceeded the CATT-established C-8 drinking water screening level of 150 µg/l. The widespread distribution of C-8 in private water supply supplies within the one-mile radial area of Dry Run Landfill indicates that air emissions may be the primary migration pathway for C-8 from the Washington Works Facility. This assumption was made due to the lack of groundwater flow into these areas.

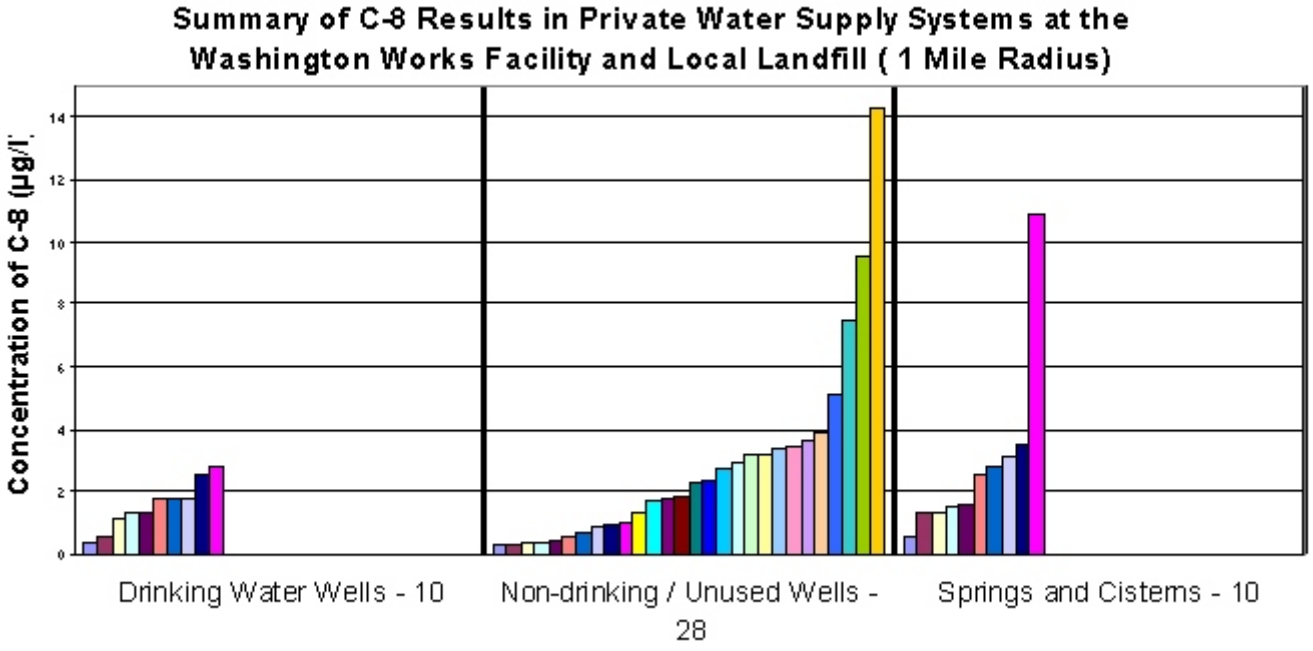
RECOMMENDATIONS:

Under the Consent Order, a significant number of private water supply samples

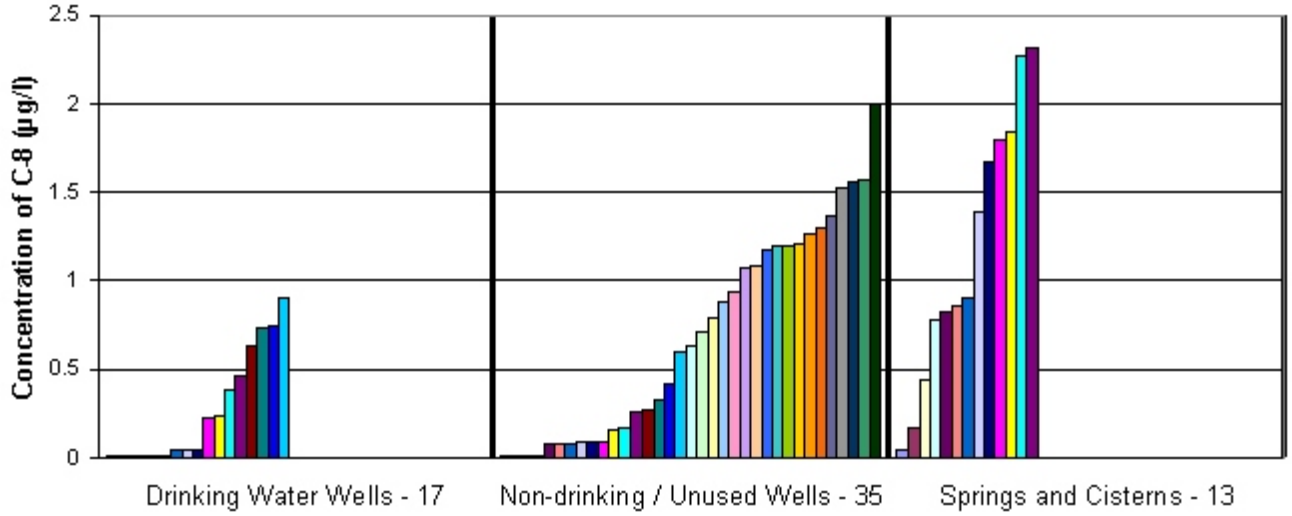
have been collected that document the extent and current concentrations of C-8 in groundwater within a one-mile radius of the Dry Run Landfill. It is unknown whether the concentrations detected in the groundwater are the result of historic or recent air emission sampled at each locations only once. Therefore, the GIST recommends that DuPont collect additional samples from selective locations to evaluate the trend of C-8 concentrations. The criteria to select repeat sample locations, with the owners' permission, may include:

- Drinking water wells with detectable levels of C-8,
- Drinking water springs with detectable levels of C-8, and
- Springs and cisterns with detectable levels of C-8.

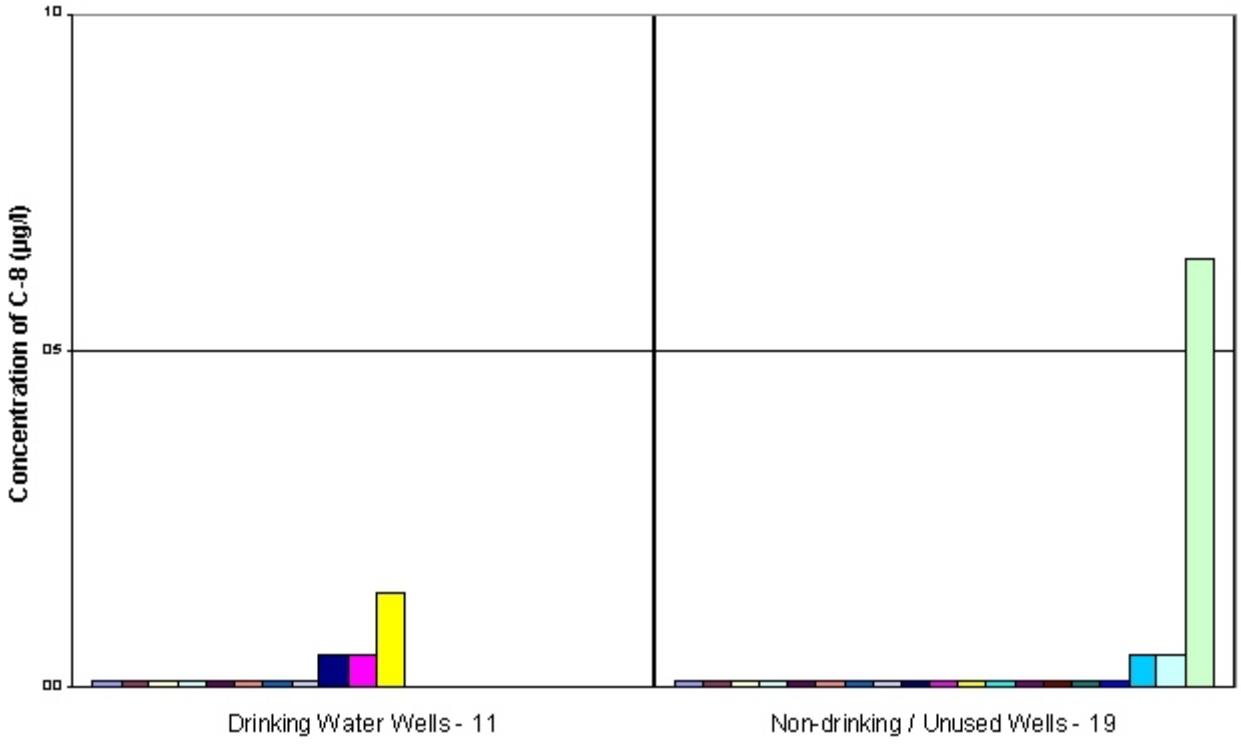
The WVDHHR-BPH and WVDEP recommend selecting ten, with at least one or more from each category, of these locations for quarterly sampling for one year. The sample frequency for sampling private water supplies should then be re-evaluated.

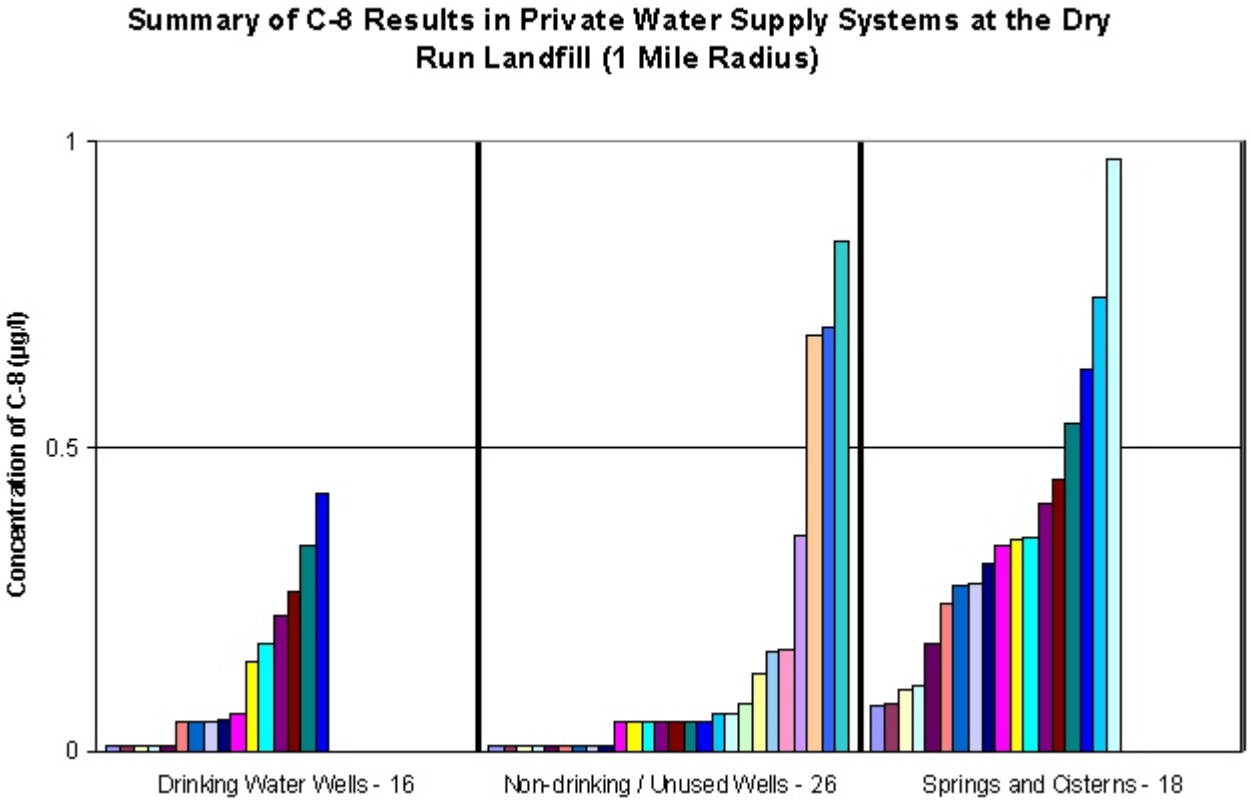


Summary of C-8 Results in Private Water Supply Systems at the Washington Works Facility and Local Landfill (2 Mile Radius)



Summary of C-8 Results in Private Water Supply Systems at the Letart Landfill (1 Mile Radius)




Summary of C-8 Results in Private Water Supply Systems at the Dry Run Landfill (1 Mile Radius)
Concentration of C-8 (µg/l)
1
0.5
0
Drinking Water Wells - 16
Non-drinking / Unused Wells - 26
Springs and Cisterns - 18

OHIO PRIVATE WATER SUPPLY SOURCES

As a result of C-8 being detected in the Little Hocking Public Water Supply in December 2001, Ohio EPA and DuPont, in addition to the work being performed under the West Virginia Consent Order, agreed to expand the private water supply sources water use survey and C-8 sampling into Ohio within a one-mile radial distance from the Washington Works Facility. Between March and June of 2002, Potesta Associates, Inc. personnel performed a door-to-door well survey and collected samples from private water supply wells, springs, and cisterns. The samples were collected following the protocols established by the multi-media Consent Order between DuPont, the WVDEP, and the WVDHHR-BPH. Representatives from the Washington County Health Department, Ohio Department of Health, or the Ohio EPA accompanied Potesta Associates, Inc.'s personnel during the initial door-to-door well survey.

In August 2002, DuPont submitted a report to the GIST and Ohio EPA documenting the well survey and C-8 sample results within the one-mile radial area. A total of 69 samples were collected from drinking water wells, non-drinking water wells, unused wells, springs, and cisterns. The C-8 concentrations measured for drinking water wells ranged from non detect (<0.01 µg/l) to 8.59 µg/l, while a single spring used for drinking water was 1.29 µg/l. The highest concentration of C-8 from the category of non-drinking water wells and unused wells was 16.9 µg/l. C-8 was detected in all the springs and cisterns sampled within the one-mile radius, including a concentration of 23.6 µg/l in a spring used for livestock. Overall, a total of nine samples collected in the one-mile radius had concentrations of C-8 above 10 µg/l. Because some of these higher concentrations of C-8 were detected at the outer limit of the one-mile radius, DuPont agreed to expand the sampling effort in Ohio to two miles from the Washington Works Facility.

The private water supply survey and C-8 sampling within the one- to two-mile radius of the facility were completed in September of 2002. The results were documented in a report submitted by DuPont to the GIST and Ohio EPA in December 2002. A total of 63 samples were collected and analyzed for C-8, including 50 drinking water wells. The C-8 concentrations measured in drinking water wells ranged from non detect (<0.01 µg/l) to 6.5 µg/l. No cisterns and springs sampled in the two-mile radius were used for drinking water. The highest concentration of C-8 from non-drinking water wells or unused wells was 8.68 µg/l. One spring sampled for C-8 had a concentration of 3.02 µg/l. Overall, no concentrations of C-8 were detected above 10 µg/l within the one- to two-mile radius.

In summary, C-8 was detected in approximately 94% and 77% of the private water supply samples collected in the one- and two-mile areas, respectively. In general, the concentrations of C-8 are lower in the two-mile radius area as compared to the one-mile radius. Because measured concentrations in the two-mile radius indicated a decreasing trend in distance from the Washington Works Facility, the Ohio EPA and DuPont determined that additional sampling beyond the two-mile radius was not necessary. No private water supply samples in the one- or two-mile radius exceeded

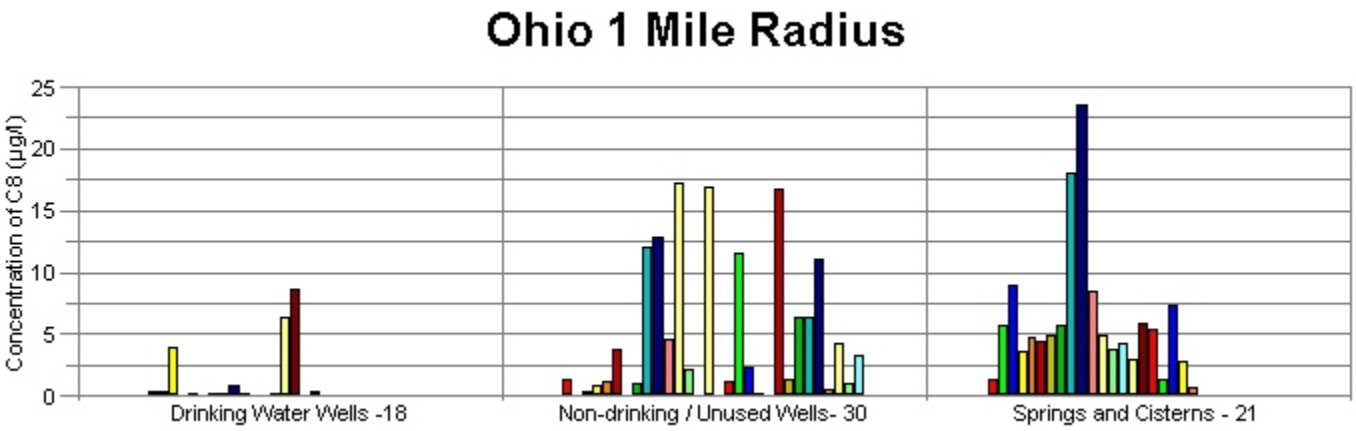
the CATT-established C-8 drinking water screening level of 150 µg/l. The wide spread distribution of C-8 in private water sources, along with the lack of a groundwater pathway, indicates that air emissions are the primary migration pathway of C-8 from the Washington Works Facility to adjacent areas in Ohio.

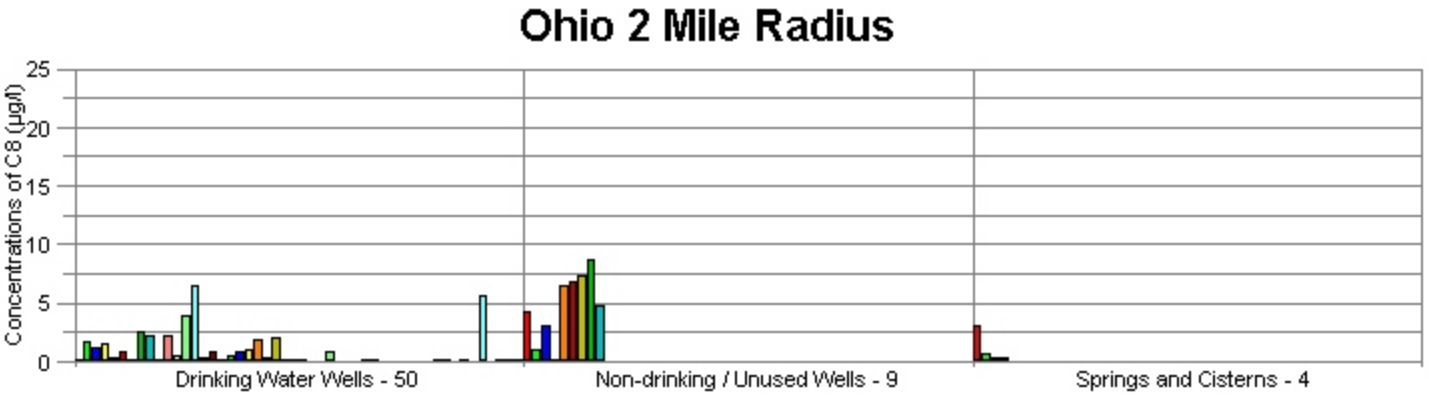
RECOMMENDATIONS:

At the request of the Ohio EPA, DuPont has collected a significant number of private water supply samples in Ohio that document the extent and current concentration of C-8 in groundwater, springs, and cisterns, within two miles of their Washington Works Facility. Each location has been sampled once, and it is currently unclear as to whether the concentrations detected in private water sources are reflective of historic air emissions or air emissions in the last couple of years. Therefore, to evaluate the trend of C-8 concentrations, the Ohio EPA recommends that DuPont collect additional samples with the owners' permission from the following categories of private water sources:

- Drinking water wells with detectable levels of C-8,
- Drinking water spring with detectable levels of C-8,
- Non-drinking water wells with detectable levels of C-8, and
- Springs and cisterns with detectable levels of C-8.

The Ohio EPA recommends selecting at least ten locations with one of more samples from each category for quarterly sampling for one year. Subsequently, the frequency of sampling will be re-evaluated by the Ohio EPA and DuPont.




Ohio 2 Mile Radius
Concentrations of C8 (µg/l)
25
20
15
10
5
0
Drinking Water Wells - 50
Non-drinking / Unused Wells - 9
Springs and Cisterns - 4

WEST VIRGINIA PUBLIC WATER SUPPLY SOURCES

Public Water Supply Sources (PWSSs) in West Virginia along the Ohio River were sampled at various points upstream and downstream of the DuPont Washington Works Facility pursuant to the Consent Order. Initial sampling of PWSSs within a one-mile upstream and ten miles downstream of the facility began in December 2001. Based on the C-8 concentrations measured, the sample area was expanded to include PWSs located as far as seven miles upstream of the facility and 54 miles downstream. Sampling efforts between January 2002 to March 2003 resulted in the following findings:

Public Water System	*River Miles from Washington Works*	*Sampling Dates*	*Well Field Results (C-8 µg/l)*	*Distribution System Results (C-8 µg/l)*
Parkersburg Water Department	-7	Mar and Apr 2002	Well #1: 0.0686 to 0.0746 Well #2: ND Well #3: ND Well #4: ND Well #5: ND	NQ
Blennerhassett Island State Park	-1	Jan 2002	Well #1: 0.165	Not tested
DuPont Washington Works Facility	0	Jan 2002 Mar 2003	AM07-PW01: NQ to 0.335 AO08-PW01: 0.308 to 0.499 AX13-PW01: 0.721 to 1.42	Not tested
General Electric	1.5	Jan, Feb, and Apr 2002	Well #3: 1.75 to 1.87	Not tested
Lubeck PSD	4.5	Jan 2002 to Feb 2003	Well A: 0.683 to 0.938 Well B: 0.443 to 0.61 Well C: 0.398 to 0.592 Well D: 0.397 to 0.758 Well E: 0.332 to 1.21 Well F: 0.283 to 1.04	0.6 to 0.69
Bellville Hydro Electric Recreation	14	Jan 2002	Not tested	ND
Ravenswood Municipal Water Works	31	Mar 2002	Well #1: ND Well #2: ND Well #3: ND Well #4: ND Well #5: ND	NQ
Mason County PSD—Letart	45	Jan, Mar, and Apr 2002	Well #1: NQ Well #2: 0.0618 to 0.0838 Well #3: 0.063 to 0.102	Not tested

Racine Locks and Dam	48	Jan 2002	Not tested	0.518
New Haven Water Department	54	Apr 2002	Well #1: NQ	ND

* A negative stream mile value refers to a location upstream from the Washington Works Facility. A positive number refers to a location downstream from that facility.

** ND refers to a "Non Detect" concentration that is at or below the laboratory's minimum detection limit. The listed concentration can vary by instrument and time; however, the Non Detect concentration for C-8 for this period of time is 0.01 µg/l.

*** NQ refers to "Not Quantifiable." It is a concentration that is below the laboratory's minimum detection limit and is therefore below the level of quantification. The Not Quantifiable concentration for C-8 for this period of time is 0.05 µg/l.

Upon completion of the C-8 Assessment of Toxicity Team (CATT) study establishing a drinking water screening level of 150 µg/l for C-8, sampling efforts were discontinued for General Electric, Parkersburg Water Department, Blennerhassett Island State Park, Bellville Hydro Electric Recreation Plant, Ravenswood Municipal, Mason County PSD—Letart, Racine Locks and Dam, and New Haven Water Department based on the measured low concentrations. Sampling was continued at the DuPont Washington Works Facility and Lubeck PSD on a quarterly basis to continue to evaluate trends in C-8 concentrations.

CONCLUSIONS:

The completion of the groundwater studies and sampling efforts performed as a part of the C-8 GIST study have resulted in the following conclusions regarding the source of C-8 in the West Virginia PWSSs:

• *Parkersburg Water Department and Blennerhassett Island State Park:* It is believed that the C-8 levels are transported from the DuPont Washington Works Facility via air emissions. Please note that C-8 transported in air emissions and deposited on surfaces is likely to be mobilized by precipitation and migrate via water transport to surface and/or groundwater.

• *DuPont Washington PSD:* It is believed that the C-8 levels are transported via air emissions, and from groundwater migration from C-8-containing materials in the on-site Solid Waste Management Units at the Washington Works Facility.

• *General Electric:* It is believed that the C-8 levels are transported from the DuPont Washington Works Facility via air emissions associated with the infiltration of precipitation or from production-well-induced recharge from the Ohio River impacted with wastewater discharges from the DuPont Washington Works Facility.

• *Lubeck PSD:* It is believed that the C-8 levels are associated with pumping-induced recharge of surface water from the DuPont Washington Works Facility's wastewater discharges to the Ohio River and possibly via air deposition.

• *Mason County PSD—Letart:* It is believed that the C-8 levels are derived from pumping-induced recharge of surface water from DuPont Washington Works Facility's wastewater discharges to the Ohio River.

• *Racine Locks and Dam:* It is believed that the C-8 levels are derived by pumping-induced recharge of surface water from the DuPont Washington Works Facility and/or the Letart Landfill leachate discharges to the Ohio River.

RECOMMENDATIONS:

Considering this data, it is the GIST's recommendation that DuPont continue the following for the PWSSs:

• *Lubeck PSD, DuPont Washington Works Facility, and General Electric:* Quarterly sampling of wells for two years to ensure that C-8 levels are being maintained or reduced. Conduct a limited field investigation to determine the extent and concentration of C-8 in soil at the Lubeck PSD in the vicinity of their production wells. When the soil sample results are available and the data is evaluated, the GIST will determine what additional sampling activities are necessary to complete the investigation. DuPont will submit a report documenting the sampling investigation and the C-8 results to the GIST when the results are finalized. After two years, the sampling program will be re-evaluated.

• *Blennerhassett Island State Park and Mason County PSD—Letart:* Annual sampling for a two-year period to ensure C-8 levels are being maintained or reduced. After two years, the sampling program will be re-evaluated.

• *Racine Lock and Dam:* Annual sampling for a two-year period to evaluate levels of C-8 due to the upstream proximity of the Letart Landfill, and to ensure that C-8 levels are being maintained or reduced. After two years, the sampling program will be re-evaluated.

• *Parkersburg Water Department, Bellville Hydro Electric Recreation Plant, Ravenswood Municipal Water Works, and New Haven Water Department:* No further action is deemed necessary at this time.

OHIO PUBLIC WATER SUPPLY SOURCES

Task A of the GIST Team Objectives and Efforts required DuPont to perform sampling of the public water supply sources along the Ohio River. As a result, the well field for the Little Hocking Water Association Public Water System was sampled for C-8 in December, 2001. The sampling results within the well field and subsequent monitoring allowed the GIST to expand the area of monitoring to include public water systems five miles up and 57 miles down the river from the Washington Works Facility. Sampling efforts between December 2001 to February 2003 have resulted in the following findings:

Public Water System	*River Miles from Washington Works*	*Sampling Dates*	*Well Field Results (C-8 µg/l)*	*Distribution System Results (C-8 µg/l)*
Little Hocking Water Association	- 0.5	Dec 2001 Jan, Feb, Mar, Apr, Aug, and Oct 2002 Feb 2003	Well #1: 1.82 to 3.65 Well #2: 2.07 to 4.26 Well #3: 0.42 to 0.952 Well #5: 5.69 to 8.58	1.82 to 4.29
City of Belpre	- 4.6	Feb, Mar, and Apr 2002	Well #1: 0.0995 to 0.13 Well #2: NQ Well #3: 0.12 to 0.141 Well #4: 0.101 to 0.133 Well #5: 0.103 to 0.111	0.081 to 0.12
Tuppers Plains/ Chester Water District	14.15	Feb, Mar, Apr, Jul, and Oct 2002 Feb 2003	Well #1: 0.486 to 0.726 Well #2: 0.235 to 0.417 Well #3: ND to NQ Well #4: ND to 0.076 Well #5: 0.201 to 0.297 Well #6: 0.433 to 0.649	0.24 to 0.363
Village of Racine	51.15	Mar 2002	Well #1: ND Well #2: ND Well #3: ND	ND
Village of Syracuse	56.9	Mar and Apr 2002	North Well: 0.208 - 0.491 South Well: ND	ND
Village of Pomeroy	56.9	Mar and Apr 2002	Well #1: ND Well #2: ND to 0.06 Well #4: 0.071 to 0.085	0.063 to 0.066

* A negative stream mile value refers to a location upstream from the Washington Works Facility. A positive number refers to a location downstream from that facility.

** ND refers to a "Non Detect" concentration that is at or below the laboratory's minimum detection limit. The listed concentration can vary by instrument and time; however, the Non Detect concentration for C-8 for this period of time is 0.01 µg/l.

*** NQ refers to "Not Quantifiable." It is a concentration that is below the laboratory's minimum detection limit and is therefore below the level of quantification. The Not Quantifiable concentration for C-8 for this period of time is 0.05 µg/l.

Upon completion of the CATT study in which a drinking water screening level of 150 µg/l for C-8 was established, sampling efforts were discontinued for the City of Belpre and the Villages of Racine, Syracuse, and Pomeroy. However, quarterly sampling was continued for the Little Hocking Water Association and the Tuppers Plains Water Systems in order to further evaluate C-8 concentration trends.

CONCLUSIONS:

The completion of the groundwater modeling and sampling efforts performed as part of the GIST study have resulted in the following conclusions being drawn concerning the source of C-8 contamination in Ohio public water systems:

• *Little Hocking:* Mainly air deposition from Washington Works Facility's stack discharges; however, pumping-induced recharge of surface water contamination from Washington Works Facility wastewater discharges to the Ohio River may have also contributed.

• *Belpre:* Air deposition from Washington Works Facility's stack discharges.

• *Tuppers Plains:* Pumping-induced recharge of surface water contamination from Washington Works Facility wastewater discharges to the Ohio River.

• *Village of Racine:* No discernible contamination.

• *Syracuse and Pomeroy:* Pumping-induced recharge of surface water contamination from the Washington Works Facility and/or the Letart Landfill leachate discharges to the Ohio River.

Considering the public water system data, and the elevated levels of C-8 noted in the Test Well 4 Investigation (see below), the GIST recommends that DuPont continue quarterly sampling of both the production wells and entry point for the Little Hocking Water Association public water system for two years. Also, annual sampling for the Tuppers Plains Water System (production wells and entry point) to ensure continued reduction of C-8 is advised. At this time, no further action is deemed necessary for the Villages of Belpre, Racine, Syracuse, or Pomeroy. After two years, the sampling frequency will be re-evaluated.

LITTLE HOCKING WATER ASSOCIATION WELL FIELD INVESTIGATION:

In addition to sampling Little Hocking Water Association's production wells, DuPont has periodically sampled ten test wells (*i.e.*, monitoring wells) within the Little Hocking Water Association well field. The concentration of C-8 is less than 2 µg/l in most of these test wells; however, a few wells exceeded 4 µg/l. In one test well, TW-4, the concentration of C-8 was measured at 37.1 µg/l in January of 2002. Subsequent sampling of TW-4 indicates generally decreasing concentrations of C-8 at 33.3 µg/l

(March 2002), 28.7 µg/l (April 2002), 12.3 µg/l (August 2002), and 14.5 µg/l (October 2002). However, in February 2003, the concentration in well TW-4 rose to 22.5 µg/l, indicating possible seasonal effects on this well.

At the request of the Ohio EPA, DuPont conducted a field investigation in the Little Hocking Water Association Well Field between August 19th and August 30th, 2002. The purpose of this investigation was to determine the extent and concentration of C-8 in soil and groundwater in the vicinity of test well TW-4. Groundwater sample results collected during this investigation ranged from non detect (<0.01 µg/l) to 78.0 µg/l of C-8. The highest C-8 concentration detected in soil from the well field is 170 µg/kg. A report documenting the results of the investigation was submitted by DuPont to the Ohio EPA and GIST in April of 2003. Once an evaluation of this report is complete, the Ohio EPA and DuPont will determine what additional activities are necessary to compete the investigation.

OHIO RIVER SAMPLING

Ohio River sampling activities were conducted to determine the concentrations and extent of C-8 in the Ohio River. Samples were collected from 12 river transects and 19 locations, and multiple depths were sampled at many of the locations.

The most distant river sampling locations were approximately 28 miles upstream and 46 miles downstream from the DuPont Washington Works Facility to determine background levels of C-8. Samples were collected adjacent to and below the DuPont Plant to determine the concentrations of C-8 in the river. The final part of the river sampling was adjacent to the Letart Landfill to determine if concentrations of C-8 were present there.

At the end of the Ohio River sampling, 49 water samples were taken, with the following results:

Transect Number	*River Mile*	*Number of across-river samples*	*Depths*	*Number of Samples collected*	*Average C-8 Concentration (µg/l)*
1	161.7	1	dip and mid-column	2	<0.01
2	179.2	1	dip and mid-column	2	<0.01
3	185.8	1	dip, mid-column, and bottom	3	<0.01
4	189.9	3	dip, mid-column, and bottom	9	<0.01
	190.3	Washington Works Plant outfalls			
5	190.4	3	dip, mid-column, and bottom	10 *	<0.01
6	191.0	3	dip, mid-column, and bottom	9	<0.01
7	192.7	2	dip, mid-column, and bottom	7 *	0.1167
8	194.0	1	dip and mid-column	2	1.0445
9	201.2	1	dip and mid-column	2	0.295
10	209.3	1	dip and mid-column	2	0.2375
11	236.3	1	dip and mid-column	2	0.105
	236.3	Letart Landfill			
12	236.5	1	dip and mid-column	3 *	0.10755

* includes a duplicate sample.

CONCLUSIONS:

No river sample exceeded the CATT-established C-8 drinking water screening level of 150 µg/l for any of the Ohio River samples. No additional river sampling is thus required as a part of the Consent Order; however, sampling should continue as part of the Washington Works Facility and Letart Landfill NPDES outfall monitoring.

SURFACE WATER AND GROUNDWATER MONITORING

It should be noted that site location maps, top-of-groundwater maps, and site geological maps are located in Appendix A, and that a complete set of groundwater data (in both table and graph form) is located in Appendix B. These data included with this final GIST report ends with the March 2003 sampling. The hydrological information is from the February 2003 *Summary Report*.

It should also be noted that the data displayed here (both historical and recent) have been generated using several different analytical methods. Prior to 1991, DuPont performed the C-8 analysis at the DuPont Experimental Station in Wilmington, Delaware. In 1991, when the Resource Conservation and Recovery Act (RCRA) Verification Investigation was conducted at the Washington Works plant, the analysis was contracted to the CH_2MHill Laboratory in Montgomery, Alabama. Both of these laboratories used a Gas Chromatography-Electron Capture Detected-based analytical methods with detection limits for C-8 that ranged from 0.1 to 1.0 µg/l. CH_2MHill conducted the C-8 analysis into the fall of 1998 when the laboratory ceased operation. At that time, the analytical work was transferred to Lancaster Laboratories, in Lancaster, Pennsylvania. DuPont continued to use this facility until October 2001, when development and testing was completed on a new analytical method utilized by Exygen Research, Inc., located in State College, Pennsylvania. This method uses a Liquid Chromatography-Tandem Mass Spectrometry. DuPont adopted the regular use of this method in November of 2001.

HISTORICAL WORK:

Before any assessment could be made of the groundwater and surface water at the four DuPont locations, a summary of the historical data was compiled. This was submitted by DuPont in January of 2002 in the document, *Compilation of Historical C-8 Data, DuPont Washington Works Facility, Main Plant, and Landfills*. This report included a brief historical, geological, and hydrogeological overview of the four sites (Washington Works Facility, Local Landfill, Dry Run Landfill, and Letart Landfill), and identified three data gaps: the need for additional groundwater monitoring wells, continued refinement of the groundwater model at the main plant, and the need to evaluate the Ohio River surface water.

This report also included location maps for the four sites, multiple geological cross-sections, four top-of-groundwater maps for each facility, and construction details for the groundwater monitoring wells. Many of the locations were sampled only once; however, samples had been collected from other locations on as many as 17 occasions. The information submitted on the four sites' historical sampling locations was as follows:

Facility	*Outfalls Sampled*	*Other Surface Water Locations Sampled*	*Groundwater Monitoring Wells Sampled*	*On-Site Drinking Water Locations Sampled*
Washington Works	2	2	62	4
Local Landfill	6	2	4	0
Dry Run Landfill	1	5	9	0
Letart Landfill	2	6	Zone A: 3 Zone B: 0 Zone C: 1 Zone D-E: 3 Zone: F: 4	0

To satisfy Task B of the GIST requirements, regular surface water and groundwater monitoring for C-8 then began in December of 2001. At first the groundwater sampling was monthly; however, this interval was modified to quarterly once the initial four sampling events were conducted. The surface water was (and still is) sampled each month. To date, including the historical data, the four DuPont sites have been sampled for C-8 for the following number of locations and occasions:

Facility	*Water Type*	*Maximum Number of Sample points*	*Maximum Number of occasions*
Washington Works	Surface	6	26
	Groundwater	20	19
Local Landfill	Surface	6	23
	Groundwater Zone A	4	13
	Groundwater Zone B	1	2
	Groundwater Zone C	3	2
	Groundwater Zone D	1	2
Dry Run Landfill	Surface	8	22
	Groundwater Zone A	3	18
	Groundwater Zone B	12	18
	Groundwater Zone C	1	2
Letart Landfill	Surface	6	25
	Groundwater Zone A	3	21
	Groundwater Zone B	0	0
	Groundwater Zone C	1	10

	Groundwater Zone D-E	5	13
	Groundwater Zone F	8	25

To satisfy Task C of the GIST requirements, it was also recognized that all of the four DuPont locations required additional groundwater monitoring wells. The following wells were added in August of 2002:

Number	*Type*	*Maximum depth*	*Drilling rig*	*Diameter*	*Screen length*
Washington Works Facility					
Three	Bedrock	about 100 feet	Rotosonic	2-inch	20-foot
Local Landfill					
Four	Overburden		Hollow-stem auger	2-inch	5 to 10 feet
Four	Bedrock	about 65 feet	Air rotary	2-inch	20-foot
Letart Landfill					
Two	Zone A	about 40 feet	Air rotary	2-inch	20-foot
Four	Zone F	about 155 feet	Air rotary	2-inch	20-foot
Dry Run Landfill					
Six	Overburden		Hollow-stem auger	2-inch	5 to 10 feet
Six	Bedrock	about 175 feet	Air rotary	2-inch	2-foot

These new wells, first sampled in October 2002, fill in missing gaps in the groundwater well fields. They provide a complete encirclement of the four DuPont locations, and should identify any C-8 groundwater plumes migrating from any of the four sites.

RESULTS AND CONCLUSIONS:

DRY RUN LANDFILL:

The Dry Run Landfill is located west of the town of Lubeck, on the headwaters of Dry Run in southwestern Wood County. The site is about eight miles southwest of the Washington Works Facility and the Local Landfill, at 39˚ 11' 07" North Latitude and 81˚ 41' 18" West Longitude. Dry Run begins at the toe of the landfill and flows to the northwest. It is a tributary of the North Fork of Lee's Creek, which flows into the Ohio River. The landfill is situated on the dissected Appalachian Plateau, and is underlain by the sandstones and shales of the Dunkard Group, which are of late Pennsylvanian or Permian age. The Dry Run Landfill began operation in 1986, and the central portion is

still active and operates under WV-NPDES Permit No. WV0076244. The upper (southeastern) portion of the landfill is closed and covered with a soil and vegetative cover. The lower (northwestern) portion also closed and is covered by an engineered-landfill cap.

The Dry Run Landfill is about 17 acres in size, and is approximately 690 feet wide and 1500 feet long, with an elevation rise of about 250 feet. It is oriented in a southeast and northwest direction, and is constructed in an old, v-shaped valley above Dry Run. Physically, the site is a long grassy slope of fill material surrounded (and situated on) the small valley's native rock and soil. The site borders no highways, residential, or industrial areas. In the late 1980s, waste sludge materials from an anaerobic digestion pond (from the main plant) was placed in the upper, southeastern side of the landfill.

Geologically, the bedrock beneath the landfill is comprised of individual layers of shale, silty clay, and sandstone and siltstone. Within this sequence the three dominant aquifers are nearly continuous sandstone and siltstone. These have been labeled by DuPont—beginning with the October 2002 groundwater monitoring report—as Zone A, Zone B, and Zone C, with Zone C being the deepest. Zone B is considered the main groundwater zone, and has eleven wells screened through it—five of these wells are newly constructed and have only been sampled on one occasion. Zone A has three wells screened within it, and Zone C has only one well.

The Zone A groundwater flows to the west-northwest, and has a gradient of 0.055 vertical feet per horizontal foot. The zone varies in depth between zero (to the northwest) and 200 feet deep (to the southeast). It is between 25 and 35 feet thick. The C-8 plume, based on three wells, appears to be moving to the west-northwest and down the axis of Dry Run.

Of the three Zone A groundwater monitoring wells, one—located northeast of the Dry Run Valley—has consistently contained concentrations below 1 µg/l. A second well, located to the southwest of the valley, contains concentrations of between 0.2 and 5 µg/l. The third well, DRMW-13, has contained the highest concentrations of C-8, ranging from 3.6 to 20.9 µg/l. This well is located in the middle of Zone A and the Dry Run valley.

The Zone B groundwater flow appears to be moving in an arc that varies between a northwestern direction in the upper southeastern portion of the site, and in a western direction in the lower western part of the site. The zone is about ten feet thick with a gradient between 0.006 and 0.023 vertical feet per horizontal foot. Zone B varies in depth from between 220 feet deep under the southeastern portion of the site to just a few feet below the surface at the toe of the landfill. It may be breached by the Dry Run surface stream northwest of the landfill. All of the wells surrounding Zone B were sampled in October 2002. Only six wells in the down-gradient western part of the landfill contained detectable concentrations of C-8. The well which consistently contains the highest concentrations of C-8 is well DRMW-13A, located directly in the Dry Run Valley and is adjacent to well DRMW-13. The C-8 concentration in well

DRMW-13A is less than in well DRMW-13; however, it does seem to indicate that Zone B's plume is also moving directly down the Dry Run valley.

As stated previously, Zone C is the deepest of the three groundwater zones. This zone is only penetrated by one groundwater monitoring well, DRMW-21B. Zone C is located approximately 120 feet below the Dry Run valley, and it has not been determined if it extends to the southeast and under the landfill. Zone C is at least 45 feet thick, and may be confined, as the groundwater surface in the well extended above the well's screen and the top of the sandstone-siltstone layer in the October 2002 sampling. Without additional wells penetrating Zone C, it is impossible at this time to determine the zone's extent or the groundwater flow direction and gradient. Well DRMW-21B contained no detectable concentrations of C-8 on the two occasions it was sampled, so it is presumed at this time that there is no C-8 in Zone C.

It is difficult to make any kind of conclusions regarding the surface water at the Dry Run Landfill because many of the sampling locations have been consistently dry during much of 2002. It is also difficult to make statements regarding the concentrations of C-8 found to date because these concentrations vary so much from sample location to sample location. The highest concentration of C-8 found at the surface sampling points is the Dry Run leachate location, where the concentrations of C-8 has ranged between 109 and 704 µg/l since December of 2001. The leachate is collected and hauled to the Washington Works Facility's treatment system, and does not discharge into Dry Run.

A further breakdown of the Dry Run Landfill sampling data is as follows:

Dry Run Landfill Surface Water: *(units are µg/l)*								
Sample Point	*Outlet 001*	*Outlet 003*	*Outlet 004*	*Property Boundary*	*Stream #1*	*Stream #2*	*Dry Run Leachate*	*Pond Under Drain*
Number of samples	15	3	2	12	11	11	12	8
Minimum C-8	17	6.77	0.7	0.88	0.54	4.6	27.4	29.3
Maximum C-8	88.5	25.3	158	39	1.63	87	704	99.7
Average C-8	58.57	17.39	79.35	11.3	1.07	40.29	205.59	50.98

Dry Run Landfill Groundwater Zone A: *(units are µg/l)*			
Sample Point	*DRMW-12*	*DRMW-13*	*DRMW-15*
Number of samples	13	12	10
Minimum C-8	<0.1	3.6	0.25
Maximum C-8	0.134	20.9	5.0
Average C-8	0.08	12.16	3.74

Note: For the purposes of averaging these values, a No Detect concentration of "<0.1" was calculated as zero.

Dry Run Landfill Groundwater Zone B: *(units are µg/l)*						
Sample Point	*DRMW-6*	*DRMW-6A*	*DRMW-12A*	*DRMW-12B*	*DRMW-13A*	*DRMW-14*
Number of samples	6	13	13	11	13	13
Minimum C-8	<0.1	0.19	<0.1	<0.1	0.07	<0.1
Maximum C-8	1.0	1.24	0.181	5.4	15	2.5
Average C-8	0.57	0.66	0.09	0.55	6.18	0.20

Note: For the purposes of averaging these values, a No Detect concentration of "<0.1" was calculated as zero.

Dry Run Landfill Groundwater Zone B: *(units are µg/l)*						
Sample Point	*DRMW-16B*	*DRMW-17B*	*DRMW-18B*	*DRMW-19B*	*DRMW-20B*	*DRMW-21A*
Number of samples	2	1	1	2	2	2
Minimum C-8	<0.1	0.155	<0.1	<0.1	<0.1	0.138
Maximum C-8	<0.1	0.155	<0.1	<0.1	<0.1	0.27
Average C-8	<0.1			<0.1	<0.1	0.204

Dry Run Landfill Groundwater Zone C: *(units are µg/l)*	
Sample Point	*DRMW-21B*
Number of samples	2
Minimum C-8	<0.1
Maximum C-8	<0.1
Average C-8	<0.1

LETART LANDFILL:

The Letart Landfill is located about 0.6 miles north of the small community of Letart in northern Mason County. It is 46 miles down the Ohio River from DuPont's Washington Works Facility, and is located at 38˚ 54' 15" North Latitude and 81˚ 55' 43" West Longitude. The site—like the Dry Run Landfill—is situated on the dissected Appalachian Plateau. Bedrock consists of the sandstones and shales of the Dunkard Group. It is sited in a valley that is directly west of the Ohio River, which is here flowing north. West of the landfill (and across the hill behind the landfill) is the north-flowing Brinker Run. The Letart Landfill was operated and closed under WV-NPDES Permit No. WV0076066, and was permanently closed by installing an engineered multi-layer

geosynthetic and soil cap in 2001. The permit requires quarterly groundwater monitoring, surface water monitoring, and cap maintenance.

Physically, the Letart Landfill is tear-shaped. It is approximately 1,400 feet long, and tapers in width from a maximum of 850 feet along its northern edge to a narrow point at the Ohio River. The elevation difference between the wider, higher northern boundary and the lowest elevation point near the Ohio River, is about 140 feet. The landfill itself is covered with grass. There are no highways, residents, or businesses adjacent to the landfill; however, U.S. Route 33 parallels Brinker Run, which is located about 700 feet to the west. This is a rural part of West Virginia, and there are no residents and businesses along this section of the highway.

Geologically, the bedrock beneath the landfill is comprised of individual layers of shale, silty clay, and sandstone and siltstone. There are, depending on how and where they are counted, between four and six aquifers at this site, which have been labeled by DuPont as Zone A, Zone B, Zone C, Zone D, Zone E, and Zone F. Zone A is the shallowest of these aquifers, and is monitored by three groundwater monitoring wells. Zone B contains no wells, and Zone C contains only one well. Zone D-E contains five groundwater monitoring wells, and Zone F, the deepest and dominant aquifer at this site, has nine wells screened through it.

Groundwater Zone A is exposed near the surface, and varies between 25 and 60 feet thick. It is continuous in nature, but apparently contains interbedded discontinuous shale, sandstone, and siltstone lens.

There are only three wells screened in Zone A. These wells are all located relatively close together and more-or-less in a straight line along the northwestern edge of the landfill. Given these limitations, the October 2002 groundwater sampling gave the appearance of a north groundwater flow and a plume that centered on well LMW-1, the central-most of the three wells.

Of the three Zone A wells, LMW-1 has the highest concentrations. These concentrations have varied since April 1996 between 1,700 and 30,500 µg/l. Well LMW-8 has the next-highest concentrations, and these concentrations have varied between 280 and 4,020 µg/l. Well LMW-7 has displayed the least concentrations of C-8 in these wells since October 1999 between 158 and 567 µg/l.

There are no wells screened through Zone B. However, judging from the cross-section produced when the deeper wells were drilled, this zone reaches its maximum thickness of more than 70 feet at the northern-most tip of the landfill, where it is combined with Zone C. Zone B pinches out (disappears) completely as one moves down the landfill toward the river.

Zone C appears to be continuous across the site. It is approximately 15 to 25 feet thick under the main and southern portions of the landfill, and combines with Zone B in the northern part of the site. Only one well is screened through Zone C, so no assessment of a plume or groundwater flow and direction can be made. This well,

LMW-3, is located near the very toe of the landfill and in close proximity to the Ohio River. This well had a concentration of 2,270 µg/l C-8 in May 2002.

Zone D-E is the most complex of the Letart water-bearing zones. These zones appear to be combined in the southern, central, and northern portions of the site. They are separated by a shale layer in the western and possibly the central portion of the landfill. It is also possible that Zone D may be completely missing in the northern and northeastern portions of the site. The thickness of this zone can range between 10 and 40 feet. Zone D-E, as mapped by DuPont in October 2002, has a gradient of 0.026 vertical feet per horizontal foot with a groundwater flow direction to the south-southwest.

There are five groundwater monitoring wells screened through Zone D-E. Most of these wells are located near the southern toe of the landfill. Of these five wells, two were only recently installed, and long-term data exists for three of the wells. LMW-4 has consistently contained the highest concentrations of C-8. These concentrations have ranged from 172 to 2,840 µg/l.

All five of the Zone D-E groundwater monitoring wells sampled in October of 2002 indicate high C-8 concentrations under the main part of the landfill, with a plume flowing due south and through LMW-4. Two wells, located just east of LMW-4 contained much lower concentrations of C-8.

As previously stated, groundwater Zone F is believed to be the dominate aquifer at the Letart Landfill. This zone is the deepest of the six aquifers. It is continuous across the site ranging from 30 to 70 feet thick. The groundwater within the zone flows to the south-southeast. This zone has a gradient of between 0.030 to 0.057 vertical feet per horizontal foot.

There are nine groundwater monitoring wells screened through Zone F positioned all around the landfill. Six of these were sampled prior to October 2002, and seven were sampled in October of 2002. These wells project a possible C-8 plume moving south down the center of the landfill. The lowest concentrations are to the west of the landfill, where there is one concentration of 105 µg/l in well LMW-14B. The highest C-8 concentration is at the very toe of the landfill at well LMW-5B, which has consistently contained high concentrations since it was installed more than a decade ago. Since July of 1999, these concentrations have ranged between 592 and 2,280 µg/l.

Zone F well LMW-2A contains high concentrations of C-8 that have varied between 242 and 913 µg/l since September of 1994. In addition, this well is located on the extreme northern edge of the landfill, away from the anticipated plume direction. Well LMW-12, drilled just to the west of LMW-2A, was dry during the October 2002 sampling event. These two wells should be monitored closely to determine groundwater flow direction and if there is a plume moving off the site to the north. It should also be noted that there is a private water source (GERLACHIBA) north of the Letart Landfill where a small concentration of C-8 was found.

It should be noted that, due to the installation of the synthetic cap, stormwater contribution to the groundwater flow has been lessened under the landfill. It is probable that the contribution of C-8 to this flow has remained stable. Less groundwater volume combined with a steady contribution of C-8 will equal a higher concentration of C-8 in the groundwater. This scenario appears to have occurred at the Letart Landfill. The site should be monitored closely to ascertain trends in C-8 concentrations.

The surface water at the Letart Landfill has been sampled for C-8 at six locations. The data for some of these points is very intermittent. While most of these concentrations are very low, C-8 has been found at the two Brinker Run sampling locations. The two highest concentrations were found at the southern toe of the landfill, at Outlet 002 (the Leachate Basin) and the Cap Runoff location, both of which indicate increasing concentrations of C-8. Outlet 002 and the Cap Runoff have had concentrations as high as 3,240 and 415.6 µg/l, respectively.

A detailed breakdown of the surface and groundwater data is as follows:

Letart Landfill Surface Water: *(units are µg/l)*						
Sample Point	*Outlet 002*	*Outlet 003*	*Stormwater Run Off*	*Route 33 Stream*	*Brinker Run*	*Cap Runoff*
Number of samples	18	6	1	13	2	6
Minimum C-8	4.52	0.06	50.9	0.57	0.06	65.1
Maximum C-8	3240	0.239	50.9	3.92	0.247	415
Average C-8	899.22	0.21		1.96	0.154	225.18

Letart Landfill Zone A Groundwater: *(units are µg/l)*			
Sample Point	*LMW-1*	*LMW-7*	*LMW-8*
Number of samples	21	20	20
Minimum C-8	60	0.1	280
Maximum C-8	30,500	567	4020
Average C-8	14,896.57	233.57	2499

Letart Landfill C Zone Groundwater: *(units are µg/l)*	
Sample Point	*DRMW-3*
Number of samples	8
Minimum C-8	<0.1
Maximum C-8	2270

Average C-8	1320

Note: For the purposes of averaging these values, a No Detect concentration of "<0.1" was calculated as zero.

Letart Landfill D-E Zones Groundwater: *(units are µg/l)*					
Sample Point	*LMW-3A*	*LMW-4*	*LMW-5A*	*LMW-13A*	*LMW-14A*
Number of samples	10	12	8	2	2
Minimum C-8	60.3	172	0.8	144	498
Maximum C-8	380	3060	112	510	974
Average C-8	170.39	1577.83	71.43	327	736

Letart Landfill Zone F Groundwater: *(units are µg/l)*									
Sample Point	*LMW-2A*	*MW-5B*	*LMW-6*	*LMW-9*	*LMW-10*	*LMW-11*	*LMW-12*	*LMW-13B*	*LMW-14B*
Number of samples	23	22	12	9	5	8	0	2	2
Minimum C-8	50	340	9.4	0.2	0.126	0.058		0.09	70.4
Maximum C-8	990	2280	30	0.91	0.298	0.159		0.149	105
Average C-8	496.8	1161.9	17.49	0.65	0.165	0.110		0.1223	87.7

LOCAL LANDFILL:

The Local Landfill is located immediately south of the Washington Works Facility in northwestern central Wood County. It consists of three separate closed cells, and is located at 39˚ 15' 54" North Latitude and 81˚ 39' 16" West Longitude. It is situated on the dissected Appalachian Plateau, consisting of Dunkard Group sandstones and shales. The three landfill cells were operated from 1964 into the 1980s, and were closed under WV-NPDES Permit No. WV0076538. They are now covered with approximately two feet of low permeability soil and vegetative cover. The site is in a somewhat rural area; however, there are a number of residential homes south of the landfill. State Highway 892 is just north of the landfill and located between the landfill and DuPont's Washington Works Facility.

Physically, the three Local Landfill cells are 60 by 140, 70 by 110, 40 by 60 feet in size; however, the landfill cells are irregular in shape and the cells are actually smaller than these dimensions indicate. These cells are sited along the tops and sides of three hills, which are located just south of the flat Ohio River flood plain.

Geologically, the bedrock beneath the landfill is comprised of individual layers of

shale, silty clay, and sandstone and siltstone. There are four principal aquifers, all of which are continuous under the overall site, and are comprised of sandstone and siltstone. DuPont has named these (in their October 2002 groundwater monitoring report), from shallowest to deepest, Zone A, Zone B, Zone C, and Zone D. Zone A is believed to be the dominant aquifer.

Zone A is usually between 10 to 20 feet thick, and varying in depth between 60 to 110 feet. This zone is continuous across the site, and has been eroded by an unnamed stream that flows out of the landfill area to the west, and then flows to the northwest. Groundwater flow in Zone A is to the north-northwest with a gradient of 0.008 vertical feet per horizontal foot. There are four groundwater monitoring wells screened in Zone A. Two of these have consistently contained C-8 concentrations that are below 1 µg/l. A third well, LLMW-6, has contained C-8 concentrations below 10 µg/l. The fourth well, LLMW-4, contains C-8 concentrations up to 79 µg/l. This supports the theory that the Zone A C-8 plume is moving north toward LLMW-4.

Zone B is generally 5 to 10 feet thick, and between 90 to 130 feet deep. It is incised by the unnamed surface stream, and grades out to the east. There is only one well screened in this zone, and has only been sampled twice. It contained a C-8 concentration of 0.0658 µg/l in October 2002 and a No Detect concentration in March of 2003. With only one well, no plume information or groundwater flow and gradient data can be generated on this groundwater zone.

Zone C is 10 to 20 feet thick, and 90 to 130 feet deep. It is continuous across the entire site. Due to Zone C's greater depth, it has not been incised by the surface stream. Groundwater flow is to the northwest, and the gradient is 0.0153 vertical feet per horizontal foot. Three wells are screened in this zone. Each well has been sampled twice, and the C-8 concentrations ranged from 0.317 to 6.61 µg/l.

Zone D is more than 12 feet thick, and is 135 to 170 feet deep. Only one well has been screened in this zone, and has only been sampled twice, with No Detect concentrations on both occasions. With only one well, no plume information or groundwater flow and gradient data can be generated for Zone D.

Six sampling locations are used to monitor the surface water at the Local Landfill. All of these locations have displayed concentrations of C-8 with the highest concentrations occurring at Outlet 101 and Outlet LM1. These concentrations ranged from 38 µg/l in June 2002 to 72 µg/l in January 2003, and dropped to 45.4 µg/l in March 2003. Outlet LM1's concentrations are higher: They were 120 and 81.7 µg/l on the two occasions this location was sampled.

The Local Landfill data can be further broken down as follows:

Local Landfill Surface Water: *(units are µg/l)*						
Sample Point	*Outfall 004*	*New 004*	*Outfall 005*	*New 005*	*Outlet 101*	*Outlet LM1*
Number of samples	15	6	15	3	19	2
Minimum C-8	1.51	9.29	6.8	9.51	12	81.7
Maximum C-8	13	14.6	51.4	34.3	115	120
Average C-8	10.1	12.69	35.19	19.94	57.1	100.85

Local Landfill Zone A Groundwater: *(units are µg/l)*				
Sample Point	*LLMW-4*	*LLMW-6*	*LLMW-9*	*LLMW-10*
Number of samples	13	13	13	10
Minimum C-8	1.4	1.32	<0.1	0.15
Maximum C-8	79.6	19.9	0.14	1.12
Average C-8	42.63	11.06	0.02	0.41

Local Landfill Zone B Groundwater: *(units are µg/l)*	
Sample Point	*LLMW-12B*
Number of samples	2
Minimum C-8	<0.1
Maximum C-8	0.0658
Average C-8	0.0329

Note: For the purposes of averaging these values, a No Detect concentration of "<0.1" was calculated as zero.

Local Landfill Zone C Groundwater: *(units are µg/l)*			
Sample Point	*LLMW-11A*	*LLMW-13B*	*LLMW-14B*
Number of samples	2	2	2
Minimum C-8	2.05	6.38	0.317
Maximum C-8	2.22	6.61	0.488
Average C-8	2.135	6.495	0.4025

Local Landfill Zone D Groundwater: *(units are µg/l)*	
Sample Point	*LLMW-11B*
Number of samples	2
Minimum C-8	<0.1
Maximum C-8	<0.1
Average C-8	<0.1

WASHINGTON WORKS FACILITY:

The DuPont Washington Works Facility is located just north of the small community of Washington and about seven miles west and downstream of Parkersburg. The facility is located at 39˚ 16' 13" North Latitude and 81˚ 40' 34" West Longitude, and is sited on the Ohio River flood plain. The flood plain here is comprised of Pleistocene glacial outwash and Holocene river sediments (alluvium) overlying the bedrock of the Dunkard Group. These sediments are comprised of sand and gravel, silt and clay, colluvium, and fill. The site is in a somewhat rural area. State Route 892 is located just south of the plant property. The Ohio River is located immediately to the north of the property.

There are more than 100 groundwater monitoring and production wells at the Washington Works Facility. Of these wells, the following 19 wells were chosen by the GIST to be sampled under the Consent Order:

AE11-MW01	D08-MW01	N04-MW01	Q04-MW02	AJ06-MW02
AM07-PW01	E13-MW01	N13-MW01	R04-MW02	N04-MW03
A008-PW01	K16-PW01	P04-MW2	V05-PW01	Y14-MW02
AX13-PW01	L04-PW01	P08-MW01	Y14-MW01	

Of these wells, five have consistently been less than 1 µg/l, and another seven have been less than 20 µg/l. Three of the remaining wells have had C-8 concentrations between 20 and 60 µg/l; however, one of these wells (P08-MW01)—when last sampled—contained 120 µg/l. A fourth well, N04-MW01, has only been sampled once, but this concentration was 689 µg/l.

The remaining three wells all contain high concentrations of C-8. These are wells P04-MW-2, Q04-MW-02, and R04-MW02, with reported concentrations as high has 46,600, 7,720, and 322,000 µg/l of C-8, respectively.

At present, six outlets are used to monitor the discharges at the Washington

Works Facility. With a few exceptions (one of which was Outfall 005 in November 2001 with a concentration of 915 µg/l), all of these outlets have had consistently discharged relatively low concentrations of C-8, ranging from ND to 54.9 µg/l.

A further breakdown of the Washington Works Facility discharge water and groundwater data is as follows:

Washington Works Facility Surface Water: *(units are µg/l)*						
Sample Point	*Outlet 001*	*Outfall 002*	*Outlet 003*	*Outfall 005*	*Outlet 007*	*Outlet 105*
Number of samples	16	25	16	26	16	16
Minimum C-8	2.15	0.118	0.175	1.43	<0.1	3.69
Maximum C-8	51.4	8.54	7.13	915	8.56	54.9
Average C-8	14.39	3.21	1.544	81.15	1.42	14.43

Note: For the purposes of averaging these values, a No Detect concentration of "<0.1" was calculated as zero.

Washington Works Facility Groundwater: *(units are µg/l)*						
Sample Point	*AE11-MW01*	*AM07-PW01*	*AC08-PW01*	*AX13-PW01*	*D08-WM01*	*E13-MW01*
Number of samples	10	16	14	7	8	11
Minimum C-8	0.41	<0.1	0.167	0.721	0.117	0.59
Maximum C-8	2.82	1.9	1.0	1.42	3.72	3.43
Average C-8	1.41	0.374	0.46	1.03	0.882	2.127

Note: For the purposes of averaging these values, a No Detect concentration of "<0.1" was calculated as zero.

Washington Works Facility Groundwater: *(units are µg/l)*							
Sample Point	*K16-PW01*	*L04-PW01*	*N04-MW01*	*N13-MW01*	*P04-MW2*	*P08-MW01*	*Q04-MW02*
Number of samples	11	13	1	3	11	4	10
Minimum C-8	0.46	0.20	689	<0.1	8300	20.7	32.2
Maximum C-8	17.2	40.9	689	57.8	46600	120	7720
Average C-8	11.3	15.01		29.13	28545	55.02	1780

Note: For the purposes of averaging these values, a No Detect concentration of "<0.1" was calculated as zero.

Washington Works Facility Groundwater: *(units are µg/l)*						
Sample Point	*R04-MW02*	*V05-PW01*	*Y14-MW01*	*AJ06-MW02*	*N04-MW03*	*Y14-MW02*
Number of samples	11	13	10	2	2	2
Minimum C-8	1300	0.66	4.95	0.099	21.2	<0.1
Maximum C-8	322000	51.2	18.4	0.133	244	<0.1
Average C-8	69729	26.2	13.76	0.116	132.6	<0.1

RECOMMENDATIONS:

The first priority at each of the four sites is to continue the surface and groundwater monitoring programs. Sampling of the groundwater should continue to be quarterly, while the outfall sampling can be either monthly, quarterly, or semi-annually, as required by each site's individual NPDES permit.

The continuing source of C-8 at the Washington Works Facility is believed to be originating from a previously reclaimed digestion pond and from the old River Bank Landfill. Currently, the facility is under a RCRA Facility Investigation, which is addressing these C-8 sources. It is the recommendation of the GIST that any action relative to the investigation or remediation of the C-8 sources be deferred to the WSEPA-WVDEP RCRA Corrective Action Program (CAP).

GROUNDWATER MODELING

Groundwater modeling of the Washington Works Facility's main location was completed independently by DuPont's URS Diamond contractor and by the United States Geological Survey (USGS). URS Diamond's modeling was completed using Groundwater Vistas software. The USGS model was completed using Visual Modflow software. Both models were based on similar calibration data and boundary conditions.

The USGS groundwater model did not address groundwater seepage from the adjacent bedrock aquifers, whereas the URS Diamond groundwater model did address this seepage. Preliminary analysis of both models show close agreement in groundwater flow directions, calibrated heads, and rate and volume of groundwater flow. The model data that follows is primarily from the URS Diamond groundwater model. The USGS groundwater model will be published as part of a larger modeling effort in corporation with the WVDHHR-BPH, Office of Environmental Health Services (OEHS).

The URS Diamond model boundary was the alluvium, and into bedrock. The URS Diamond model domain was 5.0 to 7.9 miles, consisting of 153 rows, 235 columns, and 3 cells deep. Fifty-one discharge wells were included in the simulation. In the beginning stages of building the models, a major gap in the data occurred due to lack of data concerning river bottom geometry. The data gap was eliminated by a great abundance of new data obtained from recent surveys compiled by the Army Corps of Engineers for construction projects at the eastern end of the model domain.

GEOLOGY:

The alluvium was found to be between 60 to 80 feet deep on terraces and 10 to 15 feet deep in the center of the river valley. Alluvial aquifers in the model domains were mostly unconfined, with some locally confined by Holocene overbank deposits. These alluvial aquifers consist of coarse sands and gravel underlain by predominately horizontally bedded sandstones of the Pennsylvanian Dunkard Group. The Ohio River creates a groundwater divide in the Pleistocene alluvium under the river. This groundwater divide does not appear to exist in the bedrock aquifer.

Typically, the permeability of the alluvium was 100 to 300 feet per day. Bedrock aquifers were primarily confined, and consisted of Dunkard sandstones with some minor limestone. Permeability of the bedrock aquifers ranged from 0.5 to 5 feet per day. Hydraulic conductivity used in the models were 330 feet per day for coarse alluvium, 30 feet per day for reworked alluvium, and one foot per day for fine alluvium. Hydraulic conductivity for bedrock aquifers was 0.1 feet per day. Alluvial aquifers on Blennerhassett Island had a hydraulic conductivity of 200 feet per day. The normal pool level of 582 feet above sea level was used for the hydraulic head of the Ohio River.

MODEL CALIBRATION:

A total of 50 industrial and public water supply wells are located in the model domain, 44 of which were actively pumping at the time when synoptic groundwater elevations were being measured for model calibration. The well locations to the model domain are:

- DuPont Washington Works Facility (WV): 13 wells
- Blennerhassett Island State Park (WV): 12 wells
- GE Facility (WV): 14 wells
- Lubeck (WV) PSD: 6 wells
- City of Belpre (OH): 1 well (Note: Belpre has five pumping wells; their total flow was assigned to one well for the model.)
- Little Hocking (OH) Water Well Field 4 wells
  (wells PW-1, PW-2, and PW-3 were included in the model. Although well PW-5 was included, no pumping was simulated)

The mass balance of the groundwater flow model had a total error of less than one percent, indicating very little error in simulating real world conditions.

Recharge was estimated to be an average of approximately 8 to 10 inches per year, according to the USGS model. URS Diamond's model was calibrated at eight inches per year and, as the modeler for the USGS agreed, seemed to satisfy conductivity calibrations better. Differences in the two figures arose from different interpretations of possible areas of incised valley bottom fills under the Ohio River. These areas may have slightly different hydraulic conductive properties from the adjacent sediments.

Sensitivity analysis was run on three parameters: hydraulic conductivity, recharge, and river boundary conductance. This sensitivity analysis indicated that most of the uncertainty associated with the model was in the value assigned to the re-worked Pleistocene alluvium under the Ohio River.

CONCLUSIONS:

The calibration of both models was tested and highly refined over the course of the modeling effort. Both models were only slightly different. All parties placed high confidence in the somewhat more sophisticated URS Diamond model. The USGS further refined their model by incorporating some of the data presented in the URS Diamond model.

The Ohio River creates a groundwater divide in the Pleistocene alluvium under the river. The principal conclusion, supported by both models, was that the groundwater

divide under the river, along with the pumping rates from the DuPont and neighboring GE Facility wells that draw down a cone of depression, precludes C-8 impacted groundwater from the Washington Works Facility from being drawn into either Lubeck PSD municipal well field in West Virginia, or the Little Hocking Water Association well field in Ohio. Some limited groundwater may migrate off-site in the northwest corner of the DuPont facility in response to GE pumping wells #3 and #4. Sources of C-8 in the Lubeck PSD and the Little Hocking Water Association wells, are most likely coming from the Ohio River and dispersion by air.

RECOMMENDATION:

It is the recommendation of this report that the URS Diamond model be accepted as representing real-world conditions in determining groundwater flow and contaminant transport.

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An air rotary drilling rig installing a new groundwater monitoring well at the Letart Landfill.

APPENDIX A:

Site Maps
Topographic Maps
Plan Views
Groundwater-Top Maps
Site Cross-Sections

APPENDIX B:

Groundwater data

(both graphs and tables)

APPENDIX C:

Consent Order

No. GW-2001-019