

# CONTAMINATION OF GROUNDWATER BY THE FUMIGANTS ETHYLENE DIBROMIDE (EDB) AND DIBROMOCHLOROPROPANE (DBCP) NEAR McBEE, SOUTH CAROLINA

James E. Landmeyer<sup>1</sup> and Bruce G. Campbell<sup>1</sup>

---

AUTHORS: <sup>1</sup>Hydrologists, U.S. Geological Survey, 720 Gracern Road, Suite 129, Columbia, SC, 29210; [jlandmey@usgs.gov](mailto:jlandmey@usgs.gov)

REFERENCE: *Proceedings of the 2010 South Carolina Water Resources Conference*, held October 13–14, 2010, at the Columbia Metropolitan Convention Center.

---

**Abstract.** McBee is a small town of about 700 people located in Chesterfield County, South Carolina, in the Sandhills region of the upper Coastal Plain. The halogenated organic compounds ethylene dibromide (EDB) and dibromochloropropane (DBCP) have been detected in several public and domestic supply and irrigation wells since 2002 at concentrations above their U.S. Environmental Protection Agency Maximum Contaminant Limits of 0.05 and 0.2 microgram per liter ( $\mu\text{g/L}$ ), respectively. The source(s) and release histories of EDB and DBCP to local groundwater are unknown, but believed to be related to their historical use between the 1940s and their ban in the late 1970s as fumigants to control nematode damage in peach orchards. However, gasoline and jet-fuel supplies also contained EDB and are an alternative source of contamination to groundwater. The detection of EDB and DBCP in water wells has raised health concerns because groundwater is the sole source of water supply in the McBee area. In April 2010, forensic, geochemical-based investigation was initiated by the U.S. Geological Survey in cooperation with the Alligator Rural Water & Sewer Company to provide additional data regarding EDB and DBCP in local groundwater. The investigation includes an assessment of the use, release, and disposal history of EDB and DBCP in the area, the distribution of EDB and DBCP concentrations in the unsaturated zone, and transport and fate in groundwater.

## Introduction

Since 2002, the halogenated organic compounds EDB and DBCP have been detected in several public and domestic supply and irrigation wells near McBee, South Carolina (SC) at concentrations above their U.S. Environmental Protection Agency (USEPA) Maximum Contaminant Limits (MCL) of 0.05 and 0.2  $\mu\text{g/L}$ , respectively (fig. 1). The detections of EDB and DBCP above their respective MCLs have raised health concerns because groundwater is the sole source of water supply in the area.

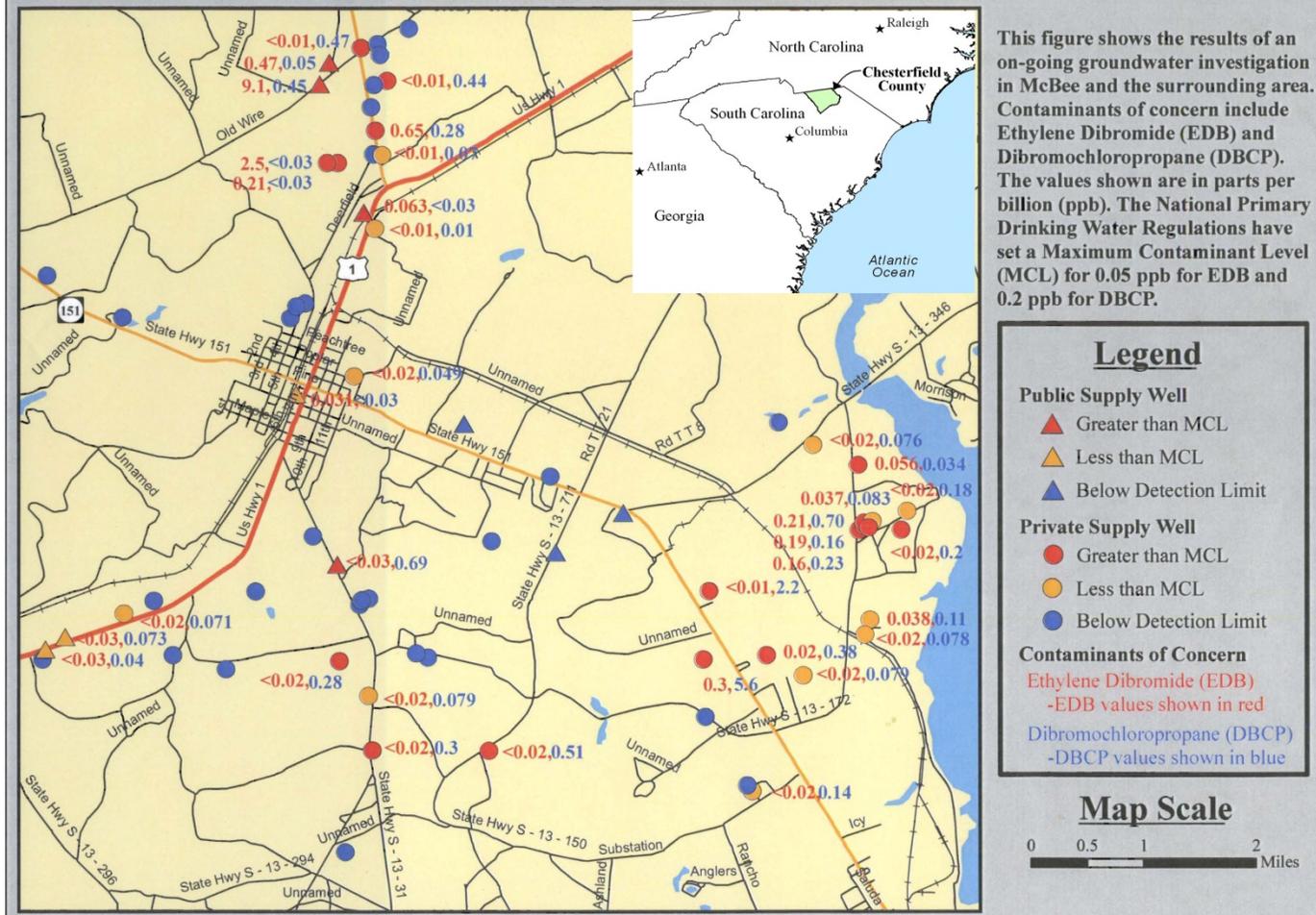
To investigate potential sources of EDB and DBCP to local groundwater, a forensic, geochemical-based investigation was initiated in April 2010 and will continue

through 2013. The investigation includes an assessment of potential source areas, use history, and release information of EDB and DBCP in the area, distribution of EDB and DBCP in the unsaturated zone, and transport and fate in groundwater in the Middendorf aquifer. Existing public wells will be sampled in the summer of 2010 for EDB and DBCP concentrations, potential breakdown products, and groundwater redox status. Delineation of the redox status of groundwater will be used in predicting the long-term fate of EDB and DBCP because these highly oxidized compounds tend to resist biodegradation in the presence of dissolved oxygen but may undergo degradation where oxygen is depleted and the appropriate microorganisms exist.

The age of the EDB- and DBCP-contaminated groundwater since time of recharge will be determined by analysis of the chlorofluorocarbon (CFC) concentrations in groundwater samples collected during 2010. This widely used age-dating method will be used to help determine the release history and possible sources of the EDB and DBCP, as well as provide an estimate of groundwater-flow rates between wells sampled for CFCs. To further facilitate the assessment of possible source areas and the fate and transport of EDB and DBCP, particle-tracking simulations will be run within a groundwater flow model being developed for Chesterfield County by the USGS (see Campbell and Landmeyer, this issue). This combination of field data and numerical simulation may allow an estimate to be made of the time needed for EDB and DBCP to be removed from the contaminated groundwater, either by discharge to springs or to wells or by dilution, assuming that any remaining source areas have been depleted or remediated (if delineated as part of this study).

Both EDB and DBCP were injected as pure-phase chemicals directly into the subsurface during the pre-planting process for peach trees grown near McBee, SC. Injections occurred along the transects to be planted, and these transects covered hundreds of acres. As a result, it is possible that the groundwater contamination observed in the McBee area results from the *non-point source* injection of EDB and DBCP over large tracts of land in the past or

# McBee Private Well Investigation



**Figure 1. Locations of public and private supply wells and extent of groundwater contamination by Ethylene Dibromide and Dibromochloropropane, near McBee, Chesterfield County, South Carolina, October 2007 (from presentation by South Carolina Department of Health and Environmental Control personnel, February 2008 public meeting).**

what remains today since the EDB ban in the late 1970s. Equally likely, however, is that the EDB and DBCP concentrations detected in groundwater are related to the use and/or disposal of these chemicals prior to or following land application. For instance, areas where the chemicals were either prepared and loaded onto tractors or where empty chemical containers were disposed of, could provide *point-source* contamination to local groundwater.

## Methods

### Source area investigation.

Prior to the summer 2010 groundwater sampling event in McBee, SC, a rapid assessment of potential source areas of EDB and DBCP was made during April 2010 using a passive soil-gas survey. The passive soil-gas approach was deployed because the physical properties of these fumigants render EDB and DBCP amenable to a volatile phase (table 1) which is easily detected through the use of soil-gas samplers. This method has a low cost

and fairly easy field installation (W.L. Gore and Associates, Inc., 2004).

The passive soil-gas survey of potential EDB and DBCP point-source areas used the GORE™ Module (module), a commercially available media based on GORE-TEX® membrane technology (U.S. Environmental Protection Agency, 1998; W.L. Gore and Associates, Inc., 2004; ASTM, 2006). The module consists of an adsorbent material placed inside a shoestring-shaped GORE-TEX® tube (fig. 2). The adsorbent material can adsorb a wide variety of volatile organic compounds (VOCs).

The modules are tied to a string, attached to a cork plug to prevent the entrance of surface water and ambient surface sources of contamination, and inserted into a shallow borehole less than 1 inch in diameter. The modules can then be removed following between 2 hours and 5 days of deployment, placed in 20-milliliter gas-tight vials (fig. 3), and sent to the commercial laboratory (W.L. Gore and Associates, Inc.) for analysis by gas

chromatography and mass spectroscopy using a modification of U.S. Environmental Protection Agency method 8260/8270 to include thermal desorption of the sample. The laboratory used as part of this study was in compliance with Good Laboratory Practices and ISO Guide 25 (International Organization for Standardization, 1990). The soil-gas contaminant results are expressed as mass of contaminant (micrograms,  $\mu\text{g}$ ) and provide screening-level data.

**Table 1. Physical Properties of the Fumigants Dibromochloropropane and Ethylene Dibromide (ASTM, 2006).**

[mg/L, milligrams per liter; mm, millimeters; Hg, mercury;  $K_{ow}$ , octanol:water partition coefficient]

Compound	Property	Result
DBCP	Solubility in water	1,230 mg/L
	Vapor pressure	0.58 mm Hg
	Specific gravity	2.08
	Log $K_{ow}$	2.43
EDB	Solubility in water	4,300 mg/L
	Vapor pressure	11 mm Hg
	Specific gravity is	2.17
	Log $K_{ow}$	1.6–2.0



**Figure 2. The GORE™ Module ready to be installed in a shallow borehole in the field.**



**Figure 3. The GORE™ Module after it was retrieved from a borehole and prior to being shipped to the laboratory for analysis.**

Passive soil-gas results can indicate the presence or absence of particular volatile contaminants. The results do not, however, reveal if the detection was derived from free product, from residual-phase adsorbed material or vapors in the unsaturated zone, or from the dissolved-phase in shallow and deep groundwater (unless the module is placed in water). In general, higher soil-gas mass in a sample tends to be related to the presence of residual contamination or free product that is close to the land surface where the soil-gas sampler is located. If such source material is located at greater depths in the soil column, however, the soil-gas contaminant mass will generally be lower. A lower value near known sources may be due to various attenuation processes that affect the soil-gas mass prior to detection. In both cases, however, the modules help to rapidly indicate the presence or absence of contaminants in question at a site.

#### Data

The passive soil-gas survey was conducted on April 27, 2010 in the McBee, SC, area where previous groundwater sampling in October 2007 found the highest concentrations of EDB and DBCP (9.1 and 0.45  $\mu\text{g/L}$ , respectively) in a migrant camp well near Old Wire Road as well as EDB and DBCP (0.21 and 2.2  $\mu\text{g/L}$ , respectively) near the railroad line adjacent to Hwy 151 (sample transects on fig. 1).

Twenty soil-gas samplers were deployed near Old Wire Road and a potential dump site and eight soil-gas samplers were deployed near the railroad. Four additional soil-gas samplers were used as trip-blank samplers for quality assurance purposes and were not deployed. Each soil-gas sampler was placed in a borehole that was 2.5-centimeter (cm) in diameter, 75-cm long, and created by a stainless steel ship-auger attached to a cordless drill. This depth is similar to that recommended by the USEPA for soil-gas investigations (U.S. Environmental Protection Agency, 1998). The auger was cleaned with a paper towel between boreholes to prevent cross contamination. The 28 modules were installed and removed on April 27, 2010 following about 4 hours of deployment, placed in 20-milliliter gas-tight vials, and sent to the W.L. Gore, Inc., laboratory for analysis.

### **Discussion**

EDB and DBCP mass was not detected in any of the 28 soil-gas samplers that were deployed nor in the trip blanks. It is possible that the lack of detection in the soil gas near groundwater that contains these compounds is the result of (1) the samplers not being deployed long enough to equilibrate with EDB or DBCP in the soil gas; (2) the concentrations of EDB and DBCP in soil gas are below the method detection limit of 0.01 µg; (3) EDB and DBCP were last applied more than 30 years ago and, therefore, the contamination resides principally in the saturated zone at depths greater than 180-ft below land surface; or (4) the 27 samplers not being deployed in areas more characteristic of the use and disposal history of EDB and DBCP in the area near McBee, SC. Additional passive soil-gas surveys are planned for the summer of 2010 to further pursue the possible point-source area hypothesis.

### **Literature Cited**

- ASTM, 2006, Standard guide for soil gas monitoring in the vadose zone: ASTM D5314-92, 36 p.
- Campbell, B.G., and Landmeyer, J.E. 2010. Development and application of a groundwater flow and management model, Chesterfield County, South Carolina: this issue, Proceedings of the 2010 South Carolina Water Resources Conference, held October 13–14, 2010, at the Columbia Metropolitan Convention Center.
- International Organization for Standardization, 1990, ISO Guide 25. General requirements for the competence of calibration and testing laboratories (3<sup>rd</sup> edition): New York, American National Standards Institute.
- U.S. Environmental Protection Agency, 1998, Innovative Technology Verification Report Soil Gas Sampling Technology: EPA/600/R-98/095.
- W.L. GORE and Associates, Inc., 2004, Surveys for environmental site assessment.

*[http://www.gore.com/MungoBlobs/239/659/surveys\\_environmental\\_brochure.pdf](http://www.gore.com/MungoBlobs/239/659/surveys_environmental_brochure.pdf)*

Disclaimer: Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.