The Impact of Known and Suspected Contaminant Sources on Select Public Drinking Water Supplies in Delaware

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This report represents a collaborative effort between the Department of Natural Resources and Environmental Control, the Delaware Health and Social Services, the Department of Agriculture and the Water Resources Agency at the University of Delaware. This report represents an assessment of the potential impact of known and suspected hazardous substance release sites on the quality of Delaware's public drinking water.

The scope of this project is the first of its kind in Delaware, and indeed the nation, and has set a precedent for water monitoring in the State of Delaware. The individuals that participated in this multidisciplinary effort are to be commended for their time and talents that they devoted to this project:

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LIST OF ABBREVIATIONS AND ACRONYMS

bgs	Below ground surface
CAS	Chemical Abstract Services Number
CSFi	Carcinogenic potency Slope Factor, Inhalation
CSFo	Carcinogenic potency Slope Factor, Oral
DCA	Dichloroethane
DCE	Dichloroethene
DCP	Dichloropropane
DHSS	Delaware Health and Social Services
DNREC	Department of Natural Resources and Environmental Control
DPH	Division of Public Health
GMZ	Ground Water Management Zone
HSCA	Hazardous Substance Cleanup Act
J	Laboratory qualifier indicating that the observed concentration is an estimated value
LUST	Leaking Underground Storage Tank
MCL	Maximum Contaminant Level
mg/L	Milligrams per Liter (parts per million)
MTBE	Methyl *tert*-butyl ether
ODW	Office of Drinking Water
PCE	Tetrachloroethene
PQL	Practical Quantitation Limit
QA/QC	Quality Assurance/Quality Control
RBC	Risk-Based Concentration
RfD	Inhalation Chronic Reference Dose
RfDo	Oral Chronic Reference Dose
SDWP Reg.	Safe Drinking Water Program, regulated compound.
SDWP Unreg.	Safe Drinking Water Program, unregulated compound.
SIRB	Site Investigation and Restoration Branch
SMCL	Secondary Maximum Contaminant Level
SOPCAP	Standard Operating Procedures for Chemical Analytical Programs
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TCA	Trichloroethane
TCE	Trichloroethene
TCL	Target Compound List
THM	Trihalomethane
URS	Uniform Risk-Based Standard
VOC	Volatile Organic Compound
µg/L	Microgram per Liter (parts per billion)

EXECUTIVE SUMMARY

This study of Delaware's public drinking water was performed in response to an increased concern about the quality of Delaware's drinking water, both by chemicals regulated by the Safe Drinking Water Act (SDWA) as well as unregulated chemicals. The study was designed specifically to monitor possible movement of contamination from hazardous waste sites that are in close proximity to drinking water supplies. It went beyond the normal monitoring, evaluating additional analytes above and beyond those required under the SDWA. As such, it has set a precedent for water monitoring in the State of Delaware.

The scope of this study included the collection and analysis of water samples from select public drinking water supply wells and surface water intakes. Samples were collected both before and after any treatment (if any treatment system was present), and were subsequently submitted for laboratory analysis. Analytical results of both the pre- and post-treatment samples were compared both to regulatory standards and to each other, in order to evaluate the effectiveness of existing treatment processes. Samples were collected throughout the state, in each of the three counties. The locations were selected based upon a review of available DNREC and DHSS information that identified these locations as potentially vulnerable. While it is recognized that a single sampling event does indeed represent a "snapshot" in time, and may not be indicative of longer-term water quality, the selected locations were identified as the potentially most threatened by contaminant plumes, and thus it was felt that this would offset any criticism that the results represent only a snapshot.

Thirty-nine public supply wells were selected for inclusion in the project. Ground water samples were collected from each of these wells. For every location, one sample was collected directly from the wellhead itself, prior to any treatment, mixing or combination with water from other wells. An additional sample was collected following treatment, for those systems that possessed a treatment system. Each of the four streams used as drinking water sources in New Castle County were also sampled, with the pre-treatment water sample collected from the closest U.S. Geological Survey Storet station(s) located upstream from the surface water intake. A total of 53 ground water samples and 8 surface water samples were collected. These include both pre-treatment (raw) and post-treatment (finished) samples. Three duplicate samples and 61 trip blanks (one trip blank per cooler) were also collected.

Samples were submitted for laboratory analysis for 188 chemicals, which include volatile and semi-volatile organic compounds, metals, cyanide, pesticides, herbicides, polychlorinated biphenyls (PCBs) and nutrients from the U.S. EPA Target Analyte List and Target Compound List, and both regulated and unregulated Compounds under the SDWA. All laboratory results were validated by DNREC in accordance with the site-specific Quality Assurance Project Plan and DNREC's Standard Operating Procedures for Chemical Analytical Programs (April 1996).

Sample results were first compared to the list of existing Maximum Contaminant Levels (MCLs) that have been established under SDWA. Additional unregulated analytes, for which no MCL has been developed, were compared to the Uniform Risk-based Standards (URS values) under Delaware's Hazardous Substance Cleanup Act (HSCA) as well as EPA Risk-Based Concentrations (RBCs).

Secondly, the potential risk to human health was determined through a risk assessment process using analyte concentrations to estimate the potential risk. Two categories of risk to human health were calculated. The first category was chemical-specific cancer and non-cancer risk posed from exposure to a single contaminant measured to be in a water sample. The second involved the cumulative sum of the individual risks from each water sample. Risk assessments were performed on both raw (untreated) and finished (treated and untreated) water samples. Excess risk was defined when any analyte(s) exceeded an increased lifetime cancer risk (assuming a 70-year lifetime). This occurs when exposure to that analyte in a specified dose would be likely to cause more than 1 additional cancer case in 100,000 exposed population. Excessive risk for non-cancer causing analytes, meaning that exposure to that analyte in a specified dose would be likely to cause systemic, adverse health effects, is based on any analyte(s) exceeding a hazard quotient/index value of 1.0.

The results of this project were very positive--the public drinking water supplies that were sampled as part of this project, which are considered the most vulnerable or threatened in the state, showed only minimal chemical contamination. There were some samples in which one or more contaminants exceeded MCLs or RBCs in raw, or untreated water. But there were no samples that exceeded drinking water standards in the finished, treated water supplies. This confirms the effectiveness of water treatment methods in delivering safe drinking water to the residents of Delaware.

Water samples from two small systems, Bulldozers Saloon in Smyrna and the Mt. Pleasant Mobile Home Park in Middletown, neither of which possesses a treatment system, slightly exceeded the EPA and State of Delaware *proposed* MCL for the gasoline additive methyl *tert*-butyl ether (MTBE). Each of these systems supplies water for a limited population. For both locations, DPH recommends installing wellhead treatment or replacing the wells to address the problem. In each instance, water from a larger system (with an existing treatment system) is readily available as a public water supply line is located nearby.

Twenty water sources exceeded either MCLs or RBCs in raw or untreated water. However, all of the finished (treated) water from these systems was found to be safe for consumption. No regulatory standards were exceeded. For these systems, the associated cumulative cancer and health risks for the chemicals detected were determined to be extremely low and in an acceptable range. In fact, most of the detected compounds in the post-treatment, or finished, samples consisted of disinfection by-products (trihalomethanes or THMs). None of the concentrations exceeded state or federal standards. It should also be noted that it is widely accepted by EPA and DPH that the benefits of disinfection far outweigh the risks associated with the presence of disinfection by-products.

1.0 INTRODUCTION AND PURPOSE

Delaware has available, accessible ground water resources from both confined and unconfined aquifers that, along with its surface water resources, are generally of sufficient quantity and quality to sustain the state's agricultural, industrial and potable needs. In much of Kent and Sussex Counties, it is the shallow, unconfined aquifer that is the sole source of potable water. Over 400 public drinking-water supply wells are screened in this aquifer. Unfortunately, the nature of the ground water in shallow, unconfined aquifers and its accessibility also make the resource susceptible to contamination. Water from the confined aquifers is much less susceptible to such contamination.

In the State of Delaware, New Castle County possesses perhaps the most vulnerable water supply because of the large quantity of surface water that is used. Surface water from four streams--Red Clay Creek, White Clay Creek, Brandywine Creek and the Christina River-- all of which are located within the Christina River Drainage Basin, is used as standalone sources of drinking water, or to supplement ground water sources. The streams are perhaps the most susceptible to contamination due. Conversely, due to the relatively short residence time (vs. that of ground water), dissolved contaminants can be transported out of the system at rates much higher than those encountered in ground water. In addition, contaminants in surface water are also more likely to undergo to rapid volatilization and increased dilution.

In some instances, water treatment may be necessary to reduce or remove contaminants in order to produce potable "safe, consumable" water. Water that is delivered to the consumer as potable water, whether it is treated or not, is required to meet the regulatory standards set by the SDWA and the State of Delaware Regulations Governing Public Drinking Water Systems. Water can only be considered potable once it has been analyzed for microorganisms and regulated chemicals and meets drinking water standards. These standards are enforceable by both the U.S. EPA and the Delaware Division of Public Health (DPH), Office of Drinking Water (ODW). Public water supply companies are required to routinely monitor their potable water for regulated contaminants and other measures of water quality to ensure that the potable water is in compliance with the standards.

This study of Delaware's public drinking water was performed in response to an increased concern about the quality of Delaware's drinking water, both by chemicals regulated by the SDWA as well as unregulated chemicals, that were suspected of leaching from hazardous substance release sites. The study was designed specifically to monitor possible movement of contamination from hazardous waste sites that are in close proximity to drinking water supplies. Contamination of wells by these chemical plumes can be detected by chemical analysis of well water samples. The public wells that were sampled during this study were located within a one-mile radius of a known hazardous waste site and drew their water from sources that are considered vulnerable; i.e., surface water and unconfined aquifer sources.

This study went beyond the normal monitoring, evaluating additional analytes above and beyond those required under the SDWA. As such, it has set a precedent for water monitoring in the State of Delaware. It builds on earlier surveys of water supply sources, routine monitoring results, and various investigations of individual sources of contamination.

In the state of Delaware, the Department of Natural Resources and Environmental Control (DNREC) has regulatory authority for the environmental water quality for water that is either in an aquifer or on the land's surface. DPH has authority for water that is removed from the ground and is being used as drinking water. Together, DPH and DNREC protect the waters of Delaware; DPH monitors public water supplies, protecting the consumer while DNREC protects water as a natural resource. DHSS-Division of Public Health, DNREC, and the Delaware Department of Agriculture collaborated to perform this investigation. This report documents the scope, investigation methods, and results of this effort.

2.0 SCOPE AND STRATEGY

2.1 Project Scope

The scope of this study included the collection and analysis of water samples from select public drinking water supply wells and surface water intakes. Samples were collected both before and after any treatment (if any treatment system was present), and were subsequently submitted for laboratory analysis. Analytical results of both the pre- and post-treatment samples were compared both to regulatory standards and to each other, in order to evaluate the effectiveness of existing treatment processes. Samples were collected throughout the state, in each of the three counties. The locations were selected based upon a review of available DNREC and DPH information that identified these locations as potentially the most threatened.

Water samples collected as part of this project fell into three categories: 1) for systems with treatment, raw or untreated water collected directly from the wellhead or surface water body prior to any treatment; 2) finished water that has undergone some form of treatment (e.g., aeration, carbon filtration, iron removal, etc.) prior to distribution to customers; and 3) finished, untreated water from smaller water systems that have no treatment prior to delivery to consumers, and thus there is consumption of untreated water directly from the well.

2.2 Selection Strategy

Sampling locations were chosen based on their vulnerability to potential sources of contamination and/or documentation of historical contamination. The final sampling locations listed in Table 1 and shown in Figures 1 and 2 represent the joint decision of DNREC-Division of Air and Waste Management, DNREC-Division of Water Resources and DPH. Selection criteria included:

- All five surface water intakes (due to inherent exposure to contaminants as mentioned earlier);

- Public water supply wells whose wellhead protection areas contain Federal Superfund (i.e., Comprehensive Environmental Response, Cleanup and Liability Act or CERCLA) sites or sites under the purview of Delaware's Hazardous Substance Cleanup Act (HSCA) Program;
- Public supply wells possessing characteristics that make it more susceptible to impacts from the hazardous substance release sites; i.e., screened in an unconfined or semi-confined aquifer, or from a carbonate aquifer with karst channels, etc;

- Location of the well or well field within a mile radius of any known CERCLA or HSCA site that has documented ground water contamination, including sites where institutional controls such as Ground Water Management Zones (GMZs) have been established;
- Public Drinking Water Systems in which volatile organic chemicals (VOCs) have been historically detected in raw or treated water above U.S. EPA Maximum Contaminant Levels (MCLs);

3.0 INVESTIGATION APPROACH

3.1 Sampling Locations

Thirty-nine public supply wells were selected for inclusion in the project. Ground water samples were collected from each of these wells (Table 1 and Figure 1). For every location, one sample was collected directly from the wellhead itself, prior to any treatment, mixing or combination with water from other wells. Throughout this report, the individual wells will be identified and referenced by their DNREC permit number. For each of the four streams included in the sampling, a surface water sample was collected from the closest U.S. Geological Survey Storet station(s) located upstream from the surface water intake. The locations of the surface water sample collection points are listed in Table 1 and shown in Figure 2. Each of the surface water sampling locations will be identified and referenced within this report by their U.S.G.S. Storet station number. For those public water supplies (both ground and surface water) that possessed a treatment system, an additional sample(s) was collected following the treatment process, in order to both evaluate the quality of water that is distributed to the public as well as gauge the effectiveness of the treatment process. All water samples were collected by DNREC and DPH-ODW staff.

Quality Assurance/Quality Control (QA/QC) samples included duplicate samples and trip blanks. These QA/QC samples were collected to provide estimates of variability, field or laboratory cross contamination, sampling methods and sample integrity. Duplicate samples were submitted for the full suite of analyses. Trip blanks were submitted for analysis of VOCs only. The frequency of QA/QC sample collection was conducted in accordance with the DNREC Standard Operating Procedures for Chemical Analytical Programs (SOPCAP) and the Quality Assurance Project Plan that was developed specifically for this project.

A total of 53 ground water samples and 8 surface water samples were collected. These totals include both pre-treatment (raw) and post-treatment (finished) samples. Samples were shipped to the laboratory in ice-filled coolers, one sample per cooler. Three duplicate samples and 61 trip blanks (one trip blank per cooler) were also collected.

Table 1: SAMPLE LOCATIONS

Water Provider/System	Water System Location	Sample Number (DNREC Well Permit No. or Storet No. plus pre/post designation)	Local Identification Number	DGS Identification Number	Well Depth	Screen Interval	Aquifer
	New Castle County						
Artesian Water Company	Hockessin	30266-Pre-treatment	Hockessin PG-1	Bb44-13	190	130-190	Cockeysville
		31614-Pre	Hockessin PG-3	Bb34-33	305	?-305	Cockeysville
		31820-Pre	Hockessin P4	Bb34-29	273	?-273	Cockeysville
		Hockessin-Finished	n/a	n/a	n/a	n/a	n/a
	Collins Park	40146-Pre	Collins Park Well	Cd42-17	145	100-125	Potomac undifferentiated
		40146-Finished & Collins Park-Post, DUPLICATES	n/a	n/a	n/a	n/a	n/a
	Llangollen	156408-Pre	Llangollen ASR	None	167	92-154	Middle Potomac
		35081-Pre	Llangollen 2	Dc23-02	172	129-154	Middle Potomac
		10049-Pre	Llangollen 7	Dc24-41	195	115-170	Middle Potomac
		10050-Pre	Llangollen G3	Dc24-18	155	115-155	Middle Potomac
		10051-Pre NOT SAMPLED	Llangollen 6	Dc23-10	165	108-160	Middle Potomac
		10052-Pre	Llangollen K-1	Dc24-15	220	135-173	Middle Potomac
		Llangollen-Post	n/a	n/a	n/a	n/a	n/a
	Airport Industrial Park	48941-Pre	Airport Ind. Park 1	9048941	122	100-112	Middle Potomac
		52445-Pre	Airport Ind. Park 2	9052445	110	80-112	Middle Potomac
		52445, 48941-Post	n/a	n/a	n/a	n/a	n/a
Mt. Pleasant Mobile Home Park	Mt. Pleasant	41457	None	None	44	40-44	Columbia

Table 1: SAMPLE LOCATIONS, Cont'd.

Water Provider/System	Water System Location	Sample Number (Well Permit No. or Storet No. plus pre/post designation)	Local Identification Number	DGS Identification Number	Well Depth	Screen Interval	Aquifer
City of Newark	Newark South Wellfield	00181-Pre	Well 16	Db22-42	164	130-164	Potomac undifferentiated
		10002-Pre	Well 12	Db12-27	188	145-170	Potomac undifferentiated
		10003-Pre	Well 11	Db11-28	136	31-62	Columbia
		10004-Pre	Well 13	Db11-27	66	41-62	Columbia
		10005-Pre	Well 14	Db11-49	129	106-129	Potomac undifferentiated
		Newark South-Post	n/a	n/a	n/a	n/a	n/a
	White Clay Creek (surface water)	105031-Pre	n/a	n/a	n/a	n/a	n/a
		Newark Curtis Plant Post (105031-Post)	n/a	n/a	n/a	n/a	n/a
United Water Delaware	Red Clay Creek (surface water)	103011-Pre	n/a	n/a	n/a	n/a	n/a
		103011-Post (post-treatment sample for 103011 & 105011)	n/a	n/a	n/a	n/a	n/a
	White Clay Creek (surface water)	105011	n/a	n/a	n/a	n/a	n/a
United Water Delaware	Christina River at Smalley's Pond (surface water)	106031-Pre	n/a	n/a	n/a	n/a	n/a
City of Wilmington	Brandywine Creek Wilmington Intake (surface water)	104011-Pre	n/a	n/a	n/a	n/a	n/a
		104011-Post	n/a	n/a	n/a	n/a	n/a
	Kent County						
Bulldozers Saloon	Bulldozers Saloon	10999-Pre & Post -- Duplicates	None	None	Unknown	Unknown	Columbia
Town of Smyrna	Smyrna	10068-Pre	Well 1	Hc34-03	95	80-95	Columbia
		94795-Pre	Well 1A	Hc34-36	105	75-95	Columbia
		85649-Pre	Well 2A	Hc34-41	100	62-92	Columbia
		85649-Post	n/a	n/a	n/a	n/a	n/a
		10068, 94795-Post	n/a	n/a	n/a	n/a	n/a

Table 1: SAMPLE LOCATIONS, Cont'd.

Water Provider/System	Water System Location	Sample Number (DNREC Well Permit No. or Storet No. plus pre/post designation)	Local Identification Number	DGS Identification Number	Well Depth	Screen Interval	Aquifer
	Sussex County						
Town of Greenwood	Greenwood	34366-Pre	Well 1	9034366	80	60-80	Columbia
		72714-Pre	Well 3	Nc25-37	63	40-63	Columbia
		72714-Post	n/a	n/a	n/a	n/a	n/a
		111078-Pre	Well 4	None	325	282-322	Unknown
Town of Georgetown	Georgetown	10325-Pre	Well 1	9010325	120	Unknown	Columbia
		62576-Pre	Well 2R	9062576	125	105-125	Columbia
		62576, 10325-Post	n/a	n/a	n/a	n/a	n/a
City of Seaford	Seaford	56265-Pre	Arbutus Avenue (1A)	None	114	74-114	Columbia
		56265-Post	n/a	n/a	n/a	n/a	n/a
		10323-Pre	Nylon Avenue (3)	Pc13-03	104	80-104	Columbia
		10323-Post	n/a	n/a	n/a	n/a	n/a
		74465-Pre & 74466-Pre DUPLICATES	Dulaney Street (5)	Pc22-06	115	63-103	Columbia
		74465-Post	n/a	n/a	n/a	n/a	n/a
Town of Blades	Blades	40024-Pre	Well 1	Pc34-07	96	66-96	Columbia
		40025-Pre	Well 2	Pc34-06	96	66-96	Columbia
		40024, 40025-Post	n/a	n/a	n/a	n/a	n/a
Colonial Estates Mobile Home Park	Colonial Estates	10697-Pre	n/a	None	57	Unknown	Columbia
		179549-Pre	Well 2	None	100	78-98	Columbia
Holiday Acres	Holiday Acres	77145-Pre	Well 1	9077145	104	94-104	Columbia
		77145-Post	n/a	n/a	n/a	n/a	n/a

Table 1: SAMPLE LOCATIONS, Cont'd.

Water Provider/System	Water System Location	Sample Number (DNREC Well Permit No. or Storet No. plus pre/post designation)	Local Identification Number	DGS Identification Number	Well Depth	Screen Interval	Aquifer
Savannah Place	Savannah Place	57474-Pre	Well 1	Ni51-36	95	75-95	Columbia
		69511-Pre	Well 2	Ni51-37	70	60-70	Columbia
Donovan/Smith Mobile Home Park	Donovan/Smith Mobile Home Park	69918-Pre	Well 2	Ni51-35	70	50-60	Columbia
		99655-Pre	Well 3	None	160	168-158	Unknown

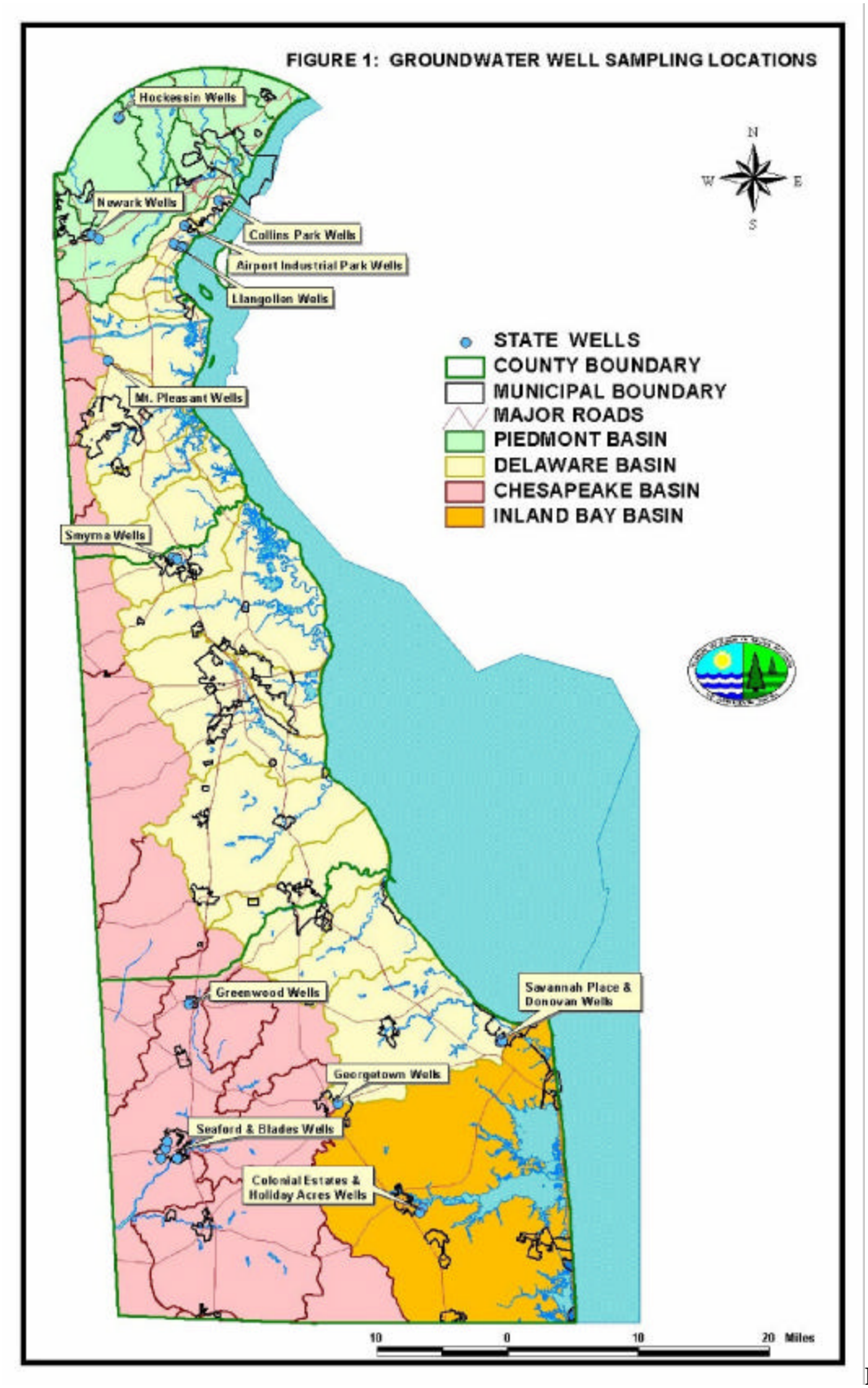
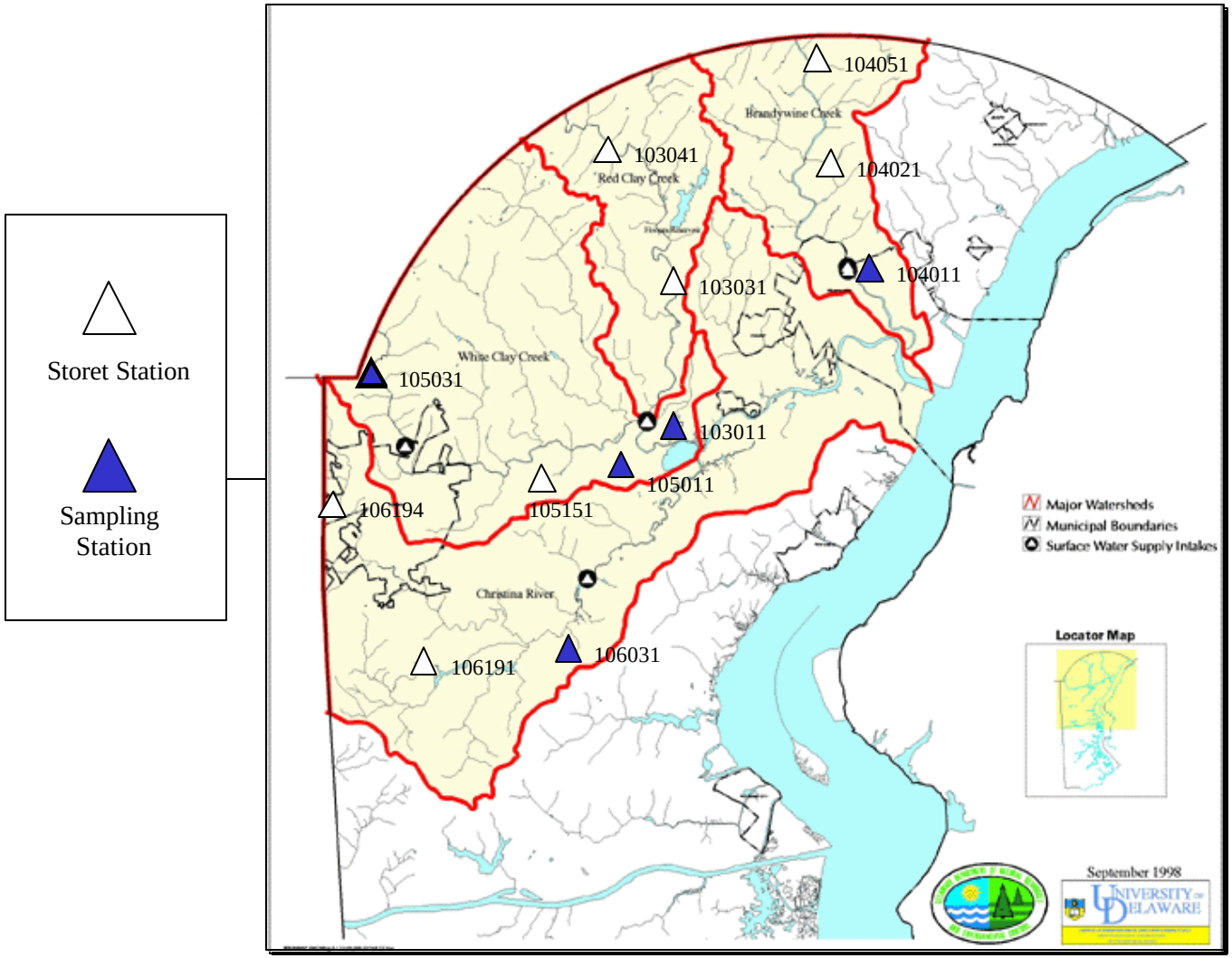


Figure 1: Ground Water Sampling Locations

Figure 2 : Surface Water Sampling Locations



Location of Sampling Sites:

104011 -Foot Bridge

103011- Stanton, Rt. 4, USGS gage

105011- Stanton, Rt. 7 bridge

105031- Chambers Rock Rd.

106031- Smalley's Dam Spillway

3.2 Analytical Protocols

Samples were submitted for laboratory analysis of 188 chemicals (Tables 2-4) which include: VOCs, semi-volatile organic compounds (SVOCs), metals, cyanide, pesticides, herbicides, polychlorinated biphenyls (PCBs) and nutrients from the U.S. EPA Target Analyte List and Target Compound List (TAL/TCL) and both regulated and unregulated Compounds under the Safe Drinking Water Act.

All analytical protocols were conducted in accordance with the site-specific Quality Assurance Project Plan (QAPP) dated March 2001. A copy of the QAPP is included as an appendix in the Drinking Water Project Sampling and Analysis Plan for Selected Public Drinking Water Systems.

All samples collected were submitted to Severn-Trent Laboratories (STL) of Edison, NJ. Analysis for VOCs, SVOC, inorganics, and wet chemistry parameters were performed by STL., STL subcontracted the analytical work for pesticide/herbicide and PCB analyses to APPL, Inc. laboratories of Fresno, CA.

All laboratory results were validated by the DNREC-SIRB chemist in accordance with the site-specific QAPP and DNREC-SIRB's Standard Operating Procedures for Chemical Analytical Programs (April 1996 update). Copies of the data validation reports and the raw analytical data are located in the appendix of this report.

Table 2

List of Volatile Organic Compounds

1,1,1,2-TETRACHLOROETHANE	**CHLOROBENZENE**
1,1,1-TRICHLOROETHANE	CHLOROETHANE
1,1,2,2-TETRACHLOROETHANE	**CHLOROFORM**
1,1,2-TRICHLOROETHANE	CHLOROMETHANE
1,1-DICHLOROETHANE	**CIS-1,2-DICHLOROETHENE**
1,1-DICHLOROETHENE	**DIBROMOCHLOROMETHANE**
1,2,3-TRICHLOROPROPANE	DICHLOROFLUOROMETHANE
1,2,4-TRICHLOROBENZENE	DIETHYLETHER
1,2,4-TRIMETHYLBENZENE	ETHYL METHACRYLATE
1,3,5-TRIMETHYLBENZENE	ETHYLBENZENE
1,2-DIBROMO-3-CHLOROPROPANE	METHACRYLONITRILE
1,2-DIBROMOETHANE	METHYL METHACRYLATE
1,2-DICHLOROBENZENE	**METHYL TERT-BUTYL ETHER**
1,2-DICHLOROETHANE	METHYLENE CHLORIDE
1,2-DICHLOROPROPANE	XYLENE
1,3-DICHLOROBENZENE	N-BUTYLBENZENE
1,3-DICHLOROPROPENE	N-PROPYLBENZENE
1,4-DICHLORO-2-BUTENE	O-CHLOROTOLUENE
1,4-DICHLOROBENZENE	SEC-BUTYLBENZENE
2-BUTANONE	STYRENE
4-METHYL-2-PENTANONE	TERT-BUTYLBENZENE
ACETONE	**TETRACHLOROETHENE**
ACRYLONITRILE	TOLUENE
BENZENE	TRANS-1,2-DICHLOROETHENE
BROMODICHLOROMETHANE	**TRICHLOROETHENE**
BROMOFORM	TRICHLOROFLUOROMETHANE
BROMOMETHANE	VINYL ACETATE
CARBON DISULFIDE	VINYL CHLORIDE
CARBON TETRACHLORIDE	

Compounds listed in **Green** were detected in one or more untreated samples.
Compounds listed in **Red** were detected in one or more post-treatment samples.
Compounds listed in **Blue** were detected in one or more untreated and finished samples.

Table 3

List of Semi-Volatile Organic Compounds

1,2,4-TRICHLOROBENZENE	CARBOFURAN
1,2-DICHLOROBENZENE	CHRYSENE
1,3-DICHLOROBENZENE	DIBENZ[A,H]ANTHRACENE
1,4-DICHLOROBENZENE	DIBENZOFURAN
2,4,5-TRICHLOROPHENOL	DIBROMOCHLOROMETHANE
2,4,6-TRICHLOROPHENOL	DIBUTYLPHTHALATE
2,4-DICHLOROPHENOL	DIETHYLPHTHALATE
2,4-DIMETHYLPHENOL	DIMETHYLPHTHALATE
2,4-DINITROPHENOL	DIOCTYLPHTHALATE
2,4-DINITROTOLUENE	DIPHENYLAMINE
2,6-DINITROTOLUENE	FLUORANTHENE
2-CHLOROPHENOL	FLUORENE
2-METHYLPHENOL	HEXACHLOROBENZENE
3,3'-DICHLOROBENZIDINE	HEXACHLOROBUTADIENE
3-METHYLPHENOL	HEXACHLOROCYCLOPENTADIENE
4,6-DINITRO-2-METHYLPHENOL	HEXACHLOROETHANE
4-CHLOROANILINE	INDENO[1,2,3-C,D]PYRENE
4-METHYLPHENOL	ISOPHORONE
4-NITROPHENOL	NAPHTHALENE
ACENAPHTHENE	**NITROBENZENE**
ANTHRACENE	N-NITROSODIETHYLAMINE
BENZ[A]ANTHRACENE	N-NITROSODIMETHYLAMINE
BENZO[A]PYRENE	N-NITROSO-DI-N-BUTYLAMINE
BENZO[B]FLUORANTHENE	N-NITROSODIPHENYLAMINE
BENZO[K]FLUORANTHENE	N-NITROSODIPROPYLAMINE
BENZYL ALCOHOL	PYRENE
BIS(2-CHLOROETHYL)ETHER	PENTACHLOROPHENOL
BIS(2-ETHYLHEXYL)PHTHALATE	PHENOL
BUTYLBENZYLPHTHALATE	
N-NITROSO-N-METHYLETHYLAMINE	

Compounds listed in **Green** were detected in one or more untreated samples.
Compounds listed in **Red** were detected in one or more post-treatment samples.
Compounds listed in **Blue** were detected in one or more untreated and finished samples.

Table 4

List of Pesticides, Herbicides and PCBs

2,4,5-T	DIELDRIN
2,4-D	DINOSEB
ALACHLOR	DIQUAT
ALDICARB	DISULFOTON
ALDICARB SULFONE	DIURON
ALDRIN	ENDOSULFAN
ALPHA-HCH	ENDOTHALL
AROCLOR-1016	ENDRIN
AROCLOR-1221	FONOFOS
AROCLOR-1232	GAMMA-HCH (LINDANE)
AROCLOR-1242	GLYPHOSATE
AROCLOR-1248	HEPTACHLOR
AROCLOR-1254	HEPTACHLOR EPOXIDE
AROCLOR-1260	METHOXYCHLOR
ATRAZINE	METHYL PARATHION
BETA-HCH	OXAMYL
CHLORDANE, ALPHA	**PERCHLORATE**
CHLORDANE, GAMMA	PICLORAM
DACTHAL	PROMETON
DALAPON	SIMAZINE
DDD	TOXAPHENE
DDE	
DDT	

Compounds listed in **Green** were detected in one or more untreated samples.
Compounds listed in **Red** were detected in one or more post-treatment samples.
Compounds listed in **Blue** were detected in one or more untreated and finished samples.

3.3 Health Evaluation Approach

Sample results were first evaluated against the list of existing MCLs that have been established under SDWA. MCLs have been established for 69 of the analytes in this study that were evaluated with regard to human health risk. MCLs also exist for two nitrogen compounds, nitrate and nitrite. Nitrates and nitrites were measured as compounds instead of individual components of nitrates and nitrites. If any sample result exceeded an MCL value, a confirmatory sample was recollected from the well or stream, and reanalyzed to corroborate the initial result. Once the results were confirmed by the retest, the Office of Drinking Water applied the standard regulatory procedure for MCL violations, which include the required public notification and correction of the contamination within four calendar quarters for VOCs, and one confirmatory sample for acute contaminants.

Additional, unregulated analytes, for which no MCL has been developed, were compared to the Uniform Risk-based Standards (URS values) under Delaware's Hazardous Substance Cleanup Act (HSCA) and EPA's Risk-Based Concentrations (RBCs). These health-based risk criteria were used for 108 analytes, 68 of which had non-cancer-causing risk values while 22 had cancer-causing risk values. An additional 18 had both non-cancer and cancer-causing effects. These latter 18 analytes were evaluated for both types of potential effects for each sample location.

The potential risk to human health was determined through a risk assessment process using analyte concentrations to estimate the potential risk. Two categories of risk to human health were calculated. The first category was chemical-specific cancer and non-cancer risk posed from exposure to a single contaminant measured to be in a water sample. The second category of risk involved the sum of the individual risks from each water sample. Risk assessments were performed on both raw (untreated) and finished (treated and untreated) water samples.

The finished (treated and untreated) risk assessments were used to evaluate the human health risk, if any, from consuming the water. The raw (untreated) risk assessment was used to evaluate the potential risk, if any, from consuming this water without any treatment. While this latter situation may not be applicable to most public supplies, which have some form of water treatment system in place, an example of such a scenario might be through the installation and use of a domestic well, which typically does not have any treatment.

All chemicals, or analytes, that have a risk-based value associated with an oral dose, including those that have been designated as having MCL values, have been deemed to exhibit human health risk and have been assigned a health risk-based value that is specific to that analyte. These values were used for the risk-based screening portion of the analysis. Excess risk was defined when any analyte(s) exceeded an increased lifetime cancer risk (assuming a 70-year lifetime). This occurs when exposure to that analyte in a specified dose would be likely to cause more than 1 additional cancer case in 100,000 exposed population. Excessive risk for non-cancer causing analytes, meaning that exposure to that analyte in a specified dose would be likely to cause systemic, adverse health effects, is based on any analyte(s) exceeding a hazard quotient/index value of 1. If such contaminants were identified, they were evaluated singly and cumulatively, in order to calculate a total risk value associated with the consumption of water from that water source.

The final 10 analytes that were evaluated reflect an aesthetic component (taste and odor of drinking water), commonly referred to as Secondary Drinking Water Standards or Secondary Maximum Contaminant Levels (SMCLs). Of these additional 10 analytes, four were evaluated with regard to human health risk (aluminum, copper, silver, zinc) and five were evaluated using the National Secondary Drinking Water Regulations (chloride, iron, manganese, sulfate, total dissolved solids).

4.0 SAMPLE LOCATION DESCRIPTIONS, RESULTS and DISCUSSION-- GROUND WATER

4.1 New Castle County

4.1.1 Artesian Water Company Hockessin Well PG1 (30266), Well PG3 (31614), and Well P4 (31820)

Background

Artesian Water Company operates six supply wells in the Hockessin area. Three of these wells were sampled as part of the project: Wells 30266 (local ID PG1), 31614 (PG3), and 31820 (P4). Each draws water from the consolidated Cockeysville marble and, as such, the wells were completed as open borehole wells, without screens. Well 30266 is open interval from 130-190 feet below ground surface ("bgs"). The open interval for Wells 31614 (PG-3) and 31820 (P4) are unknown, but total construction depths are 305 feet and 273 feet, respectively. Water from each of the wells is combined then treated with aeration to remove VOCs, and treated for iron removal, disinfection, and for corrosion control. A fourth water sample (Hockessin Post-treatment) was collected from the water system following treatment.

The karst nature of the Cockeysville aquifer permits extremely rapid migration of ground water contaminants, even from significant distances, making the wells vulnerable to contamination. This vulnerability was one reason for the wells' inclusion in the project. In addition, each of the three wells sampled has had historic instances of VOC contamination (e.g., PCE). Chlorinated VOCs were also detected in this investigation.

Results

Nine chlorinated VOCs were detected in one or more of the untreated water samples from the Hockessin wells (Table 5). The presence of low concentrations of four of these compounds (chloroform, bromoform, bromodichloromethane and dibromochloromethane) in the finished sample likely represent disinfection by-products (termed trihalomethanes or THMs) that are generated through the addition of chlorine to raw well water in order to control microorganisms (i.e., bacteria).

The remaining five chlorinated VOCs (PCE, TCE, 1,1-DCE, cis-1,2-DCE, and 1,1,1-TCA) are anthropogenic contaminants that are utilized as solvents for both laundry dry cleaning and/or degreasing. Tetrachloroethene (PCE) is utilized in the dry cleaning industry. Trichloroethene (TCE), and both dichloroethene isomers (1,1-DCE and cis-1,2-DCE) may represent either reductive degradation products of PCE, or primary components of degreasing solvents used in manufacturing and automotive degreasing. Trichloroethane (1,1,1-TCA) is a common automotive degreasing agent. There are no known sources for the solvents. Potential point sources include dry cleaning establishments (for PCE and other chlorinated ethenes) and automotive repair shops and garages (for 1,1,1-TCA and perhaps the chlorinated ethenes). Of the compounds detected, PCE slightly exceeded its MCL of 5 µg/L, and only in untreated water samples (5.6 µg/L in Well 31614 and 5.7 µg/L in Well 31820). While the same compounds were detected in the finished water sample, the observed concentrations were all below MCLs and at

levels lower than in the untreated samples, indicating that the aeration treatment is effective in lowering the concentrations of the contaminants.

Methyl tertiary butyl ether (MTBE), a gasoline additive, was also detected at trace concentrations (0.2 µg/L) in two raw water samples (Wells 31614 and 31820). Please refer to Table 5 for a complete list of detected analytes. These concentrations are well below the proposed Delaware MCL of 10 µg/L. MTBE was not detected in the finished sample. Several former and extant gas stations exist within close proximity of Artesian's Hockessin wellfield, any of which may represent a possible source for the MTBE.

The only SVOC detected in the Hockessin samples was nitrobenzene in Well 30266 at 0.086 µg/L, a concentration well below its URS of 0.4 µg/L. Nitrobenzene is utilized in the production of brake fluids and lubricating oils, as well as in the manufacture of synthetic rubber, and trace concentrations of nitrobenzene can still be found in the finished product. The occurrence of nitrobenzene may therefore be tied to the presence of MTBE and chlorinated solvents associated with automotive repair operations.

The herbicides dalapon and dacthal were both detected in wells 30266 and 31614, as well as the Hockessin Post-treatment sample, but at concentrations far below their respective MCL. Please refer to Table 5.

Results from the wet chemistry parameters (sulfate, fluoride, chloride and TDS) and nitrates fell within normal ranges, with the exception of slightly alkaline pH values 7.7-7.94, which are to be expected for wells that are screened within either limestone or marble.

Table 5: Artesian Water Company Hockessin Wells, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 30266 PG1	Well 31614 PG3	Well 31820 P4	Hockessin Post-Treatment
Bromoform	80 for Total THMs[1]	--	0.8	1.0	1.6
Chloroform		0.1 J	--	0.1 J	0.5 J
Bromodichloromethane		--	--	--	0.9
Dibromochloromethane		--	--	--	1.6
MTBE	10[2]	--	0.2 J	0.2 J	--
1,1-DCE	7[1]	0.1 J	--	--	--
Cis-1,2-DCE	70[1]	--	0.1 J	0.2 J	--
PCE	5[1]	3.1	5.6	5.7	2.1
1,1,1-TCA	100[1]	--	--	0.1 J	--
TCE	5[1]	0.1 J	0.2 J	0.4 J	0.1 J
Nitrobenzene	0.4[2]	0.086	--	--	--
Benzyl alcohol	1,100[4]	--	--	--	0.2 J
Copper	1,300[3]	--	--	--	1.3
Zinc	5,000[3]	--	--	--	72.5
Sulfate	250,000[3]	14,600	27,400	23,800	27,800
Nitrate	10,000[1]	2,800	3,600	2,600	3,700
Chloride	250,000[3]	19,500	27,500	33,000	30,000
Fluoride	2,000[3]	--	--	--	0.44
TDS	500,000[3]	242	291	354	293
pH (units)	6.5-8.5[3]	7.94	7.91	7.7	7.79
Dalapon	200[1]	0.71 J	0.73 J	--	--
Dacthal	37[2]	0.33	0.05 J	--	0.11

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected

Recommended Future Actions

The existing aeration treatment system installed by Artesian Water Company is effective in removing the observed organic contaminants to below drinking water standards. However, the existing monitoring program for the Artesian Hockessin Wellfield, which is required under the Safe Water Drinking Act, will be amended by DPH to include all of the detected organic and inorganic contaminants that were detected as part of this study. Samples from both untreated and post-treated water should be collected so as to gauge the ongoing effectiveness of the treatment systems.

DNREC-SIRB will commence an investigation into the source(s) of the five solvents (PCE, TCE, 1,1-DCE, cis-1,2-DCE, and 1,1,1-TCA) and nitrobenzene. DNREC-SIRB will conduct confirmatory sampling on each of the three sampled wells (i.e., G1, G3 and P4), as well as sample the remaining three wells of the Artesian Hockessin wellfield (P1, P2, and P3). A well survey will also be conducted in central Hockessin in order to identify any possible domestic supply wells (residential, commercial/industrial) in the area. These wells, unlike the public

supply wells, may not have any treatment system in place that would be effective in removing VOCs. DNREC-SIRB will be working with the DNREC-Division of Water Resources to develop such a list. Subsequently, DNREC-SIRB is conducting a background search into the presence of either historic or existing dry cleaning and automotive repair facilities in the area of central Hockessin in order to identify one or more potential sources of the solvents.

The detection of MTBE in one of the wells indicates the presence of at least one potential leaking underground storage tank (LUST) or spill within proximity of the Hockessin wellfield. DNREC-UST has been forwarded the analytical results from this study. Initial responses will include a review of recent tank tightness tests and inventory audits of nearby gas stations in order to help identify which facility may represent the likely source. This will be followed by hydrogeologic investigations of any facilities that fail either the tightness tests or inventory audits.

4.1.2 City of Newark South Wellfield, (Wells 00181, 10003, 10622, 10005, and 10004)

Background

The City of Newark operates a total of thirteen public supply wells in three separate wellfields. Depending upon their location and depth, wells are screened in either the fractured bedrock of the Wissahickon Formation within the Piedmont (Laird Tract), the shallow sands and gravel of the Columbia Formation, or the confined/semi-confined sands of the Potomac Group. Due to their urban setting, two of Newark's three wellfields are located in close proximity to potential or known contaminant sources such as HSCA sites, leaking underground storage tanks, and active industrial and manufacturing facilities. A review of available information has identified ground water contamination associated with several sites close to the North wellfield. However, the wellfield is no longer used by the City of Newark, and at present, the city has no plans to reactivate it. Thus no sampling was conducted in the North wellfield.

At least one VOC plume associated with the Syntech Site (a former chemical manufacturer that operated in the Delaware Industrial Park) has been identified within the vicinity of Newark's South Wellfield. Additionally, MTBE, likely associated with nearby gas stations, has been detected in a number of the South Wellfield wells, including Wells 00181, 10003, 10622, 10005, and 10004.

Five of the six wells from the South Wellfield were sampled as part of this project, with those selected based upon their proximity to the Syntech site: Well 00181 (local ID #16), 10003 (#11), 10622 (#10), 10005 (#14), and 10004 (#13). The deeper Wells #10, #14, and #16 are screened within the Potomac Aquifer, which is unconfined in this area, at depths of approximately 173-193, 106-126, and 130-164 feet bgs, respectively. Wells #11 and #13 are screened within the surficial Columbia sands, at a much shallower depth of 31-62 and 41-62 feet bgs, respectively. All of the wells are located within a New Castle County Class C Wellhead Protection Area. Water from all of the sampled wells is combined prior to treatment for iron removal, filtration, disinfection and aeration (for removal of VOCs).

Results

Low concentrations of a number of VOCs were detected in the samples from the City of Newark wells. Low levels of several THMs were detected in both raw and finished samples. Individual detected compounds include chloroform, bromodichloromethane, dibromochloromethane, and bromoform. Concentrations of these THMs were generally below the detection limit of 1.0 µg/L, and well below the MCL for Total THMs of 80 µg/L (Table 6).

Two gasoline-associated compounds were detected in the Newark samples. Benzene was identified in Well 00181 at 0.5 J µg/L but not in the finished sample. MTBE was detected in three well samples at a maximum concentration of 4.5 µg/L in Well 10004, as well as in the Newark South Wellfield finished sample at 2.1 µg/L (please refer to Table 6 for a complete list of detected analytes). These concentrations are consistent with results from previous sampling events, and each is below its proposed MCL. Potential sources include the nearby industrial complex, the former Castle Mall, and nearby LUST sites.

Several chlorinated VOCs were found in the Newark wellfield: PCE, TCE, several DCE and DCA isomers, and 1,1,1-TCA. Of these, only PCE in the untreated sample from Well 10005 (14 µg/L) exceeded its MCL of 5 µg/L. The observed PCE concentration following treatment fell to below its MCL in this sample (2.7 µg/L). TCE and 1,1,1-TCA were also detected in the Newark South Wellfield finished sample, at similar or lower concentrations. The likely source of these chlorinated compounds is the nearby industrial park. DNREC is presently investigating the extent of this PCE and TCE ground water contamination.

One SVOC was detected in the Newark well samples, 0.025 µg/L of bis(2-chloroethyl)ether (or BCEE) in Well 10002. The interim Delaware MCL for BCEE was established in 2000 of 0.096 µg/L. BCEE is a complex organic solvent that is used in a number of chemical manufacturing processes. It has also been utilized as an insecticide/fungicide. The source of BCEE in ground water in this area is unknown.

The metals barium, copper, lead, mercury, nickel and zinc were found in one or more of the pre-treated well samples, but each at concentrations below its respective MCL. With the exception of barium, the presence of these metals at the observed low concentrations are likely to be associated with the metallic construction of the well system (wellhead, pump apparatus and associated piping) that were leached due to the low pH of the shallow ground water. Barium at the observed concentration of 215 µg/L in Well 10004 is typical of ground water from the Columbia Aquifer. Detectable concentrations of the other metals--copper, lead, mercury, nickel and zinc-- are not usually found in Delaware's coastal plain aquifers. Only zinc was detected in the finished sample, at a concentration much higher than in the untreated well samples, but still below the drinking water standard.

Two pesticides were found in the Newark samples, dacthal (a common herbicide used in lawn applications) at concentrations up to 2.9 µg/L (URS of 37 µg/L) in all untreated water samples, and dieldrin in Wells 10003 through 10005, and the Newark South Wellfield finished sample. Dieldrin was detected at concentrations near its detection limit in the three untreated samples, at or exceeding its RBC of 0.04 µg/L in 10004 (0.06 µg/L) and 10005 (0.04 µg/L). It was detected at a slightly lower concentration in the finished sample (0.03 µg/L), but due to such low

concentrations, this may not be considered significantly lower, indicating that the present treatment system may not be very effective in the removal of dieldrin. Dieldrin was once used as an insecticide. Its uses included residential use against termites and as an insecticide spray on cotton and corn. Dieldrin has low water solubility, and is normally strongly adsorptive onto soil, so its presence in ground water is unusual. In this instance, its presence in ground water in the south Newark area may be associated with the dissolved chlorinated solvents in the ground water (e.g., PCE, TCE, etc.), which may have acted as a solute to mobilize the dieldrin.

Low concentrations of sulfate, nitrate, fluorides and chlorides were found in nearly every sample. Only nitrate in Well 10004 (10.3 mg/L) exceeded any regulatory threshold (the MCL for nitrate is 10 mg/L). This value is twice to four times higher than the nitrate results from the other wells in the Newark South Wellfield, and almost twice the value from the finished sample (5.6 mg/L). Although no specific source was identified, typical sources of nitrate contamination include application of fertilizers and septic systems.

Table 6: City of Newark South Wellfield, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 00181 No.16	Well 10622 No.10	Well 10003 No.11	Well 10004 No.13	Well 10005 No.14	Newark South-Post treatment
Bromoform	80 for Total THMs[1]	3.1	--	--	--	--	0.5
Chloroform		--	0.2 J	0.3 J	0.3 J	0.8	0.8
Bromodichloromethane		--	--	--	--	--	0.6 J
Dibromochloromethane		1.5	--	--	0.2 J	--	1.1
MTBE	10[2]	--	--	2.1	4.5	0.9	2.1
1,1-DCE	7[1]	--	--	--	--	0.1 J	--
Benzene	5[1]	0.5 J	--	--	--	--	--
Cis-1,2-DCE	70[1]	0.2 J	--	--	--	0.3 J	--
Chlorobenzene	100[1]	0.2 J	--	--	--	--	--
1,1-DCA	5[1]	0.2 J	--	--	--	--	--
PCE	5[1]	--	0.6	0.4 J	0.9	14	2.7
1,2-DCA	5[1]	0.8	--	--	--	--	--
1,1,1-TCA	100[1]	--	--	--	--	--	0.1 J
TCE	5[1]	--	0.4 J	--	--	0.2 J	0.4 J
BCEE	0.096[2]	--	0.025 J	--	--	--	--
1,2-dichloropropane	5[1]	--	--	--	--	0.2 J	--
Barium	2,000[1]	--	--	--	215	--	--
Copper	1,300[3]	--	34.7	--	26	--	--
Lead	15[4]	--	--	--	--	4.6	--
Mercury	2[1]	--	--	--	--	0.3	--
Nickel	100[2]	--	53	--	--	--	--
Zinc	5,000[3]	--	99.9	48.9	11.7	73.4	118
Sulfate	250,000[3]	11,400	--	23,000	27,800	15,000	15,000
Nitrate	10,000[1]	390	2,600	4,700	10,300	5,800	6,200
Chloride	250,000[3]	33,500	14,600	35,900	33,500	57,900	43,200
TKN	N/A	220	--	--	--	350	--
Fluoride	2,000[3]	--	--	--	--	--	570
TDS	500,000[3]	95,000	70,000	148,000	211,000	199,000	134,000
pH (units)	6.5-8.5[3]	4.88	5.21	5.64	5.82	5.38	7.27
Dieldrin	0.04[4]	--	--	0.03 J	0.06	0.04	0.03 J
Dacthal	37[2]	2.2	0.67	1.6	0.67	2.9	2.0

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other -- Analyte not detected

Recommended Future Actions

The City of Newark South Wellfield uses large quantities of water from a number of different wells screened within two separate aquifers. This allows dilution of contaminants that may be found within the water from any individual well, or even aquifer. Treatment, in the form of filtration, aeration and iron removal, further reduces contaminant concentrations prior to distribution. This reduction in contaminant concentrations can be readily observed in this study through comparison of untreated water from individual wells to the final, Newark South Wellfield finished sample.

The existing monitoring program for the City of Newark, which is required under the Safe Drinking Water Act, will be amended by DPH to include all of the detected organic and inorganic contaminants that were detected as part of this study, that are not already SDWA-regulated.

At present, hydrogeologic investigations are being conducted at several of the potential sources of contamination of the Newark South Wellfield, including the Syntech HSCA Site and other locations in the nearby industrial park, and nearby gas stations. Results of these investigations will provide a better understanding of the hydrologic characteristics of the Columbia and Potomac aquifers, possible interconnections between the two aquifers, natural ground water geochemistry and the scope and magnitude of the contaminant plumes. DNREC will be able to select a permanent remedy to address the ground water contamination following the collection and synthesis of the results of the hydrogeologic investigations. These permanent remedies will better protect the ground water from the contamination that is threatening this portion of the City of Newark's potable water supply.

4.1.3 Artesian Water Company New Castle Collins Park Well (40146)

Background

Artesian's Collins Park Well (permit number 40146) provides drinking water to a population in Collins Park and surrounding areas of unincorporated New Castle County. The well is located within a New Castle County Class C Wellhead Protection Area. The present well was installed in 1977 as a replacement well, and is screened within the confined or semi-confined Potomac Aquifer, at an interval of 90-120 feet bgs. Previous sampling of this well has detected VOCs and chlorinated VOCs at concentrations above drinking water standards. As a result, an air stripper treatment system was installed. As recently as November 2000, bis(2-chloroethyl)ether (BCEE) was detected at both the Collins Park Well and production Well #10 (screened in the confined aquifer) at the Atlas Point facility, the latter well containing concentrations/levels above the DPH interim standard of 0.096 µg/L. Well #10 is also screened in the Potomac Aquifer. According to records at the DNREC-Underground Storage Tank Branch (DNREC-UST), MTBE has also been historically detected at low concentrations in this well.

Results

Seven VOCs, including three THMs, MTBE and three chlorinated VOCs were identified in the untreated water sample from the Collins Park Well, and six VOCs, including four THMs, MTBE and cis-1,2-DCE were detected in the finished sample from the well. In the untreated sample, low concentrations of chloroform (4.1 µg/L), trichlorofluoromethane and bromoform (both at 0.4 J µg/L) were detected, but at levels far below the MCL for cumulative THMs of 80 µg/L. Low concentrations of THMs appear to be ubiquitous in ground water in New Castle County, as one or more of these same compounds were detected in most of the untreated samples collected as part of this project. THMs detected in finished water included a lower concentration of chloroform (0.3 J µg/L), but higher bromoform (1.4 µg/L), as well as bromodichloromethane (0.2 U µg/L) and dibromochloromethane (0.6 µg/L). Please refer to Table 7 for a complete list of detected analytes.

PCE, TCE and cis-1,2-DCE were identified in the untreated well sample, with the observed concentration of PCE of 5.8 µg/L exceeding its 5 µg/L MCL. Neither PCE nor TCE was detected in the finished samples. Cis-1,2-DCE exhibited a noticeable decrease (3.0 µg/L untreated, 0.2 J µg/L finished) indicating that the existing aeration treatment is effective in lowering the concentration of these compounds. Historically, similar concentrations of these compounds have been detected in the Collins Park Well. Possible sources include the Atlas Point Industrial Park or former dry cleaners.

MTBE was also detected in both the untreated (1.5 µg/L) and finished (0.8 µg/L) samples from the Collins Park Well. With such low concentrations, it is difficult to assess the effectiveness of the existing treatment system. MTBE is not readily amenable to treatment using granular activated carbon even though such a filter was installed during the summer of 2001. However, elevated levels of MTBE can be treated with aggressive use of aeration. Potential sources are numerous, as there are several gas stations, several automotive repair facilities and many other petroleum storage tanks within ½ mile of the well.

BCEE was detected in both the untreated and finished samples from the Collins Park Well. The untreated water result of 0.123 µg/L exceeds the proposed DE MCL of 0.096 µg/L. The finished sample concentration was 0.088 µg/L, but was not detected in the sample duplicate, which is unexplained. While there was a seeming decrease in the concentration of BCEE between the untreated and the treated samples, the relatively low detected concentrations make this difficult to ascertain. Additionally, BCEE is not normally amenable to treatment using aeration. However, since the date of collection of this sample, a granular activated carbon treatment unit, which has been shown to be effective in the removal of BCEE, has been installed on the Collins Park Well. A finished sample collected July 2001 yielded a result of 0.06 µg/L. BCEE was also detected in wells at Atlas Point, and thus the industries at Atlas Point may represent a possible source.

A second SVOC, nitrobenzene, was detected in the Collins Park finished sample, and the duplicate sample, at similar concentrations (0.076 µg/L and 0.052 µg/L). It was not, however, detected in the untreated sample. The URS for nitrobenzene is 0.4 µg/L. DHSS will conduct resampling to confirm its presence. There are no known sources for this compound in the vicinity of the well.

The pesticide dieldrin, was detected in both the untreated sample and the finished sample from the Collins Park Well at the same concentration of 0.03 J µg/L. It was not detected in the finished duplicate sample. Similar to other wells where dieldrin was detected during this project, the compound's presence seems to be linked with the occurrence of chlorinated solvents (e.g., PCE, TCE, etc.) in ground water, which may be acting as a solute for the pesticide. The observed concentrations are just below the RBC of 0.04 µg/L.

No metals were identified in the untreated sample from the Collins Park Well. In the finished duplicate samples however, both mercury (0.33 and 0.32 µg/L) and zinc (119 and 151 µg/L) were detected. The observed concentrations are below the drinking water standards for mercury (MCL of 2 µg/L) and zinc (SMCL of 5,000 µg/L). Mercury and zinc (frequently with nickel) were noted in a number of water samples, both pre- and finished during this study, and at comparable concentrations. As such, their presence is likely due to leaching from metallic components in the well and pump by acidic ground water.

Relatively low concentrations of sulfate, fluoride, chloride, TDS and nitrate were detected in the Collins Park Well at levels below their drinking water standards, but at concentrations generally higher than those observed elsewhere. The value for pH was neutral. These analytes, termed the "classic parameters" are not generally considered contaminants, per se, but are rather indicative of overall water quality. The observed pattern of generally higher values for these analytes may be reflective of infiltration of Delaware River water into the Potomac aquifers. Interaction between the various Potomac aquifers and Delaware River in high-pumpage areas near the river have been well-documented.

Recommended Future Actions

At the present time, Artesian has installed both a granular activated carbon as well as an aeration treatment unit on the Collins Park Well. In combination, these should be effective in removing any organic contaminants to concentrations below drinking water standards. Confirmatory sampling should be undertaken to confirm the presence of nitrobenzene, mercury and zinc in the finished samples. The periodic sampling program for the well system should be amended to include all of the detected organic and metallic contaminants identified as part of this project, if they are not already included in such a monitoring program. Samples should be collected from both untreated and post-treated water so as to gauge the ongoing effectiveness of the treatment systems.

An extensive ground water investigation is already underway at the Atlas Point facility under the supervision of DNREC for purposes of delineating the BCEE plume in both the Columbia and Potomac Aquifers. Several areas of BCEE-contaminated soil have been recently identified at the facility, and remedial measures are presently being developed to treat the impacted soil, and thus remove the contaminant source. In the meanwhile, continued operation of production well #10 and the carbon treatment unit at the Atlas Point facility performs as a limited ground water containment system, limiting the amount of BCEE-containing water that reaches the Collins Park Well.

Table 72: Artesian Water Company Collins Park Well, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 40146	40146-Post	Collins Park Post (duplicate)
Bromoform	80 for Total THMs[1]	0.4	1.4	1.2
Chloroform		4.1	0.3 J	0.3 J
Bromodichloromethane		--	0.2 J	0.1 J
Dibromochloromethane		--	0.6	0.6
Trichlorofluoromethane		0.4 J	--	--
MTBE	10[2]	1.5	0.8	0.9
Cis-1,2-DCE	70[1]	3.0	0.2 J	0.2 J
PCE	5[1]	--	5.8	0.1 J
TCE	5[1]	1.5	--	--
BCEE	0.096[2]	0.123	--	0.088
Nitrobenzene	0.4[2]	--	0.076 J	0.052 J
Copper	1,300[3]	--	--	30.2
Lead	15[4]	--	--	6.6
Mercury	2[1]	--	0.33	0.32
Zinc	5,000[3]	--	119	151
Sulfate	250,000[3]	42,700	41,100	41,100
Nitrate	10,000[1]	3,400	3,400	3,100
Chloride	250,000[3]	31,000	99,000	95,500
TKN	N/a	580	--	--
Fluoride	2,000[3]	--	420	450
TDS	500,000[3]	213,000	291,000	272,000
pH (units)	6.5-8.5[3]	6.01	7.34	7.39
Dieldrin	0.04[4]	0.03 J	0.03 J	--

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.
n/a Not Applicable

4.1.4 Artesian Water Company New Castle Llangollen Wellfield (Wells 156408, 35081, 10049, 10050, 10052)

Background

Artesian's Llangollen Wellfield represents a significant portion of the water supplied by the company in New Castle County. Water from these wells is used for much of the unincorporated sections of the county along the U.S. Route 13/ Route 40 corridor. Six active production wells that comprise the Llangollen Wellfield were constructed in the 1970s through the late 1990's. Each well is screened within the sands of the Potomac Aquifer, which is only semi-confined in this area, at depths ranging from 90-200 feet bgs. Four of the wells are located within a Class C Wellhead Protection Area.

Two National Priority List ("NPL") Superfund Sites: Delaware Sand and Gravel (DE-017) and Army Creek Landfill (DE-001), and two State Superfund Sites: Former Amoco Polymer Plant (DE-084) and the Denton Landfill (DE-015) are located within 0.5 miles north and northeast of the Llangollen Wellfield, each with documented ground water contamination by VOCs, SVOCs and metals. At present, a ground water containment system is in operation at the two NPL sites. Expanded environmental investigations are underway at the Former Amoco Polymer Plant and Denton Landfill.

In October 2000, sampling of the Llangollen wells indicated the presence of BCEE at a concentration of up to 1.0 µg/L in the public drinking water supply. At this time there was not an enforceable standard for BCEE. In response, Artesian installed a granular activated carbon treatment system to compliment their existing treatment system that includes disinfection, iron removal, aeration and corrosion control. Historically, BCEE had been detected in monitoring wells at both the Army Creek Landfill and Delaware Sand and Gravel Superfund Sites, which represent the likely sources of the contamination. BCEE is not a regulated chemical under the SDWA, and thus is not normally included in the regular monitoring of public drinking water supplies. Its presence was fortuitously discovered during analysis of water samples collected as part of a bioassay on the effluent of a groundwater treatment system which discharges to Army Creek. Subsequent sampling then confirmed the presence of BCEE in the Llangollen wells. Accordingly, the question arose as to whether other unregulated compounds may be present in public water supplies within the State, particularly those located near hazardous waste or hazardous substance release sites. This study was conducted to answer that question.

Due to the recent contamination of the Llangollen Wellfield, all wells in the wellfield (permit numbers 156408, 35081, 10049, 10050, 10051, 10052) were included in the sampling schedule. However, Well 10051 was inoperable during the sampling event, and no sample was collected.

Results

More than ten VOCs were detected in one or more of the untreated water samples collected from the Llangollen wells, with only two detected in the finished water sample (Table 8). For the untreated water samples, five of the detected VOCs represented THM compounds: chloroform, bromodichloromethane, dibromochloromethane, bromoform, trichlorofluoromethane. Most of the detected concentrations of THMs were below 1.0 µg/L, and none of these compounds, either

individually or cumulatively, exceeded the existing MCL for total THMs of 80 µg/L. The highest detected concentration was bromoform in the untreated water sample from Well 156408 at 7.1 µg/L. The only THM detected in the finished sample was bromoform (0.1 J µg/L).

Carbon tetrachloride, TCE, isomers from both DCE and DCA, and MTBE were all identified in various untreated water samples from the Llangollen wells. Many of the detected compounds were below 1.0 µg/L, and there only one compound exceeded a regulatory standard: the concentration of 1,2-DCA in untreated water from Well 100049 (6.0 µg/L) above its MCL of 5.0 µg/L. 1,2-DCA was also identified in the Llangollen finished water sample, but at a much lower concentration of 0.4 J µg/L. Similar levels of these compounds had been previously detected in untreated Llangollen well samples.

Two SVOCs (BCEE and nitrobenzene) and the herbicide dacthal were detected in the untreated water samples from the Llangollen wells. BCEE was detected in each of the untreated samples ranging in concentrations from 0.0044 µg/L (Well 35081) up to 3.05 µg/L (Well 10052). Well 10049 (0.6 µg/L) also exceeding the proposed DE MCL of 0.096 µg/L for BCEE. The other SVOC (nitrobenzene) was detected in Well 10049 at a concentration of 0.091 J µg/L, below its URS of 0.4 µg/L. Neither BCEE nor nitrobenzene was detected in the Llangollen finished water sample. Please refer to Table 8 for a complete list of detected analytes.

The lawn treatment chemical dacthal was identified in three untreated water samples, at concentrations ranging from 0.17 J µg/L up to 1.1 µg/L, all far below the URS of 37 µg/L. Dacthal was not detected in the finished sample.

Low concentrations of three metals, lead (3.0 µg/L in Well 35081), mercury (up to 0.32 µg/L in Well 10050) and zinc (up to 76.5 µg/L in Well 156408) were detected in the untreated Llangollen water samples, none of which exceeded any regulatory standard. Chromium (24 µg/L) and zinc (114 µg/L) were identified in the Llangollen finished sample, also at concentrations below regulatory thresholds. Comparable concentrations of these same metals were found in other water systems during this study, suggesting that their presence is likely due to leaching from metallic well and pump components.

Levels of sulfate, nitrate, fluoride, chloride and TDS from the Llangollen samples were similar, and within expected ranges. Several pH measurements, specifically for the untreated samples from Wells 10049, 10050 and 10052 were slightly below neutral pH ranges. This may be due to microbial biodegradation of some of the aforementioned VOCs and SVOCs. Acidic pH is characteristic of reductive dehalogenation of chlorinated organic compounds.

Table 8: Artesian Llangollen Wellfield, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 156408 ASR	Well 35081 No.2	Well 10049 No.7	Well 10050 No.G3	Well 10052 K-1	Llangollen-Post treatment
Bromoform	80 for Total THMs[1]	7.1	--	0.2 J	1.7	--	--
Chloroform		0.3 J	0.2 J	0.2 J	--	--	--
Bromodichloromethane		1.1	--	--	0.2 J	--	--
Dibromochloromethane		3.4	--	--	0.6	--	--
Trichlorofluoromethane		--	--	2.4	--	--	--
MTBE	10[2]	--	1.0	0.1 J	--	--	--
Diethyl ether	N/a	--	--	--	0.6 J	--	--
Cis-1,2-DCE	70[1]	--	--	0.2 J	0.1 J	--	--
Carbon Tetrachloride	5[1]	--	--	--	--	0.1 J	--
Chlorobenzene	100[1]	--	--	--	0.4 J	--	--
1,1-DCA	5[1]	--	--	--	0.1 J	--	--
1,2-DCA	5[1]	--	--	6.0	0.4 J	--	0.4 J
TCE	5[1]	--	--	--	1.7	2.4	--
BCEE	0.096[2]	0.0296	0.044	0.6	3.05	0.010	--
Nitrobenzene	0.4[2]	---	--	0.091 J	--	--	--
Chromium	100[1]	--	--	--	--	--	24.0
Lead	15[4]	--	3.0	--	--	--	--
Mercury	2[1]	0.25	--	--	0.312	--	--
Zinc	5,000[3]	76.5	--	--	--	56.0	114
Sulfate	250,000[3]	--	17,800	15,000	--	19,000	--
Nitrate	10,000[1]	2,600	3,900	3,600	1,300	2,000	2,500
Chloride	250,000[3]	82,000	19,500	22,000	57,500	73,500	58,500
Fluoride	2,000[3]	360	--	--	--	--	780
TDS	500,000[3]	202,000	94,000	69,000	129,000	144,000	169,000
pH (units)	6.5-8.5[3]	6.28	6.04	5.76	5.85	5.51	7.12
Dacthal	37[2]	--	0.75	1.1	0.17	--	--

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected

Recommended Future Actions

The existing treatment systems installed by Artesian (aeration, granular activated carbon) is effectively removing the observed organic contaminants to below drinking water standards, as reflected in the near lack of detected contaminants in the Llangollen finished sample. The present monitoring program for Artesian's Llangollen Wellfield, which is required under the Safe Water Drinking Act, will be reviewed, and amended (as necessary) to include all of the detected organic and inorganic contaminants that were detected as part of this study. As part of the ongoing monitoring, samples from both untreated and post-treated water should be collected so as to gauge the ongoing effectiveness of the treatment systems.

Two Federal Superfund Sites and two HSCA sites lie in close proximity to the Llangollen wellfield, and represent the probable source(s) of the ground water contaminants. A pump and treat system which acts to control flow of contaminated ground water from beyond the site boundaries of the Army Creek Landfill and Delaware Sand & Gravel NPL Superfund Sites has been in operation for several years. However, some migration of contaminated ground water may have taken place prior to the construction and operation of the system. Alternatively, the pump and treat system may not be capturing the entire contaminant plume. It is recommended that the capture zone of the existing system be confirmed either through tracer tests, numerical modeling, or other methods. Source identification and delineation of the BCEE plume should also be performed. Upon completion of these activities, further remedial actions may be warranted. If necessary, DNREC and EPA will consider the installation of additional recovery wells that would subsequently be incorporated into the existing system, should any gaps in the system be shown to exist.

4.1.5 Artesian Water Company Airport Industrial Park Wells 52445 and 48941

Background

Artesian operates two supply wells in the Hare's Corner area, in the vicinity of the New Castle County Airport. Each of these wells is screened within the Potomac Aquifer, with intervals of 100-112 (Well 48941) and 104-114 (Well 52445) feet below ground surface (bgs). Water from each of the two wells is combined prior to treatment with aeration, iron removal, disinfection, and corrosion control. The area served by these wells includes areas along the Rt. 13 corridor. During periods of lower demand, Artesian shuts down some of its smaller wells. As a result, water pumped from wellfields south of this location (e.g., Llangollen and Artisan's Village) provides the majority of the area's water.

Results from previous sampling of these wells have detected PCE in Well #2 at 8.17 µg/L, above its MCL of 5 µg/L. TCE and TCA were also detected at concentrations below their respective MCLs. Artesian subsequently installed carbon treatment units. Possible sources for the solvents may be former gas stations and auto repair facilities located nearby, or the airport.

Results

A similar suite of organic compounds was detected in Artesian's Airport Industrial Park wells as had been identified in other water systems in New Castle County. One significant difference however, was the detection of only one (versus several) THM compound, bromoform, in the untreated water from the Airport Industrial Park wells. The observed concentration of 0.8 µg/L was the same in both untreated well samples. Both bromoform (0.5 J µg/L) and dibromochloromethane (0.2 J µg/L) were detected in the finished sample (Table 9).

Low concentrations of several organic solvents were also detected in one or both of the Airport Industrial Park wells, including PCE, TCE, TCA, several DCE and DCA isomers, and 1,2-DCP. Please refer to Table 8 for a complete list of detected analytes. Of these compounds, most were detected at concentrations below 1.0 µg/L, with only PCE in the untreated sample from Well 48941 exceeding a drinking water standard. PCE was detected in this well at 10 µg/L, a concentration that is twice its MCL of 5 µg/L. Except PCE and 1,1-DCE, these same compounds were also detected in the finished, treated sample, but at generally lower concentrations. An exception to this trend was 1,1,1-TCA, whose concentration was slightly higher in the finished sample than in either untreated water sample (1.2 µg/L vs. 0.7 and 0.8 µg/L). The presence of so many of these compounds in the finished sample, albeit at generally lower concentrations, indicates breakthrough of the treatment system. The exact source of the chlorinated solvents is unknown. However, similar compounds have been identified in monitoring wells at nearby automotive dealerships, suggesting that one or more of these types of establishments may represent a historic, or continuing source of the chlorinated compounds.

Low concentrations of MTBE were detected in both the untreated samples (up to 1.1 µg/L in Well 52445) and the finished sample (0.6 µg/L). Potential sources include several former and existing gas stations, at least two automotive repair facilities, and numerous other petroleum storage tanks located within ¼ mile of Artesian's Airport Industrial Park wells.

Two SVOCs were detected in the untreated water samples from the Airport Industrial Park wells. Nitrobenzene was detected in Well 52445 at a concentration of 0.1 J µg/L, below its URS of 0.4 µg/L. It was not detected in the finished sample. A potential source of nitrobenzene is unknown, but may be associated with nearby automotive dealerships. A second SVOC, the plasticizer bis(2-ethylhexyl)phthalate (DEHP) was detected in the untreated water sample from Well 48941 at a concentration of 330 µg/L, in excess of its MCL of 6 µg/L. It was not detected in either Well 52445 or the finished sample. DEHP is a hydrophobic compound with low solubility, and is contained in much of the plastic tubing utilized in an analytical laboratory, as well as in rubber gloves. As such, it is a frequent laboratory cross-contaminant, although not normally at such a high concentration. The well will be resampled by DPH to confirm the presence of DEHP.

No pesticides were detected in the Airport Industrial Park wells. Zinc was the only metal detected in the untreated water samples, in Well 52445 at 68.7 µg/L, below its SMCL of 5,000 µg/L. Zinc was detected at a similar concentration (70.1 µg/L) in the finished sample. Copper was also identified in the finished sample at 121 µg/L. The presence of zinc and copper at low concentrations may either be naturally occurring, or as a result of leaching of metallic well and pump components.

Sulfate, nitrate, and chloride were detected in all samples at concentrations below their drinking water standards and similar to results from other New Castle County well samples. Fluoride was not detected. The values for pH were all within the neutral range. TDS results were all below the SMCL of 500,000 µg/L, with the highest result of 242,000 µg/L detected in the finished water sample, a level which is 2.5 and 7 times those from the untreated samples. This disparity suggests that the elevated TDS in the finished sample is an artifact from the treatment process.

Table 9: Artesian Water Company Airport Industrial Park Wells, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 52445	Well 48941	52445, 48941-Post
Bromoform	80 for total THMs[1]	0.8	0.8	0.2 J
Dibromochloromethane		--	--	0.2 J
MTBE	10[2]	1.1	0.5	0.6
Cis-1,2-DCE	70[1]	0.2 J	1.1	0.8
1,1-DCE	7[1]	0.5	0.5	--
1,1-DCA	5[1]	0.2 J	0.3 J	0.3 J
PCE	5[1]	4.4	10	--
TCE	5[1]	0.5 J	3.2	0.1 J
1,1,1-TCA	100[1]	0.8	0.7	1.2
1,2-DCP	5[1]	--	0.2 J	0.2 J
Nitrobenzene	0.4[2]	0.1 J	--	--
DEHP	6[1]	--	330	--
Copper	1,300[3]	--	--	121
Zinc	5,000[3]	68.7	--	70.1
Sulfate	250,000[3]	10,600	13,800	12,200
Nitrate	10,000[1]	2,600	2,500	2,600
Chloride	250,000[3]	19,000	30,500	25,000
Fluoride	2,000[3]	--	--	--
TDS	500,000[3]	35,000	95,000	242,000
pH (units)	6.5-8.5[3]	6.19	6.24	7.75

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Actions

Both of the untreated wells and the finished sample should be resampled in order to confirm the presence of the VOCs, nitrobenzene and DEHP. The existing monitoring program for Artesian's Airport Industrial Park wells, which is required under the Safe Drinking Water Act, should be reviewed, and if necessary amended to include all of the detected organic contaminants that were detected as part of this study. As part of the ongoing monitoring, samples from both untreated and post-treated water should be collected so as to gauge the ongoing effectiveness of the treatment systems, particularly in light of the apparent breakthrough of the aeration treatment system.

DNREC-SIRB and DNREC-UST will commence investigations into the occurrence of organic solvents and MTBE, focusing on the existing and former gas station facilities located at, or near, the intersection of Delaware Rt. 273 and U.S. Rt. 13 in order to better understand the source(s), concentrations and volume of contaminants flowing into the system. Based upon the results of these investigations, DNREC will assess possible remedial alternatives to address contaminated ground water prior to its flow into the capture zone of Artesian's wells.

4.1.6 Mt. Pleasant Mobile Home Park Well 41457

Background

The Mt. Pleasant Mobile Home Park operates three public supply wells (permit numbers 177737, 41457, and 10752) to supply drinking water to the residents of the park.

In August 2000, DNREC ordered an older well, Mt. Pleasant Well 48830, to be abandoned as a condition of the approved operation of an on-site wastewater treatment permit. Another condition of the wastewater permit was the replacement of Well 41457 with a deeper, confined well 177737. Both Wells 48830 and 41457 are screened within the surficial Columbia Aquifer at an interval of 46-50 feet and 40-44 feet bgs, respectively. Well 10752 is an older well of stainless steel construction. Its termination depth and screening interval are unknown. The newest well, Well 177737, is a confined well, screened from a depth of 222' to 242' bgs, with a terminal depth of 260 feet. Based upon the depth, it is likely that this well is screened within the upper Potomac aquifer. Only Well 41457 was sampled as part of this study.

DNREC's Emergency Response Branch was called to a fuel oil spill from an aboveground storage tank at this location in February 2000. The spill was located approximately 20-30 feet from Well 41457, and leaked 200-250 gallons of fuel oil. Contaminated soil was excavated and removed from the site, and no petroleum has been detected in the well to-date.

Two State Superfund sites are located within less than 0.2 mile from the wells: Sealand Ltd. (DE-092) and Mt. Pleasant Railroad Dump (DE-079). Both sites were used historically for landfilling operations of mostly construction materials and railroad waste. A ground water plume of nickel, flowing at a lateral gradient from the well, has been documented from the Sealand Site. No environmental sampling has been conducted at the Mt. Pleasant Railroad Dump to date.

Results

Two organic compounds were detected in the water sample from the shallow Well 41457 at the Mt. Pleasant Mobile Home Park, carbon tetrachloride and MTBE (Table 10). The concentration of carbon tetrachloride (0.4 µg/L) was well below its MCL of 5 µg/L. The source of this compound is unknown, as there are no known industrial sources of this solvent in the vicinity of the Mobile Home park. As such, its presence in ground water may be due to discharge of cleaning fluids into a nearby septic system.

The detected concentration of MTBE (12 µg/L) exceeded its Delaware MCL of 10 µg/L in the Mt. Pleasant well sample. The fuel oil spill may represent the most likely source. However,

high concentrations of MTBE in shallow ground water have also been confirmed in wells screened within the tank pit at a nearby gas station located across Rt. 896/301.

No SVOCs or pesticides were detected in Well 41457. Metals detected included barium (289 µg/L), nickel (57.5 µg/L) and zinc (51.8 µg/L), each at concentrations well below their respective drinking water standards (please refer to Table 10 for a complete list of detected analytes). Similar concentrations of barium have been detected in most Columbia Aquifer wells sampled as part of this study suggesting that the observed concentrations of barium represent naturally occurring background levels. The presence of low levels of nickel and zinc are likely due to leaching of these metals from the stainless steel well and well pump by the acidic (pH= 5.96 ground water).

Concentrations of sulfate and nitrate were below their drinking water standards and comparable to values observed elsewhere. Fluoride was detected at a low concentration of 130 µg/L. The value for pH was slightly acidic (5.96) and lower than the SMCL range for pH of 6.5-8.5. Elevated chloride and TDS were detected in the Mt. Pleasant well. While the observed chloride value of 111,000 µg/L is less than half its SMCL of 250,000 µg/L, this concentration is still much higher than expected, and notably higher than most other chloride measurements in this study. The TDS value of 478,000 µg/L nearly exceeds its SMCL of 500,000 µg/L. The cause behind these elevated values is unknown.

Table 30: Mt. Pleasant Mobile Home Park Well, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 41457
MTBE	12[2]	12
Carbon Tetrachloride	5[1]	0.4 J
Barium	2000[1]	289
Nickel	100[2]	57.5
Zinc	5,000[3]	51.8
Sulfate	250,000[3]	23,300
Nitrate	10,000[1]	6,400
Chloride	250,000[3]	111,000
Fluoride	2,000[3]	130
TDS	500,000[3]	478,000
pH (units)	6.5-8.5[3]	5.96

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Actions

It has been previously recommended by DNREC that Well 41457 be abandoned and replaced by a deeper, confined well. However, while the deeper Well 177737 has already been installed, Well 41457 has yet to be abandoned. It is therefore recommended that well 41457 be abandoned immediately, with the new confined well providing the water to the Mobile Home park. Water sampling should be conducted for both the new Well 177737 as well as on the older Well 10752, and the latter's configuration (depth, screen interval, etc.) confirmed. Analyses should include

any compounds or analytes detected as part of this investigation. A private well survey should also be conducted so as to identify all possible potable wells in the vicinity that may be impacted by the petroleum release.

DNREC-UST has been forwarded the analytical results from this study, and has subsequently contacted the owner of the nearby gas station. Tank tightness tests and inventory audits are presently being conducted. Shallow wells located within the tank pits have been sampled and indicate the presence of elevated concentrations of MTBE. As a result, DNREC-UST has recommended that the owner perform a hydrogeologic investigation in order to define the extent of ground water contamination and prevent further degradation of the shallow Columbia aquifer in this area.

4.2 Kent County

4.2.1. Town of Smyrna Supply Well #1 (10068), Well #1A (94795), and Well #2A (86549)

Background

The Town of Smyrna operates three supply wells which were included in the sampling schedule due to the prior detection of VOCs and their proximity to the Tyler Refrigeration National Priority List Superfund Site (DE-043): the Town of Smyrna public supply Well #1 (permit number 10068), Well #1A (94795), and Well #2A (85649). Each of these wells are screened within the unconfined, surficial Columbia Aquifer and the subcropping sands of the Calvert Formation, at depths of 80-95 feet bgs, 75-95 feet bgs, and 62-92 feet bgs, respectively.

Historical sampling of these wells has detected TCE and 1,1,1-TCA, resulting in the installation of an air stripper treatment system. The source of the TCE is the former Tyler Refrigeration Pit (presently Metal Masters) Site. Solvents disposed at the facility leaked into the shallow aquifer, creating a localized solvent ground water plume. Ground water remedial measures at the site include installation of the aforementioned point-of-use treatment systems on the town's wells, and the establishment of a GMZ around the plant that would prevent installation of ground water wells in the contaminated zone. Well 10069 has historically exceeded the MCL for TCE of 5 µg/L. As a result, carbon treatment was installed on this well and operated from 1985-89. It has recently been abandoned and replaced by Well 86549. Recent sampling of Well 86549 detected 0.72 µg/L of TCE. MTBE has also been identified in Well 10068 (6.85 µg/L) and Well 86549 (0.49 µg/L), although the source of this compound is yet unknown.

Results

Nine VOCs were detected in the Town of Smyrna wells, including four THMs, MTBE and four chlorinated ethenes/ethanes (Table 11). Trace levels of chloroform, bromodichloromethane, dibromochloromethane and bromoform, all below 1 µg/L, were detected in each of the three untreated well samples in addition to the two finished samples. Observed concentrations, both individually and cumulatively, did not exceed the 80 µg/L MCL for THMs.

MTBE was also detected in each of the five Smyrna samples, at concentrations ranging from 0.2 J µg/L (Well 85649) up to 9.5 µg/L (Well 94795) in the untreated well samples, diminishing to 0.2 J and 0.5 J µg/L in the finished samples. The result from untreated water from Well 94795 is approaching the proposed DE MCL of 10 µg/L, but appears to be either diluted and/or removed through treatment prior to distribution.

Four chlorinated VOCs were also detected in the untreated Smyrna water samples. This was to be expected due to the sampling history of the Smyrna wellfield and its proximity to the Metal Master's Superfund Site. Individual compounds detected in the untreated samples included TCE (up to 1.5 µg/L), 1,1-DCE (0.8 J µg/L), 1,1-DCA (0.3 J µg/L), and 1,1,1-TCA (3.2 µg/L), each at a concentration below its respective MCL. Only TCE at 0.3 J µg/L was detected in one finished sample (the MCL for TCE is 5 µg/L). These concentrations are significantly lower than previous

sampling results, which frequently exceeded the MCL for one or more of these chlorinated compounds.

No SVOCs were detected in any of the Smyrna samples. Two pesticides/herbicides, dacthal and dieldrin, were detected in both the untreated well samples and the finished samples. Dacthal was detected in Well 10068 at 0.26 µg/L, and in Well 85649 at 0.24 µg/L. It was also detected in both finished samples, but at lower concentrations, 0.05 J µg/L and 0.06 J µg/L, suggesting that either dilution or carbon treatment, or a combination of both, were successful in lowering the levels of dacthal in the water that is distributed to the system. Dieldrin was detected in both the raw and finished samples from Well 85649 at the same concentration (0.03 J µg/L), and in the raw sample from Well 94795 (0.04 µg/L). It was not detected in the finished sample for Well 94795. The RBC for dieldrin is 0.04 µg/L. Similar to the situation in the City of Newark South Wellfield, the occurrence of dieldrin, normally a relatively insoluble compound in water, may be associated with the presence of chlorinated VOCs in ground water, which acted as a solute in mobilizing the dieldrin.

Zinc was detected in two wells, with a maximum concentration of 35.6 µg/L in Well 94795, well below its SMCL of 3,000 µg/L. Its presence in such low concentrations may represent, as in other instances, leaching from the metallic components of well and pump construction. Lead was detected on one untreated well sample at a concentration in excess of its action level (15.5 µg/L in Well 85649). It was not, however, detected in the finished sample. It was not detected in any other Town of Smyrna well sample, or the sample from Bulldozer's Saloon. Lead is not normally found at such a concentration in ground water from the Columbia Aquifer. This may suggest that it too may be related to well construction (e.g., lead solder).

Chloride, fluoride, sulfate and TDS levels were within expected ranges. Measured pH values were slightly acidic (5.26 up to 6.00). Nitrate concentrations were very uniform (4.2 up to 4.8 mg/L).

Table 11: Town of Smyrna Wells, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 10068 No.1	Well 94795 No.1A	Well 85649 No.2A	10068, 94795-Post	85649-Post
Bromoform	80 for total THMs[1]	--	--	--	--	0.2 J
Chloroform		--	0.2 J	0.1 J	0.2 J	0.1 J
Dibromochloromethane		--	--	--	0.5 J	--
Bromodichloromethane		--	--	--	0.3 J	0.2 J
MTBE	10[2]	1.2	9.5	0.3 J	0.5 J	0.2 J
1,1-DCE	7[1]	--	0.8	--	--	--
1,1-DCA	5[1]	--	0.3 J	--	--	--
TCE	5[1]	--	1.5	0.9	--	0.3 J
1,1,1-TCA	100[1]	--	3.2 J	--	--	--
Lead	15[4]	--	--	15.5	--	--
Zinc	5,000[3]	--	35.6	30.2	--	--
Sulfate	250,000[3]	21,800	23,000	15,400	19,800	17,800
Nitrate	10,000[1]	4,400	4,800	4,200	4,200	4,300
Chloride	250,000[3]	17,000	19,400	14,600	18,900	14,600
TDS	500,000[3]	92,000	109,000	94,000	105,000	98,000
pH (units)	6.5-8.5[3]	5.26	5.86	6.00	N/a	7.16
Dieldrin	0.04[4]		0.04	0.03 J		0.03 J
Dacthal	37[2]	0.26		0.24	0.06 J	0.05 J

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.
N/a Analyte not analyzed.

Recommended Future Actions

The presence of the chlorinated solvents (ethenes, ethanes) were expected based upon the history of the Metal Master's Superfund Site and sampling history of the Town of Smyrna wells in this area. The soil source of the solvents at the Metal Master's Site has been addressed under the EPA Superfund Program, and an ongoing monitoring program is already in place for ground water at the Site. It is recommended that the ground water monitoring continue, and that the Town of Smyrna conduct testing of their water supply on an annual basis (at a minimum) in order to confirm the effectiveness of the existing carbon treatment.

The existing carbon treatment system is effective in reducing the dieldrin and MTBE in the Smyrna wells. The results from the sampling at the Town of Smyrna have since been forwarded to DNREC-UST, who is conducting a search into the locations of the nearest existing and former USTs in order to determine the source of the MTBE.

It is also recommended that each of the Town of Smyrna wells be tested for lead in order to confirm that the presence of lead is restricted to the one well. If this is confirmed, the town will need to include lead in any future monitoring and possibly consider installing pH adjustment if the problem persists.

4.2.2 Bulldozers Saloon Well (10999)

Background

The well that supplies Bulldozers Saloon (formerly the Glenwood Inn) is a transient, non-community public well, meaning a limited public population is served. However the well was in-place prior to the investigative and remedial activities at the Metal Masters Site (see above discussion concerning the Town of Smyrna wells), and is located within the GMZ associated with the Superfund Site. It was included in the sampling schedule due to its location within the GMZ and lack of information about the well.

Results

Three VOCs, two of which represent THMs, were the only organic compounds detected in the water sample from Bulldozer's Saloon (Well 10999). Please refer to Table 12 for a complete list of detected analytes. Observed concentrations of the two THMs, dibromochloromethane (0.2 µg/L) and bromoform (0.7 µg/L), were far below the MCL for total THMs of 80 µg/L. MTBE was also detected in the Bulldozer's sample, at a concentration of 16 µg/L, in excess of the 10 µg/L MCL. The presence of MTBE is indicative of a petroleum release, although no other petroleum or gasoline compounds were detected in the water sample. Possible sources of the MTBE include several large, former fuel oil tanks at the Metal Master's Site located across the road from Bulldozer's (residual MTBE can be found in fuel oil due to cross-contamination with gasoline during refining and transport), two nearby convenience stores which have or had gasoline USTs on their premises, or perhaps small leaks from cars parked in the Bulldozer's gravel parking lot. The MTBE in the Bulldozer's well is likely from the same ground water plume as the MTBE detected in the Town of Smyrna's wells (see previous section), and thus the same potential sources are suspected.

Metals detected in the Bulldozer's water sample include barium (232 µg/L), copper (309 µg/L), lead (3.8 µg/L) and zinc (29.1 µg/L). The barium is likely naturally occurring, with results similar to other wells screened within the Columbia. The presence of the copper, lead and zinc are likely due to leaching of metals from the well construction, associated piping and well pump by the relatively acidic (pH=5.32) ground water. None of the observed concentrations of metals exceeded any regulatory threshold or drinking water standard.

Nitrate levels (8.2 mg/L), while high, did not exceed its 10.0 mg/L MCL. Sulfate, chloride, fluoride and TDS results were within expected ranges. However, as stated previously, pH results were slightly acidic compared to a neutral pH range of 6.5-7.5.

Table 12: Bulldozer's Saloon, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 10999	Well 10999-duplicate
Bromoform	80 for total THMs[1]	0.7 J	--
Dibromochloromethane		0.2 J	--
MTBE	10[2]	16	15
Barium	2000[1]	232	234
Copper	1,300[3]	309	361
Lead	15[4]	3.8	4.3
Zinc	5,000[3]	29.1	37.4
Sulfate	250,000[3]	21,000	21,000
Nitrate	10,000[1]	8,200	8,200
TKN	N/A	--	300
Chloride	250,000[3]	13,100	12,100
TDS	500,000[3]	104,000	102,000
pH (units)	6.5-8.5[3]	5.32	5.35

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommendations

It is recommended that Bulldozer's Saloon connect to the Town of Smyrna water system due to the proximity of the town's waterline and existing treatment system, and the lack of any knowledge concerning the location, disposition and integrity of the well at the saloon. Smyrna's waterline runs underneath Route 6 in front of the property, making connection a relatively inexpensive, and simple, option. A proximal area well search will also be conducted in order to identify any other residential or commercial/industrial wells that may be impacted by MTBE.

4.3 Sussex County

4.3.1 Town of Greenwood Well #1 (34366), Well #3 (72714), and Well #4 (111078)

Background

The Town of Greenwood operates three public supply wells, all of which are screened within the surficial, semi-confined Columbia Group sands: permit numbers 111078, 72714 and 34366. Well #1 (34366) is screened at 100-120 feet bgs, with Well #3 (72714) screened from 80-100 feet bgs and Well #4 (111078) screened from 41-61 feet bgs. Sampling by DPH in the 1980's identified TCE, PCE, 1,1,1-TCA and chloroform at concentrations below MCLs. The likely source of some of these compounds, the Penn Fibre manufacturing facility, is located only a couple of hundred feet from the supply wells.

Results

Six VOCs, including four THMs, were detected in the Town of Greenwood water samples. Concentrations of each of the four THMs (chloroform, bromodichloromethane, dibromochloromethane and bromoform) were all below 1 µg/L in both the untreated and finished samples, and no regulatory standards were exceeded, either individually or cumulatively. Please refer to Table 13 for a complete list of detected analytes.

PCE was detected in all three untreated samples at the same concentration of 0.6 J µg/L, and in the finished sample for Well 72714 at 0.7 µg/L. No finished sample points were available for sample collection at Wells 111078 and 34366. The source of the PCE is likely the Penn-Fibre facility.

MTBE was also detected in all four samples (three untreated plus the finished sample for Well 72714), at a uniform concentration of 0.3 µg/L in each of the untreated well samples, and 0.4 µg/L in the 72714-Post treatment sample. The source of the MTBE is unknown.

Two SVOCs were identified in the untreated well samples. BCEE was detected in Well 34366 at a concentration of 0.019 µg/L, and 4-chloroaniline was identified in the untreated water sample from Well 72714. It was not detected in the finished sample for 72714. The observed concentrations for neither BCEE nor 4-chloroaniline were above their drinking water standards of 0.096 µg/L (MCL for BCEE) or 15 µg/L (RBC for 4-chloroaniline).

The most common use of BCEE is in chemical manufacturing. However, there is an alternate use as an insecticide/fungicide. Similarly, 4-chloroaniline is used as an intermediate in the manufacture of dyes, pigments, agricultural chemicals and pharmaceuticals, but is also a persistent environmental degradation product of some herbicides and fungicides. The presence of both of these compounds may be due to either their use in agricultural applications or from activities at the Penn-Fibre facility. No listed pesticides were detected as part of the pesticide analyses in any of the Greenwood samples.

Barium was detected in raw water from the Greenwood wells at concentrations similar to other well systems screened within the unconfined Columbia Aquifer, ranging from 220 µg/L up to

273 µg/L. In the finished sample for Well 72714, it was observed at the similar concentration of 264 µg/L. Low levels of copper (28.8 µg/L) and zinc (31.9 µg/L) were detected in the untreated sample from Well 72714. Lead was also detected in this sample at a concentration (21.4 µg/L) in excess of its 15 µg/L action level, but it was not detected in the finished sample from this well. The presence of all three metals may be indicative of the leaching from metallic components from well, piping, or pump construction. The observed concentration of lead deserves further investigation.

Zinc was detected at an elevated concentration of 3,960 µg/L in the untreated water sample from Well 34366, but was still below its SMCL of 5,000 µg/L. Its presence is very likely due to the fact that a new spigot had just recently been installed into the stainless steel piping of the well in the days prior to sampling.

Neither sulfates nor fluoride were identified in any of the Greenwood samples. Levels of chloride and TDS were within expected ranges, while pH values (7.84 to 7.9) are considered on the higher-end of neutral. Nitrate values were generally higher than those found in other areas, ranging from 7.9 (Well 34366) up to 8.6 in the finished sample for Well 72714. These results were anticipated due to the agricultural nature of the Greenwood area.

Table 13: Town of Greenwood Wells, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 111078 No.4	Well 34366 No.1	Well 72714 No.3	72714-Post
Bromoform	80 for Total THMs[1]	--	0.7	--	0.5 J
Chloroform		0.2 J	0.3 J	--	0.1 J
Bromodichloromethane		0.3 J	0.4 J	--	0.4 J
Dibromochloromethane		0.8 J	0.6	0.2 J	--
MTBE	10[2]	0.3 J	0.3 J	0.3 J	0.4 J
PCE	5[1]	0.6	0.6	0.6	0.7
BCEE	0.096[2]	--	0.019	--	--
4-Chloroaniline	0.4[2]	--	--	0.3 J	--
Barium	2,000[1]	262	273	220	264
Copper	1,300[3]	--	--	28.8	--
Lead	15[4]	--	6.5	21.4	--
Zinc	5,000[3]	--	31.90	3,960	--
Nitrate	10,000[1]	8,300	7,900	8,500	8,600
Chloride	250,000[3]	23,000	23,000	27,500	21,000
TDS	500,000[3]	188,000	112,000	188,000	16,000
pH (units)	6.5-8.5[3]	7.90	7.87	7.85	7.84

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Actions

While no detected compounds or analytes exceeded any drinking water standards, the source of the organic constituents (MTBE, PCE, BCEE, and 4-chloroaniline) and lead remain unknown. Retesting of the Greenwood wells with follow-up investigations into the possible source(s) of these contaminants will be conducted. Should the presence of the organic contaminants be confirmed, the existing monitoring program for Greenwood, which is required under the Safe Drinking Water Act, should be amended (if necessary) to include any compounds detected in this study that are not currently monitored for. A proximal well search will also be conducted in the central Greenwood area in order to identify other wells that may be impacted.

4.3.2 Town of Georgetown Wells 62576 and 10325

Background

The Town of Georgetown operates six public supply wells, two in the west wellfield: Well #3A (91619) and Well #3 (91620), three in the east wellfield: Well #1A (91618), Well #1 (10325) and Well #2R (permit number 62576), and one at the Sussex Correctional Institute: SCI-1 (107829). Wells #3A and #1A are screened at a depth exceeding 300 feet bgs within the confined Manokin aquifer, and are not considered vulnerable. Both Well #1 (unknown to 120 feet bgs) and Well #2R (105-125) are screened in the unconfined aquifer, which is a combination of the surficial Beaverdam and the Manokin Aquifers. Water from both wells is combined prior to treatment (aeration, corrosion control, fluoridation and disinfection).

Located less than ¼ mile west of the town's wells are two state Superfund sites, the Georgetown Cleaners Site (DE-113) and the Georgetown Coal Gas (DE-188) site. The Georgetown Cleaners Site is a dry cleaning facility where investigations have detected PCE and other chloroethene compounds in both the soil and ground water at the site. Two blocks away from the cleaners' site is the Georgetown Coal Gas site, at which was located a former coal gasification plant. Elevated concentrations of VOCs, SVOCs (especially polynuclear aromatic hydrocarbons, or PAHs) and PCBs were detected in onsite soils and VOCs and SVOCs in ground water.

Results

Ten VOCs were detected in the three Georgetown water samples (2 well samples and one post-treatment sample), including THMs, chlorinated ethenes/ethanes, and MTBE. Low levels of the THMs dibromochloromethane, bromoform, dichlorofluoromethane, chloroform and bromodichloromethane were detected in both untreated samples and the finished sample, with the highest concentration (2.1 µg/L of dichlorofluoromethane) in the untreated Well 10325 sample. No drinking water standards were exceeded, either individually, or cumulatively, for THMs. Please refer to Table 14 for a complete list of detected analytes.

The chlorinated solvents TCE (0.3 J µg/L), PCE (2.1 J µg/L) and 1,2-DCA (0.1 J µg/L) were identified in the untreated water sample from Well 62576, with lower concentrations of TCE and PCE in Well 10325. The MCL for each compound is 5 µg/L. No chlorinated solvents were detected in the finished sample, indicating that the existing treatment is successful in removing these compounds. The Georgetown Cleaners HSCA Site is the likely source of these chlorinated solvents.

Trace concentrations of both benzene (0.3 J µg/L) and MTBE (0.5 J µg/L) were identified in the untreated water sample from Well 62576, with a similar level of MTBE (0.3 J µg/L) in the finished sample. Potential sources for the benzene include the nearby Georgetown Coal Gas HSCA Site and several known LUST facilities.

No SVOCs were detected in any of the Georgetown well samples. Trace concentrations of the herbicide dacthal were found in both the untreated water sample from Well 10325 (0.37 µg/L) and the finished sample for both wells (0.33 µg/L), but both concentrations are below the URS of 37 µg/L. As noted previously, dacthal is a common herbicide that is currently used in lawn treatment services.

Copper (142 µg/L), lead (11.2 µg/L) and zinc (156 µg/L) were detected in the untreated water from Well 10325, but not in Well 62576 nor the finished sample. The presence of these metals at the observed concentrations are likely from metallic components of well construction and piping. As the observed lead concentration approaches its action level of 15 µg/L, confirmatory sampling should be conducted.

Results from the wet chemistry analyses for sulfate, chloride and TDS were within expected ranges. No drinking water standards were exceeded. Nitrate results were comparably low for an agricultural area (2.2 up to 3.4 µg/L), and are likely reflective of the depth of the wells located at the base of the unconfined aquifer. Levels of fluoride in the finished water sample (1,700 µg/L) were approaching the MCL of 2,000 µg/L. As a result, Georgetown should carefully monitor their fluoridation process. Similarly, excess buffering of the slightly acidic groundwater (untreated water samples yielded pH values of 5.65 and 5.71) produced a slightly alkaline measurement of 8.95. The SMCL range for drinking water pH is 6.5 to 8.5.

Recommended Future Actions

DPH will retest Well 10325 to confirm the concentration of lead detected during this study. The existing monitoring program for Georgetown, which is required under the SDWA, will be amended to include all of the detected organic and inorganic contaminants that were noted as part of this study.

The probable source of the organic solvents, the Georgetown Cleaners Site, is presently undergoing investigation and remediation under the purview of HSCA. A number of possible sources of both benzene and MTBE exist, including the Georgetown Coal Gas HSCA Site (benzene only) and numerous gas stations. Results from sampling have been forwarded to DNREC-UST, who is overseeing the investigation and remediation of at least one LUST site in close proximity to the Georgetown wells.

The Town of Georgetown should also carefully monitor their fluoridation and pH buffering activities, and adjust them as necessary.

Table 44: Town of Georgetown Wells, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 62576 No.2R	Well 10325 No.1	62576, 10325-Post
Bromoform	80 for Total THMs[1]	0.8 J	--	1.2
Chloroform		0.1 J	--	1.0
Bromodichloromethane		--	--	1.3
Dibromochloromethane		0.2 J	--	1.8
Dichlorofluoromethane		--	2.1	--
MTBE	10[2]	0.5 J	--	0.3 J
PCE	5[1]	2.1 J	1.4	--
TCE	5[1]	0.3 J	0.2 J	--
Benzene	5[1]	0.3 J	--	--
1,2-DCA	5[1]	0.1 J	--	--
Copper	1,300[3]	--	142	--
Lead	15[4]	--	11.2	--
Zinc	5,000[3]	--	156	--
Sulfate	250,000[3]	26,500	43,400	23,300
Nitrate	10,000[1]	2,200	2,800	3,400
TKN	N/A	--	580	--
Fluoride	2,000[1]	--	--	1,700
Chloride	250,000[3]	19,500	48,500	17,500
TDS	500,000[3]	158,000	230,000	--
pH (units)	6.5-8.5[3]	5.65	5.71	8.95

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

4.3.3 City of Seaford Well #1A (Arbutus Avenue Well 56265), Well #3 (Nylon Avenue Well 10323), and the Dulaney Street Well (74465)

Background

Five supply wells are operated by the City of Seaford, three of which are located in the highly-developed business and residential districts, and two are located near the Public Works facility along the city's northern boundary. Several of the wells located within the center of Seaford have had a history of contamination by VOCs from nearby leaking underground storage tanks and industrial facilities. This contamination resulted in the closing the Hall Street Well in 1994. Two additional wells, located at the Public Works facility, were installed in the mid-1990's to replace the Hall Street well. Water from these new wells has, on occasion, contained elevated levels of nitrates.

The Seaford Arbutus Well (56265) has been in operation since the mid 1960's and was relocated to the present location in the mid 1980's (the old location was inside of a building). The well is located in central Seaford, ½ mile north of Rt. 20, and is screened at an interval of 74-114 feet bgs within the lower Beaverdam Fm. In the early 1980's an industrial park was developed

immediately north of the well. Following a series of odor complaints from residents, DPH tested the water from the well for VOCs. PCE was detected in excess of its MCL in the drinking water of several homes. An investigation by DNREC identified the source of the PCE as the Southern Metals facility, and in 1993, a granular activated-carbon treatment system was installed at the Arbutus Well. This well and treatment system are still in operation, and provides a significant portion of the Town of Seaford's water supply. Additional treatment includes disinfection and corrosion control.

The Nylon Avenue Well (10323) is located in central Seaford, approximately ¼ mile south of Rt. 20. It is also screened in the lower Beaverdam Fm., at a similar interval as the Arbutus well, 80-104 feet bgs. Unlike the Hall Street and Arbutus wells, no significant contamination has been documented at the Nylon Avenue Well. Online treatment systems include disinfection and corrosion control.

The Dulaney Street Well (74465) is the fourth well installed within the city boundaries, and is located within close proximity of Rt. 20. The screening interval (63-103 feet bgs) within the lower Beaverdam Fm. is similar to the other Seaford wells. Online treatment systems include disinfection and corrosion control. All three wells were included in the sample schedule for this project due to their documented contamination and vulnerable location in a developed portion of Seaford.

Results

Nylon Avenue Well

The untreated water sample from the Nylon Avenue well contained PCE at a concentration of 0.2 J µg/L. This level is far below the MCL for PCE of 5 µg/L. There are no known sources of chlorinated solvents in the immediate vicinity of the Nylon Avenue well. However, very high permeability and transmissivity values, particularly in the lower Beaverdam Fm in which the well is screened, make it possible that the source of PCE may be distant from the well. No other VOCs were detected in the untreated sample. The finished sample contained the same concentration of PCE, as well as four THMs, chloroform, bromodichloromethane, dibromochloromethane, and bromoform, each at a concentration below 1.0 µg/L. Please refer to Table 15 for a complete list of detected analytes.

No SVOCs or pesticides were detected in the Nylon Avenue well samples. Metal analytes detected in the samples include lead in the untreated sample at a concentration of 68.9 µg/L (action level of 15 µg/L) and chromium in the finished sample at 20.4 J µg/L (MCL of 100 µg/L). The presence of chromium in the finished sample suggests that the source(s) are the metallic components of treatment system. The observed concentration of lead is very high, and in excess of the EPA Action Level for lead of 15 µg/L. Lead was not, however, detected in the finished sample. The Nylon Avenue well is a backup well for the city. As such, it is not used very often. The occurrence of lead may be due to oxidation/corrosion of some well components, which can release lead as a slug with the episodic usage of the wellhead. Confirmatory sampling needs to be conducted over an extended time period to confirm this hypothesis.

Nitrate levels were slightly elevated (6.8 mg/L) in both the untreated and treated samples, but were still below the 10 mg/L MCL. Chloride and TDS results were within expected ranges.

Neither sulfates, nor fluoride were detected in either sample. The pH measurement was a slightly acidic at 5.76, which was buffered to 7.59 in the finished sample.

Dulaney Street Well

MTBE was the only VOC detected in the Dulaney Street Well samples. It was detected at a concentration of 0.2 J µg/L in both the untreated and treated samples, well below the 10 µg/L DE MCL. Potential sources include a number of nearby gas stations. No SVOCs were detected in the Dulaney Street Well samples. Please refer to Table 15 for a complete list of detected analytes.

The herbicide alachlor was identified in the untreated water sample, its duplicate, as well as the finished sample. Concentrations ranged from 0.32 and 0.33 µg/L in the untreated duplicate samples to 0.35 µg/L in the finished sample. All detected compounds were below the MCL for alachlor of 2 µg/L. Alachlor is used as an herbicide on corn, sorghum and soybeans, all of which are grown in large quantities in Sussex County. The occurrence of alachlor is likely related to agricultural use of the product.

Two metals, barium and zinc, were detected in the samples from the Dulaney Street Well. Observed barium concentrations (215 and 223 µg/L in the untreated samples and 221 µg/L in the finished sample) are consistent with naturally-occurring concentrations of barium in the unconfined aquifer in the Delmarva area based upon the results from numerous ground water investigations by DNREC-SIRB. Zinc was detected only in the untreated sample at 61.7 µg/L. A duplicate of this sample yielded 64.8 µg/L. Both concentrations are well below the SMCL for zinc of 5,000 µg/L.

Nitrate levels from the Dulaney Street Well samples were slightly elevated and comparable to those from the Nylon Avenue Well (6.9 and 7.0 mg/L in the duplicate untreated samples). Sulfate, chloride and TDS results were within expected ranges. In strong contrast, the pH values from the Dulaney Street Well were acidic (4.50 and 4.64 duplicate results) in the untreated samples. The finished water, following pH adjustment, was a neutral 7.30. While slightly acidic pH from Columbia Aquifer ground water are not uncommon, the measured values from the Dulaney Street Well are lower than other values measured during the study.

Arbutus Avenue Well

Four VOCs were detected in the untreated water from the Arbutus Avenue Well (Table 15). Chloroform, a THM, was detected at 0.1 J µg/L. The remaining three compounds, PCE, TCE and cis-1,2-DCE, are associated with the documented PCE release from the upgradient Southern Metals facility. Both TCE and cis-1,2-DCE are degradation products of PCE. Of the three, only PCE exceeded its MCL of 5 µg/L, with a concentration of 16 µg/L. PCE was the only one of the three solvents identified in the finished sample, at a concentration of 0.1 J µg/L. One THM, dibromochloromethane, was detected in the finished sample at 0.1 J µg/L.

No SVOCs or pesticides were detected in either of the Arbutus Avenue samples. Lead was the only metal analyte detected, at a concentration of 5.4 µg/L in the untreated water sample.

Nitrate levels from the Arbutus Avenue samples (5.7 mg/L) were lower than those from the other two Seaford wells that were sampled as part of this project, but were typical of nitrate concentrations in ground water in Sussex County. Chloride and TDS measurements were comparable to results from other systems. No drinking water standards were exceeded. Neither fluoride nor sulfates were detected. The pH measurement from the untreated sample of 5.47 was slightly acidic, higher than that from the Dulaney Street Well, but below that from the Nylon Avenue Well. Following adjustment, the pH value in the finished sample was within the neutral range (7.59).

Table 15: City of Seaford Wells, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 56265 Arbutus Ave.	56265-Post	Well 10323 Nylon Ave.	10323-Post	Well 74465 Dulaney St.	74466-Post (duplicate)	74465-Post
Bromoform	80 for Total THMs[1]	--	--	--	0.1 J	--	--	0.2 J
Chloroform		0.1 J	--	--	0.2 J	--	--	0.1 J
Bromodichloromethane		--	--	--	0.1 J	--	--	0.2 J
Dibromochloromethane		--	0.1 J	--	0.2 J	--	--	0.3 J
MTBE	10[2]	--	--	--	--	0.2 J	0.2 J	--
PCE	5[1]	16	0.1 J	0.2 J	0.2 J	--	--	--
TCE	5[1]	0.3 J	--	--	--	--	--	--
Cis-1,2-DCE	70[1]	1.0	--	--	--	--	--	--
Barium	2,000[1]	--	--	--	--	215	223	221
Chromium	100[1]	--	--	--	20.4 J	--	--	--
Lead	15[4]	5.4		68.9	--	--	--	--
Zinc	5,000[3]	--	--	--	--	61.7	64.8	--
Sulfate	250,000[3]	--	--	--	--	18,600	17,800	17,000
Nitrate	10,000[1]	5,700	5,700	6,800	6,800	7,000	6,900	7,000
Chloride	250,000[3]	10,000	9,500	12,500	14,000	14,500	14,000	15,500
TDS	500,000[3]	280,000	170,000	68,000	187,000	58,900	90,000	184,000
pH (units)	6.5-8.5[3]	5.47	7.56	5.76	7.59	4.50	4.64	7.30
Alachlor	2[1]	--	--	--	--	0.32	0.33	0.35

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Actions

Of the three Seaford wells sampled, the only significant contamination was from chlorinated solvents in the Arbutus Avenue Well. The contaminants present, PCE and its degradation products TCE and cis-1,2-DCE, are associated with the known PCE release at the nearby Southern Metals facility. As a result of this release, a large-scale granular activated carbon treatment system was installed on the Arbutus Avenue well. It is recommended that ground water monitoring continue, and that the City of Seaford conduct pre- and finished testing of their water supply on an annual basis (at a minimum) in order to confirm the effectiveness of the existing carbon treatment.

Resampling of the Nylon Avenue Well is recommended, in order to confirm both the presence of the lead and PCE. Resampling should take place in a progressive manner, immediately following initial operation of the well, and after a period of continued operation, so as to monitor any changes in lead concentrations and test the hypothesis that the presence of the metal is due to oxidation/corrosion during the well's inactivity. The potential source of the PCE in the Nylon Avenue Well is unknown, and should be periodically monitored, especially if the well is ever to be brought online on a permanent basis. DNREC-SIRB will work with the City of Seaford to better understand the local hydrogeology and calculate the capture zone of the Nylon Avenue Well in an effort to help identify the source of the contamination.

The possible cause of the acidic pH in the Dulaney Street Well is unknown, but is easily treated through corrosion control measures. pH measurements are already included in the routine monitoring of the well. The tracking of changes in the pH may shed some light as to potential causes. While the observed concentration of alachlor did not exceed its drinking water standard, the existing monitoring program for the Dulaney Street Well should be amended to include alachlor.

4.3.4 Town of Blades Wells #1 (40024) and #2 (40025)

Background

Potable water for the Town of Blades is provided by two public supply wells located approximately ¼ mile south of the Nanticoke River, Well #1 (permit number 40024) and Well #2 (40025). Both wells are screened within the Beaverdam Formation at a depth of 66-96 feet bgs. Water from both wells is combined prior to treatment for disinfection, corrosion control, and iron removal via potassium permanganate. Prior to installation of the two wells, a septic system was located at the same site. It was abandoned prior to well installation. Located only several hundred feet upgradient of these wells is a manufacturing and warehousing area formerly occupied by a plating company, a vending company, a sign company, a trash hauling firm, a steel products company, a bread company distribution center, the Peninsula Plating Site and several other operations. The property is currently vacant except for one building being used for storage. Investigations by DNREC and the U.S. EPA at the plating company identified several metals, principally arsenic and significant petroleum, in onsite soils. Elevated iron and manganese were the only analytes detected in onsite ground water.

In 1995, EPA Region III conducted a CERCLA Removal Action at the abandoned plating facility building that contained numerous vats, tanks, drums and small containers of hazardous material left unsecured and abandoned. The materials included flammable liquids, corrosive liquids, oxidizers, cadmium-contaminated liquids and chromium-contaminated solids. The two supply wells for the Town of Blades were included in the sample schedule due to the proximity of the Peninsula Plating Site (DE-287).

Results

Six VOCs, four of which are THM compounds, were identified in either or both of the untreated water samples from the Town of Blades' wells. Chloroform (up to 2.4 µg/L), bromodichloromethane (4.0 µg/L in Well 40025), dibromochloromethane (3.6 µg/L in Well 40025) and bromoform (up to 1.0 µg/L) were detected in the untreated samples at concentrations well below the MCL for cumulative THMs of 80 µg/L. These same four compounds were also detected in the finished sample, but each at lower concentrations. Please refer to Table 16 for a complete list of detected analytes.

Trace concentrations of the solvent 1,1-DCE (0.1 J µg/L in Well 40025) and MTBE (up to 0.9 µg/L) were also detected in the untreated water samples. MTBE was also found in the Blades' finished sample at 0.8 µg/L. The observed concentrations are well below the respective MCLs for 1,1-DCE and MTBE of 7 and 10 µg/L, respectively. The source of these compounds is unknown.

Nitrobenzene was the only SVOC detected, at a concentration of 1.0 µg/L in the untreated water from Well 40024. This concentration is in excess of its URS of 0.4 µg/L. However, it was not detected in the finished sample. While the exact source is unknown, the presence of nitrobenzene may be tied to the occurrence of MTBE, and related to automotive repair operations located near to the well.

The pesticides dieldrin (0.04 J µg/L) and alachlor (0.21 µg/L) were identified in the untreated water sample from Well 40025, both at concentrations equal to, or below, their respective drinking water standards of 0.04 µg/L (RBC for dieldrin) and 2.0 µg/L (MCL for alachlor). Neither compound was detected in either Well 40024 or the finished sample. The fact that neither pesticide was detected in the finished sample is more likely reflective of dilution from the addition of water from Well 40024 rather than as a result of the existing water treatments.

Dieldrin has been used as a pesticide on corn and cotton in the 1950s-1970s, and for termite control through the late 1980s. Alachlor is presently used in Sussex County as an herbicide on corn, sorghum and soybeans. The occurrence of pesticides may be related to past or present agricultural use, but it is curious that they were identified in only one of the Blades' wells. Both compounds possess low solubility, and are not normally identified in ground water above the laboratory detection limit. When they are detected, it is usually in a mixed plume that includes aromatic or chlorinated solvents (e.g., the City of Newark South Wellfield) which act as solutes to mobilize the pesticides.

No metals were detected in any of the samples. Concentrations of sulfates and nitrates were comparable to other Sussex County samples, and below their respective drinking water samples.

Chloride concentrations were low. TDS values were well below the SMCL for TDS, with the highest concentration (183,000 µg/L) noted in the finished water sample, at a concentration twice that of the highest untreated sample (93,000 µg/L in Well 40025). This would suggest that the higher TDS is an artifact of the treatment system. pH values were slightly acidic (5.44 and 5.90) in the untreated water samples. Corrosion control treatment brought the pH to a slightly alkaline 8.99.

Table 16: Town of Blades Wells, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 40024 No.1	Well 40025 No.2	40024,40025-Post
Bromoform	80 for Total THMs[1]	1.0	0.9	0.5 J
Chloroform		0.2 J	2.4	0.3 J
Bromodichloromethane		4.0	0.5 J	--
Dibromochloromethane		--	3.6	0.3 J
MTBE	10[2]	0.4 J	0.9	0.8
1,1-DCE	7[1]	--	0.1 J	--
Nitrobenzene	0.4[2]	1.0	--	--
Sulfate	250,000[3]	8,300	24,600	23,000
Nitrate	10,000[1]	5,000	4,100	3,900
Chloride	250,000[3]	8,000	18,500	16,000
TDS	500,000[3]	57,000	93,000	183,000
pH (units)	6.5-8.5[3]	5.44	5.90	8.99
Alachlor	2[1]	--	0.21	--
Dieldrin	0.04[4]	--	0.04 J	--

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Actions

At the present time, there no primary drinking water standards were exceeded in any of the Town of Blades water samples. The Town of Blades should carefully monitor their fluoridation and pH buffering activities, and adjust them as necessary. The existing monitoring program for the Town of Blades should be amended to include any compounds detected as part of this study which are not currently being monitored for.

4.3.5 Colonial Estates Wells 10697 and 179549

Background

NCR Corporation manufactured cash registers and electronic equipment at a facility located 1/2-mile southeast of Millsboro. Enameling, chrome plating, assembly and degreasing operations were conducted at the NCR Plant (site number DE-042). Ground water contamination with chromium and TCE has been documented. It is believed that ground water contamination at this site resulted from disposal of chromium wastes in onsite pits, and from incidental spills and usage of TCE.

An air sparging system, ground water recovery well and an air stripper all have been installed at the site to remediate the contaminated ground water. In addition, a Ground Monitoring Zone (GMZ) was established around the facility in order to prevent installation of potable wells within the effected area.

Three public supply wells are located within ¼ to ½ mile from the NCR Site. Two of these wells provide water to the Colonial Estates subdivision. Well 10697, located east, northeast from the Site, serves the Colonial Estates subdivision. The well is screened at a depth of 57 feet bgs, within the Beaverdam Formation. A new Well 179549 was installed at Colonial Estates in the Summer of 2001. This well could not be included in the workplan for this study as it was installed following completion of the workplan. However, the well was operational at the time of sampling, and thus was included in the study. It is screened at a deeper interval in the Beaverdam Fm, from 78 to 98 feet bgs.

While shallow ground water flow from the NCR Site flows directly northeast towards Iron Branch, regional ground water flow is in a more easterly direction. It is unlikely, however, that any of these wells are impacted, due both to their distance from the Site, and implementation of the ground water remedial measures.

Results

Three THMs were detected in the Colonial Estates wells. No other VOCs, and no SVOCs were detected. Chloroform was identified in the untreated sample from Colonial Estates Well 10697 at 0.7 µg/L, and in the untreated Colonial Estates Well 179549 sample at 9.3 µg/L. Bromodichloromethane and bromoform were also detected in the untreated Well 179549 sample at 0.2 J and 0.4 J µg/L. The MCL for cumulative THMs is 80 µg/L. Please refer to Table 17 for a complete list of detected analytes.

Perchlorate, a rocket fuel compound, was detected at a concentration of 1.38 J µg/L in Colonial Estates Well 10697. The analytical method utilized in this did not identify the specific perchlorate compound, but rather documented the presence of the perchlorate anion (ClO_4). The U.S. EPA has proposed a draft reference does of 1 µg/L for perchlorate in drinking water, but the rule is in draft form and under review. Further, laboratory studies have indicated that perchlorate toxicity may vary depending on which perchlorate compound (sodium perchlorate, ammonium perchlorate or potassium perchlorate) is present. The Office of Drinking Water is presently in communication with the U.S. EPA in discussing this situation. In the meantime, confirmatory sampling using ion-specific methods is warranted. The potential source of perchlorate in such a rural part of Sussex County is unknown.

Zinc was the only metal detected in the Colonial Estates wells. It was identified in Well 10697 at 32.8 µg/L and Well 179549 at 963 µg/L. The latter value, while somewhat elevated over what might be expected to occur naturally, is far below the zinc SMCL of 5,000 µg/L. Zinc was detected in a large number of water samples during the project, often in combination with trace concentrations of lead, mercury and nickel. As such, its presence is frequently considered to have occurred as a result of leaching from metallic well and pump construction. While this may still also be the case here, the observed concentrations are significantly higher than those detected elsewhere, despite a relatively neutral pH.

Results from the wet chemistry parameters of sulfate, chloride, TDS and pH were within expected ranges for the individual parameters. Nitrate levels were noticeably lower than other locations in Sussex County. No drinking water standards, primary or secondary, were exceeded.

Table 17: Colonial Estates Wells, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 10697	Well 179549
Bromoform	80 for Total THMs[1]	--	0.4 J
Chloroform		0.7	9.3
Bromodichloromethane		--	0.2 J
Zinc	5,000[3]	32.8	963
Sulfate	250,000[3]	28,800	17,600
Nitrate	10,000[1]	280	--
TKN	N/A	--	430
Chloride	250,000[3]	21,000	27,000
TDS	500,000[3]	121,000	191,000
pH (units)	6.5-8.5[3]	5.94	6.18
Perchlorate	1[4]	1.38 J	--

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Actions

The presence of perchlorate in the Mobile Home park wells is unexpected. Comparatively little toxicological information is available concerning perchlorates. What is available suggests high but variable toxicity, dependant to an extent on the specific perchlorate compound. The occurrence of perchlorates is normally associated with the manufacture and/or use of rocket fuel, neither of which take place in the vicinity of rural Millsboro. One possible explanation for the detection of perchlorates in these samples is laboratory cross-contamination. Pesticide analyses for this project were conducted by a laboratory located in California, the location of much of the documented perchlorate contamination. Improper cleaning of the instrumentation following analysis of a sample high in perchlorates could have resulted in residual perchlorates within the sampling column. Confirmatory sampling will be conducted on all wells at the Colonial Estates for perchlorates using EPA-recommended, ion-specific analytical methods that will both confirm the presence of perchlorates as well as differentiate between the various perchlorate compounds.

4.2.6 Holiday Acres Wells 48810 and 77145

Background

Please refer to the background discussion in the previous section on Colonial Estates. Wells 48810 and 77145 are both located ESE of the NCR Site, and serve Holiday Acres. The first well is the shallower of the two, screened within the upper Beaverdam/lower Omar Formations of the Columbia Group, at a depth of 28-33 feet bgs. The latter well is screened in the basal Beaverdam, at a depth of 90-100 feet bgs.

Upon communication with the owner of Holiday Acres, the shallow well is presently offline, without power and a pump. It is intended only for emergency use. The deeper well #77145 is online, and is used as their everyday water supply source. As a precautionary measure the active well #77145 was included in the sampling schedule.

Results

The Holiday Acres Well 77145 finished sample contained 2.0 µg/L of chloroform and 0.4 J µg/L of bromodichloromethane. No THMs were detected in the untreated sample from this well. No other VOCs, no SVOCs, nor metals were detected in either of the Holiday Acres water samples. Perchlorate was detected in one of the Holiday Acres samples at a concentration of 2.33 J µg/L in the finished sample for Well 77145 (see previous Colonial Estates discussion on perchlorate). Please refer to Table 18 below for a complete list of detected analytes.

Results from the wet chemistry parameters of sulfate, nitrate, chloride, TDS and pH were close value, and within expected ranges for the individual parameters. No drinking water standards, primary or secondary, were exceeded.

Table 18: Holiday Acres Wells, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 77145	77145-Post
Chloroform	80 for Total THMs[1]	--	2.0
Bromodichloromethane		--	0.4 J
Sulfate	250,000[3]	--	--
Nitrate	10,000[1]	--	--
TKN	N/A	690	--
Chloride	250,000[3]	10,000	15,000
TDS	500,000[3]	130,000	155,000
pH (units)	6.5-8.5[3]	6.50	6.59
Perchlorate	1[4]	2.33 J	--

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Actions

See Colonial Estates.

4.3.6 Savannah Place Wells 57474 and 69511

Background

A coal gasification plant was operated in the Town of Lewes for the production of methane from coal in the early part of the twentieth century, located along the southern edge of the town boundary. The waste product from the gas manufacture was a thick, viscous tar-like material termed “coal tar”. Significant amounts of this coal tar were identified under the property during

several investigations by DNREC and the U.S. EPA. A leaking underground storage tank containing fuel oil was also identified onsite. The site is called the Lewes Coal Gas Site (DE-190).

In 1994-95, the U.S. EPA, in conjunction with DNREC, conducted a removal action at the site to remove the buried remains of the coal gas plant and surrounding contaminated soil. Subsequent ground water sampling identified the presence of low concentrations of VOCs and SVOCs associated with coal gasification and petroleum storage in nearby monitoring wells. Neither VOCs nor SVOCs were detected in the samples collected from the City of Lewes supply wells located two miles distant.

There are several public wells located within approximately ¼ mile of the site, which provide potable water to several small water systems. The Savannah Place subdivision operates two wells (69511 and 57474) both of which are screened in the basal Beaverdam Fm, at a depth of 60-70 and 75-95 feet bgs, respectively. Their relative proximity to the Lewes Coal Gas Site requires their inclusion on the project.

Results

Both Savannah Place Wells 69511 and 57474 contained the THM compounds dibromochloromethane (0.2 and 0.3 µg/L, respectively) and bromoform (0.9 and 1.1 µg/L, respectively) at similar concentrations, but far below the MCL for total THMs of 80 µg/L. No other VOCs, no SVOCs, and no pesticides were detected in the Savannah Place wells. Please refer to Table 19 for a complete list of detected analytes.

Lead (4.7 and 5.4 µg/L, respectively) and zinc (82.1 µg/L in Well 69511) were detected in the Savannah Place wells, also at concentrations below their drinking water standards. Similar concentrations of these same metals have been detected in a large number of wells sampled during this project, suggesting that their presence is related to leaching of metallic components of well and pump construction by acidic ground water.

Elevated nitrates in both Savannah Place wells were noted. Well 69511 contained 7.4 mg/L of total nitrates, higher than what was observed in most other water systems sampled during this project, but below the 10 mg/L MCL. Well 57474 contained 10.8 mg/L of nitrates, a value that exceeds the MCL. However, routine monthly samples collected from the distribution system in the same month were compliant with the MCL. This is likely due to dilution.

Observed concentrations of sulfates, chloride, TDS and pH were within expected ranges, and comparable to other water systems in Sussex County.

Table 19: Savannah Place Wells, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 69511	Well 57474
Bromoform	80 for Total THMs[1]	0.9	1.1
Dibromochloromethane		0.2 J	0.3 J
Lead	15[4]	4.7	5.7
Zinc	5,000[3]	82.1	--
Sulfate	250,000[3]	31,300	13,800
Nitrate	10,000[1]	7,400	10,800
Chloride	250,000[3]	16,000	23,000
TDS	500,000[3]	139,000	109,000
pH (units)	6.5-8.5[3]	5.99	5.80

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Actions

Both Savannah Place wells should be resampled to confirm the levels of nitrates. If concentrations remain above or near the 10 mg/L MCL, several options exist, including connection to the City of Lewes water system which runs along Route 9, turning off the highest nitrate well, installation of several treatment system options, or well replacement.

4.3.7 Donovan/Smith Mobile Home Park Wells 69918 and 99655

Background

Wells 69918 (Well #2) and 99655 (Well #3) provide water to the Donovan/Smith Mobile Home Park, which is located across the road from Savannah Place. Well 69918 is screened at an interval of 80-100 feet bgs, in the basal Beaverdam Formation of the Columbia Group. Well 99655 is screened at a much deeper interval of 105-158 feet bgs within the unconfined aquifer. In this area, there is no confining layer separating the Pocomoke Aquifer of the Bethany Formation from the overlying Beaverdam. Also, see discussion on Savannah Place.

Results

No VOCs, SVOCs, or pesticides/herbicides were detected in either of the Donovan/Smith wells. Copper (25 µg/L in Well 99655) and zinc (32 and 33 µg/L) were detected in the Donovan/Smith wells at concentrations far below their SMCLs. Results from sampling of the Donovan/Smith wells indicated nitrate values of 4.2 mg/L (Well 69916) and 2.2 mg/L (Well 99655), all of which are below the 10 mg/L MCL. Please refer to Table 20 for a complete list of detected analytes.

Observed concentrations of chloride, TDS and pH were within expected ranges, and comparable to other locations within Sussex County. Sulfates were not detected in either sample, and nitrate levels were comparably low.

Table 20: Donovan/Smith Wells, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	Well 69918	Well 99655
Copper	1,300[3]	--	25
Zinc	5,000[3]	32	33
Nitrate	10,000[1]	4,200	2,200
Chloride	250,000[3]	12,500	12,000
TDS	500,000[3]	73,000	65,000
pH (units)	6.5-8.5[3]	6.35	5.73

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Actions

No drinking water standards, primary or secondary, were exceeded. No further action is necessary.

5.0 SAMPLING LOCATION DESCRIPTIONS, RESULTS AND DISCUSSION—SURFACE WATER

5.1 New Castle County

Background

In New Castle County, four streams (Red Clay Creek, White Clay Creek, Brandywine Creek and the Christina River), all located within the Christina River Drainage Basin, are used as public drinking water sources for three water systems, the City of Wilmington, the City of Newark, and United Water Delaware (United). The water used by United and the City of Wilmington is entirely derived from surface water sources, while the City of Newark uses water from the White Clay Creek to augment its ground water supplies.

Untreated water samples were collected from each of the four surface water bodies at five locations, coinciding with U.S. Geological Survey Storet monitoring stations:

- Brandywine Creek above Wilmington intake, at Foot Bridge (City of Wilmington; 104011)
- Red Clay Creek above Stanton intake (United Water Delaware, Route 4; 103011)
- White Clay Creek above Stanton intake (United Water Delaware, Old Route 7 Bridge; 105011)
- White Clay Creek above Newark intake (City of Newark; 105031)
- Christina River above Smalley's Pond intake (United Water Delaware; 106031)

Finished water samples were collected for each of the three systems prior to discharge of the treated water to the distribution systems. The sampling points were those routinely sampled by the Office of Drinking Water. Unfortunately, during the time of sampling, United was withdrawing water from Smalley's Pond, and thus the treatment system was not operational. So while an untreated sample was collected from this location, a finished water sample was not.

5.1.1 City of Wilmington, Brandywine Creek Intake (Storet # 104011)

Results

Bromoform (a THM) was the only VOC detected in the untreated surface water from the Brandywine Creek, at a concentration of 0.2 J µg/L. One SVOC, DEHP, was also detected at a concentration of 96 µg/L, a level well above its MCL of 6 µg/L, but was not detected in the finished water sample. As with Artesian's Airport Industrial Park Well 48941, the presence of DEHP in aqueous samples is usually attributable to laboratory cross-contamination, and thus its presence here also likely represents a laboratory artifact. DEHP has a very low solubility and high affinity for adsorption onto sediments and soil particles. It is not normally found as a ground- or surface water contaminant. Please refer to Table 21 for a complete list of detected analytes.

Four THMs were detected in the finished water sample from the Wilmington Treatment Plant: chloroform (28 µg/L), bromodichloromethane (5.0 µg/L), dibromochloromethane (0.5 µg/L) and

bromoform (0.1 J µg/L). No standards were exceeded, either individually or cumulative, of the MCL for total THMs of 80 µg/L.

The herbicide dacthal, which had been identified in a number of water systems using ground water, was also detected in several of the surface water samples. Dacthal was detected in the untreated water sample at a concentration of 0.18 µg/L, and at 0.17 µg/L in the finished water sample. Both of these values are below its MCL of 200 µg/L.

The only metal detected in the Brandywine Creek samples was aluminum, at a concentration of 258 µg/L in the untreated sample. It was not detected in the finished water. There is no primary drinking water standard for aluminum. The SMCL is 200 µg/L. Aluminum is a metal that is common constituent of clay and mica minerals contained within the stream sediments and the underlying bedrock of the Wilmington area. It is likely naturally occurring.

Results for the wet chemistry/water quality parameters sulfate, chloride, and pH were all within expected ranges, with no drinking water standards were exceeded. TDS results of 139,000 µg/L and 179,000 µg/L were lower than expected and well below the SMCL of 500,000 µg/L. Nitrates were similarly lower than expected, with results for the untreated and finished samples of 1,900 and 1,800 µg/L. Fluoride was detected in both the untreated (130 µg/L) and treated samples (690 µg/L). Please refer to Table 21 for a complete list of detected analytes.

Table 21: City of Wilmington Surface Water Location, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	City of Wilmington	
		104011	104011-Post Treatment
Bromoform	80 µg/L MCL for TTHMs	0.2 J	0.1 J
Chloroform		--	28
Dibromochloromethane		--	0.5
Bromodichloromethane		--	5
DEHP	6[1]	96	--
Aluminum	200[3]	258	--
Nitrate	10,000[1]	1,900	1,800
Fluoride	1,300[1]	130	690
Chloride	250,000[3]	21,000	50,000
TDS	500,000[3]	139,000	179,000
pH (units)	6.5-8.5[3]	7.78	6.24
Dacthal	37[1]	0.18	0.17

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Action

The Brandywine Creek at Storet location 104011 should be resampled to confirm or refute the presence of DEHP. The presence of elevated aluminum in the untreated sample is to be expected and is likely due to the presence of fine sediment and floc, which is characteristic of surface water samples. As it was not detected in the finished sample, no further action is warranted.

No primary or secondary drinking water standards were exceeded in the finished water sample, and no further action is warranted at this time.

5.1.2 White Clay Creek above City of Newark Intake (Storet # 105031)

Results

No VOCs, SVOCs, pesticides or metals were detected in either City of Newark surface water sample. Observed levels of sulfate and chloride were comparable to those from other surface water and ground water locations. No drinking water standards were exceeded. Nitrate and TDS values were lower than expected for a surface water sample, and comfortably below their respective standards. Fluoride was not detected. Please refer to Table 22 for a complete list of detected analytes.

The pH value of 8.11, while within the acceptable range of 6.5-8.5, was noticeably more alkaline than most other samples, both surface and ground water, collected as part of this study. Over-buffering of the water at the Newark Curtis Plan resulted in a value of 6.47, slightly below the acceptable pH range.

Table 22: City of Newark Surface Water Locations, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	City of Newark	
		105031	105031-Post Treatment
Nitrate	10,000[1]	3,900	2,800
Fluoride	1,300[1]	--	160
Chloride	250,000[3]	24,000	25,000
TDS	500,000[3]	225,000	225,000
pH (units)	6.5-8.5[3]	8.11	6.46

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Action

The City of Newark should carefully monitor their pH buffering activities, and adjust them as necessary. Otherwise, as no primary or secondary drinking water standards were exceeded in the finished water sample, no further action is warranted at this time.

5.1.3 Red Clay Creek (Storet # 103011) and White Clay Creek above United Water Stanton Intake (Storet # 105011)

Results

Low concentrations of the THM compounds dibromochloromethane (0.2 J µg/L) and bromoform (0.3 J µg/L) were detected in the untreated surface water sample from Red Clay Creek above Stanton. No VOCs were detected in the White Clay Creek water sample. Following treatment for disinfection, three THMs were detected: dibromochloromethane (1.2 µg/L), chloroform (50 µg/L) and bromodichloromethane (11 µg/L). While the cumulative total for THMs for the finished sample of 62.2 µg/L is elevated, it is still below the 80 µg/L MCL for total THMs. Please refer to Table 23 for a complete list of detected analytes.

No SVOCs or pesticides were detected in any of the Stanton samples. Dacthal was detected in the untreated water sample from the Red Clay Creek at a concentration of 0.11 µg/L, but was not detected in the White Clay Creek sample. The joint finished water sample possessed a dacthal concentration of 0.2 µg/L, but at such low concentrations, the result should not be considered as being higher than that from the untreated sample, and both are below the MCL for dacthal of 37 µg/L.

Aluminum (253 µg/L) and cyanide (117 µg/L) were detected in the untreated surface water sample from the Red Clay Creek. Neither were detected in the finished sample. No metals were detected in the White Clay Creek surface water sample. The occurrence of aluminum, as with the case of Brandywine Creek, is likely naturally occurring. There is no primary drinking water standard for aluminum. Cyanides represent a group of compounds defined by the presence of carbon and nitrogen. They can be naturally occurring as components of plant sugars in some

species of fungi and algae, and also in commercial food crops. They can also be man-made, generated in the iron and steel industries, electroplating, and photographic industries, and in municipal wastewater streams. Toxicity of cyanide compounds is highly variable, and dependant upon the specific cyanide compound present. The analysis that was performed as part of this project does not differentiate between cyanide compounds, but rather analyzes for the presence of the carbon-nitrogen cyanide bond. In such situations, it is common practice to consider all of the cyanide that is present is "free cyanide", which is the cyanide anion without any cation present. The U.S. EPA has established a MCL of 200 µg/L for free cyanide. The observed concentration of 117 µg/L is slightly higher than half of the MCL. Cyanide was not detected in the finished water sample. The source of the cyanide is unknown.

Copper was detected only in the finished water sample at 28.3 µg/L. Its presence at such a low concentration, in only the finished water sample is suggestive of its presence due to leaching of copper components in the treatment and/or distribution system.

Sulfate, nitrate, chloride, TDS, TKN and pH were comparable between all three samples (2 untreated plus the finished sample), and to those from other surface water and ground water locations. No primary or secondary drinking water standards were exceeded. Nitrate values, ranging from 1,900 up to 2,300 µg/L, as well as TDS (106,000 up to 208,000 µg/L) were lower than expected. Fluoride was detected in the White Clay Creek sample 100 µg/L, but not in the Red Clay Creek. The finished sample contained 980 µg/L fluoride. The SMCL is 2,000 µg/L.

Table 23: United Water Delaware Surface Water Locations, Summary of Detected Analytes (µg/L)

Analyte	Drinking Water Standard	103011 Red Clay Creek	105011 White Clay Creek	103011,105011-Post	106031 Christina River
Bromoform	80 for Total THMs[1]	0.3 J	--	--	--
Chloroform		--	--	50	0.7
Bromodichloromethane		--	--	11	--
Dibromochloromethane		0.2 J	--	1.2	--
Aluminum	200[3]	253	--	--	336
Cyanide	200[1]	117	--	--	--
Copper	1,300[3]	--	--	28.3	--
Sulfate	250,000[3]	29,600	24,900	27,500	9,700
Nitrate	10,000[1]	1,900	2,300	2,000	360
Chloride	250,000[3]	32,500	27,000	37,500	37,000
TDS	500,000[3]	106,000	153,000	208,000	169,000
pH (units)	6.5-8.5[3]	7.99	7.56	7.20	7.14
Dacthal	37[1]	0.11	--	0.2	--

[1] U.S. EPA Primary MCL
[2] Delaware URS or proposed MCL
[3] U.S. EPA Secondary MCL
[4] U.S. EPA Other
-- Analyte not detected.

Recommended Future Action

The presence of cyanide in the Red Clay Creek should be confirmed through resampling, and its source identified. Cyanide will be included in the monitoring program for the United Water, Stanton Plant. United Water Delaware should carefully monitor their chlorination process, and adjust it as necessary. This project sampled surface water during low-flow (or baseflow) conditions, and not during storm water conditions. A more "time-sensitive" study would be needed to expand the assessment to include all of the flow scenarios.

5.1.4 Christina River above Smalley's Pond Intake (Storet # 106031)

Results

A trace concentration of chloroform (0.7 µg/L) was the only VOC detected in the untreated water from Smalley's Pond. No finished water sample was collected as the treatment system was offline at the time of sampling. No SVOC compounds were detected. Please refer to Table 23 for a complete list of detected analytes.

Aluminum was the only metal detected in the Smalley's Pond sample, at a concentration similar to the Red Clay Creek and Brandywine Creek samples. It is likely naturally occurring.

The common herbicide dacthal was also detected in the untreated sample from Smalley's Pond, at a concentration of 0.12 µg/L.

Observed levels of sulfate, chloride, TDS and pH were comparable to those from other surface water and ground water locations. No drinking water standards were exceeded. A nitrate concentration of 360 µg/L was the lowest concentration observed in the study.

Recommended Future Actions

No primary or secondary drinking water standards were exceeded in the finished water sample, and no further action is warranted at this time.

Figure 3: Summary List of Volatile Organic Compounds Detected in Untreated Water Samples

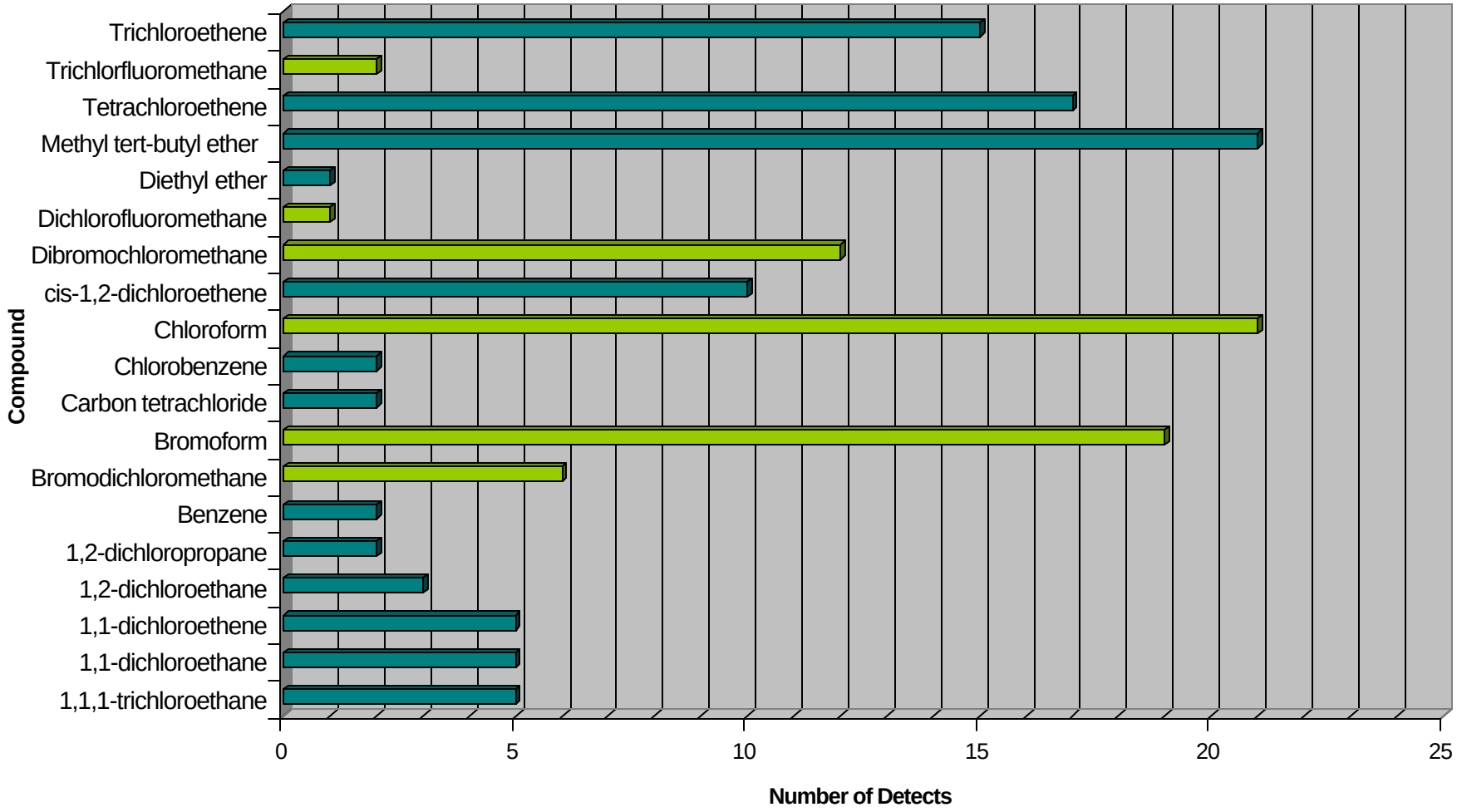


Figure 4: Summary List of Volatile Organic Compounds Detected in Finished Water Samples

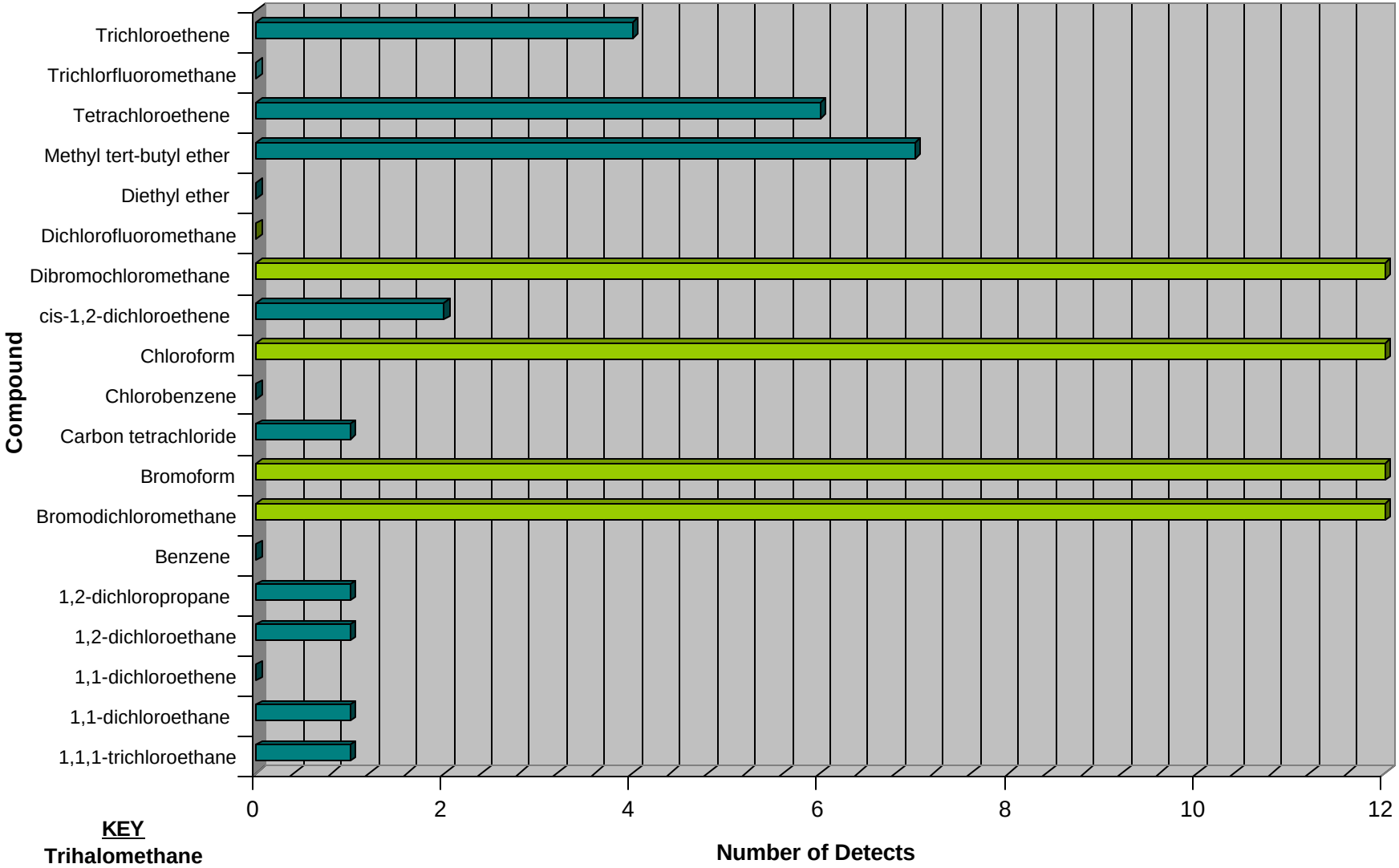


Figure 5: Summary List of SVOCs, Pesticides and Herbicides Detected in Untreated Water Samples

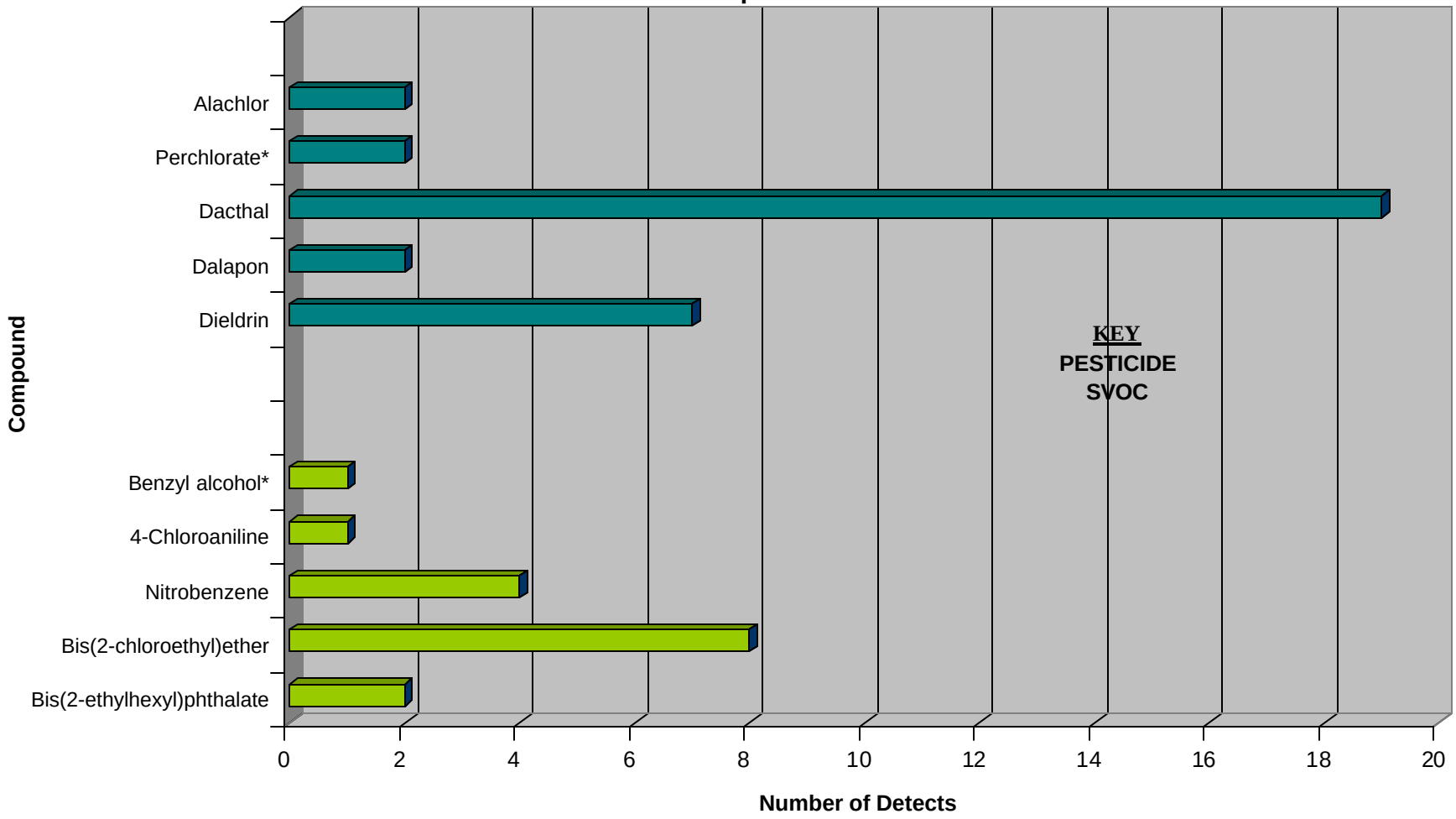
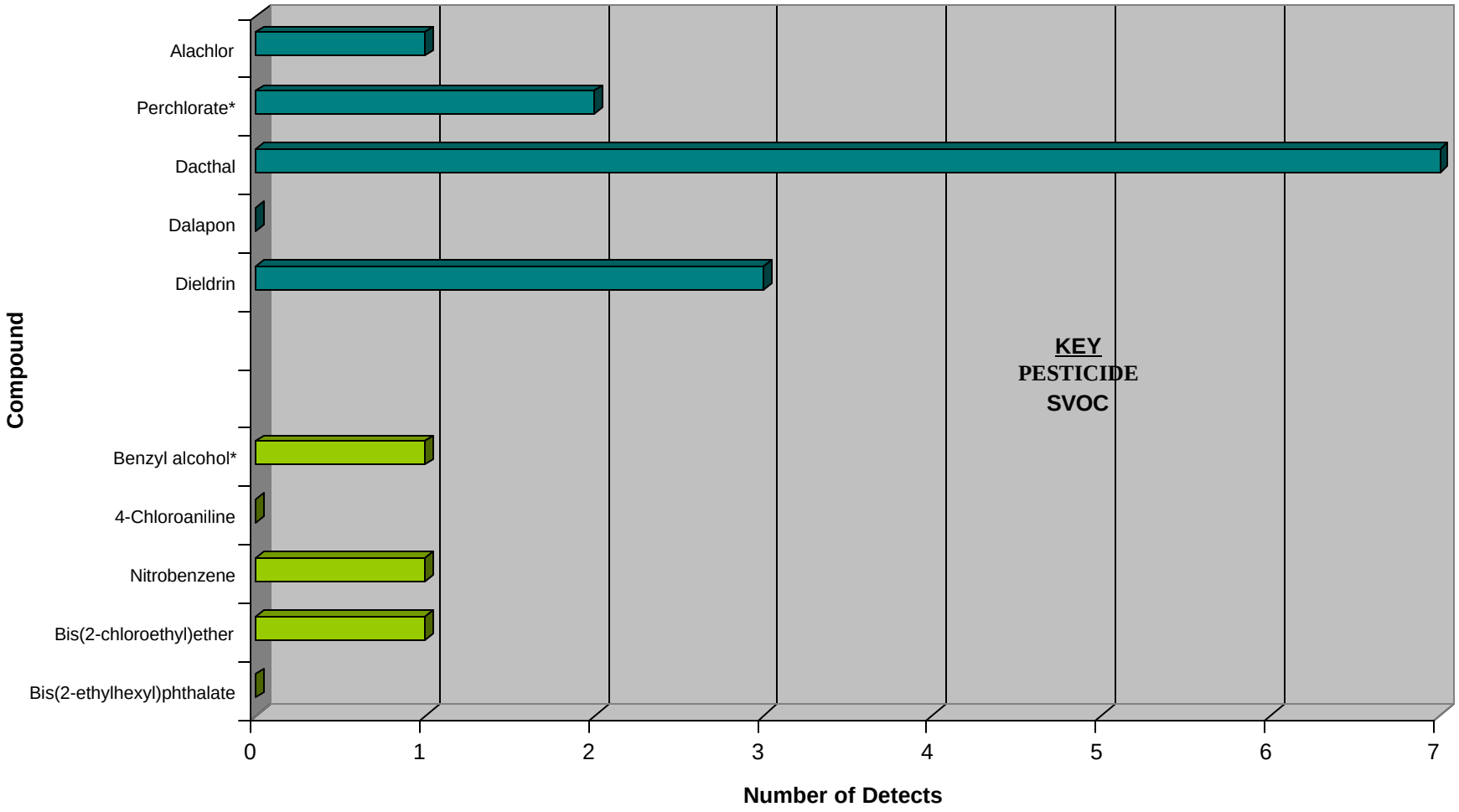


Figure 6: Summary List of Semi-Volatile Organics, Pesticides and Herbicides Detected in Finished Water Samples



6.0 HUMAN HEALTH EVALUATION AND RISK ASSESSMENT

6.1 Methods

6.1.1 Step One: Screening Evaluation

DHSS/DPH Environmental Health Evaluation & Toxicology Branch (EHETB) performed human health evaluations for all finished water samples. MCLs and RBCs were used as initial screening values in the first step of the health evaluations. The concentrations of the various chemicals detected in the sample were compared to their respective MCLs or the RBCs in order to determine which compounds were present in elevated concentrations. MCLs are recognized as the default safe value. RBCs were used for those analytes that do not possess an MCL.

Since an MCL value is a regulatory standard, any sites that produced a sample that exceeded an MCL value were resampled to confirm the initial results. Once the results were confirmed, the ODW applied the standard regulatory procedures in instances when MCLs are exceeded, which include the required public notification and correction of the problem.

An MCL is a concentration value and is defined as the maximum permissible level of a substance in drinking water delivered to the user of a public water system. MCLs are based upon a nominal lifetime excess cancer risk calculation in the range of 10^{-4} to 10^{-6} (ranging from one additional case in a population of 10,000 to one additional case in a population of one million). MCLs are determined and issued by the EPA, and enforced by both the EPA and DPH-ODW. The EPA sets maximum contaminant levels for chemicals and uses various indicators to determine the need for regulation, including the chemical's prevalence in industry or agriculture, analytical capability, treatment technology and related costs. The analytical capability needed to measure the chemical confidently as well as treatment technology to remove the chemical to the MCL level must exist prior to establishing the MCL for that chemical. The related costs for analysis and treatment are also considered when establishing an MCL. Neither analysis nor treatment can be cost prohibitive for the water supply companies when the EPA establishes an MCL.

An RBC is a concentration value and is derived from a risk model using adult and child exposures. It does not account for technology or costs. An RBC is based on theoretical or potential risks to human health. The RBC values used for this project were based on EPA's Region III RBC values (which reflect a $1x10^{-6}$ risk level) but were revised to reflect the $1x10^{-5}$ risk level as outlined in Delaware's HSCA. These revised RBC values are equal to a concentration that would produce an increased risk of cancer in one case in a hundred thousand exposed people as compared to the EPA standards of an increased risk of cancer in one in as high as a million exposed people.

In this study, RBC values are present for four compounds typically identified as disinfection by-products: chloroform, bromoform, bromodichloromethane, dibromochloromethane. These compounds typically form when added chlorine interacts with natural organic matter in drinking water, and collectively have been named the total trihalomethanes (TTHMs). Trihalomethanes have an MCL of 80 µg/L, recently reduced from the past standard of 100 µg/L, making the new level more protective of health. Although the trihalomethanes possess an MCL, this MCL is a

group MCL and was used for screening the concentration level of the group of chemicals. The RBC value for each component of the trihalomethanes was used only to evaluate the cumulative risk associated with the consumption of the water from the water source.

Adding disinfectants such as chlorine to water successfully eliminates water borne illnesses such as typhoid and cholera. Disease causing pathogens such as bacteria, protozoa and viruses can cause illnesses such as diarrhea and/or fever and, in the most extreme cases, even death. Most ground water systems in Delaware are in compliance with the SDWA microbiological standards without chemical disinfection. Delaware water suppliers add chlorine to the water they provide for several reasons, including: company policy, to prevent biological growth, to improve taste and odor, to oxidize iron and manganese, or to measure system integrity. Unfortunately, this chlorination of water that already contains natural organic matter can form the disinfection by-products listed in the previous paragraph. The EPA recognizes the health hazards associated with THMs, mostly chronic or long-term health risks, and has developed four new sets of regulations to address these potential health hazards as part of the 1996 Safe Drinking Water Act Amendments. These new regulations are titled the Information Collection Rule, the Disinfectants and Disinfection By-Products Rule (DBPR), the Interim Enhanced Surface Water Treatment Rule, and the Ground Water Rule.

The Stage 1 DBPR rule lowered the existing MCL for TTHMs from 100 µg/L to 80 µg/L. Additionally, the rule once applied to only water systems serving over 10,000 people. This new rule extends the lower MCL to water systems of all sizes, with compliance monitoring to begin in the summer of 2002. Stage 1 of DBPR also established the maximum level of chlorine allowed in drinking water called the Maximum Residual Disinfectant Level. In the near future, EPA will finalize the Stage 2 DBPR, which will re-evaluate the new assigned MCLs for the following chemicals that have been recently designated as DBPs: haloacetic acids, bromate and chlorite.

6.1.2 Step Two: Risk Assessment

DHSS/DPH EHETB performed human health risk assessments as the second step in evaluating the finished water results. The risk assessments were based on RBC values only, and modeled the potential cancer risk, using a slope factor, and adverse health risk, using a hazard index or quotient, associated with the ingestion or consumption of drinking water. Risk assessments were performed for each individual chemical (irrespective of the presence of an MCL), as well cumulatively, for all chemicals detected in a given water sample.

Risk modeling was performed on both carcinogenic and non-carcinogenic chemicals for both an adult and child receptor. If a chemical has both carcinogenic and non-carcinogenic effects, then that chemical was evaluated for both categories. Risk modeling provides a numeric value for both carcinogenic and non-carcinogenic estimated risk that is based on a set of assumptions. For carcinogenic chemicals, adult exposure, the following assumptions were used:

Body Weight: 70 kg
Consumption Rate: 2 L/day
Exposure Duration: 350 days/year, for 30 years
Averaging Time: the individual lives to age 70.

For carcinogenic chemicals, child exposure, the following assumptions were used:

Body weight: 16 kg
Consumption Rate: 1 L/day
Exposure Duration: 350 days a year, for 6 years
Averaging Time: the individual lives to age 70

For non-carcinogenic chemicals, the assumptions were the same as the assumptions for the carcinogenic assessments, except for the averaging time. For adults, the averaging time is lessened to age 30, and for children, to age 6.

The cumulative health risk for each of the four categories (cancer for adult and child, and non-cancer for adult and child) was determined by summing the health risk associated with each analyte found to be present in the water source. The sums of the individual risks represent the total estimated health risk, as defined by each of the four categories, associated with consuming the water from the given water source.

The numeric result of the risk assessment was compared to the accepted risk value of $1x10^{-5}$ risk level as defined in HSCA, and placed into three categories, or levels, of risk used to evaluate the data. The risk levels are classified according to the corresponding color range signifying Acceptable Risk, Action Required or Immediate Action. The green range (Acceptable Risk) identified a risk that was less than $1x10^{-5}$ risk level. The yellow range (Action Required) identified a risk that was between $1x10^{-5}$ and $1x10^{-4}$ risk level. Lastly, the red range (Immediate Action) was used to identify a risk that was above $1x10^{-4}$ risk level. Responses by DPH and DNREC to any results in the yellow or red ranges were outlined in the workplan. Details of any planned or already-executed actions can be found in the results discussions within Section 4 of this report.

In summary, no finished water samples, or sources, were modeled into the red range. All individual chemicals detected in the finished, consumed water samples were found to have a modeled risk within the green range. Only one finished, consumed water source (a cumulative risk of all chemicals contained within the sample), and was modeled into the yellow range. All other finished samples had a modeled risk in the green range.

6.2 Results Overview

6.2.1 Finished, Treated Samples

Analytical results were noteworthy in that there was an overall lack of environmental chemicals that were detected in the finished, treated water samples (environmental chemicals refer to those chemicals that are potential threats to water resources because they are present in the environment, and not disinfection by-products). These chemicals may be hazardous to human health if the concentrations are elevated above acceptable or regulated levels, and are consumed at those elevated levels. All of the regulated chemicals evaluated in the category of finished, treated water were in compliance with the MCLs issued by the Environmental Protection Agency, except for one nitrate test. However, when the confirmation sample was collected, the average of the two samples was in compliance with the MCL.

No environmental chemicals were present in any of the finished, treated samples at concentrations that exceeded any of the RBC screening values. All individual risk models as well as cumulative risk models for environmental chemicals were modeled to be in the green range.

The results of the screening and analysis of the non-environmental chemicals in the finished, treated water samples showed elevated levels of disinfection by-products. These chemicals were not the primary focus of this study, however, their presence impacts the overall health risk associated with the consumption of the water. All of the non-environmental chemicals that were found in the sources above were THMs.

Concentrations of some individual THMs did exceed an RBC screening value in several samples. However, none of the observed concentrations of THMs in the finished, treated water samples exceeded the regulated group MCL of 80 µg/L, the default safe value used as the primary screen for total THMs. In following the method outlined in the study plan though, the MCL is the value to be used for screening THMs, since the group of chemicals, as a whole possesses an MCL and the MCL is the primary default safe value. In addition, all THM results that exceeded any RBCs were modeled into the green range for human health risk individually, and were then subsequently modeled for the cumulative health risk associated with consumption of the water from the water source. Only one cumulative human health risk level, carcinogenic-adult, for one location, was modeled into the yellow range ($1x10^{-5}$ to $1x10^{-4}$), meaning action needs to be taken.

6.2.2 Finished, Untreated Samples

In certain locations, there is no treatment of the raw water before it enters the drinking water distribution system. In these cases, the raw water is consumed, and is therefore classified as finished, untreated water. As this water is consumed, it is of public health concern to DPH and is regulated by DPH ODW accordingly. The Office of Drinking Water does not require treatment on all raw water sources in Delaware as many wells produce water suitable for human consumption without treatment.

The results of the screening and analysis of the environmental chemicals in the finished, untreated drinking water samples showed elevated levels of MTBE in two wells: the Mt. Pleasant Mobile Home Park and Bulldozer's Saloon. Currently, there is no MCL for MTBE. However DHSS/DPH/ODW has proposed an MCL of 10 ppb. This proposed standard is scheduled to become the Delaware standard when DHSS/DPH finalizes the ruling.

ODW has been aware of the presence of MTBE at the Mt. Pleasant Mobile Home Park, and has been actively working with the water system owner to reduce the concentration to the Delaware proposed standard. Bulldozer's Saloon is a transient non-community water system that is not normally tested for volatile compounds such as MTBE. ODW is working with the owner to find an alternate source of water. One possible solution is connection to the Town of Clayton or Town of Smyrna waterline, which is located nearby.

Few non-environmental chemicals were detected in the finished, untreated water samples. This was to be expected as there is no chlorination treatment for these systems. Low levels of some THMs were detected in several finished, untreated water samples, but none of the detected levels

exceeded individual RBCs, the cumulative TTHM MCL of 80 µg/L, or the modeled cancer and non-cancer risks.

6.2.3 Raw, Untreated Samples

Low levels of contamination were found in some raw, untreated water samples. Contaminants included VOCs, SVOCs, elevated metals, a few pesticides and herbicides, and cyanide. This water was collected directly from the wellhead, without any treatment, and thus the results represent the quality of the water within the aquifer at that location. It is not usually consumed without treatment. This is especially true for public wells.

6.3 Detailed Results for Finished (Treated and Untreated) Drinking Water for Each Water System

6.3.1 NEW CASTLE COUNTY

6.3.1.1 Artesian Water Company

Four separate wellfields that are blended in the Artesian Water Company distribution system were included in this study: Hockessin, Llangollen, Collins Park and Airport Industrial Park. While water from the various components of the system are blended, the actual reach of any individual system diminishes with distance from the wellfield.

Artesian – Hockessin Well PG1 (30266), Well PG3 (31614), and Well P4 (31820)

Finished water from this system was found to contain low levels of several disinfection byproducts, TCE, PCE, copper, zinc, and a trace amount of benzyl alcohol. None of the detected chemical levels exceeded MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE accepted level of risk. An aeration treatment system is already in place to remove VOCs.

Artesian – Collins Park Well (40146)

This system was found to contain low levels of several disinfection byproducts, cis-1,2-DCE, MTBE, PCE, BCEE, nitrobenzene, copper, lead, mercury, and zinc. None of the detected chemical levels exceeded MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE accepted level of risk. Artesian recently installed a granular activated carbon treatment unit at this well site to remove the BCEE. An aeration treatment system has been in place for several years to remove VOCs. Subsequent post-treatment sampling indicated that the treatment systems are effective in removing the contaminants down to levels that do not pose a health risk.

Artesian – Llangollen Wellfield (Wells 10049, 10050, 10052, 35081, and 156408)

This system was found to contain low levels of several disinfection byproducts, 1,2-DCA, chromium and zinc. None of the detected chemical levels exceeded MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child exceeded the DE accepted level of risk. Granular activated carbon and aeration treatment are already in place on this well.

Artesian – Airport Industrial Park Wells 48941 and 52445

This system was found to contain low levels of disinfection byproducts, 1,1-DCA, cis-1,2-DCE, 1,1,1-TCA, MTBE, 1,2-DCP, TCE, copper and zinc. None of the detected chemical levels exceeded MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE

accepted level of risk. ODW continues to monitor the levels of these compounds. Aeration treatment is already in place on this well.

6.3.1.2 City of Newark South Wellfield (Wells 00181, 10003, 10004, 10005, and 10622)

The water in this system is treated, finished well water from eight wells, four of which were included in this study. This system was found to have low levels of several disinfection byproducts, MTBE, 1,1,1-TCA, TCE, PCE, and zinc. None of the detected chemical levels exceeded MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE accepted level of risk. ODW will continue to monitor this system for these compounds.

6.3.1.3 Mt. Pleasant Mobile Home Park Well 41457

The water in this system is untreated, finished well water. Levels of MTBE in excess of the proposed MCL of 10 µg/L were detected at this location. ODW was aware of the presence of this analyte in this water source prior to this study and has been monitoring for MTBE for the past year. The owners of the park in conjunction with ODW are investigating possible solutions. One possible solution would be to use an alternate water source, either by drilling a new well that is deeper, or by interconnecting with a nearby public water system. Another possible alternative is to install treatment on the contaminated well. In addition to MTBE, low levels of carbon tetrachloride, barium, nickel, and zinc were detected.

MTBE was the only chemical to exceed a screening level, which was a proposed MCL. None of the other detected chemical levels exceed MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child exceed the DE accepted level of risk.

6.3.1.4 United Water Delaware

The water in this system is treated, finished surface water. The water in this system was found to have the following disinfection byproducts: dibromochloromethane, bromodichloromethane, and chloroform. The individual risk associated with each of these chemicals did not exceed the Delaware accepted risk levels. However, the cumulative human health risk for carcinogenic chemicals for adults for this location was modeled into the yellow ($1x10^{-4}$ to $1x10^{-5}$) range. This is the only location to have exceeded a modeled cancer risk. This is due to elevated levels of THMs.

No other carcinogenic chemicals were detected. No non-carcinogenic chemical levels exceeded MCLs or RBCs. None of the cumulative human health risks for carcinogenic-child or non-carcinogenic-adult and child exceed the DE accepted level of risk. The owners of this facility in conjunction with ODW are investigating possible solutions to the problem, including investigating ways to reduce the TTHM-forming potential of their water.

6.3.1.5 City of Wilmington

The water in this system is treated, finished surface water. This system was found to contain low levels of disinfection byproducts. None of the detected chemical levels exceeded MCLs, RBCs,

or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child exceeded the DE accepted level of risk. The city is reviewing its treatment processes in order to reduce the current levels of TTHMs.

6.3.2 KENT COUNTY

6.3.2.1 Bulldozers Saloon Well 10999

The water in this system is untreated, finished well water. This water system services a transient, non-residential community, as it is associated with a local tavern. Under normal regulatory conditions, this system, since it services a non-residential transient population, would only be monitored for compliance with the total coliform rule and nitrate/nitrite standards. This system was a part of this study due to its proximity to a hazardous waste site location.

Concentrations of MTBE in excess of the proposed 10 µg/L MCL were detected at this location. The owners of this facility in conjunction with ODW are investigating possible solutions to the contamination problem. One possible solution would be to use an alternate water source, either by drilling a new well that is deeper and thus by passing the contamination or by interconnecting with a nearby public water system. Another alternative is to install treatment on the contaminated well. In addition, low levels of dibromochloromethane and bromoform (both of which are THMs), barium, copper, lead, and zinc were detected. The presence of THMs in untreated ground water likely result from the widespread industrial and domestic use of chlorine for cleaning purposes, as well as a drinking water and well disinfectant.

MTBE was the only chemical to exceed a screening level, which was a proposed MCL. No other detected chemical concentrations exceeded MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child exceeded the DE accepted level of risk.

6.3.2.2 Town of Smyrna Well #1 (10068), Well #1A (94795) and Well #2A (85649)

The water in this system is treated, finished well water. This system was found to contain low levels of several disinfection byproducts, TCE, MTBE and dieldrin. None of the detected chemical levels exceeded MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE accepted level of risk. ODW will continue to monitor the levels of these compounds in the drinking water. Dieldrin is an unregulated contaminant (a pesticide) that is prevalent in the environment and EPA has prioritized setting a future MCL for dieldrin.

6.3.3 SUSSEX COUNTY

6.3.3.1 Town of Greenwood Well #1 (34366), Well #3 (72714) and Well #4 (111078)

The water in this system is treated, finished well water. Zinc was detected in the water of this system. Zinc is a secondary contaminant with a recommend level not to exceed 5 mg/L (or 5,000 µg/L). Levels detected were below 4 mg/L. The potential source of the zinc could be the recently installed sampling tap. Delaware ground water, particularly in Kent and Sussex Counties, is acidic, with a low pH. While slightly acidic water does not have a known adverse

health effect, low pH water can leach metals from copper and lead plumbing. Many water systems now adjust their pH in order to minimize this leaching ability, or corrosivity, of the water. The zinc levels reported in this study are not indicative of the water being served to the residents of Greenwood. In addition low levels of some disinfection byproducts, PCE, MTBE and barium were also detected.

None of the detected chemical levels exceeded MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE accepted level of risk.

6.3.3.2 Town of Georgetown Well #1 (10325) and Well #2R (62576)

The water in this system is treated, finished well water. This system was found to contain low levels of some disinfection byproducts and MTBE. Although the elevated level of dibromochloromethane, a THM, was beyond the RBC screening value, the cumulative level of THMs present did not exceed the MCL for the group, which is the primary default safe value. When modeled for human health risk, the individual health risk associated with the level of dibromochloromethane detected did not exceed the DE accepted level of risk. The level of MTBE detected did not exceed MCL, RBC, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE accepted level of risk. ODW will continue to monitor this system for MTBE.

6.3.3.3 Town of Seaford Arbutus Avenue Well (56265), Nylon Avenue Well (10323) and Dulaney Street Well (74465)

The water in this system is treated, finished well water. This system was found to contain low levels of several disinfection byproducts, alachlor, PCE, MTBE, barium and chromium.

None of the detected chemical levels exceed MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE accepted level of risk. ODW will continue to monitor the levels of MTBE in this system.

6.3.3.4 Town of Blades Wells 40024 and 40025

The water in this system is treated, finished well water. This system was found to have very low levels of disinfection byproducts and less than 1 ppb (part per billion) of MTBE. ODW will continue to monitor the levels of MTBE in this system. None of the detected chemical levels exceed MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE accepted level of risk.

6.3.3.5 Holiday Acres Well 77145

The water in this system is treated, finished well water. This system was found to contain low levels of some disinfection byproducts and perchlorate. Although the elevated level of chloroform was beyond the RBC screening value, they did not exceed the MCL as a group.

When modeled for human health risk, the individual health risk associated with each of these chemicals did not exceed the DE accepted level of risk. Also, none of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child exceeded the DE accepted level of risk.

6.3.3.6 Colonial Estates Mobile Home Park Wells 10697 and 179579

The water in this system is untreated, finished well water. This system was found to contain perchlorate, and low levels of zinc and chloroform. Although the elevated level of chloroform, a THM, was beyond the RBC screening value, the level did not exceed the MCL for the group. When modeled for human health risk, the individual health risk associated with the level of chloroform detected did not exceed the DE accepted level of risk. The level of zinc detected did not exceed MCL, RBC, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE accepted level of risk.

6.3.3.7 Savannah Place Wells 69511 and 57474

The water in this system is untreated, finished well water. This system was found to contain elevated nitrates, low levels of disinfection byproducts, lead and zinc. The presence of THMs in untreated ground water likely result from the widespread industrial and domestic use of chlorine for cleaning purposes, as well as a drinking water and well disinfectant.

This system operates two wells that are both contaminated with nitrates. Nitrates are commonly found in ground water due to over-fertilization of lawns and crops, or failing septic systems. The Division of Public Health has been working with all Delaware public water systems over the last five years to remove the nitrates from their respective water systems. Solutions that have been adopted by the various water systems include blending with lower nitrate wells, drilling new deeper wells or installing nitrate removal systems. At this time all community water systems are in compliance with the nitrate standard. ODW was aware of the presence of the nitrate in this water source prior to this study and has been monitoring this water source on a monthly basis to ensure MCL compliance. ODW has recommended the development turn its highest nitrate well off and eventually installing treatment on it. ODW in conjunction with the water source owners are investigating the possibility of interconnecting with the City of Lewes water system for future water service for Savannah Place. Other inorganic compounds found in this system include lead and zinc, both below their respective regulatory levels. The likely source of these later two compounds is the sample tap.

None of the detected chemical levels exceed MCLs, RBCs, or modeled human health risk. None of the cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE accepted level of risk.

6.3.3.8 Donovan/Smith Mobile Home Park Wells 69918 and 99655

The water in this system is untreated, finished well water. This system was found to contain low levels of copper and zinc. The likely source of these compounds is the sample tap. None of the detected chemical levels exceed MCLs, RBCs, or modeled human health risk. None of the

cumulative human health risks for carcinogenic, adult and child, or non-carcinogenic, adult and child, exceeded the DE accepted level of risk.

7.0 CONCLUSIONS

This study was initiated in 2001 following the discovery of BCEE contamination in the Llangollen area of New Castle County. It was designed to determine whether other public drinking water sources were contaminated by hazardous waste sites located within a mile of public drinking water supplies. The study included four New Castle County streams with surface water intakes and 39 public water supply wells located statewide. Untreated water samples were collected from the wellheads or streams directly. Finished water samples were also collected from the distribution systems following treatment. The study assessed the health risk of 188 specific chemical compounds, making it the most comprehensive water study in Delaware history. Of the 188 chemicals, 72 are regulated under the Safe Drinking Water Act and have maximum contaminant levels (MCLs) enforced by the Environmental Protection Agency and DPH Office of Drinking Water.

The results of this project were very positive. The public drinking water supplies located near hazardous waste sites that were sampled as part of this project showed minimal chemical contamination. There were some samples that exceeded MCLs or RBCs in raw, or untreated water, but not in the finished, treated water supplies, which confirms the effectiveness of water treatment methods in delivering safe drinking water to Delawareans.

Upon receipt of the analytical results, DPH evaluated the potential lifetime cancer and adverse health risks associated with consuming water from these sources, using an EPA-accepted method. Finished, or consumed water (treated or untreated) was evaluated. In a few instances, raw ground water is not treated before consumption, and would then be classified as finished water.

Two drinking water wells, Bulldozers Saloon in Smyrna and the Mt. Pleasant Mobile Home Park in Middletown, neither of which receives treatment, slightly exceeded the EPA and State of Delaware *proposed* MCL for MTBE. DPH recommends installing wellhead treatment or replacing the wells to address the problem.

Twenty water sources exceeded either MCLs or risk-based screening levels in raw or untreated water. However, all of the finished (treated) water from these systems was found to be safe for consumption. For the finished water systems, the cumulative cancer and health risks for the chemicals detected were determined to be extremely low and in an acceptable range. In fact, most of the detected compounds in the post-treatment, or finished, samples consisted of disinfection by-products, or THMs. None of the detected concentrations exceeded state or federal standards. It should also be noted that it is widely accepted by EPA and DPH that the benefits of disinfection far outweigh the risks associated with the presence of disinfection by-products.

8.0 REFERENCES

ASTM. 1994. *Toxicological Profile for Methyl-tert Butyl Ether*.

ASTM. 1990. *Toxicological Profile for Bromoform and Chlorodibromomethane*.

ASTM. 1997. *Toxicological Profile for Chloroform.*

DHSS. 2002. *Delaware Regulations Governing Public Drinking Water Systems.* Title 16 Section 122 (3) (c) of the DELAWARE CODE.

DHSS. 2001. *Environmental Health Evaluation Branch, 2001.Information Sheet, Chlorination Disinfection Byproducts: Trihalomethanes.*

DHSS. 2001. *Information Sheet, Chlorination Disinfection Byproducts: Trihalomethanes*.

DNREC. 1996. *Delaware Regulations Governing Hazardous Substance Cleanup*. Title 7 Section 91 of the DELAWARE CODE.

DNREC. 1996. *Standard Operating Procedures for Chemical Analytical Programs Under the Hazardous Substance Cleanup Act*.

DNREC. 1999. *Remediation Standards Guidance Under the Delaware Hazardous Substance Cleanup Act.*

DNREC. 2001. *Analytical Services Quality Assurance Project Plan for Sampling of Public Drinking Water Supply Wells State of Delaware.*

DNREC and DHSS. July 2001. *Drinking Water Sampling and Analysis Plan for Selected Public Drinking Water Systems.*

DNREC. Public Wells Database.

U.S. EPA. 2001. Risk-Based Concentration Table. J. Hubbard, Superfund Technical Support.