Evolution of a Conceptual Site Model for the Botany Chlorinated Hydrocarbon 'Mega-Site' Cleanup Project

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Background/Objectives. The Botany Industrial Park (BIP), a 70 hectare facility located south of Sydney's CBD in Australia, has operated as a petrochemical complex from the 1940s. Former effluent and waste management practices, and leaks from operational plants, resulted in significant chlorinated hydrocarbon (CHC) contamination, principally 1,2-dichloroethane, chlorinated ethenes and chlorinated methanes. Dissolution of a number of distinct DNAPL source areas has resulted in formation of overlapping groundwater plumes with high dissolved CHC concentrations (near solubility limits), and a broad zone exceeding 1 mg/L extending up to 1 km wide and 1.5 km from the site. The total CHC mass in dense non-aqueous phase liquid (DNAPL), dissolved- and sorbed-phases has been estimated to be in the order of 14,500 tonnes. Risks from CHCs are low due to implementation of community-based management steps, regulatory controls on groundwater use, and a 4.5-6 ML/day groundwater extraction and treatment system ("GTP system') installed in 2004 at a capital cost of US$80 million to contain further plume migration and reduce CHC discharge to surface water bodies.
Plume migration has primarily occurred within underlying high-permeability Quaternary sand aquifer units towards Botany Bay and two intersecting surface drains. However, the distribution and behavior of CHCs is complex due to intricate source history, former industrial use of groundwater and the effects of interspersed low-permeability organic-rich sediment layers on DNAPL architecture and plume dynamics. This, and the magnitude of CHC mass, has meant investigation and remediation has had to overcome many challenges. Development and progressive evolution of a conceptual site model (CSM) has been a key tool to achieve these.

Approach/Activities. A substantial CSM has been developed, incorporating over 50,000 data points and multiple streams of work and disciplines, and has progressively evolved to reflect the stage of the project and body of knowledge:

1. The first CSM was developed following the first detailed investigations in the 1990s, and reflected the fundamental understandings of site hydrogeology, CHC distribution and exposure pathways to aid in remediation design.
2. A major revision of the CSM in 2007 captured the increased understanding of DNAPL sources and better understanding of plume dynamics from initial operation of the GTP, with a key objective to support feasibility assessment of source area remediation options.
3. A 2017 revision of the CSM incorporated the findings from 10 years of GTP operation. This CSM was structured around the '14-compartment model' (Vanderkooy et al., 2014) but adapted to better incorporate the receiving environment. The objective was to aid in evaluation of long-term management approaches and GTP system end points, with a broader target audience in mind to assist in stakeholder acceptance (including community and regulators).

Results/Lessons Learned. The CSM for the Orica Botany Groundwater Cleanup Project has required iterative development as the project has evolved from investigation, to harm prevention, to developing long-term management strategies and end points. The recent CSM revision, adapting the '14-Compartment model', may be an appropriate approach for other chlorinated solvent 'mega sites'.