ANALYSIS OF BROWNFIELD CLEANUP ALTERNATIVES

U.S. EPA Brownfield
Revolving Loan Fund Cooperative Agreement (CA) # BF-00E48101-B
Indiana Brownfields Program Site 4050006

Former RJ Refinery
County Road 350 South
Princeton, Indiana
July 2019

This Analysis of Brownfield Cleanup Alternatives (ABCA) was cooperatively prepared by the Indiana Brownfields Program (Program), Gibson County, and ATC Group Services, LLC (ATC) as a requirement for utilizing United States Environmental Protection Agency (U.S. EPA) Revolving Loan Fund (RLF) monies to remediate a brownfield. The Former RJ Refinery Site (U.S. EPA ACRES ID: 219069 and Indiana Brownfields ID: 405006), located north of County Road 350 South in Princeton, Indiana (Site) is an irregular-shaped lot totaling approximately 36.07 acres and is currently unoccupied. Much of the Site consists of overgrown vegetation and wooded areas. Several depressions, marsh areas, and ponds were also noted across the Site. Miscellaneous debris including construction rubble, piping, and metal debris are present across the Site, which appear to be remnants from former structures demolished on the Site. The Site operated as an oil refinery from circa 1950s to 1970s. Historical operations associated with the refinery appear to have been the cause for soil and groundwater contamination beneath the Site. This ABCA presents remedial alternatives considered to mitigate potential exposure to contaminated soil and/or groundwater associated with the historical Site activities. Site redevelopment is expected to include commercial/industrial space combined with parking areas.

<u>Site Details</u>

Site Name:	Former RJ Refinery County Road 350 South Princeton, Gibson County, Indiana
Site Owner:	Gibson County Courthouse Annex North 225 North Hart Street Princeton, Indiana 47670
Site Representative:	Mr. Steve Bottoms Gibson County Commissioner Courthouse Annex North 225 North Hart Street Princeton, Indiana 47670

Summary of Previous Site Activities

Site History

The Site is located north of County Road 350 South in Princeton, Gibson County, Indiana 47670. The Site is located approximately 0.2 mile west of Highway 41 and is part of the southwest quarter of Section 30, Township 2 South, Range 10 West. The Site is an irregular-shaped lot totaling approximately 36.07 acres and is currently unoccupied. The Vicinity Map is located in **Figure 1**. A Site Plan is provided as **Figure 2**.

The Princeton, Indiana Topographic Quadrangle Map (USGS, dated 1959, photorevised 1989) indicates the ground surface has an elevation of approximately 470 to 490 feet above mean sea level (MSL). The topography across the Site and surrounding area generally slopes to the west. According to information obtained from the Beacon-Gibson County GIS webSite, the Site is identified as parcel number 26-12-30-300-000.968-027.

The Site operated as an oil refinery from circa 1950s to 1970s. Bulk storage and processing of several substances including but not limited to crude oil, naphtha, No.2 and No.5 fuel oil, gasoline, diesel, and kerosene occurred on the Site. The Site was owned and/or operated by Princeton Mining Company, R.J. Oil & Refining Company, Crystal-Princeton Refining Company, Northland Oil & Refining Company, and Indiana Refining Company since 1973. Gibson County acquired the Site in 2000 via tax sale.

According to Mr. Kenneth McDaniel of the Indiana Department of Environmental Management (IDEM), clean-up activities were conducted by the U.S. EPA and IDEM on the Site from 1989 to 1994. Clean-up activities included the removal of approximately 278,000 gallons of petroleum product, aboveground storage tanks (ASTs), underground storage tanks (USTs), 6,440 cubic yards of contaminated soil, PCB-containing transformers, asbestos containing material (ACM), compressed gas cylinders, and drums. Under the supervision of IDEM, approximately 164,000 gallons of petroleum product (tar) were solidified and buried on-Site. On-Site injection wells formerly used to dispose wastes to the subsurface mine beneath the Site were capped and plugged by IDEM.

Prior Environmental Assessments

Multiple assessments have been completed at the Site property that have been documented by ATC in the following reports:

- *Phase I Environmental Site Assessment* (ESA), dated April 25, 2016;
- *Phase II Limited Subsurface Investigation* (LSI), dated January 23, 2017;
- *Asbestos Survey Report*, dated January 25, 2017;
- *Phase II Further Site Investigation and Asbestos Abatement Report*, dated June 21, 2018;
- *Phase II Further Site Investigation*, dated September 21, 2018;
- *Quarterly Monitoring Report,* dated September 27, 2018;
- *Phase II Further Site Investigation,* dated January 16, 2019;
- *Quarterly Monitoring Report,* March 20, 2019;
- *Pilot Study,* April 8, 2019;
- *Quarterly Monitoring Report*, dated April 24, 2019.

According to ATC's *Phase I Environmental Site Assessment* (ESA), dated April 25, 2016, multiple *recognized environmental conditions* (RECs) or ASTM non-scope conditions were identified at the Site. The RECs included past uses and operations associated with an oil refinery, observed debris, piping, and drums on the Site, dark brown stained water on the Site, and potential vapor migration sources associated with the oil refinery operations. Suspect asbestos containing materials were also identified on the Site in the form of asphalt coating, pipe compounds, gaskets, and insulation debris.

A total of 122 soil borings have been advanced at the Site to allow for soil and groundwater sample collection/evaluation. A total of 174 soil samples and 116 groundwater samples have been collected at the Site since 2016. There are currently 19 monitoring wells installed at the Site, and quarterly monitoring is currently ongoing.

Subsurface materials encountered below the Site included concrete, topsoil, and gravel at depths ranging from 0 to 2.0 feet below ground surface (bgs), clayey silt (CL-ML) at depths from 0 to 6 feet bgs, and silty and sandy clay (CL) at depths ranging from 0 to 40.0 feet bgs. These materials are underlain by fine to coarse-grained sand (SW) at depths ranging from 23 to 40 feet bgs.

Based on historical gauging data, groundwater appears to flow to the east-southeast beneath the east portion of the Site, and to the west beneath the western portion of the Site. Light non-aqueous phase liquids (LNAPL) have been detected above the groundwater up to approximately 10 feet in thickness. LNAPL thicknesses have been measured in monitoring wells MW-1, MW-2R, MW-8, MW-9, MW-10, MW-11, MW-12, MW-13, MW-16, MW-17, and MW-18.

Based on the historical laboratory analytical results, multiple contaminants of concern (CoCs) were detected in the soil and groundwater samples collected at the Site at concentrations exceeding their respective IDEM Remediation Closure Guide (RCG) Screening Levels (SLs). Most notably, mercury, 1,2,4-trimethylbenzene (TMB), and n-hexane were detected in the soil at concentrations exceeding their respective RCG excavation direct contact SLs. Benzene and naphthalene have been detected above the RCG commercial/industrial vapor exposure SL in the groundwater beneath the Site.

On March 29-30, 2018, approximately one (1) cubic yard of regulated asbestos containing materials (RACM) was removed from the Site by a licensed abatement contractor and disposed of at Advanced Disposal Blackfoot Landfill in Winslow, Indiana. Since the RACM appears to have been removed from the Site, asbestos removal is not addressed in this ABCA.

A pilot study was performed at the Site to determine the effectiveness of a remediation approach. Seven (7) injection points IP-1 to IP-7 were installed at the Site in the vicinity of monitoring well MW-8. On March 12-13, 2019, groundwater remediation activities were performed on the Site, which was focused at the seven (7) injections point locations and monitoring well MW-8. Remediation activities included enhanced fluid recovery of approximately 650 gallons of impacted groundwater using a vacuum extraction truck. Approximately 4,690 gallons of 15% sodium persulfate catalyzed with sodium hydroxide were injected into the seven (7) injection points utilizing a mobile injection trailer simultaneously with the vacuum extraction.

Summary of Remedial Alternatives

1. Alternative 1 – No Action
2. Alternative 2 – Targeted Excavation
3. Alternative 3 – Pump and Treat Technology
4. Alternative 4 – Enhanced Fluid Recovery
5. Alternative 5 – Air Sparging
6. Alternative 6 – In-Situ Soil Mixing
7. Alternative 7 – In-Situ Chemical Oxidation
8. Alternative 8 – Monitored Natural Attenuation

Remedial Action Objectives

An evaluation of the three default exposure pathways: soil exposure, groundwater exposure, and vapor exposure is discussed in the following paragraphs.

Soil Exposure Pathways
Soil exposure pathways may include:

- direct contact with skin (dermal absorption route);
- inhalation of CoCs on soil particulates and dust (ingestion and inhalation routes);
- volatilization from soil into the air (inhalation route);
- soil consumption (ingestion and dermal absorption routes); and
- CoC migration from soil to groundwater.

Since future use is expected to be commercial/industrial, CoC concentrations are not expected to be an exposure concern in soil at depths of less than 2 feet, with the exception of adsorbed mercury detected in in the soil at B-16 (0-2). Although volatile CoCs are present in the soil and volatilization from soil to air is possible, the absence of occupied on-Site buildings limit the potential exposure through inhalation and direct contact. CoC migration from soil to groundwater (groundwater ingestion) is a potential soil exposure pathway.

Groundwater Exposure Pathways
Groundwater exposure pathways may include:

- Volatilization from water to air (inhalation route);
- Direct contact with skin (dermal absorption route); and
- Water consumption (ingestion route).

Based on available data collected from the monitoring wells, groundwater has been impacted with CoCs at concentrations in exceedance of IDEM RCGs. The depth to groundwater beneath the Site is approximately 1.8 to 38 feet bgs and volatilization from water to air is possible. However, the absence of on-Site buildings limit the potential exposure through inhalation and direct contact.

Based on the Indiana Department of Natural Resources (IDNR) Water Well Database, water well 204423 is located on the Site and water well 204808 is located on the south adjacent property. Water well 204423 has been abandoned and well 204808 is currently not in use. ATC attempted to abandon well 204808, but was unable to locate it due to being buried and inactive. The absence of potable wells at the Site indicates a low potential for ingestion of impacted groundwater.

Vapor Exposure Pathways

Vapor (from soil/groundwater contamination) exposure pathways are discussed throughout this document.

Analysis of Remedial Alternatives

The remedial action alternatives considered were evaluated using the following criteria:

(1) Effectiveness
   a. The degree to which the toxicity, mobility, and volume of the contamination is expected to be reduced.
   b. The degree to which a remedial action option, if implemented, will protect public health, safety and welfare and the environment over time.
   c. Taking into account any adverse impacts on public health, safety and welfare and the environment that may be posed during the construction and implementation period until case closure.

(2) Technical Feasibility/Implementability
   a. The technical feasibility of constructing and implementing the remedial action option at the Site or facility.
   b. The availability of materials, equipment, technologies and services needed to conduct the remedial action option.
   c. The administrative feasibility of the remedial action option, including activities and time needed to obtain any necessary licenses, permits or approvals; the presence of any federal or state, threatened or endangered species; and the technical feasibility of recycling, treatment, engineering controls, disposal or naturally occurring biodegradation; and the expected time frame needed to achieve the necessary restoration.

(3) Cost
   a. The following types of costs are generally associated with the remedial alternatives:
      - Capital costs, including both direct and indirect costs; Initial costs, including design and testing costs.
      - Annual operation and maintenance costs.

Remedial Alternatives

Alternative 1 – No Action

The "no action" alternative has been evaluated as a baseline for comparison to other alternatives developed. The no action alternative may be appropriate under certain circumstances but the Site will not be developable since the contamination will remain in the soil and significant LNAPL will remain on the groundwater and dissolved contamination in the groundwater. Based on the identification of CoCs greater than the RCG commercial/industrial and excavation direct contact SL in the soil and groundwater beneath the Site, the “no-action” alternative is not considered to satisfy the technical feasibility criteria for remediation and is not retained for further consideration.

a. **Effectiveness** – None: This option does not decrease the toxicity, mobility, or volume of the contamination and does not protect human health, safety, welfare, or the environment.
b. **Implementability** – Easy: There are no required actions or technology necessary to implement this option.
c. **Cost –** None: This option does not require ongoing operation or maintenance costs. Any deficit incurred would be in the form of loss of potential income from redevelopment.

Alternative 2 – Targeted Excavation

According to the estimates, approximately 132,500 square feet would need to be excavated 20 to 25 feet bgs to address the upper LNAPL layer. Assuming 25% of the excavated material would require landfill disposal of an estimated total of approximately 34,351 tons (based on the conversion factor of 1.4 tons per cubic yard) of soil would require landfill disposal or ex-situ treatment to achieve cleanup goals.

a. **Effectiveness –** Easy: This option does decrease the toxicity, mobility, or volume of the contamination but only addresses the most contaminated areas in soil (only) and does not protect human health, safety, welfare, or the environment. LNAPL and dissolved-phase contaminated groundwater would require on-Site treatment (including applicable permits) or off-Site disposal.
b. **Implementability –** Moderate: Required significant removal of soil actions or technology necessary to implement this option.
c. **Cost** – Significant: Estimated costs to complete the soil excavation totaled approximately $4,000,000. The IDEM evaluated limiting excavation to address only the most heavily contaminated areas. However, even the most limited removal actions still exceeded $2,000,000 and this remedial option was determined cost prohibitive and not a viable remedial technology.

Alternative 3 – Pump and Treat Technology

Conventional groundwater pumping and treatment technology has proven to be effective in removing and containing dissolved hydrocarbons in groundwater. This is accomplished by establishing a groundwater capture zone, typically requiring a series of recovery wells or trenches. In addition to removing and containing the dissolved hydrocarbons, groundwater pump and treatment systems also remediate hydrocarbons in the saturated soil and groundwater via extraction. Through groundwater pumping, groundwater flow is induced in the direction of the recovery wells or trenches. As groundwater flows toward the wells, hydrocarbons adsorbed to the saturated soil particles will desorb into the captured groundwater, which is then pumped to the surface for treatment. This remedial technique typically operates for a longer period of time than other remedial options because the hydrocarbons must be drawn through the subsurface to recovery wells.

a. **Effectiveness** – Moderate; In some instances, the effectiveness of conventional groundwater pumping and treatment can be limited as the rate of desorption may be relatively slow.
b. **Implementability –** Moderate: In such instances, a prolonged remediation time may be necessary to achieve the groundwater closure objectives.
c. **Cost –** Significant: Based on the large area of contamination and thickness of the NAPL plume(s), the number of recovery wells required (determined by pilot testing) could be significant and extracted liquids would need to be pre-treated prior to disposal. This remedial option seems cost prohibitive and is not a viable remedial technology.

<u>Alternative 4 – Enhanced Fluid Recovery</u>
Enhanced fluid recovery (EFR) events are commonly used to periodically recover groundwater containing LNAPL and dissolved phase hydrocarbons. A mobile vacuum tank truck (vac truck) is typically utilized to perform EFR events. A vac-truck provides a mobile high vacuum source that can be attached to one or several wells at a given time. Thus, EFR events allow the flexibility to concentrate removal efforts at those locations which warrant it. Utilizing EFR events at a Site with localized elevated dissolved CoC concentrations can be a cost-effective alternative to the implementation of a permanent water recovery and treatment system. However, the remedial timeframe is extended due to only periodic operation.

a. **Effectiveness** – Moderate; In some instances, the effectiveness of conventional groundwater pumping and treatment can be limited as the rate of desorption may be relatively slow.
b. **Implementability –** Easy: No active operations are being conducted at the Site. However, a prolonged remediation time may be required to achieve the groundwater closure objectives.
c. **Cost** – Moderate to Significant: Based on the elevated CoC concentrations over a large area, this remedial approach does not appear to be a technically feasible option for this Site.

<u>Alternative 5 – Air Sparging</u>
Air sparging is a groundwater remediation technique that involves injecting air under pressure into the saturation zone. The injected air, which then travels upward through groundwater, strips volatile hydrocarbons from the groundwater and, through the addition of oxygen present in the injected air, also enhances the natural aerobic biodegradation. The volatilized hydrocarbons move with the injected air to the unsaturated zone, where a network of soil vapor extraction (SVE) points typically captures them. As with the SVE application previously discussed, recovered hydrocarbon vapors are then treated, if necessary, and discharged to the atmosphere.

The combined air sparging and SVE technique is limited to constituents which can readily be volatilized or biodegraded, such as BTEX, and to highly permeable, granular soils with few heterogeneities. Additionally, the system design may also be limited by the presence of potential subsurface vapor conduits, such as utility trenches, which can result in the transport of hydrocarbon vapors into unintended areas.

The primary advantage of air sparging and SVE is that it consists of in-situ treatment of the groundwater, thereby eliminating the need for an aboveground groundwater treatment system and water discharge or disposal. SVE also has the advantage of providing for the remediation of unsaturated soil containing adsorbed hydrocarbons. The disadvantages to air sparging and SVE are the subsurface limitations on its application and the lack of hydraulic control; however, curtains of air sparging wells can be installed to create treatment zones which groundwater flows through.

a. **Effectiveness** – Moderate; The cohesive soils associated with the vadose zone would appear to limit the amount of hydrocarbon vapors collected through SVE technologies.
b. **Implementability** – Moderate to Difficult; Since the elevated CoC concentrations detected in the groundwater at the Site represent the presence of LNAPL, the implementation of an air sparging system could potentially spread NAPL beneath the Site causing a greater zone of impact.
c. **Cost** – Significant; Based on a review of the remedial alternative evaluation criteria, air sparging is not recommended based on the subsurface geology and elevated CoC concentrations present in the groundwater beneath the Site.

<u>Alternative 6 – In-Situ Enhanced Soil Mixing (ISESM)</u>
ISESM is generally an effective method to address contaminated soil. Augers ranging in diameter from three to 12 feet would be used to mix soils up approximately 40 feet bgs. Enhancements such as injection of heated air in combination with vapor extraction, injection of oxidants, or injection of grout (e.g., bentonite clay or cement) may be a viable alternative to retard off-Site migration by immobilizing shallow NAPL within the southern (downgradient) portion of the Site.

a. **Effectiveness** – Moderate to High; Augers ranging in diameter from three to 12 feet would be used to mix soils up approximately 40 feet bgs.
b. **Implementability** – Easy to Moderate; The Site is currently vacant, so no operations would be interrupted.
c. **Cost** – Significant; The estimated cost to perform ISESM would be in excess of $1,500,000.

<u>Alternative 7 – In-Situ Chemical Oxidation (ISCO)</u>
Due to the high levels of LNAPL and oxidant demand, remedial strategy combined ISCO with simultaneous vacuum extraction (vacuum truck). The proposed treatment area includes 122 injection/extraction wells advanced to 30 feet bgs in the south-central to southeast portion of the Site. Approximately 670 gallons of 15% sodium persulfate catalyzed with sodium hydroxide would be injected into each of the 122 injection locations. Vacuum extraction would be utilized prior to, during, and following injection activities to facilitate the effectiveness of the treatment chemistry. All extracted fluids would be stored in mobile frac tanks prior to off-Site disposal. Proposed injection/vacuum locations to address existing LNAPL and dissolved contaminants are included in Figure 3.

a. **Effectiveness** – Moderate to High;
b. **Implementability** – Easy – The Site is currently vacant, so no operations would be interrupted.
c. **Cost** – Moderate; The estimated time to remove the bulk of the LNAPL is 10 days at an approximate cost of $785,000.

<u>Alternative 8 – Monitored Natural Attenuation</u>
Natural attenuation processes commonly occur in the subsurface where hydrocarbons are present. After the source area is remediated, natural attenuation processes may be effective in degrading residual hydrocarbons. Based on the current concentrations of dissolved hydrocarbons and LNAPL at the Site, natural attenuation alone does not appear to be the best remedial option.

a. **Effectiveness** – Moderate to High: This option relies on the effective initial source removal/remediation of the LNAPL and natural degradation of the remaining contaminants. Depending on the effective remediation, further on-Site remedial treatment of the contamination and/or institutional controls may be required.
b. **Implementability –** Easy: The Site is currently vacant, so no operations would be interrupted.
c. **Cost –** Low: This option only requires ongoing quarterly/bi-annual groundwater monitoring with no operation or maintenance costs required.

Remedial Alternatives with Respect to Climate Change Conditions

Any evaluation of climate change consequences (e.g., rising sea level, increased frequency and intensity of flooding and/or extreme weather events, etc.) is inconclusive whether the Site is likely to be materially affected by such conditions.

Recommendation for Site Remedy

Based on available funding and feasibility, **the appropriate cleanup alternative is Alternative 7 (ISCO) followed by Alternative 8 (Natural Monitored Attenuation) as the remedial approaches for the Site.** Due to the high levels of NAPL and oxidant demand, the recommended remedial strategy combined ISCO and vacuum extraction (vacuum truck). The proposed treatment area includes 122 injection/extraction wells advanced to 30 feet bgs in the south-central to southeast portion of the Site. Approximately 670 gallons of 15% sodium persulfate catalyzed with sodium hydroxide would be injected into each of the 122 injection locations. Vacuum extraction would be utilized prior to, during, and following injection activities to facilitate the effectiveness of the treatment chemistry. All extracted fluids would be stored in mobile frac tanks prior to off-Site disposal. Following source removal, the Site will be monitored to determine the effectiveness of the ISCO treatment.

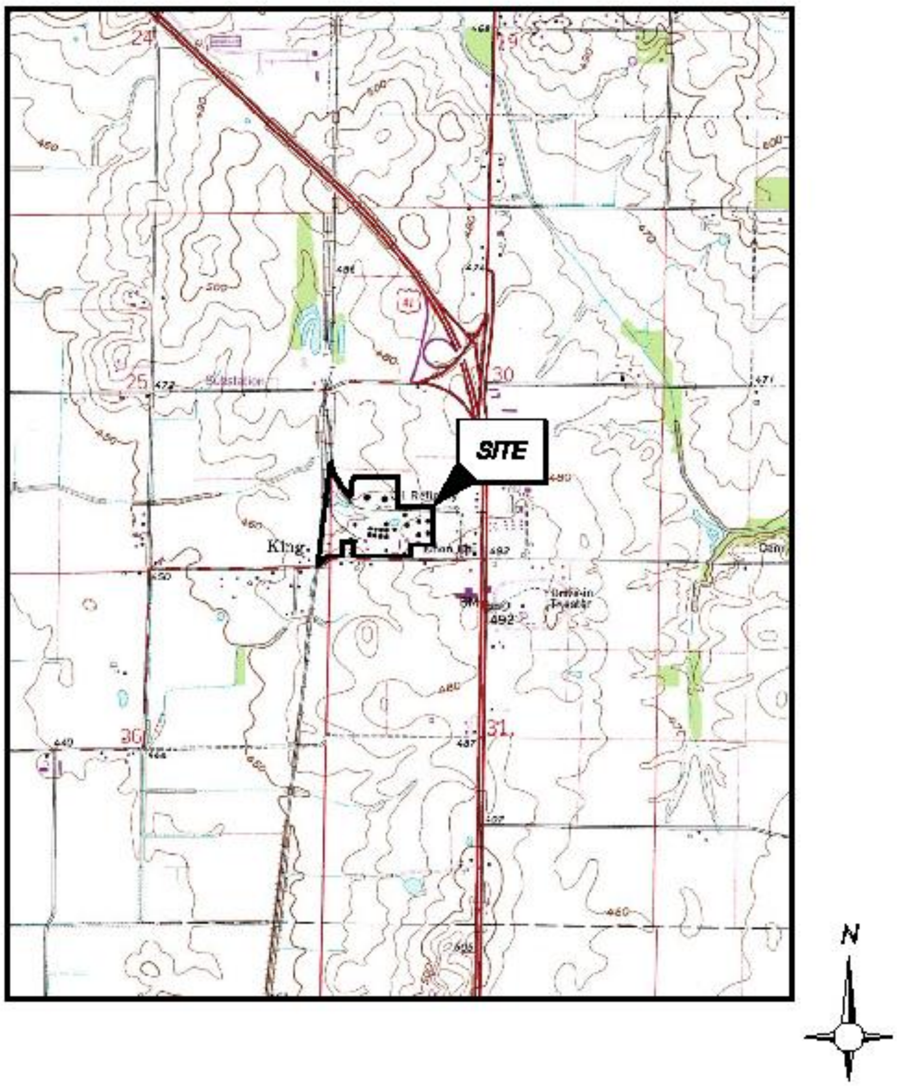
The ISCO treatment would take approximately 10 days to complete at an estimated cost of $785,000. Groundwater monitoring will be conducted following treatment for an estimated 4 to 8 quarters to evaluate the effectiveness of the ISCO treatment.

Decision Document

A decision document will be issued at the close of the designated public comment period with additional details on the selected alternative for Site remedy. The decision document will serve as a notice to proceed with federally funded remediation activities and will be available in the local information repository for public review, along with this Site ABCA and other Site-related documents.

Figures

Figure 1



FORMER R & J REFINERY

PHASE I ENVIRONMENTAL SITE ASSESSMENT
COUNTY ROAD 350 SOUTH
PRINCETON, INDIANA

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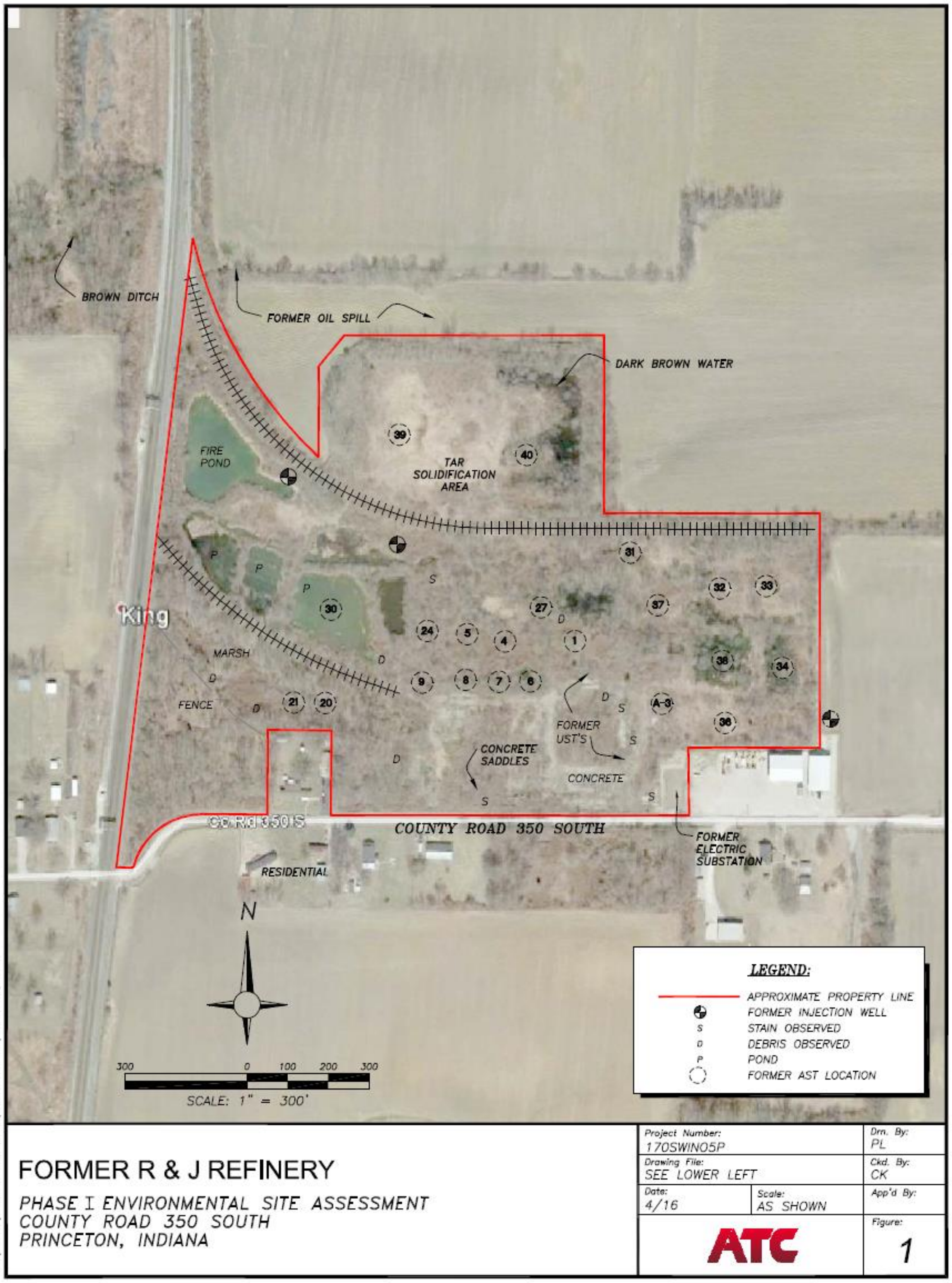
Figure 2



BROWN DITCH
FORMER OIL SPILL
DARK BROWN WATER
FIRE POND
TAR SOLIDIFICATION AREA
MARSH
FENCE
King
FORMER UST'S
CONCRETE SADDLES
CONCRETE
Co Rd 350 S
COUNTY ROAD 350 SOUTH
FORMER ELECTRIC SUBSTATION
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SCALE: 1" = 300'
LEGEND:
APPROXIMATE PROPERTY LINE
FORMER INJECTION WELL
S STAIN OBSERVED
D DEBRIS OBSERVED
P POND
FORMER AST LOCATION
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PHASE I ENVIRONMENTAL SITE ASSESSMENT
COUNTY ROAD 350 SOUTH
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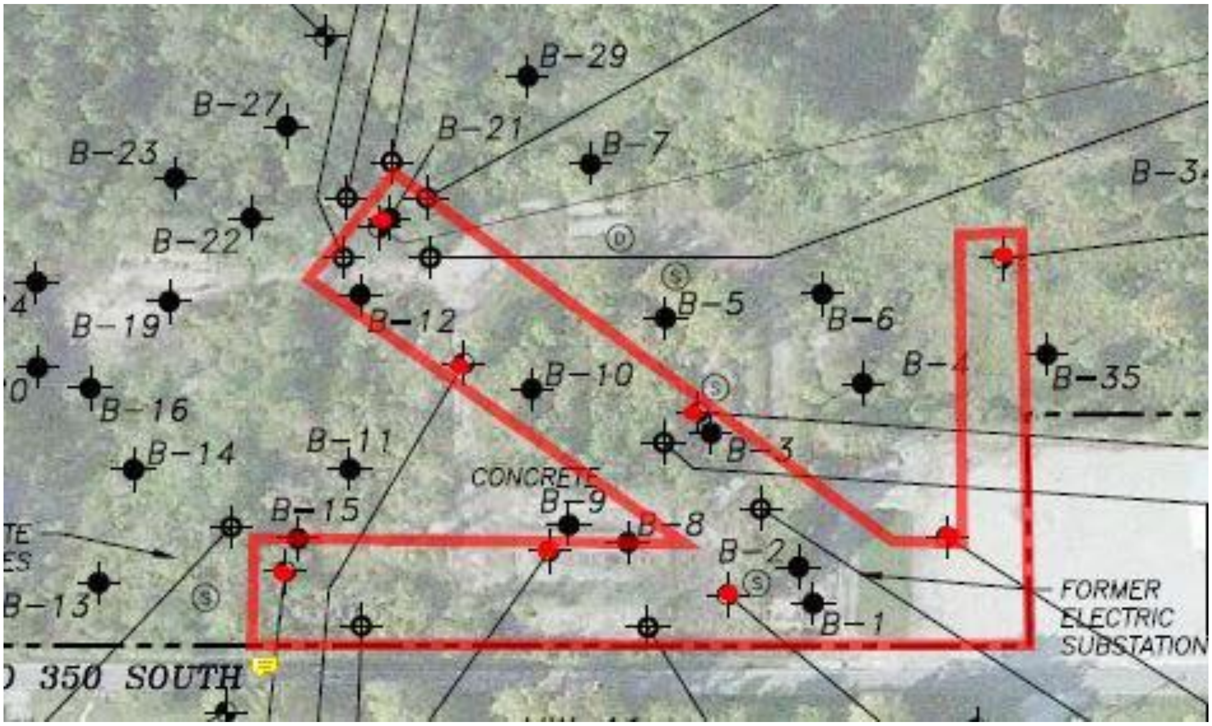
Figure 3



Proposed Treatment Area