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WORK PLAN/CONSTRUCTION QUALITY ASSURANCE PLAN
FOR
SOIL MIXING FOR GROUND IMPROVEMENT

U.S. EPA Removal Action
Walton and Lonsbury Site
Attleboro, Massachusetts

Prepared for:

Guardian Environmental Services Company, Inc.
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April 24, 2012

1.0 PROJECT OVERVIEW

In accordance with the Performance Specifications for Soil Mixing for Ground Improvement, Part 1, Section 1.6, Envirocon, Inc. (EI) has prepared this combined Work Plan/Construction Quality Assurance Plan (CQAP) for Guardian Environmental Services Company, Inc. (GES) for the Soil Mixing for the Ground Improvement project for the U.S. EPA Removal Action at the Walton and Lonsbury (W&L) Site located in Attleboro, MA. The purpose of this document is to describe EI's proposed procedures and approaches to complete the Soil Mixing activities including the means, methods and equipment to be used and the planning and testing that will demonstrate compliance with the quality control requirements. The following items are discussed in this Work Plan/CQAP:

- Key Staff and Responsibilities;
- Three-Phase Inspection System;
- Pre-Production Test Section/Full-Scale Soil Mixing Activities
    - Reagent Source and Delivery
    - Mix Design
    - Soil Mixing Equipment
    - Mixing Cell Layout and Sequencing
    - Solidification Mixing Methods
    - Field Sampling Procedures, Specimen Preparation Methods, Field Curing Procedures; Laboratory Testing
    - Field Quality Control Documentation Forms and Reporting
    - Emission Controls for Dust, Odors and Vapors
    - Equipment Cleanup Procedures

This submittal represents EI's most current plan for our work. It may be necessary to amend this plan in real time to account for unforeseen conditions or changes in the work as the soil mixing progresses.

2.0 KEY STAFF AND RESPONSIBILITIES

The following section identifies EI's key staff and their responsibilities for the U.S. EPA Removal Action at the W&L Site.

Project Director – Mike Fisher - As a Project Director, Mr. Fisher's responsibilities include: cost estimate preparation; scheduling; budget preparation; personnel allocation and management; project tracking; and, client and community relations.

Project Manager - Mike Ameel, P.E. - Mr. Ameel will serve as the Project Manager and will be on site as needed for the duration of the project. As Project Manager, he will be responsible for all aspects of project execution including: field operations; project administration; engineering; scheduling; estimating; and, health and safety.

Site Superintendent – TBD - The Site Superintendent's responsibilities will include: day-to-day on-site operational direction and oversight of projects; enforcing company policies and procedures; coordinating, planning and supervising craft labor; ensuring that all required materials, equipment and inspections support the project schedule; and, fulfilling design and construction duties as assigned by the Project Manager.

Certified Safety Professional – Loren Gunderson CIH, CSP - As a Certified Safety Professional and the Health & Safety Manager for the project, Mr. Gunderson will be responsible for supervising all aspects of health and safety program management including: hazard evaluation; sampling and monitoring; training programs; HASP development and implementation; and, compliance auditing. He will also be responsible for conducting job site health and safety audits.

Site Safety Officer – Joe Forekiller - As the Site Safety Officer, Mr. Forekiller will be on site to provide initial crew orientation and training and to review the following: hazard assessment; safety plan implementation; site safety inspections; and, daily tailgate meeting requirement. He will also be responsible for ensuring that all site employees are in adherence with applicable Federal, OSHA, industry and corporate standards. The Site Safety Officer is expected to be on site for the initial week of site activities. The day to day responsibilities for site safety will subsequently be transferred to the Site Superintendent and/or the Quality Control Manager.

Quality Control Manager – TBD - The Quality Control (QC) Manager will be responsible for: oversight of the soil mixing operation; documentation of all aspects of the soil mixing activities; preparation, control and management of soil mix samples; and implementation of the soil mixing sampling program. In addition, the QC Manager will be responsible for the collection of field data and verify layout of the soil mixing cells.

3.0 THREE-PHASE INSPECTION SYSTEM

EI will implement a Three-Phase Inspection System for the pre-production test section and for full-scale mixing activities. The primary purpose of the Three-Phase Inspection System is to require EI to plan and schedule the work to ensure that EI's crew is prepared to start this feature of work. The three phases of inspection control (preparatory, initial, and follow-up) are the core of the Construction Quality Management System.

The Three-Phase Inspection System includes a Preparatory Inspection, Initial Inspection, and Follow-up Inspection for each of these definable features of work. The Three-Phase Inspection System will encompass the following activities:

- Develop, schedule and implement procedures for tracking control phase meetings for definable features of work;
- Notify appropriate personnel of time, date and agenda;
- Conduct Meetings (preparatory and initial);
- Review safety considerations and Activity Hazard Analyses (AHAs);
- Document actual discussions and provide minutes to attendees;
- Review quality control testing and inspection activities;
- Monitor work in place through follow-up phase; and,
- Conduct additional control phase meetings, as needed.

It should be emphasized that the Three-Phase Inspection System is designed to prevent deficiencies and not to detect deficiencies. The following is a summary of the three phases of the inspection system:

Preparatory Phase

This phase shall be performed prior to beginning work on each definable feature of work. The following items will be reviewed during Preparatory Phase:

- A review of each paragraph of applicable specifications and references;
- A review of contract plans;
- A check to assure that all materials and/or equipment have been tested, submitted, and approved;
- A check to assure that provisions have been made to provide required control inspection and testing;
- Examination of the work area to assure that all required preliminary work has been completed;
- A physical examination of required materials, equipment, and sample work to assure that they are on hand and conform to approved shop drawings or submitted data;
- A review of the quality control testing and inspection activities;
- A review of the appropriate activity hazard analysis; and,
- Discussion of procedures for constructing the work.

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Guardian will be notified in advance of beginning any of the required action of the preparatory phase. This phase shall include a meeting conducted by the QC Manager and attended by the superintendent, other CQC personnel (as applicable), and the foremen responsible for the definable feature. The results of the preparatory phase actions shall be documented by separate minutes prepared by the QC Manager and attached to the daily CQC report.

Initial Phase

This phase must be accomplished at the beginning of a definable feature of work. The "Initial Phase" will verify that control for the work developed in the "Preparatory Meeting" is implemented and the work is performed to the level of workmanship mutually agreed to. The following will be reviewed during the Initial Phase:

- Review minutes of Preparatory Meeting;
- Check preliminary work;
- Verify adequacy of controls to ensure full contract compliance;
- Establish level of workmanship;
- Resolve all differences; and,
- Check safety to include compliance with the safety plan and activity hazard analysis.
- Review the activity hazard analysis with workers.

Guardian will be notified in advance of the beginning of the Initial Phase. The QC Manager will be in charge of the Initial Phase Meeting. Separate minutes of this phase shall be prepared by the QC Manager and attached to the daily CQC report. The initial phase shall be repeated for each new crew to work onsite, or any time established level of workmanship is not being met.

Follow-up Phase

Daily checks shall be performed to assure continuing compliance with contract requirements, including safety and control testing, until completion of the particular feature of work. The checks shall be made a matter of record in the CQC documentation. Final follow-up checks shall be conducted and all deficiencies corrected prior to the start of additional features of work. QC personnel should continually refer back to the standards set in the "Preparatory and Initial Phases."

A copy of EI's Three-Phase Inspection Checklist is provided as Attachment A.

4.0 PRE-PRODUCTION TEST SECTION/FULL-SCALE SOIL MIXING ACTIVITIES

The following sections summarize each definable task associated with the soil mixing activities.

4.1 Reagent Source and Delivery

The specified reagent for the soil mixing pursuant to Specification Section Part 2, Section 2.1 A, is Type I Portland cement. The Type I Portland cement will be supplied by Lafarge and delivered to the site in bulk pneumatic tankers. The material will originate at Lafarge's Boston Terminal located at 285 Medford Street in Charlestown, MA.

Upon arrival at the site, the material will be pneumatically conveyed into an on-site bulk storage container located in the contractor staging area (i.e. south of the ground improvement area) or directly into the ALLU PF-7 Pressure Feeder (further described in Section 4.3). EI may elect to utilize an additional storage silo or bulk tanker for added Portland cement storage if deemed necessary. Portland cement will be pneumatically transferred from the on site bulk storage to the ALLU Pressure Feeder as needed.

A bill of lading will be supplied by Lafarge for each bulk delivery. Material volumes will be tracked daily throughout the project on a Bulk Material Balance Sheet. The Bulk Material Balance Sheet will track by date the quantity of Portland cement delivered, the quantity of Portland cement used and the bulk quantity of Portland cement remaining on site.

4.2 Mix Design

The proposed mix design as identified in the Performance Specifications requires the addition of Type I Portland cement at 300 kilograms per cubic meter (506 pounds per cubic yard) of wet soil.

4.3 Soil Mixing Equipment

At a minimum, the following equipment will be utilized during the soil mixing activities:

- CAT 336 Excavator with ALLU PM-500 Power Mixer; equipped with GPS controls;
- ALLU PF-7 Pressure Feeder;
- Bulk Storage Container & Blower;
- GPS Rover and Base;
- PC200 Support Excavator; and,
- Water Truck.

EI will utilize the ALLU Stabilization System as the mixing method on the project. The proposed ALLU equipment is specifically designed and developed for mixing dry reagents into very soft soils for ground improvement. The system is comprised of the excavator-mounted (CAT 336) Power Mixer working in conjunction with the Power Feed unit that meters and delivers dry reagent pneumatically to the mixing head.

The ALLU PM-500 Power Mixer is a hydraulic mixing excavator attachment. The Power Mixer is mounted as an accessory onto a standard excavator by a pin mounting or quick hitch adapter plate. The mixing power is based on the horizontal location of the drums and the unique structure of the mixing parts. The drums rotate simultaneously in three ways at the same time mixing the material in a controlled manner. ALLU PM-500 can process different materials up to a depth of approximately 16 feet. The reagent (Portland cement) is fed by compressed air from the Power Feed unit and into the soil through a tube located near the mixing head.

The ALLU PF 7 pressure feeder is a track-driven unit with a 7 m^3 (the equivalent of approximately 11.5 tons of Portland cement) bulk storage tank, equipped with its own power source. By using compressed air, the pressure feeder feeds the binder into the ground in the middle of the mixing drums of the ALLU PM-500 Power Mixer. The PF 7 is driven and controlled by the excavator operator via the ALLU Data Acquisition Control (DAC) panel. The DAC control panel is located in the cabin of the excavator, and as such, the excavator operator can manage the entire system. At a minimum, EI will supply a 60-ton silo to store material beyond the capacity of the PF 7. The bulk storage unit will be used to pneumatically fill the PF 7, as needed.

EI will be using GPS guidance to mix each of the individual cells within the soil mixing area. The GPS system consists of three main components; a base station, a rover, and machine controls mounted to the CAT 336 excavator. The base station is a fixed component that will be mounted to a stationary tripod. The rover is a portable piece of equipment that calibrates the excavator GPS controls to the site coordinate system and can also be used for various staking and data collection tasks throughout the project. The GPS controls located on the excavator are used to determine the vertical and horizontal control of the mixing head of the ALLU PM-500 mixing head during soil mixing activities.

A digital terrain model (DTM), which is a three-dimensional digital file of the project horizontal coordinate system and site elevation data, will be loaded to a control box located on the excavator and will be used for vertical guidance of the excavator. A DXF file (drawing exchange format) will also be loaded onto the control box for visual horizontal guidance of the excavator. For the layout of the mixing cells, the DXF file will provide the operator with the location and identification of the mixing cell layout. During mixing of cells, the operator will have a direct readout of both the horizontal coordinates and the elevation of the tip of the ALLU PM-500 mixing head.

Prior to utilizing the GPS, EI will utilize the services of Tilton & Associates, Inc. (Tilton) of North Attleboro, MA to assist with the calibration and verification of EI's GPS with the site coordinate system. EI will not commence soil mixing activities until the calibration is independently verified by Tilton.

EI will also mobilize an excavator (PC200) and a water truck to support the mixing activities. The PC200 will be used to assist the soil mixing activities, including removal of obstructions, collection of samples, and management of swell material. The water truck will be used on an as needed basis for dust control, and equipment decontamination and cleaning.

4.4 Mixing Cell Layout and Sequencing

For the pre-production test section, a 10 foot by 10 foot will be selected at a location agreed upon by EI and the U.S. EPA representative (or designee). It is expected that the proposed test section will be located at the perimeter of the soil mixing area such that EI's soil mixing equipment can be set up on a ground surface with sufficient support for safe operation.

An example of a proposed cell layout for the full-scale soil mixing at the site is provided as Figure 1. The general dimensions of the proposed cells shown on this figure are 15' by 15'. Upon completion of the pre-production test section, EI will determine the optimal cell dimensions based on the total Portland cement storage volume of the PF-7, the refill time of the pressure feeder from the storage silo and the total cell mixing time.

Regardless of the size selected for the full-scale mixing cells, each cell will be assigned unique alpha-numeric identification for recordkeeping and sample tracking purposes. In general, during full-scale operations, EI will begin the soil mixing operations along the western limit of the ground improvement area and proceed towards the east, creating a working platform for the soil mixing equipment as the site is stabilized. A full-scale cell layout drawing will be submitted for approval after completion of the pre-production test section.

4.5 Solidification Mixing Methods

This section details the proposed procedures for implementation of the soil mixing activities.

Pre-Production Test Section

Upon field locating the horizontal limits of the pre-production test section by Tilton, the test section will be mixed from the ground surface to the top of the coarse sand and gravel unit.

Based upon the specified dimensions of the test section (10' x 10') and the specified Portland cement addition rate of 300 kilograms per cubic meter (506 pounds per cubic yard) to wet soil, the following table provides an example calculation for determining the quantity of Portland cement required for the test section:

Table 1 - Demonstration Test - Total Reagent Addition Determination

Cell Length (ft)	10	
Cell Width (ft)	10	
Cell Area (sf)	100	Calculated area.
Top Elevation	118.5	As determined by GPS.
Bottom Elevation	108.5	As determined during soil mixing activities by GPS.
Cell Depth (ft)	10.0	Calculated treatment depth.
Cell Volume (cy)	37.0	Calculated volume.
Assumed PC Addition Rate (kg/m^3)	300	As specified.
Assumed PC Addition Rate (lbs/cy)	505.7	Calculated equivalent quantity.
Required Quantity of PC (lbs)	18,711	Calculated total required quantity.

Because the actual depth of the test cell will not be know prior to mixing, an agreed upon depth will be assumed such that a calculated total quantity of Portland cement can be estimated for the test cell. During the mixing of the test section, approximately one half of the assumed total quantity of reagent will be added during the insertion of the mixing head to the assumed depth. As the Portland cement is pneumatically conveyed to the ALLU Power Mixer, the operator will blend the dry cement with the impacted soil. As the test cell is mixed, the total mixing depth of the cell will be determined by the ALLU operator based upon the expected resistance of the mixing head as the top of the coarse sand and gravel unit is encountered. Using the GPS depth readout located in the cab of the excavator, the bottom of the test cell will be determined. The required quantity of Portland cement will then be recalculated for the test section, as necessary, by the QC Manager. The remaining required quantity of Portland cement will be added the test section during the withdrawal of the mixing head. The test section will then be blended until a homogenous soil-cement mixture is obtained. Upon completion of the mixing of the test section, samples will be collected as described in Section 4.6.

Pursuant to the Performance Specifications, if the pre-production test section indicates that the required improvement has not been achieved, the U.S. EPA will evaluate whether the test failure is a result of the EI's procedures, equipment and work practices or if there is a need to change the mix, quantities of injection or procedures outlined in the Performance Specifications. If a change to EI's procedures, equipment and work practices is required, EI will revise this Work Plan to make the necessary adjustments and perform an additional test program. If the change requires a change to the mix, quantities of injection or procedures outlined in Performance Specifications, a Task Order modification will be issued by the Contracting Officer. EI will then perform an additional test program.

Full-Scale Soil Mixing

Upon successful completion of the pre-production test section, this Work Plan will be revised, as necessary, to modify the procedures required for full-scale implementation of the soil mixing program and for management of swell material.

It is expected that a general layout as that shown on Figure 1 will be used for the full-scale soil mixing. In general, EI will begin the soil mixing operations along the western limit of the ground improvement area and proceed towards the east, creating a working platform for the soil mixing equipment as the site is stabilized. Prior to beginning the soil mixing activities each day, the ALLU operator will be supplied with a list and chronology of the cells to be completed. The ALLU operator will complete the cells across the site in a checkerboard fashion. An approximate one foot overlap between solidified cells will be maintained for all subsequent cells.

The anticipated production rate during full-scale soil mixing is 400 cubic yards per day. Based on this production rate, the soil mixing will require approximately 100 tons of Portland cement per day, which is the equivalent of four bulk tanker loads.

4.6 Field Sampling Procedures, Specimen Preparation Methods, Field Curing Procedures, Field and Laboratory Testing

The following table represents the physical testing criteria and characteristics that shall be met for samples collected from the soil mixing activities that have been cured for 28 days. Samples achieving the criteria listed prior to 28 days shall be deemed acceptable.

Table 2: Post Treatment Test Criteria

Test	Test Value
Unconfined Compressive Strength (UCS)	33 psi at 28 days
Maximum Permeability	For information only
Mix Homogeneity	Visual throughout project

From each of the test cells, samples of the treated soil will initially be visually examined to determine the mix homogeneity and completeness of mixing. samples will be taken from two depths from the first 250 cubic yards of soil mixed and then every 1,000 cubic yards mixed thereafter. Meaning that there will be two sets of samples (top 20% and bottom 80%) every 1,000 cubic yards of soil mixed. EI will collect the samples from the two depths using the support excavator. EI will pass the collected sample through a one-half inch wire mesh screen and will then prepare cylinders for subsequent laboratory analyses. EI will prepare a minimum of four 3 inch x 6 inch specimen cylinders for each sample location. The cylinder specimens will be prepared in accordance with ASTM C31M-09.

Two cured samples will be tested for UCS at 7 and 28 days, one sample will be tested for permeability, and any remaining samples will be archived on site. Each cylinder will be labeled with the cell ID, sequential sample number (e.g. A-3-1, A-3-2, etc.), collection depth and date of collection. The samples will be stored and secured in the site office trailer. The 3 inch x 6 inch pre-form molds have an integral lid that will seal each mold such that the storage of the cylinders in a humidity controlled environment will not be required as the moisture within the cylinder will provide the required conditions.

EI may elect to perform pocket penetrometer testing to monitor the expected strength gain of the archive cylinders. The pocket penetrometer readings will be used to get initial determinations of the strength of the cured samples. This testing can be used as a helpful tool to get an idea of strength, but is more qualitative than quantitative. If a pocket penetrometer reading is below the expected goals (as established by the bench-scale testing), the mix design and/or mixing methods may need to be revisited in the field.

EI will utilize the services of a drilling subcontractor to acquire standard penetration test results (SPT, or blow counts) in accordance with Specification Section Part 3, Section 3.4.C.2 to measure the strength of the stabilized soil. EI's drilling subcontractor will mobilize to the site during three separate mobilization events to collect SPT results at locations that will represent each day's production.

4.7 Field Quality Control Documentation Forms and Reporting

The following quality control data will be collected during the soil mixing and documented on the Daily Soil Mixing Quality Control Log:

- Date of mixing;
- Cell identification number;
- Cell dimensions (or area), pre-treatment surface elevation, treatment bottom elevation, depth of soil mixing and cell volume;

- Calculated volume of Portland cement required and actual volume of Portland cement added to cell;
- Mixing notes; and,
- Identification of samples collected.

Attachment B contains a copy of the Daily Soil Mixing Quality Control Log.

4.8 Emission Controls for Dust, Odors and Vapors

EI will minimize and manage dust emissions within the project work areas. Dust management will be extremely important in areas of soil mixing and during the loading and transfer of Portland cement.

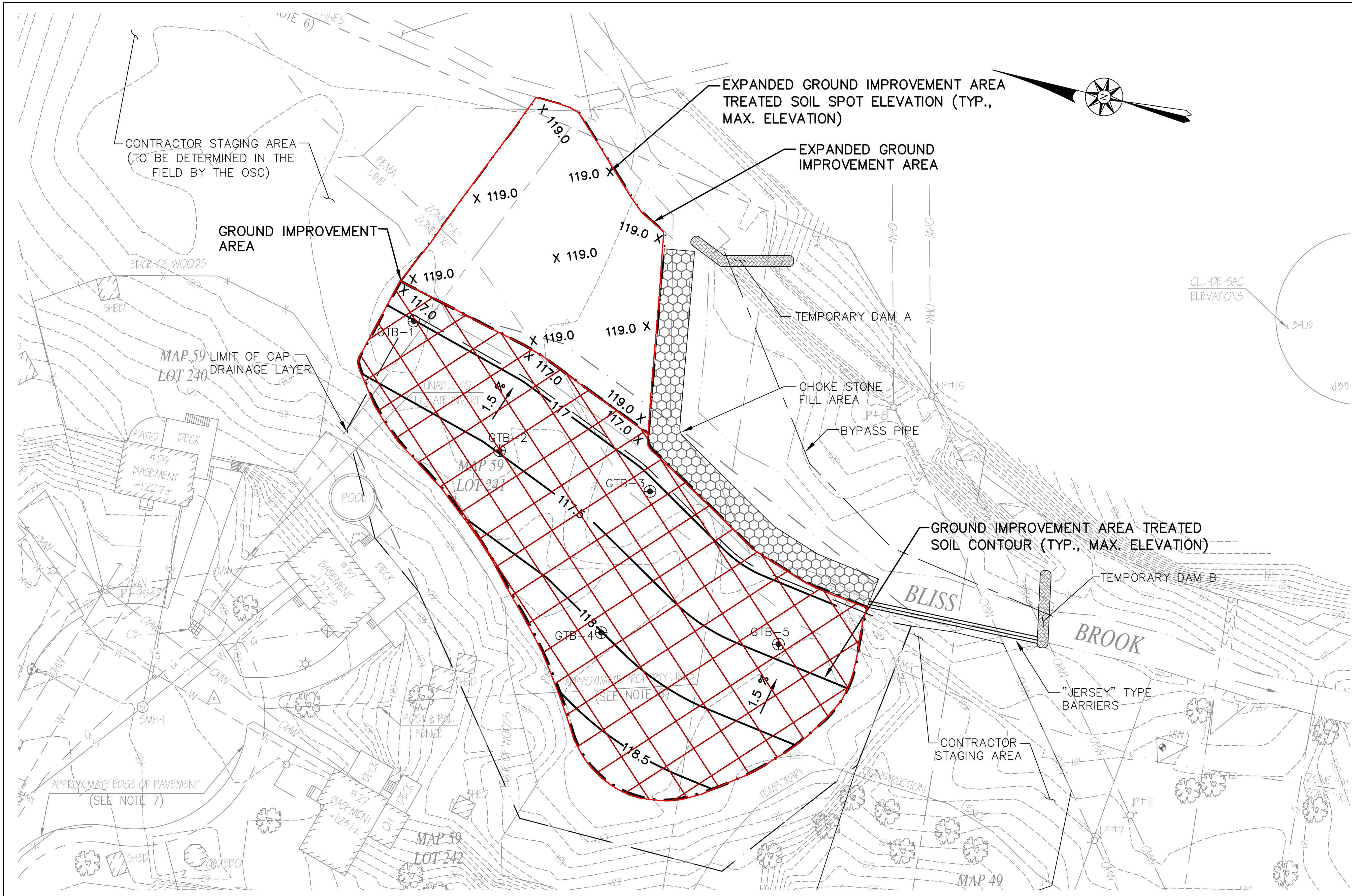
To assist with dust management, EI will mobilize a water truck for dust control. EI's silos and/or bulk storage container are equipped with filters and/or baghouses. This equipment will be maintained on a regular basis to minimize the quantity of dust being generated.

EI will perform air monitoring as outlined in the Site-Specific Health and Safety Plan.

4.9 Equipment Cleanup Procedures

As often as necessary, EI will clean the ALLU mixing head and excavator using either pressurized water from the water truck or a separate power washer. Wash water will be contained with the soil mixing area or contained on the equipment decontamination pad.

FIGURE



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PREPARED FOR: Walton & Lonsbury Site
Attleboro, MA

TITLE: Preliminary Cell Layout

C:\Users\jstone\AppData\Local\Microsoft\Windows\Temporary Internet Files\OLK2F78\Attleboro Preliminary Site Layout.dwg, 2/23/2012 8:31:59 AM, DWG To PDF.pc3

ATTACHMENT A
THREE-PHASE INSPECTION CHECKLIST

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Three Phase Inspection Checklist

(Form 1401.030.001)

Project Name:	**Date:**
Location:	**Client:**
Project Number:	**WBS Code:**
☐ **PREPARATORY** ☐ **INITIAL** ☐ **FOLLOW-UP**	**Definable Feature of Work (DFW):**
Specification or Contract Reference:	

Attendance Names:	**Signature:**	**Representing:**
1.	1.______________	1.
2.	2.______________	2.
3.	3.______________	3.
4.	4.______________	4.
5.	5.______________	5.
6.	6.______________	6.
7.	7.______________	7.
8.	8.______________	8.
9.	9.______________	9.

MANDATORY PREPARATORY REQUIREMENTS

REQUIREMENT/HOLD POINT	STATUS[1]	INITIALS	COMMENTS
1. Have the responsible personnel, e.g., Superintendent, Foreman, person responsible for safety, QA/QC, etc. been identified for this DFW?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		
2. Has the required operations equipment been identified?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		
3. Have the personnel to operate the equipment been identified and have they been qualified per SOP 1401.031?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		
4. Have all of the Safety Equipment and PPE been identified?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		
5. Has the production and schedule goal been determined without sacrificing H&S and Quality?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		

[1] All unconfirmed items are considered “open” and must be tracked to completion.

ENVIROCON

Three Phase Inspection Checklist

(Form 1401.030.001)

6. Have all AHAs been completed in accordance with SOP 1403.013 and has the crew been briefed on those AHAs?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		
7. Has task training been completed and does the crew understand their assigned work?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		
8. Have all Measuring and Test Equipment been calibrated and are certificates of calibration on file?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		
9. Have all utility locations been identified?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		
10. Has the project filing system been set up meeting the requirements of SOP 1401.015?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		
11. Have all permits applicable for this DFW been obtained and reviewed?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		
12. Has the H&A Construction Manager been informed of the nature and schedule for this defined feature of work?	☐ CONFIRMED ☐ UNCON/OPEN ☐ N/A		

ATTACHMENT B
DAILY SOIL MIXING QUALITY CONTROL LOG

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Daily Soil Mixing Quality Control Log
Soil Mixing for Ground Improvement
Walton and Lonsbury Site - Attleboro, MA

Cell Identification	A-5	
Cell Length (ft)	10	
Cell Width (ft)	10	
Cell Area (sf)	100.0	Calculated Area.
Cell Top Elevation	118.5	As determined by GPS.
Cell Bottom Elevation	108.5	As determined during soil mixing activities by GPS.
ISS Depth (ft)	10.0	Calculated treatment depth.
ISS Volume (cy)	37.0	Calculated volume.
Assumed PC Addition Rate (kg/m3)	300	As specified.
Assumed PC Addition Rate (lbs/cy)	505.7	Calculated equivalent quantity.
Required Quantity of PC (lbs)	18,711	Calculated total required quantity.

Date: 5/10/2012
Mixing Start Time: 11:00:00 AM
Mixing End Time: 12:00:00 PM

Mixing Equipment: ALLU Power Mixer PM-550 / ALLU Pressure Feeder PF 7
Mixing Tool RPM:

Mixing notes (e.g., obstructions, unusual conditions, unknown utilities, etc.):

Sample collection summary:

Actual Quantity of PC (lbs) 18,711