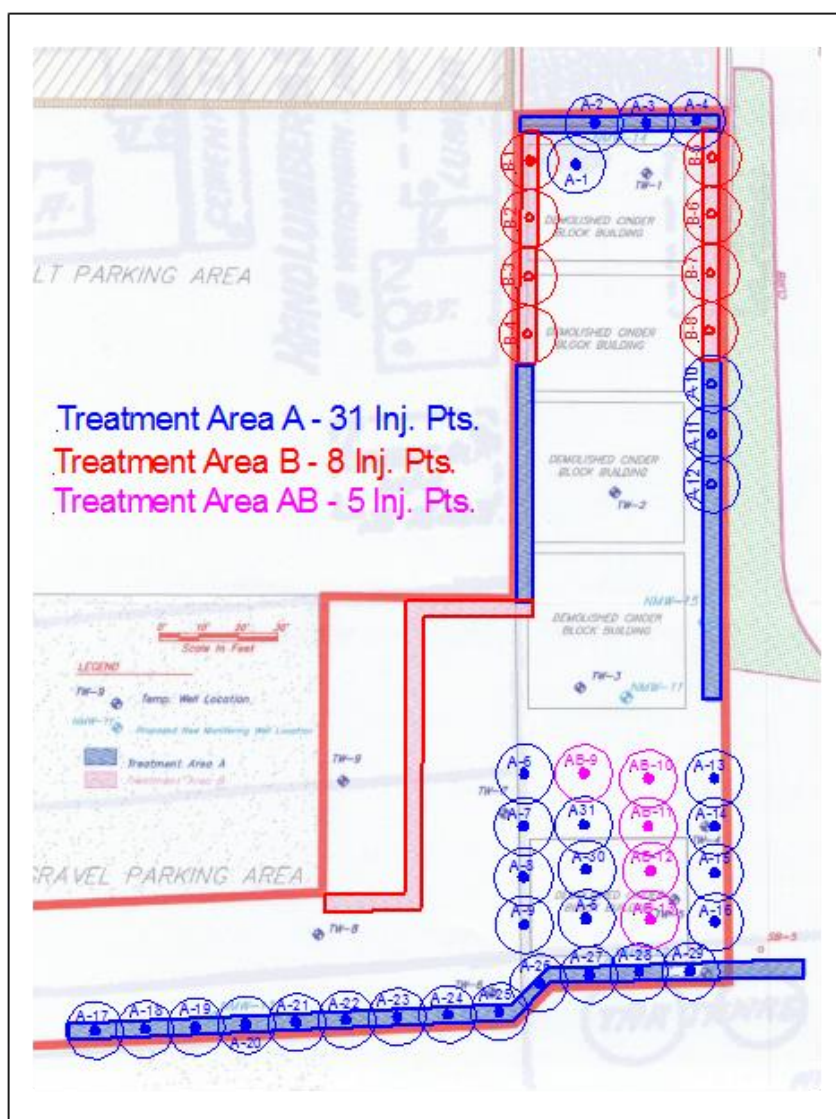


**Project Summary**

*In-Situ Geochemical Stabilization (ISGS)* was utilized at a site located near Fanwood, New Jersey to remediate soils and groundwater impacted by the historical release of coal tars and heavy ended petroleum compounds. The compounds of concern included benzene, Benzo(a)anthracene, Benzo(a)pyrene, and multiple other VOC and SVOC contaminants. The in-situ program covered a total area of 8,955 square feet and treated soil and groundwater from 5-10 ft. below ground surface. The remedial liquids were injected into 44 points via direct push technologies (Fig.1). Two intervals between from 5-7 and 8-10 feet below ground surface (bgs) were used to inject the liquids into the targeted media affecting a radius of 7.5 feet for each point.



**Figure 1.** Site map showing the location of 44 in-situ injection points.

## Remediation Plan

In-Situ Geochemical Stabilization (ISGS) entails the use of modified permanganate solutions for the purposes of mass removal and flux reduction (i.e., NAPL stabilization). As the oxidant migrates through the treatment area, various (bio)geochemical reactions destroy the targeted compounds present in the dissolved phase. This causes a “hardening” or “chemical weathering” of the NAPL as it steadily loses its more labile components. This causes a net increase in viscosity of the organic material, which yields a more stable, recalcitrant residual mass. In addition, both the insoluble  $MnO_2$  precipitate that results from permanganate oxidation and other mineral species included in the ISGS formulation accumulate along the NAPL interface, physically coating the NAPL and thereby reducing the flux of dissolved-phase constituents of interest (COI) into the groundwater.

Unlike the typical application of In Situ Chemical Oxidation (ISCO) reagents, ISGS is used to encapsulate NAPL, with chemical oxidation of COIs being a secondary affect. As a result, the overall oxidant dosing is often substantially less than with typical ISCO applications, resulting in rapid, highly effective treatment at a much lower cost.

## Results

### Monitoring Wells

Five monitoring wells were sampled during the baseline sampling event of August 2013 and the first two post-injection sampling events. These wells are: MW-11, MW-12, MW-13, MW-14 and MW-15. The locations of the five monitoring wells are presented in the map below.



### MW-11

Monitoring well MW-11 is located in the center of the main treatment area, where the demolition of the main building occurred. Based on the analytical data of the January 2014 sampling event, it appears that the remedial treatment event has dramatically impacted the concentrations of all targeted contaminants in the vicinity of monitoring well MW-11. The concentrations of almost all SVOC compounds have decreased to levels below the laboratory detection limits, while the total concentrations of the BTEX contaminants has decreased by 85%. The concentration of the total alkanes has also reached non-detect levels.

**Table 1.** CVOC Data for MW-11 ( $\mu\text{g/L}$ ).

<b>MW-11</b>			
<b>Sampling Date</b>	<b>08/30/2013</b>	<b>10/16/2013</b>	<b>01/15/2014</b>
Acenaphthylene	0.461	0.312	ND 0.10
Benzo(a)anthracene	0.255	0.847	0.146
Benzo(a)pyrene	0.172	0.54	ND 0.10
Benzo(b)fluoranthene	0.218	0.76	ND 0.10
Chrysene	0.166	0.508	ND 0.10
Fluorene	0.791	0.314	0.239
Benzene	67.5	8.4	14.4
Ethylbenzene	6.6	ND 5.0	0.77 J
Toluene	46.5	ND 5.0	3.0
Total Xylenes	19.1	ND 5.0	2.7
Total Alkanes	63 J	ND	ND

ND: Not Detected

### MW-12

Monitoring well MW-12 is located in the vicinity of injection points A-27 and A-28 in the southern part of the targeted treatment area. Based on the analytical groundwater data of the January 2014 sampling event, it appears that the remedial treatment event had a significant effect in the concentrations of the targeted SVOCs and VOCs. The concentrations of the SVOCs decreased significantly and reached levels below the laboratory detection in most occasions. Benzo(a)anthracene, Benzo(a)pyrene and Benzo(b)fluoranthene that recorded highly elevated concentrations during the August 2013 baseline sampling events have shown decreases of 93%, 96% and 95% respectively. Similarly the effect of the remedial injection was substantial for the concentrations of VOC compounds, with total alkanes decreasing below the laboratory detection limits and BTEX compounds overall decreasing by 68%.

**Table 2.** CVOC Data for MW-12 (µg/L).

<b>MW-12</b>			
<b>Sampling Date</b>	<b>08/30/2013</b>	<b>10/16/2013</b>	<b>01/15/2014</b>
Acenaphthylene	1.75	ND 0.10	0.151
Benzo(a)anthracene	5.13	0.44	0.385
Benzo(a)pyrene	6.31	0.162	0.248
Benzo(b)fluoranthene	6.30	0.222	0.292
Chrysene	5.15	0.224	0.261
Bis(2-Ethylhexyl)phthalate	5.80	ND 2.0	ND 2.0
Ideno(1,2,3-cd)pyrene	3.80	ND 0.10	0.105
Benzene	10.2	8.2	11.1
Ethylbenzene	3.8	1.6	0.51 J
Toluene	8.4	1.8	ND 2.0
Total Xylenes	22.4	7.3	2.8
Total Alkanes	412.4 J	ND	ND

ND: Not Detected

### **MW-13**

Monitoring well MW-13 is located in the vicinity of injection points A-19 and A-20 in the southwestern part of the targeted treatment area. Based on the analytical data the injection event of September 2013 had a significant impact in the concentrations of all targeted SVOC compounds. Benzo(a)anthracene, Benzo(a)pyrene and Benzo(b)fluoranthene recorded decreases of 77%, 89% and 90% respectively compared to their August 2013 baseline sampling values, while naphthalene was the compound that was massively affected with the concentration decreasing from 1,920 µg/L in August 2013 to 1.18 µg/L in January 2014. BTEX concentrations appear to have slightly spiked during the January 2014 sampling event; however it is expected that they will decrease during the upcoming sampling event.

**Table 3.** CVOC Data for MW-13 (µg/L).

<b>MW-13</b>			
<b>Sampling Date</b>	<b>08/30/2013</b>	<b>10/16/2013</b>	<b>01/15/2014</b>
Acenaphthylene	81.3	11.6	0.64
Benzo(a)anthracene	2.92	0.435	0.684
Benzo(a)pyrene	1.75	ND 0.10	0.192
Benzo(b)fluoranthene	2.24	ND 0.10	0.233
Benzo(g,h,i)perylene	0.698	ND 0.10	ND 0.10
Benzo(k)fluoranthene	0.895	ND 0.10	0.121
Chrysene	2.02	0.235	0.409
Naphthalene	1,920	187	1.18
Benzene	100	48.7	175
Ethylbenzene	43.4	10.4	61.9
Toluene	160	24.4	161
Total Xylenes	179	41.6	171
Total Alkanes	3,625 J	ND	ND

ND: Not Detected

### MW-14

Monitoring well MW-14 is located in the northern part of the targeted treatment area in the vicinity of injection points A-2 and A-3. Monitoring well MW-14 did not record elevated SVOC and VOC concentrations during the baseline sampling event with the exception of diethyl phthalate, benzene, ethylbenzene and toluene. During the 120-day post-injection sampling event the concentrations of the aforementioned compounds have all decreased to levels below the laboratory detection limits except for benzene that decreased by 43%.

**Table 4.** CVOC Data for MW-14 (µg/L).

<b>MW-14</b>			
<b>Sampling Date</b>	<b>08/30/2013</b>	<b>10/16/2013</b>	<b>01/15/2014</b>
Diethyl phthalate	7.2	-	ND 2.0
Benzene	8.1	7.1	4.6
Ethylbenzene	61.9	ND	ND 5.0
Toluene	2.0	ND 5.0	ND 1.0
Total Xylenes	ND	ND 5.0	ND 1.0
Total Alkanes	6.3 J	ND	ND

ND: Not Detected

### MW-15

Monitoring well MW-15 is located in the center of the main treatment area, where the demolition of the main building occurred. Based on the analytical SVOC data of the January 2014 sampling event, it appears that the remedial treatment event has dramatically impacted the concentrations of all targeted contaminants in the vicinity of monitoring well MW-15. The concentrations of almost every SVOC compound have decreased to levels below the laboratory detection limits, while the concentrations of the BTEX contaminants that were significantly low during the baseline sampling event have also reached levels below the laboratory detection limits.

**Table 5.** CVOC Data for MW-15 (µg/L).

<b>MW-15</b>			
<b>Sampling Date</b>	<b>08/30/2013</b>	<b>10/16/2013</b>	<b>01/15/2014</b>
Acenaphthylene	0.197	ND 0.11	ND 0.10
Benzo(a)anthracene	0.459	ND 0.11	0.153
Benzo(a)pyrene	0.497	ND 0.11	ND 0.10
Benzo(b)fluoranthene	0.607	ND 0.11	ND 0.10
Chrysene	0.397	ND 0.11	ND 0.10
Naphthalene	0.453	0.541	ND 0.10
Benzene	0.31 J	0.52 J	ND 1.0
Ethylbenzene	ND	ND 1.0	ND 1.0
Toluene	0.58 J	ND 1.0	ND 1.0
Total Xylenes	0.62 J	ND 1.0	ND 1.0
Total Alkanes	5.4 J	ND 1.0	ND 1.0

ND: Not Detected



### Free Product Data

Ten different wells were sampled before the implementation of the remedial injection event of September 2013 and the depth of the free product that was present in each well was measured. As Table 6 shows all ten wells appear to have elevated free product levels during the March 2013 baseline sampling event that ranged from 1.22 ft to 5.37 ft.

**Table 6. Injection Thickness of Free Product (ft).**

Well ID	Sampling Date					
	05/25/2012	06/07/2012	03/14/2013	10/16/13	10/18/13	01/15/14
TW-1/MW-14	4.16	3.90	4.24	ND	ND	ND
TW-2/MW-15	5.34	4.98	5.31	ND	ND	ND
TW-3/MW-11	5.26	5.12	5.37	ND	ND	ND
TW-4	5.35	5.02	5.11			
TW-5/MW-12	5.60	4.99	4.64	ND	ND	ND
TW-6	4.06	4.02	3.75			
TW-7	5.31	5.08	5.11			
TW-8/MW-13	3.43	3.07	3.26	ND	ND	ND
TW-9	1.15	1.14	1.22			
TW-10	5.02	5.09	4.16			

Five monitoring wells were sampled upon the completion of the injection event to address the effect of the remedial injection in the free product that was present in the subsurface. These wells are MW-11, MW-12, MW-13, MW-14 and MW-15.

Monitoring well MW-11 is closely located (within a few feet) from monitoring point TW-3 that recorded free product thickness of 5.37 ft in March 2013, in the area where the demolished Cinder Block Building is located. Based on the January 2014 sampling event no free product was detected in MW-11.

Monitoring well MW-12 is located in the vicinity of targeted treatment area A and more specifically close to injection points A-27 and A-28. Monitoring well TW-5 that recorded a free product thickness of 4.64 ft is also located in the same area. As the data from the last sampling event indicates the ISGS solution was very effective in treating the existing contamination since no free product was detected in MW-12.

Monitoring well MW-13 is also located in the vicinity of targeted treatment area A and more specifically close to injection points A-19 and A-20. Monitoring well TW-8 that recorded a free product thickness of 3.26 ft is located relatively close to MW-13. Based on the January 2014 data the ISGS solution was found effective in treating the targeted contamination since no free product was detected in MW-13.

Monitoring well MW-14 is located in the northern part of the targeted treatment area in the vicinity of injection points A-2 and A-3 very close to monitoring point TW-1. The thickness of free product in TW-1 was measured at 4.24 ft; however upon the completion of the remedial design no free product was detected in monitoring well MW-14.



Monitoring well MW-15 is located in the center of the main treatment area, where the demolition of the main building occurred, close to monitoring points MW-11, TW-2 and TW-3. Monitoring points TW-2 and TW-3 recorded free product thickness of 5.31 and 5.37 ft respectively. Monitoring well MW-15, similar to MW-11, did not show the presence of any free product during the January 2014 sampling event.

### **Conclusions and Recommendations**

Based on the data provided, it appears that the injection of the In-Situ Geochemical Stabilization (ISGS) solution was very effective in addressing the contamination that was present on the site located in Fanwood, NJ.

The groundwater data is extremely encouraging with almost every VOC and SVOC compound either decreasing below the laboratory detection limits or recording significant concentration reductions compared to their baseline sampling values.

**Furthermore the free product that was present in the ten wells that were sampled during the baseline sampling event disappeared within 30 days of the implementation of the injection event. All five monitoring wells that were sampled after the September 2013 injection event did not record any free product during the three post-injection sampling events of October 2013 (two events) and January 2014.**

Two pictures of the received soil samples are presented below. It appears that following the ISGS solution injection the creosote with the strong odor that was observed above the peat layer was able to “solidify”, with no associated odor (15 days following injection). In the picture below the peat layer is easily seen and the ISGS formation immediately above it.





Close-up of ISGS