

PREVENTING COLUMBIA/POTOMAC FORMATION AQUIFER CROSS-CONTAMINATION IN THE DECOMMISSIONING OF AN IN-GROUND FROZEN EARTH PROPANE STORAGE FACILITY, DELAWARE CITY REFINERY, DELAWARE

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The Frozen Earth Storage (FES) facility at the Delaware City Refinery (DCR), Delaware, utilized an earthen cavern that was excavated into unconsolidated Cretaceous and Pleistocene-age deposits to store liquid propane (C3) at -45 degrees C and low pressure (0.3 psi). At 128 feet deep and 165 feet wide, the integrity of the subsurface walls of the 500,000-barrel cavern was achieved by circulating liquid C3 through three rings of vertical pipes designed to maintain a zone of frozen soil and groundwater around the cavern. Commissioned in 1966, the cavern developed fugitive emission problems that triggered a State of Delaware Conciliation Order (CO) in 2008 requiring the Refinery to permanently eliminate C3 emissions from the FES.

The decommissioning of the FES system was complicated by the sequence of hydrogeologic units that were penetrated by the cavern excavation: the Pleistocene-age Columbia Formation aquifer, the late Cretaceous-age Merchantville Formation confining unit, and the early Cretaceous-age Potomac Formation aquifer. The Columbia Formation aquifer is impacted with petroleum hydrocarbons from historical refinery operations and the underlying Potomac Formation aquifer provides much of the drinking water in this region of Delaware. Therefore, one of the essential aspects of the FES decommissioning was designing a suitable backfill for the cavern to re-establish a low permeability horizon (akin to the Merchantville Formation) to prevent the vertical migration of contaminated groundwater downward into the Potomac Formation aquifer.

In addition to the intrinsic difficulties of safely purging and inerting a C3 storage cavern that relied upon the circulation of the stored C3 for its structural integrity, other geotechnical and environmental challenges included determining how to mix and expeditiously emplace large volumes of low-permeability grout, identifying tens of thousands of cubic yards of a low-cost environmentally suitable sand backfill, developing a strategy to abandon hundreds of vertical freeze pipes, and implementing a baseline groundwater monitoring program. The FES decommissioning commenced in August 2010 and was completed in December 2011 and satisfied the conditions of the CO, particularly the protection of the Potomac Formation aquifer and cessation of the propane emissions.