REMEDIATION WORK PLAN
REVISION 2

FORMER ELLIS BP
1718 SPRING STREET

JEFFERSONVILLE, INDIANA

UST FACILITY ID: 4898

January 17, 2011
Project No. 7893/10-191

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Prepared For
The City of Jeffersonville, Indiana

January 17, 2011
Project No. 7893/10-191

Prepared For:

City of Jeffersonville
500 Quartermaster Court
Jeffersonville, IN. 47130

Respectfully Submitted by:
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EXECUTIVE SUMMARY

The Former Ellis BP (Subject Site) is located at the southwest corner of the intersection of Spring Street and Eastern Avenue, Clark County, Jeffersonville, Indiana (Figure 1). The Subject Site was developed as gasoline retailer prior to 1925. The station (FID#4898) was closed in approximately 2001, however, the underground storage tanks (USTs) remain in place. The Subject Site has two 8,000 gallon and one 4,000 gallon gasoline tank registered and one 4,000 gallon diesel fuel tank registered. Registration documents show these tanks to be constructed of steel and were installed in 1966 and 1971. A smaller kerosene tank which is not registered is also present at the Subject Site.

In September 2010 a subsurface investigation was performed by Bruce Carter Associates, LLC (BCA) on behalf of the City of Jeffersonville to determine if petroleum hydrocarbons were present in the soil and groundwater at the Subject Site. Results of that investigation reported that total petroleum hydrocarbons (TPH) were present in the gasoline range organics (GRO) fraction in concentrations exceeding the Indiana Department of Environmental Management (IDEM) Risk Integrated System of Closure (RISC) Industrial default closure levels (IDCL) in soil. Benzene, Ethyl benzene, Toluene, and Xylenes (BETX) were detected in soil and while benzene and methyl tertiary butyl ether (MTBE) were detected in the groundwater at concentrations which exceed the IDCL.

The September investigation was limited to the Subject Site. The presence of TPH GRO and benzene in soil and/or groundwater at the southwest property line warranted investigation of adjoining properties. In October 2010 site access was granted to the adjoining properties and a subsurface investigation was conducted. Hydrocarbons were reported in the soil and groundwater in excess of the IDCL in the Alben Motel property adjoining the Subject Site to the southwest. Hydrocarbons were reported in groundwater in excess of the IDCL at the closed restaurant property adjoining the Subject Site to the northwest. No impacted soil or groundwater was found on the property of a Doctor's Office located southwest of the Alben Motel.

This Remediation Work Plan outlines the planned remediation of the Subject Site. The four registered and one unregistered USTs will be removed. Impacted soil adjoining the

UST pit will be excavated. Excavation will continue on-site where they exceed the IDCL. Excavation of soils will continue to the south on the Alben Motel property. Soil excavation on the Alben Motel site will continue until soils exceeding the residential default closure levels (RDCLs) are removed or until further excavation could endanger the buildings on the motel property.

Excavated soil will be loaded and transported to a permitted landfill. Following excavation, oxygen release compound will be added to the groundwater through the open excavation and by injection in the affected area of the plume. If necessary, additional borings will be drilled and an expanded monitoring well network will be installed. It is expected that groundwater monitoring will be initially performed to monitor the decline of hydrocarbons in groundwater for the first year. Demonstration monitoring will then be conducted for two years.

1.0 INTRODUCTION

1.1 Project Background

Site Name: Former Ellis BP FID#4898
1718 Spring Street
Jeffersonville, Clark County, Indiana

Owner: Mr. David Brar

Occupant: Sandwich Vendor (Seasonal)

Consultant: Bruce Carter Associates, LLC
David King, LPG (317-578-4233)

At the request of the City of Jeffersonville, Bruce Carter Associates, LLC (BCA) conducted investigations of the Subject Site in 2010 to evaluate the presence and extent of petroleum hydrocarbons. The City is current seeking financing to remediate and redevelop the Subject Site.

1.2 Site Information

The Former Ellis BP property is located at 1718 Spring Street, Jeffersonville, Clark County, Indiana (Subject Site). The Subject Site consists of one parcel which has the dimensions of 200'X104' as shown on the property tax card. There are three buildings at the Subject Site. These include a cashier's booth, and two concrete block storage buildings. Five underground storage tanks are present at the Subject Site. The Subject Site is currently used only seasonally by a sandwich vendor who sells sandwiches from stationary trailers.

1.3 Current Owner Information

At the time of this writing the Subject Site is owned by Mr. David Brar of Prospect Kentucky. The property tax card shows the name of the owner as Brar Devinder who is the same person.

1.4 Historical Summary

The earliest known use of the Subject Site is shown on a Sanborn Map in 1904 when the Subject Site was used as a grocery store and saloon. Prior to 1925 the Subject Site was a gasoline retailer. This land use continued until 2001. The Subject Site is currently used only seasonally by a sandwich vendor who sells sandwiches from stationary trailers.

1.5 Past and Current Operations

Most of the Subject Site's history has been as a gasoline retailer from before 1925 until 2001. The Subject Site is currently used only seasonally by a sandwich vendor who sells sandwiches from stationary trailers.

1.6 Report Contact Information

This Remediation Work Plan is prepared by Bruce Carter Associates, LLC (BCA). Contact information for BCA personnel preparing this report:

Bruce Carter Associates, LLC
6330 East 75th Street
Indianapolis, Indiana 46250
(317-578-4233)

Contact persons, David King, LPG or John Kilmer

1.7 Contamination and Spill History

This RWP has been prepared in response to evidence of petroleum hydrocarbon contamination of soil and groundwater that was discovered during a site investigation performed by BCA in September and October 2010. Evidence indicates that gasoline and (minor) diesel fuel is the contaminant of concern for the Subject Site and adjoining properties. The presence of relatively high levels of benzene in the groundwater is presented on the tables of laboratory groundwater results in Appendix A. There is no history of spills or hazardous materials incidents at the Subject Site.

1.8 Supporting Documentation

The supporting document is:

- *Phase II Site Investigation, Former Ellis BP, 1718 Spring Street, Jeffersonville, Indiana* (BCA, 2010).

Summary Lab data tables and figures from the Phase II report are included in the Figures section and Appendix A of this RWP. No prior investigations are known to have been performed at the Subject Site.

1.9 Discussion of Relevant Reports

The following environmental report has been prepared for the Subject Site:

- *Phase II Site Investigation, Former Ellis BP, 1718 Spring Street, Jeffersonville, Indiana* (BCA, 2010).

Identification of areas of concern and the scope of work for this remediation work plan are based entirely on investigation results of the above referenced report. The results of the Phase II investigation are discussed in further detail in subsequent sections of this RWP.

1.10 Description of Other Available Data and Documents for the Site

A UST registration for the Subject Site is available on the IDEM Virtual File Cabinet. The registration shows three steel USTs for gasoline (two 8,000-gallon and one 4,000-gallon) and one steel UST for diesel (4,000-gallon) installed in 1966 and 1971. No other data were available for the preparation of this workplan.

1.11 Remedial Action Objectives

The City of Jeffersonville, Indiana is acquiring the Subject Site for redevelopment as recreational/green space or commercial land use, therefore, the on-site closure objective is the industrial or recreation closure levels (Rec-DCL or IDCL). For adjoining sites which have been impacted by the release of petroleum from the Subject Site to the objective will be Residential Default Closure levels (RDCLs).

Following completion of the remediation an Environmental Restrictive Covenant (ERC) will be required for the Subject Site to limit land use to non-residential and prevent installation and use of potable water wells.

1.12 Remedial Objectives

The goal of the remediation is to do the following:

1. Close (by removal) the existing tanks in accordance with American Petroleum Institute (API) 1604 and IDEM UST guidance.
2. Remove impacted soil from the tank pit excavation down to the water table and outward where it is economical to excavate.
3. Perform confirmatory sampling at the bottom and sidewall limits of the excavation.
4. Remove petroleum hydrocarbons from the groundwater on-site and on adjoining sites by oxygen releasing compound (ORC^{TM}) injections.
5. Monitor groundwater and document decline of concentrations and completion of remediation.

1.13 Remedial Work Items

The first phase of remediation will be removal of the leaking UST system in compliance with API 1604 and IDEM UST quidance. Impacted soil located on-site exceeding the IDCL will also be removed. This will be done by removing clean overburden soil to an expected depth of eight feet. Clean soil will be staged on-site. Most on-site soils impacted above the IDCL will be exhumed and hauled for disposal.

Impacted soil located off-site at the Alben Motel which exceeds the RDCL will also be removed. This will be done by removing clean overburden soil to an expected depth of 12-feet. Clean soil will be staged on-site. Most on-site soils impacted above the RDCL will be exhumed and hauled for disposal.

Groundwater is contained in a stratum of silty sand below 20-feet in depth. The impacted area is estimated at 27,360 ft^2 (Figure 6). Treatment of impacted groundwater will be done by bio-stimulation. This will be done by admixing ORC™ into the bottom of the excavation. Where impacted groundwater is present outside the excavation, ORC™ will be injected through direct push probes rode into the 21 to 30 foot depths

Additional borings may need to be drilled to finalize delineation of the impacted area. The existing network of monitoring wells will be expanded to facilitate monitoring of groundwater which will continue until completion.

2.0 INVESTIGATION ACTIVITIES

2.1 Summary Information to Select Remedy

Laboratory results for on-site soil samples were compared to the IDCL. Samples from B-1, B-2, B-5, B-7, and B-8 were reported to have hydrocarbon parameters exceeding the IDCL for one or more parameters. Sample depths in these borings ranged from 8 feet to 16 feet.

Soil samples from off-site borings were screened for headspace gasses and only one boring (P-19) located in the parking lot of the Alben Motel south of the Subject Site had elevated readings. Laboratory analysis from this boring was compared to RDCLs. The soil sample from the 18-20 foot interval in P-19 exceeded the RDCL for TPH GRO, Naphthalene and Benzene. Locations of soil samples and laboratory results of parameters exceeding the appropriate closure level are illustrated on Figure 3.

Groundwater was collected from a silty sand unit which was encountered below the 20 foot depth in all borings. Four permanent monitoring wells and three temporary monitoring wells were sampled on-site. Eight off-site soil probes were finished as temporary monitoring wells and one off-site soil probe was finished as a permanent monitoring well and sampled. A map of groundwater flow was prepared by measuring the elevation of the wellheads of each of the permanent monitoring wells relative to an arbitrary site datum. Depth to water was measured and subtracted from the wellhead elevation resulting in a calculated elevation of groundwater. A map of groundwater elevations was prepared. A groundwater flow direction nearly due west was mapped (Figure 4). The gradient is shallow only measuring one half foot drop over 222 horizontal feet.

For the follow up investigation (October 12 and 13, 2010) borings were placed off-site on the property of a closed restaurant, (northwest), and a Doctor's office and motel both located southwest of the Subject Site. Groundwater was found to be impacted in all borings except those on the Doctors office property and in the east most sample from the motel property. A permanent monitoring well was placed on the west most side of the closed restaurant property in the most down gradient direction from the source. Analytical results show a benzene plume exceeding 1.0 mg/l on the motel property and on the closed restaurant property. The limits of the plume are defined to the south by groundwater samples from the Doctors office property (P-13, P-14, and P-20), defined to the north by on-

site monitoring well MW-4, to the west by MW-5 and to the east by boring P-18 and MW-2. Locations of monitoring wells, sampling results and groundwater flow directions are illustrated on the attached Figure 4.

2.2 Baseline Assessment and Literature Search

An Environmental Baseline Survey (EBS) has not been conducted for the Subject Site.

2.3 Potential Chemicals of Concern

Chemicals of concern (CoCs) detected in groundwater are tabulated in the tables attached in Appendix A. In groundwater all of the BETX, MTBE, n-hexane, naphthalene and poly nuclear aromatic hydrocarbons (PAH) components are potential CoCs. In soil TPH GRO/DRO, BTEX/MTBE, n-hexane, naphthalene and PAHs are potential chemicals of concern. Based on the investigation results, only BTEX, TPH-GRO and naphthalene were detected in the soil above the closure level. The various closure levels for project CoCs for soil are presented below:

RISC Closure levels soil mg/kg

Parameter	IDCL	RDCL	Recreational
Benzene	0.35	0.035	24.0
Toluene	96.0	12.0	25,000
Ethylbenzene	160	13.0	12,000
Xylene (Total)	170	170	1,800
MTBE	3.2	0.18	1,100
n-Hexane	100	100	440
Naphthalene	170	0.7	9,800
TPH-GRO	4,300	3,100	none
TPH-DRO	5,800	3,100	none

Only Benzene, naphthalene and MTBE were detected in the groundwater above the closure level. The various closure levels for project CoCs in groundwater are presented below:

RISC Closure levels Groundwater mg/l

Parameter	IDCL	RDCL
Benzene	0.052	0.005
Toluene	8.2	1.0
Ethylbenzene	10	0.7
Xylene (Total)	20	10
MTBE	0.72	0.04
Naphthalene	2.0	0.0083

2.4 Extent of Subsurface Investigations

In September 2010 a subsurface investigation was conducted that included 11 boring locations with soil samples. Most of the borings extended to the groundwater at 20 feet. Groundwater samples were obtained from temporary wells in three of the locations and permanent wells in four of the locations. TPH GRO and BTEX concentrations exceeding the IDCL were found in the soil. Benzene was also detected in groundwater at concentrations which exceed the IDCL.

The September investigation was limited to the Subject Site. The presence of TPH GRO at the southwest property line warranted investigation of adjoining properties. In October 2010 site access was granted to the adjoining properties and a subsurface investigation was conducted. The investigation included nine probes. Soil samples from two probes and groundwater from all nine locations were sampled, included one completed as a monitoring well. The four existing monitoring wells were sampled a second time.

Hydrocarbons were reported in the soil and groundwater in excess of the IDCL in the Alben Motel property adjoining the Subject Site to the south. Hydrocarbons were reported in groundwater in excess of the IDCL at the closed restaurant property adjoining the Subject Site to the west. No impacted soil or groundwater was found on the property of a Doctor's Office located south of the Alben Motel, impacted groundwater was detected close to the property line and corrective action activities may have to be conducted on the Doctors Office property.

2.5 Summary of Site Investigations

No documentation is available regarding the date of contaminant releases at the Subject Site. Petroleum Retailing activities at the Subject Site date back to before 1925, so it is possible that undocumented releases of contaminants have occurred at the Subject Site. The only known investigation to be conducted at the Subject Site is the *Phase II Site Investigation, Former Ellis BP, 1718 Spring Street, Jeffersonville, Indiana* (BCA, 2010). The impacted area is defined. Well locations and the defined impacted area are illustrated on the attached Figures 3, 4, and 5.

2.6 Baseline Assessment

An Environmental Baseline Survey (EBS) has not been conducted for this site.

2.7 Summary of Site Specific Geology and Hydrogeology

The site specific geology of the Subject Site was investigated in the Phase II ESA (BCA, 2010). A summary follows:

Soils

According to the Clark County Soil Survey the soils under the Subject Site are mapped as belonging to the Wheeling Fine Sandy Loam (WhB2) series (Nickel, 1974). The Wheeling is described as a gently sloping soil occupying dunes on terraces. The texture is a fine sandy loam with a color range from dark yellowish-brown to yellowish-brown. This soil is moderately well drained and has a fragipan in areas.

Regional Geology

The Subject Site is located in Southern Indiana approximately 1.5 miles north of the Ohio River within the Scottsburg Lowland physiographic province. Surficial deposits are mapped (Gray, 1989) as undifferentiated Pleistocene age outwash. Conditions observed at the Subject Site are overbank fluvial deposits (Sand and Silt) overlain by a yellowish silt.

Bedrock underlying the Subject Site is Devonian age limestone of the Muscatatuck group. The Muscatatuck is describes as predominantly fine-

grained to granular dolomite and limestone. The carbonate rocks range from pure to sandy or shaley. The lower part the Muscatatuck group contains some anhydrite and gypsum (Fenelon, and others. 1994).

2.8 Discussion of Identified Sources of Contamination

At the time of the investigation four underground storage tanks (USTs) were registered at the Subject Site. It is believed that five tanks are actually present. The pattern of contamination at the Subject Site generally showed the highest impact in the vicinity of the tanks with lower concentrations away from the tanks. Both Gasoline and Diesel range hydrocarbons were reported in the soil samples from this investigation, however, only TPH-GRO exceeds the IDEM limit. For the former Ellis BP site the closure objective is industrial default closure levels. There is a potential for recreational post closure land use, therefore, recreational limits should not be exceeded. For the adjoining Alben Motel site land use is residential and the RDCL is the target closure level. There are no registered USTs on adjoining sites or near enough to suspect the potential for an off-site source.

2.9 Summary of Extent of Contamination

Soil

The results of laboratory analyses of soil samples are summarized in Tables 1 and 2 (Appendix A). Locations of soil samples and laboratory results of parameters exceeding the appropriate closure level are illustrated on Figure 3.

Soil samples from on-site borings were collected at depths where elevated headspace gasses were recorded. Laboratory results for on-site soil samples were compared to the IDCL. Samples B-1,B-2, and B-7 exceeded the IDCL for TPH GRO, Benzene and Xylene. Soil from boring B-8 exceeded for TPH GRO, Benzene, Toluene and Ethylbenzene. Soil in borings B-5 and B-9 exceeded for TPH GRO only. Sample depths in these borings ranged from 8 feet to 16 feet.

Soil samples from off-site borings were screened by testing headspace gasses with a PID and only one boring (P-19) located in the parking lot of the Alben Motel south of the Subject Site had elevated readings. Laboratory analysis from this boring was compared to RDCLs. The soil sample from the 18-20 foot interval in P-19 exceeded the RDCL for TPH

GRO, Benzene, Xylene and Naphthalene. No analytes were detected in the soil sample from P-18 (18-20 feet).

Groundwater

Groundwater was collected from a silty sand unit which was encountered below the 20 foot depth in all borings. Four permanent monitoring wells and three temporary monitoring wells were sampled on-site. Eight off-site soil probes were finished as temporary monitoring wells and one off-site soil probe was finished as a permanent monitoring well and sampled.

Groundwater flow direction was inferred from the gradient which was mapped from water level data from permanent monitoring wells. A nearly due west gradient was mapped from these data. The gradient is shallow with only one-half foot drop across 222 feet.

Groundwater sample results are summarized in Tables 3 and 4 (Appendix A). Locations of monitoring wells, sampling results and groundwater flow directions are illustrated on the attached Figure 4.

For the follow up investigation (October 12 and 13, 2010) borings were placed off-site on the property of a closed restaurant (northwest) and a Doctor's office and a motel both located southwest of the site. Groundwater was sampled in each well. Because groundwater on-site did not have poly nuclear aromatic hydrocarbons (PAH) concentrations exceeding the RDCL, most groundwater samples from off-site sampling locations were analyzed for BTEX and MTBE only. Two of the off-site wells, P-18 and P-19, were sampled for BTEX/MTBE and PAHs because headspace readings indicated the presence of high concentrations of gasoline. Groundwater was found to be impacted in four borings on the closed restaurant and motel properties, but not in five other locations on the adjoining properties. A permanent monitoring well was placed on the western side of the closed restaurant property in the most down gradient direction from the source. Analytical results show a benzene plume exceeding 1.0 mg/l extending from the Subject Site onto the motel property and the closed restaurant property. The limits of the plume are defined to the south by groundwater samples from the Doctors office property (P-13, P-14, and P-20), defined to the north by on-site monitoring well MW-4, to the west by MW-5 and to the east by boring P-18 and MW-2.

2.10 Summary of Risk Associated with Site

The primary potential affect of residual groundwater contamination under the Subject Site is continued migration. Groundwater in the water bearing unit under and near the Subject Site is not a drinking water source, however, may be the source of vapor intrusion in buildings both at the Subject Site and off-site properties. Residual contamination has the potential to affect human health at the Subject Site or at surrounding sites.

2.11 Human, Ecological, and Environmental Risks

Groundwater in the water bearing unit under and near the Subject Site is not a drinking water source, however, may be the source of vapor intrusion in buildings both at the Subject Site and off-site properties.

Inhalation Exposure Pathway
There is a potential for inhalation exposure to migrating vapor for building occupants over the impacted soil and groundwater plume on the subject and adjoining motel property.

Ingestion Exposure Pathway
It is unlikely that ingestion is a risk to humans for the Subject Site because the aquifer is not a groundwater source. However, if it were used on the subject or adjoining sites exposure could potentially result.

Direct Exposure Pathway
There is no impacted soil at the surface and no potential for direct exposure. There is a potential for dermal exposure for construction workers at the Subject Site and the adjoining motel site from subsurface soils. Dermal exposure prevention will be addressed in the health and safety plan for the site.

The ecological and environmental risks are remote, however, the following exposures could occur:

Potential Impacts to Aquatic Life
There are no known potential impacts to aquatic life associated with documented contamination at the Property.

Potential Impacts to Wildlife and Vegetation

Burrowing animals over the plume may be exposed to an accumulation of vapors. Plants rooted deep in the soil may accumulate hydrocarbons which can bio accumulate in herbivores.

2.12 Future Land Use Impacts

Existing contamination at the Subject Site constitutes a legal liability for prospective buyers of the property. Human health impacts to site occupants and construction workers are also possible from current site conditions. Impact to wildlife and ecology are also possible from current site conditions.

2.13 Summary of Background Concentration

No investigation of background concentrations was done as part of this investigation. Contaminants present at the Subject Site are not believed to be from naturally occurring or background influences.

2.14 Additional Field Investigation Requirements

The impacted area has been identified. No additional field investigations are required prior to remediation. However, additional borings may be added to refine the extent of impact and the monitoring well network will be expanded to support monitoring.

3.0 REMEDIATION PLAN

3.1 Evaluation of Remedial Alternatives Soil

A remedial strategy for the Subject Site must address petroleum hydrocarbons in a silt unit below the 8 foot depth at the Subject Site and on the adjoining property to the south at the Alben Motel (Figure 2). The USTs on the Subject Site must be removed for compliance with Indiana State Fire Marshall regulations. The impacted soils are nearly all silts with only moderate permeability and relatively high impacts. Therefore, the most practical option for remediation of soil is removal. Once the soil is removed from the ground, it can be disposed of as special waste. Because the Subject Site is small, and located in an urban setting on-site ex-situ treatment is not practical, therefore off-site landfill disposal is selected

Removal of impacted soils is limited by the presence of buildings on the Alben Motel site (Figure 6). It is expected that impacted soils below the building, if even present, are near the closure levels and at a depth where they will not impact motel occupants. Regulatory compliance will most likely be achieved by statistically comparing hydrocarbon concentrations below the building to concentrations within the excavated area. The impacted zone thins (away from the tank field, to just the smear zone (16-20 feet) and a large amount of clean overburden must be removed to reach it. It is likely that some impacted soil will be left above the water table.

Other options for remediation of off-site soils that were considered include:

(1) Soil Vapor Extraction
Soil Vapor Extraction (SVE) is a very effective means of mass removal of VOCs from the vadose zone. Although ideal conditions are permeable coarse-grained soils, it is also reasonable effective in finer grained soils such as the silt and sandy silt found in the vadose zone at the Subject Site. The lower permeability means that higher vacuums must be used to achieve acceptable radii of influence. Higher vacuums result in groundwater elevation cones which reduce the effectiveness of the SVE system. This tendency can be countered by a higher density of SVE wells and the use of air recharge wells. These allow the use of a lower vacuum and lower radii of influence.

(2) SVE with water level suppression
By installing a groundwater extraction pump in the SVE well the

groundwater level can be suppressed and the effectiveness of the SVE system maximized. This allows higher vacuums, air flow rates and radii of influence and would remediate the soil more rapidly than SVE alone. This system would pump a larger volume of water needing to be treated, would be more complex to install and operate and more costly.

(3) Multi Phase Extraction. Multi Phase Extraction (MPE), also called dual-phase extraction (DPE), is a remedial technique in which all subsurface media (water, air, free product) are drawn from the ground via a vacuum pump and treated at the surface. This technique has the advantage of SVE in that any residual material in the unsaturated zone can be addressed. It has the advantage of pump-and-treat in that contaminated water is removed from the ground. It creates a groundwater gradient towards the Subject Site, preventing any further off-site migration, and the affects of draw-down, which exposes the saturated zone to air flow, thus promoting volatilization and biodegradation. Since the depth to groundwater at the Subject Site is below 20 feet, the conditions for DPE are non-ideal. However, if feasible, the system is simpler to install and operate than SVE with groundwater suppression.

Groundwater

Following removal of soil by excavation impacted groundwater must be remediated. Thus, the selected remedial technologies must remediate residual contamination in the groundwater. Several options were considered for this project:

(1) Bioaugmentation Bioaugmentation is the addition of native or non-native microbial cultures or “inocula” to the matrix to enhance or replace the native microbial population. Indigenous or native microbes are those that occur naturally at a site. They are usually present in very small quantities and they may not be able to prevent the spread of the contaminant. In some cases, native microbes do not have the ability to degrade a particular contaminant. Bioaugmentation offers a way to provide specific microbes in sufficient numbers to complete the biodegradation. Microbial inocula are prepared in the laboratory from soil or groundwater either from the site where they are to be used or from another site where the biodegradation of the chemicals of interest is known to be occurring. Microbes from the soil or groundwater are isolated and are added to media containing the chemicals to be degraded. Only microbes capable of metabolizing the chemicals will grow on the media. This process isolates the microbial population of interest, which may

contain several different strains of microbes. Experience with Bioaugmentation indicates that it usually requires several injections and supplemental nutrient injections. This technology is most frequently applied to chlorinated hydrocarbons.

(2) In-Situ Chemical Oxidation. In-Situ Chemical Oxidation (ISCO) process involves injecting oxidants (substances readily reduced) and, in some instances, other reaction generating substances (catalysts) into contaminated areas of the subsurface. The oxidant reacts with the contaminant causing decomposition of the contaminant and the production of innocuous substances such as carbon dioxide and water. This reaction, called oxidation, is a chemical reaction characterized by the loss of one or more electrons from an atom or molecule. When an atom or molecule combines with oxygen, it tends to give up electrons to the oxygen in forming a chemical bond. Carbon in the form of organic carbon and manufactured hydrocarbons are common substances readily oxidized (reductants). For ISCO to effectively reduce contaminant concentrations there must be direct contact between the oxidant and the contaminant. Soil exploration and groundwater sampling observations indicate that the geometry and texture of the water bearing unit is very homogeneous across the Subject Site. The high Benzene and TPH levels would require large amounts of oxidant to be injected. This could result in chemically unstable conditions in the subsurface. In addition, ISCO vendors report only limited success with oxidation of benzene.

(3) Bio-stimulation Bio-stimulation is the addition of limiting nutrients to stimulate the growth of naturally occurring micro flora. Usually, magnesium or calcium peroxide that releases oxygen slowly is introduced to facilitate the aerobic degradation of a range of environmental contaminants including petroleum hydrocarbons. This technology can be characterized as a time release electron acceptor, for engineering accelerated bio-attenuation. Bio-stimulation can be configured as a permeable reactive barrier, or applied as a broader plume treatment. Bio-stimulation is generally effective only for dissolved phase hydrocarbons once the free product is removed by more intensive means. Hydrocarbon concentrations at the Subject Site are too high for effective use of bio-stimulation by itself. However, bio-stimulation would be effective in association with source and vadose zone removal. This is the selected option.

(4) Monitored Natural Attenuation (MNA). MNA was considered because the primary sources, USTs and highly impacted soil will be removed along with the tank backfill. The remaining contaminants will eventually degrade. However, MNA will not prevent further off-site migration; long

time frames would be required due to the high concentrations of BTEX; and the concentrations of BTEX exceed levels IDEM considers acceptable for application of MNA. However, this option can be reconsidered in the future if a primary remediation system is implemented which reduces the peak concentrations.

(5) Groundwater sparge/soil vapor extraction. Groundwater sparging combined with soil vapor extraction (SVE) has been used at many sites in which both soil and groundwater contamination are present. Because the impacted soil is a silt and the groundwater is in sandy silt the vapor extraction in the silt would not be likely to capture the sparge gasses in the groundwater. This could have the undesired effect of spreading the hydrocarbons in the groundwater.

(7) Groundwater pump-and-treat Pumping and treatment of groundwater can have limited affect for the removal of high BTEX concentrations (though generally not for removal of low BTEX levels). The remediation method does establish hydraulic control and can prevent further off-site migration of affected groundwater. Air stripping is the most accepted technology for treating BTEX in groundwater for all but short-term projects. The air stripper would remove all but a trace of the BTEX constituents, and the groundwater would be discharged to a storm sewer under a NPDES Permit or the sanitary sewer. Groundwater would be extracted from wells in the impacted area . This option is most effective for removing free product, and, by itself, is unlikely to complete remediation to closure levels.

3.2 Selected Remediation Option

Most of the above options were discounted because they are unlikely to be effective or cost prohibitive. Source removal and soil excavation combined with bio-stimulation in groundwater appears to be the best technology combination.

3.3 Risk Assessment

No site specific Risk assessment is anticipated.

3.4 Description of Remediation Technology

Remedial Design (Soil)

The first phase of remediation will be removal of the leaking UST system in compliance with API 1604. Impacted soil exceeding the IDCL will also be removed. This will be done by removing clean soil to an expected depth of eight-feet on the Former Ellis BP site and to an average depth of 12 feet off-site. Clean soil will be staged on-site. Most soils impacted above the IDCL will be exhumed and hauled for disposal. In the event that groundwater is encountered during the soil excavation project, it may be pumped from the excavation and disposed of as special waste.

Implementation (Soil)

Impacted soil will be exhumed during tank removal activities. Removing the tanks and impacted soil will be done by the following steps:

- removing the pavement over the tanks and razing Subject Site structures that interfere with the excavation: the canopy, the cashier booth/shed and the northern storage shed;
- excavating non-impacted soil above 8 feet (average on-site) and above 12 feet (average off-site) and segregating non-impacted soil. It is estimated that 4,208 to 6,377 tons of clean overburden will be removed.
- Tank closure of all tanks and associated piping and equipment on-site including removal/disposal of any tank liquids; according to API 1604 and UST guidance
- Exhuming impacted soil below 8 feet on-site and 12 feet off-site to the limits of the impacted area as demonstrated by closure sampling results. It is estimated that at least 4,018 and up to 6,088 tons of impacted soil will be removed for disposal.
- Disposal of exhumed soil at an approved landfill.
- Oxygen Releasing Compound will be placed at the bottom of the excavation (top of the water table) prior to backfilling. ORC^{TM} will be added at a rate of 1.4 lbs per square yard and mixed with about 1.0 foot of soil/groundwater.
- Backfill and compact clean overburden soil into the excavation.
- Backfill with granular off-site fill and clean soils from on-site that have been tested.

Remedial Design (Groundwater)

During the soil excavation process, minor groundwater removal may be conducted below the former tank pit. The application of ORC™ at the bottom of the excavation is intended primarily to remediate hydrocarbons remaining in the groundwater below the excavation.

Groundwater is contained in a stratum of silty sand below 20-feet in depth. The impacted area is estimated at 27,360 ft^2. For estimating purposes, the following average BETX concentrations were calculated for the plume

Benzene	0.92 mg/l
Ethylbenzene	0.06 mg/l
Toluene	0.10 mg/l
Xylenes	0.20 mg/l
MTBE	0.07 mg/l

ORC™ will be injected at a rate of 4 lbs per vertical foot from approximately 22 to 30 feet. Injections will be made on a 10 foot by 10 foot grid for a total of approximately 115 injection points. Locations of injection points are illustrated on the attached Figure 6.

Implementation (Groundwater)

Admixing ORC™ in the bottom of the excavation will commence after the tanks have been closed and the most highly impacted soil has been removed. Injections of ORC™ outside the limits of the excavation will be performed at a later date following excavation backfilling and closure. The process of injecting ORC™ in areas adjacent to the excavation will only be done after a period of monitoring. The duration of the monitoring period is not defined at this time. Injection of ORC™ will only proceed with the concurrence of Indiana Brownfields Program (IBP) staff. During the monitoring period additional data may be generated which may result in modifications to the injection density, formulation of the injected bio-stimulant, or data may even obviate the need for bio-stimulation.

3.4.1 Permit Requirements/Disposal Approval

A contaminated water and soil disposal approval will required from the treatment facility and landfill. The receiving facilities will be contacted to determine their data needs for waste characterization. Under most circumstances the required test is for the known contaminant to be analyzed following extraction using the toxicity