# Use of an Innovative Multi-Increment Sampling Approach to Estimate Mass Balance and Optimize Remediation of PCE in Soil

**Wai Yi Ng** (waiyi.ng@honolulu.gov) (Honolulu Authority for Rapid Transportation [HART], Honolulu, Hawaii, USA)
*Sergio Cocchia* (Sergio.Cocchia@ch2m.com) (Jacobs, Honolulu, Hawaii, USA)
Frank Hopkins (Jacobs, Honolulu, Hawaii, USA)

**Background/Objectives.** The project Site is a 0.5-acre area located along the 20-mile rail guideway currently under construction on Oahu, Hawaii. A dry cleaning facility operated on site between 1978 and the late 1990s. Large volumes of tetrachloroethylene (PCE) were used and improperly stored at the facility. Previous Site Assessments conducted between 2002 and 2013 applying discrete sampling methods concluded that no impacts to soil and groundwater were present, but soil gas was not sufficiently characterized. Additional investigation was therefore conducted by CH2M for HART to characterize vapor intrusion concerns. Shallow soil gas and subslab vapor sampling confirmed vapor intrusion concerns and identified unacceptable risk. An innovative combined multi-incremental (MI) and individual borehole sampling approach was used to further investigate PCE sources in soil, and optimize and expedite remediation in advance of construction of the Lagoon Rail Station. The project team worked collaboratively with HDOH to prepare flexible and dynamic plans, streamline decision-making, and minimize uncertainties.

**Approach/Activities.** To optimize soil investigation and minimize disposal volumes, the site was divided into six decision units (DUs), with each DU further subdivided into five vertical DU layers based on anticipated future potential exposure scenarios. Additional investigation activities included 180 soil borings to 10 feet below ground surface (bgs) to collect 30 MI soil samples (one per vertical DU layer) and 180 individual borehole soil samples (one sample per increment location, each composed of 20 aliquots distributed vertically throughout the borehole) to identify sources and delineate nature and extent of potential PCE contamination; mass balance calculations to optimize soil disposal volumes; and removal of 80 percent (%) of the PCE mass in soil to achieve remediation goals. The individual borehole sample results combined with the MI sample results were used to estimate the 3-dimensional PCE mass distribution, which allowed to locate sources and identify remediation volumes.

**Results.** Soil volumes corresponding to individual boreholes with high PCE concentrations intersecting vertical DU layers/MI samples with higher levels of the same constituent were identified as sources. Remediation areas were then established to remove 80% of the PCE mass in soil. Based on collected data, 1.4 kilograms (kg) of PCE were estimated to be present in soil down to 10 feet bgs, with 70% of the total PCE mass in soil observed in the top 1.5 feet bgs, indicating that the volume and migration of PCE released was limited. Remediation activities included the removal and disposal of approximately 2,064 tons of PCE-contaminated soil as non-hazardous waste, resulting in an estimated PCE mass removal of 1.1 kg, slightly above the remediation goal of 80% PCE mass reduction. Remediation was completed in time to begin construction of the station on schedule. The combined MI-individual borehole sampling approach proved more accurate for identification and removal of PCE sources than discrete approaches used during previous assessments (which resulted in no exceedances of action levels in soil) and traditional MI sampling approaches (which would have not met the remediation goal, with an estimated PCE mass removal in soil of approximately 60%).