# Thermally-Enhanced Bioremediation for Xylene: Using Conductive Heating to 35ºC

***Gorm Heron*** (gheron@cascade-env.com), Amber Bonnarigo, and Jack Wattu (Cascade Thermal, Gardner, MA, USA)
Justin King (CHA, Albany, NY)
Dennis Keane and Michael Marley (XDD)

**Background/Objectives.** A xylene-rich LNAPL site in New York State was treated in approximately one year by using thermally enhanced bioremediation. The COCs were aerobically degradable, but the site had limited oxygen and relatively tight soils. Over decades, little mass reduction had occurred, and soil concentrations of TPH and xylene remained above 1,000 mg/kg in large volumes.

The contamination existed between ground surface and approximately 15 ft below grade, with a water table fluctuating near the bottom of this interval. The microbial population was characterized and found to be amenable to aerobic degradation of xylene and other COCs.

The objective was to reduce soil concentrations of all COCs to below 100 mg/kg.

**Approach/Activities.** To stimulate biological degradation, oxygen needed to be delivered to the target volume, and gentle heating to temperatures between 30 and 40ºC was shown to greatly enhance rates. Using Waterloo profiling, layers of high and low permeability were defined across the site, and a system of injection wells, vacuum extraction wells, and heater borings was designed. The subsurface was heated while air was pulled into the xylene-rich zones, facilitating bioremediation. Interim soil sampling was used to track the progress

**Results/Lessons Learned.** The first interim soil sampling round revealed that the goals had been met in more than 75% of the volume, with two hotspots remaining – xylene concentrations remained above 100 mg/kg. System enhancements were made to improve the distribution of heat – and more time allowed for the remediation. Subsequent soil sampling events in the two smaller areas showed significant progress towards the goals, and eventually the completion of the remedy.

This project demonstrated how thermal conduction heating, counter to common industry claims, was very effective in heating the subsurface to a modest temperature in the 30-40ºC range, and to stimulate biological degradation. Combined with a trageted investigation of permeability, and a system to deliver oxygen for the aerobic reactions, very substantial rates of biodegradation, and eventually site closure, was attained.