INTERIM REMEDIAL MEASURE WORK PLAN

FOR

ROSE CLEANERS

500 Lexington Avenue
Mount Kisco, New York 10549
Site No.: 3-60-059
Index No.: W3-0978-03-12

PREPARED FOR

NEW YORK STATE DEPARTMENT OF
ENVIRONMENTAL CONSERVATION
625 BROADWAY
ALBANY, NEW YORK 12233-7016

PREPARED BY

BEi

BERNINGER ENVIRONMENTAL, INC.

AUGUST 2008

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PROFESSIONAL ENGINEER'S CERTIFICATION

CERTIFICATION:

I hereby certify that I have personally reviewed this Interim Remedial Measure (IRM) developed for the subject property pursuant to the requirements of an executed Order on Consent (December 22, 2003) between the New York State Department of Environmental Conservation (NYSDEC), Division of Environmental Remediation (DER), and LRB Cleaners, Inc., the Respondent. The site is located at 500 Lexington Avenue, Mt. Kisco, New York 10549, fully described at Dist. 80.64, Section 01, Lot 14 (see Figures 1 and 2). This Work Plan was prepared by Jill S. Haimson, PG, CGWP Project Manager under my supervision.

John Soderberg, P.E.

Signature:

SEAL

JOHN V. SODERBERG
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Dated: August 8, 2008

1.0 INTRODUCTION

The subject property is listed on the NYSDEC DER Registry of Inactive Hazardous Waste Disposal Sites in New York State as Site Number 3-60-059 with a Classification of 2 pursuant to ECL 27-1305. The site is located at 500 Lexington Avenue, Mt. Kisco, New York 10549, fully described at Dist. 80.64, Section 01, Lot 14. This document is an Interim Remedial Measure Work Plan (IRM WP) that is predicated upon the prior remedial investigation work and includes a scope of work for the implementation of a combined remedial measure to address contaminated soil areas delineated at the Rose Cleaners property at the north, west and south sides of the building.

1.1 Status of Remedial Investigation

A first phase of the Remedial Investigation (RI) of the Rose Cleaners Inactive Hazardous Waste Disposal Site (IHWDS) was performed pursuant to the requirements of an executed Order on Consent (December 22, 2003) between the New York State Department of Environmental Conservation (NYSDEC), Division of Environmental Remediation (DER), and LRB Cleaners, Inc., the Respondent. Tasks 1 to 6 of the approved Remedial Investigation Work Plan were performed at the Rose Cleaners by Berninger Environmental Inc. (BEI) during May - October 2005.

Based upon the findings of the first phase of the remedial investigation, BEI identified significant soil and groundwater contamination, in addition to supplemental investigatory data needs for this property. An addendum (supplemental) to the RI Work Plan was prepared and implemented. These activities included an expanded delineation program relative to the identified soil source zone located at the north side of the subject property. A report on these findings was submitted in April 2008 to the NYSDEC and provides the technical basis for the scope and remedial alternative selected within this IRM.

As requested by the NYSDEC, an Interim Remedial Measure (IRM) Work Plan was to be prepared to address immediate concerns relative to shallow soils impacted by dry-cleaning volatile organic chemicals (VOCs) (specifically tetrachloroethene (PCE) and daughter products) delineated during prior RI studies at the subject property. An IRM is proposed based upon the fact that:

- Sufficient delineation of site conditions has been completed; and
- Conduct of an IRM would provide mitigation and/or the prevention of ongoing environmental impacts.

1.2 IRM Remedial Objectives

Based upon NYSDEC commentary , the IRM is required to consist of the following:

- Excavation of the "hot spot" to the water table (at a minimum);
- Injections of treatment chemicals within the area of excavation, and the other two identified "hot spots";
- Development of a comprehensive IRM report documenting these activities.

As both surficial, shallow unsaturated and saturated soil impacts have been identified, the IRM Work Plan includes a scope of work for the implementation of a combined remedial measure to address the aforementioned at areas delineated at the north, west and south sides of the building.

2.0 SUMMARY OF SITE CONDITIONS

2.1 Summary of Site Conditions

The RI soil sampling performed was biased toward the north side of the building and included other potential suspect areas such as the rear of the building, exterior to doors, exhaust fans, the historic dumpster location, etc. Primarily tetrachloroethene (PCE) has been the Volatile Organic Compound (VOC) present at the highest concentrations of concern, coupled with elevated detections of typical daughter (breakdown) VOCs such as 1,2-Dichloroethene (total) and trichloroethene. No vinyl chloride has been reported above method detection limits.

Similar to soils, PCE is the primary constituent present at the highest concentrations with the exception of one sampling location (GW-1) at the northwest corner of the building wherein daughter products of PCE such as vinyl chloride predominated. The highest concentrations of PCE were present in the shallow groundwater samples collected at the northwest and north sides of the building consistent with the soil sampling data at these locations. Localized groundwater flow direction was confirmed to be to the northwest.

In summary, three main locations of shallow PCE contamination were delineated: the north side of the building, the dumpster area and the rear of the building, exterior to the door and exhaust vents. Supplemental RI activities performed in February 2008 included the installation of thirty soil borings at which 50 soil samples were collected. This supplemental work was performed to allow for a complete delineation of the vertical and lateral extent of PCE contamination in the largest source area at the subject property. A series of isoconcentration maps were developed based upon this data set for purposes of directing the IRM efforts.

2.2 Delineation of IRM Areas (Isoconcentration Maps and Cross Sections)

In order to provide further evaluation of the northern most area of the subject site wherein an excavation program will be implemented, detailed mapping of the soil data was performed. Initially the data was evaluated relative to linear projections (lines of cross section) that would provide the most definitive analysis of subsurface conditions. The lines of cross section were established based upon linking the areas of the highest concentrations of PCE (e.g., B-20 in a north south line, and B-18 in a west -east line), cross-correlating same with Photoionization Detector (PID) field responses, logged lithology and development of PCE isoconcentration (contours of equal concentrations) maps that illustrate "hot spots", tie in with disposal issues (e.g., 12 mg/kg - TAGM 3028), regulatory action levels (1.4 mg/kg) and other pertinent conditions (e.g., depth above or below the water table, degree of saturation). Figures 2 to 8 provide detailed delineation of site conditions in both plan view and cross-section views. Based upon these representation of the site data, two areas of highest concentrations ("hot spots) of PCE are present surrounding boring locations B-18 and B-19/20 in the shallower soils (see Figure 4 and cross section views). These hot spots extend out to the 1,400 ug/kg contour and become co-joined at the B-15 sampling location. An area has been delineated between the 1,400 ug/kg and the 12,000 ug/kg that may allow for the segregation of lesser concentration soils for disposal under the TAGM 3028 rules.

However, the deeper soils (7-30 feet) that are beneath the saturated zone, depict a layer that extends north to south along the A-A' (B-19 to DS-2) axis, allowing for the fact that limited data is available in a west-easterly pattern. The cross section (Figure 6) that illustrates this pattern of migration of PCE confirms movement in a deeper zone, from north to south, dropping below the water table, with increased distance from the original source area. Shallow soils are relatively un-impacted (as evidenced from PID responses) from the B-21 location to DS-2. The base of this contamination seems to coincide with a decrease in relative permeability in lithology from fine to medium grained sands to fine grained sands, silts and clay in the deeper horizon (15 feet below grade surface (bgs).

The other north-south cross section B-B' (Figure 7) confirms a hot spot of contamination surrounding the B-4 location. PCE impacts appear to be spreading laterally, with increased depth, to the north and south from B-4, with highest concentrations at a depth of 10 feet bgs. Similarly, the base of this contamination seems to coincide with a decrease in relative permeability in lithology from fine to medium grained sands to clay with some fine-grained sand in the deeper horizon (about 12 feet below grade surface (bgs).

The east-west cross section C-C' (figure 8) depicts the hot spots of contamination surrounding the B-4/B-18 locations and the separation between this location and the B-21 hot spot. PCE impacts appear to be encroaching toward the Creek at the B-4 location, originating from the B-18 location. The impacts at B-18 originate shallow and continue until an approximate depth of 12 feet bgs. Again finer grained (lower permeability) lithology appears to create a lower boundary condition for transport.

The hot spot at B-21 has a completely different origin, with the shallow soils appearing to contain limited impacts, Based upon comparison with the A-A' section, the deep impacts at B-21 clearly originate from B-20. The contamination below the water table at this location appears to have transported deeper (approximately 16 feet bgs) within the aquifer than the B-20 location, into the lesser permeable lithology logged during the installation of soil borings.

2.3 Project Schedule

Based on the June 30, 2008 meeting at the White Plains office, it was discussed that a time frame of approximately September 15, 2008 would be a goal for getting the soil excavation work started. This time frame is contingent upon gaining access to the ten foot wide section of property along the north side of the Rose Cleaners property. BEI had our certified letter to the current property owner returned and notified the NYS-DEC of that occurrence. Once access has been obtained the first phase of work (land clearing of all trees, bushes and debris) will begin.

3.0 INTERIM REMEDIAL MEASURE NO.1- SOIL EXCAVATION

In order to address impacts to soils within the area of the highest shallow PCE contamination (the north side of the building) soil excavation is proposed. This IRM will be dependent upon the conduct of the following tasks:

3.1 Site Access & Preliminary Activities

Site Access constraints include the vegetation located on the north side of the building and access to the 10 foot strip of property north of the Rose Cleaners Building. Attempts have been made to confirm property ownership. A certified letter was sent to the property owner of record. BEI is working with the NYSDEC attorney to provide access to this area.

Prior to movement of equipment on site the following activities will be undertaken: Site inspection; boundary staking; demarcation of hot spots; and construction of access roads and construction fencing. The location of the decontamination and work areas will be outlined and set of same performed. The work zones will be identified via the construction fencing with relevant signs to limit entry to the site. The remedial construction plans needs to take into account potential or pre-existing surface drainage and subsurface utility systems, with staking of same.

Berms will be built around the proposed active excavation and storage areas, as necessary, to prevent migration of contaminated runoff away from the area. An effective erosion control program will be designed with the scheduling of construction activities arranged to limit the time of exposure of disturbed portions of the site. This will entail directing work to one area of a site, then completing and stabilizing (backfilling) that area before moving on to other areas of the site.

3.2 Grading and Clearing

The vegetation on the north side of the property includes numerous large trees, bushes and a large degree of uncontrolled undergrowth. This vegetation will be removed by hogging out the undergrowth. The larger trees will cut down, with wood stockpiled on site (other side of the property) awaiting off-site disposal. The land surface contours will be maintained as is as much as feasible, as to not create a vapor pathway until remedial efforts are underway.

3.3 Health and Safety Considerations

In order to promote the most effective health and safety protocols for workers and surrounding communities as well as site control, measures described in the United States Protection Agency (USEPA) Best Management Practices (BMPs) for Soil Treatment Technologies (EPA 530-R-97-007 May 1997) will be followed. Control of emission sources and controls during cleanup activities will be related to the emission source (soil excavation), the appropriate control technologies and the factors affective emissions (see Table 3-1 " Emissions Sources and Controls During Cleanup Activities (USEPA 1992a).

A separate Health and Safety Plan has been developed for the implementation of this project and is attached as Section 5.

The initial clearing of the larger vegetation and bushes should not require any specific health and safety concerns. Numerous walk-throughs of this area have been completed by BEI prior to and after testing with no field screening readings above ambient air concentrations. Any limited low level brush clearing, grubbing or grading will be performed using both a PID and particulate meter following the Community Air Monitoring Program described in Section 3.4.

Due to the high concentrations of VOCs that are present in soils (unsaturated and saturated), and the proximity of adjoining businesses and residences, there are significant health and safety concerns relative to the implementation of the IRM. This concern primarily includes the generation of vapors from the handling of soils and the ability to control same. A separate sequence of activities have been established to handle the anticipated vapor control issues associated with the excavation, handling, storage and off-site disposal of the site soils.

During excavation, entry to the active site work area will be limited to avoid unnecessary exposure and related transfer of contaminants, especially during site preparation and staging. All non-essential personnel will be asked to not enter the contaminated area. Fugitive dust emissions will be evaluated by air monitoring and controlled as discussed in this work plan. During transportation of contaminated soils or solid media, covers or liners will be used to prevent dust and VOC emissions. These temporary covers on trucks or other hauling equipment will be installed with care to minimize possibilities for the waste to come into contact with high winds during transport. Any offsite runoff will be prevented from entering and mixing with on-site contaminated media by building berms or adopting similar other measures.

3.4 Community Air Monitoring

The excavation part of the IRM is anticipated to pose the largest health and safety considerations relative to the surrounding community. Therefore, emphasis on the development of a Community Air Monitoring Plan (CAMP) has been placed on these primary activities versus the limited exposure to the community for injection of chemicals. Specifically, two types of air monitoring will be performed during the implementation of this IRM: 1) Perimeter for CAMP and 2) on-site monitoring inside the area of excavation for worker site safety as well as early warning relative to pending changes that will affect the property perimeters.

Perimeter Monitoring - CAMP

A Community Air Monitoring Plan (CAMP) provides for real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust) at the downwind perimeter of each designated work area when certain activities are in progress at contaminated sites. The CAMP is not intended for use in establishing action levels for worker respiratory protection. Rather, its intent is to provide a measure of protection for the downwind community (i.e., off-site receptors including residences and businesses and on-site workers not directly involved with the subject work activities) from potential airborne contaminant releases as a direct result of investigative and remedial work activities. The action levels specified herein require increased monitoring, corrective actions to abate emissions, and/or work shutdown. Additionally, the CAMP helps to confirm that work activities did not spread contamination off-site through the air.

Continuous Monitoring

Continuous monitoring will be required for all ground intrusive activities and during the excavation and injection of chemicals. Ground intrusive activities include, but are not limited to, soil/waste excavation and handling, chemical injection and the installation of soil borings or monitoring wells.

Periodic Monitoring

Periodic monitoring for VOCs will be required during non-intrusive activities such as the collection of soil and sediment samples or the collection of groundwater samples from existing monitoring wells. "Periodic" monitoring during sample collection might reasonably consist of taking a reading upon arrival at a sample location, monitoring while opening a well cap or overturning soil, monitoring during well bailing/purging, and taking a reading prior to leaving a sample location. In some instances, depending upon the proximity of potentially exposed individuals, continuous monitoring may be required during sampling activities. Examples of such situations include groundwater sampling at wells on the curb of a busy urban street, in the midst of a public park, or adjacent to a school or residence.

VOC Monitoring, Response Levels, and Actions

Volatile organic compounds (VOCs) must be monitored at the downwind perimeter of the active work area (i.e., the exclusion zone) on a **continuous** basis or as otherwise specified. Upwind concentrations will be measured at the start of each workday and periodically thereafter to establish background conditions. The monitoring work will be performed using equipment appropriate to measure the types of contaminants known or suspected to be present. The equipment will be calibrated at least daily for the contaminant(s) of concern or for an appropriate surrogate. The equipment will be capable of calculating 15-minute running average concentrations, which will be compared to the levels specified below.

- If the ambient air concentration of total organic vapors at the downwind perimeter of the work area or exclusion zone exceeds 5 parts per million (ppm) above background for the 15-minute average, work activities must be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 5 ppm over background, work activities can resume with continued monitoring.

- If total organic vapor levels at the downwind perimeter of the work area or exclusion zone persist at levels in excess of 5 ppm over background but less than 25 ppm, work activities must be halted, the source of vapors identified, corrective actions taken to abate emissions, and monitoring continued. After these steps, work activities can resume provided that the total organic vapor level 200 feet downwind of the exclusion zone or half the distance to the nearest potential receptor or residential/commercial structure, whichever is less - but in no case less than 20 feet, is below 5 ppm over background for the 15-minute average.

- If the organic vapor level is above 25 ppm at the perimeter of the work area, activities must be shutdown. All 15-minute readings must be recorded and be available for State (DEC and DOH) personnel to review. Instantaneous readings, if any, used for decision purposes will also be recorded.

Particulate Monitoring, Response Levels and Actions

Particulate concentrations will be monitored **continuously** at the downwind perimeter of the exclusion zone at temporary particulate monitoring stations. The upwind perimeter will be monitored periodically, in tandem with the downwind perimeter. The particulate monitoring will be performed using real-time monitoring equipment capable of measuring particulate matter less than 10 micrometers in size (PM-10) and capable of integrating over a period of 15 minutes (or less) for comparison to the airborne particulate action level. The equipment must be equipped with an audible alarm to indicate exceedance of the action level. In addition, fugitive dust migration will be visually assessed during all work activities.

- If the downwind PM-10 particulate level is 100 micrograms per cubic meter (mcg/m^3) greater than background (upwind perimeter) for the 15-minute period or if airborne dust is observed leaving the work area, then dust suppression techniques must be employed. Work may continue with dust suppression techniques provided that downwind PM-10 particulate levels do not exceed 150 mcg/m^3 above the upwind level and provided that no visible dust is migrating from the work area.

- If, after implementation of dust suppression techniques, downwind PM-10 particulate levels are greater than 150 mcg/m^3 above the upwind level, work must be stopped and a re-evaluation of activities initiated. Work can resume provided that dust suppression measures and other controls are successful in reducing the downwind PM-10 particulate concentration to within 150 mcg/m^3 of the upwind level and in preventing visible dust migration.

All readings will be recorded and be available for State (DEC and DOH) personnel to review.

3.5 Soil Handling Issues

Hazardous and non-hazardous soil excavation with off-site transport and disposal is the main presumptive remedy for the northern area of soil contamination. This type of remedial action dictates specialized soil handling and typically requires significantly more attention to personal protection and safety, including provisions for worker protection (special clothing, decontamination techniques, etc.) and equipment decontamination. All workers occupying the work zones will be 40-hour OSHA trained for work at Class 2 sites and currently certified.

Excavation and off-site disposal primarily involves equipment that is widely used in the construction or non-hazardous solid waste disposal industries, such as excavators, backhoes, dump trucks, and containers of various shapes, sizes, and materials. When a site is remediated by excavation and off-site disposal, the contaminated material (typically a solid or semi-solid material such as soil or sludge) is excavated, then transported off-site for treatment and/or disposal. The techniques for soil handling in order to control cross-media transfer of contaminants (such as air emission issues) during material handling (provided in Table 3-1) include the following:

1) Operation Controls - perform activities during cooler time periods (early am), maintain low speeds of equipment, control placement of stockpiles, containers, away from prevailing winds, use of larger equipment to minimize surface area/volume ratios, during dumping minimize soil drop height, during transport, cover or enclose trucks, etc.

2) Covers and Physical Barriers - physically isolate the contaminated media from the atmosphere (covers, mulch, foam coverings, wind screens, slurry cover sprays, etc.

3) Water Sprays or Suppressant Foams - reduce air emissions by adsorbing moisture from the air. Specialty VOC suppressant foams can be applied when instrumentation at strategic monitoring locations indicate that VOC concentrations exceed action levels. Within minutes of applying the foam, air-borne concentrations can be reduced from thousands of parts per million to background levels.

4) Enclosures - self-supported or air supported structures can be erected to provide a physical barrier between the air emission area and the atmosphere.

5) Soil Moisture Stabilization - As the soil column will be excavated down to the water table, moisture can be a large concern. As much of the soil excavated will be manifested as hazardous waste, a limitation on moisture **below 12% is** ~~required~~ in order to ensure that the loads are not rejected at the waste facility. Therefore, techniques such as the addition of lime or other specialty chemicals can be very effective. Because these materials typically chemically combine with water, they can be used very effectively to dry any type of wet soil. Heat from this reaction further dries wet soils. "Dry-up" of wet soil at construction sites is one of the widest uses of lime for soil treatment. Generally, between 1 to 4 percent of lime by mass of dry soil will improve a wet site sufficiently to reduce moisture content and allow construction activities to proceed. However, strict control must be implemented to ensure that the pH does not exceed 12, rendering soils unacceptable to some facilities.

6) Site drainage control - Provisions will be made to capture on-site surface water runoff in the area of excavation or other work areas by diverting it to a controlled depression-area or plastic-lined beamed area. Covers, and if necessary, liners, will be used at all times when contaminated materials are being stored. Covers will be used on trucks that are moving materials around and from the site.

3.6 Waste Classification

This IRM will result in the temporary stockpiling of hazardous and non-hazardous soils. These materials will be properly containerized for transport after characterization. If feasible a pre-classification program may be performed to allow for more efficient soil loading for off-site disposal. Representative grab[1] and composite[2] samples will be collected for the purposes of characterization of these materials for off-site disposal. As per projected facility requirements, one sample will be

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[1] Volatile Organic Compounds (VOCs).

[2] Remainder of parameters required for characterization.

collected at a frequency of one per 250 cubic yards for characterization purposes. The aforementioned activities will be undertaken after review, approval and with adequate notification to NYSDEC.

The soil waste characterization samples will be transported under appropriate chain of custody protocols to an NYSDOH ELAP-certified Laboratory. The samples will be analyzed for the following parameters at a minimum: for Pesticides/Polychlorinated biphenols (PCBs) by EPA Method 8081/8082, percent moisture, Total metals by the EPA Method 6010, Target Compound List (TCL) Semivolatile Organic Compounds (SVOCs) by EPA Method 8270, TCL Volatile Organic Compounds (VOCs) by the EPA Method 8260, paint filter by EPA Method 9095, ignitability, corrosivity, Total Petroleum Hydrocarbons (TPH) Diesel Range Organics (DRO) by EPA Method 8015 and TCLP Metals by EPA Methods 1311/6010 and 1311/7471. Other analytics may be required, dependent upon the test results and the ultimate disposal facility selected.

Waste Disposal Facilities:

Based upon the testing results and review from various off-site disposal facilities, disposal facilities will be selected. A separate facility will be designated for the transport & disposal of characteristically hazardous soils in addition to a facility for the transport & disposal of non-hazardous soils(e.g., Subtitle D landfills).

This information will be provided to NYSDEC for review and approval prior to the movement of the material off-site to its intended facility, by a Part 364-permitted transporter. Subsequent to the off-site transport and disposal, loading tickets and manifests will be provided to NYSDEC documentation.

Facility Names, licenses, permits, etc.

3.7 Decontamination Waste Handling Protocols

BEI will set up separate decontamination stations to address decontamination and waste handling protocols for personnel and equipment decontamination as follows:

Equipment Decontamination Area

The decontamination areas will be established near active (exclusion zone) work areas. An equipment decontamination area will be established on-site in areas accessible to vehicles and equipment. Site-specific locations for decontamination areas will be identified on-site prior to proceeding with the remediation project. Decontamination areas will be lined with visqueen and industrial matting that can be disposed of after closure of the decontamination area. Replacement of this material will be based on field observation. After leaving the equipment decontamination area, personnel involved in equipment decontamination will exit through a separate personnel decontamination area.

Equipment Decontamination

The Decontamination Unit will periodically clean equipment during remediation. Cleaning systems for hand tools, and heavy machinery are established at the decontamination unit, usually in the immediate vicinity of the temporary waste management area established. Steam cleaning or soap and water wash, as appropriate, will be used to decontaminate equipment. The equipment decontamination area will have a large pool or other diked impoundment for cleaning equipment for storage of liquids. The cleaning pool or dike area will be

lined with secondary containment to capture any spilled material. Equipment that cannot safely be moved will be decontaminated on-site using soap and water with a water rinse; this process will be repeated until visible contamination is removed. Areas used for cleaning will be beamed with hay bales and lined to prevent additional contamination, and the resulting water will be collected and disposed of per procedures identified below. Expendable equipment (e.g., rope mops, brushes, tarps, etc.) will not be decontaminated but will be drummed as waste.

Personnel Decontamination Areas

Decontamination areas will have large children's type wading pools or equivalent for cleaning small equipment and personnel effects for liquids generated during the decontamination process. Liquids will be transferred from the cleaning pool to the NYSDOT-approved drums as needed. The personnel decontamination area will include the wading pools for individuals to wash in while they are still wearing personal protective equipment (PPE), and three (3) drums for disposal of spill debris. Upon leaving the exclusion zone, each individual will safely go through the designated decontamination stations. Decontamination Unit personnel will be available for assistance. Decontamination procedures will generally include the following:

Personnel decontamination procedures, specifically, will include the following steps:

1. Exit the work area after removing gross contamination and leaving it in contaminated area for later disposal. Enter the decontamination area by stepping on absorbent roll (Station #1).
2. Station #2 – Step into galvanized wash tubs and remove all visible contamination from clothing and boots via wash brush. Absorbent pads and water sprayers or garden hoses will be available at this station to assist in the cleaning.
3. Station #3 – Step from washtub and walk on absorbent roll. Remove outer gloves and place in waste can.
4. Station #4
   a. Continue on absorbent roll and step into next washtub. Remove protective clothing
   b. Step out of and away from boots and clothing.
5. Station #5 – Throw disposable clothing in waste bin and place boots in personnel bags for reuse.
6. Station #6 – Remove and dispose of inner gloves and exit decontamination line into sheltered area.

All liquid generated from this cleanup operation will be transferred to storage tanks used for containment of recovered oil and water.

3.8 IRM - Excavation of Contaminated Soil

3.8.1 Hot Spots to be Addressed

One area of PCE contamination will be addressed during the IRM via excavation: the north side of the building in accordance with detailed mapping of "hot spots" presented in the isoconcentration maps developed based upon site data. Excavation is proposed for shallow accessible soils down to the upper groundwater at approximately 4-5 feet bgs.

Detailed mapping of the soil data identified "hot spots", specifically two areas of highest concentrations of PCE present surrounding boring locations B-18 and B-19/20 in the shallower soils (see Figure 4 and cross section views). These hot spots extend out to the 1,400 ug/kg contour and become co-joined at the B-15 sampling location. An area has been delineated between the 1,400 ug/kg and the 12,000 ug/kg that may allow for the segregation of lesser concentration soils for disposal under the TAGM 3028 rules.

Based upon accessible shallow impacted soils and soils that can reasonably be addressed above the water table, a total of 100 tons of soil is anticipated to be generated during the IRM. Excavation will be initiated at the northern building wall at the B-20 location and will be extended laterally in a east-west direction from B-19 to B-22. This area will be excavated down to the water table, with care exercised to not cause structural issues at the building foundation. The excavation will then be extended to the B-18 location in a lobe like manner to capture the shallow impacts mapped from B-18 extending to B-4. This overall footprint is depicted in Figure 9.

Dependent upon the soil classification (hazardous or non-hazardous) the soils will either be stockpiled (on top of and covered with plastic) or placed in appropriate lined and covered containers for off-site transport.

As necessary the excavation areas will be backfilled in sequences that support the overall IRM construction activities and maximize access and minimize health and safety concerns and soil handling issues.

3.8.2 Confirmatory IRM Soil Samples

The excavation area will be secured and soil samples will be collected to demonstrate remaining conditions after the conduct of the IRM. Samples will be collected at sidewalls of the excavation at a frequency of one grab sample (at 2/3 depth of the wall) every approximate 20 feet in length or a higher frequency dependent upon the overall size of the excavation. In instances where the bottom of the hole is in groundwater or other fill material is present that is not conducive to sampling, no endpoint samples will be collected. All samples will be maintained in an ice-packed cooler and transported under strict chain-of-custody to a NYSDOH-ELAP-certified laboratory for analysis by EPA Method 8260 Purgeable Organics by GC/MS.

3.8.3 Waste Manifesting, Weight Tickets, Truck Placarding, etc.

All soil loads, decontaminated waste, etc. to leave the site will be properly manifested based upon prior waste classification data. Both loading tickets and weight tickets will be generated relative to the waste materials. Dependent upon the particular classification, all vehicles moving wastes will be checked for proper decals, placarding, permits, and other appropriate regulatory required provisions. Waste manifest documentation will be collected from each driver by the on-site representative, as well as from the disposal facility to document waste disposal paths.

3.8.4 Installation of Future Injection Piping

BEI will install a series of two-inch diameter lateral screens throughout the overall excavation area (see Figure 10) prior to backfilling. These screen lengths will be manifolded together via couplings and will be brought to the land surface via installed using two-inch solid PVC riser. This will be left in place for future possible injection of oxidation chemicals (see Section 4.5).

3.8.5 Installation of Proposed IRM Monitoring Wells

In order to evaluate any immediate effects of the IRM and for future monitoring purposes (see Section 4.5) three additional two-inch diameter groundwater monitoring wells will be installed using a Geoprobe dual-tube drilling system along the down gradient perimeter near the northern property boundary as per Figure 4. These IRM well locations will roughly correspond with the locations of former borings, DS-1, DS-2 and DS-3.

As depth to groundwater is about four (4) feet below grade at this area, the final depth of each well will be approximately 12 feet, dependent upon depth to groundwater. Well construction will consist of a minimum of 10 feet of 2-inch diameter, schedule 40, 0.020-inch slotted well screen set approximately two feet above and eight feet below the water table. 2-inch diameter, schedule 40 flush joint threaded riser pipe will finish the well to grade. A 5-inch cast iron manhole and cover will be cemented in place to complete the installation. Drill cuttings will not be generated using this method of well installation.

Upon completion of the installation of the wells, the location(0.1 foot) and casing elevations (0.01 foot) will be determined by a New York state-licensed surveyor. Depth to groundwater will be measured from each well to the nearest 0.01 foot using a sonic interface probe. The collected data will also be used to generate updated groundwater gradient maps confirming direction of groundwater flow. The actual location of any new monitoring wells will be determined based on the presence of site constraints and IRM findings.

3.9 Demonstration of Clean Fill Requirements for Backfilling

In order to provide a physical delineation barrier within the overall excavation area, a permeable geo-textile fabric will be placed in the excavation. The remediation contractor will provide clean fill for backfilling as required. The certification of this material from its source will be reviewed by Berninger Environmental, Inc. and presented to NYSDEC prior to transport and placement at the subject property. Every clean fill load will be documented with a ticket from the source location and the total amount delivered will be demonstrated to equal the amount needed to complete the backfilling.

3.10 Surface Area Restoration & Impermeable Cap

After the completion of excavation, application of chemical oxidants into the upper water table with soil mixing, a permeable geotextile fabric will be placed in the treatment horizon to mark same. The area will then be backfilled using clean fill as described above. In order to limit future infiltration of precipitation, an impermeable membrane and an asphalt cap will be employed in this area.

Approximately six-inches below grade, a 12-mil impermeable plastic layer will installed. An asphalt cap will be placed on top of preparatory material and the impermeable plastic barrier. Any PVC risers from future injection wells will be fitted with steel man ways at the land surface as well as the down gradient monitoring wells.

4.0 IRM 2ND STAGE - CHEMICAL APPLICATION TO EXCAVATION

4.1 Application of Chemicals to Excavation Area

In order to provide treatment of entrained groundwater impacts present within the former soil source area at the subject site, the introduction of a chemical oxidant injection as an excavation application is proposed. A chemical oxidant will be introduced into the excavation pit to extend source area contamination treatment within the saturated zone, prior to backfilling. The chemical oxidate will be mechanically blended using the backhoe bucket into the contaminated upper water table. The chemicals will be added and mixed as feasible. By maximizing contact between the chemical solution and the contaminated soil, the following benefit occurs:

1. Ensures direct and immediate contact with chemical oxidant;
2. Undergoes rapid oxidation reactions;
3. Eliminates uncertainties of subsurface geology and hydrogeology;
4. More cost effective as compared to off-site disposal.

The treatment of contaminated soils with chemical oxidants via in-situ soil mixing involves chemical oxidation as well as biological and/or physical processes to transform organic contaminants in soil. The soil mixing that occurs during an ex-situ or in-situ mixing treatment serves to homogenize the soil and contaminants at the same time it forces contact with the oxidant mixture. During this process the contaminant can be diluted and some amount may volatilize. These physical losses are difficult to differentiate from chemical oxidation losses, but can be significant. The proportion of contaminant that is degraded by chemical, biological or physical processes will depend on:

- Soil type
- Contaminant type and distribution
- Oxidant Efficiency
- Soil/Water ratio
- Type & frequency of Mixing
- Temperature
- Treatment Duration.

The duration of the treatment program is very important to ensure that sufficient time has been allowed for the complete chemical reactions to occur. Additionally, many contaminants that are partially oxidized during the chemical treatment become more readily available for biological degradation. Thus, contaminant concentrations often continue to decline as a result of this post-chemical oxidation biological activity. The table below gives an idea of the proportional effects of different processes. In a typical contaminated soil treatment employing mixing and chemical oxidation technology, the actual chemical oxidation reactions can account for 10 to 60% of the contaminant removal. Biological activity can account for 20-60%, primarily depending on the time and water content. Physical processes can account for 10-90% of the contaminant removal, primarily depending on the type of mixing that is used and the volatility of the contaminant treated.

When designing an approach for implementing chemical oxidation of soil, the highest benefit would be achieved by maximizing the surface area in contact with the chemical oxidant. As excavation will occur down to the water table, this is an excellent application of this technology. The most effective soil particle is below one centimeter in size. Most soils will require the addition of water and other amendments before treatment. However, in this case, soils will be wetted through capillary action or located within the upper groundwater. Lime and/or bulking agents, such as wood chips or sand maybe needed to improve both material handling as well as to maximize biological degradation after the chemical oxidation.

4.2 Analysis of the Use of In-Situ Oxidation Chemicals

BEI has reviewed the following reference document to provide information on the range of appropriate in-situ chemical oxidation method (ISOCs): *Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater dated June 2001.* Remediation of groundwater contamination using chemical oxidation involves injecting oxidants and other amendments as required directly into the source zone and down gradient plume. The oxidant chemicals react with the contaminant, producing innocuous substances such as carbon dioxide (C02), water (H20), and inorganic chloride. However, the full spectrum of reaction intermediates and products range dramatically. The ISOC needs for each type is given in Table 2. Examples of potential contaminants that are amenable to treatment by ISOC include BTEX (benzene, toluene, ethylbenzene, and xylenes), tetrachloroethylene (PCE), trichloroethylene (TCE), dichloroethylenes, vinyl chloride (VC), MTBE (methyl- tert-butyl-ether), PAH (polyaromatic hydrocarbons) compounds, and many other organic contaminants. ISOC offer several advantages over conventional treatment technologies such as pump and treat. For instance, the technology does not generate large volumes of waste material that must be disposed of and/or treated. ISOC is also implemented over a much shorter time frame. Both of these advantages should result in savings on material, monitoring, and maintenance. The following ISOCS are commonly used; a description is provided in addition to the pros and cons for use at the Rose Cleaners Site.

Potassium and Sodium Permanganate

Permanganate is an oxidizing agent with a unique affinity for oxidizing organic compounds containing carbon-carbon double bonds, aldehyde groups or hydroxyl groups. As an electrophile, the permanganate ion is strongly attracted to the electrons in carbon-carbon double bonds found in chlorinated alkenes, borrowing electron density from these bonds to form a bridged, unstable oxygen compound known as a hypomanganate diester. This intermediate product further reacts by a number of mechanisms including hydroxylation, hydrolysis or cleavage. Under normal subsurface pH and temperature conditions, the carbon-carbon double bond of alkenes is broken spontaneously and the unstable intermediates are converted to carbon dioxide through either hydrolysis or further oxidation by the permanganate ion. There are two forms of permanganate, KMnO and NaMnO .

Manganese dioxide (MnO) is a natural mineral already found in the soils in many parts of the country. If the precipitation of manganese dioxide in the soils is excessive, it can reduce the permeability of the soil, thus limiting injection of the aqueous oxidant. The chloride ion (Cl-) released by the oxidation reaction may be converted into chlorine gas (Cl) due to the high-redox 2 conditions. Chlorine gas reacts immediately with groundwater and pore water to form hypochlorous acid (HOCl). This hypochlorous acid may react with methane to form trace concentrations of chloromethanes in the groundwater immediately after treatment. However, this phenomenon is typically short-lived as the subsurface conditions are converted from an anoxic state to an oxidized state.

Given that the work area at the subject property is surrounded by residential uses as well as an adjoining creek, the possibility of formation of chlorine gas, chloromethanes and other coloration issues make the use of this ISOC undesirable for this application.

Hydrogen Peroxide

This process involves free radical generation and direct oxidation with hydrogen peroxide. Hydrogen peroxide, which can be delivered at depth using lance permeation or soil mixing techniques or injected water amendments, is an effective oxidizing agent. However, to achieve the desired contaminant reductions in a reasonable time, a metal catalyst is required. Iron is most commonly used and, when mixed with hydrogen peroxide, the catalyst is known as Fenton's reagent. The terms "Fenton's reagent" and "hydrogen peroxide" are used interchangeably. The process is well documented for producing hydroxyl radicals by the reaction of hydrogen peroxide and ferrous iron (Fe+2). The hydroxyl radicals (OHC) serve as very powerful, effective, and nonspecific oxidizing agents, second only to fluorine in oxidizing power. The Fenton process is relatively fast acting, taking only days or weeks. The contaminants are treated in situ, converted to innocuous and/or natural occurring compounds [e.g. H O, CO , halide ions]. By acting/reacting upon the contaminant in place, the reagent serves to eliminate the possibility of vertical movement of the contaminant other than that resulting from the act of vertical injection itself, which is often a concern with other remediation technologies. As a side benefit, aerobic biodegradation of contaminants can benefit from the presence of O released, if large quantities of reagent need to be applied. However, the usefulness of Fenton's reagent may be limited by low soil permeability, incomplete site delineation, subsurface heterogeneities, and highly alkaline soils where carbonate ions are free radical (hydroxyl) scavengers. Additionally, there is a potential for a violent exothermic hazard.

Given the proximity to residential and commercial uses as well as an adjoining creek, the possibility of a violent exothermic hazard within an open excavation make the use of this ISOC undesirable for this application.

Ozone

Ozone (O_3) is one of the strongest oxidants available for ISOC. It can be delivered via horizontal or 3 vertical wells. Currently, it is most commonly used to remediate PAHs, BTEX, and chlorinated VOCs. Ozone can oxidize organic contaminants in two ways, either with direct oxidation by ozone or by the generation of free radical intermediates. The hydroxyl radicals are non selective oxidizers, which rapidly attack organic contaminants and break down their carbon-to-carbon bonds. Ozone can oxidize compounds such as aromatics and chlorinated alkenes. Ozone must be generated on site, and this eliminates the storage and handling problems associated with other oxidants. Typical application ratios for ozone range from 1 to 10 lb of ozone per 1 lb of contaminant. Given the proximity to residential and commercial uses as well as an adjoining creek, generation, and handling of ozone for this application is undesirable.

RegenOx™ RegenOx™ is a proprietary in-situ chemical oxidation process using a solid oxidant complex (sodium percarbonate/catalytic formulation) and an activator complex (a composition of ferrous salt embedded in a micro-scale catalyst gel). RegenOx™ with its catalytic system has very high activity, capable of treating a very broad range of soil and groundwater contaminants including both petroleum hydrocarbons and chlorinated solvents. Additionally, RegenOx™ has significant longevity in the subsurface allowing for both the initial contaminant degradation and the continued treatment of contaminants desorbing from the matrix. Most importantly, RegenOx, when handled appropriately, is safe and easy to apply to the contaminated subsurface without the health and safety concerns and lingering environmental issues that have become associated with other chemical oxidation technologies.

RegenOx™ can be added to excavations and soil piles using soil blending equipment. Once in contact with contaminated soil, RegenOx™ produces an effective oxidation reaction, comparable to that of Fenton's Reagent, without a violent exothermic hazard. The most aggressive approach using chemical oxidation is to maximize contact between RegenOx™ and the contaminated soil.

Due to its ready availability, relatively low cost, effectiveness, safety and use for difficult applications, the use of RegenOx™ is deemed suitable for this IRM.

Health and Safety Issues

Hydrogen peroxide and potassium permanganate are relatively safe chemicals with respect to toxicity. However, the typical dangers associated with the handling of any oxidizing chemical are present with these chemicals. Skin contact with oxidizing chemicals should be avoided, and special care should be taken to avoid breathing the chemicals in the form of a dust or mist. Also, oxidizing chemicals should never be directly mixed with combustible materials or reducing agents. Oxidizing chemicals will not only react violently with combustible materials, but they may also release oxygen gas during decomposition that could help fuel a fire. In addition, some oxidizing agents are incompatible. For example, potassium permanganate should never be mixed with hydrogen peroxide because the peroxide readily donates electrons to the permanganate ion, creating an immediate and violent reaction. The primary toxicity risk associated with oxidizing chemicals is through direct inhalation of the chemicals. Inhalation of hydrogen peroxide mist or potassium permanganate dust can irritate the respiratory tract. Inhalation of large quantities of permanganate dust can result in pulmonary edema, which could develop several hours to several days after the exposure. Severe inhalation exposure could potentially result in death from oxidation of the lung tissue. Since the above oxidizing chemicals are not volatile, inhalation of the chemicals should only occur if the chemicals are handled in a manner that would create airborne mist or dust. Workers should therefore handle the chemicals in a manner that minimizes the creation of mist or dust. Proper respiratory protection should always be worn when working directly with the chemical.

Once the chemicals are placed into the subsurface, exposure to the chemicals through inhalation pathways is very unlikely. Therefore, the threat of toxic exposure is primarily limited to those individuals working directly with the unreacted chemical. The life span of the above oxidizing chemicals is short after the chemicals are introduced into the subsurface for in situ oxidation. The life span of hydrogen peroxide may last from several hours up to several days before it is completely depleted. Potassium permanganate, on the other hand, may remain in the subsurface for several months, depending on the organic content and mineral composition of the soils. Once reacted, the threat of toxic exposure is eliminated since the byproducts of the reaction are considered safe and non-toxic.

As oxidizing chemicals, potassium permanganate and hydrogen peroxide are either potentially flammable or explosive when mixed with combustible chemicals. Oxidizing chemicals not only react violently with combustible materials, but they also release oxygen gas during decomposition, which could help fuel a fire or explosion. In addition, hydrogen peroxide can rapidly self-decompose when in contact with metals or combustible compounds at elevated temperatures. During decomposition, hydrogen peroxide releases heat and oxygen gas. The rate of hydrogen peroxide decomposition can be controlled by using low concentrations of peroxide (i.e., less than 11%). When higher concentrations of hydrogen peroxide are used, the exothermic breakdown of the peroxide generates heat and oxygen gas that tends to volatilize contaminants from the soil and/or groundwater. This rapid decomposition reaction could forseeably create an explosive condition if used for treatment of flammable or combustible compounds due to the resulting mixture of heat, oxygen and flammable compound.

Potassium permanganate is a more stable oxidizing agent than hydrogen peroxide, so the risks associated with rapid decomposition of the chemical are not as prevalent. However, fire or explosion risks still exist if an individual or contractor improperly mixes permanganate with combustible or flammable compounds. Examples of such incompatibility include a barn fire that occurred when a farmer mixed formaldehyde and potassium permanganate together for fumigation purposes. Since ozone is generated on site, handling and transportation concerns do not apply to its use. However, pure ozone is an explosive gas in addition to being an oxidizer. High concentrations of ozone (greater than 2 ppm) can cause irritation or damage to the eyes and respiratory tract. When used for in situ chemical oxidation, the ozone is typically mixed with air prior to injection, but nearly pure ozone may be present in the generating apparatus or build up in the enclosure containing the equipment. Therefore, adequate ventilation of this enclosure is necessary, and all ignition sources should be kept away from the equipment.

Potassium permanganate and hydrogen peroxide will cause burns to the skin, eyes, and mucous membranes upon contact. As with all oxidizing chemicals, the severity of the chemical reaction depends on the concentration of the oxidant in solution. The dangers of high-strength peroxide were illustrated earlier, but similar dangers may result from the use of high-strength permanganate solutions.

The solubility of potassium permanganate in water is typically limited to between 3% and 6% (depending on the temperature of the water). This lower concentration of permanganate will cause burns to the skin upon prolonged exposure. However, sodium permanganate has a much higher solubility and can therefore cause immediate and severe burns upon contact. ISOCs may have some adverse affects to native soil and groundwater conditions that may adversely affect other remedial applications. For instance, the oxidizers may inhibit some of the indigenous anaerobic bacteria in the soil that are capable of utilizing the contaminants as a source of energy. This effect may temporarily restrict natural degradation that may be occurring in the soils and groundwater.

Appropriate and Applicable Uses of the Technology

In situ chemical oxidation is useful for source area mass reduction and intercepting of plumes to remove mobile contaminants. Each oxidant chemical is effective for different contaminants. The appropriateness of ISOC technology at a site also depends on matching the oxidant and delivery system to the site contaminants and site conditions. For example, permanganate is not effective against BTEX while peroxide and ozone are. This requires careful site characterization and screening. For instance, oxidation is dependent on achieving adequate contact between oxidants and contaminants. Failure to account for subsurface heterogeneities or preferential flow paths can result in extensive pockets of untreated contaminants. The applied reagents could also be consumed by natural organic matter or dissolved iron (rather than the contaminants), thereby compromising the remediation effectiveness. In summary, the most critical success factors are:

1. Effectiveness of, and ability to control, the ISOC reaction with the contaminants, and
2. Effective delivery of the reagents to the zone to be treated.

Important advantages of ISOCs include its relatively low cost and speed of reaction; however, the design must account for the hazards of the chemicals and potential for vigorous uncontrolled reactions ions in the subsurface that may occur with Fenton's reagent. Volatile compounds may be released by even moderate changes in temperature. There could be a significant change in both the concentration and distribution of flammable vapors and/or toxic non-flammable vapors when using an in situ chemical oxidation method. This dynamic environment is less predictable than most other cleanup situations, where less powerful remediation methods are unable to drive the cleanup by greatly changing a site's established equilibrium of contaminants that are distributed amongst the vapor, liquid, and adsorbed phases.

For chlorinated hydrocarbon remediation via chemical oxidation methods, the risk of a fire is reduced since those compounds are less flammable than BTEX. However, caution should be exercised in order to prevent the release or migration of quantities and concentrations of chlorinated vapors that may be harmful from a toxicological or environmental standpoint. Design and implementation considerations related to safety may include (1) venting or negative pressure system with ozone or Fenton's reagent to accommodate off-gasses and relieve pressure and build up of organics, especially if the ground surface is paved and (2) utility surveys to account for the effect of underground piping, utilities, or trenches on preferential pathways and/or pockets for organic decomposition, explosive liquids and vapors, and oxygen.

4.3 Selected ISOC Remedy - RegenOx™

Due to its ready availability, ease of use, mixing with water to reduce worker exposure, relatively low cost, effectiveness, and overall safety and, the use of RegenOx™ is selected for this IRM.

For RegenOx™ parameters such as pH (optimum at 6-9); moisture content (optimum 70 to 95% field capacity); Particle-size distribution (optimum soil void volume >25%); Total Oxidant Demand (TOD) of 9g/kg is assumed when estimating oxidant loading. Total organic carbon (TOC) and COD need to be identified prior to implementation. If the initial values for pH, TOC, COD, and moisture are not within the optimal criteria, the overall reactions will be slower or less effective.

Typically for a chlorinated VOC contaminated site the amount of RegenOx™ oxidant used can be calculated from the stoichiometry of the average concentrations. After excavation, remaining PCE concentrations will still be very elevated in the areas of the former hot spots and significantly lesser in other areas. These concentrations will range from a high of 3,000 mg/kg to less than several hundred micrograms per kilograms (ug/kg). Therefore, BEI will utilize 10lbs per cubic yard of RegenOx for treatment of this area.

Given the size of the anticipated excavation and the degree of remaining contamination, it is anticipated that about 750 pounds of RegenOx (375 pounds each of oxidant and activator) will be required. The RegenOx will be mixed with water in a 8% solution for in-situ mixing and a 2.68% solution for injection (see Section 4.5). After the use of the RegenOx, down gradient monitoring wells installed (see Section 3.8.5) will be monitored for changes in temperature, pH and conductivity, in order to ensure that the RegenOx reaction with any residual saturated soil impacts do not occur too quickly and that the RegenOx solution does not migrate significantly beyond the intended treatment area. Appendix A to this work plan contains a remediation program designed by Regenesis, a Product Information Sheet, case studies for PCE, a RegenOx Product Manual and MSDS forms for both components of the RegenOx compound.

4.4 Post Injection Monitoring

In order to monitor the implementation of the ISOC into the soil excavation area conditions, the following activities will be conducted:

In order to ensure that the reaction rate is not too fast, background temperature readings will be collected from the newly installed down gradient monitoring wells (see Figure 5A). During the application, temperature readings will be taken from the three wells. If temperature increases of 5°C or more are observed over the background conditions, the application and mixing will be discontinued until the temperature returns to background or near background conditions.

Prior to use of the RegenOx solution, background pH and conductivity readings will be collected from the monitoring wells. Based upon the product manual provided by Regenesis, the RegenOx solution has alkaline (elevated pH) properties and can potentially raise the pH and conductivity of the groundwater when being injected. In order to monitor the RegenOx solution and to ensure that the solution remains in the intended treatment area, the pH and conductivity levels will be periodically evaluated in the monitoring wells during the application process. If the readings from the monitoring wells become elevated above the background readings, the application rate will be decreased and/or modified to assist in keeping the solution in the intended treatment area. Based upon the product manual and discussions with Regenesis personnel, as the RegenOx solution chemical reaction progresses to completion, the solution returns to a neutral Ph.

In order to perform follow-up evaluation of the RegenOx application, the following activities are proposed:

- The initial post application evaluation of temperature, pH and conductivity of the on-site monitoring wells will take place 24-hours after treatment;
- The secondary evaluation of temperature, pH and conductivity of the on-site monitoring wells will take place one week after the RegenOx application; and
- The third evaluation of temperature, pH and conductivity of the on-site monitoring wells will take place two weeks after the RegenOx application.

Depending upon results observed above, the following post-use inspections will be performed:

- Follow-up sampling of the monitoring wells. Groundwater samples from the monitoring wells will be collected after the completion of excavation and at six (6) weeks after the application of the RegenOx solution. The follow-up sampling will consist of the following:
    - Synoptic rounds of water levels to determine groundwater flow direction and purge volume for each well;
    - Purge three well volumes from each of the on-site monitoring wells and collection of field parameters including temperature, pH and conductivity.
    - Collect groundwater samples and deliver to NYSDOH certified lab for analysis of Volatile Organic Compounds by EPA Method 8260.

4.5 Injection of RegenOx at Other Areas

The other two main locations of shallow PCE soil contamination are the dumpster area and the rear of the building, exterior to the door and exhaust vents. These areas have also been delineated as source areas yielding groundwater contamination. Therefore, the application of RegenOx in these areas constitutes the remainder of the IRM. The RegenOx will be applied through the injection of same within proposed two-inch injection wells. The following are the areas of treatment and the number of proposed injection wells.

- Dumpster area - 30 feet long by 18 feet wide (4 wells); and
- Rear of building - 24 feet long by 18 feet wide (4 wells);

Injections would be applied through 2-inch diameter 0.20 slot screen set into the upper four feet of groundwater via the Geoprobe direct push drilling system. The application of RegenOx will be pumped into the well to enhance the area of influence. It is anticipated that a minimum of 500 pounds of RegenOx (250 pounds each of oxidant and activator) will be required. The RegenOx will be mixed with water in a 2.68% solution. After the use of the RegenOx, existing and newer proposed (see Figure 10) down gradient monitoring wells will be monitored for changes in temperature, pH and conductivity, in order to ensure that the RegenOx reaction with any residual saturated soil impacts do not occur too quickly and that the RegenOx solution does not migrate significantly beyond the intended treatment area. In order to monitor these conditions, the following activities will be conducted in similar pattern to the monitoring performed at the excavation area:

- In order to ensure that the reaction rate is not too fast, background temperature readings will be collected from the monitoring wells. If temperature increases of 5°C or more are observed over the background conditions, the application and mixing will be discontinued until the temperature returns to background or near background conditions.
- Prior to use of the RegenOx solution, background pH and conductivity readings will be collected from the monitoring wells.

In order to perform follow-up evaluation of the RegenOx injections, the following activities are proposed:

- The initial post application evaluation of temperature, pH and conductivity of the on-site monitoring wells will take place 24-hours after treatment;
- The secondary evaluation of temperature, pH and conductivity of the on-site monitoring wells will take place one week after the RegenOx application; and
- The third evaluation of temperature, pH and conductivity of the on-site monitoring wells will take place two weeks after the RegenOx application.

Depending upon results observed above, the following post-use inspections will be performed:

- Follow-up sampling of the on-site monitoring wells. Groundwater samples from the monitoring wells will be collected six (6) weeks after the application of the RegenOx solution and three months following the initial post-use sample round.

5.0 HASP & ENGINEERING CONTROLS

The site specific Health and Safety Plan developed for the RI will be used for the IRM. The plan will be adhered to by all personnel involved in the IRM. Incorporated into the plan is a section on community health and safety with measures to ensure the public living and working near the site, including facility employees or visitors, are protected from exposure to site contaminants during intrusive activities or on-site treatment actions. This HASP is amended via the provisions established in this IRM.

The following provides a summary of the engineering controls which will be maintained during the conduct of the IRM field activities, as necessary.

Dust Monitoring/Suppression
Dust may be generated during the IRM. No dust will be generated during any sampling, soil borings and/or during the installation of monitoring wells. As necessary, especially during the IRM, fugitive dust levels will be monitored at several locations at the property in accordance with the project Community Air Monitoring Plan (CAMP) in order to protect on-site personnel and the surrounding community.

Fencing
During the IRM activities, fencing will be utilized to secure the three areas of concern from outside intrusions. The fence will be maintained as part of post-IRM activities.

TABLES

TABLE 1
Geologic and Chemical Data Needs

Data Needs For All ISCO Agents
Volatile Organic Compounds
Contaminant Mass Carbon Dioxide
Natural Organic Matter Oxygen
Chemical Oxygen Demand
pH of Soil and/or Groundwater
Hydraulic Conductivity
Soil Characterization
Groundwater Gradient
Vadose Zone Permeability
Oxidation Reduction Potential
Dissolved Oxygen in Groundwater Oxygen
Conductivity/Resistivity of Groundwater

Additional Data Needs For Fenton's Reagent
Lower Explosive Limit

Iron content of soil and/or groundwater
Alkalinity of Soil and/or Groundwater

Additional Data Needs For Ozone

Lower Explosive Limit
Carbon Dioxide

Alkalinity of Soil and/or Groundwater

Additional Data Needs For Permanganate
Soluble Manganese Concentration in Groundwater
Permanganate Impurities
Moisture Content of Vadose Zone

Chemical Oxygen Demand (COD). COD is an essential parameter to estimate chemical dosing for all oxidant technologies. COD value would incorporate the oxidation potential of media including oxidant demand imposed by NOM, iron, manganese, arsenic, carbon monoxide (CO), methane, and acetate and therefore is a useful indicator of oxidant demand.

pH of Soil and/or Groundwater. pH values are necessary to check suitability of an oxidant especially if the contaminated zone is altered by chemical addition to suit an oxidation technology. pH should be measured to establish baseline conditions.

Oxidation Reduction Potential (ORP) and Dissolved Oxygen (DO). ORP and DO of groundwater should be measured to assess applicability of an oxidant and to establish baseline conditions. This helps determine potential impacts on speciation and mobility of non-target metals (e.g., chromium).

United States
Environmental Protection
Agency

Solid Waste and
Emergency Response
(5303W)

EPA530-R-97-007
May 1997

Best Management Practices (BMPs) for Soils Treatment Technologies

Suggested Operational Guidelines to Prevent Cross-Media Transfer of Contaminants During Cleanup Activities

3.0 Chapter Three: CROSS-MEDIA TRANSFER CONTROL TECHNOLOGIES and MONITORING

This chapter provides descriptions of some of the technologies and practices that are available to control or treat releases that might create cross-media contamination during implementation of treatment technologies for soils and/or solid media. These control technologies should generally be applied under the following conditions:

- When potential for cross-media transfer exists associated with the use of a soil treatment technology as identified in Chapters 4 through 10 of this document.
- When recommended in the general best management practices (BMPs) section (Chapter 2) or technology-specific BMPs (Chapters 4 through 10).
- When a safe exposure level for workers is exceeded during cleanup activities, as determined by the Occupational Safety and Health Administration (OSHA), per 29 CFR part 1910.
- Any other site-specific reasons that warrant their application, such as proximity of a populated area or a drinking water source to the site.

3.1 Available Control Technologies

Information contained in this chapter is mostly provided in the following five tables:

Table 3-1. **Emissions Sources and Controls During Cleanup Activities.** This table lists potential emissions sources that may be encountered during cleanup activities such as containers, tanks, and landfills. It describes some common controls that can be used to reduce those emissions, and outlines factors that may contribute to the likelihood of emissions from those sources.

Table 3-2. **Technologies for Controlling Cross-Media Transfer of Contaminants During Materials Handling Activities.** This table lists materials handling activities that may be performed during site preparation and staging, as well as pre- and post-treatment, that have the potential to create cross-media contamination. It provides control technologies that can be used during those activities, and lists factors that may influence the effectiveness of those control technologies. Some of the controls listed in this table may be applicable to treatment activities which are discussed in the individual remediation technology chapters.

Table 3-3. **Technologies for Reducing Contaminant Concentrations in Air Emissions Generated During Remediation.** This table provides a list of control technologies that can be used to reduce the concentrations of air emissions. It describes each technology, and outlines factors that may influence the effectiveness of those control technologies.

Table 3-4. **Examples of Technologies for Controlling Cross-Media Transfer to Water**. This table provides a list of controls that should be considered during all remedial activities to minimize the potential for releases from soil to surface and/or ground water. The examples provided are for relatively small-scale structures that can be applied to short-term projects; for larger-scale and long-term projects, consult the Metropolitan Washington Council of Governments document cited in the references.

Table 3-5. **Examples of Field Monitoring Technologies.** This table provides a list of technologies or practices that can be used to monitor potential emissions during remediation activities. It describes the technologies that can be used to monitor emissions from active and inactive sites. These technologies can be applied prior to and during remediation, as needed. A few simple and easy-to-use monitoring techniques are also listed in this table.

Table 3-1. Emissions Sources and Controls During Cleanup Activities (USEPA, 1992a)

Emission Source	Description of Control Technology	Factors Affecting Emissions
Surface Impoundments	Air-Supported Structures are made of light materials (often plastics, vinyls, or coated fabrics) that form a roof-like structure over the impoundment. Fans are used to maintain positive pressure to inflate the structure. For effective control, the air vented from the structure should be sent to a control device such as a carbon adsorber. Air supported structures have been used as enclosures for conveyors, open top tanks, and storage piles, as well as impoundments. Floating Membrane Covers are used to cover large impoundments containing liquids. The membrane must provide a seal at the edge of the impoundment, and provisions must be made for the removal of rainwater that accumulates on the covers. Additionally, vent systems for the removal of accumulated gases and pumping systems for the removal of accumulated sludge may be necessary.	• Volatility of constituent • Residence time • Surface area • Turbulence • Windspeed • Temperature • Extent of competing mechanisms (e.g., biodegradation)
Tanks	Fixed Roofs can be retrofitted to open tanks, or a fixed-roof tank can be used to replace an open tank or impoundment. Compared to an open tank, a fixed roof tank can provide additional control of 86 to 99 percent. Floating Roofs are common on tanks at petroleum refineries. The roof floats on the liquid and moves with changes in the liquid level, controlling working losses. Floating roofs can be installed internally in a fixed-roof tank or externally in a tank without a fixed roof. Emissions from a properly maintained floating roof are very low.	• Volatility of constituent(s) • Surface area • Turbulence • Windspeed • Temperature

Table 3-1. Emissions Sources and Controls During Cleanup Activities (cont'd) (USEPA, 1992a)

Emission Source	Description of Control Technology	Factors Affecting Emissions
Dewatering Devices	Dewatering devices, such as rotary drums and presses, provide several opportunities for volatile organics to be emitted, such as when a press is opened to remove and transport accumulated sludge, or during pressing, when volatile liquids may leak from a press into a drip pan underneath. Emissions from dewatering devices can be controlled by building an enclosure around the unit and venting it to a control device (best used for presses or rotary devices), or by collecting volatile organics in a condenser above the volatile source, treating the waste, and discharging it as appropriate (best for thin-film evaporators). In addition, sludge fixation often generates volatiles during mixing, when agitation is provided while adding the fixative agent. Emissions during fixation can be controlled by installing covers or enclosures that are vented to a control device.	• Temperature • Surface area • Turbulence • Windspeed • Concentration • Volatility
Containers	Submerged Fill Piping has been shown to decrease emissions by 65 percent relative to splash filling. In submerged filling, an influent pipe is inserted below the existing liquid surface in the container. Liquid is introduced into liquid, rather than spilled on top of the liquid surface, which reduces splashing and the degree of saturation of the displaced vapors.	See Tanks
Landfills	Carbon Adsorption, Condensation, Absorption, or Vapor Combustion are traditionally used to capture and control emissions.	See Table 3-3 for descriptions of air control technologies

Table 3-2. Technologies for Controlling Cross-Media Transfer of Contaminants During Materials Handling Activities (USEPA, 1991)

Remedial Activity	Description of Control Technology	Factors Influencing Effectiveness
All	Operational Controls: Those procedures or practices inherent to most site remediation projects that can be instituted to reduce VOC and particulate matter emissions. You should, to the extent possible: ✓ Plan site remediation for times of year with relatively cooler temperatures and lower wind speeds to minimize volatilization and particulate matter emissions. ✓ Maintain lower speeds with all vehicles on unpaved roads. ✓ Control placement and shape of storage piles. Place piles in areas shielded from prevailing winds. Shape pile in a way that minimizes surface area exposed to wind. ✓ During excavation, use larger equipment to minimize surface area/volume ratio of material being excavated. ✓ During dumping, minimize soil drop height onto pile, and load/unload material on leeward side of pile. ✓ During transport, cover or enclose trucks transporting soils, increase freeboard requirements, and repair trucks exhibiting spillage due to leaks.	
Excavation	Covers and Physical Barriers: Physically isolate the contaminated media from the atmosphere. Include soils (topsoils or clays); organic solids such as mulch, wood chips, sawdust, or straw, typically anchored with a net; asphalt/concrete; gravel/slag with road carpet; synthetic covers (e.g., tarps). Some technologies best used in active areas, others in inactive areas; see USEPA 1992b for details.	Site characteristics (terrain, vegetation, nature of contaminated media) and needs for access
	Foam Coverings: "Blanket" the emitting source with foam, thus forming a physical barrier to emissions. Also insulate emitting source from wind and sun, further reducing particulate and volatile emissions. Several commercially available. Generally used in active areas.	Drainage rates, wind speed, precipitation, surface roughness, temperature, surface activity, contaminant characteristics

Table 3-2. Technologies for Controlling Cross-Media Transfer of Contaminants During Materials Handling Activities (cont'd)

(USEPA, 1991)

Remedial Activity	Description of Control Technology	Factors Influencing Effectiveness
	Wind Screens: Provide an area of reduced velocity that allows settling of large particles and reduces particle movement from exposed surfaces on leeward side of screen. Also reduce soil moisture loss due to wind, resulting in decreased VOC and particulate emissions.	Wind screen porosity, wind direction with respect to screen, wind screen height, soil silt content
	Slurry Cover Sprays: Spray soil piles/excavated areas with a thin layer composed of a fibrous slurried aggregate that hardens to form a protective layer (see Sec. 11.6.2 for an example of commercially available materials).	
Excavation (cont'd)	Water Sprays: Agglomerate small particles with larger particles or with water droplets. Also, water added to the soil cools the surface soil and decreases air-filled soil porosity, both of which reduce VOC emissions.	Application rate, application frequency, meteorological conditions, traffic rate
	Water Sprays with Additives: Common additives include hygroscopic salts, bitumens, adhesives and surfactants. Reduce emissions by adsorbing moisture from the air, thereby increasing the soil moisture content; agglomerate surface soil particles to form a surface crust; or reduce water surface tension, thereby increasing wetting capacity of the water.	
	Enclosures: Usually self-supported or air-supported structures; for soil storage piles, usually self-supported structures similar to the "beehive" used to store road salts. Provide a physical barrier between the emitting area and the atmosphere.	Potential for enclosure materials to react with contaminants
Transportation	Covers and Physical Barriers: Road carpets are water permeable polyester fabrics that are placed between the road bed and a coarse aggregate road ballast, such as gravel, across which vehicles travel. Creates a physical barrier between moving vehicles and source of emissions.	

Table 3-2. Technologies for Controlling Cross-Media Transfer of Contaminants During Materials Handling Activities (cont'd)

(USEPA, 1991)

Remedial Activity	Description of Control Technology	Factors Influencing Effectiveness
	Covers on Loads: Cover all loads being moved by truck, open piping, or other conveyance with tarps, roofs, or other structures that will eliminate or reduce the likelihood of particulate release into the atmosphere.	
	Water Sprays of Active Areas: See Excavation Dust Suppressants: See Excavation	
Dumping	Water Sprays: Water can be sprayed in a curtain-like fashion over the bed of a truck (or over any conveyance system, such as a moving belt) during dumping; see Excavation for details on how water sprays work Water Sprays with Additives: Used like water sprays (see above), with additional substances such as surfactants; see Excavation	
Preparation of Contaminated Media and Feeding Media into Remediation System	Covers and Physical Barriers. See Excavation Enclosures. See Excavation Collection Hoods: Commonly used in small areas (e.g., waste stabilization/solidification mixing silos, bioremediation reactors) and route those emissions to air pollution control devices. Capture emissions by creation of an air flow after the emitting source that is sufficient to remove the contaminated air.	Distance between hood and emissions source; volumetric flow rate into hood; surrounding air turbulence; hood design

FIGURES

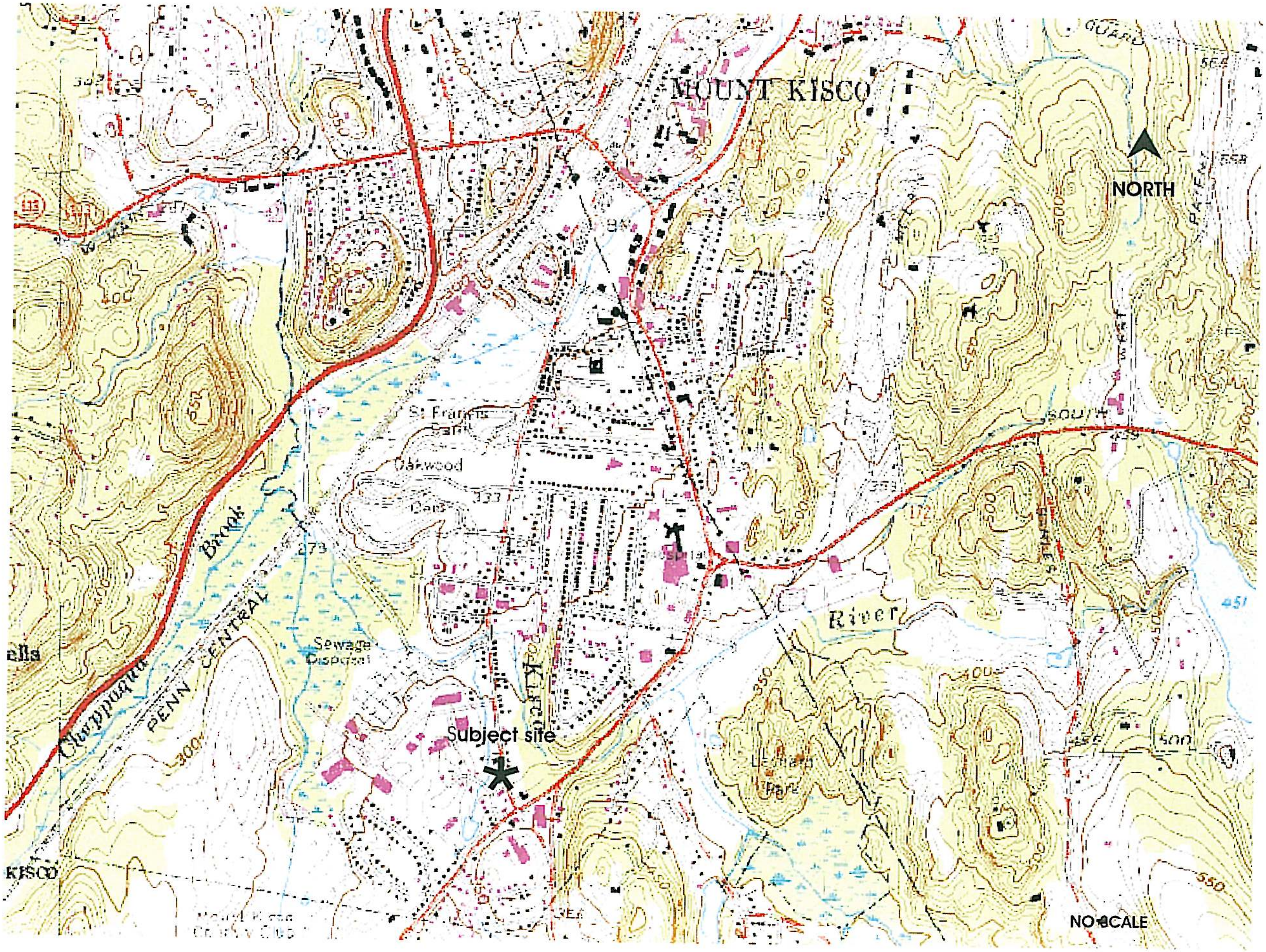

FIGURE 1 - SITE LOCATION AND TOPOGRAPHY

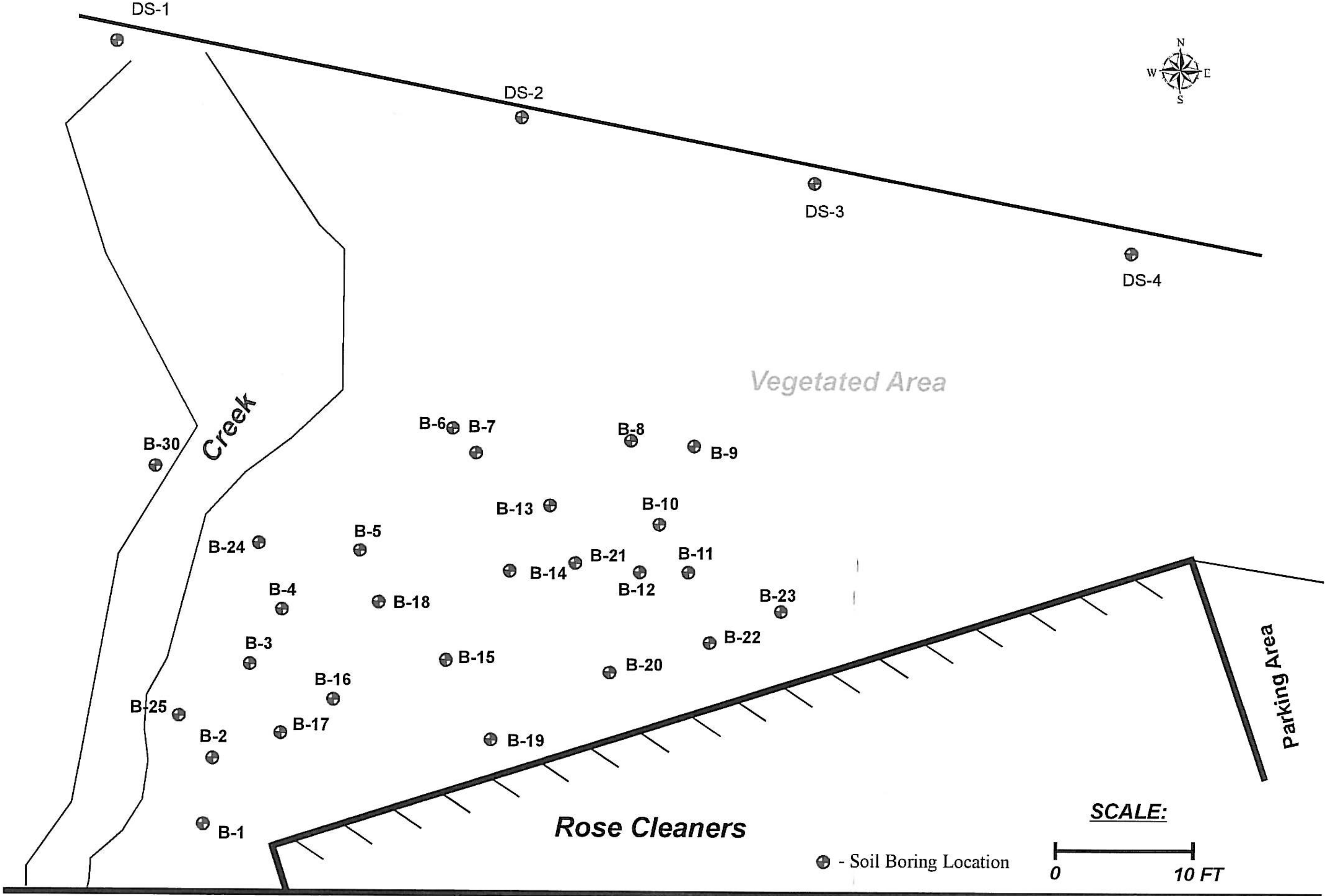

Figure 2- Soil Boring Locations
February 2008

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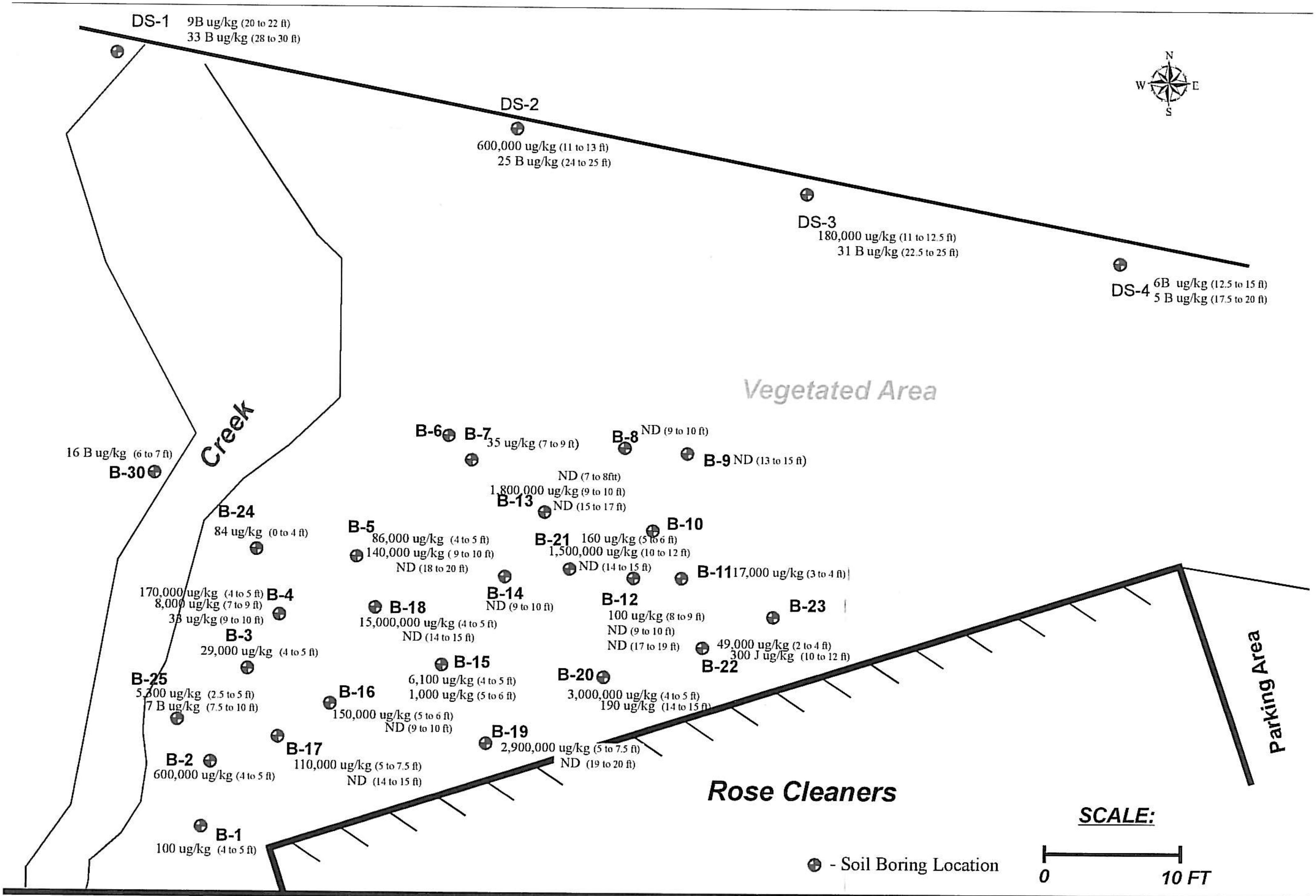

Figure - 3 - PCE Concentrations Detected in Soil Samples - February 2008

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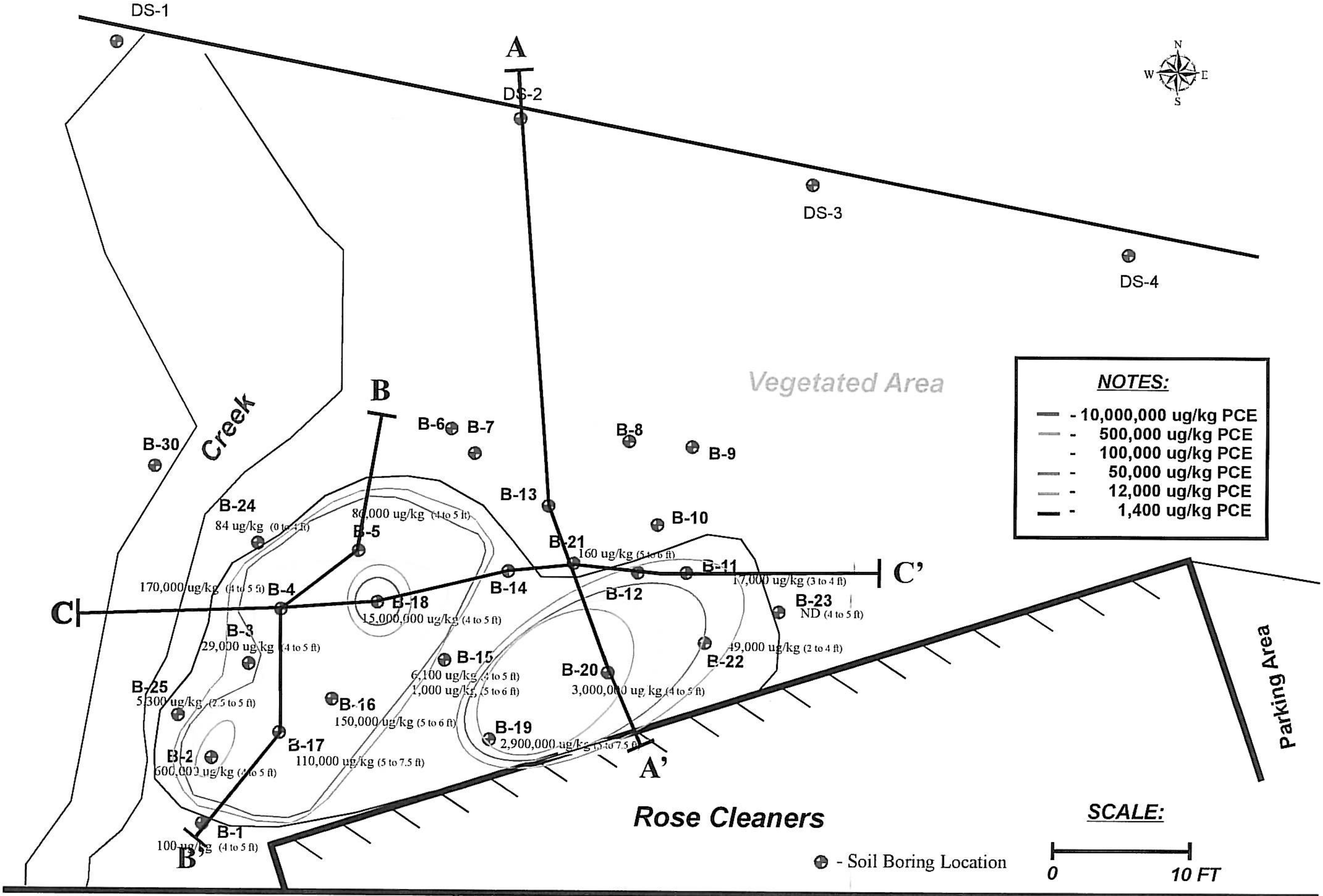

Figure - 4 - PCE Concentrations in Soil Samples from 0 to 6 ft bgs with isoconcentration contours

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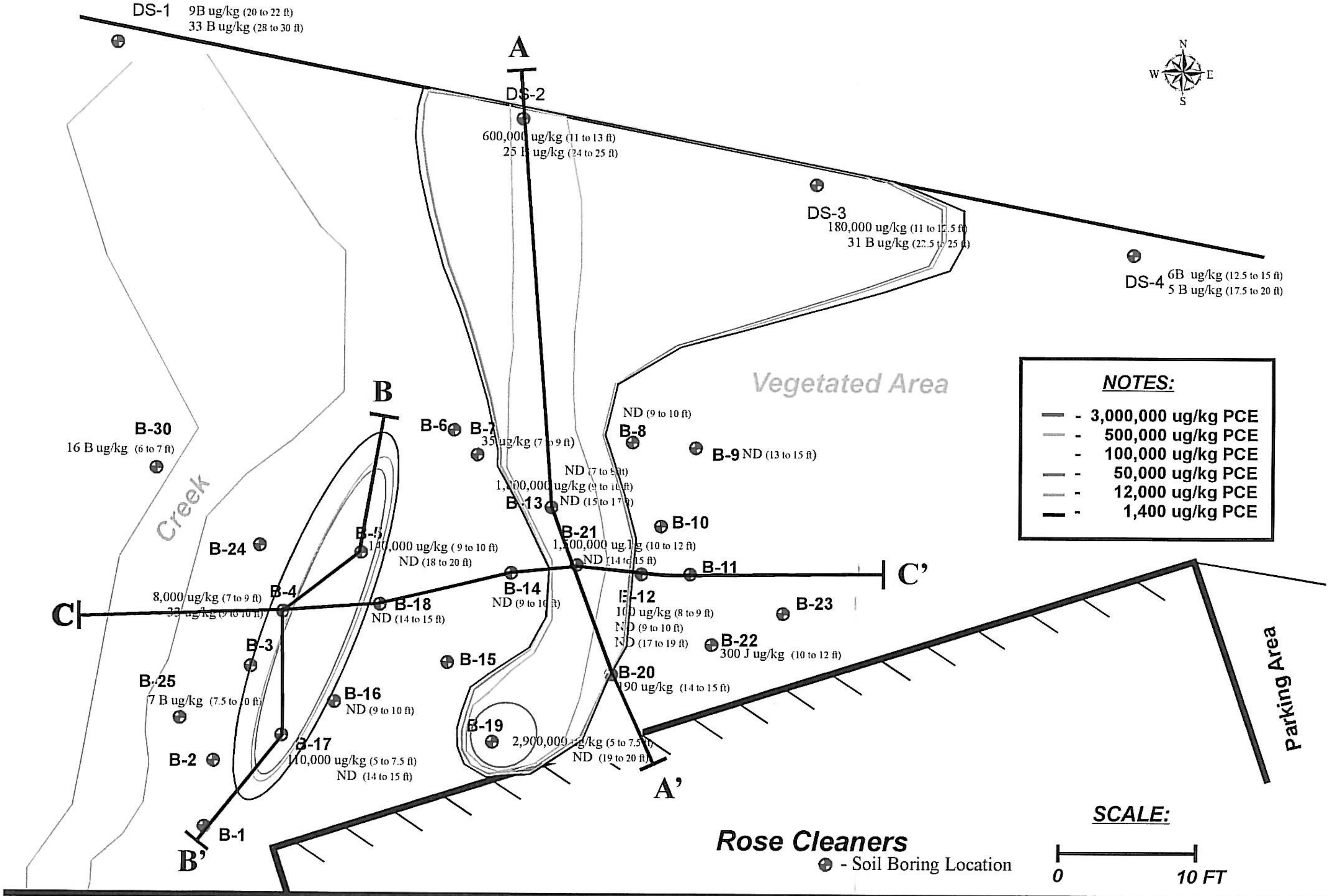

Figure - 5 - PCE Concentrations in Soil Samples from 7 to 30 ft bgs with isoconcentration contours

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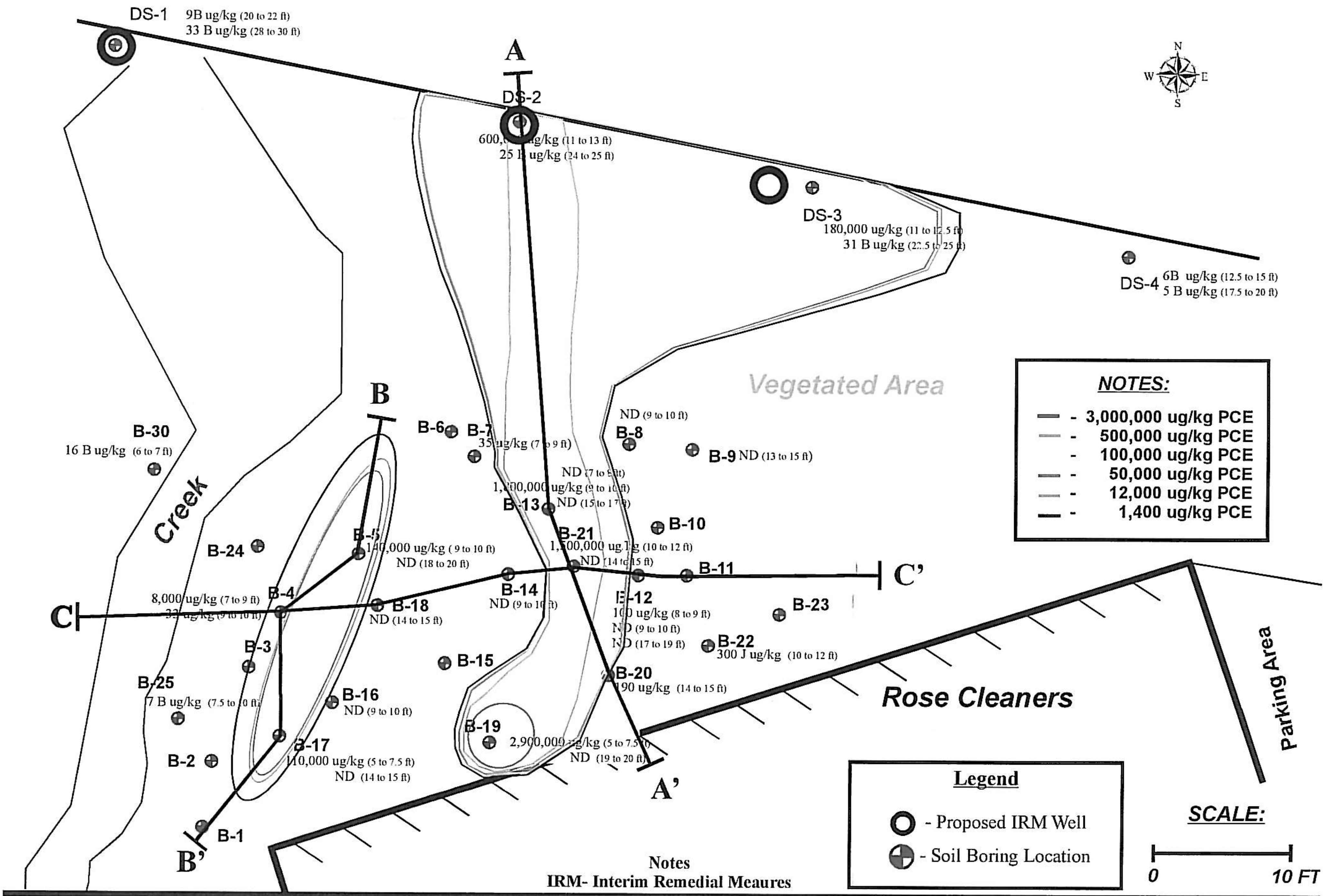

Figure - 5A - Plan view with lines of cross sections

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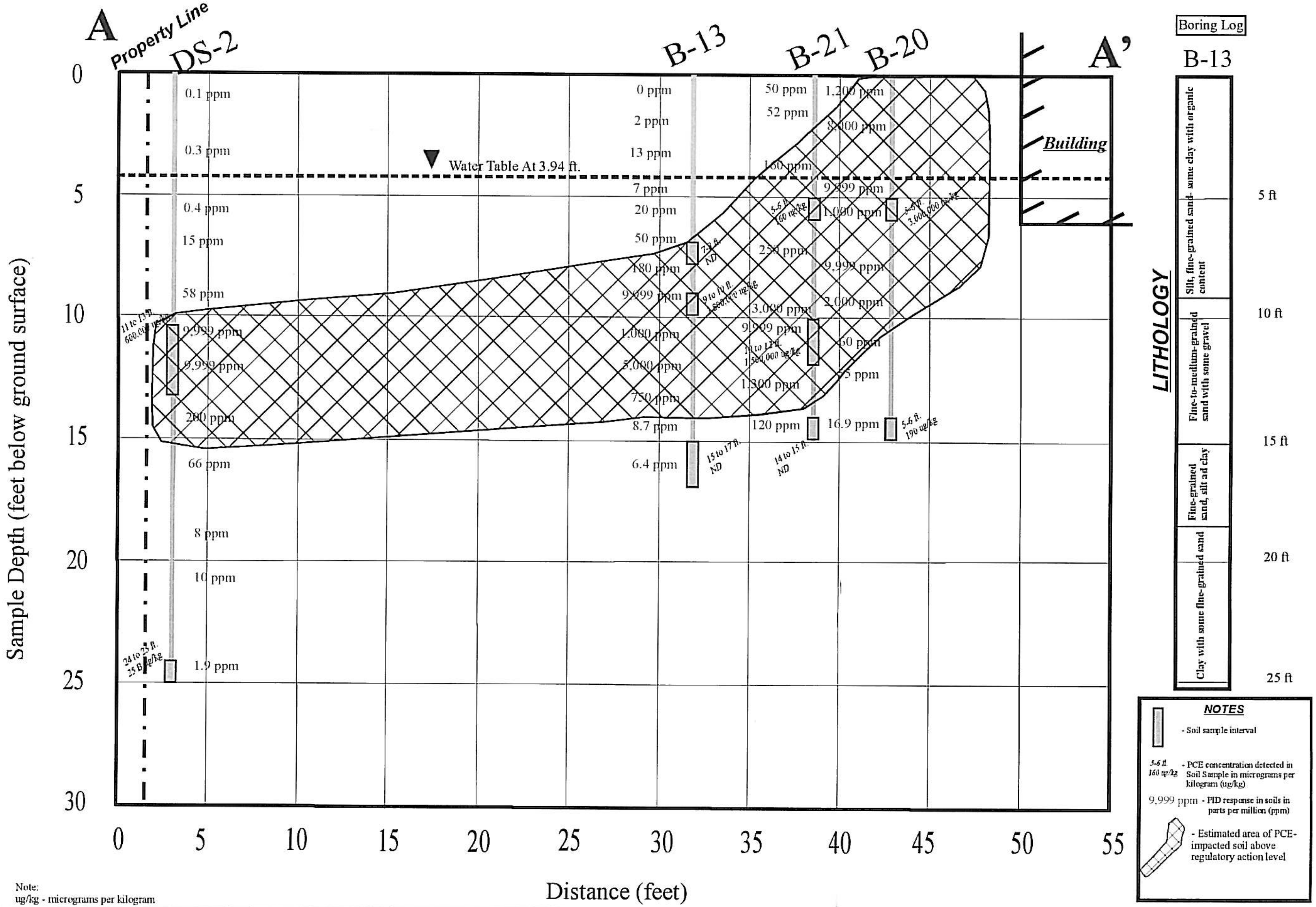

Note:
ug/kg - micrograms per kilogram

Figure 6 - North -South cross-section A to A' PCE concentrations (ug/kg) detected in samples

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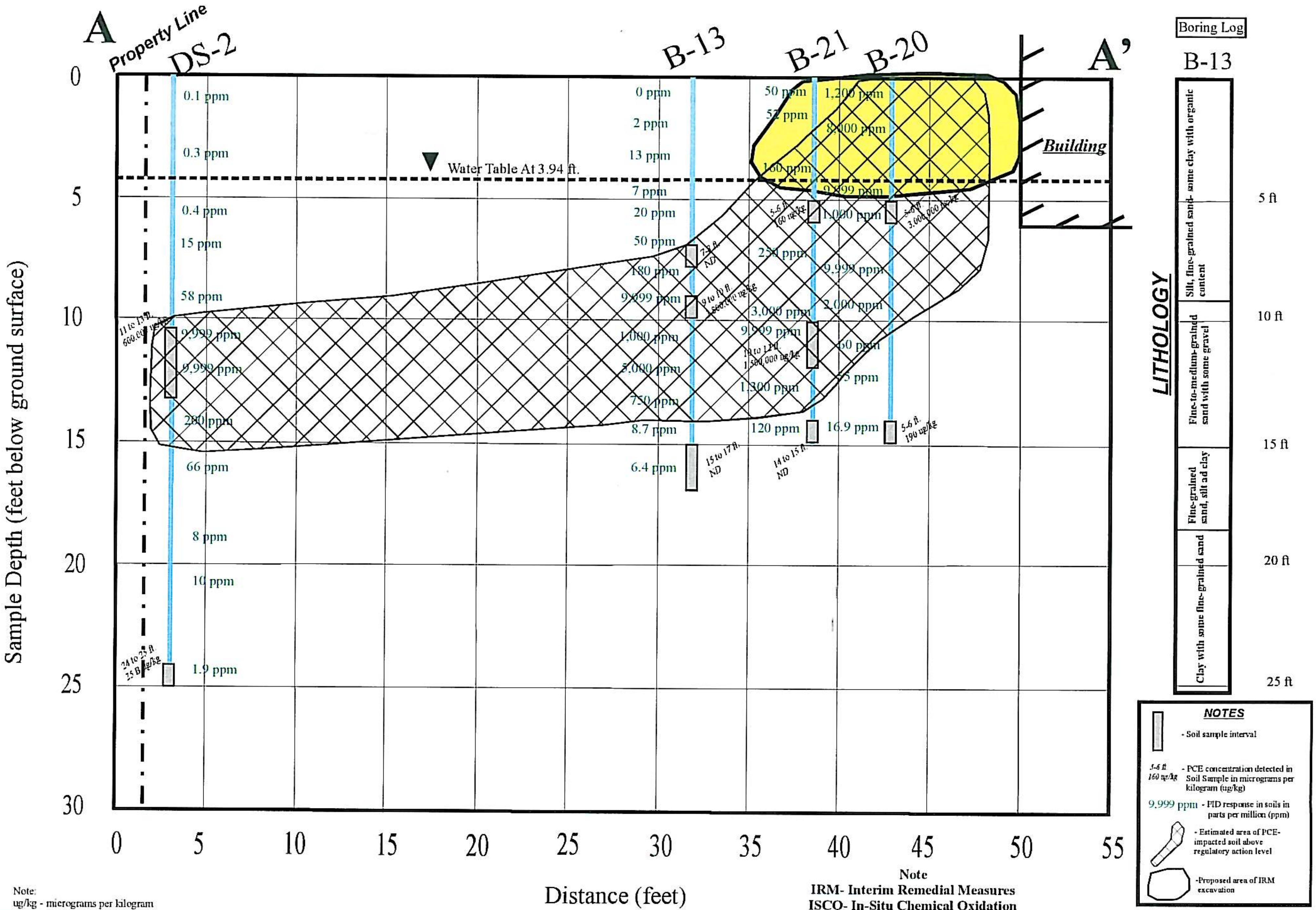

Note:
ug/kg - micrograms per kilogram

Note
IRM- Interim Remedial Measures
ISCO- In-Situ Chemical Oxidation

Figure 6A - North -South Cross-section A to A' Delineation of PCE Concentrations and IRM Excavation Area

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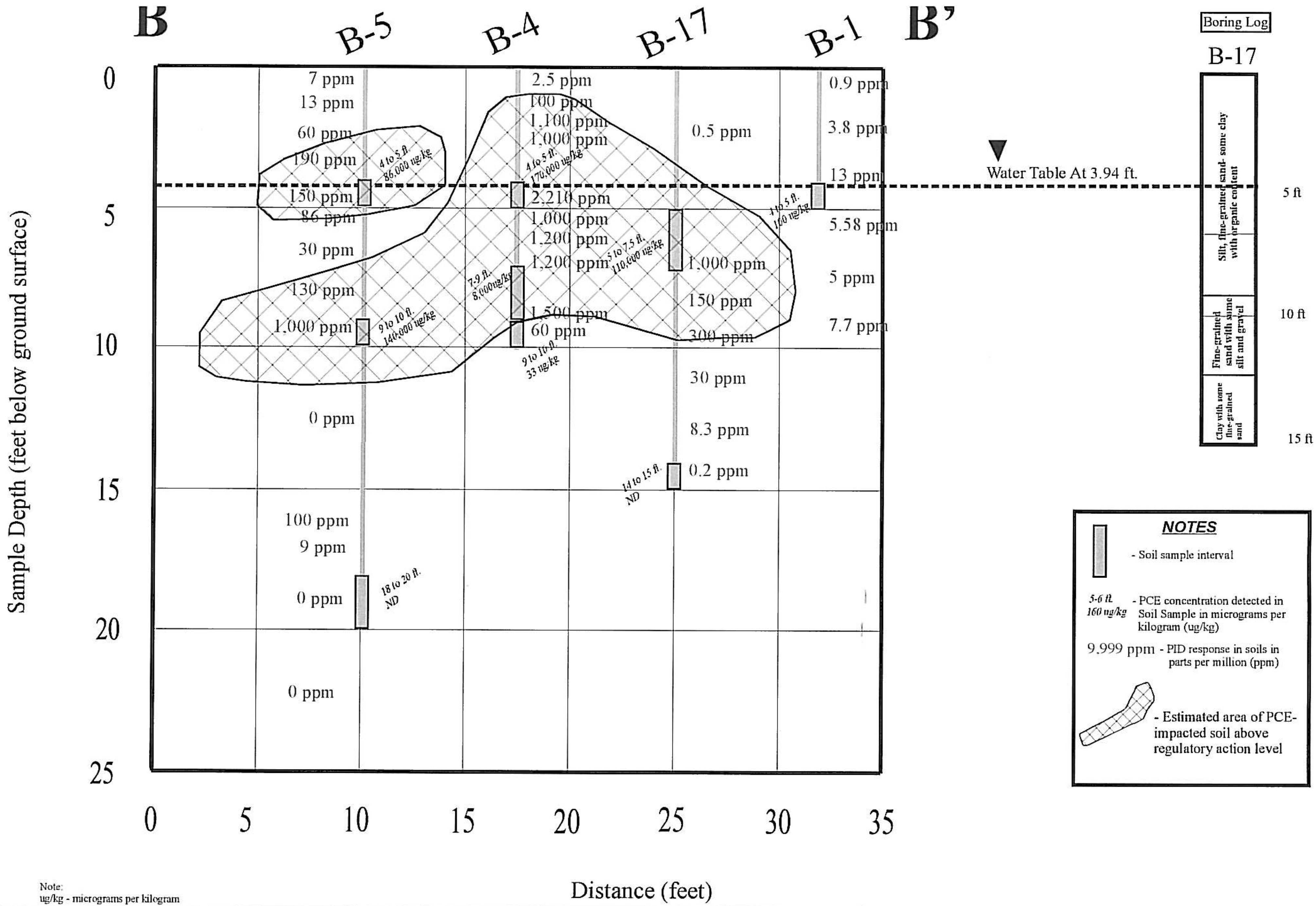

Note:
ug/kg - micrograms per kilogram

Figure 7 - North -South cross-section B to B' PCE concentrations (ug/kg) detected in samples.

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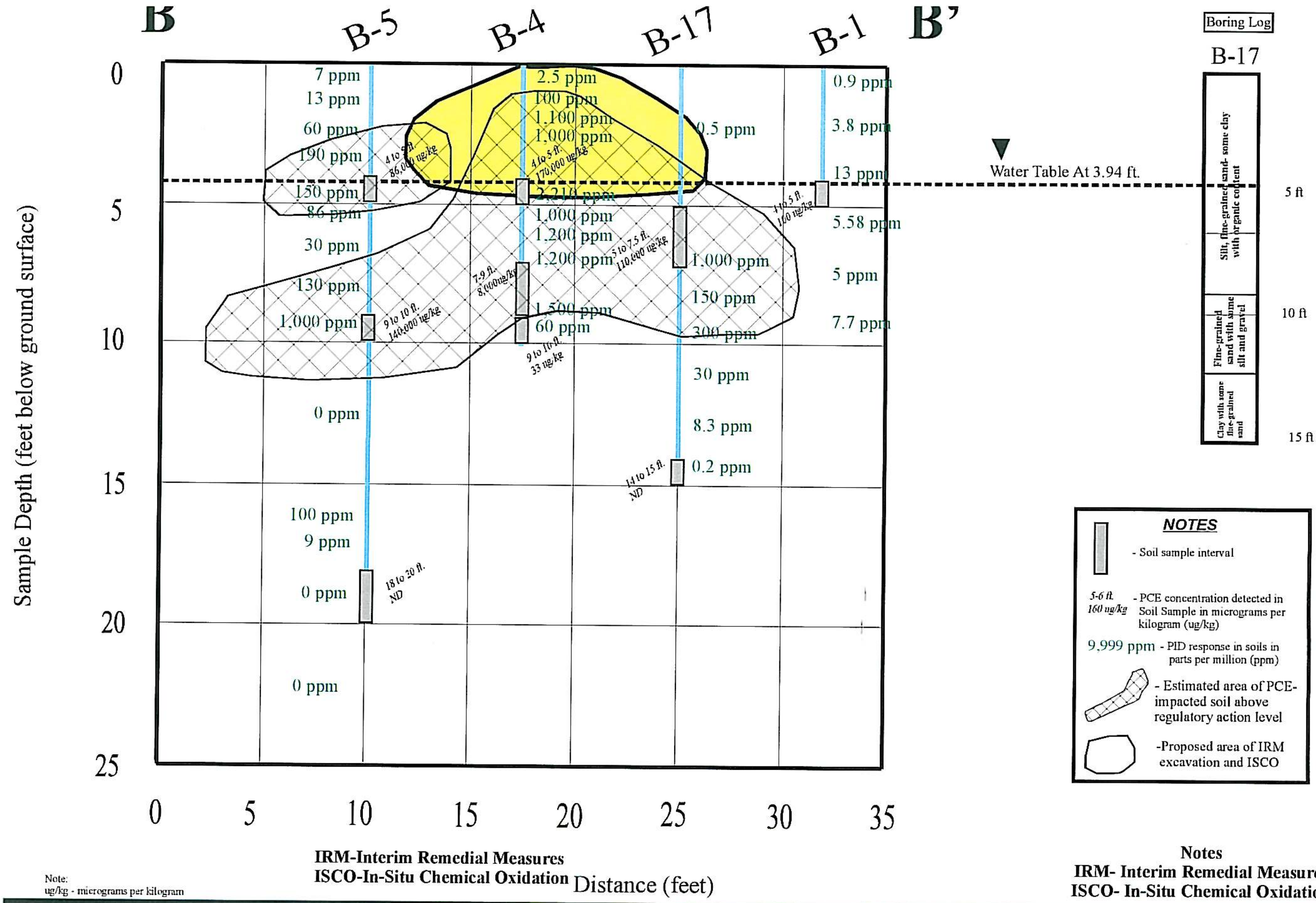

IRM-Interim Remedial Measures
ISCO-In-Situ Chemical Oxidation

Note:
ug/kg - micrograms per kilogram

Notes
IRM- Interim Remedial Measures
ISCO- In-Situ Chemical Oxidation

Figure 7A - North -South Cross-section B to B'
Delineation of PCE concentrations
and IRM excavation

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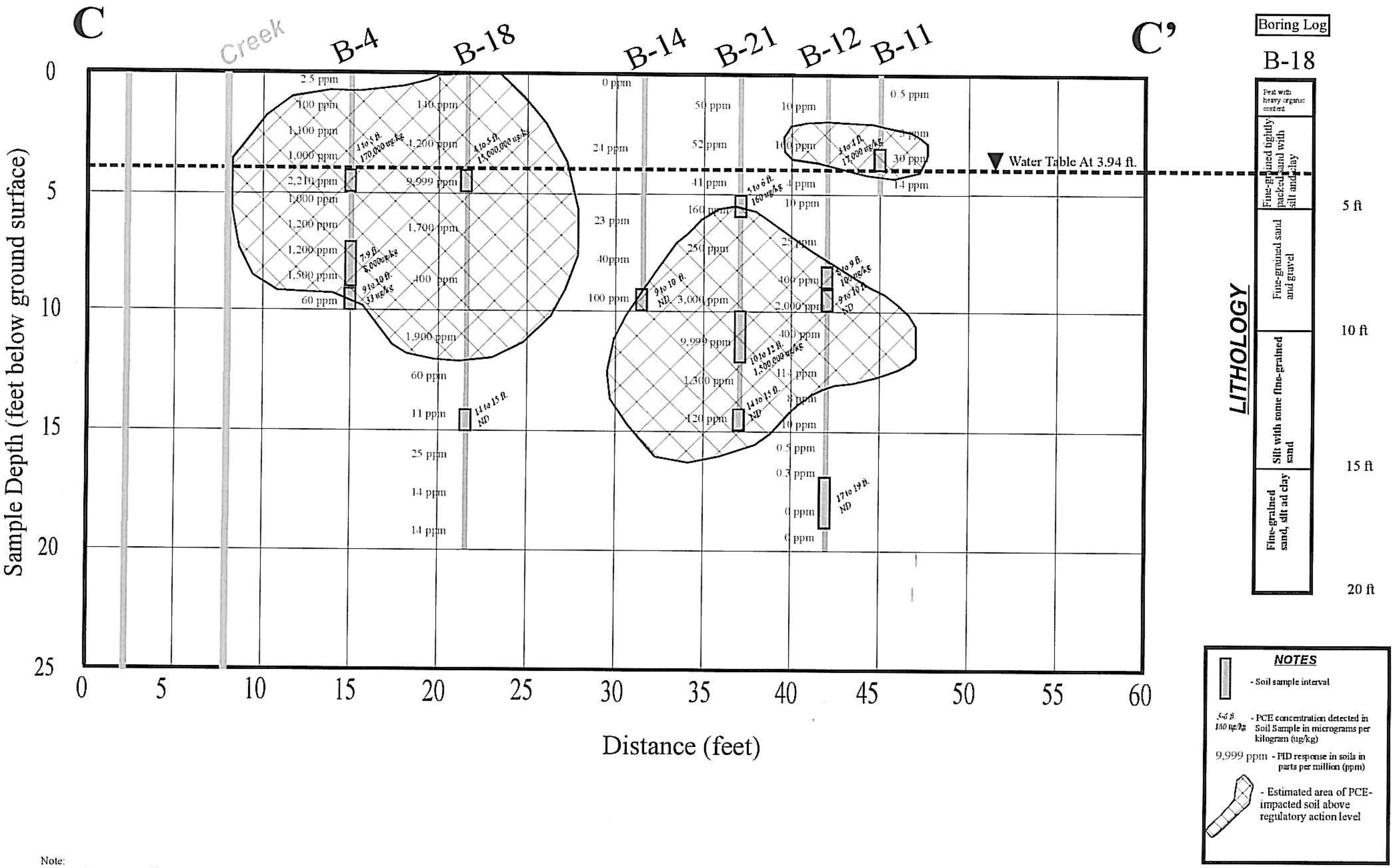

Note:
ug/kg - micrograms per kilogram

Figure 8 - West to East Cross-section C to C'
Delineation of PCE concentrations

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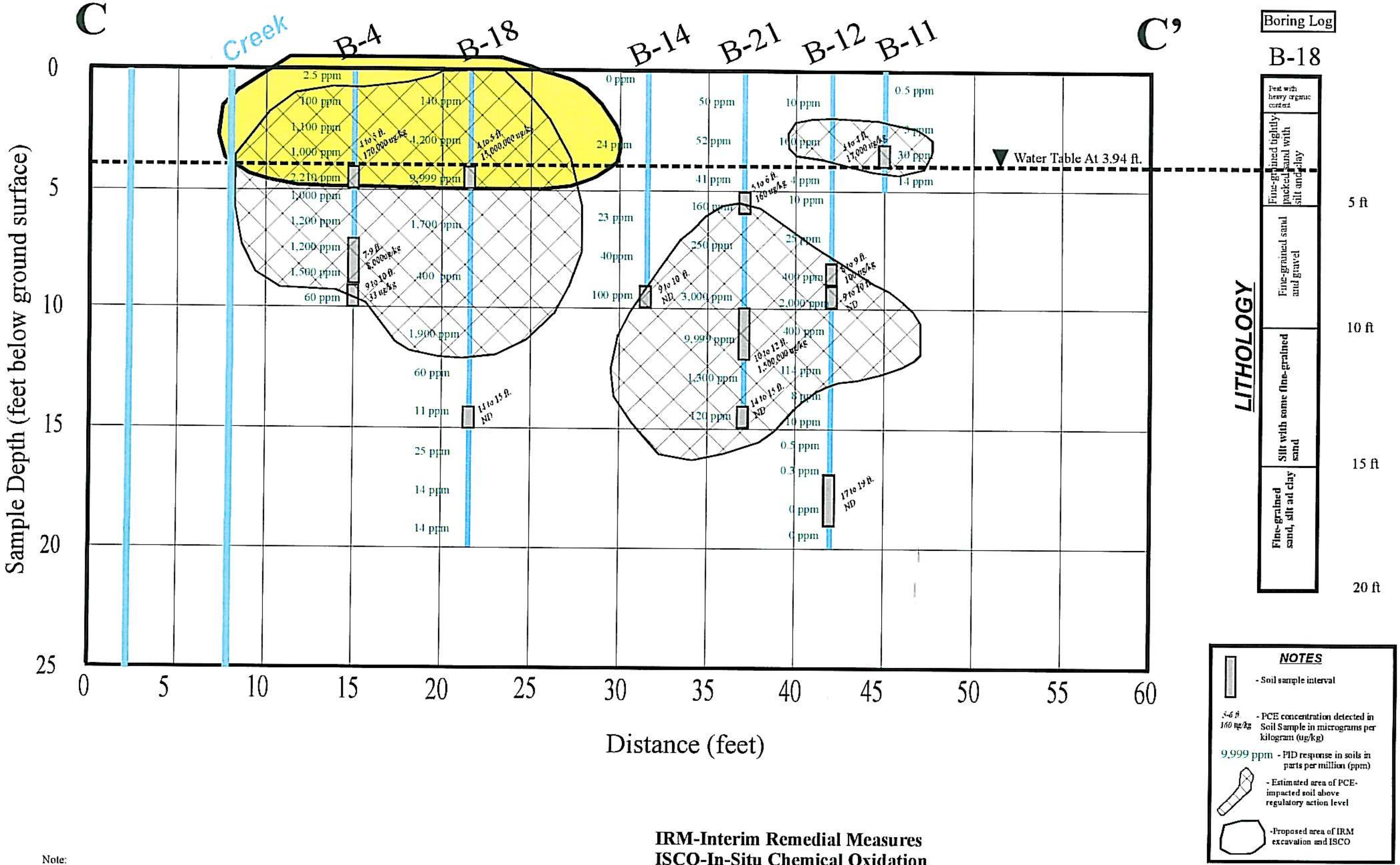

IRM-Interim Remedial Measures
ISCO-In-Situ Chemical Oxidation

Note:
ug/kg - micrograms per kilogram

Figure 8A - West to East Cross-section C to C'
Delineation of PCE concentrations
and IRM excavation

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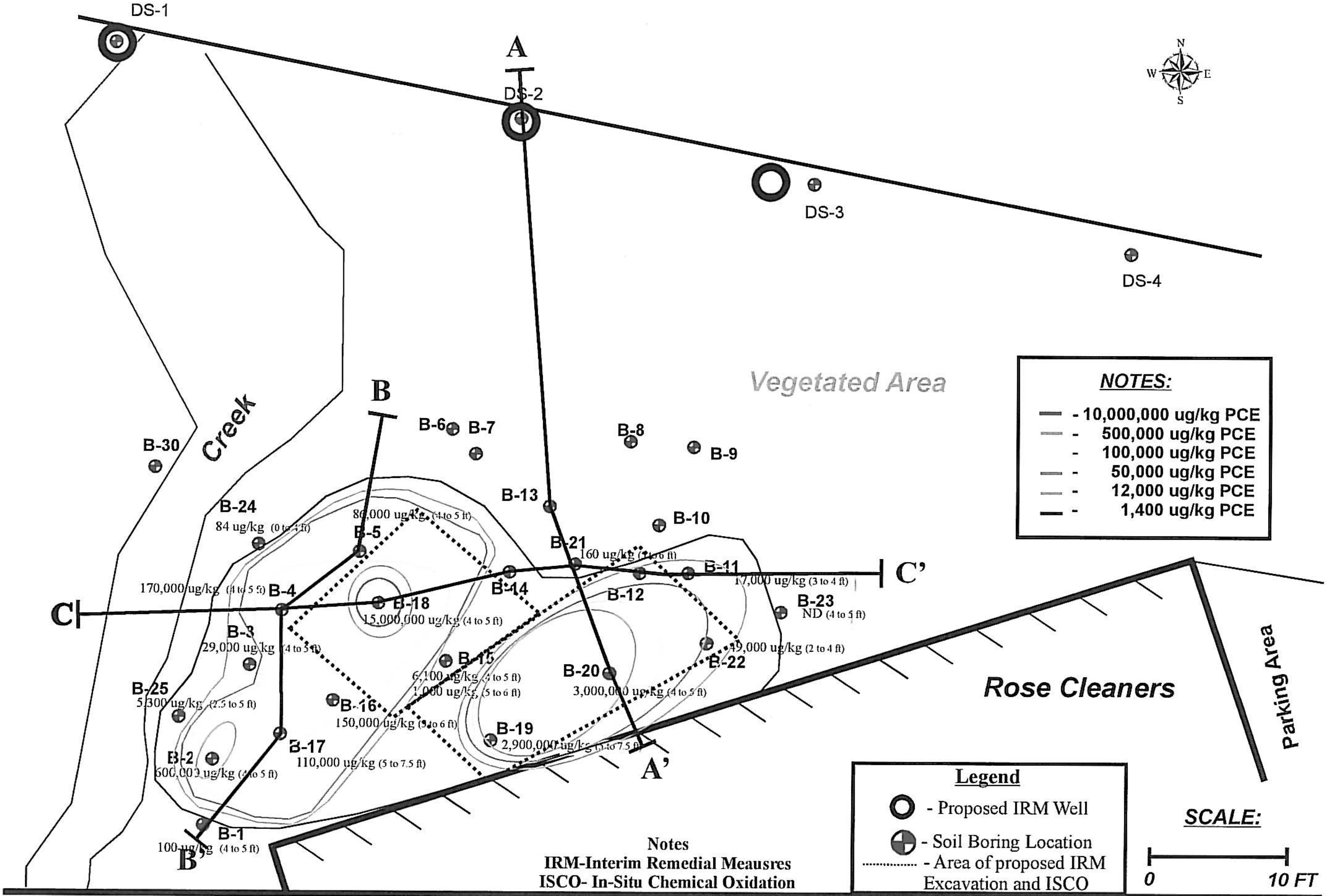

Figure - 9- Proposed IRM Monitoring Well Locations and area of IRM excavation and ISCO

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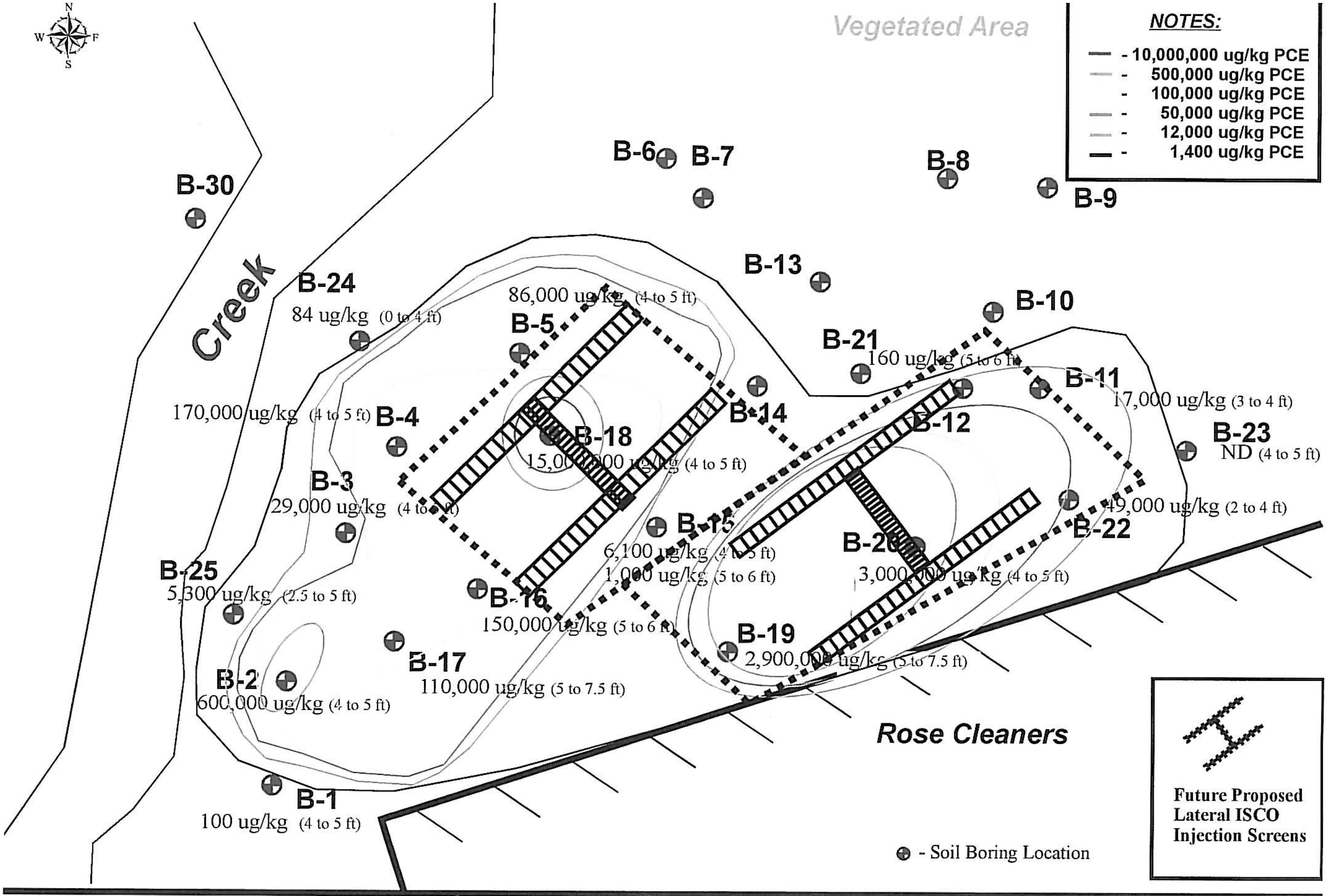

Figure - 10 - Locations of Future Proposed Lateral Injection Screens within IRM Excavation Area

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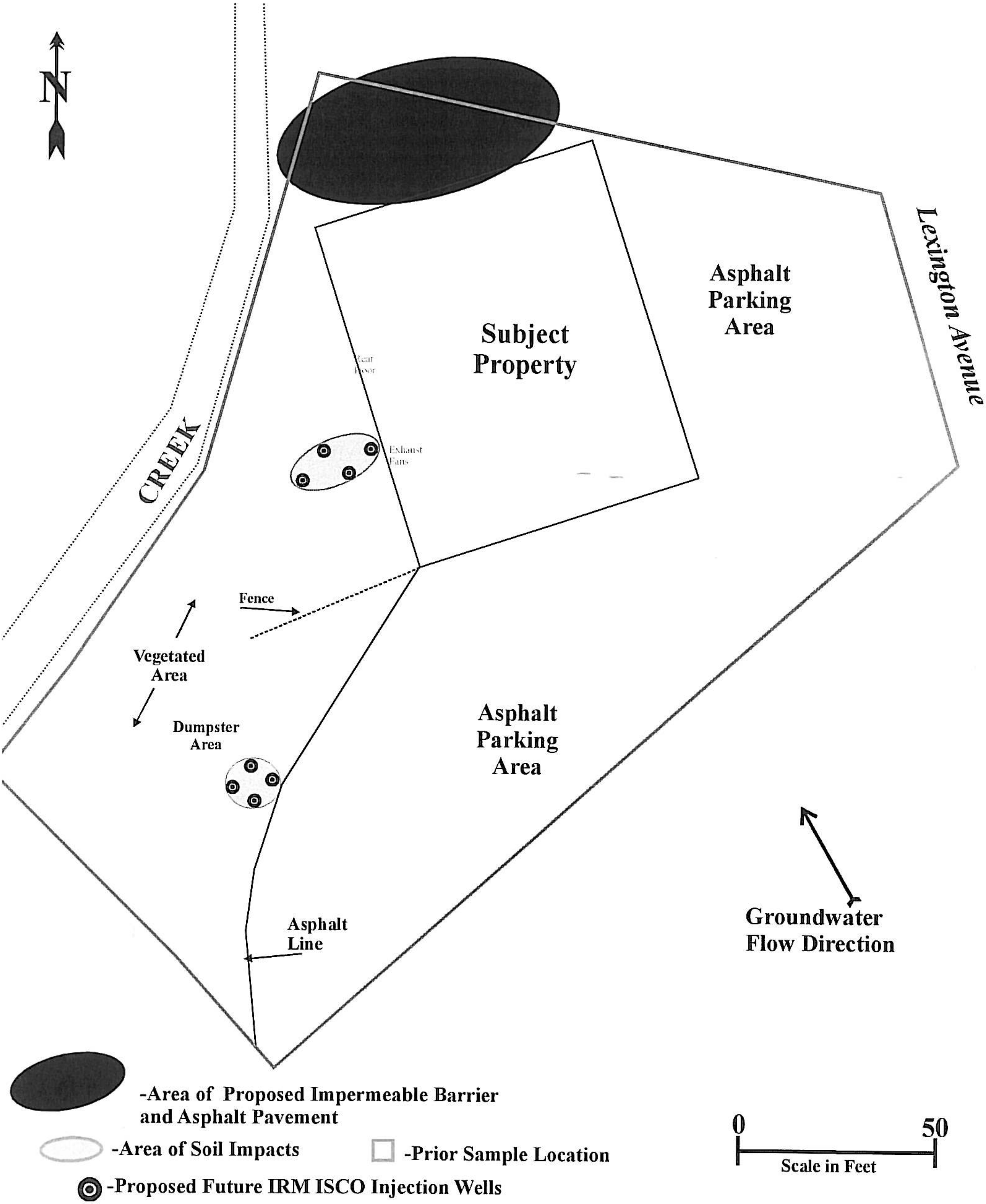


Figure 11- Proposed ISCO Injection Wells & Impermeable Barrier - North Area	Rose Cleaners 500 Lexington Avenue Mt. Kisco, New York	BEi Berninger Environmental Inc. groundwater consultants and geologists 90 B Knickerbocker Avenue Phone # (631) 589-6521 Bohemia, New York 11716 Fax # (631) 589-6528

APPENDICES

RegenOx™

Advanced Chemical Oxidation

Contaminated Soils Treatment via Ex-Situ and In-Situ Mixing Methods

The treatment of contaminated soils by chemical oxidation processes can offer significant cost savings when compared to other treatment alternatives such as incineration or excavation and disposal. While often more expensive than biological soil treatment techniques such as landfarming, *in situ* and *ex situ* chemical oxidation techniques offer the advantage of expediency, which is often favored in today's real estate transaction-driven remediation market.

Advantages and Disadvantages of Chemical Treatment

Successful use of chemical oxidation technology to treat soils on site is generally accomplished by either the in-place mixing the soils with a chemical oxidant (*in situ* treatment) or by excavating the soil and mixing the chemical oxidant with the soils in above ground vessels (*ex situ* treatment).
The advantages of chemical oxidation employing ex-situ and in-situ soil mixing are:

1. Ensures direct and immediate contact with chemical oxidant;
2. Undergoes rapid oxidation reactions;
3. Eliminates uncertainties of subsurface geology and hydrogeology;
4. Minimizes liability as compared to off-site disposal.

The disadvantages of chemical oxidation employing ex-situ and in-situ soil mixing are:

1. Not all contaminants are degraded quickly and/or completely;
2. Predicting final treatment concentrations from bench-scale studies are often difficult;
3. *In situ* treatment via soil mixing may be limited by subsurface structures; and
4. *Ex situ* treatment may require significant on-site area.

Mechanisms of In-situ and Ex-situ Soil Mixing

Treatment of contaminated soils with chemical oxidants via *in-situ* and *ex-situ* soil mixing involves chemical oxidation as well as biological and/or physical processes to transform organic contaminants in soil. The soil mixing that occurs during an ex-situ or in-situ mixing treatment serves to homogenize the soil and contaminants at the same time it forces contact with the oxidant mixture. During this process the contaminant can be diluted and some amount may volatilize. These physical losses are difficult to differentiate from chemical oxidation losses, but can be significant.
The proportion of contaminant that is degraded by chemical, biological or physical processes will depend on:

- Soil type
- Contaminant distribution

- Contaminant type
- Oxidant Efficiency
- Soil/Water ratio
- Type & frequency of Mixing
- Temperature
- Treatment Duration.

The duration of the treatment program is very important to ensure that sufficient time has been allowed for the complete chemical reactions to occur. Additionally, many contaminants that are partially oxidized during the chemical treatment become more readily available for biological degradation. Thus, contaminant concentrations often continue to decline as a result of this post-chemical oxidation biological activity.

The table below gives an idea of the proportional effects of different processes. In a typical contaminated soil treatment employing mixing and chemical oxidation technology, the actual chemical oxidation reactions can account for 10 to 60% of the contaminant removal, less for TPH compounds and higher amounts for cVOCs. Biological activity can account for 20-60%, primarily depending of the time and water content. Physical processes can account for 10-90% of the contaminant removal, primarily depending on the type of mixing that is used and the volatility of the contaminant treated.

Treatment/Contaminant	Petroleum-based	Chlorinated-Solvents
Homogenization	Low to Medium	Medium to High
Volatilization	Low	High
Chemical	Low to Medium	Medium to High
Biological	Medium	Medium

In general, chemical treatment of soils employs chemical/biological treatment and homogenization to attain cleanup goals. Complete mineralization via chemical treatment should not be the goal and is almost never achieved.

In treating total petroleum hydrocarbons (TPH)-type contaminants, adding a stoichiometric amount of oxidant is usually not necessary or economical. Instead, a sub-stoichiometric dose of a chemical oxidant can partially oxidize the contaminant to more soluble intermediate products that are readily biodegradable. Often residual oxygen left behind will stimulate aerobic biodegradation of these compounds.

When dealing with contaminants of very low solubility and low volatility, multiple chemical oxidant treatments may be required. Despite superior contact with soil mixing, the chemical treatment still requires time to permeate the soil matrix and to react with the contaminant in aqueous solution. Chemical oxidation of low solubility contaminants will be desorption-limited. Therefore, soil mixing designs may require multiple passes to desorb and oxidized the sorbed mass that is released over time. This should be recognized before embarking on any chemical oxidation of soils in order to align treatment expectations with pending reality.

Sites Appropriate for Chemical Oxidation of Contaminated Soils

Typical applicable sites are:

- Abandoned tank farms, bulk plants, where diesel fuels, gasoline and other petroleum distillates have been handled

- Old dry cleaner sites
- Industrial facilities

Typical site conditions are that the contamination is usually less than 20 ft. in depth. The bulk of the contamination may reside in the upper portion of the vertical interval, e.g. ground surface to 10 feet in depth. The soil can be sandy or clay, vadose or below the water table groundwater. Large objects and debris must be generally less than 4" in diameter. There must be an ample water source to maintain desired soil moisture during treatment. There should be ample space and an adequate buffer area around the excavation/treatment zone so as to not impact infrastructure, foundations, or neighbors.

Considerations for Treatment Design

When designing an approach for implementing chemical oxidation of soils one should attempt to maximize the surface area in contact with the chemical oxidant. Typical soil particles need to be below one centimeter in size. Most soils will require the addition of water and other amendments before treatment. In soils with high clay content, soil shredding and/or blending with a bulking agent may be needed to improve the soil structure and porosity. Prior to any soil shredding, a screening step should occur to remove rocks and debris. Lime and/or bulking agents, such as wood chips or sand may be needed to improve both material handling as well as to maximize biological degradation after the chemical oxidation.

In Situ Mixing

Use of typical construction equipment (e.g. track hoe) often does not adequately break up soil matrices and homogenize the mixture. This approach to mixing chemical oxidants often results in untreated soil in clumps, even after many passes. Specialized soil mixing equipment is available. Shallow mixing rigs that can access the top 20' are available that can operate at costs in the range of $10/CY to $25/CY. Deep soil mixing typically requires large diameter drill rigs that operate in excess of $25+/CY.

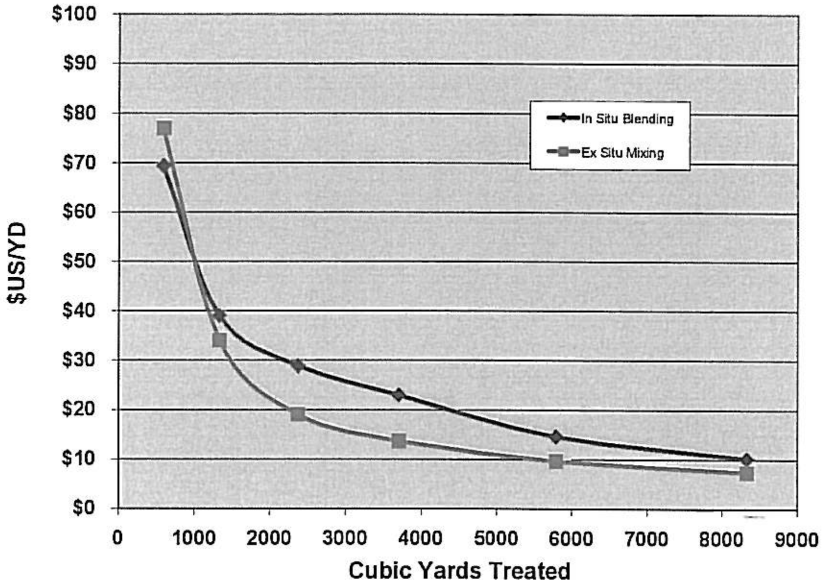
Ex Situ Mixing

Excavation methods can use conventional equipment to transfer contaminated soils surface piles or windrows where chemical oxidants are applied followed by surface mixing by compost-turning type equipment. Alternatively, the soil once excavated can be processed in a trommel screen or pug mill to shred the soil and ensure contact /mixing. Soil shred costs are typically <5$/CY. Other Ex-mixing costs are shown below in the cost analysis assumptions.

Cost Comparison of Common Mixing Methods

Criteria	In Situ Mixing	Ex Situ Mixing
Mixing Efficiency	Low- Medium	High
Mixing Equipment Cost	High	Low-Med
Mixing Throughput	Medium	High
Space Requirements	Low-Medium	High

General Cost Comparison for various mixing technologies is summarized in the figure below.



General assumption for cost comparison:

- CY treated per day: In-situ= 750, Ex-situ= 5,000
- Assumed Daily Rate of $4,500 for in-situ blending (e.g Lang Tool), Other costs are support vehicles. Monthly rate assumptions used.
- Assumed Daily Rate of $4,000 for ex-situ mixing (e.g. H&H Micro-enfractionator®), Other Costs are Support Vehicles. Monthly Rate Assumptions Used
- Caveats, if soil blending usage is greater than 10 business days, rate equal to $35,000 per month, other support equipment at $20k per month
- Caveats, if ex situ blending usage is greater than 10 business days, rate equal to $45,000 per month, other support equipment at $20k per month.
- Since Mixing is so quick, may need to mobilize equipment twice and therefore mob charges reflect a double mob, mixing perhaps 3 weeks apart

The overall costs for both ex-situ and in-situ mixing applications require a minimum 2,000 to 5,000 cu. Yds. to get to a economical cost of <$20/ cu. Yd.

Need for Bench Testing

Bench-scale testing, although not an absolute guarantee of success can substantially reduce the risk of unexpected costs or poor performance in the field. Bench-scale tests are not scalable to full-scale designs, but can point out problems early in the process to improve the final design. Fully characterizing site soils in the laboratory for contaminant type (especially important with petroleum-based contaminant) and concentration. In addition the following characterization may be helpful:

- Metals--Fe, Mn, Al, Cu, Ni, Zn, Cr, Cd, Co, As, Se
- Base Cations--Na, Mg, K, Ca
- Anions-- NO_3/NO_2, PO_4, SO_4
- pH (optimum 6-9)
- Moisture content (optimum 70 to 95% field capacity)
- Particle-size distribution (optimum soil void volume >25%)

- TOC and COD

If the initial values for pH, TOC, COD, and moisture are not within the optimal criteria, adjustments should be made and tested at the bench-scale to determine the importance of these criteria to the performance of the treatment option and to determine the feasibility of scaling up these adjustments for full-scale design. Other parameters mentioned above may be important in identifying unusual geochemistry which may also affect performance.

Need for Field Pilot Testing

Pilot-scale testing provides scalable information on the effectiveness of a given technology applied to a given soil. Critical parameters for estimating full-scale design are typically unknown. For example, unless the soils have already been stock pile and a statistical robust sampling has been done, the average starting concentrations are not known. Therefore, pilots or phased applications with intensive performance monitoring can be used to avoid uncertainty and performance problems during full-scale operations.

Estimating RegenOx™ Application Rates

Typically for a cVOC contaminated site the amount of oxidant used can be calculated from the stoichiometry of the average concentrations. These sites use 20-40lbs/CY of RegenOx which is usually economical. With TPH based contamination, the design starts with 1/10 the average concentration stoichiometry, and to be economical this usually needs to be 10 to 20 lbs/CY. We have gotten good results with lower percentage of the stoichiometry (i.e. 1/50) with some sites. So, if the calculated amount is greater than 20 lbs./CY for a TPH-based site, a pilot application might be tried to see with a less amount of oxidant can the treatment goal still be met.

Summary

There are many successful applications and sites where *in situ* mixing/blending technology is applicable and has been applied with RegenOx. The attached table summarizes those examples of these applications. Success for each of these applications is very site specific. Some sites only needed modest reduction from 1000 ppm to 400ppm, while other sites needed reduction to below 20 ppb to be considered successful. Therefore, to be successful with chemical oxidation of vadose zone contaminated soils, one must have reasonable expectations up front, and verify results through pilot/phased applications in the field.

Case History R-8

RegenOx

REGENESIS

Advanced Technologies for Groundwater Resources

Vadose Zone Treatment Using In-Situ Chemical Oxidation Via Direct-Push and Soil Mixing Applications

CASE SUMMARY

Industrial Facility, Hollywood, CA

Chlorinated solvent contamination was detected in fill material throughout this 2-acre industrial property. Before a pending real estate transaction could be finalized, approximately 1 acre of the site required treatment for perchloroethene (PCE) in vadose zone soil. To achieve this, the engineering firm in charge of remediation selected chemical oxidation using RegenOx™ based on the product's proven effectiveness, low-cost, and handling safety.

TECHNOLOGY DESCRIPTION

RegenOx™ safely, effectively, and rapidly destroys a wide range of contaminants in both soil and groundwater. RegenOx™ is a solid alkaline oxidant built around a sodium percarbonate complex, which is activated using a proprietary, multi-part catalytic formula. The product is delivered to the treatment site in two parts. The two parts are combined and then added to subsurface soil (vadose or saturated zone) using direct-push and/or soil mixing equipment. RegenOx™ can also be added to excavations and soil piles using soil blending equipment. Once in contact with contaminated soil, RegenOx™ produces an effective oxidation reaction, comparable to that of Fenton's Reagent, without a violent exothermic hazard.

Soil requiring treatment at a large industrial facility near Los Angeles, CA

REMEDIATION APPROACH

The remediation objective at the Hollywood site was to reduce concentrations of chlorinated compounds to below 20 parts per billion (ppb).

Treatment by the in-situ mixing application of RegenOx™

- **Treatment Area:** 19,220 ft^3
- **Soil Type**: Consolidated Backfill
- **Groundwater Velocity:** NA (vadose zone)
- **Depth to Groundwater:** 14 ft
- **Application Type:**
  In-Situ Treatment via Direct-Push and Soil Mixing
- **Product**: RegenOx™
- **Quantity Applied:** 217,000 lbs
- **Average Application Rate:**
  Soil Mixing: 11 lbs/yd^3, Direct-Push: 8 lbs/ft

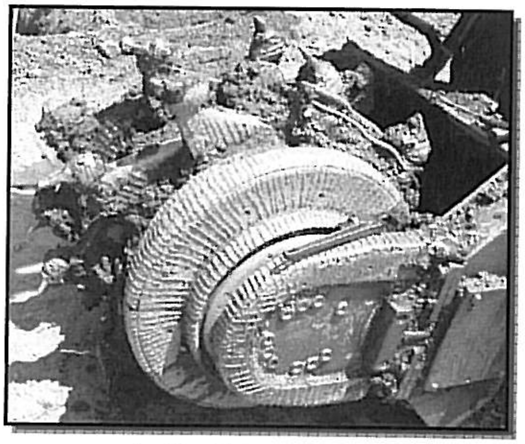
Phase I: Direct-Push Application

The first phase of remediation was performed using the direct-push application of RegenOx™ at the treatment site. The direct-push methodology uses specialized equipment to apply RegenOx™ to discrete areas of the subsurface without soil removal (i.e., *in situ*). Composite soil samples from various grid cells were taken before and after the treatment. Significant variation was seen in the PCE concentrations before treatment, with the average concentration approximately 30 ppb. Following the direct-push application of RegenOx™, the average PCE concentration was 4 ppb, a decrease of 86 percent. Similar results were seen for other chlorinated volatile organic compounds (CVOCs) in the composite soil samples. However, despite the contaminant reductions achieved by the use of RegenOx™, it was determined that the direct-push application was too slow and inefficient for treatment of the entire site. Therefore, a different, more aggressive approach was implemented to maximize contact between RegenOx™ and the contaminated soil.

Phase II: In-Situ Soil Application

To complete the soil treatment, RegenOx™ was mechanically blended into the contaminated vadose soil using soil mixing equipment (shown below). RegenOx™ was added in an 8-percent solution and mixed throughout the soil. By maximizing contact between the RegenOx™ solution and the contaminated soil, approximately twice as much soil was treated per day in comparison to the amount treatable using the direct-push application.

In-Situ Mixing of RegenOx™ On-Site

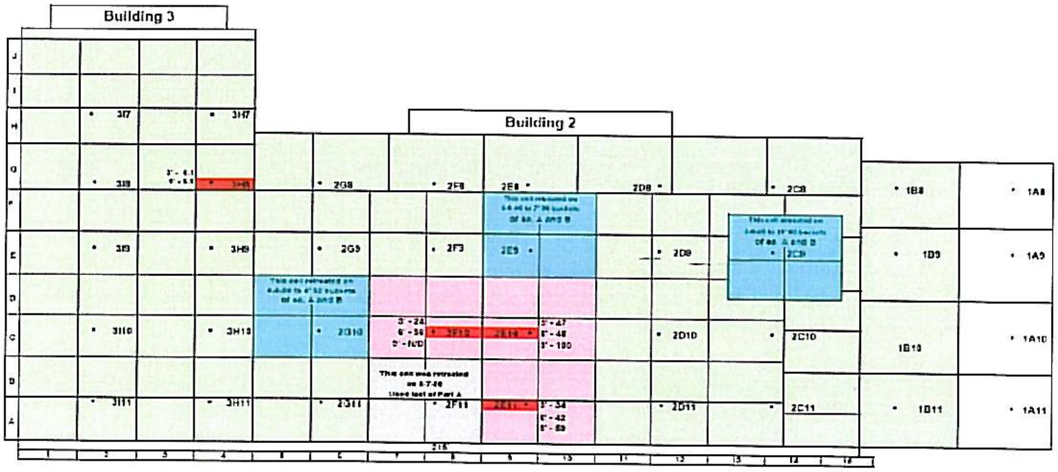


In-Situ Mixing Tool Head

Soil Mixing and Excavation Activities

Of the 111 grids treated with RegenOx™ (Figure 1), 83 required only one treatment (green), 12 required 2 treatments (blue), and 16 required more than 2 treatments (pink and gray).

Figure 1. Grid Site Map with the Treatment Effectiveness Noted



Green:	Met criteria after one treatment
Blue:	Met criteria after two treatments
Pink/Gray:	Met criteria after multiple treatments

CONCLUSION

Soil contamination at the site was effectively reduced using RegenOx™ in both direct-push and soil mixing applications. At this site, however, soil mixing was the favored approach because it maximized contact between RegenOx™ and the contaminated soil, achieving more rapid treatment. In most of the treatment grids (74 percent), contaminant concentrations were reduced from as high as 140 ppb to below the cleanup goal of 20 ppb with a single application. Additional applications in all other treatment grids also achieved concentrations below 20 ppb. This remediation approach successfully treated nearly 18,000 yd^3 of soil within 30 days for approximately \$34/yd^3, which includes the costs for RegenOx™, the soil mixer, and support equipment. Using RegenOx™ and flexible application methods, the site was quickly and effectively remediated, allowing for the real estate transaction to be completed.

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