# Quantitative High-Resolution Site Characterization to Support Petroleum Remediation in Piedmont Geology

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**Background/Objectives.** A petroleum release occurred from a former gas station which operated from the 1960s through 1981. In September 2003, during the installation of a water supply well located approximately 380 feet from the former underground storage tank (UST) system, petroleum odors were observed in soil cuttings and water from depths of 85 to 180 feet in the borehole. This well and two additional water supply wells located between 560 and 615 feet from the former UST system contained gasoline constituents exceeding drinking water standards. Subsequent soil and groundwater assessments at the site and surrounding area indicated subsurface impacts with primary constituents of concern being benzene, toluene, ethylbenzene, xylenes (BTEX), 1,2-dichloroethane (1,2-DCA), and ethylene dibromide (EDB). The bedrock at the site is comprised of foliated metamorphosed biotite monzogranite with the depth to the top of fractured but competent bedrock ranging from 60 to 80 feet below ground surface. The overlying saprolite and partially weathered rock includes residual structure from the parent bedrock with medium dip angles of 40 to 50 degrees, with more permeable layers providing preferential pathways for the migration of the gasoline constituents to the fractured bedrock. Both dissolved and light non-aqueous phase liquid (LNAPL) are present.

Soil removal conducted in May 2006 and March/April 2010 was limited to the area of the former UST system. Soil sampling results indicated gasoline constituents remained in the residual soil at levels above cleanup standards. The groundwater sampling results from monitoring wells installed in the regolith indicated a contamination plume approximately 90 feet wide and 190 feet long; however, the water supply well sampling results indicated migration of the gasoline constituents within the fractured bedrock to at least 615 feet from the former UST system. Groundwater sampling from two monitoring wells installed within the upper bedrock did not indicate the presence of gasoline constituents; however, the wells appear to be side gradient or below the plume as it moves downward from the source area. While LNAPL was not identified on the groundwater surface in the source area, the concentrations of dissolved gasoline constituents suggested residual LNAPL within the regolith below the groundwater surface.

**Approach/Activities.** Based on the limited historical soil and groundwater data, additional investigation was warranted to characterize the mass present in the subsurface. AST and A conducted quantitative high-resolution site characterization (qHRSC) consisting of soil and groundwater sampling in March and December 2019 to evaluate the horizontal and vertical extent of LNAPL in the saturated soil. The purpose was to design a groundwater remediation pilot test including the injection of BOS 200®. Discrete soil and groundwater samples were collected from the saprolite, while new monitoring wells were installed to delineate the lateral extent of the saprolite groundwater plume, and to assess the VOC concentrations within the PWR unit. To investigate the saprolite, 13 overburden soil borings were completed with soil samples collected every 2 feet vertically to quantify the soil mass contributing to groundwater impacts. The soil borings were converted to temporary piezometers to obtain groundwater samples to characterize the vertical distribution of groundwater impacts. The data collected from the discrete soil and groundwater sampling provided information to assist in choosing optimal injection locations and remediation product loading.

Based on the data collected from the additional investigation, a clearer picture of the subsurface lithology and hydrological connectivity between the overburden and PWR was confirmed. In April/May 2021, AST injected BOS 200® and amendments in 24 borings at 5-foot spacings within a 600 square foot area, with a target injection depth of 18 to 35 feet below ground surface for each boring. Two shallow groundwater monitoring wells are located within the injection area.

**Results/Lessons Learned.** The results of the qHRSC provided a better understanding of the total hydrocarbon mass present in the subsurface and identified additional data gaps. Groundwater sampling results from one year post-injection monitoring located within the injection area following the injections indicated that the injections were successful in reducing concentrations of gasoline constituents by 92 to 99 percent. Results of the qHRSC, design of the injection product loading, injection methods, and groundwater sampling results will be presented, along with lessons learned.