December 28, 2004 Project No. 29016404

Ms. Amy Williams
Remedial Project Manager
U.S. Environmental Protection Agency, Region IV
4WD-SRTMB
61 Forsyth Street
Atlanta, Georgia 30303-3104

Draft Remediation Grouting Work Plan
Cabot Carbon/Koppers Superfund Site
Gainesville, Florida

Dear Ms. Williams:

At the request of Mike Slenska, TRC is submitting to you two copies of the above-referenced report on behalf of Beazer East. The enclosed plan presents the proposed grout injection pilot test program proposed in correspondence to you from Beazer East dated August 4, 2004.

Please feel free to contact Mike Slenska at 412-208-8867 if you have any comments or concerns.

Sincerely,

Tom Patterson
Senior Project Manager

cc: Kelsey Helton, FDEP
John Moussa, ACEPD
Brett Goodman, GRU
Mike Slenska, Beazer East
Tim Basilone, Koppers
John Herbert, Jones Edmunds

bcc: Jim Erickson, GeoTrans
Jim Mercer, GeoTrans
Anthony Randazzo, Geohazards
Quenta Vettel, LQ Communications
Mason Wheeler, Sevenson Environmental
Jim Hussin, Hayward Baker Incorporated

Customer-Focused Solutions

DRAFT REMEDIATION GROUTING WORKPLAN
KOPPERS FACILITY
CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

Prepared for

Beazer East, Inc.

Gainesville, Florida

Prepared by

TRC

Irvine, California

Project No. 29016404
December 2004

TRC
21 Technology Drive
Irvine, California 92618
Telephone 949-727-9336
Facsimile 949-727-7399

TABLE OF CONTENTS

		PAGE NO.
LIST OF FIGURES		ii
ACKNOWLEDGEMENT		iii
1.0	INTRODUCTION AND SITE BACKGROUND	1
	1.1. Purpose	1
	1.2. Background	1
	1.3. Site Description	2
	1.4. Site Hydrogeology	2
	1.5. DNAPL Source Investigation	3
2.0	SELECTION OF GROUTING METHOD	6
	2.1. Grouting Methods	6
	2.2. Comparison of Grouting Alternatives	8
3.0	PILOT TEST DESCRIPTION	10
	3.1 Pre-Pilot Program Testing	10
	3.2 Site Setup and Preparation	10
	3.3 Jet Grouting Technique	10
	3.4 Grouting Program	12
	3.5 Quality Assurance and Quality Control Program	13
4.0	PERFORMANCE EVALUATION AND REPORTING	15
	4.1 Evaluation of Grouting Performance	15
	4.2 Pilot-Test Reporting	17
5.0	REFERENCES	19

APPENDIX A: STANDARD OPERATING PROCEDURES FOR PREPARING AND TESTING SOILCRETE SPECIMENS FOR PRE-PILOT PROGRAM LABORATORY TESTING

APPENDIX B: QUALITY MANUAL FOR JET GROUTING

TABLE OF CONTENTS
(Continued)

LIST OF FIGURES

FIGURE NO.	TITLE
1.1	Site Location Map
1.2	Site Plan
2.1	Grouting in Soil
3.1	Conceptual Layout for Pilot-Test Remediation Grouting
3.2	Proposed Layout for Jet Grouting Setup
3.3	Jet Grouting Systems and Applications
3.4	Former North Lagoon East-West Simplified Cross-Section
3.5	Plan of Jet-Grout Disks Layout
3.6	Superjet Grouting Process
3.7	Management of Jet Grout Spoil
4.1	Performance Evaluation Program
4.2	Locations of Performance Evaluation Tests

ACKNOWLEDGEMENT

TRC would like to acknowledge the contribution of the following individuals in preparing this work plan:

- Dr. Jim Mercer with GeoTrans, Inc., and Dr. Anthony Randazzo with GeoHazards, Inc., for their peer review;
- Mr. George Burke and Mr. James Hussin with Hayward Baker, Inc., for providing valuable information and input for the drafting of Chapter 3; and
- Mr. Mason Wheeler of Sevenson Environmental Services, Inc., for preparing Figure 3.7.

1.0 INTRODUCTION AND SITE BACKGROUND

1.1 PURPOSE

1. This workplan outlines the proposed remediation grouting pilot program which is aimed at evaluating the cement-grout injection technology as an approach for mitigating creosote mobilization risks in the Surficial Aquifer at the Koppers portion of the Cabot Carbon/Koppers Superfund Site in Gainesville, Florida (the Site).

2. The workplan is being prepared in accordance with the July 21, 2004, stakeholders meeting held at the United States Environmental Protection Agency's (USEPA's) Region IV Atlanta, Georgia offices concerning the Site, and the follow-up letter to that meeting issued by Beazer East, Inc. (Beazer) to the USEPA, dated August 4, 2004.

3. The topics of the July 21, 2004 meeting included a presentation of options for Site wide remedial action and DNAPL Source Area interim measures. A significant portion of the meeting focused on a discussion of potentially applicable remedial technologies to address the DNAPL source areas at the Site, either as a beneficial interim remedial measure, as a final remedy, or both. In the follow-up letter of August 4, 2004, Beazer provided a plan to proceed with interim measures/remedy pilot approach at the Site (Beazer, 2004).

1.2 BACKGROUND

1. The Site is located in the northern portion of the City of Gainesville, Florida. The location of the Site is shown in Figure 1.1 and the Site plan is shown in Figure 1.2. The Site is an active wood treatment facility, and impacts to soil and ground water have occurred due to historic wood treatment operations. The Site has been undergoing Site investigation, remedial planning and remedial action under the oversight of the United States Environmental Protection Agency (USEPA) since the late-1980s.

2. Wood treatment activities were initiated at the Site in 1912 by the American Lumber and Treating Company. Historically, wood treatment activities involved the use of creosote, chromated-copper-arsenate (CCA), and pentachlorophenol (PCP) as preserving compounds. Waste liquids from the treating operations were discharged to the north and south lagoons and a cooling pond located at the Site (see Figure 1.2). After the treated wood was removed from the cylinders located in the process area, it was loaded onto specially designed railcars and transported to the drip track area, where the excess fluids dripped onto the ground and the initial wood drying occurred.

3. Koppers, Inc. (KI) has owned the Site since 1988. KI has only treated wood with CCA in a smaller plant located within the Former Process Area.

1.3 SITE DESCRIPTION

1. The Site encompasses approximately 90 acres in a relatively flat industrial and commercial area within the City limits of Gainesville, Florida (see Figures 1.1 and 1.2). Elevation ranges from 165 to 185 feet above mean sea level.

2. The main historic and current processing facilities are located within the southeastern corner of the Site. This area includes a tank farm, the cylinder drip tracks, the treating cylinders' wastewater system, and drying kilns. A cooling water pond was formerly also located in this area. The central and northern portions of the Site, on the other hand, have been cleared and graded, and are used as storage areas.

3. Two historic lagoon areas, referred to as the Former North and South Lagoons, were used to manage wastewater generated by the treatment processes. The North Lagoon reportedly operated from 1956 until the mid-1970s. The operational period of the South Lagoon is not known. Both the North and South Lagoons have been closed, covered and graded, and are currently used for storage.

1.4 SITE HYDROGEOLOGY

1. The Site is underlain by a 20- to 30-feet-thick unit of Plio-Pleistocene marine terrace deposits consisting primarily of fine- to medium-grained quartz sand with trace amounts of silt and clay interbedded with laterally discontinuous zones of clayey sands and sandy clays. Within this unit is the Surficial Aquifer where depth to water ranges from 3 to 15 feet below ground surface (TRC, 2002).

2. The Hawthorn Group underlies the terrace deposits and ranges in thickness from approximately 120 to 125 feet. It is comprised of interbedded and intermixed clays, silty-clayey sands, sandy clays, and occasional carbonate beds (limestone nodules and moderately indurated sands). The upper surface of the Hawthorn Group is a greenish-grayish clay layer that is undulating and dips generally toward the northeast of the

Site. The upper Hawthorn clay is described as hard, plastic clay that ranges from 0.5 to 7 feet in thickness (TRC, 2002). The average hydraulic conductivity of this clay layer is 6.7×10^{-8} cm/sec, as determined from laboratory permeameter test results.

3. Below the upper Hawthorn clay is a clayey-sand zone (34- to 42-feet thick), which is within the upper Hawthorn Group. The clayey-sand layer has a hydraulic conductivity in the range of approximately 1×10^{-5} cm/sec. The upper Hawthorn Group hydraulic heads are approximately 1 to 2 feet lower than the hydraulic heads in the Surficial Aquifer.

4. Below the upper Hawthorn Group is a second hard, plastic clay layer that ranges in thickness from 2 to 15 feet, and is referred to as the middle Hawthorn clay. A clayey-sand layer, part of the lower Hawthorn Group, underlies the middle Hawthorn clay. The middle Hawthorn clay appears to be a more effective confining bed, as hydraulic heads in the lower Hawthorn Group are nearly 30 feet deeper than the heads in the Surficial Aquifer and upper Hawthorn Group.

5. A third hard, plastic clay layer is found at the base of the lower Hawthorn Group. This clay layer is approximately 20- to greater than 32-feet thick and makes part of the lower Hawthorn Group. Below this layer is the Upper Eocene Ocala Limestone of the Upper Floridan Aquifer. The hydraulic head difference across the lower Hawthorn clay is approximately 90 feet, suggesting that it is a very effective confining bed.

1.5 DNAPL SOURCE INVESTIGATION

1. A DNAPL source investigation field program was performed in early 2004. The results are presented in the Data Report for Additional Investigation of Hawthorn Group: DNAPL Source Evaluation for the Koppers Industries Property, Cabot Carbon/Koppers Superfund Site, Gainesville, Florida (GeoTrans, 2004). The primary objective of the investigation was to characterize the horizontal and vertical extent of creosote source zones within the Surficial Aquifer and directly below the four DNAPL entry points, respectively. The four DNAPL entry points are the Former South Lagoon, the Former North Lagoon, the Former Drip Track Area, and the Former Process Area (including former cooling pond and former tank containment).

2. Lateral delineation of creosote impacts in the Surficial Aquifer at the four source areas was accomplished using a combination of electrical resistivity (ER) measurements and

direct-push borings utilizing GeoProbe® soil borings and Rapid Optical Screening Tool (ROST™) mounted on a Cone Penetration Testing (CPT) probe. The vertical extent of creosote within the Hawthorn Group at the four source areas was determined by drilling soil borings and installing and sampling monitoring wells (GeoTrans, 2004).

3. The DNAPL source investigation confirmed that the Hawthorn Group has a low average hydraulic conductivity. The investigation also revealed properties of the Hawthorn Group that might have contributed to creosote migration. The confining properties of the clay layers improve with depth, with the upper Hawthorn clay indicating the weakest confining properties and the lower Hawthorn clay showing the strongest. The field investigation also indicated that the Hawthorn Group is more heterogeneous than previously thought. The clays and clayey sands that make up the Hawthorn Group contain sand and/or sand and gravel stringers and seams. The permeable stringers create a high degree of heterogeneity within the Hawthorn Group as a result of their high permeability relative to the average low permeability of the layer. The thin seams (about 1 inch thick) can also serve as preferred pathways for creosote migration, both horizontally and vertically.

4. The properties of the clays were found to be heterogeneous, displaying plastic qualities at some locations and friable and brittle response at other locations. Where brittle, the clay can undergo stress fractures, providing pathways through the clay. The field investigation program concluded that the creosote within the lower Hawthorn Group appears to be residual; however, there are indications of some creosote mobility in the upper Hawthorn Group.

5. The immediate areas of the Former North Lagoon and the Former South Lagoon have creosote throughout the entire thickness of the Surficial Aquifer. As the creosote migrated vertically, some lateral spreading occurred within the Surficial Aquifer, but is considered to be insignificant. Vertical DNAPL migration dominated beneath the lagoons, until reaching the upper Hawthorn clay (base of the Surficial Aquifer). At the upper Hawthorn clay, the creosote spreads laterally until being consumed at residual saturation or penetrating the clay through permeable pathways. Therefore, the creosote distribution is thick under the lagoons and thin at the base of the Surficial Aquifer away from the lagoons.

6. DNAPL impacts below the Former North Lagoon appear to penetrate the deepest of all the source areas, which could be attributed to a combination of several factors. Interpretation of historical aerial photos indicated that the Former North Lagoon operated for an extended

period from about 1937 to the 1970s, making it probably the longest, continuous operational-history area at the Site. In addition, the upper Hawthorn clay at the Former North Lagoon appears to be thinner than at other source locations, which may have allowed more creosote to penetrate the Hawthorn Group at this source area. On the other hand, creosote beneath the Former South Lagoon appears to have penetrated the upper Hawthorn clay and migrated only a short distance below the upper Hawthorn clay.

7. Unlike the former lagoons, in the former cooling pond area which is part of the Former Process Area, creosote was observed sporadically with depth within the Surficial Aquifer. Creosote in the former cooling pond area penetrated the upper clay and migrated only about midway into the upper Hawthorn Group. DNAPL source investigation at the Former Drip Track Area indicates that the upper Hawthorn clay is performing at least as a partial barrier to vertical migration, causing some lateral creosote migration at the bottom of the Surficial Aquifer. The investigation also indicates that the creosote at the Former Drip Track Area penetrated the upper clay and the upper Hawthorn Group only. The lower Hawthorn Group was free of creosote at the Former Drip Track Area, but creosote impacts were observed on the top of the lower Hawthorn clay that resulted from a currently unknown pathway.

2.0 SELECTION OF GROUTING METHOD

1. Selection of the best ground modification and improvement approach is a function of both the characteristics of the in-situ soil and the goal of the application. Ground modification and improvement techniques are continually evolving as new technology becomes available and new applications are established. The basic concepts, however, were developed and applied many years ago by civil engineers on wide spectra of projects and remain the same today (e.g., densification, drainage, cementation, reinforcement, sealing, etc.). Many of the soil stabilization and ground modification techniques that have been developed for ground strengthening, earthwork construction, and other more traditional purposes have been found useful for solution of environmental problems. These techniques include soil compaction, preload and surcharge, ground fracturing, hydraulic modification (e.g., extraction/injection wells and drains), electro-kinetics (i.e., electro-osmosis and electro-phoresis), slurry walls, sheet pile cut-off walls, deep mixing, and grouting.

2. Grouting has been used in a specific project to emplace a subsurface barrier in remedial action involving radioactive waste, and has been indicated as a potentially useful technique for neutralizing, immobilizing or containing wastes (USEPA, 1986). Typical grout utilization in remedial action has involved shallow, low-pressure injection to consolidate contaminated soil; injection into waste to provide for solidification or in-situ treatment; and injection for sealing soil around the contaminated site to form a barrier against lateral or vertical contaminant migration.

3. Cement grout injection is proposed as a pilot remedy application technology to be initiated in the Surficial Aquifer zone at the Site because it is anticipated to prevent further vertical migration of DNAPL and dissolved constituents (Beazer, 2004). The objective of pilot-testing the cement grout injection technology into the lower portions of the Surficial Aquifer is to reduce the potential for migration of fluid (ground water and/or DNAPL) from the Surficial Aquifer through preferred pathways such as fractures and fissures, thereby reducing the overall mass flux of the constituents of concern. Methods for grout injection are discussed below.

2.1 GROUTING METHODS

1. Grouting has been used in construction for over a century to improve the strength of earth materials or to control water movement in subsurface layers. One of the widely used grouting methods is permeation grouting. Permeation grouting technology was first used in

situ to install seepage barriers. Injection pipes are installed (usually vertically) and a chemical or cementicious grout slurry is forced into the soil pores to block up the granular matrix as shown in Figure 2.1. The major factors controlling groutability by permeation are the pore size and pore-size distribution of the soil, and the viscosity of the grout. One rule of thumb suggests that soils with less than 1 percent to 2 percent fines (percentage finer than #200-sieve) are easily groutable, soils with 2 percent to 20 percent fines may be only moderately groutable, and soils with 20 percent to 25 percent fines are only marginally groutable. The permeation grout, in general, is a fluid of sufficiently low viscosity that can permeate the porosity of a soil matrix. The fluid grout must be injected at relatively low pressures to prevent hydraulic fracturing of the matrix and undesirable heave of the ground surface.

2. Another grouting method is compaction grouting. The technique was originally developed in the 1950's as a remedial measure for the correction of unacceptable building settlement, and used almost exclusively for that purpose for many years. Over the past two decades, however, compaction grouting technology has evolved to treat a wide range of subsurface conditions for new and remedial construction. A very viscous (low-mobility and low-slump), aggregate grout is injected into loose soils to form homogeneous grout bulbs that displace and densify the surrounding soil as illustrated in Figure 2.1. Typically, an overburden stress greater than 1,500 pounds per square feet (psf) is required for optimum densification results. If uncontrolled heave of the ground surface occurs due to insufficient in-situ vertical stress, the horizontal displacement of the soil will be limited and the densification process will be minimized. Compaction grouting can usually be effective for densification in most sands and silts, provided that the soil is not near saturation. It is marginally effective for reducing permeability.

3. Jet grouting is a mixing grouting technology that is used to create in situ cemented formations of soil commonly called soilcrete. Applications of this technology fall into three broad categories: 1) underpinning and/or excavation support, 2) temporary or permanent stabilization of soft soils, and 3) ground water or pollution control. Jet grouting is an alternative to traditional grouting methods in creating horizontal subsurface barriers in a wide range of soil types, strengths and profiles. The technology uses the energy from injecting liquid (and sometimes air) at a very high velocity to erode the soil in situ and mix the soil with the injected grout (see Figure 2.1). Unlike most grouting methods, jet grouting does not pressure-inject the soil and relies on venting pressure to control the erosion process. Horizontal barriers are constructed by interconnecting "disks" of soilcrete formed

at the targeted depth. Since the geometry and physical properties of the soilcrete are engineered, the degree of improvement can be readily predicted.

2.2 COMPARISON OF GROUTING ALTERNATIVES

1. Grouting involves the pressure-injection of suspensions or solutions that set or harden to fill voids and cement earth materials together. Both the grout formulation selected for injection and the technique used for placement are important for grout to produce the desired benefits. Problems associated with permeation grouting technique result from the fact that most subsurface conditions are not uniform or homogeneous, and therefore the integrity of the constructed barrier is often in question. In addition, the grout slurry typically used in permeation grouting can only penetrate soils that are porous enough to assure impregnation, and even the lowest viscosity grout and finest particles can only permeate a small percentage of soils encountered in the Surficial Aquifer at Koppers Site. Soils containing about 20 percent fines (percentage finer than #200-sieve) are considered difficult to inject, and permeation grouting is considered to be ineffective for soils containing more than 25 percent fines (Nonveiller, 1989; Byle and Borden, 1995; Kutzner, 1996). Previous investigations at the Koppers Site suggest that soils of the Surficial Aquifer have more than 20 percent fines on average (TRC, 2002).

2. The grout types differ in their injectability and their effectiveness in producing a durable seal or adding strength to the grouted medium. In environmental applications where grout is used to form a barrier in geologic media, the grout must be easily injectable (i.e., have low viscosity) and must produce a decrease in permeability. Compaction grouting involves controlled injection of very stiff, mortar-like grout into discrete soil zones. The improvement mechanism is mainly densification which increases the bearing capacity. A modest reduction in permeability would be expected as a result of a reduction in the pore space of the densified soils. The irregular shapes and positions of the grout bulbs created by compaction grouting, due to the heterogeneous nature of the soils being grouted, and the low mobility characteristic of the grout make it difficult to control the construction of a continuous barrier and to assure its consistency and integrity in bottom sealing.

3. The application of jet grouting technique in geo-environmental engineering to create liquid and vapor barriers has evolved from research and development to field application (Burke, 1995; Furth et al., 1997). The construction of a horizontal barrier at the lower portions of the Surficial Aquifer using jet grouting is expected to provide a secure continuous seal that

would reduce the potential for migration of contained fluid (ground water and/or DNAPL) beyond the Surficial Aquifer. Jet grouting is effective in a much wider range of soil types (including silts and some clays) than any other grouting alternative, is applicable above and below the ground water table, and the process can be adjusted to compensate for inhomogeneous and stratified soil conditions. As a mixing technique, jet grouting produces certain amount of excess soilcrete at the ground surface. In fact, excess soilcrete return is essential to creation of uniform cemented formation of soil, as hydrofracturing could result in lieu of erosion whenever excess soilcrete return is compromised. Hydrofracturing is undesirable because it causes inconsistent soilcrete quality and geometry. For the construction of horizontal barriers, numerous vertical drill holes are necessary which will likely encounter contamination that might end up as contaminated excess soilcrete. The management of contaminated excess soilcrete is a key cost factor in implementation of jet grouting for barrier construction.

4. Based on the discussion above, jet grouting appears to be the most promising cement grout method for reducing the potential for further vertical migration of DNAPL from the Surficial Aquifer. The clayey type of soils, with high fines content, that are encountered at the Site make it difficult to effectively utilize permeation grouting in accomplishing the objective of the proposed pilot remedy. With compaction grouting, the integrity of a continuous horizontal barrier would be questionable. Therefore, jet grouting will be pilot-tested to determine if it is an effective technique in achieving the objective of the cement grout technology, i.e., to construct a horizontal barrier at the lower portions of the Surficial Aquifer.

3.0 PILOT TEST DESCRIPTION

3.1 PRE-PILOT PROGRAM TESTING

1. Additional field investigation is planned to supplement the available geotechnical information for the pilot-test location. It is anticipated that hollow stem augers will be used to drill two selected locations within the pilot-test area to investigate the soils of the Surficial Aquifer and confirm the depth of the upper Hawthorn clay layer.

2. During this additional investigation, soil samples will be retrieved to perform preliminary laboratory testing. The objective of the laboratory testing program is to assess soil-grout compatibility prior to production. Standard Operating Procedures (SOP) to conduct the laboratory testing program are presented in Appendix A.

3. The laboratory testing program will provide results of several mix designs with Site water and binder combinations with the onsite soils to assist in selecting the appropriate mix design. Hydraulic conductivity results will also be presented as "bench" test results for the proposed soilcrete to evaluate the anticipated in-situ permeability. The permeability of the soilcrete is expected to be on the order of 10^{-7} cm/sec (Sehn, 1999).

3.2 SITE SETUP AND PREPARATION

1. The selected pilot-test location is located within the Former North Lagoon as shown on Figure 3.1. The work area will be cleared of demarcated underground and buried utilities, and other obstructions, or utilities will be clearly identified prior to grouting operations.

2. The jet grouting setup area is also indicated in Figure 3.1, and the schematic arrangement of support equipment necessary to perform jet grouting is presented in Figure 3.2. In addition, Figure 3.1 illustrates the location of the planned open excavation for handling of jet grout spoil that is anticipated during the remediation pilot test. Handling and management of soilcrete return during jet grouting is discussed in Section 3.4.

3.3 JET GROUTING TECHNIQUE

1. There are three traditional jet grouting systems, namely, single fluid, double fluid and triple fluid systems. A more recently developed variation of the double-fluid system is known as

super-jet grouting system. Figure 3.3 illustrates the concept of the different jet grouting systems and some of their respective applications.

2. Selection of the most appropriate system is generally a function of the in-situ soil, the application, and the physical characteristics of Soilcrete required for that application. The general characteristics for the different jet grouting systems are presented in the following paragraphs.

3. Single Fluid Jet Grouting: Grout slurry is pumped through the rod and exits the horizontal nozzle(s) in the monitor with high velocity (approximately 650 feet/sec). This energy causes the erosion of the ground and the placement and mixing of grout in the soil. In gravely soils, Soilcrete column diameters of 2 to 4 feet can be achieved. In loose, silty and sandy soils, larger diameters are possible. Single fluid jet grouting is generally less effective in cohesive soils.

4. Double Fluid Jet Grouting: A two-phase internal rod system is employed for the separate supply of grout and air down to different, concentric nozzles as shown in Figure 3.3. Grout slurry is used for eroding and mixing with the soil. The air shrouds the grout jet and increases erosion efficiency. Soilcrete columns with more than 3-feet diameter in medium to dense soils and more than 5-feet diameter in loose soils may be achieved. The double fluid system is more effective in cohesive soils than the single fluid system.

5. Triple Fluid Jet Grouting: Grout, air and water are pumped through different lines to the nozzles. High velocity coaxial air and water form the erosion medium. Grout slurry emerges at a lower velocity from separate nozzle(s) below the erosion jet as illustrated in Figure 3.3. This somewhat separates the erosion process from the grouting process and yields a higher quality Soilcrete. Soilcrete columns with diameters ranging from 3 feet to more than 4.5 feet can be achieved. Triple fluid jet grouting is the most effective system for cohesive soils.

6. Super Jet Grouting: A variation of the double fluid system is the super jet. The super jet system combines the double rod with increased velocity jets and treatment time to create large geometries. This system uses opposing nozzles and a highly sophisticated jetting monitor specifically designed for focus of the injection media. Using very slow rotation and lift, soilcrete column diameters of 10 to 16 feet can be achieved (Hayward Baker, 2004a). Super jet grouting is the most effective system for mass stabilization application or

where surgical treatment is necessary. Because of its anticipated efficiency and effectiveness in creating overlapping grout disks, super jet grouting is the selected system to construct a horizontal barrier at the lower portions of the Surficial Aquifer at the Site.

3.4 GROUTING PROGRAM

1. The scope of work for the remediation grouting pilot program consists of performing super jet grouting to improve the continuity of the upper Hawthorn clay layer by construction of overlying soilcrete disks. The proposed location of the pilot-test area shown in Figure 3.1 covers approximately 2,500 square feet.

2. The target grouting depth is specified based on the depth of the upper Hawthorn clay at the pilot-test location. The depth of the upper Hawthorn clay can be determined from available field investigations and is expected to be in the depth range of 20 to 25 feet below ground surface (GeoTrans, 2004; TRC, 2002). The target grouting depth will be confirmed during the prepilot program testing as was discussed in Section 3.1. The thickness of the zone to be grouted is 18 inches and located near or on the top of the clay stratum. A simplified cross-section through the pilot-test area at the Former North Lagoon is presented in Figure 3.4 and illustrates schematically the horizontal grout barrier concept at the bottom of the Surficial Aquifer.

3. For the pilot test program, the scope of work includes the installation of 14 soilcrete disks near the surface of the upper Hawthorn clay as depicted by the layout presented in Figure 3.5. Two lone disks, anticipated to be approximately 14-feet diameter each, are included within the scope of work to assist in measuring the geometry that can be achieved. An evaluation of the existing soil properties and characteristics at the Site indicated that 10 feet and 12 feet on-center triangular grids are appropriate for pilot-testing (see Figure 3.5). Jet-grout disks will be constructed on two spacing-grids. Although overlap is anticipated with the larger spacing, the smaller spacing will also be performed in case overlap is not achieved with the larger spacing. The two grids were also designed to permit interstice locations for subsequent sampling and testing that is part of grouting verification (see Section 4.1).

4. The jet grouting process starts by the drilling rig positioned and drilling a borehole (typically 6- to 8-inch diameter) using grout or drilling mud to stabilize the borehole. Since jet grouting is a bottom-up procedure, erosion is initiated at the target depth with high

velocity injection of cutting and replacement grout and fluids as illustrated in Figure 3.6. This continues with consistent, uniform rotation and lifting to create disk geometry, while expelling eroded spoil out of the top of the borehole. Designed integration of adjacent disks creates a soilcrete mass. Because jet grout equipment operates from above foundation grade, and soilcrete is constructed in a designed sequence, structural integrity is maintained and safety considerations are simplified.

5. During the jetting, excess soilcrete will return to the surface and the process will create an estimated 15 inches of excess soilcrete at the ground surface over the area being grouted. The excavation repository is sized to hold approximately 100 percent of this total excess soilcrete volume (see Figures 3.1 and 3.5), so that locating, moving or transporting to a suitable handling area will not be a controlling factor in the jet grouting operation.

6. Handling and management of excess soilcrete return during jet grouting is illustrated in Figure 3.7. The excess soilcrete will be transported by a front-end loader to the contained capping cell on a continuous basis. To assure a homogeneous and consistent blend, the excess soilcrete will be mixed with the upper 1 foot of in-situ soils before its anticipated setting and hardening time (i.e., within 2 to 3 days from production). The blended soil will be left onsite to solidify for 3 days, and then will be covered with an 8-oz nonwoven geotextile and a 12-inch-thick layer of soil. The cover material will be imported from offsite and will be free of waste, vegetation, lumber or wood, root matter or other deleterious material. Prior to covering, representative samples from the blended soil will be collected for laboratory testing of unconfined compressive strength (ASTM D2166) and hydraulic conductivity (ASTM D5084).

3.5 QUALITY ASSURANCE AND QUALITY CONTROL PROGRAM

1. Quality assurance and quality control are critical components of a successful jet grouting program, ensuring that subsurface soils are consistent with design assumptions and that design parameters are met or exceeded throughout the project.

2. Quality assurance begins with a shop drawing. The specialty contractor will develop and submit a shop drawing before the work is performed, showing the drill locations. The reference points will be surveyed in by the general contractor. The specialty contractor will use these points to layout the individual locations.

3. Some of the objectives of the pilot-test jet grouting program are to verify the design geometry of the soilcrete and to evaluate the permeability characteristics of the soilcrete product. In addition to the quality control inspection items for soilcrete element construction, additional project-specific performance evaluation measures will be required as discussed in Section 4.

4. A Quality Assurance and Quality Control (QA/QC) manual for jet grouting is presented in Appendix B. QA/QC inspection items include the following:
   - Drilling: Location, angle, depth, methods to maintain repeatability.
   - Batching: Preparation of grout slurry for consistency in material content and physical and chemical properties.
   - Jetting: Checking of drill parameters (lift speed, rotation rate) and injection parameters (pressure and flow of all components).
   - Documentation: Accurate documentation for each element constructed. Construction times and correlation to any sampling performed.
   - Sampling & Testing: Retrieval of representative samples for external testing.

4.0 PERFORMANCE EVALUATION AND REPORTING

4.1 EVALUATION OF GROUTING PERFORMANCE

1. A wide variety of testing methods can be used to either directly or indirectly measure the performance of grouting. These include mechanical, chemical, geophysical, and hydraulic methods. The focus of these methods is to determine a change in some property of the subsurface after grouting or to confirm the presence of grout. Some of these methods are nonintrusive and/or nondestructive and can be used without disturbing or damaging the grouted area. The nondestructive methods generally are indirect and require interpretation of the desired information from some other measured property. The more intrusive methods require either collection of samples for inspection or other analysis, or measure some in-situ properties. A combination of mechanical and hydraulic methods is proposed to evaluate the performance of the pilot-test jet grouting as illustrated in Figure 4.1.

2. Mechanical methods are typically used for geotechnical investigations or construction monitoring for common civil engineering projects. These include penetration-resistance tests, probing and sampling, and coring.

3. The consistency of a soil is commonly evaluated by pushing or driving a probe into the soil and measuring the force needed to advance the probe. There are two basic approaches to perform penetration-resistance tests in soils: a) static, and b) dynamic. The static methods advance a probe by applying a static force to the probe to advance it. The most common static (or quasi-static) method is the cone penetration test (CPT). The CPT has the advantages of being relatively quick, low cost, and that it provides nearly continuous data over the full depth of the probe. The disadvantages are that it cannot penetrate very hard or dense materials such as rubble, large gravel and some hardened grouts and it is a test that only evaluates a very small plan area.

4. The dynamic methods of penetration-resistance tests apply an impact of known energy and count the number of impacts needed to advance the probe. The single most widely used dynamic method for soil evaluation is probably the standard penetration test (SPT) (ASTM D1586). The method is typically used in boreholes where a disturbed sample of the soil can be obtained and visually examined or submitted to laboratory testing. Boring methods, however, can influence the results of penetration tests. Methods such as jetting, wash borings, or other methods can disturb the soils to a significant depth below the sampling point, which may affect penetration values.

5. CPT and SPT field tests are proposed for evaluating the extent and continuity of the jet grout application. A grid of test points is presented in Figure 4.2. Penetration resistance by CPT will be measured at eight locations, and SPT tests will be performed at four locations (three locations as shown and one location to be determined in field). The test points are designed to determine if the jet grout achieves complete coverage in the areas being pilot-jet grouted and cures to a hard, less permeable mass. Test data from before (i.e., available field investigations) and after grouting will be compared.

6. Probing and sampling remain the most cost effective procedures for evaluating a grouted formation mass. Sampling procedures are performed after the completion of grouting. In contrast, probe tests must be done both before and after grouting, because comparative data is needed. Shelby tubes are effective in sampling loose-fine grained soils solidified with a weak grout. However, some grouted soils can be disturbed excessively by the insertion of a Shelby tube. Heavy-walled tubing can often be driven through formations not amenable to Shelby tubes, but the samples recovered will usually be fractured. The same is true for drilled samples. Sampling of the grouted mass will be performed through the boreholes used for SPT tests (see Figure 4.2). Recovery of soilcrete samples for further hydraulic conductivity testing in the laboratory will first be attempted using the Shelby-tube sampling method; otherwise, heavy-walled tubing will be utilized.

7. Coring is the process of cutting an undisturbed sample from the subsurface by drilling with a hollow bit. Coring in consolidated materials generally requires the use of a drilling fluid to lubricate the cutting shoe. Air, water and drilling mud are commonly used as drilling fluids. The operation of coring into grouted soil can create microfracturing of the sample. The microfracturing caused by coring can greatly discredit the values of permeability obtained by laboratory testing. For jet grouting applications, sampling devices are available which allow retrieval of wet samples from any depth immediately after disk construction. Figure 4.2 shows the three locations from which wet sampling will be performed to retrieve soilcrete samples for laboratory testing. In addition, one extra location will be determined in the field.

8. Hydraulic methods utilized to evaluate grouting performance include equipment and procedures related to measuring the behavior of water beneath the ground surface. The permeability of soils is one of the most difficult properties in geotechnical engineering to measure. Permeability of soil masses ordinarily is the result of flow through the interstitial

voids between the particles that make up the soil mass. The permeability of soil can be determined from tests performed on samples in the laboratory or from tests performed in situ. The falling head permeability test is a direct method for determining soil permeability in the laboratory and is appropriate for use on soils with moderate to low permeability, such as silty and clayey sands, silts and clays. A flexible-wall permeameter (ASTM D5084) will be utilized to evaluate the permeability of soilcrete mass that forms the horizontal grout barrier at the bottom of the Surficial Aquifer.

9. The purpose of the jet grouting program is to improve the hydraulic barrier characteristics of the upper Hawthorn clay layer and enhance its performance in mitigating creosote mobilization risks in the Surficial Aquifer. To achieve this goal, the soilcrete disks that form the horizontal barrier should have an overall permeability comparable to that of the clay layer (i.e., on the order of 10^{-7} cm/sec).

10. Falling head permeability laboratory tests in flexible-wall permeameters (ASTM D5084) will be used to determine the permeability of soilcrete samples (either retrieved by wet sampling or collected with Shelby tubes). This test provides direct evaluation of the effectiveness of jet grout on permeability. One of the most significant limitations of using this type of test is that the permeability test is only performed on a small discrete sample that is assumed to represent the entire grouted formation. Therefore, several samples (i.e., eight samples) will be collected for testing.

11. Another limitation of permeameter testing is that it is often difficult to obtain an undisturbed sample of the soilcrete. Unless wet samples are retrieved immediately after grouting, samples may be disturbed or completely destroyed when obtained using more aggressive techniques, like rotary borings.

4.2 PILOT-TEST REPORTING

1. A report will be prepared following collection and analysis of all the data from the jet grouting program. The report will include an analysis of implementation and effectiveness of jet grouting as a full scale remedial measure, including order of magnitude costs. The types of data that will be gathered and included in the report are described below.

2. Jet grouting is a relatively costly procedure. Information obtained during every stage of the grouting operation is valuable and can be used to help determine the appropriate type and

consistency of the grout mix, and the effectiveness of jet grouting operation. During the drilling stage, very useful information on the properties of the terrace deposits in the Surficial Aquifer zone can be obtained by observing and monitoring the progress of drilling. Optimally, the drilling data for each hole will include drilling rate, unusual action of the drill rig (such as "chattering," rods dropping, etc.), color and clarity of water return, nature of drill cuttings, and gain or loss of drill water. During the grouting operation, the grout logs provide information on the pressure that the grout was injected under, and the volume of grout that was injected.

3. Detailed and complete records of all aspects of jet grouting operations will be maintained. These data, while forming a potentially valuable part of the "as-built" construction records for the pilot test program, are even more important as a basis for: 1) continually reinterpreting the Surficial Aquifer subsurface conditions, 2) interpreting apparent changes in those conditions as a result of jet grouting, 3) identifying a possible need for modification of procedures for optimizing the results, and 4) assessing the effectiveness of the planned disk layout including the influence diameter of the super jet grouting process and center-to-center grid spacing.

4. Confident interpretation of drilling and grouting data requires that these data be continually plotted, on a daily basis and on line with the quality assurance and quality control program outlined in Section 3.5, at an equal horizontal and vertical scale on a cross-section profile along the horizontal barrier. Ideally, this section also will include interpretive projections of geologic defects (if any) observed at the bottom of the Surficial Aquifer within the pilot-test area. This way, the interrelationships of the various types of data can be placed in a proper context.

5.0 REFERENCES

American Society for Testing and Materials. Annual Book of ASTM Standards: Section 04 - Construction. ASTM, PA, 2002.

Beazer. *Proposed Interim Measures/Remedy Pilot Approach, Koppers Portion of the Cabot Carbon/Koppers Superfund Site, Gainesville, Florida*. Letter prepared for USEPA, Region IV, Superfund North Florida Section, dated August 4, 2004.

Burke, G.K. "Applying Jet Grouting Techniques to Construct Vertical and Horizontal Barriers." International Containment Technology Workshop, Baltimore, Maryland, August 29-31, 1995.

Burke, G.K. "In Situ Containment Barriers and Collection Systems for Environmental Applications." Symposium on Slurry Walls, Canadian Geotechnical Society, Toronto, Ontario, September 24, 1992.

Byle, M.J. and Borden, R.H.. *Verification of Geotechnical Grouting.* ASCE Geotechnical Special Publication No. 57, American Society of Civil Engineers, NY, 1995.

Furth, A.J., Burke, G.K. and Deutsch, W.L., Jr. "Use of Jet Grouting to Create a Low Permeability Horizontal Barrier Below an Incinerator Ash Landfill." Proceedings International Containment Technology Conference, St. Petersburg, Florida, 1997.

GeoTrans. *Data Report for Additional Investigation of Hawthorn Group: DNAPL Source Evaluation for the Koppers Industries Property, Cabot Carbon/Koppers Superfund Site, Gainesville, Florida*, September 15, 2004.

Hayward Baker. *Jet Grouting.* Hayward Baker, Inc., Pub. No. G32, 2004a.

Hayward Baker. *Compaction Grouting.* Hayward Baker, Inc., Pub. No. E36, 2004b.

Ho, C.E. "An Instrumented Jet Grouting Trial in Soft Marine Clay." *Verification of Geotechnical Grouting*, Michael J. Byle and Roy H. Borden, Eds., ASCE Geotechnical Special Publication No. 57, American Society of Civil Engineers, NY, 1995.

Hunter/Environmental Science and Engineering (ESE), Inc. *Volume I - Remedial Investigation/Risk Assessment at the Carbon/Koppers Site, Gainesville, Florida*, September 1989.

International Technology Corporation (IT). *Remedial Investigation Report, FDER Cabot Carbon/Koppers Site*. 1987.

Kutzner, C. *Grouting of Rock and Soil.* A.A. Balkema, Rotterdam, 1996.

Mitchell, J.K. and VanCourt, W.A. "The Role of Soil Modification in Environmental Engineering Applications." *Grouting, Soil Improvement and Geosynthetics,* Roy H. Borden et al., Eds., ASCE Geotechnical Special Publication No. 30, Vol. 1, American Society of Civil Engineers, NY, 1992.

Nonveiller, E. *Grouting: Theory and Practice.* Developments in Geotechnical Engineering, 57, Elsevier Science Publishers, Amsterdam, 1989.

Sehn, A.L. *Strength and Hydraulic Conductivity of a Cement-Slag-Bentonite Grout and Two Grouted Sands.* Special Study Report, Hayward Baker, Inc., Odenton, Maryland, 1999.

TRC. *Data Report April Sampling Event Investigation of the Hawthorn Group Formation, Cabot Carbon/Koppers Superfund Site, Gainesville, Florida,* June 2004.

TRC. *Addendum Hawthorn Group Field Investigation Report, Cabot Carbon/Koppers Superfund Site, Gainesville, Florida*, August 2003.

TRC. *Field Investigation Activities Report, Cabot Carbon/Koppers Superfund Site, Gainesville, Florida,* September 2002.

TRC. *Workplan for Additional Characterization of the Hawthorn Group Formation, Cabot Carbon/Koppers Superfund Site, Gainesville, Florida,* September 2001.

TRC. *Revised Supplemental Feasibility Study, Cabot Carbon/Koppers Industries, Inc. Site, Gainesville, Florida,* September 1999.

USEPA. *Contaminants and Remedial Options at Wood Preserving Sites.* U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC, 1992.

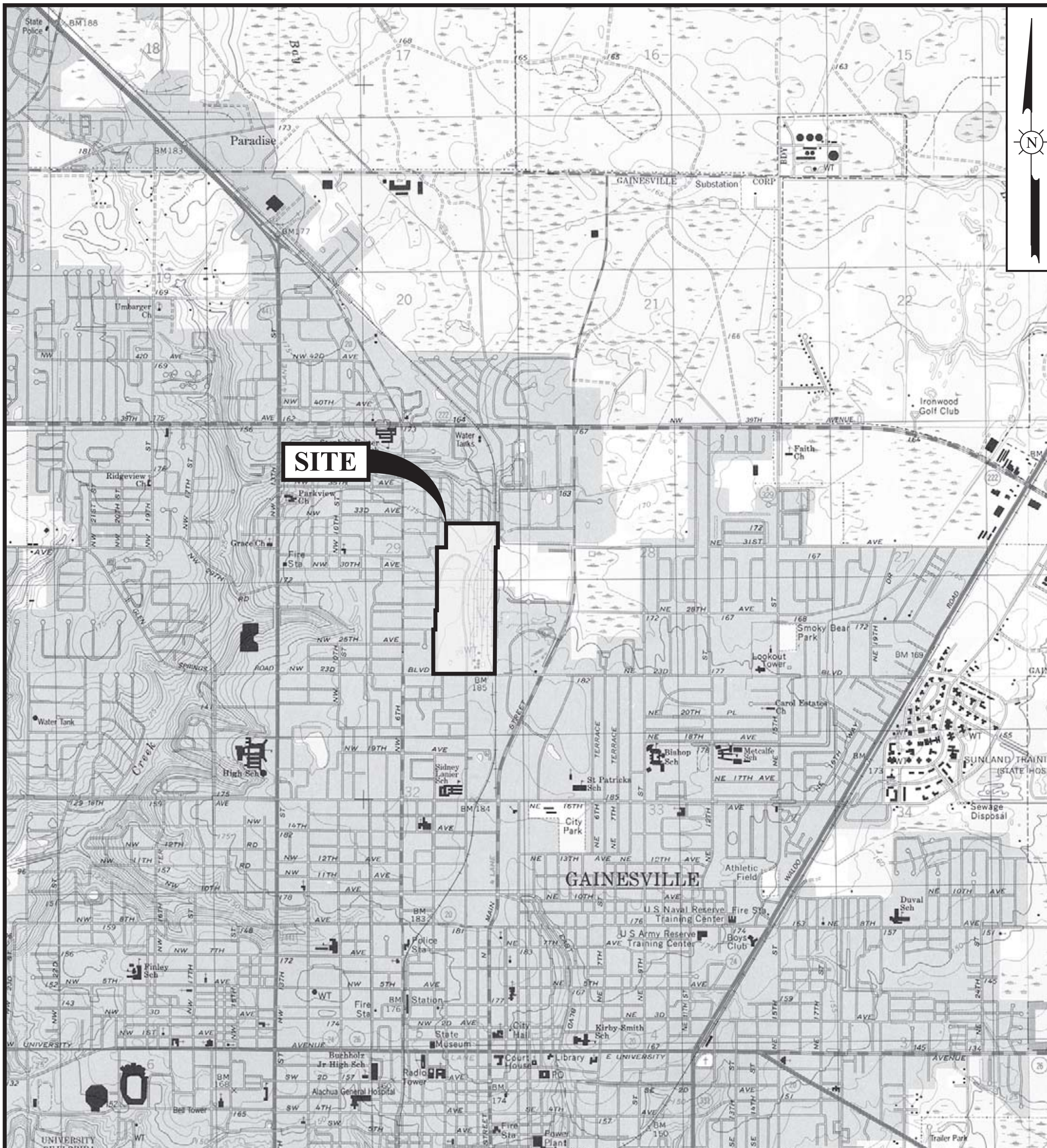
USEPA. *Ground Water Issue: Dense Nonaqueous Phase Liquids*. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC, 1991.

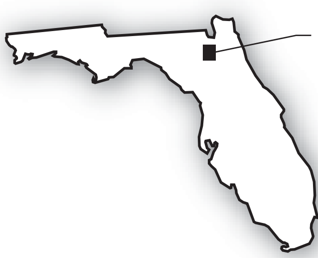
USEPA. *Grouting Techniques in Bottom Sealing of Hazardous Waste Sites*.
U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio, 1986.

USEPA. *Handbook: Remedial Action at Waste Disposal Sites (Revised).* U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio, 1985.

Warner, J. *Practical Handbook of Grouting: Soil, Rock, and Structures.* John Wiley & Sons, New Jersey, 2004.

29016404RGWP-09 REV.12/10/04





0 3,000 6,000 FEET

SCALE

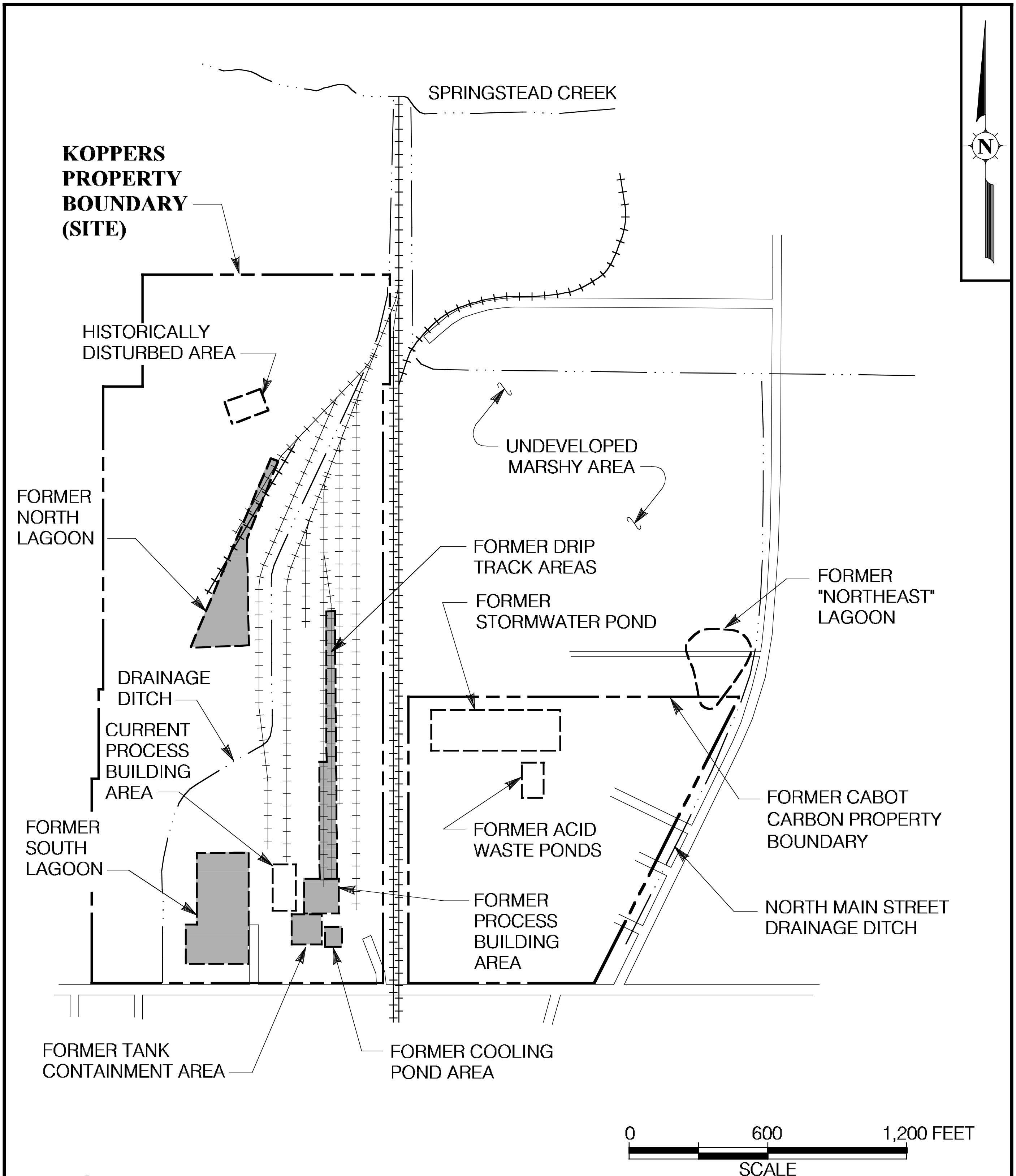
DRAFT

REFERENCE: 7.5 MINUTE USGS TOPOGRAPHIC MAP, GAINESVILLE EAST, FLORIDA QUADRANGLE, DATED 1994.

SITE LOCATION MAP
REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

TRC | **FIGURE 1.1**



LEGEND

IDENTIFIED COC SOURCE AREAS

DRAFT

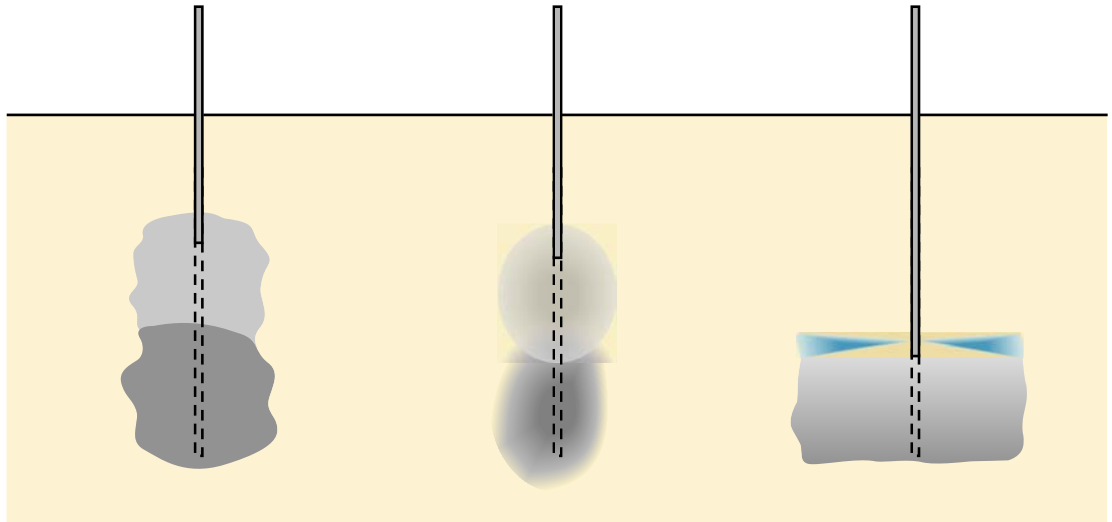
SITE PLAN
REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

TRC

FIGURE 1.2

Methodology	**PERMEATION**	**COMPACTION**	**MIXING**



Objective/rationale	Solidification	Densification	Improvement
Impact On Permeability	Decreased permeability due to added cohesion	Minor decrease of permeability	Impermeable

Reference: Warren, J. (2004).

DRAFT

GROUTING IN SOIL
REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

TRC

FIGURE 2.1

29016404RGWP-12 REV. 12/22/04

LEGEND

KOPPERS PROPERTY BOUNDARY (SITE)

APPROXIMATE DNAPL SOURCE AREA (GEOTRANS INC., SEPTEMBER 2004)

NOTES:

1. GROUT LIMITS ARE PLACE-HOLDERS AND MAY CHANGE FOR OPERATIONAL CONSIDERATIONS.

CONCEPTUAL LAYOUT FOR PILOT-TEST REMEDIATION GROUTING

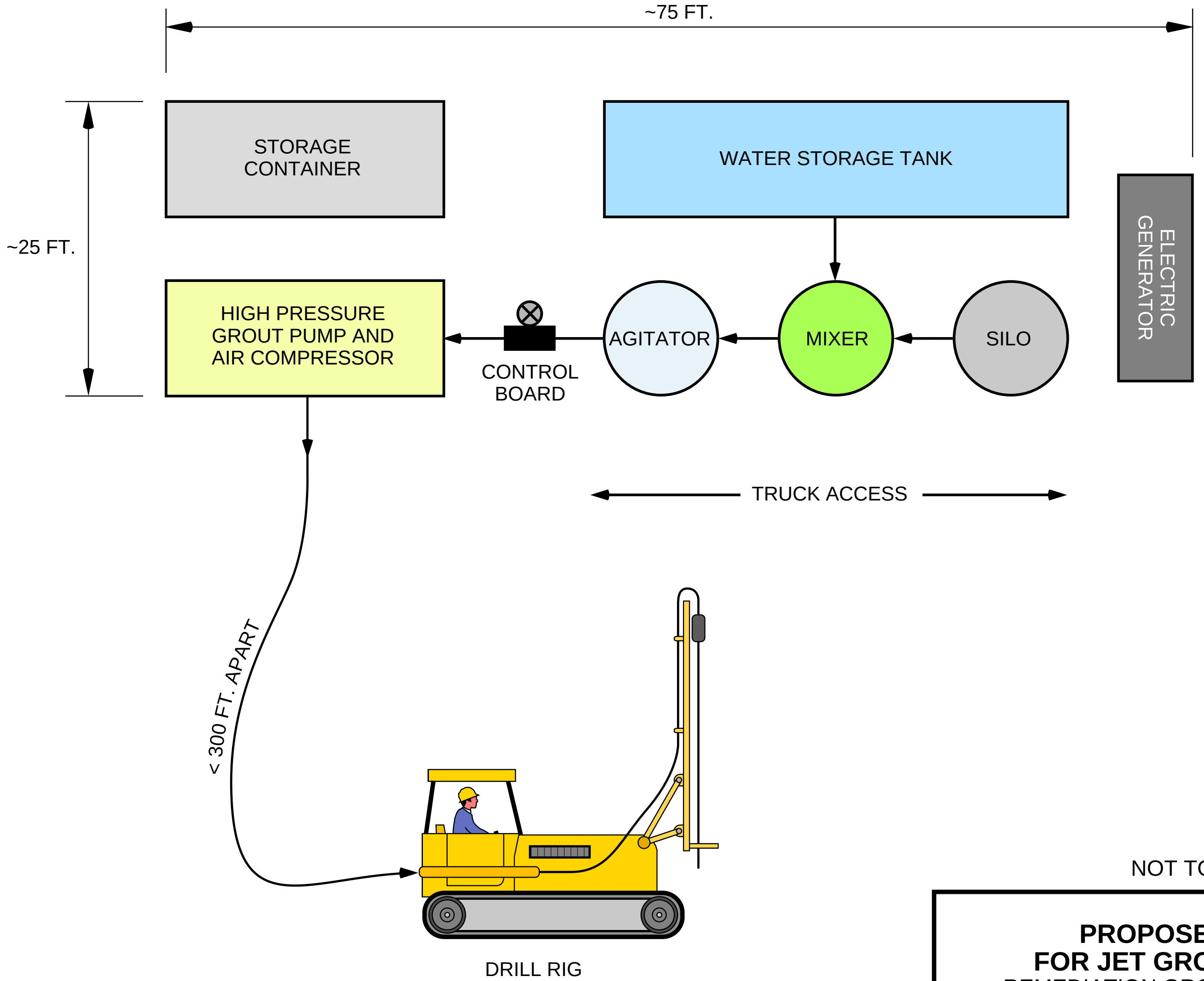
REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

TRC

FIGURE 3.1

29016404RGWP-03 REV.12/10/04



NOT TO SCALE

DRAFT

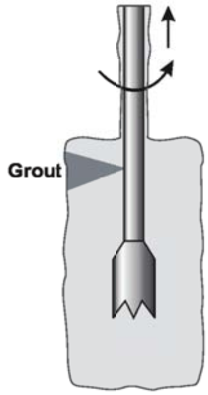
PROPOSED LAYOUT
FOR JET GROUTING SETUP
REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

TRC

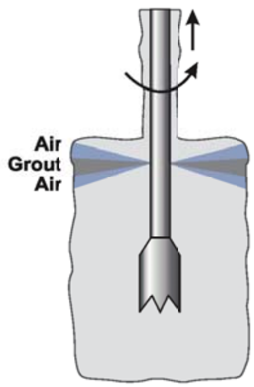
FIGURE 3.2

29016404RGWP-02 REV.12/17/04



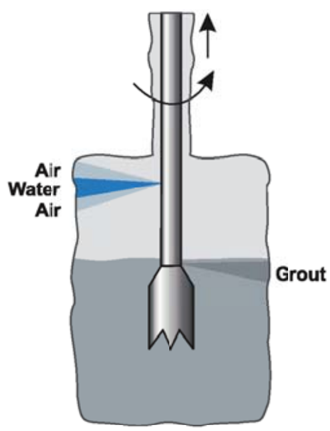
SINGLE FLUID JET GROUTING

- Soil consolidation for tunnel roof
- Bottom bracing for deep trenches in soft soil
- Anchorages
- Cutoff walls in porous soil
- Sealing Applications



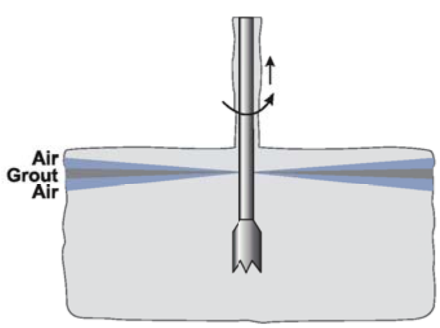
DOUBLE FLUID JET GROUTING

- Soil stabilization
- Some underpinning applications
- Panel cutoff walls
- Bottom bracing for deep trenches in soft soil



TRIPLE FLUID JET GROUTING

- Underpinning and excavation support
- Horizontal barrier/ground water control
- Panel cutoff walls
- Sealing applications
- Most fine grained soil stabilization



SUPERJET GROUTING

- Horizontal barrier/ground water control
- Stabilization of liquefiable strata
- Panel cutoff walls
- Structural supports across excavation walls
- Stabilization of soft soil for microtunneling

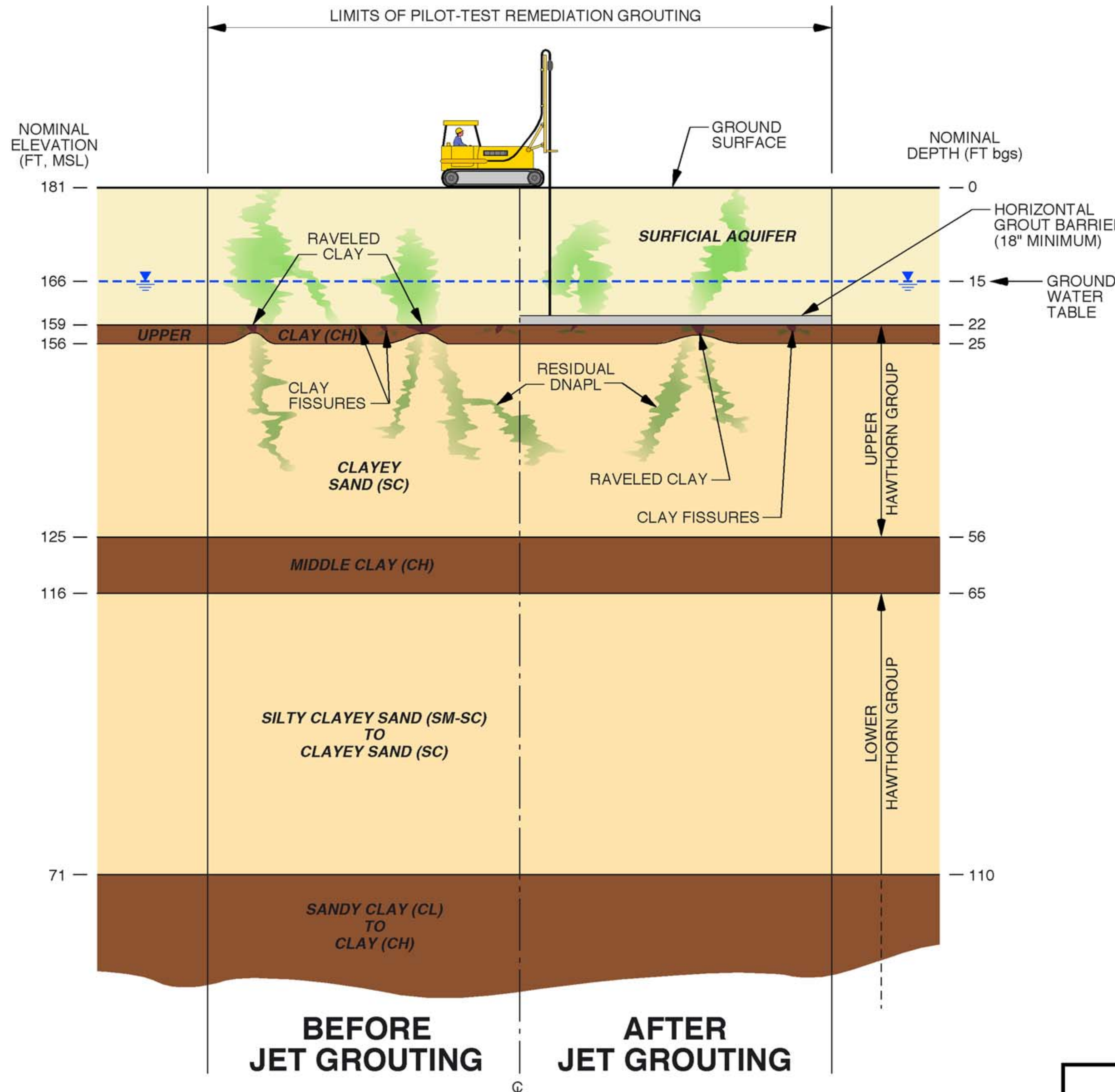
Reference: Hayward Baker Inc. (2004a).

DRAFT

JET GROUTING
SYSTEMS AND APPLICATIONS
REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

TRC | **FIGURE 3.3**



2901640RGWP-08 REV.12/17/04

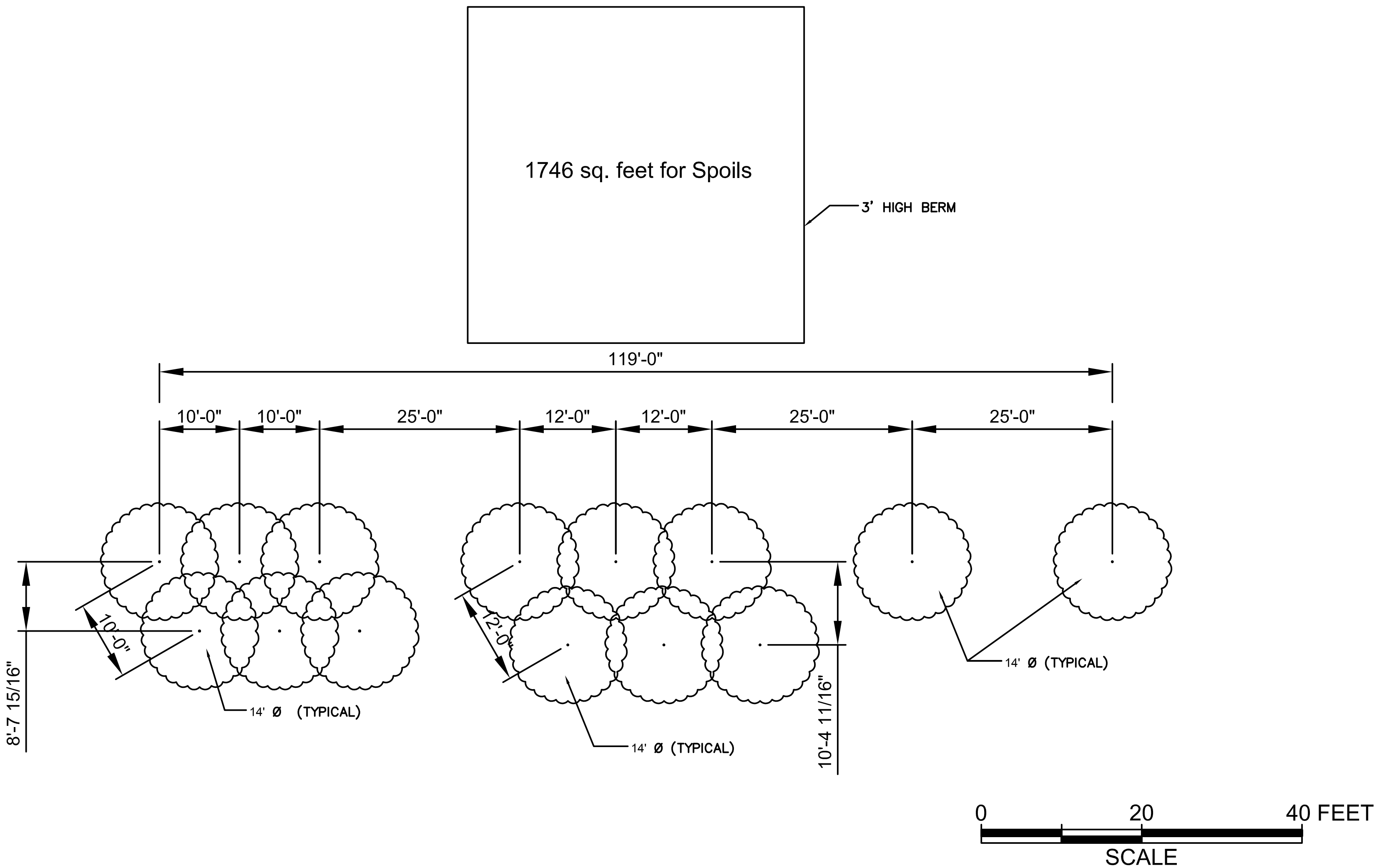
DRAFT

FORMER NORTH LAGOON
EAST-WEST SIMPLIFIED
CROSS-SECTION
REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

TRC

FIGURE 3.4



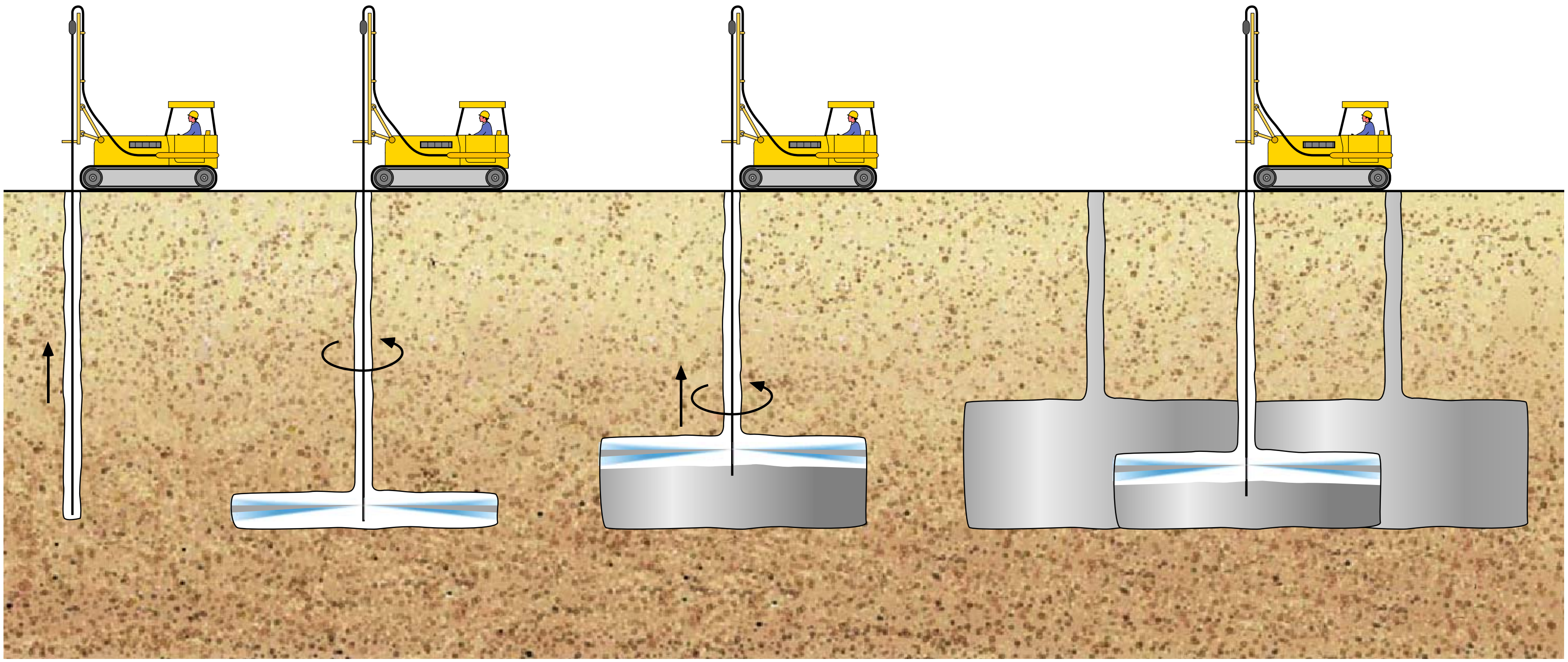
DRAFT

PLAN OF
JET-GROUT DISKS LAYOUT
REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

TRC

FIGURE 3.5



Reference: Hayward Baker Inc. (2004a).

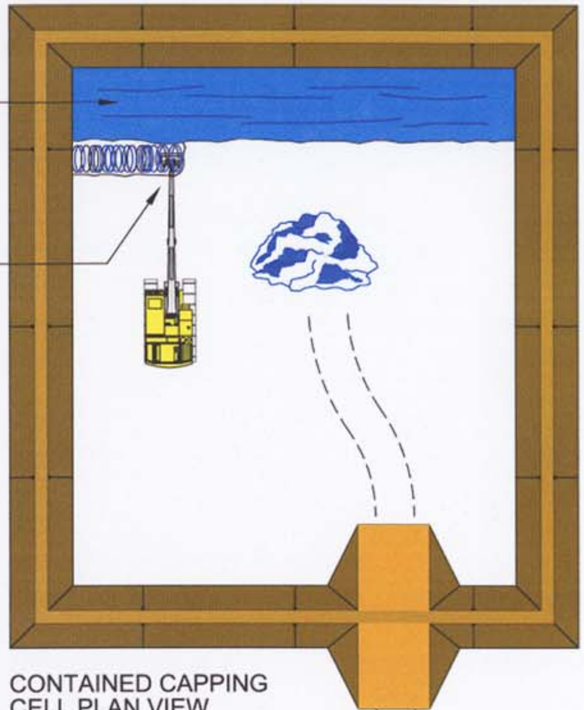
DRAFT

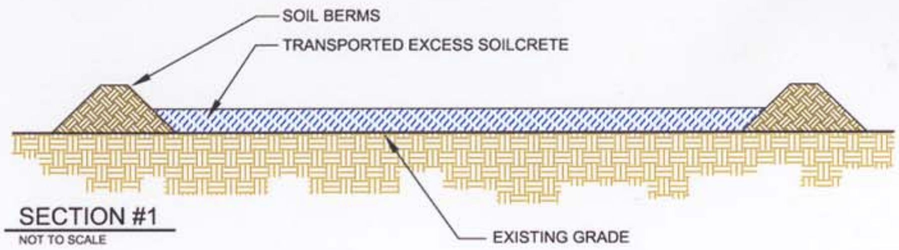
SUPERJET GROUTING PROCESS
REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

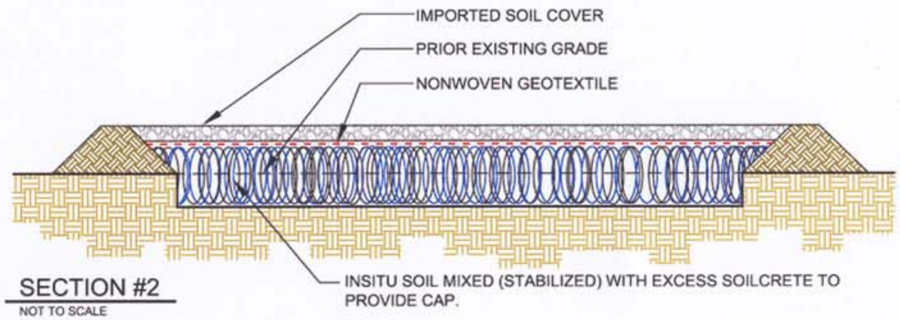
CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

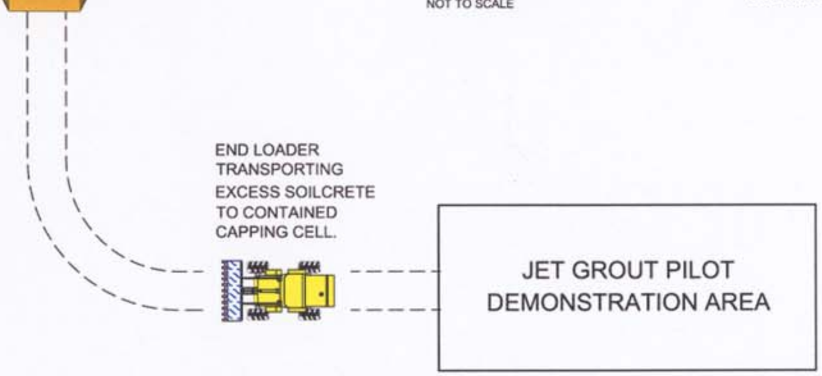
TRC

FIGURE 3.6









AS THE JET GROUTING PROGRESSES, EXCESS SOIL CUTTINGS AND GROUTING COMPONENTS (EXCESS SOILCRETE) WILL BE PHYSICALLY DISPLACED TO THE SURFACE AS THE GROUTING ADMIXTURES ARE PUMPED INTO THE INSITSU SOILS/SANDS. AS THIS MATERIAL SURFACES, IT WILL BE REMOVED AND RELOCATED TO THE CONTAINED CAPPING CELL (PLAN VIEW & SECTION #1).

THE EXCESS SOILCRETE WILL BE BLENDED WITH AN ADEQUATE AMOUNT OF THE EXISTING SURFACE SOIL BY A HYDRAULIC EXCAVATOR AND/OR LOADER TO PROVIDE A CAP.

ONCE THE BLENDED MATERIAL HAS HAD AMPLE TIME TO STRENGTHEN, IT WILL BE CAPPED WITH AN IMPORTED SOIL COVER AS ILLUSTRATED (SECTION #2).

DRAFT

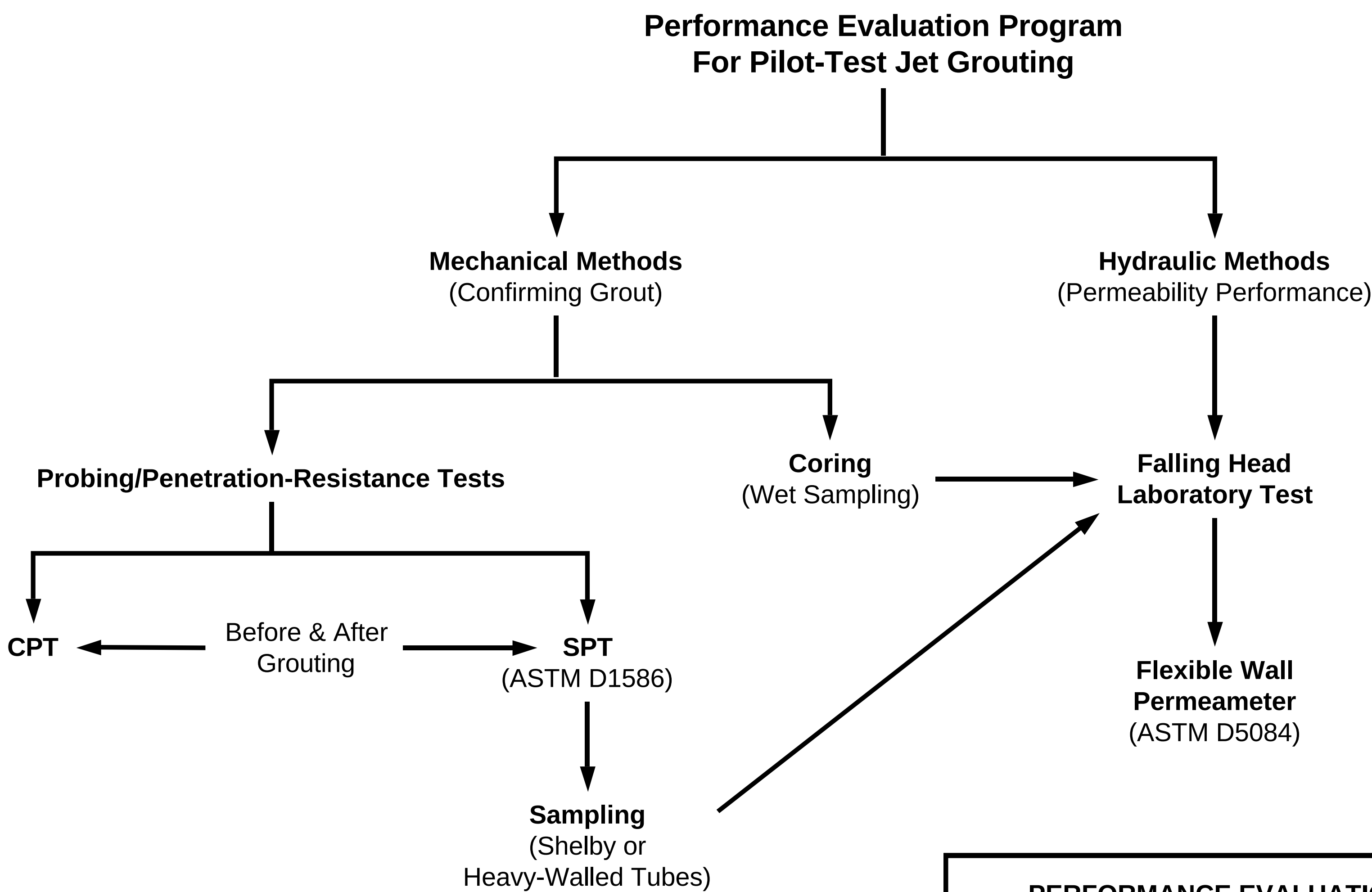
MANAGEMENT OF EXCESS SOILCRETE

REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

CABOT CARBON / KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

Sevenson Environmental Services, Inc.

FIGURE 3.7



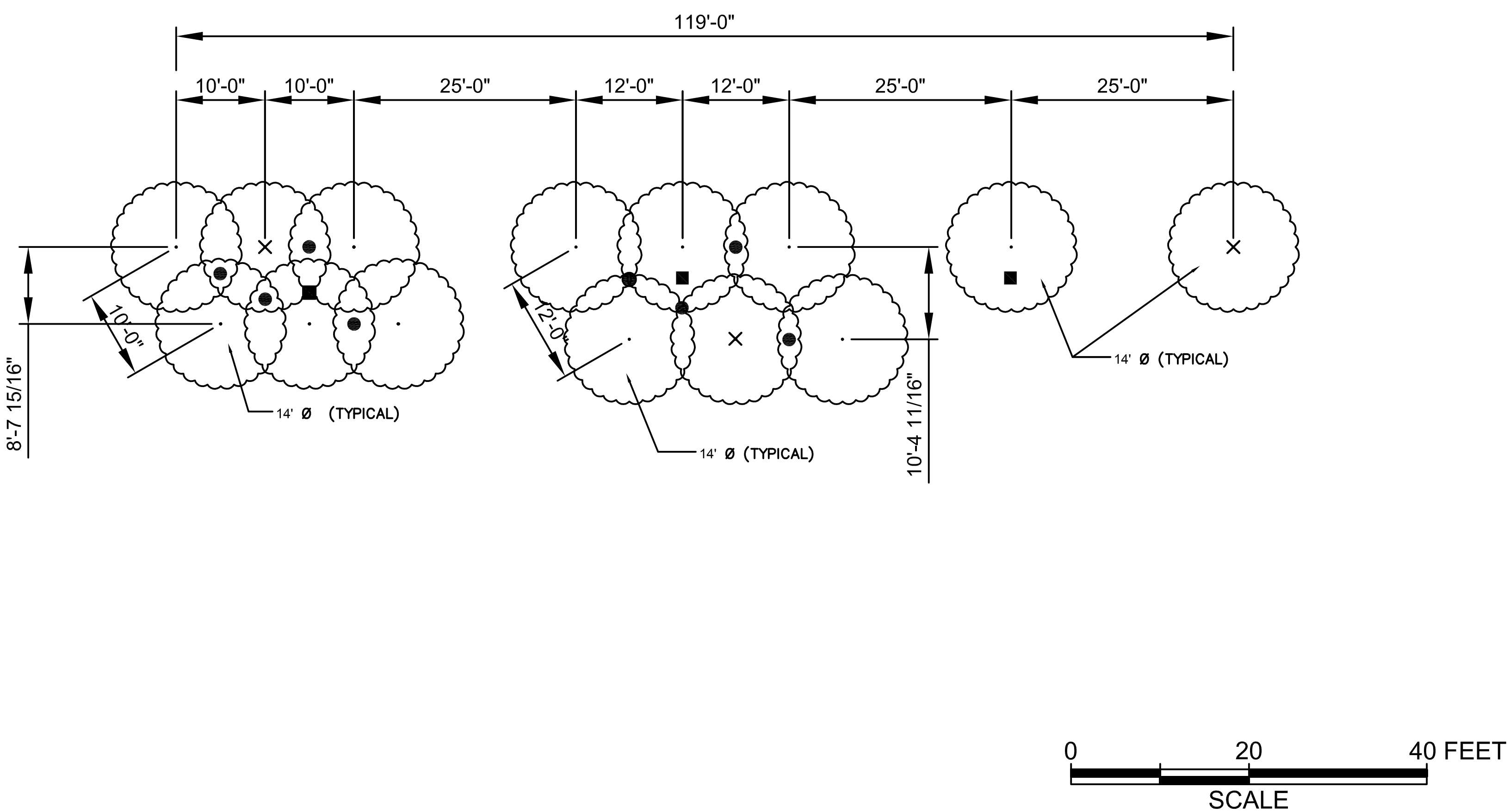
DRAFT

PERFORMANCE EVALUATION PROGRAM
REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

TRC | **FIGURE 4.1**

29016404RGWP-05 REV.12/20/04



LEGEND

● CPT

■ SPT AND SAMPLING

× WET SAMPLING

NOTES:
1. LOCATION OF ONE ADDITIONAL SPT AND SAMPLING TO BE DETERMINED IN FIELD.
2. LOCATION OF ONE ADDITIONAL WET SAMPLING TO BE DETERMINED IN FIELD.

DRAFT

LOCATIONS OF PERFORMANCE EVALUATION TESTS
REMEDIATION GROUTING WORK PLAN
KOPPERS FACILITY

CABOT CARBON/KOPPERS SUPERFUND SITE
GAINESVILLE, FLORIDA

TRC

FIGURE 4.2

APPENDIX A

STANDARD OPERATING PROCEDURES FOR PREPARING AND TESTING SOILCRETE SPECIMENS FOR PRE-PILOT PROGRAM LABORATORY TESTING

TRC
Customer-Focused Solutions

APPENDIX A

STANDARD OPERATING PROCEDURES FOR PREPARING AND TESTING SOILCRETE SPECIMENS FOR PRE-PILOT PROGRAM LABORATORY TESTING

1. Prepare a grout mixture using the following proportions by weight. The bentonite and water should be mixed together at least 18 hours before the grout is prepared to allow the bentonite to become hydrated. The mixing should be done using a colloidal mixer.
    - 8% ground granulated blast furnace slag (GGBFS)
    - 2% Portland cement (Type I, Type II, or Type I/II)
    - 4% bentonite (Wyoming premium bentonite, 90 bbl yield)
    - 86% water

2. Perform the following tests on the grout.
    a. specific gravity or unit weight (calculated SG for the grout is 1.10)
    b. Marsh funnel
    c. Temperature

3. Prepare a soilcrete mixture using equal volumes of the above grout and soil from the site. This is actually done by weight using the in-situ bulk unit weight of the soil to calculate the required amount of soil and the specific gravity of the grout to calculate the weight of grout needed. Prepare enough material to make 15 specimens (11 for testing plus 4 spare). 3-inch-diameter by 6-inch-tall specimens are commonly used. Specimen size should be selected to match the diameter of the specimens that can be accommodated by the permeability equipment. A planetary-action mixer with a dough hook has been used successfully for preparing soilcrete mixtures. A mixer similar to a Hobart Model A20 is recommended. Mix on low speed until the soilcrete is thoroughly blended. It may be necessary to stop the mixer one or two times to scrape off material that is clinging to the bowl or the mixing tool. A total mixing time of about a minute is usually sufficient.

4. Place the fresh soilcrete into plastic cylinder molds in a manner to minimize the amount of trapped air. Strike off the tops of the specimens so they are flush with the top of the molds, and cover the specimens with a sheet of plastic to minimize moisture loss. After the specimens have gained sufficient strength to be handled without damage to the specimens, transfer the specimens to a curing room or cabinet meeting the requirements of ASTM C-511. While the specimens are in the humid room, a plastic sheet should be placed over the specimens to prevent water from accumulating on the specimens. As an

alternative to using the plastic sheet, the specimens can be capped with plastic lids provided that the lids are applied before the specimens begin to stiffen or set. Applying caps to soilcrete specimens that have begun to set can damage the specimens.

5. On the day of testing, carefully remove the specimens from the plastic molds. The soilcrete strength will be very low compared to concrete or mortar mixes, and must be handled very carefully during mold removal and test setup in order to prevent damage to the specimens. If the lab personnel are inexperienced in working with low-strength soilcrete materials, the specialty grouting contractor can provide advice on proper procedures.

6. Unconfined compressive strength testing should be performed on two specimens per test age at specimen ages of 1, 3, 7, and 28 days. Prior to testing, each specimen must either be carefully trimmed to provide smooth and flat end surfaces that are perpendicular to the axis of the specimen or capped with a suitable capping material. Since the specimens will contain sand, they will be difficult to trim, and capping is recommended. Thoro Water Plug Cement has been used successfully as a capping material and sets to sufficient strength within about 10 minutes.

7. Hydraulic conductivity testing should be performed on one specimen per test age at specimen ages of 14, 28, and 56 days. The testing should be performed in general accordance with ASTM D5084. A hydraulic gradient of about 50 has been used successfully on soilcrete materials in previous testing programs. Use tap water as the permeant during the hydraulic conductivity testing.

APPENDIX B

QUALITY MANUAL FOR JET GROUTING

APPENDIX B

QUALITY MANUAL FOR JET GROUTING

1.0 INTRODUCTION

1. Quality will be assured by proper and accurate documentation of all production and testing and will always be accessible to inspection by the Owner and Engineers.

2. The specialty contractor will be capable of performing all of the sampling onsite. All sampling and testing will be under the direction of the specialty contractor's Field Project Engineer to best utilize our experience and equipment.

3. All testing will be prioritized and conducted in general accordance with applicable ASTM, ACI, or other international standards and requirements. Samples, which cannot be immediately tested, will be stored at the lab or at an appropriate onsite location. The QA/QC test results will be reported on a weekly basis as tests are completed. Attached is a table of Quality Control tests we propose and the report forms to be used onsite.

4. This Quality Control and Inspection Program is considered supplemental to the plans and specifications. Additional testing to supplement this program may be performed by the owner/engineer.

2.0 QA/QC PERSONNEL AND RESPONSIBILITIES

1. The specialty contractor recognizes that the requirements on this project are significant and have assigned dedicated personnel to perform these tasks. The specialty contractor's Field Project Engineer will be the Field QA/QC Manager assigned to the project on a full time basis.

2. Responsibilities of the Field QA/QC Manager are as follows:
    - Manage our onsite laboratory activities. Monitor for conformance with authorized policies, procedures, and sound practices.
    - Be responsible for the documentation of samples, preparation of quality control samples and introduction of samples into the sample testing sequence and establishment of testing lots.

- Verify that sampling and testing is conducted in conformance with specified procedures. If the testing is to be performed by an external laboratory, weekly meetings will be held to ensure conformance and transfer of information.
- Maintain an awareness of the entire laboratory operation to detect conditions that might directly or indirectly jeopardize control of the various analytical systems. (Examples: improper label and storage of samples, etc.)
- Verify that sampling and other handling procedures are adequate for the sample types received.
- Conduct and record all quality control testing activities in accordance with these documents.
- Coordinate all testing activities with the Owner/Engineer's field and laboratory personnel and keep them informed of progress, problems, and scheduling. A team approach to sampling and testing will be maintained.
- Verify materials received to be installed onsite are in conformance with the specifications and have certifications required.
- Complete all required quality control documentation and submit them to the Construction Manager (CM) within a reasonable time frame (i.e., 3 business days).
- Print out all recorded jet grouting data, review for conformance, and submit to the CM.
- Report to our Project Manager on all quality control activities.

3.0 LABORATORY QUALITY CONTROL PROGRAM

1. The specialty contractor can provide a field laboratory onsite, adequately equipped, to properly store samples. This will be supported by an independent testing laboratory acceptable to the Contractor and/or Owner. The specialty contractor Quality Control Testing Program is documented by written procedures, forms and instructions. The QA/QC manager is responsible for conducting quality control related activities in compliance with this document.

2. The laboratory Quality Control Program consists of three major areas:
    - Sample Handling
    - Laboratory Analysis
    - Data Management

3.1 SAMPLE HANDLING

1. The site facility will log samples and properly label and store them for the required tests. Labeling information will include the date, disk number, and other relevant information.

2. A master log will be maintained in the lab registering all samples and their disposition.

3. Sample containers will be marked accordingly with the required information. Sample containers will consist of 3-inch-diameter by 6-inch-high molds.

3.2 LABORATORY ANALYSIS

1. All lab testing will be prioritized and conducted in general accordance with the specified standards. Quality control testing requirements are discussed in detail in Section 5.

3.3 DATA MANAGEMENT

1. The quality control data will be calculated, if required, before any data is reported. Any test results that do not meet the quality control criteria of the contract will be investigated and corrective action taken. The QA/QC test results will be available on a daily basis as tests are completed and reported weekly. QA/QC forms will be submitted in conjunction with our general daily report form of site activities (also included in Section 6).

2. Jet grouting parameters are computer recorded for each disk. This data will be printed daily, reviewed, and made available to the CM.

4.0 INSPECTION ITEMS

1. During the course of the work, there are a number of items that warrant visual inspection and checking for the production jet grouting.

4.1 LAYOUT

1. The Construction Manager will furnish layout points or benchmarks from which The specialty contractor can conduct its work. This includes plan and elevation. The specialty contractor will layout individual disks in accordance with the construction drawing. Each disk will have a unique identification number. Any changes to the design location will be

brought to the attention of the CM immediately. This could include a variety of utilities or other obstructions in the area.

4.2 DEPTH OF TREATMENT

1. Construction drawings will indicate the depth of each disk. Onboard instrumentation and marks on the leads will be used to monitor depth during construction and checks are to be made from the data logged reports to assure full treatment.

4.3 GROUT INSTALLATION

1. The production jet grouting procedures will be developed during the pilot test program. This will provide for the appropriate grout mix design at minimum flow rates dependent on penetration and withdrawal rates of the monitor. Grout flow rates, total grout injected per disk, and grout pressure is monitored real time during production, as is depth, air pressure, air flow rate, rotation rate, and lift speed. Values are documented on the Daily Report.

5.0 TESTING REQUIREMENTS

1. The quality control testing requirements by the Contractor are summarized in Table B.1 at the end of this section.

2. Testing requirements for grout slurry and soilcrete material are as follows:
    - Each truckload of cement and fly ash will be accompanied by a manufacturer's certificate of compliance. Each delivery will be recorded in the daily site report and compliance certificates maintained in project files.
    - Grout slurry density will be monitored and measured using an in line densometer or mud balance.
    - Grout slurry cube samples will be retrieved and cast into molds two times per shift. Four molds per sample will be cast and tested for permeability at 14, 28, and 56 days. Density will be recorded on the molds and documented.

- Soilcrete samples will be retrieved and cast into molds for each shift, at a rate of one sample from each of two disks per six-disk group. Samples will be retrieved using an in situ wet sampler immediately after disk construction. Molds will be tested at periods of 14, 28 and 56 days. Soil clods greater than 10 percent of the mold diameter will be screened off, or pushed through and stirred into the sample.
- Core samples will be retrieved from the stabilized area. The core retrieval rig will be equipped with a triple tube PQ size wireline system, for sampling at intervals identified by the engineers. All samples will be wrapped in cellophane and stored in appropriate boxes labeling all intervals, and accompanied by a suitable core drilling log.

TABLE B.1

JET GROUTING QA/QC TESTING

SUBJECT	STANDARD	TEST TYPE	FREQUENCY	REQUIREMENTS
Water	---	pH	Per Source	As required to properly hydrate the materials and remain compatible
		Hardness		
		TDS	Per Source	<1,000 ppm
Cement Ground Granulated Blast Furnace Slag	ACI	Tests to show compliance with standard	Per truckload	Certificate of Compliance from the supplier
Grout	ASTM	Compressive Strength	2 per shift	TBD based on lab testing
	ASTM-C939	Flow	2 per shift	TBD based on lab testing
	API 13	Density	Hourly	Consistent with lab testing
Soilcrete	ASTM	Compressive Strength (Wet Samples)	1 sample round per shift to make 5 cylinders: Test 1 @ 7 days Test 1 @ 14 days Test 2 @ 28 days 1 spare	For information only
		Permeability (Wet Samples)	1 sample round per shift to make 3 cylinders: Test 1 @ 14 days Test 1 @ 28 days Test 1 @ 56 days	
	---	Core Uniformity	Recovery Soilcrete	>80% of recovery

29016403_DrReGrWP (12/28/04/ms)

TRC
Customer-Focused Solutions

DATE: ____________

SHEET NO _____ OF _____

SHIFT: ☐1st ☐2nd ☐3rd

Jet Grout Report

Job No.	Project Name
Location	Weather
Client	Engineer

Working Parameters

Grout Mix: Water --------

Cement --------

Additive #1 -------- --------

Additive #2 -------- --------

Specific Gravity --------

Element Type (Col./Panel)				
Size (Dia./ Degrees)				
Lifting Speed (cm/min)				
Rotation Speed (rpm)				
Water Pressure (Bar)				
Grout Flow (l/min)				
Air Pressure (Bar)				

Element ID No.											
Element Type											
Working Grade (Elevation)											
Depth of Water Jet (m)	Start										
	Finish										
Length Constructed (m)											
Grout Volume Used (l)	Drilling										
	Grouting										
Time Completed Lift											
Time Started Lift											
Actual Lifting Time (Mins)											

Summary Jet Grouting Work		
	Element Type -------- No. ------------ Completed This Shift Length ----------	Element Type -------- No. ------------ Completed To Date Length ----------
	Element Type -------- No. ------------ Completed This Shift Length ----------	Element Type -------- No. ------------ Completed To Date Length ----------
	Element Type -------- No. ------------ Completed This Shift Length ----------	Element Type -------- No. ------------ Completed To Date Length ----------

Remarks (Interruption to lift, delays, etc.)

Directions Received

Foreman Signature: ____________________

Form #B876

CORE LOG

DATE ____________

SHEET ____ of ____

CORE I.D. ____________________

JOB No. ________________ SURF ELEV ____________ DRILLER ____________________

PROJECT ________________________ SOILCRETE AGE ____________ INSPECTOR ____________________

RUN #	DEPTH / TIME FROM	TO	Run Length / TIME	Recovered LENGTH	RECOVERY %	TOTAL LENGTH of pcs > DIAMETER	SQD	DESCRIPTION / REMARKS

DATE SUBMITTED : ____________

UNCONFINED COMPRESSIVE STRENGTH TEST REPORT

PROJECT: **YOUR JOB NAME**

LOCATION: **YOUR LOCATION**

HB JOB No: **YOUR JOB NUMBER**

SAMPLE I D: ____________ DESCRIPTION: ____________

NUMBER of MOLDS: ________ SAMPLE DATE: ____________

MOLD SIZE: ________ in. MIX I.D. ____________

DESIGN 28-DAY STRENGTH: ____________ psi SAMPLE TAKEN BY: ________

TEST AGES REQUIRED: ________________________ days

TEST DATA

I.D.	SAMPLE DATE	TEST DATE	AGE (days)	LOAD (lbs)	AREA (sq.in.)	U.C.S. (psi)	COMMENTS
A							
B							
C							
D							
E							

SUBMITTED BY: ________________________