



Transition from Mechanical-Based Remedies to Natural Remedies: Molecular Biological Tools Demonstrate Petroleum MNA and NSZD in a Fractured Basalt Aquifer in Melbourne, Australia

POSTER GROUP 1

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INTRODUCTION & APPROACH

The project site is located on a peninsula in Victoria, Australia. Land use in the area is residential-commercial with some light industry. The site is underlain with Middle Paleozoic basaltic lava of variable texture and fabric. A petroleum hydrocarbon release in 2006 lead to the use of several mechanical remedial efforts to address the presence of light nonaqueous-phase liquids (LNAPL) and dissolved-phase petroleum constituent fractions. The ultimate remedial goal is achievement of Clean Up So Far As Reasonably Practicable (CUSFARP) in source areas. Continued remedial efforts now focus on residual (immobile) LNAPL and the dissolved-phase plume using in-situ Bioremediation supported by multiple lines of evidence for Natural Source Zone Depletion (NSZD), and Monitored Natural Attenuation (MNA).

Natural Remedy Approach

To facilitate moving the project toward natural remedy, a tiered framework was developed for evaluating NSZD and MNA, including assessment and developing a biogeochemical conceptual site model (CSM) and establishing baselines, design, and performance monitoring which integrated primary (petroleum hydrocarbons), secondary (geochemistry and redox parameters) and tertiary (MBTs) lines of evidence.



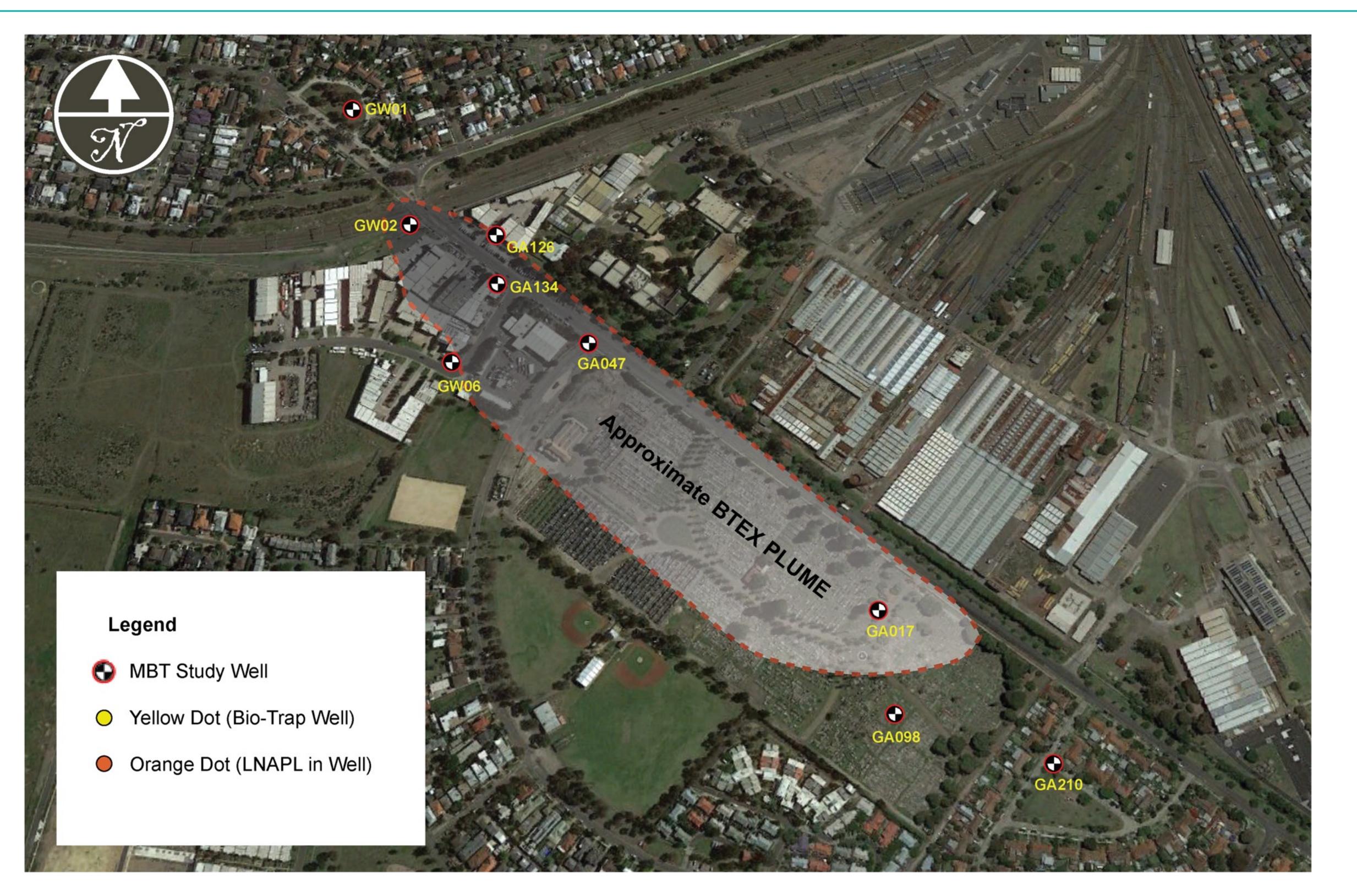
Dissolved-Phase Plume Management System EPA Approved Shut Down September 2021

MBTs were analyzed on samples primarily collected utilizing groundwater grab sampling methods, but also included the novel deployment of Bio-BagsTM within the riser space of monitoring wells within the vadose zone for evaluation of fermentation and methanogenesis, as well as CENSUS® Quantitative PCR (qPCR) (Microbial Insights, Knoxville, TN) for specific gene targets within the contaminant plume. The MBT assessment also included deploying Bio-Traps® across the LNAPL/water interface within the fractured basalt bedrock matrix.

Project Goals

The overall project goals are to transition the site remedy to NSZD and MNA using a weight of evidence approach including use of molecular biological tools (MBTs) and to achieve CUSFARP.

METHODS



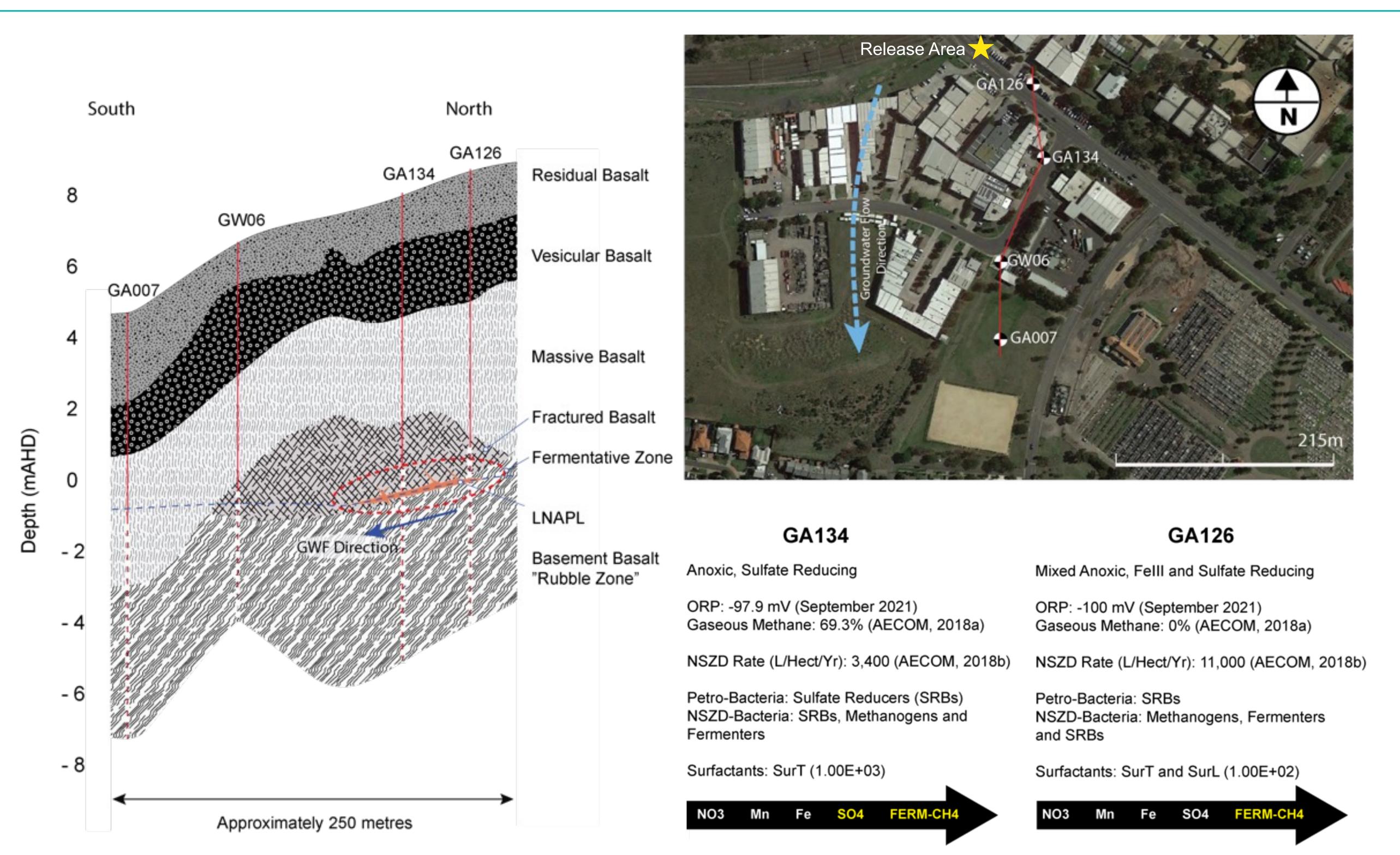
Dissolved-Phase BTEX plume and MBT performance monitoring wells. Locations GA126 and GA134 were also evaluated for CO2 flux and temperature profiling as part of a LNAPL NSZD study culminating in 2018. GW01 is an upgradient background control well, while GA210 is a distal plume sentinel well.

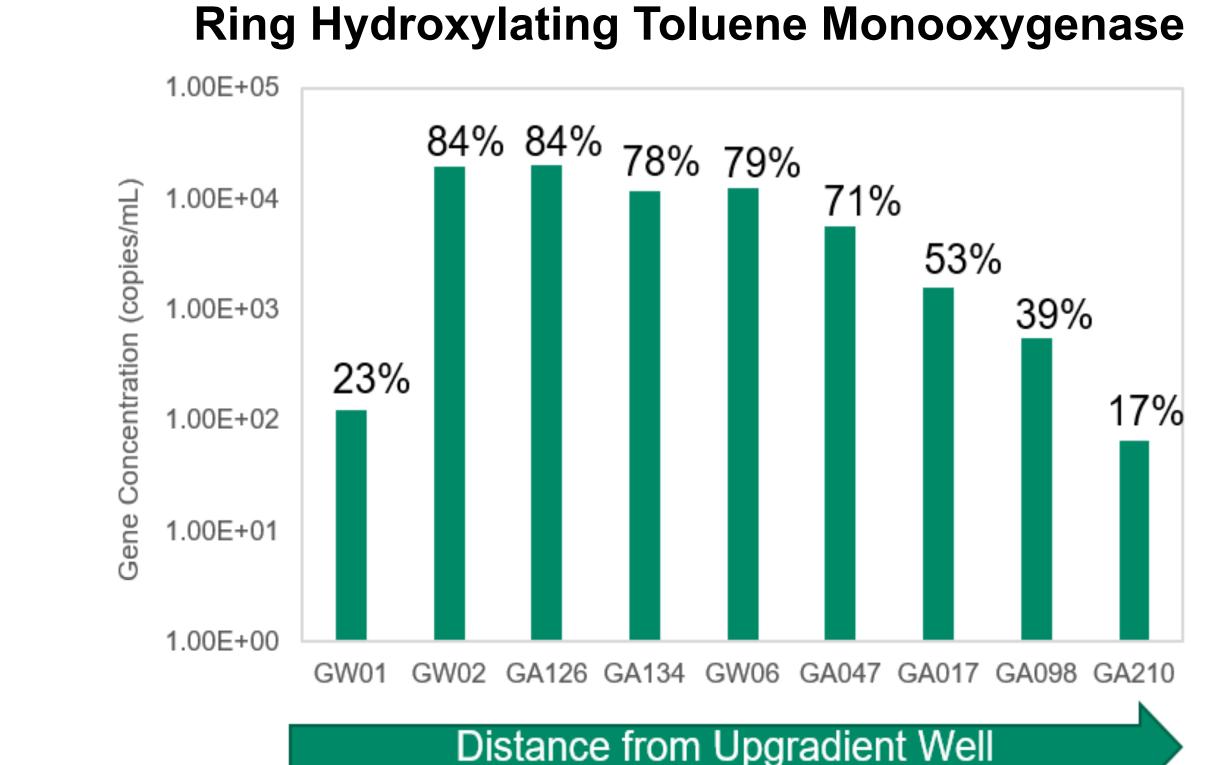
MBTs and Monitoring Parameters

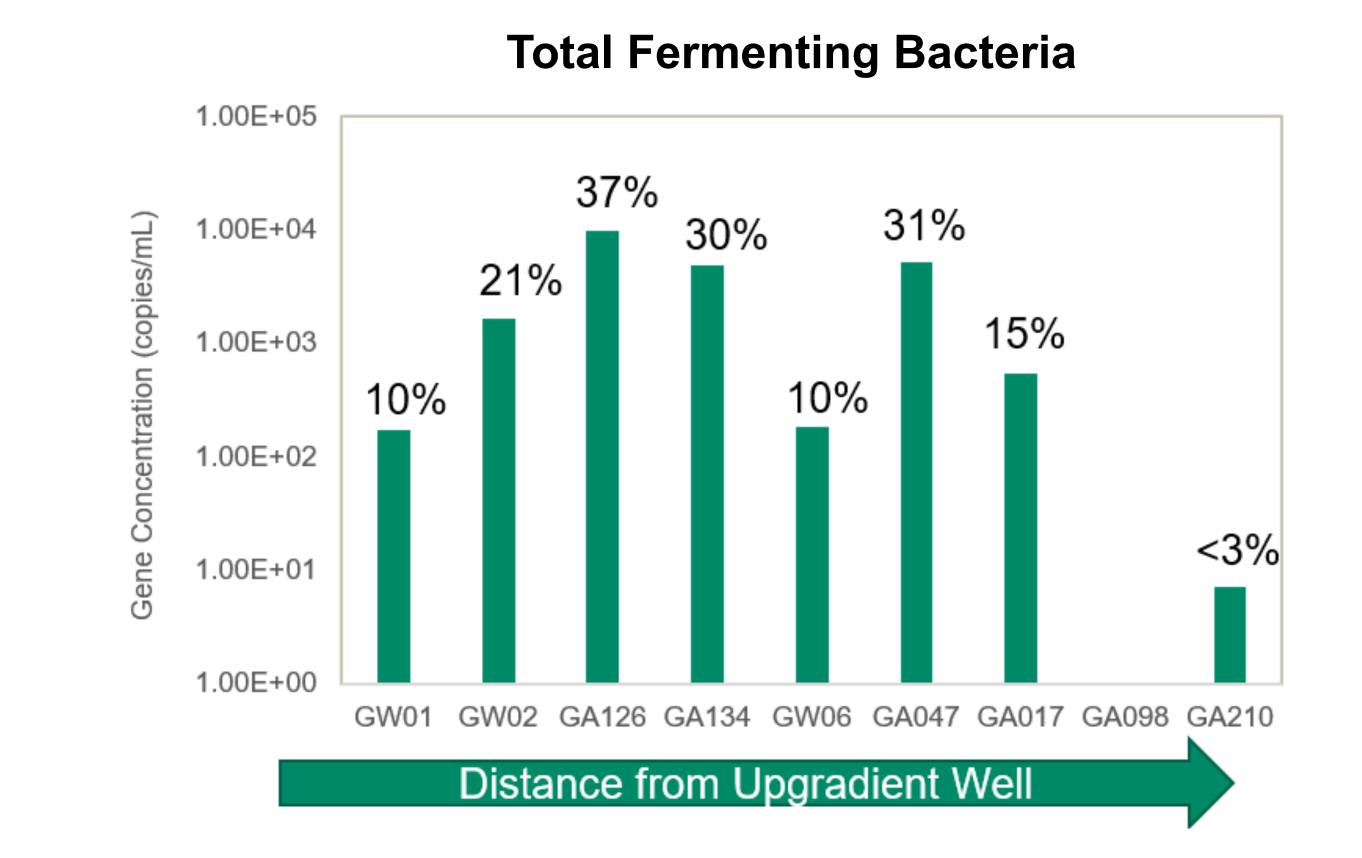
A MBT Sampling and Analysis Quality Plan (SAQP) was developed for the project. Well selection was based on historical petroleum constituent monitoring, MNA parameters, and NSZD data from previous assessments. Monitoring parameters were as follows:

- qPCR targets for EBAC, ARC, SRB/APS, MGN, IRB, FER, acetoclastic methanogens (AMGN), and acid producing bacteria
- Catabolic pathway markers (genes) for benzylsuccinate synthase (bssA), ring hydroxylating toluene monooxygenase (RMO), and methane monooxygenases (MMO)
- Glycolipid, liposaccharide, lipopeptide and trehalose biosurfactants
- Redox Mapping prescribed by USGS (Jurgens, et al., 2009)
- Installation of Bio-Traps® at water/NAPL interface and deeper screened interval and in vadose zones as Bio-Bags™ using QuantArray-Petro and QuantArray-NSZD (Microbial Insights)

RESULTS







Results

- MBTs supporting LNAPL NSZD and biodegradation include anaerobic and aerobic BTEX and alkane degrading genes, presence of fermenters, CO2 emissions, and presence of biosurfactants.
- Regulatory feedback has been positive in moving the site remedy toward a natural remedy which will involve continued monitoring of the plume.



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