Site Hydrostratigraphy Refinement: Integrated Field Methods for Characterizing a NAPL-Impacted Sedimentary Aquifer in Brazil

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Background/Objectives. Since 1987, various companies have produced nitrated and chlorinated benzenes at a 14-hectare industrial site at the Camaçari Petrochemical Pole (COPEC) in Bahia, Brazil. Mixed organic compounds from multiple sources impacted the upper fluvial sandstones of the Marizal Formation, which overlies the regional water supply — the deltaic sandstones of the São Sebastião aquifer. Since 2001, a comprehensive investigation program enlightened by sustainability principles has been conducted to refine the conceptual site model (CSM) using both conventional and high resolution techniques, providing technical basis to identify preferential groundwater flow paths and support remedial design activities. Both lithological characteristics (low cementation and poorly-indurated Cretaceous sedimentary rocks) and increasing fluid pressure with depth (flowing sands typically found >24 meters below ground surface [mbgs]) have challenged conventional drilling and sampling methods. This study used integrated direct and indirect characterization methods to inform: (1) the depth extent of hydrostratigraphic units, and (2) the lateral continuity of an aquitard layer thought to be present at approximately 50 mbgs.

Approach/Activities. An integrated approach using both conventional and high resolution techniques was applied to target specific depth intervals of a 90 m stratigraphic sequence. *Direct methods*: direct push techniques (DPT) such as Macro-Core continuous coring and Membrane Interface Probe/Hydraulic Profiling Tool (MiHPT) were used to characterize the 0-15 mbgs interval at 25 borehole locations. Hollow stem auger (HSA) drilling was successfully used to perform standard penetration tests (SPT), soil sampling and monitoring well installation down to 61 mbgs. Mud rotary drilling was used to install co-located monitoring well pairs screened in local (50 mbgs) and regional (80 mbgs) aquifers, enabling measurement of vertical hydraulic gradients. *Indirect methods*: borehole passive gamma logging down to 86 mbgs was performed at six wells to assess stratigraphic sequences. An improved surface electrical resistivity imaging (ERI) approach, unprecedented in Brazil, was conducted at 24 transects across the site to survey depths down to ~60 mbgs.

Results/Lessons Learned. MiHPT logs and slug testing for the 0-15 mbgs interval suggested preferential flow paths associated with higher hydraulic conductive zones, ranging over three orders of magnitude. DPT Macro-Core sampling was successful to ~24 mbgs and, complemented by SPT sampling from 24 to 61 mbgs, provided reliable samples even in flowing sands, completing a semi-continuous lithologic profile down to 61 mbgs. Monitoring well pairs indicated an upward hydraulic gradient. Natural gamma profiles showed at least four stratigraphic sequences consistent across the site, indicating a characteristic signature of the clayey aquitard between 50 and 60 mbgs. Critically, the aquitard does not appear to be laterally continuous across the site. ERI successfully delineated the unconformity between the Marizal and São Sebastião formations around 24 mbgs, which represents an important stratigraphic control of groundwater flow and solute transport. The contributions of this work extend beyond site boundaries providing important hydrostratigraphic information for the COPEC.