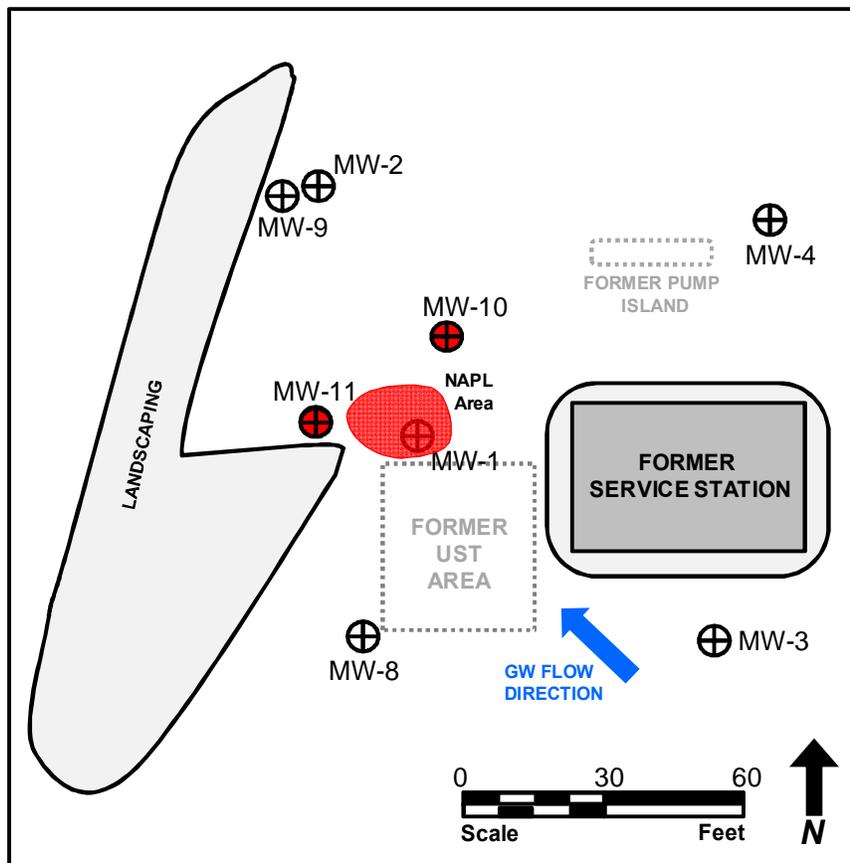


SURFACTANT-ENHANCED LNAPL RECOVERY PETROSOLV™ SURFACTANT

Type of Project:	Pilot-scale/Full-scale
Contaminants Treated:	Light non-aqueous phase liquid (LNAPL) gasoline fuel
Concentration:	NAPL layer ranging from 0.01 to 0.22 feet in thickness
Technology Applied:	One surfactant injection/extraction event using injection pumps and submersible extraction system
Geology:	FRACTURED BEDROCK
Treatment Interval:	GW and smear zone at 18-22 feet bgs
Average % Reduction:	99% - eliminated NAPL thickness
Timeframe:	1-Day Injection/Extraction Event
Project Reference:	Available on request.

SITE SUMMARY: During a Phase II Site Investigation at a site in Pennsylvania, free product (NAPL) was discovered in a monitoring well (MW-1) in the vicinity of former gasoline USTs. The groundwater and NAPL occurred in fractured limestone bedrock. For several years, passive and temporary/intermittent recovery methods (bailers, sorbent socks, 8-hr. vacuum events) were applied, but persistent NAPL thickness remained in MW-1. In 2009, a surfactant injection/extraction event was proposed, approved, and performed at the site. The event consisted of injection of surfactant solution into MW-1, MW-11, and MW-10, with simultaneous extraction of fluid from MW-1 in order to maintain hydraulic control (see Description below). Following surfactant injection and extraction, biological amendments were injected to stimulate biological degradation of residual dissolved-phase compounds in groundwater.

RESULTS: No NAPL has been detected in MW-1 for 5 consecutive months of post-injection monitoring. In addition, no increases in dissolved-phase constituents have been measured in surrounding monitoring wells, indicating successful capture of residual NAPL and surfactant solution.



DESCRIPTION OF SURFACTANT RECOVERY EVENT: With fractured bedrock lithology, hydraulic capture of NAPL and surfactant solution is critical, requiring a focused injection/extraction procedure. For this site, the following procedure was used:

- 1) A small volume of 7% PetroSolv[®] solution was injected at low pressure into MW-1. After injection, MW-1 was surged using a surge block to promote better contact with surrounding NAPL-impacted fractures and voids, and allow better peripheral distribution of the surfactant solution around MW-1.
- 2) After surging MW-1, groundwater extraction from MW-1 was implemented to remove the injected PetroSolv[®] solution and produce a cone of depression around MW-1.
- 3) Water levels in monitoring wells MW-10 and MW-11 were gauged during GW extraction from MW-1 to ensure an adequate cone of depression before injecting into MW-10 and MW-11. After 90 minutes of GW extraction, drawdown of 0.21 feet and 0.46 feet were observed in MW-10 and MW-11, respectively, indicating that an adequate cone of depression was established to induce flow toward MW-1.
- 4) After the cone of depression was established, a 13% PetroSolv[®] solution was injected into MW-10 and MW-11, while GW extraction was maintained at MW-1. The PetroSolv[®] solution injected into MW-10 and MW-11 included a red dye to verify that the injected solution was captured at MW-1. The GW extraction hose was equipped with a clear sight tube to allow visual observation of the extracted liquid. Red dye was observed at MW-1 approx. 30 minutes after initiating injection at MW-10 and MW-11.
- 5) GW extraction at MW-1 continued for 1 hour after the surfactant injection in MW-10 and MW-11. Water level measurements collected from MW-10 and MW-11 indicated that a cone of depression was maintained around MW-1 during and after surfactant injection. The red dye observed in the sight tube was significantly reduced during the continued extraction at MW-1, indicating that the majority of the injected surfactant was recovered.
- 6) Following extraction at MW-1, the wells were allowed to recharge. During groundwater recharge at MW-1, a small volume of 10% PetroSolv[®] solution was injected at low pressure into MW-1. This allowed the surfactant solution to flow into exposed fractures and voids, helping optimize contact with any trapped NAPL. MW-1 was again surged to promote better contact with the surrounding fractures and voids.
- 7) After surging MW-1, GW extraction from MW-1 was re-activated for approximately 1 hour to re-create an adequate cone of depression before re-injecting into MW-10 and MW-11. Drawdown of approximately 0.43 feet and 0.67 feet below static levels were observed in MW-10 and MW-11, respectively, prior to re-injection at MW-10 and MW-11.
- 8) Once the cone of depression was re-established, a small batch of 10% PetroSolv[®] solution (with red dye) was simultaneously injected into MW-10 and MW-11 using the previous methodology (see item #4). Red dye was observed in the sight tube at MW-1 approximately 20 minutes after initiating the re-injection at MW-10 and MW-11.
- 9) GW extraction at MW-1 continued for approximately 2 hours following the re-injection in MW-10 and MW-11 to ensure recovery of the injected surfactant solution. The red dye observed in the sight tube was significantly reduced during continued extraction at MW-1, indicating that the majority of the injected surfactant was recovered.
- 10) Over the course of the pilot test, 600 gallons of PetroSolv[®] solution was injected into MW-1, MW-10 and MW-11, while 3,000 gallons of fluid was removed from MW-1. This extraction volume was five times the volume of surfactant solution that was injected, thus promoting effective hydraulic control. Furthermore, red dye was not detected in any surrounding monitoring wells during or after the injection event.
- 11) After surfactant injection/extraction was completed, 150 pounds of CBN nutrients were mixed with approximately 200 gallons of water and injected evenly into each of the injection wells (MW-1, MW-10, and MW-11). The nutrient addition was intended to stimulate biological degradation of remaining dissolved-phase constituents.

COST: 60 gallons of PetroSolv[®] and 150 lbs. of CBN nutrients were used for the entire project, at a total cost of \$4,000, including shipping. Consultant labor and equipment costs were not available.