BOS 200® Remediation at a Iowa City Terminal Coralville, Iowa USA

Background Information

The Iowa City Terminal is an approximately 66-acre refined products terminal that stores and distributes various petroleum derivatives for transfer to other pipelines and tanker trucks. The terminal formerly was serviced by a rail spur for transfer of petroleum products to and from rail cars. Investigation and corrective action work conducted at the facility under the oversight of the Iowa Department of Natural Resources (IDNR).

Investigations and remediation of petroleum releases to the subsurface had been conducted at the terminal since at least 1991. Subsurface impacts have historically included accumulations of petroleum hydrocarbons in soils, accumulation of light non-aqueous phase liquids (LNAPL) in on-site monitoring wells, and aqueous phase (dissolved) fuel constituents in groundwater that extends off-site. A series of investigations have been performed over the years.

Figure1 provides the approximately area of the injection effort. The hydrocarbon plume extends approximately 3,000 feet from site. The primary constituents of concern in the plume are benzene and MTBE.

Remedial Effort

In 2007, Remediation Products, Inc., (RPI) and AST Environmental, Inc., (AST) teamed to address the on-site LNAPL impacts in the source area at the Iowa City Site. Specifically, an injection design was prepared and implemented to address LNAPL and dissolved phase petroleum hydrocarbons in the following monitoring wells:

- MW-23
- EP-01B
- EP-26
- EP-27
- MW-47D

The first four of these wells have a similar mechanism of NAPL occurrence, LNAPL accumulation happens during periods of low water table. The apparent source was LNAPL drainage from secondary permeability features in silt soils that are normally submerged. The source of the LNAPL in MW-47D was a continuously saturated sand layer beneath the zone of water table fluctuation.

Bench Adsorption Test

As part of the scope RPI preformed an adsorption test to explore the capacity of activated carbon to assimilate potential LNAPL hydrocarbon contaminant persisting at the Iowa City Terminal Facility. The test consisted of contacting known amounts of LNAPL with activated carbon in small clear vials so that readily observable changes in the amount of LNAPL would result. Two vials were prepared as shown on the attached photograph. The first vial

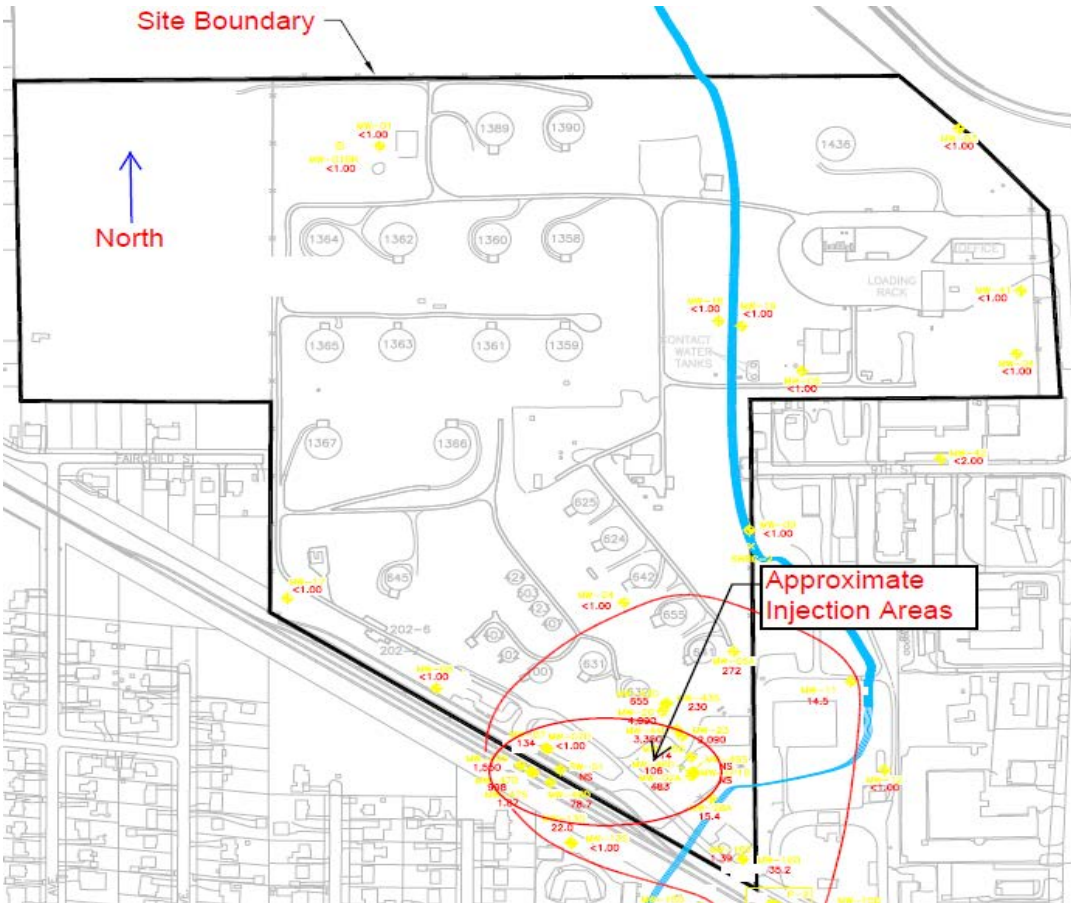

Figure 1 – Site Plan View

contained 5 ml of LNAPL and 10 ml of reagent water while the second vial contained 10 ml of LNAPL along with reagent water. The reagent water was added to allow a clear phase separation between the saturated carbon and any LNAPL remaining after the carbon addition.

No visible amount of LNAPL persisted in the 1st vial after treatment (see the photographic documentation below). Based on this result, the capacity is greater than 80% wt. The second vial was also treated with 5 grams of carbon and a residual layer of LNAPL is clearly visible in the photograph. The layer measured 9 mm, so 59.1% of the LNAPL was adsorbed. The calculated capacity based on this result is 94% wt.

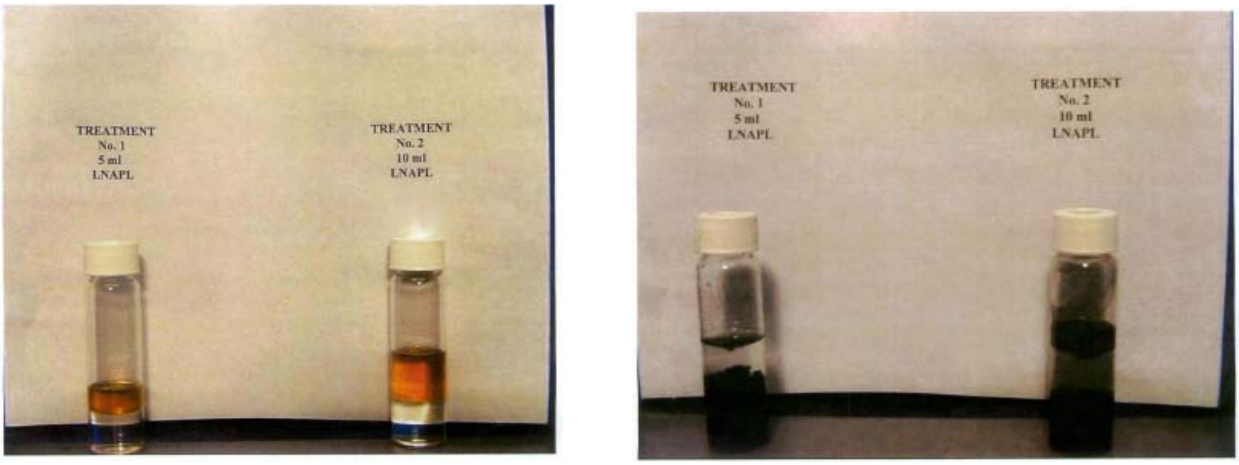

Figure 2 – Photographic Documentation

Full Scale Design and Implementation

The adsorption data from the bench testing was combined with soil, groundwater and LNAPL data from the wells of concern, to prepare an injection design. The goal of the injection design was to install BOS 200® at a rate of approximately 0.81 lbs/ft3 of saturated zone. This loading varied based on the amount of LNAPL present and the soil and groundwater concentrations of hydrocarbons. An area of approximately 500 square feet was the target injection area around each of the impacted wells. The injections point spacing varied from 5 to 7.5 feet. The injection design for each of the five (5) areas was as follows:

EP- 1B Area –

- 13 injection points (5 to 7.5 foot centers)
- Alternating injections depths between locations: 17’ 18.5’, 20’, 21.5’, 23’ 24.5’ & 26’ and 17.75’, 19.25’, 20.75’, 22.25’, 23.75’, 25.25’, 26.75’, 28.25 and 29.75.
- 117 total injections, injecting approximately 37 lbs of BOS 200® per interval - 4,370 pounds of BOS 200®

EP- 26 Area –

- 13 injection locations (7.5 foot centers) – borings to 30’ bgs, 9 injection intervals per location
- Alternating injections depths between locations: 17’ 18.5’, 20’, 21.5’, 23’ 24.5’ 26’, 27.5’ & 29’ and 17.75’, 19.25’, 20.75’, 22.25’, 23.75’, 25.25’, 26.75’, 28.25 & 29.75.
- 117 total injections, injecting approximately 40 lbs per interval - 4,770 pounds of BOS 200®

MW-23 Area –

- 13 injection locations (7.5 foot centers) – borings to 28’ bgs, 10 injection intervals per location
- Alternating injections depths between locations: 13’, 14.5’, 16’, 17.5’, 19’, 21.5’, 23’, 24.5, 26 & 27.5’ and 13.75’, 15.25’, 16.75’, 18.25’, 19.75’, 22.2’, 23.75’, 25.25, 26.75 & 28.25’.
- 130 total injections, injecting between 30 and 55 lbs per injection for a total of 5,565 pounds of BOS 200®

EP-27 Area –

- 13 injection locations (7.5 foot centers) – borings to 33’ bgs, 11 injection intervals per location
- Alternating injections depths between locations: 16’, 17.5’, 19’, 21.5’, 23’, 24.5’, 26’, 27.5’, 29, 30.5, & 32’ and 16.75’, 18.25’, 19.75’, 22.25’, 23.75’, 25.25’, 26.75’, 28.25, 29.75, 31.25, 32.75.
- 143 total injections, injecting approx 45 lbs of BOS® per injections for a total 6,435 pounds of BOS 200®

MW-47D Area –

- 13 injection locations (7.5 foot centers) – borings to 30’ bgs, 6 injection intervals per location
- Alternating injections depths between locations: 23’, 24.5’, 26’ & 27.5’ and 23.75’, 25.25’, 26.75’ & 28.25’.
- 78 total injections, injecting 46 lbs of BOS® per injections for a total 3,588 pounds of BOS 200®

Figure 3, below provides the five injection areas:

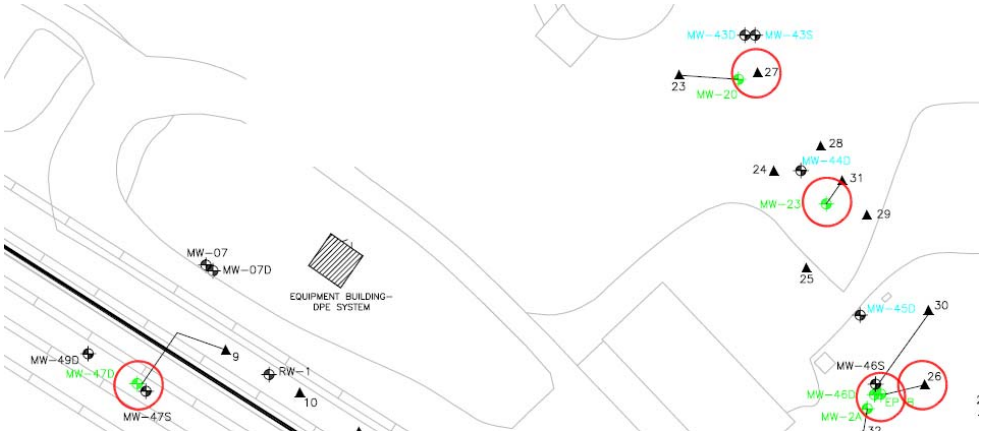

Figure 2 – Injection Areas

On December 10, 2007, AST mobilized to the site and began injection of BOS 200® at the site. AST prepared BOS 200® slurry's and injected it into the subsurface through probe rods. The slurry is pumped through the probe rods using a positive displacement diaphragm pump capable of delivering 1,200 psi at 35 gpm. The injection pressure varied from 200 to 400 psi. The pressure injection scheme created extensive "fracturing or soil lifting" of the soil to create preferential pathways within the silt which are filled with BOS 200®. The fractures filled with BOS 200® are more permeable than the primary silt matrix. LNAPL present within secondary permeability features in the silt were drained into the BOS 200®-filled fractures, where the LNAPL was sorb to the activated carbon and then underwent biodegradation. In intervals where there was higher sand content, there was more radial flow from the injection point that resulted in a much more homogeneous distribution of material than in silts and clay, where fractures predominate.

The two photos below provide photo documentation of BOS 200® distribution in the EP-1B area. The boring was performed within 3' of one of the 13 injection points. As can be seen a more homogenous distribution in the more coarse grain soil (photo #2), will small seams of BOS 200® is more predominant in the fine grain soil.

EP-1B Close up of 22'bgs.

PHOTO #1

EP-1B Cross-section from 26-30' bgs. Deeper to top.

PHOTO #2

The table below provides the results for the LNAPL monitoring and the post-injection analytical. As seen in the table the BOS 200® injections were successful in remediating the LNAPL at the site. Additionally, in September 2008, Iowa Department of Natural Resources (IDNR) issued a "No Further Action" not only for the LNAPL but for the dissolved phase impacts in the injection areas.

Table 1 – Pre- and Post-Injection Results Summary

Well ID	Post-Injection Total TEX (ug/L)	LNAPL (ft) Pre-Injection	LNAPL (ft) Pre-Injection	Notes
EP-01B	36	>0.2	Non-Detect	MW-2A and MW-46D in the same area as EP-01B had >0.2 ft of LNAPL prior to the injection
EP-26	ND	>0.02	Non-Detect	
EP-27	ND	>0.2	Non-Detect	MW-20 and EP-23 in the same area as EP-27 had >0.2 ft of LNAPL prior to the injection effort
MW-23	2500 (within 4months but by 2 months later (<100 ug/L)	>0.2	0.03 (within 4 months and then Non-Detect 2 months later	EP-29) in the same area as MW-23 had >0.2 ft of LNAPL prior to the injection effort
MW-47D	No Data Provided by the Consultant	>0.2	Non-Detect	LNAPL varied from 0.1 to 0.5 ft (within the previous 6 months prior to the injection)