Public Health Assessment for

COLONIAL PIPELINE DANIELSVILLE BOOSTER STATION
DANIELSVILLE, MADISON COUNTY, GEORGIA
JUNE 22, 2006

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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PUBLIC HEALTH ASSESSMENT

COLONIAL PIPELINE DANIELSVILLE BOOSTER STATION

DANIELSVILLE, MADISON COUNTY, GEORGIA

Prepared by:

Georgia Department of Human Resources
Division of Public Health
under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

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Glossary of Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CAP	Corrective Action Plan
COC	Contaminants of Concern
CPC	Colonial Pipeline Company
CREG	Cancer Risk Evaluation Guide
CSF	Cancer Slope Factor
CVs	Comparison Values
DBS	Danielsville Booster Station
EPA	United States Environmental Protection Agency
GDPH	Georgia Division of Public Health
IARC	International Agency for Research on Cancer
LOAEL	Lowest Observed Adverse Effects Level
mg/kg/day	milligrams per kilogram per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MCL	maximum contaminant level
MRL	minimal risk level
NOAEL	No Observed Adverse Effects Level
NTP	National Toxicology Program
ppb	parts per billion
ppm	parts per million
PAHs	polycyclic aromatic hydrocarbons
RfD	Reference Dose
RW	residential well
SVOC	semi-volatile organic compound
TPH	total petroleum hydrocarbons
ug/L	micrograms per liter
VOC	volatile organic compound

Summary

Colonial Pipeline Company (CPC) operates two petroleum pipelines that pass through Madison County near Danielsville, GA. The Danielsville Booster Station (DBS) serves one pipeline for transporting diesel fuel, kerosene, and other fuel oils. The Agency for Toxic Substances and Disease Registry (ATSDR) received a request from a concerned citizen to conduct a public health assessment for the community surrounding Colbert Grove Church Road in Danielsville, Madison County, Georgia. Specifically, this request was to address potential exposure to petroleum contamination from Colonial Pipeline Company's Danielsville Booster Station leak site near Colbert Grove Church Road. Residents living near the Danielsville Booster Station (DBS) have expressed concern about petroleum contamination underlying the booster station and surrounding area. Working in partnership with the ATSDR, the Georgia Division of Public Health was asked to evaluate these concerns regarding exposure to petroleum hydrocarbons.

This public health assessment contains information about the extent of contaminated, groundwater, soil, and surface water, and conclusions about the health risks posed to the public. A public health assessment is specifically designed to provide information about the public health implications of a specific site and to identify populations for which further health actions or health studies are needed. It is not intended to serve the purpose of or influence any other environmental investigation such as risk assessment or selection of remedial measures, or to address liability or other non-health issues.

GDPH has determined that this site poses **no apparent public health hazard**. Human exposure to contaminated media occurred in the past, but the exposure was below a level of health hazard. Remediation at the site is on-going and all exposure pathways have been eliminated.

Recommendations include continual monitoring of residential wells in the area in accordance with the Georgia Environmental Protection Division's approved Correction Action Plan, semi-annual monitoring of the bedrock and saprolite aquifer plumes in accordance with the Correction Action Plan, continuing remediation measures undertaken at the DBS site and monitoring the effectiveness of such remediation actions, and now that municipal water is available to residents in the Colbert Grove Church Road area, residents should hook up to the municipal water source for their household use. If additional data become available, the information will be reviewed by GDPH, and appropriate actions will be taken.

Statement of Issues

The Agency for Toxic Substances and Disease Registry (ATSDR) received a request from a concerned citizen to conduct a public health assessment for the community surrounding Colbert Grove Church Road in Danielsville, Madison County, Georgia. Specifically, this request is to address potential exposure to petroleum contamination from Colonial Pipeline Company's Danielsville Booster Station leak site near Colbert Grove Church Road. (Figures 1, 2). Residents living near the Danielsville Booster Station (DBS) have expressed concern about petroleum contamination underlying the booster station and surrounding area. Working in partnership with the ATSDR, the Georgia Division of Public Health was asked to evaluate resident's concerns regarding the petroleum leak at the DBS.

In response, GDPH reviewed residents' concerns, health outcome data, and environmental sampling data to assess whether exposure to contaminated groundwater has occurred, is occurring, or may occur at levels of health concern. The purpose of this public health assessment is to evaluate whether exposure to petroleum contamination from the DBS could represent a health hazard to children and other residents living near the DBS.

Background

Site Description and History

Colonial Pipeline Company (CPC) operates interstate pipelines transporting refined petroleum products from Texas and Louisiana to locations throughout the southeast and eastern seaboard. Two of these petroleum pipelines pass through Madison County near Danielsville, GA. The Danielsville Booster Station (DBS) is located approximately 2.2 miles southwest of Danielsville, approximately 1000 feet east of U.S. Highway 29 and approximately 1500 feet northeast of Colbert Grove Church Road. The site is located on a hilltop and is surrounded by gently rolling hills covered with hardwood and pine forests and open fields. [1]

Constructed in 1963, the DBS consists of four large booster pumps with associated valves and controls. Other structures on the DBS property are a control building, a 625-barrel utility tank, an oil-water separator, a retention pond, a septic tank system, and a water supply well. A 36-inch pipeline was also constructed in 1963 and used to transport diesel fuel, kerosene, other fuels oil, and gasoline from 1963 until 1979. A 40-inch pipeline was added in 1979 and is used to transport gasoline. Currently, the DBS only serves the 36-inch pipeline for transporting diesel fuel, kerosene, and other fuel oils.

This photo was taken at the entrance gate to the Danielsville Booster Station. Note the periphery fencing surrounding the facility extends at least 100 yards from operational equipment and also serves to keep out trespassers. Petroleum contamination around the DBS yard has remained relatively constant from 1995 to 2003, but the levels are decreasing in some of the saprolite monitoring wells on the property.

The water supply well at the DBS is constructed with a 6-inch steel casing from the ground surface to a depth of 18 feet. The well is 276 feet deep and has an open interval from the bottom of the 6-inch casing to the bottom of the well [1].

Seven known releases of petroleum products have occurred at the DBS including the release that this public health assessment concerns. The following is a summary of known information concerning each of the prior releases at the DBS [1]:

- 1966 - release of unknown product type, unknown origin
- 1975 - fuel oil release from tubing in DBS yard
- 1975 - Gasoline release from tubing in DBS yard
- 1977 - gasoline release from valve in DBS yard
- 1977 - second gasoline release from a valve in the DBS yard
- 1979 - hydraulic oil released from central hydraulic system in DBS yard

In December 1994, petroleum odors were noticed in the DBS water supply well. CPC personnel sampled the water supply well and five residential wells located adjacent to the DBS. The samples were analyzed for BTEX (benzene, toluene, ethyl benzene, and xylene) and TPH (total petroleum hydrocarbons). No evidence of these petroleum constituents was found in the residential wells. However, benzene, toluene, ethyl benzene, and xylenes were found in the DBS water supply well at concentrations of 58 micrograms per liter (ug/l), 19 ug/l, 240 ug/l, and 120 ug/l, respectively [1]. Benzene was the only constituent above the U. S. Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL1) for benzene of 5 ug/l.

In January 1995, CPC's environmental contractor conducted a residential well survey in the site area. Initially, the survey identified 66 residential water wells within a 0.5 mile radius of the site. During subsequent residential well sampling, CPC discovered that in many instances, several residences are connected to the same well. A door-to-door survey of the area revealed that there were approximately 50 residential wells within a 0.5 mile radius of the site (Figure 2) [1].

In June 1995, a resident living approximately 1000 feet northeast of the DBS noticed that his water supply had an unusual odor (residential well 00, RW-00). The resident contacted the Madison County Health Department which collected three samples from the resident's well. On June 27, 1995, the Georgia Environmental Protection Division (GEPD) notified CPC that BTEX compounds had had been detected in water samples collected from RW-00. CPC responded on June 28, 1995 and began to investigate the DBS station site [1].

From June 29 through July 6, 1995, CPC sampled an additional 26 residential wells in the vicinity of the DBS. The 26 property owners were interviewed to gain additional information on well construction and water quality. Petroleum constituents were not detected in any of the 26 residential wells sampled [1].

Site assessment activities began in September 1995. Monthly sampling of selected residential wells in the vicinity of the DBS was initiated as part of the site assessment. On December 16, 1995, BTEX compounds were detected in another residential well (RW-10), located approximately 1000 feet northeast of the DBS. Benzene was detected at 21 ug/l, and ethyl benzene and naphthalene were detected at 4.9 and 2.5 ug/l (below MCLs); respectively.
The following additional residential wells have been contaminated with petroleum constituents (all of them are drilled wells in the bedrock aquifer):

- July 1996, RW-74 located approximately 1600 feet east of the DBS (below MCL).
- August 1996, RW-37 located approximately 2200 feet east of the DBS.
- September 1999, RW-78 located approximately 2400 feet southeast of the DBS (below MCL).
- September 2001, RW-79 located approximately 2600 feet southeast of the DBS.

Natural Resources Use

Several surface water features exist near the DBS site. The primary surface water features are the South Fork Double Branch Creek and the South Fork Broad River located approximately 3000 feet north and northeast of the site. Unnamed tributaries to the South Fork Double Branch

1 Maximum Contaminant Level (MCL) – The highest level of a contaminant that is allowed in drinking water. MCLs are enforceable standards. http://www.epa.gov/OGWDW/mcl.html#mcls

Creek are located west and east of the site and feed the South Fork Double Branch Creek, which in turn, drains into the South Fork Broad River. Three small man-made ponds are situated approximately 1600 feet east of the site (Figure 2). These ponds are fed by natural springs and discharge into the eastern unnamed tributary of the South Fork Double Branch Creek [1].

Historically, groundwater use in the vicinity of the DBS site was limited to private residential wells. To date, CPC has identified approximately 180 residential wells within a one-mile radius of the DBS. Forty-seven are drilled wells into the bedrock aquifer and 133 are shallow (water-table wells), bored or dug wells in the saprolite aquifer [2]. Twenty-six wells (18 drilled, 8 bored) were converted to monitoring wells where CPC purchased the property. The Madison County Industrial Development Authority negotiated an extension of a municipal water line to the Colbert Grove Church Road community with CPC in 2001. CPC agreed to fund most of the costs associated with this waterline extension project. Construction of the water extension line began in early 2005. As of November 2005, 59 residences in the area have been connected to public water [3].

The city of Danielsville maintains three public water supply wells. Two of these wells are within the city limits of Danielsville. The third is approximately 0.5 miles southwest of the city limits, although it is not used because of high iron concentrations [1].

Site Geology and Hydrogeology

Three distinct lithologic (rock formation) zones exist below the DBS and surrounding vicinity: the soil and saprolite (disintegrated rock), partially weathered bedrock, and competent bedrock layer. The transition between zones is generally gradual. Laterally discontinuous layers of low-permeability material (competent bedrock or very hard saprolite) exist above the actual bedrock. Soft weathered soil and saprolite may be found below the resistant layers. The resistant layers in the saprolite may act as local confining layers, resulting in a localized perched aquifer above the layer. The shallow saprolite aquifer is contiguous across the DBS site but groundwater flow may be obstructed by laterally discontinuous low-permeability layers [4].

Petroleum released at the DBS infiltrated through the soil and into the shallow, saprolite aquifer. Local preferential pathways and groundwater gradients caused the petroleum to slowly seep into the bedrock aquifer. The saprolite layer acts as a storage medium and allows recharge into the bedrock aquifer in the area of the DBS [4].

The petroleum plume in the saprolite did not migrate very far because of the relatively low concentrations of toxic chemicals in the products released, allowing petroleum tolerant microorganisms to thrive and biodegradation to occur. This plume has reached a state of equilibrium and has been naturally attenuating (through adsorption, dispersion, and biodegradation) at a rate fast enough to prevent significant migration of the plume (Figure 3) [4].

The DBS water supply well may have acted as the primary conduit for contaminants to enter the bedrock aquifer, although there is also a natural hydraulic connection and downward gradient between bedrock and saprolite aquifer. Some contaminants migrated into the bedrock aquifer because the DBS well was constructed with a shallow surface casing and is open hole for the majority of its depth. In addition, geophysical logging revealed that the surface casing was deteriorated (corroded iron) or missing and an open interval existed across the shallow saprolite aquifer.

Use of the DBS well for pipeline operations caused a cone of depression[2] around the well. The water levels in the DBS well were reduced to levels below the original shallow, saprolite aquifer and contaminated water entered the well from the saprolite aquifer during pumping. Downward flows in the DBS well may have caused the petroleum to be spread to deeper fractures in the bedrock and eventually to migrate off-site. In April 1996 a packer was installed in the DBS well to isolate the pumping zone and prevent migration of hydrocarbons from the saprolite aquifer into the bedrock aquifer through the station well. The DBS well was permanently abandoned in June 2002 to eliminate this contamination pathway [4].

Groundwater in the bedrock recharges at the DBS yard and in an area located approximately 800 feet south of the DBS (non-contaminated recharge) and flows radially towards the unnamed tributaries of the South Fork Double Branch Creek. Strong upward flows of groundwater are located near the tributaries. The plume in the bedrock reaches its limits at the unnamed tributaries under static conditions. Where pumping continues, the plume has been drawn across the boundary in the past. However, major creeks and streams (South Fork Double Branch Creek) appear to be strong flow boundaries where residential pumping has less of an effect [4]. Residential pumping appears to be a major controlling factor for plume migration in the bedrock aquifer.

Demographics

The population within one mile of the DBS is approximately 374 people. Using 2000 U.S. Census data, the Agency for Toxic Substances and Disease Registry (ATSDR) calculated population information for individuals living within a 1-mile radius of the DBS (Figure 1).

Community Health Concerns

On August 2, 2005, GDPH participated as panelists in a public meeting at the Danielsville City Hall concerning the DBS site. Also in attendance were Dr. Frank Bove, an epidemiologist with the ATSDR, Dr. Louis Kudon of the Georgia Northeast Health District, Dr. Ray MacNair of the University of Georgia, and two representatives of the GEPD Northeast District Office. The purpose of the public meeting was to gather health-related concerns from residents regarding exposure to petroleum contaminated groundwater. Representatives on the panel responded to inquiries regarding well water testing, the potential for benzene exposure, and cancer risks of benzene exposure. Approximately 30 residents and two Madison County officials attended the session. The health concerns gathered during these sessions are addressed in the Discussion section of this document.

Health Outcome Data

In July 2005, the GDPH Cancer Control Section analyzed current (1999-2002) cancer incidence data available for the 30633 zip code (Danielsville). Zip code areas are the smallest geographic units for which data are available. Analysis of a distribution of cancer cases in the 30633 zip code show that no cancer clusters and no significant numbers of cancer cases have been reported (Appendix A). No other health outcome data such as mortality or birth defects were evaluated. No site-specific health outcome data related to this site exists.

2 When pumping begins, the water level in the well progressively drops until an equilibrium is reached. Outside the well, the potentiometric (water flows from higher levels of potential to lower levels of potential) surface forms what is called a cone of depression. The cone progressively expands until an equilibrium is reached where net recharge to the aquifer equals discharge from the well [R.W. Cleary, *The Princeton Groundwater Pollution and Hydrology Course Manual*, February 2005.] Recharge comes from the contaminated shallow, saprolite aquifer and petroleum contaminants are transported into the deep, bedrock aquifer.

Discussion

Environmental Sampling Data

Ongoing investigations have been conducted at the DBS site and surrounding community since 1995 to characterize the extent of contamination released to environmental media (soil, groundwater, and surface water) from the site. Available data include groundwater samples collected from shallow saprolite monitoring and residential wells in the area and deep bedrock monitoring and residential wells in the area. Subsurface soil samples were collected from soil borings taken underneath the DBS yard, and surface water samples were collected from 21 locations along the two unnamed tributaries of the South Fork Double Branch Creek.

Pathway Analysis

GDPH identifies pathways of human exposure by identifying environmental and human components that might lead to contact with contaminants in environmental media (e.g., air, soil, groundwater). A pathways analysis considers five principle elements: a source of contamination, transport through an environmental medium, a point of exposure, a route of human exposure, and a receptor population. Completed exposure pathways are those in which all five elements are present, and indicate that exposure to a contaminant has occurred in the past, is presently occurring, or will occur in the future. GDPH regards people who come into contact with contamination as exposed. For example, people who reside in an area with contaminants in air, or who drink water known to be contaminated, or who work or play in contaminated soil are considered to be exposed to contamination. Potential exposure pathways are those for which exposure seems possible, but one or more of the elements is not clearly defined. Potential pathways indicate that exposure to a contaminant could have occurred in the past, could be occurring now, or could occur in the future. However, key information regarding a potential pathway may not be available. It should be noted that the identification of an exposure pathway does not imply that health effects will occur. Exposures may, or may not be substantive. Thus, even if exposure has occurred, human health effects may not necessarily result [5].

GDPH reviewed the site's history, community concerns, and available environmental sampling data. Based on this review, GDPH identified an exposure pathway that warranted consideration. The completed and potential exposure pathways identified for the DBS site are discussed in the following sections.

Evaluation Process

For each environmental medium; GDPH examines the types and concentrations of contaminants of concern (COCs). In preparing this document, GDPH used the ATSDR comparison values, and other agencies' reference values, to screen contaminants that may warrant further evaluation. Comparison values (CVs) are concentrations of contaminants that can reasonably (and conservatively) be regarded as harmless, assuming default conditions of exposure. The CVs generally include ample safety factors to ensure protection of sensitive populations. Because CVs do not represent thresholds of toxicity, exposure to contaminant concentrations above CVs will not necessarily lead to adverse health effects. CVs and the evaluation process used in this document are described in more detail in Appendix B. GDPH then considers how people may come into contact with the contaminants. Because the level of exposure depends on the route and frequency of exposure and the concentration of the contaminants, this exposure information is essential to determine if a public health hazard exists.

The contaminants identified for the completed exposure pathway are discussed in the following sections and presented in Table 2. Other contaminants not exceeding CVs were reviewed, but not selected for additional evaluation in this assessment. The tables also include the chemical-specific CVs, which GDPH considered in the selection process.

Exposure to site related contaminants at the DBS site could occur through three routes: ingestion, inhalation, and dermal adsorption of petroleum contaminated groundwater. Ingestion is defined as *direct ingestion* or actively drinking water. However, it is important to note that the other routes of exposure; inhalation of vapors into the lungs, and direct skin contact (dermal absorption), may contribute additional exposure to contaminants at this site.

At the DBS site, exposure to contaminated bedrock groundwater is the only exposure pathway that encompasses the five principal elements of a completed exposure pathway: a source of contamination, transport through an environmental medium, a point of exposure, a route of human exposure, and a receptor population.

Exposure Pathways

Completed Exposure Pathway

Table 1: Completed Potential Exposure Pathway

Pathway	Exposure Pathway Elements					Time
	Source	Transport	Point of Exposure	Route of Exposure	Exposed Population	
Drinking water	Movement of contaminants from the Danielsville Booster Station	Bedrock Groundwater	Residential taps served by bedrock well water	Ingestion Inhalation Dermal	Residents using well water as water supply source	Past Future

Bedrock Aquifer

In June 1995, a resident located approximately 1000 feet northeast of the DBS noticed that his water supply had an unusual odor (residential well 00, RW-00). Analytical results revealed that a sample collected at the well head contained benzene at a concentration of 65 ug/l, a sample collected outside the residence prior to the water filter, contained benzene at a concentration of 318 ug/l, and a sample collected at the kitchen sink after the water filter, contained benzene at a concentration of 24 ug/l. Each of the samples collected also contained traces of ethyl benzene, xylenes, and naphthalene; however, none were above the MCL. No other volatile organic compounds (VOCs) or polycyclic aromatic hydrocarbons (PAHs) were detected in the samples [1]. Additional samples were collected from RW-00 and analyzed for VOCs, semi-volatile organic compounds (SVOCs), and for total lead. The analytical results showed that benzene was detected at 360 ug/l [1].

On December 16, 1995, BTEX compounds were detected in another residential well (RW-10), located approximately 1000 feet northeast of the DBS. Benzene was detected at 21 ug/l, and ethyl benzene and naphthalene were detected at 4.9 and 2.5 ug/l (below MCLs); respectively.

The following additional residential wells have been contaminated with petroleum constituents (all of them are drilled wells in the bedrock aquifer):

- July 1996: RW-74 located approximately 1600 feet east of the DBS
- August 1996: RW-37 located approximately 2200 feet east of the DBS
- September 1999: RW-78 located approximately 2400 feet southeast of the DBS
- September 2001: RW-79 located approximately 2600 feet southeast of the DBS

Table 2 summarizes historical sampling data for all wells in which exposure occurred in the past.

Table 2: Summary of off-site residential well water sampling results

Residential Well	Contaminant	No. of Samples	Range of Concentrations (ppb)	Health-Based Comparison Value ppb	Type of CV
RW-00	Benzene	16	9.6 to 360	0.6	CREG
RW-10	Benzene	30	ND to 81	0.6	CREG
RW-37	Benzene	26	ND to 49	0.6	CREG
RW-78	Benzene	37	ND to 3.6	0.6	CREG
RW-79	Benzene	26	ND to 5.7	0.6	CREG

ND: non-detect
ppb: parts per billion
CREG: Cancer Risk Evaluation Guide
Source: ATSDR drinking water comparison values

Twenty-eight bedrock monitoring wells have been installed at the DBS (Figures 3, 4, and 5). In addition, 32 drilled residential wells have been sampled periodically from 1995 through 2005. BTEX and PAHs have been detected in the DBS yard and as far away as 1000 feet north and northeast of the DBS yard. Benzene and ethyl benzene have been detected in the bedrock aquifer as far as 2200 feet east of the DBS yard. Benzene has been detected as far as 2600 feet southeast of the DBS yard at RW-79. Benzene is the only petroleum contaminant detected in the bedrock aquifer above the MCL. The highest benzene concentration found was 2900 ug/l, in a monitoring well located at the DBS yard [6].

Packer tests (isolating specific sections of a bedrock borehole) conducted at the DBS well and RW-00 showed that BTEX and PAHs were vertically distributed throughout the entire bedrock (100-300 feet) interval at each location, with the highest benzene concentration generally occurring at the greatest depth.

The BTEX concentrations in and around the DBS yard remained relatively constant from 1996 to 2003. However, since December 2003 there has been a noticeable decrease in benzene concentrations in the bedrock monitoring wells historically exhibiting the highest concentrations. There has been some indication of a reduction in benzene migration and changes in plume shape along the eastern margin in response to various wells being shut down. One example of this is the presence of benzene in a bedrock monitoring well approximately 1800 feet east of the DBS for the first time in November 2001, and consistently since, after a nearby bedrock monitoring well approximately 2000 feet southeast of the DBS was shutdown in March 2001 [2]. Benzene plume maps of the bedrock submitted to EPD demonstrate a reduction in the eastern extent of the plume from May 2003 through December 2005 in response to pumping of recovery wells.

Actions Taken to Reduce Exposures to Petroleum Contaminants in Residential Wells

Once petroleum was discovered in RW-00, CPC moved the residents into temporary accommodations on June 28, 1995. During that time, CPC arranged for a water treatment system to be installed on their residential well [1]. Residents were moved back on July 8, 1995 when installation of the water treatment unit was completed. The water treatment system consisted of carbon filtration to remove petroleum constituents from the water combined with ultra-violet radiation for sanitation. Samples were collected from the treated water and analyzed for BTEX compounds. No BTEX was detected in the treated water samples. In addition, CPC also supplied the residents with bottled water for drinking. In November 1995, CPC purchased this property and converted the residential well into a groundwater monitoring well (RW-00).

Monthly sampling of selected residential wells in the vicinity of the DBS was initiated as part of the site assessment in September 1995. When petroleum contamination was discovered in a second residential well (RW-10) in December 1995, CPC removed the water treatment system from the property where RW-00 is located, and installed it on the property where RW-10 is located. This residence was also supplied with bottled water immediately after BTEX compounds were found in their water supply. Samples were collected from the treated water and analyzed for BTEX compounds. No BTEX compounds were detected in samples collected from the water treatment system. Samples were then collected weekly from the treatment system to ensure that it was operating efficiently [1]. This property was subsequently purchased by CPC.

Upon the subsequent detection of petroleum constituents at each location, CPC immediately provided bottled drinking water, installed whole house water treatment systems, and subsequently purchased all properties where contamination was found except where RW-79 is located [2]. CPC installed a shallow bored well for these residents's use at this location. In addition, CPC purchased another 20 properties in the Colbert Grove Church Road community in an effort to maximize monitoring and remediation of the plume and to prevent human exposure to petroleum contamination. Furthermore, municipal water lines have been extended to residents of the Colbert Grove Church Road community for their voluntary hook-up to a municipal source of water.

<u>Remediation of Dissolved Petroleum Compounds</u>

In August 1996, pumping of the DBS water supply well (as modified with packer) and the RW-00 residential well began to recover contaminated water from the bedrock aquifer. Contaminated water was treated using an air stripper and discharged to a tributary of the South Fork of the Double Branch Creek in accordance with a GEPD Consent Order [7]. The DBS well was pumped continuously from August 1996 to December 1998. RW-00 was pumped continuously for 15 minutes every 6 hours at a rate of 10-12 gpm, to mimic residential use. The DBS water supply well was shut down at the end of November 1998 for an evaluation period before being permanently abandoned in June 2002. Bedrock pumping was resumed from two other bedrock monitoring wells from June 2000 through the middle of February 2003. Over 12 million gallons of contaminated groundwater were recovered from the bedrock aquifer between December 1996 and February 2003. In February 2003, CPC began the installation of an expanded pump and treat remediation system for the bedrock aquifer. This system consists of nine recovery wells. The system was started on April 8, 2003 and continues operating to present. The capture zone (cones of depression) created by the remediation system further reduces groundwater flow away from the station, thus minimizing the migration of hydrocarbons from the source area to surrounding vicinity. Of particular note, the eastern leg of the bedrock plume has receded to a point approximately 1200 feet east of the DBS underneath property now owned by CPC. The northern leg of the bedrock plume extends approximately 1600 feet from the DBS. As of May 2005, the extent of benzene contamination in the bedrock aquifer (to the MCL of 5 ug/l) measures approximately 1900 feet in an east-west direction and approximately 2000 feet in a north-south direction (Figure 6). More importantly, the extent of the contamination underlies an area where no one is currently residing.

Remediation of Free-Phase (Pipeline) Product

In September 1995, free-phase/free product was discovered floating in the DBS water supply well and measured approximately 2.4 feet thick. To remove free product from the well, CPC installed a skimmer pump for a period of about 3 months. Approximately 20 gallons of free-phase product, which had an odor and consistency of weathered diesel fuel or kerosene, was recovered and the thickness was reduced to 0.02 feet after 3 months of recovery [1]. Free-phase product was detected early in the investigation in five shallow monitoring wells underneath the DBS yard at a thickness generally less than 0.1 feet, however, free-phase product has not been detected in any monitoring well since May 2004. The product is a mixture of kerosene, fuel oil, and gasoline. No free-phase product has been detected in other monitoring wells for the past several years. The relatively low concentrations of dissolved benzene that detected in these wells are consistent with a free-phase source, which has a low percentage of gasoline [2]. The extent of free product at the site has been shown to be contained within the general limits of the DBS yard.

Potential Exposure Pathways

Surface Water

Seven samples were collected from surface water bodies in the vicinity of the DBS in July 1995, and analyzed for BTEX, MTBE (methyl tertiary-butyl ether), and naphthalene. Benzene was detected in unnamed tributary of the South Fork Double Branch Creek at a concentration of 1.5 ug/l approximately 600 feet west of the DBS. Toluene was detected in the same unnamed tributary at a concentration of 31 ug/l approximately 400 feet southwest of the DBS. No other BTEX compounds were detected in these samples. Furthermore, no BTEX compounds were detected in any of the other surface water samples collected [1].

Surface water samples have been periodically from 1995 to 2005 and collected from 21 locations along the two unnamed tributaries of the South Fork Double Branch Creek (Figure 6). There are no significant impacts to surface water. Benzene is the only petroleum compound that has been detected. Benzene was detected in 4 of 18 samples from an unnamed tributary of the South Fork Double Branch Creek approximately 500 feet west of the DBS at a concentration of 1-4 ug/l, which is below the MCL of 5 ug/l. However, benzene has not been detected at this location since March 2003. This tributary is a very narrow and shallow body of water. Although it is possible that this tributary can be crossed on-foot, recreational activities such as wading and swimming are unlikely.

Shallow/Saprolite Aquifer

Twenty-six monitoring wells were installed in the saprolite at and around the DBS yard from September to November 1995 (Figure 3). BTEX and PAHs have been detected in the DBS yard. Benzene is consistently found in nine or ten of the 26 shallow saprolite monitoring wells at a concentration ranging from 10-1000 ug/l. The dissolved benzene plume has been defined as largely confined to the station yard. The benzene plume in the shallow saprolite aquifer is in equilibrium: the concentrations and plume size have remained relatively constant from 1995 to 2005. However, there is an apparent trend of decreasing benzene concentrations in some of the saprolite monitoring wells. **To date, no petroleum hydrocarbons have been detected in any bored (shallow) residential wells in the area** [2].

Eliminated Exposure Pathway

Soil

Thirty-eight soil borings were extracted at the DBS yard from September through November 1995. Fifty-two samples were submitted for BTEX and PAH analysis. BTEX compounds were detected in eight samples and PAH compounds were detected in 9 samples. Benzene (detected in 3 of 52 samples) was the only compound that was detected above applicable GEPD Underground Storage Tank soil threshold limits of 5 micrograms per kilogram (ug/kg). The highest benzene concentration, 21 ug/kg, was detected in a sample collected 13-15 feet below ground level directly under the center of the DBS yard. However, no benzene was detected in a sample collected 28-30 feet below ground level at the same location. The next highest benzene concentration, 6.2 ug/kg, was collected at a depth of 29-31 feet below ground level, also located underneath the DBS yard [1, 2]. None of the soil samples analyzed contained toluene, ethyl benzene, xylenes, or PAHs in excess of GEPD's soil threshold limits [2].

All of the soil samples collected were subsurface samples underneath the DBS operational equipment platform. Perimeter fencing, which is gated and locked to keep out trespassers, also surrounds the entire DBS yard. Because of the fencing and subsurface location of petroleum contamination, this potential pathway is incomplete.

Toxicological Evaluation

When a contaminant exceeds a CV, the toxicological evaluation presented requires a comparison of calculated site-specific exposure doses (e.g., amount of the contaminant believed to enter the body at the person's body weight for an estimated duration of time) with an appropriate health guideline. The health guidelines are health-protective values that have incorporated various safety factors to account for varying human susceptibility. These guidelines are developed using human exposure data when it is available and animal data when human exposure data is not available. Health guidelines used are ATSDR's Minimal Risk Levels (MRLs). MRLs are described in more detail in Appendix B. Usually little or no information is available for a site to know exactly how much exposure is actually occurring, so in some cases, health assessors assume worse case scenarios where someone received a maximum dose. As a result, actual exposure is likely much less than the assumed exposure. In the event that the calculated, site-specific exposure dose for a chemical is greater than the established health guideline, it is then compared to exposure doses from individual studies documented in the scientific literature that have reported health effects. If a contaminant has been determined to be cancer causing (carcinogenic), a cancer risk is also estimated [5] (Appendix B).

Using residential well sample results from the DBS site, exposures were evaluated to determine the likelihood of adverse health effects. Estimated exposure doses were calculated for adults and children based on the highest concentrations of benzene found above the health-based comparison value for benzene detected in each residential well. This is considered the most conservative approach to estimating exposure levels. However, as is true with most sites, assuming use of the maximum concentration is not reasonable; therefore, any conclusions based on a highly exposed person should be viewed as an overestimation of true risk.

For this evaluation, long-term, chronic exposure was not considered. Upon the discovery of petroleum contamination in the DBS water supply well, the sampling of the five nearest residential wells adjacent to the DBS site was initiated immediately and no petroleum contamination was found in these wells. A residential well survey of all wells within a half-mile radius of the site was conducted and a sampling program was initiated. Petroleum contamination was discovered in the first residential well about six months after contamination of the DBS water supply well was confirmed. This discovery was made by this resident noticing odors and an off-taste in his water supply, not because of investigative sampling. Although there is no evidence that this resident was exposed for a longer period than assumed for the purposes of this public health assessment, the length of exposure cannot be made with any certainty. However, based on the migration rate of petroleum hydrocarbons in the bedrock aquifer, and because of the residential well sampling regimen ensued after the discovery of petroleum contamination at the DBS site, it is likely that exposure could not have technically occurred more than six months, and likely no more than a few days or a month. Therefore, the effects of intermediate exposure (15-364 days) were considered for this public health assessment. For the purpose of this public health assessment, exposures were assumed to occur 7 days a week. Adults were assumed to drink two liters of water per day, and children were assumed drink one liter of water per day. Bathing was also assumed to be a daily activity, so GDPH assumed that exposure doses for dermal contact and for inhalation were equal to those from ingestion of contaminants in water. Potential adverse health effects from intermediate exposure will be considered in this discussion.

The only contaminant of concern detected in off-site residential wells was benzene. Levels of other chemicals were detected below MCLs and are, therefore; not of public health concern. Using the above assumptions, calculated exposures doses resulting from ingestion, inhalation, and dermal contact with benzene from the five residential wells known to be contaminated are presented in Table 3.

Table 3: Calculated doses from exposure to bedrock groundwater contaminated with benzene

Contaminant	Total Estimated Dose mg/kg/day	Health Guideline mg/kg/day	Numeric Cancer Risk
Benzene RW-00	Adult: 0.02 Child: 0.03	0.004	7.86×10^{-6}
Benzene RW-10	Adult: 0.005 Child: 0.0065	0.004	2.83×10^{-7}
Benzene RW-37	Adult: 0.003 Child: 0.004	0.004	1.07×10^{-6}
Benzene RW-78	Adult: 0.0002 Child: 0.0003	0.004	8.73×10^{-8}
Benzene RW-79	Adult: 0.0003 Child: 0.0005	0.004	1.31×10^{-7}

Non-cancer Health Effects

RW-00

The site-specific child and adult exposure doses calculated using the highest (360 ppb) benzene concentration measured in drinking water are 0.03 and 0.02 milligrams per kilogram per day (mg/kg/day), respectively. Because the estimated exposure doses for children and adults exceed the health guideline of 0.004 mg/kg/day for benzene, the possibility of health consequences was evaluated further.

To further evaluate the possibility of adverse health effects, GDPH divides the lowest observed adverse effect level (LOAEL) and/or the no observed adverse effect level (NOAEL) by the site-specific exposure doses. The LOAEL and NOAEL can be found in the Toxicological Profile for Benzene published by ATSDR and are based on animal and/or human studies, if available [8]. Interpretation of the resulting value is subjective and depends on a host of toxicological factors. Further evaluation consists of a careful comparison of site-specific exposure doses and circumstances with the epidemiologic and experimental data on the chemical. The purpose of the comparison is to evaluate how close the estimated exposure doses are to doses that cause health effects in humans or animals.

The estimated exposure dose for adults of 0.02 mg/kg/day is 50 times lower than the NOAEL of 1 mg/kg/day for benzene. The estimated exposure dose for children of 0.03 mg/kg/day is approximately 33 times lower than the NOAEL of 1 mg/kg/day for benzene. Although estimated exposure doses are many times lower than the NOAEL, but less than 100 times lower, GDPH further evaluated the possibility of benzene to cause harmful effects in children and adults.

The benzene health guideline is based on the results of oral studies conducted on animals exposed to benzene over an intermediate period (15-364 days). Adverse effects observed were decreased numbers of red blood cells and white blood cells of test animals at the lowest doses tested (approximately 1-10 mg/kg/day); 8 mg/kg/day appeared to be the boundary at which effects began to be observed (LOAEL)[8]. The estimated exposure dose for adults of 0.02 mg/kg/day is 400 times lower than the LOAEL of 8 mg/kg/day for benzene. The estimated exposure dose for children of 0.03 mg/kg/day is approximately 267 times lower than the LOAEL of 8 mg/kg/day for benzene. Therefore, GDPH concludes that adverse (non-cancer) health effects are not likely in children and adults exposed to the highest benzene concentration detected in this residential well water. Moreover, given the conservative assumptions made to estimate this dose, and knowing that the concentration of benzene in tap water in this residence measured 24 ug/l (instead on the 360 ug/l concentration used to estimate exposure dose), this conclusion most likely overestimates the true likelihood of harm to residents at this site.

RW-10

The site-specific child and adult exposure doses calculated using the highest (81 ppb) benzene concentration measured in drinking water 0.0065 and 0.005 milligrams per kilogram per day (mg/kg/day), respectively. Because the estimated exposure doses for children and adults exceeds the health guideline of 0.004 mg/kg/day for benzene, the possibility of health consequences was evaluated further.

The estimated exposure dose for adults of 0.005 mg/kg/day is 200 times lower than the NOAEL of 1 mg/kg/day for benzene. The estimated exposure dose for children of 0.0065 mg/kg/day is approximately 154 times lower than the NOAEL of 1 mg/kg/day for benzene. Furthermore, the doses for adults and children are over 1000 times lower than doses know to cause adverse health effects in animal studies (8 mg/kg/day). Therefore, GDPH concludes that adverse (non-cancer) health effects are not likely in children and adults exposed to the highest benzene concentration detected in this residential well water.

<u>RW-37</u>

The site-specific child and adult exposure doses calculated using the highest (49 ppb) benzene concentration measured in drinking water 0.004 and 0.003 milligrams per kilogram per day (mg/kg/day), respectively. Because the estimated exposure doses for children equals the health guideline for benzene of 0.004 mg/kg/day and adults are very close to this health guideline, the possibility of health consequences was evaluated further

The estimated exposure dose for adults of 0.003 mg/kg/day is 333 times lower than the NOAEL of 1 mg/kg/day for benzene. The estimated exposure dose for children of 0.004 mg/kg/day is approximately 250 times lower than the NOAEL of 1 mg/kg/day for benzene. Furthermore, the doses for adults and children are over 1000 times lower than doses know to cause adverse health effects in animal studies (8 mg/kg/day). Therefore, GDPH concludes that adverse (non-cancer) health effects are not likely in children and adults exposed to the highest benzene concentration detected in this residential well water.

<u>RW-78</u>

The site-specific child and adult exposure doses calculated using the highest (3.6 ppb) benzene concentration measured in drinking water 0.0003 and 0.0002 milligrams per kilogram per day (mg/kg/day), respectively. Because the estimated exposure doses for children and adults are approximately 10 times lower than the health guideline of 0.004 mg/kg/day, health consequences will not evaluated further. GDPH concludes that adverse (non-cancer) health effects are not likely in children and adults exposed to the highest benzene concentration detected in this residential well water.

<u>RW-79</u>

The site-specific child and adult exposure doses calculated using the highest (5.7 ppb) benzene concentration measured in drinking water 0.0005 and 0.0003 milligrams per kilogram per day (mg/kg/day), respectively. Because the estimated exposure doses for children and adults are approximately 10 times lower than the health guideline of 0.004 mg/kg/day, health consequences will not evaluated further. GDPH concludes that adverse (non-cancer) health effects are not likely in children and adults exposed to the highest benzene concentration detected in this residential well water.

Cancer Health Effects

The International Agency for Research on Cancer [9], the EPA, and the National Toxicology Program have determined that benzene is human carcinogen. Long term exposure to high levels of benzene in the air can cause leukemia, and cancer of blood-forming organs [10].

The estimated theoretical risk for cancer from exposure to the contaminants usually is calculated by multiplying the exposure dose by EPA's corresponding cancer slope factor 0.055 $(mg/kg/day)^{-1}$ for benzene. For more information, see Appendix B.

Assuming an adult drinks two liters of water containing benzene from RW-00 at the maximum detected concentration every day for the maximum estimated exposure time of 6 months and assuming a cancer slope factor of 0.055 $(mg/kg/day)^{-1}$, the predicted theoretical increased risk for cancer for this person would be low (8 cancer cases per 1,000,000 people exposed, or 8×10^{-6}). Assuming an adult drinks two liters of water containing benzene from RW-10 at the maximum detected concentration every day for the maximum estimated exposure time of 1 month, and assuming a cancer slope factor of 0.055 $(mg/kg/day)^{-1}$, the predicted theoretical increased risk for cancer for this person would be very low (3 cancer cases per 10,000,000 people exposed, or 3×10^{-7}). Assuming an adult drinks 2 liters of water containing benzene from RW-37, 78, and 79 at the maximum detected concentration every day for the maximum estimated exposure time of 6 months, and assuming a cancer slope factor of 0.055 $(mg/kg/day)^{-1}$, the predicted theoretical increased risk for cancer for these persons would be very low (1 cancer cases per 1,000,000 people exposed, or 1×10^{-6}; 8 cancer cases per 100,000,000 people exposed, or 8×10^{-8}; 1 cancer cases per 10,000,000 people exposed, or 1×10^{-7}, respectively).

Child Health Considerations

To protect the health of the nation's children, ATSDR has implemented an initiative to guard children from exposure to hazardous substances. In communities faced with contamination of the water, soil, air, or food, ATSDR and GDPH recognize that the unique vulnerabilities of infants and children demand special emphasis. Due to their immature and developing organs, infants and children are usually more susceptible to toxic substances than are adults. Children are more likely to be exposed because they play outdoors and they often bring food into contaminated areas. They are also more likely to encounter dust, soil, and contaminated vapors close to the ground. Children are generally smaller than adults, which results in higher doses of chemical exposure because of their lower body weights relative to adults. In addition, the developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

At the DBS site, children may have been exposed to contaminants in groundwater if they lived in any one of the six residences where contaminated drinking water was found. It is not known whether benzene exposure affects the developing fetus in pregnant women. However, animal studies have shown low birth rates, delayed bone formation, and bone marrow damage when pregnant animals breathed benzene. Long-term exposure to high levels of benzene in air can cause leukemia in children and adults [8]. It must be noted, however, that high levels of benzene in air were not present at the DBS site and surrounding community because the medium of contamination was deep, bedrock groundwater. Moreover, based on the concentrations found in contaminated residential wells, bathing activities are not likely to generate high levels of benzene in the air. Furthermore, the exposure duration was not long-term. The longest exposure duration at this site could have been six months, however, based on sampling frequencies, and immediate mitigation of residential contamination, the actual exposure period would have been much less than the exposure period used in this public health assessment to calculate exposure doses. Currently, children are not being exposed to site-related contaminants and exposures in the future are unlikely due to remediation processes, which have included the issuance of bottled drinking water to residences whose wells were found to be contaminated, the installation of water treatment systems at these residences, purchasing of residential properties surrounding the DBS site by CPC, the installation of an enhanced groundwater pump and treat system to continue treating and containing the groundwater plume at the site, and the installation of municipal water lines in the community.

Conclusions

GDPH developed the following conclusions and assigned a public health hazard category to the site. A description of public health hazard categories is provided in Appendix C.

Based on the data evaluated, GDPH considers this site to pose **no apparent past or current public health hazard**. Specifically:

1. Exposure to benzene above health based comparison values is known to have occurred at six residences in the past, all of whom had drilled, bedrock wells on their properties. For the purposes of this public health assessment, the maximum concentration of benzene measured at each of these properties was used as a conservative measure for estimating the highest exposure doses one could have received. Children and adults exposed to the maximum concentration of benzene from any of these six residences are likely not at any increased risk for non-cancer health effects. The actual concentrations of benzene that residents were exposed to are likely to be less than the maximum concentrations found. The longest exposure duration at this site could have been six months. However, based on sampling frequencies, and immediate mitigation of residential contamination, the actual exposure period is likely to have been less than the exposure period used in this public health assessment to calculate exposure doses.

2. The pathway and migration of petroleum contamination that lead to human exposure has been confined to the deep, bedrock aquifer underlying the DBS site and the surrounding area. Shallow, saprolite groundwater contamination has remained confined to an area underlying the DBS yard and has been a source of bedrock groundwater recharge. Shallow aquifer contamination has never migrated off-site to residential property near the DBS. Of the approximately 180 residential wells within a one-mile radius of the DBS, 133 (74%) are shallow (water-table wells), bored or dug wells in the saprolite. Residents having shallow, bored wells in the Colbert Grove Church Road community have never been exposed to site-related contaminants.

3. Residents exposed to benzene at the maximum level found have a low to very low risks for developing cancer from exposure to these concentrations over the periods that they may have been exposed.

Recommendations

1. CPC, with GEPD’s oversight, should continue to monitor residential wells in the area in accordance with their Correction Action Plan.
2. CPC, with GEPD’s oversight, should continue semi-annual monitoring of the bedrock and saprolite aquifer plumes in accordance with their Correction Action Plan.
3. CPC, with GEPD’s oversight, should continue remediation measures undertaken at the DBS site and monitor the effectiveness of such remediation actions.
4. Now that municipal water is available to residents in the Colbert Grove Church Road area, residents should hook up to the municipal water source for their household use.

Public Health Action Plan

Actions Completed

- On June 28, 1995, after GEPD notified CPC about discovery of petroleum contamination in a nearby residential well, CPC arranged temporary accommodations for the residents until a water treatment system could be installed on their property.
- In early July 1995, the installation of a water treatment system to remove petroleum contaminants from residential well water was completed and the residents returned to their home. In December 1995, a month after CPC purchased the property where contamination was first discovered, the water treatment system was installed on the second property where contamination was discovered.
- In late June 1995, CPC provided bottled drinking water to the residents whose home was fitted with a water treatment system. Subsequently, bottled drinking water was provided to residents of all five properties where petroleum contamination was eventually discovered.
- CPC purchased all properties where contamination was found except the property where benzene contamination was found in September 2001 (RW-79). CPC installed a shallow bored well for these residents’s use. In addition, CPC purchased another 20 properties in the Colbert Grove Church community in an effort to maximize monitoring and remediation of the plume and to prevent human exposure to petroleum contamination.
- CPC completed a well survey of all residential wells within a one-mile radius of the DBS.
- GDPH, ATSDR, the Georgia Northeast Health District, and GEPD participate in a public availability session on August 2, 2005, to gather health concerns from the community.
- Public water supply has now been extended to the community surrounding the DBS. As of November 2005, 59 residential properties have been connected to public water.
- GDPH made this public health assessment available for public comment to residents of the Colbert Grove Church community and responded to all comments made.

Actions Planned

- If additional data become available, the information will be reviewed by GDPH and appropriate actions will be taken.
- CPC, with GEPD's oversight, will continue to monitor the area surrounding the DBS for new residential wells and the conversion of current residents to public water.
- CPC will update the community well survey on a semi-annual basis. The well survey will be updated to include all new wells in the area brought on-line since the previous surveys were completed.
- CPC is in the process of contacting all residents on Double Branch Road, less than one-mile northeast of the DBS, that have a drilled residential well but did not connect to public water.
- Residents that refuse to connect to public water will be placed on a yearly sampling schedule if permission is granted to sample their well.
- GDPH will create a Fact Sheet summarizing the findings of this public health assessment to be mailed to residences, with known addresses, in the Colbert Grove Church Road community.
- GDPH will make this final public health assessment available to residents of the Colbert Grove Church community.
- If community members request, GDPH will hold another public availability session to explain the findings of this public health assessment.

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1. Environmental Corporation of America, *Site Assessment Report for Colonial Pipeline Company Danielsville Booster Station*, June 1996.

2. Georgia Environmental Protection Division, *Memorandum regarding Site Investigation and Remediation Activities to Date, Georgia Geological Society*, June 20, 2003.

3. Georgia Environmental Protection Division, *Email correspondence with petitioner*, November 16, 2005.

4. Mill Creek Environmental Services, *Corrective Action Plan for Hydraulic Control in the Fractured Bedrock for CPC Danielsville Booster Station.* September 2002.

5. Agency for Toxic Substances and Disease Registry. *Public Health Assessment Guidance Manual (Update)*. U.S. Department of Health and Human Services. Public Health Service. Atlanta, Georgia. March 2002.

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8. Agency for Toxic Substance and Disease Registry. *Toxicological Profile for Benzene - Update.* Atlanta: US Department of Health Human Services. September 2005.

9. International Agency for Research on Cancer (IARC). Available at http://www.iarc.fr/.

10. Agency for Toxic Substances and Disease Registry. *ToxFAQs - Benzene*. U.S. Department of Health and Human Services. Public Health Service. Atlanta, Georgia. September 1997.

CERTIFICATION

This Colonial Pipeline Company Danielsville Booster station public health assessment was prepared by the Georgia Division of Public Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodologies and procedures existing at the time the public health assessment was initiated. **Editorial Review was completed by the Georgia Division of Public Health.**

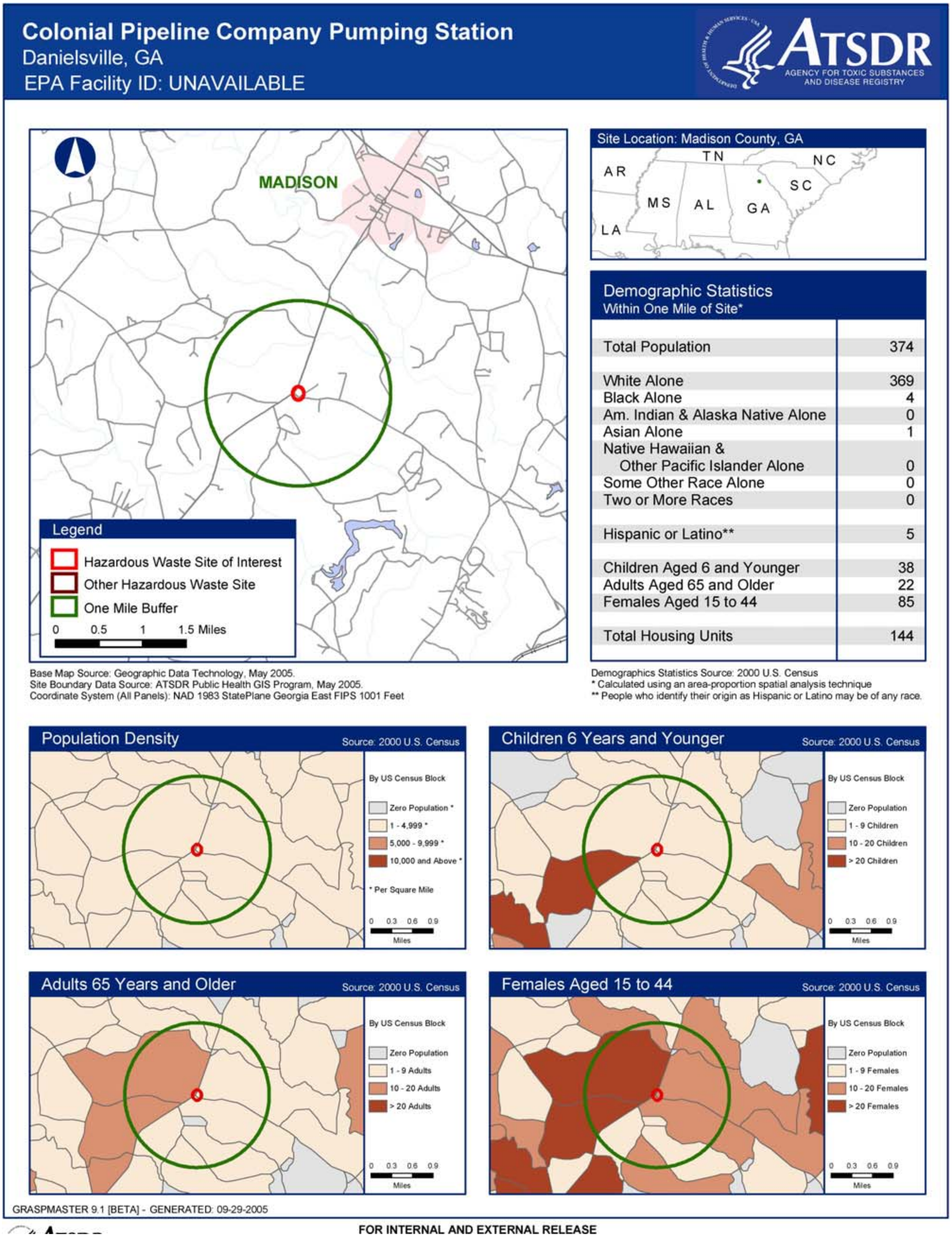
Technical Project Officer, CAT, SPAB, DHAC

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this public health assessment and concurs with its findings.

Team Lead, CAT, SPAB, DHAC, ATSDR

FIGURES

Figure 1: Site Map and Demographic Characteristics



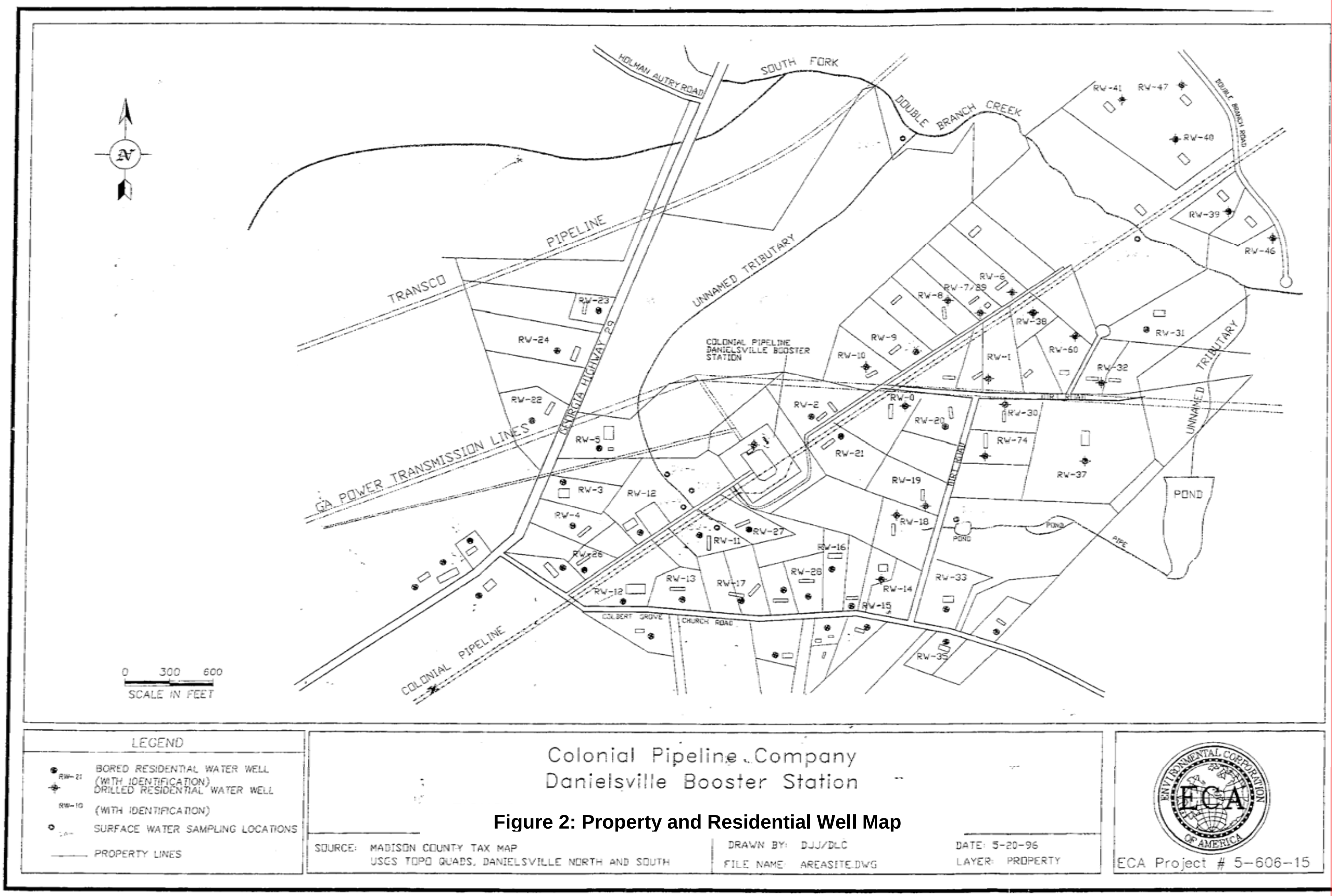
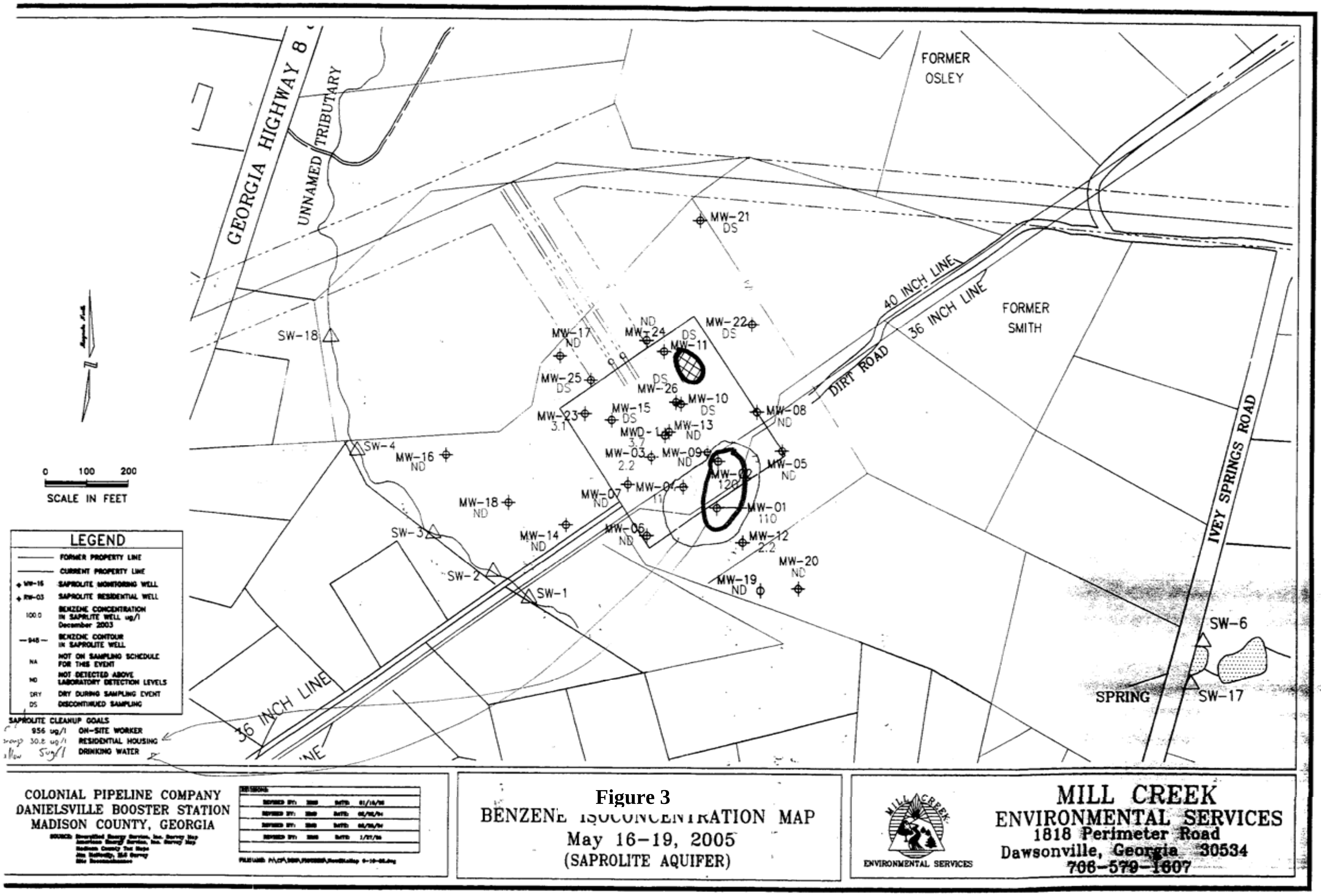


Figure 2: Property and Residential Well Map



GEORGIA HIGHWAY 8
UNNAMED TRIBUTARY
FORMER OSLEY
FORMER SMITH
40 INCH LINE
36 INCH LINE
DIRT ROAD
IVEY SPRINGS ROAD
SPRING
SCALE IN FEET
LEGEND
COLONIAL PIPELINE COMPANY
DANIELSVILLE BOOSTER STATION
MADISON COUNTY, GEORGIA
BENZENE ISOCONCENTRATION MAP
May 16-19, 2005
(SAPROLITE AQUIFER)
MILL CREEK
ENVIRONMENTAL SERVICES
1818 Perimeter Road
Dawsonville, Georgia 30534
706-579-1607

Figure 3

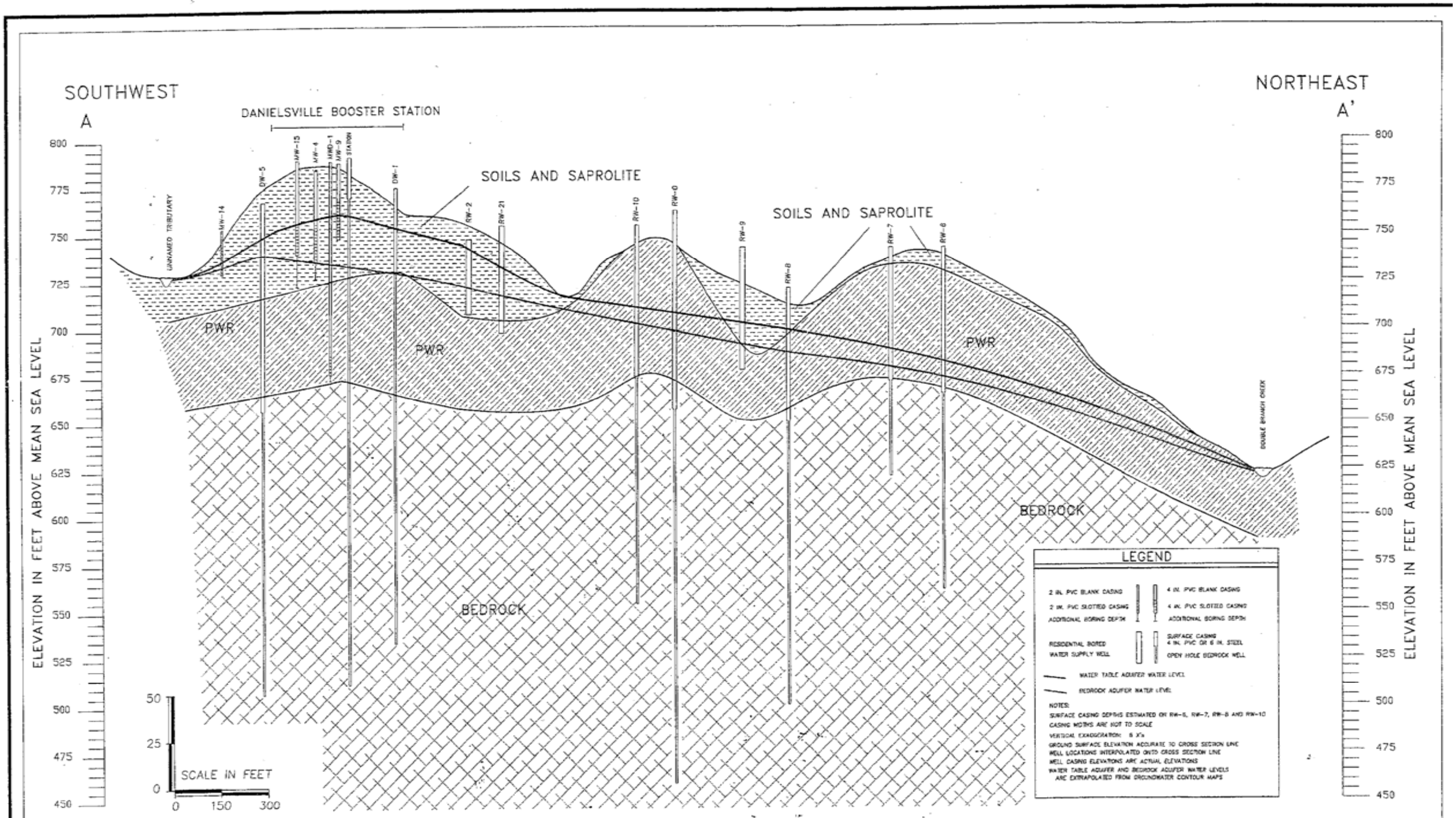


Figure 4

Colonial Pipeline Company
Danielsville Booster Station

CONCEPTUAL HYDROGEOLOGIC CROSS SECTION, A–A'

SOURCE:

DRAWN BY: DJJ
FILE NAME: SECAA

DATE: 05/29/96

ECA Project # 5-606-15

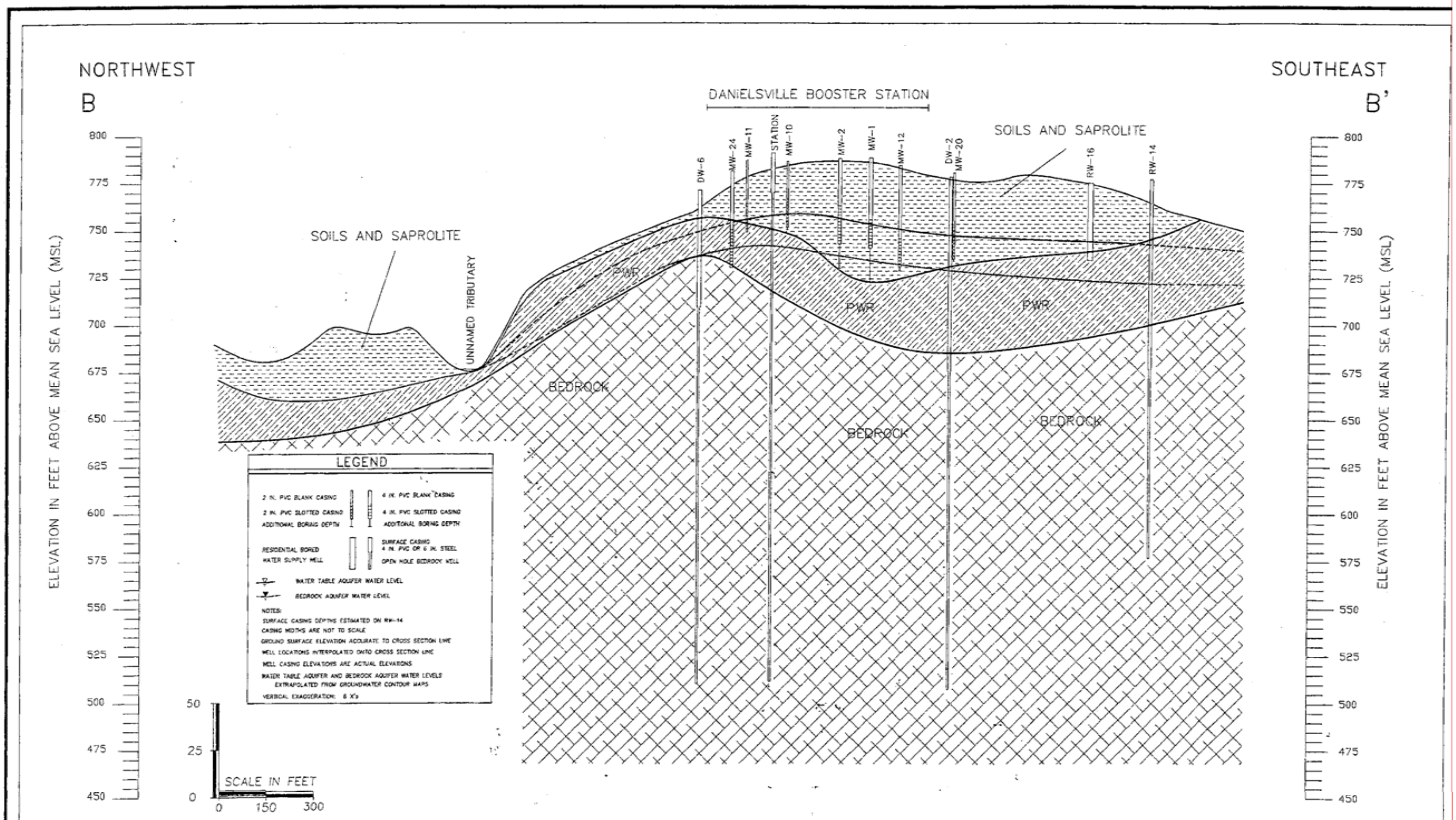


Figure: 5

Colonial Pipeline Company
Danielsville Booster Station

CONCEPTUAL HYDROGEOLOGIC CROSS SECTION, B–B'

DRAWN BY: DJJ DATE: 03/12/96

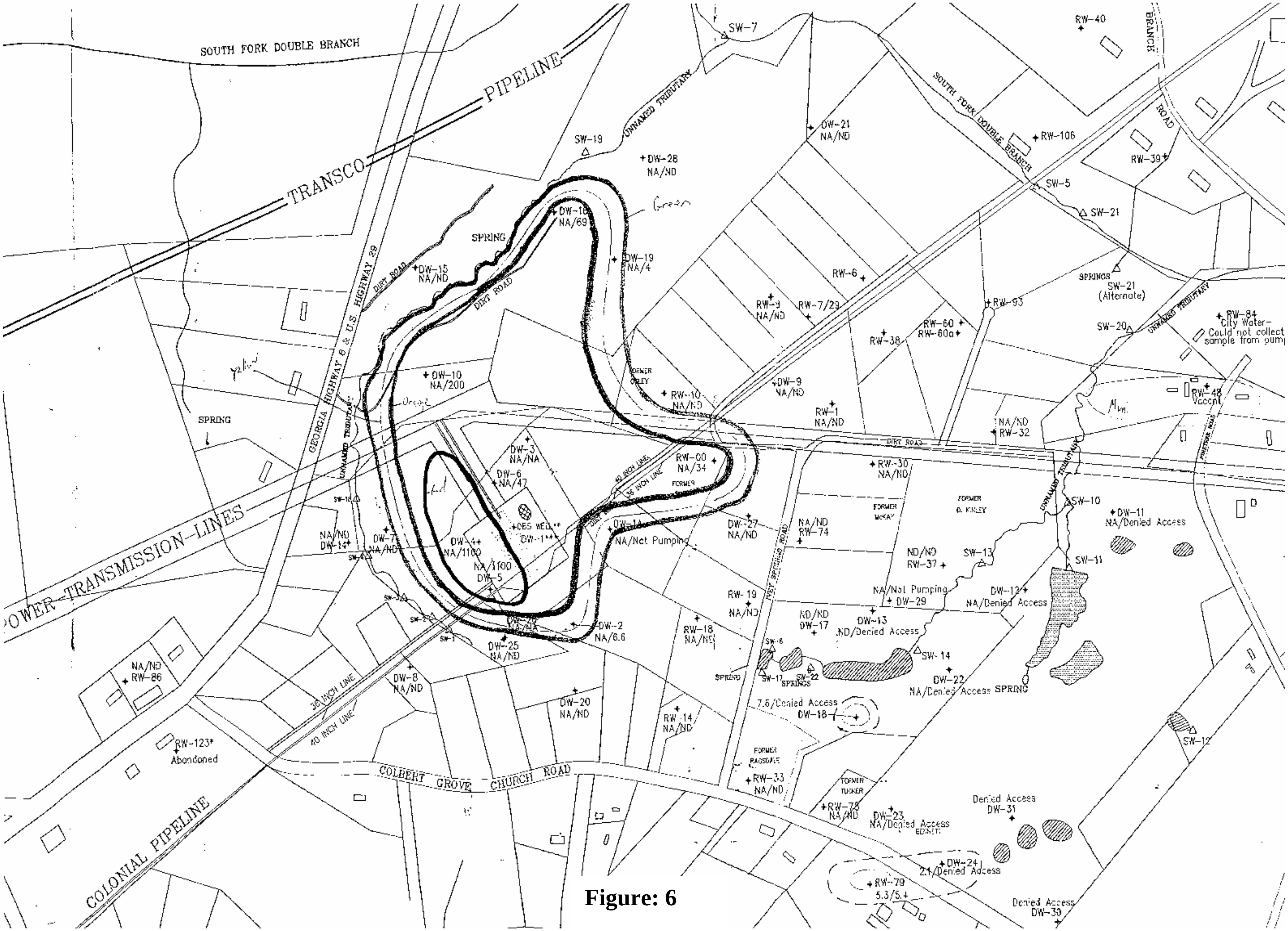

SOUTH FORK DOUBLE BRANCH
TRANSCO PIPELINE
POWER TRANSMISSION LINES
COLONIAL PIPELINE
GEORGIA HIGHWAY 6 & U.S. HIGHWAY 29
COLBERT GROVE CHURCH ROAD
SPRING
DW-15 NA/ND
DW-10 NA/200
DW-16 NA/69
DW-19 NA/4
DW-28 NA/ND
DW-21 NA/ND
SW-19
SW-7
RW-40
RW-106
RW-39
SW-5
SW-21
RW-6
RW-9 NA/ND
RW-7/29
RW-60
RW-60a
RW-38
RW-93
SW-21 (Alternate)
SW-20
RW-84 City Water- Could not collect sample from pump
RW-48 Vacant
RW-10 NA/ND
DW-9 NA/ND
RW-1 NA/ND
NA/ND RW-32
DW-3 NA/NA
DW-6 NA/47
RW-00 NA/34
RW-30 NA/ND
DW-14 NA/Not Pumping
DW-27 NA/ND
NA/ND RW-74
ND/ND RW-37
SW-13
SW-10
DW-11 NA/Denied Access
SW-11
DW-4 NA/1100
NA/1100 DW-5
DW-7 NA/ND
NA/ND DW-18
OBS WELL DW-1
RW-19 NA/ND
NA/Not Pumping DW-29
DW-12 NA/Denied Access
DW-2 NA/6.6
DW-25 NA/ND
RW-18 NA/ND
ND/ND DW-17
DW-13 ND/Denied Access
SW-14
DW-22 NA/Denied Access
SPRING
NA/ND RW-86
DW-8 NA/ND
DW-20 NA/ND
RW-14 NA/ND
7.5/Denied Access DW-18
SW-12
RW-123 Abandoned
RW-33 NA/ND
RW-78 NA/ND
DW-23 NA/Denied Access
Denied Access DW-31
DW-24 2.1/Denied Access
RW-79 5.3/5.4
Denied Access DW-30
36 INCH LINE
40 INCH LINE
DIRT ROAD

Figure: 6

APPENDICES

APPENDIX A: CANCER INCIDENCE, 1999-2003

(Source: GDPH, Cancer Control Section)

Age-Adjusted Cancer Incidence Rates for Zip Code 30628, GA, 1999-2003

	Total		Male		Female	
Site	**Cases**	**Rate**	**Cases**	**Rate**	**Cases**	**Rate**
All Sites	99	486.7	56	666.0	43	367.0
Oral Cavity	<5	~	<5	~	<5	~
Esophagus	<5	~	<5	~	<5	~
Stomach	<5	~	<5	~	<5	~
Colon and Rectum	8	~	<5	~	<5	~
Liver	<5	~	<5	~	<5	~
Pancreas	<5	~	<5	~	<5	~
Larynx	<5	~	<5	~	<5	~
Lung and Bronchus	16	~	11	~	5	~
Bone and Joints	<5	~	<5	~	<5	~
Melanoma	<5	~	<5	~	<5	~
Breast	--	--	--	--	15	~
Uterine Cervix	--	--	--	--	<5	~
Uterine Corpus	--	--	--	--	<5	~
Ovary	--	--	--	--	<5	~
Prostate	--	--	14	~	--	--
Testis	--	--	<5	~	--	--
Kidney and Renal Pelvis	<5	~	<5	~	<5	~
Bladder (Incl in situ)	<5	~	<5	~	<5	~
Brain and Other Nervous System	<5	~	<5	~	<5	~
Thyroid	<5	~	<5	~	<5	~
Hodgkin Lymphoma	<5	~	<5	~	<5	~
Non-Hodgkin Lymphoma	<5	~	<5	~	<5	~
Multiple Myeloma	<5	~	<5	~	<5	~
Leukemias	<5	~	<5	~	<5	~

Average annual rate per 100,000, age-adjusted to the 2000 US standard population.
***GDPH does not calculate rates where the number of cases (or deaths) is less than twenty. For small numbers, the rates can vary dramatically with the slightest shift in actual numbers.**

Data Summary

All Cancer Sites

- 99 new cancer cases were diagnosed in zip code 30628 from 1999 to 2003, an average of 25 new cases per year.
- It is expected that about 14 males and 11 females will be diagnosed with cancer every year in zip code 30628.
- The overall age-adjusted cancer incidence rate in zip code 30628 is 486.7 per 100,000 population. This is higher than the rate for Georgia (463.3 per 100,000), but this difference is not statistically significant.

Males

- The overall age-adjusted cancer incidence rate for males in zip code 30628 is 666.0 per 100,000 population. This is higher than the rate for Georgia males (570.4 per 100,000), but this difference is not statistically significant.
- Prostate, lung, and colorectal are the top cancer sites among males in both zip code 30628 and the State of Georgia.

Females

- The overall age-adjusted cancer incidence rate for females in zip code is 367.0 per 100,000 population. This is lower than the rate for Georgia females (393.6 per 100,000).
- Breast, and lung cancer are the top cancer sites among females in both zip code 30628 and the State of Georgia.

Age-Adjusted Cancer Incidence Rates for Danielsville GA (Zip 30633), 1999-2002

	Total		Male		Female	
Site	**Cases**	**Rate**	**Cases**	**Rate**	**Cases**	**Rate**
All Sites	146	457.6	82	644.6	64	363.1
Oral Cavity	<5	~	<5	~	<5	~
Esophagus	<5	~	<5	~	<5	~
Stomach	5	~	***	~	<5	~
Colon and Rectum	15	~	9	~	6	~
Liver	<5	~	<5	~	<5	~
Pancreas	<5	~	<5	~	<5	~
Larynx	<5	~	<5	~	<5	~
Lung and Bronchus	24	71.8	12	~	12	~
Bone and Joints	<5	~	<5	~	<5	~
Melanoma	<5	~	<5	~	<5	~
Breast	--	--	--	--	19	~
Uterine Cervix	--	--	--	--	<5	~
Uterine Corpus	--	--	--	--	<5	~
Ovary	--	--	--	--	<5	~
Prostate	--	--	21	177.4	--	--
Testis	--	--	<5	~	--	--
Kidney and Renal Pelvis	<5	~	<5	~	<5	~
Bladder (Incl in situ)	9	~	***	~	<5	~
Brain and Other Nervous System	<5	~	<5	~	<5	~
Thyroid	<5	~	<5	~	<5	~
Hodgkin Lymphoma	<5	~	<5	~	<5	~
Non-Hodgkin Lymphoma	6	~	<5	~	<5	~
Multiple Myeloma	<5	~	<5	~	<5	~
Leukemias	<5	~	<5	~	<5	~

Average annual rate per 100,000, age-adjusted to the 2000 US standard population.
***GDPH does not calculate rates where the number of cases (or deaths) is less than twenty. For small numbers, the rates can vary dramatically with the slightest shift in actual numbers.**

Data Summary

All Cancer Sites

- 146 new cancer cases were diagnosed in Zip Code 30633 from 1999 to 2002, an average of 49 new cases per year.
- It is expected that about 27 males and 21 females will be diagnosed with cancer every year in Zip Code 30633.
- The overall age-adjusted cancer incidence rate in Zip Code 30633 is 457.6 per 100,000 population. This is lower than the rate for Georgia (461.4 per 100,000).

Males

- Males are 45% more likely than females to be diagnosed with cancer in Zip Code 30633.
- The overall age-adjusted cancer incidence rate for males in Zip Code 30633 is 644.6 per 100,000 population. This is higher than the rate for Georgia males (569.8 per 100,000).
- Prostate, lung, and colorectal are the top cancer sites among males in both and Zip Code 30633 and the State of Georgia.

Females

- The overall age-adjusted cancer incidence rate for females in Zip Code 30633 is 363.1 per 100,000 population. This is lower than the rate for Georgia females (390.7 per 100,000), but this difference is not statistically significant.
- Breast, lung and colorectal are the top cancer sites among females in both Zip Code 30633 and the State of Georgia.
- The age-adjusted breast cancer incidence rate is lower for females in Madison County (119.9 per 100,000) than for Georgia females (124.3 per 100,000), but this difference is not statistically significant.
- The age-adjusted lung cancer incidence rate is higher for females in Madison County (56.0 per 100,000) than for Georgia females (52.5 per 100,000), but this difference is not statistically significant.
- The age-adjusted colorectal cancer incidence rate for females in Madison County (43.7 per 100,000) is similar to that for Georgia females (43.9 per 100,000).
- The age-adjusted leukemia incidence rate could not be calculated because there were fewer than twenty cases, but there does not appear to be an excess of cases.

APPENDIX B: Explanation of Evaluation Process

Step 1--The Screening Process

In order to evaluate the available data, GDPH used comparison values (CVs) to determine which chemicals to examine more closely. CVs are contaminant concentrations found in a specific environmental media (for example: air, soil, or water) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, soil, or water that someone may inhale or ingest each day. CVs are generated to be conservative and non-site specific. The CV is used as a screening level during the public health assessment process where substances found in amounts greater than their CVs might be selected for further evaluation. CVs are not intended to be environmental clean-up levels or to indicate that health effects occur at concentrations that exceed these values.

CVs can be based on either carcinogenic (cancer-causing) or non-carcinogenic effects. Cancer-based CVs are calculated from the U.S. Environmental Protection Agency's (EPA) oral cancer slope factors for ingestion exposure, or inhalation risk units for inhalation exposure. Non-cancer CVs are calculated from ATSDR's minimal risk levels, EPA's reference doses, or EPA's reference concentrations for ingestion and inhalation exposure. When a cancer and non-cancer CV exist for the same chemical, the lower of these values is used as a conservative measure. The chemical and media-specific CVs used in the preparation of this public health assessment are listed below:

An **Environmental Media Evaluation Guide (EMEG)** is an estimated comparison concentration for exposure that is unlikely to cause adverse health effects, as determined by ATSDR from its toxicological profiles for a specific chemical.

A **Reference Dose Media Evaluation Guide (RMEG)** is an estimated comparison concentration that is based on EPA's estimate of daily exposure to a contaminant that is unlikely to cause adverse health effects.

A **Cancer Risk Evaluation Guide (CREG)** is an estimated comparison concentration that is based on an excess cancer rate of one in a million persons exposed over a lifetime (70 years), and is calculated using EPA's cancer slope factor.

Step 2--Evaluation of Public Health Implications

The next step in the evaluation process is to take those contaminants that are above their respective CVs and further identify which chemicals and exposure situations are likely to be a health hazard. Separate child and adult exposure doses (or the amount of a contaminant that gets into a person's body) are calculated for site-specific scenarios, using assumptions regarding an individual's likelihood of accessing the site and contacting contamination. A brief explanation of the calculation of estimated exposure doses used in this public health assessment are presented below. Calculated doses are reported in units of milligrams per kilogram per day (mg/kg/day).

Ingestion of contaminants present in drinking water

Exposure doses for ingestion of contaminants present in groundwater were calculated using the average detected concentrations of contaminants in milligrams per liter (mg/kg [mg/kg = ppm]). The following equation is used to estimate the exposure doses resulting from ingestion of contaminated groundwater:

$$ED_w = \frac{C \times IR \times EF}{BW} * 2$$

where;

ED_w = exposure dose water (mg/kg/day)
C = contaminant concentration (mg/kg)

IR = intake rate of contaminated medium
(based on default values of 2 liters/day for adults, 1 liter/day for children)

EF = exposure factor (based on frequency of exposure, exposure duration, and time of exposure). The exposure factor used for CPC is 1.0 based on 24 hour day, 7 days a week.

BW = body weight (based on average rates: for adults, 70 kg; children, 25 kg).

* 2 = dose was multiplied by 2 to account for inhalation and dermal absorption during bathing activities.

Non-cancer Health Risks

The doses calculated for exposure to individual chemicals are then compared to an established health guideline, such as an ATSDR minimal risk level (MRL) or an EPA reference dose (RfD), in order to assess whether adverse health impacts from exposure are expected. Health guidelines are chemical-specific values that are based on available scientific literature and are considered protective of human health. Non-carcinogenic effects, unlike carcinogenic effects, are believed to have a threshold, that is, a dose below which adverse health effects will not occur. As a result, the current practice to derive health guidelines is to identify, usually from animal toxicology experiments, a no observed adverse effect level (NOAEL), which indicates that no effects are observed at a particular exposure level. This is the experimental exposure level in animals (and sometimes humans) at which no adverse toxic effect is observed. The known toxicological values are doses derived from human and animal studies that are summarized in ATSDR's *Toxicological Profiles (www.atsdr.cdc.gov/toxpro2.html).* The NOAEL is modified with an uncertainty (or safety) factor, which reflects the degree of uncertainty that exists when experimental animal data are extrapolated to the human population. The magnitude of the uncertainty factor considers various factors such as sensitive subpopulations (e.g., children, pregnant women, the elderly), extrapolation from animals to humans, and the completeness of the available data. Thus, exposure doses at or below the established health guideline are not expected to cause adverse health effects because these values are much lower (and more human health protective) than doses, which do not cause adverse health effects in laboratory animal studies.

For non-cancer health effects, the following health guidelines were used in this public health assessment:

Minimal Risk Levels (MRLs) are developed by ATSDR for contaminants commonly found at hazardous waste sites. The MRL is developed for ingestion and inhalation exposure, and for lengths of exposures: acute (less than 14 days); intermediate (between 15-364 days), and chronic (365 days or greater). ATSDR has not developed MRLs for dermal exposure (absorption through skin).

Reference Doses (RfDs) EPA developed chronic RfDs for ingestion and RfCs for inhalation as estimates of daily exposures to a substance that are likely to be without a discernable risk of deleterious effects to the general human population (including sensitive subgroups) during a lifetime of exposure.

If the estimated exposure dose to an individual is less than the health guideline value, the exposure is unlikely to result in non-cancer health effects. If the calculated exposure dose is greater than the health guideline, the exposure dose is compared to known toxicological values for the particular chemical and is discussed in more detail in the text of the public health assessment. A direct comparison of site-specific exposures and doses to study-derived exposures and doses found to cause adverse health effects is the basis for deciding whether health effects are likely to occur.

It is important to consider that the methodology used to develop health guidelines does not provide any information on the presence, absence, or level of cancer risk. Therefore, a separate cancer risk evaluation is necessary for potentially cancer-causing contaminants detected at this site.

Cancer Risks

Exposure to a cancer-causing chemical, even at low concentrations, is assumed to be associated with some increased risk for evaluation purposes. The estimated risk for developing cancer from exposure to contaminants associated with the site was calculated by multiplying the site-specific doses by EPA's chemical-specific cancer slope factors (CSFs) available at *www.epa.gov/iris*. This calculation estimates a theoretical excess cancer risk expressed as a proportion of the population that may be affected by a carcinogen during a lifetime of exposure. For example, an estimated risk of 1×10^{-6} predicts the probability of one additional cancer over background in a population of 1 million. An increased lifetime cancer risk is not a specified estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person may develop cancer sometime in his or her lifetime following exposure to a particular contaminant under specific exposure scenarios. For children, the theoretical excess cancer risk is not calculated for a lifetime of exposure, but from a fraction of lifetime; based on known or suspected length of exposure, or years of childhood.

Because of conservative models used to derive CSFs, using this approach provides a theoretical estimate of risk; the true or actual risk is unknown and could be as low as zero. Numerical risk estimates are generated using mathematical models applied to epidemiologic or experimental data for carcinogenic effects. The mathematical models extrapolate from higher experimental doses to lower experimental doses. Often, the experimental data represent exposures to chemicals at concentrations orders of magnitude higher than concentrations found in the environment. In addition, these models often assume that there are no thresholds to carcinogenic effects--a single molecule of a carcinogen is assumed to be able to cause cancer. The doses associated with these estimated hypothetical risks might be orders of magnitude lower that doses reported in toxicology literature to cause carcinogenic effects. As such, a low cancer risk estimate of 1×10^{-6} and below may indicate that the toxicology literature supports a finding that no excess cancer risk is likely. A cancer risk estimate greater than 1×10^{-6}, however, indicates that a careful review of toxicology literature before making conclusions about cancer risks is in order.

Evaluation of Chemical Mixtures

No data are available on toxic or carcinogenic responses to whole mixtures benzene, toluene, ethylbenzene, and xylene (BTEX). To conduct exposure-based assessments of possible health hazards from BTEX in the absence of these data, a component-based approach that considers both the shared (neurologic) and unique (hematologic/immunologic/carcinogenic) critical effects is recommended. In particular, ATSDR advises that (1) the Hazard Index approach be used to assess the joint neurotoxic hazard of the four mixture components, and (2) the hematological and carcinogenic hazards be assessed on a benzene-specific basis.

Neurotoxicity is the critical noncancer effect of concern for BTEX mixtures. Neurological impairment forms the basis for 9 of the 13 MRLs for the component chemicals, including 6 of 8 **inhalation** MRLs. Results of Physiologically Based Pharmacokinetic (PBPK) model simulations and experimental exposures with BTEX strongly suggest that joint neurotoxic action is expected to be **additive** at BTEX concentrations below approximately 20 ppm of each component. **Inhalation MRLs** and Risk Guidance values for neurological effects of BTEX have been developed by ATSDR; however, oral MRLs have not been developed.

An exposure-based assessment using the Hazard Index approach of joint toxic action of the BTEX mixture can be used as a guideline to determine if further evaluation for health effects is warranted. Under conditions for proceeding with the hazard index approach, the hazard quotients are summed to derive the hazard index for neurological effects as follows:

$$HI = Dose_{Benzene\ (B)} / MRL_{Benzene} + Dose_{Toluene\ (T)} / MRL_{Toluene} + Dose_{Ethylbenzene\ (E)} / MRL_{Ethylbenzene} + Dose_{Xylene\ (X)} / MRL_{Xylene}$$

Where HI is the hazard index, $Dose_{subscripts}$ represents the exposure dose estimates for the individual components, $MRL_{subscripts}$ represents the appropriate minimal risk level or health guidance value for the components, and B, T, E, and X represents benzene, toluene, ethylbenzene, and xylene. A hazard index is derived for duration of exposure (chronic) and exposure route of concern. The calculated indexes will provide indicators of the hazard for neurotoxicity from exposure to the BTEX mixture. Preliminary evidence that exposure to the mixture would constitute a hazard for neurological impairment is provided if the hazard index for a particular exposure scenario exceeds one. As the value of the hazard index exceeds one, there is increased concern for the possibility of a health hazard as well as the need for further evaluation.

The hazard index method of evaluating the BTEX mixture once present in residential wells with known exposure to DBS site-related contaminants is described as follows:

RW-00

$$HI = 0.02_B \text{ mg/kg/day} / 0.004 \text{ mg/kg/day} + 0_T/0.08 \text{ mg/kg/day} + 0.001_E \text{ mg/kg/day} / 0.1 \text{ mg/kg/day} + 0.0002_X \text{ mg/kg/day} / 0.1 \text{ mg/kg/day}$$

$$= 5.015$$

Since the HI>1, there is a need to evaluate further.

RW-10

$$HI = 0.005_B \text{ mg/kg/day} / 0.004 \text{ mg/kg/day} + 0_T / 0.08 \text{ mg/kg/day} + 0_E / 0.1 \text{ mg/kg/day} + 0_X / 0.1 \text{ mg/kg/day}$$

$$= 0.058$$

Since the HI<1, there is no need to evaluate further.

RW-37

$$HI = 0.003_B \text{ mg/kg/day} / 0.004 \text{ mg/kg/day} + 0.0001_T \text{ mg/kg/day} / 0.08 \text{ mg/kg/day} + 0_E / 0.1\text{mg/kg/day} + 0_X / 0.1 \text{ mg/kg/day}$$

$$= 0.701$$

Since the HI<1, there is no need to evaluate further.

RW-78

$$HI = 0.0002_B \text{ mg/kg/day} / 0.004 \text{ mg/kg/day} + 0.0001_T \text{ mg/kg/day} / 0.08 \text{ mg/kg/day} + 0.0001_E \text{ mg/kg/day} / 0.1\text{mg/kg/day} + 0_X / 0.1 \text{ mg/kg/day}$$

$$= 0.116$$

Since the HI<1, there is no need to evaluate further.

<u>RW-79</u>

$$HI = 0.0003_B \text{ mg/kg/day} / 0.004 \text{ mg/kg/day} + 0_T / 0.08 \text{ mg/kg/day} + 0_E / 0.1\text{mg/kg/day} + 0_X / 0.1 \text{ mg/kg/day}$$

$$= 0.086$$

Since the HI<1, there is no need to evaluate further.

For RW-00, approximately 99.7% of the weight of the HI is contributed from benzene alone. Again, referring to the discussion of noncancer health effects associated with chronic exposure to benzene at 360 ppb:

The estimated exposure dose for adults of 0.02 mg/kg/day is 50 times lower than the NOAEL of 1 mg/kg/day for benzene. The estimated exposure dose for children of 0.03 mg/kg/day is approximately 33 times lower than the NOAEL of 1 mg/kg/day for benzene. Although estimated exposure doses are many times lower than the NOAEL, but less than 100 times lower, GDPH further evaluated the possibility of benzene to cause harmful effects in children and adults.

The benzene health guideline is based on the results of oral studies conducted on animals exposed to benzene over a chronic period (>364 days). Adverse effects observed were decreased numbers of red blood cells and white blood cells of test animals at the lowest doses tested (approximately 1-10 mg/kg/day); 8 mg/kg/day appeared to be the boundary at which effects began to be observed (LOAEL) [8]. The estimated exposure dose for adults of 0.02 mg/kg/day is 400 times lower than the LOAEL of 8 mg/kg/day for benzene. The estimated exposure dose for children of 0.03 mg/kg/day is approximately 267 times lower than the LOAEL of 8 mg/kg/day for benzene. Therefore, GDPH concludes that adverse (non-cancer) health effects are not likely in children and adults exposed to the highest benzene concentration detected in this residential well water. Moreover, given the conservative assumptions made to estimate this dose, and knowing that the concentration of benzene in tap water in this residence measured 24 ug/l (instead on the 360 ug/l concentration used to estimate exposure dose), this conclusion most likely overestimates the true likelihood of harm to residents at this site.

APPENDIX C: ATSDR Public Health Hazard Conclusion Categories

ATSDR Public Health Hazard Categories
Depending on the specific properties of the contaminant, the exposure situations, and the health status of individuals, a public health hazard may occur. Using data from public health assessments and consultations, sites are classified using one of the following public health hazard categories:

Category 1: Urgent Public Health Hazard
Sites that pose a serious risk to public health as the result of short-term exposures to hazardous substances.

Category 2: Public Health Hazard
Sites that pose a public health hazard as the result of long-term exposures to hazardous substances.

Category 3: Potential/Indeterminate Public Health Hazard
Sites for which no conclusions about public health hazard can be made because data are lacking.

Category 4: No Apparent Public Health Hazard
Sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.

Category 5: No Public Health Hazard
Sites for which data indicate no current or past exposure or no potential for exposure and therefore no health hazard.

APPENDIX D: ATSDR/GDPH Glossary of Environmental Health Terms

Absorption
The process of taking in. For a person or animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with **chronic**].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with **intermediate duration exposure** and **chronic exposure]**.

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with **antagonistic effect** and **synergistic effect]**.

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems.

Aerobic
Requiring oxygen [compare with **anaerobic**].

Ambient
Surrounding (for example, *ambient* air).

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation
Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Cancer
Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk of for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

Chronic
Occurring over a long time (more than 1 year) [compare with **acute**].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with **acute exposure** and **intermediate duration exposure**].

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see **exposure pathway**].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as **Superfund**, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated

water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [**dose**] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, **biota** (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and **biota** (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The **environmental media and transport mechanism** is the second part of an **exposure pathway**.

EPA
United States Environmental Protection Agency.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute exposure**], of intermediate duration, or long-term [**chronic exposure**].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a **source of contamination** (such as an abandoned business); an **environmental media and transport mechanism** (such as movement through groundwater); a **point of exposure** (such as a private well); a **route of exposure** (eating, drinking, breathing, or touching), and a **receptor population** (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a **completed exposure pathway**.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with **surface water**].

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Public health assessment
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Public health assessments are focused on a specific exposure issue. Public health assessments are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with **public health assessment**].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see **route of exposure**].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with **acute exposure** and **chronic exposure**].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

mg/kg
Milligram per kilogram.

mg/cm^2
Milligram per square centimeter (of a surface).

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].

No apparent public health hazard

A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see **exposure pathway**].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

ppb
Parts per billion.

ppm
Parts per million.

Public health action
A list of steps to protect public health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with **public health assessment**].

Public health hazard

A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are **no public health hazard, no apparent public health hazard**, **indeterminate public health hazard**, **public health hazard**, and **urgent public health hazard**.

Receptor population
People who could come into contact with hazardous substances [see **exposure pathway**].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

RfD
See **reference dose**.

Risk
The probability that something will cause injury or harm.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [**inhalation**], eating or drinking [**ingestion**], or contact with the skin [**dermal contact**].

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see **population**]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or environment.

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an **exposure pathway**.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents which, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a **safety factor**].

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

APPENDIX E: GDPH Response to Public Comments

The Public Comment period for the Colonial Pipeline Company's Danielsville Booster Station Public Health Assessment was from March 16, 2006 to April 16, 2006. The comments received and GDPH's responses to these comments are contained in this section of the Colonial Pipeline Danielsville Booster Station Public Health Assessment.

Comment: We are in disagreement with your conclusion that this site poses "no apparent public health hazard". Your finding are in contrast to the letter issued by the Madison County Board of Health, and read by out Chairman of the Board of Commissioners, Mr. Wesley Nash, at our March 9, 2006 meeting.

Response: The letter issued by the Madison County Board of Health served as a general precautionary statement regarding the potential for benzene contamination of private wells. The point of this letter was to encourage residents who have not connected their residences to municipal water to do so. The letter stated that levels of benzene were found above the US EPA drinking water standard (MCL) of 5 ppb for public water systems, and that levels above the MCL could be indicative of possible negative health effects. The letter referred to was written before the public health assessment was completed and, after rigorous analysis, GDPH found the residents exposed to contaminated drinking water were not at risk for adverse health effects. Please refer to Appendix B for an explanation of the toxicological evaluation process used to arrive at the conclusions stated in this public health assessment.

Comment: The PHA references five (5) initial residential well tests from December, 1994 performed by Colonial. These five well tests are non-existent; therefore, cannot be used as fact in a scientific document. GA EPD informed us that these tests are not in their files and requested copies from Colonial Pipeline. As of today, these tests have not been located and cannot be validated. The PHA makes note of these tests several times throughout the document to establish a timeline of exposure and promote Colonial's integrity. Without the verification of these tests, the timeline is not credible, and no references can be made to exposure duration. Any references based upon this unconfirmed data is speculative.

Response: GDPH used EPA's chronic oral RfD (health guideline) to evaluate long-term effects of benzene exposure at the maximum concentration found in the affected residential wells.

Comment: The PHA claims all contaminated wells were drilled wells. This is inaccurate. Mr. Benny Jack Craft (RW-9) was on a bored well at a depth measured at 64 feet. His property was purchased, his dwelling moved, and his residency re-located. Mr. Craft was treated for cancer not long after his relocation.

Response: RW-9, belonging to a resident (all names were removed from original comments to protect the privacy of the individuals), was sampled for BTEX, Naphthalene, MTBE, and lead 7 times between June 1995 and February 1997. In all instances, none of these constituents were detected in this resident's well. As stated in the public health assessment, petroleum contamination affected only the drinking water wells in the deep, bedrock aquifer, not the shallow, water-table aquifer.

Comment: PHA fails to report in the Natural Resource Use that the South Fork Broad River to which petroleum products flow is biologically impaired.

Response: GDPH did not review any sampling data regarding water quality of the South Fork Broad River located because the petroleum groundwater plume from the DBS site has never migrated to the South Fork Broad River. Surface water samples have been periodically collected between 1995 and 2005 from 21 locations along the two unnamed tributaries of the South Fork Double Branch Creek (Figure 6). Sample analysis results show no significant impacts to surface water. Benzene is the only petroleum compound that has been detected. Benzene was detected in 4 of 18 samples from an unnamed tributary of the South Fork Double Branch Creek approximately 500 feet west of the Danielsville Booster Station (DBS) at a concentration of 1-4 ug/l, which is below the MCL of 5 ug/l. However, benzene has not been detected at this location since March 2003. The plume in the bedrock reaches its limits at the unnamed tributaries under static conditions. Where pumping continues, the plume has been drawn across the boundary in the past. However, major creeks and streams (South Fork Double Branch Creek) appear to be strong flow boundaries where residential pumping has less of an effect.

Comment: PHA fails to list Colbert zip code 30628 which is also in the contaminated groundwater plume.

Response: The zip code used to look at cancer mortality was the Danielsville zip code 30633. However, when GDPH looked at a zip code map of Madison County, we discovered that the plume does indeed lie in zip code 30628, a Colbert zip code. Appendix A has been amended to include cancer data for zip code 30628.

Comment: PHA dismisses the ambient air exposure pathway although the family at Residential Well 3 experienced severe decreased lung capacity while living there. A resident, who was neighbor to RW-3, and lived at his place of residency for 30 years, was NOT listed on the initial survey conducted by Colonial. His wife passed away from a lung disease in 2004. This resident, who was on oxygen and suffered with respiratory disease, died in July 2005. Unless ambient air sampling has been conducted, this exposure pathway cannot be eliminated.

Response: Residential Well 3 is a bored well that has never been contaminated with DBS site-related petroleum constituents. Exposure to contaminated bedrock groundwater is the exposure pathway of most concern at this site. Data for ambient air near this site does not exist, and therefore, cannot be evaluated. "Decreased respiratory capacity" is a very broad term, as is "lung disease". Without specific medical diagnoses, and detailed history (such as smoking and occupational history), no conclusion can be drawn or inferred regarding possible ambient air exposure and any lung disease seen in these individuals.

Comment: PHA eliminated soil as an exposure pathway based upon the results of soil sampling at the Booster Station. However, no offsite soil samples were taken from residential areas to determine soil contamination. The document assumes that no soil contamination exists on residential properties. This is speculation.

Response: In the spring of 1996, an extensive soil investigation was conducted at the DBS site to determine the extent of surface and subsurface soil contamination. Soil contamination was determined to be within the DBS station yard; therefore, sampling off-site residential properties for site-related petroleum constituents was not warranted.

Comment: PHA failed to address high levels of lead found in residential well samples and the health effects to children and adults from these exposures.

Response: Lead occurs naturally in groundwater of the Piedmont due to the dissolution of lead-containing minerals present in the water-bearing fractures of the crystalline aquifer. Elevated lead concentrations are common in wells completed in crystalline aquifers regardless of whether there is any hydrocarbon contamination. Typically lead concentrations increase as the sample turbidity (amount of sediment) increases. Colonial analyzed lead in multiple samples collected from 1995 – 1997 in 46 monitoring wells and 28 residential wells completed in the saprolite and bedrock.

Lead was detected above the MCL in 12 saprolite monitoring wells, but was not detected in any of the bedrock monitoring wells. The lead detections do not appear to be related to hydrocarbon releases from the facility because the concentrations of lead did not correlate with BTEX concentrations. For instance, the highest benzene concentration (2,700 ppb) at the site was detected in bedrock monitoring well DW-4 that had no lead detections. Initially samples were analyzed for total lead. In all instances where total lead concentrations exceeded the MCL, subsequent dissolved lead analysis resulted in no detections. This can be attributed to the high turbidity or amount of sediment that is common in monitoring wells installed in the saprolite.

More than 150 water samples were collected from 28 residential wells for total or dissolved lead analysis. Lead was only detected above the MCL at the wellhead in samples from two residences (RW-10 and RW-37). At RW-10 only one out of eight samples had a lead concentration (total) above the MCL. This sample also contained elevated dissolved and ferrous iron. At RW-37 total lead was detected above the MCL in two consecutive quarterly samples. Since total lead or dissolved lead was not detected before or after these back-to-back sampling events, it is likely that the positive results were statistical outliers. It is important to note that the family living at the RW-10 and RW-37 location were being provided with bottled water for consumption, and that a water treatment system had been installed for other household use at the time lead was detected in their wells.

Comment: PHA failed to address the noncancer health effects from a multiple mixture of petroleum constituents, including lead, for families living in the contaminated groundwater plume.

Response: According to ATSDR, there is no data regarding health effects of humans or animals exposed exclusively to benzene, toluene, ethylbenzene, and xylene. To conduct exposure-based assessments of possible health hazards from BTEX in the absence of these data, a component-based approach that considers both the shared (neurologic) and unique (hematologic/immunologic/carcinogenic) critical effects is recommended. In particular, ATSDR advises that (1) the Hazard Index approach be used to assess the joint neurotoxic hazard of the four mixture components, and (2) the hematological and carcinogenic hazards be assessed on a benzene-specific basis.

An exposure-based assessment using the Hazard Index approach of joint toxic action of the BTEX mixture is added to this document in Appendix B. Hematological and carcinogenic hazards to a BTEX mixture have already been assessed in this public health assessment based on a benzene-specific basis because the other mixture components do not induce these effects.

Comment: PHA failed to address the known environmental causes of cancer cases within the contaminated plume, and the health effects that result from being exposed to a multiple mixture of petroleum constituents, including lead.

Response: The PHA did address benzene, the only known carcinogen within the contaminated plume. Please refer to pages 17-18 of this document. For health effects resulting from exposure to a mixture of petroleum constituents, please refer to Appendix B.

Comment: PHA failed to document the community health problems which were brought to the attention of the Chemical Hazards Division of GA Public Health in 2003 by a non-resident property owner. We would like to know why the Division failed to evaluate the health problems this property owner relayed. We would also like to know if the Division has collected health data that it requested from this property.

Response: GDPH spoke with this property owner in July 2003 regarding his concerns about excess cancer in his community. Specifically, the property owner claimed that numerous people are afflicted with cancer and rare blood diseases along Colonial Road and Colbert Grove Church Road in Danielsville. GDPH contacted this property owner and asked him to provide GDPH with contact information of those citizens he stated had illnesses in the Colbert Grove Church Road area so that GDPH could conduct interviews with these citizens. The property owner never again contacted the GDPH after this request was made.

Comment: PHA incorrectly stated that, "it is not known whether benzene exposure affects the developing fetus in pregnant women". Human research studies from Frederica Perera indicate that benzene exposure to the fetus begins genetic mutations in utero which lead to childhood cancer. Please inform us according to your benzene subregistry how many children are diagnosed with childhood cancers from water containing benzene? Please review benzene research from Dr. Perera and Dr. Martyn Smith of University of California Berkeley and report your review of the literature.

Response: The statement "it is not known whether benzene exposure affects the developing fetus in pregnant women" was taken from an ATSDR Toxicological Profile for Benzene most recently updated in September 2005, was used to verify the above statement. The Toxicological Profiles base all statements on literature review. We do not review and comment on specific literature as academic research is ongoing. The benzene registry has two people under the age of 18 years old that self-reported having cancer out of a total of 389 people under the age of 18 that were exposed to water containing benzene. We do not know if these people were exposed to other chemicals. In order for someone to be eligible for the Benzene Registry they would have had to live at one of the exposure addresses for 30 consecutive days.

Comment: Please explain how the new EPA Childhood Cancer Guidelines are relative to our community exposures.

Response: ATSDR and GDPH recognize that the unique vulnerabilities of infants and children demand special emphasis. Due to their immature and developing organs, infants and children are usually more susceptible to toxic substances than are adults. In addition, the developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

Comment: Please explain how low doses of chemical mixtures found in residential wells can produce synergistic effects, and the health outcomes on children and adults.

Response: No data are available on toxic or carcinogenic responses to whole mixtures benzene, toluene, ethylbenzene, and xylene (BTEX). However, results of Physiologically Based Pharmacokinetic (PBPK) model simulations and experimental exposures with BTEX strongly suggest that joint neurotoxic action is expected to be **additive** at BTEX concentrations below approximately 20 ppm of each component.

The addition of hazard quotients for a particular exposure scenario assumes that the mixture components additively act on common toxicity target by a common mechanism or mode of action, and that less-than-additive (e.g. antagonistic interactions) or greater-than-additive (e.g. synergism or potentiation) interactions do not occur among the components of the mixture.

For health effects resulting from low doses to a mixture of petroleum constituents, please refer to Appendix B.

Comment: Please explain how epigenetics is relevant to our community exposures.

Response: **Epigenetics** is the study of reversible heritable changes in gene function that occur without a change in the sequence of nuclear DNA. It is also the study of the processes involved in the unfolding development of an organism. In both cases, the object of study includes how gene regulatory information that is not expressed in DNA sequences is transmitted from one generation (of cells or organisms) to the next - that is, 'in addition to' the genetic information encoded in the DNA.

Epigenetics as being relevant to community exposures is beyond the scope of any public health assessment. The purpose of a public health assessment is to review existing data relevant to a contaminated site and assess whether there are any community exposures to hazardous contaminants. If exposure is determined to be occurring, has occurred in the past, or likely to occur in the future; the likelihood of community adverse health effects is assessed based on published toxicology literature and health guidelines established by ATSDR and other agencies.

Comment: PHA failed to evaluate long-term, chronic exposure to benzene. Given the decades that Colonial Pipeline has operated in our community and the fact that all spills and leaks are not reported, this warrants evaluation of long-term chronic exposure of children and adults. One family lost a young son and grandfather to leukemia. Again, as listed in #2 above, the PHA relies heavily on data that has not been located and reviewed to validate the decision not to evaluate long-term, chronic exposure.

Response: GDPH used EPA's chronic oral RfD (health guideline) to evaluate long-term effects of lifetime benzene exposure at the maximum concentration found in the affected residential wells. Please refer to Appendix B for an explanation of the evaluation process.

Comment: PHA failed to investigate the problem mentioned in the citizen's petition for of enamel erosion on children's teeth, and the discovery of high levels of fluoranthene and fluorine found in the groundwater analysis results of the Danielsville Booster Station.

Response: GDPH has not seen data for fluoranthene and fluorine found in residential wells in the sampling results reviewed.